Sustainable Arsenic Mitigation (SASMIT)

Community driven initiatives to target arsenic safe groundwater as sustainable mitigation strategy

Sida Contribution No.:73000854

The SASMIT Protocol

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Sustainable Arsenic Mitigation (SASMIT) protocol is an outcome of the action research project that has developed a community based and cost efficient strategy for installation of safe drinking water tubewells in arsenic affected regions of Bangladesh. The installations are optimised on the basis of increased local hydrogeological knowledge and the demand for safe water among the underserved segments of the society and can be applied for scaling-up safe water access in arsenic affected areas in Bangladesh and other similar affected regions of the world.

1. Introduction

Access to safe drinking water is a basic human right and an important component for effective public health protection. The widespread occurrence of natural arsenic (As) in groundwater in Bangladesh (**Fig. 1**) and its scale of exposure have drastically reduced the safe water access across the country. Despite several efforts, there has been very little success in mitigation since the discovery of arsenic in the country in 1993; still tens of millions of people are exposed to concentrations above the Bangladesh drinking water standard (BDWS; 50 µg/L) which is even 5 times higher than WHO guideline (10 µg/L). The toxic effect of long-term exposure to As, a well known carcinogen, can extend from pigment changes and hard patches on the skin to gangrene and lung, kidney and bladder cancer, and those drinking water with As in excess concentrations are obviously considered at risk. The magnitude of the continuation of this human tragedy will depend on the rate at which mitigation programmes are implemented and now, the main challenge is to develop a sustainable and cost-efficient mitigation option that will be adopted by the people for scaling up safe water access.

1.1 Rationale

Although significant progress has been made to understand the source and distribution of arsenic in the respective aquifers, and its mobilization in groundwater, there has been limited success in transferring this knowledge towards large-scale and substantial mitigation efforts to reduce arsenic exposure from drinking water sources in Bangladesh. Different options have been implemented including household and community As-removal filters (ARF), rainwater harvesters (RWH), pond sand filters (PSF), dug wells (DW), hand tubewells (HTW) at targeted depths and deep tube wells (DTW) usually installed at depths of 200-250 m. These options have been assessed on several criteria, such as community acceptability, technical viability and their socio-economic implications and

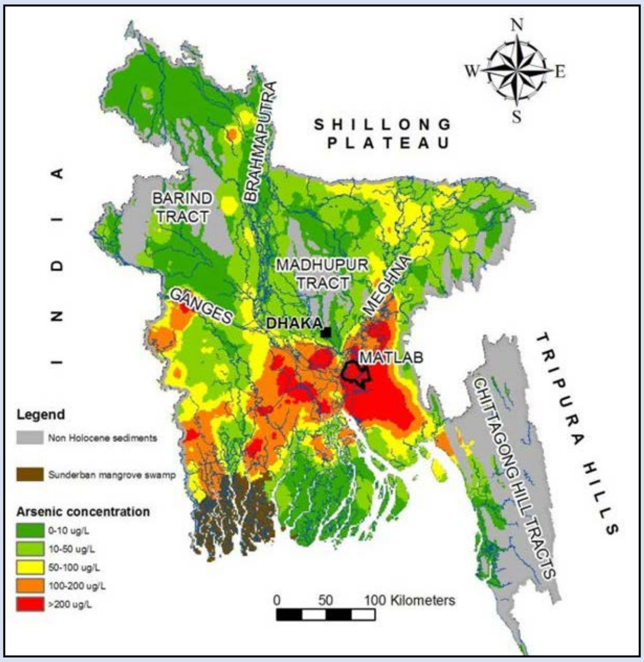


Figure 1. Map of Bangladesh showing the distribution of of arsenic in groundwater and the location of the SASMIT intervention site.

it has been found that community acceptance of many of the options is very low and only tubewells offer a source of As-safe drinking water acceptable to communities over major part of the country.

However, drilling to depths beyond 100 m is expensive and cannot be accomplished by locally available hand-percussion technique. The SASMIT project was conceived to develop an systematic approach that can scale-up the provision of safe drinking water to communities exposed to elevated arsenic at a low cost. SASMIT also aimed to provide the local drillers in the rural communities with specific knowledge to improve their indigenous skills and entrepreneurship to target safe aquifers for tubewell installation.

1.2 Societal needs and cross-cutting issues

Water plays a pivotal role in human well-being and in economic development. Because of the need of water in domestic use (drinking and cooking) and in food production (primarily for irrigation), conflict over water and the effects of gender influenced decisions about water may have far-reaching consequences on human well-being, economic growth, and social change. Water handling in Bangladesh, as in the case of other developing countries, is generally the task of women and in general their opinions on the safe drinking water supplies therefore need to be integrated during the installation of new hand tube wells (HTW) (**Fig. 2**).

Figure 2. Safe drinking water wells provided during SASMIT project implementation addressing the cross cutting issues including gender consideration and child health.

The societal impacts of As poisoning is reflected in several ways by socio-economic status and gender. While close proximity of the households with safe water access points simplify the task of women for water handling, the easy access to water through family hand tubewells (HTWs) are also crucial in maintaining a healthy drinking water supply, beside promoting the custom of hand-washing after toilet use and before food preparation. The proximity of the safe HTWs also are important in close vicinity of the school to protect the health of the children. The sensitivity to As poisoning is also related to economic status of the individuals which in turn affect the nutritional status as well as affordability to secure access to safe water. Higher cost involvement in installing As-safe deep wells causes the poor communities vulnerable to arsenic poisoning. The poorer sections of the society consume more water (hence exposed to more arsenic) as they work harder. The worse nutritional status of poor households, and particularly the women of those households, may mean that As contamination has more severe physiological consequences for them.

2. SASMIT Implementation

2.1 Assessing available safe water options and livelihood status

Based on the evaluation of of the various alternative drinking water options that were provided in Matlab area during the Sida supported-AsMat (Arsenic in Matlab) project (2001-2006) and the social survey in the project intervention area, tubewells emerged as the most preferred and accepted safe drinking water option. Tubewells were ranked as the most feasible and

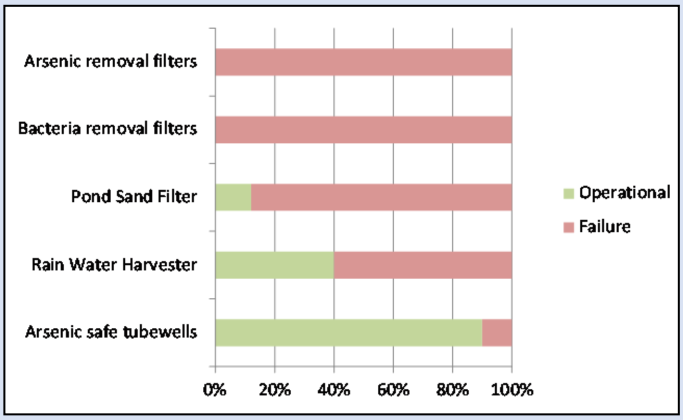


Figure 3. Performance analysis by SASMIT on different options adopted for arsenic mitigation.

viable option for safe drinking water supply, mainly due to technical suitability in terms of installation and operation, almost negligible cost of maintenance and availability of good quality water throughout the year (**Fig. 3**). Moreover, the tubewells are also ranked high due to their user-friendliness, especially to women and children. It is important to note that as compared to safe water demand, the number of safe wells is very low, as the cost of installation for deeper tubewells is beyond affordability of the local community especially for the poor section of the society.

2.2 Local drillers - the drivers

Although tubewell technology was introduced by governmental and non-governmental agencies, 90% of the estimated more than 10 million tubewells in Bangladesh are installed privately by local drillers (**Fig. 4**). Undoubtedly ground-water exploitation will increase for drinking purposes both in rural and urban areas of Bangladesh and if local drillers could target safe aquifers, it would be a very viable option for arsenic mitigation as the practice of using tubewells is deep-rooted in the rural peoples' mind. The awareness of local drillers on elevated As concentrations in tubewell water at shallow depths have made them change their practice of installation of tubewells. Using the visual colour attributes of the shallow sediments (<100 m) and content of dissolved iron, generally associated with high As concentrations, the local drillers presently install community tubewells at depths targeting red/brownish or off-white sediments (**Fig. 5**).

Figure 4. Community initiative of the local driller for targeting safe sediments for tubewell installation in Bangladesh – the emergence of "the sediment colour concept".

2.3 Sediment Colour Tool for targeting As-safe aquifers at shallow depths

Distinct relationship of sediment colour and corresponding As concentrations in water has been documented through a number of recent studies. Local drillers follow the practice of installing shallow tubewells in red sediments with low concentrations of As, with average and median values below the WHO drinking water guideline (10 µg/L). The levels of As in the off-white sediments are also similar, however, targeting off-white sands could be limited due to uncertainty of proper identification of colour, specifically when day-light is a factor. Elevated manganese in both red and off-white sands is a concern for installation of safe tubewells, which warrants a better understanding on the impacts of elevated Mn on human health. White coloured sediments are rare at shallow depths and thus less important for well installations. In most of the shallow wells (> 90%)

installed in black sands (n=66), As concentration was high with an average of 239 μg/L and therefore installation of wells in shallow black sand aquifers must be avoided. Based on these findings a simple colour based tool for targeting shallow aquifers for the installation of arsenic safe community tubewells have been developed for the local drillers (**Fig. 6**). The low As wells installed in red coloured sediments comply with the drinking water standards for As, although concentrations of Mn in many of these wells are above national drinking water standards, although manganese has been recently withdrawn from WHO guideline. However, As warrants highest attention due to its acute health effects.

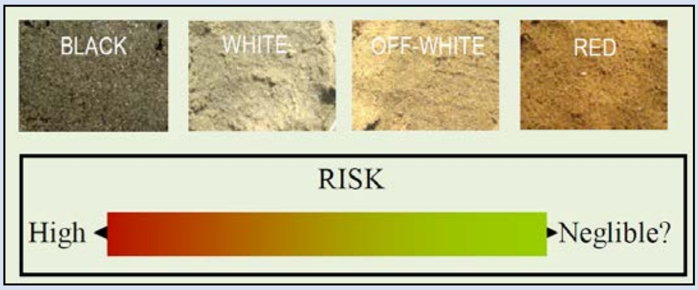


Figure 5. Local drillers' perception of sediment colour and identification of safe aquifers for well installations.

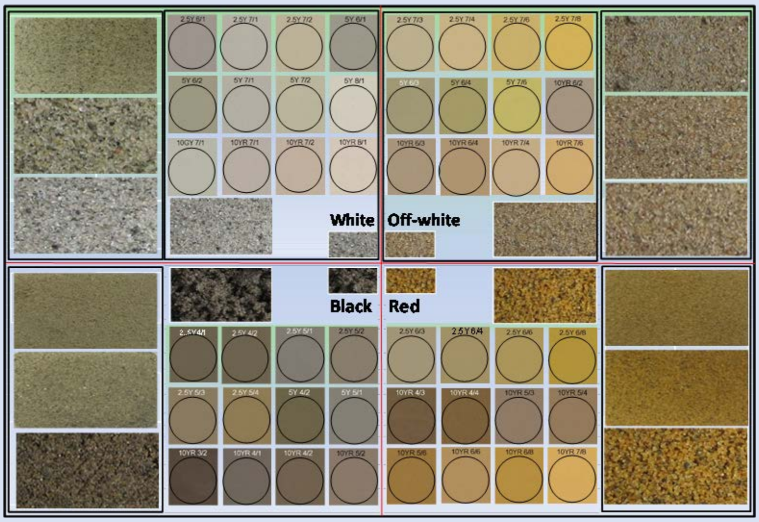


Figure 6. A prototype of the simplified colour tool for the use of local drillers for targeting safe aquifers at shallow depths (< 100m).

2.4 Intermediate Deep Tubewells (IDTW) - An emerging source of safe drinking water

Considering elevated concentration of Mn in red sand aquifer, an attempt was taken through

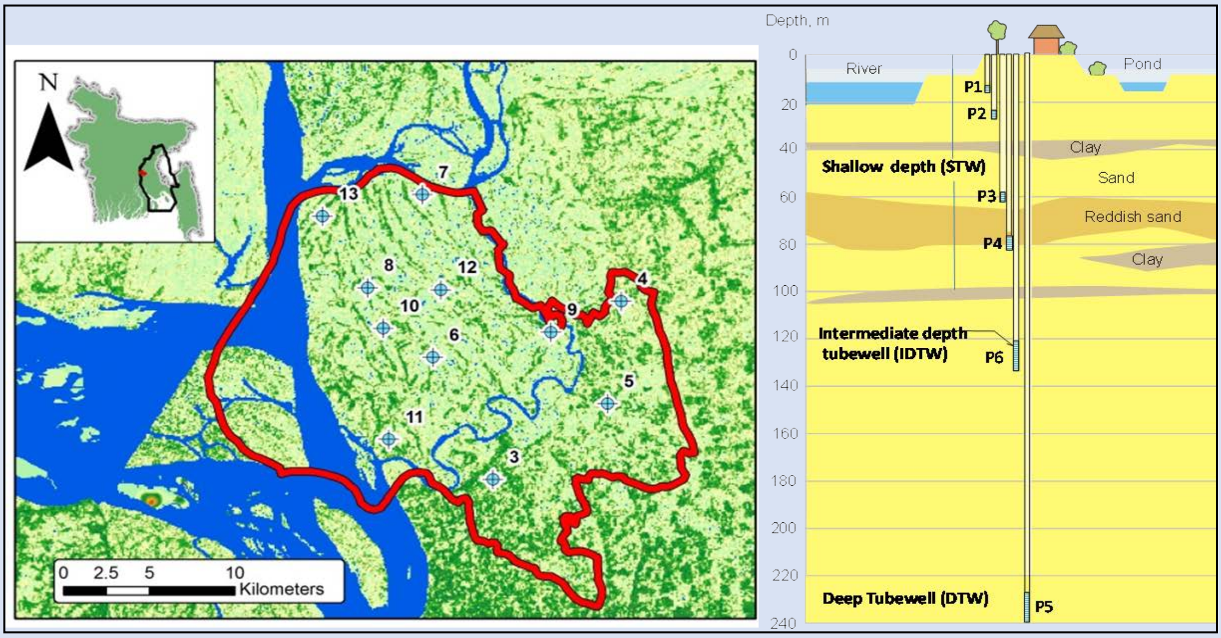


Figure 7. Schematic sketch for assessment of hydrogeological suitability for installation of piezometer nests (groundwater observation well-nests) at shallow, intermediate and deep aquifers in Matlab, Bangladesh.

field based trial and piezometer monitoring to find an option which is suitable for both As and Mn. Based on the comprehensive hydrogeological investigation, a strategy was developed systematically, to target the intermediate deep aquifer to avoid the health risk for both As and Mn. The undiscovered groundwater resources between traditional shallow and deep aquifers was explored for the first time and found potential sources for both As-safe and low-manganese water for drinking water supplies. These aquifers were targeted at a depth of 120 m and below and termed as intermediate deep aquifers (IDA) and hereafter the tubewells installed are termed as intermediate deep tubewells (IDTW) (**Fig. 7**). SASMIT project installed 245 IDTW at depths between 120-130 m. Among 245 wells installed, 96 % (n=234) are As-safe with respect to drinking water standard of Bangladesh (BDWS) and 91% (n=221) are low in manganese compared to the previous WHO guideline value of 0.4 mg/L (**Fig. 8**). Currently there is no health based limit for Mn in WHO drinking water guideline. The cost of the IDTWs is cheap and affordable by the local communities at approximately half of the cost of the conventional deep tubewells (DTW). These newly explored aquifers at intermediate depth are a potential source for As- and Mn-safe water supply that would scale up the safe water access in the country at a reasonable cost. Replication trials in five neighbouring upazilas of Gazaria, Bhedarganj, Shibchar, Palong and Muradnagar in southeastern Bangladesh validated the wider applicability of the IDTW strategy for As mitigation.

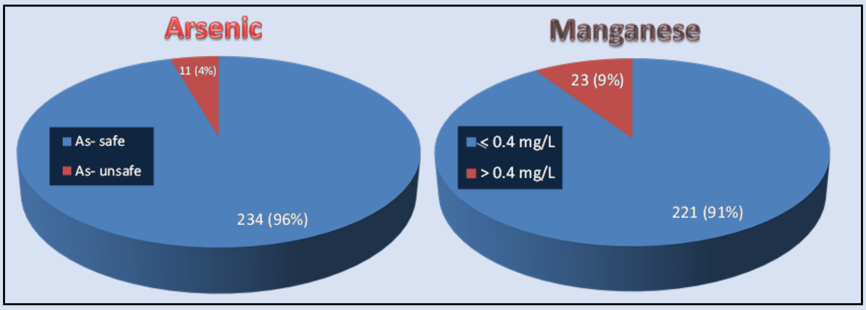


Figure 8. Success rate of the 245 wells installed in the intermediate deep aquifers (IDTW) in Matlab, Bangladesh.

2.5 Upscaling Sustainable Arsenic Mitigation – Integration of technical and socioeconomic aspects for optimisation of safe water access

The uniqueness of the development of SASMIT strategy was based through a process of action research considering both technical (hydrogeological suitability) and social aspects of arsenic mitigation which involved and strengthened the initiative and capacity building of the local drillers and the community. Based on the water quality monitoring in piezometers and considering a safe buffer distances around the piezometer locations, clusters of villages (mauzas) were intervened for safe tubewell installation. Social mapping of all the villages within the targeted mauzas were done to evaluate the availability of safe water options for all clusters of households (baris). In selection of tubwell installation sites, priority was given to the baris with no/poor safe water access, greater number of beneficiaries especially poor households,

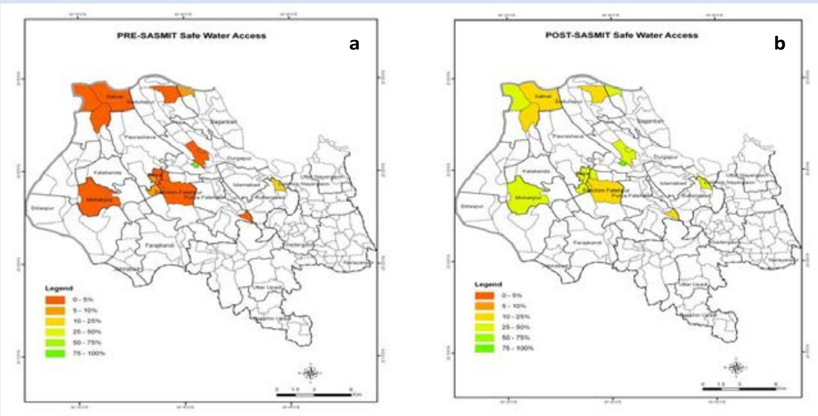


Figure 9. Improvement of safe water access through SASMIT implementation. a) pre-SASMIT and b) post-SASMIT.

and easy access to the tubewell site from all households of the respective cluster. Following this method, it was thus possible to make 96% of the newly installed wells As-safe and scale-up the safe water access even from 0 to 40 percent (**Fig. 9**) in some mauzas. However this intervention accounted for only 30% of the total implementation capacity compared to the overall assessment of hydrogeological suitability and the safe water demand. This also indicates the necessity of further improvement of safe water access through future implementation.

3. Strategy for Developing Sustainable Arsenic Mitigation (SASMIT) protocol

The SASMIT protocol for safe tubewell installation developed through an action research strategy that combines the local hydrogeological knowledge and socioeconomic perspectives of the communities, to optimize the locations for installation and thereby to improve the safe water access. The components of the SASMIT protocol is based on the following considerations:

- Assessing hydrogeological suitability (shallow, intermediate and deep aquifers) of the intervention area
- Developing implementation strategy based on the identification of underserved cluster of households:
    - Prioritisation of intervention areas through mapping of socio-economic status of the communities and safe-water access
    - Optimization and prioritization of Baris (cluster of households) through village consultation meeting and social mapping
    - Site-selection through dialogue with villagers and local drillers
- Water quality assessment of installed wells and monitoring
- Capacity building of the local drillers to enhance their indigenous skills and develop entrepreneurship for safe tubewell installation.

3.1 Assessing hydrogeological suitability

Understanding hydrogeological suitability of a given project area is of prime importance for tubewell installation. Depending upon the scope and objective of the project, the assessment of targeting the safe aquifers may vary from a detailed investigation of subsurface hydrogeological system to a more simple installation of a number of test wells only. For detailed investigation, we recommend installation of multi-level piezometer nests (groundwater observation well-nests) at shallow, intermediate and deep aquifers for monitoring depth to groundwater with respect to time and water quality (e.g. **Fig. 7**). For selecting the sites for monitoring wells it would be recommended to discuss with the local drillers to incorporate their knowledge about the aquifers. Any available secondary information mainly the existing borelogs and water quality data can be merged and analysed for the decision making process for hydrogeological suitability. In addition, mapping of large capacity water supply wells and clusters of irrigations wells is preferred to be done in order to identify the risks for cross contamination which could be induced due to multiple abstractions.

For understanding the aquifer system in a rather simple manner, some test wells can be installed to have a reasonable spread in the project area in collaboration with the local drillers. These test wells will allow delineating the depth of the targeted safe aquifers (red sand/IDA) and ascertain water quality to make a decision on the hydrogeological suitability.

3.2 Developing implementation strategy

Systematic mapping of safe water access and livelihood status helps to identify the most underserved communities. For selection of intervention area, village consultation is an important tool for generating social data, with emphasis on the existing status of safe tubewells and livelihood. Simplified analysis of the collected information and interpretation along with GPS coordinates locating the cluster of houses (baris) is used to prepare the maps (**Fig. 10**). Additionally the village consultation meetings serve as a platform for general awareness-raising about the health effects of As and importance of safe water, as well as for developing initiatives to ascertain the sustain-ability of the installed tubewells through local level continued monitoring. This strategy is recommended for the stakeholders during the planning and implementation of safe tubewell installation, which ensures the optimization of site selection to maximize the safe water coverage and the beneficiaries. Maps prepared in this manner on the basis of GPS coordinates will also be useful to visualize the improvements in the safe water coverage on a long term basis.

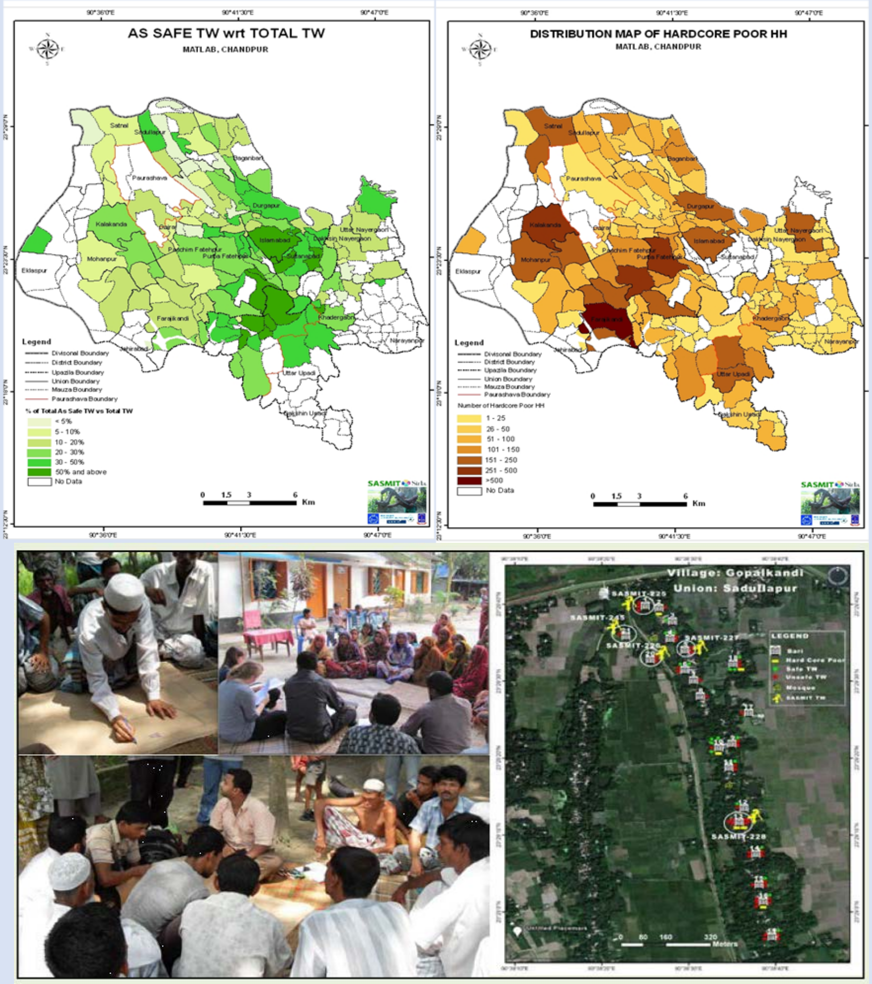


Figure 10. ***(Top)*** **Exisiting safe water options and socioeconomic status.** ***(Bottom left)*** **Village consultation meetings; and** ***(Bottom right)*** **cluster of households (baris) identified for tubewell installation during SASMIT implementation.**

3.3 Baseline water quality of the installed tubewells and monitoring

Sustainability of the provided safe water option needs to be ascertained by conducting a baseline water quality survey of the installed wells and thereafter continued monitoring which gives essential information for the sustainability of the targeted aquifers.

3.4 Capacity building of the local drillers

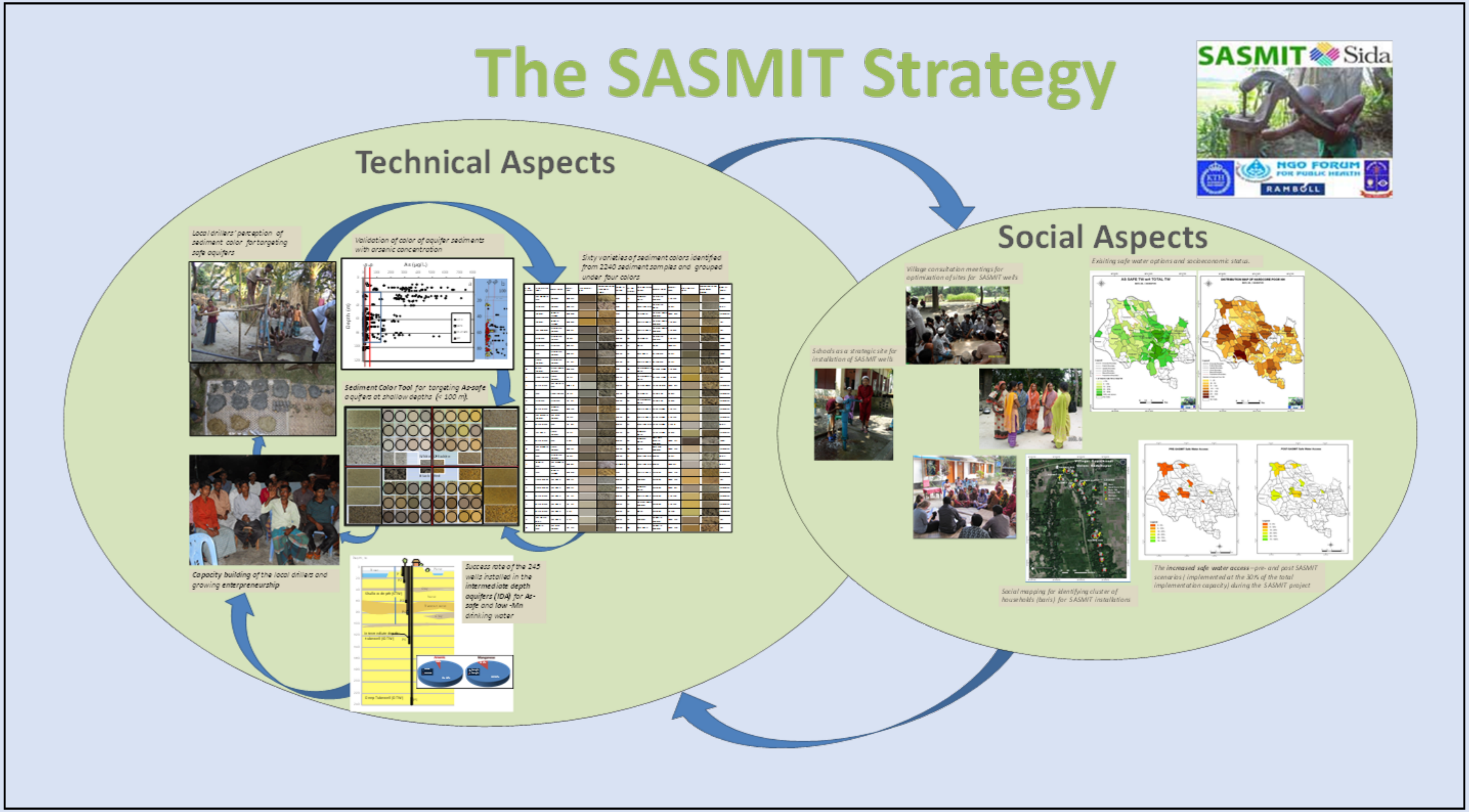
The increased dependence on groundwater for drinking in Bangladesh enhance the importance of the role of the local drillers and As contamination pose a challenge to them for tubewell installation. Considering local drillers as the driving force, their perception on the nature of the sediments (layers) in terms of colour, depth and water quality should be taken as a key consideration during implementation of drinking water supply projects. The close interaction and mutual sharing of knowledge and experience between the local drillers and the project team will contribute to optimize the sites for installation of safe tubewells. As a part of the broader capacity building, involvement of the drillers would also help to develop entrepreneurship in addition to enhance awareness and knowledge for targeting safe aquifers, and thereby to reduce the exposure to As through installation of drinking water wells on a country-wide scale.

4. Compliance with the Policy Regime of Sustainable Arsenic Mitigation in Bangladesh

Lack of scientific evidences and not considering the social aspects with due attention, earlier efforts of arsenic mitigation could not bring any visible improvement and hundreds of alternative options such as ARF, PSF and RWH became non-operational within a short period of installation. The Sector Development Plan (FY 2011-2025) for the Water and Sanitation Sector in Bangladesh (http://www.psu-wss.org/assets/book/sdpeng.pdf) highlighted the dependence on groundwater for water supply in Bangladesh, where arsenic has been identified as one of the three major challenges in Bangladesh rural water supply. As a water quality parameter, arsenic has been given highest priority in the sector considering its health effects.

The Sida-SASMIT protocol offers a unique example for scaling-up the safe water access through:

- Providing safe and affordable access to water for the remaining areas in Bangladesh with high risks of arsenic exposure
    - Red sand aquifers could be a low-cost option which would minimize the exposure of arsenic
    - Intermediate deep aquifers (IDA) could be a feasible option for tackling both arsenic and manganese. Approximately at half of the cost needed for DTW, the IDTWs affordable by the communities would be helpful to enhance the save water coverage faster.
    - Wider applicability of SASMIT strategy through mapping of intermediate deep aquifers as safe water source (envisaged as the research component of SASMIT Phase II) at a country wide scale
    - Incorporate relevant social aspects for implementation of tubewell installation considering the demand and ensuring the optimization of the resources and greater number of beneficiaries
- The recognition of the role of the local drillers as the driving force in tubewell installation is important to regulate the abstraction of water through different wells according to the recently ratified Bangladesh Water Act (2013).
- The Sida-SASMIT project implementation has adequately addressed the local drillers perception and their capacity building which could be helpful for them to participate in decision making process when the end users (villagers) come to the drillers for installing a new tubewell.



The SASMIT Strategy
SASMIT
Sida
NGO FORUM FOR PUBLIC HEALTH
RAMBOLL
Technical Aspects
Local drillers' perception of sediment color for targeting safe aquifers
Validation of color of aquifer sediments with arsenic concentration
Sixty varieties of sediment colors identified from 2240 sediment samples and grouped under four colors
Sediment Color Tool for targeting As-safe aquifers at shallow depths (< 100 m).
Capacity building of the local drillers and growing enterpreneurship
Success rate of the 245 wells installed in the intermediate depth aquifers (IDA) for As-safe and low-Mn drinking water
Social Aspects
Village consultation meetings for optimization of sites for SASMIT wells
Existing safe water options and socioeconomic status.
Schools as a strategic site for installation of SASMIT wells
Social mapping for identifying cluster of households (baris) for SASMIT installations
The increased safe water access - pre- and post SASMIT scenarios (implemented at the 30% of the total implementation capacity) during the SASMIT project

SASMIT

SUSTAINABLE ARSENIC MITIGATION

Community driven initiatives to target arsenic safe groundwater as sustainable mitigation strategy

Sida Contribution: 73000854 (2007-2017)

OBJECTIVES

To develop a sustainable option for safe drinking water for rural and disadvantaged communities through targeting safe aquifers in regions with high arsenic groundwater of geogenic origin by installation of community hand-operated tube wells.

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SASMIT protocol developed through combination of hydrogeological suitability and social aspects would improve the safe water access in the arsenic affected areas. It also ensures the capacity building of the local drillers for targeting safe aquifers for tubewells installation. Social mapping is an important tool used for optimization of sites for ensuring easy access to new safe well installations and greater number of beneficiaries.

Sediment colour tool developed on the basis of the local drillers perception, monitoring of water quality and sediment characterization has been recommended to target safe aquifers for provision of arsenic-safe drinking water. However for compliance to the Water Safety Plan, SASMIT has also pioneered to target the intermediate deep aquifers (IDA) for the installation of intermediate deep tubewells (IDTW) producing arsenic-safe and low-manganese water. Wider applicability of SASMIT strategy through mapping of intermediate aquifers as safe water source is envisaged as the SASMIT Phase II at a country wide scale.

Sustainability of the SASMIT protocol is assessed through long term water quality monitoring (2009-2017) as prioritized in the Sector Development Plan (2011-2025). Collaboration of the Strategic National Partners with the Sida-SASMIT project consortium would facilitate the process of up-scaling the safe water access in Bangladesh.