ITN RESEARCH SERIES 01

SITUATION ANALYSIS

Water Supply & Sanitation Sector Research in Bangladesh

ITN-BANGLADESH
Center for Water Supply & Waste Management
BUET, Dhaka, Bangladesh

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Abbreviations and Acronyms

ADA	Accelerated District Approach
ADB	Asian Development Bank
ADP	Annual Development Program
AEC	Atomic Energy Commission
ARU	Arsenic Removal Unit
BARD	Bangladesh Academy of Rural Development
BAU	Bangladesh Agricultural University
BCSIR	Bangladesh Council for Scientific and Industrial Research
BRAC	Bangladesh Rural Advancement Committee
BUET	Bangladesh University of Engineering and Technology
DCC	Dhaka City Corporation
CTF	Caretaker's Family
CUP	Coalition of Urban Poverty
DANIDA	Danish International Development Agency
DCH	Dhaka Community Hospital
DFID	Department for International Development
DO	Dissolved Oxygen
DPHE	Department of Public Health Engineering
DTW	Deep Tubewell
DU	Dhaka University
DSK	Dustha Shasthaya Kendra
DWSSD	Drinking Water Supply and Sanitation Decade
ETDA	Employment and Technological Development Agency
ESA	External Support Agency
FFYP	Fourth Five Year Plan
GOB	Government of Bangladesh
GSS	Gono Shahajya Sangstha
HTMP	Handpump Training and Monitoring Program
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
IDA	International Development Agency
IPGMR	Institute of Post-Graduate Medicine and Research
IRU	Iron Removal Unit
ITN	International Training Network
JICA	Japan International Cooperation Agency
KAP	Knowledge Attitude and Practice
LGED	Local Government Engineering Department

LWT	Low Water Table
MAWTS	Mirpur Agricultural Workshop and Training School
MLGRD&C	Ministry of Local Govt. Rural Development & Cooperatives
NGO	Non-Government Organization
NIPSOM	National Institute of Physical and Social Medicine
NSW	Sanitation Week
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
PMED	Primary and Mass Education Department
PP	Project Proposal
PPM	Parts per Million
PRA	Participatory Rapid Appraisal
PSF	Pond Sand Filter
R&D	Research and Development
RWSG-SA	Regional Water Supply and Sanitation Group-South Asia
SAFE	Sanitation and Family Education
SDC	Swiss Agency for Development and Cooperation
SOCMOB	Social Mobilization
SOES	School of Environmental Studies
SSF	Slow Sand Filter
STIDP	Secondary Town Infrastructure Development Project
STW	Shallow Tubewell
SWM	Solid Waste Management
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USEPA	United States Environmental Protection Agency
VIP	Ventilated Improved Pit
VSC	Village Sanitation Centre
WASA	Water Supply and Sewerage Authority
WASP	Water Analysis Simulation Program
WATSAN	Water and Sanitation
WHO	World Health Organisation
WSP-SA	Water and Sanitation Program-South Asia
WSS	Water Supply and Sanitation
WB	World Bank

FOREWORD

One of the main objectives of ITN-Bangladesh is to undertake appropriate research in the fields of Water Supply and Waste Management. An assessment of the status of research works conducted in Water Supply and Sanitation (WSS) sector was considered important to find the research needs, avoid duplication in research works and delineate the priority research areas to address the problems of the this sector in Bangladesh. Accordingly the study on 'Situation Analysis on Water Supply & Sanitation Sector Research in Bangladesh' was commissioned by ITN-Bangladesh during 1998-99. This publication is the outcome of this initiative.

The report gives an overview of WSS sector in Bangladesh as background information, followed by documented research and study reports summarized under literature review. The situation of WSS research in Bangladesh with emphasis on technical, social and arsenic interventions has been analyzed. The policies, strategies, major issues, organization and development partners in Water Supply and Sanitation sector research have been identified. Finally, the research priorities and specific areas of technological research, social and extension research and research in operation and maintenance requiring immediate attention have been delineated in the report.

By and large, this document is a comprehensive database of research and development activities of the government, non-government organizations, development partners and other agencies working in the WSS sector. I hope this publication of ITN-Bangladesh will be useful to the scientists, researchers and sector professionals to understand the status of research in the sector and undertake new research initiatives to address the water supply and waste management problems in Bangladesh.

M. Feroze Ahmed
Centre Director

EXECUTIVE SUMMARY

One of the main objectives of the International Training Network (ITN-Bangladesh) is to undertake research projects relevant to water supply and sanitation sector. The 'Situation Analysis on Water Supply and Sanitation Sector Research' was commissioned by ITN during 1998-99. The objectives of the study is to know the state of art of WSS sector research in Bangladesh by reviewing and analyzing research and development oriented activities in the sector focussing on access and use of the facilities, technological and social interventions, etc. The study is based on the secondary information gathered from agencies working in the field of WSS. A survey by participatory rapid appraisal (PRA) was carried out to determine specific areas of need. Research documents on WSS sector available in different libraries were consulted. A total of eighty-seven reports documented.

In Bangladesh, research in WSS actually evolved and developed in stressed situation prompted by nature and people in survival. People's struggle for existence promoted by some pro-active dedicated personalities working with people are responsible for the present state of research in the country. It was actually gradual evolution of technological and social interventions supported by the government and development partners.

Bangladesh have two water regimes with plenty of water in wet months of June to October and scarcity in dry months especially during February-April. Rivers and floodplains dominate the landscape, endowing it with an extraordinary fertility. However, nature's drainage system is overwhelmed and surface water is dangerously polluted with human waste. Every day, around 20,000 metric tons of excreta is discharged into the open, in fields, ponds and waterways. In some areas the water is chemically contaminated too. The incidence of water and excreta related sickness is high. Diarrhea alone accounts for one in three deaths of children under five each year.

Today, almost everyone (97%) is able to drink water from protected tube wells. This change in behavior was due to a huge government drive which ensured that hand pump tube wells were installed into most communities and households. There are 1 million publicly installed hand pumps and 1.5 million private installations, a remarkable success is observed in rural Bangladesh.

At the end of the 4th five-year plan (1990-95) the service coverage stood at 107 persons per tube-well against a target of 95 persons per tube-well. The causes of shortfall are non availability of materials (particularly TARA) in time, delay in local procurement of materials, curtailment of funds, lengthy approval process of project proposals (PP), delay in tube well site selection etc. During the plan period, 96 production wells, 303-km pipeline, 7 water treatment plants, 13 overhead tanks and 52 km drains were constructed while 6,074 house connections were made in Pourashava and Thana.

The collected documents/information are sorted into a number of major heads as Policy Research, Technological Research, Social Research, Extension Research, General Research and Arsenic Research. The document focuses on research activities on technological and social interventions in WSS sector with special emphasis on people's participation in WSS and contains abstracts of 34 (23 for WSS and 11 for arsenic) studies, documents, theses and reports. Documents are prepared containing gist of the document, basic information and brief analyses of the research outputs. As many as 87 reports were documented.

Policies and strategies of the government related to WSS research include declining ground water, coverage to difficult areas like stone problem areas and coastal belt, rain water harvesting, desalination and iron removal, further improvement of TARA, social mobilization intensified through allies and communication technique. Strategies include low cost technological option of latrine, establish close linkages between research and academic organizations, extension agents and implementing agencies. Research and development will also cover monitoring of declination of ground water table, water quality etc.

The evolution of WSS Sector research is actually the technological and social development in the sector with extension of activities. The action-oriented projects and programs and pilot experiments are all based on technical and social research undertaken by individuals, communities, government agencies, development partners, non-government organisations and private entrepreneurs either individually or jointly between and amongst them.

The national rural drinking water supply program was inaugurated in 1972 after the war of liberation with UNICEF assistance. The technological research and development thus began. The DPHE-UNICEF partnership has continued to navigate the program ever since. The main research and development emphasis was on hardware like pump breakdowns, clogged tube-wells, and corroded iron pipes. The two key criteria of research were durability and low cost. And today, applying the same criteria, UNICEF remains the program's research and development mentor and primary investor. Other partners include RWSS Group of WB, SDC, ICDDR, B, WHO, NGO Forum, government agencies like DPHE, LGED, local government bodies like WASAs, municipalities, Union and Thana Parishads.

Social research identified the key program evolution as decentralization. The main focus of DPHE supervisory activity was placed at *Thana* (sub-district) level. A system of community involvement in the form of application for tube-wells was introduced. User groups applied to their *Union Parishads* (Councils), which then submitted a list to the *Thana* (Sub-district) authorities. This allocation system remains in force today.

During the 1980s, many NGOs began to promote tube-wells among their beneficiaries. The research on equitable distribution started with NGOs focussing on the poor structuring water supply assistance to reach them. UNICEF entered into an agreement with the Grameen Bank to enable members of their savings groups to take out loans for private tube-wells. Most of them are extremely poor and are women.

When the problem of the declining water table in the middle of 1980s, Government with assistance from UNICEF and WB addressed the new technological challenge with action research to extract water from below the suction level. 'Tara' was developed and started production in 1987, and has since become the standard pump for low and marginal water table areas.

Now research focus is on the under-served, low water table areas, the coastal belt, highlands, chemically contaminated area and city slums. Focussed research and applied research activities are the lessons learned with private sector, credit mechanism, unregulated free market, innovative pilot experimentation and WATSAN Partnership.

During the 1990s, social and extension research efforts have been concentrated on developing a comprehensive hygiene promotion agenda. UNICEF acted as facilitator in developing this new evolution. Key messages and communications vehicles have been tested. Different strategies have been piloted with different audiences, schoolchildren, householders, teachers, community and religious leaders.

The most important finding in the technical, social and environmental research in sustained WSS is the responsibility at all levels of society. Water resources, their quality and quantity, and contamination in the environment are the concern of everyone, not just public health officials and engineers. The correct treatment of ponds and waterways, the security of pathogenic latrine contents from open exposure, and the abandonment of personal habits such as open defecation are an individual, household and community responsibility, as well as a responsibility of government.

In WSS, equity, affordability and vulnerability are socio-economic issues. The water-seal latrine favored by DPHE remains far outside the financial reach of most rural households, and for this reason the home made pit latrine continues to be heavily promoted. At present, the ratio of water-seal latrines with concrete linings to home made pit latrines is one to four.

NGOs involved in WSS have played a leading part in the social mobilization movement. Motivational activities ranged from latrine construction demonstrations, household visits and courtyard meetings, to discussions with Ansars and Village Defense Party cadres, health and family planning workers, film shows and rallies.

The promotion of women in the water and sanitation profession, as sanitation motivators and mechanics helps ensure that women's needs are better catered for and their perspective better understood. Where it has been evaluated, women employees' performance in social mobilization and hygiene education tends to outclass men's. It is worth mentioning the number of professional engineers working in WSS projects in LGED. It has shown although it is difficult to find women candidates in the engineering profession, gender barriers are gradually breaking down.

In the early days of the School Sanitation Project, emphasis was focused on the construction of water and sanitation facilities. As time goes on, more emphasis is being placed on ensuring that personal hygiene and clean living become integral part to the school children's lifestyle. Where education officials are supportive and head teachers are keen, school children can become a force for environmental health in the community. Around 55% of the 57,600 government primary schools in Bangladesh still have no sanitation facilities. The goal of the School Sanitation Project is to ensure that all these, and all non-formal primary schools are promoting a 'safe learning environment' by the year 2000.

Research for technological approaches to reduce water supply disparities have been developed, such as the "Shallow" and "Very Shallow Shrouded Tube-well" suitable for some pockets in the saline area and the 'Pond Sand Filter' (PSF). PSF is a simple technology that greatly improves water quality if properly maintained. In iron-excess areas, water is similarly pumped into a simple plant, which removes iron by aeration and filtration. In most of the low water table areas, the key technology is the shrouded tube-well capped by a Tara hand pump. Two adaptations of the Tara, the Tara II and the mini-Tara, are now being tried out on an experimental basis.

Fortunately government and non-government organizations have taken recent step to provide safe water and sanitation facilities to the slum dwellers. The research and development efforts under `Slum Improvement Project' of LGED provide excellent insight for emancipation of the poor slum women for sustained employment, income and social status.

The statutory responsibility for the water supply and sanitation (WSS) sector is vested in the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C). Only recently the MLGRD&C developed and adopted a national policy in the name of National Policy for Safe Water and Sanitation 1998 that describes the objectives and strategies in the WSS sector. Department of Public Health Engineering (DPHE) is responsible for planning, designing, and implementing water supply and sanitation services in rural areas, *Thana* towns and *Pourashavas*. In recent years, Research and Development activities in DPHE has largely concentrated on (a) hand pumps, including the Mini Tara for declining water table areas (Wan 1992) and Tara II for use in low water table areas, (b) duckweed for waste treatment, and (c) iron contaminated aquifers.

In Dhaka and Chittagong, Water and Sewerage Authorities (WASAs) provide services within the metropolitan boundaries of Chittagong and Dhaka. City Corporations (CC) in Dhaka, Chittagong, Khulna and Rajshahi have responsibilities in WSS including waste management. Dhaka City Corporation is in charge of solid waste management, surface drainage and implementation of on-site sanitation. Chittagong, Rajshahi and Khulna CCs are responsible for surface drains, solid waste management and maintenance of water supply provided by DPHE and LGED. None of the organizations has any research and development activities by themselves with pilot projects supported by development partners. Provision for, operation and maintenance of water supply is a statutory responsibility of *Pourashava*, but it has limited technical competence and rely on DPHE or LGED for WSS projects, design and construction.

Private sector involvement is a recent phenomenon in WSS. The government water and sanitation program has stimulated a demand to which the private sector is responding well.

The parameters of research design have been deduced from technological and socio-economic realities of Bangladesh. Public and private sector officials, professionals, practitioners and NGOs working and involved in the field of WSS were interviewed and a questionnaire was administered to know about the research activities and issues on WSS sector research. A cross-section of people interviewed through participatory rapid appraisals to know the needs and demand of people in WSS so that research priorities could be identified for immediate benefit of the people. Since slums lack adequate water supply and sanitation facilities, discussions on PRA sessions were arranged.

Abundance of Water of water is the first parameter of technological and social research in relation to WSS on making safe water available for domestic use and sanitation facilities in public health. Shortage of Water is the second parameter of design is shortage of water. Extraction of water by tube-wells, use of surface water for domestic use, salinity of water for different uses, removal of iron contents are the issues. The third parameter is the water, diseases and sanitation for technical, social and extension research.

Sanitation research in Bangladesh is very different from water supply. The main problem for the sanitation is universal coverage. The sanitary disposal of human excreta and waste are of greater importance. If the disposal of excreta and waste is correctly managed or controlled there will be little risk of human fecal contamination and pollution of living environment.

Behavioral issues are an important parameter of research. The next parameter is social mobilization. Social and extension research has been on to involve all catalytic agents of change existing in the society. The most significant aspects of this process are local resources are tapped to its fullest, existing service delivery

channels are involved and people's participation are ensured to achieve the sustainability in the long run.

Community participation is an important parameter of research as a community could take a greater responsibility to supply different components of service delivery within the means of individual beneficiaries. The sixth parameter of research design is women, children and hygiene education. Women's key role in the collection, management and use of household water supplies makes them the primary beneficiaries of services. The parameter of research in arsenic has important implications for the new challenges that lie ahead.

Unfavourable areas, an important parameter of research areas are the coastal belt, highlands and hills, poor water quality areas, low water table areas, high water table areas. In the coastal belt, inhabited by 19% of the population two alternative technologies for saline areas have been developed. One is the Shallow or Very Shallow Shrouded Tube well, which is very inexpensive, but suitable conditions are rare and drilling failure is very common. The second technology, the Pond Sand Filter uses a hand pump to deliver pond water into a small sand filter. It is simple to construct and operate but requires a high level of user motivation to keep the filter clean.

Formation of the Water and Sanitation (WATSAN) Committees in every Union has been one of the major steps in successful social research. The WATSAN committees have been given the responsibilities of increasing the demand for sanitary latrines and disseminating water, sanitation and health messages. The WATSAN committees at the grassroots act as the channels for ventilating the local demands, complaints and innovative ideas to the government officials.

The research and development in social issues emphasize on an effective communication plan for WSS especially sanitation comprising of three main elements i.e. high level advocacy to gain national leadership support, social mobilization to bring on-board new partners for both communication activities and service delivery and program communication, which involves the creation of a number of strategies for behavioural change, which are delivered through mass media, traditional media and interpersonal, interactive channels.

There is no doubt that the arsenic situation in Bangladesh is very grave to say the least. Patients are suffering and physicians are at a loss. We are optimistic that with joint efforts of the government, national organisations, international agencies and scientific community some solution will be reached that will bring smile to faces of the distressed. A concerted and well coordinated effort and research with action programs are necessary.

The growth of network of actors and stockholders in safe water and sanitation in recent years is a testimony to the importance attached by the society towards a better standard of environmental health. Two decades of people-oriented action

research, pilot experiments and development efforts confirm that for sustenance WSS will have to be a combination of technical know how along with local wisdom and community participation is imperative for a sustained system. The technological along with social research interventions established that low cost appropriate technology, social mobilization, community participation and hygiene education are the key elements for cost-effective affordable water supply and sanitation practices in our country.

In turn, government agencies, local bodies, international organizations, donors, NGOs followed the path. In recent times, key bilateral donors, notably WHO, DANIDA, SDC, RWSG of UNDP-WB, have faithfully supported research oriented development. These partners have acted as advisers, stimulators, watchdogs, colleagues and evaluators. Their insights have helped in the past to promote such issues as equity in tube-well siting, gender dimensions and the need for close monitoring and accountability, community participation, the involvement of the private sector, and the role of government as facilitator.

Present research challenge is to scale up community-based and demand-responsive approaches into national policies and programs. Considering the present situation of WSS, research objectives and priorities should be directed to issues of learning and communicating knowledge, strengthening policies, improving investment effectiveness, development of appropriate technology in technical and social realities of Bangladesh.

There is urgent need for research to generate knowledge based on field activities. Primary focus of research should be on pilot projects supported by program and field experiences to test sustainability of specific approaches before scaling them up. Research should delineate the roles of formal water and sanitation utilities, private sector actors, local government and community organizations in service delivery, financing mechanism including micro credit, pricing of the expansion of service to the poor, compatibility of WSS with multi-service slum- upgrading projects. Research design should focus financial policies. Research and development activities should set design criteria depending on price, which the purchasers are willing to pay rather than considering cost as a function of the design criteria. Research should offer modifications to existing practice or technology by changing or replacing components rather than offering a completely a new package of technology.

Research should focus on assessing acceptability of the product or the technology by consulting potential purchasers or users at every stage of its development. Research should directed to generate demand for WSS services at the same time improve the products (technologies) by accommodating variations thereby enlarging people's choices.

There is no reliable and good publication of research study on WSS. There is lack of adequate skill of the researchers in the field of arsenic. Government and donors

should come forward to provide funds for capacity building of researchers for conducting different research studies on arsenic as well as other areas of the WSS like sanitary land fill.

There is also lack of co-ordination among the researcher; as a result maximum researchers do not know the finding of the many research studies, even they do not know on what issues or problems they should carry out research. In this situation some one should take proper initiative immediately. ITN has started the work, the institute could be effectively used to coordinate research activities, research institutions and researchers in the field of WSS.

Immediate technological research attention in water supply is needed on the field of contamination and pollution of water from open defecation and pits travel horizontally and vertically under different surface and ground water conditions; safe water for flooded and high water table areas. A range of alternatives technologies for overcoming arsenic problem e.g. arsenic removal unit attached with hand pump or small scale arsenic removal plant, options for declining of water table and recommendations to counter; rain water harvesting; pond sand filter; iron removal unit attached with hand pump or small scale iron removal unit; development of low-cost technology for water extraction are the priorities.

In sanitation technological research should cover distance pollution from pits travel horizontally and vertically in different soil type under different ground water conditions; sanitation for flooded areas; soil types of onsite sanitation; collection and disposal of wastes and sanitary land fill; development of low-cost technology for environmental latrine; dug well with sanitary protection; latrines in high water table areas; latrines in flood-prone areas and in coastal belt within tidal zone.

Social and extension research should include co-ordination among sector stakeholders in undertaking WSS research projects and activities; process and role of private sector in WSS service provisions; role of credit mechanism in WSS provisions; trans-sector linkages; cost sharing; water supply and sanitation for slums; primary and secondary collection of wastes in cities and municipalities; behavioral issues; health and hygiene issues; assessment of effectiveness of communication materials; women's roles and responsibilities in WSS sector.; effective community participation; awareness creation about arsenic problems to handle the critical situation in arsenic affected areas.

Research should look into the deficiencies in undertaking actual research projects/activities in WSS sector, deficiencies in proper documentation of the research outcomes, deficiencies in proper dissemination of research outcomes, duplication of research activities due to lack of co-ordination, information dissemination etc, expected role of different organizations involved in WSS sector regarding research and need of field testing of research outcomes for further improvement.

1. INTRODUCTION

1.1 BACKGROUND

The primary goal of ITN-Bangladesh is to achieve an improved human resource base in water supply and waste management in Bangladesh.

One of the major objectives of ITN-Bangladesh is to undertake research projects relevant to water supply and sanitation sector. A Research Sub-Committee was formed for identification, assessment, selection and guiding the research projects under ITN-Bangladesh. The Sub-Committee felt some research work is necessary to develop an inventory of research and development activities within water supply and sanitation sector. Accordingly, ITN-Bangladesh invited proposals for research projects on four broad-based topics. The 'Situation Analysis on Water Supply and Sanitation Sector Research' is one of the topics commissioned for completion during 1998-99.

1.2 OBJECTIVES

The objectives of the study is to know the state of art of WSS sector research in Bangladesh by reviewing and analyzing research and development oriented activities in the sector focussing on access and use of the facility, technological and social interventions and beneficiary participation, particularly involvement of women.

Specific objectives are to

i. Assess present status of research in WSS sector on the technological and social interventions and beneficiary participation, particularly involvement of women.
ii. Develop and prepare a database and document the activities of government, non-government organizations, development partners and other involved agencies in WSS sector.
iii. Identify through analysis of data what research activities should be undertaken in near future.

1.3 METHODOLOGIES

Documents /information Collection and Sorting
The study is based on the secondary information gathered from concerned

agencies working in the field of water supply and sanitation. A list of organizations visited for collection of information regarding research activities in WSS sector is given at ***Annex - 1.***
Principal researcher discussed professionals working is WSS sector research to know the previous activities, present status and possible sources of information regarding research and development. Their views were also sought on future research and development in the sector. A list of persons visited is given at ***Annex - 2.***

Relevant reports of various agencies and entrepreneurs reviewed to get information of the innovative approaches. A questionnaire was administered to the involved agencies and a survey by participatory rapid appraisals (PRA) was carried out to determine specific areas of need. ***Annex - 3***

Research documents on WSS sector available in different libraries were consulted and include ITN, BUET, BARD, UNICEF, Community Development Library and NGO Forum. A total of eighty-seven reports documented.

The collected documents/information are sorted into a number of major heads. The major heads are:

a) Water Supply and Sanitation: Policy Research
Contains reports and documents that have policy implications like technological options, role of agencies, local government institutions, development partners, community participation, privatization, framing principles and strategies etc. A database of nine documents has been prepared.

b) Water Supply and Sanitation: Technological Research
This includes research and development of different types hand-pumps (e.g. Tara I and II), alternative technologies (e.g. PSF, SST), different types of sanitation options (e.g. Water-sealed latrines, Pond Sand Filter etc.), Operation and maintenance (O&M) of Water and Sanitation facilities. There are seventy-two documents under the database.

c) Water Supply and Sanitation: Social Research
Different approaches taken by different projects in relation with soft issues (e.g. public-private partnership in water supply and sanitation), Women participation in water supply and sanitation activities, Health Promotion & Hygiene education) etc. Eighteen reports are documented.

d) Water Supply and Sanitation: Extension Research
This documentation contains result of technical and social research that lead to extension research development in water and sanitation sector.

For example extension of social research finding involving WATSAN Committees. There are thirteen documents added.

e) Water Supply and Sanitation: General Research
This includes research activities of eight reports that are general in nature.

f) Water Supply and Sanitation: Arsenic Research
Arsenic is now an established phenomenon in our water and many studies have been conducted on its extent, causes and some of these studies are documented. Fifteen documents are collected.

Documentation and Organization
The document focuses on research activities on technological and social interventions in WSS sector with special emphasis on people's participation especially women in WSS and contains abstracts of 33 (22 for WSS and 11 for arsenic) studies, documents, theses and reports. Documents are prepared containing gist of the document, basic information and brief analyses of the research outputs.

The report is organized into seven chapters:

Chapter 1 Introduction
Chapter 2 General overview of Water and Sanitation in Bangladesh
Chapter 3 Literature Review
Chapter 4 Situation Analysis in WSS
Chapter 5 Issues and Organizations in WSS
Chapter 6 Research Interventions in WSS
Chapter 7 Conclusions

Chapter 1 analyses the state of arts in WSS Sector Research with the Background and Objectives, Methodologies, Documents and Information Collection, Sorting and Documentation.

Chapter 2 describes general overview of WSS in Bangladesh and contains chapters on Introduction (Country Profile, Water and Sanitation, Review of National Plans (Rural and Urban Water Supply and Rural and Urban Sanitation). In this part the objectives and strategies with regard to research are described. It also reviews performances and policies for past plans especially the fourth five-year plan (1990-95) in rural and urban water supply and sanitation sectors.

Chapter 3 deals with the literature in Water Supply and Sanitation and Arsenic Contamination. The review is expected to help the planners, professionals, service providers, academicians, government agencies, NGOs and development partners involved in the field to know the situation in WSS sector particularly of

research and development. A Database in matrix of research literature on policy, technical, social, extension and, general research in WSS is prepared

Chapter 4 presents a situation analysis in relation to Policies and Strategies, Research Status and Evolution in WSS sector research. Evolution includes Water Supply, Sanitation, Hygiene Education, Sustenance, Behavioral Issues, Social Mobilization and Community Participation, Children and Women, Problem Areas and New Focus Areas.

Chapter 5 discusses the issues and organizations in WSS sector research and includes the role, responsibilities and activities of the stakeholders in WSS sector in a chapter that includes, Government Agencies, Local Government Bodies, Urban administrative units, Rural Administrative Units, Non-governmental Organizations (NGOs), Private sector and Development Partners. The contexts of WSS Sector Research on Water Conditions, Water and Diseases, People's Participation and Involvement of Women are described in a separately.

Chapter 6 delineates research interventions in WSS. Technical Research on Water Supply and Sanitation and Social Research focusing Social Mobilization, Community Participation, Women as Key Role Players and Other Social Issues are described in separate chapters.

Arsenic Contamination chapter deals with the summary of findings of some recent studies by the universities, research institutes, development partners and agencies like UNICEF, ICDDR, B, BUET, DCH, LGED, DPHE, WB, SDC.

Chapter 7 describes Research Priorities and Conclusions. In Conclusion joint effort of all the stakeholders has been emphasized. Lastly Recommendations for future research in WSS sector have been incorporated.

1.4 LIMITATIONS

The research in WSS actually evolved and developed by stakeholders in stressed situation prompted by nature and people in survival. People's struggle for existence promoted by some pro-active dedicated personalities working with people are responsible for the present state of research in the country. It was actually gradual evolution of technological and social interventions supported by the government and development partners especially UNICEF.

It is recently that need for research is recognized by government agencies, non-government organizations, private entrepreneurs, academic or research institute has been initiated towards to research activities in water supply and sanitation sector in Bangladesh. ITN, Bangladesh probably is the first to take the lead.

They undertook the present situation analysis to document the research activities so that a future framework for policy direction can be started.

Government agencies, local government institutions, research organizations, non-government organizations contacted all described their research as an end product of programs or projects, action programs and pilot experimentation. Obviously projects and programs have been developed on the basis of need and improvement of existing efforts. Government agencies like DPHE and LGED, institutions like BUET, BARD, DU, development partners like UNICEF, WHO, ICDDR-B, SDC, WB, ADB, DANIDA, non-government organizations under the umbrella of NGO Forum, ETDA, CUP and private efforts like that Kurrum Khan have taken projects that have technological, social, environmental and extension research in-built. The interventions were analyzed in the light of their present research elements and future research implications.

Therefore, in the absence of any concerted and directed research activity by any organization or agency in Bangladesh, project documents, published reports, documents, papers, manuals and even brochure are the basis of the database. This at least gives a chronology of research activities that led to the present state of research in WSS.

Government, on its part put only marginal emphasis on research its policy and other documents just in a sentence or two and one has to derive from that the research policy directions. In the water and sanitation policy published only recently (1999), the story is the same. Probably it has come out of the proposition that research will be an automatic thing and there is nothing to bother about.

2. GENERAL OVERVIEW OF WATER SUPPLY AND SANITATION IN BANGLADESH

2.1 COUNTRY PROFILE

Bangladesh is a delta of 147,570 square kilometre formed by the rivers, the Ganges, the Brahmaptura and the Meghna systems. The country lies between 20° 34' and 26° 28' north latitude and 88° 01 and 92° 41' east longitude. It has India on the east, north and west and the Bay of Bengal on the south with small boundary with Myanmar in Southeast.

In general, the climate is monsoon tropical with hot wet summers and cool dry winters. The highest temperature is recorded at 40° C in April and the lowest at 6° C in January. Average rainfall ranges from 1200 mm in the west to 5200 mm in the extreme north. Most of the year, the relative humidity is high from 80% to 95%.

Over 120 million people make the country most densely populated rural nation in the world with more than 800 people per square kilometer. They live in about 70,000 villages. There are two groups of people. The Bengalis are the most numerous. They are age-old brown-skinned inhabitants of this land. They live in broad plain areas. The other group consists of tribal people who live in the areas where jungle covered hills exist.

The land is largely flat. Arching around the flat plains are the foothills of the Himalayas. There are broad plains, medium level ridges and shallow basins in the west region and smooth broad basins with flood plain ridges and narrow rims of higher land in the east. One-third of the country is flood free highlands. Two-thirds are shallowly to deeply flooding medium highlands to lowlands. The flood depth in these lands ranges from 0.3 m to more than 5 m during the monsoon season.

Flood is a formidable natural calamity of excessive water. Flood occurs when the rivers and canals cannot contain water and overflow their banks. This excess water submerges localities and habitation and cause heavy damage to life and property. Cyclones and tidal waves also cause floods in the southern parts of Bangladesh.

Floods destroy houses; uproot trees; fields and roads go under water. People, cattle and other domestic animals are in miseries without food and shelter. Epidemics break out as an after effect of flood. Scarcity of pure drinking water becomes acute. Bangladesh had devastating flood during 1954, 1970, 1988 and 1998. Most areas went under water. Communication was disrupted and people suffered untold miseries.

The life expectancy of the Bangladeshi is 55 years. There is only one doctor for every 9,500 people, a factor influencing the high infant mortality rate of 120 per 1,000 live births. The average per capita calorie intake is less than 2,000 calories per day.

Bengali is the mother tongue and official language although English is spoken among the educated. The Bengali language has a long and very rich literacy tradition with a magnificently broad and expressive vocabulary.

2.2 WATER AND SANITATION

Bangladesh have two water regimes with plenty of water in wet months of June to October and scarcity in dry months especially during February-April. Rivers and floodplains dominate the landscape, endowing it with an extraordinary fertility. Every contour of the countryside is threaded with streams and ponds. They are all with water in wet and with a little in dry months.

But this source of life is also threat to life. Nature's drainage system is overwhelmed and surface water is dangerously polluted with human waste. Every day, around 20,000 metric tons of excreta is discharged into the open, in fields, ponds and waterways. In some areas the water below ground is chemically contaminated too. The incidence of water and excreta related sickness is high. Diarrhea alone accounts for one in three deaths of children under five, that is 110,000 child deaths each year.

Drainage pattern is generally north to south and Southwest. The cross-boundary rivers carry huge volume of sediments of which two-thirds are flashed out. The reminder is deposited mainly on the riverbeds, *beels* and cultivated lands. The rivers are changing their courses regularly and *beels* are drying up due to this and other man-made interventions.

Following the success in providing safe drinking water to the population, this dire picture of Bangladesh is improving. In 26 years since independence, there has been a revolution in drinking habits. A generation ago, people drank water from open ponds and streams. Today, almost everyone (97%) is able to drink water from protected tube wells.

This change is behavior was due to a huge government drive which ensured that hand pump tube wells were installed into most communities and households. There are 1 million publicly installed hand pumps and 1.5 million private installations, a remarkable success given the very low income of average rural family.

Unfortunately this picture has a discouraging side as the reduction expected in water and hygiene-relates sickness has been very encouraging. However, this should not be seen as a disappointment, but rather as an essential step towards the gains in disease reduction for which pure drinking water paves the way.

Bringing about change in hygiene habits remains the outstanding environmental health challenge in Bangladesh. This is now being pursued by the public health authorities and their partners, both internal and external, non-governmental and governmental donor and beneficiary. But new problems are continually surfacing, such as drop in the water table leaving increasing areas of the country seasonally water-sort. The added new problem is arsenic contamination in the groundwater.

2.3 REVIEW OF NATIONAL PLANS

Rural and Urban Water Supply

The main objective of Rural Water Supply Program for the period 1990-95 was to increase service coverage through installation of hand tube-wells and to minimize discrimination among areas by providing more tube-wells of appropriate technology in the under-served areas. At the end of the 4th plan (1990-95) the service coverage stands at 107 persons per tube-well against a target of 95 persons per tube-well. A comparative picture of targets and achievement with regard to major components is given below.

Table 1 Comparative Picture of Targets and Achievement in Rural Areas during 1990-95 and Position in June, 1997

Name of the works	Position 1990	Plan Target 90-95	Achieve-ment 1995	% Achieve-ment	Position June,97
Sinking of Shallow Tube-well	718168	97313	95795	98	849233
Sinking of Deep Tube-well	22498	71670	68800	96	108135
Sinking of Tara Tubewell	27231	28718	26255	91	75623
Construction of Ring well		850	805	95	
Sinking of VSST/SST		3100	3033	98	
Construction of PSF		925	891	96	
WS Coverage in Rural Areas in TW/Person	1/125	1/95	1/107	86	1/105

Source: The Fifth Five-Year Plan, 1997-2002, Planning Commission

The above table shows that the physical achievements are quite appreciable. Efforts are on to conduct research and development (R&D) activities to innovate appropriate and low cost technology suitable for different areas of the country.

The causes of shortfall to achieve targeted objectives identified are non availability of materials (particularly TARA) in time, delay in local procurement of materials, curtailment of funds, lengthy approval process of project proposals (PP), delay in tube well site selection etc. In urban areas a comparative picture of targets and achievement is as follows.

Table 2 Comparative Picture of Targets and Achievement in Urban Areas during 1990-95 and Position in June, 1997

Name of the works	Position 1990	Plan Target 90-95	Achievement June, 95	Position 1997
Dhaka City Water Production in MLD	546	250	227	850
WS Coverage in Dhaka City in %	50	15	10	65
Chittagong City Water Production in MLD	136	68	23	168
WS Coverage in Chittagong City %	45	-	5	52
Pourashava & Thana Water Production in MLD	250	227	45	518
WS Coverage in Pourashava & Thana %	41	35	8	51

Source: The Fifth Five Year Plan, 1997-2002, Planning Commission

'During the plan period of 1990-95, 96 production wells, 303-km pipeline, 7 water treatment plants, 13 overhead tanks and 52 km drains were constructed while 6,074 house connections were made in Pourashava and Thana.

Rural and Urban Sanitation

A long-term objective of Rural Sanitation Project has been to reduce incidence of water borne diseases through installation of sanitary latrines. The sanitation program in the name of "Village Sanitation Project" was commenced in 1974 and continued up to June 1996. This program had three different phases with versatile experiences in this field.

From commencement of the project a total of about 0.5 million latrine was sold which contributed to 11% coverage by population till 1990. The experiences gained from the project and the lessons of other studies on sanitation promotion revealed that the mere service delivery in the form of latrine component hardly achieves the objective of the program. It is felt that a massive awareness creation program towards health-hygiene through social mobilization should be launched throughout the country in order to increase the existing coverage drastically to an acceptable level. Subsequently a massive program for awareness creation in the name of Social Mobilization for Sanitation SOCMOB came into being 1992. This program encompasses the potentials NGOs, local leaders, professionals, religious leaders, teachers, women and others who have key role in the society. Several means of communications are utilizing to disseminate sanitation massage. It is observed that the program is going in the right direction creating massive

awareness among the people. However, poverty and other social conditions are identified hurdles for which program targets are not achieved at the envisaged rate.

At the onset of 4th five-year plan a target of production of 1.815 and selling of 1.50 million sets of latrine was set. Up to June 1995 a total of 1.337 and 1.287 million sets of latrine was produced and sold respectively. The percentage of achievement of production and selling is 74% and 86% respectively. (Planning Commission, 1998)

Table 3 Comparative Picture of Targets and Achievement in Sanitation during 1990-95 and Position in June, 1997

Name of the works	Position 1990	Plan Target 90-95	Achievement 1997	Position June,97
Distribution of Water Sealed Latrines (Numbers)	918125	1500000	1209624	2557749
Sanitation Coverage in Rural Areas (Percent)	11	-	36	40
Sanitation Coverage in Dhaka City through Sewerage (Percent)	25	10	33	35

Source: The Fifth Five-Year Plan, 1997-2002, Planning Commission

Due to wide spread demonstration, production and sale of latrines from DPHE and private enterprise productions centers over the years and promotion of sanitation through hygiene education, social mobilization a favorable situation has been created for the accelerated sanitation program. There are now roughly 3000 private and NGO production cum selling centers producing latrines. Social leaders are now gradually becoming aware about the importance of sanitation and are urging people to improve their sanitation and personal hygiene practices. It is estimated that the social mobilization program along with service delivery up to June 97 has raised the coverage to 40% of rural population inclusive of home made pit latrine.

In order to increase people's involvement in Rural Water Supply Program the contribution was raised in 1993. The present contribution a STW, Tara and DTW is Tk. 700, Tk. 1000 and 2000 respectively. The contribution for re-sinking of shallow is 700. Since the contribution is same for new and re-sinking people demanded new wells instead re-sinking old ones. Care Taker's Family (CTF) training program has been introduced to train the beneficiaries towards maintenance of the tube-wells by beneficiaries themselves. The program is releasing GOB gradually from the burden of maintaining wells huge recurring expenditure.

During the 4th plan mass scale mobilization program in the name of "Social Mobilization for Sanitation" was lunched in order to bring about a dramatic improvement in coverage.

The introduction of revolving fund in the 3rd phase of the Village Sanitation Program (VSP) provided a unique opportunity to maintain the continuity of the production of latrine sets with reduced subsidy.

The water supply and sanitation sector is a service sector. The projects under this sector are designed to provide services at the operational cost but not to earn profit out of them. However, the program has both direct and indirect affect on employment generation and private sector development opportunities.

During the 4th plan (1990-95) as many as 0.227 million different type of tube-wells have been installed or rehabilitated and 1.09 million sanitary latrine sets have been delivered through public sector. An equal number of facilities of latrine sets have been marketed through private sector.

It is estimated that about 0.75 and 0.5 million man-days were created in rural and urban sector respectively through water supply and sanitation program only during the plan period. The employment generated in the private sector through GOB initiative may even exceed the above estimate.

2.4 WSS IN FFYP, 1997 - 2002

The general objectives of water supply and environmental sanitation program for the fifth five-year plan period are to

- improve health status of the people through improved & increased access to safe water sanitation and improved personal and domestic hygiene practices,
- improve and strengthen capacity of sector institutions towards sustainable development of water supply and overall sanitation, and
- contribute to overall environmental improvement through minimizing Air, Soil and Water pollution caused by human feces and refuges

3. LITERATURE REVIEW

3.1 REVIEW OF LITERATURE RELATED TO WATER SUPPLY AND SANITATION

1. New Concepts for Partnership in Rural Water Supply and Sanitation for the Low Water Table Areas Of Bangladesh, Swiss Agency For Development and Cooperation (SDC), 1997

This is a report on new concept for partnership in water supply and sanitation for low water table (LWT) areas of Bangladesh initiated by GOB and SDC. The working group from DPHE, UNICEF, RWSG-SA and NGO-Forum compiled the report. Report indicated significant progress by the increase in access to tube well water (90%). The private sector, public sector and NGO played a vital role in achieving increase in overall latrine coverage.

It is estimated that by 2010 about 22% of Bangladesh will be affected by a lowered water table in dry season, making hundreds of thousands of pumps non-operational for 3 to 4 months of the year. Therefore under the new approach

- A marketing strategy and plan for selected water and sanitation facilities would be developed and tested by specialized marketing agencies.
- Intermediary organizations such as NGOs and local government bodies would be strengthened through networking promotion, advocacy with provisions of application friendly training packages on (I) social mobilization, (ii) hygiene behavior, (iii) organization and (iv) use of existing credit and savings programs.
- Through participatory research and development, low cost options of hard ware namely LWT hand pumps and latrine parts would be developed and marketed.
- Policy dialogue would be specially emphasized through creation of specific platforms that contribute to enhance a more concerted policy making among a wider range of government and non-government stakeholders.

2. Twin Pit Sanitary System for Bangladesh, Local Government Engineering Department, May, 1994

Acceptable sanitation options in use in Bangladesh are single and twin pit latrines, septic tanks and water borne sewerage system. Water borne sewerage system is

capital intensive and is used only in Dhaka. Septic tank system is too costly and soak wells integral to septic tanks, are seldom constructed. Municipalities do not service bucket or service latrines in use. Individual households make their own arrangements to empty latrine pits and septic tanks by sweepers. A part from health risks, the practice is an aspersion on human dignity. Raw sewage collected by sweepers is not disposed off properly; dumping indiscriminately in open fields, ditches, drains or watercourses is common.

Choice of proper sanitation system depends on behavioral and cultural attitudes, status in the community, available water supply, willingness of public authorities to bear and people to pay the costs, social factors, use of digested excreta, institutional support, self help and re-use potential etc.

On consideration of the above factors Twin Pit Sanitary System seems the most appropriate for both poor and rich people living in urban and rural areas. In case of dearth of water, or cultural habits that make water seals inappropriate, direct Discharge Pit Systems and Ventilated Improve Pit (VIP) latrines or Twin Pit Sanitary System (non water seal) may be proposed.

3. A study of filtration process for the treatment of surface water, a thesis by Md. Masuduzzaman, supervised by Dr. Farooque Ahmed

The objectives are to study the effect of arrangement of aggregates in a horizontal flow roughing filter bed for the removal of turbidity and bacteriological impurities from surface water and the functional capability of the filter media to remove the turbidity and bacteriological impurities.

The roughing filter consists of three chambers was filled with aggregates of different sizes. Artificially contaminated turbid water of 130 NTU turbidity was allowed to pass through the filter medias with constant rate of filtration. The model plant effectively reduced the raw water turbidity to the level of average 3.27 NTU. Provision of an intermediate buffer zone in first chamber increased the effective length of filter run by about 80 percent.

A sedimentation basin, designed on the basis of settling column test has been observed advantageous over second chamber of roughing filter.

The third chamber of the model plant which consists of only gravel and coarse sand significantly reduced the bacterial concentration, but traditional method of filtration/disinfaction is further necessary to reduce the coliform counts to the level of acceptance.

4. Water quality modeling of mixing zones of rivers for multiple outfalls, a thesis by Abul Kalam Azad and supervised by Dr. M. Habibur Rahman, October 94

In this study, a 2-D model and a computer program have been developed for multiple point outfall, diffuse outfall and mix outfall to compute water quality distributions in the mixing zones of shallow rivers under steady-state conditions. The development of the model utilizes the basic concept of the stream tide, principle of superposition and product law. The stream tubes are of unequal width in natural channels and the lateral concentration distributions predicted by the stream tube model is a function of cumulative partial discharge, instead of lateral distance.

The application of the model indicates that at some stations of the Buriganga River, the water quality is in critical state of allowable value. Some proposal for pollution control of the Buriganga River is also indicated in the thesis. An analysis of the predicted results obtained from computer program for proposed pollution control measures is done. As predicted from the model the DO level after adoption of proposed pollution control measures would increase from 4.5 mg/1 to a value above 5.5 mg/1 at all sections of the river.

The model developed herein can be effectively used to assess the assimilation capacity off shallow? Rivers receiving discharges from multiple point diffuse and mix outfalls. Management options such as treatment levels locations of outfalls, expansion of existing treatment plants can be evaluated with respect to specified in-stream water quality objectives.

5. Development of a low cost iron removal plant for hand tube-well, a thesis by Md. Karamot Ali, supervised by Dr Farooque Ahmed

The rural water supply in Bangladesh is based on hand pump tube-wells installed to collect water from shallow aquifers. But the use of tube-well water for domestic purposes is declining due to the presence of high concentration of iron in the ground water of some rural areas.

In a locality where iron concentration of tubule water was above 20.0 mg/1, an iron removal plant with a gravity flow aerator, a coarse media flocculate a plain sedimentation tank and a coarse media filtration chamber was constructed and its performance was observed. The iron removal efficiency was good enough, but the yield as well as filter run was neither satisfactory nor acceptable to the rural people. Then the design of the plant was modified e.g. tubesettlers were placed in the sedimentation chamber instead of a plain sedimentation chamber, and an additional narrow plain sedimentation chamber was built after the filtration

chamber. The performance of the modified plant was found quite satisfactory iron removal efficiency was found to be 99.3%, the yield was 14.4 litters/min which was about 75.6% higher than the yield of the previous plant.

Maintenance problem: The most important problem of all the Iron Removal Plants constructed so far, was also removed by increasing the filter run to 22 days, an increase of about 55% compared to the filter run of the previous plant. The cleaning procedure, which is very simple and easy to do, is also accepted to the consumers.

After the construction of the plant, the households using the effluent water were also interviewed and it has been observed that the water quality, plant yield and cleaning frequency are acceptable to the people. Can remove iron from ground water without extra cost of aeration or the addition of chemicals for coagulation.

6. Sustainability study of water supply and sanitation system of Netrakona town, a thesis by Md. Obaidul Kabir, supervised by Dr. M. Habibur Rahman, August 1999

This study is aimed to make an assessment of the level of sustainability of Netrakona water supply & sanitation system and impact of beneficiary participation in enhancing attainment of sustainability. The in - depth study has been made to evaluate effects of beneficiary participation in the areas like, increase of house connection. Water bill collection, reduction of water wastage, improving of hand tube wells condition, solid waste collection, sanitary latrine use, health condition aspects and willingness to pay for water. The objectives of the study are: (I) to estimate the water requirements of rural people in Bangladesh for domestic uses (ii) to determine the consumption from tubules against total requirements (iii) to assess the dimensions of the rural water supply problem in Bangladesh and to find out effective measures to improve the water supply situation, (iv) to establish some basic design criteria like appropriate tube-well site, platform dimension, water quality standard: (v) to design a suitable treatment unit to improve the water quality to an acceptable limit for rural people ; (vi) to determine the optimum number of users per well considering various factors ; and (vii) to determine the suitability of No. 2 pump for the future water supply program.

It is evident from the study that the operation and maintenance cost of Netrakona water supply system can be recovered from their collected revenue but additional grants are required for future investment of development works, which is one of the important criteria of sustainability assessment.

The Netrakona water supply and sanitation system also achieved other criteria like, cost sharing approach applied in solid waste collection & hand tube wells maintenance, toilets exists are culturally & technically acceptable, production tube

wells produce sufficient water for supply throughout the year to sustain the system.

7. Drinking water supply and sanitation to suit post cyclone situation in the coastal region of Bangladesh, a thesis by Md. Khoda Bux, supervised by Dr. Md. Mujibur Rahman, July 1995.

In general, the coastal region of Bangladesh is identified as a saline problem area. Complexity in hydrogeological situation makes the water supply in that region relatively difficult compared to other parts of the country. This is reflected in the low service coverage with potable water in the coastal region is also extremely poor.

This particular thesis work has focused on the overall water supply and sanitation in the coastal region of Bangladesh. The major thrust of the thesis has been put to find out ways and means to tackle the post disaster crisis of safe water supply and sanitation.

The overall objective of this study is to find out a reliable and sustainable post cyclone water supply and sanitation system in the coastal region of Bangladesh.

The findings are: a) the present practice of tackling the post disaster situation in respect of water supply and sanitation is inadequate, time consuming and expensive, b) almost all the water supply facilities specially hand tube-wells can be protected against the damages by a simple measure of sealing the tube-wells before occurrence of cyclones and tidal surges and c) post disaster sanitation situation can also be improved through increasing sanitation coverage in the coastal area. The most important aspect of sanitation improvement is to bring about behavioral changes among the people of their defecation practice

8. A study on water supply and sewerage problems in Dhaka city, a thesis by A. F. M. Abdul Aziz, supervised by Dr. M. Feroze Ahmed, January 1990

This study investigates the water supply and sewerage problems in Dhaka City. The trend of population growth, ground water movement, the provable effects of Crash Program and WASA third project and sewer facilities of Dhaka city have been studied and presented in this report.

With a view to investigate the ground water situation in Dhaka, this study attempts to measure the present situation of ground water levels of existing tube-wells of Dhaka WASA and compared with the previous works. The effects of continuous heavy withdrawal or ground water from the aquifer beneath Metropolitan Dhaka are also discussed in this study.

A study is performed on the existing sewerage system of Dhaka City. This study identified the present problems of sewerage system, uncovered sewer areas of Dhaka City and asses the extent of sewerage facilities needed to be expanded to cover the total metropolitan area of Dhaka City.

9. Effect of different impurities in potable water on iodine, a thesis by Reba Paul, supervised by Dr. Md. Delwar Hossain, December 1996

In this study different experiments have been conducted to observe the behavior of iodide salt in distilled water containing these two different impurities independently at different temperatures, with elapsed time at various temperatures and pH conditions.

The study reveals that if iodide salt is used in chlorinated water, free iodine will liberate. Due to volatile nature of iodine, the liberated free iodine will escape into air under exposure condition even at low temperature with elapsed time.
The experimental results show that no rapid reaction of ferric iron with iodide ion is observed even in water containing 10-PPM ferric iron. A rapid reaction occurs at 15-PPM iron concentration in water with 90-PPM iodine as iodide form. This states that there is no significant effect of iron on iodine if iodine is used as iodide form in table salts.

A field survey on iodine deficiency disorders and people's argument about iodized table salts has been carried out in different districts of Bangladesh. The survey shows that now a days most of the people in Bangladesh, use iodized table salts to mitigate iodine deficiency in their bodies. In the coastal zone of Bangladesh where seafood are available and soil contains iodine, goitrous problem and the iodine deficiency disorders are insignificant. But in the northern zone of Bangladesh these problems are very severe. Because people in those areas are in crisis of seafood's and soil lacks iodine. Poor people specially women suffer much more than males from iodine deficiency disorders.

10. Development of a water quality model using finite segment method, a thesis by Md. Rezaul Karim, supervised by Dr. A. B. M. Badruzzaman

In this study, the finite segment method was used to develop the one dimensional water quality model. The well-established Water Quality Analysis Simulation Program (WASP), developed by the USEPA addressed the advective despersive transport phenomenon of the mass transport equation. The kinetic phenomenon involving phytoplankton, nitrogen, phosphorus and dissolved oxygen in the water column was developed in a kinetic module using FORTRAN 77-computer language. The basis of the kinetic transformations was adopted from literature.

The model was applied to the lower reach of the river Sitalakhya to test the model

performance. The model was calibrated and verified for the low flow period. Field data were collected to substantiate the calibration and verification process.

Model results indicate that the river contains an abundance of nutrients. Lower light penetration resulting from high level of turbidity limits the alga growth under low flow conditions. Most concentration profiles do not show much spatial variations in the longitudinal direction. River flows dominate the kinetics in the water column and uniform mixing caused the water quality parameters uniformly distributed along the river. The dissolved oxygen concentration remains above the critical level, indicating that the water is still suitable for the survival of aquatic life including fish. Some water quality parameters such as ammonia nitrogen, suspended solids and carbonaceous biochemical oxygen demand (BOD5) are at a critical state. Although their steady state concentrations remained above the recreational and fishing standards, set by the Department of Environment, immediate pollution control and Waste management measures are needed to prevent further deterioration.

The model indicates that the effluent loading from the major point sources have minor effect on the overall spatial distribution of pollutants. The model is a generalised program addressing nutrient transport and kinetics interaction of phytoplankton, nitrogen, phosphorus and dissolved oxygen in river system. It can be applied to any river system in Bangladesh with appropriate calibration and verification.

11. Simple and Low Cost Tube Well and Latrine Technology, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

Simple low-cost and affordable tube well and latrine technologies have been invented and introduced to the poor people of Bangladesh. The booklet provides information on different low-cost technologies currently available in Bangladesh.

Information on a total of fourteen types of tube wells and water purifying technologies, nine different types of low-cost hygienic latrines have been described in the booklet. These technologies are suitable for different areas, environment and seasons. Detailed description with key drawing of each technology including advantages and disadvantage, required materials, construction techniques and approximate cost has been given in the manual. By giving correct information on different technologies, this booklet plays supporting role in the planning of Government and NGOs who are implementing WATSAN program at the grass-root level.

12. Manual on proper installation of No. 6 Tube well, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

WATSAN experiences reveals that supply of safe water at the community level cannot be ensured only through supply of tube well. It depends on appropriate site selection for installation, identification of water layer, proper installation for tube well and construction of platform and bottom of tube well. This manual has been developed to address these issues.

Information with appropriate photographs on tube well sinking and installation such as materials required for installation, caution during boring period, directions for platform construction, etc. are provided in the manual. This manual is a training material for the tube well sinking training as well as a boring guideline for the private tube-well installation (Mistiry) vendors.

13. Role of Imams in Safe Water and Environmental Sanitation, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 19967

Imams are very respected in the community and they easily influence and motivate people on health. The Imam Booklet has been developed to help Imams to advocate and motivate people on WATSAN from the religious point of view. In this booklet, importance of safe water, hygienic latrine, personal hygiene and environment have been explained on the basis of the Holy Koran, Hadith and science. This is a support material to be utilized in Imam training and orientation.

14. No. 6 Tube well Cleanliness Manual, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

In Bangladesh a large number of tube wells become inoperative only due to lack of proper maintenance and cleaning. This can be reduced through building awareness on keeping the tube well clean and hygienic. Keeping this in mind, NGO Forum has developed the tube well manual about cleanliness. The manual has been very systematically designed with a set of color photographs giving the users a clear idea on how tube well can be kept clean and hygienic. It is a support material for field workers, tube well users and caretakers. It can also be utilized as training material in caretakers training.

15. No. 6 Tube Well Maintenance Manual, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1996

It has been observed that due to lack of necessary technical knowledge and skill of tube well users and caretakers, the wells become inoperative within a very short period. This manual has been produced to help the participants remember the technical aspects along with the training knowledge.
In the manual, various parts of a tube well, its function and joining techniques have been shown through colored and bright photographs along with a short

narration. Basically support material for tube well caretakers it is training material for field workers and trainers.

16. School Program Manual, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997.

School program is one of the key components for successful implementation of WATSAN program. School has an important role to play in changing behavior and promoting good practices among of the students. The objective of the WSS can be achieved through creating awareness and motivating the school students so that they transmit the knowledge to their family and neighbors. The teachers are also part of the process. The manual is developed as a support material for conducting WATSAN school program effectively.

The WATSAN school program, steps and activities for implementing it, information on how to promote hygiene practice among students, etc. are the topics included in the manual. This support material is targeted to the NGO staff and the teachers.

17. Manual on Village Sanitation Centre (VSC), NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

NGO Forum through its participating NGOs has established a number of VSCs to provide sanitation facilities in under served areas.

The manual provides detail information on pre-condition of VSC establishment, different types of latrine technologies, advantages and disadvantages of these latrines, production of different types of latrines and estimated cost, activities of VSCs, pre-conditions for re-location of VSCs etc. This is an essential support material for management level staff of PNGOs involved in planning, implementing and managing VSCs.

18. Tara Hand Pump, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

Because of the heavy extraction of water through deep and shallow tube-wells, the water table in Bangladesh is declining. Tara pump is very effective in low water table area for supplying safe water. There is a need to disseminate basic information on Tara hand pump for promotion of the technology.

A brief description of Tara pump, its technical aspects and data, its advantages and disadvantages, different parts of Tara and their functions, repair and maintenance has been given in the brochure. This brochure will encourage people to install Tara hand pump in low water table area. This will also provide necessary

information to NGO staff in promoting Tara Hand Pump.

19. Water Vending in Old Dhaka by Iftekher Haider et al, UNDP-World Bank Water and Sanitation Group, Bangladesh, 1997

This describes an innovative effort developed and pioneered by a local enterprise, Tiash Water Supply (TWS) to supply pure drinking water in congested urban area in old Dhaka where roughly 3 million are not serviced by DWASA at all and must fend for their water needs themselves. The old part of the city with 60 per cent of Dhaka's population suffers an additional problem. The water from taps in this area is unfit for consumption contaminated in the rusty old and leak-prone mains and contains suspended matter. Foreign material entering the system further deteriorates water quality.

This bleak situation sparked off on idea that is remarkably simple and equally effective. TWS distributes 9000 litres of potable water to some 1500 consumers' everyday. A shop-cum-holding area stocks water in durable plastic container (4-12 litre) for sale and delivery to clients. Delivery personnel in Richshaw carts and on foot go round the narrow roads in the morning to deposit a pre-determined quantity at each stop. Water is sold to homes and offices at competitive price increasing huge demand. While Tiash's rates are higher that those charged by DWASA but are more affordable than bottled water and make safe drinking water available to at doorsteps. Shops, offices, commercial banks, insurance companies, and roadside vending units constitute the majority of subscribers.

20. Water Supply for Urban Poor, Small Private Initiative, RWSG, South Asia, World Bank, August 1997

In Dhaka, 70 per cent of the estimated 2 million squatter dwellers are deprived of safe water. DWASA and DCC do not consider the settlements as legal entities eligible for basic services. Using NGOs as intermediaries, a pilot project has been launched to bring piped water within legal access of them. The project is spear headed by SDC, WB and Dustha Shasthaya Kendra (DSK) under the guidance of UNDP-WB RWSG, SA.

The project, launched in 1996, uses NGO mediation and user participation to construct, maintain and pay for shared water points in slum communities in Dhaka and brings together user communities, DSK, DWASA and DCC into an alliance. The objectives are to develop a community water supply with cost recovery; identify institutional changes to formalise and sustain, and explore possibilities for extending the project in Dhaka and beyond.

The project demonstrates how 'informal' communities can have access to 'formal' utility services. The key principal is responding to demand for water with willingness to pay. The project works with communities willing to form groups; provides training on management, health habits and behavioural change; and formulates rules on water access and cost sharing and mediates with formal utilities.

21. Manual on Production of Ring, Slab and Pansyphon of Water Sealed Latrine, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

Production of ring, slab, and pansyphon is a technical process. Experiences show that the durability of latrines depends on appropriate technology, technical knowledge and skill of the mason.

Information of required raw materials, appropriate proportion of materials and the steps of production of water seal latrines have been provided in the manual with photographs.

This production manual can be utilized as support material in VS mason training. They will also be able to get a clear idea and necessary information of production process of water-seal latrine.

22. Hygienic Latrine Maintenance Manual, NGO Forum for Drinking Water Supply and Sanitation, Dhaka, 1997

Hygienic latrine is the pre-requisite for healthy life and environment. To ensure this, latrines at the household level should be properly maintained and kept clean. This manual has been developed and produced to address this issue.

The manual has ten instructions. The themes of the instructions, through appropriate photographs are how to maintain and keep a latrine clean and hygienic. Instruments required for cleaning are also introduced through photographs. In addition, messages on hygienic sanitation are disseminated through the manual.

This has been developed for the latrine users at the community level both male and female and the field workers engaged in WATSAN program.

23. An Assessment of National Sanitation Week by UNICEF, Research and computing services private limited, 1998.

This is a final report based on comprehensive observation on assessment of national sanitation week (NSW) 1998.

The aim of the NSW was to address leaders, administrators and policy makers to the needs of programmatic interventions for promoting proper sanitation practices and through motivating the general public to adopt desired sanitation practices with implementing agencies and support organizations. About 40% of community members were found to be aware of the week's on-going communication campaigns. Reason for this was very low (5%) effectiveness of communication campaign to general people. The recommendations put forwarded for making future NSWs more effective included administrative issues requiring immediate attention, communication issues requiring subsequent attention and general logistic issues requiring long term attention.

Some suggestions put forward for effectiveness of the program are selection of districts at random; assessment of KAP of the general public on sanitation conducted separately after a base line survey and a baseline survey carried out to measure specific indicator.

3.2 REVIEW OF LITERATURE RELATED TO ARSENIC ISSUES

1. Drinking Water Contamination by Arsenic: People's Perception and Communication Challenge, Dr A Z M Iftikhar Hussain, M/O Health and Family Welfare, Government of Bangladesh.

Communities have acquired knowledge of the potential health implications from prolonged ingestion of arsenic contaminated tube-well water mainly from two sources, interaction with the officials in the field and media coverage. As a comprehensive solution is yet to be found to this danger to public health, effective awareness creation remains the best hope. It is true that semi-urban and rural communities are mostly dependent on the authorities not only for various services but also for information and knowledge. Often these are accepted without question or serious thought to consequences. Communication handled with sensitivity using the right channels can therefore play a significant role in this respect. It is a fact that greater knowledge itself can be a solution. It is therefore imperative that anyone visiting the field and interacting with the people is made completely aware of the issues involved with arsenic and also trained in the use of correct interpersonal communication techniques. This baseline survey was conducted to see the existing situation, people's knowledge on arsenic contamination and its effect on their health, their attitude towards using hand pump tube-wells as safe water source for all purposes and present water use behaviour after knowing the hand pump tube-wells are contaminated by arsenic.

2. Studies of Drinking Water Quality and Arsenic Calamity in Ground Water of Bangladesh, S. Amin Talukder et al, DPHE, Karl-Franzens University,

Austria, 1997.

In this study, the authors collected more than 200 tube-well water samples and 70 core samples from drilling of the affected districts and analyzed total arsenic, and other trace metals by different methods. The amount of total arsenic found in these samples range from 0.01 mg/L to 2.75 mg/L. About 75% of the water samples contained arsenic above the WHO maximum permissible limit 50pg/L.The studies indicated that only 2 samples out of 24 contain no As III and almost all the samples contain As III and As V as major species. In many samples a high concentration of iron (0. 1 0 to 1 6.6 mg/L) was found and pH value ranges from 7.8 to 8.7 but no correlation with arsenic concentration was obtained. The results of the drilling samples show, that the arsenic rich layers are in the strata closer to the surface down to 100 ft. Multivariate analysis of the 22 analyzed elements may give some insight to the geological situation in the Rajshahi area, where the drilling was performed.

3. Geo-chemical Mapping and Spaciation of Arsenic in the Groundwater of Faridpur Municipality, S. Safiullah et al, Department of Chemistry, JU and DU.

A total of 250 shallow and deep well samples were measured for arsenic content by spectrophotometric method using both Zn/HCL and NaBH4 for Arsine generation. The concentration ranged from 1.7 to 0 ppm. Spatial maps were prepared based on results obtained. Highest arsenic concentrations were found to have occurred at a depth of 60-100 feet. Some deep tube-wells also recorded arsenic in the concentration range 0.25-0.16 ppm. Particularly, the block (Goalchamat) showed arsenic in the deep tube-wells (>250 ft) while the shallow layer in this block (22 ft) recorded no arsenic. Specification for As +3 and As+5 done in the field, showed that As +3 ranged from 12-50%, while As+5 ranged from 88-50% of the total arsenic. It was found that in the areas which recorded high AS+3 percentage even though the total As may have been low (>1 ppm), cases of arsenic affected persons were more prevalent. Eight persons with high As content in their urine (>250 ug/d) were monitored on monthly basis and were found to be free of As in their urine on administration of As free drinking water.

4. Ground Water Treatment for Arsenic-Iron Removal, M.Feroze Ahmed et al, Department of Civil Engineering, BUET, Dhaka, Bangladesh

Arsenic and iron coexist in soil and dissolute in groundwater under certain conditions. Co-precipitation of arsenic with flocculated ferric salts is a known process of arsenic removal. It has been found that hand tube-well water in 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. In general, arsenic in groundwater in higher concentrations has been found in acute iron problem areas.

In this paper, an attempt has been made to correlate the presence of iron and arsenic in groundwater of Bangladesh. The efficiency of ferric chloride in removing both arsenite and arsenate has been tested in laboratory batch experiments and the role of naturally occurring iron in removing arsenic from groundwater has been evaluated. A good correlation has been observed between the presence of arsenic' and iron in groundwater of Bangladesh. Iron, added as ferric chloride, has been found to be very effective in removing arsenic from water. With an initial arsenate concentration of 0.5 mg/l, about 12 mg/l of iron was required to bring the concentration below 0.05 mg/l level. Such a scheme is important for removal of arsenic from groundwater using naturally occurring iron present in the water. This will remove both arsenic and iron - two major water quality constraints in the development of groundwater based water supply system in Bangladesh.

5. Hydrogeological Investigatory Approach to Address Arsenic Pollution in Urban Groundwater Supply, Mohiuddin Khan, M/O of Environment and Forest, GoB

Historically from early 1960 the expansion of urban water supply facilities gained momentum. Each production tube-well installation was preceded by hydro-geological investigation and three cardinal water quality parameters viz Iron, Chloride and Hardness received priority consideration for the acceptability of water. Now the addition of Arsenic to the list, which unlike the other parameters is toxic to the extent of causing serious diseases, has turned the hydro-geological investigation exercise into a more rigorous and uphill task than ever before.

In order to meet the challenge of arsenic pollution in groundwater, appropriate hydro-geological investigation in each urban block should be initiated to understand the arsenic mobilisation mechanism and to identify arsenic free groundwater pockets and provision should be accommodated in the future planning process of groundwater development.

6. Arsenic Contamination in Soil Water and Human Health, Sattar & Mandal, Department of Soil Science, BAU, Mymensingh, Indian Institute of Chemical Biology, Calcutta

In the present findings, As contamination was largely studied in soils, water and human health. The results reviewed the total and available As levels in different soils at various depths. As concentrations in Bangladesh soils were also reported where wide variations were recorded on the basis of parent materials. Some factors like pH, organic matter, clay contents, CEC, iron, soil depths etc. sharply influence the As concentration in soils. The as levels in surface and groundwater were also reported. The As concentrations varied widely in surface water at different industrial areas of Tongi. The As contamination in groundwater of

Bangladesh is also reviewed. The critical and standard levels of As in soils and water were also reported. Finally, As toxicity and hazards to human health were also evaluated. Above the critical limits or high As intake causes nausea, vomiting, diarrhoea, burning of mouth and throat and chronic exposure results in weakness, prostration, muscular achieving, gastro-intestinal disorders, skin and mucosal changes, peripheral neuropathy, pigmentation of fingers and nails, headache, drowsiness, confusion and convulsions. As exposure can even cause lung and skin cancer.

7. Arsenic Contamination in Drinking Water in Bangladesh, Md Munir Hussain, Geological Survey of Bangladesh, Dhaka

Arsenic is a relatively common trace element found in nature. An abundance of 2.87 mg/l of arsenic concentration has been reported from the southwest districts of Bangladesh. The principal manifestations of chronic arsenic poisoning like pigmentation, eruption and cracking of human skin have been reported. The source of arsenic in drinking water is yet unknown, but it is speculated that the source of arsenic may have a close relationship with the geological formation.

The factors causing arsenic contamination have to be identified through geo-scientific investigations. This will help to find out the right means for mitigation of arsenic pollution in drinking water. Regular exchange of information related to the extent of contamination and identification of the source area among the scientists will produce a positive impact to combat the arsenic hazard.

8. Arsenic Distribution and Mobility in Ground waters from Chapai Nawabganj, PL Smedley et al, British Geological Survey, UK and Geological Survey of Bangladesh

Reconnaissance sampling of groundwater from dug wells and tube-wells in and around the town of Chapai Nawabganj in western Bangladesh has revealed concentrations of dissolved arsenic of between <0.004 mg/l and 2.4 mg/l. Highest concentrations of arsenic are found in samples from tube-wells abstracted from recent alluvial sediments. Samples from shallow dug wells in the recent alluvium and from older tertiary (Dupi Tila) sediments had low concentrations of less than 0.009 mg/l.

At present, there is no clear evidence from the data collected that oxidation of pyrite is a key cause of the high arsenic concentrations. The reducing nature of the high-arsenic ground waters suggests that availability of oxidising agents (e.g. oxygen, ferric iron) is limited and the low sulphate concentrations also do not suggest widespread sulphide oxidation. By contrast, isotopic ratios of dissolved inorganic carbon in ground waters suggest that the high alkalinity be produced by oxidation of solid organic matters. This is likely to have initiated and maintained

the reducing character of the ground waters. Limited sulphur-isotopic data suggest that sulphate reduction may have been a more important process in the tube-well waters than sulphide oxidation.

9. Arsenic Contamination of Drinking Water in Bangladesh, Jadavpur University, Calcutta and Dhaka Community Hospital, Bangladesh

Dhaka Community Hospital in collaboration with the School of Environmental Studies, Jadavpur University, West Bengal collected and analysed 6101 water samples for arsenic till 1997 from 60 districts of Bangladesh by Spectrophotometer (GF-AAS). 10% of the samples were analysed by spectrophtometry with hydride generation and absorption in Silver DDTC in Hexamethylene tetramine. The content of arsenic in ground water from 52 districts has been found to be above 0.01 mg/l. In 41 districts the arsenic level in ground water is above 0.05 mg/l. Out of the 5078 water samples analysed in 41 districts, 45 % contain arsenic above 0.05 mg/l. The area and population of these 41 districts is 87390 km2 and 65 million people respectively. Though all of these 65 million people may not be drinking arsenic contaminated water, it clearly indicates that a large section of this population is at risk. Since tube-wells are the main drinking water source in Bangladesh, it has become essential to provide an alternative drinking water source for the general people of this arsenic affected area.

10. Cost Effective Approach of Arsenic Analysis and Two Low Cost Arsenic Removal Techniques for Use in Bangladesh, Workshop on 'Arsenic problems and dearsination of water', ITN/ BUET, 1997

Arsenic analysis by field test kit is a semi quantitative method. By NIPSOM test kits arsenic can be detected from 0.01 mg/l to 0.5 mg/l. The method is very simple and takes five minutes to get the result. In ground water some chemicals, KI and Sncl2 are required to convert pentavalent form of arsenic to trivalent form.

Photometer can give accurate quantitative results having the advantage of spectro-photometer (cost $1000).

Electrochemical method is laboratory based and can give accurate result where detection level is less than 20 ppb but it needs skill and trained personnel (cost is Taka 4 to 5 lakh).

Atomic Absorption Spectrophotometer is time consuming method but provides very accurate quantitative result where detection level is less than 10 ppb and needs highly skilled and trained personnel.

It is recommended that above methods of arsenic analysis would economical if arsenic is first detected by field test kit and then photometer is used for quantitative analysis.

11. Case Study on Arsenic analysis in 11 districts under Secondary Town Infrastructure Development Project, LGED, August, 98

LGED started arsenic analysis in tube-well water in 1997 under its Secondary Towns Project financed by ADB. The study area includes 11 districts namely Kushtia, Meherpur, Chuadanga, Jhenaidah, Magura, Narail, Rajbari, Faridpur, Gopalganj, Pabna and Khulna. The project covered shallow and deep tube-wells.

Out of 500 water samples, 472 were analyzed at a computer Controlled Electrochemistry Work Station, a private laboratory of Sono Diagnostic Center Environment Initiative (SDE-EI). The rest were analyzed in Khulna Environmental Laboratory of LGED recently established to analyze arsenic with other parameters.

An NGO named 'Shubashati' was engaged to collect samples and analyze the water samples. Results of 500 samples are interpreted. Narail is widely contaminated. Out of 26 tube wells, 57.6% are affected by arsenic. Then come Meherpur, Paridpur, Jessore, Chuadanga, and Kushtia in that order. The maximum level of arsenic was 993 ppb against the permissible limit of 50 ppb. Some deep tube wells were found contaminated. The test results give an indication that from 40-200 ft ground water is usually arsenic contaminated. Below 200 ft no contamination was reported.

The workshop felt measuring trace amount of arsenic and its treatment is a challenging issue and a collaborative effort is needed to face this problem.

3.3 DATABASE MATRIX OF LITERATURE

Database Format

The database of research documents in water supply and sanitation sector is documented under several broad headings. Under each broad head a number of research document are presented. As many as seventy-nine reports are cited. These are:

i. Water Supply and Sanitation: Policy. Nine reports have been documented.

ii. Water Supply and Sanitation: Technical Intervention. Twenty-four reports

have been documented.

iii. Water Supply and Sanitation: Social Intervention. Eighteen reports have been documented.

iv. Water Supply and Sanitation: Extension. Thirteen reports have been documented.

v. Water Supply and Sanitation: General. Eight reports have been documented.

vi. Water Supply and Sanitation: Arsenic. Fifteen reports have been documented.

The database is presented in ***Annex - 3.***

Chronology of Technological and Social Research
The chronology of technological and social research is given below.

CHRONOLOGY OF TECHNOLOGICAL AND SOCIAL RESEARCH

Year	Chronological Evolution
1972 :	Extension Research: UNICEF – DPHE partnership launches 'crash' Handpump Tubewell program
1974 :	Research on low cost technology and involvement of entrepreneurs: Private industry involved; local manufacturing of PVC pipes.
1975 :	Technological research involving pump manufacturers: local foundries produced new No. 6 hand-pumps. UNICEF/ BARD extended water-sealed latrines as an output of social research. Imams, primary school teachers and women health workers were involved.
1976 :	Social Research: Communities were involved; Concepts of 'User's contribution' and 'Caretaker' were introduced. Extension Research: Involvement of NGOs; UNICEF allocation to cover NGO installations.
1978 :	Extension Research: Masons were involved; first DPHE Village Sanitation Centers were established.
1982 :	Extension and Social Research: NGO Forum, an apex body for local NGOs working in WSS was established. Technological research on partnership between World Bank, UNICEF, MAWTS were undertaken to develop Tara hand-pump.
1984 :	Research on appropriate technology: Village Mistris (handymen) were involved; self-help tube-well sinking began.
1985 :	Extension Research: Involvement of Grameen Bank; loans were given to the members for installation of tube-wells. Social Research: Women involvement: hand pump caretakers must

Year	Chronological Evolution
	include women.
1986 :	Extension Research: Private masons involvement: training given and latrine production started up.
1987 :	Social and Extension Research: Tubewell mechanics were involved in latrine promotion (integrated approach).
1988 :	Technological Research: Hydro-geological experts were involved: DPHE groundwater monitoring unit was established.
1990 :	Extension Research: First multi-partnership, Thana-wise sanitation campaign in Barisal.
1993 :	Social Research: Religious leaders were involved: imams addressed at national conference. First women were appointed as DPHE tube-well mechanics. Union WATSAN Committees established.
1994 :	Social Research: Media was involved in social mobilization exercise; first Sanitation Week was observed.
1995 :	Extension Research on private and public partnership. Communications experts were involved; Meena cartoon on water and sanitation. Bangladesh Standards Institute was involved; handpump standards were set. Boy Scouts, Girl Guides, Village Defense Party cadres were involved. LGED launched experimental project on Public-Private Partnership on Sanitation and Solid Waste Management with Pourashava (Mymensingh, Sylhet) and NGO (ETDA)
1996 :	LGED successfully introduced new innovation: Small bore sewerage system with biogas plant in Bauniabad slum, Mirror. School Management Committees were involved to take over school latrine construction. Users were involved to take over all maintenance of No. 6 handpumps. All stakeholder groups attend national conference to plan WS future.

4. SITUATION ANALYSIS IN WSS RESEARCH

4.1 STATUS OF WSS RESEARCH IN BANGLADESH

Research status on water supply and sanitation described herein is based on discussions with professionals, practitioners and persons working in various organizations and involved with WSS activities. Till 1995 there was no research work as such in WSS by any organization. There is some research work in the universities for thesis work. Though the topics selected do reflect need of the people to some extent nevertheless they are not commissioned by any government, private sector organizations. The present development in the sector, therefore, does not base on any concerted and planned research work needed by the society, people and the country. The research is a natural evolution of people's need and actions by the stakeholders to that need. Though there has been development of technology in both water and sanitation this remained a disjointed effort without a proper research base and consequently extension was slow and not necessarily sustainable.

Discussions on status of WSS research reveal an emphasis on the need for proper policy and strategy in the use of water resource. Till now water has not been considered as a finite resource or used judiciously. The organizations like DPHE, LGED and WASA have started developing a research base for success and sustenance of their projects and programs and a close collaboration between them, the academic institutes and development partners have started. The areas are also identified and research for sustainable cost-effective systems are on.

4.2 EVOLUTION AND STATUS OF WSS SECTOR RESEARCH

The evolution of WSS Sector research is actually technical, social development in the sector that lead to extension of activities. The action-oriented projects and programs and pilot experiments are all based on technical and social research undertaken by individuals, communities, government agencies, development partners, non-government organisations and private entrepreneurs either individually or jointly between and amongst them. An attempt has been made to project the performance top show the effectiveness or problems of these efforts.

Rural drinking water supplies coverage record of Bangladesh since independence has been outstanding. To date 2.5 million public and private hand pump tube-wells have been installed bringing safe drinking water to 97% of the rapidly growing population (Rivers of Change, DPHE/UNICEF, 1997). Women no longer have to walk long distances to fetch their drinking water. Study findings show that in the 1970s, 60% of households lived within 250 metros of a tube-well; today, the

distance has been reduced to 150 metros for more than 85% of households. The average number of people per tube-well has also dropped, from 400 in 1970, to 107 in 1997.

Though not as impressive, sanitation coverage is also quite encouraging. In 1980, only 1% of the population used latrines, which safely confined human feces. By 1997, this proportion had risen to 44% (DPHE/UNICEF, 1997). Now a high proportion of rural families has one latrine. They are still 'hanging latrines' and their contents become exposed degrading environmental health. Sanitation coverage is still far from universal.

Water Supply

The national rural drinking water supply program was inaugurated in 1972. After the war of liberation, which caused devastation to existing installations, UNICEF offered assistance for a crash program of hand pump tube-well rehabilitation. The technological research and development thus began. The DPHE-UNICEF partnership has continued to navigate the program ever since. The DPHE was rapidly built up between 1972 and 1976 to oversee the program.

In the 1970s, the main research and development emphasis was on hardware. Pump breakdowns, clogged tube-wells, and corroded iron pipes, were the major problems of pre-1972 installations. While DPHE built up its human resources and developed logistics and managerial systems, UNICEF set out to identify the water-well technologies best suited to the environment. The two key criteria of research were durability and low cost. And today, applying the same criteria, UNICEF remains the program's research and development mentor and primary investor. Other partners particularly in research include RWS Group of WB, SDC, ICDDR, B, NGO Forum working with government agencies like DPHE, LGED, WASAs, local government bodies like municipalities and Union and Thana Parishads.

In the technological interventions during early 1970s, PVC piping was introduced for tube-well casing. Bangladesh soon set up its own PVC industry, the first of many technology transitions. A redesigned cast iron hand pump, the 'New Number 6', also began local production. This cheap and sturdy equipment remains the country's standard suction pump even today. It soon entered the local economy, boosting the market in tube-well construction and creating thousands of jobs in local foundries and consumer outlets.

Having laid the technological groundwork, DPHE and UNICEF then attended to program structure and sustainability. Key issues were maintenance and community involvement, two sides of the same coin. Community had the notion that a tube-well was a service under government control, they need not keep it in repair. Everything was left up to DPHE mechanics. Thus numbers of tube-wells mounted into the hundreds of thousands and became almost impossible to keep

them running.

Social research identified the key program evolution as decentralization. The main locus of DPHE supervisory activity was placed at *Thana* (sub-district) level. A system of community involvement in the form of application for tube-wells was introduced. User groups applied to their *Union Parishads* (Councils), which then submitted a list to the *Thana* (Sub-district) authorities. This allocation system remains in force today.

The community involvement has been in-built in the application form. A user group with ten members, including one male and one female from each family agrees to certain conditions such as cash contribution, siting the tube-well in a public place, and the nomination of a 'hand pump caretaker' family. Today, there is both a male and a female hand pump caretaker for every tube-well. These conditions ensure disadvantaged families, small land holdings, fewer and dirtier ponds, and fewer resources to install tube-wells of their own, did not get left out. There is a deliberate attempt to increase participation of women.

During the 1980s, many NGOs began to promote tube-wells among their beneficiaries. The research on equitable distribution started with NGOs focussing on the poor structuring water supply assistance to reach them. UNICEF entered into an agreement with the Grameen Bank to enable members of their savings groups to take out loans for private tube-wells. Most of them are extremely poor and are women.

When the problem of the declining water table began to emerge in the middle of 1980s, Government with assistance from UNICEF and WB addressed the new technological challenge with action research to extract water from below the suction level. To reach the correct hydro-geological strata, a new direct-action pump named 'Tara' was developed by UNICEF together with the WB and the Mirpur Agricultural Workshop and Training School (MAWTS). The 'Tara' pump started production in 1987, and has since become the standard pump for low and marginal water table areas.

The research for need-based and appropriate technologies for normal and difficult areas, for poor and the well served made this important input available to every one's doorstep. People can obtain tube-wells either from private suppliers out of their own pocket, or by individual or group NGO loans. As a result, government has been gradually ceasing subsidize the installation of public 'Number 6' hand pump tube-wells.

To days research focus is on the under-served and poor water quality areas, low water table areas, the coastal belt, highlands, chemically contaminated area, city slums, now demand the lion's share of water supply attention. In some of these

areas over 200 or 300 people share a source, installation costs are high, and salinity, iron or other contamination often requires filtration. Water supplies problems though affect only a small proportion of the population, have moved to center stage.

RWSG, SA of WB has focussed research and applied research activities in documentation of lessons on private sector in WSS, credit mechanism in WSS, unregulated free market etc. They have innovative pilot experimentation on WS for Urban Poor and Watsan Partnership

Sanitation

In early sixties with little demand for a sanitary latrine and no easily affordable technological formula awaiting mass promotion, UNICEF imported a well-known sanitary latrine from Thailand in the early 1960s. The bowl, set in a concrete slab, is like a conventional lavatory pan with a U bend water-seal at the base. When flushed by a jug of water, the water provides a barrier between the waste below and the open air. Placed near a water source, built over a well-lined pit, surrounded by a bamboo super structure and regularly cleaned, this latrine is hygienic and odorless. But it is not cheap.

The first comprehensive effort to promote the sanitary latrine began in 1978 with an action research. Along with five concrete rings for the pit lining, the water-seal latrine slab was manufactured in 100 *Thana* production centers and sold at a highly subsidized price as a package. The cost of manufacturing a slab and five rings was Taka 750, whereas the sale price was set at Taka 250. Take-up was encouraging, although small in relation to the total target population. By the late 1980s, latrine shops selling water-seal slabs and concrete rings had begun to appear in the bazaars of many large towns. By the early 1990s, Government through DPHE has established production centers in all 460 *Thanas* and 540 at union level. Many private centers also started manufacturing the slabs and rings and started marketing all over the country.

However, even at a subsidized price, the water-seal pit latrine is out of financial reach of the great majority of households. Research was initiated for cheaper alternative designs. Soil tests have shown that in many areas of the country, pit lining with concrete is not essential. Woven bamboo, baked clay or even packed earth may be adequate.

Though preferable, a water seal pan is not essential either. A slab with a hole and removable cover is much cheaper and will be 'sanitary' if firmly fixed so that wastes do not wash out at times of flood. In the early 1990s, the countrywide sanitation program moved into a much higher gear. An 'integrated approach' was pursued to start with. Because communities were keen to have water supplies, but were less interested in sanitary latrines, the installation of a hand pump tube-well

for a group of 10 families, was made conditional on their initial construction of at least five sanitary latrines.

To prepare for an increase in demand, local masons were trained to make and supply water-seal latrines. The home made sanitary pit latrine was also promoted, and successful latrine-building campaigns in certain areas, began to dispel skepticism concerning the prospects for a sanitary revolution in Bangladesh. However, external donors to the program saw in the 'integrated approach' an element of coercion, and insisted that it be dropped. Since then, the idea of 'latrines first' is still promoted alongside hand pump tube-well installation, but compliance is voluntary.

In 1993, a new approach to sanitation and latrine promotion, social mobilization was introduced. An annual 'Sanitation Week' was launched in which society would be mobilized around sanitary latrine construction and hygienic living. Coupled with expanded latrine production in both public and private sectors, this drive has raised coverage in the rural areas from 16%in 1990 to 39%in 1987, and in the Urban areas from 40% in 1990 to 87% in 1997.

Hygiene Education

From late 1970s onwards, the lack of progress in educating people about the connections between water, cleanliness and disease reduction, was a constant theme of surveys and program assessments. One of the problems was that hygiene education was not obviously the task of engineers, neither was it seen as the job of the government's health services. Today this problem is recognized and efforts are being made to address the concern.

During the 1990s, social and extension research efforts have been concentrated on developing a comprehensive hygiene promotion agenda. UNICEF acted as facilitator in developing this new evolution. Key messages and communications vehicles have been tested. Different strategies have been piloted with different audiences, schoolchildren, householders, teachers, community and religious leaders.

Hygienic living, which both helps to improve family health and reduces the pathogenic load present in the natural environment, thus remains the outstanding challenge of research and development. Campaign for hygienic living requires a radical change in perspective about what is demanded of a water and sanitation program, beyond the achievement of coverage targets.

Sustenance

From 1993, certain key principles have now come to dominate sector perspectives. One is that the environment is a reservoir of natural resources whose contents must not be depleted in an unsustainable way. Water is not 'free'

any more. Water must be seen as a commodity with a realistic price tag. It follows that costs must be recovered and user energies deployed. Appropriate facilities for low-income communities mean those that are within their comprehension, technological participation and consumer reach. Environment and its resources need to be viewed holistically. Since 1993, the concept of 'primary environmental care' has been promoted whereby efforts to improve human quality of life and livelihoods are dovetailed with the management and conservation of natural resources. In this perspective, food production, health, and utility provision, water and energy is all part of one environmental package.

The most important finding in the technical, social and environmental research in sustained WSS is the responsibility at all levels of society. Water resources, their quality and quantity, and contamination in the environment are the concern of everyone, not just public health officials and engineers. The correct treatment of ponds and waterways, the security of pathogenic latrine contents from open exposure, and the abandonment of personal habits such as open defecation which have hazardous implications for others are an individual, household and community responsibility, as well as a responsibility of government.

In Bangladesh, the need for reorientation of government agencies towards a facilitating role has been accepted. A review carried out in 1994 emphasis on building of capacity for social mobilization and behavioral change has been given. Greater attention is given to research and to the role of women, both professionally and among service users. An extensive program of reorientation has been put in hand to help government personnel understand the 'primary environmental care' approach. There is no need to feel uniquely responsible for hygiene progress in the country. They can catalyze others, building alliances with NGOs, *Union Parishads*, and in departments such as Health Services, Primary Education, and Women and Family Welfare.

In WSS, equity, affordability and vulnerability are socio-economic issues. The water-seal latrine favored by DPHE remains far outside the financial reach of most rural households, and for this reason the home made pit latrine continues to be heavily promoted. At present, the ratio of water-seal latrines with concrete linings to home made pit latrines is one to four. However, efforts are being made to reduce the costs of sanitary latrine components. Tests have shown that it is possible to reduce the thickness, and therefore the price, of the concrete rings sold for pit lining. And in 1995, plastic pans (without water-seals) started manufacture and sale.

Unless people have a sound appreciation of a latrine's health benefits it will not be used properly and sanitary objectives will be defeated.

The participation of local NGOs is one way of ensuring a focus on the marginalized and most vulnerable. For example, between 1995-96, an NGO called Otikrom in Moulvibazaar district conducted a house-to house intensive sanitation and hygiene program in over 2,000 villages and in 60 tea gardens, with support from UNICEF. Without this kind of grass-roots effort, groups outside the mainstream such as the tea garden workers could not be reached.

The sustainability of services needs not only sound and cost-effective technology and management; it needs user knowledge and attitudinal endorsement too.

Behavioural issues

People have varying patterns and different levels of knowledge. It is difficult to draw definitive conclusions about the elusive software, which would finally unlock the Bangladeshi environmental health puzzle. The answer may be that there is no one single approach; elements need to be interwoven and complementary.

This certainly seems to be indicated by the results of a Sanitation and Family Education (SAFE) project run by CARE Bangladesh among 9,000 households in the coastal belt. Here, hygiene education activities were designed to reinforce existing beneficial behaviors and specific, appropriate alternatives to harmful ones were developed; this was intended as an opposite strategy to that of promoting a set off pre-determined 'perfect' water and hygiene behaviors. This approach, which embraced clean water, latrine use, environmental cleanliness, hand-washing, food hygiene and diarrhea management, succeed in reducing diarrhea by two thirds in the intervention areas. Perhaps the element of sensitivity and adaptability to local practice is the closest it is possible to get to a universal 'key'.

A 1994 survey in Barisal undertaken by ICDDR,B bears that there is a vital knowledge gap about fecal hazard in the environment, in surface water and on hands, bodies and clothing. Without tackling that knowledge gap, behavioral change will be slow in coming. A 1990-91 campaign in three *Thanas* integrating latrine construction with tube-well installation resulted in 60% sanitary latrine coverage in two *Thanas* and 80% in the third.

It is not enough to say "Build a sanitary latrine', or even 'Use the latrine'. People's hygienic ignorance and bad habits demand a new evolution in program thinking and research, an evolution towards which the Sanitation and Family Education Project (SAFE) experience of CARE-Bangladesh is a pointer. Hygienic understanding and its inter-relationship with good and bad water and sanitation behaviours have to be at the centre of any programme strategy, alongside the creation of supply and demand for facilities. SAFE evolved from post 1991 cyclone relief project Water and Sanitation/Hygiene Project (WASH)

Sanitation and Family Education Resource Project (SAFER) is a follow-up project of SAFE in order to facilitate broader implementation of successful hygiene behavior change programs. Proposed measures are to develop and conduct workshops on hygiene behavior change programming, develop and maintain a 'Model Site', extension in urban area, produce information video/workshop, participate in national dialogue on water and sanitation, provide on-site technical assistance to selected NGOs and dissemination strategy. Direct beneficiaries include approximately 15,000 households with estimated 90,000 people in 3 model sites.

Social Mobilization and Community Participation

During 1970s BARD, Comilla as a part of its social research put first efforts to use Imams, one of the most important groups to to be used as motivators. Later in 1993, at a special Imams' conference, stress was placed on the religious virtues of cleanliness. At subsequent workshops, imams were invited to take the lead in promoting latrine coverage in their communities. Many responded vigorously to the call and have since sustained their involvement, with special drives during 'Sanitation Week'.

During the 1980s, the strategy of 'social mobilization' was developed to build momentum behind the goal of universal immunisation. During the 1990s, UNICEF has fostered the incorporation of social mobilization techniques into the drive for sanitation in Bangladesh. People in Bangladesh are great enthusiasts for grand events, national days and rallies. There is a huge resource of popular energy to be tapped behind the cause of good health. On annual National Immunisation Days, volunteers turn out in their thousands to sing, march, carry banners and see that mothers deliver their immunised babies to the vaccination posts. The idea of tapping the same kind of energy behind thinking clean was the underpinning rationale for the inauguration of 'Sanitation Week' in 1994.

However, the story of social mobilization for sanitation goes further back and is broader in scope. In 1992, a national conference on social mobilization for sanitation heralded a new political willingness to tackle the sensitive subject of environmental pollution by human wastes. A national sanitation logo was launched, with three messages for health: use a latrine, wash hands, and use tube-well water for all domestic purposes.

NGOs involved in water and sanitation have played a leading part in the social mobilization movement. An NGO Forum for Drinking Water and Sanitation was created in Bangladesh in 1982. It has a well-developed infrastructure for supporting NGOs at community level, helping them to promote tube-wells and latrines to their beneficiaries. The Forum is ideally placed to do extension research to promote hygienic behavioral change.

In 1993, the NGO Forum embarked on a special three-year social mobilization project in 20 *thanas* with UNICEF assistance. Orientation workshops with local NGOs and discussion forums with local imams paved the way. Motivational activities ranged from latrine construction demonstrations, household visits and courtyard meetings, to discussions with Ansars and Village Defence Party cadres, health and family planning workers, film shows and rallies.

From 1993 onwards, LGED and DPHE began to develop their own capacity for social mobilization and communication. This was not an easy transition. Primarily engineering, they have been trying to become a force for communication of sanitation to motivate and recruit others to join in a multi-faceted sanitation movement.

A core communications package for uses in all social mobilization activities was developed with UNICEF assistance. Based upon it, training packages were also developed for all sprats of audiences with influence among householders: community leaders, teachers, and imam's field workers, tube-well mechanics and masons. District teams were set up to carry out a programme of training sessions. Their participants were expected to set and example in their own communities by building, using and maintaining sanitary latrines. They are also supposed to spread correct messages about hand washing with soap or ash and hygienic defecation.
Children and Women

The introduction of the hand pump caretaker system, and insistence on female participation, was the first step in this context. Since the 1980s, many initiatives in the sector have singled out women for special attention. But they cannot do what their men folk disapprove. So men, too, need to be targeted to reach women effectively.

The promotion of women in the water and sanitation profession, as sanitation motivators, mechanics and engineers, helps ensure that women's needs are better catered for and their perspective better understood. Where it has been evaluated, women employees' performance in social mobilization and hygiene education tends to outclass men's. It is worth mentioning the number of professional engineers working in WSS projects in LGED. It has shown although it is difficult to find women candidates in the engineering profession, gender barriers are gradually breaking down.

A disadvantaged group whose situation need more attention is slum and shantytown dweller, During the recent past, Bangladesh has experienced rapid and unplanned urbanisation; Dhaka, already with a population over 8 million, is one of the fastest growing cities in the world. Although poverty in Bangladesh is thought of as a rural phenomenon, over 50% of urban inhabitants live below the

poverty line, and 30% qualify as 'very poor'.

A special School Sanitation Project was launched in 1992. The first object was to ensure that sanitation facilities existed in schools: without the possibility of usage, no progress could be made. Through co-operation with Primary and Mass Education Division (PMED), DPHE and UNICEF developed a plan for constructing water and sanitation facilities in primary schools where they did not exist. Criteria were established so that the most needy schools received priority.

Experience showed that school latrines frequently became noxious and were soon abandoned by their users. So great care was taken with the design of the facility. Its core is a tube well whose hand-pumped water enters a 500 liter tank equipped with a drinking water tap. The tank is raised so that water pipes from it lead directly to other taps in the latrine compartments. Two compartments, back to back, provide a 'girls' and a 'boys' lavatory. The taps allow the pans to be flirted clean on every occasion. Soap or ash is provided in each compartment for hand washing.

During the first phase of the project, over 1,000 sanitation facilities were constructed. The facilities were welcomed, not least because their presence was an incentive for girls to stay at school. In the past, if girls needed to relieve themselves they tended to go home and not reaper. The programme was counted a success. However, and evaluation uncovered various flaws: construction delays, use of poor quality materials, and lack of maintenance by the users.

Lack of community involvement and ownership seemed to be the problem. To this end UNICEF undertook pilot action research with five schools in Moulvibazaar District. The responsibility of construction was vested in the School Management Committees. Sub-Assistant Engineers and Thana Education Officers provided technical support. Necessary funds, materials and design off the facilities were given directly to the Committees, who employed masons to do the work according to the specifications. The water and sanitation facilities were built much more quickly and the quality of the work was better. More attention was given to maintenance and cleanliness of both water tanks and latrines. As a result, the construction of Water & Sanitation facilities has now been devolved to School MC in more than 1500 schools in seven districts, under supervision of the *Thana* authorities.

In the early days of the School Sanitation Project, emphasis was focused on the construction of water and sanitation facilities. As time goes on, more emphasis is being placed on ensuring that personal hygiene and clean living become integral part to the school children's lifestyle. Where education officials are supportive and head teachers are keen, school children can become a force for environmental health in the community.

Some of Bangladesh's non-formal educational programs have also begun to incorporate hygiene learning into the curriculum. An example is the primary education program run by Gono Shahajya Sangstha (GSS). Students take up cleanliness as a class project, conducting community surveys, discussing the topic with people in their neighbour hood, and reporting back to school. At the end of the project, the children write a play demonstrating their new knowledge and perform it for the rest of the school and in the community.

Around 55% of the 57,600 government primary schools in Bangladesh still have no sanitation facilities. The goal of the School Sanitation Project is to ensure that all these, and all non-formal primary schools urn by NGOs, both have sanitation facilities and are promoting a 'safe learning environment' by the year 2000.

Problem Areas

Bangladesh were one of the earliest countries to ratify the convention on the Rights of the Child following its passage by the UN in 1989. To meet obligations of the convention UNICEF has helped the Government of Bangladesh develop a planning strategy known as the 'Accelerated District Approach' (ADA). This takes as its starting point the knowledge that most development processes are inherently uneven, tending to favour districts or areas which are environmentally or economically better-endowed and have better-developed infrastructures.

As far as drinking water supplies in Bangladesh are concerned, the ADA district-by-district analysis of data has focused attention on communities in undeserved areas, in low water table areas, in the coastal belt, and in story highland areas. In areas such as these, the number o people per tube well and distance to the water supply are much higher than in the high water table areas.

In keeping with the rights perspective and the ADA approach, these will now receive extra attention. But there are problems. Since their hydro-geological conditions are much less favorable, tube-well installation costs are much higher. Investment therefore needs to be made in developing the most appropriate and affordable systems.

An area, which presents very different water supply problems from the rest of Bangladesh is the Chittagong Hill Tracts. The area is mainly inhabited by hill tribes, whose settlement patterns are highly dispersed. The difficult terrain, lack of roads, and lack of hydro-geological mapping have proved major stumbling blocks to experimental hard rock drilling. Instead of hand pump tube-wells, the solution so suited to the rest of the country, technologies for safe surface water supplies, including disaffection of Lake Water, are more appropriate.

New Focus Areas

a. Rain water Harvesting

A new technology to be introduced by the government with UNICEF is rainwater harvesting. This is an attractive alternative to the hand pump tube well, not only in areas where terrain and cost rule out the drilled bore hole, but also in areas where groundwater is contaminated with iron, salt, or, frighteningly, arsenic. With an average annual rainfall of 2,500 mm over 7 months, rainwater is a plentiful and under-utilised resource in Bangladesh. Households in areas with relatively few rivers and ponds do sometimes collect and use it, but unsystematically and in small containers. At present, they do not store it beyond the wet season.

Between 1994 and 1995, trials and studies were undertaken in some coastal districts and Hill Tracts to work out whether rainwater harvesting was worth promoting. Experts from Thailand trained DPHE engineers, Village Sanitation Center personnel and private masons in how to fabricate Ferro-cement jars in two sizes (1,000 liter and 2,000 liter) and tanks of 3,200 liter capacity, and how to fix guttering and down-pipes. The jars and tank cost US $50, US $75 and $120 respectively; communities and households are expected to provide 50%.

Gradually, interest in rainwater harvesting is growing. Technical drawings for steel moulds and manuals on making the jars have been distributed. Requests have come from other districts to conduct training sessions. In less motivated areas, take-up is slower. Officials, both government and NGO, are positive about the technology, not least because it is within the range of local technological and financial resources. Quality questions remain; will stored water stay pure over a two or three month period?

b. Tube-wells for Problem Areas

Research for technological approaches to reduce water supply disparities have been developed, such as the "Shallow" and "Very Shallow Shrouded Tube-well" suitable for some pockets in the saline area and the 'Pond Sand Filter' (PSF). PSF is a simple technology that greatly improves water quality if properly maintained. In iron-excess areas, water is similarly pumped into a simple plant, which removes iron by aeration and filtration. This, too, depends on motivated consumers to keep it clean. In most of the low water table areas, the key technology is the shrouded tube-well capped by a Tara hand pump. Since the Tara was first developed, over 100,000 of the regular model have been installed. Two adaptations of the Tara, the Tara II and the mini-Tara, are now being tried out on an experimental basis.

c. Slum Areas

In the slums, occupied by 22% of urban inhabitants, less than one- third of people have access to a public water supply and less than one-fifth to proper sanitation.

There is no operating tube well per 527 persons, and each latrine serves 13 users. Not surprisingly diarrhea and other hygiene-related diseases, flourish. The Infant Mortality Rate in urban slums is higher that that in the countryside: UNICEF analysis of 1991 figures showed that there were 142 deaths per 1000 live births in poor urban areas compared to the rural rate of 93 or the national rate of 90.

Fortunately government and non-government organizations have taken recent step to provide safe water and sanitation facilities to the slum dwellers. ADB, RWSG of UNDP-WB along with NGOs have several efforts, especially in urban slums of Dhaka and Khulna.

The research and development efforts of LGED for sustenance of WSS in the slum areas deserve special mention. The project named `Slum Improvement Project' is to provide basic infrastructure and municipal services to the slum dwellers, especially with participation from women. The project is in operation in municipalities and city corporations. The broad aim is to improve the quality of life by providing basic services through operational strategies of community organization, enhancing role of women and environmental promotion. Project priorities are determined on the basis of opinions, perceptions and preferences of the slum women. Women are given skill development training to create self-dependence in them and enabling them to use credit and saving for income generation. Women's participation in health and sanitation has increased because of empowerment of the women to manage, thereby increasing their overall status in the family as well as in the community leading to less incidence of divorce or abandonment.

The efforts provide excellent insight for emancipation of the poor slum women for sustained employment, income and social status. It teaches a simple lesson that women participation is crucial for a sustained municipal service system in the slums.

The small bore sewerage system in Bauniabad slum is an excellent mix of technological and social parameters to develop a sustained sanitation for the slum dwellers. The families are enjoying a sanitary system with added benefit of bio gas use by some of the families. This project developed in 1995 is a joint effort of LGED and ICDDR, B.

4.3 POLICIES AND STRATEGIES TO WSS RESEARCH

- Ground water is declining day by day rendering the suction mode hand pumps inoperative for dry months of a year. To overcome this problem the affected tube wells are to be converted to ensure water supply through out the year.

- Extended coverage of water supply to difficult areas like stone problem areas and coastal belt where suitable aquifer is not available within reasonable limit by innovation of appropriate technical options through Research and Development (R&D) activities.

- R&D activities in the field of rain- water harvesting, desalination and iron removal. R&D will also cover monitoring of declination of ground water table, water quality etc. Innovation of low cost technical options will also be continued for higher coverage.

- Tara is a new technology and further improvement of the same is still under process. Moreover Tara spare parts are not easily available in the market. However this calls for technical and extension research to hand over to users in phase.

- Research on social mobilization will be intensified through various allies and communication technique for behavioral change towards sanitation. Strengthening of R&D activities to innovate low cost technological option as well as to reduce present production of latrine.

- Close linkages between research organizations and extension agents and implementing agencies. WASAs, DPHE, BUET and AEC shall conduct research and development activities for the development of appropriate technologies and other developments with special emphasis on difficult and under-served areas. They shall share the results of research and development and provide technical support to the private sector.

Source: Adopted from National Policy for Safe Water and Sanitation 1998 and The Fifth Five- Year Plan 1997-2002

5. ORGANIZATIONS AND ISSUES IN WSS

5.1 ORGANIZATIONS IN WSS

Stakeholders in WSS Sector

This chapter deals with the responsibilities and activities of different stakeholders involved in WSS with reference to research and development efforts. As research is only a marginal activity of the most stakeholders, their activities having research orientation are described in short.

The statutory responsibility for the water supply and sanitation (WSS) sector is vested in the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C), which shares with the Planning Commission the tasks of policy decisions, sector allocation and funding, as well as project appraisals, approval, monitoring and evaluation. Only recently the MLGRD&C developed and adopted a national policy in the name of National Policy for Safe Water and Sanitation 1998 that describes the objectives and strategies in the WSS sector.

Government Agencies

Department of Public Health Engineering (DPHE): DPHE is responsible for planning, designing, and implementing water supply and sanitation services in rural areas, *Thana* towns and *Pourashavas*. Traditionally DPHE has been performing the task of providing domestic water supply as a government agency to *Zila* and *Thana Parishads*, *Pourashavas* and rural Bangladesh. DPHE has supervisory staff at *Zila* and *Thana* levels and is represented at Union *Parishad* level by tube-well mechanics and masons. One Executive Engineer is assigned to each of the *Zila* offices.

With a mission to provide universal access to water and sanitation facilities for the people, DPHE was founded and has developed with a strong technical bias emphasising WSS infrastructure development. DPHE now strives to become more "client-oriented' through adopting measures for improving local accountability and through a reorientation of the entire staff in the WSS sector. (Matrix 1993)

The research activities are vested with the Research and Development Section. The section of its own does not have any research activities or documentation of research on the sector. With development partners like UNICEF, World Bank, Asian Development Bank, Swiss Development Agency it is involved with research and innovations in technological as well as social aspects.

In recent years, Research and Development activities has largely concentrated on (a) hand pumps, including the Mini Tara for declining water table areas (Wan 1992) and Tara II for use in low water table areas, (b) duckweed for waste

treatment, and (c) iron contaminated aquifers. Yet in terms of priority the activities of research are marginal to other functions. In the sector, donors provide the lead. The R&D Division deals with technical aspects, particularly hand pumps, despite the fact that in recent years other factors affecting use have become important.

A great deal of research on technology, mapping of aquifers and management has been proposed or initiated.

Local Government Engineering Department (LGED): Local Government Engineering Department (LGED) has the mandate of infrastructure development of local government bodies in urban and rural areas, including feeder roads, small culverts and small-scale irrigation. The department implements some WSS activities as components of infrastructure projects. LGED provides water supply and sanitation facilities in growth centers, eco-villages and primary

schools, municipalities, especially in slum areas of the municipalities under infrastructure development projects. LGED has offices in each *Zila* and *Thana*, which provide technical guidance to the *Thana Parishads* and *Pourashavas*.

National policy for safe drinking water and sanitation '98 recognises LGED as one of the key implementing agencies for promoting water supply and sanitation in the country. DPHE and LGED would complement each other's activities.

LGED's research focus is on promotion of private sector, cost recovery mechanism for WSS, co-ordination with all public and private sectors, adaptation of least cost technologies, construction and management of WSS facilities with representation of slum dwellers. Hygiene education is a part of continuous training program with institutional strengthening of Pourashavas and due cognizance of urban management policy statement of the government to provide WSS facilities.

Local Government Bodies: Urban Administrative Units
Water and Sewerage Authorities (WASAs): In Dhaka and Chittagong, Water and Sewerage Authorities (WASAs) provide services within the metropolitan boundaries of Chittagong and Dhaka. WASAs are semi-autonomous bodies with management entrusted to boards and report directly to MLGRDC. Dhaka WASA has charge of water supply, subsurface drainage, and sewerage. Chittagong WASA, in the absence of sewerage, deals only with water supply.

The WASAs were meant to be semi-autonomous entities to develop and operate water and sewerage systems on a commercial basis. Yet in matters off policy, staffing, or fixing of water tariff, WASAs exercise little authority (GOB 1984). The World Bank has recently proposed institutional reforms, including autonomy and power to make policy decisions, as preconditions to an IDA credit for the Fourth WASA project (IDA 1993). Dhaka WASA has been given limited autonomy in that direction

Dhaka WASA and Chittagong WASA do not have any R&D section nor any co-ordination and linkage with R&D activities of other agencies.

City Corporations: City Corporations (CC) in Dhaka, Chittagong, Khulna and Rajshahi have responsibilities in WSS including waste management. Dhaka City Corporation is in charge of solid waste management, surface drainage and implementation of on- site sanitation. Chittagong, Rajshahi and Khulna CCs are responsible for surface drains, solid waste management and maintenance of water supply provided by DPHE and LGED.

On-site sanitation is also the responsibility of the DCC, which is currently implementing the IDA-assisted First Urban Development Project (FUDP) that includes on-site sanitation and a drainage component.

With DPHE and LGED involvement in planning and implementation, the Rajshahi and Khulna City Corporations provide and operate water supply and sanitation services. None of the organizations has any R & D activities by themselves with pilot projects and development activities supported by development partners..

Municipalities (Pourashava): Under the administrative control of the Ministry of LGRD&C, the Pourashava Chairman and his Committee of Ward Commissioners are locally elected. The Pourashavas are responsible for development and maintenance of social services and physical infrastructure in municipal areas. The Pourshavas collect and dispose of solid wastes and are mandated to maintain a sanitary environment. They are also expected to operate and maintain piped water systems, which the DPHE may install, despite the fact that Pourashava involvement in planning and implementation is minimal with no research section or activities.

Provision for, operation and maintenance of water supply is a statutory responsibility of *Pourashava*, but it has limited technical competence and rely on DPHE or LGED for WSS projects, design and construction and in many cases O & M.

Local Government Bodies:Rural Administrative Units
Zilla Parishads (District Councils) are involved in planning, implementation and monitoring of development activities within the district. They review proposals made by the Thana Development Coordination Committees and undertake construction and maintenance of drainage improvements, which are outside areas covered by Pourashava responsibility.

Thana Unnayan Samanaya Committees (Thana Development Coordination Committes) chaired in turn by Union Parishad Chairmen, shoulder responsibility

for planning, implementation and evaluation at Thana level. Water and sanitation provisions of the Thana centers are the responsibilities of the Thana committees. Recently government approved a four tier local government as Zila, Upazila, Union and Gram Parishads. However, the role and responsibilities of the local government bodies in WSS are yet to get a formal shape.

Union Parishads are responsible for promotion of hygiene education and creation of awareness about environmental sanitation among the rural population. The Union Water Supply and Sanitation Committees, which exist in all unions, are comprised of community leaders and DPHE representatives and play an important role in distribution of tube-wells. The Union Parishads co-operate with DPHE and Thana committees in identifying households for government funded water supply and sanitation activities. The revised local government system devolves more authority for local planning to the Union Parishads and village development committees and are involved in social research activities with agencies, development partners and NGOs.

Non-Governmental Organizations (NGOs)
Non-governmental organizations are active in water and sanitation program financing and implementation in both urban and rural areas.

There are many NGOs devoted to work at local levels. The NGO Forum, an apex service body associated with ADAB (Association of Development Agencies in Bangladesh) is the premier NGO in the WSS sector, assisting 460 "partner" NGOs by providing hardware support, advocacy, networking, institution bolding, training, information, research, evaluation, and monitoring. Since 1982 it has assisted in the installation of over 16,000 tube-wells and 123,000 latrines. NGO Forum enjoys support from the DPHE and UNICEF in implementing sanitation and hygiene programs in selected Thanas, The NGO Forum shares with the government a strategy of an "integrated approach," combining water, sanitation, and hygiene education.

Despite the more extensive and direct contact of NGOs with the rural population, one study concludes that NGOs have yet to develop as a significant channel for delivery of sanitary latrines (Chadha and Strauss 1991). This may be changing (UNICEF 1994). Their activities more selectively target the poorest who may not be adequately served by other channels or access to credit.

Private Sector
Private sector involvement is a recent phenomenon in WSS. The government water and sanitation program has stimulated a demand to which the private sector is responding well.
Private hand-pumps comprise 71% of all rural hand-pumps and 88% of all urban hand-pumps. Sanitary latrines are mostly privately owned, although urban areas

have some public latrines. In rural areas 61% of all households have some sort of latrine, and over 25% have a sanitary latrine (i.e., with a pit). In urban slums and fringes the rates were even higher: 83% of all households had a latrine, and almost 50% had a sanitary facility (Mitra 1992). People in many rural communities are making their living as hand-pumps drillers, fitters, repairers and plumbers. In rural Bangladesh there are about 700 private producers of latrine components having an annual production capacity of 140,000 latrine units. (Chadha and Strauss 1991).

Private supplies of hand pumps have responded well to demand. The 1991 survey finding that 71% of all rural hand pumps were private represents enormous growth from just five years earlier, when another study estimated that only one in three shallow tube-wells were private. Fewer private tube-wells had missing parts (27%, compared with 43% of public tube-wells), indicating either better maintenance or better availability of parts in the private sector. In addition, private mechanics provided repair services to 22% of public tube-wells and 27% of private tube-wells, compared with DPHE mechanics who serviced 10% of the public wells and 3% of the private wells (Mitra 1992).

Private producers of latrines feel that the lack of an easily accessible credit system for investment and working capital is a major limiting factor for expanding their production. Despite the advantage enjoyed by DPHE production centers in their ability to offer latrines at subsidized rates, the private sector has thrived due to lower production costs and better service. One study provides a figure of 39% of a sample of latrine-owning respondents who had paid no more than the government subsidized price for slabs and rings. Remaining 61% probably bought their components from private producers. Private producers do not consider themselves on direct competition with the DPHE production centers, and apparently are producing for different market segments. While the government-subsidized latrines are within the means of most of the poor, about 20% of population cannot afford even these. (Chadha and Strauss, 91).

Development Partners

Multilateral donor support has been provided by the development partners that include United Nations Children's Fund (UNICEF), World Bank (WB), International Development Agency (IDA), Asian Development Bank (ADB), International Center for Diarrheal Diseases Research in Bangladesh (ICDDR,B), Swiss Development Co-operation (SDC) and World Health Organization (WHO) as some of the prominent ones.

The UNDP-World Bank Water and Sanitation Program focuses on sustainable WSS services to the poor. Institutional capacity building, human resources development, promotion of community based approaches, and structured learning focussed on informal institutions comprise its agenda. Within the limits of its

mandate, the program responds to government, donor and NGO requests for technical assistance in preparation, appraisal and supervision of sector activities. The Program has assisted in developing and testing the Tara hand-pump, has demonstrated low cost sanitation options in Pourashavas; and has contributed to building capacity in Pourashavas. It has provided technical inputs to IDA and other donor activities and has assisted WASA in improving their management capabilities. The program is currently working with GOB, UNDP and UNICEF in preparing situation analysis for the Sector, and in formulating a National Program Document and a subsequent Program Support Document for UNDP, DPHE, DANIDA-assisted Hand pump Training and Monitoring Program (HTMP) is being implemented under direct Program supervision.

UNICEF's program has been extensive in content and national in scope. Its assistance by June 1991 supported the installation and maintenance of 732,000 hand pump systems, rehabilitation of 190,000 choked up tube wells and production and sale of over 1.2 million latrines. UNICEF has also provided technical assistance and support to technology design and quality control to hydro-geological mapping, to the adoption of community participation, and to the development of infrastructure and human resources (GOB-UNICEF 1992).

External Support Agencies (ESAs) have also supported NGOs for a wide range of project activities including improving access to water and sanitation.

ICDDR,B has been engaged in research innovations in WSS since its inception. In 1984, the organization along with Department of Social Welfare and later with LGED initiated an action research for WSS in Bauniabad slum. In 1994 a small bore sewer system was constructed to covering the slum families under a sanitation system along with community bio gas facilities for 30 families where they could meet their cooking needs under a joint system.

It is expected that this dissemination effort will have implications for planning, program and policy formulating and the local, regional and global levels concerned with similar activities.

During 1995 onwards. WSP-SA of WB focussed on research and applied research activities on documentation of lessons on private sector in WSS, credit mechanism in WSS, unregulated free market and Innovative pilots on SWM in Khulna, WS for urban Poor and WATSAN Partnership. WS for urban poor thrives to evolve a replicable model based on water as both social, economic good and management.

5.2 ISSUES OF WSS RESEARCH

The parameters of research design have been deduced from technological and socio-economic realities of Bangladesh. Public and private sector officials, professionals, practitioners and NGOs working and involved in the field of WSS were interviewed and a questionnaire was administered to know about the research activities and issues on WSS sector research. A cross-section of people interviewed through participatory rapid appraisals to know the needs and demand of people in WSS so that research priorities could be identified for immediate benefit of the people.

Since slums lack adequate water supply and sanitation facilities, discussions on PRA sessions were arranged in two slum areas of Dhaka and municipal and rural areas of two districts of Kushtia and Comilla. The participants were drawn from cross section of people of different professions and income range.

Abundance of Water
The first parameter of technological as well as social research is the abundance of water in relation to WSS on making safe water available for domestic use and sanitation facilities in public health.

In rural Bangladesh there is no engineered public health system to hygienically confine the water supply in pipes and faucets and to remove waste liquid. In the cities and towns, only a relatively small proportion of inhabitants have running water, septic tanks or sewer connections in their homes.

People themselves are environmental engineers, shafting soil, deepening ponds, carving out platforms and steps and taking water to their domestic convenience. They have created bathing places, reservoirs, pools, shrines, livestock watering holes and laundry areas, in rural and urban areas alike. But too few appreciate their germ-laden condition. People bathe daily in ponds, streams carefully removing their clothes for washing. Children swim in them, emitting a stream of water from their mouths as they surface. The same ponds and streams are used for garbage disposal, or. When it rains becomes a sewer for excreta deposited in surrounding bushes. Dishes and kitchen utensils are washed away on their bands, banks from which bamboo walkways lead to hanging latrines. These are perched above the water's edge so that their products fall directly into the water below. Clearly, doing all these things in the same open waters poses serious risks to health. As they shrink, their pathological concentration increases. Diarrhea rampages through these communities, communities where people have no choice but to drink from ponds because they have no functioning tube well.

However still villagers do not always understand the link between excreta, bacteria and disease. And even if they do, there is a limit to what they can do or are willing to do, to adapt to this reality. One thing is sure.

Shortage of Water

The second parameter of design is shortage of water. Extraction of water by tube-wells, use of surface water for domestic use, salinity of water for different uses, removal of iron contents are the issues. Because of the heavy extraction of water for irrigation and decreased groundwater recharge, the water table is declining. 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 predictions suggest that by the year 200, as much as 50% of the high water table areas may find their suction pumps without yield during the dry season.

This means that more call will progressively be made on hand pumps capable of raising water from below the suction level. These 'deep-set' pumps are much more expensive than the standard 'Number 6' although the specially developed 'Tara' pump, which operates by direct action, is still a relatively modest investment.

From a public health point of view, the declining water table has many implications. People may revert to taking water from ponds or other unhygienic sources. The problem water areas, which altogether contain 26% of the population, therefore need extra water supply attention. They also contain additional contamination problems. Salinity in the coastal belt means that 25% of tube wells produce water with high levels of chloride (660 mg/1 or above). In the hilly areas, 77% of tube-wells discharge water with a high iron content (above 5ppm), as do 43% of tube wells in shallow and low water table areas. Water with too much iron discolours food, teeth and clothes and causes stickiness in people's hair.

Water, Diseases and Sanitation

The third parameter is the water, diseases and sanitation for technical, social and extension research. In 40 of the 50 diseases prevalent in Bangladesh, including diarrhoea, dysentery, typhoid, parasitic worm infestation, measles and polio, unsafe water and human excreta are the main elements of transmission. Apart from causing one in three child deaths, this caseload of sickness is a major contributor to malnutrition, a condition suffered by over 90% of young children.
Safe drinking water is the first line of defense against hygiene-related sickness. And in Bangladesh safe drinking water via the hand pump tube well, is a potentially standard amenity for almost every inhabitant. The country sits upon a vast, spongy aquifer replenished by the annual rains ad inundation; As the floods recede, streams and ponds dwindle and the water table drops But in much of the country it remains high above the 7 metre from which water can be lifted by suction.

Sanitation research in Bangladesh is very different from water supply. The main problem for the sanitation is universal coverage. The sanitary disposal of human

excreta and waste are of greater importance. If the disposal of excreta and waste is correctly managed or controlled there will be little risk of human fecal contamination and pollution of living environment. If per capita production of excreta is taken as one pound, total daily production excreta of 120 million stands about 50000 M tons. It is appalling to imagine the cumulative effect of pollution load discharged to environment every day.

Behavioural Issues

Information and knowledge interact with beliefs and practice. Alongside institutional change in the sector has come a determined effort to develop a much clear picture of people's hygienic understanding. Those planning and providing services needed to know why people continue to live un-hygienically and how the health-protection potential of safe tube-well water comes to be nullified between pump, spout and lip. Behavioral issues are an important parameter of research. Anthropological studies have been commissioned to explore uses of tube-well and pond water, defecation practices, hand washing habits, and household water storage methods. Results have been highly revealing.

Researchers have boldly questioned people about their most intimate personal habits. As far as defecation is concerned, the main users of latrines are women, for reasons of privacy and convenience rather than disease prevention. Although the connection between diarrhea and drinking water is appreciated, the faecal-oral, hand-to-mouth route of diarrhea infection is not.

Social Mobilization and Community Participation

The next parameter is social mobilization. The process is a complex operation. In this process all the potential alliances are brought together to arrange a joint attack against the alarming WSS situation. Social and extension research has been on to involve all catalytic agents of change existing in the society. The concept is an extreme positive significance where a real change could be initiated by breaking the shackles of colonial legacy with a minimum social conflict. The most significant aspects of this process are local resources are tapped to its fullest, existing service delivery channels are involved and people's participation are ensured to achieve the sustainability in long run.

The general objective is to develop the competence at community level for the management of integrated WSS services through community initiative and participation. Changing people's hygiene habits is one of the challenges currently facing in community mobilization.

Community participation is an important parameter of research as a community could take a greater responsibility to supply different components of service delivery within the means of individual beneficiaries. These could be either in kind-providing physical labour, supplying required inputs, acting as work supervisors,

or cash form. A detailed list of such inputs could be prior identified, and valuation worked out. The members of the beneficiary community will take the responsibility to supply those inputs to the project. Amongst the individual members those who can afford to pay in cash should do so: while others will pay in kind - free labor/supervision, inputs from own sources, etc. Various local level organizations, e.g., social clubs, religious and educational institutions, as well as the affluent section of the society could also contribute towards the cost of a project in one form or another. If preference could be given in public fund allocation to those communities who can share a greater proportion of the cost, the participation of the locality in cost sharing will be much greater.

Women, Children and Hygiene Education

The sixth parameter of research design is women, children and hygiene education. Women's key role in the collection, management and use of household water supplies makes them the primary beneficiaries of services. Research shows that girls start carrying water as young as five, and women aged 21-25, spend between 1 and 5 hours per day fetching water. Their water-related behavior is decisive in terms of family hygiene and health.

But women mobility outside the home is restricted. They tend to eat less than men, their educational standard, and therefore their knowledge about how to protect health, is much lower. Consequently, it is necessary to make special efforts to reach out to women to involve them in issues of access and water and sanitation usage.

In the growth of water supply and sanitation coverage, the program's accomplishments have been accompanied by the realisation that installations by themselves do not transform public health. There is need for social and extension research. Emphasis on safe water gave way to emphasis on the sanitary latrine; but among a population uninformed of the need for hygiene, higher coverage rates still failed to produce a significant reduction of ill- health.

Arsenic Contamination

This parameter of research in arsenic has important implications for the new challenges that lie ahead. A new contamination scare is now causing deep anxiety. During 1996, arsenic poisoning in groundwater samples was found in 34 districts in the west of the country. It is thought that heavy extraction of groundwater exposed it to the air, triggering oxidisation and consequent changes in the soil. Around 700 Bangladeshis have already been treated for serious arsenic poisoning. Understandably, people in affected areas now distrust tube-well water. Where people are once again resorting to surface water for drinking and other domestic purposes, measures to render it safe are desperately needed.

Safe drinking water is a pre-condition for hygienic living. But it is not only the

drinking water supply, but also other features off the environment and people's interaction with it, that also require attention. In such a crowded country, the capacity of the natural environment for self-regulation is deeply impaired. Value systems and the knowledge that informs them have, until recently, been given less attention than problems of engineering.

Problem Areas

Unfavourable areas are an important parameter of research in WSS. Unfavourable water conditions do not apply universally in our country. They are the coastal belt , highlands and hills, poor water quality areas, low water table areas, high water table areas.

Coastal Belt

In the coastal belt, inhabited by 19% of the population conventional percussion or cable tool methods cannot be used for sinking tube wells. Here the groundwater at 100 metes is saline so it is necessary to sink much deeper. Also sinking costs for these tube wells are much higher than for shallow. Two alternative technologies for saline areas have been developed. One is the Shallow or Very Shallow Shrouded Tube well, which is very inexpensive, but suitable conditions are rare and drilling failure is very common. The second technology, the Pond Sand Filter uses a hand pump to deliver pond water into a small sand filter. It is simple to construct and operate but requires a high level of user motivation to keep the filter clean.

Sustenance

The parameter of sustainability or sustenance in research of WSS, especially in the social context has put forward quite a good number of lessons for sustainability. During the International Drinking Water Supplies and Sanitation Decade (IDWSSD) 1981-90 and around the 1992 Earth Summit, a great deal of rethinking took place concerning humankind's interaction with the natural environment. This re-thinking has been mirrored at our national level. With its water-dominated economy and lifestyle, Bangladesh offer an environmental laboratory from which both its own WSS programs and others can learn.

For sustenance, the balance between what is equitable, what is affordable and what is truly, sanitary in such an over-crowded, easily polluted, and frequently flooded environment is an important but difficult parameter. DPHE still tends to believe in latrine promotion by subsidies and supplies of better-quality items. NGOs tend to believe in creation of consumer demand for adequate home-made facilities even at short-term environment health risk. They assume that once the latrine habit is entrenched, families will upgrade to the sanitary model when they can afford to.

New cost-saving technologies and their promotion are one way to redress

disparities. But attention is also constantly given to other types of affirmative action on behalf of disadvantaged groups.

5.3 NEW FOCUS AREAS

Rain water Harvesting
This is an attractive alternative to the hand pump tube well, not only in areas where terrain and cost rule out the drilled bore hole, but also in areas where groundwater is contaminated with iron, salt, or, frighteningly, arsenic. With an average annual rainfall of 2,500 mm over 7 months, rainwater is a plentiful and under-utilised resource in Bangladesh. Households in areas with relatively few rivers and ponds do sometimes collect and use it, but unsystematically and in small containers. At present, they do not store it beyond the wet season.

Pond Sand Filter
An alternative and popular option of potable water supply in coastal areas is the pond sand filter (PSF). A PSF comprises of a hand pump and a small sand filter. It is a package type filter unit developed to treat surface water, usually pond water for domestic use. PSFs are installed near or on the bank of ponds, which do not dry up in dry months. As pond water passes through the filter it is purified and water is stored in the storage tank. It has been tested and found that the treated water is normally bacteriologically safe. PSFs are suitable for the coastal belt areas where tube-wells are not successful. PSFs may also be used as alternative water supply system for small to medium settlements in arsenic affected areas.

Solar Desalination
Solar desalination unit based on conventional evaporation and condensation facilities can be installed for drinking water supply. Experimental units constructed in the coastal areas of Bangladesh have produced 0.6 - 2.4 $l/m^2/d$ of water with an average yield of 1.41 $l/m^2/d$. The water produced by solar desalination is completely free from salinity and can be mixed with tube-well water to increase the volume of drinking water supply. The present technology can not produce adequate quantity of water at a reasonable cost. Further research is necessary to develop and improve the system for water supply in rural areas.

Slum Areas
In the slums, occupied by 22% of urban inhabitants, less than one- third of people have access to a public water supply and less than one-fifth to proper sanitation.

In spite of the difficulties of service installation in densely crowded and irregularly occupied settlements, urban-rural disparity in water supply and sanitation service provision needs to be addressed. If no environmental action is taken, the Bangladeshi urban habitat will become a by-word for pollution and a major threat to public health.

6. RESEARCH INTERVENTIONS IN WSS

6.1 TECHNOLOGICAL RESEARCH INTERVENTIONS

Water Supply

In Bangladesh, water sources are surface, ground and rain. However, ground water still remains the only source for supply of domestic water in most municipalities (Pourashavas). In Pirojpur, Bagerhat, Sunamgonj, Rangamati, partly Faridpur and partly Chandpur surface water is treated for domestic use.

Raw water obtained from natural sources (surface and ground water) is not completely satisfactory for domestic use. Surface water contains pathogenic (disease producing) organisms, suspended matter or organic substances. Except in limestone areas, ground water is not reported to have pathogenic organisms, but sometimes contain undesirable tastes and odors or mineral impurities limiting its use or acceptability. Some of these objectionable characteristics are tolerated but it is desirable to raise the quality of the water to the highest possible level by suitable treatment.

In the last twenty years Govt. of Bangladesh, with support of donor assisted research and development has created a countrywide demand and remarkable achievement of tube well technology for drinking water. Today 85 million people in rural, urban slums and fringe areas have access to a tube-well within a distance of 150 meters. Similarly 40% of the population now use sanitary latrines compared to just 10% in 1989. The rural water supply and sanitation program in Bangladesh has made huge progress due to following technological and social research with innovations:

- Low cost technologies to reach the poor majority.
- Easily maintained and culturally acceptable technologies.
- Appropriate drilling technology making installation of tube wells easy in most areas.
- Sustainability through
  - Cost sharing
  - Local participation
  - Local production
  - Quality control
- Forging alliances with local agencies and community leaders
- Recognizing of the vital role of women in promoting health education messages
- Stimulating the role of the private sector in manufacturing and sales.

Water Supply Technologies

Over time technologies evolved to suit the demand of the users. The base technology for water supply from ground water is the familiar pitcher pump. Available varieties of technologies have been developed to serve in different hydro-geological conditions as well as to keep costs as low as possible. The primary tube-well/pump technologies in rural as well as urban slums and fringe areas include

a) Shallow tube-well (STW)
b) Deep tube-well (DTW)
c) Shallow shrouded tube-well (SST)
d) Very shallow shrouded tube-well (VSST)
e) Deep set Tara tube-well (DTT)
f) Deep set Tara II tube-well (DT2T)
g) Ring well (RW)
h) Pond sand filter (PSF)
i) Iron removal unit (IRU)
j) Iron removal plant (small scale)
k) Arsenic removal unit (ARU)
l) Iron cum Arsenic removal plant (small scale)
m) Dug well with sanitary protection

Generally ground water is free from pathogenic and other microorganisms but contains excess Iron, Manganese, Arsenic etc. It requires proper treatment to make suitable for drinking. With the assistance of donors, DPHE has constructed Iron Removal Plants (IRP) in many Pourashavas, like Gopalgonj, Serajgonj, Chandpur, Hobigonj, Jessore, Tangail, Manikgonj, Sathkira etc.

Recently, arsenic contamination in ground water has created havoc in Bangladesh. With the Dutch assistance, DPHE is to start construction of an Arsenic Removal Plant (ARP) at Meherpur Pourashava.

In treating ground water through IRP & ARP, aeration, sedimentation, filtration & disaffection processes are carried out.

Sanitation

Sanitation options include a wide variety of latrines as well as sewers in the major urban areas. While many households have latrines of some sort many of this discharge directly into drains or surface water sources. Efforts have been directed at encouraging adoption of pit latrines. Low cost on-site technologies developed and in use are.

a) Home-made Latrine (HML)
b) Ventilated Improved Pit Latrine (VIPL)
c) Water Sealed Latrine (WSL)

d) Twin Pit Water Sealed Latrine (TPWSL)
e) Public toilet (with septic tank and soak away)
f) Community latrines (with pits or attached with biogas plant)
g) Pour flush latrines (with septic tank and soak away or sewer system)
h) Small bore sewer system

6.2 SOCIAL RESEARCH INTERVENTIONS

Social Mobilization and Community Participation
DPHE and LGED projects include the community mobilization program for sustainability. The main focus is to motivate and educate the target people on safe water use, hygiene and improved sanitation practices, increase the awareness and involvement, promote affordable appropriate technology, mobilize resources and build alliances with all potential partners. The partners are local government, professional groups, NGOs, women groups, educational and religious institutes, mass-media cultural groups, clubs, scouts etc. Community based committees with representatives from community were formed to select the beneficiaries/caretakers of facilities.

Evidences from various research activities accumulated during the International Decade for Drinking Water Supply and Sanitation (IDDWSS) suggests that maximum health benefits will only occur if facilities are functioning properly and are well utilized. There is a vast range of direct and indirect benefits of WSS facilities likely to provide. Direct benefits include reduction in diseases, increased time for women to engage in non-illness related child care activities, enhancement of agriculture and commerce, improved school attendance, reduced cost for health care, freeing of health service for attention to other problems, and an easing of the physical burdens of daily life. The indirect benefits are potentially more numerous and diverse, although these may be difficult to document or quantify.

Realizing the need for effective and sustainable integrated water, sanitation, solid waste and hygiene education (WSSH) intervention, Government of Bangladesh launched its "Social Mobilization for Sanitation" (SOC-MOB) project in late 1994. The objective was to improve excreta disposal, personal hygiene practices, and the use of safe water for all domestic purposes aiming at reducing diarrhea diseases and improving the quality of life of the rural people. The SOC-MOB program is a well-conceived program with sustainability potential, there is still scope for applied research on the operational issues, coordination and collaboration among allies, community participation. Currently, the project (action research) activities are being carried out in partnership with the M/O LGRD & C, DPHE, LGED, DG of Primary Health Care and ICDDR, B.

Formation of the Water and Sanitation (WATSAN) Committees headed by the chairman, Union Parishad in every union has been one of the major steps in successful social research. The WATSAN committees have been given the responsibilities of increasing the demand for sanitary latrines and disseminating water, sanitation and health messages. The WATSAN committees at the grassroots act as the channels for ventilating the local demands, complaints and innovative ideas to the government officials. These committees are still in the pilot phase of operation.

Women as Key Role Players

In the context of rural Bangladesh, women are responsible to collect water, to do household washing, cleaning and cooking, to take care of children and elderly people of the family and also to maintain the environmental sanitation around the house. Doing so women irrespective of age are imparting a vital role in the maintenance of household activities. Under the patriarchal social structure of rural Bangladesh, women have little to contribute in the decision making part of a family. Low literacy rate (19.2 percent) and lack of cash-incomes are two major obstacles on the way to women empowerment. Research has established "One female is one institution". This great concept emphasizes the importance of women in launching out any successful development program in the community; as their task in agriculture, animal husbandry as well as in household works made them the daily manager off the natural environment and family. So, to improve the WSS situation, perception and role of women need to be assessed carefully and its resulting impact on them should be surfaced.

Bangladesh by the late 1970s was beginning to recognize that a very important impediment to the spread of understanding about the links between water sanitation and health lay in the exclusion of women from health improvement strategies.

In WSS projects special measures taken to involve and influence women to ensure that they participate more fully in the program and in the activities necessary to achieve the health impact. The women are encouraged to select actual location of well and they are trained for maintenance as well. DPHE makes provision for replacement of male tube-well mechanics to encourage women participation. They will be supported and monitored among others by senior female engineer in future. Field level NGO/partners extension workers will be female facilitating interaction with female family members.

Other Social Issues

The research and development in social issues emphasize on an effective communication plan for WSS especially sanitation comprising of three main elements.

1. High level advocacy to gain national leadership support
2. Social mobilization to bring on-board new partners for both communication activities and service delivery and
3. Program communication, which involves the creation of a number of strategies for behavioural change, which are delivered through mass media, traditional media and interpersonal, interactive channels.

6.3 ARSENIC RESEARCH INTERVENTIONS

Perhaps genesis of Arsenic problem, causes of Arsenic contamination, patients' and groundwater situation etc. are not needed to be included in this report. This chapter may be re-writen in a way that it would include,
extent of arsenic problem and need for research on this issue (very briefly).
what are the research interventions (technical and social) undertaken in relation with Arsenic problems?
organisations involved in mitigation efforts (9.6) etc.

Emergence of Arsenic Problem
It is only recently (during 1996 onwards), the arsenic in our ground water has surfaced as a problem. In neighboring West Bengal it became evident in the mid-eighties and it was predicted that as the younger deltaic deposition stretched from West Bengal into Bangladesh, the latter might also have arsenic contamination of groundwater. The predictors held true as patients from the bordering districts with arsenic skin lesion have been going to Calcutta for treatment. Government of Bangladesh (GOB) and the World Health Organization (WHO) were warned about the situation in Bangladesh in the early nineties.

Judging from the scattered reports published to the press from time to time many organisations have found unacceptable level of arsenic in ground water from a vast majority of the district of the country and a large number of patients suffering from arsenicosis and its complications.

From the present state of knowledge, it can be concluded that although not all tube wells are contaminated, there are thousands of pockets of contaminated ground water in at least two thirds of the districts of Bangladesh. People living there are at real risk of developing arsenic toxicity.

DCH conducted surveys for arsenicosis patients in 22 districts and found patients with arsenical skin lesions in 21 of them. They examined 5554 people in the affected villages and 33.6% of them were diagnosed as patients with arsenical skin manifestations. A report from the National Institute of Preventive, Social and Occupational Medicine (NIPSOM) stated that they had more than 800 arsenicosis patients in their list. At the skin department of IPGMR, 250 patients with arsenical

skin lesions have been investigated and treated. It is obvious that if systematic surveys are conducted in all the districts where there is high level of arsenic in underground water, more patients will be found.

To present a systematic view and statistically sound conception of the extent of the arsenic problem in Bangladesh, a concerted and co-ordinated research is necessary by the concerned agencies, departments, NGOs, Academic and specialized institutions and development partners.

Earlier, several hypotheses were put forward including one that the arsenic compound treated rural electrification poles were the source of arsenic contamination of ground water and the other that insecticides and fertilizers were the culprit, but these did not hold good. Now it has been more or less generally agreed upon that the source of arsenic contamination is geological with mobilization of arsenic due to some geo-chemical processes.

Mitigation Efforts

Since 1996 different organisations including the government, NGOs and private organisations have come forward to study different aspects of the arsenic problem and find out ways to counter it. The government has formed a National Steering Committee with the Minister of Health and Family Planing as its chairmen. Other government departments, agencies and bodies involved in the arsenic work are ministries of Local Government, Rural Development and Co-operatives and Health and Family Welfare, Economic Relations Division, Planning Commission, Environmental and Geographic Information System, National Institute of Preventive, Social and Occupational Medicine, Department of Public Health Engineering, Local Government Engineering Department, Institute of Postgraduate Medicine and Research and International Centre for Diarrheal Diseases Research, Bangladesh.

International donor agencies have shown their interest in the arsenic problem. At least 3 arsenic teams of the World Bank visited Bangladesh by December 1997. The UNDP has funded a Rapid Action Program (RAP) which is currently being implemented jointly by the Ministry of Health and Family Welfare and Dhaka Community Hospital in 200 villages of the arsenic affected districts. The UNICEF has provided field test kits to DPHE and other organization and is considering elaborate program. The British High Commission /DFID, the Embassies of Japan/JICA, Denmark/DANIDA, Canada/CIDA and the Netherlands have shown their willingness to take part in the fight against arsenic.

UNICEF has committed itself to providing technical assistance to DPHE with the objective is to establish the magnitude and extent of the problem, through a systematic surveillance of tube-wells, and identify appropriate measures for mitigating the effects of arsenic. UNICEF has supplied arsenic field test kits and

trained DPHE personnel. UNICEF is working closely with various stake holders including relevant Government Agencies, NGOs, and External Support Agencies, to develop a multi-media communication strategy responsive to community concerns. UNICEF is thus launching an integrated and self-sustaining community-based initiative, designed to lay the basis for a sustainable support. These pilot activities shall be tired out in a few selected districts to assess acceptability. Dhaka Community Hospital (DCH), Grameen Bank and Gono Shahajjo Sangstha, are the main NGOs working in collaboration with DPHE, to implement the project.

Some NGOs are actively involved in efforts to solve the arsenic problem. The Disaster Forum, an association of NGOs working in disaster management was once very active in organizing arsenic activities, but now it seems to have lost its tempo. Some other NGOs deserve mentioning like ADAB, NGO Forum, BRAC etc. Some private initiatives, notably Sono Diagnostic Centre in Kushtia through environmental initiative also deserves special mention.

As a private organization Dhaka Community Hospital has been involved in the alleviation of the arsenic problem from the very beginning. It has conducted extensive surveys sampling supportive treatment of patients, training programs for doctors and other health and community workers and awareness programs. DCH sponsored an international seminar in January 1996 and more than twenty studies concluded that it was a real threat to our public health.

School of Environment Studies, Jadavpur University of Calcutta, West Bengal, India (SOES), has been the pioneer organization in ringing alarms for arsenic calamity in Bangladesh. Actually it is in the laboratory of this school that most of the water samples and almost all the biological samples from Bangladesh have been tested for arsenic.

Other organisations deserve to be mentioned include Atomic Energy Commission and the BCSIR Laboratories who have some facilities for water testing. ICDDR-B is experimenting with removal of arsenic from contaminated water, Geological Departments of Rajshahi and Dhaka Universities Chemistry Department of Jahangirnager University and BUET are doing some work in their respective fields. Local Government Engineering Department (LGED) has set up an environmental laboratory in Khulna where arsenic tests are made by both electro chemistry and spectrophotometry.

There is no doubt that the arsenic situation in Bangladesh is very grave to say the least. Patients are suffering and physicians are at a loss. We are optimistic that with joint efforts of the government, national organisations, international agencies and scientific community some solution will be reached that will bring smile to faces of the distressed. A concerted and well co-ordinated effort and research with action programs are necessary.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The growth of network of actors and stakeholders in safe water supply and sanitation in recent years is a testimony to the importance attached by the society, from the political establishment to humble citizens towards a better standard of environmental health. The most important thing is that WSS research would now have a direction as described in the document strategy policy.

Two decades of people-oriented action research, pilot experiment and development efforts confirm that WSS will have to be a combination of technical know how along with local wisdom and community participation for a sustainable system. The technical and social research interventions in WSS established that low cost appropriate technology, social mobilization, community participation and hygiene education are the key elements for sustainable water supply and sanitation system in our country.

Development of hardware aspect of WSS in isolation may result in poor achievement. However, as a part of package of development projects, the extension of tube-wells and sanitary latrines have been successful in many cases.

First extension research started in 1972 when DPHE administered rural water supplies and sanitation program. UNICEF has been its key external donor and source of inspiration for quest of replicable models acceptable and appropriate for Bangladesh. The partnership of BARD-UNICEF in early seventies for social and extension research to popularize sanitation using imams, teachers, women workers, masons and artisans was the beginning and deserve special mention.

In turn, government agencies, local bodies, international organizations, donors, NGOs followed the path. In recent times, key bilateral donors, notably WHO, DANIDA, SDC, UNDP and World Bank have supported research oriented development. During the International Water Decade, the World Bank, UNDP and other partners began to participate, and now attach great importance to inter-agency coordination.

Creation of Union WATSAN Committees is an important step to ensure their representation and participation. The successful organization of School Sanitation by School Management Committees indicates that when a clear goal is in view, community leaders are more than willing to join in. The Annual Sanitation Week provides an opportunity for building new partnership.

A new set of partners to come on the scene the advent of social mobilization and a

partnership strategy for water and sanitation, is those professionally involved with mass communication. The Meena animated video series, cinema shows microphone van folk songs, traditional plays entertainment are all being allies helping promote hygienic living throughout Bangladesh.

7.2 RESEARCH PRIORITIES

Present research challenge is to scale up community-based and demand-responsive approaches into national policies and programs. Considering the present situation of WSS, research objectives and priorities should be directed to issues of learning and communicating knowledge, strengthening of policies, improving investment effectiveness, development of appropriate technology in technical and social realities of Bangladesh. The following research issues may be considered:

i) There is urgent need for research to generate knowledge based on field activities. Primary focus of research should be on pilot projects supported by programs and field experiences to test sustainability of specific approaches before scaling them up.

ii) Research should be undertaken on development of viable water supply chains of private vendors and in identifying obstacles that discourage private sector supply of goods and services.

iii) Research should be undertaken to delineate the roles for water supply and sanitation utilities. Private sector actors, local government and community organizations in service delivery, financing mechanism including micro credit, pricing of expansion of service to the poor, capability of WSS with multi-service slum upgrading projects.

iv) Research design should focus financial policies e.g. what policies would result in informed users' decision regarding service levels and corresponding to local contributions.

v) Research and development activities should set design criteria depending on price, which the purchaser are willing to pay rather than considering cost as function of the design criteria.

vi) Research should offer modifications to existing practice or technology by changing or replacing components rather than offering a completely new package of technology.

vii) Research should focus on assessing acceptability of the product or the

technology by consulting potential purchasers or users at every stage of its development.

viii) Research should directed to generate demand for WSS services at the same time improve the products (technologies) by accommodating variations thereby enlarging people's choice.

7.3 ISSUES AND RECOMMENDATIONS

There is a lack of interest of different organizations and institutions to carry out action research. The approach has been project-oriented rather than research oriented. There is an urgent need for creation of awareness of need and importance of action research and develop interest for the same among all the stakeholders to make the intervention appropriate and sustainable.

There is a deficiency in proper documentation of the research outcomes. The project report or project evaluation report often indicated the potential for research but no documentation of the important findings of project was done by any organization. Research is urgently needed to ensure of proper documentation of the research findings and preservation of the same.

There is no substitute for research for developing cost-effective and sustained methods, techniques, arrangements and procedures in WSS. The sector would only flourish if research organizations are promoted. Defining specific roles and responsibilities of different organizations / institutions to take part in research activities in WSS sector and co-ordinate among themselves is a major issue. Establishment of a research and development (R & D) cell within any particular organization/institution for collecting documents and information on research outputs is recommended. ITN center has already started the work; the center may co-ordinate research activities, research institutions and researchers in the field of WSS.

There are deficiencies in proper dissemination of research outcomes. Outcome of research was usually not put into actions or activities. They were identified and used for the purpose of use of project requirements only. There is urgent need for ensuring proper dissemination of research outcomes and adequate field-testing for evolving appropriate sustainable models. It is very important to share the knowledge and experience on the specific areas to be addressed immediately under the action research activities in the context of Bangladesh.

There are duplications of research activities due to lack of co-ordination and information dissemination. It is necessary to ensure proper co-ordination of different organizations and institutions in research activities to avoid duplication and speed up

the research activities.

Research has to be full time activity with strong commitment and can be more effective through contracts with dedicated researchers. More inter-action among the researchers and more scope of publicity research findings are required. More opportunity for WSS research should be created. Research should be undertaken maintaining proper co-ordination with the WSS stakeholders.

It is recommended that works and meetings be arranged with the active participation of the key WSS stakeholders with a view to identifying the important possible WSS areas on which research could be undertaken considering the comparative advantage and specialization of WSS stakeholders.

There is no quality publication of research study on WSS as well as adequate skill of researchers in this field. Government and donors should come forward to provide funds for capacity building of researchers for conducting research studies on various areas of the WSS in the country.

7.4 SPECIFIC RESEARCH AREAS OF IMMEDIATE ATTENTION

Some areas of technological, social and extension interventions that need immediate research are highlighted below:

I. Technological Research

Water Supply

- Contamination and pollution of water from open defecation and pits travel horizontally and vertically under different surface and groundwater conditions;
- Safe water for flooded and high water table areas;
- A wider range of alternative technologies for overcoming arsenic problem e.g. arsenic removal unit attached with hand pump or small scale arsenic removal plant;
- Options for declining of water table and recommendations to counter;
- Rainwater harvesting;
- Pond Sand Filter;
- Iron removal unit attached with hand pump or small scale iron removal unit;
- Development of low-cost technology for water extraction.

Sanitation

- Distance pollution from pits travel horizontally and vertically in different soil type under different groundwater conditions;

- Sanitation for flooded areas;
- Soil types of on-site sanitation;
- Collection and Disposal of wastes and sanitary landfill;
- Development of low-cost technology for environmental sanitation (latrines);
- Dug well with sanitary protection;
- Latrines ion high water table areas;
- Latrine in flood-prone areas;
- Latrine on coastal belt within tidal zone.

II. Social and Extension Research

- Co-ordination among sector stakeholders in undertaking WSS research projects and activities ;
- Process and role of private sector in WSS service provisions;
- Equitable distribution of water with different stakeholders;
- Role of credit mechanism in WSS provisions;
- Trans sector linkage;
- Cost sharing;
- Water supply and sanitation for slums;
- Primary and Secondary collection of wastes in cities and municipalities;
- Behavioral issues;
- Health and hygiene issues;
- Assessment of effectiveness of communication materials;
- Women's roles and responsibilities in WSS sector;
- Effective community participation;
- Awareness creation about arsenic problems to handle the critical situation in arsenic affected areas.

III. Research in Operation and Maintenance

- Development of standard operators manual
- Participation of local community in O & M;
- Capacity building in O & M;
- Development of cost-effective and sustainable O & M systems;
- Women's role in O & M;
- Standardization of fittings.

ANNEXES

Annex - 1

DATABASE

Documents on water supply and sanitation sector

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
Water Supply and Sanitation : Policy				
1.	National Drinking Water Supply and Sanitation Policy, 1998	Document	Local Government Division	Ministry of Local Government Rural Development and Co-operatives, Dhaka, 1999.
2.	The Bank Policy on Water	Working Paper	Not Applicable	Asian Development Bank, Dhaka, 1998.
3.	The Fifth Five-year Plan - 1997-2002	Document	Not Applicable	Planning Commission, Ministry of Planning, Government Peoples' Republic of Bangladesh, Dhaka,1997
4.	National Workshop on Strategic Sanitation Approach	Proceedings	Not Applicable	UNDP – World Bank Regional Water and Sanitation Group (South Asia) Bangladesh – August 1997.
5.	New Concepts for Partnership in Rural Water Supply and Sanitation for the Low Water Table Areas of Bangladesh	Report	Not Applicable	Swiss Agency for Development and Co-operation (SDC), Dhaka, 1997
6.	Sanitation and Water Supply: Practical Lessons from The Decade. Water and Sanitation Discussion Paper Series No. 9	Discussion Paper	Cairncross, S.	UNDP-WB, Water and Sanitation Program, Dhaka, 1997
7.	Water Supply Sanitation Sector in Bangladesh: A Proposal for Future Strategies	Study Report	Not Applicable	UNDP, Dhaka, 1991
8.	Position Paper on Water Supply and Sanitation Sector, Bangladesh UNDP- World Bank Supply and Sanitation Program.	Paper	Not Applicable	UNDP-World Bank, Dhaka, 1991
9.	Global Consultation on Safe Water and Sanitation for the 1990s, "The New Delhi Statement"	Document	Not Applicable	UNDP, New Delhi, 10-14 September, 1990

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
Water Supply and Sanitation : Technological research				
1.	Review the Cost and Design of the Water and Sanitation Facilities of School Sanitation Program.	Review	Not Applicable	BETS, Dhaka, December,1998
2.	Simple and Low Cost Tube Well and Latrine Technology.	Booklet	Not Applicable	NGO Forum for Water Supply and Sanitation, Dhaka, 1997.
3.	Course on Epidemiological Methods in Public Health, Volume 1, 2, & 3	Training Materials	Not Applicable	International Center for Diarrhoeal Disease and Research, Bangladesh (ICDDR, B), July 1993.
4.	A study of filtration process for the treatment of surface water	Thesis	Md. Masuduzzaman	Bangladesh University of Engineering and Technology, (BUET) Dhaka
5.	Development of a low cost iron removal plant for hand tube-well	Thesis	Md. Karamot Ali	BUET, Dhaka October, 1994
6.	Sustainability study of water supply and sanitation system of Netrakona town	Thesis	Md. Obaidul Kabir	BUET, Dhaka August, 1999
7	Drinking water supply and sanitation to suit post cyclone situation in the coastal region of Bangladesh	Thesis	Md. Khoda Bux supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka July, 1995
8	A study on water supply and sewerage problems in Dhaka city	Thesis	A. F. M. Abdul Aziz	BUET, Dhaka January 1990
9	Effect of different impurities in potable water on iodine	Thesis	Reba Paul	BUET, Dhaka December 1996
10	Water quality modeling of mixing zones of rivers for multiple outfalls	Thesis	Abul Kalam Azad	BUET, Dhaka October 94
11	Development of a water quality model using finite segment method	Thesis	Md. Rezaul Karim	BUET, Dhaka
12	Effect of impurities in potable water on Iodine	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1996
13	Ground water Quality in Deep Aquifers of Bangladesh.	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1995
14	The Status of Water Supply and Sanitation access in Urban slums and Fringes of Bangladesh	Report	F. Ahmed and Md. Hussain	Journal of Water Supply Research and Technology Aqua-UK, Vol 46 # 1 1997
15	Iron removal of water by coagulation and sedimentation	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
16	Removal of Microorganism and Suspended materials by Coagulation and Filtration.	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
17	Study of Mohara Water Treatment Plant	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
18	Characteristics of Major Industrial Liquid Pollutants in Bangladesh.	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1999
19	Ground Water Impurities of Dhaka City Aquifer	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
20	Treatment of Tannery Liquid Waste	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
21	Water Supply and Sanitation Condition in Rural Areas of Bangladesh	Thesis	Supervisor: Porf. Delwar Hossain	BUET, Dhaka, 1996
22	Assessment of water Quality of the River Buriganga	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1996
23	Deep Tubewell water quality of Bangladesh	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
24	Study on Arsenic and Iron Remove in Groundwater of Bangladesh	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
25	Sewage Treatment with Duckweed.	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1997
26	A study of water Supply of BUET Campus	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1995
27	Water Supply, Sanitation and Socio-Economic Condition of Slum People in Dhaka City.	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1995
28	Lead Pollution of Dhammondi Lake	Thesis	A.N.M. Ahsanuzzaman	BUET, Dhaka, 1996
29	Arsenic Removal from water by Ferric chloride	Thesis	Supervisor: Prof. Delwar Hossain	BUET, Dhaka, 1999
30	Analysis of Heavy Metals in Bed Sediments of Dhanmondi Lake.	Thesis	Khondkar Nurul Ashfaq supervised by AB Badruzzaman	BUET, Dhaka, 1999
31	A study of performance of the Pagla Sewage Treatment Plant of Dhaka WASA.	Thesis	Md. Naziruzzaman supervised by ABM Badruzzaman	BUET, Dhaka, 1999
32	Comparative Study of Copper Contamination in the Dhanmondi and Ramna Lakes.	Thesis	Hafis Ahmed supervised by ABM Badruzzaman	BUET, Dhaka, 1998
33	Assessment of Impact of Pollutants in the River Buriganga using a Water Quality Model	Thesis	Mir Mustafa Kamal supervised by ABM Badruzzaman	BUET, Dhaka, 1996

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
34	Development of a Water Quality Model using Finite Segment Method.	Thesis	Md. Rezaul Karim supervised by ABM Badruzzaman	BUET, Dhaka, 1995
35	Analysis and design of Solid Waste Management System for a Residential Area of Dhaka City.	Thesis	Md. Abdus Salam supervised by ABM Badruzzaman	BUET, Dhaka, 2000
36	Lead Pollution in the Dhanmondi Lake.	Study report	Ali, M. A. Ahsanuzzaman et al	BUET, Dhaka, 1997
37	Some Characteristics of Various Waters in and around Dhaka City	Thesis	Tazul Islam Supervisor Prof. M. Feroze Ahmed	BUET, Dhaka, 1977
38	Design Parameters for Rural Water Supply in Bangladesh	Thesis	Md. Habibur Rahman supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1981
39	Development of a Computer Model of Unsteady Flow in Water Supply Pipe Network	Thesis	Md. Mahbubul Bari Prof. M. Feroze Ahmed	BUET, Dhaka, 1986
40	Numerical Modeling of Contaminant Transport in Ground Water	Thesis	Lutful Islam Khan supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1987
41	Effect of Dissolved Oxygen on Biodegradability of Domestic Sewage	Thesis	N.C. Das supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1988
42	Effect of Chlorination on sewage Disposal	Thesis	M.A. Jalil supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1988
43	Characterization, Treatment and Disposal of Sewage of Dhaka City.	Thesis	N. M. Kazi supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1988
44	A Study on Decay of Faecal Coliform in Aquatic Environment	Thesis	Md. Zamir Bin Alam supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1996
45	Arsenic Removal Technique from Groundwater	Thesis	M.M. Taimur Khan Supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1999

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
46	River Water Treatment for Water Supply in Dhaka City	Thesis	Kazi Md. Abu Sohel supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1999
47	Development of Sanitation Facilities inRural Areas with Special Reference to Sonagazi and Meherpur Upazilas	Thesis	Md. Yusuf supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1988
48	Hazaribahg Tanneries : A comparative study of pollution control options	Thesis	Md. Badiur Rahman supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1988
49	Health Impact of Water Supply and Sanitation Intervention in Meherpur Paurasavas	Thesis	Md. Imam Zafar supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1997
50	An Evaluation of Groundwater Abstraction for Water Supply in Dhaka City	Thesis	Md. Moniruzzaman supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1998
51	Standardization of Septic Tank for Bangladesh	Thesis	M. Rafi Al Basher supervised by Prof. M. Feroze Ahmed	BUET, Dhaka, 1990
52	A Comparative Study between small bore sewerage system and conventional sewerage system	Thesis	Mr. Hoque supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka, 1992
53	Impact of greater Dhaka city flood protection works on the environment with specific reference to industrial waste disposal	Thesis	Mr. Karim supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka, 1992
54	Deterioration of yielding capacity of water production wells in Dhaka city.	Thesis	D.R. Dhar supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka, 1995
55	Problems and Prospects of Solid Waste Management in Dhaka Metropolitan city	Thesis	Mr. L. Rahman supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka, 1995
56	Causes of Water Logging in Dhaka Metropolitan City	Thesis	Mr. S. Rahman supervised by Prof. Mujibur Rahman	BUET, Dhaka, 1995
57	Studies on Septic Tank Effluent Quality and Soakage	Thesis	Mr. Shahidullah supervised by Prof. Md. Mujibur	BUET, Dhaka, 1995

			Rahman	
Sl No	**Title of Document/ Paper**	**Type of Document**	**Author(s)/ Supervisors**	**Source, Place and Date**
58	Investigation on Lead Contamination of Dhanmondi Lake	Thesis	Mr. Zaman supervised by Prof. Md. Mujibur Rahman	BUET, Dhaka, 1996
59	No. 6 Tube well Cleanliness Manual	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
60	No. 6 Tube well Maintenance Manual	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
61	Manual on Production of Ring , Slab and Pan-siphon of Water Sealed Latrine	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
62	Hygiene Latrine Maintenance Manual	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
63	The Mini Tara: A Solution to the Adverse Impact of Declining Water Table on Potable Water Supply in Bangladesh		Wan, P.	DPHE Journal, Dhaka, December, 1987.
64	Pilot Study on Fresh Water Resources in the Coastal Belt of Bangladesh.	Research Report	IWACO, Rotterdam	DPHE-UNICEF, September 1985.
65	Municipal Waste Management in Bangladesh with Emphasis on Waste Recycling.		Ahmed, M. F	BUET, Dept. of Civil Engineering, Dhaka, 1993.
66	Bangladesh University of Engineering and Technology, Dept. of Civil Engineering, Dhaka, 1993.	Research Report	Not Applicable	WHO- DPHE-UNICEF, Dhaka, June 1990.
67	Caretakers Training Manual (for No. 6 and Tara pump): Netherlands-Bangladesh Development Co-operation Program DPHE- Water Supply and Sanitation Project.		Not Applicable	DPHE, Dhaka, 1993
68	Report on Slab plus One Ring Latrines.	Report	Not Applicable	DPHE-WHO-UNICEF, Dhaka, 1992.
69	Water and Sanitation in Bangladesh, DPHE, August 1993.	Booklet	Buksh, Khuda.	DPHE, Dhaka, August, 1993.
70	Report on Home made (Do-it-yourself) Latrines.	Evaluation Report	Not Applicable	DPHE-WHO-UNICEF-SDC, Dhaka, May-June1993.
71	Report on Study of Pond Sand Filters.	Evaluation Report	Not Applicable	WHO-DPHE-UNICEF, Dhaka, March 1991

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
Water Supply and Sanitation : Social Research				
1.	Water Supply and Sanitation Problems in the Slums of Mohammadpur, Dhaka.	Research Publication	Not Applicable	Water Aid, Actionaid, VERC, June, 1997.
2.	Paribesh O Sanitation Unnayane Gonojogajog O Samaj Andolon (Published in Bengali)	Book	Dr. Kazi Ali Azam	Dhaka, 1997.
3.	Water, Sanitation, Solid Waste and Hygiene Education System in Rural Bangladesh	Research Report	Not Applicable	ICDDR,B, Dhaka, 1995.
4.	Technical Assistance to UNICEF on Home Management of Water and Ingestion of Polluted Water in urban and Rural Areas in Bangladesh.	Research Report	Bilqis A Haque, Shaiful A Ahmed	ICDDR-B , Dhaka, 1995.
5.	A Fork in the Path : Human Development Choices for Bangladesh	Brochure	Not Applicable	LGED UNDP, ILO, UNFPA, Dhaka, 1994
6.	Water Supply and Sanitation in Dhaka.	Booklet	Buksh Khuda	DPHE, Dhaka, 1993.
7.	Bangladesh Rural Water Supply and Sanitation, DANIDA and Swiss Development Co-operation.	Review Report	Not Applicable	DANIDA-SDC, Dhaka, 1993.
8.	Towards a Better Health: The Rural Water Supply and Sanitation Programme in Bangladesh.	Evaluation Report	Not Applicable	UNICEF, Dhaka, December, 1992.
9.	Promotion of Rural Sanitation on Bangladesh with Private Sector Participation	Report	Chadha, S. and M. Strauss	SDC, Dhaka, 1991
10.	Socio-economic Survey, Low Cost Sanitation Project for 84 Municipalities.	Research Report	Not Applicable	UNDP -World Bank Water Sanitation Program, 1988.
11.	Participation of women in Water Supply and Sanitation: Roles and Realities. Technical paper No. 22.	Paper	Van Wijk-Sijbesma, C	The Hague-International Reference Center for Community Water Supply and Sanitation, 1985
12.	The National Survey on Status of Rural Water Supply and Sanitation: Tube well Sample Forms (TSF)	Survey Report	Not Applicable	Mitra and Associates, Dhaka.
13.	Lessons Learned From the WASHH Project, Ten Years of WSS Experience in Developing Countries, WS HP	Evaluation Report		

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
14.	Report on Evaluation of Tara Caretakers Training	Evaluation Report	Not Applicable	DPHE-WHO-UNICEF, Dhaka
15.	Community Participation and Waste Management: Dhaka City	Study Report	Haque, N.	Regional Workshop on Urban Waste Management in Asian Cities. Dhaka: BCAS and Goethe Institute.
16.	Water Vending in Old Dhaka.	Booklet	Iftekher Haider et al	UNDP-WP, Dhaka, 1998.
17.	Report of a comparative study between SMC and DPHE Contractor Constructed Facilities under School Sanitation Program in Noakhali District	Evaluation Study	Not Applicable	M/s Niza Consulting Associates (NCA)/ UNICEF, Dhaka, 1998.
18.	The Role of Imams in Safe Water and Environmental Sanitation	Study Report	Not Applicable	NGO Forum, Dhaka, 1997.

Water Supply and Sanitation : Extension

1.	Rivers of Change : New Direction in Sanitation, Hygiene and Water Supply in Bangladesh	Report	Not Applicable	DPHE/ UNICEF, Dhaka, 1997.
2.	Hosta Chalita Tara Pump (Published in Bengali)	Manual	Not Applicable	UNICEF, Dhaka, 1995.
3.	Manual on proper installation of No. 6 Tube well.	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
4.	Assessment of National Sanitation Week.	Evaluation Study	Not Applicable	UNICEF, Dhaka, 1998.
5.	Chittagong Health City Project, Health for All – All for Health, Chittagong City Corporation and World Health Organization, City Health Plan.	Document	Not Applicable	WHO, Dhaka, 1994
6.	Sector Analysis Report. T. A. NO. 1684-Ban: Second Water Supply and Sanitation Project, Bangladesh	Document	BKH Consulting Engineers	DPHE and Asian Development Bank, Dhaka, 1993.
7.	1993 Action Research Project Document on Sanitation Focusing on Latrine Producers and Latrine Market.	Research Report	Not Applicable	GOB - UNICEF, Dhaka, November, 1993.
8.	Operational Manual Promotional Activities.	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
9.	Manual on Village Sanitation Center (VSC)	Manual	Not Applicable	NGO Forum, Dhaka, 1997.

Sl No	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
10.	Manual of Village Development Committee (VDC)	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
11.	School Program Manual	Manual	Not Applicable	NGO Forum, Dhaka, 1997.
12.	Project Co-operation agreement, United Nations Children's Fund and Coalition for Urban Poor (CUP).	Project Document	Not Applicable	UNICEF and CUP, Dhaka, 1998-99.
13.	A Study on the Implementation of Latrines and Water Supply System in Primary Schools through School Managing Committees, United Nations Children's Fund (UNICEF).	Evaluation Study	Dr. Tofail Ahmad	UNICEF Chittagong Division Office, October, 1995.

Water Supply and Sanitation : General

1.	Progotir Pathey: Achieving the Goal for children in Bangladesh: UNICEF – 1998.	Progress Report	Not Applicable	UNICEF, Dhaka, 1998.
2.	Sanitation and Water for All, 24th WEDC Conference.	Proceedings	Not Applicable	Islamabad, Pakistan, 1998.
3.	18 DTP A DPHE Project with Dutch Aid Drinking Water, Sanitation Hygiene Education, WSSC Review.	Project Paper	Not Applicable	DPHE, Dhaka 1998.
4.	Association of Development Agencies in Bangladesh (ADAB), "Tube wells are not Enough".		Not Applicable	ADAB News March - April, 1998.
5.	Brochure on Tara Hand Pump, NGO Forum for Water Supply and Sanitation, 1997.	Brochure	Not Applicable	NGO Forum, Dhaka, 1997.
6.	Sector Analysis Report, TA No. 1684-Ban: Second Water Supply and Sanitation Project, Bangladesh.	Review	Not Applicable	DPHE, ADB & BKH Consulting Engineers, Dhaka, 1993.
7.	Pilot Study on Fresh Water Resources in the Coastal Belt of Bangladesh.	Survey Report	IWACO, Rotterdam	DPHE-UNICEF, September 1995.
8.	Sanitation Situation in Sunamgonj, United Nations Children's Fund (UNICEF).	Survey Study	Dr. Tofail Ahmed, Syed Ahsanul Alam	UNICEF, Chittagong Office, June, 1997.

Sl No.	Title of Document/ Paper	Type of Document	Author(s)/ Supervisors	Source, Place and Date
Water Supply : Arsenic				
1.	A Short Report on Geological Interpretation of Arsenic Contamination in Ground Water of Bera Pourashava	Survey Report	Dr. Aftab Alam Khan, Md. Khairul Amin and Md. Nurul Nabi	DPHE, Dhaka, 1997.
2.	Studies of Drinking Water Quality ad Arsenic Calamity in Ground Water of Bangladesh.	Study Report	Siddique Amin Talukder et al.	DPHE / Institute of Analytical Chemistry Karl-Farl-Franzens University, Austria, 1997.
3.	Geochemical Mapping and Speciation of Arsenic in the Ground water of Faridpur Municipality.	Research Paper	S. Safiullah et al.	Department of Chemistry, Jahangir Nagar University and Dhaka University.
4.	An Analytical Aspects of Arsenic in Ground water, An Electrochemical Approach.	Research Paper	A. K. M. Munirul et al.	SDC/ Environ Initiative, Kushtia /AECD, George Mason varsity, USA/ Deptt of Chemistry, DU.
5.	Drinking Water Contamination by Arsenic: People's Perception and Communication Challenge.	Survey Report	Dr A Z M Iftikhar Hussain	M/O Health and Family Welfare, GoB, 1998.
6.	Arsenic Pollution in the Southwestern Part of Bangladesh - A Case Study of Tara-Paikgacha Area.	Case Study	Reshad Md. Ekram Ali	Geological Survey of Bangladesh, Dhaka, Bangladesh.
7.	Ground Water Treatment for Arsenic-Iron Removal.	Research Report	M. Feroze Ahmed et al.	Department of Civil Engg, BUET, Dhaka
8.	Hydrogeological Investigator Approach to Address Arsenic Pollution in Urban Groundwater Supply.	Research Report	Mohiuddin Khan	M/O of Environment and Forest, GoB.
9.	Arsenic Contamination in Soil Water and Human Health.	Research Report	M.A. Sattar and C. Mandal	BAU, Mymensingh, Indian Institute of Chem. Biology, Calcutta.
10.	Arsenic Contamination in Drinking Water in Bangladesh.	Research Report	Md Munir Hussain	Geological Survey of Bangladesh, Dhaka.
11.	Arsenic Distribution and Mobility in Groundwater from Chapai Nawabganj, Western Bangladesh.	Research Report	PL Smedley et al.	British Geological Survey, UK and Geological Survey of Bangladesh.
12.	Arsenic Contamination of Drinking Water in Bangladesh.	Research Report	Dipankar Chakraborti et al.	Dhaka Community Hospital, Bangladesh.
13.	Rapid Action Programme.	Proposal	Q. Quamruzzaman et al.	Dhaka Community Hospital, Bangladesh.
14.	Cost Effective Approach of Arsenic Analysis and Two Low Cost Arsenic Removal Techniques for Use in	Research Report	Not Applicable	ITN-BUET

	Bangladesh.			
15.	International Conference on Arsenic Pollution of Ground Water in Bangladesh. Causes, Effects and Remedies, Abstracts.	Proceedings	Not Applicable	UNICEF, Calcutta, February 1998.

Annex - 2

LIST OF AGENCIES/ORGANISATIONS/NGOs VISITED

Government Organisations/Projects in WSS Sector

Department of Public Health Engineering (DPHE)

Research & Development Wing of DPHE
Training Division of DPHE

Local Government Engineering Department (LGED)

Secondary Towns Infrastructure Development Project (STIDP)
Urban Basic Services Delivery Project (UBSDP)
Training Unit of LGED

Bangladesh Academy for Rural Development (BARD), Comilla

Dhaka City Corporation (DCC)

Dhaka Water and Sewerage Authority (DWASA)

Development Partners / Other Organisations / NGOs

World Bank (WB)
Asian Development Bank (ADB)
United Nations Development Program (UNDP)
NGO Forum for Water Supply and Sanitation
United Nations Children's Emergency Fund (UNICEF)
Environmental Division, ICDDR'B
Sanitation and Family Education Resource (SAFER) Project, CARE-Bangladesh
Employment and Technological Development Agency (ETDA)
Shubashati
Assistance for Development Program (ADP)
Coalition of Urban Poverty (CUP)
Community Development Library (CDL)

Annex - 3

RESEARCHERS, OFFICIALS AND PRACTITIONERS MET

Dr. Azharul Haq, Managing Director, Dhaka WASA
Mr. S.M. Ihtishamul Huq, Executive Engineer, R& D, DPHE, Dhaka.
Mr.Mustafizur Rahman, Executive Engineer, Training, DPHE, Dhaka.
Prof. Mujibur Rahman, ITN/BUET
Prof. Habibur Rahman, BUET
Mr. SMA Rashid, NGO Forum
Mr.Haroon-or-Rashid, RWGS-SA, The World Bank
Mr. Abu Jafar Shamsuddin, RWGS-SA, The World Bank
Mr. Abdul Gaffar, Project Director, STIDP, LGED
Mr.ABM Ashraful Alam, Executive Engineer, STIDP, SGED, Dhaka
Mr. Nasir Uddin Ahmed, Project Director, UBSDP, LGED
Ms. Nazneen Afroze, Deputy Project Director, UBSDP, LGED
Mr. Deepak Bajracharia, Chief, WES, UNICEF
Mr. Shafiqul Islam, WES, UNICEF
Ms. Shirin Hussain, WES, UNICEF
Ms. Afroza Ahmed, WES, UNICEF
Ms. Bilqis Amin Haque, Head, Environmental Health Programme, ICDDR'B
Mr. Mohammad Mofazzal Haque, National Field program Officer, WHO
Ms. Shirin Banu, CUP
Dr. Tofail Ahmed, Associate Professor, CU
Dr. H.R. Khan, Water Resources Adviser, SSWRDSP, LGED

Annex 4

QUESTIONNAIRE ON WSS SECTOR RESEARCH IN BANGLADESH
For Organisations/Researchers/NGOs

Name of Organisation :

Name of Individual :

Position in the Organisation :

Date of Interview/Discussion :

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1. What are the activities of your organisation in relation to WSS?

2. Is your organisation involved in any research activities in WSS ? If yes what are research topics?

3. Is there any report/publication on WSS research of your organisation? Please list

4. Are you involved in any research activities in WSS? If yes what is the research topic? Please give some detail about objectives, methodology, expected output etc?

5. What do you think are issues and problems of WSS research in Bangladesh?

6. Do you have any suggestion or recommendation in WSS sector research?

7. Can you give me some reference and name researchers/ practitioners/ implementers/ on WSS research?

QUESTIONNAIRE ON WSS SECTOR RESEARCH IN BANGLADESH
For Resident Individuals

Name of Individual :

Place of Residence: Village/Area:

Union/Ward : Upazila/Pourashava:
Date of Interview/Discussion :

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1. How long are you living here : Years

2. How do you get your drinking/domestic water:

   Piped water/House Tap/ Street hydrant
   Hand tube-well/Tara Pump
   Deep tube-well
   Dug well/pond/river
   Any other

3. Do you face any problems of water availability, difficulty about the operation of the HTW and purifying water for drinking etc.

   Yes No

If yes please explain

4. Did any body talk to you about problems of water availability, operation of the HTW and other difficulties you face and how to improve the situation etc.

   Yes No

5. Do you face any difficulty in using the Tara pump? Please explain

6. What type of latrines do you have?

Sanitary latrine
Pit latrine
Home made latrine
Community latrine
Any other

7. Did anybody ask you about sanitation/sanitary latrine, like do you face any difficulty in using a latrine, is there any smell or problem with the design etc.

Yes No

8. Can you name the organization/NGO who asked?

9. Do you have any suggestion about research or development in water supply and sanitation?