Understanding how locally led initiatives through digitalisation help strengthen water governance

SOPPECOM

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Foreword and Acknowledgement

Society for Promoting Participative Ecosystem Management (SOPPECOM) is a non-profit, non-governmental organisation based in Pune, India, working in the area of natural resources management, primarily in rural areas. The organisation is committed to the principles of sustainable and rational use of natural resources, equity, and social justice in the distribution of benefits, especially to disadvantaged groups like Dalits, the landless, and women. As an organisation committed to these principles, SOPPECOM extends its support to grassroots groups working on NRM issues through training, resource literacy, participatory planning, research, and policy advocacy.

TMG Research gGmbH is a Berlin-based research organisation working on sustainability issues in the areas of sustainable management and responsible governance of land and oceans, food systems, and climate. As an organisation, TMG brings sound knowledge and practical experience in facilitating national, European, and international processes and is dedicated to the analysis and solution of new and complex challenges.

This study was done under the 'The SEWOH Lab Project' that analyses the linkages between digital and social innovations for achieving Sustainable Development Goal 2. The SEWOH lab project aims to improve livelihoods for smallholder farmers and marginalised land users, including women through. The focus of the ongoing research is to learn from various initiatives in the water sector and understand how local institutions use digital tools in participatory water monitoring, water budgeting, and water-sensitive crop planning among others. Three sites were selected as case studies under this study.

First and foremost, we thank the TMG Research Group for collaborating with us and on this very critical subject. Especially, we are very thankful to Larissa Stiem-Bhatia from the TMG Research group for coordinating with our team and sharing her valuable feedback with our team from time to time.

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List of Acronyms

ABhY	Atal Bhujal Yojana
ACT	Arid Area Communities and Technologies
ACWADAM	Advanced Center for Water Resources Development and Management
BJ	Bhujal Jaankaar
CLART	Composite Landscape Assessment and Restoration Tool
CRP	Community Resource Person
CWB	Crop Water Budget
DET	Design Estimation Tool
EbA	Ecosystem Based Adaptation
FES	Foundation for Ecological Society
FPO	Farmer Producer Organization
GIS	Geographic Information Systems
GMT	Groundwater Monitoring Tool
GSS	Geo- Science Service
ICFOSS	International Center for Free and Open-Source Software
IIT	Indian Institute of Technology
MMISF	Maharashtra Management of Irrigation System by Farmers
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NGO	Non-Government Organization
PGWM	Participatory Groundwater Management
PRI	Panchayati Raj Institution
SHG	Self Help Group
SOPPECOM	Society for Promoting Participative Ecosystem Management
TDS	Total Dissolved Solids
VDC	Village Development Committee
VWMT	Village Water Management Trust

WOTR	Watershed Organization Trust
WUA	Water User's Association

Introduction

Society for Promoting Participative Ecosystem Management (SOPPECOM) and TMG Research gGmbH (TMG) are collaborating on 'The SEWOH Lab Project' that analyses the linkages between digital and social innovations for achieving Sustainable Development Goal 2. The SEWOH Lab is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and aims to improve livelihoods for smallholder farmers and marginalised land users, including women. The research study was carried out as a part of the 'Ecosystems-based climate adaptation (EbA) workstream: Digitalisation in ecosystem-based climate adaptation—Bridging the last mile through social innovations.'

The EbA work stream of the SEWOH Lab investigates how local support systems can provide "last mile connectivity" through facilitating access to digital information in climate adaptation. In this regard, digitalisation is not regarded as an end in itself but as a means to enable farmers and other land users to make better informed decisions to enhance the resilience of their production systems in the face of climate change. We seek to learn from existing EbA approaches that merged technological solutions within the architecture of community-led water governance.

Objective

The objective of the research study was to learn from various initiatives in the water sector and understand how local institutions use digital tools in participatory water monitoring, water budgeting, and water-sensitive crop planning among others. The study would also help in understanding the role of social support systems, e.g., water user associations (WUAs), community facilitators, women self-help groups and farmer producer organisations (FPOs) in facilitating access to digital technologies and information for their members, and data collection and monitoring.

Background

India ranks among one the most water-stressed country in the world. The per capita availability of the people living in the twelve major rivers basins in the country is lower than 1000 m^3 which is the threshold for water scarcity according to the Falkenmark Index (Falkenmark et al., 1989). By 2030 the water demand is expected to be two times

that of the supply (availability) leading to significant impacts on livelihoods, health, economy, and ecosystems in the country.[1]

Water is not only becoming an increasingly limited resource but the inequity in its distribution and use is also increasing. For instance, in Maharashtra, 70% of the water available for irrigation is used to cultivate sugarcane, which is grown by about 1.1 million farmers on 4% of agricultural areas.[2] In contrast, 10% of irrigation water is used by the roughly 10 million farmers who cultivate less water-intensive crops including sorghum, pulses, and oilseeds.[3]

In general, there is a clear correlation between property ownership and the availability and access to water, particularly groundwater. In comparison to small and marginal landholders, large landholders can typically assert more water rights, weakening the fair access to water that small landowners have. This can also be seen in the tail-end regions of the surface irrigation projects. People in the head reaches get better access to the water depriving the people in the tail-end of the entitled access to water in the command areas.[4] Moreover, increased uncertainties in weather patterns due to climate change add to the complexity.

On one hand, where newer challenges are emerging in the management of natural resources, especially water, the role of digitalisation is rapidly increasing bringing transformations within this sector. Globally, there is increasing evidence showing the potential of digital technologies and what they can achieve in the effective management of natural resources. For instance, the Google map, a simple digital tool that allows you to record GPS readings of a particular area of concern, etc. Digital technology has definitely changed the way we been collecting data and information for decision making. Though digital technologies are becoming an indispensable part of human lives, they pose challenges, especially like creating digital divides. From SOPPECOM and TMG's previous research work it was seen that they can tend to dilute participatory processes under the pretext of real-time monitoring and efficiency (Samuel et al, 2023). Lack of access to digital technology due to socio-economic factors including patriarchy can further widen the inequity depriving certain sections of the society, especially the dalits and women from getting access to resources. Though there are efforts been taken to address these challenges they have been mostly fragmented and not really taken off.

SOPPECOM and TMG are planning to do a pilot action research to understand how digital tools can be used by local institutions and communities in a participatory manner

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[1] http://social.niti.gov.in/uploads/sample/water_index_report2.pdf

[2] Ministry of Agriculture 2013.

[3] https://scroll.in/article/809086/how-water-inequality-governs-drought-hit-maharashtra

[4] SOPPECOM(2002) https://soppecom.org/pdf/Tail%20ender%20study%20report.pdf

with more emphasis on demand-side management, especially crop planning. For the preliminary understanding, we visited a few initiatives by different organizations working in the field of natural resources management that have either developed or are using different digital tools/applications in their respective regions of work, especially for water management. Through this report, we have attempted to synthesize the field insights based on the objective stated above. The idea was that learnings from the scoping studies would inform the pilot action research and help refine the research programme.

With that background, the following report is organised into four main sections namely

- Methodology: This section briefly describes the process followed for carrying out the scoping studies
- Results: This section is divided into three parts; each part discussing and detail the field insights from the selected scoping study sites
- Discussions: The section sythesizes the overall learnings, discusses the implications and trade-offs, etc.
- Conclusion: This section summarizes the overall research study

Methodology

Selection of the sites for the scoping study

The selection of the project sites was guided by the following questions:

1. Present status – water governance: What is the current water health situation in the particular study site? How are water budgets currently being calculated? How, if at all, are water use and crop plans currently developed and implemented?
2. Equity: How is the water being shared among the community? Are there any groups left out in the allocation of the water? How, if at all, do vulnerable groups (Eg. Dalits, Adivasi, women) participate in local water management? Are the ecosystem needs considered?
3. Local institutions: What role do the different local institutions currently play in water management at Panchayat and aquifer level? What (general) challenges do they face in local water management? How, if at all, do they use digital tools to support water management – and what challenges do they face (e.g., digital literacy)?
4. Present status – digitalisation: What datasets and sources are required for effective and inclusive water governance at Panchayat and aquifer level? What data is currently available, and who manages and owns it?

5. Sharing of digital data: How can data be made more widely available? What methodologies need to be developed to ensure that the collected data can be trusted and shared within the larger community/ at the aquifer level?

The criteria for selection of the scoping study sites was based on the following:

- Experience of working in the field of natural resources management
- Level of community engagement and participation
- Local level institutions actively taking part in water governance
- Use of digital tools in planning and management of water resources

The selection of the sites for the scoping study was initially done through a web search and literature review. Based on this initial search and also with the guidance of experts like Dr. Himanshu Kulkarni from Advanced Center for Water Resources Development and Management (ACWADAM), Pune six project sites were short-listed. From the six sites, three sites were selected as given below:

1. Foundation for Ecological Security (FES): Understanding participatory groundwater management in Bhilwara district, Rajasthan.
2. Arid Area Communities and Technologies (ACT): Resolving water issues through participatory groundwater management in Kutchch district, Gujarat
3. Gram Vikas: Springshed management in Gajapati district, Odisha

The map below shows the geographic locations of the sites within India.

Figure 1: Map of the scoping study locations

The rationale for the selection of the three sites was the extent of the use of digital tools and also the different local and social innovations used for decision support in the planning and management of water resources.

Field interviews and focus group discussions

For understanding the applications of digital tools in local water governance and the role of local institutions, field interviews and focus group discussions were carried out. The interactions were carried out in three parts. First, to understand the various digital tools and applications developed or used, detailed interviews were carried out with the technical staff of the concerned organization. Second, community resource persons (CRPs) appointed by the organisation as an interface between the communities and the organisation were interviewed to understand their roles and functions in handholding and providing support to the communities. Third, focus group discussions were carried out with the communities to understand how they reciprocate these tools including the advantages and challenges. The detailed interview guide is given in Annexure 1.

Field Insights

Case Study 1: Foundation for Ecological Security (FES): Understanding the participatory groundwater management in Bhilwara district, Rajasthan

About FES

FES works towards ecological restoration and conservation of land and water resources. Established in 2001, FES engages with the government to implement policies and programs that promote the local management and governance of common-pool natural resources, use of technology to improve civic engagement, and partner with research institutions to improve understanding and field-level implementation.[5]

In May 2020, an initiative called "Napo Jal Bachao Kal" (Measure water and save future) was started by FES to collect well water level data using an offline android-based app. A web platform, called the "India observatory", was also created along with the app which helps visualize the collected groundwater data.[6] In the Bhilwara district, about 400 wells are monitored. This is then converted to water table maps, which are then used with other tools like the crop water budgeting tool and the CLART which have been developed by FES for water governance. This site has been selected to understand how digital tools are helping in the decision support for water governance and cropping patterns.

The four main components that they use in their interventions in the villages are as below:

1. *India Observatory*: The India Observatory is a collaborative, action-oriented tech initiative. It aims to demystify and present comprehensive information on India's social, ecological, and economic parameters on a single spatial and temporal platform. The India Observatory has developed several tools and data analytics for decision support.
2. *Prakriti Karyashala and Collaboration*: This is a capacity-building component that is mainly used to build a strong rural cadre for local stewardship, and to equip the local communities with different tools for planning and governance of natural resources.

[5] https://fes.org.in/

[6] https://wmt.indiaobservatory.org.in/

3. *Direct Engagement*: This is their stakeholder engagement model which is used to develop replicable institutional models for natural resources management in rural areas.
4. *Commons Collaborative*: Through this component FES attempts to policies and programmatic actions, develop knowledge products for informed actions and build robust data and evidence.

Digital tools developed by FES for water management

Table 1: Digital tools developed by FES for water management

Tool	Planning	Implementation	Monitoring	Evaluation
Composite Landscape Assessment and Restoration Tool (CLART)	✓	✓		
Design Estimate Tool (DET)	✓	✓		
Crop Water Budgeting Tool (CWB)	✓			
Groundwater Monitoring Tool (GMT)	✓	✓	✓	
Experimental Games (EG)	✓			

Brief description of the tools:

- ***Composite Landscape Assessment and Restoration Tools (CLART)***[7]: This is a Geographic Information System (GIS) based Android tool developed to enhance the planning of region-specific soil and water conservation measures. CLART enables rural communities in designing measures that would either help the recharge of groundwater or augment surface water availability, depending upon the location-specific geo-hydrological characteristics. Simple colours used like red, yellow, and green based on the recharge potential help the villagers understand the recharge and discharge zones of the aquifer. The information required for the preparation of the map is entered into the app the help of FES's technical team. The tool also shows the movement of the

[7] https://www.indiaobservatory.org.in/tool/clart

groundwater within the aquifer. Thus, this helps the village community to come together and plan their water harvesting structures.

- ***Design Estimation Tool (CLART-DET)***[8]: This tool aids in the design and estimation of the cost for the water and soil conservation structures.
- ***Crop Water Budget Tool (CWB)***[9]***:*** This is an android-based tool that has been developed to assist communities to manage their surface and groundwater efficiently without further depleting their resources. Farming communities are at the centre of Crop Water Budgeting exercises because water availability, whether groundwater or surface, is deeply impacted by their actions, and in turn, the availability impacts their livelihoods. The effort is to build awareness about efficient demand-side management, by assisting village communities in viewing water as a Commons and taking decisions on sustained availability of water.
- ***Groundwater Monitoring Tool (GMT)***[10]: This is an open-source Android-based tool that allows the collection of groundwater data which can help in the monitoring of the water tables and the use of groundwater. This tool is used at the village scale by the community resource partners and some key persons in the villages to monitor the pre- and post-monsoon water levels. Currently, it is actively being used. The data goes to a central server space. Here the data is analysed and used for water budgeting.
- ***Experimental games for demand-side management***: This is a capacity-building tool developed to sensitize farmers on crop water use and availability. The game is played in a total of 20 rounds with a group of farmers where each farmer gets to take a crop of her/his choice. However, at the end of each round (which represents the crop cycle), the farmers come to know how much water they have collectively consumed and how much is available to them now for the next crop cycle. They are then provoked to come together and collectively decide which crops to take based on the water availability.

Issues related to water

The major issue related to groundwater in the Bhilwara is the geology of the region. The hard sandstone does not allow the water to percolate into the ground and similar to the Deccan traps in Maharashtra, water can percolate only through cracks. Thus, the availability of water is limited though there is an assured rainfall of 500 to 600 mm in this region. Many villages did not have sufficient water for meeting their domestic requirements as well because of this. However, through water harvesting structures like gabions, bunds, tanks, etc., and moving towards demand side management the villages now have been able to shift towards better management of water resources such that they have sufficient water for Kharif and rabi irrigation.

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[8] https://www.indiaobservatory.org.in/tool/clart-det

[9] https://www.indiaobservatory.org.in/tool/cwb

[10] https://www.indiaobservatory.org.in/tool/gmt

Process of engagement with communities

FES has been working in the Bhilwara district and Rajasthan for the last thirty years mainly on land commons. Their main focus had been on pasture land conservation which has been largely leveraged through schemes like MNREGA. Their main entry point into the villages for intervention has largely been through their conservation of land commons programs. However, as all the natural resources are connected intricately, they also started working on water. From continuous engagement with the communities, the organisation employs CRPs that form an interface between them and the organisation. The CRPs directly coordinate with the field coordinators who then coordinate with the higher-ups in the organisation. The CRPs are given training on all the tools and they work closely with the members of the village committees for the planning, implementation, and monitoring of the project.

Brief Profile of the villages

The villages visited in the Bhilwara district were: Dhanwada in Kotri block and Savrapura and Amaritya in Mandalgarh block. Table 2 summarizes the profile of each of the village.

Table 2:Profiles of the villages visited in Bhilwara, Rajasthan

	Dhanwada	**Savrapura**	**Amaritya**
Geographic area	500 ha	200 ha	300 ha
Population	950	700	600
Number of households	150	115	130
Average rainfall	600-700 mm	600-700 mm	600-700 mm
Major crops taken	Maize, bajra, cotton, wheat, chickpeas	Maize, cotton, mustard, wheat, chickpeas	Sesame, masoor
Total cultivable area	200 ha	50 ha	180
Major water sources	Wells and borewells	Wells and borewells	Wells and tanks
Internet connectivity	Poor to Moderate	Poor	Moderate to Good
Digital tools used	CLART, GMT, CWB	CLART, GMT, CWB	GMT, CWB

Insights

Overall status of water

The main source of water in all three villages visited was groundwater. Though there is an awareness about common pool resources and the nature of the groundwater, from the focus group discussions, it remains largely inconclusive as to how much knowledge the people from the three villages have about the aquifer they are with neighbouring villages. It was observed that the water management was happening only at the village scale and not the aquifer scale. That is also mainly because the organization is not engaging with the communities at the aquifer scale but village scale. Therefore, there are no 3D aquifer models developed. The communities largely have a good knowledge of the recharge and discharge areas of groundwater in their village and CLART has help them in identify these recharge and discharge areas.

In two villages visited in the Mandalgarh block, ie. Savrapura and Amaritya the situation of the water before the intervention was poor. They did not have enough water for drinking and domestic needs as soon as the monsoon got over. However, after the intervention through the organisation it was observed that there was some positive change in the village in terms of the availability of water. Though Savrapura was water deficient according to their water budget chart, the reason cited was that they had not utilised the full potential of harvesting the water and planned works would help them move towards water sufficiency. Amaritya showed surplus water availability. On the contrary, in Dhanwada from Kotri block, the people responded that earlier they had water tables at 20ft and now the same has dropped to 60 ft. The reason given was that the rainfall in their village has been extremely erratic and it does not rain enough.

With the help of the GMT, the communities are also monitoring the groundwater levels. This is done twice a year; pre-monsoon, and post-monsoon. Once the post-monsoon data is collated, the total water availability is determined. It was observed that there are a couple of active members in the village that help in the monitoring exercise, for example in Dhanwada, there was one person who monitors the levels of four wells in the village. Community resource persons also take the readings independently to maintain the records on the India Observatory data platform.

Overall, the status of the water in two villages ie. Dhanwada and Savrapura, appeared to be poor from the perspective of water availability and the villages need to put in more efforts collectively for the management of water. People in Amaritya for the last 30 years have been diligently taking efforts towards land and water conservation and hence have reaped the results.

In terms of equity, in all three villages, there was more or less homogeneity due to which the team did not come across a particular section that had absolutely no access to

water or even other common pool resources like the grazing land. However, it was observed that there are no existing norms for equitable water distribution within the villages.

Water budget

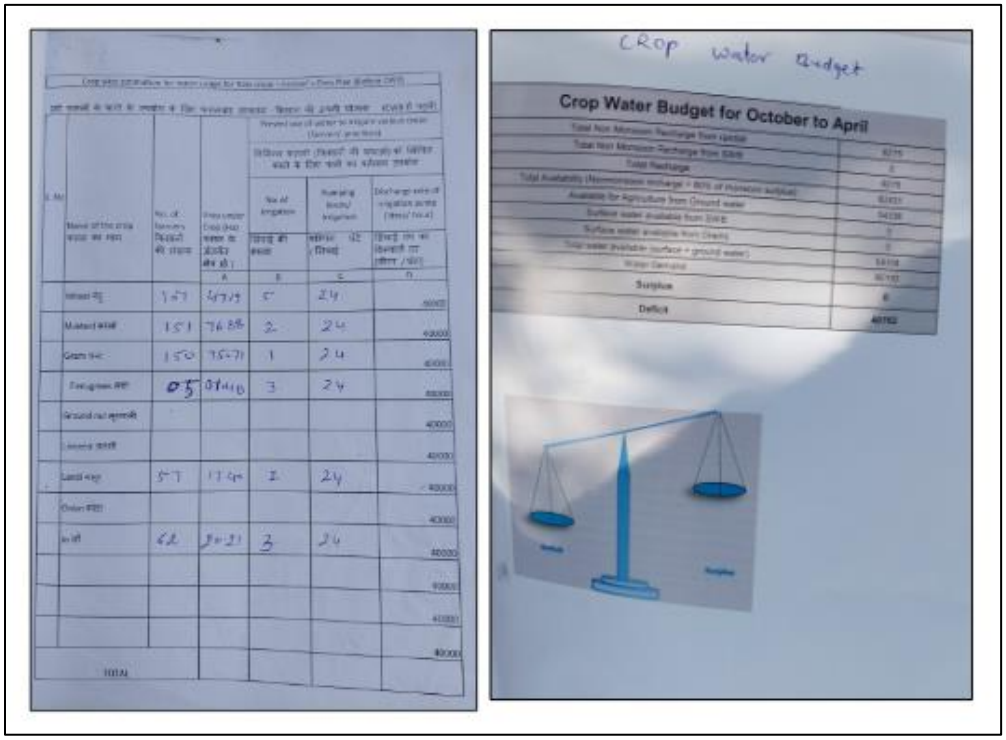

Figure 2: Crop information form (left), Crop water budget (right)

All the villages are doing a water budget for their respective villages using the crop water budget tool. In Dhawada the process has begun fairly recently and hence they are yet to see impacts. For the crop water budget, information regarding the crops planned and the area under cultivation is collected from each farmer by the CRP manually as can be seen in Figure 2 (left). This information is then entered into the crop water budget app by either the CRP or the field coordinator. This directly gives a value of whether the village is water surplus or deficient as shown in Figure 2 (right). It was observed that the process is largely manual at the moment because the internet connectivity in the villages is not good and also, they do not have enough capacity to be able to do it on their own. The process of developing the water budget is done only for the rabi season. Post kharif season, this information is collected and as far as possible collated well before the rabi season sowing begins so that if the village is water deficient the village can come together to plan for the optimum planning of the available resource. It is expected that the village conducts a gram sabha to decide the changes that would be required in the existing cropping pattern so that they do not have a deficit at the end of the rabi season. In Dhanwada, the people responded that they do have meetings to discuss the water budget and that they had one such meeting planned.

Savrapura did not hold any meetings despite the deficit, and Amaritya did not feel the need as they had surplus water. Therefore, it was observed that though the crop water budget is derived based on the actual information of the crops and the cropped area, its impact in terms of amending the cropping patterns based on water availability is yet to be seen.

However, to make the communities aware of crop water use, the organisation uses an experimental game called the 'Crop water budget game'. The game sensitizes the village communities as to how their individual crop choices affect the overall availability of the common pool resource. The SOPPECOM team also played one round of this game in Savrapura village, as shown in Figure 3, and found the game interesting and useful for creating awareness among the farmers on demand-side management, especially related to crop choices.

Figure 3: Experimental Games for sensitising farmers on crop choices and water use

Local institutions for water management

Dhanwada did not have a separate village-level committee for the management of the water. The decisions are taken at the gram panchayat. Savrapura has a separate 'Charaga Vikas Samati' (Pasture land development committee) that also takes decisions related to the planning and management of water. However, the committee looks more into the planning and implementation of only the watersheds work whereas the demand-side decisions are taken at the panchayat level. Amaritya had a local water management committee with a very active management board which also includes women.

There are no by-laws constituted by the people in Dhawada and Savrapura, however, Amaritya had by-laws related to water. There is a ban on borewell drilling in the village. They are also conserving the forest area around the village for soil and water conservation through a strict no-felling rule. It was also observed that over the years the village has been able to empower itself to be able to negotiate with the district

administration for the implementation of watershed works or even get funds approved. Overall, the community in the Amaritya was more organised and mobilised compared to Dhawada and Savrapura, especially the younger generation.

Use of digital tools by the communities

The communities are aware of the different digital tools that have been introduced and their specific application. However, it was observed that the overall use of these tools by the communities, including the local institutions is low. They are mostly dependent on the CRP to handhold the process. However, the process is not completely top-down. There is active community participation. Take the example of the CLART. Four to five key resource persons from the village accompany the technical staff in mapping the resources in the villages with the help of CLART. With the inputs from the people including their participation in the survey work, an output in form of a simple map is generated that can be easily understood by the people. This enables them to plan and implement water harvesting structures. GMT is being used by a few people from the villages including women as was seen in Savrapura for the monitoring of groundwater. CWB is a very useful tool. However, currently it is being used by only the community resource person and/or the field coordinator. The forms are manually filled out and then entered into the computer program for generating the water budget. Also, it may take a long time for the communities to develop the confidence to use CWB as it is a data-intensive app. The current interface of the app requires a lot of technical information and not many people in the village may be able to fill in all that information. Therefore, if the communities have to use CWB in its current form they would require technical support. This would have post-project implications when the organisation would withdraw from the site and it would be up to the community to continue to use the tool.

The other reasons observed as to why the communities didn't quite resort to the use of digital tools was poor internet and telephone connectivity in both Kotri and Mandalgarh blocks. Also, many farmers do not have smartphones.

Case study 2: Arid Area Communities and Technologies (ACT): Resolving water issues through participatory groundwater management in Kutchch district, Gujarat

About ACT

ACT is a professional voluntary organization based in Kutch, Gujarat (Western India). The organisation aims to strengthen the livelihoods of communities in arid and semi-arid regions by supporting communities to resolve ecological constraints through facilitation, or by providing access to technologies and also to engendering technological and institutional solutions. The major programmes the organization works on are: Participatory Groundwater Management (PGWM), Urban watershed programme through the PGWM approach, and developing a cadre of barefoot hydrogeologists or Bhujal Jaankars.[11]

Issue related to water

The Kutchch region in Gujarat receives a low rainfall of around 300 mm and has marine geological formations, metamorphosed limestone, and sandstone, with clay being a dominant material across the geological layers. According to the Founder and Director of ACT, Dr. Yogesh Jadeja, the geological setting in this region allows an infiltration rate of approximately 13 litres/second. Also, the proximity to the coastline causes seawater intrusion increasing the overall salinity of the water. The quality of water is not suitable for agriculture and many of the borewells ranging at a depth of 200-400 feet became defunct. Agriculture was largely rainfed before the interventions by ACT.

Process of engagement with communities

The major intervention of ACT is in the Kankavati aquifer that spreads across Abadasa, Mandvi, Mundra, and Anjar blocks. Currently, their efforts are concentrated in 19 villages in Mandavi and Mundra blocks. This initiative called the Kankavati Managed Aquifer Recharge through Community (K-Marc) began in 2010 in collaboration with Geo-science Service (GSS) and PARAB water management. The main activities carried out under this project were:

- Primary data collection of the biophysical and socio-economic parameters

[11] https://act-india.org/

- Preparation of maps – basic topography, village administrative boundaries, geological map, surface morphology, surface water resources map, watershed map.
- Aquifer mapping and preparation of the 3D model (As shown in Figure 5)
- Capacity Building – This has been one of the most important components for ACT where there are creating a local cadre of people from villages what they call 'Bhujal Jaankars' (BJs). These BJs or barefoot hydrogeologists are given intensive training to carry out all the village-level activities. These BJs have undergone intensive 45-day training and they train many other community members as well. The main criteria for selecting the BJs is by approaching the village panchayat, followed by an interview to check their interest and keenness to work at the ground level.
- Stakeholder engagement – The BJs are the main interface between the organisation and the village communities. ACT is working with the government to implement the Atal Bhujal Yojana (AbhY)[12] in the Kutchch district, therefore a complete orientation is given to the Gram Panchayat and the village communities. The BJs carry out the following activities in a participatory manner involving the village communities
    - Groundwater monitoring – regular monitoring of the water levels. In some places, the BJs are using digital water level recorder which has a sensor that sends data directly to the computer
    - Monitoring of the data from the automatic weather stations and rain gauges – this is currently done manually and then the information is entered in an excel sheet.
    - Monitoring of water quality, especially Total Dissolved Solids (TDS) with a portable digital TDS meter
    - Developing the water security plan with the help of the village communities
    - Flow measurements to monitor the crop water use
    - Conduct village-level meetings to sensitize farmers on crop water budget and water conservation practices

Brief Profile of the villages

Three villages were visited in the Mandvi Block – Mota Badhiya, Bidada and Tragadi. Table 3 below summarizes the basic information of the villages visited.

[12] https://ataljal.mowr.gov.in/

Table 3: Profile of the villages visited in Kutchch, Gujarat

	Mota Badhiya	Bidada	Tragadi
Geographic area	~ 440 ha	2760 ha	1450 ha
Population	~ 3200	~ 9500	~ 1300
Number of households	~ 650	~ 1950	~ 220
Average rainfall	300 – 400 mm	300 – 400 mm	300 – 400 mm
Major crops taken	Castor, maize, fodder grasses like alfa alfa and NB21, horticulture crops like apple ber (indian jujube) and pomegranate	Castor, wheat, fodder grasses like alfa alfa and NB21	Castor, cotton, wheat, fodder grasses like alfa alfa and NB21
Major water sources	Borewells, tubewells	Borewells, tubewells	Borewells, tubewells
Internet connectivity	Moderate to Good	Moderate to Good	Moderate to Good
Digital tools used	Excel sheet, whatsapp, google form	Excel sheet, whatsapp, google form	Excel sheet, whatsapp, google form

Insights

Overall Status of water

As mentioned earlier the salinity of the water is the biggest concern in the Kankavati aquifer which has rendered many borewell defunct. In villages visited, there are atleast over a 100 borewells that are defunct. The average TDS in this region has always been above 3000 mg/L. Therefore, water availability for irrigation is a less as it makes the saline water makes the soil infertile. Now under the ABhY, there is a systematic effort done to recharge the borewells. ACT is actively involved as an implementation partner in that.

Due to the sowing season, the farmers were extremely busy and we could not conduct village-level FGDs. However, the team met up with individual farmers at their farms with the help and coordination of the BJs. On the first day of the visit, in a meeting with the organisation, in the 19 villages where the organisation is concentrating its efforts at the

moment has created an informal forum called the 'Kankavati Bhugarbh Vyavasthapan Manch' (which translates to Kankavati Aquifer Management Forum). A few members of this forum from different villages were present for the discussion. These members mentioned how the 3D model helped them understand the behaviour of the groundwater within the Kankavati aquifer. While explaining the 3D model as shown in Figure 4, Dr. Yogesh Jadeja said that the model has been developed to show all the characteristics of the aquifer and at what levels in the water was found. One of the farmers at the meeting said that the dark black patch helped them understand the presence of a dyke in the aquifer. A dyke is a completely impervious formation in the aquifer that does not allow the lateral transmission of water as can be seen. The farmer said that it was initially baffling for them as to why water available a few feet away on one side of the dyke but not on the other side. Once they understood this nature, they were able to plan the water harvesting and borewell recharge structures accordingly. The farmers also added that they also learned where the clay layers are placed which also helped them understand the movement of the groundwater. This model though looks bulky, is extremely lightweight and the BJs carry it with them for the orientation and capacity-building programs.

Figure 4: 3D model of the Kankavati aquifer

One important thing that was observed, is that ACT has given importance to the measurement and monitoring of water and uses different instrumentation for it like the borewell water level sensor, flow meters, soil moisture sensors, and TDS meter. These instruments were given to different farmers as a part of their action research under the K-Marc project and also to build evidence. It was observed that one of the limiting factors for the excess use of water in this region is the salinity of water, therefore in a way, the farmers are forced to regularly monitor the water given in each rotation as it may affect the quality of the soil.

Also, within the villages visited it was observed that there was homogeneity with respect to caste. The only outlier was a small 'vasti' or hamlet of women from Mota Bhadhiya who mentioned that sometimes they faced difficulties d difficulties is getting their grievances and issues resolved. This group of women with whom ACT is working are either widowed or divorced or single. These women are practicing agriculture mostly cultivating castor, fodder grasses ad also have kitchen gardens. From the perspective of equity related to distribution and use of water, the team cannot say anything concrete. The collective efforts by the community are currently from the supply-side that is in terms of recharging defunct borewells.

Figure 5: Discussion with the farmers sharing a common borewell and practicing PGWM

Local Institutions

ACT works with Gram Panchayats. However, within the Gram Panchayat ACT has been working with clusters of farmers as a part of their action research. They worked closely with a cluster of 14 farmers that are sharing groundwater through common borewells. They have installed flowmeters for every individual farmer as shown in Figure 5 on the shared common borewell. The chart helps them keep a record of the amount of water consumed for each season. This way they are able to optimize the water use. In a discussion with the farmers, they said that they regularly record the flow meter reading before and after the irrigating their field which gives them the exact volume of the water consumed. The farmers are also, recharging their defunct borewells for source

augmentation and trying to optimize water use by continuous monitoring in a participatory manner. This data is also recorded by the BJs.

Where the farmers are accurately measuring the water consumed, they are also trying to optimize water consumed by monitoring soil moisture. One such farmer we met was Shri. Mohan bhai from Mota Badhiya. He has been able to reduce the irrigation rotations given to his wheat from twelve to eight by just regularly measuring the soil moisture. In his 2.5 acres of land, he was able to produce 45 quintals of wheat. Shri. Mohan Bhai also told us that they have a farmer's organisation called the 'Bharat Kisan Sangh'. The group conducts meetings regularly to discuss which crops should be taken, optimize water use, and how to improve soil quality. They have a WhatsApp group on which the information is shared. He also uses Windy, an application to get all the meteorological information.

The farmers have also developed their innovations (not digital) which they are using for optimizing water use. One example of that was Shri. Amrut Bhai from Bidada village. He has immense knowledge and experience in farming practices that he has devised his own technological devices to measure the amount of water for his crop intake, despite having no prior technical background. Shri. Amrutbhai has installed a simple cylindrical tube at one of its drip holes to measure the amount at which the drip pump has to be stopped. He initially got soil quality tested and after many experiments concluded that till the cylinder fills up to 3 litres, all his apple ber plantations receive a good amount of water, till the next rotation after a period of 4-5 days. He says, water budgeting goes beyond the mathematical equation and one needs to incorporate observations and experience for better water-saving practices. It is all about improving water efficiency practices. Besides the drip, Amutbhai has designed a vermicompost plant, which automatically collects the vermiwash in a tank below, which he has connected to the 'apple ber' plantation.

Largely through different interventions especially of repair and recharge of defunct borewell in all the three villages through participatory groundwater management they have been able to manage the TDS and also have been able to reduce is from 5000 ppm to 2600 ppm. This has been able to bring more area under irrigation and also grow fodder crops like alfa alfa and NB21. These crops not require less water but have better nutrient value and good for their livestock. This has increased their milk production and provided additional support through these allied livelihood activities. It was found to be especially useful for a group of women in Mota Badhiya village. A Self-Help Group (SHG) has been formed through ACT's intervention who are promoting kitchen garden along with fodder crop cultivation among these women.

ACT is now in the process of developing a digital application, where the app will be used to make information like water tables in groundwater, water budget for the village, and

an advisory section, wherein the farmers can make use of the data and take informed decisions to manage water for their crops. For this, they are collaborating with IIT Mumbai and a new start-up in Bengaluru to monitor the surface water quality. Currently, the BJs are now adding the data online in a google sheet. Though the use of digital tools is minimal right now, mostly in form of google forms and excel sheets which are tabulated by the BJs, there is a system in place for the measurement of the parameters accurately by the farmers themselves using various instrumentation. Therefore, once the app would be introduced, it appears that it would not be very difficult for the farmers to adapt and use the app as the farmers in Kutchch appeared to be more open to the use of new technology and innovations.

Case Study 3: Gram Vikas: Springshed management in Gajapati district using mWATER, Odisha

About Gram Vikas

Gram Vikas is a non-profit organisation based in Odisha that works with communities, especially the Tribal groups around issues related to water and sanitation, access to clean and safe drinking water, migration, education, securing livelihoods, and so on. The organisation has been working in Odisha for the last four decades, beginning since the late seventies.

Issues related to water

The region receives very high rainfall, however, due to high slopes because of the eastern ghats, most of the water drains down. Agriculture is mainly practiced in the monsoon and is largely rainfed. The community here used to initially (and traditionally) practice slash-and-burn agriculture (shifting cultivation). This practice was largely for subsistence. However, deforestation in the region led to the decline of the springs. This led to water scarcity post-monsoon for even drinking and domestic needs. Many people from the region migrate to Kerala and Gujarat as labourers as the income from agriculture is not sufficient. With the current springshed management program through the intervention by Gram Vikas, the springs in the region are being mapped, rejuvenated, and protected by conservation of forests in the upper catchment.

Process of engagement with communities

The SOPPECOM team visited the Gram Vikas project site to specifically understand the use of the mWATER[13] application for making the communities sustainable in water management by making water security plans, through its Water Security Gram Panchayat Program. The reason behind this was the SOPPECOM has used mWATER for – i) conducting an intensive socio-economic survey of over 25000 households and ii) Mapping all the wells (close to 16000 wells have been mapped) in Atpadi block, Sangli district. Therefore, the purpose of this visit was also to learn from Gram Vikas's water resources team and explore the possibility of use of mWATER for the SEWOH lab action research.

Gram Vikas is currently executing the programme in 27 Gram Panchayats across 5 districts, namely, Ganjam, Gajapati, Kandhamal, Nayagarh, and Kalahandi. The preliminary plan is to build an inventory of all the water sources in every village with the help of the community. Thus, the aim is to build a database knowledge system to to be able to make the communities understand springs and groundwater in their region.

[13] https://www.mwater.co/

For the implementation of the Water Secure Gram Panchayat Programme the following approach is taken:

- The geographic unit taken is Gram Panchayat
- The institutional platform is the Gram Sabha
- Larger stakeholder engagement through the convergence of local institutions with local governments
- Effective utilization of the existing skills and social capital in the communities
- Leveraging government programmes – Jal Jeevan Mission, Swach Bharat Mission, and MGNREGS
- Data-based planning
- Elucidation of natural resources science and technologies at the community level
- Capacity building so that the communities themselves can manage their resources

Gram Vikas has formed village development committees (VDCs) in every village, which is a committee of five men and five women. These VDCs work with the field experts, and the thematic coordinators appointed by Gram Vikas on issues related to the water problems in the village. The process followed is summarised below:

- *Preparation of the resource map* – The resource map is prepared by field-level experts with the help of the VDCs. Transect walks are conducted to understand all the biophysical characteristics. All the water sources are mapped using mWATER. Hydrogeological mapping is also carried out by understanding the characteristics of springs. All the historical information is also collected from the village to understand the nature of the sources.
- *Aquifer(s) mapping* – The information collected from the transect walks and discussions with the communities is then converted into an aquifer map at the village scale. Recharge and discharge areas are demarcated on the map and the number of aquifers within the village are also determined. With the help of the geolocations and other marked features, the aquifer map is created in GIS software and its area is determined. Based on the hydrogeological parameters the storativity and transmissivity of the aquifer are determined.
- *Monitoring and measurement* - The VDC appoints a cadre from the village, who then undergoes training with Gram Vikas. The cadre is given training to measure the water levels from different water sources using mWATER application. This data is collected weekly and then Gram Vikas makes assessment of this data.
- *Deriving the water passbook for the village* – Based on the pre monsoon and post monsoon water level measurement, a water passbook is created. A water pass book basically gives the amount of water available in the aquifer after the monsoon season. This water passbook is shared with the Gram Panchayat

through the VDC. The VDC through the gram sabha then take decisions on the planning and management of the water depending on the availability

Profile of the villages visited

As mentioned earlier, Gram Vikas is working with mostly tribal communities in the remote regions of Eastern Ghats. Though the road network is good the villages are spread afar and therefore it was possible to only visit one village called Anusahi. Table 4 summarizes the profile of the village. Gram Vikas began its work in Anusahi in 1993 through their drinking and sanitation programme.

Table 4:Profile of the village visited in Gajapati, Odisha

	Anusahi
Geographic area	~ 250 ha
Population	~ 300
Number of households	~ 50 to 60
Average rainfall	1900 mm
Major crops taken	Paddy
Forest Area (Through community forest rights)	1000 ha
Forest Produce	Cashew, teak, amla and mahua
Major water sources	Springs tapped through 'chuans' (small dug out cisterns), wells
Internet connectivity	Poor
Digital tools used	mWATER

Insights

The work in Anusahi though began under the drinking and sanitation program it has eventually evolved into a Water Security Gram Panchayat Programme under which the village is trying to conserve the springs in the village. One peculiar observation about this village was that 100% of the population accepted Christianity as their religion and therefore there is homogeneity in the village. Also, since the number of households is less it is far easier to build consensus for the implementation of programmes. As there was a religious programme in the village, unfortunately, we could not conduct an FGD in the village, however, the team got a chance to have an in-depth discussion with the sarpanch and also the members of the VDC. The village cadre that was appointed by the VDC which is termed as 'jal bandhu' was also interviewed to understand his/her responsibilities.

The most important source for Anusahi is a perennial spring that is located deep into the forest. The village has collectively taken the responsibility of protecting the spring. The mWATER app has been installed on jal bandhu's phone. Each of the water points for example a well or a 'chuan' has been geotagged and converted into a site (a feature in mWATER that allows monitoring of the water point at regular intervals). The 'jal bandhu' monitors all the sites weekly. For example, if it is a spring, the spring discharge is recorded or if it is a well, the water level is recorded, etc. The advantage of using mWATER here is that it works well in offline mode, so all the information about the site can be added, and once the 'jal bandhu' reaches a place where there is internet connectivity all the data gets synced to the cloud. Therefore, updating the records is not an issue. However, the issue in this region is that of the GPS signal. The GPS signals are weak and can affect the accuracy of the location of the site. This is not necessarily an mWATER problem but the geographical disadvantages of the place itself. For that, some manual recordings have also been taken so that locations can then be triangulated later with the help of satellite images.

Also, here the 'jal bandhu' is a person appointed by the village. The VDC is responsible for paying the salary or the remuneration for the time given by the jal bandhu. Therefore, this way it can be made sure that this is a self-sustaining position even beyond the project period or after Gram Vikas withdraws from the village.

The farmers are currently practising largely rainfed agriculture. 100 ha of the village is under paddy cultivation largely in a terraced drainage area of the village as can be seen in Figure 6 Currently, water availability for rabi season is only for growing a few vegetables, that too in the fields of those people who are in the proximity of discharge points with base flows. However, now on higher slopes through bunding and soil and water conservation structures, a few plantations like lemons, oranges, pineapples, and bananas have also begun.

Figure 6: Terraced paddy cultivcation practised on the drainage line

The concept of the water passbook is similar to the bank's passbook which gives information on savings and expenditures. At the start of the post-monsoon season, total water availability is derived (currently by the water resources team and Gram Vikas) and then given to the VDC. The VDC calls for meetings within the Gram Panchayat to discuss how water use should be prioritized after securing the drinking and domestic needs. The water passbook derived from Anusahi village is shown in Figure 7.

At the moment the water passbook is largely being used by the villagers to see if the available water is enough to meet their domestic needs. Post kharif harvest many people from the village migrate as seasonal labourers and therefore currently there are not many livelihood options for the people in the village. How mWATER can be used to create data and evidence through continuous monitoring is something that would require time. This would hopefully then eventually lead to the implementation of programmes and policies to develop more livelihood options for the seasonal migrants.

Head	Unit	Quantity
Village Name		Anusahi
Gram Panchayat & District		Khajuripada, Gajapati
No. of HH		
Aquifer Material		Weathered White Rock material
Aquifer Area (A)	sq. m	300742
Aquifer Thickness (T)	m	8.8
Ground Water Level_bgl	m	
Post Monsoon 2021	m	2.94
Pre-Monsoon (May 15, 2022)	m	6.1
Post-Monsoon (Nov 22, 2022)	m	3.2
Average Water Level Drop (Δwl)	m	3.06
Total Water out of aquifer (Q)	cu. m	18909.80
Evapotranspiration (ET)	cu. m	12639.50
Total Natural Discharge (ND)	cu. m	2332.8
Total Abstraction (Ab)	cu. m	3937.5
Storativity (S)		7.24%
Water Availability (WA) - As on Nov 22, 2022	cu. m	121865.14

Figure 7: Water passbook for Anusahi village (Source: Gram Vikas)

Currently, Gram Vikas is trying to work with ICFOSS14, an agency affiliated with the Kerala government, that is creating open-source software and digital tools for different applications. Currently, they are collaborating with Gram Vikas to provide automatic weather stations. Through the open networks this information would be shared with the Gram Panchayats.

14 https://icfoss.in/

Discussions

The case studies provided good insights into different efforts taken by the three different organisations to bring about good water governance with the help of digital tools. Though these organisations have been able to build a good rapport with the communities, the whole concept of digitalisation is fairly new for the communities to grasp quickly. Grounding these tools requires a lot more effort because there are many constraints right from poor internet connection to owning a smart phone. Despite these challenges, it can be said that there have been significant efforts taken to ground the tools in a way that can aid the communities in better water governance. However, some implications that require consideration before making a choice of any digital application are discussed below. Some good practices that were observed are also discussed in detail.

Need based assessment for grounding the tools and strong local institutions

From all three case studies, it was evident that the use of the tools by the communities themselves was minimum. The communities at all the project sites are highly dependent on the project staff in form of CRP/ bhujal jankaar/ jal bandhu, etc, to maintain records and also to provide them with the information. Even in the most preliminary format like filling up a google form and sending it to the organisation, the information was collected by project staff. Therefore, in its current form, the use of digital tools is more NGO-driven than community-driven. The need for the development of digital tools has not really come from the ground or the communities themselves but is something that the NGOs have developed largely for – i) their understanding of water and other natural resources ii) ease of data collection and iii) better visualization and quicker interface with other digital formats like excel and GIS based software. So though each of these tools has its benefits and capabilities of being able to provide good decision support, they require tremendous hand-holding effort. One has to be prepared to provide good and constant on-field support to see these tools being used independently by the farmers.

For tools like water budget apps, the accuracy of the results is highly dependent on the quality of the data. Therefore, the participation of most of the farmers in the village is a critical factor. Also, the tool has to be in a form that can be easily used by the farmer. Water budget apps are too complicated for farmers to use on an individual basis. That can be only done at the level of a local institution as the larger data related to all the local water sources would be available only at that level. At the farmer level, there needs to be a simpler process. To understand what suits farmers the most it would be good to carry out a need assessment survey. For example, for the Water Users Association formed under the MMISF Act 2005, the most basic requirements are of getting the

information on - i) the total water allocated in a particular year to the WUA depending upon the total water availability in the dam, ii) the water demand raised by each farmer under for a particular season iii) record of the water tariffs paid by farmers. Therefore, the digital app should be mostly created understanding the systems on ground, rather than trying local systems trying to adapt to the functions provided within the applications. This was also observed by Samuel et al (2022) where certain features within a particular digital application analysed were redundant as the communities did not feel the need of using it.

Having said that, even if a digital tool that suits the needs of the farmers was provided to them, to what extent would farmers participate in regular monitoring of water use, etc? In all probability, it would be highly inconsistent. Either the farmers would have to be incentivized in some way so that they involve themselves in the process or there needs to be a local institution backed by some legal framework.

In the case of the pilot action research site, this is possible because, under the MMISF Act, the legal institution is a Water User's Association and all the laws and rules are binding for all the members of the WUA. Therefore, the onus of filling up the crop water requirement and monitoring the water use would be on the farmers. This can be done using very basic digital tools.

Digitalisation of status-quo

From the previous study by SOPPECOM (Samuel et al., 2022) it was seen that largely digitalisation diluted participatory processes. Also, certain sections of the society like the landless largely remained devoid of any sort of digital information related to water or natural resources. From this study, nothing concrete can be said about the digital divide within the communities and the access to digital information. It was observed that the communities in the villages were fairly homogenous and therefore there was information sharing.

Need for a technical person at village-level for the using the digital tools

In continuation to the earlier point, one thing that was common in all three case study sites was the approach taken for grounding the digital tools as shown in Figure 8.

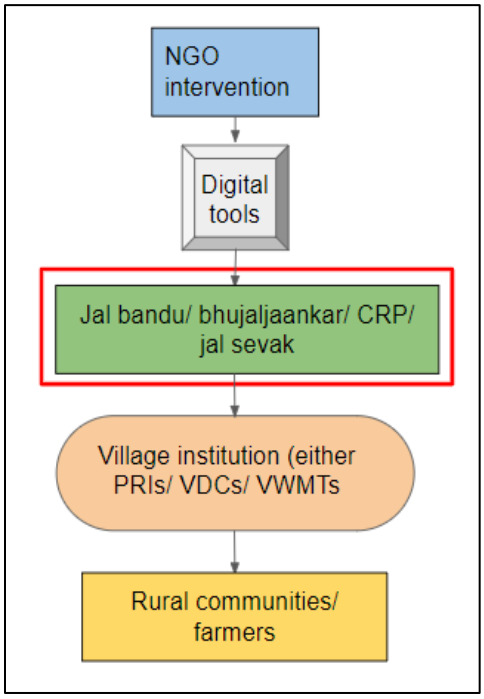

Figure 8: Process of grounding digital tools at ground level

Here,the emphasis is on the role of the jal bandhu/ BJ / CRP / jal sevak. Essentially, they have been the most important interface between the village communities and project implementers. During the project phase, the village-level cadre is doing the job of collecting information and data and also giving it back to the communities very efficiently. However, how does one ensure post-project sustainability? Either the communities would have to take ownership of the project and maintain the records themselves or continue the recruitment of the staff appointed under the project under the Gram Panchayat funds. This was seen in the case of Gram Vikas, the village-level cadre is appointed by the VDC and is directly paid by the village through individual contributions. This to a certain extent can ensure post-project sustainability, at least till a point where some of the prominent members of the village Gram Panchayat and/ or other institutions like VDC or VWMTs, and even SHGs understand and adopt the digital tools. But there is need for a village level technical staff that can provide support to the farmers and this has to be a paid position.

Technical support and back up

One important implication concerning the use of digital technology is that of technical support and data backup. The communities largely interact with only the user interface of the digital tool. They do not have much idea about what processes at the back end are driving the tools. There could be different issues related to the software systems

that would need maintenance, data backups, fixing of bugs, etc. from time to time. How does one ensure that there would be a good technical backup available to these communities either free of cost or at concessional rates? In the case of mWATER, since it is a global open-source software, that kind of support is available. That may not be the case with digital tools that are developed by for-profit companies and start-ups as they have contractual arrangements with NGOs. Therefore, reliable open-source networks need to be explored if one expects long-term use of digital applications. The second aspect related to the digital apps is the ownership of the data. Currently, except for the open-source datasets, the ownership of the data largely remains with the implementing agency and the developers. The data ownership has to remain with the communities.

Role of instrumentation in digital tools and applications

It would be interesting to discuss the concept of digitization here to understand the role of instrumentation in digital processes. Digitization is a process where any analog signal is converted to a digital form that can be readily used. For example, a discharge through a pipe would be converted into rotations per minute of a turbine which in turn would be calibrated to a proportionate volumetric flow in the form of a digital read-out. This is exactly where the role of sensors and instrumentation comes in handy. Instrumentation plays a key role in creating data and a body of evidence for water management. This was observed in the case of ACT's project site. The use of sensors has accurately aided the farmers to understand the crop water requirement and also make decisions based on that. As the process is largely digitized, the farmers do not have to put their efforts to measure and monitor each parameter separately and even calculate it. A record of this digitized data can then be directly entered into the digital applications. Though sensors are accurate and efficient. For the action research, it could be interesting to see if a sensor like the soil moisture meter could be made available to the Water Users Association. This could be one instrument that can be shared among the farmers and can be useful in conserving water by effectively making use of the greenwater component in the soil.

Individual vs collective actions

Ultimately, water governance all boils down to individual crop choices by the farmers. Even if farmers work collectively towards the conservation of water, once there is surplus water in the village, farmers go lax on water budgeting and crop water use and go for water-intensive crops as they have high returns. This was seen in the case of one of the villages in Bhilwara and also during the visit to one of the villages in Maharashtra for the analysis of the Water Stewardship Initiative by WOTR. There are extremely few examples like the Hivare Bazaar where communities have been collectively deciding the cropping patterns for their village. However, the case of Hivare Bazaar has a very poor chance of being replicated elsewhere. Hivare Bazaar has a distinct social homogeneity that is rarely found in the other rural areas of Maharashtra.

There needs to be a systematic restructuring of the irrigation systems or even aquifer systems for that matter on equitable lines such that the quantum of water used remains the same for all irrespective of the crop taken. This would ensure that there is the optimal use of water taking into account the livelihood needs of all the people. This would require a different level of engagement and efforts by the NGOs with the community. Without such a system in place, no farmer would take a conscious decision of cultivating less water-intensive crops and would eventually put forward his/her own economic needs against overall water availability.

Conclusions

The three case studies provided some good insights into the applications of digital tools in water management and governance. There is no doubt that digital technology can be a game changer when it comes to sharing data and information at a mass scale and at the right time.

With advanced technologies, there are offline modes available for digital tools too. This can work well, especially in very remote areas with limited internet connectivity. The architecture and the interface need to be as simple as possible such that they can be used by a maximum number of people in the villages. If possible, there should be an option of being able to provide and get information through text messages, especially for those who don't have a smartphone. To ensure post-project sustainability, the digital tool needs to be hosted on an open-source platform so that the data can be accessed at any point and also a network that can provide tech support to the communities if possible free of cost. There is also a need for full-time staff, recruited by the local institution who can act as the interface between the farmers and the local institutions. The use of sensors and instrumentation not just for also accurately monitoring the crop water use but also for building a body of evidence on optimal water use through good agronomic practices should be considered.

Lastly, cropping patterns are largely individual choices and these cannot be easily transformed through mere sensitization of the people. Though people understand the implications of their individual actions, they eventually prioritize their own economic needs. Such transformations need a backing of a good system that can govern water on equitable lines beyond the individual needs of the farmers. Else, we will keep missing the forest for the trees.

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Annexure 1: Interview guide used for the case studies

Generic information collected from the NGO at project level

Profile of project areas:

Name of villages where the project is implemented:

Total geographical area:

Population:
Number of households:
Communities/ caste composition:
Religious composition

Internet network: good/ moderate/ poor?

Land use

Land use type	**Before intervention**	**After intervention**
Grassland/ shrubland		
Fallow land		
Irrigated land		
Rainfed land		

Major sources of irrigation:

Source	**Number of sources**	**Area under irrigation**
Surface Irrigation projects minor/ major/ medium		
Tanks/ lake /ponds		
River Lift irrigation/ surface water bodies		
Wells		
Borewells		

Crops:

Major crops	**Before intervention**	**After intervention**
Kharif		
Rabi		

Summer		
Two-seasonal		
Annual		

Questionnaire for the community:

- Describe the situation related to water and agriculture in your village before the intervention
- (water use/ irrigation and crops taken) and what were the water management problems and issues faced by village?
- What is the current situation of groundwater in your village or villages that share a common aquifer?
- Was the aquifer mapped in your village? Was the village community involved in the mapping of the aquifer?
- Has the village developed a water budget?
- What is the method used for the determining the available water (water budget)?
    - Who participates in measuring water availability? Is anybody left out in this process?
    - Do you use any digital tools for collection of rainfall, groundwater and surface water? If digital tools: who collects the data and who processes, uses and owns the data?
    - How are water use plans currently being developed and implemented?
- How is the cropping pattern decided? Do you take into account the water availability for that? What is the methodology/ approach you are using to determine that?
- How did you learn the process of crop planning based on groundwater availability? What were the challenges faced?
- Is there any local institution in form or WUA or water management committee that looks after the management of the water? If not how is the water managed?
- What was the process for the formation of the committee?
- What are the specific roles of the managing committee members? Does the committee meet regularly?
- What are the rules and regulations set by the committee for water use and management within the village/ aquifer? Are these rules decided by the consensus of the village and how? How is the collected water data informing this process
- What were the challenges faced while implementing all these processes and elements related to water management?
- Have there been behavioural changes in the farmers in the way they use water (demand side management) – efficiency of water use, cropping patterns, agronomical practices, etc.
- What were the impacts and benefits? Has it assured water and livelihood security?

- Do you think this process of water governance is appropriate and should be continued in future? Or do you think any changes need to be made? If any, what?
- Do you feel that the way you are managing the water will help you cope up with changing climate and other external drivers/ stressors?
- Are there any digital tools that are being used for data collection, monitoring, working out crop and water management?
- Are these helping in the decision support for the management of water?
- If not do you think where would it be useful to use digital tools to improve the efficiency of the water management?
- Do farmers in this area use smartphone, and if so, how/ for what purposes?

Questionnaire for the NGO:

- Since how long have you been working in the region?
- According to you what are the major issues related to groundwater management in the region?
- How did you select these villages for the interventions (what were the deciding criteria)?
- What was the process followed to approach the people in the village for the intervention? How did the people reciprocate?
- What was the method used for determining the groundwater availability and aquifer mapping?
- While using this method to understand the groundwater and aquifer what was the extend and form of involvement of the village communities?
- Have you developed a process for water budgeting? What is the method you are following?
- Did you conduct any awareness building/ capacity building programs before implementing the model? What specific capacity building programs were conducted to make people aware about the issues related to water management, agriculture and livelihoods?
- What were the difficulties did you face in process? (example hint: both as capacity of the organization, hesitance from the community etc)
- What was the role of the NGO in helping the community in determining the cropping patterns? To what extent does it match with the water availability?
- Have you used digital tools in your interventions? Which tools?
- If not do you think where would it be useful to use digital tools to improve the efficiency of the water management?
- How do you visualize the future (post project sustainability)?