Government of Bangladesh
Local Government Division, Policy Support Unit

Sector Development Plan (FY2011-25)

Water Supply and Sanitation Sector in Bangladesh

WORKING DOCUMENT NUMBER 4

Recommendations for Revised Implementation Plan for Arsenic Mitigation

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December 2009

The working documents were used as background materials for preparing the Sector Development Plan (SDP). The factual information and views expressed in the working documents are of the authors and does not necessarily of the Policy Support Unit or of the agencies that the authors belong to.

IMPLEMENTATION PLAN FOR ARSENIC MITIGATION IN BANGLADESH

Recommendations for a Revised Implementation Plan for Arsenic Mitigation (IPAM 2009)

Prepared for

Water and Sanitation Program,
World Bank
and
Policy Support Unit,
Local Government Division
Ministry of Local Government, Rural Development and Cooperatives

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November 2009

EXECUTIVE SUMMARY

Introduction

Attaching top priority to the problem of arsenic in drinking water, the Government of Bangladesh adopted the National Policy for Arsenic Mitigation 2004 (NPAM) and Implementation Plan for Arsenic Mitigation in Bangladesh (IPAM 2004). The policy provided guidelines for arsenic mitigation in the drinking water, health and agriculture sectors. Since 2004, knowledge of arsenic contamination, its risks and mitigation options, has improved significantly. Thus, reflecting a widely felt perception amongst stakeholders, the Local Government Division of the MLGRD&C requested a review of IPAM 2004. This review is presented in two parts:

Part 1. Recommendations for a revised Implementation Plan for Arsenic Mitigation (IPAM 2009)

Part 2. Status of Arsenic Contamination in Bangladesh in 2009.

Review of IPAM 2004

The difficulty of assessing the current status of exposure, contamination of the current stock of wells, and the provision of safe-water in arsenic affected areas are core issues that affect the design of IPAM 2009. Limitations in reporting and data management make it difficult to determine the effectiveness of the Emergency and Medium-Term responses under IPAM 2004. The performance of arsenic test kits has improved, and their utilisation by LGIs is encouraging. There has been progress in expanding the network of laboratories, but they have yet to become fully effective.

IPAM 2004 made progress on mapping wells in deep aquifers, but little has been achieved in monitoring or determining the sustainability of this resource. Methods for the safe disposal of arsenic-rich sludge from treatment plants are yet to be agreed. Little progress was made in either establishing the feasibility of *in-situ* arsenic removal or in developing a Ground Water Act.

In the **Health Sector**, major achievements under IPAM 2004 included (i) training staff at different levels in the identification, diagnosis and treatment of arsenicosis patients (ii) a national inventory of arsenicosis patients; and (iii) developing patient management system. In the **Agriculture Sector**, IPAM 2004 commenced from a position of uncertainty, but research in the last five years has shown that arsenic is accumulating in the food chain and is, in some areas at least, reducing rice yields. This will require a major programme of action.

National Policy and Implementation Plans

The primary, high-level recommendation is that the NPAM should remain unchanged, but that each of the key ministries – Agriculture, Health, Local Government (for water supply), and Water Resources – should develop separate implementation plans for arsenic mitigation in each sector. Coordination between sectors will be achieved through a combination of the National Arsenic Committee, an Arsenic Implementation Monitoring Unit (AIMU), and annual reports to the general public on the state of arsenic pollution.

Formulation of IPAM 2009

The recommendations for IPAM 2009 are built around a number of core themes:

(1) Arsenic mitigation will be delivered through the combined efforts of government, NGOs, the private sector and individual citizens. The role of government under IPAM 2009 is to ensure that no-one, including future generations, is excluded from a basic right to safe water for reasons of poverty or lack of awareness.

(2) Following the (chemically and bacteriologically) safe water concept, there should be a shift in emphasis away from recommending technologies towards an informed citizenry (a) holding government accountable to ensure access to safe water technologies for all and (b) holding providers accountable to deliver safe water.

(3) The sectoral relationships should evolve whereby

   i. Local Government Institutions (LGIs) are accountable to **ensure** safe water for all through determining needs, mobilising demand and registration of providers. DPHE will support to LGIs through programming and budgeting of mitigation measures,

   ii. The Government of Bangladesh is accountable to **regulate** LGIs to eliminate exposure to unsafe water through a system of targets. DPHE will play a greater role in strategic planning, monitoring and impact assessment, and quality assurance in testing and technology development.

   iii. Providers (i.e. households, vendors, communities, government and NGOs) are accountable to citizens and LGIs to **deliver** safe water.

   iv. Research organisations, donors and partners **offer** technical and capacity support to ensure the sustainability of mitigation. DPHE will provide technical advice on mitigation, and resources and training for monitoring.

At the centre of IPAM 2009 are simple non-excludable targets[1] that create incentives for LGIs and water service providers to work together to mitigate water quality risks. Targets will exist at local-level to guide LGIs, and at national level to prioritise the population at risk, where and when, and hence to ensure adequate budget provision. This will be supported by improved systems for planning, monitoring and reporting. This will also require a major improvement in data management, and a commitment to share information across ministerial, and government and non-governmental, boundaries.

Coordination will be simplified by clarifying the roles of the arsenic committees at each level. The committees should concentrate on the exchange of information[2]. In all sectors, raising awareness and knowledge of the situation across sectors must first ensure that there are no gaps in knowledge, and second that awareness is turned into behavioural change.

[1] The idea of a non-excludable target can be illustrated by an example such as that there are no wells in a union that have not been registered and tested for arsenic. Achieving targets could be supported by recognising and rewarding LGIs that ensure no wells are uncoloured and unregistered; and later rewarding LGIs that guarantee no exposure to unsafe water.

[2] Local Government, Health and Agricultural departments should share union-wise data on (i) the incidence of arsenicosis; (ii) water testing, and the numbers of unprotected, uncoloured & unregistered sources; (iii) villages with high-As concentrations in soil, crops or food.

Legislation and regulation, including licensing of abstraction, will be required to protect critical water resources, especially the deep aquifers of southern Bangladesh. Two key concerns are the sustainability of deep aquifer pumping and facilitating decentralised arsenic testing:

1. Mitigation has been dominated by abstraction from deep wells and is likely to continue to do so, therefore drawdown of arsenic and saline intrusion due to over-pumping must be guarded against by monitoring water quality, water levels and abstraction from deep aquifers, and thereby determining their sustainable or long-term yields.
2. The number of wells is increasing at around 5% a year and most of these are not tested for arsenic. Further, the arsenic concentrations in shallow wells can increase over time to unsafe levels. Thus, there is a massive requirement for testing new and existing wells, and this should be done at union level by LGIs, NGOs or the private sector, but will require support from DPHE and others. Testing must be affordable, demand-driven, and ensured by the LGIs.

R&D is required for (i) the safe and practical disposal of treatment wastes; (ii) *in-situ* (subsurface) treatment to remove not only arsenic but also iron and manganese and (iii) numerical modelling of deep groundwater.

Third-party audits will verify the provision, status and quality of mitigation. Random, annual monitoring surveys will quantify the actual extent of residual arsenic exposure in communities that have received mitigation.

CONTENTS

Abbreviations

APSU	Arsenic Policy Support Unit
BADC	Bangladesh Agricultural Development Corporation
BAMWSP	Bangladesh Arsenic Mitigation Water Supply Project
BRAC	Bangladesh Rural Advancement Committee
BWDB	Bangladesh Water Development Board
CEGIS	Centre for the Environment and Geographical Information Systems
DCH	Dhaka Community Hospital
DGHS	Directorate General of Health Services
DPHE	Department of Public Health Engineering
DWSP	Drinking Water Safety Plan
IWM	Institute of Water Modelling
LGI	Local Government Institution
MLRGD&C	Ministry of Local Government, Rural Development and Cooperatives
MoWR	Ministry of Water Resources
NAMIC	National Arsenic Mitigation Information Centre
NILG	National Institute of Local Government
NWRD	National Water Resources Database
RDA	Rural Development Academy
WARPO	Water Resources Planning Organisation
WASA	Water and Sewerage Authority
WASH	Water, sanitation and hygiene

1. INTRODUCTION

1.1 Background

Since its detection in 1993, various initiatives have been taken to mitigate the problem of arsenic in drinking water. Attaching top priority to the issue, the Government of Bangladesh quickly adopted the 2004 National Policy for Arsenic Mitigation (NPAM) and Implementation Plan for Arsenic Mitigation in Bangladesh (IPAM 2004). The policy created a framework for arsenic mitigation in the water supply, health and agriculture sectors. Since 2004, knowledge of arsenic contamination, its risks and mitigation options, has improved significantly. A revised Implementation Plan (IPAM 2009) was requested by the Local Government Division of the MLGRD&C, and initiated through a Policy Advisory Note in November 2007, which led to preparation of this plan.

1.2 Arsenic Policy and Sectoral Implementation Plans

The Implementation Plan for Arsenic Mitigation is driven by the National Policy for Arsenic Mitigation, and also conforms to the 1998 National Policy on Safe Water and Sanitation and the 1999 National Water Policy. No change in the NPAM is proposed at this stage, however, separate implementation plans should be prepared for water supply, health, agriculture and water resources, as illustrated in Figure 1. Each of the four ministries should create an implementation plan for the relevant sector, encompassing all of the relevant stakeholders: government; non-government and private citizens.

1.3 Objectives and Scope of the Report

The over-riding objective of IPAM 2009 is to ensure access to safe water for all people living in arsenic affected areas in the shortest possible time and in the most cost-effective and socially and environmentally acceptable manner. IPAM 2009 involves a fundamental change of emphasis away from top-down allocation of resources through DPHE toward a bottom-up demand-driven accessing of resources by Local Government Institutions (LGIs), who will be helped to play a central role in ensuring access to safe water by monitoring progress, and soliciting action towards, a series of non-exclusive goals.

Section 2 of this report summarises lessons learned during IPAM 2004. Section 3 presents an overview of recommended changes across all the sectors. Sections 3.4 to 3.6 identify features of the health, agriculture and water resources plans that overlap with the water supply sector. They do not, however, represent the full scope of those plans. Section 4 details the implementation plan for the water supply sector. The format of Section 4 is such that, in general, each subsection forms the basis for being expanded to create a project, programme or other specific action, that together constitute the Implementation Plan for Arsenic Mitigation in Water Supply (IPAM-WS).

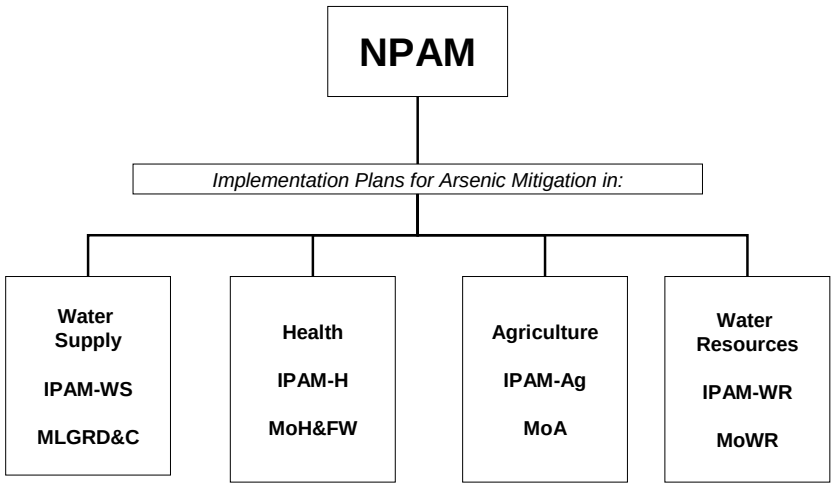

Figure 1 Organisation of Policies and Plans

2. LESSONS LEARNED FROM IPAM 2004

2.1 Status of Contamination

A national reconnaissance survey in 1998-99 estimated that 29% of wells exceeded the Bangladesh standard of 50 ppb As. Screening of all (about 5 million) wells in 272 upazilas in 2000-03 under BAMWSP revealed that 29% exceeded 50 ppb. Subsequent DPHE surveys of 1000 wells in each of the remaining 192 upazilas found that 3% of wells exceeded 50 ppb. Combining the two surveys indicated the total proportion of unsafe wells was around 20%. There has been no systematic update of the DPHE surveys cited above, but evidence from 34 arsenic affected upazilas in BRAC's WASH Project indicates that the total number of wells has increased, on average, by 30%, and it is likely that most of these wells have not been tested.

Estimates of the population exposed to >50 ppb in drinking water come from different studies. From the 1998/99 DPHE survey, it was suggested that 27M were exposed to drinking water with >50 ppb and around 50M to >10 ppb (the WHO guideline). In 2002, the GoB estimated that 29M were exposed to >50 ppb, whereas the BAMWSP/DPHE surveys estimated the exposed population at 20.2M[3]. The BAMWSP screening surveys also identified over 38,000 suspected arsenicosis patients in the period 2000-03. However, the DGHS survey in 2008 identified 24,389 confirmed arsenicosis patients in the country[4].

There are no reliable statistics on the proportion of the exposed population now served by arsenic-safe water. A significant, but unknown, proportion of people living in arsenic affected areas have switched to nearby safe wells. A 2007 Policy Advisory Note estimated that about 14% of the exposed population had access to some kind of arsenic safe technology.

Further details of the state of arsenic contamination in Bangladesh in 2009 are presented in a companion report.

2.2 Successes and Failures

Since the adoption of IPAM 2004, various activities have taken place in the country. The screening of 5 million wells in 272 upazilas was the most remarkable achievement. Although there are some doubts about the quality of the field kits, in particular their precision in waters close to 50 ppb, the programme was very valuable in identifying the most severely affected areas, populations, and prioritising mitigation efforts.

Overall progress in mitigation has not kept pace with the magnitude of the arsenic problem. Major shortcomings in IPAM 2004 were (i) the lack of quantitative time-bound targets, and (ii) the weak monitoring and evaluation framework for projects.

[3] There are various reasons for the differences including testing methods; the calculation scheme; real changes in arsenic concentrations; and the progress of mitigation.
[4] It is noted that both surveys refer only to skin manifestations. Also, although water analysis is useful supporting evidence, it is not a necessary condition for diagnosing arsenicosis which can result from poisoning through the food chain.

Public awareness about the health effects of arsenic has risen remarkably all over the country. A large number of activities took place in the Health Sector in the diagnosis and treatment of patients, and in epidemiological research.

Over the last five years, much has been learnt about safe water technologies and complementary approaches to mitigation. Some of the key insights include:

- The concept of 'safe water' has evolved, and the issue of risk substitution investigated. Many exposed people have switched to nearby safe wells or have re-installed private wells at depths they believe to be safe.

- Deep wells accounted for more than 80% of arsenic mitigation interventions. This water is drawn from a resource that probably has a small renewable yield and is at long-term risk of pollution by salinity and arsenic. To date, this solution has been popular and cost-effective, but very little has been done to monitor its status and provide warning of deleterious trends. This resource legal protection to ensure its beneficial use, however, no progress was made in either creating a Groundwater Act or modifying the Draft Water Act to take account of the needs of arsenic mitigation.

- Dug wells and pond sand filters can provide safe water if properly maintained, but carry microbiological risks[5], and their relative contribution to the overall mitigation is small.

- Introduction of arsenic removal technologies has been regulated through and Environmental Technology Verification (ETV) programme. To date, four technologies (Sono, Read-F, Alcan and Sidko) have been issued provisional licences, but the technology verification process has been far too slow.

- Rural piped water systems have had mixed success. In most cases water was drawn been from tubewells, but surface water and dug wells have been used. Greatest success came from schemes pumping groundwater for both drinking and irrigation, an approach that cannot be recommended for deep aquifers until proper yield assessments have been carried out. On the other hand, single use piped systems have not been widely adopted.

Laboratory facilities have been enhanced significantly, but the benefits have yet to be realised. Field test kits have been improved and used by LGIs and communities to test wells. No progress has been made in developing a locally-manufactured arsenic field test kit.

Although a huge amount of data has been generated, data management and dissemination have been poor. NAMIC created a database of the 5M wells tested by BAMWSP, but did not collect other data, and NAMIC ceased operating when BAMWSP closed. APSU continued to disseminate data until this unit closed in 2006.

In the agricultural sector, a major change in risk perception has taken place. Important research has been conducted, but very little action on agricultural mitigation has taken place.

[5] The dangers of substituting arsenical for microbial risks have been spelled out in the Risk Assessment of Arsenic Mitigation Options (RAAMO) study.

3. OVERVIEW OF IPAM 2009

3.1 Plans and Policies

The National Policy for Arsenic Mitigation will continue to guide arsenic mitigation. Under IPAM 2009, there will be one policy and four implementation plans, one each for agriculture (IPAM-Ag), health (IPAM-H), water resources (IPAM-WR) and water supply (IPAM-WS).

3.2 Institutional Structures, Responsibilities and Co-ordination

3.2.1 Co-ordination

Each implementation plan should be elaborated by the respective ministry, but coordinated and monitored through the office of the Principal Secretary, who will be advised by the National Arsenic Committee, and supported by an Arsenic Implementation Monitoring Unit (AIMU) to collate, analyse and report information. The proposed arrangements for coordination and monitoring are shown in Figure 2.

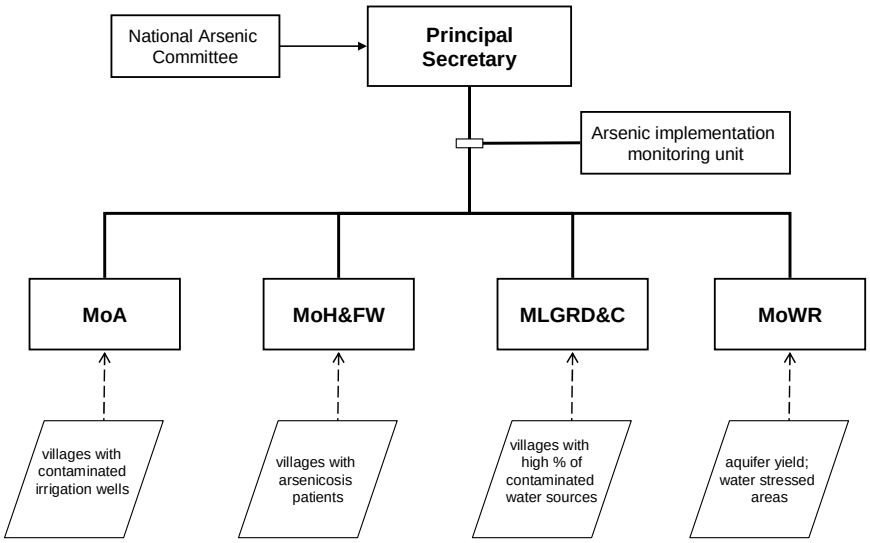

Figure 2. Co-ordination and Monitoring of Implementation Plans

3.2.2 Arsenic Committees

Arsenic committees exist at various administrative levels: national, district, upazila, union and ward. Presently, some activities of the arsenic committees overlap with others such as the Watsan committees, and it considered that the scope and frequency of theses meetings can be reduced. A

detailed review of the functioning of these committees will be undertaken to clarify their roles, membership and functions as discreet entities.

The National Committee will advise on policy, inter-sectoral coordination and the principles evaluation of the plans, but will not normally be concerned in the execution of individual implementation plans.

Key functions of the upazila and union level committees are to exchange information on patient identification, and the results of testing of drinking-water and irrigation wells, in order that mitigation can be prioritised. The role of the ward committee is unclear and requires justification.

3.2.3 Arsenic Implementation Monitoring Unit

In order that activities in each sector can be evaluated and coordinated, it is necessary to establish an Arsenic Implementation Monitoring Unit (AIMU) reporting to the Principal Secretary. The AIMU should have a small permanent staff, supported by expert advisers, and would collect, collate, analyse and report on the activities in each sector. The functions of the AIMU will not replace or duplicate the routine reporting functions of the individual ministries. The AIMU will engage a competent agency, such as CEGIS, IWM or a private company, to carry out the data management functions. The Principal Secretary, through the AIMU, will prepare an Annual Report for the general public explaining the current status of contamination and exposure, ongoing and planned activities, and future needs for arsenic mitigation.

3.2.4 Arbitration

During the early stages of IPAM 2009 there will a delivery gap between the aspirations expressed in regulatory targets set by government, the demand-based targets derived by LGIs, and the ability of the sector to provide safe water to all. The National Committee, based on information supplied annually by the AIMU, to advise government on the acceptability of the shortfall on delivery, either by reallocation of resources or setting interim targets. At a lower level, it is possible that an organisation such as a strengthened WARPO could perform the arbitration role for both IPAM-WS and IPAM-WR.

3.3 Implementation Plan for Water Supply

This implementation plan for water supply (IPAM-WS) is detailed in Section 4. This plan will be carried out under the guidance of MLGRD&C through a combination of government departments, NGOs, the private sector, and individual citizens. It is anticipated that the main information to be passed to other sectors will be the current and historic states of well contamination, and the numbers of untested wells.

3.4 Implementation Plan for Health

The Implementation Plan for Arsenic Mitigation in Health (IPAM-H) should build on the substantial progress made to date in the identification, diagnosis[6] and management of patients. *Inter alia*, IPAM-H should stress the following:

(i) Disseminating information, through the relevant arsenic committees, to the water supply and agricultural agencies, on the location, by village, of confirmed arsenicosis patients. Identifying the names of individual patients is not required; the most detailed information that might be transmitted would be a particular water source.

(ii) Making health professionals aware of villages where proportions of contaminated wells, the As-concentrations in drinking and/or irrigation water and/or rice are particularly high.

(iii) Consideration of the impact of arsenic in food chain, its contribution to arsenicosis, and its mitigation through modified cooking and par-boiling procedures.

(iv) Identifying excess morbidity and mortality due to non-dermatological symptoms of arsenic poisoning.

(v) Collaborating with stakeholders in the water supply and/or agriculture sectors to evaluate the health impact of current or post-mitigation conditions.

3.5 Implementation Plan for Agriculture

Implementation Plan for Arsenic Mitigation in Agriculture (IPAM-Ag) should scale-up the knowledge gained from research in the last six years. A prerequisite, however, will be to map the extent and severity of As-contaminated irrigation water, taking due account of the complexity and variability of agro-ecosystems in Bangladesh. Water surveys should be supplemented by focused analysis of arsenic in soils and crops. Thereafter, there should be complementary packages of mitigation measures to reduce the accumulation of arsenic in soils; develop low-As sources of irrigation water; promote biomethylation; reduce the uptake arsenic into the edible parts of plants; and to resist the toxicity of arsenic in the soil-water complex. The areas where IPAM-Ag overlaps with other implementation plans include:

(i) Notifying health professionals where there is likely to be high daily intake of arsenic from food.

(ii) Prioritise investigations and, if appropriate, mitigation efforts in villages where arsenicosis patients have been diagnosed.

(iii) Because irrigation and drinking water wells do not necessarily draw water from the same aquifers, DPHE and BADC officials should compare data to identify (a) combined exposure form food and water may be greatest, and (b) where there is scope for As-avoidance by modifying well design.

[6] The DGHS diagnostic criteria for arsenicosis require determination of >50 ppb As in a drinking water source. While this may add confidence to the diagnosis, the diagnosis should not be rejected in its absence. Exposure may result from one or more of the following: food; water containing <50 ppb; historic exposure; migration; and anthropogenic sources.

(iv) Undertake collaborative research to assess the sustainability of irrigated agriculture in different agro-ecosystems under the business-as-usual scenario with regards to the balance between As-accumulation in soils and declining concentrations in groundwater in the aquifers from which irrigation water is drawn[7].

(v) After the geographical extent of the agricultural arsenic hazard has been defined, collaboration with MoWR and/or DPHE could identify where surface water or low-As groundwater may be brought in for irrigation purposes. In the medium term, this may identify any resource in excess of that required for potable purposes from deep aquifers.

(vi) Where topsoil removal is planned as a means of agricultural rehabilitation, protocols for its disposal should be agreed with the Ministry of the Environment.

3.6 Implementation Plan for Water Resources

The Implementation Plan for Arsenic Mitigation in Water Resources (IPAM-WR) will create the environment in which the plans for water supply and agriculture may be managed and, where necessary, controlled. With regards the water supply and agricultural plans, IPAM-WR should include:

(i) Monitoring of water levels and water quality in deep wells and nested piezometers throughout the exploited deep aquifers, and extending coastward of the most distant freshwater abstractions. Information on trends in water levels or quality should be shared with DPHE and BADC on, at least, an annual basis.

(ii) Based on the above, and in collaboration with DPHE and IWM, determine the long-term and/or yields of the various deep aquifers, and predict the evolution of piezometric levels for a range of credible pumping scenarios. To this end, information on deep aquifers should be freely exchanged between MLGRD&C and MoWR through the National Water Resources Database (NWRD) and databases held by DPHE.

(iii) Create the legal and regulatory environment to define Water Stressed Areas, as per the NWP, within which groundwater quality can be protected.

(iv) Create a system of abstraction licensing that can be used to prevent over-exploitation and wasteful use or loss of groundwater within Water Stressed Areas without unnecessarily constraining economic development.

Identify sources of surface water or low-As groundwater that can be economically exploited for irrigation where current practices are harming agriculture.

[7] There is a finite amount of arsenic in the ground. With tubewell irrigation, arsenic is gradually transferred for groundwater to soil, and so the relative health risk is transferred from drinking water to food. The rate at which this is happening varies greatly depending on As-concentrations and the local agro-ecology. This research will identify the priority areas and urgency for interventions, and could, for instance, guide the allocation of the limited surface water sources available for irrigation.

4. IMPLEMENTATION PLAN FOR WATER SUPPLY

4.1 Guiding Principles

(i) The extent, nature and causes of arsenic pollution in Bangladesh, and its health effects through exposure from both drinking water and food, are sufficiently well known not to hinder the provision of mitigation. The technologies suitable for water supply mitigation are substantially proven, and their strengths and weaknesses understood. Proven technologies include deep tubewells, dug wells, pond/river sand filters, rainwater harvesting and some arsenic removal plants. Other technologies may be deployed in the future.

(ii) Mitigation will be delivered through the combined efforts of government, NGOs, the private sector and individual citizens.

(iii) Arsenic is only one of the obstacles preventing universal access to safe water. There should be no *a priori* preference for any technology, but should be selected to suit local circumstances, and should not involve the substitution of chemical risks by unacceptable microbiological risks.

(iv) It is the duty of those who provide water to ensure its safety. It is the duty of government to ensure that none are excluded, albeit involuntarily, from obtaining access to safe water, and that this is achieved both with maximum urgency and without undue adverse affects on other individuals or groups.

(v) The immediate goal of mitigation is to prevent exposure to arsenic concentrations of >50 ppb, but it should be a target to prevent exposure to concentrations of >10 ppb now, and a legal requirement on a time-scale to be defined by GoB.

(vi) Mitigation must respect the rights of present and future generations by conducting such monitoring as is required to ensure the sustainability of water resources.

(vii) LGIs should ensure access to arsenic mitigation, and thereby to safe water. They need not play major roles in either delivering mitigation or in testing water, but rather to ensure that these activities are done. The LGIs will require substantial training and support, especially from DPHE. LGIs will monitor rights-based targets through the registration of all water sources, and monitoring their status and water quality.

(viii) Demand-led monitoring by LGIs will be complemented by risk-based targets for planning and prioritising interventions and budgetary requirement through DPHE.

(ix) Independent evaluations will ensure the quality and effectiveness of interventions, and that the expected health-based outcomes are actually achieved.

(x) Clear reporting and public accountability are fundamental to monitoring, coordinating and managing the activities of stakeholders across sectors.

4.2 Institutional Overview

A large number of institutions will be involved in IPAM-WS. The main stakeholders, and their responsibilities, in water supply will be:

- DPHE will play a central role in strategic planning and monitoring of mitigation, in supporting LGIs; and an important role in delivering mitigation, especially the larger scale or more technically challenging aspects.
- LGIs will play a critical role in planning by identifying needs, monitoring the provision of safe water, and a minor in delivering mitigation.
- RDA should play a key role in demonstrating and training; making new approaches operational and passing on the lessons learned for others to replicate; and then moving on to new challenges.
- NGOs, the private sector, and individual citizens will primarily be involved in delivering mitigation, which is taken here to mean the whole sequence from awareness-raising to O&M.
- Donors should support government and NGOs, financially and through technical assistance, in implementing components of IPAM 2009. Donors should seek to ensure that any mitigation they finance is properly reported and evaluated within the principles contained herein.

The activities of research organisations should be encouraged and supported where they demonstrate commitment to (i) disseminate information amongst stakeholders in mitigation, and (ii) develop capability in Bangladesh.

4.3 Local Government Institutions

4.3.1 Roles and Responsibilities

Local Government Institutions (LGIs) will play a central role in ensuring access to safe water by monitoring progress and soliciting action towards a series of non-exclusive goals[8]. The most important LGI in IPAM-WS is the Union Parishad, who will carry the main responsibility to ensure safe water for all, through the following activities:

i. Maintaining a register of all water sources in the union, including their status (e.g. unpainted, red or green, last tested), and based on this information, determining demand for safe water in the union. However, the registration of water sources by LGIs may be superseded where WASAs have been created by government.

ii. Through registration, providing a first level of control over well drilling and use.

iii. Ensuring that water providers conduct tests to demonstrate the safety of the water supplied, and conducting spot checks on arsenic with field test kits to ensure this

iv. Exchanging information through Arsenic Committees, notably information of tubewell status, agricultural hazards, and the location of patients.

[8] Such as that all wells are registered and tested.

4.3.2 Institutional Strengthening

To make IPAM-WS effective, institutional strengthening of both DPHE and LGIs is required, with greatest effort required at union level. The processes are linked, because DPHE will need strengthening at upazila level to bring about strengthening of LGIs. DPHE's representatives in Arsenic and Watsan committees at upazila and union level tend to be less well educated than other members and therefore less able to promote the importance of water and sanitation. To meet the evolving needs of the water supply sector, DPHE staffing should move toward employing graduate level staff at upazila level to better carry out their decentralised roles in planning, monitoring, training and advocacy. Likewise, at union level, representation by a 'mechanic' undervalues the importance of DPHE's work. DPHE will provide technical support in selecting arsenic mitigation options, training LGI staff in testing, and reporting, and will need their own internal training to carry this out.

LGIs will need thorough training, through formal courses, in how to carry out their enforcing role: in maintaining registers; reporting procedures; water quality testing; needs assessment; facilitation and advocacy. Training courses may be prepared and piloted by BUET-ITN and delivered through the National Institute of Local Government (NILG). This training will need to be piloted, evaluated and refined during implementation.

4.4 Water Supply Mitigation

4.4.1 Mitigation Options and Delivery

Various intervention technologies (DTW, dug well, ARP, rainwater harvesting and PSF/RSF) have been assessed in terms of health effects, cost, acceptability and reliability. All may be promoted by GOs or NGOs in the context of a water safety framework. Other technologies, such as *in-situ* removal or ARPs currently being evaluated under the BETV-SAM programme may be promoted in the future.

A major component of mitigation is delivered by private citizens through switching or resinking shallow wells. Likewise, the continued use of shallow wells that have been tested and determined to be safe is fundamental to arsenic avoidance in affected areas, and yet it is proven that wells cannot be presumed to remain safe. In both situations, providing local testing facilities and ensuring that wells are monitored is essential to effective arsenic mitigation.

4.4.2 Cost Sharing

No changes to cost sharing policies are proposed, but are subject to periodic review by GoB.

4.4.3 Technology Guidelines

Based on the best available knowledge, DPHE will issue and periodically revise guidelines for the selection, installation and operation of all safe-water technologies recommended for arsenic mitigation. Guidelines will also be produced for water quality testing, the disposal of arsenic-rich wastes, and other activities as deemed necessary. DPHE may prepare such guidelines internally or through other organisations as appropriate, but always in consultation with stakeholders representing both scientific and users' perspectives. All guidelines shall be consistent with a Water Safety Framework.

4.4.4 Selection of Mitigation Technologies

Where two or more technologies appear technically feasible, preference may be given to surface water sources. The determination of feasibility shall consider at least the following factors: (i) the chemical and biological safety of the water; (ii) cost; (iii) social acceptability and; (iv) the temporal reliability of the water source.

In combination with technology guidelines, based on the most up-to-date information, DPHE will regularly produce guidelines for the geographical (hydrological or hydrogeological) suitability of safe-water technologies. These guidelines should include gradational ratings of suitability to each region.

4.4.5 Water Safety Framework

Arsenic pollution of drinking water in Bangladesh is unique in the world with respect to the severity of health impacts, the proportion of the population affected, and the speed of discovery. Consequently, arsenic mitigation has been subject to many dedicated programmes. Nevertheless, as the impacts are brought under control, arsenic mitigation should be incorporated into the mainstream of watsan activities as embodied in Drinking Water Safety Plans (DWSPs). Indeed, depending on the type of mitigation intervention, the risks from bacterial contamination may be a greater threat to health.

All providers of arsenic mitigation should introduce DWSPs at the earliest practical date, and with highest priority given to those technologies prone to bacterial contamination. Providers must ensure both low arsenic concentrations and microbiologically safe water.

DWSPs will apply a holistic approach to water quality management from the catchment area to the point of use. To this end, DPHE should introduce the practice of defining source protection zones.

4.5 Planning, Monitoring and Evaluation

4.5.1 Strategic Planning and Monitoring of Mitigation

Demand-led provision of mitigation through multiple agencies leads to fundamental difficulties in tracking the ongoing need for mitigation, both in its location and mode. Resolving this will be achieved by integrating bottom-up monitoring by LGIs and top-down monitoring by DPHE. The latter will require improved reporting systems at local level, and improved data management in DPHE, supported by targeted field surveys to resolve ambiguities. Planning should include outline budgeting, not only for government but for the sector as a whole. All plans should be quantitative and time-bound, specifying how many people in which places will be reached, and also the means of verifying whether this has been achieved.

DPHE should produce annual programmes for each upazila indicating the total requirements for mitigation, and planned actions by both itself and other stakeholders. The programmes must be realistic and highlight shortfalls in planned delivery (against needs) so that LGIs and other stakeholders are aware of the additional requirements for mitigation in each area. Each annual programme should include the previous years target and progress.

Based on the annual programmes, DPHE shall produce rolling estimates for the total investment required to mitigate arsenic contamination of water supplies. The source of financing, or its absence,

for each item in the annual programme shall be specified, and made available through the AIMU website.

MLGRD&C will set final and interim targets leading to achieving access to safe water for all, and LGIs will be responsible for measuring, and facilitating, progress towards these goals. The monitoring of demand will be achieved through the flow of information from LGIs, by way of the Union Arsenic Committee, to DPHE who will summarise data and estimate technology and funding requirements as part of a decentralised planning process, in collaboration with the Upazila Arsenic Committee[9]. Exposed population figures and mitigation requests will be evaluated at national level by DPHE and AIMU on the basis of risk and available funding.

4.5.2 Third Party Evaluations

Audits will verify the provision, status and quality of particular technologies and/or agencies. The results will feed back to refine monitoring and improve planning and technology guidelines.

Random, annual monitoring surveys will quantify residual arsenic exposure in communities that have received mitigation, and will require the participation of public health specialists to measure biomarkers.

Evaluation differs from the monitoring described above. Monitoring measures the activities and their direct outputs. Evaluation will first establish, on a sample basis, whether these data are correct and second measure to what extent these outputs are contributing to higher objectives of improved public health. Therefore, at the start of IPAM 2009, the National Arsenic Committee and the AIMU will first establish a hierarchy of indicators, each with a realistic means of verification, to measure the effectiveness of the Implementation Plan, and second ensure there is an adequate baseline against which to measure the intended change.

4.6 Deep Aquifer Management

Over ten years of arsenic mitigation, deep wells have been the predominant safe-water intervention, reaching approximately ten times more people than any other technology. Because deep wells are expected to remain the principal means of mitigation for the foreseeable future, existing and future users must be protected from, or forewarned of, the dangers of saline intrusion, arsenic migration and falling water levels.

Addressing these questions requires knowledge of the distribution and properties of the deep aquifers and intervening aquitards; water quality and water level monitoring in shallow and deep aquifers; and an inventory of tubewells and their abstraction history. Some data exist but are not systematically organised and consistently recorded.

General aspects of water resource management are described in section 4.7, but three specific projects for implementation under IPAM-WS are presented below.

[9] Recent work by DPHE and JICA should be considered when designing this activity.

4.6.1 Delineation of Groundwater Management Units for Deep Aquifers

The response of the deep aquifers will vary between regions, and a sound spatial framework, geographic and vertical, is required to assess and control abstraction. Mapping units, which may be further subdivided in the future, should be defined following hydrological principles and, as far as possible, administrative units. Within units, as far as practical, the number and depths of aquifers present should be defined and linked to DPHE's inventory of deep wells. The mapping should be undertaken as a project, using GIS, and taking the DPHE-JICA Deep Aquifer Database Project as a starting point. WARPO should be consulted during the design of this project, and the results should be produced in a format suitable for incorporation into the NWRD.

4.6.2 Study to Predict Declining Water Levels in Deep Aquifers

Abstraction from deep aquifers is increasing rapidly, and as a consequence piezometric levels in these aquifers are certain to decline. This is the same as happened earlier in shallow aquifers, and will cause the suction pumps to fail in many areas. Unlike with shallow wells, the pump (even Tara pumps) represents a very small portion of the capital cost. However, deep hand tubewells can be installed with larger diameter casing so that the pump unit can be replaced later without having to abandon the well.

In the absence of reliable regional groundwater models, which will take many years to produce, a rapid and pragmatic study should be undertaken to predict where and when seasonal water levels will fall below suction limits. In 1994, DPHE/UNICEF conducted a 'Study of Declining Water Levels' to predict upazilawise requirements for Tara and Super-Tara pumps outside the coastal area and Hill Tracts. An equivalent approach is required for the areas where deep wells are exploited, based on correlations between water levels and well numbers. The models should be capable of being periodically updated, and become self-correcting as more data are collected.

4.6.3 Mathematical Modelling of Deep Aquifers

Mathematical modelling of deep aquifers will be required, but its value will be limited until the two previous studies are completed; more field investigations conducted; and a monitoring system (section 4.7.1) has been operating for several years. Modelling should be developed in phases incorporating both local resources, such as IWM, and international experts. Modelling of the deep aquifers will be technically challenging, and may require several iterations to produce reliable management tools, with integration of different models being produced at local (e.g. the Khulna urban area), regional and basinal scales. Modelling will need to be supplemented by specialist hydrogeochemical investigations.

4.7 Water Resource Management and Regulation

4.7.1 Water Monitoring and Assessment

Time-series monitoring of water levels, water quality and abstraction is a prerequisite for assessing the yields of, and deleterious trends in, all aquifers and is a critical constraint upon the use of deep aquifers for water supply throughout Bangladesh.

BWDB, the main agency responsible for water resource monitoring, has a good network for monitoring groundwater levels, and a more limited network for monitoring water quality, in the shallow (< c.150 m) aquifers of inland Bangladesh, but has a very limited network in deeper aquifers and in the coastal zone in general. DPHE monitors water levels twice a year in selected deep tubewells. A deep well monitoring network in Khulna City was recently established, and some deep monitoring wells have been installed in paurashavas in Noakhali, Lakshmipur, Patuakhali and Barguna districts.

Systematic and continuous monitoring of groundwater quality and levels in deep aquifers is urgently required. A coordinated, non-duplicating, monitoring network should be established and maintained between MoWR, DPHE and relevant WASAs. MoWR, through BWDB or WARPO, should take overall responsibility for the state of the aquifers, but DPHE should take responsibility for monitoring in and around municipal wellfields. Projects should be undertaken to install nested piezometers to fill all data gaps. The projects should commence with a review of the hydrological network to ensure that other issues, such as climate change and groundwater interactions with rivers and wetlands, are considered.

4.7.2 Abstraction Management and Licensing

An appropriate regulatory framework is essential for effective management of water resources, particularly for the deep aquifers. Although there are no specific laws or regulations to protect the quality of groundwater, some, as listed below, are relevant:

Year	Act/Ordinance	Executing/Target Agency	Major areas covered
1972	Bangladesh Water and Power Development Board's Order	BWDB	Assigns BWDB as the controlling body for surface and ground water resources
1983	Irrigation Water Rates Ordinance	BWDB/BADC	Supersedes the Bengal Irrigation Act 1876 for imposing water rates for irrigation and drainage.
1985	Ground Water Management Ordinance	MLRGD&C	Formation of Thana Irrigation Committee for controlling installation and spacing of minor irrigation technologies
1992	Water Resource Planning Act	WARPO	Assigns WARPO the role for the development of water resources

Currently there are no controls on abstraction of groundwater outside the WASA areas. Two levels of abstraction control should be developed. First, LGIs will maintain a compulsory register of all water sources. Second MoWR should introduce a system of abstraction licensing, which while it may exempt some categories of well[10], will be applied to control abstraction from stressed aquifers, and may be implemented through the Draft Water Act, which allows for defining Water Stressed Areas, otherwise a Groundwater Act will need to be introduced.

[10] Such as manually operated wells.

Although many organisations have interests in groundwater, control of abstraction should rest in MoWR. However, it is important that the roles of resource management and control should not be combined with the role of an executing agency for water resource development projects (e.g. as is done by the BWDB). Currently, no existing agency has the appropriate institutional status and staffing to perform this role. It is recommended that responsibility should lie with either a reformed WARPO or a new groundwater resource management organisation. In its present form, WARPO could not take this responsibility because it has no field offices. The same constraint would apply to any new organisation. This could be readily resolved by the transfer of the Groundwater Circle and/or the Hydrology Wing of BWDB. Responsibility for licensing would provide WARPO or the new organisation with a source of income, as well as routine activities in between national water planning activities.

Given the critical role and potentially limited yield of deep aquifers, licensing should include the power to impose restrictions on inefficient use or leakage of water.

4.7.3 Water Quality Standards

The Department of Environment (DOE) is responsible for drinking water standards through The Environment Conservation Rules 1997. All standards should be revised periodically in the light of improved knowledge and local circumstances, especially where they differ from WHO guidelines or raise special problems for implementation in the country. The Bangladesh standard for arsenic is currently 50 ppb, whereas since 1993, WHO has recommended a guideline value of 10 ppb. This guideline should be adopted as a standard, but its implementation should be carefully phased with removal of exposure in excess of 50 ppb, initially as a non-binding target, and later as a requirement for new water supplies and then for existing supplies.

Drinking water standards should be made binding for public and commercial water supply providers and NGOs. Standards should, however, differentiate between health-based on aesthetic (taste, colour, odour) considerations.

4.8 R&D and Supporting Activities

4.8.1 Field testing and laboratories

By 2003, 29% of 5 million wells in As-affected areas exceeded the 50 ppb standard, but many of the 71% that complied exceed the 10 ppb target. Further, since 2003, the number of operating or replacement wells in affected areas has increased by about 30% and most of these have not been tested for arsenic. It is also well established that many wells increase from safe to unsafe concentration over periods of a few years. There is therefore a massive requirement for monitoring and provision of local testing facilities.

Currently there is no manufacturer of validated field test kits in Bangladesh. Ideally, there should be at least two manufacturers/vendors in country, and this is best achieved where there is a predictable procurement pipeline. Based on the number wells that ought to be tested, the requirement is of the order of 10-20,000 kits a year. However, it is unlikely that there is the capacity to use this many kits initially.

The primary responsibility to test and monitor water sources should lie with the providers of the water supplies. In the case of DPHE and NGOs, they should either conduct the testing themselves or provide the users with a reimbursable ticket system to allow them to procure testing through income-generating activities of government, NGOs or the private sector. The responsibility to see that testing is done lies with LGIs, who will also carry out random verification tests.

To support field testing, there should be a QA system involving DPHE laboratories conducting random checks on field tests and determining other parameters that cannot be tested in the field. In the short term DPHE laboratories should support LGIs through the supply of test kits, training, and carrying out verification surveys. Presently, DPHE laboratories are performing well below their capacity, but could be improved by commercialising operations whereby staff salaries are paid through income from testing. To be effective, water supply providers and GOs should have a duty to commission a certain number of tests each year, although they should have freedom to choose labs based on the cost and quality of the service.

4.8.2 Disposal of Arsenic-Rich Sludge

Despite research and the fact that arsenic removal plants are operating, there is no agreed protocol for disposing of As-rich wastes. A variety of disposal methods have been proposed[11], however, all have disadvantages or constraints. A rapid study or expert consultation (including the ministries of agriculture, water resources, and environment) should be undertaken to recommend practical methods for the disposal of As-rich wastes. The study should apply risk assessment techniques, supported by trials only if significant knowledge gaps are identified. The recommendations must also be socially and politically acceptable, and should not contradict recommendations in other areas of arsenic mitigation such as the management of irrigation water.

Notwithstanding the above, providers arsenic removal plants have a responsibility to ensure environmentally safe disposal of all wastes generated.

4.8.3 *In-situ* (Subsurface) Arsenic Removal

In-situ treatment of groundwater, a long-proven process for public water supplies in Europe, involves the cyclic injection of aerated water and withdrawal of water from which iron, manganese and arsenic are removed. It is the only mitigation technique that both permanently removes arsenic from water in the aquifer and does not generate an As-rich waste. The only chemical added is air from the atmosphere, and should be cheaper than other treatment methods. However, the method has not been applied for public supply in aquifers with such high As-concentrations as are found in Bangladesh. *In-situ* removal was a recommended R&D activity in IPAM 2004, but to date there has been minimal testing in Bangladesh.

A feasibility study of in-situ techniques to remove arsenic, iron and manganese should be undertaken. Field trials should be carried out at about five sites representing different water chemistries. The trials should be conducted with motorised wells and with discharges sufficient to determine the feasibility of the method for community and municipal supplies. The study first determine the technical feasibility

[11] Such as application to agricultural and non-agricultural soils, encasement in bricks or concrete, dilution in rivers or the sea, and landfilling.

and optimum conditions for As removal; and, if successful, then focus on optimising costs and operating procedures for implementation by GOs or NGOs.

4.9 Reporting and Accountability

4.9.1 Principles

Transparent and comprehensible reporting is central to public accountability, and has a number of requirements: (i) reporting of physical and financial reporting within the line ministries and NGOs; (ii) collation and exchange of summarised data between ministries and sectors; (iii) skilled analysis and reporting of this information; and (iv) appropriate policies or rules to facilitate the first three actions.

4.9.2 Annual Reporting

With guidance from the National Arsenic Committee, the office of the Principal Secretary should publish an annual 'State of Arsenic in Bangladesh' report that shows the evolving status of contamination, disease and mitigation, and the activities and plans of major stakeholders. The purpose of this report is to inform government and civil society, with minimal technical language, about: (i) the number of contaminated and untested drinking water wells; (ii) the number of arsenicosis patients have been diagnosed; (iii) how many arsenicosis patients have had their symptoms improve or deteriorate; (iv) how many irrigation wells are contaminated; (v) what mitigation has been installed or is planned; and (vi) how the health and economy of the nation is being affected.

The AIMU will be responsible to supply the necessary information, or provide a public statement of why it is not available, to produce the report. Production of the report may be contracted to an organisation skilled in explaining science to the general public. Apart from providing a public service, it is expected that this report will be a self-regulating mechanism for all stakeholders in IPAM 2009. The Annual Report should become a rolling vehicle for revisions to the Implementation Plan.

4.9.3 Data Management

Data management is fundamental for designing, monitoring and evaluating mitigation; and will require the integrated working of LGIs, DPHE and the AIMU.

Union Parishads will compile raw data on the number and status of water sources. DPHE should collate the LGI reports. DPHE have insufficient capacity to process these data effectively and should contract organisations such as CEGIS and IWM to assist. The compiled data should be interfaced with the NWRD held by WARPO.

The AIMU should commence by reviving the NAMIC and APSU websites, and should present mouza, union, upazila and district-wise summaries of drinking water and irrigation well testing and patient diagnoses.