DeltaMAR
Progress report

June 15, 2019 – September 15, 2019

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1. Introduction

PROGRESS INTEGRATED OUTPUTS

In accordance with the timeline of milestones and deliverables presented in our previous report (DeltaMAR revised workplan, table 5, page 12), we now report on the following:

- *Water quality guidelines:* First starting point available for discussion with stakeholders that regard recommendations or (i) improved recovery, and (ii) water quality (i.e. push-pull results).
- *Governance guidelines:* Draft policy briefs on (i) the role of NGOs in community management of MAR, and (ii) co-production arrangements available for discussion with statkeholders (NGOs, DPHE, local governments).
- *Site selection tool:* Draft maps on (i) drinking water risks and (ii) technical potential of MAR available for discussion.

In this report, you will find an outline for each of these three integrated outputs envisioned by the DeltaMAR project, plus a description of how *stakeholder commitment* will be further strengthened by means of a series of events during which relevant stakeholders will co-create, test and validate said outputs (see Revised work plan, figure 1, page 6). The stakeholder events are scheduled to take place between 5-7 November, 2019 (in order to dovetail with the *Dhaka Water Knowledge Days*).

In our next progress report (due on December 15, 2019), we will present updated versions of the integrated outputs that are based on stakeholder inputs and further research.

PROGRESS RESEARCH

The tables below inform about planned and produced research outputs for each one of the four sub-projects (SPs).

TABLE 1: SP1: FRESH WATER RECOVERY (MD. IMRAN HASAN)

Authors	Title	(Estimated) date of submission	(Target) journal
Rafiq, Muhammad Risalat; **Hasan, Mohammad Imran**, Ahmed, Kazi Matin; Rietveld, L. C.; van Breukelen, Boris M.	Identification of MAR archetypes through statistical and time trend analysis on basis of hydrochemical data from 99 UNICEF MAR sites, SW Bangladesh	December 2019	t.b.d.
Hasan, Mohammad Imran; Rafiq, Muhammad Risalat; Ahmed, Kazi Matin; Rietveld, L. C.; van Breukelen, Boris M.	ASTR modelling of MAR system with variable salinity distribution in SW Bangladesh	January 2020	t.b.d.
Hasan, Mohammad Imran; Ahmed, Kazi Matin; Rietveld, L. C.; van Breukelen, Boris M.; Bakker M.	Assessment of aquifer storage and recovery efficiency in coastal aquifers	February 2020	t.b.d.

TABLE 2: SP2: DRINKING WATER QUALITY (MD. RISALAT RAFIQ)

Authors	Title	(Estimated) date of submission	(Target) journal
Rafiq, Muhammad Risalat; Hasan, Mohammad Imran, Ahmed, Kazi Matin; Rietveld, L. C.; van Breukelen, Boris M.	Identification of MAR archetypes through statistical and time trend analysis on basis of hydrochemical data from 99 UNICEF MAR sites, SW Bangladesh	December 2019	t.b.d.
Rafiq, Muhammad Risalat; Ahmed, Kazi Matin; van Breukelen, Boris M.	Monitoring and mass balance modelling of Hydrogeochemical processes governing MAR water quality in SW Bangladesh	November 2019	t.b.d.
Rafiq, Muhammad Risalat; Ahmed, Kazi Matin; van Breukelen, Boris M.	Hydrogeochemical processes (im)mobilizing trace metals in MAR for drinking water provision: a case study in SW Bangladesh	November 2019	t.b.d.

TABLE 3: SP3: MAR GOVERNANCE (MD. BADRUL HASAN)

Authors	**Title**	**(Estimated) date of submission**	**(Target) journal**
Hasan, M.B., Driessen, P., Zoomers, A., van Laerhoven, F.	How can NGOs support collective action among the users of rural drinking water systems? A case study of Managed Aquifer Recharge (MAR) systems in Bangladesh.	Revisions resubmitted on: August 4, 2019	World Development
Hasan, M.B., Driessen, P., Zoomers, A., Majumder, S., van Laerhoven, F.	Collective action and collaboration in the context of rural drinking water systems governance: A comparative case study of Pond Sand Filter (PSF) systems in Bangladesh.	November, 2019	International Journal of the Commons
Hasan, M.B., Driessen, P., Zoomers, A., Majumder, S., van Laerhoven, F.	Factors affecting the consumption of water from a newly introduced drinking water system: The case of Managed Aquifer Recharge system (MARs) in Bangladesh.	November, 2019	International Journal of Water Resources Development
Hasan, M.B., Driessen, P., Zoomers, A., Majumder, S., van Rijnsoever, F., van Laerhoven, F.	Elucidating consumer drinking water preferences. A choice experiment in Southwestern Bangladesh	December, 2019	Journal of environmental management; Water Resources Research

TABLE 4: SP4: A PRIORI ASSESSMENT OF MAR (FLORIS NAUS)

Authors	Title	(Estimated) date of submission	(Target) journal
Naus, F., Schot, P., Groen, K., Ahmed, K.M., Griffioen, J.	Groundwater salinity variation in Upazila Assasuni (southwestern Bangladesh), as steered by surface clay layer thickness, relative elevation and present-day land use	Published on: March 14, 2019	Hydrology and Earth System Sciences
Naus, F., Schot, P., Ahmed, K.M., Griffioen, J.	Influence of landscape features on the large shallow groundwater salinity variation in southwestern Bangladesh	Revisions resubmitted on:	Journal of Hydrology
Naus, F., Burer, K., van Laerhoven, F., Griffioen, J., Achmed, K.M., Schot, P.	Behavioural barriers and facilitators for switching away from unsafe drinking water options in southwestern Bangladesh.	Submitted on: September 2, 2019	International Journal of Water Resources Development

As observed by the reviewers during the mid-term review, the research of sub-projects 1-3 is behind on schedule. The researchers are expected to be able to continue contributing to the development of the respective integrated outputs in a timely manner. However, they will not finish their dissertations on time.

For Imran Hasan (SP1) it is unlikely that he will earn his PhD degree. This impression is shared by his supervisors (i.e. Prof. dr. Mark Bakker, Prof dr Kazi Matin Ahmed) and the TU Delft graduate board. As he stays committed to contributing to the water quality guidelines as scheduled, this is not expected to jeopardize the development of the integrated outputs.

Floris Naus (SP4) is expected to finish his research and reporting before the end of his contract (31 September, 2019) and is therefore likely to be able to defend his dissertation in the Spring of 2020. We expect Risalat Rafiq and Badrul Hasan to finalize their dissertation within 3-6 months after the termination of their contracts on 31 December, 2019.

FIGURE 1: From left to right: Prof. Dr. Jasper Griffioen, Dr. Boris van Breukelen, Floris Naus (SP4), Risalat Rafiq (SP2), Prof. Dr. Shantanu Majumder, Badrul Hasan (SP3) and Imran Hasan (SP1).

2. Background: Drinking water problems and MAR as a solution

DRINKING WATER PROBLEMS IN SOUTHWESTERN BANGLADESH

Coastal regions and deltas are among the most heavily populated areas in the world and their water resources are experiencing increasing stress. One of the largest and most densely populated deltas is the Ganges–Brahmaputra–Meghna (GBM) delta. Here, manifestations of this stress are arsenic contamination of shallow groundwater resources, severe pollution of surface water resources, and limited availability of the meteorological water resources, due to pronounced seasonality. In the coastal southwestern region of Bangladesh, available drinking water is further limited by the salinity of the surface- and groundwater. The groundwater salinity variation in the coastal area is large and, therefore, hard to predict. The stress of saline water intrusion on the groundwater is increasing due to natural changes in the form of natural land subsidence and sea level rise, and due to anthropogenic changes in the form of man-induced land subsidence, decreased Ganges outflow and increased groundwater extraction.

FIGURE 2: PUMP MARKED AS UNSAFE DUE TO ARSENIC

MAR AND ITS ADVANTAGES

In a MAR system, water is collected from ponds and rooftop rainwater. After passing through a sand filter, the water is infiltrated into the aquifer to create a bubble of fresh water. Users can subsequently abstract the water using standard hand tube-wells (see figure 1).

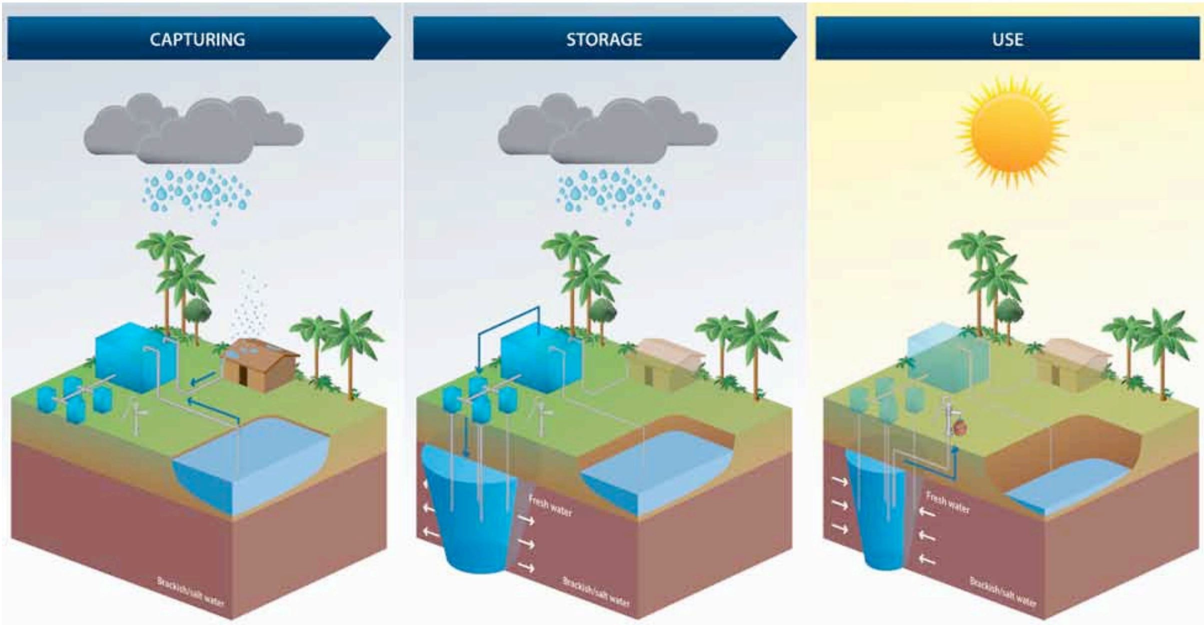


FIGURE 3: HOW MAR WORKS (SOURCE: TOLK ET AL. 2014)

Compared to other major drinking water systems in the area, MAR is contamination free, cyclone proof, and it is reliable as it provides water in sufficient quantities of drinking water throughout the year. In terms of installation costs, MAR is considerably less expensive than most of the available alternatives. It is also relatively easy to operate. In sum, MAR advantages include:

- Improved year-round water availability
- Improved water quality and reduced health risks
- Suitable for local-scale application
- Cost-effectiveness
- Resilience to disasters

FIGURE 4: PART OF THE DELTAMAR PROJECT TEAM AND LOCAL MAR USERS

3. Guidelines for water quality of MAR systems in Southwestern Bangladesh (draft)

DEFINING MAR IN BANGLADESH

This document provides general guidelines and recommendations with the aim to improve the water quality of the current and potential future MAR systems in coastal SW Bangladesh.

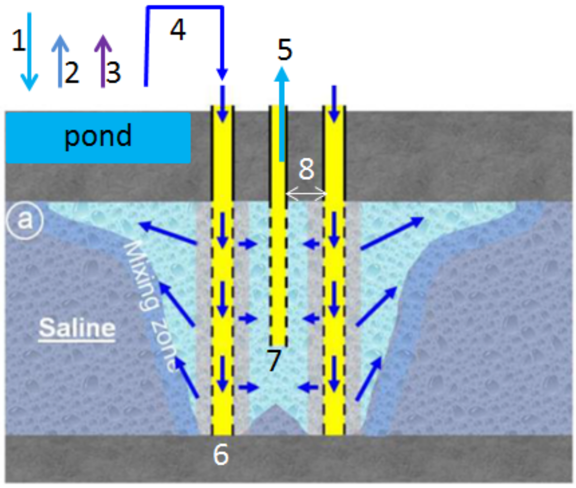


FIGURE 5: DIAGRAM OF MAR SYSTEMS AS IMPLEMENTED IN SOUTHWESTERN BANGLADESH

The diagram in figure 5 depicts the following. The maximum amount of infiltration water available for MAR (#4) depends on the yearly amount of rainfall (#1) minus the yearly amount of open water evaporation (#2) multiplied with the surface area of the pond. Other water uses like water fetching (#3) are subtracted.

Another design parameter is the amount of water abstracted by the MAR system (#5). Infiltration (#4) should (largely) exceed abstraction (#5) at least on yearly basis to prevent salinization of the fresh water bubble (cyan) by mixing with saline water (purple). Abstraction (#5) also aids in flushing of the core of the bubble and water quality improvements. High abstraction rates together with even higher infiltration rates are therefore expected to lead to best water quality in shortest duration.

Given the projected infiltration and abstraction rates and properties of the aquifer (permeability, salinity, thickness) the optimal lengths (and number) of the infiltration wells (#6) and the optimal length of the abstraction well (#7) placed at the top of the aquifer, as well as their horizontal spacing (#8) can be calculated/estimated.

WHAT ARE THE CONDITIONS FOR WATER QUALITY IMPROVEMENT OF MAR?

Based on our research we have identified the following parameters with the potential to improve MAR water quality.

TABLE 5: CONDITIONS FOR IMPROVED MAR WATER QUALITY

Condition	Description	Integration with other SPs
Clean pond water	*Site selection*: Ensure that the pond water quality is not compromised by pollution sources like discharge of latrines, dirty water, and litter. *MAR governance*: Can the pond be kept clean or cleaned up when used for MAR? The higher the pond water quality, the higher the MAR WQ.	SP4: a priori assessment of MAR SP3: MAR governance
Sufficient supply of pond water	*Site selection:* The more pond water is available for MAR (thus the larger the pond's surface area), the more water can potentially be infiltrated, the larger the stored fresh water bubble becomes, and the less MAR water in the core at the abstraction well may mix with the native groundwater being of poor WQ (brackish; frequently high Fe, Mn, As).	SP4: a priori assessment of MAR
Large(r) rates of infiltration	*Site selection:* See above. The more pond water is available for MAR (thus the larger the pond's surface area), the more water can potentially be infiltrated *Fresh water recovery:* The capacity of the infiltration wells is sufficiently high and *MAR governance*: The human capacity is sufficiently high (i.e. the number of hours care-taker(s) can spend each day on letting the MAR system infiltrate).	SP4: a priori assessment of MAR SP1: fresh water recovery SP3: MAR governance
Avoid locations with high levels of geogenic elements (Fe, As, Mn) in groundwater	*Site selection:* Select locations where the native groundwater is low in the geogenic elements Fe, Mn, and especially As. In case some mixing of infiltration water and native groundwater occurs, the MAR water becomes (much) less deteriorated in water quality.	SP4: a priori assessment of MAR

	Fresh water recovery: In case background levels are high, high infiltration and abstraction rates are essential.	SP1: fresh water recovery
Adjust the lengths of the infiltration wells to projected rates of infiltration	*Fresh water recovery:* We found that in case the target infiltration rate is too low compared to the (default) lengths of the infiltration wells, relatively small diameter freshwater "bubbles" are formed, which are more vulnerable for mixing with native groundwater. With shorter infiltration wells, the radius of the bubble will be larger, probably leading to less mixing with native groundwater. Information on infiltration capacity (SP1) is essential for meeting this water quality conditions.	SP1: fresh water recovery
Make the abstraction well shorter than the infiltration wells and place it at the top of the aquifer	*Fresh water recovery:* This finding of our research led to proposing an adjustment in the design of the pilot MARs: In contrast to the current design, the abstraction well should not be centred in the middle of the bubble.	SP1: fresh water recovery
Increase the rate of "flushing" between infiltration and abstraction wells	Our research (SP2) shows that oxygen in pond water has positive effects on the removal of Fe, Mn, and As. Oxygen is however rapidly consumed in the MAR bubble, while (longer) anaerobic conditions may lead to elevated Fe/Mn/As levels as organic matter from the pond may dissolve iron-oxides sorbing Mn and As. Flushing of the core of the fresh water bubble is enhanced when infiltration and particularly abstraction rates are higher. Water quality in "failed" MAR systems may have remained poor because of limited abstraction (as the water quality was poor). The MAR systems may thus need a start-up time or even a development time where the MAR water is deliberately abstracted at rates (almost) equal to infiltration rates to speed up the oxygenation of the core of the fresh water bubble. To consider: • Inject at start up (chemical) oxidants to oxidize the core of the fresh water bubble? • Perform even subsurface iron-removal (SIR) in the abstraction well as a more effective way to oxygenate the core	

DESIGN CRITERIA FOR IMPROVED MAR WATER QUALITY:

A next step – that is yet to be completed - is to formulate design criteria that are in line with the conditions for improved MAR water quality listed in table 5, above. These design criteria are to serve as a set of steps that need to be taken when selecting a site and building a MAR, in order to produce good quality water.

TABLE 6: DESIGN CRITERIA FOR IMPROVED MAR WATER QUALITY

Design criteria	Pending – tasks to be executed	Integration with other SPs
1. Determine water availability for MAR		
Calculate water balance of the pond	Explain how the water balance can be calculated to determine how much water is max available for MAR. Provide as example the calculations for the present 99 sites.	SP1: fresh water recovery
Determine expected MAR water use and set upper limit on infiltration rate	Provide a rule of thumb or an educated guess on the max amount of MAR water than can be expected to be abstracted based on population density around ponds and willingness to use MAR. We expect that the research within SP3 (MAR governance) on drinking water system preferences and willingness-to-use will provide valuable insights with regard to this step. It is essential to have an idea on how much water could be asked for by the local community. When abstraction is lower than what maximally can be infiltrated there is no need to infiltrate more. However, in this case water quality would be less than it could be. Less use or abstraction means less flushing, meaning that it would take longer for good water quality to become available (see table 5: condition *Increase the rate of "flushing" between infiltration and abstraction wells*)	SP3: MAR governance
Establish infiltration capacity	Based on the calculated water balance and the expected MAR use, the infiltration and abstraction capacity can be calculated, as well as the minimum number of wells and their lengths. The details for developing this particular step will come from the research performed in SP1	SP1: fresh water recovery

2. Optimize recovery efficiency		
Optimize well lengths	With input from SP1 we will be able to provide simple equations and formulate the assumptions to estimate recovery efficiency. Note that although these recovery efficiency values are not directly applicable to the MAR systems in the UNICEF pilot (but apply only for classical MAR systems), we expect them to give an idea of how recovery efficiency could be improved by optimizing the infiltration and abstraction well lengths given a certain pond and native aquifer salinity, aquifer permeability, and infiltration (and abstraction) rate. Eventually we expect to be able to update the above with insights gained from the SEAWAT model (SP1 & SP2). To consider: • Optimize the horizontal spacing of infiltration and abstraction wells. • Simple equations to calculate travel times from infiltration to abstraction depending on abstraction rate.	SP1: fresh water recovery
3. Determine geogenic elements and travel times		
Determine expected mixing of geogenic elements in MAR water	Based on the previous, explain simple equations to calculate water quality deterioration by mixing of geogenic elements.	n.a.
Establish travel time	Formulate simple means for travel time calculation as indicative measure of pathogen removal.	SP1: fresh water recovery
4. Anlyze biogeochemic processes		
Biogeochemical processes in MAR bubble	Explain expected biogeochemical processes in the fresh water bubble and how they improve or deteriorate the water quality in relation to operational/design conditions.	n.a.

STAKEHOLDER WORKSHOP OBJECTIVES

STAKEHOLDER WORKSHOP: WATER QUALITY GUIDELINES	
Objective	1. Discuss the *Conditions for improved MAR water quality* listed above (table 5), with water professionals with the purpose to validate and adapt them where and when necessary. 2. Discuss the *Design criteria for improved MAR water quality* listed above (table 6) with water professionals with the purpose to steer the further development of the preliminary criteria 3. Provide training to water professionals on ways to augment water quality in MAR.
Participants	Department of Public Health and Engineering (DPHE); Bangladesh Water Development Board (BWDB); UNICEF Bangladesh
Format	Break-out groups; World Café, Training (capacity building)

FIGURE 6: ALMOST HALF OF THE POPULATION OF BANGLADESH HAS NO ACCESS TO GOOD QUALITY DRINKING WATER

FIGURE 7: DISCUSSION WITH NGO REPRESENTATIVES

4. Guidelines for the governance of MAR systems in Southwestern Bangladesh (draft)

DEFINING GOVERNANCE

A MAR system can be seen as a *socio-technological system*. In these guidelines, we consider a MAR system as (i) the actual physical infrastructure (i.e., the *resource system*) that produces (ii) drinking water (the *resource units*), plus (iii) the set of end-users that together with others (i.e., the *actors*) engage in the (iv) *governance* of the system (figure 2).

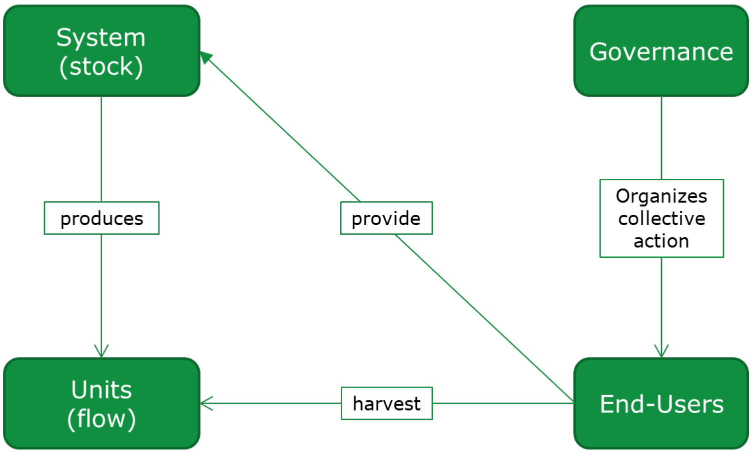


FIGURE 8: DRINKING WATER FROM A SYSTEM ANALYTICAL PERSPECTIVE

Individual users face a *provision dilemma*, as costs related to the investment in the operation and maintenance (i.e. effort or resources) are private costs, whereas the benefits of the joint investment (e.g., a well-working MAR infrastructure) are shared among the group of users of that system. As a result, individual users are tempted to under-invest in operation and maintenance.

Appropriation dilemmas occur because the benefits related to the extraction of water are private benefits, whereas the costs of this extraction (e.g., a decreasing production capacity of MAR) are shared among the whole group of end users. As a result, individual users are tempted to extract too much water, such that the combined extraction exceeds the depletion rate.

By governance we mean the range of political, organizational, and administrative processes through which government and non-government stakeholders articulate their interests, exercise their legal rights, take decisions, meet their obligations, and mediate their differences. Whereas *management* refers to the organization of the operation and maintenance of MAR, *governance* refers to the broader set of actors that can, could or should play a role in determining the parameters for management.

The primary objective of good governance of MAR is:

(i) to counter the tendency of individuals to under-invest in operation and maintenance, and;
(ii) to counter the tendency of individuals to over-exploit the pool of MAR water.

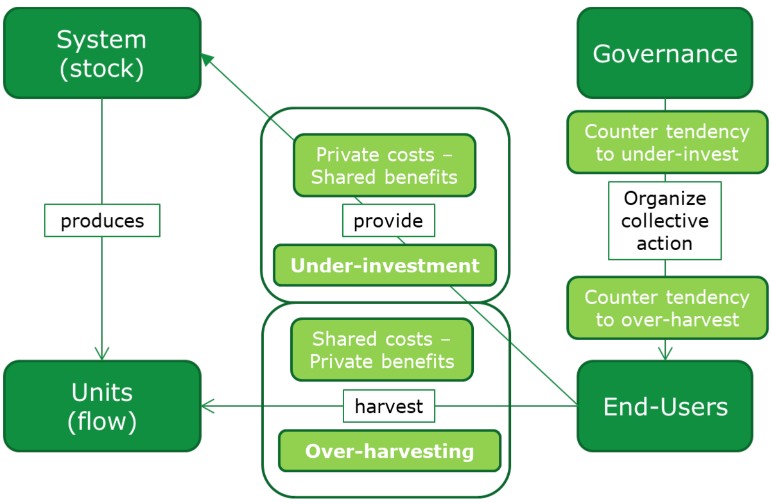


FIGURE 9: A DRINKING WATER TRAGEDY OF THE COMMONS

As is the case with many rural drinking water systems in Bangladesh, the operation and maintenance of MAR is to rely to a large extent on a *community management service model*. Bangladesh's National Policy for Safe Water Supply and Sanitation (1998) explicitly calls for community participation in the governance of drinking water systems.

Hutchings et al. (2015, p.153)) state that "*for too long the assumption that consumers can run their own water supply has led to situations of communities unable to cope with management of their schemes, poor maintenance, lack of financing, breakdowns, poor water quality, lack of support and, ultimately, an unreliable and disrupted supply of water to households*." Harvey and Reed (2007, p365)) hold that *"[i]f community management systems are to be sustainable, they require ongoing support*." In other words, pure self-governance models depending on sustainable, ongoing collective action among the end-users of MAR may well be a dead-end road. Support is needed. Who can give this support? What should the support consist of?

We propose a set of guidelines for what we call Community Management Plus^{+} - i.e. a form of community management embedded in an appropriate support structure with roles for NGOs, DPHE and authorities. In what follows, we will address the following questions:

- What are the requirements for community management?
- How can NGOs help communities meet these requirements?
- How can DPHE assist communities in operating and maintaining their MAR?

WHAT ARE THE REQUIREMENTS FOR COMMUNITY MANAGEMENT?

From our own and from earlier research we have learned that the following appears to increase the likelihood of success of community management service models for a drinking water system like MAR. We differentiate between requirements for day-to-day and for durable collective action, respectively.

FIGURE 10: DISCUSSION WITH COMMUNITY LEADERS

TABLE 7: COMMUNITY REQUIREMENTS FOR COLLECTIVE ACTION

Day-to-day collective action
MAR users have an arrangement of regular meetings in place to discuss the issues related to the operation and maintenance of the MAR system
There is a clear arrangement regarding who has access to the MAR site
There are rules in place regarding who can extract how much water, and when
There is a mechanism in place to monitor MAR use and rule compliance
There is a mechanism in place to punish rule breakers
There is a mechanism in place to hold monitor/s accountable to the MAR users.
There is a low-cost system in place to resolve conflict between users
Durable collective action
All resource users understand the rules and policies guiding the management MAR
General users – not only committee members – have the opportunity to participate at all levels of the decision-making process regarding MAR governance
MAR users have the technical and managerial skill and knowledge required to manage and operate the system
There is a system in place to fairly allocate the benefits (e.g. water) and burdens (e.g. costs) associated with the resource among the users
The users have sufficient financial means to pay for the operation and maintenance of the MAR system
The users are willing to pay for the operation and maintenance of the MAR system
All the users are aware of MAR, its operation and maintenance rules and the activities of the committee that is responsible for the management
Leadership is closely familiar with the changing external governance environment, has frequent interactions with all users and regular contact with local traditional leaders
The autonomy of users to manage their MAR system is not significantly undermined by any external authority

HOW CAN NGOS HELP COMMUNITIES MEET THESE REQUIREMENTS?

Evidence from our own and from earlier research suggests that the users of a drinking water system like MAR often face collective action dilemmas that are difficult for them to overcome, independently. In too many cases still, this leads to the abandonment of drinking water systems. We see that NGOs often step in or are called upon to support the development and consolidation of collective action (or, organization) among the group of users of a drinking water system. How can NGOs best support community management? How can they best help communities to meet the criteria listed in chapter 2, above?

In the table below, we list activities that NGOs have reported to us to engage in with MAR users to (implicitly or explicitly) address the design principles for successful community management of MAR.

TABLE 8: NGO ACTIVITIES TARGETING COMMUNITY REQUIREMENTS FOR COLLECTIVE ACTION

Community requirements for collective action	**Reported NGO activities targeting community requirements**
Day-to-day collective action	
MAR users have an arrangement of regular meetings in place to discuss the issues related to the operation and maintenance of the MAR system	Convening monthly meetings with the user group; Providing informal guidelines for the continuation of monthly meetings
There is a clear arrangement regarding who has access to the MAR site	Conducting household surveys to assess (i) willingness to join and (ii) household drinking water needs; Selecting 50 to 60 prospective households based on the outcome of the survey
There are rules in place regarding who can extract how much water, and when	Providing formal (written) and informal (verbal) instructions on MAR operation and maintenance
There is a mechanism in place to monitor MAR use and rule compliance	Setting up and running a monitoring system with users, and gradually handing it over to the community
There is a mechanism in place to punish rule breakers	*Not found*
There is a mechanism in place to hold monitor/s accountable to the MAR users.	*Not found*
There is a low-cost system in place to resolve conflict between users	*Not found*

Durable collective action	
All resource users understand the rules and policies guiding the management MAR	Conducting monthly meetings with user groups; organizing workshops with the user committee chairperson
General users – not only committee members – have the opportunity to participate at all levels of the decision-making process regarding MAR governance	Providing informal advice to the user committees; motivating user committees to include the general users in decision-making processes
MAR users have the technical and managerial skill and knowledge required to manage and operate the system	Training the caretaker; providing basic tools
There is a system in place to fairly allocate the benefits (e.g. water) and burdens (e.g. costs) associated with the resource among the users	*Not found*
The users have sufficient financial means to pay for the operation and maintenance of the MAR system	Assisting the user group in collecting community contributions (to cover operational costs and set up emergency funds); setting up a monthly payment structure; Providing material support
The users are willing to pay for the operation and maintenance of the MAR system	Motivating users through monthly meetings with them; informal household visits
All the users are aware of MAR, its operation and maintenance rules and the activities of the committee that is responsible for the management	Meetings at the Upazila (sub-district) premises involving local administrator, local government representatives, DPHE officials and local people; monthly meetings (i.e., tea stall meetings, yard meetings, mosque meetings) with the user group; Bi-weekly meetings with female users; bi-weekly sessions with teachers and students at educators; regular door-to-door visit to households; Handing out leaflets to local people; banners on MAR in the villages
Leadership is closely familiar with the changing external governance environment, has frequent interactions with all users and regular contact with local traditional leaders	Training the chairperson of the user committee; organizing workshops with committee chairpersons; connecting the user committee chairperson with local governments and agencies
The autonomy of users to manage their MAR system is not significantly undermined by any external authority	Advocacy and lobbying with external actors (i.e. Dhaka University MAR office, DPHE, local administration, and local government representatives, etc.)

In the figure below, we show the results of a comparison between 11 MAR sites where NGOs supported and prepared communities to operate their MAR system. We observe variation in the apparent effectiveness of activities, and in the extent to which NGOs actually target the requirements.

FIGURE 11: NGO SUPPORT EFFECTIVENESS

Overall, our research suggests that NGO activities seem based on applying standard approaches to training and awareness raising, and less on empowering users to craft their own solutions.

HOW CAN DPHE ASSIST COMMUNITIES IN OPERATING AND MAINTAINING THEIR MAR?

Evidence from our own and from earlier research suggests that the users of a drinking water system like MAR are less likely to abandon their drinking water system when there is a good relation with the Department of Public Health and Engineering, DPHE. To give an example, we compared 30 rural drinking water systems in the southwestern coastal region of Bangladesh. Out of the 14 cases with strong internal collaboration, 11 (79%) reported to find the collaboration with DPHE helpful and meaningful. In contrast, out of the 16 cases with weak internal collaboration, only 5 (31%) reported to be satisfied with DPHE support.

How can DPHE officials best support community management? How can they best help communities to meet the criteria listed in chapter 2, above? Based on our research we suspect that the following aspects are crucial:

TABLE 9: REQUIREMENTS FOR COLLABORATION BETWEEN DPHE AND COMMUNITIES

Relationship between user group and public agency	
Trust	Mutual trust between DPHE and MAR users regarding the fulfilment of tasks and responsibilities
Communication	MAR users and DPHE communicate regularly
Institutional arrangements	
Inclusive decision-making	DPHE takes the opinion and interests of the user group into account
Clarity on tasks and responsibilities	The respective tasks and responsibilities of our user group and DPHE are clear and well-understood
transparency	Decision-making and operation of DPHE with regard to MAR is transparent

STAKEHOLDER WORKSHOP OBJECTIVES

STAKEHOLDER WORKSHOP: MAR USERS	
Objective	Discuss the community requirements for collective action listed above, with the purpose to validate and adapt them where and when necessary.
Participants	Users of MAR systems that have been handed over to the community for some time now (women, men, committee members, regular users)
Format	Break-out groups; World Café
	Training / Capacity building with MAR users

STAKEHOLDER WORKSHOP: NGOs	
Objective	Discuss what types of activities could be used to target the development of the community requirements for collective action; discuss if and/or how NGO support can target the empowerment of MAR users such that they can take charge of crafting their own tailor-made solutions.

Participants	NGOs (Shushilon, LoCOS, AOSED, LDARS, Jagroto Jubo Shogho)JJS), Mukti Foundation, Gono Milon Foundation)
Format	World Café, *pre-mortem* exercise, break-out groups Training / capacity building of NGOs

STAKEHOLDER WORKSHOP: DPHE OFFICIALS	
Objective	Discuss how a good working relation between DPHE officials and MAR users can be established and maintained
Participants	DPHE representatives
Format	Open discussion

5. Site selection tool (draft)

DEFINING SITE SELECTION OBJECTIVES

The aim of the site selection tool is to help identify the suitability of a specific predetermined location for the installation of a MAR system. Alternatively, the tool may be used on a more regional scale to indicate where to find promising locations.

It is important to be aware from the start that the reliability of the tool depends heavily on the amount of data present in a particular area. Since both geology (sand and clay layers) as well as groundwater quality (eg. salinity and arsenic concentrations) in Southwestern Bangladesh show large variations at short distances this may influence the reliability of the produced (interpolated) maps.

Due to inaccuracies at the local level (as mentioned above), the tool is best suited for application at the regional scale. At the local scale the amount of nearby data points needs to be specifically taken into consideration to get an impression of the perceived accuracy of the indicated MAR suitability.

The intended users of the site selection tool are primarily Bangladeshi government agencies responsible for drinking water provision, such as the Department of Public Health and Engineering (DPHE) and the Bangladesh Water Development Board (BWDB).

HOW IT WOULD WORK

Unlike the water quality guidelines (chapter 3) and the MAR governance guidelines (chapter 4), the site selection tool doesn't take the form of a written document, the draft of which can be readily inserted into the current report.

The DeltaMAR site selection tool basically consists of the following two components:

- A database (Excel), based on the research in SP1-4 with information on groundwater wells, their location, filter depth, groundwater quality, etc.
- A map viewer (ArcGIS, or a non-commercial free-ware equivalent) which enables to display the spatial distribution of the data from the database (e.g. as interpolated maps using Kriging)

Establishing potential demand for MAR

MAR is a viable drinking water solution, particularly in areas without deep and/or shallow groundwater availability. Also, MAR is a solution in areas where access to drinking water is jeopardized by arsenic and/or salinity. The map viewer allows for identifying broad-stroke areas where MAR would solve drinking water problems related with the unavailability of groundwater sources, and/or arsenic and salinity limitations. Figures 12 and 13 give an illustration of the kinds of maps that can be produced.

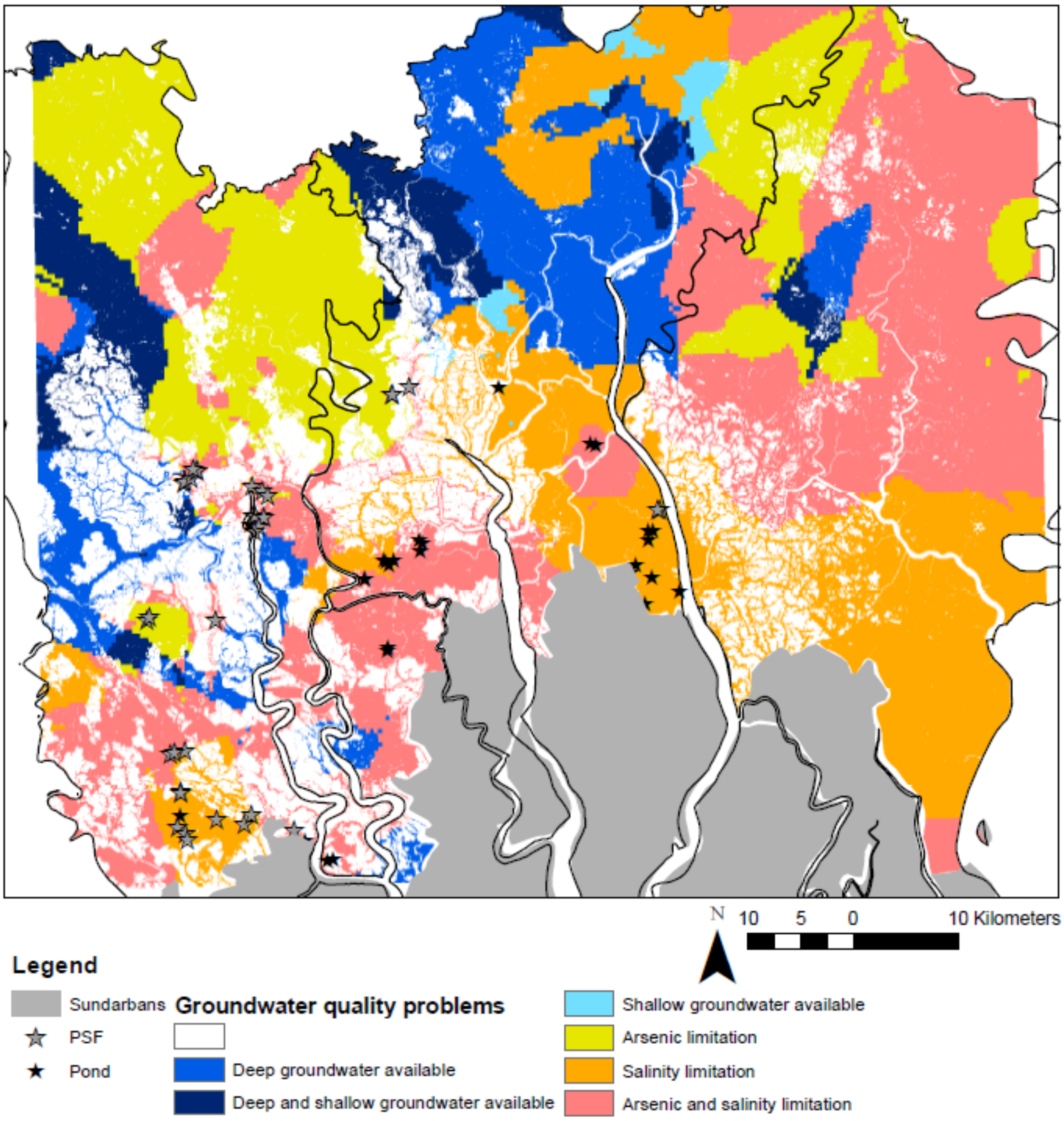


FIGURE 12: EXAMPLE 1 – REGIONAL POTENTIAL DEMAND FOR MAR DEPENDING ON GROUNDWATER (UN)AVAILABILITY AND ARSENIC & SALINITY LIMITATIONS.

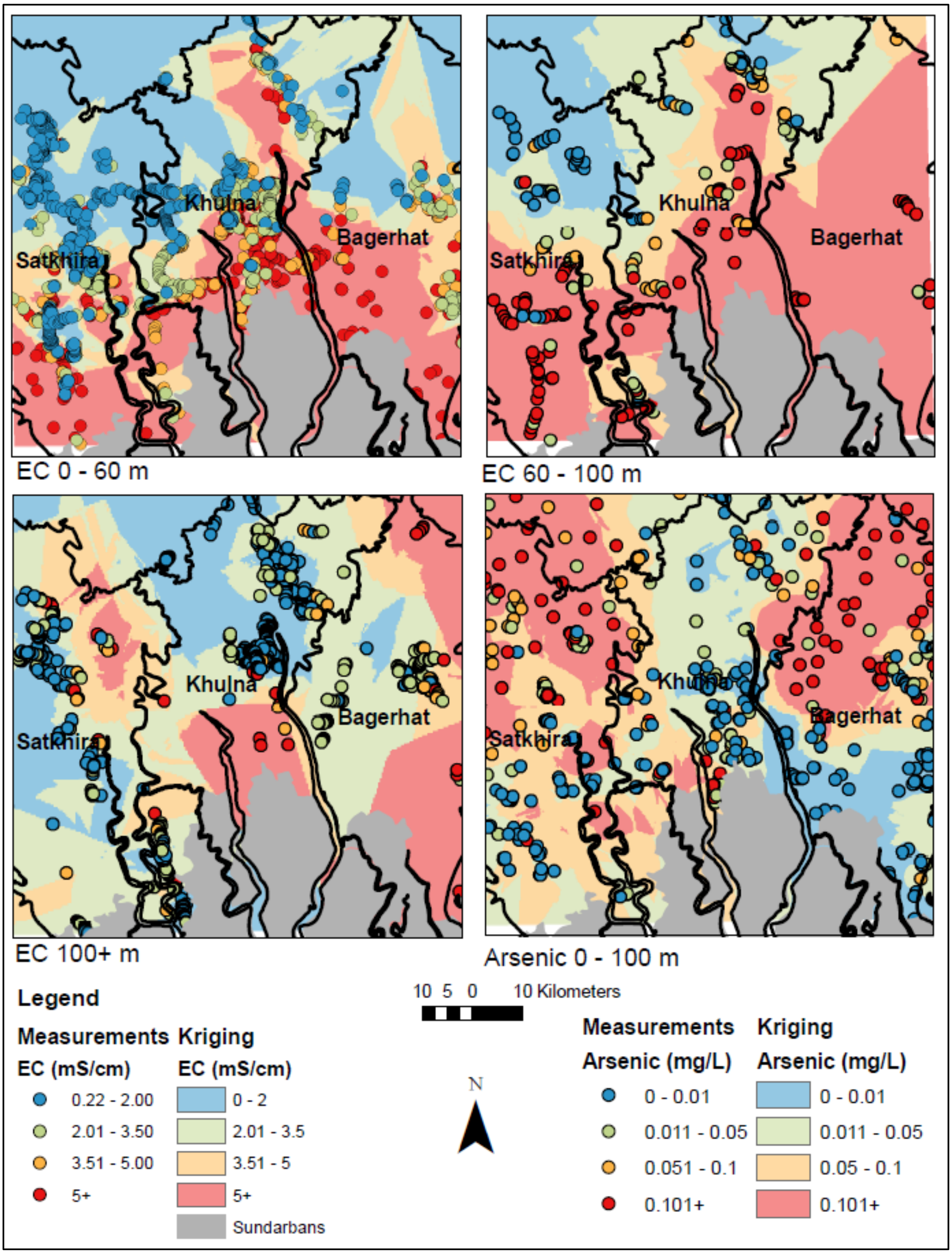


FIGURE 13: EXAMPLE OF ARCGIS MAP VIEWER RESULTS USING A SELECTION OF VARIABLES (EC AND ARSENIC) ACCORDING TO CERTAIN CONSTRAINTS (DEPTH INTERVAL)

Establishing expected technical performance of MAR

Apart from identifying the broad-stroke areas where MAR is expected to be in demand, the site selection tool will also attempt to establish the expected technical performance of MAR in a given region. This is done by means of the following flow-chart (figure 14).

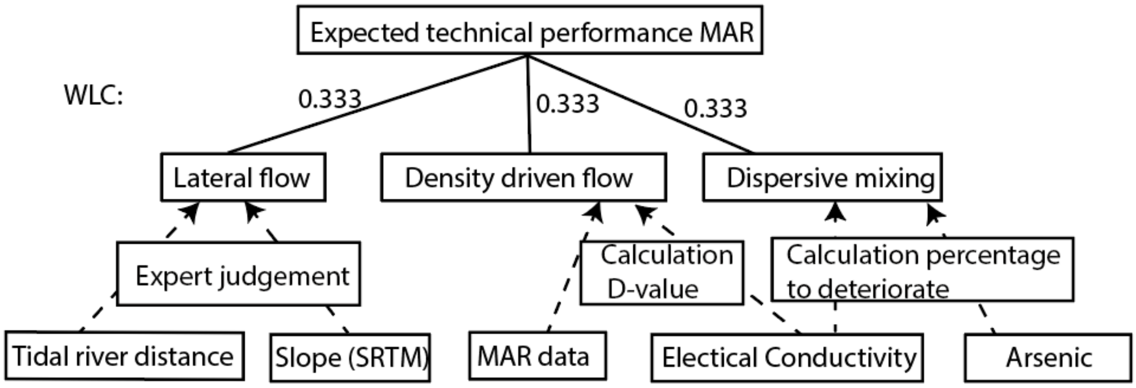


FIGURE 14: DETERMINING EXPECTED TECHNICAL PERFORMANCE OF MAR

The map viewer allows for broad stroke identifying identification of the extent to which MAR can be expected to perform well, based on criteria related with lateral flow, density driven flow, and dispersive mixing. Figure 15 provides an illustration – the greener the area, the more likely it is that MAR will work optimally.

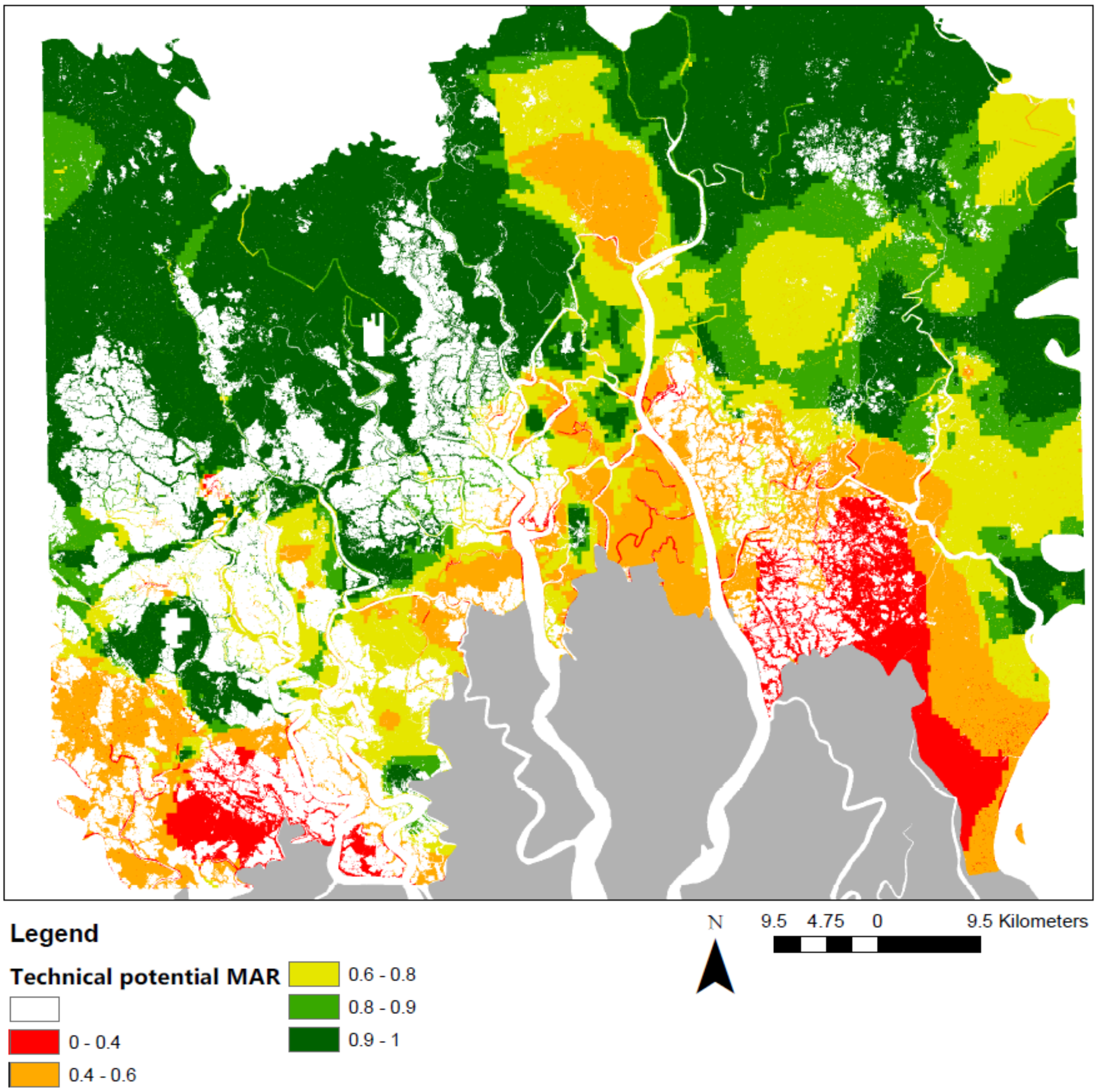


FIGURE 15: SPATIAL DISTRIBUTION OF THE EXPECTED TECHNICAL PERFORMANCE OF MAR

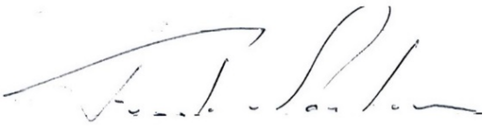
Ultimately, by overlaying both types of maps users and authorities will be able to allocate MAR sites according to expected demand and technical performance criteria.

STAKEHOLDER WORKSHOP OBJECTIVES

	STAKEHOLDER WORKSHOP: SITE SELECTION TOOL
Objective	Explain how the site selection tool works; Discuss the interpretation and accuracy of the resulting maps; Discuss possible improvements
Participants	DPHE representatives; BWDB representatives; UNICEF Bangladesh; NGOs; End-users
Format	Open discussion

Signatures

This progress report is the result of multiple sessions – both plenary and smaller sized meetings. By signing this report, all core project team members take full responsibility for the content.



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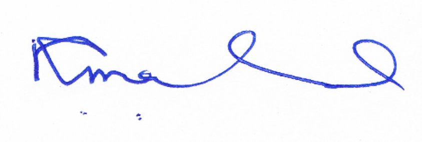

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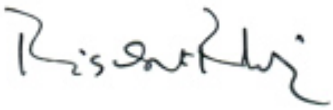

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