Report on
Participatory groundwater management to address water scarcity due to climate variability

Submitted by:
Grass Roots Action for Social Participation (GRASP)
Aurangabad, Maharashtra, India

Submitted to:
India Water Partnership (IWP, Gurugran (Harhana), India

December, 2023

Abbreviations and Acronyms

CCA	Climate Change Adaptation
CSO	Civil Society Organisation
CSR	Corporate Social Responsibility
FFS	Farmers Field School
FGD	Focus Group Discussion
GoI	Government of India
GoM	Government of Maharashtra
GRASP	Grass Roots Action for Social Participation
GSDA	Groundwater Survey and Development Agency
GWP	Global Water Partnership
ICT	Information and Communication Technology
IWP	India Water Partnership
KVK	Krishi Vigyan Kendra
LEISA	Low External Inputs Sustainable Agriculture
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NABARD	National Bank for Agriculture and Rural Development
PRA	Participatory Rural Appraisal
SDG	Sustainable Development Goal
SHG	Self Help Group
SWC	Soil and Water Conservation
VWMC	Village Water Management Committee

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Acknowledgement

Grass Roots Action for Social Participation (GRASP) is grateful to India Water Partnership (IWP) and Global Water Partnership – South Asia (GWP-South Asia), for supporting this endeavour to empower rural communities to manage their own water resources. We would like to place on record our gratitude and appreciation to Dr. Veena Khanduri, Executive Secretary-cum-Country Coordinator (IWP) and her team comprising Mr Mangla Rai and Mr Neeraj for constant support and guidance in completing the project mandate.

GRASP would like to express gratitude towards the experts and subject matter specialists from Marathwada Sheti Sahayya Mandal's Krishi Vigyan Kendra (Kharpudi, District Jalna), Geo-Forum (Aurangabad), Department of Geology, Rajashree Shahu Arts Commerce and Science College (Pathri, District Aurangabad) and several independent experts who extended their timely support to the project, especially in terms of building capacities of the community and the committees and providing on-site guidance on pertinent technical matters.

GRASP would also like to place on record the valuable contribution of Prof P S Kulkarni, retired Head of Geology Department, Maulana Azad College, Aurangabad and Dr P S Salve, Retired Joint Director, Groundwater Survey and Development Agency (GSDA), Government of Maharashtra, Pune in the aquifer assessment study.

Internally, GRASP is thankful to Mr Yugandhar Mandavkar, Chairman and Mr Sanjay A Nagesh, Secretary, for their untiring support and guidance at various stages of planning and implementation of the project.

Finally, and most importantly, GRASP is grateful to the community from the project villages for sharing their concerns, aspirations and valuable inputs, without which this project could not have been completed.

Executive Summary

The initiative

Grass-Roots Action for Social participation (GRASP), a Civil Society Organisation, was established in 1992 to empower rural men and women and to professionalise the process of rural development at the grassroots by providing an interactive platform for the stakeholders. GRASP initiated this project in 2022 with a goal of increasing resilience of smallholder farmers against climate variability through participatory groundwater management. It was supported by IWP and GWP-South Asia under their global theme of "Climate Resilience through Water". After successfully completing the first phase, the project got an extension for two years, and the second phase was sanctioned for the year 2023.

Achievements

The project could achieve the following deliverables by the December 2023.

- Five Water Management Plans were prepared by Village Water Management Committees (VWMCs) based on village wise water budgets. These plans will be upgraded as Adaptation Plans in early 2024 based on aquifer mapping and then presented in the Gram Sabha for adoption.
- Crop plans were prepared by the farmers groups in each village of the 5 project villages for the last summer season and 5 for the current winter season.
- In all, 107 farmers adopted climate smart agricultural practices, including 19 installed new drip units under convergence and their own investment.
- In all, 288 farmers were trained in climate smart agricultural practices, out of which 220 formed FFS groups.
- Aquifer delineation and mapping was carried out in all five project villages. This will form basis for preparing Adaptation Plans in the coming months in 2024.
- Ten youth and fifty farmers trained on groundwater assessment are monitoring well water levels on seasonal basis.

Future Plans

The project will work towards building resilience against climate variability through participatory groundwater management through VWMCs. Their capacities will be built on water use and governance, advanced aspects of groundwater and climate change adaptation measures. The project will work for mobilising convergence through Gram Panchayats for water augmentation and groundwater recharge.

1. Project Background

1.1 About the project

As a part of the larger initiative on "Climate Resilience through Water" of the IWP and GWP-South Asia, Grass-Roots Action for Social participation (GRASP) launched in 2022 a project with a goal of increasing resilience of smallholder farmers against climate variability through participatory groundwater management in 5 selected villages of Fulambri Block, Aurangabad District, Maharashtra. During the first year, VWMCs in each project village were formed and village level water budgets and collective crop plans were prepared. In order to sustain these results and have a lasting impact, IWP and GWP-South Asia decided to extend the project by another two years, granting support for one year at a time. This report covers the work carried out and its achievements during the year 2023.

1.2 Project Objectives

The overall goal of the project was increasing resilience of smallholder farmers against climate variability through participatory groundwater management. The project worked on mobilising community, building awareness on aquifer and groundwater use and formed of VWMCs during the last year. The main objectives of the interventions in the second year (2023) were:

- To strengthen the VWMCs to undertake the role of water governance;
- To capacitate youth to anchor and steer the water stewardship processes; and,
- To plan and implement scientific adaptation measures, including water augmentation and groundwater recharge, based on assessment of aquifer and its characteristics.

1.3 Project activities

The project carried out the following main activities during the year 2023.

- Training to farmers through Farmers Field Schools (FFSs) for water saving in agriculture.
- Demonstration of Climate Smart Agricultural technologies to farmers.
- Assessment of aquifer characteristics and delineation with hydrogeological surveys in five project villages.

- Hands-on training of VWMCs for their capacity building on water management planning.
- Planning done for formulating comprehensive water management plans, including water augmentation and groundwater recharge in the five project villages.

The progress of the project and its achievements are presented in this report. The next section describes the activities carried out, followed by the results achieved in terms of main outputs and outcomes.

2. Project Activities and Achievements

This section describes the progress of various activities implemented and the results achieved during the year 2023. It presents the details according to the main outputs and outcomes achievements.

2.1 FFS for water saving in agriculture

2.1.1 Purpose

Farmers Field School (FFS) is a proven approach to address the technological problems of the farmers with respect to specific crops in a given season. It has been used the world over for dissemination of knowhow, mutual learning and for participatory technology development. The project adopted this approach with a view to help farmers assess and choose various techniques for water saving and improving the productivity.

2.1.2 Activities conducted

Project village-wise and date-wise details of FFS Sessions conducted for farmers both for Kharif and Rabi seasons are given in Table-1 below:

Table 1 : Details of FFS Sessions

S No	Village	Kharif farmer participants		Dates of sessions	Rabi farmer participants		Dates of sessions
		Women	Men		Women	Men	
1	Adgaon	5	15	11 May, 15 Jun,15 Jul	7	14	16 Nov, 22 Dec
2	Murshidabadwadi	6	16	9 May, 22 Jun, 3 Aug	5	14	17 Nov, 23 Dec
3	Ranjangaon	3	15	9 May, 21 Jun, 29 Jul	6	12	11 Nov, 19 Dec
4	Sultanwadi	6	12	17 May, 19 Jun, 1 Aug	4	13	12 Nov, 20 Dec
5	Vitthalwadi	7	11	8 May, 23 Jun, 3 Aug	4	11	17 Nov, 24 Dec

2.1.3 Brief Description of FFS

GRASP formed two FFS groups in each village, one each for the prominent crops in Kharif and Rabi season. Cotton was chosen as the main Kharif crop and wheat as Rabi crop, as these are the main crops of Marathwada region. In each season, three FFS sessions were conducted – one before sowing, the second one in the mid-season and the third one before harvesting.

In the **pre-sowing sessions**, guidance was provided on preparation of land, where the farmers were advised to use minimum tillage and recycling the agricultural residues. This session also discussed about the use of organic manures. These sessions were followed up by demonstrations of locally manufactured various organic manures. There were also discussions on selection of varieties, in which the farmers shared their experiences of using various varieties in the past.

Demonstration of organic formulation in village Murshidabadwadi

Expert guiding on Bee-keeping at KVK, Gandheli (Aurangabad)

Demonstration of marigold as trap crop at KVK, Gandheli (Aurangabad)

Training on Integrated Pest Management (IPM) in village Ranjangaon

The **mid-season sessions** were conducted at about 40-45 days after sowing. The focus was on managing the moisture stress. Incidentally, the entire project area experienced long dry-spells after sowing, resulting in a severe drought situation. The farmers were guided on using mulching with farm waste, foliar spraying of nutrients (2% urea spray) instead of soil application, and use of drip irrigation, wherever possible. These sessions also covered the topic of pest and disease management in arid conditions in the respective crops. The farmers were guided on the methods of Integrated Pest Management and Natural Pest Management (IPM and NPM).

As the yields have been seriously affected by the drought conditions during the Kharif season, the **end-season sessions** covered the topic of harvesting, and more prominently, of planning water use in the following rabi season.

2.1.4 Outputs and outcomes

These FFS sessions conducted with over 100 farmers covered various aspects of crop production and protection technologies, which helped them take the right crop management decisions at every stage of the crop. During the process, the farmers shared among each other low cost and effective methods of controlling basic pests and diseases using organic formulations and water conservation in times of stress. As a long term outcome, the farmers developed a regular habit of visiting their fields and monitoring of crops, pests and diseases.

2.2 Demonstration of climate smart agricultural technologies

2.2.1 Purpose

Various climate smart technologies are available to farmers in drought prone areas, but their adoption is limited due to inadequate extension. This activity was taken up with a view to appraise the farmers of the correct knowhow and method through on-site training and demonstration.

2.2.2 Activities conducted

Three main technologies were identified which were most suited for the main crop, cotton, in the project area. These are vermi-compost, Integrated Nutrient Management (INM), and Integrated Pest Management (IPM). Sample collection method was demonstrated in villages Ranjangaon and Adgaon, after which the sample collection was carried out. The details of soil testing and demonstration given to farmers on climate smart technologies are given in Table-2 below:

Table 2 : Details of Demonstration on Climate Smart Technologies

S No	Village	Soil Testing	Integrated Pest Management	Vermi-compost
1	Adgaon	8 May (6W+14M)	10 Aug (20 M)	20 Sep (6W+14M)
2	Murshidabadwadi	15 May (5W+10M)	12 Aug (25 M)	10 Sep (9W+16M)
3	Ranjangaon	25 May (10W+15M)	24 Jul (10 M)	19 Sep (10W+15M)
4	Sultanwadi	20 May (7W+10M)	25 Jul (15M)	15 Sep (5W+10M)
5	Vitthalwadi	16 May (2W+8M)	3 Aug (5W+20M)	11 Sep (4W+6M)
	Total	**30 W + 57 Men**	**5 W + 90 Men**	**34 W + 61 Men**

S No	Village	Int. Nutrient Management 1	Int. Nutrient Management 2
1	Adgaon	7 Jun (10W+20M)	29 Jul (22 M)
2	Murshidabadwadi	10 Jun (5W+10M)	4 Jul (20 M)
3	Ranjangaon	15 Jun (30W)	14 Jul (17 M)
4	Sultanwadi	22 Jun (8W+16M)	9 Jul (10 M)
5	Vitthalwadi	12 Jun (10M)	3 Jul (15 M)
	Total	**53 women + 56 men**	**84 Men**

2.2.3 Brief description

The following three main technologies were demonstrated in the project area.

- **Vermicomposting** is a biotechnological composting process that uses certain earthworms to enhance the process of biomass waste conversion to produce good-quality compost. GRASP demonstrated a simplified technique of producing this compost with higher nutrient contents in all 5 villages.
- **Integrated Nutrient Management :** focused on use of locally manufactured formulations of solid and liquid micro-nutrient supplements in form of *Jeevamrut*, an organic formulation.
- **Integrated Pest Management :** included cost effective measures like seed treatment with Trichoderma, fixing of Pheromone traps and lures, sticky traps, sprays of neem seed extract and other organic formulations, etc).

Demonstration of harvesting of worms in village Ranjangaon

Experts guiding on manufacture of organic manures at KVK, Gandheli (Aurangabad)

Worms harvested

Women's group manufacturing organic formulations in village Sultanwadi

In addition to the above, there was a field level follow up and handholding support provided by GRASP team and experts from KVKs and government line departments. During their visit, various techniques of climate smart agriculture were explained to the farmers; these included :

- **Irrigation scheduling :** to determine the appropriate amount, timing, frequency and duration of watering based on weather forecasts, soil moisture, and plant conditions.
- **Conservation tillage :** comprise techniques of reducing soil erosion, conserving water, and enhancing soil health, which are important in times of limited water availability or frequent drought conditions.
- **Compost and mulch :** The combination of compost and mulch can be highly effective in improving soil health and fertility. These are produced on-farm, making them a cost-effective technique for farmers to enhance soil quality.
- **Cover crops :** protect bare soil from erosion, water loss, and compaction by providing a protective layer that reduces the impact of wind and water erosion. They help control weed growth by competing with weeds for water and nutrients.
- **Drip irrigation :** is the most efficient way to provide water and nutrients directly to the root zone of each plant in precise amounts and at the right time, thus saving water, fertiliser, and energy.

2.2.4 Outputs and outcomes

The most significant outcome of the interventions was that the farmers could manage to save their kharif crop and get some produce during the severe drought this year. This also reinforced their belief in the usefulness of these techniques in preventing the adverse impact of drought condition, in addition to their relevance for sustainable agriculture.

2.3 Hydrogeological Survey

2.3.1 Purpose

Like in the most part of drought prone Marathwada region, the government has constructed a number of rainwater harvesting structures for surface storage and groundwater recharge in Fulambri block. These structures are not always effective because of underground rock structure and its hydrogeological characters, which varies considerably within a village and across villages. Effective conservation and management depends on understanding the spread and characters of the underlying rocks. A technical synopsis on aquifer delineation in hard rock areas is given in Annexure 1.


Well survey in village Ranjangaon


Well survey in village Ranjangaon


Well survey in village Adgaon Khurd


Reviewing well data in village Vitthalwadi

2.3.2 Activities conducted

The effectiveness of water conservation and recharge measures depends on geographic factors like slopes, soils and land-use as much as the hydrogeological factors like the underlying geology, aquifer expanse, storage potential and most significantly their recharge areas.

A comprehensive hydro-geological study was carried out in the project villages, along with the measurement of static water levels in the representative wells two times in the year, firstly in May-June as pre-monsoon season and in November-December as post-monsoon season. The study was conducted by post-graduate students of Department of Geology, Rajarshi Shahu College of Arts Commerce and Science, Pathri, under the supervision of Dr Pramod Pathrikar, faculty and under the overall guidance of Dr P S Kulkarni, retired Head of Geology Department, Maulana Azad College, Aurangabad. Dr S Salve, retired Joint Director, Groundwater Survey and Development Agency (GSDA), Government of Maharashtra provided special assistance in marking the multi-layer aquifers in the field. Project village-wise and date-wise details of hydrogeological study carried out pre & post monsoon are given in Table 3 below.

Table 3 : Coverage of Hydrogeological Study

S No	Village	Pre-monsoon		Post-monsoon	
		Dates	Open wells studied	Dates	Open wells studied
1	Adgaon	19 Jun	21	3-4 Nov	9
2	Murshidabadwadi	25 Jun	15	10 Nov	7
3	Ranjangaon	18 Jun	20	24 Oct	8
4	Sultanwadi	1-2 Jul	17	20 Oct	9
5	Vitthalwadi	24 Jun	10	10 Nov	6
	Total		**83**		**39**

2.3.3 Outputs and outcomes

The study brought out the significant characteristics of the underlying rocks (geological formation) and its water bearing behaviour. This comprehensive study helped map the geological formations in the five villages and its surrounding area, along with the water table in the wells. These observations were used to interpret the aquifer expanse and its water bearing zones.

Similarly, it was useful in identifying the potential recharge zones, where soil water conservation works could be taken up to increase groundwater recharge. The well water levels also indicated the water bearing potential, and thus, the irrigation potential in different parts of the village was observed and noted. The depletion in water tables also indicated the scope of winter crop in various parts of the village. Details are provided in Table 4 below:

Table 4 : Static water levels in open wells (metres b.g.l. average)

S No	Village	Pre-monsoon		Post-monsoon	
		Min	Max	Min	Max
1	Adgaon	13	16	11	15
2	Murshidabadwadi	14	18	13	16
3	Ranjangaon	15	15	12	16
4	Sultanwadi	13	20	14	18
5	Vitthalwadi	13	17	13	16

It may be noted that the water levels of pre-monsoon and post-monsoon show very limited fluctuations, which was because of scanty rainfall in the monsoon of 2023. It is expected that the figures would be more encouraging in a normal rainfall year.

2.4 Hands on training of VWMCs

2.4.1 Purpose

The Village Water Management Committees (VWMCs) formed during the last year have played an important role in making the farming community aware of the need for water conservation and planning for water use in each crop season. The VWMCs carried out preliminary analysis of rainfall data and water balance in the village and guided the farmers on crop planning in rabi and summer season. During this year, the focus was on assessing water balance, water budgeting and collective crop planning.

2.4.2 Activities conducted

A brief refresher training was conducted in each village during February, 2023 after which the VWMC members along with the barefoot technologists and the representative visited wells in March 2023 to check the well water levels so as to plan summer season crops and the area that could be irrigated in summer season. Further, the VWMC members discussed the performance of wells in the summer season. It was possible due to systematic training inputs followed by handholding support during implementation. Project village-wise and date-wise details of hands on training imparted to the VWMC members and their exposure visit are given in Table 5a & 5b below:

Table 5a : Hands on training of VWMCs

S No	Village	Refresher 1	Refresher 2	Refresher3
1	Adgaon	11 Apr (2W+7M)	15 Jul (2W+9M)	5 Nov (2W+5M)
2	Murshidabadwadi	9 Apr (2W+5M)	18 Jul (0W+5M)	7 Nov (0W+5M)
3	Ranjangaon	16 Mar (4W+6M)	25 Jul (4W+5M)	9 Nov (4W+3M)
4	Sultanwadi	17 Mar (3W+7M)	20 Jul (2W+5M)	8 Nov (3W+4M)
5	Vitthalwadi	9 Apr (3W+5M)	21 Jul (3W+4M)	10 Nov (2W+4M)

Table 5b : Exposure Visits of VWMCs

S No	Village	Exposure visits of Men	Exposure visit of Women
1	Adgaon	20 Oct (5 M)	7 Nov (1M+4 W)
2	Murshidabadwadi	20 Oct (5 M)	7 Nov (1M+6 W)
3	Ranjangaon	20 Oct (5 M)	7 Nov (1M+5 W)
4	Sultanwadi	20 Oct (5 M)	7 Nov (1M+4 W)
5	Vitthalwadi	20 Oct (5 M)	7 Nov (1M+6 W)
	Total	**25 men**	**5 men + 25 women**

W- Women; M-Men

Experts guiding the women farmers at KVK, Gandheli (Aurangabad)

Experts guiding women farmers on integrated nutrition gardens at KVK, Gandheli

2.4.3 Outputs and outcomes

This set of activities led to capacity building of the VWMCs and barefoot water technologists for carrying out the water budgeting. About 50 members of the VWMCs and ten youth acquired knowledge and skills of hydrology and groundwater, which they used to guide the farmers on sustainable water use in agriculture. The VWMCs developed skills of managing their water requirement and identifying water augmentation and recharge measures accordingly. A technical synopsis on Groundwater Recharge in Hard Rock Areas is presented in Annexure 2.

Guidance by scientists at KVK, Gandheli (Aurangabad)

Organic setup in village Vitthalwadi

Exposure to water harvesting at KVK, Gandheli (Aurangabad)

Guidance by scientists at KVK, Gandheli (Aurangabad)

2.5 Water Use Planning

2.5.1 Purpose

Water used planning was the crucial component of the project aiming at strengthening the VWMCs to undertake the role of water governance in the light of growing climate variability. Towards this long term goal, this activity provided inputs to the VWMCs to plan and implement scientific adaptation measures, including water augmentation and groundwater recharge, based on assessment of aquifer characteristics.

2.5.2 Activities conducted

Water management decisions are taken by the VWMCs based on scientific observations and analysis of hydrology and groundwater data. Village-wise water use plans were prepared in participatory manner in the two seasons of Summer 2023 and Rabi 2023. These were discussed within all farmers groups and crop planning was conducted accordingly. Details of water use planning exercises done in project villages for Summer and Rabi season are given in Table 6 below. A sample of Water Use Plan for village Adgaon Khurd in presented in Annexure 3.

Table 6 : Water Use Planning Exercises

S No	Village	Summer 2023	Rabi 2023
		Date & Participants	**Date & Participants**
1	Adgaon	Apr 9 (40 M)	Dec 29 (5W+40M)
2	Murshidabadwadi	Apr 15 (4W+21M)	Dec 25 (0W+25M)
3	Ranjangaon	Apr 10 (10W+15M)	Dec 21 (10W+20M)
4	Sultanwadi	No crop	Dec 23 (5W+40M)
5	Vitthalwadi	Included in 2 above	Included in 2 above

W- Women; M-Men

Village-wise adaptation plans are under way, and are expected by early 2024, as the detailed findings of the hydrogeological study and aquifer mapping are complete. A sample of Adaptation Plan for village Adgaon Khurd in presented in Annexure 4. These will be presented in the Gram Sabhas in respective villages. These plans will be prepared with the help of groundwater scientists drawn from public institutions and State Government departments.


Block officials guiding VWMC on Water Budgeting at Ranjangaon


Crop and Water Use Planning at village Adgaon Khurd

Water Budgeting exercise at village Sultanwadi


Well water level monitoring in village Vitthalwadi

2.5.3 Outputs and outcomes

Village-wise water use plans were prepared and the farmers groups planned their crops in view of the available water in the last seasons of Summer 2023 and Rabi 2023. The VWMCs in five villages got the skills and methods of assessing their water requirement and identifying water augmentation and groundwater recharge accordingly. The farmers and VWMCs could take decisions on crops based on assessment of available groundwater data.

The next step is preparation of aquifer level comprehensive water management plans comprising water augmentation and groundwater recharge in the five villages, and presenting these plans in the village meeting for approval.

2.6 Other interventions and achievements

2.6.1 Drought of 2023

Review of drought situation : This year the project area received scanty rainfall and experienced long dry spells. The VWMCs and the barefoot water technologists carried out detailed review of drought situation in all five project villages. Due to the failure of monsoon this year, the productivity and production of kharif crop has significantly reduced. It was found that the production of cotton, the main crop in the region, dropped from 5-6 quintals per acre to 2-3 quintals per acre. Similarly, the yield of maize has come down from 25-30 quintals per acre to about 10 quintals per acre. Further, the crops like pearl millet and pigeon pea were totally lost. The situation in project villages was found to be slightly better than the surrounding villages, because the farmers had adopted *in situ* moisture conservation and organic manure which helped in conserving soil moisture to support the crops during stress period.

This review helped the farmers in the project villages realise the importance of in situ moisture conservation and use of organic manure in conserving soil moisture and thus reducing the moisture stress.

Groundwater : Due to the drought, groundwater availability has considerably reduced this year, forcing the farmers to refrain from growing crops like wheat, maize and sorghum in the coming rabi season. The Gram Panchayats have started drinking water supply by tankers in the villages. GRASP conducted meetings in all villages to identify various soil and water conservation works which could be taken up under MGNREGA in the coming work season.

2.6.2 Soil Health

Soil testing : Farmers were motivated for soil testing in their farms where organic manures and formulations were used. GRASP guided these farmers in collection of soil samples and sending it to the State laboratories for testing.

Soil health management : Farmers were guided on integrated crop management like composting methods and organic formulations. Demonstrations of *panchagavya* and *dashaparni ark* were organised, where the experienced farmers from the last year played the role of the resource persons.

As an effect of demonstrations carried out by GRASP, about 10-12 farmers not linked to the project in the past have started using organic manures in each village.

2.6.3 Women's development

GRASP always encouraged women to participate in the village water management activities. With a view to increase the outreach and their engagement, GRASP team interacted with women's SHGs and the State Agriculture Department and Maharashtra State Rural Livelihoods Mission called as Umed. With the help of the later, a training programme was organised on tailoring by convergence.

2.6.4 Review Meeting with IWP Board

A Review Meeting was held at IWP office in Gurgaon, Haryana on July 22, 2023 with two esteemed members of the Board of Governors of India Water Partnership. At this meeting, Mr D K Sharma and Mr A B Pandya reviewed the design and progress of the project and guided the future steps. They discussed the various aspects like criteria of village selection, groundwater study, well water-level monitoring, hydrologic analysis and offered valuable guidance.

2.6.4 Monitoring visit by IWP

A team from India Water Partnership visited the project area from September 20-22, 2023 for monitoring of the progress and guide on the future steps. The team, comprising of Mr Mangala Rai and Mr Neeraj, visited all five villages and interacted with the community and the important stakeholders. They offered practical suggestions on mitigating the prevailing drought condition and for addressing various issues of the farming community.

VWMC Meeting at Murshidabad wadi

Studying ginger crop in Ranjangaon

Vermicompost unit at Ranjangaon

Addressing SHG at Ranjangaon

2.7 Convergence and local contribution

This section presents how the project helped GRASP to channelise the funds from other sources like Government and raise local contribution from farmers.

Soil-water conservation : In all 43 farmers from five villages carried out well recharge, as against 20 farmers planned. The farmers had invested about Rs 2,30,000 (EUR 2,875) as their own contribution in cash and kind and were granted a subsidy of Rs 8,60,000 (EUR 10,750) from the government for this activity. In addition, ten farmers repaired their farm bunds with their own financial resources.

Farms ponds : These rainwater harvesting structures provide a safeguard against water shortages during dry spells and scarcity drought conditions, in addition to increasing groundwater recharge. In all 24 farmers constructed an equal number of farm ponds at an investment of Rs 18,00,000 (EUR 22,500). They were granted a subsidy of about Rs 12,00,000 (EUR 15,000) from the government, and the balance came as their own investment or local contribution.

Table 7a : Coverage of Open Well Recharge and Farm Ponds

S No	Village	Well Recharge Units installed	Approximate Subsidy, Rs	Farm Ponds constructed	Approximate Subsidy, Rs
1	Adgaon Khurd	13	2,60,000	5	2,50,000
2	Murshidabadwadi	2	40,000	-	-
3	Ranjangaon	13	2,60,000	4	2,00,000
4	Sultanwadi	14	2,80,000	15	7,50,000
5	Vitthalwadi	1	20,000	-	-
	Total	**43**	**8,60,000**	**24**	**12,00,000**

Water saving through drip : As an adaptation measure, 41 farmers installed drip irrigation systems on their farms. Out of these, 34 farmers were covered under the government schemes and could get a subsidy of Rs 7,28,000 (EUR 9,100). The remaining 7 farmers installed the drip units on their own, with their own investment of about Rs 1,75,000 (EUR 2,190). With the prevailing drought situation in the current year, more farmers are likely to adapt these practices during this rabi crop season.

Table 7b : Coverage of Drip Irrigation System

S No	Village	Supported by Government	Approximate Subsidy, Rs	Installed by farmers	Approximate investment
1	Adgaon Khurd	14	3,08,000	2	50,000
2	Murshidabadwadi	4	88,000	-	-
3	Ranjangaon	10	220,000	2	50,000
4	Sultanwadi	3	66,000	1	25,000
5	Vitthalwadi	3	66,000	2	50,000
	Total	**34**	**7,28,000**	**7**	**1,75,000**

Climate smart agricultural practices : In all 107 farmers adopted climate smart agricultural practices such as mulching, recycling of farm waste, organic manuring, soil amendments, reduced tillage, etc. These practices helped them reducing emission and evaporation, thereby conserving green water or soil moisture in the root zones. Most of the farmers covered under the project could save their crops in spite of the severe drought during the last year.

3. Achievements against targets

3.1 Significant Achievements

Main achievements of the project against planned outcomes are presented in the following table. It indicates that the project could achieve most of its planned outputs with the support from IWP.

Table 8 : Key achievements in the year 2023

Indicator	Targets set	Explanation of targets	Results achieved	Explanation of results achieved
Adaptation plans prepared by Village Water Management Committees (VWMCs)	5	Water management plans in each of 5 villages based on rainfall data	Five water management plans prepared based on village wise water budgets	These plans will be refined based on the findings of hydro-geology study
VWMCs presented adaptation plans in Gram Sabha	5	Plans were discussed in village council meetings	Broad plans will be refined in early 2024 based on aquifer mapping	Village councils requested GRASP to prepare location wise treatment details
Farmer groups prepared water use plans	10	Water use plans prepared for rabi & summer crop seasons	Five plans prepared for the last summer season, and five for the winter season	Farmers groups adopted these plans and chose crops accordingly
Farmers adopted climate smart agricultural practices	100	100 farmers adopted such practices	107 farmers adopted climate smart practices, and 41 installed new drip irrigation units.	Due to prevailing drought condition, the number of drip units is likely to increase
Farmers got trained in climate smart agriculture	250	250 farmers learnt the practices	288 farmers trained, out of which 220 formed FFS groups	
Aquifer delineation and mapping done	5	Village-wise maps prepared as base of planning	Field surveys and analysis completed. Mapping under way.	Expected by mid-Feb 2024
Youth and farmers trained on groundwater assessment	50	Ten farmers per village got knowledge and skills in groundwater assessment	50 youth and farmers trained	They are regularly monitoring well water levels and preparing water budgets

3.2 Water management and governance

Water resources assessment and monitoring : All main water bodies were surveyed and well inventory recorded in all five villages registers. Important hydrologic parameters, including well water levels are being monitored on seasonal basis.

Hydro-geology Study : Detailed hydro-geological study conducted in the five villages for mapping of aquifers and assessment of groundwater potential. The aquifer delineation maps are presented in Annexure 5.

Adaptation plans : Village-wise water use plans were prepared in the last three seasons (Rabi 2022, Summer 2023 and Rabi 2023). Village-wise adaptation plans, based on the findings of the hydrogeological study and aquifer mapping, are being prepared for presentation in the Gram Sabha.

3.3 Human and institutional development

Youth training : Ten youth trained to work as Barefoot Water Technologists on various aspects of water resources development and management

VWMC : Five Village Water Management Committees (VWMCs) were organised, one per village, for village level water resources planning and management.

Farmer groups : Ten groups, one of kharif crops and one for rabi crops in each village formed and trained for promotion of climate resilient agricultural techniques. Over 220 farmers, both men and women, trained on various agricultural techniques so far.

Groundwater Assessment : Ten farmers from each village trained for groundwater assessment. They are using their knowledge and skills for monitoring the village water resources and for participatory water budgeting and collective planning.

Aquifer Delineation in Hard Rock Areas

Introduction

Groundwater is the main source of irrigation in peninsular India, including the drought prone region of Marathwada. Likewise, the Fulambri block of Aurangabad district is mainly dependent on dug wells, where huge withdrawal of groundwater has resulted in depletion of groundwater reflected in the drying up of most of the wells in summer. The government has constructed a large number of rainwater harvesting structures for surface storage and groundwater recharge. These structures do not always give expected results, mainly because the groundwater occurrence solely depends on the type of underground rock structure and its hydrogeological characters, which varies considerably from village to village or within a single village having an area of 100-200 ha. Understanding the spread and characters of the aquifers is necessary for prospecting, conserving and managing groundwater in hard rock areas.

Main rock types

The rocks in Maharashtra state are mostly basalts formed by eruption of lava flows. Four main types of basalt flows are found in this area, namely, compact basalt, vesicular or amygdaloidal basalt, tachylitic basalt and volcanic breccia. These different types show different field characters and a large variation in their geo-hydrological behaviour. The first two types are particularly important for groundwater point of view.

Compact basalt is hard and tough, but develops contraction joints during cooling of lava flows non porous and impermeable. These joints show variation in jointing pattern, either broadly spaced or closely spaced joints or columnar, through which water percolates or moves.

The **vesicular or amygdaloidal basalt** flows occur as a pile of number of thin and irregular flows. They are free from jointing when fresh, but due to weathering horizontal sheet jointing develops in it through which water percolates up to shallow depth of 3-15m.

Tachylytic basalt flow is formed naturally by the rapid cooling of molten and viscous lava. Tachylytic basalt is very brittle and occurs in dykes, veins and intrusions, and are seen mostly in pockets and lenses.

Volcanic breccia is a type of basalt flow composed predominantly of angular fragments of pre-existing unitary igneous rocks ejected by volcanic blast which is engulfed in lava martix. They are exposed in limited areas of Penganga and Wainganga basins in Maharashtra.

Hydrological properties : The basalt flows in their hydrogeological properties, like porosity and permeability, which in turn define infiltration rate and specific yield.

S No	Basaltic flow type	Rainfall infiltration factor	Specific yield
1	Broadly spaced and columnar joints	0.05 to 0.08 (Median 7%)	0.01 to 0.03 (Median 1.75%)
2	Closely spaced and sheet joints	0.10 to 0.15 (Median 13%)	0.02 to 0.05 (Median 3%)
3	Hydrothermally altered and fresh VAB	0.01 to 0.02 (Median 1.5%)	0.003 to 0.01 (Median 0.5%)

In absence of any detailed observations, the median value given in the parenthesis may be used for determining the groundwater potential and its estimation.

Hydrogeology Study of the area

In order to determine the groundwater potential zones and for estimating the groundwater resource in five villages of Fulambri block in district Chhatrapati Sambhajinagar (Aurangabad), a detailed hydrogeological mapping was carried out with critical observations of different basalt flows spread on the surface as well as exposed at depth in the dug wells.

Methodology

Base Maps : Two kinds of maps formed the basis of spatial analyses, were procured; namely, cadastral maps of the study villages on 1:10,000 scale and topographic maps as Topo sheets on 1: 50,000 scale from Survey of India. The study villages fell in the Topo sheets 46-P/8 and 46-P/12.

S No	Village	Latitude	Longitude	Toposheet
1	Adgaon Khurd	20º6’15”N	75º33’22”E	46-P/12
2	Ranjangaon	20º5’50”N	75º32’28”E	46-P/12
3	Sultanwadi	20º5’00”N	75º30’00”E	46-P/8
4	Murshidabad Wadi	20º2’25”N	75º23’25”E	46-P/8
5	Vitthalwadi	Part of above	Part of above	46-P/8

Marking contours on maps : For surface and subsurface geological studies, it is essential to reduce the contour interval from 20 m from the Topo sheets to 5 m, and to mark it on the village cadastral maps. For this purpose, the contour lines and altitudes of the benchmarks on the Topo sheets were digitised, followed by demarcation of latitude, longitude and elevation of entire study area for selected contour points. This generated contour line data was plotted on the village cadastral maps, to obtain the base map to carry out hydrogeological survey at village level using GIS softwares like ArcGIS and Surfer.

Field assessment : The survey team carefully demarcated surface exposures of the basalt flows on the base map by noting down their field as well as hydrogeological characters, simultaneously measuring the exposed thickness and lateral extent of different basalt flows encountered. The surface data thus collected from field survey was plotted on the village map by categorizing basalt flows with respect to their infiltration rate, in order to measure their horizontal extension within the village area.

Well inventory : With a view to identify the subsurface basalt flows and their hydrogeological characters, selected scattered open wells were inventoried by measuring and recording prominent characteristics and water use data. The well sections observed were plotted along with pertinent description of basalt flows with respect to field and hydrogeological characters. The subsurface data obtained from well inventory survey was used to estimate the available thickness of each categorized flow.

Analysis and Interpretation

The data collected from the field was analysed for demarcation of groundwater potential zones in the area and for further estimation of groundwater.

Groundwater potential of the village area was estimated from the hydrogeological map prepared on the basis of surface data with demarcation of basalt flows with different categories. It was calculated by using the formula,

Groundwater potential = Area X Mean Rainfall X Rainfall Infiltration Factor

Aquifer volume : The lithological profiles prepared from the well inventory data were used to measure the thickness of each categorized basalt flow occurring in the village area. This was used to calculate the volume of each categorized basalt flow using the following formula.

Volume = Area X Thickness

Groundwater storage : The volume of the basalt flows thus obtained was used in getting the exact space available to occupy for groundwater using the formula

Groundwater Estimation = Volume X Specific Yield

Groundwater estimation in the project villages

The groundwater estimation was carried out in the five project villages in Fulambri block as per the methodology explained above. Since, village Vitthalwadi is part of village Murshidabadwadi, the revenue data and cadastral maps were not separately available for them. Hence, for the purpose of estimation, these two villages were considered as a single unit.

S No	Village	Groundwater potential, ha-m	Aquifer volume, ha-m	Groundwater estimation, ha-m
1	Adgaon Khurd	16.23	60.33	104.43
2	Ranjangaon	26.82	38.18	67.77
3	Sultanwadi	10.80	61.53	104.45
4	Murshidabad Wadi and Vitthalwadi	43.41	102.56	220.10
	Total	**97.26**	**263.60**	**496.75**

These findings will be used in preparing aquifer level water management plans in future.

Groundwater Recharge in Hard Rock Areas

Introduction

Groundwater is the main source of irrigation in peninsular India, including the drought prone region of Marathwada in Maharashtra state. It is becoming an increasingly popular resource because of the relative ease and flexibility in accessing it. with which it can be tapped. While it has helped alleviate poverty in many areas, its sustainable use and management is a major challenge, as huge withdrawal of groundwater has resulted in its depletion. The government constructed a large number of rainwater harvesting structures for increasing surface storage and groundwater recharge, but their effectiveness is not uniform all across. Groundwater recharge is always a challenging affair in hard rock areas as the underground rock structure and its hydrogeological characters vary considerably within a small area. This document explains the challenges, approaches and practical responses to groundwater recharge in simplified terms.

Hard rock terrain

More than two third part of India is underlain by hard rock, occurring in the states of Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, Maharashtra and parts of Gujarat. Hard rocks have very limited ground water potential, yet these aquifers play an important role in meeting the drinking, agricultural and industrial needs in the entire Indian peninsular shield areas. In a hard rock terrain ground water resources is limited, unevenly distributed and varies within a short distance. Groundwater occurs in fractures (referred to a secondary porosity) developed due to folding, faulting, jointing, or such geological features. At some places the hard rocks are devoid of any secondary porosity. In such areas depletion of water table and severe scarcity of water in summer season are observed, mainly due to erratic
monsoon and deficient rainfall.

Arid or semi-arid tracts

In the arid and semi-arid tracts of India, lack of recharge into the aquifers due to the low rainfall is the major constraint in development of ground water resources for boosting food production. Prospects of development of ground water available in the deeper aquifers are also limited in these areas due to lack of recharge and sometimes (especially in crystalline rocks) due to mineralization of available ground water. Due to hot and dry climate, the surface storages are subject to higher evaporation in summer season. Under such circumstances increasing groundwater recharge is an important strategy to reduce water stress. Augmentation of available resources through rainwater harvesting and artificial recharge, water saving measures, efficient use of water and monitoring groundwater development are among the options available for management of ground water resources is such areas.

Challenges of depleting resources

Poor farmers are forced to abandon irrigation as falling water tables limit access to those who cannot afford to deepen wells. Deep wells need more electricity, and thus, lead to increase in cost. Moreover, depletion of water tables poses a threat to food security. As water tables decline, poor farmers find it difficult to meet the cost of deepening wells and ever-increasing energy requirement, which ultimately lead to decline in food production. Conservation of this vital resource is utmost necessary for food security, preservation of environment and sustainable livelihoods of rural people. These challenges manifest differently in areas with different resource endowment influencing the vulnerability of the people living in such areas. The hilly areas and the arid or semi-arid areas of India are particularly vulnerable to fluctuations in water availability, mainly attributed to groundwater recharge.

Advantages of induced recharge

Induced recharge, or managed aquifer recharge as it is often called, is an important groundwater management tools for replenishing depleted aquifers, improving water quality through filtration and chemical and biological processes when combined with water harvesting and reuse. It helps enhance volumes of groundwater abstracted and play an important role in restoring the groundwater balance. Essentially, it helps in storing water in aquifers for future use, smoothing out supply and demand fluctuations, stabilising or raising groundwater levels where over-exploited, reducing loss through evaporation and runoff, improving water quality and maintaining environmental flows in streams and rivers.

Strategies and options

Groundwater management can be done by rainwater harvesting and induced recharge of groundwater and conjunctive use of available surface and ground water, etc.

Options based on geology

In hard rock areas, the fractures are only the conduit for refill and water transport rather than serving as space for storage of ground water.

The fractures tend to close at depth and 60 m which is approximately is the optimum depth within which potential aquifer is obtainable. Thus, it is only the vadose zone which undergoes re-saturation during infiltration of rain water or through other source of recharging water.

The vadose zone and its weathering is important since the fracture porosity of hard rock is very low (as small as 1-2%), and therefore, fracture zone alone is not considered productive zone unless it is connected with recharge boundary. Therefore, weathered horizons play a dominant role for consideration of water circulation and recharge. The cracks in the weathered zones are sometimes filled with concretionary material as *Kankar*. The recharge capability of basaltic rocks is greatly influenced by the overlaying thickness, texture and structures of the soil and their location with reference to topography and geomorphology of landscape units.

Factors guiding the strategies

In basaltic plateau region, the feature of low permeability of rocks, their multilayered occurrence, fractured and jointed natures, vesicular character besides topographic and other geological features are to be normally considered in the formulation and construction of recharging schemes, since the success of a recharge measures will depend on a combination of various topographic and hydrologic situations.

Table : Topographic - Hydrogeological framework

Topic	Features
Hydrologic considerations	The weathered, fractured and vesicular basalts constitute most favourable hydraulic zones at shallow depth which need to be delineated on large scale maps.
Topography of watershed area	The piedmont slopes constitutes the best topographic geologic environment followed by valley floors. Highly dissected slopes and plateau tops are

	less favourable
Hydraulic conductivity of basaltic layers	The weathered, jointed and vesicular portions of basaltic rocks have high permeability and shall constitute favourable places in comparison to massive and hydrothermally altered basalts that are less suitable for recharge and percolation.
Groundwater table and fluctuation in levels	The position of water table and its value of annual fluctuation
Thickness of soil cover and infiltration rates	Granular soil cover will have high infiltration rate in comparison to clay / black cotton soil that would impede infiltration and deep percolation.
Rate of recharge	In favourable zones, fractured and vesicular basalts are expected to attain a recharge of 10 to 15% whereas in non-favourable zones, underlain by massive basalts the rates may be 2 to 3%.

Accordingly, the topographic and geologic considerations that shall govern suitability of recharging works in basaltic plateau region are outlined below:

Table: Framework for Topographic-Hydrogeologic Model for water harvesting and recharge

Topography	Areas/ Region	Feasible Method
Plateau Area	Western Ghats	Pits, ponds and shafts
Highly dissected plateau slopes (gradients of 1:10 and more)	Narrow areas flanking hill ranges and ghats	Recharge shafts feasible locally.
Moderately dissected plateau, foot hills and piedmont region (gradients 1:10 to 1:100)	Areas between interbasin divides plateau and valley floors.	Recharge trenches, Nala bunds, contour bunds, percolation tanks and groundwater dams.
Low lying valley areas (gradients of 1:100 to 1:500)	Valley floor of rivers (e.g., Godavari, Bhima, Nira, Krishna, etc. and their tributaries)	Water spreading basins and groundwater dams (conservation structures)

These considerations will provide guidance in preparing aquifer level water management plans in future.

Water Budget and Water Use Plan – 2023-24

Village Adgaon Khurd, Block Fulambri, Dist Aurangabad

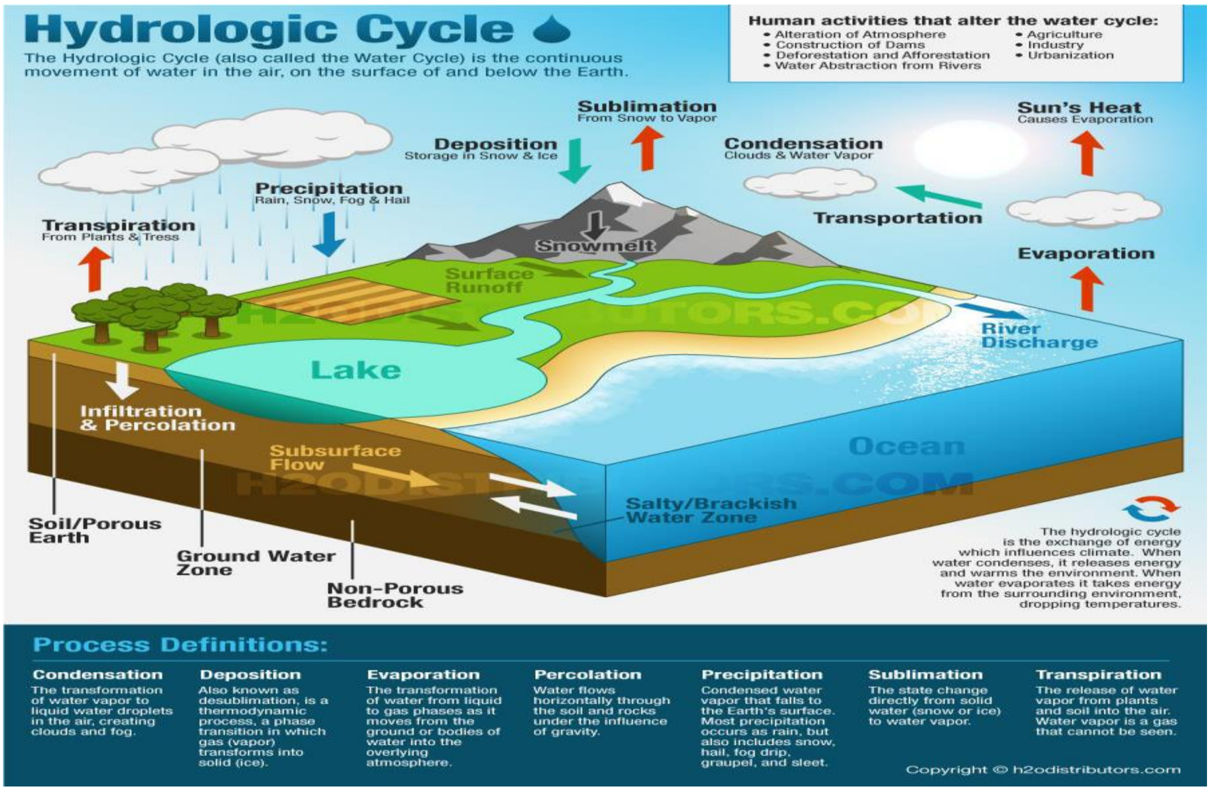
Introduction

Sustainable groundwater management depends on assessment of water resources and using water balance estimation and water budgeting. These methods are used to support water planning decisions by farmers groups and village water resources managers as they assess potential actions to improve the water portfolio and sustainability within their management areas. Additional guidance and methods beyond those discussed below are required for making allocation decisions or for framing rules and regulations for larger water governance at watershed or aquifer level.

Part 1 : Conceptual Understanding

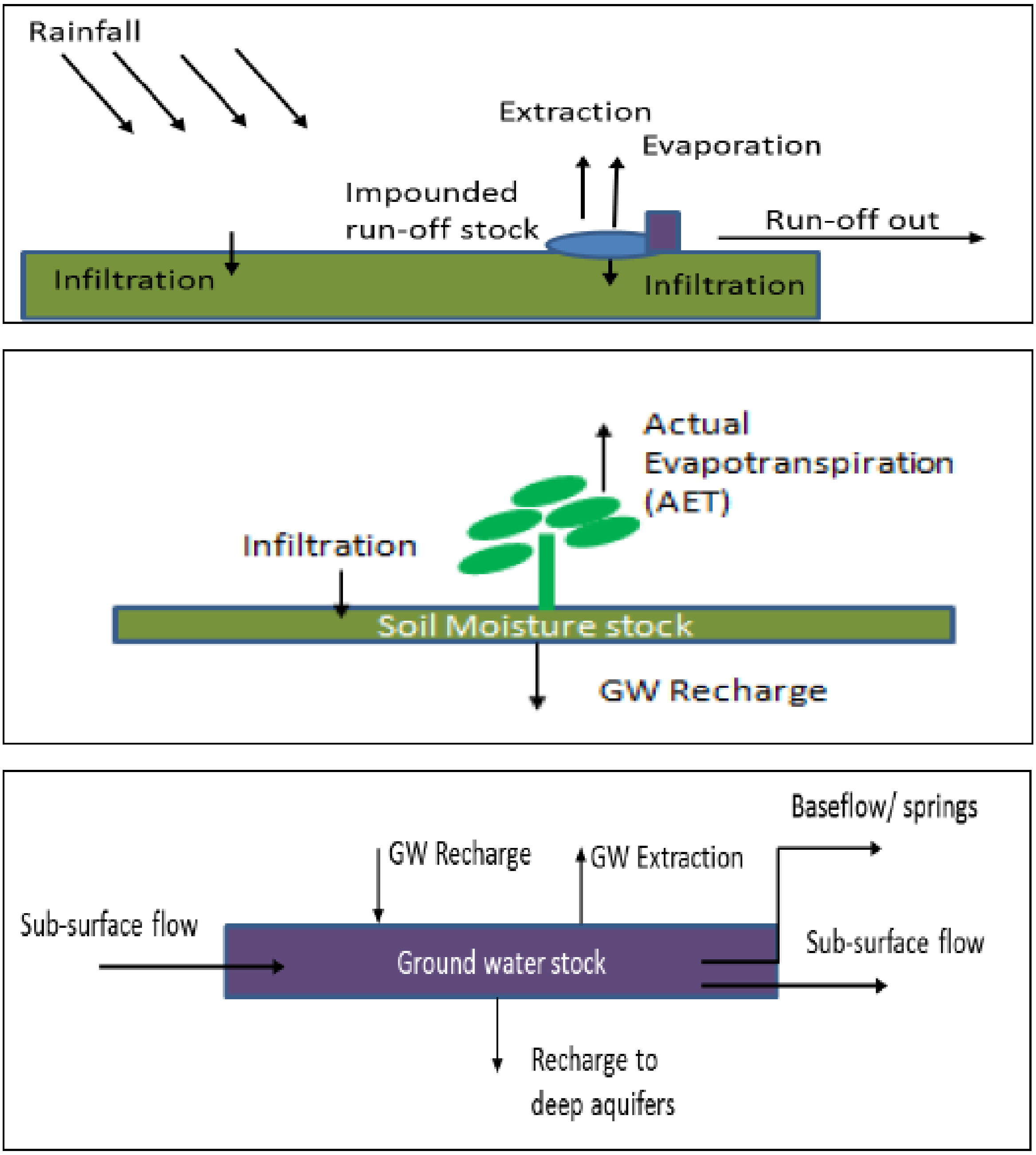
Hydrologic cycle

The fundamental principles of water balance are drawn from understanding of the hydrologic cycle and its component.



Basic water balance concept

To properly account for all water budget components under the wide range of circumstances in a village or a watershed, a systematic process of identifying, classifying, verifying, summarizing, interpreting, and communicating water budget information is needed. A simplified water balance model is used in the analysis in the project villages.



Simplified water balance equation

It refers to calculating the balance between inflow and outflow, and the water required for soil to become saturated and is expressed as the depth of water. This method was initially developed by Thornthwaite and modified by many researchers.

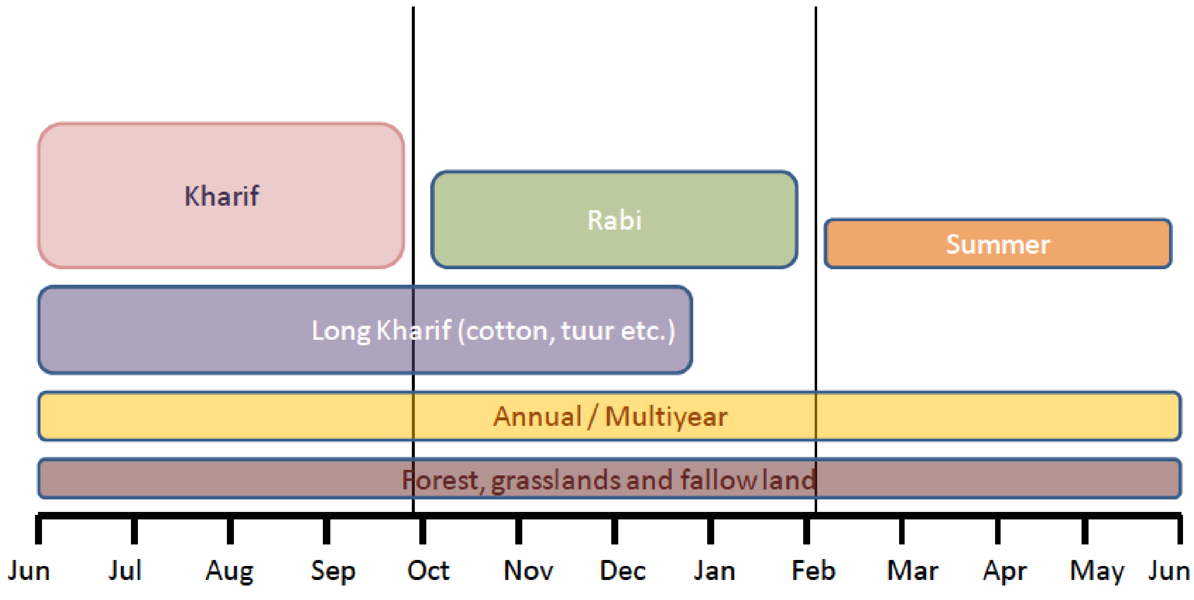
Thus, a simplified water balance equation can be expressed as:

$$R = P - Ea + \Delta W - Ro$$

Where
R = recharge
P = precipitation
Ea = actual evapotranspiration
ΔW = change in soil water storage, and
Ro = runoff.

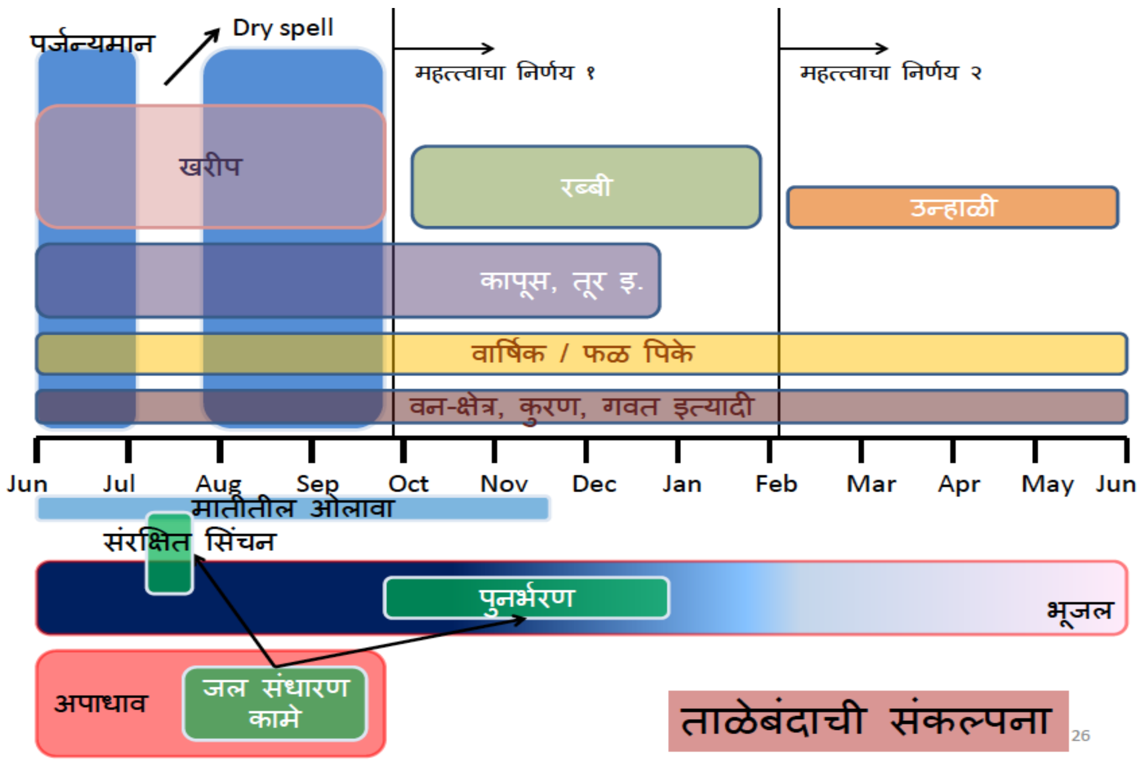
Agricultural calendar

The water use in agriculture can be depicted as follows, where the demand for water is felt throughout the year, that is to say, in all crop growing seasons of Kharif, Rabi and summer.



Concept of water budgeting

In the arid and semi-arid tracts of India, the availability is uncertain in all these seasons. Hence, water use planning is necessary. Water budgeting is a tool to match the water demand and supply by assessing the availability at the beginning of each crop season. It is equally important to review the situation at the end of every season, so that any modifications can be carried out in the water use plan for the next season.



The water budgeting and water use planning exercise was carried out it five project villages as per the approach mentioned above. The results and inferences of the exercise in village Adgaon Khurd is explained below.

Part 2 : Water Use Planning Exercise

1. Estimated inflow (precipitation)

Village Adgaon Khurd has a geographic area of 392 ha. During the rainy season of 2023, it received a seasonal rainfall of 464.7 mm. Thus, the total water received was 182.16 hectare-metres. Note: One hectare-metre of water is equivalent to 1 crore litres (ten million litres).

It may be noted that the current year has been a severe drought year, and hence the rainfall was low, thus affecting water availability. A normal rainfall year would generally offer more choices to the farmers by virtue of higher water availability than in a drought year.

2. Water stored as soil moisture and groundwater

The estimated water availability for crops in Village Adgaon Khurd during the Kharif season was 72.86 ha-m as shown below.

S No	Storage type	As %	Available inflow, ha-m	Storage volume, ha-m
2.1	Soil moisture (30% of inflow)	30	182.16	54.65
2.2	Groundwater recharge (10% of inflow)	10	182.16	18.22
	Total			**72.86**

3.1 Storage in existing soil water conservation structures

As per the assessment of existing soil and water conservation structures, total amount stored in surface water bodies was found to be 15.24 ha-m.

S No	Type of structure	Work done	Storage capacity	Actual storage	Number of filling during monsoon	Effective storage, ha-m	Net of evaporation (%)	Total water available, ha-m
1	2	3	4	5	6	7= (5)x(6)	9=100-(8)	10=(7)x(9)
1	Farm ponds	8	1.44	1.440	2	2.88	50	1.44
2	Nalla deepening and widening	2	2.16	2.16	2	4.32	70	3.02
3	Check weirs	6	2.7	2.7	2	5.4	70	3.78
4	Percolation tanks	1	10	10	1	10	70	7.00
	Total	**23**	**39.70**	**39.70**	**0**	**22.60**		**15.24**

There was no water imported from outside the watershed boundary by way of canal, pipeline or streams into village Adgaon Khurd. Hence, total water availability (supply side) was 88.11 ha-m.

Total Water Availability =

Soil moisture and groundwater (Item 2)

\+ Storage in existing soil water conservation structures (Item 3.1)

\+ Water imported from outside the village (Item 3.2)

Thus, Total Water Availability

= 72.86 + 15.24 + 0.0 ha-m

= 88.11 ha-m

4. Drinking water requirement

The requirement of water for drinking, livestock and domestic needs was estimated to be 2.53 ha-m as follows.

S No	Water use	Number	Requirement, lpd	Days/ year	Annual water requirement, ha-m
	1	2	3	4	5=2x3x4
1	Human population	1090	55	365	2.19
2	Large ruminants	240	35	365	0.31
3	Goats and sheep	150	5	365	0.03
4	Poultry	50	2	365	0.00
	Total				**2.53**

In addition, there was some evaporation from about 50 ha of fallow land to the tune of 2.50 ha-m. Deducting these, the water availability, which can be used in agriculture was found to be 83.08 ha-m.

5. Crop Water Requirement for Kharif season

Looking at the sown area under Kharif crops, the water requirement was estimated using the crop water use requirement data for the region. It was found that the total water requirement worked out to 198.59 ha-m, which was far higher than the water availability of 83.08 ha-m.

5.1 Field crops in Kharif season : The total water requirement for the field crops (cereals and pulses) in Kharif season was found to be 44.15 ha-m.

Crop	Rainfed area, ha	Unit WR, ha-m	WR for rainfed crops, ha-m	Area under micro-irrigation, ha	Unit WR, ha-m	WR for micro-irrigation, ha-m	Total WR for Kharif crops, ha-m
1	2	3	4=2x3	5	6	7=5x6	8=4+7
Maize	75	0.45	33.75	0	0.3	0.00	33.75
Green gram	6	0.30	1.80	0	0.2	0.00	1.80
Black gram	3	0.33	0.99	0	0.2	0.00	0.99
Soybean	12	0.40	4.80	0	0.2	0.00	4.80
Groundnut	4	0.50	2.00	0	0.3	0.00	2.00
Fodder crops	0	0.45	0	3	0.3	0.81	0.81
Total	**100**		**43.34**	**3**		**0.81**	**44.15**

5.2 Vegetable crops : The total water requirement for the vegetable crops in Kharif season was found to be 5.19 ha-m.

Crop	Area under micro-irrigation, ha	Unit WR, ha-m	Water required for micro-irrigation, ha-m	Total water requirement for Kharif crops, ha-m
1	2	3	4=2x3	5=4
Chilly	5	0.5	2.55	2.55
Lady's finger	4	0.3	1.2	1.20
Other veg	3	0.5	1.44	1.44
Total	12	0	5.19	**5.19**

5.3 Long duration Kharif crops : Crops like cotton and pigeon pea, which grow for about 6-8 months are grown in the project area. The total water requirement of such long duration crops was found to be 149.25 ha-m.

Crop	Rainfed area, ha	Unit WR, ha-m	WR for rainfed crops, ha-m	Area under micro-irrigation, ha	Unit WR, ha-m	WR for micro-irrigation, ha-m	Total WR in Kharif, ha-m
1	2	3	4=2x3	5	6	7=5x6	8=4+7
Cotton	145	0.75	108.8	30	0.5	13.5	122.25
Pigeon pea	25	0.60	15.0	0	0.4	0.0	15.00
Ginger/ turmeric	10	1.20	12.0	0	0.7	0.0	12.00
Total	**180**		**135.8**	**30**		**13.5**	**149.25**

6. Drought situation in 2023

As the above analysis indicated, there was severe moisture stress during Kharif season, which led to crop failure or significantly reduced yields. The worst sufferer was the cotton crop, where more than half the farmers had to abandon their crop, whereas the remaining farmers had to live with significantly reduced production of about 10-20% of normal.

Kharif water use index, which is a ratio of total crop water requirement in Kharif season (= 198.59 ha-m) to the water available for agriculture (= 83.08 ha-m) is 2.39. It should be well below 1.0, which means there would be some water resources available for the next seasons.

7. Planning for Rabi season

The village level situation clearly pointed out at water deficit in Kharif due to the low and sporadic rainfall in the monsoon. Some late rains in the early part of September provided some solace to the rainfed farmers, and gave them the hope and motivation to plan for the Rabi season. Due to the late seasonal rains, and the existing soil water conservation structures, there was some water in the wells in certain pockets of the village. Therefore, it was decided to carry out the Rabi season water use planning, ignoring the overall water resources deficit from the monsoon. It was also decided to grow all winter crops only under drip irrigation method, and thereby, make optimal use of the limited water available.

8. Additional water inflows for Rabi season

Village Adgaon Khurd received a late-season rainfall of 112.3 mm over its geographic area of 392 ha, yielding a gross inflow of 44.02 ha-m. The estimated water availability due to this delayed rainfall in Village Adgaon Khurd were estimate to be 17.61 ha-m as shown below.

Storage type	**As %**	**Available inflow, ha-m**	**Storage volume, ha-m**
Soil moisture (30% of inflow)	30	44.02	13.21
Groundwater recharge (10% of inflow)	10	44.02	4.40
Total			**17.61**

9. Crop water requirement in Rabi season

Crop water requirement for Rabi season was worked out for the proposed crops intended by the farmers and tentative area under those. It was found that the farmers, on their own, have decided to scale down their goals and expectations to broadly match the availability. Yet, there was a deficit of 30.28 ha-m or 37% of total water demand expected.

Crop	**Area under micro-irrigation, ha**	**Unit WR per ha, ha-m**	**Water required for micro-irrigation, ha-m**	**Total water requirement for Rabi crops, ha-m**
1	2	3	4=2x3	5=4
Sorghum	102	0.27	27.54	27.54
Bengal gram	88	0.21	18.48	18.48
Wheat	6	0.31	1.87	1.87
Total	**196**		**47.89**	**47.89**

Rabi water use index, which is a ratio of total crop water requirement in Rabi season (= 47.89 ha-m) to the water available for agriculture (= 17.61 ha-m) is

2.77. Since this was found to be well above 1.0, which is the water security level, the farmers were asked to reduce their crop area and irrigate crops only using drip and sprinkler irrigation.

10. Future steps

Water use plan was proposed to encourage farmers to optimise their crop choice and use water saving techniques. It will be monitored at the end of the season, the effectiveness of the measures proposed and adopted.

Adaptation Plan 2023

Village Adgaon Khurd, Block Fulambri (Aurangabad)

1. Introduction

Adaptation refers to the adjustments in human and natural systems in response to actual or expected climate stimuli or their impacts that moderate harm or exploit beneficial opportunities (according to IPCC, 2007).

IPCC defines Adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Adaptation Strategies

In the context of Marathwada region of central Maharashtra, where recurrent droughts are having increasingly severe impacts on the vegetation; crops; livestock; and people in the past few decades, adaptation can mean several strategies, such as:

Agriculture related : changing land use, changing cropping pattern changing crops or soil management, improve seed research

Water related : Rainwater harvesting, groundwater recharge, conservation, changing the water use practices in management of dykes and dams and at farm level, and redistribution of water to avoid scarcity, change behaviour and rules of water use

Social : It would also include strategy of sharing losses by strengthening social support networks, insurance, or social programmes.

National priorities : National Action Plan on Climate Change (NAPCC) for India, launched in 2008, emphasises on some of the above strategies. The relevant among those are : improvement in water use efficiency under National Water Mission, afforestation of degraded forest lands and the extension of forest cover; National Mission for Sustainable Agriculture supports climate adaptation in agriculture, through development of climate-resilient crops, expansion of weather insurance, mechanisms and innovative agricultural practices. All these considerations guided the Adaptation Planning process in the present project in Fulambri cluster.

2. Planning Process

2.1 Four step approach

Preparation of Adaptation Plans Towards preparation of the village level adaptation plans, GRASP adopted a four-step approach. Its foundation was laid last year by way of formation of the Village level Water Management Committees and their capacity building. The four steps include :

- Training and capacity building of VWMC
- Hydrologic monitoring
- Water budgeting and water use planning
- Planning for adaptation

2.1.1 Training and capacity building

Objectives : Training and capacity building of the community and the Village Water Management Committees has been an important pillar of this project with was drive by two objectives, namely,

- To increase the knowledge and capacity of communities to adapt to climate variability and change, and
- To contribute to knowledge building and experiences in integrating climate change adaptation in land and water use in drought-prone areas.

Training and capacity building covered four main areas of hydrology, groundwater, assessment and budgeting of water resources and planning. These topics were explained in the initial training programmes conducted during the last year, and refresher training sessions were conducted this year, prior to undertaking the planning exercise.

Table 1 : Refresher training of VWMCs

S No	Village	Refresher 1	Refresher 2	Refresher 3
1	Adgaon Khurd	11 Apr	15 Jul	5 Nov
2	Murshidabadwadi	9 Apr	18 Jul	7 Nov
3	Ranjangaon	16 Mar	25 Jul	9 Nov
4	Sultanwadi	17 Mar	20 Jul	8 Nov

5	Vitthalwadi	9 Apr	21 Jul	10 Nov

Hydrology : This area covered the basic understanding of hydrologic cycle, its components and their measurement. Focus was mainly on rainfall and runoff, together with various forms of water storage in the systems.

Groundwater : This topic covered the occurrence of underground water in the rocky formations typically found in central Marathwada region. The VWMC members were given special practical training in the field while carrying out the well inventory and the well water measurement.

Water resources assessment : This topic covered the quantitative aspects of hydrologic cycle and its measurement. Youth identified and trained as barefoot water technologists during the last year played an important role in assisting the VWMC members in the assessment methods.

2.1.2 Hydrologic monitoring

Objectives : To build the understanding of the community about methods of measurement of water in their village and build their skills in measuring rainfall and storages.

Approach : Together with the barefoot water technologists, the VWMC members carried out field measurement of rainfall from rain gauge stations and well water levels. These observations were discussed in the respective villages to assess the rainfall-runoff relationship was calculated on seasonal basis. These discussions were useful is understanding its relevance to rainwater harvesting (RWH) interventions and on surface runoff.

Use of data : Monitoring stream stream-water quantity was used for assessing seasonal and long term effects on water availability in the watershed. Well water level data was corroborated with groundwater availability. These were used for crop planning for rabi and summer.

2.1.3 Water Budgeting

Water budgeting was an important part of this topic, which dealt with a systematic process of identifying, classifying, verifying, summarizing, interpreting, and communicating water resource situation in the village. budget information is needed. A simplified water balance model was used in the analysis in the project villages. The water budgeting and water use planning exercises were carried out in five project villages as a precursor to the adaptation planning.

Table 2 : Water Use Planning and Water Budgeting Exercises

S No	Village	Summer '23	Rabi '23
1	Adgaon Khurd	Apr 9	Dec 29
2	Murshidabadwadi and Vitthalwadi	Apr 15	Dec 25
3	Ranjangaon	Apr 10	Dec 21
4	Sultanwadi	No crop	Dec 23

2.1.4 Planning for adaptation

The village level adaptation planning exercises were conducted soon after the crop planning was done in each village. These were guided by the experts from GRASP and the faculty from two academic institutions. Further, support was mobilised from experienced resource persons from KVK, Jalna and GSDA, Aurangabad for facilitating these workshops. During these exercises, knowledge accumulated by the main stakeholder over the last one year from monitoring of data on rainfall, runoff, water availability in wells, cropping patterns, and farmers' preferences for certain crops were useful. Prior understanding of these key stakeholders on droughts and coping with it were also useful in shaping or refining the strategies.

The village level adoption plans were prepared while the results of the hydro-geology and aquifer delineation study were not available. As a result, it was decided to prepare draft (or tentative) adaptation plans, which could be modified on the basis of the hydrogeology and aquifer study report, as and was it was received. Thus, these adaptation plans are dynamic, in the sense that they are amenable to modification based on the newer knowledge on hydrogeology and hydrologic monitoring data is received periodically.

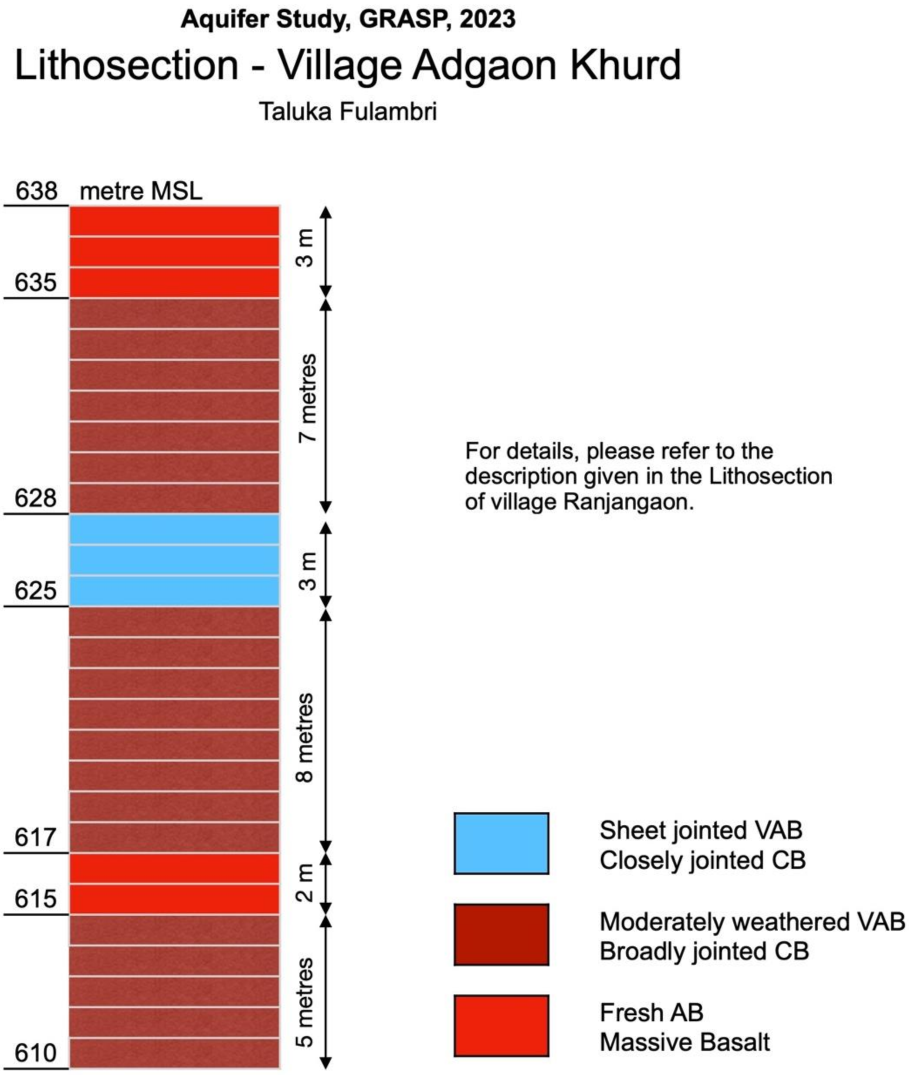
3. Adaptation Plan – Adgaon Khurd

3.1 Background

In drought prone areas, the rural households have been spontaneous using several risk management strategies against climate induced stresses. Such micro level strategies largely included natural resource management (soil and water conservation), non-farm activities (diversification) and social measures like mutual help. A participatory review of such conventional crop-level and village level natural resource management adaptation methods was carried out in each village, which provided the basis for preparing adaptation plans in the project villages. It was supplemented by guidance by experts from KVKs at Kharpudi, Jalna and Gandheli, Aurangabad. In addition, periodic guidance by the officials from Agriculture and Groundwater Departments proved useful in forming a solid foundation of the adaptation planning.

3.2 Water budgeting

Preparation of water budget was the precursor of adaptation plans. It was carried out by calculating the balance between inflow and outflow, and the water required for soil to become saturated. Estimation of groundwater recharge and groundwater storage was corroborated with the well water levels data collected two times in the year.



A detailed water budgeting exercise for summer season was conducted in village Adgaon Khurd on May 9, and for Rabi season on Dec 29. It was during the second exercise, a tentative adaptation plan was prepared, which was refined later when the findings of aquifer delineation and groundwater assessment were available.

The groundwater assessment was carried out in the five project villages as a part of hydrogeological study. It was found that the groundwater yield estimate (105.43 ham) in village Adgaon is far higher than the present estimated groundwater levels (18.22 ham). It may be noted that this was partly due to the available infrastructure for storage and recharge, and partly due to low rainfall in the present year (drought conditions).

Table 3 : Groundwater situation in village Adgaon

S No	Type of basalt flow	Area, ha	Thickness of the flow, metre	Volume, Ha-m	Ground water potential	Specific yield	Ground water estimate
1	Moderately weathered vesicular amygdaloidal basalt (VAB)	279.3	20.0	5586.0	11.731	1.75	97.76
2	Hard or compact basalt	57.4	5.0	287.0	0.344	1.00	2.87
3	Closely jointed compact basalt/ sheet jointed VAB	53.3	3.0	160.0	4.157	3.00	4.80
	Total	**390.0**	**28.0**	**60.33**	**16.232**		**105.43**

Water budgeting exercise also pointed out that the surface water storages in the village are only 15.24 ham, which should be increased. In addition, there lies a great potential in increasing soil moisture through scientific *in situ* soil conservation measures.

3.3 Adaptation measures

Based on the aforementioned analysis, it was decided to focus on three types of adaptation measures in village Adgaon Khurd.

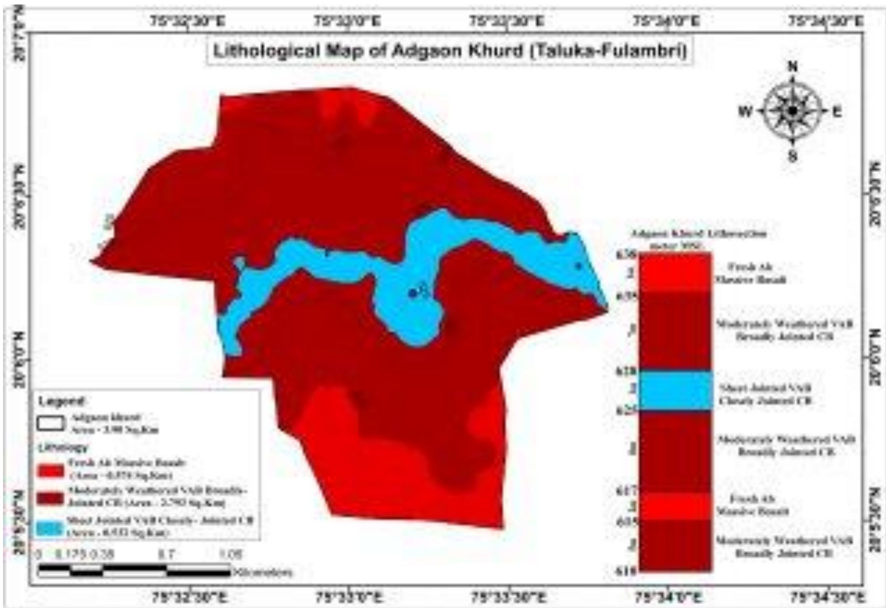
Surface water storages : It is proposed to iincrease water storage by collecting excess runoff during rainy seasons, these will include small dams and decentralized storage structures like tanks. In addition to taking up new drainage line structures, it is also proposed to improve rainwater flow by cleaning riverbeds and deepening, dredging and cleaning existing water bodies and channels. It will include decentralised farm ponds with private investment and subsidy under existing state programmes.

Area recharge : This approach provides the largest potential for increasing the soil moisture and groundwater recharge. It is proposed to carry out *in situ* soil moisture conservation (mainly trenching and bunding) on private and common lands. It will also help iincrease trees and green cover to protect against erosion during floods. In addition, it will help reduce degradation so that topsoil is not washed away in flash floods.

Farm level water management : This is a set of interventions which farmers can initiate in terms of conserving their farmlands, allowing rainwater to infiltrate into the groundwater through recharge zones identified. It will include farm bunding, tree plantation of bunds, creating micro-basins in wastelands for water harvesting and recharge and farm ponds. Another set of interventions at the farm level includes water management by using water saving irrigation techniques like ridges and furrows, drip and sprinkler, and fertigation. Increase use of organic and bio-fertilizers will improve moisture holding capacity of the soil and help balance soil nitrogen. It will also help in improving soil health conserve soil flora and fauna, nutrients, besides moisture. Further, the farmers will be encouraged to iincrease soil organic matter by way of mulching and biochar.

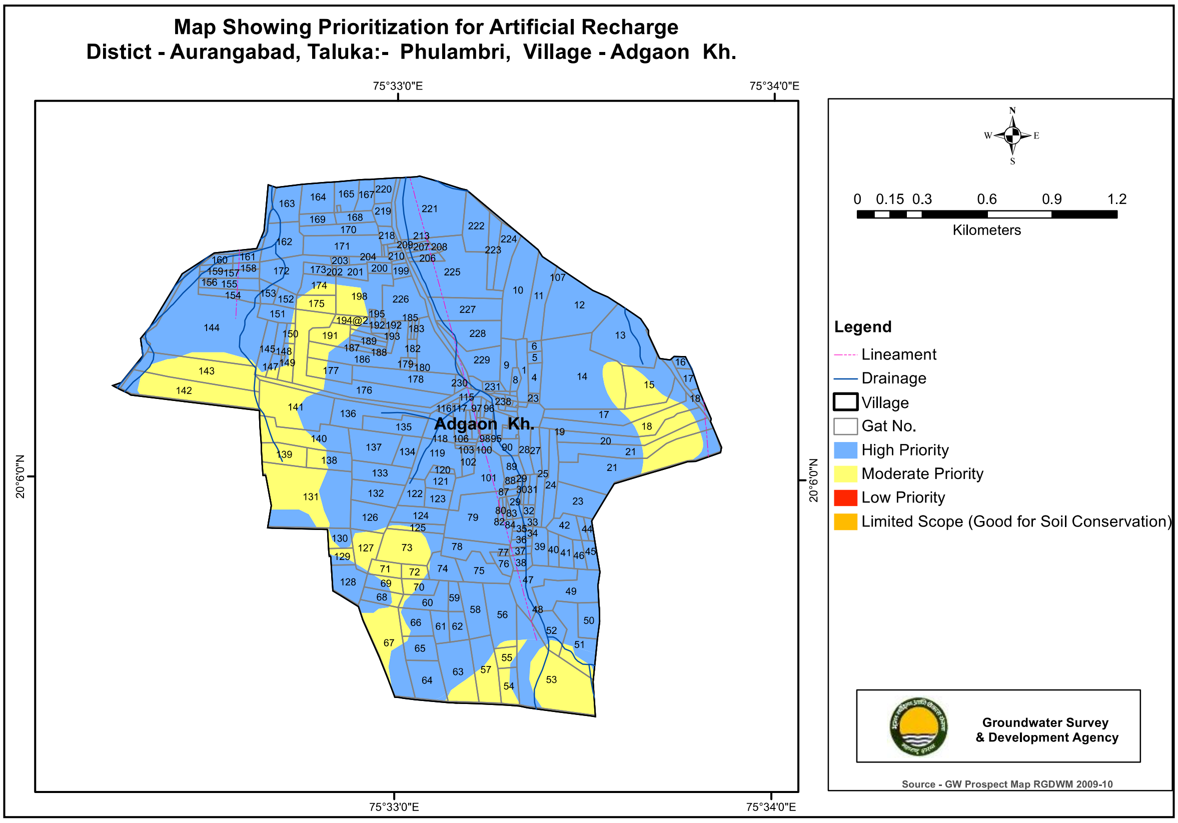
3.4 Operational strategy

Detailed quantification and pin-pointed location of these interventions will be carried out in consultation with the larger group of stakeholders and the Gram Panchayat in the coming months.



In order to identify the locations where these interventions could be taken up, the hydrogeological maps were studied. In addition, the groundwater recharge potential maps prepared by the Groundwater Survey and Development Agency (GSDA), Government of

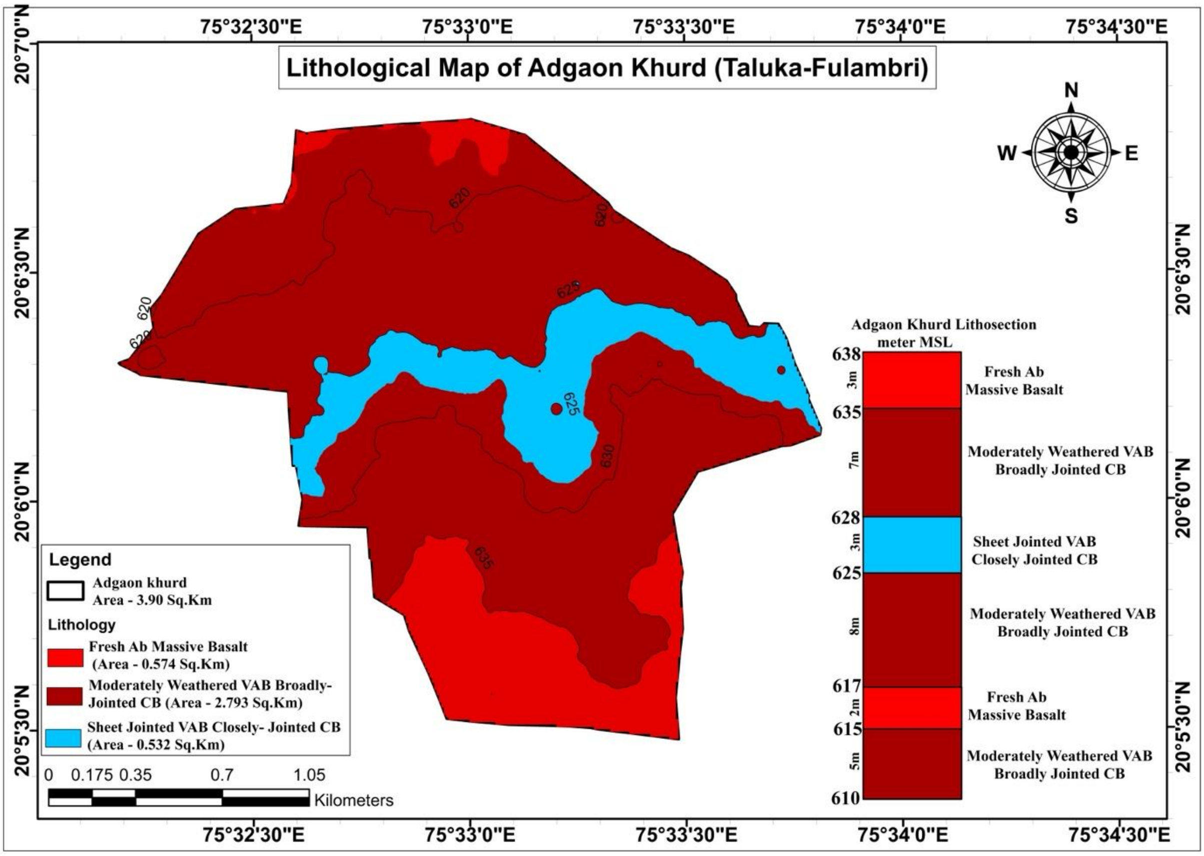
Maharashtra, were referred to.

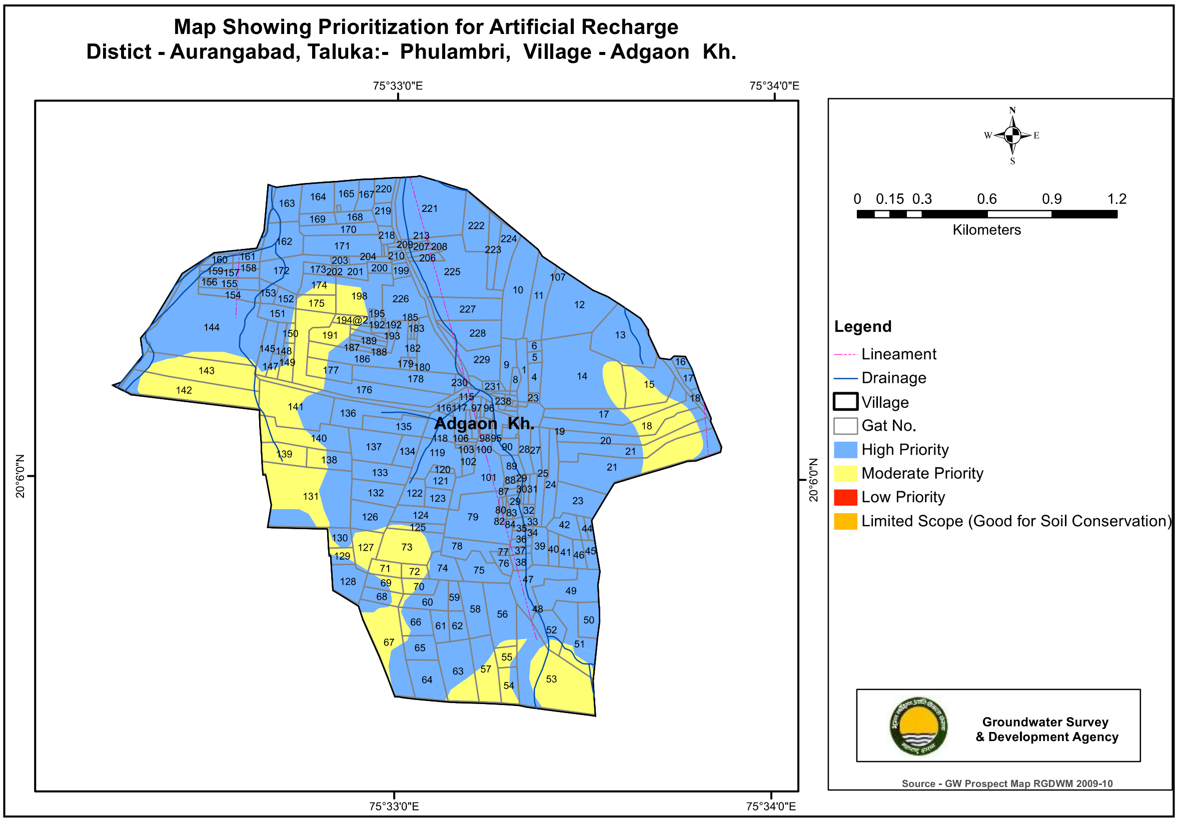


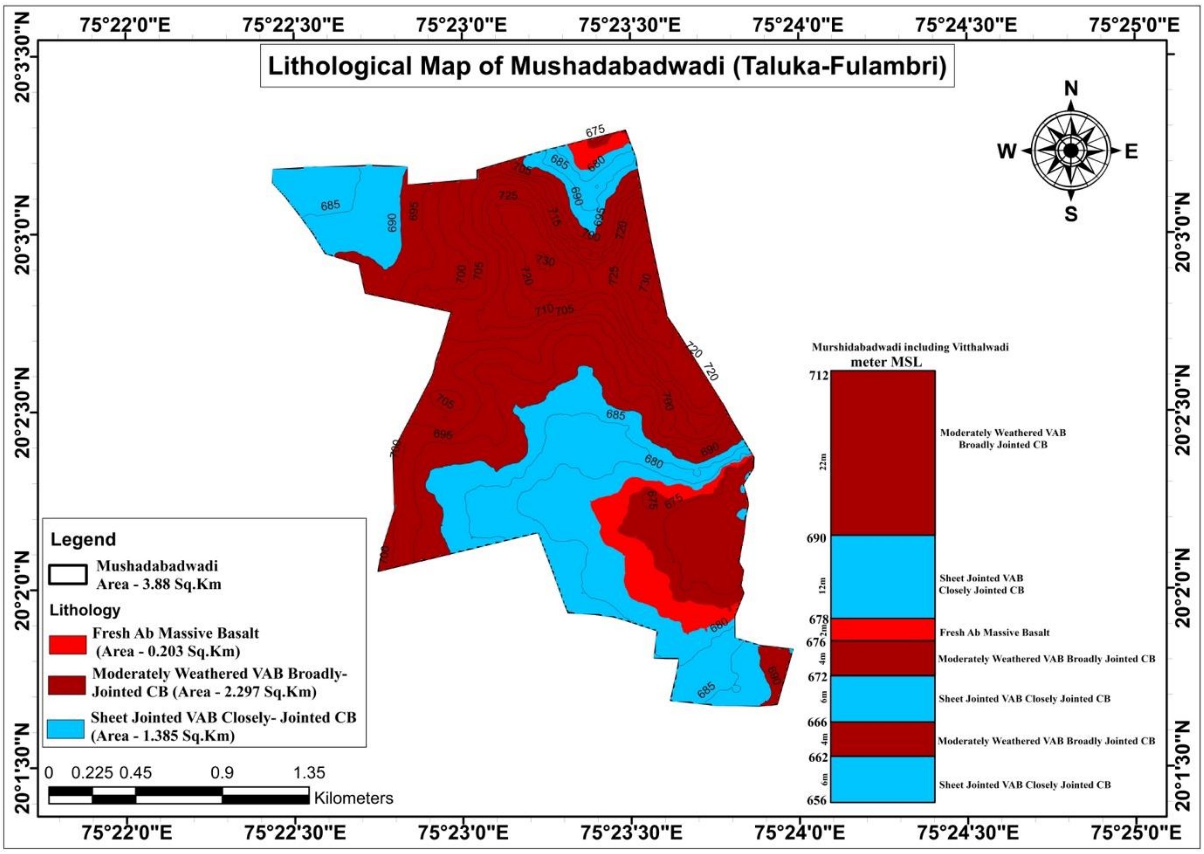
3.5 In summary

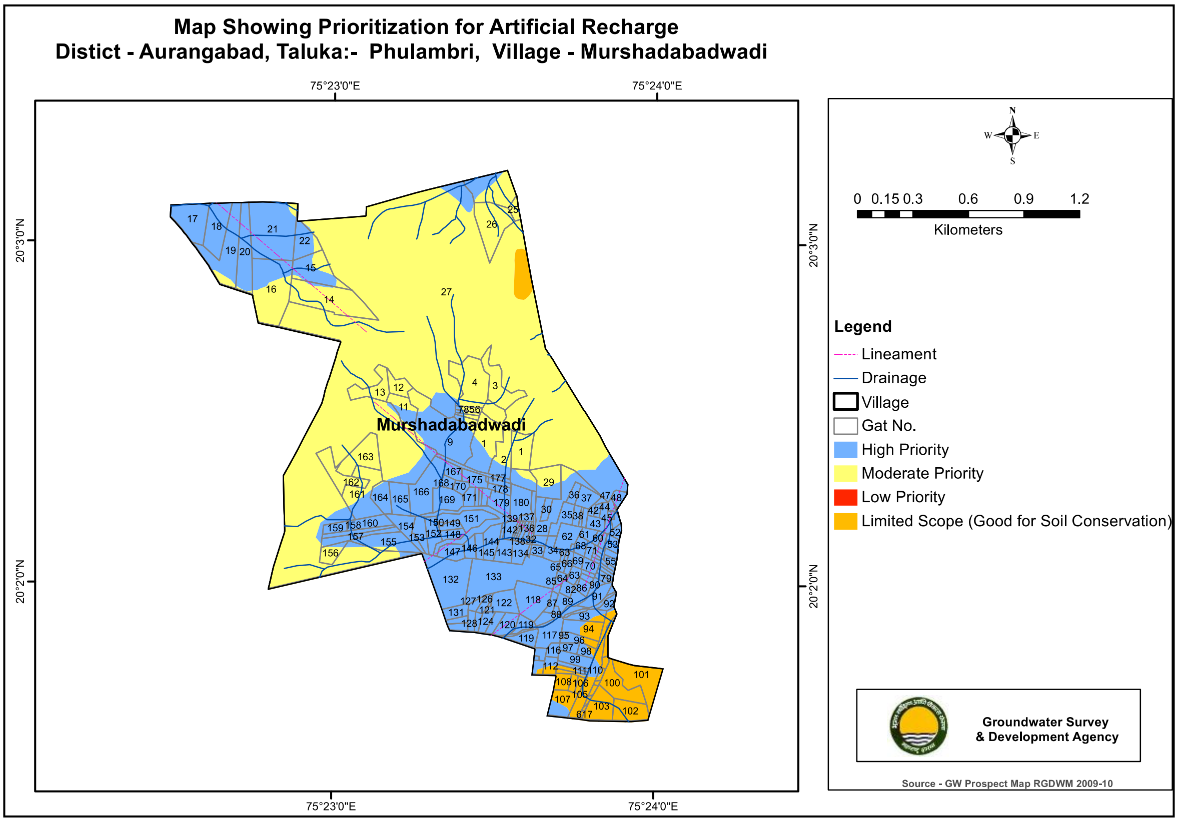
Systematic implementation of the above Adaptation Plan is expected to support overall development of the village community, especially the vulnerable sections. By participating in various activities under this project, the farmers have already become familiar with climate change challenges and pragmatic strategies to overcome the ill effects of droughts and building resilience. Implementation of the above adaptation measures will give them an opportunity to practice those methods and gain further knowledge and skills. Risk management is a key feature of adaptation; water management measures proposed above would help in reduction and sharing of climate risks. It is expected that the Gram Panchayat and the district administration will play a supportive role in this initiative. These climate proofing measures will thus be able to seek options for how the government schemes could further prepare communities for climatic change adaptation.

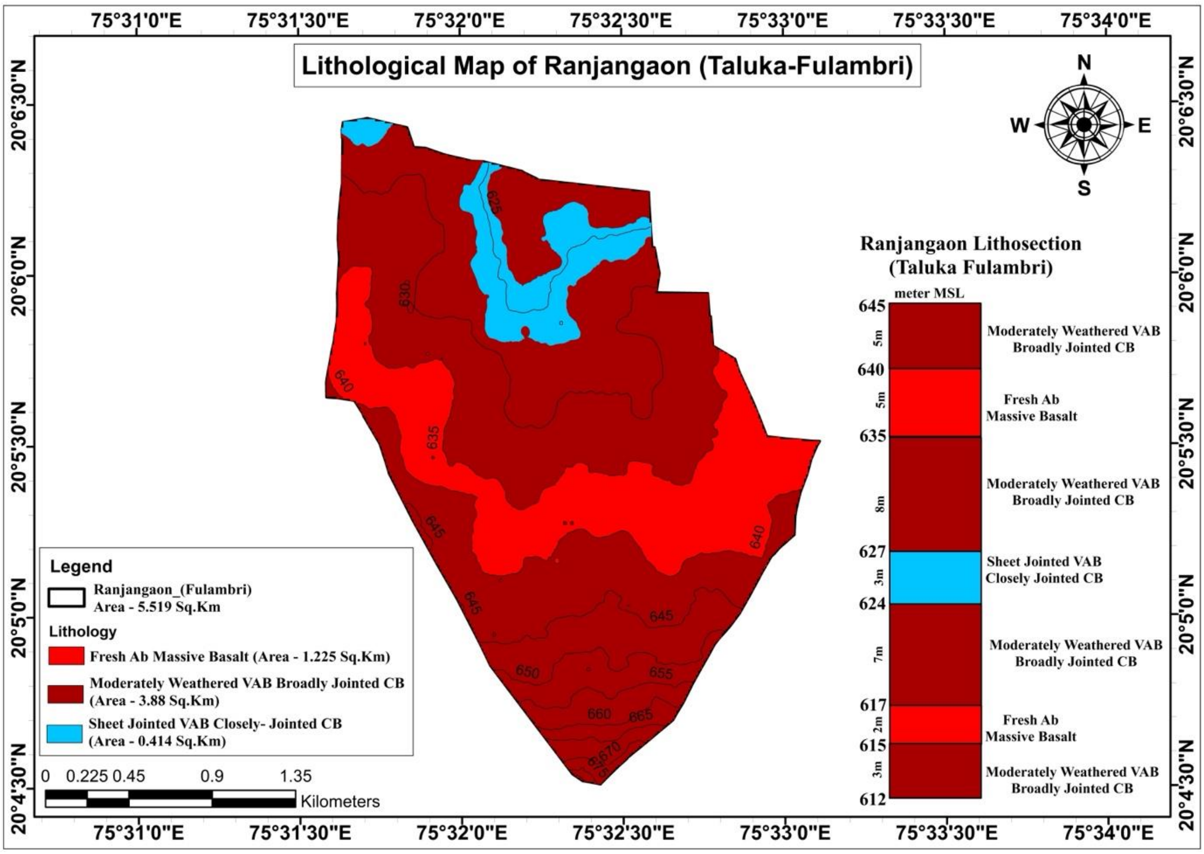
Annexure 5 : Aquifer delineation maps

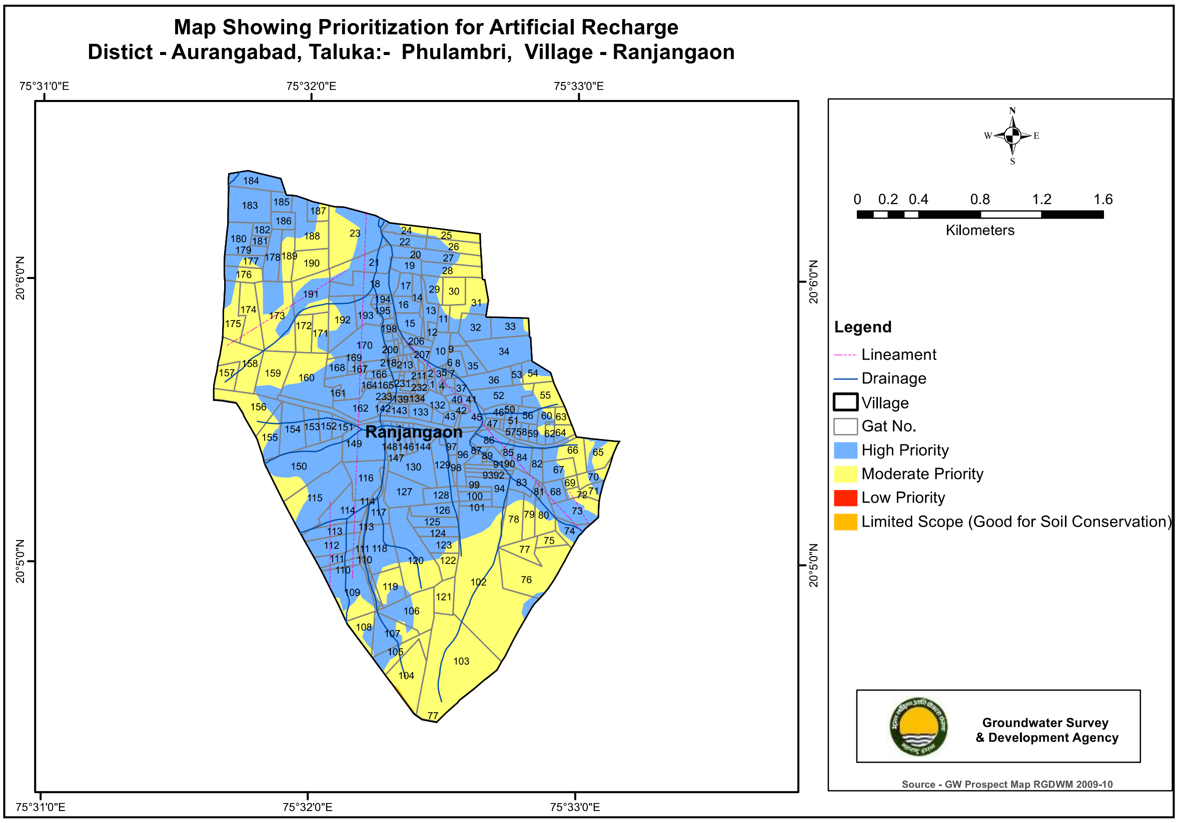


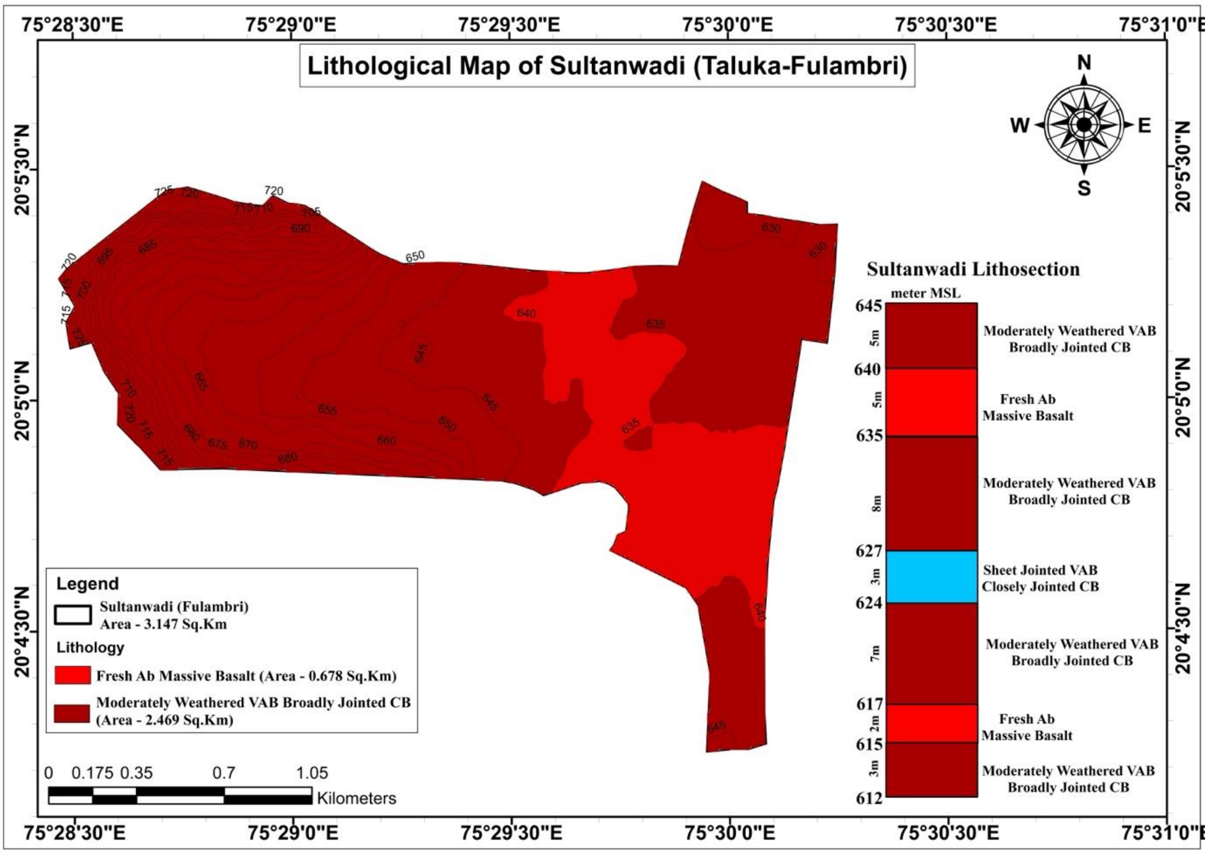


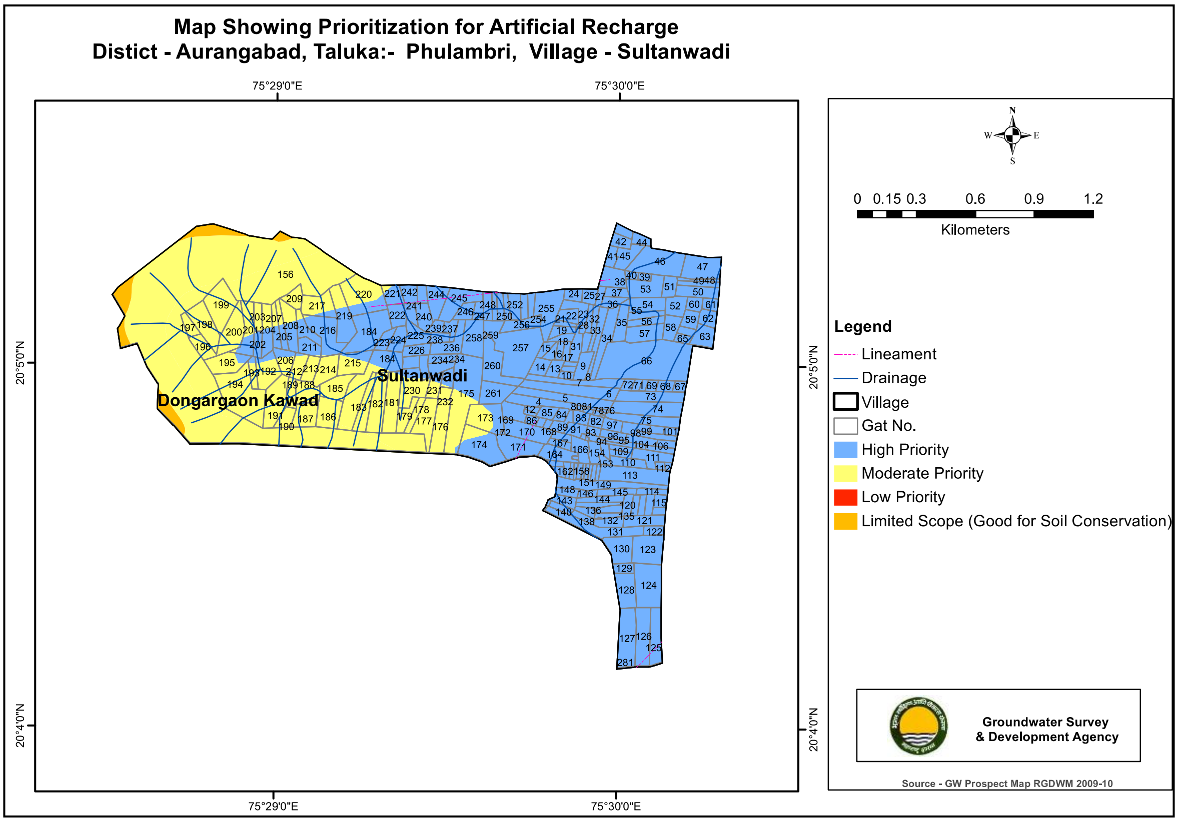

Lithological Map of Mushadabadwadi (Taluka-Fulambri)
Legend
Mushadabadwadi
Area - 3.88 Sq.Km
Lithology
Fresh Ab Massive Basalt (Area - 0.203 Sq.Km)
Moderately Weathered VAB Broadly-Jointed CB (Area - 2.297 Sq.Km)
Sheet Jointed VAB Closely- Jointed CB (Area - 1.385 Sq.Km)
0 0.225 0.45 0.9 1.35
Kilometers
Murshidabadwadi including Vitthalwadi
meter MSL
712
690
678
676
672
666
662
656
Moderately Weathered VAB Broadly Jointed CB
Sheet Jointed VAB Closely Jointed CB
Fresh Ab Massive Basalt
Moderately Weathered VAB Broadly Jointed CB
Sheet Jointed VAB Closely Jointed CB
Moderately Weathered VAB Broadly Jointed CB
Sheet Jointed VAB Closely Jointed CB
75°22'0"E
75°22'30"E
75°23'0"E
75°23'30"E
75°24'0"E
75°24'30"E
75°25'0"E
20°3'30"N
20°3'0"N
20°2'30"N
20°2'0"N
20°1'30"N
N
S
E
W


Map Showing Prioritization for Artificial Recharge
Distict - Aurangabad, Taluka:- Phulambri, Village - Murshadabadwadi
Murshadabadwadi
75°23'0"E
75°24'0"E
20°3'0"N
20°2'0"N
0 0.15 0.3 0.6 0.9 1.2
Kilometers
Legend
Lineament
Drainage
Village
Gat No.
High Priority
Moderate Priority
Low Priority
Limited Scope (Good for Soil Conservation)
Groundwater Survey
& Development Agency
Source - GW Prospect Map RGDWM 2009-10


Lithological Map of Ranjangaon (Taluka-Fulambri)
75°31'0"E
75°31'30"E
75°32'0"E
75°32'30"E
75°33'0"E
75°33'30"E
75°34'0"E
20°6'30"N
20°6'0"N
20°5'30"N
20°5'0"N
20°4'30"N
N
S
E
W
Ranjangaon Lithosection
(Taluka Fulambri)
meter MSL
645
640
635
627
624
617
615
612
5m
5m
8m
3m
7m
2m
3m
Moderately Weathered VAB
Broadly Jointed CB
Fresh Ab
Massive Basalt
Moderately Weathered VAB
Broadly Jointed CB
Sheet Jointed VAB
Closely Jointed CB
Moderately Weathered VAB
Broadly Jointed CB
Fresh Ab
Massive Basalt
Moderately Weathered VAB
Broadly Jointed CB
Legend
Ranjangaon_(Fulambri)
Area - 5.519 Sq.Km
Lithology
Fresh Ab Massive Basalt (Area - 1.225 Sq.Km)
Moderately Weathered VAB Broadly Jointed CB
(Area - 3.88 Sq.Km)
Sheet Jointed VAB Closely- Jointed CB
(Area - 0.414 Sq.Km)
0 0.225 0.45 0.9 1.35
Kilometers


Map Showing Prioritization for Artificial Recharge
Distict - Aurangabad, Taluka:- Phulambri, Village - Ranjangaon
75°31'0"E
75°32'0"E
75°33'0"E
20°6'0"N
20°5'0"N
Ranjangaon
N
S
E
W
0 0.2 0.4 0.8 1.2 1.6
Kilometers
Legend
Lineament
Drainage
Village
Gat No.
High Priority
Moderate Priority
Low Priority
Limited Scope (Good for Soil Conservation)
Groundwater Survey
& Development Agency
Source - GW Prospect Map RGDWM 2009-10


Lithological Map of Sultanwadi (Taluka-Fulambri)
Sultanwadi Lithosection
meter MSL
Moderately Weathered VAB Broadly Jointed CB
Fresh Ab Massive Basalt
Sheet Jointed VAB Closely Jointed CB
Legend
Sultanwadi (Fulambri) Area - 3.147 Sq.Km
Lithology
Fresh Ab Massive Basalt (Area - 0.678 Sq.Km)
Moderately Weathered VAB Broadly Jointed CB (Area - 2.469 Sq.Km)
Kilometers


Map Showing Prioritization for Artificial Recharge
Distict - Aurangabad, Taluka:- Phulambri, Village - Sultanwadi
Dongargaon Kawad
Sultanwadi
Kilometers
Legend
Lineament
Drainage
Village
Gat No.
High Priority
Moderate Priority
Low Priority
Limited Scope (Good for Soil Conservation)
Groundwater Survey & Development Agency
Source - GW Prospect Map RGDWM 2009-10