Volume IV:

The Sourcebook

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Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP)
Dhaka, Bangladesh
The PMU Implementation Manuals

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Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

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Volume 4: The Sourcebook

1. Project Description

1.1 Background

Bangladesh has achieved a commendable success among the developing countries in provision of basic water supply through handpump mounted tubewells. Ninety-seven per cent of the population had access to drinking water from improved sources (tubewell, dugwell or tap) in 1997, those served being 97% in rural and 99% in urban areas, but only 68% in the tribal areas. There are an estimated 3 million tubewells in rural Bangladesh. About two-thirds of these tubewells were installed and owned by individuals and NGOs. The remainder is publicly owned, mainly by the Department of Public Health Engineering (DPHE), and operated by caretaker families.

However, in recent times arsenic in groundwater has come as a threat to the drinking water supply system of Bangladesh. Arsenic is not an uncommon contaminant of groundwater. It is a naturally occurring element and usually presents itself in the form of compounds with sulfur and with many other elements. However, arsenic contamination of drinking water supplies has recently been recognized as a global problem. Some of the severe cases have been documented in Taiwan, Argentina, Chile, Canada, Mongolia and Mexico. But, probably the largest outbreak of arsenic poising has been discovered in Bangladesh, and the consequences are particularly severe given the use of groundwater for drinking by a large majority of the population.

The Supply-Led vs. Demand Led Approach

Furthermore, the arsenic crisis has highlighted a broader problem, which is that in the past sector approaches to delivery of water and sanitation services have been overly centralized, supply-driven, and primarily limited to technology provision. These approaches have failed to build local capacity for developing and managing sustainable water use and sanitation systems by which communities can ensure their own access to safe water in the long term, and better management of the environment as well

There are consequences to this scenario. For example, since there is inadequate community awareness and involvement, it is not certain that the majority of households use only bacteriologially safe water for drinking. In 1997, approximately 38% of the population were using hygienic water for all their household needs, leaving unclear what proportion of the others use bacteriologially safe sources for drinking and food preparation. More people in rural areas use unsafe water for their household work than those in the urban areas, the percentage being highest in the urban slums (98%) It is notable that slum women spent more time, 30 minutes to two hours, in fetching water, illustrating just one example of gender imbalances resulting from current sector approaches.

Another symptom of a centralized and narrowly focused approach is increasing failures of the existing water supply systems. For example, seasonal inaccessibility due to lowering of ground water during dry season poses problems in 39 districts. According the 1997 Tubewell Survey conducted by DPHE, 35% of the tubewells with low-cost No.6 handpumps are inoperative during dry months. The survey shows that 13% of the villages in these Low Water Table areas have no Tara handpumps and 52% of the villages are under-served, where 250 people use each Tara handpump. The falling water table due to extraction of ground water for irrigation in many parts of the country is also rendering thousands of suction hand pumps unserviceable for part of the year.

Assumptions that people would automatically improve their sanitation with access to safer water have proven an ill-founded assumption. Improvement in sanitation or sanitary means of excreta disposal is lagging far behind the improvement in water supply. In 1997, 44% of the population was using the sanitary latrines of which coverage in rural areas was only 39%, 50% in tribal areas and 87% in urban areas. Of the total number of hygienic latrines in rural areas, 16% are water sealed, 27% pit latrines. Thirty six per cent of the households use hanging latrines and 21% households practice defecation in the fields. The sanitation situation suffers due to flood. During floods the water gets extensively polluted with the spread of excreta from the pit and other surface latrines, causing epidemics of diarrhea and other water born diseases.

While 90% of the families having a sanitary latrine use it regularly, the use rate is about 10% among the under-five children and 50% of the older children. Only 35% of the population wash hands with soap after defecation. The large majority use ash or soil or only water.

In summary, the main weakness of existing modes of service delivery, in addition to questions of effective use, adaptation of sanitation technologies, and increasing system failures due to arsenic contamination and lowering water tables, is that of sustainability. Without local involvement, capacity building, management, and true ownership—investments will often be wasted or less effectively used and sustained in the long term. Thus in addressing the arsenic problem, developing a new approach to service delivery overall is required.

Responding to Arsenic Crisis: A Demand-Led Approach to Service Delivery

Thus the GOB and World Bank decided that to resolve the arsenic problem, a broader change was needed in the nature of public service delivery overall, and to some degree, to delivery modes of the NGOs and private sector. The World Bank and other donors have thus agreed to assist the GOB to mitigate the countrywide arsenic contamination of drinking water through the innovative, demand-led "Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP)" The mitigation strategy consists of government taking a facilitative role, rather than an operational one. The Project will help community women and men, and their CBOs, determine water quality of each well, and facilitate their own investigation, analysis, technology choice, planning and implementation of local solutions according to local needs and capacities.

1.2 Basic Issues

(a) **Impact of the arsenic crisis:** Arsenic contamination has been found in water from thousands of wells across more than half of Bangladesh's 64 districts where tests have been conducted with the help of arsenic test kits. A limited number tests have been done all over the country and a significant percentage of the tested tubewells have been found contaminated with arsenic above the maximum permissible limit of 0.05 milligrams per liter. The full extent of the problem and its impact on health and production are still unknown, but there have been number of arsenic-related deaths and related illness since 1993 and millions more people are threatened. There are examples of geologic arsenic contamination in other parts of the world (including West Bengal in India) and these are all relatively site-specific affecting limited numbers of people. This arsenic crisis in Bangladesh is, however, of an unprecedented magnitude.

(b) **Lack of information/knowledge:** A major constraint to addressing the arsenic problem in Bangladesh is the lack of information on the extent, causes and proven remedial interventions. Although many of the research organizations, governmental agencies and NGOs are now engaged in data gathering, information on groundwater arsenic contamination does not cover all areas of potential contamination and is not always reliable or conclusive. Data on possible causes of groundwater poisoning are also inclusive. The presence of arsenic-containing pyrite in the alluvial and deltic sediments is cited to be the underlying cause, leading to the hypothesis that increased extraction of irrigation water from shallow tubewells in the last 15 years has seasonally lowered the groundwater table and allowed the oxidation of pyrite and the release of arsenic. The evidence for this hypothesis, however, is largely indirect and as yet unproved. Knowledge on long-term, sustainable, remedial intervention is also inadequate and investigations on appropriate low-cost technical options for alternative or treated water supply are urgently needed.

(c) **On-site issues:** The present arsenic crisis is jeopardizing the progress made in water supply sector in the last two decades. There are two major on-site impacts of the crisis: (i) in the absence of acceptable alternatives, people are continuing to consume arsenic-contaminated water and (ii) in the absence of proper on-site water and sanitation, communities that are worried that their groundwater might be contaminated with arsenic may end up drinking pathogen contaminated surface water that is more harmful than arsenic.

The technical options for safe water supplies for arsenic contaminated areas will need to be based on an analysis of existing water supply infrastructure, options for alternative supply and the ability of the proposed technical solutions to be socially acceptable, cost-effective and sustainable.

(d) **Policy/institutional issues:** There are several issues related to sector strategy and institutional functioning that potentially hinder an effective management of the present situation. These are.

- *Limited institutional capability* – DPHE and other organizations working in water supply and sanitation sector have limited institution capability to promote social awareness of the linkages between water, sanitation, hygiene and health. This issue is likely to affect arsenic mitigation. In particular, without the requisite experience in community-based activities, DPHE lacks the skills, data and experience that would have enabled effective implementation of grassroots arsenic mitigation strategies.

- *Weak local government* – Gram Parishads have been institutionalized on paper at local level by an act in 1997, but they have yet to become actually formed, activated and entrusted with water and sanitation responsibilities. In the future the Gram Parishad may play an important role in legitimizing participating CBOs, in which case appropriate training will be necessary.

- *Limited research activities* – DPHE's investigation activities receive low priority and limited focus on technology development and hydrology to improve the design of projects. In addition, water quality monitoring and surveillance receive little emphasis. Laboratory findings are not incorporated into operational activities and the quality of laboratory analyses is questionable.

- *Poor strategic content of Government's sector work* – Limited participation of local communities in the design and implementation of sector projects, limited knowledge of local capacity in cost recovery for water and sanitation works, and lack of clarity on central vs. regional division of responsibilities in the sector result in some poor key strategic results in this sector.

- *Limited capacity in institutional co-ordination* – Although DPHE under the Local Government Division (LGD) is responsible for water supply, other governmental agencies such as the Ministry of Health and Family Welfare and the Ministry of Water Resources also are concerned with various aspects of the problem. Given the intersectoral nature of the overall arsenic problem, co-ordination between these agencies is essential, but likely to be difficult. In addition, the centralized nature of the agencies, especially DPHE, causes poor responsiveness to local needs, slow processing and decision making, and is likely to affect implementation. The involvement of NGOs, the private sector and donors also requires effective co-ordination.

(e) **Governmental strategy:** At present, planning in the sectors of environmental health, water supply and sanitation and overall water resources is still predominantly project-based and not part of a long-term sector development vision. The arsenic emergency, however, has created consensus within Bangladesh on the need to deal with the arsenic situation in a well-coordinated and programmatic two-pronged approach: (i) emergency investments to cover immediate needs arising from the discovery of the arsenic problem; and (ii) a longer term program to address policy, institutional and technical issues in a financially and environmentally sustainable way that enjoys the support of the populations.

1.3 Project Objectives and Interventions

The development objective of the project is to alleviate arsenic water contamination as the factor in the reduction of arsenic-induced mortality and morbidity.

Although physical improvements are to be achieved, the main objective of the Arsenic Mitigation Project is participatory strategy development and capacity building for arsenic mitigation measures. The strategic objectives of the project include: (i) improvement of rural and urban infrastructure through increased access to safe water, especially for the poor; (ii) improvement of service delivery in health; and (iii) assistance in redefining and supporting the government's role in designing more effective institutions.

To accomplish the above objectives, the Project will promote and facilitate:

- Investigation and continuous monitoring of arsenic contamination of all drinking water sources in the suspected regions of the country, and support for related short-term education, mitigation, and health measures;
- Strategy formulation based on monitoring;
- Co-ordination of efforts to strengthen both short-term emergency/relief responses to the problem and long-term handling of the issue as part of regular program efforts;
- Continuous assessment of the range of feasible social and technical options being utilized to resolve the problem. To ensure that over the progress of the project ever more technically sound, safe and cost-effective solutions are implemented;
- Financing of alternative sustainable, reliable and cost-effective water supplies and environmental sanitation services, and of screening and educational interventions, with an emphasis on community-based, demand-oriented approaches, in both urban and rural areas;
- Community information, education, and communication (IEC) campaigns, both as an integral part of service delivery, and as nation-wide or regional media-based communication strategies;
- Health monitoring and preventive/curative services for affected populations;
- Support to sector review in providing a better frame-work for the Project and to describe the mandate and structure for a "re-invented" DPHE into which the Project will be gradually mainstreamed; and
- The development of the Project as a "Role model" and platform for DPHE staff to build capacity in demand-driven and participatory approaches.

1.4 Project Components

The Project includes the following three components.

(a) **On-site mitigation:** The Project will support interventions in the rural areas (villages) and in urban areas (municipalities). Peri-urban areas will be considered rural, where institutionally appropriate. The municipalities will be assisted in their surveys, feasibility studies and implementation by DPHE and LGED, with the LGED being active in those towns where it is already working in water supply. Physical interventions in towns include installation of deep tubewells, provision of hardware for rainwater harvesting and/or water treatment plants (for arsenic removal or to treat alternative surface water) and expansion of distribution systems.

In the rural program, the Project Management Unit (PMU) will select Support Organizations (SOs) to carry out surveys, pre-feasibility studies, community development and appropriate mitigation measures in prioritized villages in a participatory fashion. Organizational responsibilities will include development of a CBO or village water committee. consisting of the users themselves. This CBO may later become a recognized sub-committee of the Permanent Committee of Gram Parishad, or equivalent, but also registered with Social Welfare or become any other legal entity. Physical works will be low cost and include installation of shallow and deep tubewells, ponds with filters, handpumps, treatment and rainwater catchment systems.

Each intervention in a village or municipality consists of a sequence of actions. The typical sequence of action is:

- Strategy development and planning at a district and thana (sub-district) level;

- Participatory assessment of situation in villages/municipalities together with simultaneous engagement in a discussion with the community and with local government; where contamination is excessive, health has deteriorated and no good water supply alternatives are available, drinking water will be provided on a short-term relief basis;

- Social preparation and community action planning. Community women and men engage in participatory investigations, analysis of options, resolution of disputes and other problems, choice of technologies, rough layout of their water schemes, and in development of series of action plans. They also organize a community-based organization that is able to sustain remedial activities, in particular the operation and maintenance of alternative water supply/sanitation infrastructure, and is willing to contribute 20-40% of capital costs;

- Preparation of a technical and financial proposal together with the community;

- Submission of proposal to PMU and vetting of proposal,

- Implementation of proposal and community take-over of Operations and Maintenance (O&M) responsibilities; and

- Auditing, evaluation and monitoring of project impact and of groundwater quality.

For the purpose of project preparation, rural and municipal schemes will be classified according to the vulnerability to contamination, social characteristics and demand of the community. Schemes will be grouped according the following three intervention categories:

- Category A - only local capacity building required,
- Category B - capacity building and limited physical intervention, or
- Category C - capacity building and substantial physical intervention.

The subprojects within these broad categories will be prioritized by PMU following the selection criteria. During intervention, however, the actual situation in each community/village will determine the local intervention.

(b) **Improved understanding of arsenic problem:** Ongoing field surveys will yield baseline data on arsenic contamination and set in place a mechanism for continuos monitoring. The National Arsenic Mitigation Information Center (NAMIC) would be established as part of the Project. It will: organize existing data; develop and implement strategies for further investigations and monitoring; initiate public health and mass media campaigns, and manage, interpret and disseminate all relevant hydrological, water quality, health, socioeconomic and technical information necessary for PMU to devise strategies, prioritize action and monitor progress. NAMIC will interact with a network of other established research and study agencies that will be both providers and users of information A Technology Advisory Group (TAG) will be set up to review technology options in an objective and impartial way. A DFID-funded hydrogeological study has commenced to elucidate the origin and extent of arsenic release into groundwater. As part of that effort and in follow-up, a laboratory system is being set up to ensure analytical quality control. Funds will be provided to undertake studies and research on all aspects of the arsenic problem.

(c) **Strengthening of implementation capacity:** As part of the on-site mitigation interventions, capacity-building measures will include training and development of co-ordination and supervision arrangements. Capacity will be strengthened within communities (water committees or equivalent), and to the extent necessary, Pourashavas, to implement and maintain the field interventions and manage funds allocated or collected for the purpose. Planning, co-ordination, supervision and capacity building activities will be implemented within DPHE and Gram Parishad and higher levels of local governments. For the health sector, selective support for capacity building will be included. Assistance on arsenic diagnosis will be provided to medical universities and colleges. Training material will be provided to Directorate General of Health Service (DGHS) medical and field staff, and Private Practitioners Medical Association to address arsenic-related diagnosis and patient referral. The Project will pilot new approaches in water services delivery as well as in strengthening of the village level government. These activities will support the National Water Supply and Sanitation (WSS) Sector policy, 1997.

1.5 Project Approaches and Methods

The approach of the project is based on the three key overall goals:

- Enhance the quality of life and environment in and around project locations;
- Prevent adverse environmental and social impact; and
- Mitigate possible adverse environmental and social impact.

The Project will serve as a multi-agency umbrella effort, facilitating GOB, donors/lenders, NGOs, local governments and other interested parties to mount a well-coordinated and strategically aligned effort in Arsenic Mitigation-Water Supply/Sanitation services. It will support the creation of a Project Management Unit and a package of investments to address the critical arsenic problem in possibly over 50% of Bangladesh's urban and rural communities.

The basic approaches of the Project will be as follows:

- **Participatory approach**: The Project will facilitate the participation of the community, NGOs and the private sector in all aspects of the subproject identification and implementation, as well as monitoring of the arsenic situation in Bangladesh. It will follow a participatory, community-based approach in financing social organizing, interventions for community action planning, and water supply schemes in urban and rural communities. The Project will also ensure that its community-based approach is both gender and poverty conscious. As most of the rural communities lack the organizational and technical skills to design and construct schemes on their own, they will be assisted by SOs (defined as NGOs by the Development Credit Agreement) with the requisite skills. Local participation, defined as educated decision-making by those community members who use the system and local control over project resources through community procurement and management, will increase the benefits from local public goods and improve collective activities.

- **Demand-driven approach:** The Project will follow a demand driven approach. The beneficiaries can choose from alternative levels of service and an array of tested technical solutions, depending on how much the villagers are willing to contribute the basic investment funds provided by the Project. This process will improve the project performance by involving the beneficiaries directly, by seeking their early consensus on the project and by mobilizing cash or in-hand contributions from them.

At first instance, residents of all socio-economic groups in each cluster, village leaders and leaders of the community organizations will be consulted and informed the need of for participatory investigations to collect baseline information, and to verify the relevance of water supply and sanitation improvements to mitigate the arsenic problem in the context of overall community concerns. Arrangements will be made for the community to carryout data collection with the help of SO facilitators over a period of few weeks. After completion of the investigations, a series of community meetings will be held to: analyze collected information, analyze issues and problems, choose among options, conduct technical field studies and prepare estimates, and plan for scheme implementation. Plans will include water supplies, non-subsidized sanitation, and a series of software activities to ensure sustainability, effective use, and long term management capacities in the community. Special measures will be built in and initiated to ensure that women and the poor have equal rights to participate and that they do not contribute disproportionately to scheme financing and/or labor.

- **Flexible approach**: The Project will take a flexible, phased approach. The present four-year project will be used to a large extent to launch pilot and demonstration projects, from which lessons will be drawn and applied and through their application make the phases more effective. The piloting will pertain notably to the data collection and management systems, the institutional arrangements at the village and municipality levels, the project organization arrangements, and the technologies for alternative water supply. All pilots will be based on the agreed principles of the project.

  An agreed strategic framework emphasizing sustainable and participatory development of water supply and sanitation will be closely monitored during implementation. Within this framework, individual site-specific investments (subprojects) will be worked out in detail in annual work plans. Throughout the period of project implementation, proposals for the funding of subprojects will be prepared by municipalities and rural communities (with project assistance) and will be reviewed and prioritized according to agreed eligibility and prioritization criteria. As the first subprojects are being implemented, experience with concept, technological options, and institutional options will be incorporated to improve subsequent subproject design. Similarly, where information is inadequate, different options will be piloted, and lessons learned. Project supervision will be continuous as well (through external and internal auditing and supervision and through external monitoring and evaluation) and annual workshops will be based on progress achieved in the implementation of previous work plans. It is expected that implementation will accelerate after a certain initial lag, and the annual work plans will reflect this acceleration.

- **Effective technical assistance:** Technical assistance is an interactive process between the persons offering help and the persons receiving it. Technical assistance will be provided through the collaboration of multilateral and bilateral agencies and the Project for making maximum use of the scarce resources.

The Project will mobilize both government and non-government capabilities and resources in order to address the local decline of freshwater resources and increase in cost of treatment, as well as to fulfill the high social content of the project and its geographic spread. It will work by ensuring proper co-ordination between line agencies and local administrations.

The PMU will also help to ensure multi-donor coordination related to the arsenic problem and its mitigation. In the first instance, it will help to facilitate the specific efforts of donors in supporting various components, technical assistance, or other ventures related to the arsenic mitigation task, and in a broader sense, to the national urban and rural water and sanitation strategies. In the longer term, the PMU will explore the feasibility of creating and managing a Bangladesh Arsenic Mitigation Fund to which a large number of donors can contribute knowledge, mechanisms and institutional capacity to handle the problem expands over time.

1.6 Project Resources

1.6.1 Management and Support

- **Communities:** Community residents, men and especially women, who have a higher stake in the water supply than men, will be the prime mangers and their own best resource in the design of the Bangladesh Arsenic Mitigation Water Supply Project. The Project requires the entire community to be included for a proposed scheme to be eligible for development assistance for type C projects. In type B Projects, partial schemes could involve users in their own local forms of CBO organization **What is critical is that the CBO actually represent the users of the scheme who have a stake in the long-term sustainability of the scheme in an equitable manner (i.e., without either excluding or disproportionately burdening certain groups). This is a primary principle of the Project.** The CBO can have any kind of legal identity, e.g., registration with Social Welfare, as a contracting entity with a license, or, if and when possible, recognition from local government as a Permanent Committee (subcommittee) of the Gram Parishad.

  Various types of community associations may already exist. Most of the extant associations are based on credit and other forms of productive income generation activities. In this Project each of such associations should be able to play an important role in establishing and in being part of the Community Based Organizations (CBOs) that equitably represent or are chosen to service their neighborhood (type B schemes) or represent their entire village (Type C Schemes). Those community residents (users) who are not represented should be included in new or existing groups to form a broad based CBO. Representativeness of CBOs is one of the aspects that the Project will monitor.

Working with Cluster Groups and, if so wanted, combining them into a Core Group requires intermediation from Community Facilitators (from the SOs) working in the village. Training and facilitation by SOs is required to familiarize people with: the problems associated with arsenic and other contaminants of drinking water, selection of a safe water source, treatment of drinking water, protection of existing source, hygiene and sanitation, and arsenic monitoring. For the long term, SOs also needs to help villagers develop a Community Action Plan, and the financing and plan maintenance of the water system.

The Project should carefully arrange its initial community/village survey and subsequent CAP process, in close collaboration with the existing associations and in partnership with the local government organizations. Representative Community Based Organization (CBO) will be responsible for planing, designing, implementation and management of both short- and long-term mitigation measures including mobilization of own resources through:

-Financial contributions,
-Labor contribution,
-Access to credit, etc. to complement Project/GOB fund.

- **Gram Parishad's Permanent Committee:** The Gram Parishad is the lowest tier of Local Government. Article 14 of The Gram Parishad (GP) Act includes support to village water supply and sanitation. The Permanent Committee (PC) constituted by the GP is to focus on the water supply and sanitation development and can own such assets. These PCs may act as facilitation body for financial transaction of the Project once its capacity to do this has been developed. Gram Parishad and its Permanent Committee are yet to be operational. It is therefore essential that the training of the PC members are planned and conducted at the outset before any responsibility assigned to them, once this tier of local government is actualized.

- **Support Organizations (SOs):** A support organization (SO) is defined as any non-governmental organization meeting the eligibility criteria. SOs will recruit additionally needed staff and will be trained before starting work at the field. SOs will assist the communities and their CBOs in emergency and long-term mitigation measures for sustained access to safe drinking water supply and sanitation. SOs will handle those numbers of schemes for which they have demonstrated adequate management capacity. On average, a district-based SO might support 7-10 Type A subprojects and 3-7 Type B&C subprojects per batch. As capacity grows, the number of such subprojects may be increased. Smaller SOs may need to start on only one or two subprojects. SOs will assist the communities and will act as catalysts or consultants in building sustainable organization and capacities at the grass-roots level. SOs will act as contractors to the Project to operate as partners for the CBOs for: (i) mobilization of communities and formation of CBOs; (ii) identification of mitigation needs, health, hygiene awareness; (iii) operationalising short term emergency and longer term responses; (iv) assisting the village to prepare community action plans in coordination with local government and local agency offices (DPHE. LGED, Health); (v) design of and assisting CBOs in implementation of sustainable water and sanitation schemes; (vi) training CBOs on management of schemes including technical and financial management. SOs will have a mix of professional (social and technical) expertise as well as be gender-balanced.

- **Service Agencies (SA): Service** Agencies (SAs) comprise of institutions that provide specialized services to strengthen the capacity of SOs and communities to implement schemes. These may include NGO apex bodies, specialized NGOs, and private sector firms and entrepreneurs, or educational and research institutions. They will be engaged for variety of services including training and capacity building, monitoring and evaluation, site appraisals, special studies, development of training and communication materials and technology support, larger-scale mobilization, special studies, scheme proposal review, training, hygiene awareness, social marketing, etc. SAs also need training to serve as trainers in the Project approach, and, for example, in participatory methods and tools, certain technologies such as rainwater harvesting, and other training tailored to project needs (See Volume II, Training). Based on actual assessments of need, the Project will define SA support requirements at an early stage to ensure that such capabilities are in place when SO training and fieldwork start.

- **Local government, Local DPHE/LGED/Ministry of Health Offices, NGO Apex Chapters, Etc.** Local government (Pourashavas, Gram Parishad, Union Parishad, Thana Parishad), and the field offices of relevant sectoral Ministries, will all serve to support and facilitate the management of the schemes by the community. They will also support coordination of project efforts, better linkages between the communities and the PMU, and the involvement of SOs.

  Proper definition and delineation of roles and responsibilities and consistent approach will be required to avoid duplication and confusion at the community level. Local administrative procedures notably for GP and PC need to be developed, to ensure accountability and transparency. For example, local government may be directed at an appropriate stage to recognize the user-selected CBOs or VWSCs as the permanent committees for water and sanitation and provide them legal status. However, <u>in **no** circumstances should the local governments have the power appoint members of such committees or take control their funds.</u>

  Regular interaction with these institutions based on the identified roles will facilitate strengthening or development of specific capabilities of these organizations to support the project. For example, when an apex NGO is assigned to undertake a large-scale mass campaign to raise awareness among men, women and children in the villages on arsenic vs. bacteriological contamination, it will coordinate with and receive support from these institutions in developing coherent messages and tools. Similarly, consultants assigned to conduct technical surveys may require special test kits to detect arsenic. An impact evaluation or assessment may call for clearly defined objectives and formats/methodologies before launching. As the project is flexible, participatory, and adaptive, a constant dialogue with the apex partners will greatly assist in strengthening the project strategy and help to smooth implementation.

- **Project Management Unit (PMU) and the Regional Project Management Unit (RPMU):** The PMU aims to fulfil the overall objectives of the Arsenic Mitigation-Water Supply Project, and manage the components of the Project. The PMU/RPMU is headed by a Project Director (PD), two Deputy Directors (DDs) and four Assistant Project Directors (APDs). It will also consist 12 specialists and 18 support staffs. The RPMU will comprise a multi-disciplinary team of three, complemented by DPHE staff on lien or as part of a short-term immersion program. The Chief Technical Advisor and at least two advisors for technology and institutional issues will support the PMU units and its network.

  The PMU will serve as a facilitator/convenor for the programmatic effort, and serve as a financial and technical resource body in support of communities, local government entities and central public sector agencies and the private sector (including NGOs, and firms). The PMU will support those entities that are actively engaged in arsenic mitigation activities and the provision of alternative water supply and environmental sanitation services to affected urban and rural communities of Bangladesh.

- **Steering Committee:** To facilitate the Project, the Secretary Local government Division (LGD) will establish a PMU Steering Committee. The Steering Committee of nine members will be drawn from noted representatives of the public and non-governmental sectors. It will be chaired by the Secretary Local Government Division, and include representatives (Joint Secretary level) from the Ministries of Health & Family Welfare, of Environment and of Water Resources, as well as a representative of the Planning Commission. Two representatives selected by the NGO sector, and academic representatives (one with an engineering or technical background, and one with an socio-economic background) will be members. The PMU Project Director will be ex-offcio secretary to the committee. A set of draft by-laws has been prepared for the Steering Committee keeping in mind its roles as a "virtual board" (See Annex Q). Development of such bylaws is needed to ensure adequate project autonomy, better accountability, and more equitable representation of the stakeholders in the Project. Such rules are also meant to ensure that the Project will serve as a catalyst of change in the Water and Sanitation Sector, not just become part of the existing service delivery system.

  The Steering Committee will act as a "Board of Directors" and will meet on a quarterly basis, or more frequently, as required. Its voting powers will be limited as per its Rules.

- **Strategy Network:** The PD, or his/her designee, will facilitate the creation and regular work of a Stakeholders' Strategy Network. The Network will be an iterative

learning, programming, and policy development process related to the arsenic mitigation water supply program. It will focus on the three major work phases: assessment, analysis and action. The Network will include public, private, educational, and NGO/CBO sector representatives from organizations concerned with the Project and its objectives. The PD will chair the Network for the first six months, and subsequently a chairperson of its own choosing will chair the Network.
The Strategy Network can delegate specific assessment, analysis and strategy development tasks to subgroups of its members. The Network and its subgroups can also develop specific TORs for participatory planning activities, rapid investigative studies, field tests of socio-technical options, and other activities which can further advance work on development of the national arsenic mitigation strategy. These can in turn be financed by the PMU, and the results used to further build the learning, programming, and policy development process.

- **National Arsenic Mitigation Information Center (NAMIC):** The National Arsenic Mitigation Information Center (NAMIC) will be established as part of the Project. The information center will be a technical and operational entity without a major decision- making role, supervised and guided by the PMU and the Strategy Network under the PMU.

  The NAMIC will compile and analyze data on the hydrogeological and water quality situation, as well as all other technical, health, economic and social data that are relevant in the development of priorities and a strategy. The NAMIC will comprise one NAMIC manager (Assistant Project Director) who will report to the PD. In addition it will comprise 10 technical and 8 support staff.

  A Consultative Group of the NAMIC will be developed to ensure quality, comprehensiveness and consistency of the data. It will participate in the collection of specialized data and to assist NAMIC in developing its own and data collection strategies. NAMIC will also initiate public health and mass media campaigns.

- **Technical Advisory Group (TAG):** This will be a unit or cell at the disposal of PMU to address the technical uncertainties related to arsenic mitigation and to help develop project and design guidelines. It will assess the feasibility of emerging technical and social options for arsenic mitigation, and study related questions, through contracting out focused studies.

  The TAG will have at its disposal a study fund managed by a designated official coordinator in the PMU. The coordinator functions as the TAG's executive secretary, under the direct supervision and guidance of an external Assessment Committee comprising eight highly qualified members from academia, research establishments (both categories together supplying three members), governmental agencies (supplying two members), and NGOs (supplying two members).

The Committee independently assesses study proposals and allocates funds for their implementation; it reports half-yearly to the PD and Steering Committee, outlining its policy, selection criteria, and operational priorities and procedures.

The TAG will be assisted by local consultants (under PMU budget), as well as by short-term international Technical Advisors providing a variety of expertise (0.5 man-year per year to be provided through a separate budget). The tasks of the consultants are to organize guidance in defining goals and ensuring quality in the studies.

- **Rehabilitated Zonal Laboratories:** The DPHE zonal laboratories presently have limited capacity and are not working properly. These laboratories will be strengthened so that they can be used for arsenic surveys and monitoring. To this end, they will be provided with equipment and manpower to achieve the goal of setting up a nation-wide system for chemical analysis quality assurance, and for calibration of field test kits. Two additional sample takers and one analyzer will strengthen the existing manpower of the zonal laboratories.

1.6.2 Finances

The Project will be equipped with vehicles, furniture, and fixtures according to requirement and as per estimated Project costs (see Table 1.1, next page). The Project will have computer equipment consisting of one terminal for each professional staff, and requisite software and multimedia equipment.

Each zonal laboratory will be considered, according to need and capacity, for provision of arsenic analysis equipment, bacteriological testing equipment, equipment to test for standard parameters, testing equipment for field surveys, one special car for testing/sampling, two motor cycles and chemicals for analyses.

Table 1.1: Estimated Project Costs

Items	*Project Costs (US$ million)* Local Sources	Foreign Sources	Total
Investment Cost			
Equipment	0 06	0.47	0 52
Construction	7 85	0.82	8.67
Community Development	7 61	-	7 61
Studies & Sector Development	3 32	0.88	4 21
Emergency Relief	5 07	1.30	6 37
Furniture	0 04	0 01	0 05
Vehicles	0 04	0.39	0 44
Training	0 86	0 01	0 87
Technical Assistance	1 04	2 59	3 63
Health	0 83	0 02	0 85
Total Investment Costs	**26.74**	**6.48**	**33.22**
Recurrent Costs			
PMU Operating Costs	4 40	0 03	4 43
Other Operating Costs	0.32	-	0 32
Total Recurrent Costs	**4.72**	**0.03**	**4.75**
Total BASELINE COSTS	**31.46**	**6.51**	**37.97**
Physical Contingencies	**3.15**	**0.65**	**3.80**
Price Contingencies	-	-	-
Subtotal Price Contingencies	**2.20**	**0.44**	**2.64**
Total PROJECT COSTS	**36.81**	**7.61**	**44.72**

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

Volume 4: The Sourcebook

2. Health and Hygiene

2.1 Water, sanitation and health

2.1.1 Introduction

Water and life are inseparably linked. Without enough good water there can be no good hygiene. A reliable and plentiful supply of safe water and adequate hygiene are essential conditions for healthy and dignified living. Equally important is safe sanitation. The World Bank reports that poor sanitation, insufficient and unsafe water supplies and poor personal and food hygiene and other household environmental factors are associated with 30% of the global burden of disease (World Bank, 1992). Lack of safe water and poor sanitation share the major responsibility for disease, disability, and loss of work and deaths.

Safe sanitation implies having and using the means to dispose of *all* wastes hygienically and in an environmentally sound manner: waste water, solid wastes and human and animal excreta. Among these the safe disposal of human excreta is the first requirement for better health. In practice adequate sanitation is therefore often taken as equivalent to the sanitary disposal of fecal matter,

Good health is more than an absence of disease; it is *complete mental and physical well being*. Another definition of good health is *the ability to satisfactorily adapt one's environment*, with water and sanitation issues as integral components. Water, sanitation and health are our daily realities, but together are such a vast and complex topic that any effort to describe it is bound to be incomplete. We will here therefore present only a modest review of water, sanitation and health. Thereafter we will focus on the two main disease risks in Bangladesh: a) diarrheal diseases and b) arsenicosis.

2.1.2. Infectious diseases related to water supply, sanitation and hygiene

According to Cairncross and Feachem (1983) there are four types of diseases related to water, sanitation and hygiene. Each type relates to the ways in which the particular infections are transmitted from one (diseased) person to another (healthy) person:

I. **Water-borne diseases** - With water-borne diseases an infected person or animal excretes the pathogens into a water source. Or the excreta are deposited near a water source and the rain flushes it into the source. When another person or animal drinks this infected water, he, she or it may also become infected. But drinking infected water is not the only way by which such excreta-related diseases are spread. Any route, which permits that fecal materials from an infected person pass into the mouth of another person, can also transmit all water-borne diseases. For example cholera is a water-borne disease, but it also spreads by indirect fecal-oral routes, for example via food that is washed in infected water.

II. **Water-washed diseases** - Skin and eye infections and infections of the intestinal tract are diseases that are significantly reduced when domestic and personal hygiene are improved by more frequent washing, bathing and cleaning. Hence the term water-washed, as they are more common in areas where water use and washing are limited.

III. **Water-based diseases** - A water-based disease is a disease in which the pathogens spend a part of their life cycle in a water snail or other aquatic animal. Examples are guinea worm and schistosomiasis. A healthy person may develop guinea worms when (s)he drinks water thus infected. (S)he may develop schistosomiasis when standing or swimming in such water.

IV. **Insect and vector related diseases** - These are diseases that are spread by insects which either breed in water or bite near water. Examples are malaria, filariasis, dengue and river blindness.

In Table I all the diseases are listed that are spread along these four water and sanitation and hygiene related routes. The table also gives the strategies that can be used to prevent these diseases from spreading.

Table 1: Environmental transmission mechanisms, infection and preventive strategies

Transmission Mechanism	Infection	Preventive strategy
1 Water-borne & Water-based	Diarrheas and dysenteries Amoebic dysentery, Balantidiasis, Campylobacter enteritis, Cholera, E.Coli diarrhea, Giardiasis, Rotavirus diarrhea, Salmonellosis, Shigellosis (bacillary dysentery), Yersiniosis Enteric fevers, Typhoid, Paratyphoid Poliomyelitis, Hepatitis A, Leptospirosis, Ascariasis, Trichusriasis	***- Improve quality of drinking water Prevent casual use of other unimproved sources*** - Increase water quantity used - Improve accessibility and reliability of domestic water supply - Improve hygiene
2 Water-washed a. Skin & eye Infections b. Other	 Infectious skin diseases Infectious eye diseases Louse-borne typhus Louse-borne relapsing fever	 Increase water quantity used Improve accessibility and reliability of domestic water supply Improve hygiene
3. Water-based a Penetrating skin b Ingested	 Schistosomiasis Guinea worm Clonorchiasis Diphyllobothriasis Fasciolopsiasis Paragonimiasis Others	Decrease need for contact with infected water Control snail populations Reduce contamination of surface waters by excreta

Transmission Mechanism	Infection	Preventive strategy
4 Water-related insect vector a. biting near water b. breeding in water	Sleeping sickness Filariasis, Malaria, River blindness, Mosquito-born viruses, Yellow fever, Dengue, Others	Improve surface water management Destroy breeding sites of insects Decrease need to visit breeding sites Use mosquito netting

Source: Compiled from Sandy Cairncross and Richard G. Feachem, 1983

2.2 Diarrheal diseases

2.2.1 Transmission

Among the above-listed diseases the diarrheal diseases remain a leading cause of illness and death in the developing world (Bern C, Martines J, et al 1992). This is also the case in Bangladesh. The diarrheal diseases are the causes of people visiting health clinics and the major cause of death for children under five.

Diarrheas are spread from one diseased person to another through infected water and lack of good sanitation and hygiene. Figure 1 shows how difficult it is to prevent diarrheal diseases when people do not have a safe way to dispose their own and their children's excreta and do not have enough water to wash and water that is free from germs to drink and prepare food with. The figure shows the many ways in which infective organisms excreted in feces can enter into the environment: into water, on the land, onto food (directly in the case of vegetables fertilized with raw excreta, or indirectly, by handling food with hands that are soiled by excrements), via hands that directly reach one's mouth, as happens with e.g. small children, and via soiled clothes (Bilqis A. Hoque and Sack R.B. 1993).

Even water which contains pathogenic bacteria at doses *below* those necessary to infect human is a potential risk (Feachem, 1983). This water may be used for the preparation of food and if not cooked adequately the bacteria may incubate and multiply in the food.

To reduce attacks and death from diarrheas people may undertake a number of actions:

- safely dispose human excreta, including those of babies and infants
- use only protected sources of water, especially for drinking and preparing food
- practice good personal hygiene, especially washing hands after defecation and cleaning babies bottoms and before preparing and eating food
- breastfeed babies
- learn about safe weaning
- get immunization (Feachem R, 1986).

Figure 1 shows the way these actions cut the disease transmission routes from a diseased to a healthy man, woman or child. Safe disposal of feces is a primary intervention. It directly reduces the pollution burden on the environment and consequently eases the tasks to be carried out at the secondary level.

But even in developed countries where water supply and sanitation are usually satisfactory and environmental contamination rather low, action at the secondary level remains necessary. For example in day care centers diarrhea incidence is allegedly high, due to improper personal hygiene (Black RE, 1991). Thus proper personal hygienic measures continue to be important even in areas with a comparatively safe environment, as it is difficult if not impossible to completely protect the environment.

Small infants are particularly at risk. For their protection, exclusive breast-feeding should be practiced up to 5-6 months of age. Even then personal hygiene of the breastfeeding mother is an important factor in protecting the small child from his/her polluted surroundings. At that age the small child has not yet built up its resistance against diseases and is therefore susceptible to catching all kind of infections from its immediate environment. The use of safe water and good hygiene when preparing weaning food is therefore of the utmost importance.

Immunization, through part of listed preventive measures, is selective. It is therefore not an effective means for the general prevention of diarrheal infections.

Once a child or adult has caught diarrhea the greatest threat to life comes from dehydration, when the body fluids lost are not consistently replenished through drinking a mixture of water with salt and sugar (Oral Rehydration Therapy or ORT). ORT is very effective in treating incidental cases of diarrheas. However, we are learning that it is less effective in reducing death from *chronic* or *dysenteric* diarrhea. ORT also does not appear to lower the total number of cases of diarrhea in a country (Feachem R, 1986).

Because diarrheas can be spread in so many ways, none of the above-mentioned measures are by themselves sufficient. To make a noticeable difference to people's health we must combine all of the above, except perhaps immunization, as this is the least effective.

2.2.2 Water, Sanitation, Medicine and Social Variables

To effectively block the transmission routes of diarrhea it is important to consider the major factors influencing the transmission. Based on available environmental studies for diarrhea control from different parts of the world, we drew a simplified illustrative scheme of such factors. This is shown in Figure 2.

A first set of factors, which determine if a person falls ill, is the type of pathogens, the load of pathogens and the infective dose The type of pathogen may be highly risky or less risky. he excreted pathogen load is the concentration of pathogens that an infected person brings into the environment. This concentration, or load, varies from case to case. The health implications depend on the method of excreta disposal (risky or non-risky), the ability of the pathogen to survive in the environment in which it has been deposited and the dose of infection that will cause another person to contract the disease. As we shall see this dose also varies from case to case.

The reaction between the two variables of excreted load and infective dose is complex, because of the differences in latency, persistence and multiplication (Feachem, 1983). The helminthes that cause various worm diseases and schistosomiasis cannot infect another person immediately after they have been excreted, but need to develop first in soil, pigs, cows or aquatic animals. Another important difference in pathogens is their persistence, or how quickly the pathogen dies after leaving the human body. A third factor playing a role is multiplication. A low number of pathogens can multiply and produce a potentially infective dose under favorable conditions. Bacteria may multiply on a favored substrate, for example, in food, or heavily contaminated water.

In Fig. 2, many variables related to health have been included in the system. The nutritional status of a person may determine the infective dose for that person and whether or not and when the person will become sick. Because of the variable infective dose of most pathogens and the uneven distribution of organisms in the environment, it is difficult to calculate a true infective dose. Often an infective dose is calculated using a controlled experiment with volunteers who are well nourished and may come from non-endemic areas. The calculation that is thus found must be applied with caution to a malnourished population that is continually exposed to an infection. It will also make a difference how immune other persons are to the particular infection. Young children and elderly persons often have a lower immunity and so will fall ill more easily than people with a better resistance (Feachem, RG, et al 1983).

Social factors play a significant role by confounding or interacting with other factors. In this way they introduce an additional complexity in the observations. Examples of social factors that influence disease transmission are gender and literacy (which is gender-related in itself).

Gender factors have led to increased infections in women in cultures where women are less well nourished than men because men and boys get served and eat first and best and mothers eat last and least. Infections are also more rampant where women and girls have more or longer contacts with infested water because of their domestic work (Wijk, C 1985). Regarding literacy, two-week incidence of diarrheal morbidity was found significantly more in children of illiterate mother than in children of literate mother (Singh J., et al, 1992). Breast-feeding provides a significant protection against diarrheal disease for infants in all environments. Administration of even small portions of contaminated water supplements to fully breast-fed infants nearly doubles their risk of diarrhea (Van Derslice, J., et al 1994). A study on effect of toilets, piped water and maternal literacy on infant mortality showed that literate mothers protect their infants especially in unsanitary environments lacking toilets, and that when piped water is introduced, they use it more effectively to practice better hygiene for their infants (Esrey and Habicht, 1988).

Water supply and sanitation facilities are not meaningful unless they are used properly (Feachem RG, 1984). The local convenience and culture may determine the acceptance and use of a certain water supply or sanitation technology. About 90% of the families of a slum in Dhaka used sanitary pit latrines, but most of those were maintained in an unsanitary way, contaminating the environment with fecal wastes (Bilqis A. Hoque, et al 1994). So when wishing to eliminate or reduce transmission of diarrhea one has to go carefully into epidemiological and behavioral processes. The following paragraphs set our what previous work tells about the impact on diarrheas from improved water supplies, sanitation and hygiene.

2.2.3 Diarrhea and water

There are doubts whether improvements in the quality of drinking water alone can show a reduction in diarrhea in areas where environmental fecal contamination is high (Esrey S.A., 1990 and Esrey S.A., 1986). Any or all of the transmission modes shown in Figure 2 can lead to diarrhea. Studies in Bangladesh (Hughes JM, et al 1977 and Curlin GT, 1977) and Nigeria (Huttly SRA, 1987) found little or no association between the quality of drinking water and diarrhea in children. Providing potable water for drinking and washing is critical to reducing diarrheal disease transmission in this setting (Esrey SA, et al 1991).

Providing a safe drinking water source may nevertheless fail to reduce diarrhea because transmission of diarrheal pathogens continues through foodborne or person-to-person routes of spread or because people are exposed to contaminated water during bathing and other activities (Mintz, ED, et al 1995). People have also been observed taking pond (contaminated) water inside mouth during bathing, while they may use a safe water source for drinking (Hoque BA, et al 1995).

Drinking water also becomes contaminated *after* collection either during transport or storage in the home (Mintz, ED, et al 1995, Hoque BA, et al). A recent study has shown that the bacteriological quality of water samples collected directly from tubewells is more or less acceptable, but the count is unacceptably high in water samples from storage containers (Hoque BA, et al 1995, Bilqis Amin Hoque et al 1999). This means that the supply of safe water does not necessarily mean a safe *consumption* of water. Epidemiological investigations of the Latin America cholera epidemic in the 1990s have repeatedly implicated untreated drinking water and water touched by hands during storage as important vehicles of disease transmission (Quick, RE., et al 1996). Of 7 studies that examined the issue of increased amounts of water independent of water quality the median reduction in incidence of diarrhea was 27 percent (Esrey SA, 1990).

2.2.4 *Diarrhea, sanitation and hygiene*

A multi-country study showed that incremental benefits in sanitation were less diarrhea and an increased weight and height, or better growth, of children (Esrey, SA, 1996). Health benefits from improved water were less pronounced than those for sanitation. The authors advise technologies adjusted to people's needs and capacities and incremental improvements in water supply and sanitation services.

Combined improvements in sanitation and hygiene may have a considerable impact on health. An educational intervention to improve water and sanitation behaviors, such as handwashing before preparing food, no more open defecation by children in the family compound, and attention to proper disposal of garbage and feces, resulted in 26% fewer diarrhea episodes (P<0.0001) in children (Stanton BF, 1977). The integrated water, sanitation and hygiene education intervention in rural Mirzapur reduced the prevalence of diarrhea in small children by almost half (Aziz KMA, et al, 1990). Analysis of diarrhea rates in subgroups within the intervention area suggested that incidence of diarrhea was lower in households within 25 meters of a handpump and among those using handpump water exclusively for all major domestic activities in the wet season. Another study, by CARE Bangladesh, reported an estimated two-thirds reduction in diarrhea prevalence following extensive hygiene education intervention related to: clean water, latrine use and feces disposal, environmental cleanliness, handwashing, food hygiene, and diarrhea management (Bateman, M 1995).

Importance of *personal and domestic hygiene* has been emphasized already in 1984 (Feachem RG, 1984). Yet is has been found lacking/neglected in sanitation projects undertaken even quite recently (Bilqis A. Hoque, et al 1996). Improved personal hygiene may have considerable impact on reducing diarrhea. Handwashing alone was reported to reduce shigella dysentery by 35 percent (Khan MU, 1982). In Burma (Aung Myo Han, 1989), mothers and children suffered from 30 percent less diarrhea when they were provided with soap and encouraged to wash their hands both before preparing meals and after defecation. However, about 80% of the slum people in Bangladesh could not afford to buy soap (Hoque BA and Briend A, 1990). An experimental study in rural Bangladesh reported that local washing agents, such as, soil, ash or soap, have similar potentials to reduce bacterial contamination from hands (Hoque BA, et al, 1995).

Promotion of changes that are realistic and wanted by the people themselves and the use of effective promotion methods are very important to achieve a general practicing of better hygiene behaviors. Study of a second recent educational intervention found that the water knowledge among Dhaka slum dwellers had improved significantly, but that the related practices remained more or less poor and same (Hoque, BA., et al., 1997) . It was claimed that lack of appropriate facilities and its related services created a barrier in improving the practices. In other words, 'people could not practice what was preached' or 'preaching was no answer to what people wanted and were able to do'.

2.3 Arsenicosis

2.3.1 Arsenic Poisoning and Health

There are two distinct forms of arsenic poisoning— acute and chronic. Acute arsenic exposure (high concentrations ingested over a short time period) can cause a variety of adverse effects. The severity of the effect depends primarily on the level of exposure. The symptoms of acute toxicity include Chronic toxicity of arsenic is best discussed in terms of the organ systems affected -the skin, nervous system, liver, cardiovascular system, and respiratory tract.

Effects on skin:
A number of skin lesions have been attribute to chronic exposure to inorganic arsenic compounds. Symmetric hyperkeratosis of the palms and soles is a characteristic finding after long-term ingestion of inorganic arsenic in drinking water or drugs. Approximately 1 mg of arsenic intake per day for several years may give rise to skin effects. Hyper pigmentation (melanosis) of the skin, often associated with paler spots (depigmentation), is commonly encountered and occurs mainly in the areas of the skin not exposed to the sun, i.e., axially and trunk. Melanosis is not always associated with keratosi but keratosis always associated with melanosis. Melanosis is also observed in tongue and buccal mucus membrane. Other than Bangladesh these lesions have been reported from regions in Argentina, Chile, Taiwan, Japan, Mexico and India where the contents of arsenic in drinking water were elevated.

Liver Toxicity:
The chronic absorption of arsenic occasionally produces hepatocellular toxicity that may be the result of an inhibition by arsenic of the enzymes involved in cellular respiration. Trivalent arsenic binds readily to sulfhydryl groups of enzymes and has been shown to inhibit pyruvate dehydrogenate function that alternation has been correlated with the swelling and distortion of the hepatic mitochondrias. Chronic exposure to arsenic has been reported to produce reversible liver enlargement and has been associated with cirrhosis of the liver. Nonchirrhotic portal hypertension has also been reported following chronic arsenic intake.

Cardiovascular Toxicity:
Peripheral vascular disease has been observed among persons in Chile and in Taiwan who had chronic exposure to arsenic in drinking water. Early symptoms included acrocyanosis and Raynaud`s phenomenon. Those changes were associated with hyper pigmentation and hyperkeratosis. These progressed in severe cases to frank gangrene of the extremities ("blackfoot disease") associated with endarteritis obiliterans. In Chile, infants and children showed more pronounced vascular symptoms than adults, and myocardial infarction was reported even in children.

Neurologic Toxicity:
Peripheral neuropathy affecting primarily sensory function has been encountered in several studies of persons with chronic exposure to arsenic. The prevalence of sensory and motor symptoms correlated positively with the concentration of arsenic in well water as well as with the arsenic content in hair. Hearing loss possibly reflecting arsenic toxicity to the eighth cranial nerve was reported in a study.

Heaemopoietic Toxicity:
Chronic exposure to arsenic has been associated with disturbed erythropoiesis, and megaloblastic formation has been noted. These changes may reflect the inhibitory effects of arsenic on cellular respiration. Depression of delta aminolevulinic acid synthetase and of ferrochelatase activity in experimental animals dosed with arsenic has been reported severe vomiting and diarrhea, muscular cramp, facial oedema and cardiac abnormalities. An ingested dose of 70-180 mg of arsenic (III) oxide has been reported to be fatal in man. Symptoms of acute toxicity may occur within a few minutes of exposure if the arsenic compound is in solution but may be delayed for several hours if it is solid or taken with a meal.

Chronic exposures are due to low concentrations of arsenic and related with the drinking water contamination. The most common signs of long-term, low-level arsenic exposure from drinking water are dermal changes. The clinical manifestations due to chronic arsenic toxicity develop very insidiously after six months to two years or more depending on the amount of arsenic intake.

Respiratory Toxicity:
In early stages of arsenic intoxication respiratory infection is found to be associated with other clinical manifestations. lung cancer has been found among the people exposed to arsenic trioxide.

Endocrine Toxicity:
Diabetis Mellitus and Goiter have also been reported in association with prolonged ingestion of arsenic through drinking water.

Carcinogenecity:
Available epidemiological and toxicological data indicate that arsenic is a toxic chemical and carcinogen in man. Arsenic has been found to cause cancer of the skin, liver, lung, urinary bladder, prostate, and possibly of haemopoietic and lymphatic tissues. Inorganic arsenic have indicated an association with lung cancer.

The coetaneous effects including skin cancers of chronic exposure to high levels of arsenic in drinking water have been demonstrated by epidemiological studies of exposed populations in South America, Taiwan, India, Argentina and Mexico.

Arsenic exposure has been associated with three types of skin cancers-Bowen`s disease, Basal cell carcinoma, and Squamous cell carcinoma; these cancers are frequently multiple in origin and develop primarily from arsenical keratoses. The prevalence of arsenic-related skin cancer appears to be depend upon total absorbed dose of arsenic. A total of about 20 mg arsenic over a lifetime resulted in a prevalence of skin cancer of about 6%.

When arsenic is absorbed into the human body, the major portion is excreted in the urine (approximately 50%), a small portion via the feces and through the skin, hair and nails and possibly a trace through the lungs. Even if only a small amount of arsenic is absorbed, a portion of the amount absorbed is deposited in the skin, hair and nails where it is firmly bound to keration. Storage in these metabolically 'dead' tissues is responsible for the slow elimination rate of arsenic from the body. Arsenic in the hair, urine, and the nails has thus been used as an index for monitoring the exposure of victims to arsenic.

Clinical Feature:
Sign and symptoms of chronic arsenicosis differ in manifestations in different countries. In Bangladesh skin manifestations are prime and common. The clinical manifestations are categorized in the following stages.

Pre clinical stage	Not detectable by clinical manifestation.
Initial stage	Melanosis (spotted, diffuse) Keratosis (spotted, diffuse) Conjunctivitis. Bronchitis. Gastroenteritis.
Second stage	Depigmentation (Ieucomelanosis-rain drop pigmentation) Hyperkeratosis Oedema of legs (non pitting) Peripheral neurophathy Nephrophathy (early stage) Hepatopathy (early stage)
Last stage	Nephrophathy (late stage) Hepatopathy (late stage) Gangrene Cancer (skin, bladder and lung)

In Bangladesh majority of the patients are found in the initial and second stages.

Operational Definitions:

Melanosis: Blackening/ darkening of skin diffuse or spotted due to deposition of black pigment (melanine) in the skin and mucous membrane due to stimulation of melanocyte.

a) Mild- blackening of skin (melanosis), thinly distributed in palm, trunk, gum, tongue, lips etc. (both spotted and diffuse).

b) Moderate- melanosis densely affecting gum, palm and trunk (spotted and diffuse) with leucomelanosis (rain drop pigmentation).

c) Severe- melanosis densely and extensively affecting gum, palm, trunk and whole body with leucomelanosis.

Leucomelanosis: Depigmentation in hyper pigmented area characterized by whitish/ pallor patch in raindrop manner, due to exhaust melanocyte.

Keratosis: Rough, dry, hard, and thickening of epithelium due to increased keratinization. Keratosis is palpable and in most cases distribution is symmetric.

a) Mild- Just palpable keratosis (spotted & diffuse) but not clearly visible scatteredly affecting palm and sole.

b) Moderate- Palpable and visible keratosis (spotted and diffuse) affecting palm and sole.

c) Severe- wart-like keratosis (spotted and diffuse) hands, legs and feet.

HyperKeratosis: Densely and extensively distributed keratosis affecting whole palm and sole.

Table 2.1: The summary of toxicological effects of arsenic reported to high arsenic concentrations in drinking water.

Effects	*Symptoms*	*Remarks*
Blackfoot disease Arsenical dermatosis	On abdomen and palm and sole and mucosa of mouth cavity Pigmentation, Keratosis, Depigmentation, and Dermal lesion.	May necessitate operation
None specific	Nausea, Abdominal pain, Diarrhoea, Vomiting, Conjunctivitis, Oedema, Hepatic abnormality, Peripheral circulatory disorder & neuropathy.	Mainly due to acute intoxication or heavy long-term exposure
Pregnancy disorders	Spontaneous abortions, miscarriages	-
Heart Disease	Coarctation of aorta, Cardiovascular disturbs.	Among children
Cancer	Bladder, Kidney, Skin, Lungs, Liver & Colon.	-
Mortality	-	Mainly due to cancer

Source WHO, 1996, Wadud Khan, 1997

Arsenic contaminated water is tasteless, colorless, odorless and even clear, tangible effects of groundwater contamination usually come into light long after the actual contamination has started. It may take six months to fourteen years after starting to drink arsenic-contaminated water for symptoms to appear. This period depends on the amount of arsenic ingested, the length of exposure and immunity level of the person. People with poor socio-economic and nutritional status are also more vulnerable to arsenic poisoning. Most arsenic symptoms are confused with malnutrition, and it is further true that most older people, 40 years and above, deficient in vitamins A, C, and E are most susceptible to arsenic related diseases.

2.3.2 Social Impacts

Although arsenicosis is not an infectious or hereditary disease it creates many social problems for the victims and their families. A large number of people, due to their ignorance, superstitions and lack of information consider the disease as a 'curse from God'. Patients suffering from arsenicosis are often ostracized socially as most people consider it like leprosy or other contagious diseases. It is very difficult to arrange marriage for a young girl affected by arsenic poisoning. Some affected housewives are divorced by their husband and even forcibly send to their parental home together with their children. In fear of social problems, some affected people feel hesitant to express their illness, which will ultimately complicate their disease condition (adapted from Milton et al, 1998).

2.3.3 Treatment and Management

So far there is no specific treatment for chronic arsenicosis.

Drinking arsenic free water can improve the cases. Chelation therapy and vitamins and nutritious diet enhance the recovery.

1) **Chelation therapy:** Recently chelation therapy for the treatment of arsenicosis has been considered to be specific therapy for relief of systemic clinical manifestations and reduction of arsenic stores in the body, decreasing subsequent cancer risk. The chelating agents which are currently recommended for the treatment of chronic arsenicosis are:

d-Pencillamine is a costly drug and in 20 to 30% cases may develop toxic effects. These include skin rash. fever, thrombocytopenia and leucopenia. Rare side effects include autoimmune hemolytic anemia and Stevens- Johnson Syndrome, anorexia, nausea, sleep disturbance, urinary frequency and nephrotoxicity may be seen occasionally. Patient receiving Penicillamine should be carefully monitored for these side effects by observing manifestations and blood examination.

DMSA (dimercapto succinic acid) 10 mg/kg body weight for first 7 days, followed by 10 mg/kg thrice daily for 14 days. DMPS (dimercapto propane sulphonate) 100 mg 3 to 4 times a day for every alternate week up to 3 courses.

2) **Nutritious diet and vitamins**: symptoms are improved by good diet and vitamins. High protein diet helps in the clearance of inorganic arsenic by increased methylation and protects against toxic effect of arsenic. The antioxidants vitamins, A. E & C play an important role for management of cases. Vitamin C reduces the toxicity of arsenic and deficiency of vitamin A increases sensitivity to arsenic. These vitamins may by given to the arsenicosis patient in the following doses for 3 months.

Vitamin A - 50,000 i. u daily for adult. Vitamin E- 200 mg daily. Vitamin C - 500 mg daily. In case of children reduced dose should be given.

Excessive intake of vitamin A more than 100,000 I. U. daily for months may produce chronic toxicity in the body such as appetite loss, dry skin, bone and joint pain, enlarged liver and spleen, abnormal skin pigmentation. Acute toxicity of vitamin A may develop if more than 300,000 IU is taken at a time. Vitamin E is relatively non toxic. Adults appear to be able to tolerate dose as high as 1000 I. U per day. Excessive dose of vitamin C. 2 gm or more may produce side effects.

People should be advised to take more protein and vitamin rich food like beans, peas, pulse, lentils, wheat, soyabeans, green & leafy vegetables.

3) **Other symptomatic treatment**: keratosis of Palm and sole can be treated by local application of keratolytic ointment - 20% Urea and 10% to 20% Salicylic acid in cream or Vaseline. Cryosurgery can also be done to remove keratosis. Treatment of associated fungal infection with ointment and medicine also improve the cases.

2.4 Water, Sanitation and Disaster Relief

The importance of good water supply and sanitation to prevent post-disaster diarrhea epidemics has been both reported (Siddique AK, et al, 1989, Woodruff, et al, 1992) and suggested (Pan American Health Organization, 1981 and Kafiluddin AKM, 1991). Although the UN General Assembly has proclaimed the International Decade for National Disaster Reduction beginning from 1 January 1990, disaster-related activities in water supply, sanitation and hygiene are either lacking or not effective (Hoque BA, 1993, Hoque BA, et al 1996). During a recent post-cyclone activity, for example, relief personnel were as usual trying to improve access to safe water by distributing water-purifying tablets. However, about 63% of these tablets were found to have lost potency (Hoque BA, et al, 1993). All of the tested water samples from flooded ponds were contaminated beyond acceptable standards for domestic water use. Even field clinics or shelters did not have sanitary latrines. Unfortunately, an assessment of the environmental health conditions even after the 1998 flood in a recent cyclone in coastal areas of Bangladesh showed similar results (Bilqis Amin Hoque, 1998).

2.5 Conclusion

Arsenicosis and diarrhea are both dangerous and potentially fatal diseases. Replacing an arsenic contaminated well by untreated surface water is not a solution, as the users will exchange one disease for another, and even worse a slow killer for a rapid one.

An arsenic mitigation project such as the BAMWSP can only make a contribution to the improvement of public health if it provides bacteriologically *and* chemically reliable water supply. In practice this means that the BAMWSP has to consider the following options:

1. *Reduce* arsenic to a level below 0.05 PPM, by treating the water from the arsenic contaminated well; or
2. *Replace* the existing groundwater source with another one, i.e. unsuspected groundwater (a new well), treated surface water, or treated rainwater; or
3. Make arrangements for affected users to have access to and *share* water from unsuspected sources that are in use by others; or,
4. Import water from outside, by tanker truck or by bringing in bottled water.

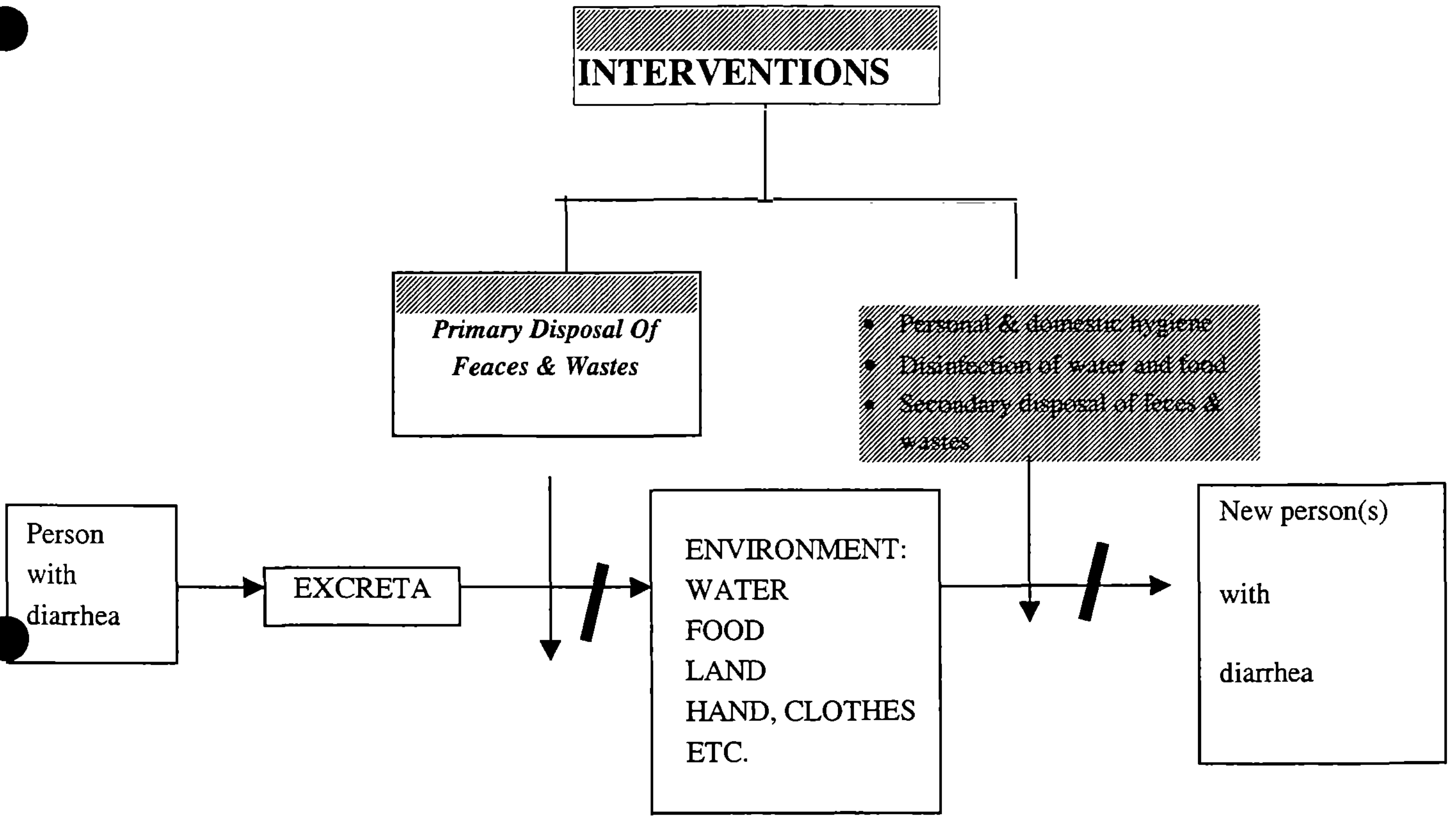
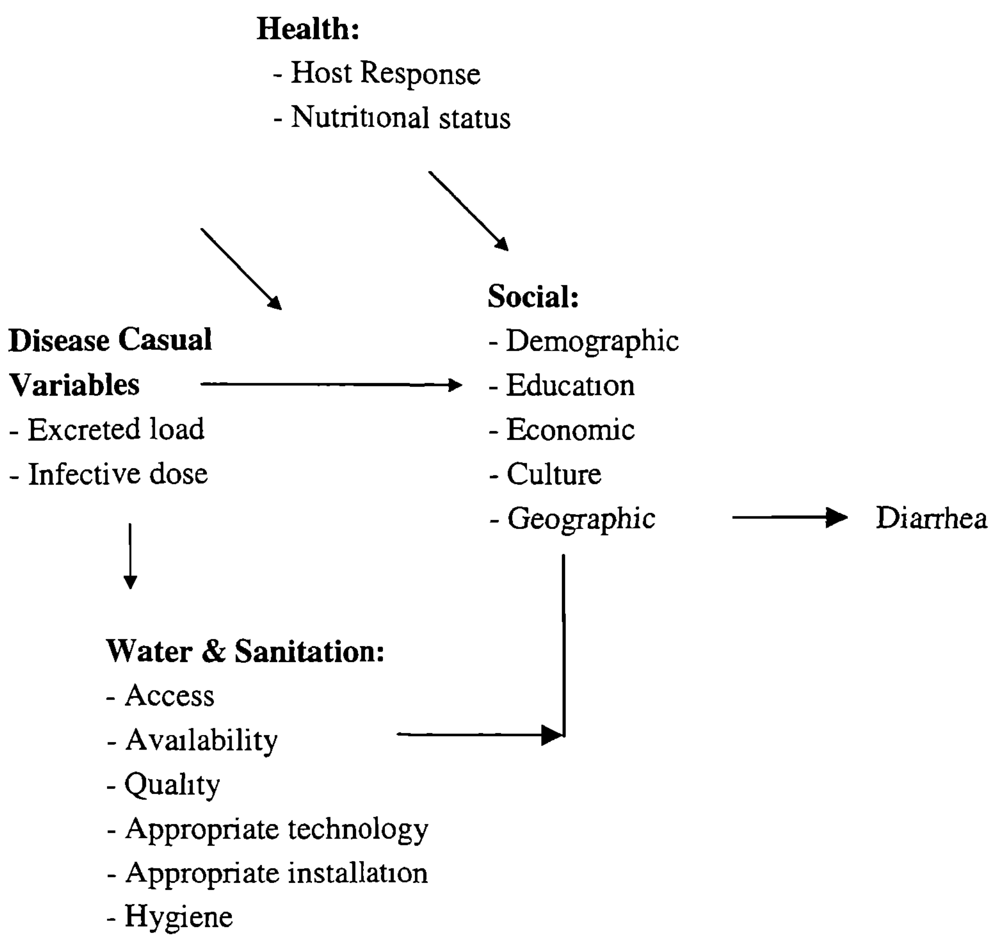


Figure 1: Common fecal-oral diarrhea transmission modes and water and sanitation intervention options.



SOCIO-ENVIRONMENTAL MEDICINE VARIABLES

Figure 2: Major water sanitation medicine and social variables.

Source: Bilqis A. Hoque and Sack R.B. (1993). "Environment and Diarrhea" in Recent Trends in Diarrhea & Malnutrition, Editors: AS Mcneish, SK Mittal and JA Walker Smith. Published by Dr. SK Mittal, Secretary, Conference on Diarrhea & Malnutrition, Department of Pediatrics, Maulana Azad Medical College, New Delhi-110002.

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Volume 4: The Sourcebook

3. Arsenic Mitigation/Water Supply Technologies

3.1 Introduction

Water is essential for life. People use a variety of technologies to draw water from its source and prepare it for household uses. Determinants of these technical options varies with time and local factors such as availability and access to water sources, planning and design capacities, operation and maintenance requirements, costs and affordability, organizational capacity and constraints, seasonal variation, culture, amount and purpose of use of the water, etc. The choice of a technology will or should be based on all of these factors and the relationships between them. In this chapter we consider options for potable water that may be managed at rural level and provide minimum of 5 liters of arsenic-free and otherwise safe water per capita per day, primarily for drinking and other uses leading to the ingestion of the water. The minimum amount of drinking water required for survival in a tropical area is the range of 1.8 to 3.0 liters per day, so that another 2 to 3 liters per capita is available for other strategic uses.

The adequacy of water sources and the need for water treatment are important considerations that have a linkage with most of the above determinants. Source adequacy being a pre-condition to any decision on source selection, the effectiveness of treatment is considered the most critical aspect of drinking water supply. Treatment effectiveness is a function of the quality of the source water and the efficiency of the matching treatment system. In rural areas with limited capacities in obtaining high levels of treatment efficiency, complicated treatment must be avoided.

Therefore, the selection of the source for drinking water supply may be prioritized as follows:

(i) sources requiring no treatment at all to meet bacteriological, physical, and chemical requirements and delivery to the consumer at source, or by a gravity distribution system;

(ii) sources requiring no treatment to meet quality requirements, but the water must be pumped to the consumers;

(iii) sources requiring simple treatment before the water can meet the requirements, and delivery by gravity or pumping; and,

(iv) sources requiring advanced treatment and which must be delivered to the consumers by pumping.

The options under group (i) would usually be limited to uphill springs. This may be only considered in a few selected hilly areas of Bangladesh. However, arsenic contamination has not been reported there yet, and therefore spring-based options will not be included in the manual. Another group (i) source is rainwater. But even though rain is abundant in this country, its present use for domestic water supply is very limited and has in the past not been widely documented or studied It could however be re-developed as a source, and of late, research and development of this source has started. Under group (ii) would fall most of the groundwater sources, equipped with handpumps or motorized pumps. Provided the water is of good chemical quality, which is very often the case, and provided wells are well constructed and maintained, only periodical disinfection may be required to provide wholesome water. Surface water fits categories (iii) and (iv), depending on quality of the source. In group (iii) may be placed ponds which receive only rainwater, but no inflows from ground surface or from drains, and that are used for no other purpose than drawing water. In group (iv) are placed all other surface water sources, and all chemically contaminated groundwater.

Although surface water will not contain *arsenic* in dangerous concentrations, rivers, streams, canals and lakes are generally biologically, physically and chemically contaminated to such an extent that water drawn from them requires extensive treatment. The water is polluted because of upstream erosion and contamination from human settlements, agricultural, industrial and other activities. The pollution consists of pathogens, detergents, oils, pesticides, herbicides, insecticides, residual fertilizers, chemical waste, etc. The water quality from these sources is highly suspect, and cannot be treated with simple treatment methods. Because of the complexity of treatment of these waters, the use of the group (iv) sources for village water supply in the context this project is considered inappropriate. For that reason, these sources and the related water supply technologies will not be discussed further in this manual.

3.2 Arsenic Removal: State of Art

3.2.1 Removal mechanisms

Effective removal of arsenic is a complicated task due to different forms of arsenic in groundwater. It requires combinations of several treatment methods. In a large-scale application, such as urban and industrial water treatment plants there are established technologies for achieving reliable separation of arsenic.

Arsenic comes in different forms. Arsenite [As(III)] is the most toxic form and very difficult to remove. Therefore, it is has to be pre-oxidized into arsenate [As(V)], which is less toxic and also easier to remove. This oxidation is usually accomplished with chlorine or hydrogen peroxide. The second step is precipitation with lime or coagulation/ flocculation with some salt while controlling water's pH. Then follows filtration. Activated alumina is often recommended as adsorptive media. Another novel approach to large-scale purification, which has been developed in the United Kingdom and United State of America, uses an electric field in combination with ion-exchange resin.

With skilled staff, good monitoring equipment and a well-managed facility, arsenic removal does not constitute a major problem in large-scale water treatment. But, the demographic and socio-economic status of rural Bangladesh does not permit the installation of large-scale water treatment plant and associated transport and distribution system. Even the urban water supply system faces the problem of inefficient state-owned management, unskilled technical staff, capital shortage, inferior quality materials, inadequate power supplies etc.

It is also possible to achieve good removal on a small scale with modern purification technology, but it is quite complicated. For instance, reverse osmosis or distillation can be used, but it has to be in combination with both pre-oxidation and some form of after-treatment such as anion exchange or activated alumina adsorption. A small home water purifier based on membrane distillation developed by a Swedish firm also seems an attractive solution. It claims easy maintenance and operation and works irrespectively with raw water qualities. However, the initial unit cost of this unit is beyond the reach of the poor people and it also requires uninterrupted electricity supply.

3.2.2 *Treatment processes*

The following are the different available treatment processes for arsenic removal, each one with a brief description:

I) ***Fe-Mn Oxidation:*** The geochemistry of arsenic reveals that high arsenic concentrations are often correlated to high Fe(II) and/or Mn(II). During Fe(II) and Mn(II) removal the arsenic can be removed through oxidation. Fe(II) and Mn(II) leads to the formation of hydroxides that remove soluble arsenic by co-precipitation or adsorption reactions.

II) ***Removal addition of a coagulant:*** Potable water treatment with coagulants has traditionally been used to reduce turbidity by removing nonsettling, slowly settling solids from source water. Dissolved inorganic contaminants, such as arsenic, can also be removed during coagulation treatment with alum or ferric chloride through adsorption, occlusion, and solid-solution formation.
The type of coagulant, dosage and pH effect the efficiency of the process. Alum performance is slightly lower than ferric sulfate. Others were also less effective than ferric sulfate. Disposal of the -contaminated coagulation sludge may be a concern especially if nearby landfills unwilling to accept such sludge.

III) ***Lime Softening:*** Arsenic removal can be facilitated by a variety of solids formed during softening including $CaCO_3$, $Mg(OH)_2$, $Mn(OH)_2$ and $Fe(OH)_3$. Arsenic removal follows a linear isotherm for $CaCO_3$, Mg(OH) and $Fe(OH)_3$ with constant percentage of arsenic removal regardless of the initial arsenic concentrations. On the other hand, for $Mn(OH)_2$ solids, the arsenic removal is sensitive to the initial arsenic concentrations in the water.

The arsenic removal efficiencies of the lime softening process are significantly affected by pH. The use of chlorination as a pre-treatment can improve the arsenic removal. McNeil & Edwards (1995) demonstrated that up to 90% of the soluble arsenic(V) can be removed if softening pH is higher than 10.5.

IV) ***Activated Alumina:*** Activated alumina is aluminum oxide (Al_2O_3) grains prepared in a way that the grains have high absorptive surface. When the water passes through packed-bed configuration of activated alumina, arsenic and other compounds in the water are absorbed on the surfaces of grains. The capacity of activated alumina for arsenic is strongly pH dependent. As(V) is effectively adsorbed in the pH range 4-7. Selenium, fluoride, chloride, and sulfate, if present at high levels, may complete for adsorption sites. Both As(III) and As(V) species are adsorbed by activated alumina. Activated alumina is highly selective towards As(V); and this strong results in regeneration problems, possibly resulting in 5 to 10 percent loss of capacity for each run.

V) ***Activated Carbon:*** Different graded activated carbons are commercially available. Electrostatic attraction and the formation of specific chemical bonds were the major adsorption mechanisms. Activated carbon can absorb around 84% amount of As(V) and As(III). The pH, carbon type, and total As(V) concentration determine the removal of As(V) from water by carbon adsorption. Maximum As(V) removal occur at pH 4 to 5. Presence of Fe(II) drastically increase both the rate and extent of As(V) removal. The regeneration of arsenic-laden activated carbon is necessary.

VI) ***Iron Coated Sand:*** Iron oxide-coated sand can be prepared by mixing ferric nitrate ($Fe(NO_3)_3.9H_2O$) solution with washed and dried river sand followed by drying in oven and washing with distilled water. Iron coated sand has the potentiality to remove arsenic from groundwater. It has been reported that iron oxide-coated sand removed more than 90% of arsenic(V) and arsenic(III) in the laboratory study. Periodic regeneration is required.

VII) ***Ion Exchange:*** Ion exchange is normally used to demineralise, to soften and denitrate the water. It is an adsorption process similar to activated alumina; jut medium is a better-defined synthetic resin with a well-defined ion exchange capacity. As arsenic is present in water in anion form, anion exchanger can remove arsenic from water. Arsenic removal efficiency with this technology is about 93%.

Passage through a series of columns could improve removal and decrease regeneration frequency. Suspended solids and precipitated iron can cause clogging of the ion exchange bed. Sulfate, TDS, selenium, fluoride, and nitrate, if present at high levels, may compete with arsenic and can affect run length. Systems high levels of these constituents may require pre-treatment.

VIII) ***Reverse Osmosis:*** Reverse osmosis can separate aqueous solutions of different salt concentrations by a semi-permeable membrane. Pore size and size of ions are main determinate of RO. It is capable of rejecting contaminants or particles with diameters as small as 0.001 µm.
RO can provide arsenic removal efficiencies of greater than 95 percent when operating pressure is at an ideal psi. Discharges of reject water or brine may also be a concern. The increased water recovery can lead increased costs for arsenic removal.

IX) ***Electrodialysis Reversal:*** It is a separation process based on the transport of ions through membranes as result of an electrical current.
Electrodialysis is expected to achieve removal efficiencies of 80 percent.

X) ***Nanofiltration:*** NF is called membrane softening or loose RO. It can reject contaminants or particles with diameters more than 0.001 µm.

NF is capable of arsenic removals of over 90%. The recoveries ranged between 15 to 20%. The increased recovery can lead to increased costs for arsenic removal.

In fact, it would appear that there are only a few arsenic removal processes that can be immediately applied in rural Bangladesh. Table 3.1 summarizes the main advantages and disadvantages of the available processes for arsenic removal.

Table 3.1: The main advantages and disadvantages of available technologies for arsenic treatment.

Method	*Advantages*	*Disadvantages*
Fe-Mn Oxidation	Simple treatment process Low cost technology	Effective only when water contains sufficient ferrous iron. Less effective against As(III)
Co-precipitation	Low capital cost Readily available or common chemicals	Problems with toxic sludge Ineffective at very low and high pH Skilled operation is required
Alum coagulation	Durable powder chemicals normally available	Efficient pre-oxidation is a must.
Iron coagulation	More efficient than alum on weigh basis.	Medium removal of As(III).
Softening	Low capital cost. Low operating cost	pH adjustment required especially for As(III).
Lime softening	Most common chemicals.	Oxidation may be required as pre-treatment.
Adsorption	No daily sludge problem Effective for both As(III) & As(V).	Requires well monitoring Periodical regeneration is necessary
Activated alumina	Relatively well known and commercially available. Expected to be cheap	Re-adjustment of pH is required.
Activated carbon	Effective against other contaminants especially organic contaminants	pH dependent.
Iron coated sand	Expected to be cheap	Yet to be standardized. Toxic solid waste.
Ion exchange resin	Well-defined medium with high capacity.	High cost medium. High tech operation &maintenance. Sulfate, fluoride, nitrate levels may affect run length. Suspended solids and precipitated iron salts can cause clogging of ion exchange bed.
Other adsorbents	Plenty of possibilities & combinations	Not yet properly studied
Membrane techniques	Well-defined performance. High removal efficiency. No solid waste Low space requirement. Capable of other contaminants, if any.	High investment costs High running costs High tech operation & maintenance costs. Toxic waste water. Membrane doses not withstand oxidizing agents.
Reverse Osmosis		Ideal pressure is required.

Nanofiltration		Low recoveries (15 – 20%).
Electrodialysis	Easier to operate.	Costlier than RO & NF Low process efficiency.

Table 3.2 is an attempt to review the above mentioned treatment process in terms of applicability to the rural areas. The treatment process is judged on the basis of cost, skills required in operation, availability of local materials, sensitivity of process to water quality parameters, availability of the external inputs (energy and chemicals) and environmental risk (handling of waste).

Table 3.2: The applicability of arsenic removal treatment process.

Method	*Cost Estimate*	*Skill required for operation*	*Availability of Local materials*	*Sensitivity of process to water quality*	*External Input requirement*	*Environ-mental Risk*
Fe-Mn Oxidation	+	+	+	-	+	-
Co-precipitation	+	-	+	-	0	-
Softening	+	-	+	-	0	-
Adsorption	0	-	0	-	-	-
Membrane techniques	-	0	-	+	-	+

Legend + = favorable, 0 = neutral, - = unfavorable

From the table it can be seen that none of the processes is considered ideal for application in rural areas of Bangladesh. However, oxidation, co-precipitation and softening come out better than adsorption and membrane filtration.

3.3 Arsenic Mitigation: Options in rural Bangladesh

In this section we present the available technologies as reported by various agencies in Bangladesh. It may be pointed out that many of these arsenic mitigation technologies are still at a research or development stage, so that revisions in design may follow. Also, field level testing of technologies under different conditions and at the user level are yet to be done in many cases. This section is therefore concluded with a review that discusses technologies with immediate applicability in the Project.

3.3.1 Water Sources and the Necessity of Treatment

The Arsenic Mitigation-Water Supply Project seeks to remedy the intake of arsenic contaminated water by the application of a variety of water supply technologies. The selection of the appropriate technology will be situation specific. The technologies can be distinguished by those where the arsenic-affected groundwater is actually treated and those where the arsenic-containing groundwater source is replaced by an arsenic free source. The arsenic-free sources are groundwater from other aquifers, rainwater, and surface water from ponds, and if worst comes to worst, tanker truck water or bottled water.

The choice of source and related technology needs to be very carefully considered, particularly in terms of public health considerations. The categorization for the prioritization of sources that was presented in the introduction to this chapter is particularly relevant in this respect. For example, when moving away from arsenic-containing groundwater to surface water, one dangerous contaminant, arsenic will be replaced by another equally or more dangerous one, pathogens, the removal of which will require water treatment ranging from simple disinfection to slow sand filtration with pre-treatment. In the public health sense, a move to unpolluted groundwater or rainwater will be much less risky, as this water is free of any significant contamination. The different water sources and the associated need for water treatment is shown in table 3.3.

Table 3.3. Water sources and the need for treatment

Source of Water	Concentration of		Need for Treatment to reduce	
	Arsenic	Pathogens	Arsenic	Pathogens
Groundwater	<0.05 ppm	Negligeable 1)	No	No 2)
	>0.05 ppm	Negligeable 1)	Yes	No 2)
Rainwater	Negligible	Negligeable 1)	No	No 2)
Surface Water	Negligible	Significant	No	Always

1) except where water abstraction technologies have not been properly installed or maintained
2) periodic disinfection may be considered

3.3.2 Categorization of Options

The arsenic mitigation options can be categorized in 4 groups. These are follows:

1. ***Arsenic reduction option:*** Removal of arsenic to an acceptable level by simple treatment of water from the present source. Example - Household arsenic treatment by bucket type method.

2. ***Replacement of source option:*** Developing a source with an acceptable arsenic level. Example- A new arsenic-free well, rooftop rainwater harvesting, and pond water with adequate treatment.

3. ***Source sharing option:*** Obtaining drinking water from a neighboring unsuspected source, whilst continuing to draw for other uses from the present well. Example- Arrange permission to take or buy a certain quantity of water from a nearby, arsenic-free well.

4. ***Imported water option:*** Getting wholesome water carried in from elsewhere. Example- Tanker truck water delivery, and bottled water.

3.4 Groundwater Abstraction

3.4.1 Technologies for Groundwater Abstraction

In this section we will describe the various pump types in use in Bangladesh, the various types of wells, and the most commonly found combinations of wells and pumps.

a. Pumps for Static Water Level down to -7.5 m

a.1. Bamboo pump

This is one of the cheapest versions of shallow handpump. These handpumps usually operate in the tubewells with 15 - 18 m deep. These handpumps mainly consists of bamboo pipes, bamboo handle and bamboo filters, in addition to a common pump body, rod and bucket. No test result is available on the performance of the Bamboo pump and this pump is not widely used.

a.2. No. 6 handpump

No. 6 handpump is the most common and popular technology used for abstraction of groundwater in Bangladesh. It is a suction mode handpump. A vacuum is created within the cylinder of the pump by raising the pump as a result to fill up the vacuum water enters in the cylinder. In the second stroke when the piston is lower down, the water enters in the upper chamber and comes out of the pump through spout when the piston is raised to create vacuum again.

a.3. Rower pump

The Rower pump is also a shallow handpump in principle, which is commonly used for irrigation. It is also used frequently for drinking and domestic water supply. It is a manually operated reciprocating pump with 54-mm diameter PVC pipe as pump cylinder. The piston inside the cylinder operates by pulling and pushing a T-handle attached to the end of the piston rod The pump is installed inclined at 60^0 with vertical tubewell pipe through a "Y" connector piece. The operator pull and push the piston back and front by moving the "T" shaped handle and withdraw groundwater by means of suction. No independent test result is available on the performance of the Rower pump.

a.4 Moon pump

This pump is the local modification of the No. 6 handpump to withdraw water when water level goes beyond the suction limit for a limited period. A 75-mm diameter GI pipe is used as the casing up to 3 m below the ground surface. The suction action is extended by increasing the length of the piston rod. The limitation of the moon pump is that it can be used where the water level will remain within 10 m from the ground surface. There is no independent test result available on the performance of the Rower pump

a.5. Threadle pump

A threadle pump is a shallow pump in which legs are used to extract groundwater It is commonly used for irrigation purposes and not well suited for drinking water supply as the pump is easily polluted from the top. It works with two cylinders (paralleled positioned), two threadlike, one pulley and one cell on tubes which may be lined by PVC or bamboo pipes. The pumping motion resembles more or less cycle riding. A new version of threadle pump for drinking water supply is being developed.

b. Pumps for Static Water Level down to -30 m

b.1. Tara Handpump (-15 m)
The Tara pump belongs to deep-set handpump group. It is a direct action handpump in which the piston of the pump operates below static water level to eliminate the limitations of suction mode handpumps. The cylinder of the pump is set at 18 m below the ground surface and the piston is operated by a vertically set PVC pump rod. The pump was designed to reduce manual force by using buoyancy of the pump rod. But the buoyancy force is not always available due to leakage in the pump rod. The lifting capacity of a standard Tara pump is limited up to 15 m. The repair of the pump is easy and normally does not require special tools, but the unavailability of high quality spares is a major concern. The pump has been promoted by UNICEF, DPHE, DANIDA and World Bank, but is not readily available in the local market. This is probably due to low acceptability by the user of the typical pumping action.

b.2. Bangla Handpump (-15 m)
It is a local modified version of Tara pump that is locally produced. The head of the Tara pump has been replaced by that of the No. 6 handpump given the advantage of lever action; also, the PVC pump rod has been replaced by metal rod. The lifting capacity of the pump is limited to 15 m. There is a detailed test result available about the good performance and acceptability of the pump.

b.3. India Mark II Handpump (-30 m)
This is a deep-set pump widely used India and many parts of the world It has a deep-set pump capable of lifting water from a depth over 30 m. The piston in the pump is operated by connecting rod instead of PVC pump rod. The main components of the tubewells are pump head assembly, blind pipe and filter and the cylinder assembly. The pump head assembly consists of chain and bearing system. This makes water extraction easy and smooth. This pump is not widely used in Bangladesh. A well-trained mechanic is required for pump repair.

c. Pumps for Static Water Levels below -30 m

c.1. Motorized submersible pump (any depth)
For static water levels below -30 m motorized submersible pumps are most commonly used. These require a larger diameter tubewell. Usually, submersible pumps deliver water to storage reservoirs from where water is drawn. Drawl of water may be done directly, from taps fitted to the tank, or from a distribution system.

d. Types of Wells

d.1. Dugwell
Dugwells are large diameter shallow wells for ground water extraction. This used to be a common option for potable water before the success of tubewell program. Water of these dugwells have been found to contain nil or negligible arsenic (below WHO standard) in many arsenic affected areas, for example, Singair, Matlab, etc. But this water is generally highly contaminated with fecal bacteria.

A dugwell can be used with handpumps following its disinfection (chlorination), the installation of a raised, protective platform over the entire opening, and the sealing of the upper portion of the well to prevent seepage into the well of polluted water from the ground surface. This system provides nil or acceptable coliform bacteria and arsenic contamination. The disinfection/chlorination of the dugwell was required at a certain frequency. A dugwell can be lined with brick masonry, cast-in-situ concrete or precast concrete rings (ringwell).

d.2. Very Shallow Shrouded Tubewell (up to 10 m depth)
This is a low-cost tubewell about 8 m in depth with 2 m strainer shrouded with coarse sand. The VSST is designed to be fitted with a handpump and collects water from very shallow aquifers formed by displacement of saline water by continuous flow of accumulated fresh water. The lenses of fresh water formed by this process are found beneath old ponds in coastal area. In many areas, ponds are dry up but fresh water in shallow aquifer remains beneath the pond. Immobile preserved aquifers are also found at shallow depths at various locations in the coastal area. It is convenient method for withdrawal of fresh water in limited quantity. Identification of existence of fresh water pockets is difficult. The life span of VSST is also short.

d.3. Tubewell (locally up to 300 m)
A tubewell installed to withdraw water from deeper aquifers is called a tubewell. In the coastal belt, the depth of deep tubewell can go up to 300 m. The unconsolidated soils allow for the construction of shallower wells by the so-called 'sludger' method, that is entirely done by hand and cheap.

e. Common combinations of wells and pumps in Bangladesh
In Bangladesh the wells and pumps are found in combinations as shown in table 3.4.

Table 3.4. Common technologies for groundwater abstraction

Well type	Dug well		VSST	Tubewell			
Depth well			<10 m	Up to 300 m			
Depth water table	< 7.5 m	7.5-15 m	< 7.5 m	< 7.5 m	7.5-15 m	15-30 m	> 30 m
Pump type:							
Bamboo	-	-	-	✓	-	-	-
No.6	✓	-	✓	✓	-	-	-
Rower	-	-	-	✓	-	-	-
Moon	-	-	-	✓	-	-	-
Threadle	-	-	-	✓	-	-	-
Tara	-	✓	-	-	✓	-	-
Bangla	-	✓	-	-	✓	-	-
Mark II	-	-	-	-	-	✓	-
Motorized Submersible	-	-	-	-	-	-	✓

3.4.2 *Arsenic-free Groundwater*

(Arsenic-free in this context means less than 0.05 mg/l)

The findings of the investigations into the occurrence of the arsenic problem in groundwater in Bangladesh include the following:

- The median arsenic concentration found in 2023 groundwater samples collected from 252 thanas was 0.0108 mg/l, just above the WHO recommended limit of 0.01 mg/l for arsenic in drinking water. 35% of the samples had concentrations above the Bangladesh drinking water standard of 0.05 mg/l.

- Much of Bangladesh is characterized by a two-aquifer system. A shallow aquifer typically extending from 10 to 70 m's below ground level and a deeper aquifer below about 200-m. In the south the shallow aquifer is divided in two.
- The top of the shallow aquifer, at depth of less than 10 m appears to be less contaminated, and shallow wells are usually uncontaminated even in areas of otherwise high arsenic concentrations,
- Samples collected from wells with depths between 10 and 100-m, showed that about 40% of these have arsenic concentrations above the Bangladesh drinking water standard of 0.05 mg/l.
- Most of the very deep wells (depth greater than 200 m) had low arsenic concentrations, often significantly below 0.01 mg/l. Only 4% of these wells had arsenic concentrations above 0.05 mg/l,
- Changes, for better or worse, are likely to be slow, and if they occur, will happen over time scales of years and decades.

The importance of these findings to the Arsenic Mitigation Water Supply project is that, for the purpose of guiding project operations, the following low-arsenic occurrences may be assumed:

1. Where groundwater can be drawn from wells with a very shallow depth (less than 10 m), the water is likely to have an arsenic concentration less than 0.05 mg/l;
2. Where drilling of wells in deep aquifers (> 200 meters) is feasible, the water may be expected to have an arsenic concentration below 0.05 mg/l;
3. That where groundwater in the most common wells with a depth of 10 - 70 m is found to contain less than 0.05 mg arsenic/l, the source may continue to be used, and needs to be re-sampled only every few years.

Needless to say, actual arsenic levels have to be ascertained in each location.

Table 3.5.Common groundwater abstraction systems in Bangladesh that are appropriate and likely[1)] to yield water with an arsenic concentration less than 0.05 mg/l

Well type	Dug well		VSST	Tubewell			
Depth well	< 10 m		<10 m	More than 200 m			
Depth water table	< 7.5 m	7 5-10 m	< 7.5 m	< 7.5 m	7.5-15 m	15-30 m	> 30 m
Pump type[2)]:							
Bamboo	-	-	-	✓	-	-	-
No.6	✓	-	✓	✓	-	-	-
Rower	-	-	-	✓	-	-	-
Moon	-	-	-	✓	-	-	-
Threadle	-	-	-	✓	-	-	-
Tara	-	✓	-	-	✓	-	-
Bangla	-	✓	-	-	✓	-	-
Mark II	-	-	-	-	-	✓	-
Motorized Submersible	-	-	-	-	-	-	✓

Note 1) actual Arsenic levels must be always established on site

2) for comments on pumps see relevant section in 3.3.3

3.4.3 Arsenic-contaminated Groundwater

(Arsenic-contaminated water in this context contains arsenic in excess of 0.05 mg/l.)

If the groundwater is contaminated with arsenic above the threshold value of 0.05 mg/l, which is most likely in wells with a depth between 10 and 70 m, then the groundwater abstraction technologies have to be combined with attached or separate arsenic removal treatment devices. Attached devices are treatment modules that are installed in, at or near the pump, while separate technologies are those where arsenic-contaminated water is carried home, and treated there. These devices are described separately below, and include both tested and untested technologies, as well as technologies subject to ongoing research. All technologies for arsenic removal will yield residues containing arsenic and, where applicable other chemical compounds used in the treatment process. The collection, treatment and disposal of these residues have not been studied, but this will need to be taken up sooner rather than later.

a. Attached Devices

a.1. Iron-removal plant

Iron removal plants usually combine aeration, coagulation and filtration. They are used for iron removal but, if present, arsenic co-precipitates. The arsenic-removal efficiency improves when alum added. The plant consists of stapled gravel, sand and filtered water chambers in series, with a downward gravity water flow. It often used as community-based system. Reportedly, removal efficiency varies widely, mainly between 55% and 95% (Liang, 1998).

a.2 Arsenic treatment inside tubewell

Jahangir Nagar University is studying this technology option. The study result is not yet available.

a.3 DANIDA – designed arsenic removal unit

The DPHE-DANIDA Urban Water and Sanitation Project has developed a prototype filter to remove arsenic from tubewells. It can serve up to 25 families or 200 individuals. This arsenic removal unit (ARU) comprises one compact unit. There are five compartments inside that unit: a buffer chamber to control chemical addition, a mixing chamber, an aeration chamber; and a chemical stock solution. The removal efficiency is reportedly 70% (from about 0.14 arsenic mg/l). Alum dosing was about 200-300 mg-alum/l.

b. Separate, Household-based Devices

b.1. Bucket type removal by coagulation

This widely promoted method requires a few clockwise stirrings of arsenic contaminated water using suitable dosages of coagulants (alum, ferrous sulfate and ferric chloride) followed by undisturbed storage of water. After 24 hours, the top portion of water is to be separated out. The reduction in arsenic content varies depending on the concentration and nature of arsenic, concentration of iron, pH, hardness, contact period and type and dosages of coagulants. Addition of bleaching powder can improve the removal efficiency. Two buckets are required for the treatment purposes, one for addition of coagulant, floc formation and settlement and another one for pouring in the supernatant. Reportedly, complete (100%) removal can be achieved.

b.2 Chemical package treatment at household level
Chemical packages (tea bags) were distributed by a local agency for treating arsenic contaminated tubewell water. Although the constituents of this package were kept secret, a strong chlorine smell was observed. It reportedly showed 70-100% removal. The efficiency of the packages was not scientifically investigated and the efficiencies claimed must be viewed with caution. The people's acceptance for this method was very low, on account of the strong smell and poor palatability.

b.3. Bucket removal - Spontaneous precipitation of arsenic by storage
Arsenic can be reduced spontaneously by leaving the water undisturbed over 24 hours without adding any chemicals. Then the top portion of is separated out slowly. The arsenic removal in this method is highly depended on the composition of the water, especially the iron content. The method produces better results with high initial iron concentrations. The method is promoted by a few major agencies. Arsenic removal efficiencies using this approach are typically 20-70% which may not be sufficient to reduce the arsenic concentration to the desired level but it could at least provide an emergency option to reduce the intake of arsenic. In case of very iron concentration, more than 90% removal is also possible.

b.4. Commercial filter
There are some commercial arsenic removal filters are available now in the market. Of those, some would be appropriate for rural use. However, no results of independent investigations are available regarding the arsenic removal efficiencies of these devices.

b.5. Sand-khoa (brick chip) filtration
This household filtration unit has been developed based on traditional household practices. This follows slow sand filtration technique. It consists of two or more filtration units; the units are placed one under the other. Earthen wide mouthed pits with about 15-liter capacity are used to form the filtration units. Each pot contains at least one layer of brick chips followed by layer of sand. Three pieces synthetic or nylon cloth cover the top layer, between the chips and sand layer and cover the bottom inside part of the pot. One to three small holes should be made at the bottom of the pot. The units require cleaning and disinfection at a regular intervals to avoid the growth of bacteria.

This aeration-filtration unit for arsenic treatment reportedly provides 60-100% reduction of arsenic depending on the initial arsenic concentration, proportion of arsenic III and presence/concentration of iron.

3.5 Rainwater based Technologies

Rainwater is pure and a preferred source of drinking water in many countries. Rainwater can be collected from rock and roof catchments and other hardened and sloping surfaces. If collected from an elevated surface such as a roof and stored in a hygienic manner it is usually suitable for drinking without treatment and is only very rarely contaminated with pathogenic organisms. The rainwater is free from arsenic contamination.

a. Roof water-harvesting system
The rainwater harvesting system requires a roof of a particular minimum size to collect water, and a storage tank with an adequate volume to ensure continued supply over prolonged dry periods. The

monthly rainfall figures and rainfall pattern suggest that rainwater harvesting is a potential source of potable water in Bangladesh.

The very common corrugated iron sheet rooftops Bangladesh are quite suitable, but also tiled and asbestos-sheet roofs can also be used. Thatched roofs pose problems as the runoff is lower and generally of a lower quality. Rooftop catchment systems collect rainwater precipitated on the roof using gutter and downpipes (made of local wood, bamboo, GI or PVC) and lead it to one or more storage containers ranging from simple pots to large masonry concrete, and ferrocement tanks, or even disused, sealed wells. To ensure good quality drinking water, simple devices are built into the downpipe system to divert first runoff. In addition, a small filter is often constructed on top of the tank.

a.1. Household-based roof water harvesting

A rainwater storage tank can be constructed at each house for individual household use. If financial means do not allow for the construction of a purpose-made tank, then multiple, commercially available vessels can also be used. These then need to be interconnected.

a.2. Community-level roof water harvesting

Communal use of rainwater is also an option, particularly where household roofs are not suitable, or where such a solution would be agreeable to the users and less expensive. At communal level, a tank can be constructed for few households using a single or multiple roof catchments. In addition to or instead of residential roofs, water can be drawn from the rooftops of public buildings. The water can then be stored in single or multiple communal tanks with public taps.

3.6 Surface Water Based Technologies

Surface water has shown nil or negligible concentration of arsenic. But then surface water is often biologically and physically contaminated, and can only be ingested after prior treatment. Surface water in Bangladesh may be found in rivers, streams, lakes, canals, and ponds.

Ponds served as a prime drinking water source in earlier times when groundwater was not widely used and extreme care was taken to protect and maintain the ponds. After the introduction of groundwater technologies, the ponds have gradually lost their original use, and are nowadays not kept clean, neglected or more often, put to other uses such as fish farming, laundry, bathing, sanitary drainage outlet, cattle watering, etc. Water drunk from this type of modern-day pond carries a high risk of diarreahl and other water-related diseases.

Pond water

Pond water will be classified here in two types: the type with little or no pollution, and the pond with limited pollution. The initial indicator used to classify a pond is the turbidity. In the course of project development, more parameters need to be determined to establish the quality of pond water and determine treatment needs.

Pond water can be used for the drinking purposes after simple treatment, if the pond is protected against the unwanted flows. There should be arrangements in place to guarantee that the pond is free from human access, livestock watering and bathing, washing clothes, garbage dumping, drainage of irrigation return flows, rainwater runoffs, sanitary runoffs, fish farming, etc. The pond that will be considered for drinking purposes with limited treatment should be filled with the rainwater only, and not be used for any other purpose. For drawing water from the pond, a mechanical device is required, so that people do not need to enter the pond and create a possible health risk. The water can be abstracted by simple handpumps mounted on a platform constructed over or by the side of the pond.

Pond water from the cleaner ponds can be treated right at the pond, or at the household.
Several simple treatment methods are available to treat this pond water. The most important objective of treatment is to bring down the presence of pathogens to acceptable levels. The Bangladesh standard for bacteriological quality of drinking water is less than one fecal coliform bacterium per one hundred milliliter of water (1 FC/100 ml).

a. Pond water with turbidity <1 NTU and fecal coliform <10/100 ml
If the water quality of the pond is in the above range, the water can be used with only simple disinfection. It may be noted that this a fairly *hypothetical* case. In reality, very few ponds are expected to meet the above criteria.

Simple disinfection methods are:

a.1. Chlorine Tablets
The easiest way to disinfect drinking water is to add chlorine tablets to it. These tablets can be bought in a chemistry or pharmacy. The tablets are quite cheap, but to use them continually will turn out to be very expensive. Therefore, their use could be limited to periods with increased risks, for instance during epidemics. If the turbidity of the surface water is within the acceptable limit, the method can be applied only during high-risk periods. This method may give a distinct taste of chlorine to the water.

a.2. Bleaching Powder
Another method to disinfect contaminated water is to add a bleaching powder solution. The volume of the bleach to be added should be prescribed by a specified institution, like a Public Health Laboratory, and periodically re-established. It takes about one hour for the chlorine in this solution to destroy the bacteria in the water. Application of this method requires some training and some specialized tools. The addition of bleaching powder may also impart a distinct taste to the water that is often not appreciated by the user. Bleaching powder usually loses half of its strength within a period of one year, even stored in a cool dark place.

a.3. Boiling
Boiling kills the disease-carrying organisms in water. Just bringing water to the boiling point is not sufficient to kill all microorganisms that may be present in the water. To be totally safe for consumption, water must be boiled for twenty minutes. This is quite long and expenditures on firewood or other fuel will be high in the long run. To boil water for a few minutes is any case better than not boiling it at all.

a.4. Solar disinfection (SODIS)
This technique has been developed by SANDEC/EAWAG. The principle of this technique is to use solar radiation to inactivate and destroy pathogenic microorganisms present in the water. The treatment basically consists in filling transparent containers with water and exposing them to full

sunlight for about five hours. The process has been found satisfactory to disinfect small quantities of water used for consumption.

Solar radiation can be used to disinfect any water. With dugwell water SODIS showed better results than pond water because it had lower initial bacteriological and organic pollution than pond water. The SODIS treatment process is under study by the Watsan partnership (SDC).

b. Pond water with turbidity <10 NTU and fecal coliform <100/100 ml

The pond water quality in this range requires more treatment than only disinfection. The water can be treated at the household level with the simple treatment method. These treatment methods must be combined with any one of the disinfection processes described in 3.3.7.a1 to a4.

The simple household treatment processes are:

b.1. Conventional Household Filtration

There are different types of conventional filtration units used in Bangladesh and elsewhere. Mostly, the filtration process is based on the principle of slow sand filtration. These filters usually will reduce the number of fecal coliforms and pathogenic bacteria. However, because of common negligent maintenance there are reservations about the continuous reliability of household sand filters to produce bacterially pure water.

One of the common type of household of filtration is Pitcher (Kalshi) filter. The principle of this type of filtration was used widely in the rural areas for treatment of surface water. But, this method has been phased out with the introduction of handpumped tubewells at the villages in the last decades. This process can not produce completely bacteriological free water.

b.2. Commercial Household Filter

Different types of modern, mass-manufactured filtration units are available in the Bangladesh market. One of these common units is known as the Puritas filter. Independent research results on the performance of cheap and commonly available filters for pond or ditch water treatment could not be located.

b.3. Household treatment by using alum

Alum can be used to treat the pond water at the household level. This can be done by adding alum to a bucket of water, mixing thoroughly and allowing it to sit for at least 1 hour. The clear top water is separated carefully. The water is generally safe for drinking purposes, may taste acidic and bitter.

b.4. Moringa Olifera Seeds

This technique has been developed by SANDEC/EAWAG. Powder of Moringa Oliefera seeds are used as coagulant to reduce the turbidity of the raw water It has been reported that powder of two Moringa Olifera seeds can reduce the turbidity within the acceptable range within one hour. There are three types of Moringa Olifera are available in Bangladesh and the removal efficiencies may vary with the type of Moringa Olifera. This treatment process is still under study.

*c. **Pond water with turbidity 10-100 NTU***

Where turbitities are in excess of 10 NTU, treatment at the pond site is advised together with household disinfection.

c.1. Pond Sand Filter

A pond sand filter is a manually operated small filtration unit used to treat the adjacent pond water using the principle of slow sand filtration. Brick chip (khoa) and sand chambers are arranged in series. Water is pumped from ponds through filter piped connected to a bent PVC pipe joined to a head assembly of commonly available shallow handpumps. Ponds that are more or less protected from indiscriminate pollution and hold water round the year are selected for this purpose. A check on the technical feasibility of the pond sand filter used by the PHED in Bangladesh is based on salinity and iron content of the pond water; these must not exceed 600 mg chloride /l and 5 mg/l respectively at the any time of the year.

Pond sand filters in Bangladesh have been observed to produce disappointing, but yet what are considered acceptable results (20-70 FC/100 ml) during most part of the year. During the rainy season performance becomes even poorer and provided water with what is considered unacceptable quality with up to a few hundred fecal coliform bacteria per 100 ml (personal communication, Bilqis A.H., 1998). Compared to normal drinking water standard this level of contamination is high.

Reasons being advanced for the mediocre performance of the pond sand filter relate not so much to the principle of slow sand filtration, but to the design and use of the system. The main problems identified are poor maintenance of ponds that consequently deliver an inferior quality of water to the filter, a too thin filter bed with only 30 cm of sand that needs to be cleaned too frequently, and misuse of the installation including the reconstruction of the outlet arrangement resulting in a dry filter bed. Most of these shortcomings may have resulted from poor motivation and training of the users, resulting in a low level of awareness and action on the operation and maintenance of the system.

In view of the observed, limited bacteriological treatment efficiencies it is considered preferable to carry out disinfection at the household level before use, particularly so during the rainy season. The disinfection methods are those described above in 3.3.7.a1 to a4.

3.7 Other Methods

In this section, some technologies and arrangements applied elsewhere in the world for safe drinking water supply to rural villages will be described. These will be distinguished in arrangements for sharing and importing of water, and the treatment of surface water and arsenic containing waters.

d. Sharing arrangement

d.1. Sharing Arrangement

It has been observed that there are large differences in the extent of contamination of the shallow tubewells in different districts, from 'hardly affected' in the northwest to 'nearly all affected' in the southeast. The pattern of arsenic contamination is irregular in the medium arsenic contamination area. Also, there may be some occasional 'hot spots' in the low arsenic contamination area, and vise-versa.

Research also showed that not all the tubewells in an effected area would necessarily show a too high arsenic concentration. Also, it was concluded that changes in arsenic level are likely to be slow, and if they occur, will happen over time scales of years and decades. The implication of all this is that the users of an arsenic-contaminated deepwell may well find ways to satisfy their drinking water requirement from a nearby arsenic-free well. An arrangement may be required to allow such water collection with the owners/users of that well. The arrangement could include for paying the cost of water through flat or graded rates, or cash payment when drawing at the source (vending). Community mobilization is required in both the deprived and providing communities in this case.

Imported Water

d.2. Bottled water

d.3. Tanker water

These are measures with an emergency character that may however need to be implemented for a prolonged period of time. At this time, these measures are not applied in rural areas of Bangladesh, primarily because of their high cost. These means of supply must be considered however, as a last resort in arsenic contaminated areas where the development of other sources is not feasible and where water sharing proves impossible. Here bulk water needs to be trucked in, or bottled water made available. Tanker trucks can collect the water from nearby municipal supplies or irrigation wells, and distribute the arsenic free safe water to a specific village to a certain time of the day. Alternatively, if available, or constructed under the project, the arsenic-free water can be deposited in a service reservoir fitted with public taps. As an alternative to tanker water, bottled water may be distributed. For this, the village shop may be stocked with bottled water. Cost recovery is an important constraint here. The cost of tanker water and bottled water may prove prohibitive, and the pricing and possible subsidization of arsenic-free water must be decided with the public health motive foremost in mind. In principle, this drinking water can be sold to the villagers through regular flat or graded rates, or against cash payment per unit volume when drawing from the source (tanker truck, service reservoir or shop). The water quality of the tanker and bottled water should be monitored regularly by the concerned authorities.

Surface water

d.4. Roughing Filter and Slow Sand Filter

A slow sand filter in combination with a roughing filter is used to treat the surface water for village water supply. Slow sand filters are characterized by a very low rate of filtration, where bacteriological action aids in improving treatment efficiency, backwashing of the filter is not required, and pathogen-free water is produced. The sand is cleaned by scraping off the surface layer periodically. To avoid the clogging in the slow sand filter, a coarse-media filter is used as pre-treatment. This filter is called roughing filter. The roughing filter acts as a filtration and sedimentation unit and has remarkable efficiency in the removal of suspended solids and the improvement of bacteriological quality. This system is considered as an appropriate choice for surface water treatment in rural areas in many developing countries due to its low cost, ease in construction, simplicity in operation and maintenance, high treatment efficiency including pathogens, and reliability.

d.5. Commercially available compact surface water treatment units
There are some commercially available compact surface water treatment units for household level in different parts of the world. These units are mainly based on the filtration process.

Arsenic treatment

d.6 Commercially available compact arsenic treatment units
Small water purifiers based on membrane technology or ion exchange treatment process are available in industrialized countries. The test results shows that these small treatment units are capable of producing high quality drinking water. But operating requirements are such, and the capital cost so high that these units are not suitable for application in rural Bangladesh.

3.8 Review of technologies

The overview shown in the table below attempts to capture the information contained in the above sections of this paragraph.

Table 3.6. Technologies for Arsenic Mitigation, showing arsenic removal efficiency and Applicability

Type	*Source*	*Technology*	*Arsenic Removal Efficiency*	*Applicability in the BAMWSP*
Technologies for ground-water extraction	Very Shallow Groundwater <10 m	1. Dug well + handpump 2 Very shallow shrouded tubewell	Zero Zero	Suitable* Where water pocket is available
	Shallow to medium depth groundwater	3 Suction mode handpump 4 Deep-set handpump	Zero Zero	Only where As<0.05 mg/l Only where As<0.05 mg/l
	Deep ground water >150 m	1 Manually operated handpump 2. Motorized pump	Zero Zero	Suitable* Suitable*
Technologies for Arsenic Removal from arsenic-affected well water	Attached Devices	3 Iron removal plant 4 Arsenic treatment at tubewell site 5 Arsenic treatment inside tubewell 6 DANIDA design arsenic removal unit	Variable (55-95%) Variable (up to 100% for As below 0 15 mg/l) Not known Variable (around 70% for As 0.14 mg/l)	If raw water contains high iron - - -

	Separate household based devices	7 Bucket type removal by Coagulation 8. Chemical package treatment at household level 9. Bucket removal - Precipitation by storage 10 Commercial Units 11 Sand-khoa (brick chip) filtration	Variable (up to 99%) Variable (70-100%) Highly variable (typically 20-70%, but 90% is also possible for very high Fe content) Not known Variable (60-100%)	Suitable (dosing is important) No If raw water contains high iron - -
Technologies for Rainwater collection and Storage	Rainwater	12. Rooftop rainwater harvesting system	Zero	Suitable
Technologies for treatment of pond water	Pond Water	1 Disinfection- Chlorine tablets/ Bleaching powder/ boiling/solar disinfection 2 Conventional Household filtration and disinfection 3 Commercially available filter and disinfection 4 Household treatment by alum and disinfection 5. Moringa Olifera seeds and solar disinfection 6. Pond Sand Filter	Zero Zero Zero Zero Zero Zero	NTU>1 and FC>10/100ml NTU>10 and FC>100/100ml -do- -do- Under study Suitable, but requires improvements.

* - water should tested for As concentration.

3.9 Currently Acceptable Technologies for Use in the Project

A simple, affordable, technically feasible and socially acceptable safe drinking water system in the rural areas of Bangladesh is very much in demand. Unfortunately, Bangladesh' experience is limited mainly to groundwater exploitation from unsuspected sources by means of a handpump mounted tubewell. Alternative water technologies like rainwater harvesting and pond sand filters (PSF) are practiced, but only in a very limited way, and until recently, without much detailed study of technical, social, financial and other aspects. At present, triggered by the arsenic problems, many more technologies are being actively researched, however until now without much conclusive evidence regarding their efficiency and applicability.

When taking in only the experiences in Bangladesh, and considering the socio-economic and technical constraints presented by their possible application for village water supply, only a very limited number of technologies can actually be confidently promoted for the application to the arsenic contaminated areas in rural Bangladesh. These include arsenic-free groundwater abstraction (new wells), plus the importation of arsenic-free water in bottled or tanker form (only a temporary solution, and very expensive).

This selection is very limited and would not permit the use of treated pond water, rainwater, or treated groundwater. Such would ignore experiences elsewhere, and discredit long lasting but poorly documented experiences with conventional treatment in Bangladesh. It is therefore proposed to allow the qualified use of other technologies. These include a selection of technologies for the abstraction and treatment of pond water, rainwater harvesting from roof catchments, and the treatment of groundwater from arsenic-affected wells. The selection has been guided primarily by an assessment of the amount and quality of experience with the technologies by the authors of the manual, and would certainly be subject to discussion and further developments. The table is therefore preliminary and temporary, and should be extensively discussed, approved, and thereafter be reviewed and possibly revised from time to time, on the basis of new information and insights. (See also table 3.7).

Table 3.7. The Currently Acceptable Technologies

Application Options	*Household level*	*Community/ Village level*
Treat water from existing arsenic-affected groundwater source (deep or shallow well)	- <u>Bucket chemically assisted removal (coagulation)</u> 1) - <u>Bucket spontaneous removal (under specified conditions</u> 2)	No acceptable and appropriate technologies available
Start with a new arsenic-free Ground water source 3)	Well < 10 m deep - Very shallow shrouded Tubewell + Handpump - Dug well + Handpump	Well < 10 m deep: - Very shallow shrouded Tubewell + Handpump - Dug well + Handpump Well > 200m deep - Deep well + Handpump - Deepwell + motorized pump and (limited) distribution
Start with a Rainwater source 4)	- *Individual, Household-based Rainwater Harvesting from rooftops*	- *Rainwater Harvesting from rooftops of public buildings* - *Rainwater Harvesting from house rooftops to common reservoir*
Start with a Surface water source (pond)	Pond NTU<1, FC<10/100 ml Community based Handpump abstraction, followed by household- based disinfection - <u>*Chlorine Tablets*</u> 5)	Pond NTU<1, FC<10/100 ml - Handpumped abstraction plus household-based disinfection (see left hand box)

	- *Bleaching Powder* 5) - Boiling - Solar Disinfection (SODIS) 6) Pond NTU<10, FC<100/100 ml Community based Handpump abstraction, followed by household treatment (and disinfection as above) - Conventional Household filtration 7) - *Household treatment by using alum* 8) - Treatment by Moringa Oliefera seeds 9)	Pond NTU<10, FC<100/100 ml - Handpumped abstraction plus household-based treatment and disinfection (see box to left) Pond NTU<100 - *Pond sand filter* 10) and optional disinfection (see left hand box)
Share an existing source (deep or shallow well)		- *Sharing arrangement between existing and new users*
Import water	- Bottled water	- Tanker water

Legend Bold- proven in Bangladesh, *Italics- proven elsewhere and considered feasible*, *Italics with underlines*- Proven and used in Bangladesh, but effective only with due care, Underline- Experimental or ill-documented, but considered feasible with due care

Notes

1) Extreme caution with dosing and sludge disposal
2) Actual removal water-matrix specific, As effluent may not be below standard.
3) Subject to testing for As, and FC (shallow wells only) Deeper, machine drilled wells will be too costly for household use
4) Design guidelines for Bangladesh are yet to be established, periodic disinfection may be required
5) Dosing must be appropriate
6) Selection of appropriate bottle and correct placement of bottle during use are critical
7) Produces water with slightly elevated FC, must be periodically cleaned and disinfected
8) Appropriate dosing must be determined, associated risk of excess alum ingestion
9) Appropriate choice to be advised
10) Pond-sand filter needs to be re-designed to reduce present operating deficiencies

3.10 Potentially suitable technologies for use in the project

Table 3.8 presents a list of other potentially suitable technologies, distinguishing for household level solutions and community level solutions. Some of these technologies could possibly be applied in the future.

Table 3.8: The potentially suitable, additional technologies

Application *Options*	*Household level*	*Community level*
Treat water from existing source (deep or shallow well)	– Sand-Khoa filtration (aeration-filtration) – Chemical package (improvement required) – Commercially available filter - local – Commercially available household units (membrane distillation, ion exchange)	– HP + iron removal plant (aeration) – Arsenic treatment at tubewell site – DANIDA designed arsenic removal plant – Arsenic treatment inside tubewell.

Start with a Surface water source (pond)	– Commercially available filtration units- improved	– Roughing filter + Slow sand filter

3.11 The Capital Cost of the Acceptable Technologies

Most of the acceptable technologies requiring capital investments are described in the Fact Sheets of Chapter 5 of the Source Book. Drawing the capital cost data from these sheets, an impression can be obtained on the comparative cost of these technologies. All technologies are meant to deliver the same 5 liters per capita per day. There are differences between the technologies however. These differences, that are very important when assessing the capital costs, are the following: 1) the number of families served from the technology; this varies from 1 family for a rooftop based rainwater harvesting system to 600 families for a village based deepwell with motorized pump; 2) the service levels differs in terms of walking distance; the water may be drawn from a rainwater tank by the side of the house at say 5 meters distance, or may need to be carried from the village level reservoir at several hundred to one thousand meters away from the home.

Following user groups have been distinguished for enabling the cost calculations: a single family (6 persons), a family compound (6 families living in one compound - usually an extended family), cluster (5 family compounds situated closely together), a village (20 clusters).

Typical user groups have been assumed for each of the technologies, as shown in Table 3.9. In some cases the size of the user group was obvious, or had to be made while making the concerned cost calculation, as in the case of the bucket-type removal (obvious - 1 family), the rainwater harvesting system (conditioned by cost calculation - 1 family), the tubewell with motorized pump and distribution (same - 600 families). For the other technologies, either use by a cluster of family compounds, or by an extended family (family compound) has been assumed. The choice has been guided primarily by present practice and cost. Where these are high such as in the case of the pond sand filter, the deep tubewell and the ringwell, cluster use has been assumed. Where the cost is relatively low, family compound use has been assumed.

Table 3.9. Capital Cost of Technologies

Technology	Approximate Capital Cost (Taka)	Typical User Group (F = family)
Arsenic removal: bucket type	1,500	Family (1 F)
VSST + handpump	7,158	Family Compound (6
Rainwater harvesting system	7,725	F)
Pond sand filter	18,809	Family (1 F)
Deep Tubewell (200 m) + handpump	46,028	Cluster (30 F)
Ringwell + handpump	56,750	Cluster (30 F)
Deep Tubewell + motorized pump		Cluster (30 F)
a. With 1 village-level reservoir	1,021,050	
b. With distribution to 20 cluster-level tanks	1,768,100	Village (600 F)
c. With distribution to family compound	2,258,100	Village (600 F)
tapstands		Village (600 F)

In table 3.10 the per family capital costs have been calculated using the assumptions made above. The technologies have been arranged in order of the water source options. The per family cost when calculated this way vary between a low Taka 630 for the cluster-based pond-sand filter and Taka 7,725 for the family-based roofwater harvesting system. Most technologies cost between Tk. 1000 and 3000.

Table 3.10. Capital Cost of Technology per Family of Six Persons for a Water Supply of 5 lpcd

Technology	Approx. Capital Cost per Family (Taka)	Walking Distance in meters	Typical User Group (F = family)
Shallow, arsenic-free groundwater:			
• VSST + handpump	1,193	15 m	Family Compound (6 F)
• Ringwell + handpump	1,891	50 m	Cluster (30 F)
Arsenic-contaminated groundwater:			
• Arsenic removal: bucket type	1,500	-	Family (1 F)
Deep, arsenic-free groundwater:			
• Deep Tubewell (200 m) + handpump	1,534	50 m	Cluster (30 F)
• Deep Tubewell + motorized pump			
a. with 1 village-level reservoir	1,701	1000 m	Village (600 F)
b. with distribution to 20 cluster-level tanks	2,946	50 m	Village (600 F)
c. with distribution to family compound tapstands	3,764	15 m	Village (600 F)
Rainwater:			
• Roof water harvesting system	7,725	5 m	Family (1F)
Surface water from pond:			
• Pond sand filter	630	50 m	Cluster (30 F)

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4. The Technology Selection Process

4.1 Introductory Remarks

The technology selection process will depend largely on the basic strategy applied by planners as well as the general trends that are emerging in the water and sanitation sector. A basic principle outlined in this document is the need to involve communities right from the start in the selection of technologies. Hence, agencies, communities and users should work together as partners, and plan subsequent activities in mutual agreement. This prerequisite is particularly important in the context where users and communities, both men and women, are more and more endowed with the responsibilities, maintaining and managing their water supply systems.

Concerning technology, various formulations can be found in the literature, such as appropriate technology, progressive technology, intermediate technology, village technology, low-cost technology, labor intensive technology, self-help technology or technology with a human face. A technology should, as much as possible, match people's needs, expectations, preferences and cultural habits. It should be convenient, manageable, maintainable and affordable.

Furthermore, there is a tendency to decentralize O&M activities and to permit, encourage and stimulate the involvement of the private formal or informal sector in maintenance activities. The trend towards greater involvement of the private sector, in both the construction and upkeep of water supplies, brings potential advantages of flexibility and cost efficiency to operation and maintenance activities. However, the interest of private sector involvement may be limited by the low profit margin, particularly in scattered rural communities.

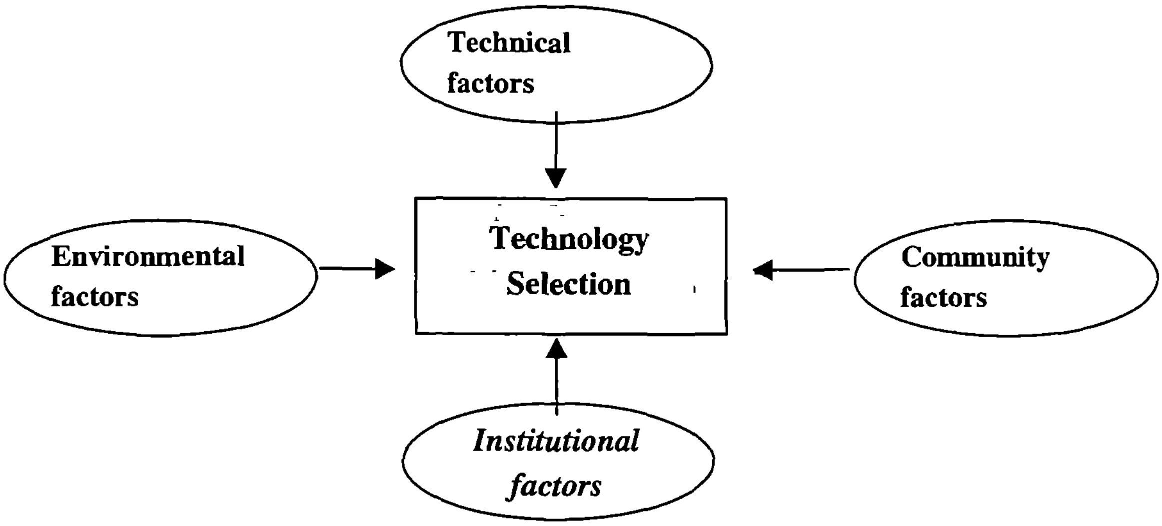
In the absence of rigorous control and regulation there is a problem of private sector accountability Communities that contract services from the voluntary and private sector need to be sure that they get a job well done at fair price. To some extent, communities themselves can monitor the quality of work. The control system and procedures may, initially, require water agency assistance. If the private sector is to be promoted, guidelines must be developed and communicated to the communities to ensure cost-effective interventions and minimum quality standards for the work. Any such monitoring and regulation will have a cost which governments will need to meet.

Governments provide the framework within which O&M policy is developed. The role of government is vital to create an 'enabling environment', one of the key elements of sustainability. Appropriate legal provisions, regulations, education, training and information can foster an enabling environment If a supportive O&M policy is not forthcoming from central government then support for O&M at the local level will be considerably hindered.

Local government promotes an awareness of national policies and supports water user committees. However, many local government departments are under-resourced and are unable to give effective support. The degree of support may also be influenced by local politics.

4.2 Factors Influencing Water Supply Technology Choice

In this section, an overview of the factors influencing technology choice is provided, because linking technology choice with operation and maintenance is a part of a larger context. The factors can be grouped in four different fields, as shown in the tables below, each with a series of key criteria to be considered.



Factors influencing technology choice with their specific O&M criteria

Factors	*General criteria*	*Specific O&M criteria*
Technical factors	- Technical standards - Demand (present and future consumption patterns) versus supply. - Capital costs - Extension capacity. - Compatibility with norms and legal framework - Compatibility with existing water supply systems - Comparative advantages. - Technical skills needed within or outside the community.	- Dependence on fuel, power, chemicals. - Quality and durability of materials - Availability and price of spare parts and raw material. - Operation and maintenance requirements. - Compatibility with users' (men's and women's) expectations and preferences. - Availability of mechanics, plumbers, carpenters, masons in or outside of the community. - Potential for local manufacturing - Potential for standardization - Dependence on imported material and parts.

Factors	*General criteria*	*Specific O&M criteria*
Environmental factors	- Availability and reliability of water sources (springs, groundwater, rainwater, and surface water, streams, lakes and ponds). - Seasonal variations. - Water quality and treatment needed. - Water source protection. - Risk for negative impact - Waste water drainage. - Accessibility.	- O&M implications of water treatment. - O&M implications of water source protection and wastewater drainage - Existence and use of alternative traditional water sources.
Institutional factors	- Legal framework - National strategy. - Existing institutional set-up. - Support from government, Non Government organizations, External Support Agencies. - Stimulation of private sector. - Availability and capacity of training - Practice of know-how transfer - Skills requirement (software). - Monitoring	- Roles of different stakeholders and ability/willingness to take responsibilities (O&M) - Potential involvement of private sector. - National budget allocations for O&M and subsidies. - Training and follow-up - Does the technology match the existing O&M system, or does the O&M system have to be adjusted to the most suitable technology.
Community factors	- Local economy. - Living patterns and population growth. - Living standards and gender balance - Household income and seasonal variations - Users preferences. - Historical experience in collaborating with different partners - Village organization and social cohesion	- Managerial capacity and need for training - Willingness and ability to pay. - Gender balance - Perception of benefits from improved water supply - Felt need - Cost/quality awareness - Level of recurrent costs to be met by the community. - Payment system and availability of financial resources - Availability of technical skills. - Ownership.

Linking operation and maintenance and technology selection encompasses not only technical, environmental, institutional and community aspects, but also the testing and feasibility of the O&M system required. An O&M system is the framework defining all actors and their involvement in O&M, the way they are organized and interrelated to one another.

Choosing an appropriate water supply system needs to match the basic criteria for technology selection as outlined in the table above, with the involvement and participation of users and community right from the start.

Experience shows that non-technical issues play a considerable role in determining the effectiveness of O&M. Therefore, personnel involved in O&M assessment and development should cover a range of relevant disciplines: social development, economic, health, management, as well as engineering. It is important that the process is consultative and carried out in partnership with the operators and users of schemes.

Rehabilitation of defective schemes can provide an economic alternative to investments in new projects, but that decision should not be automatic. Just as with a new scheme, the rehabilitation option has to be evaluated by balancing community needs, preferences and capacity to sustain the option with the support potential of the water agency. In assessing the scope for rehabilitation, the community and the agency together need to review what made the system breakdown, with a problem analysis and recommendations of feasible technologies. Furthermore, rehabilitation should not simply be a matter of replacing broken equipment or infrastructure. The most common cause of failure is organizational.

If a risk analysis is carried out for each water supply option then an attempt can be made to anticipate factors, which may change and affect O&M. This will not be easy, especially is unstable economics where inflation and the availability of imported equipment and spare parts are difficult to predict. However, a comparison of technologies can indicate the degree of risk attached to each option.

4.3 The Process of Community Water Supply Technology Choice

The process of water supply technology choice should have a series of steps, which include in a direct or indirect way all the factors and subsequent criteria for technology choice mentioned earlier. Operation and maintenance, being part of the process, cannot be dissociated from all key factors. The following steps are proposed:

1 **Community is selected** for water supply improvement when it demonstrates demand for the service (demand-driven approach). This could be preceded by general promotion and mobilization campaigns, and by prefeasibility assessments which assess-demand, assess levels of arsenic contamination, and the willingness, in principle, of villagers to contribute to the potential scheme in case and kind. Motivation and users' (men's and women's) expectations and preferences should be addressed in broad terms at this time.

2. **Initial service level assumptions** – what service level corresponds to the environment and users' (men's and women's) preferences? What are the comparative advantages between various options? These questions are answered in detail through a four to six month planning process, in which the answers are expressed by the community through their own inquiry process

3. **Participatory Mapping and other Investigations**– This is part of a larger Community Action Planning Process (CAP) which enables the community to organize effectively, and make educated choices about the selection of technology options, using technical staff as "consultants" while retaining responsibility as the scheme managers for decision-making,

procurement and execution of the scheme. Using a range of tools, such as Village and Resource Mapping, questions such as these are first researched by the villagers:

- What reliable water source is available?
- Can this source provide the required quantity and quality of water?
- What is the treatment needed?
- What materials and spares and skills are needed to sustain the desired service level?
- What is the most appropriate structure to sustain the desired service level that corresponds to the management capacity of the communities?
- What are the costs (capital and recurrent) of options considered?
- What are the financial resources available and the willingness to pay?
- What is the present approach to O&M applied within the program or the country area?
- What are the causes and effects of poor O&M within the area?
- Should technology match the available O&M system and capacity (including spare parts distribution), or should the O&M system be adjusted to match the most suitable technology?
- What type of support can the communities receive, in terms of technical, financial and capacity building assistance?

4. **Collection of local information** by agencies, including confirmation on validity of collected data by local resource persons (hydrological, technical and institutional data, as well as assessment of human resource development and capacity building). SAs and SOs, for example, can collect this, and help verify scheme choices made by the community.

5. **Analysis of data regarding choices** by the users, with the assistance of technical staff of SOs and SAs. Basically, the technical staffs serve as "architects" to fulfill and test the feasibility of the technical options selected by the community.

6. **Choice of Technology(ies) by the users**, considering all O&M implications and commitment to long-term management of O&M. Clarification should be made at the same time with regard to all necessary adjustments of the existing O&M system, with a definition of the responsibilities of the actors implied in the development of the project. The community is encouraged to prepare a rough layout of their scheme, and detail, for example, source points and other information they wish to include in the scheme. If a basic choice is ill informed, the SO may advise the community to reconsider and provide the rationale. Also, a SA or RPMU staff (the portfolio manager) later conducts a site appraisal to ensure sound technical choices are made. After an agreement is reached, the SO Engineers carry out a field survey and complete the design and estimates.

7. **Formal agreement on technology selection** between community and all partners involved, once the survey is conducted and discussed in detail at an "agree to do meeting" between the SO and the Community in a community-wide meeting. Is the technology and service level affordable, manageable and agreed between all partners? Once agreed, and all details reviewed, the community prepares its Implementation Proposal.

8. **Development of the project:** The proposal, which also includes an overall Action Plan, is prepared and submitted, and presented to the PMU.

4.4 Factors Influencing Sanitation Technology Choice

The past has shown that many sanitation projects followed a technical approach where the intervention and the type of the technology were determined by the implementing agency. Demand for sanitation was not assessed. Hardly any communication between the future users and the project took place, and social, gender, cultural and religious aspects were not sufficiently taken into consideration in the project approach.

In other cases, environmental factors were not considered in the design, leading to the collapse of pit walls and unsafe situations. In low-income urban areas, where pit emptying is a necessity, such services were often absent, or could not be sustained. Hygiene education for changed sanitation behavior was hardly included in the sanitation project approach, as this had another time-scale of implementation.

Planning for sanitation interventions requires a comprehensive approach with many aspects to be included. The factors which influence sanitation technology choice can be grouped into four different groups, and the specific O&M criteria area a part of general context, see diagram below.

Factors influencing sanitation technology choice:

Factors	*General criteria*	*Specific O&M criteria*
Technical factors	- Technical standards. - Availability of construction material - Cost of construction - Design preference (sub-structure, floor slab, squatting or raised seat, and superstructure).	- O&M requirements - Ease of access. - Use of decomposed waste
Environ-mental factors	- Soil texture, stability, permeability. - Ground water level. - Control of environmental pollution. - Availability of water	- O&M implications for environmental protection - Groundwater contamination

Factors	*General criteria*	*Specific O&M criteria*
Institutional factors	- Existing national/local strategies. - Role and responsibilities of actors implied - Training capacity - Availability of subsidies and loans. - Availability of masons, carpenters, plumbers, sanitary workers, pit emptiers and diggers.	- Pit emptying services (municipal/private). - Sewerage maintenance capacity. - Potential involvement of private sector. - National budget allocations for sanitation. - Training and sensitization
Community factors	- Socio-cultural aspects Taboos, traditional habits, religious rules	- O&M costs. - O&M training and sensitization

	and regulations, cleansing material, preferred posture, attitude to human feces, gender-specific requirements - Motivation aspects: Convenience, comfort, accessibility, privacy, status and prestige, health, environmental cleanliness, ownership - Discouraging factors: Darkness, fear to fall in hole, fear of collapsing pit, fear to be seen from outside, smells, insect nuisance - Social organization factors: Role of traditional leadership, religious leaders, school teachers, community-based health workers - Population factors: Population densities, limited space for latrines, presence of communal latrines.	about sanitation - Health awareness and perception of benefits. - Presence of environmental sanitation committee. - Women groups - Social mobilization on hygiene and sanitation behavior.

The philosophy of considering upgrading the existing sanitation facility, as the first option for improvement of the sanitation conditions, is based on the understanding the existing sanitation facilities are a reflection of the local and cultural preferences, as well as the local economic and technical capacities. If existing facilities are not meeting basic hygienic requirements, then upgrading hygienic shortcomings is to be considered first. If no sanitation facilities are present, the simplest hygienic shortcomings is to be considered first. If no sanitation facilities are present, the simplest technology is to be considered, tanking into account the factors mentioned before.

4.5 The Process of Low-Cost Sanitation Technology Choice

It is assumed that the following technology selection process is preceded by, or based upon, a participatory needs assessment, carried out following an expressed demand for improved sanitation facilities. Hygiene awareness and promotion campaigns can result in an increase in the demand for improved sanitation facilities. The process of choosing sanitation technology should include at least the following steps by the community with help from the SO:

1. **Participatory assessment of problem** related to the existing human excreta disposal system, hygiene behavior, hygiene environment and human excreta-related diseases.

2. **Participatory assessment of cultural, social and religious factors** influencing human excreta disposal and sanitation technology choice.

3. **Participatory assessment of local conditions**, capacities and resources (material, human resource and finance).

4. **Identification of local preferences** for sanitation facility and possible variations.

5. **Matching preferences** with local capacities and environmental conditions as well as contamination risks.

6. **Determination of O&M requirements** and other implications of pre-selected technology.

7. **Discussion with the community** about the implementation of different sanitation technologies.

8. **Selection of technology**.

Information, Education, and Communication (IEC) activities to promote safe sanitation behavior and proper hygiene should accompany sanitation facility improvement. These activities have a longer time horizon than the physical improvement of structures. An important role is to be taken by schools, institutions, churches and social community groups to promote proper hygiene and sanitation behavior. Attention must be paid to the selection of the most appropriate technology, design and site, in order to prevent possible pollution of the environment, in particular water resources and direct living environment. Control measures must be carried out to minimize these risks.

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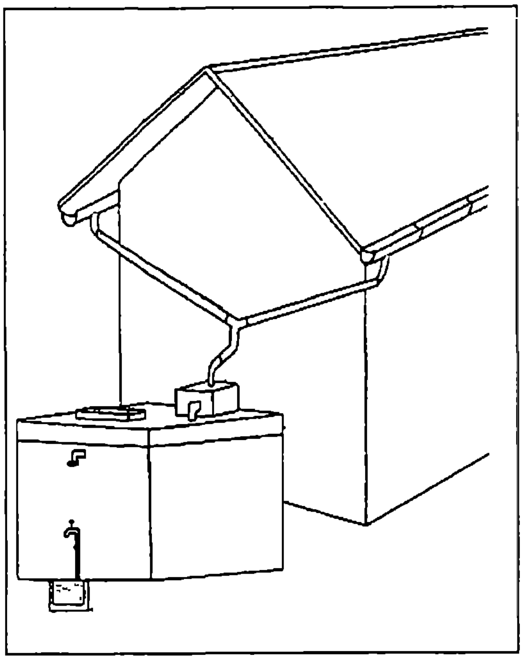
5. Fact Sheets Water Supply Technologies

5.1 Rainwater Harvesting (Rooftop Catchment)

1. Brief description of technology



Rainwater can be collected from roofs of buildings, courtyards or large ground catchments. Rooftop catchments are usually best for satisfying the domestic requirements of family. Rooftop harvesting systems are comprised of the rooftop as the catchment area, connected by gutters and pipes to a storage container. The most suitable rooftop surfaces are corrugated iron sheet, although tiled and asbestos-sheet roofs can also be used. Thatched roofs pose problems, as the runoff is inadequate both in quality and quantity. Rooftop catchment systems collect rainwater precipitated on the roof using gutter and downpipes (made of local wood, bamboo, GI or PVC) and lead it to one or more storage containers ranging from simple pots to large masonry concrete or ferrocement tanks.

A wide range of tanks is being used for the rainwater storage in the different parts of the world. The most important are:

- Cement Water jars
- Standing tanks (ferrocement, brick masonry or RCC)
- Sub-surface ground tanks (ferrocement, brick masonry or RCC)
- Factory-made tank (pre-fabricated made of either PVC or galvanized iron sheet)

If properly designed, a first flush device or detachable downpipe is fitted for exclusion of the first 20 liters of runoff during a rainstorm, which is generally most contaminated with dust, leaves, insects and bird droppings. Sometimes runoff water is led through a small filter consisting of gravel, sand and charcoal before entering the storage tank. Water may be abstracted from the tank by a tap or handpump.

Yield: Potentially almost 1 liter per horizontal square meter per mm rainfall. This quantity is usually sufficient for drinking purpose.

Area of use: At the places where one or two rainy seasons (especially in arid and semi-arid zones with average annual rainfall figures ranging from 250-750 mm) and where other improved water supply systems are difficult to realize.

Construction: Systems are usually produced locally.

2. Capital cost

The capital cost of rainwater storage depends on materials and size of the tanks. Rainwater storage tanks are not widely used in Bangladesh and water storage for long-term use is still at research stage in Bangladesh.

Botswana has a long experience with rainwater harvesting. The capital cost of the three major types of rainwater storage tanks can be compared with their life expectancy (see Table 5.1).

Table 5.1: Cost and Life-expectancy of different types of reservoirs

Type of Tank	*Construction cost (P per m^3)*	*Estimated Life Expectancy (yr.)*
Corrugated iron tank	About 70 P, decreasing to 55 P with increased capacity	8-15
Ferro-cement structures	About 50 P decreasing slightly with the increased capacity	15-20
Reinforced brick tank	About 100 P, and above 100 m^3 decreasing 85 P	30-40

3. Description of O&M activities

Operation: In case there is no first flush device, the user has to divert away the first 20 liters or so of every rainstorm. Fully automatic first flush devices often are not very reliable. Water is taken from the storage tank by tapping, or pumping.

Maintenance: Just before the start of the rainy season, the complete system has to be checked for any damage of the components and repaired if necessary. Taps should be serviced.

During the rainy season the system is checked regularly, cleaned when dirty and after every dry period of more than a month. Filters should be cleaned every few months, filter sand should washed at least every six months and painting of the outside of ferrocement, masonry, concrete and metal tanks may be needed about once a year. Leaks have to be repaired throughout the year. Chlorination of the water is necessary.

The users of the system can normally execute all operation and maintenance activities. A local craftsman, using locally available tools and materials can usually execute major repairs such as that of broken roof or tank. Maintenance is simple but should be given ample attention.

O&M requirements:

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning system	1-3 times per year	Local	Water	Broom, brush, bucket
Diverting first flush	Every storm	Local		

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning filters	Twice a year	Local	Water	Screen, spade, bucket
Disinfecting reservoir	Occasionally	Local	Chlorine	Bucket
Repairing roof, gutters & piping	Occasionally	Local	Tiles, metal sheet, asbestos cement sheet etc., bamboo or PVC pipes, nails, wire	Hammer, saw, pliers, tin cutter, chisel
Repairing tap	Occasionally	Local or area	Washers	Spanner, screwdriver
Painting outside of metal reservoir	Annually	Local	Anticorrosive paint	Steel brush, paintbrush
Repairing ferrocement reservoir	Occasionally	Local	Cement, sand, metal mesh, wire	Trowel, bucket, pliers, steel pan

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Divert first flush, close taps after taking water, keep system clean	No special skills
Caretaker	Check functioning, , clean filters and rest of system, perform small repairs	Basic skills
Water committee	Supervise caretaker, collect fees	Organizational skills
Local craftsman	Repair roof, piping and tank	Basic plumbing and masonry
External support	Check water quality, stimulate and guide local organization, train users	Microbial analysis, extension work

Organizational aspects: The organization of O&M of community shared roof or ground tank supplies is considerably more difficult than for privately owned systems. Rooftop harvesting systems at school for instance may suffer water losses from a tap left open and padlocks are often needed to ensure careful control over the supply. Ideally one person should be responsible for overseeing the regular cleaning and occasional repair of the system, control of water use etc. Where several households have installed a communal system, for instance, several roofs connected to one tank, a village water and sanitation committee of the users shall manage distribution and O&M activities. This may include collection of fees, control of the caretaker's work and of the water use by each family.

A village water and sanitation committee can play an important role in monitoring the condition of the systems and the water quality, providing access to credit facilities in order to buy or replace a system, training of users/caretakers for management and execution of O&M, and training of local craftsmen for larger repairs.

Recurrent costs: Recurrent costs for materials and spare parts are very low. Generally these costs are negligible. The recurrent personnel costs, in cash or kind (for caretakers and craftsmen), will need to be added.

4. Problems

Corrosion of metal roofs, gutters etc. Failure of functioning of the first-flush diverter due to neglect of maintenance. Leaking taps at the reservoir and problems. Tanks may provide a breeding place for mosquitoes, which may increase the danger for diseases such as malaria or dengue.

5. Limitations

The water may be inadequate to meet the drinking water demand throughout the year, making it necessary to look for alternative sources or go back to traditional sources to overcome this problem.

The initial investment cost needed for the construction of a tank, accessories and suitable roofing may often go beyond the financial capacity of rural households or communities (low-income group).

6. Arsenic Mitigation Efficiencies

The rainwater has virtually no bacterial or arsenic content. However, in using rainwater for drinking water supplies, it is not so much the quality of the rainwater itself that is important, but rather the quality of the water as drawn from the storage tank in which the water is collected and stored for later consumption. The issues with water in storage are related to the bacteriological quality, not with the arsenic content. The stored rainwater is free from arsenic contamination.

7. Remarks

Thatched roofs produce inadequate water both in terms of quality and quantity. It is also more difficult to fix gutters to thatched roofs. The water collected from thatch is usually colored, unattractive and more often contaminated. Tiled or metal roofs give the cleanest water .The acceptance of rooftop water harvesting as a suitable system may depend on the users' perception regarding the taste of the water.

Example for Calculating Volume of Rain Water Harvesting System by a Simple Method

Assumptions

No. of persons in family n = 5
Average consumption per capita q= 5 liters/ day for drinking only
Annual rainfall p = 750 mm
Runoff coefficient f= 0.8 (for corrugated metal sheet)
Dry period t =250 days
Size of roof = 5m x 4m

Calculations

Consumption for dry period

$Q_a = n \times q \times 250$
$= 5 \times 5 \times 250 = 6250$ liters $= 6.25\ m^3$

Required roof catchment

$A = Q_a / (f \times p)$
$= 6.25 / (0.8 \times 0.75) = 10.4\ m^2$

Required Tank Volume

Assuming that the tank will be full at the start of the dry season and only has to satisfy the water needs for the dry period; and no evaporation of stored water will take place, the required tank volume

$V = t \times n \times q = 250 \times 5 \times 5 = 6250$ liters = 6.25 cum say 7 cum

Length of water collecting channel = 2 x length of roof + width + extra up to first flush diverter
= 2 x 5.0 + 4.0 + 2.0
= 16 m

Note The required storage volume calculation depends on the monthly rainfall data, pattern, roof size, family size, and demand The other methods to calculate the rainwater storage volume are mass curve analysis and minimum volume and minimum catchment method

Example for calculating cost for rainwater harvesting system (3200 liters storage tank and collection system)

SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	Cement	10 bags	250/bags	2500 00
2	Sand- good quality	1.13 m^3	530/ m^3	600.00
3	Local sand- for filling	0.57 m^3	353/ m^3	200 00
4	Khoa	0.28 m^3	1060/ m^3	300.00
5	MS wire	4.5 kg	30/kg	135.00
6	Wire Mesh (net)	1roll (14 sqm)	600/roll.	600.00
7	Gutter	9 nos.	70/no.	630.00
8	GI wire	2.5 kg	45/kg	113.00

9	GI pipe with Ball valve (tap)	1 no.	125/no	125.00
10	PVC pipe	1 no.	35/no.	35 00
11	Elbow	1 no.	30/no.	30.00
12	Drainage pipe	1 no.	60/no.	60.00
13	Hanger or backed	16 nos.	LS	150.00
14	Mosquito net	As required	LS	5.00
15	Others (22 Gauge GI wire etc.)	-	LS	20.00
16	Contingency	-	LS	122.00
Labor				
17	Mason and helper	7 days	250/group	1750 00
Transportation				
18	Transportation of materials at site	-	L.S.	125.00
Tool set				
19	Slide Wrench	1 no.	75/no	75 00
20	Pipe Wrench	1 no.	125/no.	150.00
			Total capital cost =	7725 00

N.B The cost may vary location to location and quality of materials

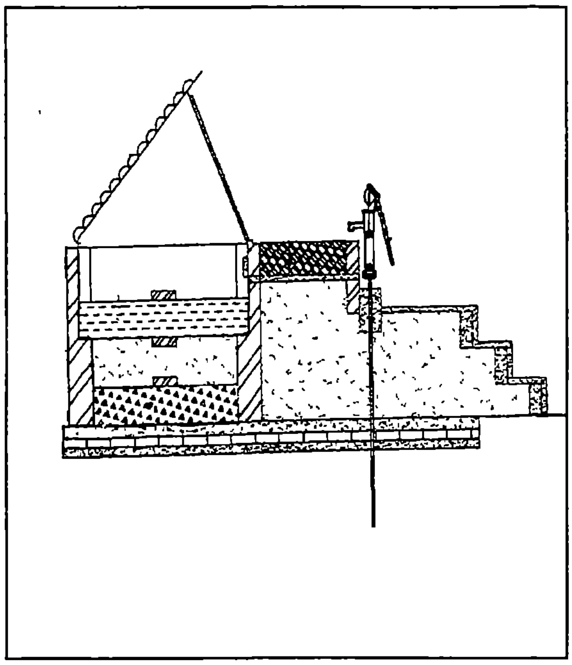
SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Mould sets				
1	Pre-cast cement segment mould	10 bags	100/nos.	1000.00
2	Lower cover mould- 3 types	3 nos.	500/no	1500.00
3	Upper cover mould	1 no.	550/no.	550.00
			Total capital cost =	3050.00

N B . The cost may vary location to location and quality of materials

5.2 Pond Sand Filter

1. Brief description of technology

A pond sand filter is a manually operated filtration unit of small size placed by the side of a pond. It is used to treat the pond water using the principle of slow sand filtration. It consists of small two chamber tanks constructed above the ground. Water is pumped up from a screened floating intake in the pond. This is done by a handpump The handpump discharges through a pre-filter into the water above the sand in the filter chamber. Brick chips are used as pre-filter. Water, which passes through the sand filter, is collected at the base of the filter chamber from where it flows into adjacent storage chamber. Water is drawn from the chamber using a tap.



It has been reported that water from a PSF is normally clear and bacteriologically safe or at least safe enough. Concentrations of more than 100 Fecal coli/100 ml in the rainy season are reported however, so care must be taken in promoting the technology as safe. Much depends on the quality of pond water and the periodic cleaning of the filters. The sand filter will get progressively clogged, and on average the operating period of a PSF between filter bed cleanings is 2 months. During sand filter cleaning, the top 3" of sand need to be scraped off, washed and dried, and replaced with clean sand.

Capital cost: The capital cost of a pond sand filter is Tk. 18, 000 to 30,000.

Yield: The effective capacity of a typical storage tank (3ft x 4ft x 5ft) is 1000 liters. About 500 people can use a pond sand filter for drinking water purposes.

Area of use: Where other safe water systems are not possible, and at places where people use ponds only for drinking water purposes, pond-sand filters may be an appropriate option. The pond must be large enough to ensure that it will not dry out in the dry season, at the time of the maximum use. For reasons of palatability, the salinity and iron content of the pond water must not exceeded 600 mg/l chloride and 5 mg/l respectively at the any time of the year.

Construction: Systems are usually produced locally.

2. Description of O&M activities

Operation: The filterbed must be permanently submerged, and a minimum flow of the water must be maintained to provide the microorganisms in the filterbed with a stable flow of nutrients and oxygen. Users must pump into the unit in order to draw from the outlet. The inspection cover has to be closed at all times except during the cleaning of the PSF. The raw water quality and treated water quality must be monitored on regular basis.

Maintenance: Filter cleaning is the main maintenance activity of the pond sand filter. The caretaker family is trained to clean the PSF. The PSF requires cleaning when the filtration rate falls below the tolerable rate The cleaning of PSF mainly comprises scraping off 3 inches of sand from the top of the filter and replacing with clean sand The scraped sand is washed, dried in sun and stored for future use. The users of the system can normally execute all operation and maintenance activities. The repair of lid is within the competence of any local carpenter. Maintenance specifically cleaning is simple but should be given ample attention.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Checking inflow	Daily	Local		
Cleaning site	Daily	Local		Broom
Scraping off sand, wash, dry and store	Occasionally	Local	Water, disinfectant for tools	Bucket, ladder, broom, wash basin
Resanding filter	Occasionally	Local	Clean sand, disinfectant for tools, water	Sieve, bucket, ladder
Cleaning of pre-filter	Occasionally	Local	Water	Bucket, ladder, broom, wash basin
Repair of lid	Occasionally	Local carpenter	Wood, nails	Hammer, saw, pliers, chisel
Replacement/ repair of movable parts	Occasionally	Local	Parts like hose pipe	Spanners, screwdriver, wrench
Oiling of pump handle fulcrum pins	Occasionally	Local	Mustard oil	
Repairing roof, gutters & piping	Occasionally	Local	Tiles, metal sheet, asbestos cement sheet etc., bamboo or PVC pipes, nails, wire	Hammer, saw, pliers, tin cutter, chisel
Repairing tap	Occasionally	Local or area	Washers	Spanner, screwdriver
Analyzing water quality	Regularly	Local or area	Water sample, test media	Test kit

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Close tap after taking water, pumping, keep site clean, assisting in scraping and resanding of filter units	No special skills
Caretaker	Check functioning, , scraping off sand, resanding, cleaning of scraped sand, perform small repairs, regular monitoring	Fair understanding of filtration process and hygiene, organizational skills

Water committee	Supervise caretaker, monitor water quality, collect fees, organize scraping and resanding	Organizational skills, basic water quality testing skill
Local carpenter	Repair of lid	Basic carpentry skill
External support	Check water quality, stimulate and guide local organization, train users	Microbial analysis, training skills.

Organizational aspects: As the PSF is a small unit for 300-500 people, community involvement and maintenance is absolutely essential to keep the pond clean and the system safe and operational. The communal and safe use of a pond requires regularly organized education and communication sessions. These help to maintain a high level of motivation in the community so that all users continue to ensure the continued cleanliness of the pond, and resist the use of the pond for any other purpose than the collection of drinking water. Also, some level of organization is needed in order to have enough labor for scraping and resanding of filter units. Pumping of an amount of water to maintain the filtration rate is also an important activity. A local caretaker will have to trained and some other people may need training for water quality testing and to be able to replace the caretaker.

Recurrent costs: The caretaker's fee, test of water quality and the cost of additional sand are the main recurrent costs, assuming that water users provide occasional labor inputs free of charge

4. Problems

The problems encountered are low discharge, difficulties or laxity in washing the filter beds, quality problems because of poor pond water quality, or infrequent resanding. After the resanding the filter does not deliver disinfected water for a few days.

5. Limitations

The problem of preventing the pond from any other uses and unwanted inflows. To safeguard the wholesomeness of the water additional treatment at the home is required. Construction, operation and maintenance of PSF are difficult. The effective use of PSF is largely depends on the community participation and their willingness to operate and maintain the system. Improper operation and maintenance can make the system ineffective. Sometimes, pipe breaks the under drain and collects water directly below the filter bed. It creates problem with the weir system of the filter and filter bed becomes dry. The community should be properly mobilized and trained for PSF operation and maintenance.

6. Arsenic Mitigation Efficiencies

The pond sand filter uses the water extracted from the pond. As the pond water contains nil or negligible concentration of arsenic, the treated water from the pond sand filter is also free from arsenic contamination (Bangladesh limit 0.05 mg/l).

7. Remarks

PSF has not yet established as successful and low cost technology option. Therefore, further research is needed on its performance, O&M and users' reaction.

Example for calculating cost for pond sand filter for 300 people

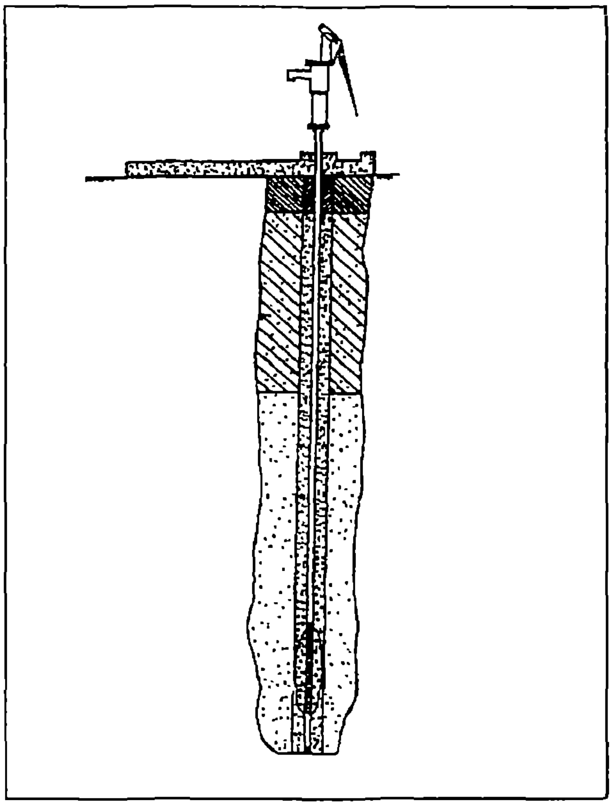
Sl. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	Pump assembly	1 no	800/no.	800.00
2	GI pipe	1.5 m	300/m	450.00
3	38 mm PVC pipe	31 m	50/m	1550.00
4	38 mm sand strap	0.72 m	75/m	54.00
5	38 mm strainer	2 m	75/m	150.00
6	Adapter	1 no.	30/no.	30.00
7	Cement	13 bags	250/bag	3250.00
8	Brick	950 nos	3/no.	2850.00
9	Khoa	0.625 m^3	1050/m^3	660.00
10	Khoa (Filter)	0 45 m^3	1050/m^3	450.00
11	Sand (Masonry)	1.7 m^3	530/ m^3	900 00
12	Sand (Filter)	1 42 m^3	1050/ m^3	1500.00
13	Sand (Filling)	0.425 m^3	175/ m^3	75.00
14	Other materials	-	-	2500.00
Labor Cost				
15	Mason- skill	9 days	150/day	1350.00
16	Helper & Labor	15 days	80/day	1200.00
17	Carpenter- skill	LS	-	150.00
Transportation				
18	Transportation of materials at site	-	L.S.	500.00
Tool set				
19	Wrench set	1 set	200/set	200.00
20	Pipe wrench	1 no	150/no.	150.00
21	Screw driver	1 no	40/no.	40.00
			Total capital cost =	18809.00

N B The cost may vary location to location and quality of materials

5.3 Very Shallow Shrouded Tubewell

1. Brief description of technology

A very shallow shrouded tubewell is a special type of technology used in installation of handpump mounted tubewells in a fresh water pockets. The strainer of this type of tubewell is usually shrouded by coarse sand to obstruct the fine sand or clay and to facilitate the pumping of water. Shallow tubewells are operated in a suction mode that can abstract groundwater from shallow depth by creating a vacuum in the suction pipe. The suction handpump can practically extract water from up to a depth of 7.5-m static water level. The very shallow shrouded tubewells work on the same principle, but are installed in appropriately very shallow fresh water pockets. These special types of tubewell are installed between 8 to 10 meters below the ground level.



These tubewells can operate where a pocket of fresh water exists and where an aquifer (a sand layer) exists within fresh water zone. A no. 6 handpump tubewell is the most common technology used for this purpose. The name comes from the barrel diameter of the tubewell in inches

Capital cost: The capital cost of this system is Tk. 7,000 to Tk. 11,000.

Range of depth: From 8 m to 10 m.

Yield: 0.4 to 0.6 l/s.

Area of use: At the places where suitable water pockets are available. It is mainly used in the saline belt of Bangladesh.

2. Description of O&M activities

Operation: Operation includes handling of the handpump, i.e., water is drawn from a well by moving a handle up and down. Men, women and children can easily operate the Handpump.

Maintenance: With most or all moving parts above ground level, no. 6 suction pumps are relatively easy to maintain. This can normally be done by the users themselves or by a village pump caretaker, using simple tools, basic spare parts and materials. The basic skills needed for preventive maintenance (e.g., greasing, being able to take pump-stand apart, replace spare parts etc.) can be taught to pump caretakers within few days.

Preventive maintenance usually consists of checking the pump's functioning and cleaning the platform and site daily, greasing weekly, checking of all parts of the pump stand monthly, taking the whole pump apart for a check, cleaning the parts with clean water and painting the pump stand annually. Usually most of these jobs can be done by one or two persons. During these inspections, smaller repairs like replacement of washers, etc. may prove necessary. For major repairs (e.g., broken of rising main, cracks in welding of metal parts), more highly skilled persons as well as more specialized tools and materials may be needed.

3. O&M requirements:

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Checking functioning	Daily	Local		
Cleaning system	Daily	Local	Water	Broom, bucket
Greasing pump stand parts	Weekly	Local	Oil or grease	Lubricator
Check pump stand parts	Monthly	Local		Spanners
Replacing pump stand spares	Occasionally	Local	Washers, cupseals, bearings etc.	Spanners, Wrench screwdriver etc.
Adjusting loose bolts	Occasionally	Local		Spanners
Checking whole pump	Occasionally	Local or area		Spanner, pipe wrench
Repairing broken spares	Occasionally	Area	Welding electrodes	Spanners, pipe wrench, welder, file etc.
Painting pump stand	Annually	Local	Anticorrosive paint	Brush
Repairing platform	Annually	Local	Cement, sand	Trowel, bucket, steel pan

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Pump water, keep site clean, warn in case of malfunctioning	No special skills
Caretaker	Keep site clean, give regular maintenance, perform small repairs, keep pump and site clean	Basic skills
Water committee	Supervise caretaker, collect contributions for maintenance and repair	Organizational skills
Area mechanic	Perform major repair	Basic plumbing, treading,

		welding
Local or area merchant	Sell spare parts	No special skills
External support	Check water quality, stimulate and guide local organization, train users	Microbial analysis, arsenic analysis etc.

Organizational aspects: The handpump can be a family pump and is cared by family members. For a community-based pump, the user group or the community will need an organization with several skilled persons. Private enterprises sometimes play an important role in performing repairs and selling spare parts.

Recurrent costs: Recurrent costs for materials and spare parts are around Tk. 300 to 400 per pump per year. The community will provide the labor. In case larger repairs are needed, mechanics or other skilled people will need to be added.

4. **Problems**

Worn washer, cupseals and bearings. Excessive corrosion causing pump rods and leaks in raising mains. Low quality of pumps and spares also cause problem. Repair always requires tools.

5. **Limitations**

Identification of existence of fresh water pockets is difficult. The life span of VSST is short. Drilling failure is common as VSST replies on to very specific conditions for success: can operate where a pocket of fresh water exists and where an aquifer (a sand layer) exists within fresh water zone.

6. **Arsenic Mitigation Efficiencies**

The water is withdrawn from very shallow depth. The groundwater within 10 m appears to be less contaminated. However, the water should be tested for arsenic and bacteriological standard before using as drinking water. The VSST is a groundwater extraction device, which can not remove arsenic itself. But it can be used for groundwater extraction where suitable water pocket is available.

7. **Remarks**

A VSST is very inexpensive and suitable in the saline belt area where appropriate fresh water available. It has very limited site specific application.

Example for calculating cost for very shallow shrouded tubewell

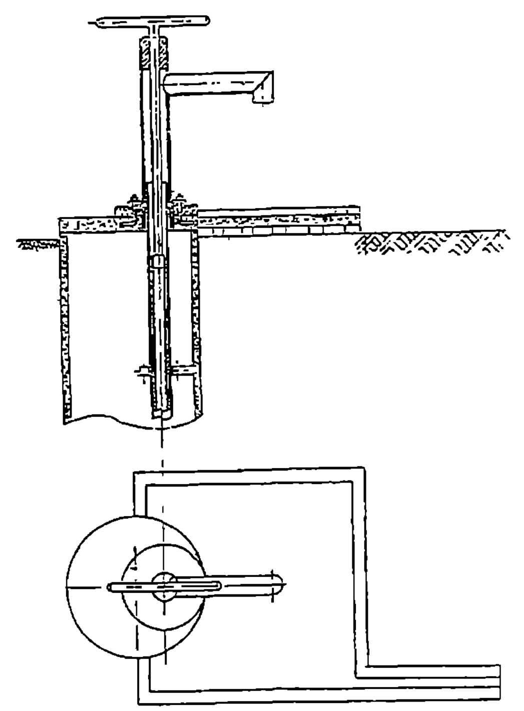
SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	Pump assembly	1 no.	800/no.	800.00
2	GI pipe	1.5 m	300/m	450.00
3	38 mm PVC pipe	8 78 m	50/m	439 00
4	38 mm sand strap	0.72 m	75/m	54.00
5	38 mm strainer	2 m	75/m	150.00
6	Adapter socket	1 no.	25/no.	25.00
7	Solvent cement 50 mg	1 no.	50 00/no	50.00
Sinking and Platform				
8	Sinking	13 m	150/m	1950.00
9	Platform	1 no.	2500/no	2500.00
Transportation				
10	Transportation of materials at site	-	LS	500.00
Tool set				
11	Wrench set	1 set	200/set	200.00
12	Screw driver	1 no.	40/no	40 00
			Total capital cost =	7158.00

N.B.: The cost may vary location to location and quality of materials.

5.4 Ringwell with Handpump System

1. Brief description of technology

A ringwell with a handpump is a modified form of the dugwell. The dugwell is the oldest and simplest method of groundwater abstraction. A hole is dug in the ground to a certain depth below the groundwater table for groundwater withdrawal. In a ringwell with a handpump system, the well is lined with precast concrete rings and water is drawn with the help of a handpump. The No. 6 handpump and Tara pump are mainly used for these purposes.



No special equipment or skill is usually required for the construction of the wells. These wells are dug by hand or by machinery. The depth of the well is dependent on the depth of water table and its seasonal fluctuations. The minimum depth of water column within the ringwell during peak dry season should be 1.75 m.

The type of handpump in the ringwell depends on the water level in the ringwell. Suction mode handpump No. 6 is used for a water table within the range of 0 to 8 m from ground level throughout the year and Tara pump for water table from 0 to 17 m from ground level.

The wells are normally 150 cm in diameter. The lining provides protection against caving and collapse of soils during construction and a seal against polluted water seeping from the surface into the well during operation. Normally a lining is provided up to clay layers (above groundwater level) and no lining is provided in the sandy layer. If a lining is provided in the sandy layer (under water level), the material is perforated with small holes or given a slightly different composition (e.g., permeable concrete or masonry jointed left open) as compared to the lining above the groundwater layer. The upper part of the well lining and the space between the wall and soil should be properly sealed to prevent the percolation of contaminated surface water.

The system consists of a platform depending on the type of handpump. The system also includes a drain to guide the waste water further away from the well, usually towards a soakpit, filled with large stones where the water can infiltrate back into the ground or evaporate from the stone surfaces at a safe distance from the well The expected life of a ringwell with handpump system is at least 50 years. Water in the well should be chlorinated for disinfection after construction.

Capital cost: The capital cost of this system is about Tk. 55,000 to 90,000.

Range of depth: From 10 m to over 30 m. However, the water within 10 m appears to be less arsenic contaminated. So, it is convenient to use the water within 10 m of depth.

Yield: About 5 cum. per day can be considered as a good yield.

Area of use: In areas where sinking tubewell is not possible by sludger method due to rocky/stony layers. It is suitable with aquifer minimal thickness (2 m) and adequate transitivity. The minimum depth of the water column within the ringwell during peak dry season should be 1.75 m.

2. Description of O&M activities

Operation: Operation includes handling of handpump, i.e., water is drawn-out from well by moving a handle up and down. Men, women and children can easily operate a handpump.

Maintenance: Usually little maintenance is required. Maintenance activities may consists of:

- For preventive maintenance of handpump to refer the fact sheet of shallow tubewell.
- Clean the platform and drainage and repair if required.
- Ensure that no latrines or other contamination sources are constructed within 30m from the well.
- Disinfection may be required occasionally.

Maintenance can normally be executed by the users of the system or by a caretaker or watchman, whereas larger repairs may require higher skilled labor that can usually be provided by local craftsmen.

3. O & M requirements

Activity	*Frequency*	*Human resources*	*Materials & spare parts*	*Tools & equipment*
Cleaning platform	Daily	Local	Water	Bucket, broom
Disinfecting well	Occasionally	Local	Chlorine	Bucket, wrench
Repairing platform and drain	Annually	Local	Cement, sand, gravel, bricks	Trowel, bucket, wheel barrow, spade
Repairing lining	Occasionally	Local	Cement, sand, gravel, bricks etc	Trowel, bucket, wheel barrow, spade
Cleaning drain	Occasionally	Local	Water	Hoe, spade, bucket, wheel, barrow

The O&M requirement for handpump part is the same as for the Very Shallow Shrouded tubewell

O&M requirement for Tara pump.

Activity	*Frequency*	*Human resources*	*Materials & spare parts*	*Tools & equipment*
Checking pump performance	Weekly	Local		
Checking whole pump	Yearly	Local		
Replacing cupseal and washer	Occasionally	Local	Cupseal and washer	
Replacing/repairing pump rod	Occasionally	Local	Pump rod, solvent cement	Hacksaw blade

Activity	*Frequency*	*Human resources*	*Materials & spare parts*	*Tools & equipment*
Replacing pump handle	Occasionally	Local	Pump handle	
Repairing pump handle	Occasionally	Local or area		Welding
Repairing foot/flap valve	Occasionally	Local	Foot valve, Flap valve	

Actors implied and skills required in O & M

Actor	*Role*	*Skills*
Water user	use water, keep site clean, assist with major maintenance tasks	No special skills
Caretaker	monitor water use, keep site clean	Basic skills for cleaning and disinfection
Water committee	supervise caretaker, organize major maintenance, collect fees	Organizational skills
Mason	Repair platform	Masonry
Area mechanic	Perform more major repair	Some special skills on hp
Welder	Welding of Tarapump handle	Welding
External support	Check water quality, stimulate and guide users' organization	Microbial analysis, arsenic analysis etc

Organizational aspects: A village water supply and sanitation committee can deal with issues such as the control/ supervision of the water use, prevention of water contamination, execution of O&M and monitoring of water quality. Normally the number of O&M activities required is limited and usually its costs are very little. Maintenance of well should be given ample attention, as large number of well have been abandoned because, they were contaminated and collapsed for lack of maintenance and proper care. The village water and sanitation committee should monitor well maintenance. Proper management may also contribute to preventing social conflict over such and other issues.

Recurrent costs: Recurrent material costs are usually small. The recurrent personnel costs, in cash or kind (for caretakers, labors and craftsmen), will need to be added but usually will be low as well.

4. **Problems**

Frequent problems: Collapse of the well where a lining is not properly maintained. Wells running dry or yielding less than before because: dry season water levels were not taken into account, water abstraction is higher than natural recharge rates, inflow of groundwater is reduced due to clogging of lining. The groundwater may get contaminated through the well or by pollutants seeping to the aquifer through the soil.

5. **Limitations**

Well construction depends on geohydrological conditions like presence, depth and yield of aquifers, Wells constructed at locations which are too far from the users' households or which are too difficult to reach, will not or insufficiently be used and /or maintained.

Wells should not be sunk near places with latrines or where cattle gathers and vice versa; usually the distance should be 30m, although this is no guarantee that contamination will not occur. The investment, in labor, cash and / or kind, needed for the construction of a well may be beyond the capacity of communities.

6. **Arsenic Mitigation Efficiencies**

Dugwell draws water from a very shallow depth, and the water (within 10 m) is likely to have arsenic contamination less than 0.05 mg/l. However, it is suggested to test the water for arsenic and its bacteriological standard before consumption for drinking purposes.

7. **Remarks**

The system can be constructed with only locally available tools, materials and skills The surroundings should be kept clean and the water quality should be monitored regularly to prevent the possibilities of any contamination of water.

Sample for calculating cost of Dugwell Handpump W/S System

Assumptions

Design population = 2500

Diameter of well = 1.5m

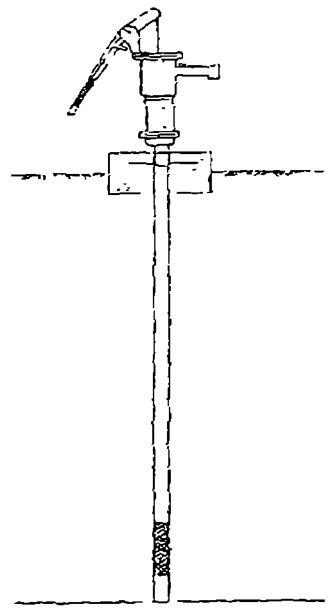
Itemized Costs of the No. 6 handpump with 10 m total depth

SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
1	Excavation of soil	10 m	2000/m.	20000 00
2	Well casing (RCC ring)	22 nos. (h 0.46 m)	1000/m	22000.00
3	Setting RCC ring into well	21 nos	100/no	2100 00
4	RCC cover	0 15 m^3	5000/m^3	750 00
5	Setting handpump	1 set	1000/set	1000.00
6	Clamp	4 nos.	150/no	600.00
7	Placing coarse sand	1 no.	400/no	400.00
8	Filling	15.5 m^3	300/ m^3	4650.00
9	Compacting soil	1 no.	400/no	400.00
10	Platform	1 no.	2500/no	2500 00
11	Disinfecting with bleaching powder	1 no.	150/no	150.00
12	No 6 handpump with all materials	1 set	2200/set	2200.00
			Total capital cost =	56750 00

N.B . The cost may vary location to location, type of handpump, depth and quality of materials

5.5 Deep Tubewell with Handpump

1. Brief description of technology



A deep tubewell is technically defined as the tubewell that is installed at a suitable aquifer after penetrating at least one impervious layer. On the other hand, according to the common definitions in Bangladesh, tubewells that are installed beyond 200 ft. are termed as deep tubewells. Deep tubewells operate exactly on the same principle (suction mode) as a shallow tubewell. The only difference is that the lengths of deep tubewells are normally more than 75m. These deep tubewells are usually installed in saline areas where drillers reach the deep end of ground water aquifers. Mechanical devices are used for construction of these tubewells. These expensive tubewells require greater construction time than that of shallow tubewells. Direct action handpumps can also be used as deep tubewells where the static water level is beyond the suction limit.

Capital cost: The capital cost of this system is Tk. 40,000 to Tk. 75,000.

Range of depth: From 75 m to 300 m.

Yield: 0.2 to 0.3 l/s.

Area of use: At the places where suitable water is not available at the shallow depths and where appropriate deep ground water is found with accessible drilling facilities. The static water level should be in the suction limit. Deep tubewell is presently used in the saline belt in Bangladesh.

2. Description of O&M activities

Operation: Operation includes handling of handpump i.e., water is drawn from well by moving a handle up and down. Men, women and children can easily operate the handpump.

Maintenance: With most or all moving parts are above ground level, No. 6 suction pumps are relatively easy to maintain. This can normally be done by the users themselves or by a village pump caretaker, using simple tools, basic spare parts and materials. The basic skills needed for preventive maintenance (e.g., greasing, being able to take pump-stand apart, replace spare parts, etc.) can be taught to pump caretakers within few days.

Preventive maintenance usually consists of checking pump functioning and cleaning the platform and site daily, greasing weekly, checking of all parts of the pump stand monthly and taking the whole pump apart for a check, cleaning the parts with clean water and painting the pump stand annually. Usually one or two persons can do most of these things.

During inspections, smaller repairs like replacement of washers, etc. may prove necessary. For major repairs (e.g. broken of rising main, cracks in welding of metal parts), more highly skilled persons as well as more specialized tools and materials may be needed.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Checking functioning	Daily	Local		
Cleaning system	Daily	Local	Water	Broom, bucket
Greasing pump stand parts	Weekly	Local	Oil or grease	Lubricator
Check pump stand parts	Monthly	Local		Spanners
Replacing pump stand spares	Occasionally	Local	Washers, cupseals, bearings etc	Spanners, Wrench screwdriver etc.
Adjusting loose bolts	Occasionally	Local		Spanners
Checking whole pump	Occasionally	Local or area		Spanner, pipe wrench
Repairing broken spares	Occasionally	Area	Welding electrodes	Spanners, pipe wrench, welder, file etc.
Painting pump stand	Annually	Local	Anticorrosive paint	Brush
Repairing platform	Annually	Local	Cement, sand	Trowel, bucket, steel pan

Actors implied and skills required in O&M

Actor	*Role*	*Skills*
User	Pump water, keep site clean, warn in case of malfunctioning	No special skills
Caretaker	Keep site clean, give regular maintenance, perform small repairs, keep pump and site clean	Basic skills
Water committee	Supervise caretaker, collect contributions for maintenance and repair	Organizational skills
Actor	*Role*	*Skills*
Area mechanic	Perform major repair	Basic plumbing, treading, welding
Local or area merchant	Sell spare parts	No special skills
External support	Check water quality, stimulate and guide local organization, train users	Microbial analysis, arsenic analysis etc

Organizational aspects: Deep tubewells are expensive for family use and are appropriate for use at community level. The price of these pumps also means that the community will have to raise more funds. Communities will also have to organize themselves in order to maintain the pump in good working condition.

Recurrent costs: Recurrent costs for materials and spare parts are around Tk. 400 to 500 per pump per year. The community will provide the labor. In case larger repairs are needed, mechanics or other skilled people will need to be added.

4. Problems

Worn washer, cupseals and bearings. Excessive corrosion causing pump rods and leaks in raising mains. Low quality of pumps and spares also cause problem. Repair always requires tools.

5. Limitations

The force required to turn the handle of the pump may be high in certain cases, depending on the depth of the well.

6. Arsenic Mitigation Efficiencies

Most of the very deep wells (depth greater than 200 m) appear to have low arsenic concentrations, often significantly below 0.01 mg/l. Only 4% of these wells had arsenic concentrations above 0.05 mg/l (BGS Report, 1998). Where drilling of wells in deep aquifers (>200 m) is feasible, the water may be expected to have an arsenic concentration below 0.05 mg/l.

7. Remarks

The quality of the material used for the riser pipe should be as high as possible to reduce the number of repairs needed on this part. Rigorous quality control is needed.

The sealing of first strata of water is necessary to check the transmission of contamination from first strata to second strata.

Example for calculating cost for deep tubewell with depth 200 m

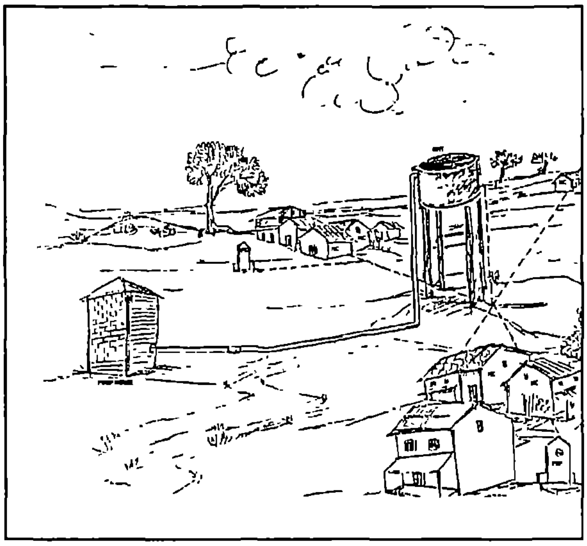
SL No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	Pump assembly	1 no.	800/no	800.00
2	GI pipe	3 m	300/m	900.00
3	38 mm PVC pipe	195 m	50/m	9750.00
4	38 mm sand strap	1.5 m	75/m	113.00
5	38 mm strainer	4 m	75/m	300.00
6	Adapter socket	1 no	25/no.	25.00
7	Solvent cement 50 mg	8 no	50.00/no.	400.00
Sinking and Platform				
8	Sinking	200 m	150/m	30000.00
9	Platform	1 no	2500/no.	2500.00
Transportation				
10	Transportation of materials at site	-	LS	1000.00
Tool set				
11	Wrench set	1 set	200/set	200.00
12	Screw driver	1 no	40/no.	40.00
			Total capital cost =	46028.00

N B The cost may vary location to location and quality of materials

5.6 Motorized DeepTubewell with Limited Distribution

1. Brief description of technology

A motorized deep tubewell is a bigger diameter tubewell used for withdrawal of groundwater from the deep aquifer with the application of a motorized pump. These tubewells are used for community application. In these systems, centrifugal pumps are used in a single unit combining a common housing fitted with an electrical motor. Because pump and motor are submerged under water, this is called a submersible pump. Usually it is a multi-staged pump, placed above the motor and under a non-return valve that leads to the rising main.



Submersible pumps are self-priming. In order to prevent the pump from running dry, the water level in the well must be monitored and pumping must be stopped if the water level drops to the intake level of the pump. Power is delivered through a heavily insulated electric cable connected to a switch panel at the side of the well. It may come from an AC mains connection or a generator. Water may be pumped to an overhead tank (CWR) for gravity distribution or it can be directly pumped into distribution pipes. The water is distributed to the community through small reservoir tanks, taps, stand posts and house connections.

Capital cost : The capital cost of the motorized deepwell depends on depth of the deepwell, capacity, brand of the pump, location, geology, etc. On an average, the capital cost for a deep tubewell is around Tk. 900,000. This cost includes the pump house cost, but does not include the distribution cost. The distribution cost depends on type of distribution, number of connections, distance between source and distribution pump station and length of distribution network, topography, electricity costs, etc.

Range of depth: 200 m or more.

Efficiency range: 40-70%.

Area of use: Where underground water, technical service and electric power are available.

2. Description of O&M activities

Operation: During pumping, check water flow, clearness and power consumption of pump. If water is turbid only during the first stages of pumping, the rising main is corroding. If turbidity continues, the well has to be cleaned or the pump will wear quickly. Report running hours, problems, servicing, maintenance and repairs in logbook. Pump operation and closing of the valves is done by a caretaker.

Pressure chlorination is done and dosing is so adjusted that 0.2 ppm chlorine is available at the remote water point. The CWR is filled by pumping water from tubewell. The supply of water is controlled with the help of valves.

Maintenance: Remove the pump and rising main from well and inspect annually. Check the inlet screen, check valve, and pipe threads and re-cut corroded or damaged threads. Replace badly corroded pipes. Inspect electric cables and check insulation between cables. Check leakage in CWR, pipelines tap-stand & HCs. The CWR is checked and clean occasionally and if silt is found, should be cleared through washout. All the repairs should be attended to immediately.

All other repairs, like replacement of stages, involve high costs and have to be done by a qualified technician.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Taking pump out of well, cleaning inlet screen and checking valve	Annually	Care taker		Chain, pulley, two pipe wrenches, screwdriver, spanner
Replacing fuse	Occasionally	Care taker	Fuse	Screwdriver
Replace piping	Occasionally	Skilled labor		Chain, pulley, two pipe wrenches, screwdriver, spanner
Replace stages	Occasionally	Skilled labor		Chain, pulley, two pipe wrenches, screwdriver, spanner, specialized tools
Repairing of pump house, CWR, pipe and tap-stand	Occasionally	Skilled labor	Cement sand pipe specials & fittings	Pipe wrenches, dyes
Cleaning of CWR	Occasionally	Skilled labor	Lime	Broom and bucket

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Occasionally assist caretaker	No special skills
Caretaker	Operate pump, check water quantity and clearness	Operation and maintenance of pump, CWR, more than basic skills
Area mechanic	Perform major repairs	Specific skills
External support	Check water quality, stimulate and guide organization	Microbial analysis, arsenic analysis, extension work

Organizational aspects: Submersible pumps can function for years with hardly any maintenance at all. Organization has to focus on training and the reliability of the caretaker, fund-raising and quick mobilization of the area mechanic in case of breakdown of pumps or leakage.

Recurrent costs: Recurrent costs will mainly depend on the costs for electricity, the pumping head and quantities pumped. Wages for a caretaker can also be large cost element. The costs for spare parts, materials, tools and equipment are often low compared to the expenses for electricity.

4. Problems

Sand or other particles entering the pump, causing abrasion. Corrosion of the rising main. Damage to the pipeline system due to severe pressure surges caused by abrupt starting and stopping of pump. Leakage is in distribution pipelines and tap-stands.

5. Limitations

Price and reliability of electricity and high technology level are the main limitations.

6. Arsenic Mitigation Efficiencies

Most of the very deep wells (depth greater than 200 m) appear to have low arsenic concentrations, often significantly below 0.01 mg/l. Only 4% of these wells had arsenic concentrations above 0.05 mg/l (BGS Report, 1998). Where drilling of wells in deep aquifers (>200 m) is feasible, the water may be expected to have an arsenic concentration below 0.05 mg/l.

7. Remarks

Since submersible pumps are designed for specific ranges of flow and pressure, it is important to match pump characteristics with operating conditions in order to keep power consumption down. Promptness in attending the leakage in the system is also equally important, as to have the water supply at required pressure.

Cost for motorized deep tubewell

Diameter = 350mm x 150 mm
Depth = 200 m

SL. No.	*Components*	*Amount (Tk.)*
1	Pre-construction work (supplying and transportation of boring equipment, erection of drilling rig, transportation of their materials, installation of 38 mm diameter test well)	60000 00
2	Drilling and driving casing pipe	28000.00
3	Drilling and lowering of well fixtures with all materials	450000.00
4	Shrouding, clay packing and backfilling	40000 00
5	Well development	25000 00
6	Pumping test	20000 00
7	Verticality test	1500 00
8	Sanitary seal	3000 00
9	Disinfection	600 00
10	Site clearance	10000.00
11	Pump and pump installation	150000 00
12	Pump house construction	150000 00
		938100 00

N B The cost may vary location to location and quality of materials

Cost of water distribution

In view of high capital cost (Tk. 900,000) of well and comparatively low cost of other technology (say, Tk. 15,000), this technology will have to serve a large number, say 600 families in order to be cost effective.

Service level:
The cost of distribution depends mainly on the walking distance to the drawing point. Three service levels are assumed:

a) Walking distance of several hundred to one thousand meters. Only one tank at source fitted with multiple taps;
b) Walking distance max. 50 m. Pipes from source to dispersed tanks (one per cluster) with multiple taps;
c) Walking distance say 15 m. Pipes from source to dispersed tanks and from there pipes to compound-level tapstands

Technical assumptions and Costing:

1 Assumptions

Assume 600 families, and a water storage volume equal to the daily demand (1-day).

1 family = 6 people, 1 family compound = 6 families, 1 cluster = 5 family compounds, 1 village = 20 clusters
The no. of family compounds = 600/6 = 100
The no. of cluster = 100/5 = 20

The distance between clusters in the village = 200 m
The distance between family compounds in the cluster = 20 m

Total length of pipe line to interconnect the clusters = 4000 m (b and c options)
Total length of pipe to interconnect the compounds = 2000 m (extra for c option)
Total number of tapstands = 100 (1 per each compound, c option)

Total village population = 600 * 6 = 3600
Total water demand = 3600* 5 lpcd = 18000 lpd = 18 m^3/d
Total volume of reservoir = 20 m^3

option a) 1 reservoir of 20 m3
option b) 20 reservoirs of 1m3 each
option c) as for b, but with pipes to compound level tapstands

2. Capital costing[1]

Option A - R.C.C. reservoir tank of 20 m^3 volume with multiple taps, other fittings and one large platform.
Cost of R.C.C. tank = Tk. 68,950[2]
Cost of taps and other fittings = Tk. 4,000
Cost of platform = Tk. 10,000
Total cost = Tk. 82,950

Option B - 20. nos. R.C.C. reservoir tank of 1 m^3 volume with multiple taps, other fittings valve, 4000-m pipeline and 20 platforms cost.
Cost of R.C.C. tank = Tk. 5000 * 20 = Tk. 100,000
Cost of taps and other fittings = Tk. 500 * 20 = Tk. 10,000
Cost of pipe line = Tk. 170 * 4000 = Tk. 680,000
Cost of platform = Tk. 2000 * 20 = Tk. 40,000
Total cost = Tk. 830,000

Option C - 20. nos. R.C.C. reservoir tank of 1 m^3 volume with multiple taps, other fittings valve, 6000-m pipe line, 20 platforms, 100 tapstands with small platform cost.
Cost of R.C.C. tank = Tk. 5000 * 20 = Tk. 100000
Cost of taps and other fittings = Tk. 500 * 20 = Tk. 10000
Cost of pipe line = Tk. 170 * 6000 = Tk. 1,020,000
Cost of platform = Tk. 2000 * 20 = Tk. 40000
Cost of standpost with small platform = Tk. 1500 * 100 = 150000
Total cost = Tk. 1,320,000

[1] All costs are calculated based on the above assumptions. The cost will vary from locations to location, quality of materials etc. The pipeline cost includes the supply of pipe, laying, fitting, fixing, cleaning and also with required supply of sand

[2]~~Cost of 20 m^3 R.C.C. tank~~

Reinforced cement concrete works (1:2:4) - 5 cum = Tk.6000 * 5 = Tk. 30000

Mild steel rod - 770 kg = Tk. 35 * 770 = Tk. 26950

12 mm thick cement plaster (1:4) - 120 m^2 = Tk. 100 * 120 = 12000

Total cost = Tk. 68950

Alternative tank- Brick and C.C. tank

Reinforced cement concrete works (1:2:4) - 2 cum = Tk.6000 * 5 = Tk. 12000

Mild steel rod - 300 kg = Tk. 35 * 300 = Tk. 10500

125 mm Brick work (1:6) - 30 sqm = Tk. 300 * 30 = Tk. 9000

12 mm thick cement plaster (1:4) - 120 m^2 = Tk. 100 * 120 = 12000

Total cost = Tk. 43500

5.7 Arsenic Removal: Bucket Type

1. Brief description of technology

Arsenic can be removed at the household level by the bucket type method. The bucket type treatment can be of two types. One is chemically assisted treatment, i e., by coagulation, and the other is by spontaneous removal.

Coagulation Process

In this process, a suitable dosage of coagulant (Alum/ferrous sulfate/ferric chloride) and bleaching power are added to a plastic bucket (10 to 15 liters) containing raw water. The chemicals are mixed by fast manual stirring for a minute and slow manual stirring for half an hour. A settled floc is formed during the process of stirring. If aluminum sulfate is used, the flocs are mainly white in color and if ferrous sulfate or ferric chloride is used, the flocs are reddish in color. The water is kept undisturbed for about 4 hours so that the flocs settle. The supernatant water is drawn out slowly and carefully and stored for drinking purposes. It is suggested that the water should be filtered with a simple cloth filter before final use for removing the micro-sized flocs.

Picture to be added

A Two-bucket system can be used for this purpose. The first one is used for mixing the coagulant and bleaching powder, floc formation and settling. The second one is for collection and storage of treated water. The water is best drawn from a water tap fixed two-thirds down on the first bucket.

DPHE's Urban Water and Sanitation Project is promoting the two - bucket type method. They are using 4 g of powered alum and 0.03 g of powered potassium permanganate to treat water of 20-liter bucket for the arsenic concentrations in the raw water ranging from 0.16 mg/l to 1.1 mg/l. It is reported by the Project that the arsenic concentrations came down to levels between 0.01 to 0.02 mg/l regardless of the concentration of raw water.

Spontaneous Removal

If the raw water contains high iron with the arsenic, arsenic can be removed spontaneously by standing water undisturbed in a bucket for 24 hours. This process is based on the natural co-precipitation. The supernatant can be separated in the same way as for coagulation, thus also for spontaneous removal two buckets are required, one of them with affixed tap.

Capital cost: The capital cost of bucket type treatment is around Tk. 1, 500. This cost includes 6 buckets and 3 taps.

Yield: The yield from a six bucket system is about 30 liters, which would satisfy the need of 6 people at 5 liters per day per person

Area of use: Where arsenic-free water systems are not possible.

Construction: Systems are produced locally.

2. Description of O&M activities

Operation: Purchasing of chemicals, addition of chemicals, stirring, collection of the supernatant, and simple filtration are the main operational activities. The waste produced in the process can be dumped with cow dung in a hole far away from water source. In case of spontaneous removal, the operation is much simpler than the chemically assisted treatment.

Maintenance: Cleaning is the main maintenance activity of the bucket type treatment. The bucket and tap should be washed clean after each operation.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Purchasing chemicals	Weekly	Local		
Addition of chemical	Each operation	Local	Coagulant, bleaching powder	Bucket
Stirring	Each operation	Local		Manual stirrer
Collection of supernatant	Each operation	Local		Bucket
Cleaning of bucket, tap	After each operation	Local	Water	Bucket, brush
Replacement/ Repair of tap	Occasionally	Local	New tap, washer	Wrench, screwdriver
Dumping of waste	Daily	Local	Cow dung	Container, broom etc
Analyzing water quality	Regularly	Local or area	Water sample, test media	Test kit

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Water use, assistance in purchasing chemicals, cleaning, waste dumping	No special skills
Caretaker (possibly educated person of the family/head of the family)	Purchasing chemicals, dosing, cleaning, water collection, waste dumping	Fair understanding of chemical process and hygiene, organizational skills
Water committee	Supervise caretaker, monitor water quality, dosing, etc.	Organizational skills, basic water quality testing skill
External support	Check water quality, analysis of chemical quality at the market, identify suitable dosing, stimulate and guide local organization, train users	As analysis, training skills

Organizational aspects: This treatment process is based on the household use. The role of family members in each of the activities must be decided. All members can make a contribution to the work. So, the role of community involvement and maintenance is not very important here. But, the continuous monitoring of water quality and chemical dosing, chemical quality analysis are the most important parameters for this process. A water committee with some external support has to monitor these issues routinely.

Recurrent costs: The spontaneous removal normally does not require any recurrent cost. The taps may require replacement or repair occasionally The recurrent costs for chemical assisted treatment is the cost of chemicals and simple filter cloth/ papers.

4. Problems

The arsenic removal mainly depends on the dosage of the chemicals. To attain a certain percentage of removal, the required dosage depends on the water matrix. Identification of most suitable chemical dosing requires a jar test experiment, which can be undertaken only by a qualified laboratory, and made known to all well users that apply the bucket method.

5. Limitations

The waste of the treatment process can create environmental hazards if the wastes are not dumped in a proper way. All users of the bucket method should dump waste in an agreed place. A water committee with some external assistance should determine the best place, guided by the proximity of water sources, play grounds, etc.

6. Arsenic Mitigation Efficiencies

The arsenic mitigation efficiency of this process depends on water matrix and chemical dosage (in case of coagulation). 100% of arsenic removal efficiencies can be achieved through this process by using proper coagulant dosages. If the water contains high iron contains, the arsenic content of the water can be reduced to acceptable level by using spontaneous removal. It should keep in mind that arsenic removal by bucket method should be tested periodically before regular consumption.

7. Remarks

Bucket type treatment with or without chemicals is not yet established a suitable treatment process for the rural Bangladesh. More studies are required to categorize the chemical requirement for different water qualities. The chemicals can be sold in a small packet, and are to be added to a certain size of bucket for a specific water quality. The quality control of the chemicals and its availability at the rural area are also important factor to be considered.

Cost calculation for Bucket type treatment

Cost of Bucket = Tk. 225 * 6 = 1350
Cost of taps = Tk. 25 * 6 = 150
Total capital cost = Tk. 1500

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

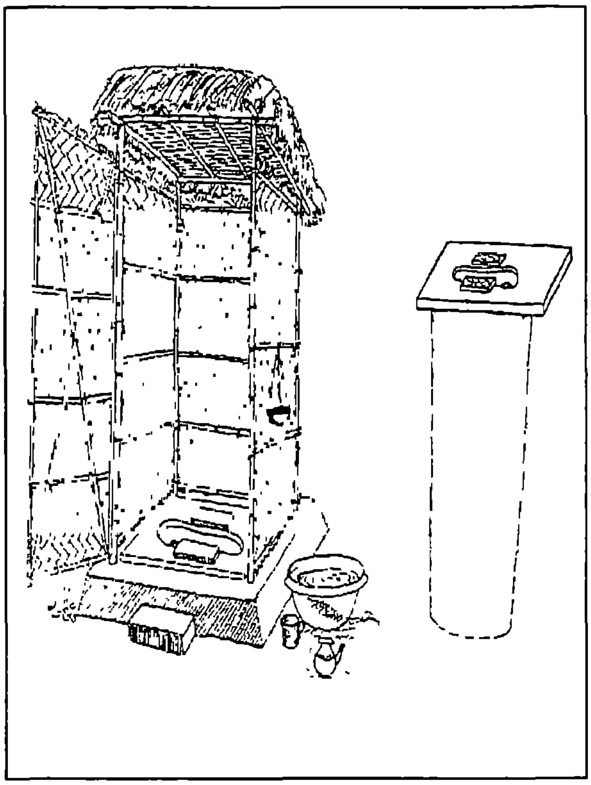
Volume 4: The Sourcebook

6. Fact Sheets Waste Disposal Technologies

6.1 Simple Pit Latrine (San Plat)

1. Brief description of technology

Pit latrines are the simplest of all on-site disposal systems. A pit latrine consists of a pit with a platform having a defecation hole. Excreta fall into the pit through squat hole. Simple pit latrines are the simplest and cheapest improvement over the homemade traditional pit latrine. A simple pit latrine consists of a prefabricated slab with a squatting pan. Reinforcement is provided for structural stability The steel reinforcement requirement is depended on the shape of the slab. Steel reinforcement can be reduced by making the slab domed or conical in shape. The prefabricated cement slab of simple pit latrine prevents transmission of hookworm. Pits in unstable soils must be fully lined, otherwise there is risk that the pit will collapse and the superstructure may fall into it.



A wide variety of materials can be used to line the pit; for example, concrete blocks, bricks, cement-stabilized soil blocks, masonry, perforated oil drums etc. The pit can also be strengthened against collapse by putting a ring beam around the upper part. The effective pit volume can be calculated from solids accumulation rate, the number of users and desired life of pits.

The cover slab should be raised 150 mm above the surrounding ground to divert surface water away from the pit.

Capital cost: The capital cost of this system is Tk. 250 to Tk. 650 without superstructure.

Area of use: Rural and peri-urban areas, household and public use. Soils with permeability below 2.5mm/hour are unsuitable, as the liquid fraction of excreta is unable to infiltrate into soil.

2. Description of O&M activities

Operation: Operation of simple pit latrine is quite simple and consists of regularly cleaning the slab with water (and a little disinfectant if available) to remove any excreta and urine. The door must be always be closed so the superstructure remains dark inside. A movable cover with a handle should cover the squat hole. This cover is normally made by wood,

bamboo or CC. Non-biodegradable material like stones, glass, plastic, rags etc., should not be thrown in the pit latrine as they reduce the effective volume of the pit.
Maintenance: Every month the floor slab has to be checked for cracks. Repair of the superstructure (especially light leaks) may be necessary too. When the contents of the pit reach the level of 0.5 m below the slab, a new pit has to be dug and the old pit covered with soil.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning drop hole, seat and superstructure	Daily	Household	Water, ash	Brush, Bucket, Broom
Inspecting floor slab	Monthly	Household		
Repairing slab, seat or superstructure	Occasionally	Household or local	Cement, sand, water, nails, local building materials	Bucket or bowl, trowel, saw, hammer, knife
Digging new pit and transfer latrine slab and superstructure	Depending on size and number of users	Household or local	Sand, possibly cement, bricks, nails and other local building materials	Shovels, buckets, wheelbarrow, hammers etc.
Emptying pit (if applicable)	Depending on size and number of users	Household or local	By hand: water	By hand shovel, bucket.

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Use latrine, keep clean, inspect and perform small repairs, empty full pit, dig new pit and replace latrine	Understanding of hygiene
Local unskilled labor (sweepers/scavengers)	Dig pits, transfer structures, empty full pits, small repairs, solving small problems	Knowledge about the simple pit latrine and how to solve minor problems
local mason	Build and repair or transfer latrines	Basic masonry, latrine building
Sanitation committee/Health Department	Monitor latrines and hygienic behavior of users, train users	Training skills and knowledge on sanitation

Organizational aspects: Where a single household uses latrines, O&M tasks are implemented by the household itself or by the hired labor. If more households use the latrine, arrangements or rotation of cleaning tasks have to be made and agreed upon to avoid social conflicts.

Recurrent costs: Recurrent costs for simple pit latrine are very low, as normally maintenance activities are few (mainly cleaning) and can be done by households themselves. The maximum recurrent cost is about Tk. 100 on average per year. Even if local labor has to be hired for digging a new pit, the recurrent costs per time unit and user are low although paying in full at once may pose a problem.

4. **Problems**

Bad quality of the floor slab due to inappropriate materials or improper curing of concrete. Flies lay their eggs in feces within poorly built latrines. The superstructure frequently becomes infested with flies and mosquitoes and full of pungent odors because users do not replace the squat hole cover after use. Increase in the population of flies helps in spreading of diseases caused from fecal pathogens carried by files. Odor may be created in many cases.

5. **Limitations**

In hard soils it may be impossible to dig a proper pit. Pits should preferably not reach groundwater level and latrines must be 15 to 30 meters away from ground and surface water sources.

6. **Remarks**

Simple pit latrines are structurally safer. They are free from the risk of a child falling in, and therefore are safer and less frightening for children. Use of these low cost latrines reduces the hookworm transmission.

Example for calculating cost for simple pit latrine with one ring

SL No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	San plat	1 no.	125/no	125.00
2	Ring	1 no	80/no.	80 00
Labor (for installation)				
3	Labor	As req	LS	80 00
Transportation				
4	Transportation of materials at site	-	LS	30 00
			Total capital cost =	315.00

N B The cost may vary location to location and quality of materials

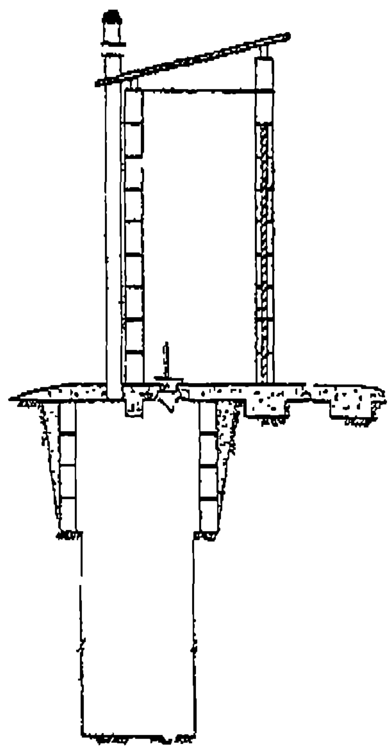
The above cost does not include the superstructure cost. The cost varies with the type of the materials used and the economic condition of the user. On an average a temporary superstructure can be built with a cost of Tk. 200 to Tk. 500

6.2 Ventilated Improved Pit (VIP) Latrine

1. Brief description of technology

Ventilated Improved Pit latrines are an improvement over the simple pit latrines, and can reduce two frequently encountered problems by using simple pit latrines, namely their smell and their insect production. A VIP latrine differs from simple pit latrine by including a vent pipe covered with a fly screen. The principle mechanism of ventilation in VIP latrines is action of the wind blowing across top of the vent pipe. The wind effectively sucks air out of the vent pipe and this air is replaced from atmosphere via latrine superstructure and squat-hole. Moreover, gases generated in the pit are warmer and lighter. Therefore, the gases flow through the vent pipe. A constant circulation of air from outside the latrine, through the superstructure and squat-hole, and up and out of the vent pipe keeps the latrine odor free.

Female files, searching for an egg-laying site, are attracted by fecal odors coming from the vent pipe but they are prevented from entering by the fly screen at outlet of vent pipe.



Some flies may enter into the pit via squat-hole and lay their eggs there. When new adult flies emerge they instinctively fly towards the light, however, if the latrine is dark inside the only light they will see is that at the top of the vent pipe. If the vent pipe is provided with fly screen at its top, new flies will not able to escape and they will eventually fall down and die in the pit

VIP latrines can be constructed with a single pit or with double pits. The latrine with double pits has two shallow pits, each with their own vent pipe but only one superstructure. The cover slab has two drop holes, one over each pit. Only one pit is used at a time. When the one is full, its drop hole is covered and the second pit is used. After a period of at least one-year, the contents of the first pit can be removed safely and used as soil conditioner. The pit can be used when the second pit has filled up. The alternating cycle can be repeated indefinitely.

Capital cost: The capital cost of this system depends on pit volume, quality and quantity of lining, slab and superstructure quality, type of pits (single or double), and the extent to which locally available materials are used. The cost of this latrine with twin pit is Tk 600 to Tk. 1600. This cost does not include the superstructure cost. The superstructure can be built with thatch, C.I. sheet or bricks.

Area of use: Rural and peri-urban areas, household and public use Soils with permeability below 2.5mm/hour are unsuitable, as the liquid fraction of excreta is unable to infiltrate into soil.

2. Description of O&M activities

Operation: No special operation is required. Regular cleaning of the slab with water (and a little disinfectant if available) to remove any excreta and urine is the main operational activity. The door must always be closed so the superstructure remains dark inside. The drop hole should never be covered, as this would impede airflow. No-biodegradable material like stones, glass, plastic, rags etc., should not be thrown in the pit latrine as they reduce the effective volume of the pit.

Maintenance: Every month the floor slab has to be checked for cracks and the vent pipe and fly screen must be inspected to ensure they are in good condition. Repair of the superstructure (especially light leaks) may be necessary too. When the contents of the pit reach the level of 0.5 m below the slab, a new pit has to be dug and the old pit covered with soil.

In case of a twin pit system, one should switch over to the other pit when a pit is full. The full pit can be emptied safely by hand after it has been standing for a year or more.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning drop hole, seat and superstructure	Daily	Household	Water, ash	Brush, Bucket, Broom
Inspecting floor slab, vent pipe and fly screen	Monthly	Household		
Cleaning fly screen and vent inside	Every one to six months	Household	Water	Twig or long bendable brush
Repairing slab, seat, vent pipe, fly screen or superstructure	Occasionally	Household or local	Cement, sand, water, nails, local building materials	Bucket or bowl, trowel, saw, hammer, knife
Digging new pit and transfer latrine slab and superstructure	Depending on size and number of users	Household or local	Sand, possibly cement, bricks, nails and other local building materials	Shovels, buckets, wheelbarrow, hammer etc

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Switching to other pit when pit is full	Depending on size and number of users	Household or local		Shovels, buckets, wheelbarrow etc
Emptying pit (if applicable)	Depending on size and number of users	Household or local	By hand water	By hand: shovel, bucket

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Use latrine, keep clean, inspect and perform small repairs, empty full pit, dig new pit and replace latrine	Understanding of hygiene
Local unskilled labor (sweepers/scavengers)	Dig pits, transfer structures, empty full pits, small repairs, solving small problems	Knowledge about the VIP latrine and how to solve minor problems
local mason	Build and repair or transfer latrines	Basic masonry, latrine building
Sanitation committee/Health Department	Monitor latrines and hygienic behavior of users, train users	Training skills and knowledge on sanitation

Organizational aspects: When a single household uses latrines, O&M tasks are implemented by the household itself or by hired labor. If more households use the latrine, arrangements for rotation of cleaning tasks have to be made and agreed upon to avoid social conflicts.

If double pit latrines are used, the users need to understand the concept of the system fully in order to be able to operate it properly. User education has to cover aspects such as reasons for switching, using one pit at the time, use of excreta as manure and the need to leave the full pit at least a year before emptying The users also need to know how to switch the pit and how to empty it, even when they do not do these tasks themselves. Where these tasks are carried out by the private (informal) sector, the laborers also have to be educated in the concept of the system and its operational requirements

Recurrent costs: Recurrent costs for simple pit latrine are very low, as normally maintenance activities are few (mainly cleaning) and can be done by households themselves. The maximum recurrent cost is around Tk. 150 on an average per year. Even if local labor has to hired for digging a new pit, the recurrent costs per time unit and user are low although paying in full at once may pose a problem.

4. Problems

Bad quality of the floor slab due to inappropriate materials or improper curing of concrete. Inferior quality fly screens get damaged easily by the effects of solar radiation and foul gases. Improperly sited latrines can get flooded or undermined. The defecation hole must be left open to allow free passage of air. If the superstructure allows too much light to come in, flies will be attracted by the light coming through the squat hole and may fly out into the superstructure; this may jeopardize the whole VIP concept. The problem can be solved when a fly-catching squat hole cover made of screen material is used. It is important that the cover is always put in place properly and that the screen is not damaged. Odor problems may occur during the night and early morning hours in latrines relying more on solar radiation for the air flow in the vent pipe than on wind speed. In double pit systems switching from one pit to the other is often difficult because of the things that have to be replaced or opened (vent pipe and access hole for emptying) are fitted too tightly in place, often with cement or other mortar and difficult to remove.

5. Limitations

Difficulty of construction in rocky and high water table area. Pits should preferably not reach groundwater level and latrines must be 15 to 30 meters away from ground and surface water sources. Lack of space for relocating the pit in densely populated areas.

6. Remarks

Adjacent soakaway (1.5-m dia and 2.0 m depth) can increase the pit life. In that case, the latrine is completely sealed with cement mortar or mortared brickwork and a PVC pipe of 75mm dia is attached at a height of 2.25 m above the pit base that leads to the adjacent soakaway.

Example for calculating cost for twin pit VIP latrine

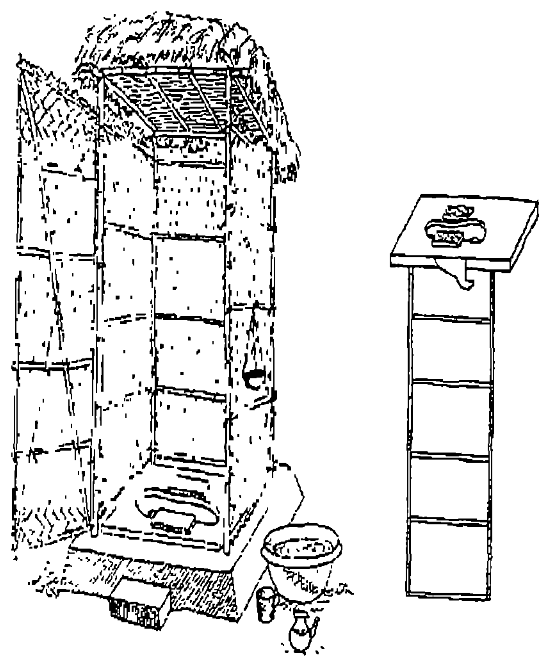
SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	San plat (R.C C slab)	1 no.	175/no	175.00
2	Ring	2 nos	80/m	160 00
3	PVC Vent pipe	6 m	50/m	300 00
4	Fly screen	2 nos.	50/nos	100.00
Labor (for installation)				
5	Labor	As req	LS	160 00
Transportation				
6	Transportation of materials at site	-	LS	50.00
			Total capital cost =	945.00

N.B.: The cost may vary location to location and quality of materials

The above cost does not include the superstructure cost The cost varies with the type of the materials used and the economic condition of the user. On an average a temporary superstructure can be built with a cost of Tk. 200 to Tk 500

6.3 Direct Single Pit Pour Flush Latrine

1. Brief description of technology



A Latrine having an in-built water seal trap with its slab directly placed over a pit is called a direct pit pour flash latrine. A pour flush latrine is the further improvement of the pit latrine with a water seal. A waterseal is a U-pipe, also called gooseneck and it is filled with water, attached below the squatting pan and thus completely prevents passage of flies and odors. The water seal is only 15-25 mm deep and the latrine can be flushed by hand using 1.5 to 2.0 liters of water. The flushing water has the added advantage of reducing the risk of groundwater pollution. Once the latrine is flushed, the excreta fall into the pit and are no longer visible. The pan has a uniform slope from front to back with a smooth finish The trap is a bent pipe that holds water and provides the necessary 'water seal'. The water seal is the distance between the level of water in the trap and the lowest point in the concave upper surface of the trap.

Pits may be lined with precast concrete rings, burnt clay, brick masonry, or even bamboo. Usually five precast concrete rings are used. One is placed over the ground level and the slab is placed over it. Four rings are placed in the pit. The last two rings can be made perforated so as to allow lateral percolation of water produced in the anaerobic decomposition of fecal matters.

When the pit fills up, a new pit has to be dug and superstructure has to be relocated over the new one or the pit has to be emitted. It is convenient to construct a new pit with four rings and to relocate the slab and top ring. After one year or more, the contents of the first pit can be removed safely and used as soil conditioner After filling of new pit, old pit can be used and new pit can be kept for cleaning with at least 150-mm topsoil cover.

Capital cost: The capital cost of this system depends on pit volume, quality and quantity of lining, slab and superstructure quality, and extent to which locally available materials are used. The cost of this latrine is Tk. 400 to Tk. 800. This cost does not include the superstructure cost. The superstructure can be built with thatch, C.I. sheet or bricks.

Area of use: Rural and peri-urban areas, household and public use. Sandy or silty soil with/without clay is considered ideal.

2. Description of O&M activities

Operation: Before use the pan is wetted with a small amount of water to avoid feces sticking to the pan. After use flush the pan with a few liters of water. If water is scarce, bathing or washing water may be used. No material that could obstruct the U-trap should be thrown into the pan. The floor, squatting pan (or seat), door handles and other parts of superstructure have to be cleaned daily with brush and water. Wastewater from bathing or washing clothes should not be drained into the pit (unless used for flushing), but disposed off elsewhere.

Maintenance: The floor slab, pan and U-trap have to be checked monthly for cracks. Repair of the superstructure (especially light leaks) may be necessary too. When the contents of the pit reach the level of 0.5 m below the slab, a new pit has to be dug and the old pit covered with soil.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning pan or seat and superstructure	Daily	Household	Water, ash	Brush, Bucket, Broom
Inspecting floor slab, squatting pan, U-trap	Monthly	Household		
Repairing slab, pan, U-trap or superstructure	Occasionally	Household or local	Cement, sand, water, nails, local building materials	Bucket or bowl, trowel, saw, hammer, knife
Closing the pit with soil digging new pit and transfer latrine slab and superstructure	Depending on size and number of users	Household or local	Sand, possibly cement, bricks, nails and other local building materials	Shovels, buckets, wheelbarrow, hammer etc
Emptying pit (if applicable)	Depending on size and number of users	Household or local	By hand: water	By hand· shovel, bucket.

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Use latrine, flush, keep clean, inspect and perform small repairs, empty full pit, dig new pit and replace latrine	Understanding of hygiene
Local unskilled labor (sweepers/scavengers)	Dig pits, transfer structures, empty full pits, small repairs, solving small problems	Knowledge about the pour flush latrine and how to solve minor problems
local mason	Build and repair or transfer latrines	Basic masonry, latrine building
Sanitation committee/Health Department	Monitor latrines and hygienic behavior of users, train users	Training skills and knowledge on sanitation

Organizational aspects: Where single households use latrines, O&M tasks are implemented by the household itself or by hired labor. If more households use the latrine arrangements or rotation of cleaning tasks have to be made and agreed upon to avoid social conflicts.

Recurrent costs: Recurrent costs for simple pit latrine are very low, as normally maintenance activities are few (mainly cleaning) and can be done by households themselves. The maximum recurrent cost is around Tk. 100 on an average per year. Even if local labor has to be hired for digging a new pit, the recurrent costs per time unit and user are low although paying in full at once may pose a problem.

4. Problems

These include:

- Bad quality of the floor slab due to inappropriate materials or improper curing of concrete.
- Block of the U-trap because of bad design or improper use.
- Damage of the U-trap caused by improper deblocking (sometimes U-traps are broken on purpose to prevent blockage).

Foul gas can come up from the pit when: i) water evaporates from the U-trap in case the latrine is not used regularly, ii) water is completely washed out of U-trap because it was poured too forcibly, and iii) the U-trap is damaged or broken.

5. Limitations

Difficulty of construction in rocky and high water table area. Pits should preferably not reach groundwater level and latrines must be 15 to 30 meters away from ground and surface water sources. Water must be available throughout the year. Lack of space for relocating the pit in densely populated areas.

6. Remarks

The construction of direct single pit pour flush latrine is simple and less expensive compared with other conventional latrines. Potential resource recovery is possible by using the sludge as soil conditioner. Bulky materials such as corncobs or stones must not be used for human cleaning purposes as these can block the U-trap. Children should to educated not to drop any stones or brickbats in the U-trap.

Example for calculating cost for direct single pit pour flush latrine

SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	R.C C. slab with in-built pan	1 no	150/no	150.00
2	Ring	5 nos.	80/m	400.00
Labor (for installation)				
3	Labor	As req.	LS	100.00
Transportation				
4	Transportation of materials at site	-	LS	50.00
			Total capital cost =	700.00

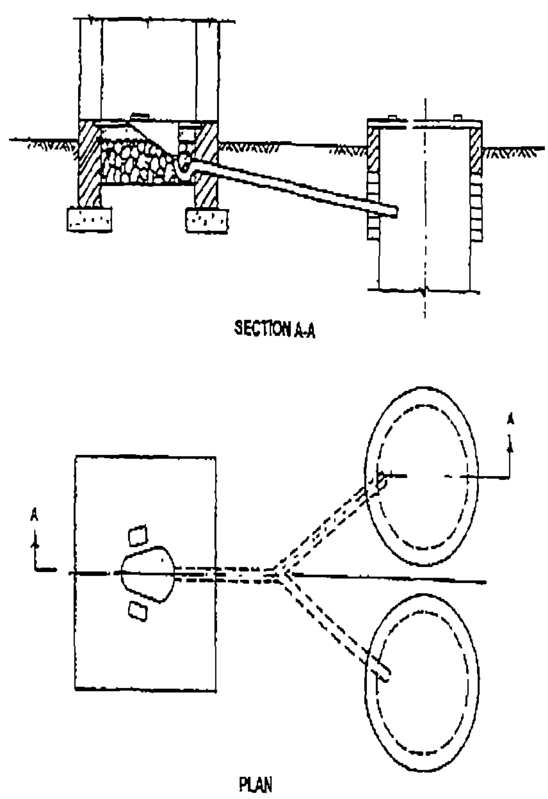
N B : The cost may vary location to location and quality of materials

The above cost does not include the superstructure cost. The cost varies with the type of the materials used and the economic condition of the user. On an average a temporary superstructure can be built with a cost of Tk. 200 to Tk. 500.

6.4 Off-set Pour Flush Latrine

1. Brief description of technology

An extension of the idea of the pour-flush pan with a water seal latrine is for the pit to be outside the latrine building. The contents of the pan are discharged through a short length of small diameter pipe or covered channel Like the direct single pit pour flush latrine, U-trap filled with water, attached below the squatting pan that completely prevents passage of flies and odors. Off-set latrines can be single pit or twin pit. In this system, a short length of sufficiently sloping (with a minimum gradient of 1 in 30) pipe (termed as soil pipe) from the U-trap down to the pit, or in case of a double pit system, to a diversion box which diverts the flush to one of the pits. The double offset system enables alternating use of the twin pits. When the first pit is full, the flow excreta is directed to the second pit through a Y-junction and contents of the first pit are left to decompose. The contents of first pit decompose to safe, pathogen free humus in around one year or more The contents of the first pit may then be dug out and the pit is kept ready for reuse. The pit emptying should be done during dry seasons and humus may be used as manure.



Generally speaking, an offset pour-flush latrine requires a larger volume of flushing water than a simple pour-flush latrine. The amount of water required depends on the pan design, pipe slope and roughness.

The water seal and the pan are similar to direct single pour flush latrine. Pits may be lined with precast concrete ring, burnt clay, brick masonry, or even bamboo. Usually five precast concrete rings are used. One is placed over the ground level and the slab is placed over it. Four rings are placed in the pit. The last two rings can be perforated so as to allow lateral percolation of water produced in the anaerobic decomposition of fecal matters.

If possible, the distance between the pits should not be less then the depth of a pit to reduce the possibility of liquid from the pit in use entering the pit not in use. If pits are built adjacent to each other, the dividing wall should be not-porous and preferably extended beyond the side walls of pits to prevent cross-contamination. Alternatively, the pit lining can be constructed without holes for a distance of 300 mm or either side of the dividing walls.

Offset systems usually have a more permanent character than direct systems and have smaller pits. This makes them also suitable for areas where it is impossible to dig deep pits. Pour-flush latrines are most suitable where people use water for anal cleansing and squat to defecate.

Capital cost : The capital cost of this system depends on pit volume, quality and quantity of lining, slab and superstructure quality, length of soil pipe, extent to which locally available materials are used. The cost of this latrine with twin pit is Tk. 800 to Tk. 2000. This cost does not include the superstructure cost. The superstructure can be built with thatch, C.I. sheet or bricks.

Area of use: Rural and peri-urban areas, household and public use. Sandy or silty soil with/without clay is considered ideal. Pour-flush latrines are most suitable where people use water for anal cleansing and squat to defecate. These types latrines are promoted by many organization in Bangladesh.

2. Description of O&M activities

Operation: Before use the pan is wetted with a small amount of water to avoid sticking of faces to the pan. After use flush the pan with a few liters of water. If water is scarce, bathing or washing water may be used. No material that could obstruct the U-trap should be thrown into the pan. The floor, squatting pan (or seat), door handles and other parts of superstructure have to be cleaned daily with brush and water. Wastewater from bathing or washing clothes should not be drained into the pit (unless used for flushing), but disposed off elsewhere.

Maintenance: Floor slab, pan, and U-trap have to be checked monthly for cracks. The junction chamber has to also be checked monthly for blockage. If the excreta does not flush quickly, the soil pipe and/or junction chamber may be choked. Deblocking without delay using scoops and long twigs is then needed. Repair of the superstructure (especially light leaks) may be necessary too. When the contents of the pit reach the level of 0.5 m below the slab, a new pit has to be dug and the old pit covered with soil in case of single pit. In a double pit system the switching is necessary when the first pit is almost full.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning pan or seat and superstructure	Daily	Household	Water, ash	Brush, Bucket, Broom
Inspecting floor slab, squatting pan, U-trap	Monthly	Household		
Inspecting junction chamber for blockage	Monthly	Household or local	Water	
Deblock U-trap, PVC pipes or junction chamber when blocked	Occasionally	Household or local	Water	Bendable twig or other flexible tools
Repairing slab, pan,	Occasionally	Household	Cement, sand, water,	Bucket or bowl, trowel

U-trap or superstructure		or local	nails, local building materials	saw, hammer, knife
Closing the pit with soil and digging new pit	Depending on size and number of users	Household or local	Sand, possibly cement, bricks, nails and other local building materials	Shovels, buckets, wheelbarrow, hammer etc.
Diverting excreta flush to other pit (in case of double pit system)	Depending on size and number of users	Household or local	Water, sand, cement, bricks, clay etc	Shovel, bucket
Emptying pit	Depending on size and number of users	Household or local	By hand· water	By hand: shovel, bucket.

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
User	Use latrine, flush, keep clean, inspect and perform small repairs, switch pit, empty full pit, dig new pit	Understanding of hygiene
Local unskilled labor (sweepers/scavengers)	Dig pits, transfer structures, empty full pits, small repairs, solving small problems	Knowledge about the pour flush latrine and how to solve minor problems
local mason	Build and repair or transfer latrines	Basic masonry, latrine building
Sanitation committee/Health Department	Monitor latrines and hygienic behavior of users, train users	Training skills and knowledge on sanitation

Organizational aspects: Where latrines are used by a single household, O&M tasks are implemented by the household itself or by the hired labor. If more households use the latrine arrangements or rotation of cleaning tasks have to be made and agreed upon to avoid social conflicts.

If double pit latrines are used, the users need to understand the concept of the system fully in order to be able to operate it properly. User education has to cover aspects such as reasons for switching, using one pit at the time, use of excreta as manure and the need to leave the full pit at least a year before emptying. The users also need to know how to switch the pit and how to empty it, even when they do not do these tasks themselves. Where these tasks are carried out by the private (informal) sector, the laborers also have to be educated in the concept of the system and its operational requirements.

Private companies and individuals can produce and supply all pour-flush latrine components. Local manufacturing is possible for lining of pits, building materials for junction chamber (blocks or bricks), lids, floors, pans and superstructure. The pan can be made of different materials (smooth concrete, ceramic, glass, fiber, plastics). The design of the pan and U-pipe is very critical for effective flushing with a minimal amount of water. Quality control of all these construction materials is required.

Recurrent costs: These costs are usually low as most O & M activities can be carried out by the households themselves, provided the latrine is well designed and constructed. Costs may have to be incurred when poorly designed or used U-traps block and break while deblocking. The main cost is probably incurred when the pit needs to be emptied, although this is often less frequently necessary than anticipated. If pits cannot be emptied and new ones are to be dug, the superstructure of the old latrine can be transferred. Labor costs for digging and costs for lining material are to be paid directly however, which may be a problem for households.

4. Problems

Poor quality of the floor slab due to unsuitable materials or improper curing of concrete. Frequent obstruction of U-trap because of bad design or improper use. Damage of U-trap caused by improper deblocking (sometimes U-traps are broken on purpose to prevent blockage). Blocked junction chambers and /or soil pipes. Improperly sealed pit access holes. During transport pans crack or get damaged. Contents in pit do not decompose safely because the double pits are too close to each other without an effective seal between them, allowing liquids to percolate from one pit to the other. Leaking of drain pipes going to the pits.

Foul gas can come up from the pit when: i) water evaporates from U-trap in cases when the latrine is not used regularly, ii) water is completely washed out of U-trap because it was poured too forcibly, and iii) the U-trap is damaged or broken.

5. Limitations

Difficulty of construction in rocky and high water table area. Pits should preferably not reach groundwater level and latrines must be 15 to 30 meters away from ground and surface water sources. Only to be used in areas where sufficient water available for flushing.

6. Remarks

Pour-flush latrines are unsuitable where bulky materials are used for cleansing such as corncobs or stones which cannot be flushed through the U-trap. Double offset pits are usually much smaller than single pits because they need to last for twelve to eighteen months only after which they can be emptied by hand. In a direct pit system less water is needed for flushing than in an offset system. Pour-flush latrines may be upgraded to a septic tank with drainage field or soakpit. Advantages of water-economic pans are reduced amounts of water required for flushing and with that, there are reduced risks of groundwater contamination.

Example for calculating cost for off-set twin pit pour flush latrine

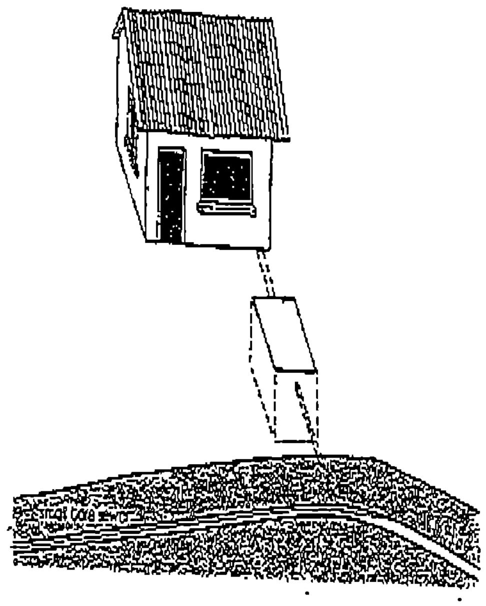
SL. No.	*Components*	*Quantity*	*Rate (Tk.)*	*Amount (Tk.)*
Material				
1	R.C.C. slab with in-built pan	1 no	150/no.	150.00
2	Ring	10 nos	80/m	800.00
3	Junction box with plate	1 no	100/no.	100.00
4	Siphon	1 no.	50/no.	50.00
Labor (for installation)				
5	Labor- skill & unskilled	As req.	LS	300.00
Transportation				
4	Transportation of materials at site	-	LS	100.00
			Total capital cost =	1500.00

N B The cost may vary location to location and quality of materials

The above cost does not include the superstructure cost. The cost varies with the type of the materials used and the economic condition of the user. As offset latrines have more permanent character, a superstructure can be made with brick, cement at around Tk. 2000. This cost varies with the type of structure

6.5 Small Bore Sewerage (SBS) System

1. Brief description of technology



The Small-bore sewerage system (or settled sewerage) is a recent sanitation technology that offers a modification of the traditional sewerage system, a at a cost far less than that of a conventional one. The SBS system is designed to receive only the liquid fraction of household wastewater for off-site treatment and disposal Grit, grease and other troublesome solids that might cause obstruction in the sewers are separated from the waste flow. These settled solid components of the waste are kept in an interceptor tank (septic tank) which needs periodic desludging.

As the sewers only receive the liquid sewage, SBS systems have some advantages:
i) Less water is required for transportation,
ii) Less excavation costs,
iii) Reduced material cost due to small diameter pipe, and
iv) Reduced treatment is required.

The interception tank has performed the specific functions:

1. Sedimentation of undissolved , settleable solids, storage of sludge and scum for at least three to five years or more,
2. Reduction of BOD through anaerobic decomposition of organic matters, and
3. Substantial attenuation of peak flows within the tank.

The SBS system consists of a house connection, an interception tank, sewers, cleanouts/manholes, vents, a sewage treatment plant and lift stations (if there is no gravity flow). The system is most appropriate in areas that already have septic tank but where the soil cannot (any longer) absorb the effluent or where densities are such that there is no room for soakaways. It also provides an economical way to upgrade existing sanitation facilities to a level more comparable to conventional system.

Capital cost: The capital cost of this system depends on the present condition of the house septic tank, number of house connection, type of connection pipe, volume of tank, location of treatment plant, topography of the location etc The cost should be calculated on the basis on the location and facilities.

Area of use: Areas where individual soakaways are not appropriate (soil condition or densities) and areas where pour-flush latrines with soakpit can be upgraded to a small bore sewer system. This can be used in urban slum and peri-urban areas.

2. Description of O&M activities

Operation: The main operational requirement for the household is to ensure that no solids can enter the system and that the interceptor tank functions properly.

Maintenance: Regular removal of the sludge in the interceptor tank. This has to be checked by the local public health engineering department because the system will be at risk if solids can enter. Removal of blockages, regular control of sewage pipes and periodic flushing. The performance of appurtenances in the pipeline system such as cleanouts, manholes, (possible) lift stations, and ventilation points should be regularly checked and maintained.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning grease trap	Daily/weekly	Household	Water	
Repairing and removal of blockages	Occasionally	Local (labor/mechanic)	Water, specialized materials and spare parts	Rodding tool, mechanic's tool set
Checking inspection chambers, appurtenances such as pumps and controls, vacuum and surge chambers, check valves	At least annually	Household or local	Water	Basic mechanic tool set
Inspect street sewers	Regularly	Local Public Health Engineering Department	Specialized spare parts and materials	Specialized tools and equipment

Actors implied and skills required in O&M:

Actor	*Role*	*Skills*
Household	Check appurtenances within pot, assist community organization in maintenance of inspection chambers and common block sewer line	Understanding of system, some technical skills to check appurtenances
Local labor/mechanic	Check on-site appurtenances, perform small repairs, removal of blocks	Mechanical skills
Community organization	Organize regular checking of block sewer, notify agency for problems, collect sewer charges	Understanding of system and bookkeeping skills, organizational skills,

		monitoring skills, communicative skills
Actor	*Role*	*Skills*
Agency	Monitor system's performance, keep regular contacts with community organizations and monitor their performance; train teams, mechanics, organization staff and maintain collector sewer, pumping station and treatment plant	Technical skills, administrative skills, organizational skills, monitoring skills, communicative skills, training skills.

Organizational aspects: The main organizational aspects associated with the system are the organization of desludging services for the interceptor tank. The principle problems related to this desludging revolve around who takes responsibility. Normally this lies with the property owners since the interceptor tank is on their property. Residents who are not owners have no incentives to desludge regularly. Desludging costs money, is inconvenient, and sludge overflowing in the sewer system will not directly affect the residents but will affect the communal sewer system downstream. If the sewer system is to work effectively, therefore, responsibility for tank desludging must devolve to the organization responsible for communal sewer maintenance. The organization also has to bear the responsibility for treatment of the liquid from the sewers and the sludge from the interceptor tanks.

Recurrent costs: The main expenditure of recurrent costs is the emptying of the interceptor tanks, which vary with volume of the tank and location. Other recurrent costs are needed for treatment, including the occasional flushing of the system and repairs to the system maintained.

4. Problems

Overflowing interceptor tanks because they have not been desludged in time. Blockages due to illegal connections without interceptor tank.

5. Limitations

Basically the technology is only suitable where septic tanks or other on-site system are in existence. If a new system needs to be installed, the shallow sewer system is more appropriate as it does not need as it does not need an interceptor tank. The dependency on regular desludging of the interceptor tank means that a well-organized sewerage department is necessary. Space required for interceptor tank may be available everywhere.

6. Remarks

The system needs a somewhat regular layout along back lanes and a regular (be it limited) water supply system. In many low-income urban areas these conditions do not apply and therefore the system is not appropriate for application.

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

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Volume 4: The Sourcebook

7. Fact Sheets Environmental Management Technologies

7.1 Drainage above the Ground

1. Brief description of technology

The water used for the household purposes is converted into wastewater. Adequate arrangements are required to made for quick collection, conveyance and disposal of used water from the kitchen, bathroom, etc., without any risk to the health of the occupants. It is also essential that the rain or storm water from the roof and ground surface is suitably collected and discharged without flooding the area. The drainage system can be broadly divided in two parts: (1) Drainage above the ground (surface drainage, and (2) drainage below the ground (underground drainage).

Surface drains are the most common types of drains used to remove unwanted or used water from the houses and inhabited areas, in a safe manner, in low-income communities. The drainage systems are provided to avoid ponding, rapid deterioration of road/path surfaces, damage to buildings and to avoid unsanitary conditions like breeding places for mosquitoes and flies creating from sullage.

The surface drains can be open or can be partly or fully covered by slabs. These are usually provided at sides of the lanes and streets and along the boundary lines of buildings. For efficient drainage, the surface drains should have a gradient to develop self-cleaning velocity and a reasonable free board at the top. The joints and inside should be smooth finished These drains should be cheap in construction and maintenance.

The cheapest drains of all are unlined channels, which can be cut along the roadside with a road grader. The sides of an unlined drain should not slope by more than 1 in 2 to ensure that they will be stable. If the slope along the drain is greater than 1%, the drain may be damaged by scouring, and some lining will usually be required to protect the channel bottom from the fast-flowing water. For slopes of 1-5%, partial lining is likely to be sufficient and will cost less than complete lining. In a partially lined drain, special protection is needed at the most vulnerable points, such as culverts, drain junctions, sharp bends, and steep sections. Drains with vertical sides always need a lining to support the sides. At this type of channel is used only when space is in short supply and when the drains have to pass close to houses, the lining must be strong enough to protect adjacent house foundations.

Capital cost: The capital cost of the surface drain depends on different factors. The quantity of sullage produced from the community varies with the quantity of water supplied, and local bathing and washing practices. Drainage systems also depend on type of terrain, soil condition, slope of ground and availability of local materials etc.

Area of use: These drains are constructed along the road or street with or without pavements of streets. These also can be constructed in the area used for drainage line only.

2. Description of O&M activities

Operation: Operating a drain system requires only cleaning and clearing of blockages.

Maintenance: In open drains the major problem is falling garbage, leaves, animal waste and dry fodder which blocks flow of sullage in the drain. These should be removed and washed regularly. The problem of breaking and damage to the drains by animals, bullock-carts, tractors, etc., is very frequent. This damage should be taken care of and repaired immediately.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning of surface drain	Daily	Household or hired labor	Water	Broom, bucket, long stick & trowel etc.
Deblocking of delivery pipe/drain	Occasionally	Household, caretaker or local artisan	Water, piece of pipe	Broom, shovel, long stick or flexible brush, knife, saw
Repairing of damages of drain	Occasionally	Caretaker or local artisan	Cement, sand, bricks, slate, concrete, stone	Trowel, bucket, steel pan, chisel, hammer, brush

Actors implied and skills required in O&M

Actor	*Role*	*Skills*
Household user or local caretaker	Clean silt catcher, surface drain, and removing of earth, tree leaves, garbage etc	Understanding of hygiene, some technical knowledge of drain system
Local artisan	Repair parts, if broken, remove obstructions in delivery pipes/channel	Basic masonry, piping, knowledge of system functioning
External support organization	Monitor performance of systems, train users/caretakers and locals artisans, provide assistance in large problems	Training skills, technical skills for repair and maintenance of surface drains.

Organizational aspects: Minor repairs and O&M activities are usually executed by the household users themselves or by hired laborers who are paid for their activities by the household users. If common repair is to be done, the cost shall be collected and repair will be managed by village water and sanitation committee. External support may be needed for training of users and artisan on technical and O&M tasks. Assistance may also be required for larger technical problems.

Recurrent costs: Recurrent costs are low for surface drainage. Some provisions for labor costs should be made for deblocking clogged delivery pipes, repair of cracks and damages of drains etc. This will be about 1-2 % of the capital cost.

4. Problems

An unpleasant odor emanates, if proper cleaning is not done regularly. The another major problem in the open drain is the risk of children playing in or falling into polluted water, and the possibility of vehicles damaging the drains or falling into them. Sometimes community disputes arise because of problem of blockage of drains and damages caused.

5. Limitations

Insufficient space for construction of drains in lanes and streets.

6. Remarks

Open surface drain cannot function satisfactorily until the street and lanes are paved. Every house should be connected through an effective silt catcher or a trap with screen. Street side drains are generally constructed on street slopes.

Example for costing of a open surface drain

Length = 1 m
Bottom width = 250 mm
Depth = 500 mm

SL. No.	*Components*	*Amount (Tk.)*
1	Earth excavation	40.00
2	125 mm brick work (1 4) and soling	425.00
3	18 mm plastering (1:4) with neat cement finishing	150.00
4	25 mm patent stone flooring with neat cement finishing	50.00
		665.00

N B The cost may vary location to location and quality of materials

7.2 Drainage below the Ground Underground Drainage System

1. Brief description of technology

A common type of drainage below the ground is constructed from prefabricated sections of cement pipe, typically 1-m long and 50-mm in diameter. A tongue of the end of each section fits into the next, ensuring that they are properly aligned. The diameter of the drainage varies with the inflow. This system comprises house drain, silt catcher, connection chamber inspection chamber, main drain or sewer, manholes, ventilation shifts, etc. provided for conveying the sanitary sewage and storm water for final treatment or disposal.

Illustration To Be Added

Underground drainage can be divided into three systems: (a) *combined system*- the storm water is completely mixed with the sanitary sewage and conveyed through a single drain or sewer; (b) *separate system*- the storm water is not allowed to get mixed with the sanitary sewage; (c) *Partially combined system*- a part of storm water is mixed with sanitary sewage and conveyed through sewer and remaining storm water is conveyed through surface drains.

Traffic load should be considered while designing closed drains. The pipe should be laid 0.75 m approximately below ground level so that it is safe against loads of carts & tractors.

This system has some specific facilities. These are: i) low cost and much effective for rural sanitation, ii) not likely to be misused by the community, iii) not needs frequent repair and maintenance, iv) easy to maintain and v) community can be trained easily to cast pipes in the village itself.

Capital cost: The capital cost of the underground drain depends on different factors. The quantity of sullage produced from the community varies with the quantity of water supplied, and local bathing and washing practices. Drainage systems are also depends on type of terrain, soil condition, slope of ground, type of pipes and availability of local materials, etc. The cost of underground drainage system consisting of 150-mm diameter R.C.C. pipe runs about Tk. 505 per running meter.

Area of use: These drains can be constructed and used in a village where trenches can be excavated up to depth of 0.70 m at least, for laying of pipes. This system is not suitable for rocky strata.

2. Description of O&M activities

Operation: Cleaning of the silt catcher should be done every week or as required There should always be flow of sullage in the pipes to avoid cracks in the joints.

Maintenance: Inspection chambers should be checked regularly so that any blockage in the pipeline can be removed. House connection pipes should be checked periodically. Any breakage/damage of the pipeline should be attended and repaired immediately.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Checking silt catcher and connection chamber and clean	Weekly	Household	Water	Broom, brush, tool to open access etc.
Deblocking of house connection pipe and connection chamber	Occasionally	Household or caretaker	Water, piece of pipe	Broom, brush, shovel, long, stick or flexible brush, knife, saw.
Repairing of drains and inspection chamber	Occasionally	Household or caretaker	Water	Broom, shovel, and tool to open access Material to dismantle pipes
Monitoring, training, activities, support with drainage problems	Regularly	Village water and sanitation committee	Writing materials, training materials	Means of transport, documentation etc.

Actors implied and skills required in O&M

Actor	*Role*	*Skills*
Household/user or local caretaker	Check outflow of closed drains leakage from pipes, contact external support agency when problems	Understanding of hygiene, some technical knowledge of closed drain system, inspection of inspection chamber, connection chamber, and communication skills.
Local artisan	Repair if damaged or leakage in pipes	Basic masonry, piping techniques, knowledge of system techniques and functioning
External support organization	Monitor performance of systems, train users/ caretakers and local artisan, provide assistance with large problems	Training skills, technical skills or repair and maintenance of closed drains, monitoring skills

Organizational aspects: O&M activities are usually performed by household itself or by hired labor who are paid by the household. The collection of funds and management should be done by an organization like the village water and sanitation committee. External support may be required for monitoring the performance of the closed drain and for training of users and artisans on technical O&M tasks. Assistance may be required in case of large technical problems.

Recurrent costs: Recurrent costs are almost negligible Sometimes expenditure may be required to clear blockages, repair underground pipes and to replace pipes, if required.

4. Problems

Unpleasant odor in case of leakage, and community disputes may arise due to blockage of drains. Proper sloping is a major concern in the construction phase. Polyethylene bags should not enter in the drain; otherwise the drain will be easily blocked.

5. Limitations

The pipe should be laid at least 0.70 m below the ground level; otherwise loads of carts or tractors can damage the drain. If the actual traffic load exceeds the design load, there is chance of damage to the pipe. Difficult to lay in area where the water level is high. Besides, there are chances of contamination in the case of leakage in the drains.

6. Remarks

Laying of closed drains should be done at minimum gradient of 1.100 and they should be carefully placed. Underground drainage should be kept safe against rupture load. Joint should be properly sealed to minimize the leakage

Example for costing of a 150 mm R.C.C. pipe

Length = 1 m

SL. No.	*Components*	*Amount (Tk.)*
1	Cost of pipe	300.00
2	Cost of cement concrete	100 00
3	Cost of labor of earth cutting	30.00
4	Labor for fitting and fixing including cost of gaskit, cement mortar etc	25.00
5	soling	50.00
		505.00

N B The cost may vary location to location and quality of materials

7.3 Pond Water Influent Diversion

1. Brief description of technology

Often surface water is polluted because people use it for all kinds of activities such as bathing and washing. Defecation is also often done in or nearby water sources. The water does not only become dirty; drinking this water is also a great health risk. The water may also become unsafe for drinking because farmers use pesticides and insecticides that get into the water. The water also becomes polluted from the unwanted water from the household- toilets, kitchen etc. A pond can be used for drinking and cooking purposes (with limited treatment) when it will be free from all unwanted water flow. There is no single technology to protect or improve the quality of the pond water. It also requires social mobilization and people's participation to make the program successful.

A community by-law could forbid use of the lands close to the pond for agriculture or at least forbid use of chemicals in farming these lands. This could also help to limit the use of the pond water for other purposes.

To divert the water from the kitchen and bathrooms to the pond, a drain and soak pit can be constructed. Drains can vary from simple trenches to concrete pipes. The choice of a particular type of drain will depend on the available financial and material resources. It must be realized that, where there is hardly any money to spend on materials, a simple system of dug split and waste water drains, preferably plastered with clay, can already mean a great improvement.

At the end of a drain the soil will be muddy, and especially if the soil is not permeable, pools with stagnant water are formed. This may pose a health risk. A soak-pit can solve these problems A soak-pit is a pit dug at the end of a drain that is filled with coarse gravel of more than 20-mm diameter. The water drains into the pit and seeps into ground through the sides and the bottom. The size of a soak-pit will depend on the permeability of the soil and the quantities of water being drained. If the area around the pit becomes muddy or if pools start appearing, the pit should be enlarged Additionally trees, such as banana, could be planted at the end of the drain. These will use much of the water.

Capital cost: The capital cost of soak-pit for 30 users is around Tk. 15,000 to Tk. 20,000.

Area of use: It is convenient to use a common soak-pit for a few families. It is essential where central wastewater discharge system is absent and the pond water is used for drinking and cooking purposes after treatment. It is also necessary to protect the groundwater where shallow tubewell is still in operation without any risk.

2. Description of O&M activities

Operation: Operation includes cleaning of the drainage system and the pit.

Maintenance: garbage, leaves, animal waste and dry fodder can block the open drains. It requires cleaning and clearing the blockages to maintain continuous disposal. Regular cleaning of is also needed because mud and dirt may block the seepage.

Occasional repairing of the drainage and pit from any breakage or damage.

3. O&M requirements

Activity	*Frequency*	*Human Resources*	*Material & Spare Parts*	*Tools & Equipment*
Cleaning of drain	Daily	Household or hired labor	Water	Broom, bucket, long stick & trowel etc
Cleaning of pit	Weekly	Household or hired labor	Water	Broom, bucket, long stick & trowel etc.
Deblocking of drain & pit	Occasionally	Household, caretaker or local artisan	Water, piece of pipe	Broom, shovel, long stick or flexible brush, knife, saw
Repairing of damages of drain and pit	Occasionally	Caretaker or local artisan	Cement, sand, bricks, slate, concrete, stone	Trowel, bucket, steel pan, chisel, hammer, brush

Actors implied and skills required in O&M

Actor	*Role*	*Skills*
Household user or local caretaker	Clean silt catcher, drain, pit and removing of mud, tree leaves, garbage etc.	Understanding of hygiene, some technical knowledge of drain system
Local artisan	Repair parts, if broken, remove obstructions in drain/pit	Basic masonry, piping, knowledge of system functioning.
External support organization	Monitor performance of systems, train users/caretakers and locals artisans, provide assistance in large problems	Training skills, technical skills for repair and maintenance of surface drains.

Organizational aspects: Community involvement is absolutely essential to protect the pond. It does not include only the operation of maintenance of the drains and the pits; it also requires regularly organized education and communication sessions. These help maintain a high level of motivation in the community in order for all users to ensure the continued cleanliness of the pond, and to resist the use of the pond for any other purposes but the collection of drinking water.

Minor repairs and O&M activities are usually executed by the household users itself or by hired labor who is paid for his activities by the household users. If common repairs are to be done, the cost shall be collected and the repair will be managed by village water and sanitation committee.

Recurrent costs: Recurrent costs are normally low for drainage and pit Some provisions for labor costs should be made for deblocking clogged, repair of cracks and damages of drains and pits, etc. This will be about 2-5 % of the capital cost.

4. Problems

Unpleasant odors emanate if proper cleaning is not done regularly. If the size of the pit is not adequate, the pit becomes muddy or pools start appearing.

5. Limitations

In the highly dense community, space is a major concern for construction of drains and pits.

6. Remarks

Community willingness is the major factor for protection of a pond. If the parts of the village have other alternative water sources, they may not pay proper attention in protecting the pond. Proper communication and community mobilization are very much important to protect a pond.

Example for costing of a soak-pit for the users 30

SL. No.	*Components*	*Amount (Tk.)*
1	Earth work	500.00
2	R C.C. (1:2 4) in curb well with 1.5% reinforcement (excluding cost of rod)	1500.00
3	250 mm Honeycomb brick work (1:6) in cement mortar	3200.00
4	250 mm solid brick work (1:6)	4000.00
5	100 mm R.C.C. (1 2:4) slab with 1% reinforcement (excluding cost of rod)	1000.00
6	Supplying and fabrication of reinforcement	1700.00
7	Supplying, fitting & fixing 450 mm dia cover	350.00
8	Supplying & filling graded khoa and sand	4500.00
		16750.00

N B The cost may vary location to location and quality of materials

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

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Volume 4: The Sourcebook

8. Community and Household-based Management Systems

8.1 Introduction

One of the main concerns both in project implementation and during operation and maintenance is the involvement of all stakeholders, in particular the women.

Public meetings - To enable women to attend meetings the project must meet the women's practical needs. This goes both for the more conventional types of meetings where only discussions are being used, and for meetings which use participatory techniques. Practical gender needs are met when the meetings are held at suitable times and places for women. Special efforts must be made to involve poor women, who are often not represented in women's organizations. Neighbourhood delegations or meetings may help in this regard as poor and wealthy households are often located in different parts of the community. Small neighborhood meetings also facilitate women's participation.

Care is needed to ensure that information about meetings reach women and men along the channels that both groups use. Project staff often assume that when they tell the men, the women will hear about it. However this does often not happen because the men may simply think that meetings on village affairs are not for women, even when they are about water, sanitation and health.

At the meetings, use of the local language or dialect and gender-appropriate seating (that is, in a circle or two groups next to one another and not behind one another) enable also women to hear and understand what is being discussed. Feedback from women and men can be improved by the attitude of the discussion leaders and by prior discussion with the women.

In formal meetings a break in proceedings for men and women to discuss issues, and the use of a spokesman and spokeswoman to voice the opinions of each category can also assist. In meetings where participatory tools and techniques are used, it is often easier for women to take part on an equal footing with men. Pocket voting, for example, is a technique where male and female participants have equal chances for participation and equal votes. Results can be reported in a gender-specific manner when men and women use different colour beans or slips. In participatory mapping, separate mapping by women and men, followed by each group reporting its findings and decisions in a plenary for joint decision-making. This is sometimes more effective than joint mapping. The use of small-scale models, photographs and drawings of the proposed facilities has also stimulated women to participate in decision-making and to provide valuable feedback from men on male views and from women on the female perspectives.

Local educated women, such as midwives, nurses and teachers, may be chosen by community women to be their representative and go-between. The use of gender approaches as part of regular procedures makes it possible to get gender-specific results without significant additional costs. But if women are culturally too restricted to participate much in mixed gatherings separate sessions with women and men will be required.

Staff have also contacted women at their places of work (in the field, at washing sites, etc.) because the women did not have the time to meet elsewhere. These approaches will not be appropriate in areas where women live in seclusion and social contacts are confined to the family. In such cases female workers have made home visits and organized meetings in the homes of leading local women, taking care that poor women were not left out.

Decision-making bodies - A more balanced gender representation on decision-making bodies needs support from both men and women in the community. Women's participation is more readily accepted by the men if responsibilities are divided along existing gender lines, for example, if women on water committees are responsible for health

Often the local women themselves make the best reasoned choice of their representatives. Selection criteria that are of importance include the following:

- The women selected should represent the interests of various socio-economic groups in the community
- They must have sufficient time and mobility to carry out the work.
- Their position must be respected by both men and women
- They should have the support of their relatives.
- A strong personality and experience with organizational work are advantages.
  Often, single women are selected because of their greater freedom of movement.

Several women on a committee can give one another mutual support. Attendance of the first meetings by an extension worker, who may need to be a woman, also helps. In many cases, women representatives will need special training, particularly in leadership skills, confidence building and communication with those they represent. Training must also be given to the men to prevent them from feeling bypassed and then objecting to the women attending their training.

In areas with strong gender segregation, a gender approach is more generally practised through parallel organization of men and women. In some locations women's organizations have a long tradition and considerable status and power in issues concerning women, such as health, cleaning and village beautification. They also finance women's activities and facilities benefitting especially women, such as rainwater tanks and handpumps and latrines through savings and loan associations. One can however question whether the construction and financing of such facilities, which also benefit the men in the households, should be shouldered solely by women.

The reason that women sometimes insist on being solely in charge is that they fear than when the men come in, they will no longer have any say in the matter. In that case field workers clearly have a task to discuss gender division of burdens and decision-making with also the men. This helps both women and men to become more aware of gender and to arrive at a better division of the burdens and benefits of the project.

Table 8.1. Mechanisms to promote the active involvement of Women

Activity	*Mechanism*
Project initiation	Programmes establish contacts with male leadership to understand and also support participation of women
Information and dialogue	Programmes use information channels and materials that also reach women
Meetings	Programmes facilitate women to participate and speak out in project meetings by organizing: • a suitable time and place • awareness of meeting and invitation to attend • appropriate seating arrangements (not at the back) • the facilitation of women speaking out (vernacular language, discussion breaks, choosing spokeswoman, etc) • separate meeting with women where necessary
Planning	Water and sanitation projects are linked to economic and educational development programmes, so that women can make developmental use of water and time gains and get new meeting and learning opportunities when traditional meeting and learning opportunities are reduced
Decision making	Programmes also enable women to participate in making informed choices on. • caretakers and mechanics • committee membership • design and location of facilities

	• local management arrangements • local financing systems
Representation	Women choose their own representatives for trust, ease of contact, leadership capacity, feasibility (time and family support)
Management	Programmes build on traditional tasks, skills and knowledge of women for new roles in water supply, sanitation and water management (without excluding men): • management of water, waste and soil use • maintenance and repair of water points • hygiene education with fellow women • construction of latrines and monitoring their maintenance and use • management of funds
Training	Women also are trained for technical and managerial tasks Programme staff and management are aware of reasons and trained on practicalities of equivalent participation of women and men

8.2 Management for Operation and Maintenance of Household-based Systems

Most household-based technologies require some kind of internal management arrangements. For example, in household level water treatment the right amount of alum has to be added in relation to the seriousness of the contamination, and enough water treated to serve the drinking and cooking needs of the family. In the case of rainwater harvesting, careful management of the amount of water is needed to ensure that the water lasts until the next rains. Children need to be taught and supervised to avoid taps being left open. These tasks generally fall to the women and some of them will need training. However care is needed to ensure that when the work adds to women's already heavy workload (e.g., in case of daily treatment) the issue of availability of time is addressed, also with the men. Good participatory techniques and tools are available that give both women and men better insight into the gender division of workloads and stimulate addressing this issue.

Apart from managing water quality and quantity some technical work again will be involved. Some of this work, e.g., cleaning the roof and gutters before the on start of the rains in the case of rainwater harvesting will culturally fall mostly to the men. Other technical tasks, such as preventive maintenance of a handpump, or replacing a washer in a tap, may be done by either sex. This is an -informed- decision, best taken by the householders themselves, but it will be useful to point out, either through discussion or a participatory tool that some technical tasks are actually better carried out by women (provided they are allowed the time), as they use pumps, tanks, etc., daily. Technical training and access to tools and spares helps them to recognise and diagnose problems early and undertake remedial action directly, rather than report to and depend on others. Here again, the responsibilities of men may then shift to other aspects (such as better drainage) rather than 'dropping from the scene'.

8.3 Management for Operation and Maintenance of Community-based Systems

8.3.1 Management Tasks

Technical Management
(To be added)

Commercial Management
Tariff setting - The tariff system must be fair and achieve recovery of operating costs. This means there must be both a tariff system and a rate. The tariff system may or may not distinguish between the various users. The first case leads to what is called a flat rate system, the second one to a graded rate system, metering and/or water vending by unit quantity. The rates must be derived from the estimated operating cost of the system, and the average rate must be calculated from the operating cost and the estimated rate collection efficiency. This average rate must then be applied to the chosen system. This means for the flat rate system that the operating cost is simply divided by the expected number of paying users. For the graded rate system, the desired number of grades and the number of payers in each grade must be found first. Then, by trial and error, graded rates can be set such that the sum total of receipts equals the operating cost. Likewise, other rates can be calculated.

Where some or all groups cannot pay rates in cash, communities have also set rates in kind. In this way, each household will pay a (varying or fixed) amount of rice (or other local staple crop) into a rice fund at the time of the harvest. The grain is stored by the Water Management Organization and sold at the time when grain prices are high (usually in the time before the next crop). They then deposit the money in the bank and account for their management of the fund in the same way as a monetary fund

The rates need to be charged, by distributing bills or otherwise. A system needs to be devised. The frequency and timing of billing needs to be looked into also. This may be different for various occupations groups, and could be accommodated in the system.

Tariff collection - Tariffs can be collected in different ways. A common system is to collect user payments through home visits. Women can do this work. Female tariff collectors have been preferred by communities, because home visits by male collectors at times when male relatives may be away for work was deemed culturally unacceptable. Other reasons for this preference are a high trustworthiness and commitment to work a task that will sustain the reliability of the water supply. Where tariff collection involves much work, care is needed to ensure the work is compensated for in some way. Instead of collecting the rates through house calls, it can also be decided that rates are paid at a periodic meeting or at the office or house of a local functionary.

Arrangements need to be put in place to take care of defaulters, i.e., people who do not pay the bill in full or in time.

Financial Management
General - The financial management of a community-operated and maintained water supply should be simple. A simple but reliable system of financial records can greatly improve community management of the water supply system. With good record keeping and record reviewing, water committees can not only work more effectively and take corrective action, but also justify their action with the users to whom they are responsible. (See also the Monitoring Manual)

Budgeting - Budgets for the expected expenditure and necessary income over the next operational period should be made well in advance. The preparation and timely discussion of the budget facilitates a review of expenditure items and their necessity and magnitude, and, on the income side allows for sufficient time to propose and get approval for an adjustment of the rates.

To facilitate budgeting, an itemized list of expenditure items must be prepared, possibly with some external assistance and cover at least the cost of labor, chemicals, materials, spares, stocks, equipment, bank charges, stationary, etc.

Accounting - In small systems the keeping of a record book of all income and expenditure may suffice. Formal bills and receipts for all financial transactions facilitate the record keeping. For this purpose the treasurer needs to have a numbered receipt book at his or her disposal for every payment made into the treasury.

Placing the funds in a special bank account makes it possible to draw interest, keeps the money safe and separated from other interests, and automatically provides a regular picture of the financial situation It also enables the committee to build-in further safeguards, such as two signatures for every withdrawal of money.

Most important is the establishment of a committee to audit the accounts once a year. The more democratically this auditing committee is created, the greater the chance that financial malpractice threatening the functioning of the village water supply will be prevented

Personnel Management

Recruitment - To operate and maintain the water supply, one or more full or part-time staff may be required. It is best for the CBO to select and recruit such staff during system construction, so that the selected person(s) can take part in construction, or at least be acquainted with all that is going on. Depending on the technology, workers may include pump mechanics, plumbers, water point caretakers, vendors and watchmen. In the selection, both technical and socio-economic criteria play a role. Candidates should not only be able to master each technical task and keep records and tools in order, but also report regularly to the management and maintain contacts with the users. Conscientious people who are residents in the village and who have social and economic ties in it will be more likely to stay on and use the investments in their training to benefit of the community. Gender awareness precludes that all technical functions automatically go to only the male members of the community. It has led to some interesting innovations such as, engaging and training a couple where male mechanics or operators had at times to be away from their place of contact for prolonged periods.

Remuneration - The management has to make decision as to whether to pay the various workers or not, and if so, how much and in what form. For some jobs and in some cultures, the official character and status of the worker and the position may be a sufficient reward. Regular communication with the committee and involvement in water supply meetings can also stimulate continued functioning. There may be some compensation in kind, such as the right to plant vegetables or fruit trees at the end of a drainage channel for a water point caretaker, or the waiving of other community duties. Other options for remuneration are to combine the job on the water supply with another, paid village job such as the community health worker position. Some villages may also share one worker between them for more occasional jobs, such as repairing handpumps, scraping of a sand filter, etc.

Other Management Tasks

Stores and stocks - For regular maintenance and speedy repair of a simple kind, the management should know what spares and tools to stock, and how to store them in a safe way. Good communication between workers and management is needed to keep the management informed of the need for spares and tools on a timely basis. Expensive tools and spares may be kept jointly by neighboring villages.

Voluntary labor - Voluntary labor from the community can lead to valuable cost savings. The success of community self-help depends to a great extent on the quality of the labor organization and the attitudes of the project staff to working with the community. Project staff sometimes blame the community for not showing up in sufficient numbers or delivering poor quality work. However, this may be done because the work coincides with other important community activities such as harvesting, which the people cannot or should not neglect.

Good labor organization can guide the initial enthusiasm when scores of people may turn up, and contribute to a high quality labor performance. The usual task of the management is to divide the work in a fair way, check attendance, supervise the quality of the work and exercise sanctions on defaulters. Good planning and monitoring prevents that certain groups or genders shoulder a disproportional burden of (voluntary) work. Sometimes these groups then also do not get an equal share in the benefits of their labour, such as, equitable access to water points. (For a simple monitoring tool see the community-scoring matrix in Annex A in the Monitoring Manual).

Communication - Some types of repair or maintenance may be beyond the capacity of the community. There may also be administrative and management problems, a need to train workers, amend the bookkeeping system, or execute other adaptations to the water supply. For these and similar issues, the management should know if and when it can call for help on external parties, and whether there is any payment involved Some level of communication with external support organizations is required to maintain contacts and be appraised of developments that may be interesting for the village water supply

Communication with the users is a recurrent responsibility, which takes many forms. Periodically, the management has to account for its deeds to a user assembly, a community audit committee or other body, which directly represents those who sustain the water service in labor and cash. They may also communicate more indirectly with the users through caretakers, e.g., when the service is suspended for maintenance. Communication consists of giving information to the users and getting information from them, e.g., on user needs. In addition, the management can also participate in local hygiene education activities, e.g., to promote that non-users join the supply or to improve hygienic water use. An improved water supply can have a tremendous effect on the health status of the community, but only when all or nearly all households use the safer water in safe way and also improve their local hygiene and sanitation practices.

Monitoring and evaluation - Participatory monitoring and evaluation by users can enable management to take decisions on what improvements could be made to the system. Thus, monitoring and evaluation becomes a process of self-development for users and management, from which both will benefit. In addition, the availability of records on the operation of the water supply system, and on reasons and duration of breakdowns make it easier for national or regional agencies to carry out periodic evaluations of the water supply services and to introduce benefiting structural improvements that may be needed.

8.3.2 Organising for Operation and Maintenance

Stakeholders
(To be added)

Organisation for Daily Management
Water user groups - In general, it is preferable that users groups are composed of those users directly involved in the water supply. Depending on system size and preferences, users groups may be organized at the level of the village, para or lower, where inhabitants form a social unit and are in the habit of maintaining and financing joint facilities. Water user groups need not be set up separately, but be part of or integrated in other groups looking after community concerns.

Water committees - A water committee is a committee that is formed with the specific purpose of administrating the water supply system. The water committee may represent the whole community when everyone can use the improved water supply. Alternatively the committee may represent only the members of a water users' association or co-operative. An advantage of a special water committee is that participation in the local planning and administration of the water supply in their only concern. A separate committee also facilitates representation of all sections of the community.

8.3.3 The formation of a representative body

When planning and managing a new water supply, or combination of a set of new and traditional water systems it is very important that the interests of the different types of water users are represented honestly and fairly. When working with a small group of people who all know each other they often make informal arrangements amongst themselves. In a larger group some kind of representation is usually required. Options for managing water and sanitation include:

- A local leader. This has worked well when the local leader is well respected and protects the interests of all groups equally well. However in many cases a local leader has many other responsibilities, thus day to day management of a water system or sanitation program suffers. In many cases temptations also prove too great, especially when money is involved and misuse of power and funds are the results. Dependency on one person also often causes problems when that person stops or dies.
- Local government. This option may work, but local government is often responsible for many things; thus day to day management of water and sanitation suffers. Also the temptation is great to use funds collected for water supply for other things, especially when there are no immediate problems with the water supply or sanitation systems and other developments call for immediate action of the local authorities. Where local governments are elected the water and sanitation provision becomes politicized. Weaker groups tend not to be represented equally in local governments and when present may have less say.
- Existing development committees. Where present they often need to be involved, but tend to have no direct representation of women and other weaker groups. Sometimes the committees agree to correct this and either have a separate women's committee or involve women. Even then, women's actual "say" may not be guaranteed and requires monitoring.
- Sub-committees to Local Government or General Development Council. This is often a way to overcome problems of lack of specialization, politicization and representation. A Local Government Act often allows for the establishment of special committees. When people chose their own representatives for planning and management on merit they tend to include local leaders only when they are an asset to the committee, or so powerful that people fear to bypass them. Where people did not expect help from local leaders but could not bypass them for reasons of respect they have also made them ex-officio members. Electing own sub-committees gives the users a mechanism to reduce the influence of unfair and corrupt leaders, except in cases where they are too strong.

  To ensure that also women are represented women should be encouraged to choose their own candidates and these should get support from the SO to enable them to function on an equal footing with male representatives.
- Small enterprises. In more developed communities where people have more money one often sees that for day to day management the community engages paid staff, such as an administrator, system operator/mechanic and a (part time) bookkeeper. In time this develops into a small enterprise, which also starts to manage related community services, e.g. solid waste collection and disposal, management of the public environment (environmental hygiene, children's playground, park)

Hints for checking suitability of an existing organization to manage water supply and sanitation

- What are the major functions of the organization and how closely does it relate to the water/wastes authority?
- What has been its history and duration?
- What is the size, type of membership, leadership? What overlap is there with area traditional leadership? How are members chosen?
- To what extent does the organization represent or bring together the different subgroupings or factions (religious, caste, gender, economic, tribal, etc) May the membership be expanded to make it representative?
- To what extent is the organization tied to municipal, district, regional or national hierarchy? How good are information flows and what accountabilities exist between the different levels?
- What accountability does the organization have to its members, to any other entity, or to the people it represents?
- Do members participate actively in decision making? All? Some? Certain subgroups?
- What has been the proven managerial experience of the organization? How transferable are experiences and skills to the particular water/wastes activity?
- How capable has the organization shown itself for mobilizing internal and external resources in general, that is, mobilizing labor, collecting fees, dues, tariffs, etc ?
- What relationship, if any, does the organization have with government agencies or political parties or semi-autonomous bodies? How do these in turn relate to the water/wastes authority and the present political structure of the country?
- To what extent is the organization overburdened already with present functions, or able to handle new ones?
- What incentives, training (technical and management), or other forms of support would be required?
- What structural changes might be called for in the organization?
- What is its past experiences in dealing with infrastructure types of activities?
- What are its present record keeping activities and how suitable are they for possible project functions? Can these form the basis for a continuous monitoring of performance during implementation (with a view to helping it out when needed), and after completion of physical structures (to keep an eye on use, maintenance, payment, etc)?

Hints for choosing suitable women and men on committees

Materials needed Assorted pictures of women and men dressed as higher, medium and lower income level householders and with different ages, Pictures of props and situations needed in various functions of a committee, e g. papers, money box, tools/toolkit, a man/woman communicating with others, presiding a meeting Cloth to lay pictures on For several groups, several sets of the same pictures

Procedure Divide the audience into small groups Ask each group to identify the tasks that committee members will have to do and the requirements needed for that task Ask the groups to select the picture of the type of person that according to them is most suitable to carry out each task and determine the reasons why they chose that type of person for that task When each group has made its choices, they present their choices and reasons to the plenary The plenary chooses/ votes for the final combination of types of men and women for each task The group then identifies who in their neighborhood/community will fit the profile and when these show interests helps them obtain acceptance and support from their environment

Source. Srinivasan, L Tools for community participation New York, PROWWESS/UNDP and PACT, 1990, 1993 Adjustments from Wijk, C van, Gender in community water supply, sanitation and water resource protection The Hague, IRC, 1995

8.4 Management for the Construction Phase

(To be added)

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) Dhaka, Bangladesh

Volume 4: The Sourcebook

9. Community and Household-Based Financing Systems

9.1 Introduction

One of the most important decisions in planning a community-based water supply system is the actual financing system or mix of systems that the communities adopt There are many ways in which rural and peri-urban households can decide to share in the financing of capital and recurrent costs of the water supply and sanitation in their communities or neighborhoods.

This section of the sourcebook gives an overview and description of the various financing options and under what conditions either of these options is most suitable.

The actual decision on what type of types of financing systems the communities will adopt is a decision that the communities, and the men and women in them, will make for themselves. The role of the SOs is to present them with options, and then relate information about these options and to help them discuss the pros and cons of the options in their particular situations. In these discussions both the communities and SOs will have had experience with some of these options and can point out risks and benefits. In the end the users and communities who will make an informed decision - and the proof of it being correct will come from putting it into practice. Then further adjustments may need to be made; so that monitoring how well the financing system(s) work will be an important part of the job.

Missing tools
Missing in the decision making on financing, and indeed underlying the whole set of the manuals, are the tools -visual, games and so on - that help village people go through these financing options and compare their respective merits and demerits. These aids will help making financing issues less abstract and to make it easier for the people who are less familiar with financial issues to take part. These tools need urgently to be developed, tested and made part of an overall tool set.

A broad distinction in presenting financing options is between:
a) financing systems for financing individual household solutions and
b) financing systems for financing communal systems (neighborhood systems or full community systems)

The individual options are listed in table 3.7 of the Sourcebook and are basically for water supply: home filtration, rainwater harvesting, solar purification and sharing of a "green" handpump. Details of these technologies are given in section 5 of the Sourcebook. Sanitation options for individual households are various types of latrines and the household soakpit. These technologies are described in section 6 of the Sourcebook.

Two general principles to consider when choosing the type of financing are:
- who in the community may not be able to afford (all) the costs of the safer facilities
- the issue of social and religious duties of the better-off towards the disadvantaged; and
- what it means for public health when a substantial number of families cannot use water and sanitation facilities that are bacteriologically safe. No reduction of infectious diseases related to water and sanitation can be realized, when only a few wealthier or subsidized families use safe water and sanitation instead of a large percentage of the total village population

- the so-called "critical mass" (Figs. 1 and 2)

Fig. 1

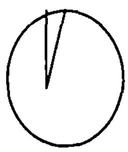

Fig. 2

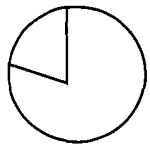

Fig 1. No difference for people's health when only a few households adopt safer facilities and practices

Fig 2 Impact on health when a sufficient proportion of families adopt safer water use, sanitation and hygiene

9.2 Operations and Maintenance Financing

The costs of operating and maintaining the infrastructure created by the project will be the full and exclusive responsibility of the users. This implies that the user community will have to prepare for financing these operational expenditures from revenue generated by the users.

9.2.1 Financing of household options

Household rainwater tanks, latrines and private tubewells are some of the options for safe water and sanitation that are individually owned Households vary in the capacity to which they can pay the costs of these options. Some can pay directly and for all costs, some can only pay the full share through savings and/or credit and some cannot pay at all A growing number of projects recognize these differences and make provisions for them. Here are some examples:

- In Kerala, India, only poor households get support to install a sanitary latrine. Better-off households pay the full costs themselves, poor households ('below the nationally defined poverty line") get half of the agreed costs of the facility paid by a combination of the Panchayat (25%) and the Government (25%). The remaining 50% the householders pay themselves. The subsidy has been defined as a flat amount (half of the present cost), so that the proportion the households that pay increases over time. The neighborhoods select the qualifying households The Panchayat displays the names of those selected for internal accountability.
- In NE-Thailand, the Panchayats establish a revolving fund for rainwater harvesting tanks and latrines. Households wishing to install a facility take a loan that they must pay off after their harvest. There are no subsidies. The CBO manages the loan in a similar way as savings and credit programs in Bangladesh do, e.g., Grameen Bank and the larger NGOs. Many households take a small loan and build a small rainwater tank first. The tank is built as a large pot, but using the ferro-cement technique. When the loan is paid off, they take a new loan and build a second pot-shaped reservoir.
- In East Kenya and Fiji, women form groups to save money and, in Kenya, they hire themselves out as land labor in the planting and harvesting season. When enough money has been earned to finance gutters and a storage tank, they draw lots and build the tank themselves at the house of the woman who has won. Next, another member gets a chance. The project only provides the training and support; the members pay all direct costs themselves. There is some gender balance in it, as the women do it all while the men benefit equally from the drinking water. However the women chose not to involve men, as they fear that these would take over their groups. Now, after more than 10, and in some cases 20 years, the groups are strong and the women have built their self-

confidence and capacities. The women have now opened the discussion on males and females sharing the workload more equitably.

9.2.2 Community Financing System

The main options are **community fund-raising, regular user charges, water vending** and **indirect taxation**. Each of the options has its own advantages and disadvantages which should be fully considered in the planning of water supply, at both the program level as well as in local planning with the community itself.

Options for community fund-raising: A common form for financial participation is community fund-raising. A characteristic of such fund-raising is that families do not pay regular contributions towards the cost of the community water system Instead, money is periodically accumulated in other ways.

Community water funds can be created through voluntary fund-raisings, the use of other community income, or the establishment of a community revolving fund or production cooperative.

Options for regular charges: The alternative to community funds is that user households pay a regular contribution for the special purposes of financing the water system. Payments are made to the water agency, the local government or a water users' organization.

The advantages of regular and direct water charges are that they can more easily related to actual water use and to the operation and maintenance costs of an improved water supply. For charging a choice has to be made among general payment of flat rates, graded rates, mixed rates or rates based on metering.

Vending: The improved vending system can provide better quality water to the consumers for a reasonable price. It is especially suitable in communities where other solutions are technically, economically or politically impossible and where a socially valuable vending system can be improved. The price of the water should not be higher than that of public and private connections. At the same time it should preserve the income of the actual carriers.

Taxation: In this system, municipalities collect the necessary funds not through direct charges but indirect taxation. Taxes are used exclusively for financing one or several basic services and categories of payment are based on level of service or housing conditions. It is suitable in communities where the transfer of sufficient funds to the water organization is assured and taxation can be related to water use and costs.

9.3 Fund raising

9.3.1 Voluntary Funds

With incidental fund-raisings, local leaders or a community group collect voluntary contributions for the construction, repair and expansion of the community water supply. Funds are collected at public meetings, bazaars, lotteries, festivals, and similar social activities, or through door-to-door collections.

The total amount that can be collected in this way is uncertain when the size of the contributions is left to be decided by individual households. Setting a target for the period to be provided for and dividing this target by the estimated number of user households can help. Each household then has a yardstick with which to set its personal contribution.

Annual voluntary fund-raising for maintenance can be a good solution in communities with seasonal income. In farming communities for example, a special campaign can be organized to raise money for the running costs of the community water supply at the time when the cash crops have been sold. The amount of money that needs to be raised should of course not to be large. An advantage is also reduction of work for the local organization, as it needs to come into action for fund collection only once a year. This can be done at the time when agricultural work is slackening and traditionally much attention is paid to social activities.

A limitation of the system is that there is no link with actual water use. Households, which use large quantities of water for domestic and perhaps also productive purposes such as livestock and vegetables, may not pay in proportion or may even evade payment completely. The system is therefore only suitable when there is enough social control in the community to ensure that all user households pay a voluntary contribution in accordance to their capacity and benefits received.

9.3.2 General Community Revenue

Some communities jointly own and mange communal enterprises, such as a communal field for a cash crop, a village shop or flour mill. The profit made on these enterprises, or community funds generated by other means (e.g. levies on crops, cattle sales, or business) are used to pay for other community expenditures, such as maintenance and repair of a public standpost system.

A precondition for this type of financing is that all households have more or less equal access to the improved water supply. Otherwise the less fortunate households will quite rightly object that the service is paid for from funds to which they also contribute.

A disadvantage of relying on general community revenue is that the availability of funds for the water system depends on the income and profits from the other enterprises. The enterprises may fluctuate considerably in their results and also need their own investments. One option is to try and expand the number and variety of sources of community revenue, so that risks are more divided.

9.3.3 Community Revolving Fund

Another interesting way to involve the community in the financing of community water supplies is a community-based revolving fund. Starting capital may come from a government donation or the issue of shares to individual shareholders. Often there is an upper limit to the number of shares each household may buy. This prevents wealth accumulating in the hands of a few families, and decision-making becoming dominated by the wealthier fund-members.

Using the initial capital, loans are given to individual households or groups to start small enterprises or improve housing and sanitation. Upon repayment new loans are given to other members, according to the decisions of the group. Repayment of loans plus interest makes it possible to give a greater number of new loans to others. The community may also use the capital to setup communal enterprises, such as a community shop or a work yard producing building blocks, latrine slabs and other building materials In this way, community income slowly grows until it becomes possible to finance some basic service. One of these services may be safe water. Common characteristics of successful revolving village funds are strong leadership, high village unity, a high level of participation, diversified sources of income, diversified services, compensation for fund managers, external inputs, including technical and organizational training, periodic review and support visits, and good return of investments.

Despite initial skepticism, experience with loan repayment by low-income households is very positive. Women in particular have gained outstanding repayment records in many countries. Contributing factors are the intimate knowledge which small communities or neighborhoods have of their members' capacities and reliability, the creation of group liability and control, and the strong motivation to make life better for the children.

9.3.4 Production Cooperatives

Sometimes, an improved water supply is established and run by a group of households rather than the community as whole. The water supply serves either the group or the whole community. One type of group is a production cooperative. Its members contribute regular payments in cash or kind, or buy shares The resulting fund is used to finance cooperative enterprises or give loans to individual members.

Once the group has got sufficient revenue, the members frequently decide to use part of their funds to finance basic services for the group, such as water supply and household latrines. The fund is used to pay all or part of the construction costs, or to establish a maintenance fund for an externally financed system. Because social services to members usually come in a later stage, cooperatives are already well organized by the time that they start a water supply project. Their earlier experience with social organization and financial management is also good proof of their capacity to administer a small water system.

A special form of a cooperative approach to an improved water supply is a saving club. Each member of the club (often a women's group) makes a small regular contribution to a communal fund. These contributions can be in cash or in kind. In some groups, for example, members save a handful of rice every day. When enough rice has been collected it is sold to increase the funds of the group, e.g. by hiring themselves out for agricultural labor during peak season. The group's savings are paid out to each member in turn to finance a major acquisition, e.g. a corrugated iron roof with gutter and rainwater collection tank. In this way the women have succeeded in assisting each other to make important improvements for family hygiene and labor reduction. In other cases, the groups have initiated and contributed financially to the improvement of the community water supply, and have also succeeded in mobilizing help the men.

9.4 Rates

9.4.1 Flat Rates

In a flat rate system, each user household pays a fixed amount of money, regardless of the volume of water used. In its simplest form, the total amount of money needed for the upkeep of the improved water system is divided equally over the number of households using the water. Payment may be per month, per season, or per year. This should depend on when it is most convenient for the people to pay.

Flat rates are easiest to organize to organize with private taps or groups connections. In these cases, it is clear who are users and who are not. They should also be limited to situations where benefits are more or less equal. Individual households those are making much more use of water should be charged proportionally. With public standposts, families who live at further distance or have their own water source may particularly object to paying the same amount of money as those who live close to a tap.

One possible solution to distinguish between regular and occasional users is to form a tap committee at every public tap to collect water rates for the overall water administration. These committee can advise or decide on which households are regular users and should pay a full flat rate; which households should get a lower rate because of greater distance to and periodic use of taps, and which households should not be charged at all. They can also consult the user households directly and discuss the importance of reliable and safe water with them, even when this means walking a somewhat greater distance to get it.

An alternative to free public taps and private house connections is the introduction of paid group connections. This is particularly suitable where strong social ties already exist within small groups living close together. Often, for example, groups of low-income households already share and care for traditional water sources. Sharing a yard connection or standpost with a small group of neighbors can be a good alternative when a private connection is too expensive.

9.4.2 Graded Rates

A major disadvantage of flat rates is that they press more heavily on low-income households than on the better off, even though the latter often use relatively more water than the former. Graded rates are introduced to overcome this limitation of flat rates. Taps are not metered, but the user households are classified into two or three rate categories. These categories are based on estimated differences in water use and income (e.g high, medium, low) The advantage of graded user rates is that they take a rough account of volume used and payment capacity, without having to go to the expense of installing and reading water meters. Water authorities could try to develop graded rates especially in areas with considerable differences in income and in water use related to these income levels.

The introduction of graded rates is easiest when clear and valid indicators of water use and income level can be found. This will of course depend on local circumstances. For example, in some areas, the size of land holding is a good indicator of income. In other areas the productivity of the land varies too much for this, and the quality of housing is used instead. An alternative to working out graded rates through assessments and dialogue in individual communities is to ask a social scientist to develop a system of valid, easy-to-measure and acceptable indicators of household income and volume of water use for the area concerned. The applicability of this system can then be tried out on a small scale.

9.4.3 *Mixed Rates*

A mixed system is another option to cover the recurrent costs of a community water scheme. It combines paid private connections with free public standposts. When there are enough private connections it becomes possible to finance the cost of public taps for the lowest income groups from a surplus of the rates paid by the private users. However, it is not always easy to get a good balance between free public taps and paid private connections. Households, which can afford to take a house connection, do not always do so, when there are enough free standposts. Reduction of the number of standposts can stimulate more wealthy households to take paid house connections. However, it also reduces the access to a minimum service for those who cannot afford a private tap.

Sometimes it is possible to raise the number of paid connections in other ways. One such way is the education of better-to-do households on the advantages of a private tap in terms of family health and more time for children's school education, women's classes, childcare, production of family food etc. An increased awareness of the multiple benefits of good water in the home can in particular stimulate male support for private house connections.

In some communities where houses of low and high-income families are not mixed or too close together, it may also be possible to limit free public standposts to the poorer neighborhoods. The wealthier sections must then be helped to understand why, for reasons of public welfare, only private connections are made available to them. This can be combined with the promotional activities mentioned above, to avoid the wealthier sections feeling discriminated against by not getting free standposts.

9.4.4 *Metering*

While graded rates based on social judgements or indicators have the advantage that they avoid the introduction of more complex metered connections, water meters do enable the agency to charge accordingly to actual volumes used. However, metering raises considerably the costs of the water system. On the other hand, if properly enforced, meters induce users to avoid water wastage, which will reduce long-term costs. Metering is therefore often introduced in larger communities where water is scarce, or is becoming so, and new sources are expensive to develop.

Individual household meters are not only expensive to install, they also need to be read regularly and make administration more complex. Separate staff to read meters, write bill and accept payments reduces chances to fraud, but also increases the cost to the users. Mailing the bills is an additional safeguard, but is less feasible in areas where few people have post boxes. Payment in person at a distant central office, which is open only during office hours, is often difficult for the users and alternatives may be necessary. Metering therefore places high demands on the administrative capacities of the managing water organization. It has happened that the cost of billing and collection alone surpasses the total amount of money collected. In addition, both meters with billing, and their alternative, coin-operated meters are sometimes tampered with to reduce payments. Meters are also subject to technical problems. For small community water supplies, unmetered systems are therefore to be preferred initially. An exception is peri-urban group connections, as discussed below under metered group connections.

With metered house connections different types of water charges are possible. Flat rates mean that every meter holder pays the same amount per unit quantity of water consumed, irrespective of whether the household is a small or a large user.

With a progressive rate, the amount of water consumed is divided into blocks. The price charged for the first block of, say, 18 cubic meters per month, is kept low, because this water used for basic family and health needs, such as drinking, cooking, bathing, washing and cleaning. For subsequent blocks of water use, a progressively higher rate is charged, because this water is used for amenities such as flush toilets and watering of lawns, or for productive purposes.

Regular payments are more easily obtained for private taps than for public standposts. Two possible financing solutions for standposts, are mixed systems whereby free standposts are cross-subsidized by paid house connections, and the option of an unmetered group connections with flat or graded rates that has already been discussed. A third option is the installation of metered group connections. This is especially suitable in urban areas when the usual metered house connections are too expensive for low-income households, and unmetered group connections are not viable because the population is frequently moving, so strong social ties and control do not develop.

9.5 Vending

Partial or full recovery of costs for piped water supplies is hardest for public standposts. Water agencies have therefore also resorted to formal water vending systems for the o n-the-spot collections of revenue. Options are the establishment of vending points as part of the water distribution network; or, instead of having a piped distribution system at all, selling safe water by water trucks, official vendors or carriers. For the first of these options, vending points as part of a water distribution system, the alternatives are: water kiosks, concession sales and coin-operated taps.

At water kiosks, the water is sold to the users per liter or type of container. Operators are either employed by the agency or are license holders to whom the kiosk is rented. Advantages of kiosks over public taps are that water wastage, vandalism and unhygienic conditions around the tap can be minimized and that user payment is assured. Kiosk holders may also be responsible for making small repairs, such as replacement of washers and repair of platforms and kiosk buildings. Vending also accustoms users to making payments, so that group or house connections become more attractive, especially because they offer better services at often lower prices.

However, the system usually means much higher costs to the users than yard or group connections, and the users are vulnerable to exploitation in times of water shortage. The users pay not only for the water, but they also pay the salary or profit of the vendors. In fact the greater part of the price paid may be for the work of the vendors, and not the water itself. In the best case, the agency sells bulk water at a low price to license holders and stipulates that the price charged per cubic meter is not higher than the one charged in the lowest-rate group of the private taps. Nevertheless, the users get a lower level of service for this price than they would get from private taps or group connections. Also, the kiosks are often limited in number and spread out thinly to ensure sufficient earnings for each vending point. This can result in long waiting times at peak hours and continued use of contaminated alternative sources. Users are also inconvenienced when taps are locked up at night, or when the license holder is absent. In general therefore, kiosks are a less satisfactory solution than other system of cost-recovery.

With concession sales, owners of a house connection get the right to sell water from a metered tap at their home to other households in their neighborhood who do not have a private connection. As a result poor users may pay more per liter for a lower level of service than the higher income households may. In addition, local businessmen who already have a considerable income from other interest may take on these concessions If vending by concession holders is preferred over mixed systems or group connections, the agency should therefore at least consider giving the right of sale to persons who need the additional income, such as women heads of households.

The advantages of choosing such women as concession holders are several. They are homebound, so that chances of their absence during the day or evening are lower. Because of limited job alternatives, it is also less likely that there will be problems of a high turnover or double jobs, to reduce the quality of the service. For the same reason such women are motivated to do a good job, while the income goes to person who does the actual work. Finally, female concession holders can communicate easier with other women on the health aspects of safe water collection, storage and use, when given some training in this subject. Their involvement therefore appears to be worth trying in cases where concession sales are planned or in existence.

Some agencies have installed coin-operated taps to reduce water wastage and to increase cost recovery from public standposts. However, current experiences are not positive because such devices are very sensitive to breakdowns and to interference with the operating mechanism. This solution is not recommended.

9.6 Taxation

Sometimes municipalities collect the necessary funds for the maintenance of their water supply system not through direct charges but through indirect taxation. Taxes used most commonly are property or housing taxes. This tax either finances the water service to the plots or standposts concerned as well as other community services, or has added to it a special surcharges for water. In this way only one collection system is needed, which is easier and saves administrative costs. For the same reason other municipalities combine water rates with electricity charges.

The system is simplest when, within each housing area, all households have the same service levels and the same organization manages both funds and water services. This is the case, for example, in some site-and service schemes Every household in these schemes has a standard size plot with a latrine or a wet core. For water, more expensive housing areas have their own yard connection. Holders of lowest-cost plots share a tap with several neighbors. A part of the property tax paid by the households goes toward the running costs of the water supply.

Administration is more complex when there is a mixture of service levels, from public taps to unmetered multiple house connections. One option is that the different types of households get a different surcharge for water. The water agency subsequently informs the rate-collecting agency about every change in service level.

Another is that a general tax is raised, based on the size of the property and the quality of the housing Large users will thus pay more, because better housing is associated with higher water use and higher income. The advantage of this is that there is no longer a need to keep track of actual service levels and changes.

The advantage for the water authorities that others collect the charges should be set against the need for the transfer of funds from the collecting agency to the water organization. The ultimate amount received frequently does not keep pace with the demands of the water administration. Their costs are apt to increase with inflation and the aging of the system. In addition, the government institution deciding on the distribution of revenues sometimes reduces its allocation to water authorities because more pressing obligations have to be met. The users then naturally get frustrated because they are paying taxes for a deteriorating service. In this turn, the water agency gets frustrated because it can do nothing about it.

Some water authorities have installed water meters to register the volume of the water supplied. This enables them to strengthen their claims for transfer of funds by the revenue-collecting agency. Others demand an advance payment from the municipal authorities, so that at the end of the year only the surplus delivered still has to be paid. So far, neither measure appears to be fully effective. Other disadvantages of indirect charges are that they do not inform the users about the real costs of the system nor allow them to participate in decision- making and maintenance.

All things considered, indirect taxation as means for cost-recovery to maintain and expand community water supplies seems to be most suitable when a specialized agency is in charge of both tax raising and water administration. In other cases, it is in general better to have separate financing for water supply. This makes it easier for the administrating organization to control both income and expenditure and run a reliable and financially healthy service.

9.7 Summary Table of Community Financing System

What?	*When?*	*What for?*	*Who organizes?*	*How?*
Voluntary funds	In communities with a tradition of fund-raising, seasonal income, and a good knowledge and control of payments according to household capacity and benefits.	Financial contributions to construction; occasional larger contribution to maintenance and repair of simple systems with public water points.	Traditional leadership, voluntary organization, e g. women's groups, tap organizations.	Targets are set and funds collected periodically through meetings, house-to-house collections, bazaars etc. Funds are collected in advance or when required.
General community revenue	In communities with own sources of income and a water supply with public facilities.	Annual maintenance and repair, financial contributions to construction; depreciation and expansion where possible.	Local government, community water committee or subcommittee.	Reservation of funds based on the estimated costs and net annual income of the community; cost-reduction or income generation where necessary
Community revolving funds	Initial capital from government donation or the issue of shares to individual household Loans to individual households or groups for small enterprises or improving housing and sanitation.	Annual maintenance and repair, financial contributions to construction; depreciation and expansion where possible	Local government, supporting organization, community water committee or subcommittee.	Reservation of funds based on the estimated costs and net annual income (repayment) of the community; cost-reduction or income generation where necessary.
Cooperative funds	Water supply initiated and financed through production cooperative or village revolving fund; no direct payments for water used.	Annual maintenance and repairs; replacement of construction loan, depreciation and expansion here possible.	Cooperative's executive committee, community water committee or subcommittee.	Reservation of funds based on estimated costs and income from cooperative ventures and/or member fees; cost-reduction or income generation where necessary.
Flat rates	Families have private taps, or share taps with well-defined social group, have fairly reliable incomes and share benefits more or less equally.	Repayment of community loan for construction; annual maintenance and repairs; depreciation and expansion where possible.	Water committee or subcommittees, board of water users cooperative, local government, tap users' committee.	Project agency advises on initial rate for approval by users; rates are collected and administrated by the local water organization.

Contd.

What?	*When?*	*What for?*	*Who organizes?*	*How?*
Graded rates	In communities with appreciable differences in water use and benefits and sufficient community spirit to divide user households into different payment categories.	Repayment of community loan for construction; annual maintenance and repairs; depreciation and expansion where possible.	Community water organization with support from promoters or other social experts assisting the project agency.	Private tap owners are classified in high and low rate categories, using local indicators of water use and wealth; users sharing taps individual rate.
Mixed Systems	In communities with large differences in payment capacity and water use, with high and low-income households living in separate sections.	Repayment of community loan for construction; annual maintenance and repairs; depreciation and expansion where possible.	Water agency with community water committee or subcommittee.	Surpluses or private taps are used to finance the costs of free public taps in poorer sections.
Water metering	In large communities with limited water resources and an efficient administration.	Repayment of community loan for construction; annual maintenance and repairs; depreciation and expansion where possible.	Water agency and/or community water organization.	Meter reading, billing and rate collecting by separate workers, or payment through banks, at central government offices or local branches.
Vending instead of a piped distribution network	In communities where a socially valuable vending system can be improved, where other solutions are technically, economically or politically impossible.	Contribution towards financing of the recurrent costs of the agency, and financing of vendor service costs, including upkeep of hygiene and simple repair.	Water agency with paid operators, women's groups or water seller's cooperative.	
Vending as part of a piped distribution network	In communities where group connections or cross subsidies between private and public taps have not worked.	Contribution towards financing of the recurrence costs of public taps and the service of the vendors, including upkeep of hygiene and simple repairs.	Water agency with paid operators or socio-economically appropriate concessionaires, e.g. women heads of households.	Water is sold from metered taps at controlled prices; when buying prices are subsidized; selling prices may equal private rates, the difference forming the vendor's income.
Coin-operated taps	Not recommended because of their great sensitivity to breakdown and interference.			

Taxation	In communities where the transfer of sufficient funds to the water organization is assured and taxation can be related to water use and costs.	Annual maintenance and repair; repayment of construction loan; depreciation and expansion where possible.	Local government service organization for a specific area, e.g. a low-cost scheme.	Taxes are used exclusively for financing one or several basic services, categories of payment are based on level of service or housing conditions.

9.8 Investment Financing

Limiting Investment Cost

The project will support only *least-cost investments* for arsenic mitigation. Choice of technology will be by the community, in consultation with the SO. Should the community have technology preferences with cost implications above the least-cost level which they are not willing to pay for themselves, then the Project can decide to withdraw investment support altogether. Such proposals will be subject to review at the decision-making level. A threshold level will be defined in terms of a maximum percentage excess over the least-cost (or a maximum per capita cost).

The table shows an example of two cases, where least cost is Rs 10,000, whilst community preference is for a technology with higher cost. Assuming the threshold to have been set at a maximum percentage excess over least cost of 50%, then Case A will be supported by the Project, whilst case B will need to be referred to the highest decision making level in the Project.

Project Financial Support Decision (limit at 1 5)				
	Least Cost	Actual Cost Community Preference	Ratio of Actual over Least Cost	Project Financial Support Decision
Case A	10 000	11 000	1 1	Positive
Case B	10 000	18 000	1 8	To be Referred

Cost Sharing

The project will support water supply investments in types A and B villages, on a cost-sharing basis. The cost-sharing arrangement is tied to the least cost-design, and the Project will contribute 60% of the associated least-cost investment cost. The community will contribute 40% of the investment cost (1% cash and 39% kind), plus 100% of the incremental investment This principle is illustrated in the table below, using the same cases A and B, and assuming they have both been approved.

Sample Investment Cost and Cost Sharing Arrangements For 2 Alternative Technologies in a Community Water Scheme					
	Least Cost (a)	Actual Cost (b)	Incremental Cost ©	Project Share of Actual Cost (d = 60% of a)	Community Share (b-d)
Case A	10 000	11 000	1 000	6 x 10 000=6 000	11 000-6 000=5 000
Case B	10 000	18 000	8 000	6 x 10 000=6 000	18 000-6 000=12 000

The project will not support investments in human waste disposal and environmental management, with one exception. In case of the Pond-Sand Filter, investments required to divert the inflow of surface water in the pond will be supported under the same cost sharing arrangements.

Community fund raising for Capital Cost Contribution

For raising the capital contribution of 1% of the capital cost, the financing options discussed under 9.3 (fund raising) may be considered. Care must be taken to ensure that investments are undertaken shortly after the capital cost contribution; there are many cases where projects lost credibility for allowing incomprehensibly long delays between collection from users and the start of actual field level investment activities.

Community contributions to Capital Costs in Kind

The contributions in kind represent the largest share of contribution to the capital cost. Contributions in kind may be in the form of labor, materials, and other. There is ample experience with contributions in kind, and key is to take a flexible approach where each person of family can contribute relative to his and her capacity. Very often, communities have well established procedures and practices for collecting community contributions that in fact distinguish for the diversity of personal circumstances, wealth, skills and other important parameters. It is important that required individual contributions are arrived at through a transparent and a publicly accountable system. The system chosen is best based on the prevailing practices in the concerned community, and where necessary, the choice is assisted with some outside help.

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10. Fact Sheets Community Action Planning (CAP)

10.1 The Community Action Plan (CAP) and CAP Process: What is it? Why is it Undertaken?

Definition: In the context of BAMWSP, the "Community Action Plan" is a tangible output, a set of "8" specific plans which are prepared by villagers with the sensitive facilitation of SO community workers and technical staff, and which serve as the major content of the Villager's Implementation Phase Proposal. The Community Action Planning (CAP) Process refers to a progressive series of participatory interventions by the SOs which help villagers to investigate their situation, needs and environment; resolve problems and obstacles; analyze and project solutions; and assess and make educated choices between technical options; and complete action plans for the Implementation Phase of their community scheme. Using a range of participatory tools and techniques, the SOs help the community prepare a CAP which contains their specific plans for at least the following 8 dimensions:

1. A (Safe) Water Supply Scheme Layout and/or Management Plan
2. A Scheme Procurement and construction Plan, including timetable, manpower plans, and plans for controlling the quality of materials
3. A Community Finance Plan for Local Resources Mobilization, cost contributions, collections and accounts management
4. An Environmental Sanitation Plan, which consists of initiatives undertaken by the community on a non-subsidized basis
5. A Village Environmental Action Plan, in which any potential impacts of the project are managed through, for example, proper drainage of runoff water, protection of sources, etc.
6. A Plan for Hygiene and Sanitation Education
7. A Plan for Scheme Management, Operations and Maintenance, and
8. A Plan for Monitoring and Evaluation Activities at the Community Level.

10.2 What underlines the Community Action Planning Process:

While the project defines the CAP and its eight subplans as a tangible output of its Planning Phase, there is a substantial body of experience internationally to support the Project's use of the CAP Process as a strategy, which to a large degree, builds local capacity for educated decision-making and planning in the self-provisioning and management of water and sanitation schemes using a range of participatory methods, techniques and tools. A Guidance Sheet, in Section 10.3 provides a sample process of how a SO might facilitate the CAP Process. This section, however, explores some of the underlying principles and growing body of experience internationally for using a CAP Process, and its associated participatory methods.

10.3 Different Models for Mobilizing Community Participation and the Participatory Approach:[1]

Confusion over what is "participation" has often led to disillusion with approaches that are *said* to be "community-based" or "participatory" Truly participatory projects provide the means for people to take an active role --from the stage of investigating their own situation, resolving their own problems,

[1] / Based on "Community Participation Strategies and Tools, A Trainers' Manual for the Rural Water Supply and Sanitation Sector in Pakistan (Srinivasan, Zafar, Minnathullah)

analyzing and deciding among options and planning, implementing, and managing change--at a level appropriate to the project and situation. In reality, projects which in name are "community-based" but treat people as passive recipients, or which are overly controlling or suspicious, or which have an overly limited definition of participation may fail as frequently as conventional, supply-led projects. In order to understand why, we need to look at the different concepts of participation. Any strategy for participatory training and technical assistance must be rooted in on clear definitions of the community-based approach implies. Four commonly held views include:

- *The Cheap Labor Concept:* The view that participation is "free labor" and that obtaining such labor is sufficient "participation"

- *The Cost-Sharing Concept:* The view that the payment of some share of capital and maintenance costs in cash or kind is sufficient defines "participation".

- *Formal Agreement Concept:* The view that when users commit themselves to perform specific tasks for a project through a formal, preferably written agreement the project has achieved adequate "participation".

- *Decision-centered Concept:* the view that participation has taken place only if users have been involved in decision-making at critical stages -- from project preplanning to the planning stage through implementation, maintenance and evaluation.

These definitions need not be mutually exclusive; the BAMWSP Project builds in elements of all these concepts. "Cost-sharing" could easily include free labor as a way to reduce project expenditures; a formal agreement could include commitments to perform all kinds of obligations including cost-sharing and labor contributions. Above all, the Project follows the "decision-centered" model and includes all the three preceding concepts and much more.

Critical to our strategy design that we understand the limits of each of these perspectives and that, without diligence in laying the groundwork for participatory decision-making, the Project would fall short of the mark, would not be truly demand-led, and that *sustainability* will suffer. For example, if a project only follows the *cheap labor* concept, influentials in the village may exert pressure on poorer villagers to contribute labor whether or not they see the benefits of a particular approach. When labor is not provided as a voluntary decision, one result might be no pride in the construction. Once the job is done, the larger community may lose interest in maintaining the water system or in transforming more complex problems such as attitudes and behavior regarding sanitation.

Realizing that labor contributions themselves many not be a good indicator of community commitment, some project managers focus on cost sharing. People's willingness to pay for capital and maintenance costs would indicate that they value the improved system as their own. Unfortunately this rationale does not always apply in practice. People will only value the new water services to the extent that it meets their own criteria, e.g. that it is conveniently located, that the technology is not too complicated, burdensome or costly, that the water is of acceptable quality and taste, that service levels and designs of tanks and taps have been based on community preferences, etc. This implies that they must be party to other decisions before they can be expected to pay towards maintenance costs. In particular women, who are the main users and managers of domestic water supply, must be satisfied that the repairs are worth paying for. If not, they will revert to their traditional sources. For example, if a pump is located in a place to which lower-caste women do not have easy access, they will have no interest in paying for its repair – or perhaps even using it.

Another perspective is that of the *formal agreement model.* Formal agreements, such as those provided for in the tri-partite contracts of the PMU with communities and SOs, help to ensure that the community fully understands and commits itself to a number of roles and responsibilities, matched by commitments of inputs of the sponsoring agency Such agreements may only be meaningful, however, if they allow enough time for the community to consider the agreement from all angles, and in particular whether average and poorer villagers have had the opportunity to think through its implications, express their reservations, or have their views reflected in the negotiation process Agreements which have been negotiated primarily through village leaders and endorsed at large village wide meetings may not be fully understood or embraced by the larger community. As a result, problems may arise when the time comes for individual members to do their part. Women's viewpoints must receive special consideration in this regard.

The *decision-making model,* which has been adopted by the BAMWSP Project, includes cost sharing, labor contributions and the accountability of formal agreements; but those contributions and commitments must flow out of a process that evokes full community participation in decision-making The community *is* the designer, builder, owner and operator of the system. Thus each of its segments must be party to decisions and feel pride of ownership at each project phase. The initiative must create opportunities for small groups of villagers to engage in an analytic and creative process of planning and decision-making; that process must include all clusters, ethnic and economic groups, genders and other categories of people in the community. This is done through informal participatory processes that provide every community segment access to techniques and tools to investigate, problem-solve, make decisions, plan and take responsibility for their project. The decisions reached through this process have the advantage of being thoroughly assessed by the broad base of the community and not simply by the top leadership. The process itself builds the confidence among those who normally would hesitate to speak up at large gatherings or hesitate to express their opinions in front of authoritative figures. This is particularly pertinent to the status of women. Having a larger role in the analysis of the water and sanitation situation, and in identifying alternative means of solving their problems, community members are in a better position to assess the terms of their tripartite agreements and to take intelligent and firm decisions on how they can contribute, throughout all project phases.

The Project thus stresses a dynamic community action planning process (CAP) where villagers, regardless of their socio-economic and literacy levels, increasingly take responsibility themselves to plan, manage, control and take part in collective actions, including improvement of their own skills and in generating their own capital for the sustainability and continuous growth of needed services. The informal group planning and decision-making sessions culminate in a formal "agree to do" meeting of the community to finalize its overall design choices and plans. This is followed by technical design, a final formal review and adjustment of the design by the community, and then preparation of the written implementation Phase proposal by the community. The CAP Process is then followed by the experience of workplanning, procurement and completing implementation, and then moving on to operations, maintenance, and self-evaluation. These stages are core experiences at the heart of the Project 's training and technical assistance strategy. The approach also takes into account the need to build a set of related *skills* to ensure sustainability. The Project thus provides for additional training of the community, including, health, arsenic mitigation, hygiene and sanitation education, technical training on operations and maintenance, and management training for the CBOs/VWSCs.

At the support level, this community-based, *decision-centered* approach requires the building up and reinforcement of an **alternative support system** rather than a delivery system. It means a strong emphasis on process ("facilitative skills") rather than content-oriented, didactic approaches to community assistance. Training and technical assistance approaches should evoke self-expression, confidence and build new management skills rather than enforce passive compliance. A base of facilitative skills is needed throughout the Support Organizations (SOs) that comprise this decentralized approach. The Project must also imbue technicians with this new orientation so that they can more effectively link their inputs to community preferences, and effectively build people's technical skills rather than simply create physical systems that later fall into disrepair. Indeed, the Project is by its nature a "capacity-building project" at all levels.

There are many risks associated with the training and technical assistance efforts of this sort. We may underestimate the importance of orienting personnel of SOs in understanding and being able to perform "a facilitative" role rather than that of a provider. We may neglect the ongoing development and consistent use of methods/tools to engage villagers' talents, enthusiasm, and their latent capacity for decision-making and planning--moving them from passive to active roles. We may also underestimate the complexity of providing an environment for community decision-making, and grow satisfied that so many formal courses were held, that so many agreements were signed, and so many contributions made. However, there is also ongoing importance of providing sound technical support and knowledge--when it responds to the community's expressed need to know. Such skill and content training must be relevant to the context, technically sound, and provided in a manner that is easy to absorb. Just as other aspects of Project, training and technical assistance must be demand-led rather than supply-led if it is to be consistent with the Project's underlying premises.

10.4 CAP Process Methods, Techniques and Tools

The Guidance Sheet, Sample CAP Process provides suggested methods and tools, both from SARAR[2] educational methodology and that of PRA[3]. These CAP Process methods have been tested thoroughly in the region, but SOs are free to adjust them, innovate new tools, and use techniques that produce similar results. What must be consistent is the facilitative approach in which the assessment, thinking, analysis and decision-making is done by the members of the community, and not by the outside change agent. However, a few core tools, such as "mapping", "Story with a Gap", and "Technical Option Cards" have been found indispensable in implementing the CAP Process for Water and Sanitation.

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[2] / SARAR A participatory education methodology widely applied in the Water and Sanitation Sector. SARAR includes a wide range of motivational, investigative, analytical, informational, planning techniques and tools. SARAR stands for Self Esteem, Associative Strength, Responsibility, Action Planning, and Resource.

[3] / PRA: Participatory Rapid Appraisal: A school of techniques and tools which, compatible with SARAR, helps community residents to investigate and collect their information for use in planning and management of their own initiatives.

While used extensively in similar projects in the region in Nepal and Uttar Pradesh, the CAP Process has been widely used in Asian, African and Latin American contexts, and is often given different names.

It may, for example, be subsumed under the term "Participatory Action Development Approach" which is covered by a series of articles prepared recently by IRC. [4]

[4] / Lammerink, Bolt, and Bury Community Managers for Tomorrow Series, Documents #3 and # 4, 1998.

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11. Project Level Planning

11.1 Selection and Characterization of Hot-Spot Areas

Selection and characterization of actual villages ideally should be done after completion of the well tests at village level during prefeasibility studies, because thana level information is not adequate to determine the detailed characteristics of the hot-spot areas required make a selection. Most of the existing Thana level information has been drawn based on results of several wells, except in few cases where special groups have undertaken detailed analysis. It is to be noted that in some cases village, union, and Thana level results will vary significantly However selection of the hot-spot areas at thana/union level may be acceptable for narrowing down to the Unions where the prefeasibility studies will be conducted by the SOs.

The report on "Groundwater studies for arsenic contamination in Bangladesh" by Mott MacDonald,Ltd. for British Geological Survey (January, 1999) under assignment to DfID, UK, provides the latest and most detail information on the identified contaminated wells by the various (GO and NGO) agencies and DFID. It should be consulted during hot-spot area selection.

Although the field test results indicate that while the Southwest region is extensively contaminated the most intensively contaminated region is the Southeast of Bangladesh. The selected Thanas/unions may be located in the both regions depending on the level of contamination.

The level of contamination may be estimated based on the proportions of contaminated wells and possibly exposed population. The contaminated wells may be grouped as ≤ 0.05 and > 0.05 mg/l. of Arsenic in water samples. The estimation of proportion of possibly exposed population may consider values of average person/wells of shallow and deep; both tubewells.
For example:

Thana	Estimated statistics of shallow tubewells				Estimated statistics of deep tubewells				Estimated % exposed population
	# of wells a	Prop. >0 05 b	Avg /per/ wells c	Popn Using d=a*c	# of wells e	Prop. >0.05 mg/l f	Avg./pers/ well g	Popn Using h=e*g	$\frac{d*b+h*f}{d+h} \times 100$
A	100	0.90	70	7000	10	0.10	300	3000	66%
B	200	0.50	50	10000	0	0	0	0	50%
C	150	0.90	100	15,000	20	0	400	8000	59%

11.2 Process and Criteria for Selection of Hot-spot Thanas and Unions

The first stage of sub-project selection is narrowing the focus to the prioritized Unions where communities are affected or are more vulnerable to arsenic contamination.

The STAC reviews available data to determine to rank the Districts/Thanas and as possible, the Unions. Four factors are considered in this ranking, which consist of the criteria listed in Box 1below:

Box 1: Hotspot Selection Criteria: To be Applied for Each Batch

Union Selection by:

1. Overall Arsenic Levels according to available information, based on sample or comprehensive testing
2. Relative wealth, health/nutrition status of the District, then the Unions within the District.
3. Whether or not the Unions are clustered so work can be undertaken in a cost-effective manner
4. Relative Accessibility for the PMU teams and intensity of prior activities of NGOs in the Union

The list of Hotspot Unions is discussed and finalized and made public. Villages are not selected at this stage, but only after detailed prefeasibility studies have been undertaken based on a much more detailed analysis of each village's situation.

Choice of Unions for prioritization is to be made strictly on the basis of criteria. In the case where data from different sources vary, the Union will not be selected until the sources are verified. The work of the STAC in prioritizing Hotspot Unions will be a part of the technical audit of the Project.

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12. Village Based Pre Planning

12.1 The Prefeasibility Study Process

The execution of a number of surveys and the preparation of a number of maps are required:

- Village location map
- Village General Plan
- Village Priority Survey
- Village Water Source Plan
- Village Wealth Map
- Village Priority Re-setting Survey
- Willingness to pay survey

Steps and tools

Steps 1-10 are ordered according to the order of the data of the pre-feasibility form. After doing a participatory activity together the CBO and SO fill in the data in the form and move on to the next step.

1. Initial Contacts
Initial contacts with formal and informal village leaders, female and male and village NGOs/CBOs

2. Organizing for Community Mapping
Organization by leaders of CBOs of a team with local women and men who will help to draw the community maps for the pre-feasibility study.

3. Village Location
Find and mark the location of the village on union map

4. Village General Plan
The users draw, in a general meeting, the village plan with the general layout and settlement pattern of village, taking the para as a unit and providing the following information:

- Physical infrastructure (roads, larger water sources, schools, mosque
- Border of the paras
- Number of households in each para
- Locations and numbers of scattered households
- Total No. of households (make an internal check with village statistics)
- Approx. total present population

5. Open Discussions on Priority Needs
Open discussions are then held on the situation of different groups in the village, e.g., using flexiflans. This is followed by identification and prioritization, through open discussion and drawing and ordering of cards that represent the three priority felt needs in the village This is done with separate groups of women and men.

For the cards drawing and grading activity, both groups are provided with a set of cards and felt pens. Participants are invited to identify the major needs in their village and once agreed on a need, draw it on a card. The cards are then laid out in a prioritized order. Thereafter the women visit the men and the men present explain their three priority needs. The men then join with the women and the women present and explain their lists. If so desired both may arrive at a unified list. The three priority needs of the women and of the men are listed in the format.

Data storage: The CBO numbers and separately ties the two sets of cards and keeps them in a community file for further reference and use.

6. Arsenic testing

Arsenic testing (see Source Book I, paragraph 2.2) and painting of wells green (As<0.5 ppm) or red (As>0.5 ppm) with participation of community members

7. Village water source mapping

This activity is done in combination with activity 8. It is done with the whole village if it is small, or para by para in case of a large village. The map(s) will indicate:

- Location of drinking water sources, by type (tubewell, ringwell, etc)
- Whether the source is contaminated by arsenic or not contaminated
- No. of families dependent on the source

The map(s) will be used to fill in the table on the feasibility form and will remain in the village 'archive' for further reference and use.

8. Wealth ranking

To determine the local characteristics of a poor, medium class or wealthier household the group is asked to draw a picture of a poor couple, a medium class couple and a wealthy couple. The participants then discuss and agree on what are the characteristics of a poor, medium class and wealthier family. Having agreed on the characteristics they mark the houses in the water resources map(s) according to this classification.

9. Priority Re-setting

Having done the source testing and mapping, the village may wish or not wish to modify its priorities. Data are recorded in the pre-feasibility format

10. Social survey on willingness to pay:

The CBO (planning) visits the households using red handpumps, or meets with them in an informal meeting. The households give their willingness to contribute in cash or labour or both. The data per thana is recorded and totals of households participating and totals willing to contribute in the respective ways are each added up and filled in the pre-feasibility form.

Alternative ways of assessing willingness to pay may be used as well, e.g. assessment by voting in village assemblies or other meetings. Note that all voting has to be by household, so where male and female heads of households are both present they need to be given time to discuss and come up with one household vote. (Having cards of 3 different colours that can be raised by the husband and/or wife is one way of facilitating such voting, but others are possible and SOs can show creativity by thinking up appropriate tools and sharing experience of their use with others).

12.2 Arsenic Testing

Prerequisite

It is assumed that the Project has chosen one reliable equipment for arsenic testing. Considerations: Qualitative kits such as the one in use by DPHE/UNICEF will provide limited information (Arsene above or below .05 ppm). Semi-quantitative kits such as the one in use by the Asia Arsenic Network (0- 02, .02-.05, .05-.08, 08-2, >.2 ppm) will provide more detailed information. If chemical-assisted arsenic treatment technologies would be introduced, then semi-quantitative kits will have advantages over qualitative kits.

Test kit

Test kits use chemicals that have an expiry date, after which they are no longer effective. Manufacturer's instructions on storage and expiry date of chemicals should be strictly observed. Used strips and expired chemicals are toxic, and should be disposed of safely (e.g. brought back to a central location, stored and safely disposed off).

Insert relevant sections of the manufacturers' information sheet on expiry date and storage of chemicals

Sampling and testing

All wells in the village are to be tested. The test kits allow for on-the-spot analysis.

Insert relevant sections of the manufacturers' information sheet to explain how samples are actually taken and analyzed

A random percentage of the samples will be counterchecked by a third party for monitoring purposes.

Marking the Well

If the well has an arsenic level above .05 ppm it is to be marked with red paint. If the level is below .05 ppm it is to be marked with green paint.

Data entry

The outcome of the test should be entered on the attached Arsenic level survey form. (check (!): perhaps, if the village map is good enough, results can be recorded in colour - red or green - on the village map.)

Arsenic Levels in Wells
Village:
Project Code:
Sampling Period: from .... to ....

Well Identification (location, year of construction, owner, depth, pump mounted, etc..)	Arsenic level	
	Above .05 ppm	Below .05 ppm

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13. Sample of a CAP Process for the Planning Phase"

13.1 Introduction

There is no hard and fast sequencing of interventions to achieve the outputs of the Planning Phase. However, the following may help serve as a resource for the SOs in designing their own CAP process in the village. In addition to the CAP, which results in a series of community-generated plans, the Planning Phase includes provision for other activities, e.g., hygiene and environmental sanitation education sessions, community organizing and development of organizational capacity. There are also formal training sessions associated with the creation and development of the CBO, whether as a VWSC or other body. The following sample sessions and options for tools focus on the community action planning, but also describe how the CAP Process fits into these other activities.

13.2 Entry Phase (I)

1. ENTRY PHASE: CAP Visits 1-3: Weeks 1 to 2

1.1 ***Objective:*** These sessions are primarily informal, and held to develop rapport with community members. This is particularly important where the SO has had little previous experience with the particular community. The objective is to build rapport and a base of trust for working with the community. Another objective is to obtain agreement with the various clusters of the community for holding future meetings at times and places convenient to them.

1.2 ***Steps to be taken by Community Facilitator:***

1. walking about the village and informally starting conversations
2. being helpful and creating trust
3. explaining to the community the intentions and interests of the SO
4. Listening to what villagers have to say, about whatever concerns them
5. getting familiar with the layout of the village
6. calling informal groups together and planning times for future visits which are convenient to their schedules
7. using some creative techniques for building rapport
   - *storytelling by villagers using unserialized posters*
   - *storytelling by villagers using flexiflans*

Be careful to avoid practicing any (unintended) biases when building rapport. Male workers need to be sensitive to giving equal interest to women and women's interests. Female fieldstaff can avoid reconfirming stereotypes by talking not just only with women, but also with men. Going to where (poor) men and women work and assisting them in their work while talking is another way of avoiding bias and burdens in your visits.

Monitoring: how do the so workers keep track of whether they are working equally in the various parts of the communities? And how do the neighborhood women and men note how often the so workers visit their cluster in relation to other clusters? One option is that the fieldworkers keep a logbook of cluster and community visits, signed off by one of the cluster inhabitants at every visit paid to that village (See Annex A in the M&E Manual). But how can the community have the total picture of the so workers visits? One idea is to have quite early a village map or list giving each cluster and to display this map in public place (e.g. on a large tree, a wall in a central place, a CBO office, etc. Mosques and houses of leaders are generally not suited as they are not acceesible for all women and men). Every time the SO worker visits a cluster this visit is also marked in the map or on the list for the other clusters to know how often each cluster is visited.

13.3 Investigation Phase (II)

2. BUILDING CLUSTER GROUPS AND CREATIVE INVESTIGATION PHASE: CAP Visits 3-8: Weeks 2-7

2.1 ***Objectives:*** To strengthen cluster groups and work with them in investigation of their own situation, first in general terms, and then regarding water and sanitation. At this stage, dialogue with the community is first held cluster by cluster, unless the community is very small. Groups can be informally organized as learning groups, i.e., groups of residents in a neighborhood who agree to help work in developing the CAP. If the neighborhood is large, try to break it into manageable units which would approximate future groups using a point source or set of sources. Groups should be formed almost naturally based on proximity of homes and social relations. Work with any existing organizational forms or CBOs where appropriate, such as traditional labor sharing, religious, or women's neighborhood groups. Ensure that women play a key role in this effort. Engage villagers in a series of activities which help identify resources and problems in the community which will affect the project, and then to identify specific water and sanitation, and arsenic related problems and resources. Also. enable the villagers to investigate their own beliefs. values. and attitudes. Build individuals as part of groups, i.e., build their strength through association with their peers

2.2 Steps to be take by the Community Facilitator

1. meet with informal groups as agreed during the entry phase, at their convenience
2. plan sessions based on their interests
   use human development techniques to build the group's strength
   - *corn and bottle game*
   - *personal symbolism*
3. keep groups small, built around natural clustersstart with investigative techniques which are more creative
   - *SARAR mapping, open criteria*

   progress towards specific investigative techniques and community monitoring methods for establishing a baseline, e.g.,
   - *SARAR pocket charts on water usage habits*
   - *SARAR pocket charts on personal hygiene and defecation habits*
   - *Community mapping with specified criteria: PRA Community Resource Maps*
   - *Community Census activity*
   - *Healthy Homes Community Monitoring Tool*
   - *Wealth Ranking (PRA)*
   - *SARAR time assessment and management cards for Women*
   - *Additional arsenic testing of wells as appropriate*
   - *Gender Analysis*

4 regularly review the needs of each learning group in a cluster and use appropriate tools to build their self-awareness
5. carry out all activities in such a way as to build participants self-esteem, confidence and sense of control over their environment and situation
6. identify issues, concerns, problems to be resolved in the community as part of the CAP

2.3 ***Roles of Other SO staff:*** The community facilitator should lead the above sessions, but with the support of the other staff A diploma engineer may observe and be a resource for community mapping and its various permutations, but it is critical that the community facilitator ensures that all such activities are undertaken by the villagers themselves, and that s/he facilitates such sessions. At this stage, hygiene and sanitation education sessions are integrated at cluster level with all other investigations--and the existing situation is studied by the groups as a whole, i.e. incorporating arsenic, water and sanitation problems and resources, the situation of women, water usage, health and other needs, resources, problems, and opportunities.

13.4 Analysis Phase (III)

3. PHASE FOR ANALYZING PROBLEMS AND INTEGRATING NEW INFORMATION: CAP visits 8-12, weeks 8-12

3.1 ***Objectives:*** A large variety of issues, concerns and problems, opportunities, etc., should have emerged from the community at this point regarding their planning process. The community facilitator can structure specific sessions to help deal with these issues systematically. Training sessions should be progressive, each building on the last Initially, villagers may need to prioritize or rank issues. They may need to analyze the relationships between various needs and problems in the village, e.g., to see how women's problems are part of contribute to overall problems in the community, and how their problems are interrelated. All these activities and learning experiences can be structured so as to build a sense of control over problems and solutions. It is critical that underlying concerns such as source disputes be resolved, and other such issues brought to light and dealt with. This phase also brings participants closer to the decision-making point regarding specific technology choices. For this purpose, exercises in which they can analyze technologies by features most appropriate to their own needs, and according to criteria which they prioritize themselves, can be structured. Informative games depicting the features and implications of different technology choices can help to strengthen this analysis, and provide information about new options not previously known. The important thing is to structure this information so that it helps to support the villagers' own analysis.

3.2 ***Steps to be take by the Community Facilitator:***
1. hold regular sessions to move from investigations to analysis of project issues, problems, options
2. prioritize and classify issues to consider with villagers regarding the various components of their action plans
    - SARAR problem classification cards
    - SARAR three pile sorting
3. help villagers to analyze specific problems and solutions, such as poor sanitation, water needs, health problems, source disputes, environmental problems, etc.

- SARAR open ended poster dramas, maxiflans
- role plays which pose a problem for solution
- SARAR three pile sorting, cards hygiene, sanitation and health practices
- force-field analysis/ SARAR carts and rocks tool
- conflict resolution tools
- community resource maps
- SARAR pocket charts for gender analysis
- Technical Option "Features" Cards and Sheets

4. identify information gaps during these analysis sessions. Weave back and forth between specific analyses and information techniques which inform each analysis further. For example, discussions of environmental problems can be interspersed with exposure to different options for solution, perhaps through filmstrips on technical options, or cross visits with other villages who have taken initiatives to solve a specific environmental problem. Similar strategies could be taken with source disputes, environmental sanitation problems, health issues, etc.
   - Informative filmstrips
   - Cross visits to see successes
   - BAMWSP Scheme Management Game
   - Technical information cards on different technologies and the resources needed to implement them, and their advantages and disadvantages
   - The Health Game
   - Self-Health Concentration Cards Game
   - Disease Transmission Routes Cards, etc.
5. From these sessions, communities will build a base for planning activities. It may be appropriate to move from one analysis directly to related planning--e.g., analysis of how to maintain the system to information about costs and O&M responsibilities. Then proceeding to other informed analyses and plans for O&M. However, the overall pattern is to move from analytical work and on to actual planning.
6. At the end of this stage, villagers will already have made some tentative decisions about specific issues or technologies related to their future plan. Record these for use in Planning Sessions.

3.3 Other Activities and Roles of other SO staff:

At this stage, may be appropriate for the Community Facilitator to also start the CBO/VWSC selection process, so that by the end of the next "planning" stage the CBO/VWSC has been selected by the villagers and are ready to take leadership. You may find that cluster leaders naturally emerge from all the discussions thusfar. In any case, you should let the villagers decide how they will select their own representatives on the CBO/VWSC, within the project criteria. During analytical discussions, it is important for the diploma engineer to participate, particularly at those points when villagers want outside information to inform their own analyses. However, the diploma engineers should operate as advisors, not as directive figures. The problem solving is to be done by the villagers themselves. As such, it is best if the Community Facilitator first enables the villagers to identify what gaps they have in knowledge,, and what information they want from the diploma engineers to be a resource in their own decision-making. The Supervisor should keep a close watch on process overall to ensure that villagers take leadership at all stages, and also to ensure analyses include a balance of focus on water supply, environment, sanitation, hygiene, and related gender issues.

13.5 Planning Phase (IV)

4. DECISION-MAKING AND COMMUNITY ACTION PLANNING PHASE, INCLUDING FORMAL COMPOSITION OF VWSC: CAP visits 13-18, weeks 13-16:

4.1 ***Objectives:*** The Objective is for villagers to develop a Community Action Plan. In this phase the villagers move from analyses, to decision-making and appropriate planning. At least eight "CAP Plans" have been identified, but plans are not limited to these. In reality, each of the nine plans is an aspect of the Community Action Plan which becomes the basis for the Implementation Proposal.

4.2 ***Steps to be taken by the Facilitator:***

1. Help cluster groups move from analysis of scheme issues to specific decision-making and planning in sessions which complete the action plans
2. Depending on the size of village, move from cluster-based to village wide planning or holding sessions with the CBO/VWSC as appropriate. Keep planning activities as broad as possible, and hold some planning activities in each cluster
3. Utilize overall planning and informative activities, in which the relations of various scheme components can be seen in relationship to each other. Utilize these activities as a starting off point for making each of the nine plans which compose the CAP
   - SARAR Story with a Gap
   - BAMWSP Scheme Mgt. Game
   - Broken Squares with different components of schemes.
4. Facilitate sessions in which decisions are taken on specific issues key to planning:
   - Using Technology Options Cards Choose Among Water /Sanitation /Drainage/ Environmental Technologies
   - Making the Scheme Layout on the Community Resource Map (or use 3 dimensional models)
   - Detailed sets of Planning Cards for each technology, e.g., latrines construction
   - Use of community maps again as a basis for defining VEAPs
5. Bring in technical staff as appropriate to help spell out the implications of different technical options to villagers
6. Help villagers move back and forth between analytical and informative activities, as necessary, to complete their plans. For example, review gender analysis as a basis for planning WDI aspects of CAPs, etc.
   - Gender Analysis Pocket Chart
   - Land Use Analyses drawn on Community Maps
   - Matrices on advantages and disadvantages of different technologies
7. Through processes such as described above develop a minimum of the eight aspects of the CAP Plan:
   - A (Safe) Water Supply Scheme Layout Plan
   - A Procurement and Construction Plan, including timetables, manpower plans, and materials quality control
   - A Community Finance Plan for Local Resources Mobilization, cost contributions, collections and accounts management

- A Village Environmental Sanitation Plan
- A Village Environmental Action Plan
- A Plan for Hygiene and Sanitation Education Activities (HESA)
- A Plan for Scheme Management, Operations and Maintenance
- A Plan for M&E at community/SO level

8. Record Action Plans on Paper for the Implementation Proposal as each aspect planning is finished, as discussed in clusters
9. Hold formal meetings of the CBO/VWSC to review and consolidate plans of each of the clusters
10. Hold "Agree-to-Do-Meeting" (Whole Community Meeting) in which scheme layout is presented by the CBO/VWSC (with other villagers present) to the SOs' engineers who then discuss and agree on the basics of the design, **BEFORE** having engineers carry out formal surveys and technical designs with villagers' help.

4.3 ***Other Activities and Roles of other SO Staff During This Phase:*** Before these activities reach the stage where plans must be discussed across the community, the community facilitator must have help the villagers select and set up the CBO/VWSC, and helped it to begin functioning. They are responsible for adjusting plans for all the clusters in the community, and ideally have representatives of each cluster who have been through the CAP process so far in each cluster. Thus they bring to the final planning process the deliberations of people in their own clusters. The Diploma Engineer plays a resource person role throughout this stage, but should never direct the discussions. The CF should call them in when their ideas and information can be a resource to the villagers' own planning.

13.6 Design Phase (V)

5. TECHNICAL DESIGN, IMPLEMENTATION PROPOSAL AND CONSOLIDATION STAGE: Weeks 16 to 20

5.1 ***Objective:*** The Objective is to come up with the Implementation Proposal, based on the CAP plan and technical studies, and to ensure villagers are engaged in planning and agree with all the contents of the final Implementation Phase Proposal.

5.2 ***Steps to be taken:***

1 Engineers take the CAP and then begin the field and technical surveys with the help of the villagers, leading to actual preparation of technical designs and estimates

2. The CF continues to develop the formal skills of the CBO/VWSC, with specified trainings on roles and responsibilities, accounts training, etc.

3 The CF reminds the CBO/VWSC to complete activities necessary for approval and in preparation for the implementation phase: i.e , appointment of VMWs, collections of all capital contnbutions, O&M contributions.

4. Training of VMWs are assured
5. The CD supervisor and Community Worker start preparing and conducting regular HESA activities now that the CAP Planning has moved to technical studies.
6. The final technical designs are discussed with the Villagers and CBO/VWSC. Once confirmed, the final Implementatıon Proposal containing the CAP Plans, Technical design, and estımates is prepared and signed by both the CBO/VWSC and the SO and submitted.

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14. Selection of Technology and Management Systems

14.1 Introduction

The Fact Sheets in Part I of this Volume presented an array of water supply and sanitation technologies, and of household and community based financing and management systems. In the planning phase of the project, the household/community will need to make their own choices from the multitude of available technical and management options. The process of demand-based choice is fundamental to the BAMWSP, and quite novel in Bangladesh, or anywhere else for that matter. Projects usually do not offer a choice of technologies and management systems to the users It is much more common for projects to only offer *one technology* (e.g., handpumps), or for *others* to select technology and associated management systems on behalf of the users. Here, the choice is by the users and a rather complicated one on account of the number of available options and the number of factors to be considered. For example, the number of technology options for water supply is more than twenty, and the rate collection options number ten.

For the facilitation of the selection of appropriate technology and management systems by the users, the guide sheets in the following sections have been designed, in the form of algorithms. These algorithms can be the basis of discussions with the community, and by their design are expected to provide a user-friendly, systematic and logical framework for guiding these discussions. The challenge in making these guidance sheets was to simplify the process of choice without removing any of the options from the array beforehand. Even when done with the best intentions, the prior removal of options by Project Staff (be it PMU or SO) must be considered at odds with the principles of Project Design. Allowing pre-selection by staff rather than by users is an invitation to start driving choices from the top, and for that reason is considered undesirable. At the same time professional guidance in making choices is indispensable, as expert advise provides for knowledge and experience that is not available in the community, and may be crucial to the success of the project (e.g. the knowledge on arsenic in different aquifers, or on the design and cost of rainwater harvesting systems). However, this expertise needs to be brought into the selection process at the village level, and not be applied beforehand.

The algorithms facilitate a discussion at village level of technologies and management systems, during which both villagers and (SO) experts can both make their contributions, and work toward a well-reasoned decision by the users in favor of only some technologies and management systems, and rejecting all others (pre-selection). The favored solutions can then be worked out in some more detail, on which final choices will be based (selection).

The array of solutions, both technical and managerial, is quite large and may be confusing when put to the users in its' entirety, at once. Instead, the algorithms go over the options one by, starting with the more obvious ones and ending with the least obvious. The selection of the order of discussing the options must be flexible, and with the SO staff based on the findings in the pre-planning phase. The process of facilitating choice may be illustrated with the technology choice algorithm. The algorithm has been designed on the assumption that the project is working in an arsenic affected type B or C community where the common water source is a handpump mounted well with a depth between 10 and 70 m deep in which an Arsenic concentration was found to be in excess of 0.05 mg/l Starting from this reality that is first confirmed with the user group, options to treat water from the contaminated source with one of the acceptable individual treatment technologies can be discussed, as well as possible sharing arrangements from neighboring uncontaminated wells. After this, technical options for a new shallow or very deep well may be discussed, followed by a discussion on rainwater harvesting, the use of pond water, and ultimately, if all fails, the use of imported water.

Considerations for choosing from the technologies are multiple, and Chapter 4 of Volume I of this Source Book can be referred. The specific technical, financial and management information can be taken from the various Fact Sheets. Information on the water supply technologies, their cost, operation and maintenance requirements and skills, etc, can be drawn from Chapter 5. Likewise, information on management and management options can be drawn from Chapter 8, and on financing options from Chapter 9.

In their present state the algorithms are not fit for direct use in discussions with the users. For that, special SARAR/PRA type of materials need to be developed based on the algorithms. As the selection process by the users is so fundamental to the project, the preparation of these materials as part of the TOOLKIT is considered an absolute priority.

14.2 Selection of Water Supply Technology

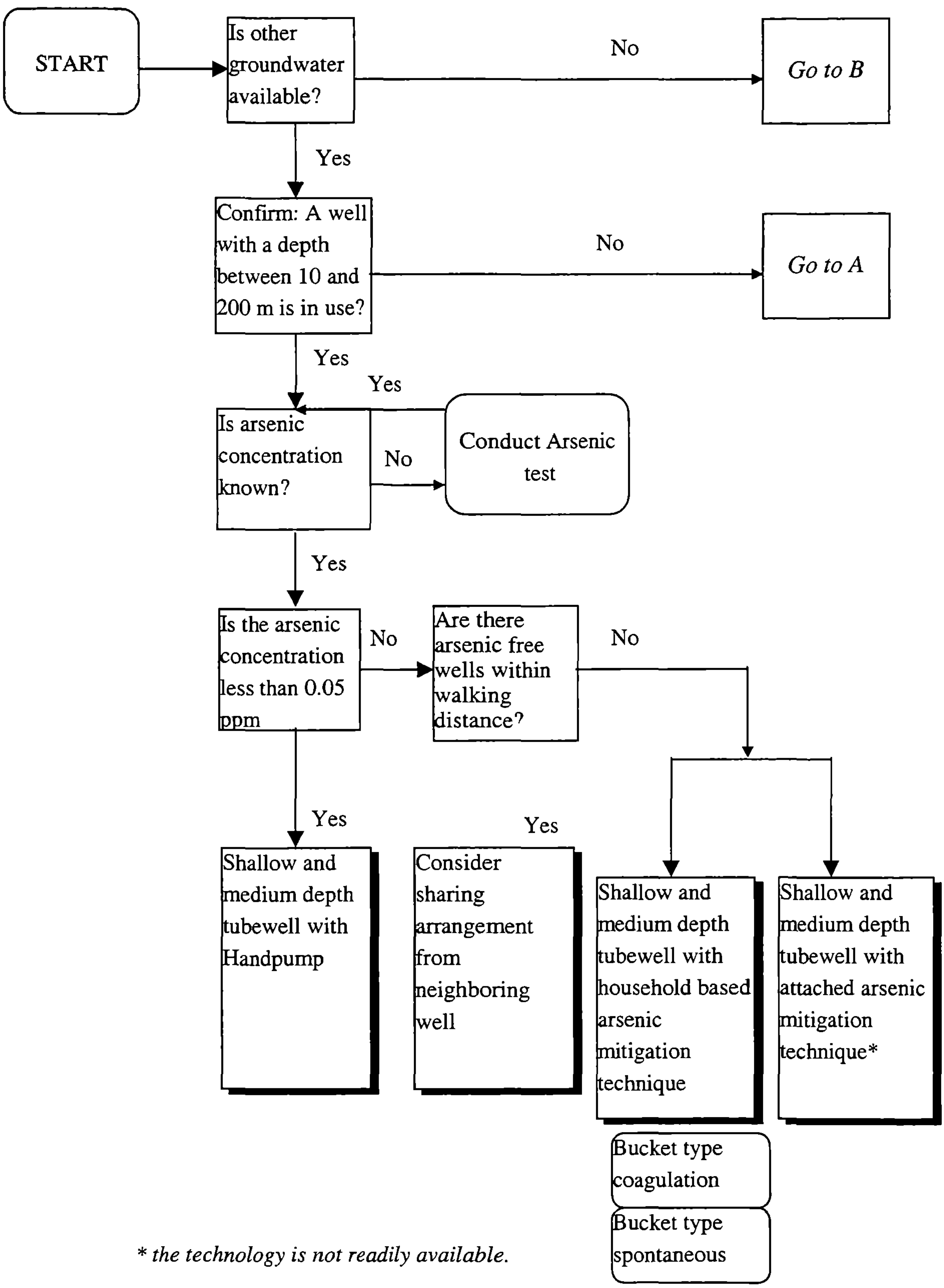
The algorithm for technology choice was introduced above. As stated, its design is based on the assumption that in the present situation, at the start of the planning phase there is an arsenic-contaminated well with a depth between 10 and 70 m. The algorithm then goes through a logical sequence in the course of which all the currently acceptable technologies (table 3.7) are presented.

14.3 Selection of Rate Collection System

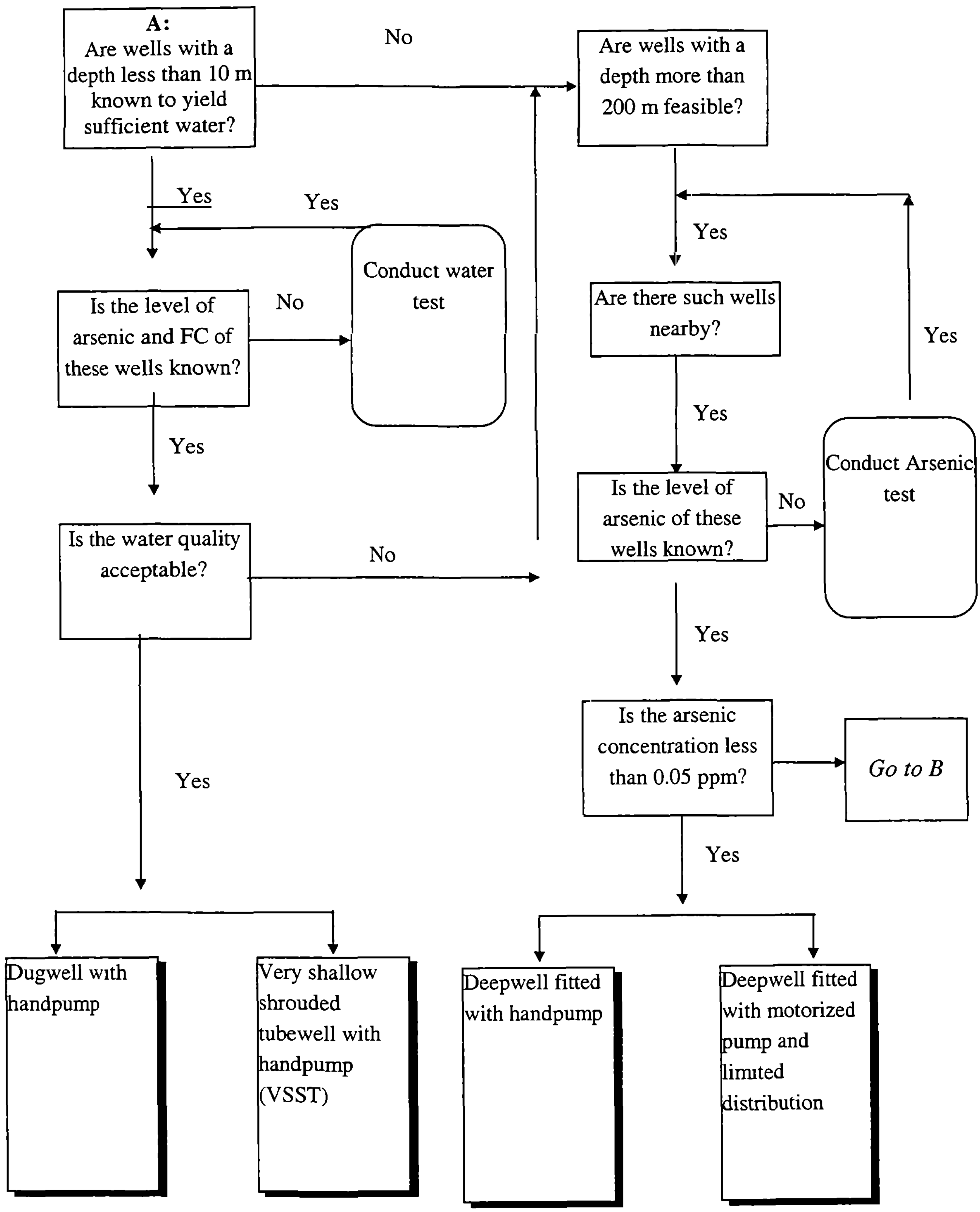
14.4 Selection of Management System

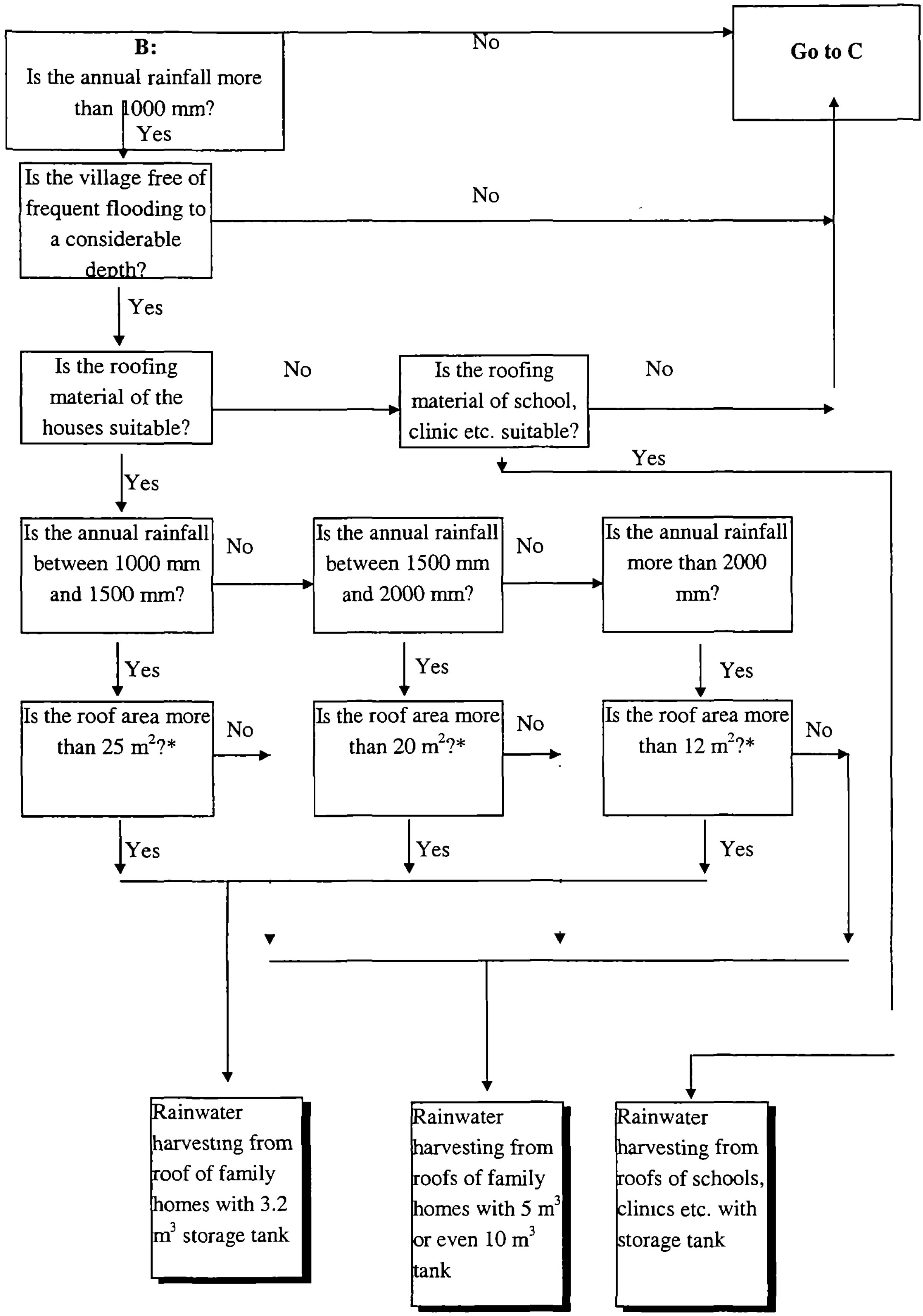
14.5 Algorithm for Water Supply Technology

Assumption: Village uses arsenic-contaminated well water from well 10-70 m deep.

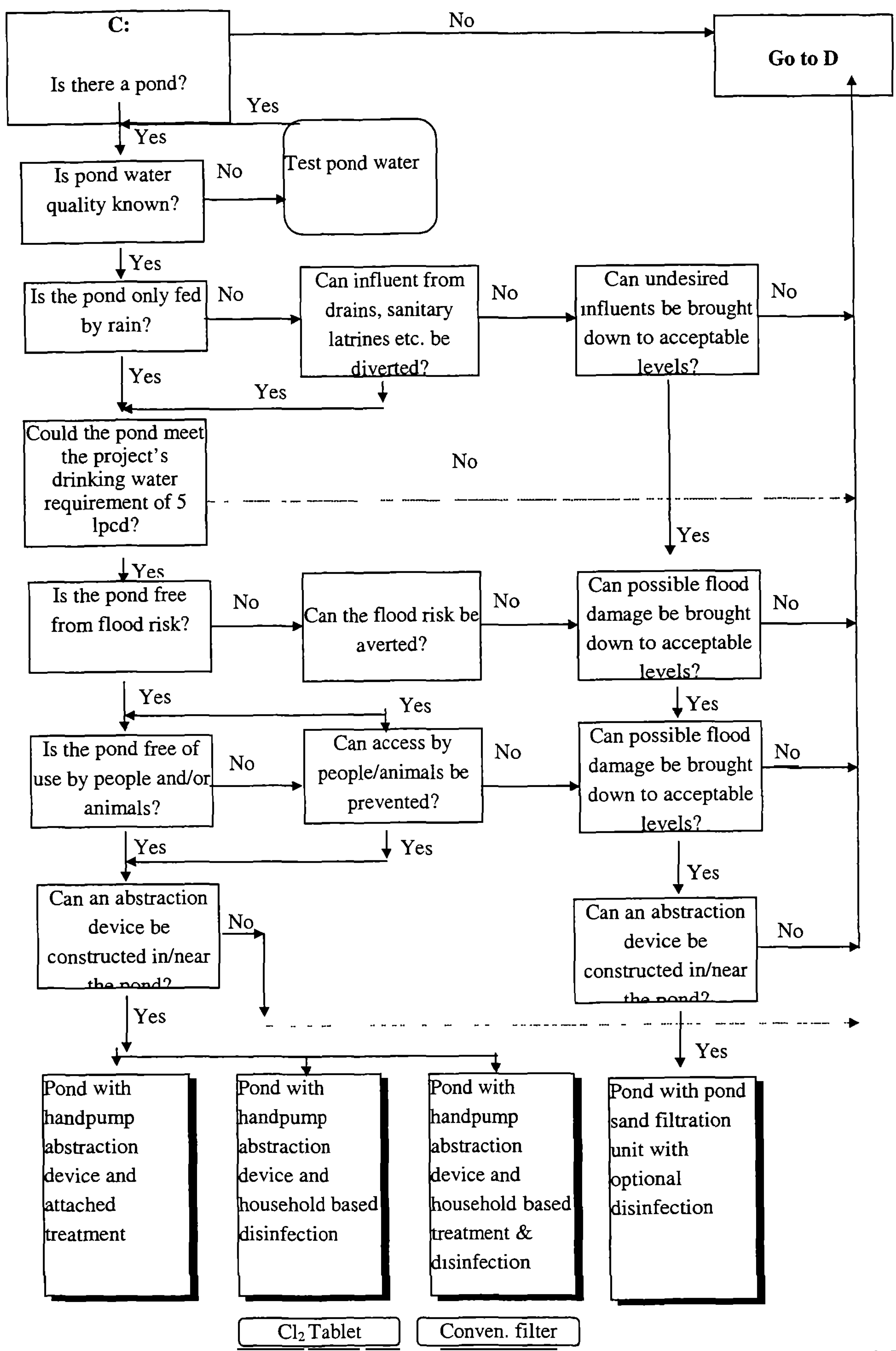


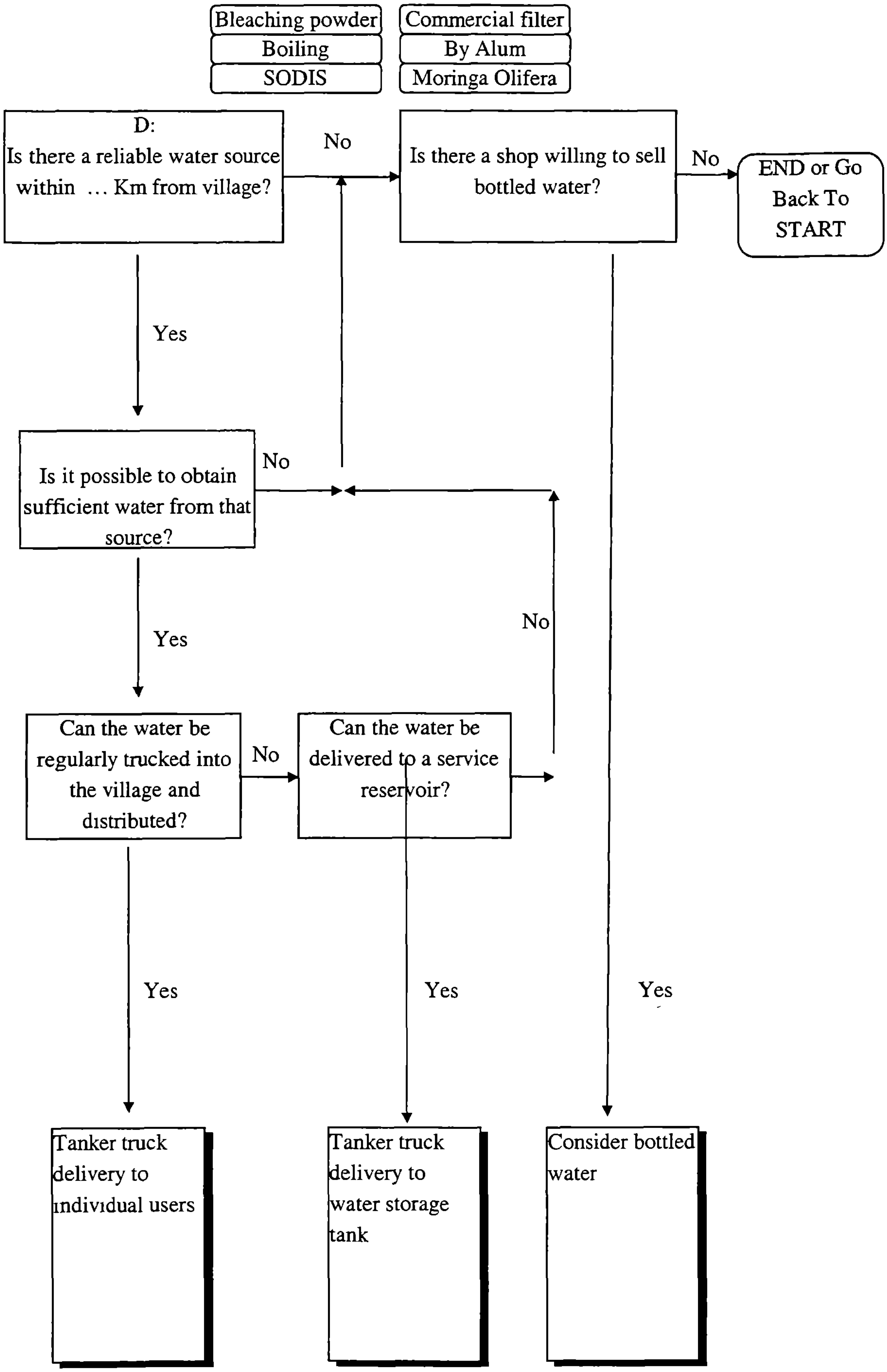
** the technology is not readily available.*


A:
Are wells with a depth less than 10 m known to yield sufficient water?
No
Are wells with a depth more than 200 m feasible?
Yes
Yes
Conduct water test
Is the level of arsenic and FC of these wells known?
No
Yes
Are there such wells nearby?
Yes
Yes
Conduct Arsenic test
Is the water quality acceptable?
No
Is the level of arsenic of these wells known?
No
Yes
Yes
Is the arsenic concentration less than 0.05 ppm?
Go to B
Yes
Dugwell with handpump
Very shallow shrouded tubewell with handpump (VSST)
Deepwell fitted with handpump
Deepwell fitted with motorized pump and limited distribution



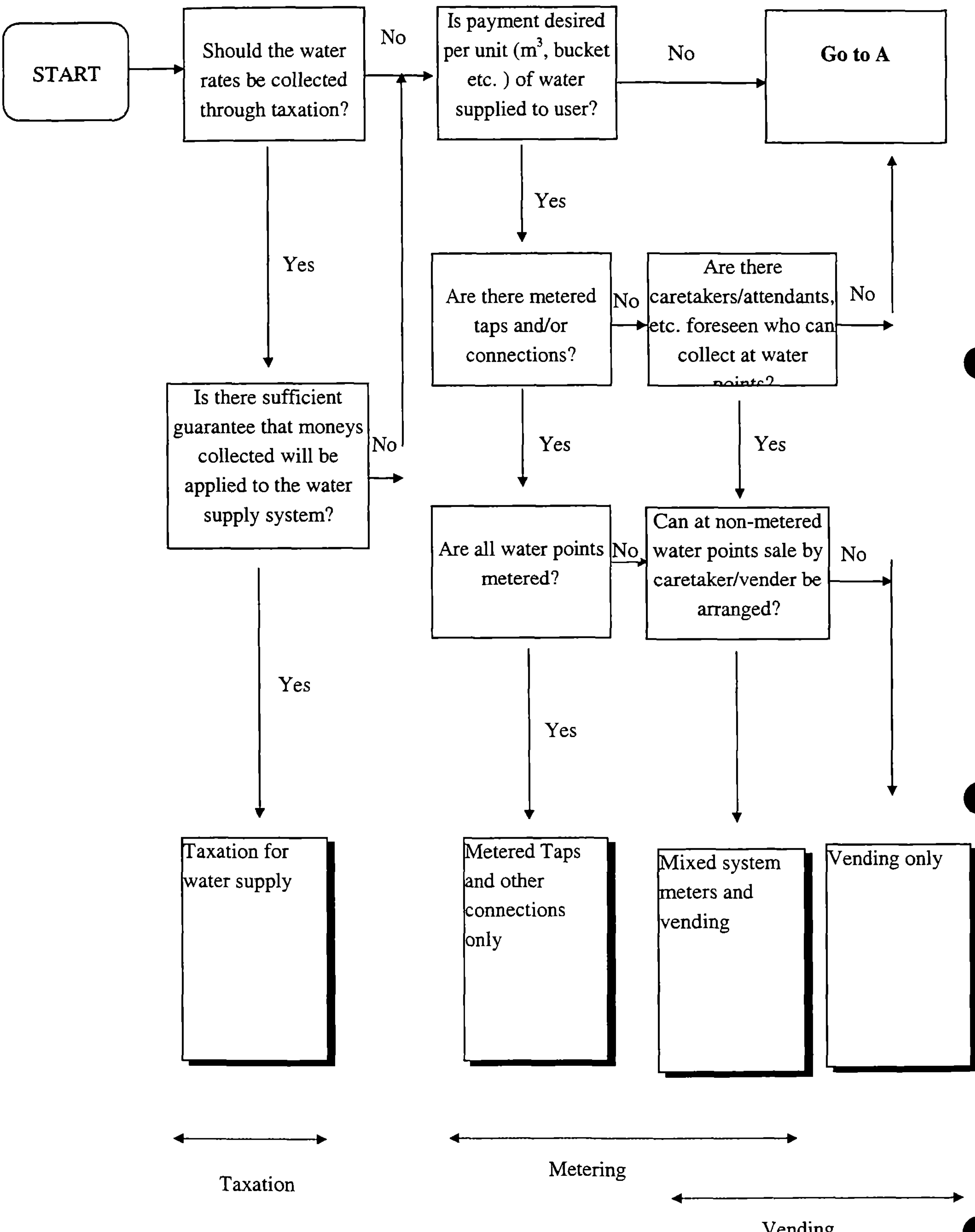
* the calculations are based on typical yearly rainfall, family size 7 members and with per capita demand 5 liter per day

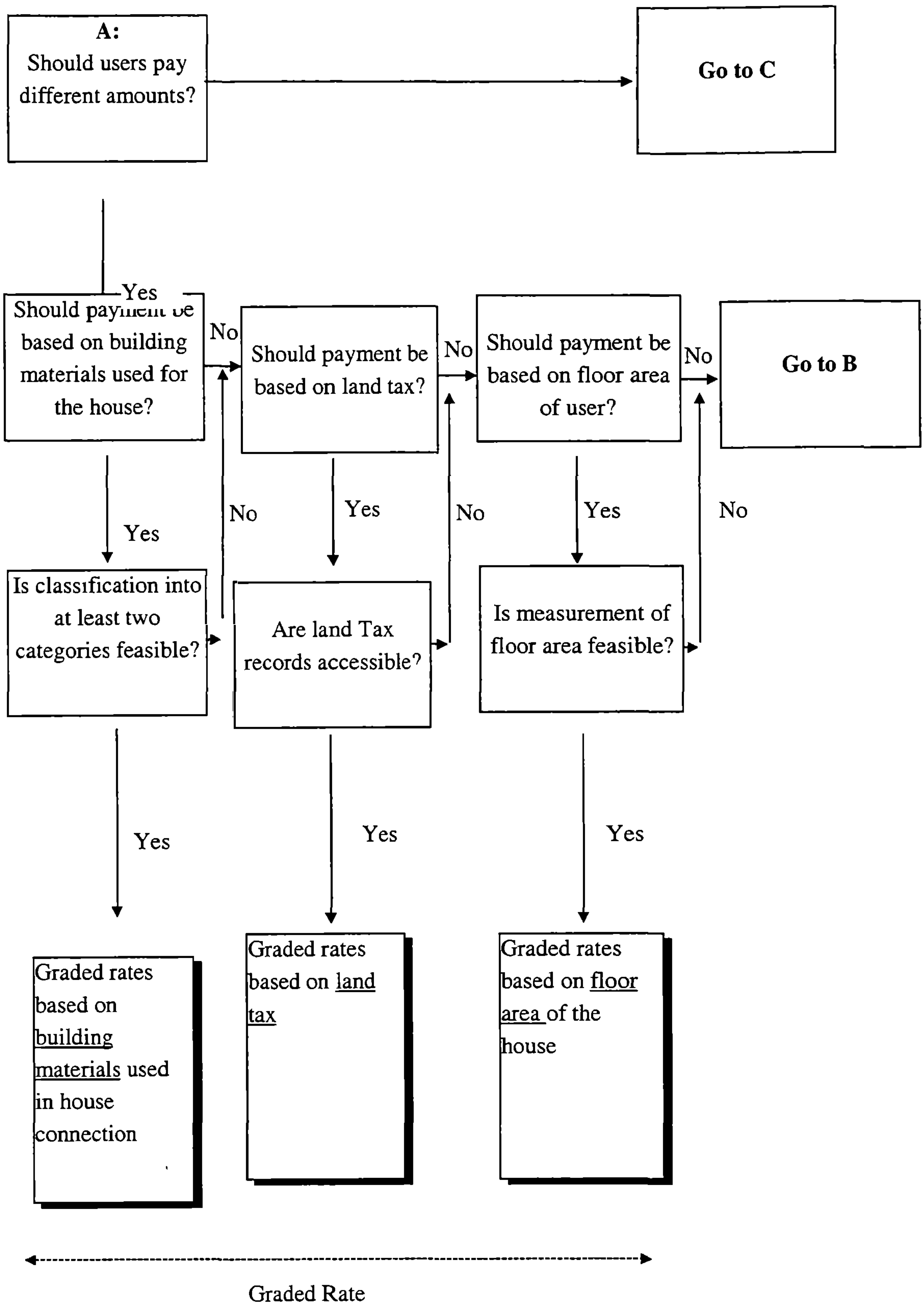

C:
Is there a pond?
No
Go to D
Yes
Test pond water
Yes
Is pond water quality known?
No
Yes
Is the pond only fed by rain?
No
Can influent from drains, sanitary latrines etc. be diverted?
No
Can undesired influents be brought down to acceptable levels?
No
Yes
Yes
Could the pond meet the project's drinking water requirement of 5 lpcd?
No
Yes
Yes
Is the pond free from flood risk?
No
Can the flood risk be averted?
No
Can possible flood damage be brought down to acceptable levels?
No
Yes
Yes
Yes
Is the pond free of use by people and/or animals?
No
Can access by people/animals be prevented?
No
Can possible flood damage be brought down to acceptable levels?
No
Yes
Yes
Yes
Can an abstraction device be constructed in/near the pond?
No
Can an abstraction device be constructed in/near the pond?
No
Yes
Yes
Pond with handpump abstraction device and attached treatment
Pond with handpump abstraction device and household based disinfection
Pond with handpump abstraction device and household based treatment & disinfection
Pond with pond sand filtration unit with optional disinfection
Cl2 Tablet
Conven. filter

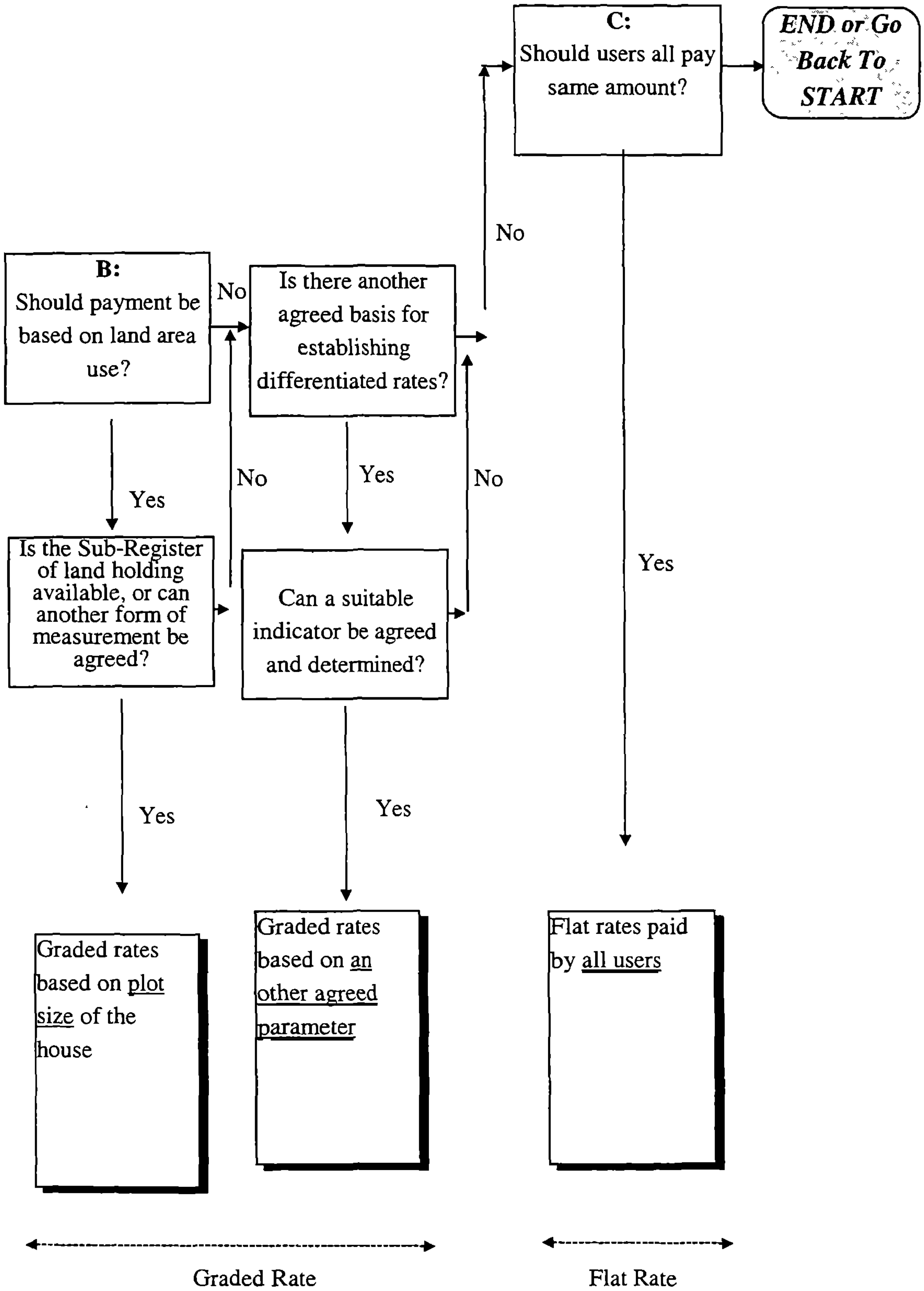


Note: doted line is used to make difference between overlapped lines.

14.6. Algorithm for Rate Collection




A:
Should users pay different amounts?
Go to C
Yes
Should payment be based on building materials used for the house?
No
Should payment be based on land tax?
No
Should payment be based on floor area of user?
No
Go to B
Yes
No
Yes
No
Yes
No
Is classification into at least two categories feasible?
Are land Tax records accessible?
Is measurement of floor area feasible?
Yes
Yes
Yes
Graded rates based on building materials used in house connection
Graded rates based on land tax
Graded rates based on floor area of the house
Graded Rate


C:
Should users all pay same amount?
END or Go Back To START
No
B:
Should payment be based on land area use?
No
Is there another agreed basis for establishing differentiated rates?
Yes
No
Yes
No
Yes
Is the Sub-Register of land holding available, or can another form of measurement be agreed?
Can a suitable indicator be agreed and determined?
Yes
Yes
Graded rates based on plot size of the house
Graded rates based on an other agreed parameter
Flat rates paid by all users
Graded Rate
Flat Rate

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