Groundwater Management in India

A multi-state field study of availability, utilisation and locally appropriate solutions for sustainable, equitable and efficient use of groundwater

Maharashtra State Report

October 2022

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1 Executive summary

1.1 Groundwater scenario in India

Over the last few decades our dependence on ground water has increased tremendously. It has become a major source of water for domestic and agricultural use in India. According to an estimate the ground water resource meets 80% of our water demand. Agriculture is a major consumer of the ground water; it supplies nearly 60% of water demand of the agriculture sector. Worryingly, since the 1990s the area under canal and tank irrigation has observed absolute decrease in India, whereas, ground water fed agricultural area has increased in these years. The convenience and efficient last mile connectivity of ground water resources encouraged many farmers in this country to switch from canal/tank irrigation to the tube well/bore well.

A committee constituted by the government of India to review water governance in the country led by Dr. Mihir Shah in his report in 2016 observed that the public finance on water resources after independence largely focused on surface water.[1] Huge amount was invested on creating surface water infrastructure. The ground water resource remains neglected despite it is replacing surface water from agriculture to domestic use in the last some decades. Individuals invested hugely in ground water infrastructure especially after the green revolution as it was easier and efficient in terms of available for the end use. The technological advancement and availability & affordability of power also helped individual investors (largely farmers) to create groundwater structures. Currently there are around 30 million groundwater structures in this country.

For the purpose of ground water extraction, enough knowledge and data is available. The problem is with lack of data on aquifer management. Being a large country, the geological and hydrological characteristics of the landmass varies from region to region. It further creates complexity to understand sub-surface characteristics pertinent to water seepage, storage and water movement. The CGWB has categorized 14 different aquifer settings in India. Major aquifers include Alluvial, Laterite, Sand stone, shale aquifer, Lime stone aquifer, Basalt aquifers and Crystalline aquifers. According to a classification of geohydrologist Dr. Kulkarni, Crystalline and Alluvial aquifers comprise 59% of the total aquifer area in the country. The mountain and volcanic system of aquifers accounts for 16% of the total area each. These complex aquifer systems require detailed mapping and study for better management of ground water.

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1 https://www.indiawaterportal.org/sites/default/files/iwp2/report_on_restructuring_cwc_cgwb.pdf

1.2 Groundwater policy gaps

The increasing unsustainable extraction of groundwater is a serious issue that has now turned into a water crisis in many parts of the country. In the states like Punjab, Rajasthan, Haryana, Delhi, Madhya Pradesh, parts of Uttar Pradesh and Tamil Nadu have started withdrawing more water from sub surface than available for usage. This gap in demand and supply is continuously increasing as there is no aquifer management system in the place. The numbers of critical and over exploited units are on rise. This invited crisis due to mismanagement of natural wealth has serious social, economic and ecological consequences. There are many reasons behind this problem and these problems have been discussed a number of times.

Ground water extraction is largely unregulated. The only law that loosely governs this precious resource in India is the Indian Easement Act, 1882. This law gives all rights to land owners to extract the ground water. In other words it excludes land less people from access and use of groundwater. This law does not control or regulate water extraction and its usage by the land owner. To strengthen the regulatory mechanisms, the central government has so far issued four versions of model law to be adopted by state governments. The first model bill was released in 1992 and the latest bill was released in 2017.

Yet not all states have converted the model Bill into state legislation. Andhra Pradesh, Assam, Goa, Bihar, Delhi, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Lakshadweep, Puducherry and West Bengal have adopted the older version of model bill, but in most cases the attempt is half hearted.[2] Moreover experts believe that the model Bill must also move from command and control mode to participatory mode to ensure full participation of people.

The unavailability of data and knowledge on aquifer systems is another big problem in developing better management plans for the ground water. The CGWB collects data from selected wells four times a year to monitor ground water development. The sample size for this yearly exercise is so low that nothing can be argued conclusively based on collected information. There is a long pending demand of mapping aquifers in this country for better management plan. The CGWB has been attempting to map aquifers for all districts in the country. This data and mapping of aquifers would definitely improve our ability to manage groundwater better.

The absence of an integrated approach of ground water recharge and extraction is completely missing in India. There have been some attempts through government and non-government agencies to integrate both of these aspects, but this idea is still not part of national or state level management plans. The absence of regulations and public finance for the management of ground water further discourages any national or state level plans for ground water resource management.

In the past the CGWB attempted to design a national level master plan for artificial recharge of aquifers in 2002 and 2013. The board has now revised this master plan in 2021. According to this master plan, nearly 1.41 crore artificial recharge structures are needed across the country. The type of structures recommended for states and districts varies depending on their geological and hydrological features. The plan is expected to be financed by ongoing projects such as MGNREGA and Watershed Management. The implementation of the master plans requires investment of Rs. 1.33 lakh crore.[3]

Involvement of people in planning and execution of activities related to artificial recharge and ground water extraction has not been seriously promoted at the policy level. However, we have numerous small examples across the country to show that if people are involved aquifers can be managed sustainably and benefits can be shared equitably.

1.3 The multi-state study

There have been some attempts in various states commissioned by nongovernmental organizations to empower farmers with knowledge and capacity to help them to make the right agricultural decisions and choices. Many of these serious attempts helped in yielding good results as well. On the other hand there are numerous examples where projects related to artificial recharge were carried out successfully both by the government and non-government agencies. Some states also tried to regulate groundwater resources. All these actions by different organizations generated huge knowledge and experiences to vet success and failure of each type of programs. These small scale and localized solutions for ground water management are effective in terms of striking a balance between water supply and demand.

Learning from these models can help improving ground water regulations in different states. Therefore this study was commissioned by Rajiv Gandhi Institute for Contemporary Studies (RGICS) in 2021 in ten different states namely Punjab, Rajasthan, Gujarat, Uttar Pradesh, West Bengal, Assam, Madhya Pradesh, Maharashtra, Telangana and Tamil Nadu. Main objectives of the study were as follows:

- To develop an overview of the hydro-geological characterises of different states/regions and the extent of ground water extraction.
- To document and assess the regulatory framework in different states for the management of ground water resources.
- To assess the ability of localized solutions for management of ground water resources to strike a balance between demand and supply of groundwater.
- To draw policy lessons from successful localized solutions for ground water resource management

Groundwater experts and NGOs specialized in groundwater management in different states helped us to implement this project. This is a qualitative research project which involved methods like field work, stakeholder consultation and secondary data analysis. This state report gives an overview of the context and main natural features- geographical, geological, hydrological and hydrogeological- which impacts that status of groundwater in the state. Then it deals with the human interventions – in terms of demand and utilisation, the major policies, laws and regulations, programs, schemes and institutions pertinent to groundwater in the study state.

The main incremental contribution is in the section on lessons from locally appropriate solutions for sustainable groundwater management. We have given summaries of case studies from different location in the study state documenting such locally appropriate solutions.

Finally we summarise the main lessons from the study in a section titled the eightfold path.

[2] https://scroll.in/article/929433/as-the-water-crisis-deepens-can-india-afford-to-leave-groundwater-unregulated

[3] http://cgwb.gov.in/Whatisnew/2021-06-30-Final-Approved%20Master%20Plan%202020-00002.pdf

2 Maharashtra state report

2.1 Context and key features

Use of surface water storages for irrigation has been an age old practice in India. After independence, India invested huge amounts on creating surface water and canal infrastructure. The ground water resources became a choice of farmers for irrigation through the construction of millions of private wells, resulting in a phenomenal growth in the exploitation of groundwater in the last six decades. Today, India is the largest groundwater user in the world, with an estimated usage of around 230 cubic kilometres per year, more than a quarter of the global total. With more than 60 percent of irrigated agriculture and 85 percent of drinking water supplies dependent on it, groundwater is a vital resource for rural areas in India (World Bank, 2010).

With increased access to knowledge, technology, finance and energy for the purpose of groundwater extraction, depletion of groundwater is a serious issue that has now turned into a water crisis in many parts of the country. The gap in demand and supply is continuously increasing, as also the numbers of critical and over exploited units are on rise. This mismanagement of natural wealth has serious social, economic and ecological consequences. In order to address the problem, one of the hindrances is the lack of data on the geological and hydrological characteristics and the health of the aquifers in different regions.

The present study is an attempt to study the ground situation in some of the critical regions of India, with a view to provide guidance for sustainable groundwater management in India. The present assessment of groundwater situation in Maharashtra, which is presented in this note, has been taken up towards this end.

Groundwater has been the most preferred source of water for domestic use and irrigation in Maharashtra since 1970s. Changes in groundwater availability and quality impact human health, livelihoods, food security and economic development. Sustainable management of groundwater requires reliable estimates of its availability and dependability in terms of the timing, quantity or quality. This paper looks at the assessment of groundwater resources carried out in Maharashtra state over the last two decades.

The objective of the study is to develop an overview of the hydro-geological characterises of Maharashtra state and the extent of ground water extraction. It entails the study of the key characteristics of hydrology and hydrogeology of the state and the extent of groundwater availability on a sustainable extraction basis. It also looks at the state of groundwater extraction in the state at present and how has it changed over the years.

This note is based on a quick review of available reports and papers from official agencies and academics. It is written with a view to provide an overview of the situation of groundwater management in the state, and more importantly, to give a diagnostic view of the broad canvas on which the future strategies of groundwater management should be designed and developed.

2.1.1 Hydro-geological characteristics of Maharashtra

The hydro-geological characteristics of the state were understood from the textbooks on geology and the finer aspects were understood from the academics and experts through discussions. Groundwater Survey and Development Agency (GSDA), which is the groundwater department of Government of India and Central Ground Water Board (CGWB) carried out periodic assessments in the state. Their reports were used to analyse the status of groundwater for this note. In addition, some research papers and articles on localised observations were used to corroborate the findings of the official assessment report.

Maharashtra, the third largest state in India has a total geographical area of 307,762 sq km, lies between latitudes of 15°45′ and 22° 00′ N and longitudes of 73° 00′ and 80° 59' E in the west-central part of India. Maharashtra is divided in three main physiographic units the Sahyadri Range (Western Ghats), the Western Coastal Tract (Konkan), and The Eastern Plateau (Deccan Plateau). It is drained by Rivers Godavari, Krishna, Tapi, Mahanadi, Narmada and westward flowing rivers of Konkan; these constitute the six major river basins.

Physiographic Map of Maharashtra

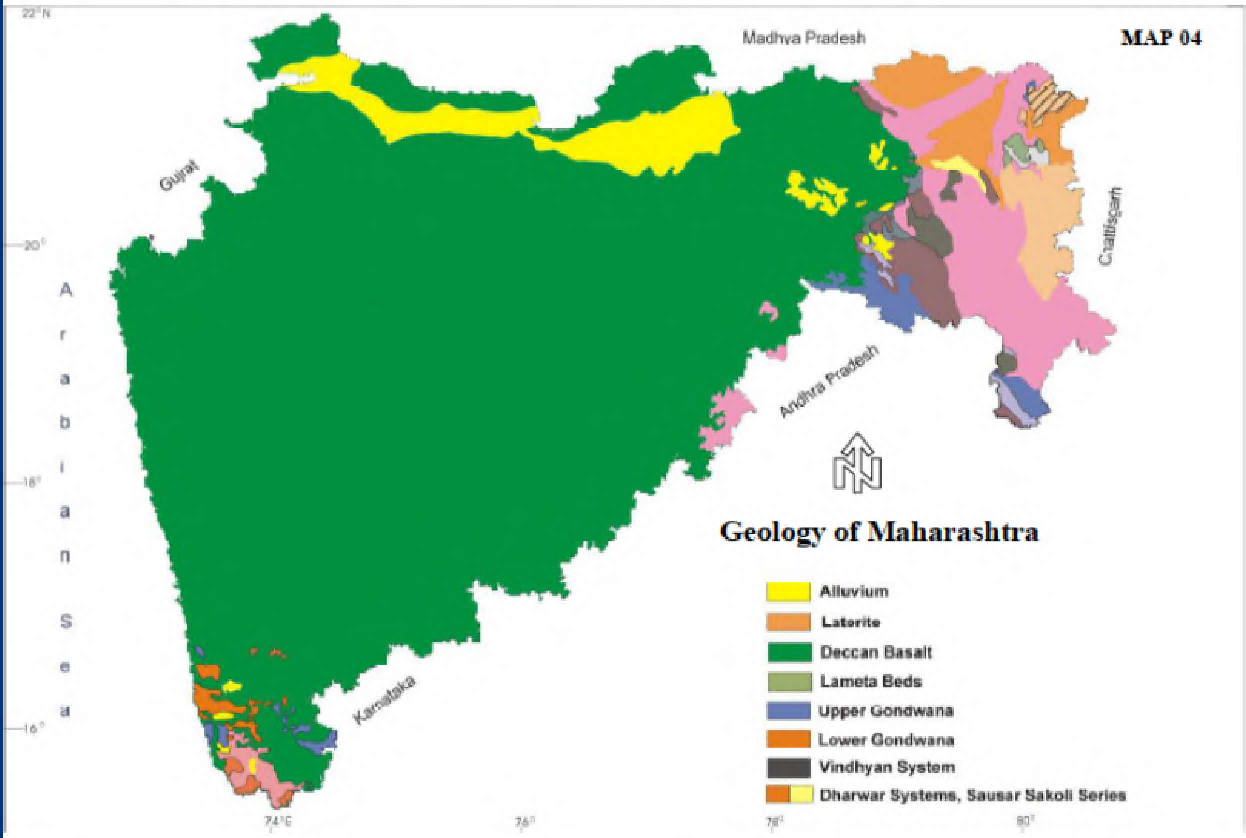
Maharashtra has five socio-cultural regions namely Konkan, Western Maharashtra, Khandesh, Marathwada and Vidarbha, which broadly match with the six administrative divisions namely Konkan, Pune, Nashik, Aurangabad, Amravati and Nagpur. These administrative divisions are divided into 36 districts. Further, the State can be divided into six distinct agro-climatic zones, each with its typical hydro-meteorological parameters. Thus, Maharashtra State has diverse physiography, hydrology and hydrogeology besides varying rainfall patterns. Physiography and geology have played a vital role in the availability of natural resources including water resources.

2.1.2 Geology of Maharashtra

Geology of Maharashtra State is practically the geology of Deccan Trap, which occur in all the districts of the State excepting Bhandara. The other geological formations, older and younger than Deccan Trap, occur in the districts of Bhandara, Wardha, Chandrapur, Gadchiroli, Nagpur, Yavatmal, Buldhana, Akola, Amravati, Dhule, Jalgaon, Nanded, Kolhapur, Sindhudurg and Ratnagiri. In the remaining 14 districts, Deccan Trap is the only geological formation occurring in them. These Deccan Traps are capped by laterites as seen in Raigad, Ratnagiri, Sindhudurg, Satara, Sangali, Kolhapur and Osmanabad districts. The distribution of these formations is given in Table and depicted below:

S No.	Formation	Area, sqkm	Percentage
1	Pleistocene and Quaternary Alluvial Sediment	14,500	4.71
2	Deccan Trap lava flows	2,50,000	81.20
3	Gondwana Sedimentary rock formation	4,800	1.55
4	Vindhyan and Cuddappah Pre-Cambriansediments	6,200	2.00
5	Archean and Dharwad Metamorphic complexes	32,200	1.048

(Source : GSDA)



Hydrogeology of Maharashtra

Alluvial groundwater province: The alluvium in Tapi and Purna valleys are deposits in faulted basins. The weathering and erosion of the Satpuras have contributed considerable volume of material in filling up of the two basins. The foothills of the Satpuras have a thick accumulation of pediment deposits commonly referred to as the bazada zone. The thickness of the zone varies considerably but holds tremendous potential as far as artificial recharge to the depleting groundwater is concerned.

The alluvial sediments in the two basins generally consist of clays, silt, sand, pebbles and boulders. The sand, gravel, boulders etc. occur in one or more beds within a depth of about 100 m and sometimes even down to the depth of 250 m below surface. The water levels in open wells vary in depth from15 to 30 m. In areas bordering the Satpuras in the north water levels are deeper and the wells are 30 m or more in depth.Most of the existing dug wells yield 100 to 300 m3/day, though in few case higher yields are observed.

Deccan Trap volcanic groundwater province: The Deccan Traps, which occupy about 82% of the total area of the State, is a major groundwater province for consideration and valuation of groundwater potential in the State. The basalt lava flows are formed as wide spread flows forming extensive plateaus. The entire pile of near horizontal lava flows show variation in their physical character, thereby influencing the aquifer parameters.

Basaltic rocks have negligible primary porosity, and hence, groundwater occurs in secondary features like weathering, jointing, and shearing develop storage space. The vesicles, the joint system and inter flow zones contribute considerably to the yield, based on the degree of weathering and topographic setting. The entire succession of lava flows acts as multi-layer aquifer system. The average depth of wells varies from 9 to 15 m and diameter varies from 4 to 8 m. The range of water level varies from 3 to 7 m and the yield ranges from 75 to 100 m3/day in winter. Wells located in favourable sites have very good yields ranging from 150 to 200m3/day.

Gondwana sedimentary groundwater province: The Gondwana sedimentary rock formations are confined chiefly to the districts of Nagpur, Chandrapur, Yavatmal and Amravati. These sediments occupy a total area of about 4,801 sq km and comprise of sandstones, shales and clays of varying thickness and degree of compaction. These rocks possess primary porosity. However, due to block faulting and intra-formational faulting and fracturing, secondary porosity is generated within these formations. The dug wells in these types of rocks vary in depth from 10 to 20m. The water levels vary from few metres to 8 m.b.g.l. The yield ranges between 50 and 300 m3/day.

Proterozoic sedimentary groundwater province: The compact sediments mainly comprise of Vindhyan and Kaddappa formations, occupying an area of 6,217 sq km. The Vindhyan comprise of limestones, sandstones and shales. Geomorphological features such as sink holes, galleries and caverns associated with this topography impart secondary porosity and permeability to this formation. Groundwater occurs in these rocks under phreatic as well as semi-confined conditions. The dug wells piercing the Vindhyan rock types range in depth between 5 and 12 m and static water levels range between 2 and 7 m. b.g.l. The diameters of the wells range between 3 and 5 m. The wells in this area generally sustain a discharge of 50 to 100 m3/day.

Precambrian metamorphic groundwater province : It comprises of basement complex rock types such as schists, gneisses, granite, amphibolite and basic intrusives. The rocks are very hard and compact and possess practically no primary porosity. However, these are highly weathered and are fractured, sheared and jointed due to numerous tectonic episodes. The secondary porosity is therefore of prime importance in this province. The yield from the wells in this province generally varies from 45 to 80 m3/day and the water level fluctuation varies from 2 to 8 metres b.g.1. However, the wells located on major lineaments or shear zones have higher yields (100 to 150 m3/day).

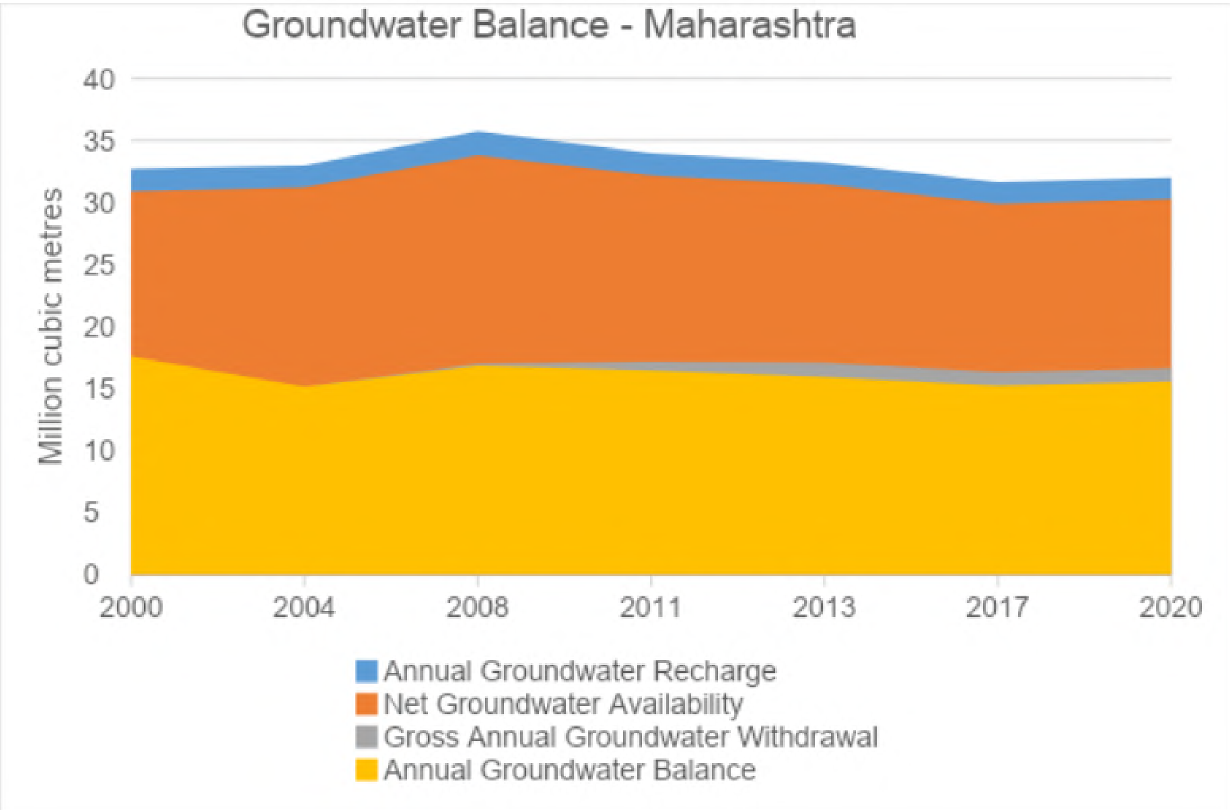
Groundwater occurrence is affected by the geological formation. Basaltic aquifers which occupy most part of Maharashtra comprise multiple flows (traps), each one being marked by a potential vesicular zone at the top and a massive rock unit underneath. The weathered part of the top flow and the vesicular zone of the successive flows below and the intertrappeans form aquifers. Groundwater occurs more in the cracks and fissures in these rocks. Locating and marking these flows and understanding their characteristics is a challenge and it affects the determination of aquifer expanse, which is the main factor in computing the volume of rechargeable groundwater.

2.2 Groundwater availability and utilization:

The groundwater assessment, both recharge and draft, was carried out considering watershed as unit and within that command, non-command and poor quality zones as subunits. The final assessment of the potential is apportioned and presented as taluka wise. For the purpose of analysis, this study looked at the periodic assessments carried out from 1987-88 to 2019-20. However, data on similar variables was not available consistently for this period, and therefore, the trends from 2000 to 2020 were analysed for those variables for which data was available.

The total rechargeable groundwater resource has been around 30 billion cubic metres (BCM) to 35 BCM. However, a slight reduction (of around 5%) is expected on account of outflows or losses from the aquifer, and around 95% of it is available for abstraction as the net amount. The groundwater withdrawal has been varying from 13.33 BCM in the year 2000 to 17.18 BCM in year 2011.

Trends in dynamic groundwater resources



Trends in dynamic groundwater resources

SNo	Details of assessment	2000	2004	2008	2011	2013	2017	2020
1	Annual Groundwater Recharge	32.69	32.96	35.73	33.95	33.19	31.64	32.01
2	Net Groundwater Availability	30.89	31.21	33.81	32.15	31.48	29.90	30.25
	As % of Net availability	94.49	94.70	94.61	94.71	94.85	94.50	94.50
3	Gross Annual Groundwater Withdrawal	13.33	15.09	17.00	17.18	17.07	16.33	16.63
	As % of Net availability	43.15	48.34	50.29	53.42	54.22	54.62	54.97
4	Annual Groundwater Balance	17.56	15.13	16.81	16.45	15.93	15.19	15.54

(Source : Compiled by author from GSDA and CGWB data)

There has been a reduction in this figure during the last two assessments (16.33 BCM in 2017 and 16.63 BCM in 2020), which is due to change in methodology as per the GEC-15 guidelines, where the draft was calculated on the basis of the wells which were functional during the year. It was observed that the Gross Annual Withdrawal has been continuously increasing from 43.15% of the Net Groundwater Available in 2000 to 54.97% in 2020.The increase in draft has mainly been due to increase in number of irrigation wells.

The categorisation of watersheds according to the severity of groundwater exploitation until 1990 is presented in the following table.

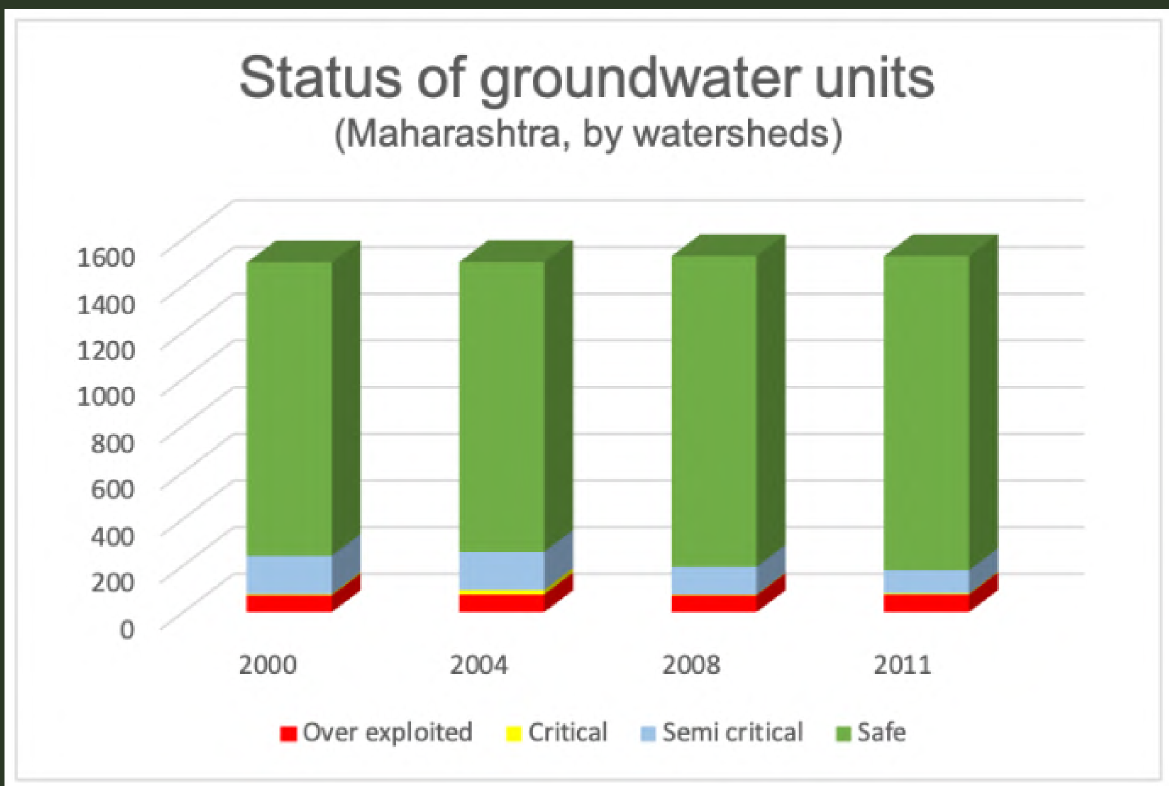
Categories of Watersheds (until 1990)

S No	Category	Stage of Development	No of watersheds in 1987	No of watersheds in 1990
1	White	Up to 65%	1414	1392
2	Grey	65% to < 85%	57	87
3	Dark	85% to < 100%	34	26
4	Overexploited	Over 100 %	0	0

(Source : GSDA)

The names of the categories and method of categorisation changed from 2004 onwards as per the GEC guidelines. The observed trend is presented graphically in figure below.

Categorisation of Watersheds (2000-2011)



It may be noted that the watershed-wise data on the categories are not available from GSDA from 2013 onwards as these reports are not yet made public.

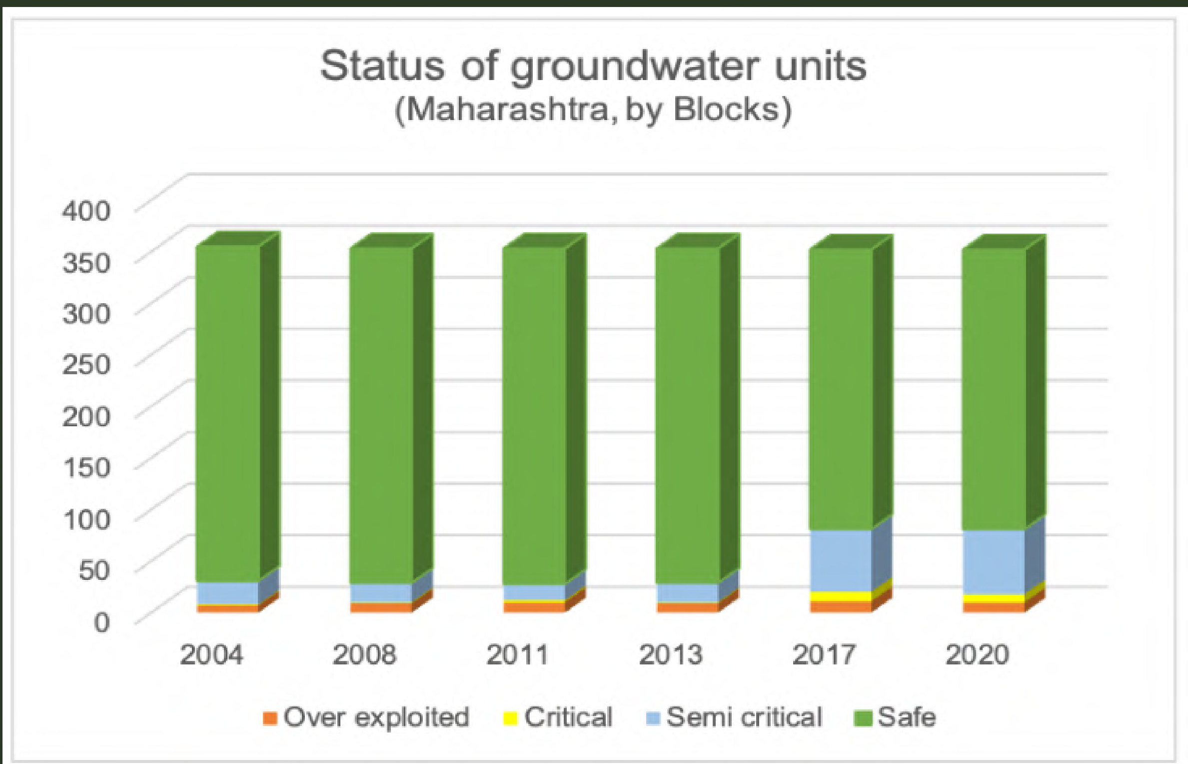
Watershed-wise Groundwater Status

Number of watersheds	2000	2004	2008	2011
Over exploited	72	76	73	76
Critical	6	20	3	4
Semi critical	164	163	119	100
Safe	1257	1242	1332	1347

(Source : Compiled by author from GSDA and CGWB data)

The Central Ground Water Board compiles and published the data on the basis of administrative units like Tehsils, Talukas, Blocks, Mandals, etc. The trends in block-wise categorisation indicates that the proportion of unsafe blocks has been increasing over the years.

Categorisation of Blocks (2000-2011)



While the trend does not prominently show any major changes in the over-exploited blocks, the rise in the critical and semi-critical blocks has been on the rise (Table 7b). Even if we tend to attribute the sudden jump in the number of such blocks from 2017 onwards due to change in methodology, the other parameters are indicative of the declining trend.

Block-wise Groundwater Status

Number of blocks	2004	2008	2011	2013	2017	2020
Over exploited	7	9	10	9	11	10
Critical	1	1	2	1	9	8
Semi critical	23	19	16	19	61	63
Safe	287	324	325	324	271	271

(Source : CGWB)

CGWB has also been publishing the changes in the categories of blocks, which corroborates the above observation on trends. While the figure of 345 blocks out of 353 showing no change may be consoling, it has to be viewed in the overall context and other indicators.

Change in status of blocks in successive assessments

Category	2011-2013	2013-2017	2017-2020
Improved	5	3	5
Deteriorated	5	63	3
No change	343	286	345

Out of the total area under irrigation, groundwater accounts for 71%-75% across different years. Out of the total groundwater consumed, 85 per cent is for irrigation, 10 per cent is for industries and only 5 per cent is for domestic consumption. Drinking water needs of 90 per cent of the total rural population are entirely met from groundwater.

The groundwater balance, or the amount of groundwater available for abstraction for various uses, has been broadly around 15 BCM or 45%-55% of the net groundwater availability during the last two decades. Unfortunately, major part of it exists in the areas where development is not required for either irrigation or for drinking and/or is in areas, which are not favourable for development.

Groundwater availability depends on good rainfall in addition to the recharge from surface irrigation systems and soil water conservation measures, which replenished the groundwater in the non-monsoon period. On the other hand, the use in areas where well irrigation is common, the draft is often limited by the availability. Thus, higher monsoon rainfall leads to higher recharge, which further leads to increase in groundwater abstraction and use.

Identifying groundwater occurrence and assessing its availability in hard rock area are affected by the assessment geological formation and availability of reliable data. An example of the latter is the data on irrigation wells. After electrification of wells the numbers of irrigation wells with pumpsets are increasing continuously. As per the estimate of GSDA (2013), there were 10.07 lakh irrigation wells with pumpsets in the year 1988, which rose to 16.71 lakhs in the year 2007 and 21.07 in the year 2011.

It is a well-known fact that large number of irrigation borewells or tubewells are the main source of irrigation in all the parts of the State and large number of them are not on Revenue records or on electricity connections. The draft from those borewells or tubewells was the missing component from the assessment.

2.3 Groundwater policies and governance in the State

Assessment of groundwater resources assumed importance as dependence on groundwater for drinking and domestic uses and irrigation started growing. In Maharashtra, groundwater exploration was started in 1973 soon after the formation of Groundwater Survey and Development Agency (GSDA) as the state groundwater department. A comprehensive groundwater resource assessment in Maharashtra was carried out in 1979. From 1987 onwards, it became almost a regular feature with an interval of about 3-4 years. The Central Ground Water Board (CGWB) started collaborating with these state level initiatives, and from the turn of the century started compiling the report at national level.

While the first ad hoc attempt of estimating groundwater resources in Maharashtra was made during 1973, the first scientific assessment was carried out during 1979 on the basis of Overexploitation Committee Report published by Agricultural Refinance and Development Corporation (ARDC). Since then, various committees constituted by Government of India and Government of Maharashtra have suggested improvements in the methodology to estimate the groundwater resources. The estimations of 1987 and 1990 were carried out based on the methodology suggested by Groundwater Estimation.

Source: ACWADAM

Committee constituted in 1982 by Government of India (GEC-84), whereas that from 2000 to 2013 were carried out according to the guidelines of the Groundwater EstimationCommittee 1997 (GEC-97). Subsequently, the guidelines were further modified in 2015 (GEC-15), which were used for assessment during 2017 and 2020.

Key characteristics of Groundwater Assessment Studies in Maharashtra

Details of assessment	**1988**	**1990**	**2000**	**2004**	**2008**	**2011**	**2013**	**2017**	**2020**
No of Watersheds	1,505	1,505	1,505	1,505	1,531	1,531	1,531	1,531	1,535
Methodology	GEC-84	GEC-84	GEC-97	GEC-97	GEC-97	GEC-97	GEC-97	GEC-15	GEC-15

(Source : Compiled by author from GSDA and CGWB data)

The state of Maharashtra has 35 districts and 353 talukas, out of which the two urban districts of Mumbai and Mumbai Suburban (erstwhile Bombay and Greater Bombay districts) were excluded from the assessment, thus covering the remaining 33 districts which are rural. Until 2004, the estimation was carried out for 29 districts before bifurcation, i.e., combined estimate for Parbhani-Hingoli, Dhule-Nandurbar, Bhandra-Gondia and Akola-Washim. Similarly, the 2004 assessment compiled the status based on 318 talukas before bifurcation.

For the purpose of groundwater estimation and evaluation, Maharashtra State was divided into 1535 elementary watersheds (This number was 1505 until 2004, 1531 from 2008 to 2013 and 1535 from 2017 onwards).

The recharge was estimated for the groundwater worthy area of all the watersheds, while the non-worthy area comprising of steep slopes more than 20 per cent, hill tops and rocky wastelands have been left out. Each watershed was further delineated into poor groundwater quality area, where the quality of the groundwater was beyond the usable limits, as also into command and non-command area. In this fashion, each watershed was divided into three assessment subunits, but all the subunits may not be present in the single watershed. Hence, the assessment was carried out on a watershed basis, although initially the assessment was carried out for the command and non-command areas.

Until 1990, the status of groundwater situation was defined using the following terminology, as per the protocols of GEC-84. For working out the water balance, 70% of the gross extraction was taken as net draft. The rest 30% was presumed to go as return flow to the groundwater regime. The categories of watersheds were made on the basis of stage of development over a five year period.

Categories of Watersheds (until 1990)

S No	Stage of Development	Category
1	Up to 65%	White
2	65% to < 85%	Grey
3	85% to < 100%	Dark
4	Over 100 %	Overexploited

From the assessment of 2004 onwards, the status of groundwater situation was defined using a new terminology, in line with the recommendation of GEC-97. The units of assessment are categorised for groundwater development based on two criteria, viz., stage of groundwater development, and long term trend (preferably, over a period of 10 years) of pre and post monsoon water levels. The assessment of 2011-12 was based on the guidelines issued in 2010 (first in January and subsequently revised in July 2010). The national level groundwater assessment of 2019-20 was carried out following the guidelines mentioned in the GEC-2015 methodology using appropriate assumptions depending on data availability. However, the Groundwater Yearbook of 2019-20 for Maharashtra is silent on the methodology.

Four categories were defined as safe, semi-critical, critical and over-exploited. In Semi-Critical areas, cautious groundwater development is recommended; whereas in Critical and Over-exploited areas, intensive monitoring and evaluation was recommended and water conservation measures along with any future ground water development. The criteria for categorisation of assessment units are as follows.

Criteria of categorisation (After 2000)

S No	Stage of GW Development	Significant Long Term Decline		Category
		Pre-monsoon	Post-monsoon	
1	Up to 70%	No	No	SAFE
		Yes/No	No/Yes	To be re-assessed*
		Yes	Yes	To be re-assessed*
2	70% to 90%	No	No	SAFE
		Yes/No	No/Yes	SEMI CRITICAL
		Yes	Yes	To be re-assessed*
3	90% to 100%	No	No	To be re-assessed*
		Yes/No	No/Yes	SEMI CRITICAL
		Yes	Yes	CRITICAL
4	Over 100%	No	No	To be re-assessed*
		Yes/No	No/Yes	OVER EXPLOITED
		Yes	Yes	OVER EXPLOITED

*Note : The term 'To be re-assessed' means that the computation should be reviewed and the reliability of the data used is to be checked for the purpose of categorisation.

Major Policies and Legislations Governing Ground Water Resources in Maharashtra	
The Maharashtra Groundwater (Development and Management) Act, 2009.	• Constitution of The Maharashtra Water Resources Regulatory Authority to notify any area in the state to regulate water extraction • Formulation of Watershed water Resource committees in notified areas • No user of groundwater shall do anything or release any effluent that contaminates the groundwater either temporarily or permanently. • The State Authority shall regulate, including total ban on, the construction of wells, including deep-wells, for any purpose within the notified areas. • The State Authority shall direct the District Authority to exercise a total prohibition on pumping of groundwater from the existing deep-wells of a depth of sixty metres or more, in the notified area. • to prepare an Integrated Watershed Development and Management Plan for artificial recharge of groundwater on priority for the notified areas and subsequently for the non-notified areas.
The Maharashtra Water Resources Regulatory Authority Act, 2005	• Constitution of Maharashtra Water Resources Regulatory Authority determine the distribution of Entitlements for various Categories of Use and the equitable distribution of Entitlements of water within each Category of Use • to establish a water tariff system, and to fix the criteria for water charges at sub-basin, river basin and State level • to review and clear water resources projects proposed at the subbasin and river basin level
Maharashtra Management of Irrigation Systems by Farmers Act, 2005	• Formation of Water Users' Association for equitable distribution of water resources within an irrigation scheme. • Maharashtra Management of Irrigation Systems by Farmers Act, 2005
Maharashtra State Water Policy, 2019	• Engagement of stakeholders for inclusive water governance. • Strategic planning and prioritizing investments; • Continuous monitoring and updating the policies • Demand Management; v. Improving Water Use Efficiency in all water use sectors; • Increasing quantity of usable water;

3 Locally appropriate solutions for groundwater management

Groundwater has become a major source of water for domestic and agricultural use in India in the last three decades meeting nearly 60% of irrigation demand. The relative ease in accessing a captive source and extraction technology has facilitated this phenomenal rise in groundwater use, often threatening the sustainability of the very groundwater sources. Determining sustainable levels of extraction, in proportion to the recharge, is a challenge in complex aquifer systems in hard rocks, which comprise nearly two third of the country. Understanding the behaviour of groundwater in an aquifer is essential/ prerequisite to its use in sustainable and viable manner.

The state of Maharashtra is having basaltic formations on nearly 85% of its area and nearly half of its geographic area is under semi-arid region with unpredictable rainfall (high variability across seasons and years). Recurrent droughts and complex, multi-layer aquifers is a double whammy for the farmers living in such regions, where groundwater development is a complicated because of the diversity of hydrogeological and socio-economic conditions that influence the patterns of groundwater utilisation even in a small area. It requires an understanding the underlying drivers of a particular groundwater problem - physical and anthropogenic characteristics of groundwater resources, and thus, current status of groundwater exploitation.

There are few examples where the community has come together to find solutions to cope with such vagaries of nature. Watershed Organisation Trust (WOTR), a civil society organisation based in Ahmednagar, Maharashtra launched a Water Stewardship Initiative (WSI) with the goal to promote climate smart water governance through community participation. It entailed helping various stakeholders to understand the realistic information of their climate, water resources, related productivity within their socio-economic context, which motivated and mobilised them to act for effective water governance. Malegaon initiative is an example of effective community managed groundwater systems.

3.1 Participatory groundwater management of Malegaon aquife

Watershed Organisation Trust has been working for integrated watershed development in a cluster of four villages including Malegaon from 2008 and expanded the work to another three villages in 2009. The Village Watershed Committees implemented comprehensive soil water conservation measures using ridge-to-valley principle and promoted several crop production technologies under these projects. During the severe drought that extended continuously over the three years of 2012-14, the people realised that their efforts at watershed development could not ensure them adequate availability of water to take care of their agricultural needs beyond one season. This realisation prompted the community to look at the hydrogeology in these watersheds.

Around the same time, the results of aquifer level water conservation interventions carried out by the Government of Maharashtra's Jalswarajya Aquifer Water Management Pilots in six diverse locations of Maharashtra and CSOs like ACWADAM in Purandhar in district Pune and MSSM in Shivni in district Jalna, underlined the importance of geology in the development planning. On these considerations, WOTR carried out detailed hydrogeological studies in these two watersheds. During the course of the analysis, it was found that the groundwater in these watersheds are connected to few other surrounding villages.

Further investigations confirmed that the aquifer spans an area of over 11500 ha from 14 villages. These villages are Malegaon, Warud Budruk, Ralegaon, Mohlai, Kosgaon, Kautha Jahagir, Wadala, Walsa Wadala, Borgaon Jahagir, Nimbola, Vadsed, Godri, Tadkalas and Kolegaon. Thus, a cluster of 14 villages in Bhokardan block was demarcated as an aquifer and was named at Malegaon aquifer based on the villages at its geographic centre.

Watershed Organisation Trust has been working in Bhokardan block of district Jalna for nearly 20 years for watershed development and rural livelihoods. WOTR implemented an integrated watershed development project in village Kautha Jahagir, covering parts of the villages Kosgaon and Ralegaon during 2008-11. Similarly, they implemented the Integrated Watershed Development Programme (IWDP) of Government of Maharashtra in villages Malegon, Kolegoan and few other villages during 2009-13.

These projects transformed the economy of the villages from a drought stricken to lush green agricultural landscape. However, during the three years of successive drought from 2012-14, the villagers realised the need for managing their water use collectively based on the availability. WOTR appraised them of the results of aquifer level water conservation interventions carried out by the Government of Maharashtra's Jalswarajya Aquifer Water Management Pilots in six diverse locations of Maharashtra (2007-10) and a groundwater management project (2006-08) implemented by the Groundwater Survey and Development Agency (GSDA) of GoM in eight villages of Bhokardan and Badnapur blocks of district Jalna.

Similar work by CSOs like ACWADAM in Purandhar in district Pune and MSSM in Shivni in district Jalna underlined the importance of geology-based development planning. The Watershed Development Committees in the above villages showed interest in taking up community based water management measures, which led WOTR to launch the groundwater management project in 2014. Started as a groundwater recharge initiative, it soon started working on water use planning and gradually culminated into an aquifer based project.

The experiences of the community and the implementing organisation were studied through a series of interactions with the stakeholders and field observations. The main findings of this study are presented below, listing and explaining the unique/ best practices and their effectiveness (what worked, what did not) signifying the approach. The applicability of these methods in other areas (replication potential) and a summary of what can be learnt from the case, is also given.

3.2 The story from the eyes of the community

This section narrates the initiative from the perspective of the people, and therefore, care is taken to not alter or modify the content or messages according to any "scientific validity", in order to retain the original reflection on their awareness, concerns and aspirations.

Interaction with the Water Management Committee members and the farmers revealed that increased water availability as a result of watershed projects led to the farmers taking up new wells or deepening existing wells so that they could take two or three crops in a year, and also crops like wheat and maize which required more water. Three-year long drought spell of 2012-14, which led to drying of about 75% of their winter crops, made them realise that they have to limit their water use.

The Watershed Committees set up during the watershed projects came together to find a solution. Initially, they wanted to take up more water harvesting structures and soil conservation works, and took up deepening of village streams and desilting of old ponds. Some of these works were carried out from the meagre Maintenance Fund they had created during the watershed projects. Once that was done, they approached WOTR for additional support and guidance.

The interaction between WOTR and the community gradually exposed the limits of supply side interventions like nalla deepening or pond desilting and made them realise the need for demand side management through collective water use planning. In 2015, WOTR brought in water experts like hydrologists and geologists and carried out detailed investigation of the area. The study showed that the water availability in the watershed villages was influenced by the water use in a much larger area spanning 14 revenue villages. This led to increasing the outreach and awareness building work in those villages, as any development planning and works were required on the basis of the entire aquifer.

Working on such a large scale required mobilising community and working with them through organised groups. The older watershed committees which were formed during the watershed programme in the older villages were activated, with some existing members continuing and some new members joining. They started with water augmentation and repair of old structures, as they felt that although 70-80% of soil and water conservation work was done during the watershed projects, it was not sufficient. From 2015, they started deepening of the streams, desilting of about four check weirs constructed by the Department of Agriculture and four check weirs constructed by WOTR and one percolation tank for increasing the storage.

However, understanding groundwater was not easy. Prompted by similar observations in other projects, WOTR launched a Water Stewardship Programme in 2016 to prepare barefoot water technologists to build the knowledge and skills of groundwater management in the community. The idea was to equip rural communities with the necessary knowledge and tools to ensure sustainable use and management of water. It covered areas of assessing and monitoring the rainfall, runoff, well water fluctuations, and based thereon, prepare water budgets, monitor its application and build resilience to water scarcity and droughts.

Under this programme, WOTR promoted Village Water Management Teams to prepare and monitor water management plans. In practice, many active members of the Village Watershed Committees formed under the earlier projects, who brought in their experience on technical and social aspects, joined the new teams.

It followed a process of mapping of water resources, its monitoring, planning and budgeting its use at different stages of hydrologic cycle. These committees developed, with the help of experts from WOTR, three dimensional visual models of water resources for each village, and for the aquifer as a whole. This tool called Community Driven Visual Integrator (abbreviated as CoDriVE-VI by WOTR) was a participatory mapping tool for delineating surface and subsurface features (characteristics) of each village. It was as an effective tool to educate the communities on the complex nature of hydrology, recharge mechanism and groundwater behaviour. For example, farmers in Malegaon and Tasgaon acknowledge that their wells dry up faster, in spite of having more rainwater harvesting structures (earthen dams or percolation tanks) due to shallow depth of aquifer. On the other hand, village Walsa has only 32 ha of farmland treated with bunds, but has more water availability because of its location and thicker weathered zones.

A training was organised by WOTR on July 3-4, 2015 on this concept and model. Once these concepts were understood by the community, it was easy to organise to work together on a larger unit of aquifer. Thus, the members of village level committees found it easier to for the aquifer level committee. Some experience people who had seen the benefits in other places where similar work was done also joined. The village and aquifer level committees started working on local level water issues and building consensus on norms of water use at the aquifer level. They collected the hydrological data (rainfall runoff, well water levels, etc.). It was after all these efforts that the WOTR team emphasised the necessity to work on limiting the water use, and that ushered in the demand side management. They helped the aquifer level committee to analyse data and to prepare the village and aquifer level water balance situation, water health charts and village water budgets. Then they discuss the aquifer characteristics of different regions of the village and accordingly plan how much how much area they could cultivate under different crops.

In the month of October every year, the water management committee meets to assess the water availability based on well water levels and the rainfall in that area in the year. Based on the water availability at the end of monsoon season, they plan water use and determined the crop plans collectively. Some villages started planning summer crops based on the water availability estimates around February. As a result, the farmers moved to vegetable cultivation in summer instead of water intensive field crops like chilli, fenugreek, coriander, etc. Almost entire area is under either drip or sprinkler, particularly in summer.

The committees made use of the provisions of Clause 21.1 of the Maharashtra Groundwater Act, 2009, to register their aquifer level committee. They carried out awareness, promotion and capacity building work as per the clause 9.9. They formed rules for governance and management of water that inhibited cultivation of water intensive crops based on water availability. Nobody grows water intensive crops like sugarcane and banana; in fact, these two crops have been banned from the entire aquifer.
The committees have started preparing their annual water management plans focussing on required development works and submitting it to the concerned authority at the block level. During the year 2021-22, eight villages have already submitted their development plans to the block authority.

3.3 Other innovation in groundwater management

During the course of aquifer management project, several other initiatives were taken up by the community and WOTR that led to many developments in agriculture and other areas.

Other Programmes: Several other programmes like Jalswarajya, crop water management, Nirmal Gram, Vasundhara, etc were implemented in these villages. These programmes significantly raised the awareness level of the community on various aspects of development, including health, nutrition, education and WASH. Various committees and Gram Panchayats have been active in engaging students with activities like essay competitions, organising village rallies, mashal fery (torch rally), drawing and painting competitions on environmental issues. All these were useful in raising general awareness among the younger generation and their involvement in the development activities.

Farmers Field School (FFS) approach has been used in many villages to promote organic farming and water efficient agriculture. The emphasis on reducing the chemical use started in the last two to three years, partly because increase in the cost of supplies/ chemical fertilisers, partly due to reducing food productivity, and largely due to awareness on soil health and healthy foods. Farmers are also concerned about the groundwater quality and are exploring ways to reduce use of chemicals in agriculture. Routine monitoring of drinking water quality started under Jalswarjya programme is still continuing in almost all villages.

App Based Solutions: The farmers get crop advisory based on weather conditions using an app developed by WOTR. They get messages on possible storms, extreme weather events, high winds, etc. and plan their operations. For example, a month before this study, they got the forecast on unseasonal rains about three days in advance. It helped them save their harvested crops, which was kept for drying in the field, by keeping it in a safe place. Farmers now schedule their harvesting operation as per the advisory.

Source: WOTR

This application, Farm-PRECISE working on Android platform, is provided free of cost by WOTR to about 50000 farmers in the region. Approximately 2500 farmers of Malegaon aquifer are using it. The farmers also have access to pest surveillance advisory application provided by WOTR. This app gives user specific advisory based on the data on crop and date of sowing is fed at the beginning of the season. In addition, market information on market prices of about 100 towns and cities are accessible to the farmers, along with the distance to those cities and expected transport time. This application also gives the gross margin analysis for the farmer (farm level profitability for each crop) based on tracking the inputs used, farm level operations carried out and related data, which the farmer has to key in at various stages of crop season.

3.4 Best practices and their effectiveness

This section lists and explains some unique good practices signifying the approach and its effectiveness.

Learning orientation: The case study is more of a narration of the learning process of community and their committees based on the experiences over a long period of time cutting across a few development projects. Conscious efforts by WOTR to facilitate this learning process by offering timely advice, technical assistance and handholding support was useful in building a learning atmosphere, if not culture, in the community and their organisations.

Organising and Institutionalising: That the community could understand the legal provisions and use it for management, a first step towards governance, is an important achievement of the awareness efforts of WOTR. For example, the Maharashtra Groundwater (Development and Management) Act 2009, which came into force in June 2014, accepts the principle of subsidiarity which proposes to give the function and authority of groundwater management at the ground level to Watershed Water Resource Committee (WWRC) to be constituted among a cluster of at least 11 villages. The local committees from the existing watershed villages showed a level of understanding by taking an inclusive approach to join hands with the other villages in the aquifer. The people have contributed financially towards the registration of their committees.

Technical Support: is crucial for the community to understand the groundwater behaviour, and participatory approach is needed to match the local observations with the scientific understanding. The role of Groundwater Survey and Development Agency (GSDA) officials is crucial in providing this technical support to village communities for preparing and implementing groundwater security plans and prospective crop plans. Further, the role of external facilitators or experts in motivating, supporting and facilitating farmer communities to adopt appropriate groundwater practices is well acknowledged in overall groundwater management efforts. However, GSDA has very limited capacity in view of the magnitude and spread across the state. WOTR could fill this void in the present case.

3.5 Significant lessons

Towards sustainable water governance: Moving from conservation oriented development to managing the use, the community demonstrated the capacity to work on both the supply side management options and demand side management strategies. By studying the provisions under the law, and using it for developing water resources in the aquifer, the community underscored their will and ability to move towards community driven water governance. Two years ago, the aquifer level committee has initiated the process for its registration under the Societies Registration Act of 1860. It is another indicator of their commitment to sustainability of the institution.

Capacity Building: Capacities of the community and their CBOs (committees at various levels) were built systematically through aquifer literacy and the concept of a shared aquifer. It helped them to get adequately motivated for collective management and ownership. Although it was challenging, the committees built their capacity to use restrictive measures and to take action to avoid further depletion of groundwater. This was evident from their work in the areas of water harvesting plans, induced recharge measures, adopting techniques of water saving, collective crop planning based on water availability in their aquifer, formulation of village level rules for water use and crop selection, etc.

Key performance indicators: The community showed their ability to use relevant provisions of the 2009 Act like formation of the WWRC for aquifer level water management, limiting the depth of borewells or restricting its use only for drinking water, activities for water harvesting and budgeting, seeking support from Block-level authorities in development activities, etc.

3.6 Applicability in other areas

This section talks about the replication potential of the approach used in Malegaon aquifer. The main strategies and activities used in this aquifer project include the following:

Awareness building: Raising awareness of the farmers and other water users sharing a shallow aquifer and mobilising them to come together for planning and managing this as a common property resource. Awareness of the causal relationship between their water usage and management practices and the recurrent water crisis was understood and the communities developed action plans for both supply side and demand side water management.

CBO Formation: Village Water Management Teams or VWMT at the village level for management of the water resources in their respective village were formed by WOTR. These were then brought together for participatory management in form of an Aquifer Management Committee (AMC) at the shallow aquifer level. These committees played a crucial role of being vigilant about groundwater dynamics and the consequences of over extraction, and ensure that they adopt self-regulations for appropriate remedial measures.

Engaging with Gram Panchayat: Each Gram Panchayat nominated two members from its VWMT to the AMC, one of whom is a member of the Gram Panchayat.

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Scientific inputs: The AMC proactively created awareness about groundwater situation and its causes using the Community Driven Vulnerability Assessment Visual Integrator (CoDriVE-VI or CDVI) model of the aquifer to each village. They developed indicators of the "health of the aquifer", which was the central purpose of the water management plans.

Water budgeting as a tool: Water budget preparation was found to be a powerful tool to empower farmers to choose appropriate crops based on the available aquifer stock, while prioritising drinking water for all households throughout the year. It would be interesting to see its actual effectiveness, but it could not be done as the detailed village data on the components of water budget (measurement or estimates of hydrologic parameters) for the last 3-4 years was not available with WOTR.

Water Stewards: To facilitate the awareness on scientific knowledge and for planning and Implementation, WOTR promoted the concept of barefoot technicians and trained a cadre of Water Stewards (Jal Sevaks) at the aquifer level who manage the use of water at the aquifer level effectively, efficiently and sustainably. They played an important role in sensitising and mobilising people to undertake the necessary actions at the village level. It was supported by well planned interactions and formal workshops that brought together village representatives, experts, service providers and government agencies and provided a platform where local water challenges were discussed and joint action plans agreed upon.

Participatory Planning: The AMC worked for motivating and mobilising the community to prepare the plans and discuss the decisions made at the AMC meetings in each Gram Panchayat. The plans were reviewed and revised based on the discussions and suggestions from such meetings and the Gram Panchayat, and executed in the respective villages.

Source: WOTR

3.7 Suggestions for future

The committee members gave the following suggestions for future and for the government.

- Water management cannot be done by government agencies. The government should engage voluntary organisations in these efforts.
- The government has several schemes of individual benefits the government should reduce this and spend more money in community resources.
- Number of wells has to be controlled. Government should not give new wells but spend that money on groundwater recharge and making the existing sources functional.
- Tree plantation is important. Farmers should start planting trees at least on their bunds and fallow lands.

4. Lessons from the fieldwork in Maharashtra – The eightfold path

This is a multi-state study of locally appropriate solutions of groundwater management to draw policy lessons from them. In each state, we found exceptional work at micro level ensuring sustainable, efficient and equitable management of groundwater resources. Based on our findings from ten different states, we have developed eight principles which can guide our policy formulation and actions on ground. This section attempts to describe this eightfold path in the context of Maharashtra.

4.1 Need for a new approach to achieve sustainable, equitable, efficient use

Geology of Maharashtra State is practically the geology of Deccan Trap, which occur in all the districts of the State excepting Bhandara. The other geological formations, older and younger than Deccan Trap, occur in the districts of Bhandara, Wardha, Chandrapur, Gadchiroli, Nagpur, Yavatmal, Buldhana, Akola, Amravati, Dhule, Jalgaon, Nanded, Kolhapur, Sindhudurg and Ratnagiri. In the remaining 14 districts, Deccan Trap is the only geological formation occurring in them. These Deccan Traps are capped by laterites as seen in Raigad, Ratnagiri, Sindhudurg, Satara, Sangali, Kolhapur and Osmanabad districts. Maharashtra is divided in three main physiographic units the Sahyadri Range (Western Ghats), the Western Coastal Tract (Konkan), and The Eastern Plateau (Deccan Plateau). It is drained by Rivers Godavari, Krishna, Tapi, Mahanadi, Narmada and westward flowing rivers of Konkan; these constitute the six major river basins.

Thus, Maharashtra State has diverse physiography, hydrology and hydrogeology besides varying rainfall patterns. Physiography and geology have played a vital role in the availability of natural resources including water resources. The highly diverse hydro-geological formation of the state provides for differentiated regional potential of groundwater recharge and withdrawal. In such conditions, locally appropriate approaches for groundwater recharge and withdrawal is important.

4.2 The efficacy of participatory data collection

Assessment of groundwater resources assumed importance as dependence on groundwater for drinking and domestic uses and irrigation started growing. In Maharashtra, groundwater exploration was started in 1973 soon after the formation of Groundwater Survey and Development Agency (GSDA) as the state groundwater department. A comprehensive groundwater resource assessment in Maharashtra was carried out in 1979. From 1987 onwards, it became almost a regular feature with an interval of about 3-4 years. For last more than four decades, state has been estimating groundwater recharge and withdrawal, yet it has not arrested the unscientific and unsustainable withdrawal of groundwater resources in the state. Therefore, it is important to involve community members in this process of measuring groundwater resources to help change in their farming pattern and water consumption.

4.3 Understanding the prevailing policy framework and using it beneficially

Policies have a crucial role in regulating and managing natural resources to ensure sustainable usage and equitable distribution of benefits. Maharastra has enacted the Maharashtra Water Resource Regulatory Authority Act in 2005 to rationally distribute water related entitlements to various usages in the state. The authority has taken responsibility to fix the criteria for water charges in various river basins and sub-basins. This approach promotes localization of policy implementation, which in turn yields better results. Further the state has enacted the Maharashtra Management of Irrigation Systems by Farmers Act in 2005. This legislation provides for constitution of water users association to manage and de-centralized regulations of irrigation water by farmer themselves.

To regulate groundwater resources, the state had enacted the Maharashtra Groundwater (Development and Management) Act in 2009. This legislation provides for the formation of the Water Resources Regulatory Authority that has power to notify areas in the state to regulate groundwater extraction. Maharashtra has various progressive legislations to regulate groundwater and other water resources. It is important for the institutions and public to make better use of these policies.

For example, under the initiative of WOTR in Malegon, various aquifer level committees made use of the provisions of Clause 21.1 of the Maharashtra Groundwater Act, 2009, to register their aquifer level committee. They carried out awareness, promotion and capacity building work as per the clause 9.9. They formed rules for governance and management of water that inhibited cultivation of water intensive crops based on water availability. Nobody grows water intensive crops like sugarcane and banana; in fact, these two crops have been banned from the entire aquifer.

4.4 Whistleblowing in the face of non-Implementation of laws and regulations

Once the community is involved with collecting the data and understands the prevailing policy, laws and regulations, it can become a watchdog against any violations. Moreover, demands can be raised for more appropriate laws and policies. Like in many other parts of the country, concerned individuals and institutions have been raising voices against non-implementation of existing laws in the state. India has updated its national water policy in 2012 that has set new priorities. Maharashtra has updated its state policy in accordance with prioritises highlighted by the national policy in 2019. Various organizations and individual had persuaded the state government to enact this policy. Such concerted effort and voices from people would strengthen policy discourse leading to better management of groundwater resources in the state.

4.5 Planning for balancing demand with supply

From year 2000 to 2011 the total rechargeable groundwater resource in Maharashtra has been around 30 billion cubic metres (BCM) to 35 BCM. However, a slight reduction (of around 5%) is expected on account of outflows or losses from the aquifer, and around 95% of it is available for abstraction as the net amount. The groundwater withdrawal has been varying from 13.33 BCM in the year 2000 to 17.18 BCM in year 2011. It was observed that the Gross Annual Withdrawal has been continuously increasing from 43.15% of the Net Groundwater Available in 2000 to 54.97% in 2020.The increase in draft has mainly been due to increase in number of irrigation wells.

The groundwater balance, or the amount of groundwater available for abstraction for various uses, has been broadly around 15 BCM or 45%-55% of the net groundwater availability during the last two decades. Unfortunately, major part of it exists in the areas where development is not required for either irrigation or for drinking and/or is in areas, which are not favourable for development. This gap in demand and supply of the groundwater is increasing exponentially. The urgent need is to balance this gap both by enhancing recharge capacities and rationalizing demand.

4.6 Enhancing supply by groundwater conservation and recharge

Watershed Organisation Trust (WOTR) has been working in Bhokardan block of district Jalna for nearly 20 years for watershed development and rural livelihoods. WOTR implemented an integrated watershed development project in village Kautha Jahagir, covering parts of the villages Kosgaon and Ralegaon during 2008-11. Similarly, they implemented the Integrated Watershed Development Programme (IWDP) of Government of Maharashtra in villages Malegon, Kolegoan and few other villages during 2009-13.

These projects transformed the economy of the villages from a drought stricken to lush green agricultural landscape. However, during the three years of successive drought from 2012-14, the villagers realised the need for managing their water use collectively based on the availability. WOTR appraised them of the results of aquifer level water conservation interventions carried out by the Government of Maharashtra's Jalswarajya Aquifer Water Management Pilots in six diverse locations of Maharashtra (2007-10) and a groundwater management project (2006-08) implemented by the Groundwater Survey and Development Agency (GSDA) of GoM in eight villages of Bhokardan and Badnapur blocks of district Jalna. Similar work by CSOs like ACWADAM in Purandhar in district Pune and MSSM in Shivni in district Jalna underlined the importance of geology-based development planning.

4.7 Rationalising demand for water by rationalising prices for crops and energy

India has 18% of world population, having 4% of world's fresh water, out of which 80% is used in agriculture. India receives an average of 4,000 billion cubic meters of precipitation every year. However, only 48% of it is used in India's surface and groundwater bodies. A dearth of storage procedure, lack of adequate infrastructure, inappropriate water management has created a situation where only 18-20% of the water is actually used. India's annual rainfall is around 1183 mm, out of which 75% is received in a short span of four months during monsoon (July to September). This results in run offs during monsoon and calls for irrigation investments for the rest of the year.

Examples documented in this report shows that wherever the supply of the water has increased due to locally appropriate solutions, the agricultural productivity has also increased. In many cases farmers have started harvesting two crops in a year. Such developments are really good, but it is necessary to rationalize demand to ensure sustainability of demand and supply of water. Moreover, pricing of energy and water is an important factor to ensure sustainability.

4.8 Building capacity of the community for the above functions is a must

It is very clear that the 'one size fits all' approach is not going to solve the problem of groundwater. Every step from groundwater recharge to the utilization of water has deep social, economic, geological, hydro geological and geo morphological underpinning. Therefore, it is necessary to understand physical and social sciences in each region to experiment locally appropriate solutions for groundwater management. Moreover, this exercise cannot be done without building capacities of the community. It is worth mentioning here that all successful interventions documented in this study have attempted to develop the capacity of people.

In Maharashtra organizations like WOTR, ACWADAM and MSSM are engaged in building capacities of community member to understand aquifer and their characteristics to develop village level plan. In all successful villages in Malegon, villagers are capable of developing their village level plan and conducting water audit to sustainably use groundwater resources.

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