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Using community data to improve rural water infrastructure in India

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India continues to struggle with the combined effects of water stress alongside poor access to water and sanitation. However, data-driven infrastructure planning is helping to bring a more integrated, sustainable approach to water management and the provision of water, sanitation and hygiene in rural areas. Working with non-governmental organisations in Chhattisgarh and Madhya Pradesh, a project was undertaken to introduce consistent digital data collection, analysis and sharing processes for water resources and water demand data. Key outputs from the project included a toolkit and mobile application, the wider adoption of which could transform rural water access.

1. Introduction

According to UNESCO, global water demand is rising by approximately 1% per year and is expected to continue to rise at a similar rate until at least 2050. Approximately 2 billion people worldwide currently live in countries experiencing water stress, while 4 billion people experience water scarcity during at least one month a year. Concurrently, three out of ten people around the world continue to lack access to safe water supply services, while six out of ten lack access to improved sanitation (UNESCO, 2019). Efforts to address pressures on water resources and to reduce water scarcity intersect with efforts to tackle low levels of access to safe water and sanitation.

Integrated water resources management (IWRM) forms a critical part of the global development agenda. The United Nations Environment Programme (UNEP) believes that IWRM has a significant role to play in the process of sustainable development through promoting the environmental sustainability of the water resources base, social equity of water allocations and economic efficiency of water resources use (UNEP, 2020).

UN Sustainable Development Goal indicator 6.5.1, ‘degree of integrated water resources management implementation’, is a global indicator which provides a qualitative national-level comparison of four key components of IWRM: an enabling environment, institutions and participation, management instruments and financing. Many countries, including India, have yet to report against this indicator at a national level (Figure 1), and investigations in the early stages of the project found little evidence to suggest that the indicator is driving better access to safe water and sanitation in countries where existing access rates remain low (Hay *et al.*, 2018; Shah, 2007).

Throughout both the global north and south, there are many examples of countries implementing IWRM frameworks, although the south is underrepresented. Implementation is often most successful where the water sector is highly formalised, such as in the European Union (Rahaman *et al.*, 2004). On the other hand, efforts to implement IWRM-type reforms on the African continent have typically had little relevance for informal water abstractors, and implementors have frequently ignored community-level customs and institutions for water resource allocation.

In addition, the concept of a river basin as a unit of analysis and management may be less useful in low-income countries, where groundwater and rainwater capture are the most important sources for local water supply. Efforts to introduce IWRM here have, at worst, distracted from the pressing developmental need to expand access to safe water and sanitation (Shah and van Koppen, 2005).

India, in common with many other nations, continues to struggle with the combined effects of water stress alongside low levels of access to water, sanitation and hygiene (WASH) in many parts of the country. Groundwater resources are under significant pressure and over-development could result in further depletion and deterioration of quality (Dinesh Kumar and Singh, 2007). Recent national research shows that 54% of wells are declining due to abstraction exceeding the rate of recharge (NITI Aayog, 2018).

The governance of water resources in over 600 000 villages in India involves an extensive and complex system of institutions at multiple levels, aided by special purpose agencies. Although planning and implementation within the entire system is highly decentralised, this presents a barrier to the coordination of holistic water management issues.

Based on the experience of project partners People’s Science Institute (PSI) and Samerth Charitable Trust (Samerth), data availability on water resource usage is generally poor, which makes it difficult for planners and practitioners to make effective decisions on resource allocations. Numerous civil society organisations collect and store vital data at a local level, on aquifer levels and recharge rates, for example. However, there is little evidence of data being shared within civil society or with governance institutions.

Despite pressures and ongoing governance challenges, India has a rich heritage of effective surface and groundwater management, particularly in water-scarce regions. States such as Rajasthan have numerous examples of historic water storage and groundwater recharge structures to support both agriculture and drinking water supplies throughout the year.

2. IWRM project in India

The WASH Basins project was initially funded as part of Arup’s global challenge in 2017, in close partnership with Frank

Figure 1. A screenshot from IWRM Data Portal showing baseline Sustainable Development Goal indicator 6.5.1 reporting results – data for India has not yet been provided

Water, a water and sanitation charity. It aimed to increase the coverage of safe water and sanitation services in India through harnessing the principles of IWRM, while recognising that top-down interpretations of this concept have failed in the past. The challenges that the project aimed to address included

- providing a framework for application of IWRM at a local level in India, while avoiding inappropriate applications unsuitable for the local community context
- addressing the lack of consistency in methodologies for local water resources management
- addressing the limited or poor use of water resources data for decision making on water management and allocations
- addressing low levels of participation and empowerment in water governance issues within marginalised communities.

Samerth has been actively involved in restoring ponds, step wells and rainwater harvesting structures. It is improving water security and helping communities to increase their livelihoods and incomes, while up-skilling community members in hydrogeology and traditional water management techniques (Samerth Charitable Trust, 2020). Similarly, PSI has mobilised local communities for the construction of both traditional surface water harvesting structures and innovative technologies such as deep infiltration wells (People's Science Institute, 2020).

The project brought together the on-the-ground knowledge of Samerth and PSI, the project delivery expertise from Frank Water and the hydrogeological and water resources management expertise

of Arup. Together, they created a toolkit for the delivery of WASH projects, aimed at community-based practitioners such as water user committees, Gram Panchayats (village councils, the basic governing institutions in India) or non-governmental organisations (NGOs).

The WASH Basins toolkit (Frank Water, 2020) is built around a process for water security arranged around six stages, which guides practitioners through the process of initiating, nurturing and finally evaluating a water resources supply and management programme. It is supplemented by simplified data collection and management processes, using forms developed with the KoBo Collect platform and Excel-based data collection and analysis sheets. Through the application of the toolkit, the project is bridging a gap between research and practical guidance.

The toolkit was created following 2 years of water resources and supply work in 35 villages in Chhattisgarh and Madhya Pradesh in combination with development of a new process for water security. Project partners PSI and Samerth delivered new water supply infrastructure, sanitation systems, hygiene education programmes and agricultural programmes all underpinned by water security planning, including demand-supply forecasting, hydrogeological assessments and the design and construction of groundwater recharge systems.

In parallel, Frank Water and Arup documented the process of water resources and water security planning from start to finish. These processes were progressively refined and rationalised through multiple site visits (Figure 2), an externally facing workshop in Raipur and ongoing knowledge sharing. The final outputs were the WASH Basins toolkit and the WASH Connect mobile application.

Figure 2. A field visit in Madhya Pradesh with Arup and Frank Water

Through the project, Samerth and PSI up-skilled their internal teams in Chhattisgarh and Madhya Pradesh in IWRM processes. As a result, over 40 communities have had their water management analysed using IWRM principles over the past 2 years and over 8000 people have directly benefitted. Both Samerth and PSI have played an advocacy role at district and state levels and IWRM has been introduced into district-level planning documents. Both NGOs are now recognised as national leaders on IWRM and have been asked to support their respective state governments in developing their water management frameworks.

3. Water security planning: a six-stage process

The project studied existing processes for water security and water programme planning carried out by Samerth and PSI, along with international guidance provided by WaterAid India, the Global Water Partnership and IRC Wash. This review revealed some inconsistency and duplication in those processes, which made information sharing and consistent reporting difficult. Through practical involvement in the WASH programmes in Chhattisgarh and Madhya Pradesh, the project simplified and rationalised the core elements of the processes and created a clear and systematic six-stage process for water security planning (Figure 3).

The process begins following a needs assessment of a community's livelihood and water requirements, supported by

contextual data. Needs assessments often require a pre-project visit to the community and need not focus solely on water issues. However, the community's water-related priorities and local WASH needs, and how these relate to day-to-day activities, are all critical pieces of information. Ideally, local information should be obtained chiefly from the community in question and supplemented with local government-level data. A wide range of views and a broad information base can help to avoid potential bias and the possibility that political priorities could influence the nature or form of the information. Often, needs assessments are carried out prior to projects being funded.

3.1 Stage 1

Stage 1 is a reconnaissance visit to investigate and document basic community parameters. The focus of this stage is to develop a qualitative understanding of patterns of water availability and use and how these relate to livelihoods. This includes a rapid assessment of water sources and key hydrogeological features, which allows practitioners to identify issues, barriers and key areas of focus with respect to water resources.

Where the practitioner is not already based in or well connected with the community concerned, this stage will include an assessment of local governance structures and systems of power. This can be critical for understanding how scarce resources are allocated at present, how decisions are made, and the levels of technical understanding within the

community. Georeferencing water sources and water features can be important for recording data in the future, through platforms such as the KoBo toolbox.

3.2 Stage 2

Stage 2 requires formal documentation of key social, geographical and hydrogeological features of the community, based on information collected during the field visit in stage 1 and additional findings from a desk-based study. Often, this includes writing an interim report, the outputs of which could include land-use mapping, simple conceptual models of groundwater and a basic analysis of water availability. The report should also highlight water needs and pressures in the community, and how scarce water resources are allocated by existing power structures.

Ideally, data sources should include geological and topographical maps, meteorological data and groundwater data from the India Central Groundwater Board, where available. The report should also highlight opportunities for development of water infrastructure, such as locations that might be suitable for groundwater recharge wells.

Figure 3. An overview of the six-stage process (Frank Water, 2020)

3.3 Stage 3

Stage 3 is a more detailed site visit. It focuses on capturing a range of qualitative and quantitative data at a much greater level of technical detail, which requires the involvement of field staff with appropriate technical expertise or training – for example, in hydrogeology, hydrology, or civil engineering. Water demand use patterns can be understood using household and institutional door-to-door water use surveys and meetings with community members.

Inventories of water sources should include key parameters, identified through pumping and water quality tests, alongside rainfall, surface water and groundwater patterns. Obtaining a longitudinal dataset can be useful at this stage, given that rainfall and groundwater conditions are highly seasonal in India and significantly vary year on year. Where this is unrealistic, historic time series data or even qualitative estimates may be available from local project partners. A lack of data should not inhibit project progress where there is a genuine identified need and local knowledge to fill in gaps in datasets.

The WASH Basins project reviewed a range of technical spreadsheets used for collecting and analysing data including groundwater pumping tests (to determine transmissivity, hydraulic conductivity and storativity), water quality surveys and household and institutional water survey forms. The project redeveloped these as simplified and standardised calculation sheets, supported by survey and data collection forms in the KoBo toolbox platform (Figure 4) to aid mobile data collection. Importantly, digital data processing removed the need for transcription and reduced delays in analysis as basic quantitative assessments are built into the KoBo toolbox.

3.4 Stage 4

Stage 4 is the most detailed technical stage and involves extensive analysis of primary and secondary datasets. For groundwater

26/01/2021 WASH Basins Toolkit | Annual Water Level Monitoring Form - Ver. 1 Oct 2019

WASH Basins Toolkit | Annual Water Level Monitoring Form
- Ver. 1 Oct 2019

Background Information
Fill in a new version of this form for all wells every time a survey is carried out. The form can be expanded to cover as many wells as necessary, by clicking on the + at the end of the form

Year
Enter monitoring year

Village Name
Enter the Village name

Well Details

Name of Well Owner

Well Code

Well Location
GPS location of well

latitude (x.y °)

longitude (x.y °)

Figure 4. A screenshot of the annual well monitoring form in the KoBo toolbox

sources, transmissivity, hydraulic conductivity and storativity are calculated based on data collected in the pumping test form in the KoBo toolbox. For surface water systems, flow frequency and flow duration curves should be developed where possible by collating river or stream flow time series data, which can be used to determine sustainable abstraction and recharge amounts. A 10 year or longer time series is ideal at this stage but, where this is not available, local knowledge can be vital for generating qualified estimates instead.

In addition, it may be useful to use a digital geographical information systems (GIS) platform for spatial mapping. The Bhuvan platform for India is an example of a free-to-use platform for hydrological and geological spatial analysis, which allows practitioners to harness other datasets to aid analysis and identify the best locations for recharge structures and wells.

3.5 Stage 5

At stage 5, quantitative data are brought together to complete a water balance or water budget assessment for the baseline year and subsequent years. The total demand, referred to here as 'aggregate demand', should include all abstractions for domestic, agricultural and industrial purposes, along with potential future demand, considering uncertainty. Crop water requirements can be complex and location specific and depend on the cropping patterns used.

Aggregate supply includes existing water sources, with consideration given to the sustainability of existing arrangements and seasonal variations. The likely potential yield of new sources, including wells and rainwater harvesting structures, is also considered. The final water balance is used to calculate the desired minimum rate of groundwater recharge, considering the technical feasibility of different forms of recharge structures along with geographical and social factors that could influence their performance.

The project developed a simplified and streamlined water balance assessment worksheet, which provides essential baseline constants (such as individual crop water demand), which are typically required for assessing aggregate water demand in India. In many cases, civil society or community-based actors are by far the best placed stakeholders to provide estimates or averages for different baseline constants. National or state-level data can also play a role, particularly when considering the impact of population changes on demand, and climate change on supply.

3.6 Stage 6

The final stage, stage 6, is a detailed project report or water security plan. This provides a comprehensive overview of current and future water needs, how they will be met, and how water resources in and around a community will be monitored and managed in the future. The report also includes a summary of the water balance, proposed water supply infrastructure, proposed water recharge structures, proposed catchment management solutions and an economic plan.

The report should provide technical and economic justifications for the interventions, and the role of stakeholders in both initial construction and long-term monitoring and engagement. A sample review of past reports showed that such reports can be long and contain duplications, and so the project developed a simplified structure to guide the inclusion of all vital parameters. Using this structure, the report or plan should be sufficiently detailed to enable a community organisation, NGO, or public body to demonstrate the need, justify the solution, apply for funding and deliver the project.

It was found that such reports in India are typically used to apply for funding for infrastructure as part of Gram Panchayat development plans or as funding applications for external donors. Therefore, a consistent approach to producing these reports can significantly improve the efficiency of their production and increase their chances of successfully gaining funding.

4. Data collection and analysis

Water resources planning and programme management in small civil society actors in India is heavily reliant on paper-based forms, which are typically processed and archived at offices away from project sites. Working with Frank Water's partners also revealed that data sharing and centralised analysis across multiple organisations are extremely rare, creating a 'siloed' approach to data collection and analysis on a project or programme basis.

Across the world, the number of digital tools for data collection and analysis is expanding, as is their utility – examples being mWater, KoBo toolbox and Akvo Flow. The project chose to use the open-source KoBo toolbox platform and accompanying KoBo Collect mobile application, as it provided sufficient flexibility and ease of use on an open-source platform and is commonly used in humanitarian and development contexts. The KoBo Collect application can be used offline on Android mobile devices, which are widely used and available to field staff in India.

The project developed customised data collection forms that users can load into their individual project accounts. The forms were based on existing versions used by PSI and Samerth, with improvements for clarity and digital data collection. Basic analysis, data cleansing and error isolation can be performed quickly within the KoBo toolbox platform. The use of any new tool requires changes to organisational workflows, upskilling of staff and inevitable short-term disruption to ways of working.

The project supported Samerth to deploy KoBo toolbox forms on a demonstration project in two village clusters (Gram Panchayats) in Chhattisgarh state. This led to much faster completion rates than previously experienced and helped to up-skill field staff in the use of the KoBo and Bhuvan digital platforms.

The India-based project partners' workflow traditionally involves producing large-scale physical maps, in close collaboration with local communities, which include land-use and water-feature maps (including existing infrastructure and natural sources). The collaborative nature of this process can help to foster organisational relationships, but typically takes 2 weeks or longer.

Several free GIS platforms now exist, which offer advantages in terms of speed of data collection, accuracy and the ability to integrate with other data sources. An increasingly popular solution in India is the Bhuvan online platform, which overlays national water resources datasets with user-created layers. This allows project implementors to identify and utilise national datasets such as rainfall data or groundwater monitoring points that help to contextualise their work.

The platform is cloud based and, therefore, not always suitable, and the shift to an electronic platform can require a big change in organisational processes, technical requirements and up-skilling. There is also a risk in losing the benefits of paper-based collaborative mapping, which makes extensive use

of community knowledge. Taking these challenges in hand, the project supported Samerth in using Bhuvan for their projects, including upgrading office internet connectivity where necessary. The challenge for project managers is to harness national datasets without losing the close connection with local knowledge held at a community level.

5. Managing and protecting groundwater resources

India meets 85% of drinking water needs from groundwater, and is the largest user of groundwater in the world (World Bank, 2012). Thus, hydrogeological models are vital for establishing groundwater parameters for aquifers. They are an important part of project planning, determining sustainable abstraction levels and estimating the long-term water balance.

A conceptual model is a powerful, qualitative way of demonstrating how a system works for non-experts and experts alike, and can evolve into a more quantitative model at a later stage when required. Such a model includes the different natural and anthropogenic factors that govern and contribute to the movement of water below the surface, including subsurface geology, flow paths, discharge points and sources of recharge.

The project found it useful to treat a conceptual model as an evolving collaborative process, with more detail added as the project or programme progresses from stage 1 to stage 6 of the

water security process. The WASH Basins toolkit includes a detailed conceptual overview that introduces practitioners to the concept of aquifers and groundwater systems, and key parameters that can be measured on the ground, including hydraulic conductivity and transmissivity.

A key skill for practitioners is often to identify the most likely successful locations for groundwater recharge (Figure 5). Experience from Samerth demonstrated that even reasonably basic formal training in elements of geology and hydrogeology led to improved outcomes in terms of the ability of staff to identify areas with greater likelihoods of establishing successful wells and recharge structures.

Monsoon patterns in India have behaved erratically over the past 20 years, often arriving late and in a more concentrated manner, which has been linked to climate change (Jones, 2006). Vernacular reports from project villages suggest that, in the WASH Basins project areas, the monsoon season has become more intense in recent years and is concentrated over a shorter time period. Opportunities for increasing the water resource base typically involve slowing the flow or storing water, either above or below the surface. This can be done at a household or community level through rainwater harvesting systems (which can be more appropriate in urban areas) or at a catchment scale across whole catchments.

Artificial recharge of subsurface aquifers has a long and proud heritage in India, especially in the more drought-prone regions such as Rajasthan, but appropriate methods and technical interventions are highly context specific and dependent on local factors.

Figure 5. Assessing the suitability of a stream bed for groundwater recharge in Madhya Pradesh

6. Groundwater recharge

Techniques for recharge can be broadly split into three categories: surface-spreading, subsurface and indirect techniques.

Surface-spreading techniques can be successful where geological and superficial conditions promote the percolation of groundwater into an aquifer over a reasonable timeframe. Subsurface techniques are more complex and include injection wells, recharge pits and shafts. In many cases, old or dry wells can be repurposed for groundwater recharge. Indirect methods of recharge include borehole blasting, hydrofracturing and subsurface structures to modify subsurface flows. These are far more technically complex and cash intensive and are unlikely to be appropriate for many rural settings or be managed within limited NGO budgets.

In almost all cases, maintenance requirements are a critical consideration, and there are numerous examples of abandoned recharge structures across India where periodic maintenance has not been carried out. Many structures are vulnerable to becoming infilled with silt and deposits, which was a problem observed in newly constructed sites in the project area but can be monitored or mitigated to avoid impacts on performance.

Nevertheless, it is worth noting that the function of structures can evolve over time, and infilled tanks may support community livelihoods in other ways. Before rehabilitation, such livelihood functions should be fully understood (Shah and Raju, 2003).

7. Reporting and funding

Reporting should support and justify decision making, with the goal of delivering sustainable and holistic WASH services. In India, detailed reporting is the primary means of gaining access to funds, both from local government (such as through Gram Panchayat development plans) and through the private sector. Information, therefore, needs to be presented in a clear and repeatable manner and to an appropriate level of detail.

The project's experience was that there was significant variation – or repetition – in reporting between the two project partners, which took significant effort to overcome. The reasons for this were mainly twofold: reporting requirements to funders, but also organisational perceptions that longer reports were inherently better. The WASH Basins project recommends just two project or programme reports: an interim report at stage 2 and a final report, also known as a detailed project report or water security plan, at stage 6.

The primary purpose of an interim report is to present the scale of the problem within the local context, outline possible solutions and their benefits at a high level, and identify the information gathering required at the next stage. Interim reporting within the WASH sector can be inconsistent or, in many cases, not carried out at all for many projects and programmes. Reporting may be required for the express purposes of monitoring and reporting for certain stages of funding. The project developed a consistent template for interim reporting to add clarity and robustness to the project process.

The most important stage of reporting is the detailed project report. This brings together all the project information in a clear and coherent manner, enabling external parties to understand the problems faced, solutions developed, how the solutions were arrived at and how they will be executed in the long term. The report should make the link between high-level project objectives and the specific activities proposed. It is important to note that

there can be many different potential audiences: the stakeholders delivering the project; local government; project funders; project auditors; internal stakeholders and external interested parties.

There are many ways of referring to the reporting at this stage, such as a 'water security plan', an 'integrated water resources management plan' or a 'water management plan'. What is paramount is that it should provide all the necessary information, at an appropriate level of detail, for construction, operation and handover to the project implementing agency. It should also be sufficiently robust to allow a funding agency to make a long-term commitment to the project, including maintaining infrastructure.

The report should set the project firmly in the hydrogeological context of the area and include sufficient information on the state of surrounding water resources. Information on threats (both short-term shocks and longer-term stresses) should also be included, such as the impact of climate change on water resources. In practical terms, this is difficult to assess at a catchment or a community level, so in many cases assessments will involve inferring the local implications of national-level assessments or reporting down to the local level.

It should also, qualitatively where necessary, include a summary of other threats and risks to water supply, both on the demand and supply side, and options for mitigation. Such threats could include lack of implementation of state or national legislation, or local industrial activity. The report should also detail how regular monitoring of water resources will take place, and how this will be shared with local government or other third parties when appropriate. Monitoring templates are provided in the toolkit, and the use of such templates can help the long-term impacts of recharge to be more visible to communities, NGOs and state or national government water resources functions.

There is little specific guidance for detailed project reporting of WASH projects at a community level at present, and the guidance produced by the WASH Basins project is unique and targeted in this respect.

8. Institutions, governance and people

The Dublin statement, which was submitted to the Earth summit in Rio de Janeiro in 1992, stated that a participatory approach involves engagement at all levels – including users, planners and policy makers (World Meteorological Organization, 1992). Crucially, it also argues that decisions should be taken at the lowest appropriate level by those most affected, and with the most appropriate knowledge of local water resources.

The Institution of Civil Engineers (ICE), Oxfam GB and WaterAid highlighted in 2011 how communities are frequently excluded from such projects which involve the management of common pool resources, such as aquifers, to their detriment (ICE *et al.*, 2011). They argue that this is especially important where government capacity is weak, or communities exist on the periphery of support from the government. Such a trend is highly observable in policy debates around IWRM, which are heavily focused on top-down policy making and high-level water governance.

The perceived applicability of IWRM principles has been limited by the focus on state control mechanisms for water resources management, and not on devolved alternatives. This is keenly felt in India, which has a highly devolved and decentralised system of government. Village and multi-village bodies play a key role in water resources management and service provision, supported by

a highly complex system of institutions at multiple levels, aided by numerous special purpose agencies. Despite the high level of participation in such a system, the complexity of hierarchy and the number of institutions presents a risk to effective coordination.

The WASH Basins project premise is that communities can be empowered to make decisions on water resource applications at a local level where they have the skills and information to do so, and that such decision making can be integrated at a horizontal and vertical level.

Vertical integration involves local communities working with institutions at higher levels of governance. Communities that formed part of the project have better capacity to control abstraction, bargain over water rights and establish local operations principles while monitoring rainfall, recharge and groundwater levels. Such data and decisions can in turn help higher-level administrative bodies make better decisions about water resource allocations if they have a clearer picture of what is happening at watershed or community level. Similarly, where data collected at a higher level are made available to communities, these aid local decision making.

Horizontal integration involved data sharing between communities, and between higher-level institutions. Therefore, focusing on data-sharing platforms, multi-level awareness and up-skilling in water resources management can help achieve policy goals more effectively than simply advocating for top-down frameworks. In this regard, the use of the KoBo toolbox data collection and sharing platform, consistent data collection spreadsheets, common reporting templates, and common monitoring, evaluation and learning frameworks all play a facilitating role.

9. Conclusions

The WASH Basins toolkit and WASH Connect mobile application were a cumulation of more than 2 years of intensive work with partner organisations in the UK and India. The project was initiated by a shared desire to address both the poor understanding of IWRM at a local level, and inappropriate applications of IWRM techniques at a national and international level. There was also a drive to address the critical issues of justice in access to water and sanitation, the most pressing needs on the ground for marginalised communities, and the poor use of data and hence poor decisions around water resource infrastructure and water allocations.

The project found the solution in on-the-ground knowledge of local partners, and combined this with global expertise to create a simplified toolkit, mobile application and body of knowledge. By demonstrating the value of the toolkit and by up-skilling, through the respective teams of the partner organisations, in IWRM techniques, the project gained influence among local government and non-state actors.

The project has demonstrated the power of simple groundwater recharge interventions, appropriately situated in the context of a water security plan, to improve access to water and sanitation and provide resilience of supply. Such an approach has clear global applicability, and the application of robust, simple engineering principles has the potential to empower communities and governments for achieving UN Sustainable Development Goal 6 – clean water and sanitation for all.

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