

# Comprehensive hydrogeological study of Katarkhatav Village of Satara Maharashtra, India

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## Abstract

This research paper is outcome of the central government and World Bank funded project Atal bhujal yojana. In satara, there are 97 grampachayat which are categorised as semicritical watershed. Katarkhatav grampanchayat located in Khatav Tehsil of Satara distract of Maharashtra, iNdia. The detail hydrogeological study of village is done in Atal bhujal Project by District Project Management Unit (DPMU) and District Implementing Partner (DIP). The detail result is described in the paper about this project using mainly groundwater is tool.

From the study it can reveal that, there is need to establish mechanism and train the Community Resource Parsons (CRP) to continue water level and quality monitoring and update the water security plan at frequent interval by involving the community and VWSC members. The understanding developed from the analytical results as discussed above shall be used in future planning including GP wise annual / seasonal ground water resource estimation as well in day to day management of ground water.

**Keywords-** Groundwater, GSDA, DIP, DPMU, Water security Plan, Atal bhujal Yojana

## Introduction

The aim of this study is to provide an insight and overview of the ground water scenario in the Gram Panchayat and initiatives taken under Atal Bhujal Yojana to meet the objective of community driven sustainable groundwater management. Attempt has been made to highlight the unique initiative towards strengthening ground water monitoring and analytical facilities at Gram Panchayat level. Special emphasis has been given to create community awareness and active involvement of community in monitoring, water budgeting, planning and implementation of demand and supply side interventions to improve the groundwater situation, to ensure the long-term source sustainability. One of the critical steps in the implementation of the Atal Jal program is preparation of water budget at GP level. To appraise the water balance worked out at the level of gram panchayat, GP level meetings organized by Village Water and Sanitation Committee (VWSC) involving the farmers and other stakeholders and willingness were sought to adopt suitable demand and supply side measures to ensure sustainability of ground water. Eventually, a community led Water Security Plan (WSP) has been prepared with

the help of DIP/DPMU by incorporating all the suggested interventions that has been finalized during the GP level meetings. Collective and collaborated efforts by the community, DIP/DPMU/SPMU and the line departments in implementation of the water security plan has fostered significant increase in areas under water efficient practices, shift from high water consuming to low water consuming crops eventually leading to a positive impact in terms of improvement in groundwater levels at the level of Gram Panchayat. The scheme has also successfully demonstrated the benefits of the participatory groundwater management at local level.

Katarkhatav village is located in Khatav tehsil of Satara district in Maharashtra, India shown in fig.1. It is situated 8 km away from sub-district headquarter Khatav (tehsildar office) and 50km away from district headquarter Satara. The Area of Gram Panchayat is 2676.00 Hectare, Total Human Population is 3997, the number of Total Livestock is 5298, Total Cultivable area is 1975.48 Hectare. Net Sown Area is 702.3 Hectare. Net Irrigated Area is 236 Hectare, Gross Area Irrigated by Ground water is 295.1 hectare, Area Irrigated by Surface water is 70 Hectare, Number of Bore well and Dug well are 527, Major Crops are Onion, Tomato, Wheat, Bajra, Pearl, Millet, Maize, & Sugarcane. *(Data source: GPDCI, MIS, Atal Jal Portal)*

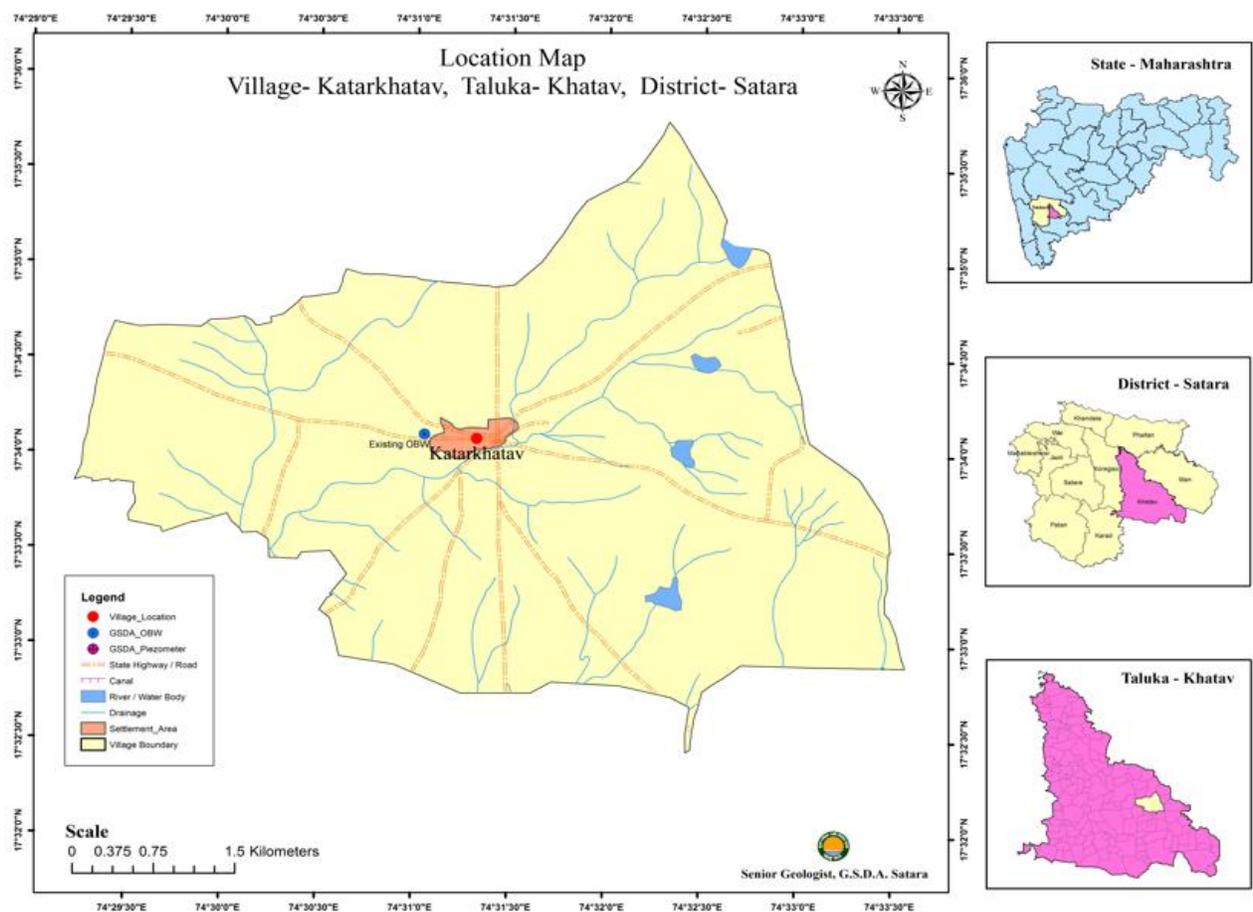
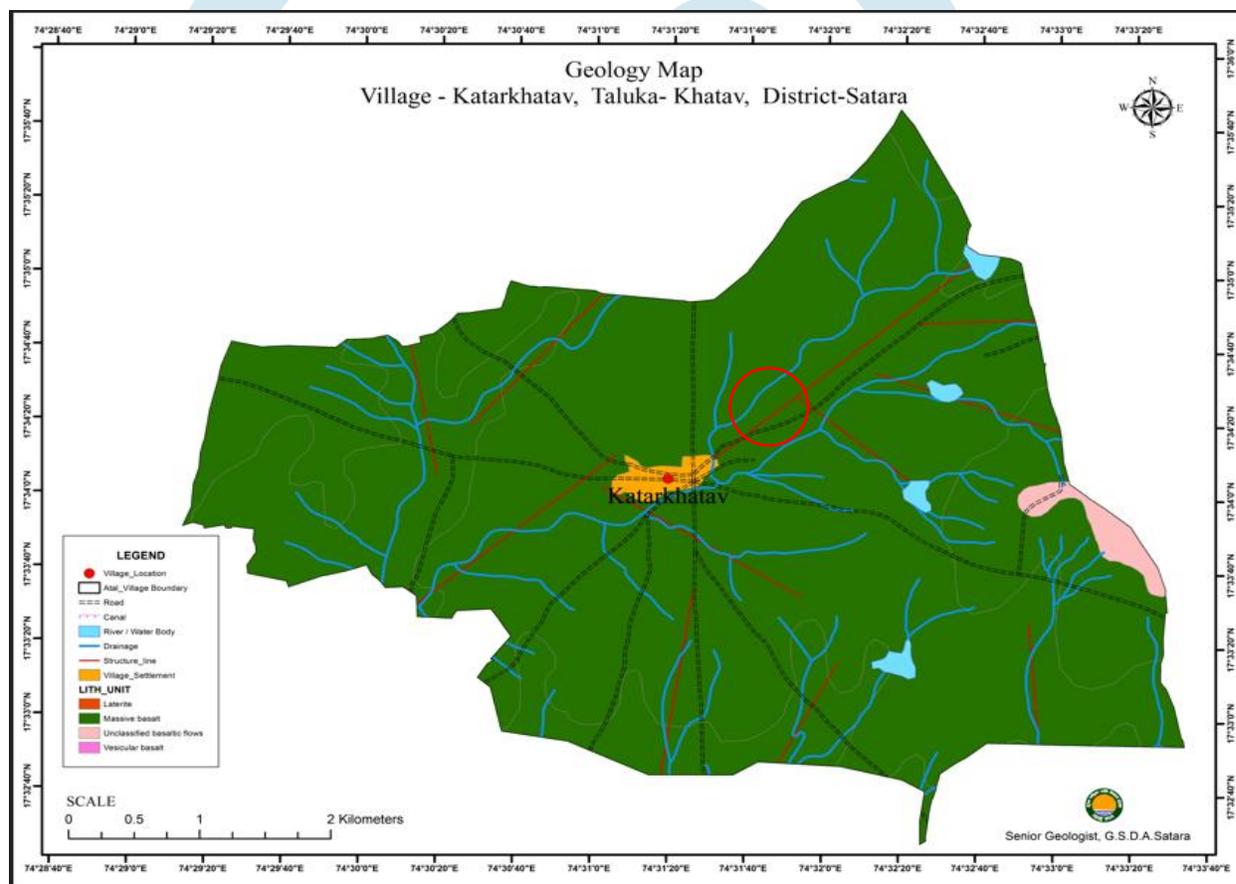


Figure 1: Location map of study area

Khatav taluka in Satara district is characterized by a hydrogeological setting dominated by Deccan Trap basalt. The primary water-bearing formations are weathered, fractured, and jointed basalt, found under both phreatic (unconfined) and semi-confined conditions. The hydrogeological map of the Khatav block and a lithological cross section is presented in Fig 2. Ground water is the primary source of irrigation in the area and hence there is heavy stress on ground water. The block has been categorized as Semi Critical as per computation of dynamic groundwater resources of India-2024.



**Figure.2: Geological Map of study area**

### Data sharing through Atal Jal mobile application

The data / information collected under the Atal Jal program has been brought under the common database and shared in public domain through Atal Jal Mobile App, the screen shot of key information pertaining to population, area, rainfall, water level, water quality etc. is shown as below: As per the Atal bhujal yojana program design, community led water budget and Water Security Plan (WSP) has been prepared for the Gram Panchayat. The demand and supply side interventions proposed in the WSP have been implemented through convergence of funds from the ongoing schemes of central and state by the line departments as well as using the incentive funds. Summary of various interventions already implanted as per the WSP, the various initiatives taken during the program along with key outputs / outcomes in terms of water savings and beneficiaries.



### Strengthening of groundwater monitoring network

One of the key initiatives under the program is to strengthen the Institutional framework at GP level through installing various equipment. From these equipment various kind of data like water level, water quality, rainfall, and groundwater draft are being captured through Atal Jal mobile application. All data are being converted into information and further interpreted in form of graphs, tables and maps. Dissemination of groundwater related information is attributed to sensitize the community about the water levels and water quality issues if any and is helpful to the community for self-interpretation and decision making. To strengthen the groundwater management in the gram panchayat, few works/activities have been undertaken as Well inventory , Establishing new water level monitoring / Observation stations, Installation of Rain Gauge , Construction of Piezometer fitted

with DWLR and telemetry, Water level indicator, Water quality testing kit, Installation of Flow meter etc. All the activities pertaining to installation of various equipment, data collection mechanism and their interpretations are briefly discussed in following paragraphs to help the community and stakeholders for in depth understanding of ground water regime and outcomes of various activities.

### **Well inventory (*One-time registration of well*)**

The objective of well inventory is to capture GW related data to understand the spatial variations in GW regime at GP level and help in preparing water budget and WSP. It is one-time exercise and as per the guideline, at least 50% of wells being used for ground water withdrawal need to be inventoried. For this purpose, it is essentially required to collect GW-related data of all existing groundwater abstraction structures used for various purposes like irrigation, drinking, domestic & industries. At GP level well, inventory of different types of GW abstraction wells have been carried out and the information such as well type, diameter, depth, water level, water potability, purpose of usage, functional or non-functional wells etc. are collected. A total 527 nos. of wells have been inventoried in the gram panchayat using the Atal Jal Mobile App and available in the Atal Jal MIS. The data generated through inventory has been critically analyzed, the summary details of well inventory is given in table 1.

**Table 1: Summary table of well Inventory**

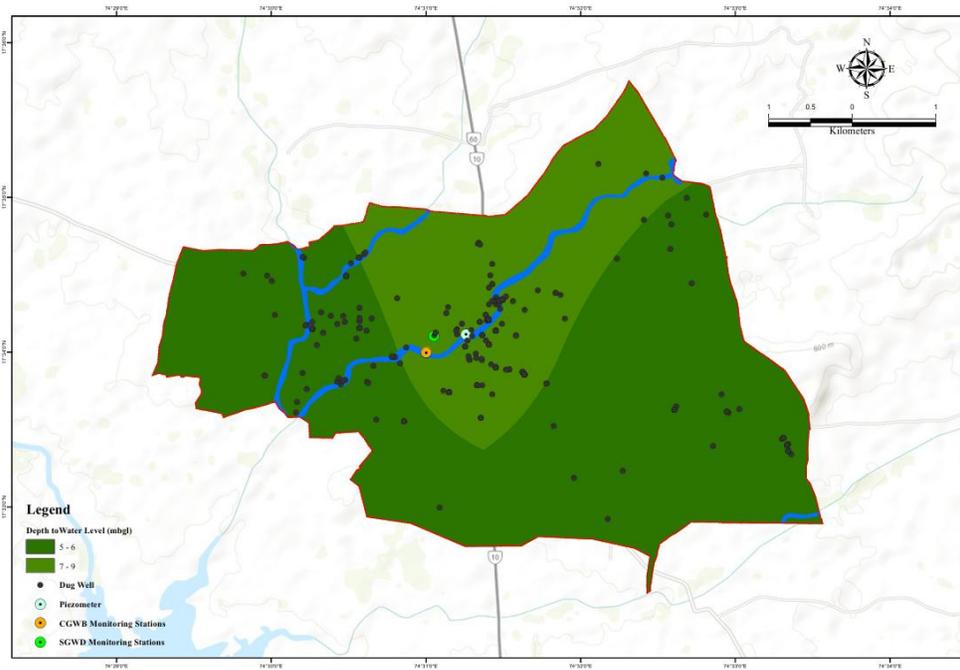
Well Types	Number of Wells	Usage	Well Depth (m)	Water Level (mbgl)
Bore Wells	293	Irrigation & Domestic (293 no. of wells)	60 to 100	10 to 80
Dug Wells	234	Irrigation & Domestic (234 no. of wells)	8 to 13.2	1 to 13.2
Total	527			

### **The key observations / findings are as below:**

1. As per the above table, there are two types of groundwater abstraction wells in the Gram Panchayat i.e. Bore well and Dug wells.
2. Geotagged points of wells inventoried (refer fig 3, 4), the density of wells is high in the middle and North-western part of the GP.
3. 55.59% wells are bore wells with depth ranges between 60 m to 100 m and 44.40 % are dug well with depth range 8 m to 13.2 m.
4. Approximately, 10.43% of wells are being used for irrigation purpose and 89.57% of wells are being used for both domestic/irrigation purpose.

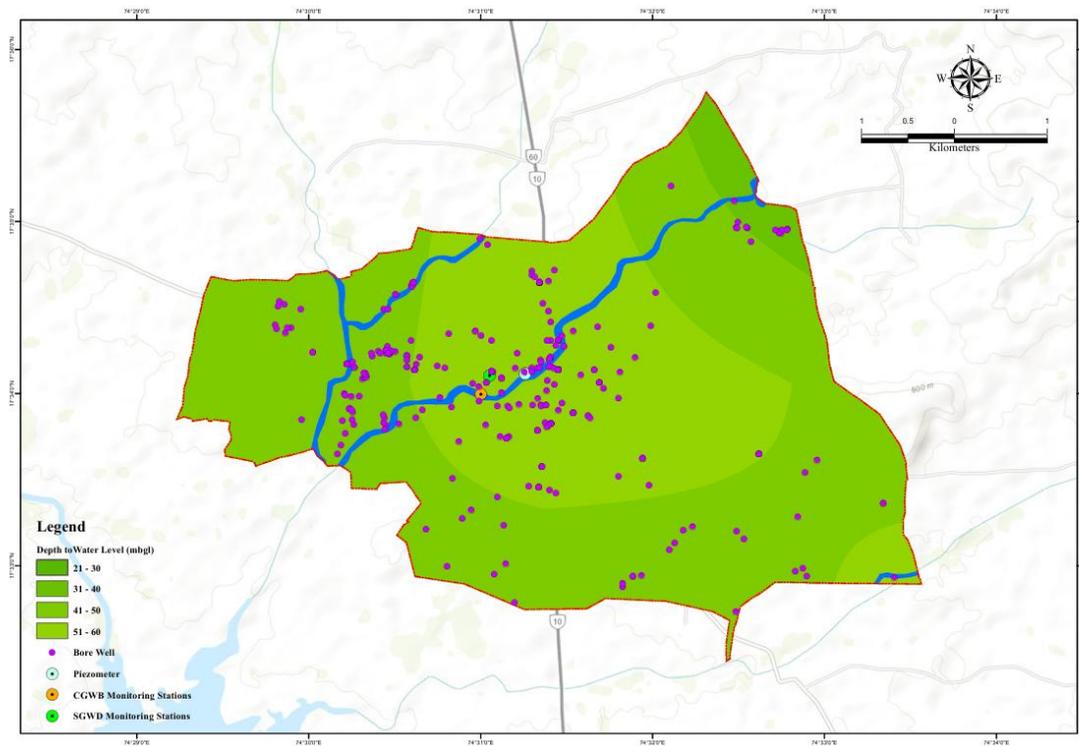
5. Aquifer system- Based on the well inventory data and other information available at GP level, it is inferred that there are two types of aquifer systems through which ground water is abstracted i.e bore wells generally tapping deeper aquifer / semi confined and Dug wells tapping shallow unconfined aquifer. Unconfined aquifer- 0- 30 mbgl, all dug wells are abstracting groundwater from this aquifer zone. Confined or Semi-Confined aquifer- 30 mbgl to 120 mbgl, 100% bore wells are abstracting groundwater from this aquifer zone

### Analysis and interpretation of water level data



**Figure.3: Depth to water level map of Shallow Aquifer ( Irrigation wells)**

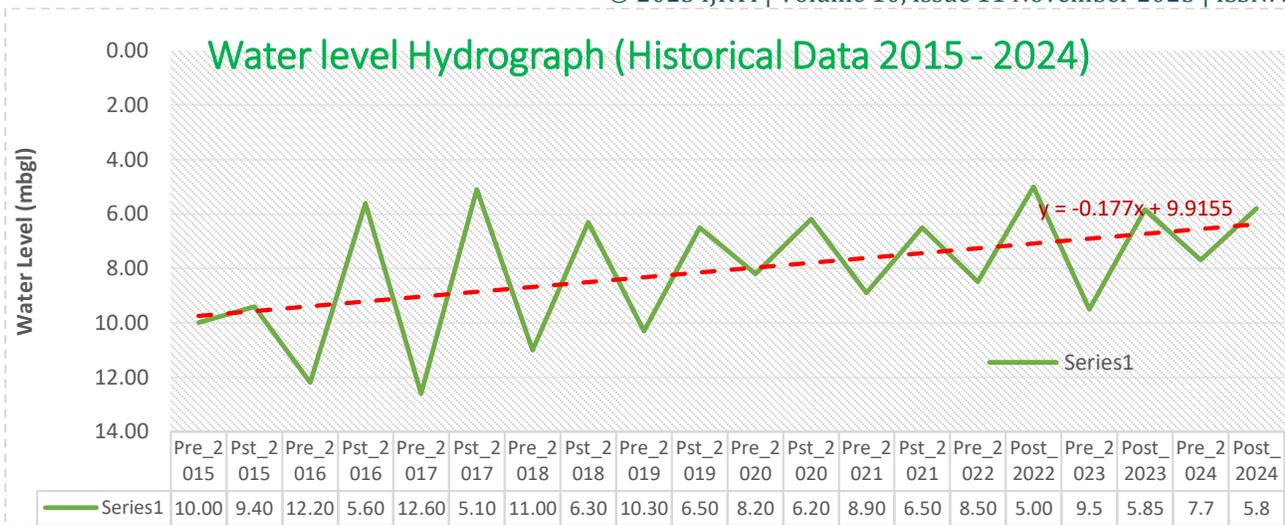
The water level data captured during the well inventory has also been analyzed. In general, the inventory continued for longer period and the water level observations represents both pre / post monsoon data. From the well inventory data and the lithological cross section of the area it is apparent that there are two aquifer systems in the area. Accordingly, water level data captured during inventory has been grouped for shallow wells and deeper wells representing the two-aquifer system though connected. Fig 3 represents the water level map of the shallow aquifer. From the map it may be observed that in general, the depth to water level in shallow aquifer ranges between 1 mbgl to 13.2 mbgl.



**Figure.4: Depth to water level map of Deeper Aquifer (Bore wells)**

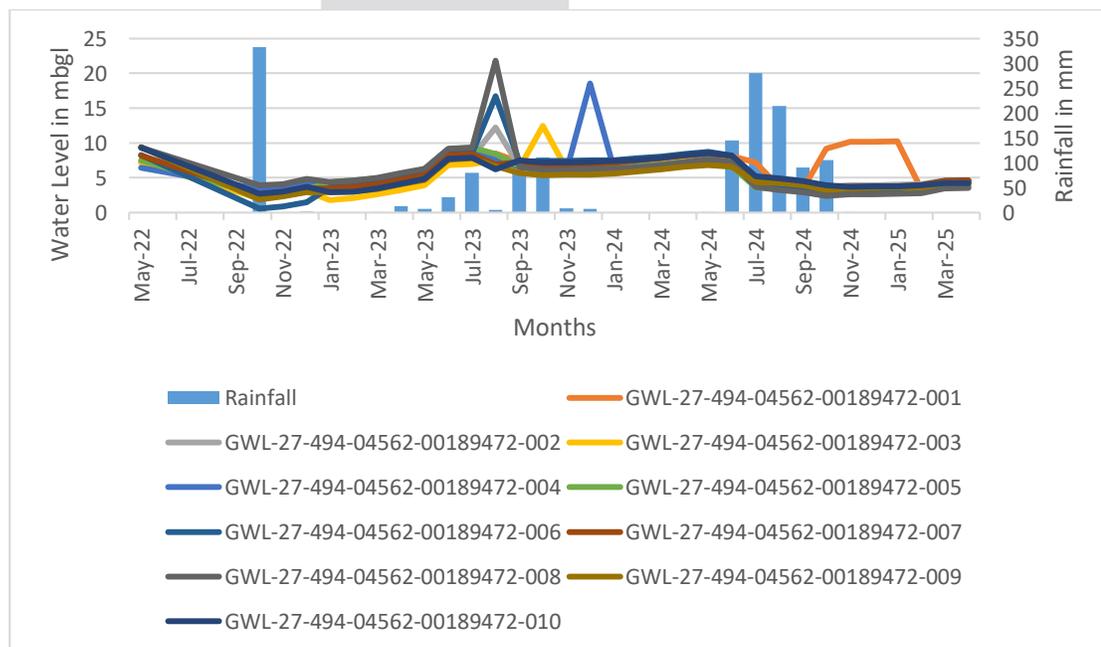
Fig 4, represents the depth to water level map of deeper aquifer tapped by bore wells, the map clearly depicts that in general the depth to water ranges between 10 - 80 mbgl.

The data of existing water level monitoring wells has been collected from different agencies (CGWB/SGWB) under disbursement linked indicator-1, Atal Jal. The entire data has been brought into the database and disseminated publicly through various modes at GP level. As per the table below there are Twelve observation wells in the GP, one well belongs to SGWB, another ten Private Dug wells and One Piezometer were selected for Monthly water level monitoring. The pre and post monsoon groundwater levels data (s.no.12) have been disclosed under DLI#1, additionally two wells (s.no.1&11) have been selected in the gram panchayat for monthly monitoring of groundwater levels. One dedicated piezometer (s.no. 12) has been constructed under the Atal Jal and fitted with DLWR through which high frequency groundwater levels data is being generated. Same piezometer used for monthly monitoring and Pre & Post Monsoon water level monitoring. The historical data available from the Dug Well for the period May 2015 to Oct, 2024 has been subjected to analysis, the hydrograph is shown in Fig. 5.



**Figure 5: Hydrograph based on Historical Data**

Figure-5, above shows the field hydrograph of Dug Well, based on manual monitoring carried out during the pre-and post-monsoon, from 2015 to 2024. The data is maintained by SPMU, Maharashtra. The observations from hydrograph shows a rising trend in groundwater levels; however, the magnitude of fluctuation and rise has significantly increased after the year 2022. It is observed that from pre-2015 to pre-2018, average GW fluctuation is about -0.45 m, however in 2019 and 2021 average GW fluctuations is about 0.23 m. The change in groundwater fluctuations may be attributed to changing groundwater withdrawal pattern in the gram panchayat and also due to the change in storage of the aquifer. In general, the groundwater storage has improved over the time, but simultaneously stresses on groundwater has also increased, however, it may be noted that the water level recoups and maintaining a rising trend, displays the aquifer potential to withstand the stresses acting upon it. As given in the table, in order to strengthen the water level monitoring, additional eleven observation wells have been established. The water level data of all the eleven observation wells along with the rainfall have been plotted simultaneously to understand the spatial variations on water level changes with time, the same is shown in Fig. 7.

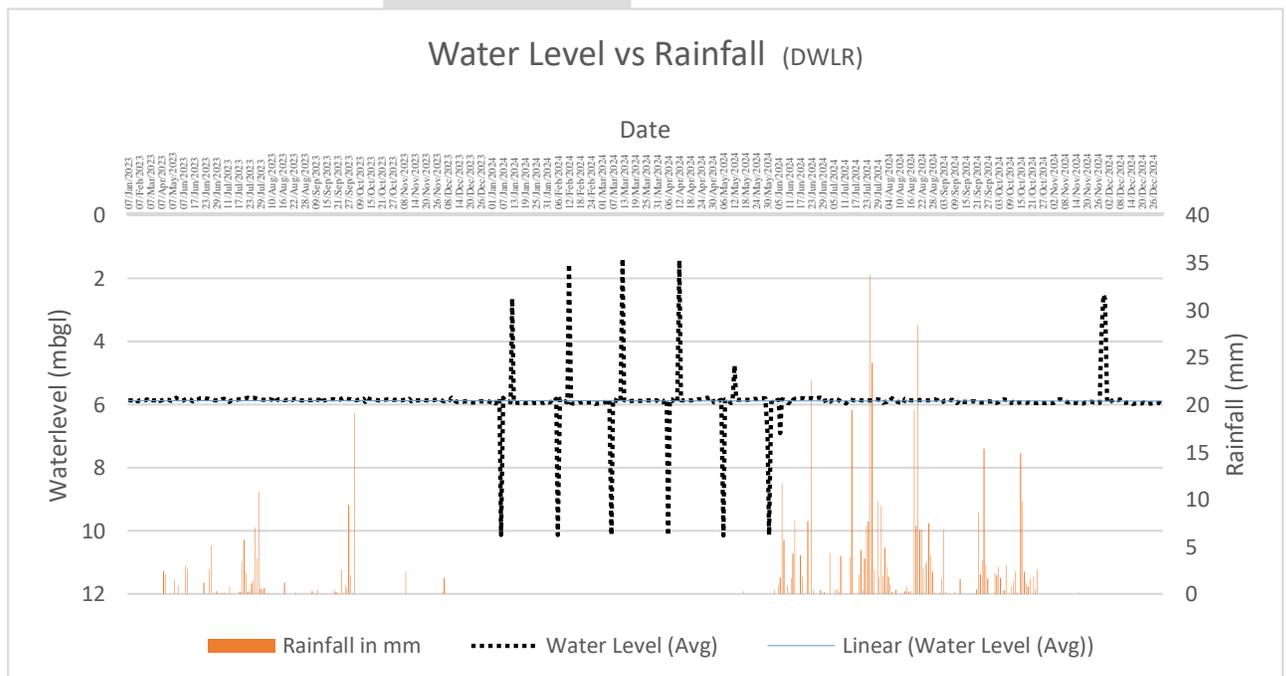


**Figure.6: Hydrograph vs rainfall of monthly monitoring wells (from May 2022-Dec 2024)**

Site Name	TYPE	Well ID	Latitude	Longitude	Well Depth (m)	Monitoring Period
Katarkhatav	Piezometer	MAHGW 599	17.568621	74.520968	60.0	Jan 2023 to Dec 2024

All the wells tapping Shallow aquifer in general show a rising trend in groundwater levels. At the Katarkhatav piezometer, clear fluctuations in groundwater levels were observed. In 2023, the deepest water level was recorded at 8.5 meters in August, while the shallowest was 7.1 meters in October. Similarly, in 2024, significant fluctuations were also evident, with the deepest water level of 10.24 meters observed in December, and the shallowest level of 3.4 meters recorded in September. It was observed that from April 2023 to April 2025, there was an increase in groundwater levels, which may be attributed to reduced groundwater extraction, recharge from canal and Rainfall during that period. The deepest pre-monsoon and shallowest post-monsoon water levels shall be compared and verified with high-frequency data to determine realistic groundwater level fluctuations, which will be used for the estimation of rainfall recharge. Under the Atal Jal a dedicated piezometer has been constructed in May 2022 and fitted with DWLR along with telemetry system for real time data acquisition. The data is transmitted directly to NIC cloud and also maintained at Atal Jal MIS. The data is subjected to preliminary analysis. The six hourly data have been used to plot the hydrograph with daily average water level data for the period Jan 2023 to Dec 2024 as shown in Fig 7. The pre and post monsoon water level arrived after averaging of six hourly data shall be used for any comparison and reporting as well as for resource estimation purpose. Looking at the time series data plotted as hydrograph along with the rainfall, the ground water withdrawal cycle can be identified.

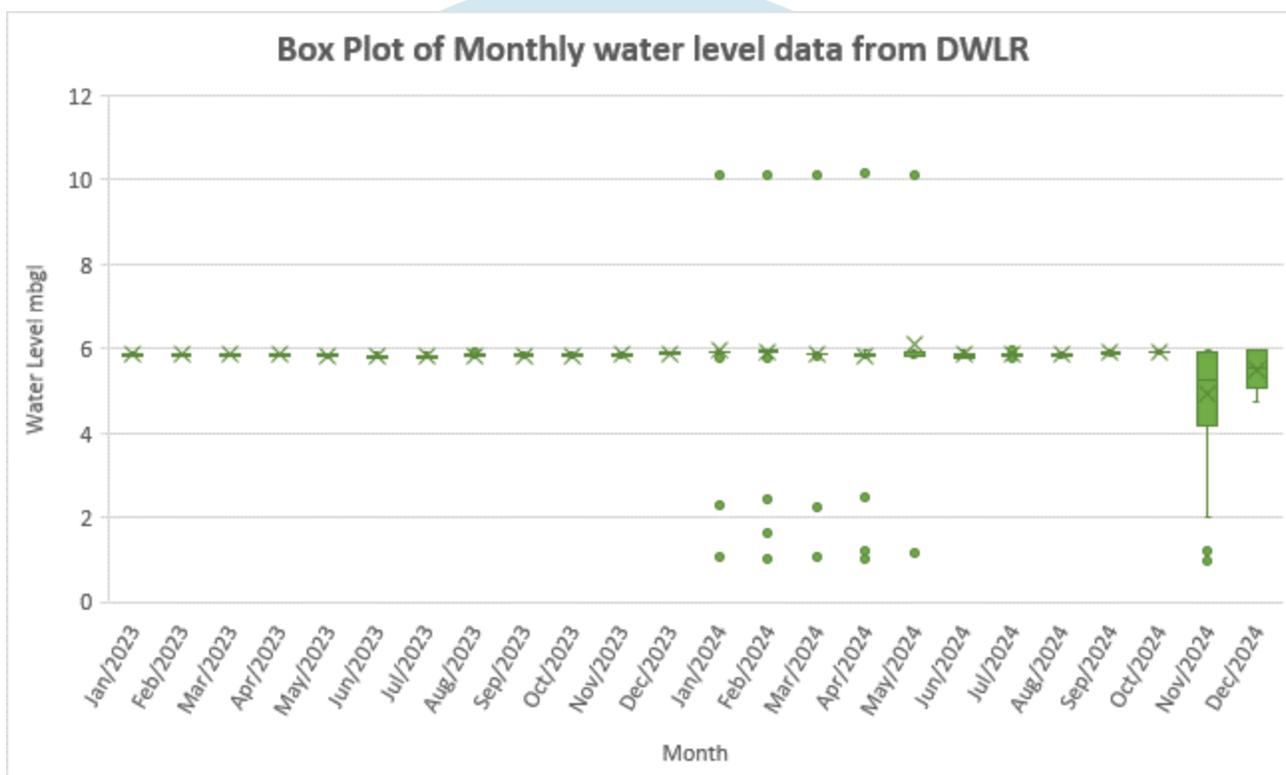
**Table 2: Details of Piezometer**



**Figure.7: Hydrograph of high frequency groundwater level**

### Analysis of high frequency data (Box Plot)

General Statistical Representation of High Frequency water level Data has been attempted through Box Plots, which is commonly used to represent key statistical parameters and for visual comparison of water level time series data.



**Figure 8: Box Plot of Monthly water level data from DWLR**

### Key observations of the high frequency data

Box Plot Analysis plotted in fig. 8 of Monthly Groundwater Levels at Katarkhatav (2023–2024) Y-Axis: Water Level (mbgl – meters below ground level) Lower values indicate higher water tables, i.e., groundwater is nearer to the surface. Higher values mean the water table is deeper. From January 2023 to around October 2024, the groundwater level remains relatively stable, mostly hovering around 6 mbgl Data points in this period are mainly shown as green asterisks, indicating outliers or consistent single-value measurements, likely due to limited variation or consistent recording values. The consistent water level values suggest minimal seasonal fluctuation or measurement limitations, possibly due to: Stable hydrogeological conditions. Uniform recharge/discharge patterns. Insufficient data resolution (e.g. single-point values). From October to December 2024, box plots appear with: Wider interquartile ranges (IQR). Lower minimum values (down to ~2 mbgl). Presence of multiple outliers (green dots).

This indicates that a significant rise in groundwater level (i.e., water table rising closer to the surface). Possibly due to heavy post-monsoon recharge by water conservation structures, increased rainfall, or a reduction in groundwater extraction. The range and whiskers suggest greater temporal variability or heterogeneous recharge patterns during this period. Outliers below 3 mbgl in early 2024 (Jan–May) suggest

unusual recharge events or local variations. Spikes at ~10 mbgl in late 2023 may indicate abnormal drawdown, possibly due to over-extraction or temporary well failures. This box plot reveals a relatively stable groundwater system for most of the 2-year period, with significant fluctuations and recharge events emerging in late 2024. These could be due to climatic, hydrological, or anthropogenic influences. Further investigation into precipitation, pumping records, and land use patterns could help interpret the observed variability more accurately.

### **Statistics of High frequency water level data**

The summary statistics of the hourly data for each month is presented in fig.7, which gives the minimum, maximum, quartile values, mean, variance etc. of monthly water level data. Median is better representation of central tendency of skewed data or data with outliers. Water levels in 2023 were fairly stable, with: Mean values hovering around 5.83 to 5.89m. In 2024 standard deviation in the month of Jun.2024, Feb 2024, March 2024, April 2024, and May 2024 stands high, which indicates the variation in the water levels during these months. It can be seen that the variation in the water levels during monsoon period might be due to the rainfall as well as groundwater withdrawal during that period. A high standard deviation of 1.27 indicates substantial variability in the data, which leads to a significant difference between the mean and median values. In general, the variability in the data can be correlated with the groundwater withdrawal for irrigation purposes, since maximum variations are concentrated in these months.

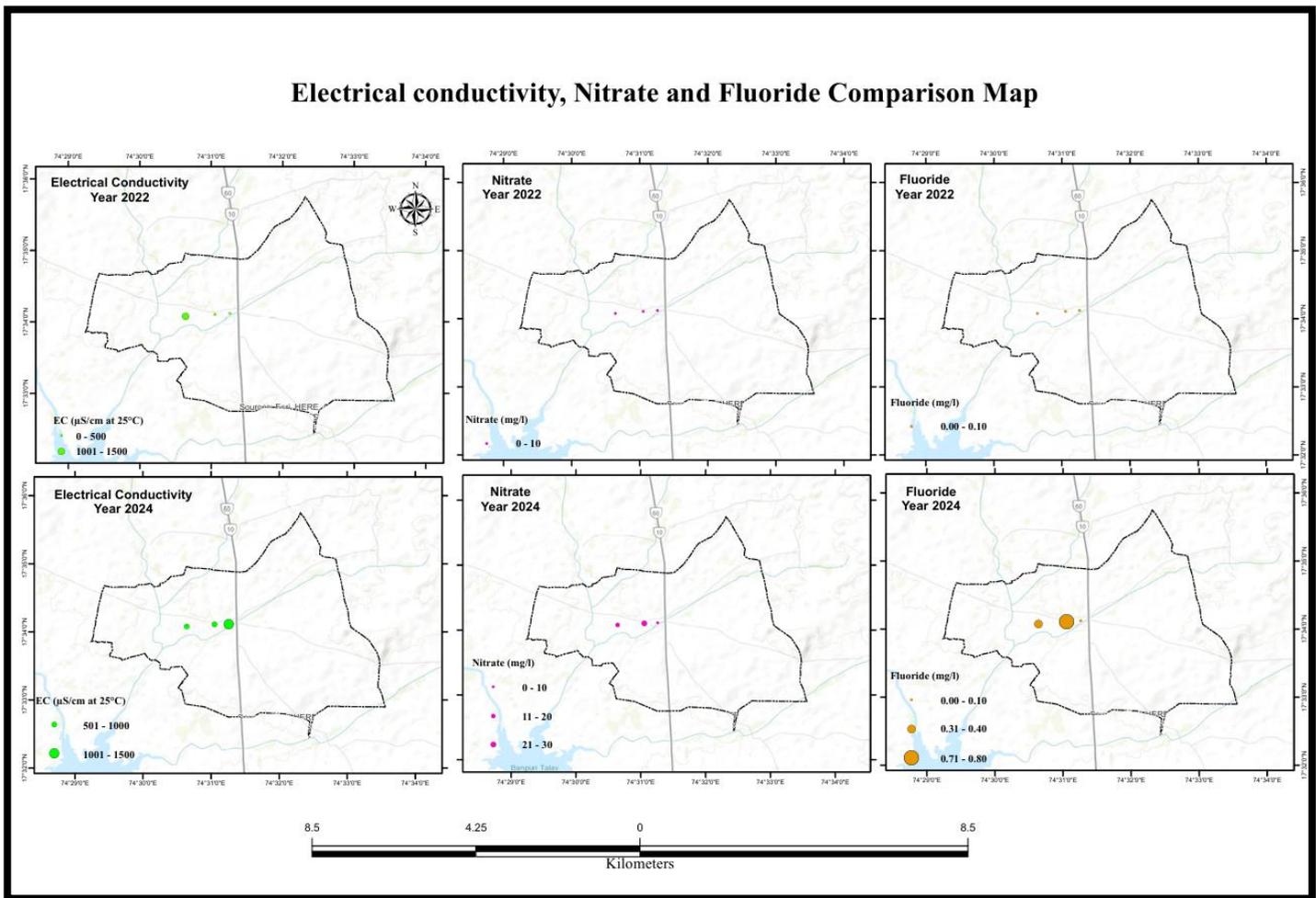
In the current scenario, the piezometers fitted with DWLR are limited in number and for spatial analysis, there is always a need of comparing the high frequency data with manual measurements, usually taken four times a year. For the comparison of manual ground water level monitoring data with the high frequency (six hourly) data coming from DWLR, an average of 5 weeks six hourly water level for pre and post monsoon period separately and average water level arrived, has been compared with the manual monitoring data. The 5-week period for pre-monsoon averaging of hourly data from DWLR taken for the period 1st May to 7th June, similarly post monsoon period taken as 15th Oct to 20th Nov. Based on the DWLR data for the deeper aquifer, the annual water level fluctuation is 8.77 m, whereas the fluctuation calculated from manual monitoring data is 6.78 m. Therefore, it is important to compare both data sets to determine a more accurate and realistic estimate of water level fluctuation. The year on year identification of cycle of peak and trough can clearly define the ground water stress period which will be helpful in scheduling the ground water withdrawal. The actual data captured from DWLR with hydrograph and an example of taking average of 5 weeks water level for pre and post monsoon is given in Box Plot.

**Table 3: Analysis and interpretation of water quality data**

Year	2023												2024											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min.	5.8 4	5.8 2	5.8 3	5.8 4	5.7 8	5.7 9	5.8 1	5.8 3	5.8 3	5.8 2	5.8 1	5.7 8	2.6 4	1.5 4	1.3 7	1.4 3	4.7 6	5.8 3	5.8 3	5.8 4	5.8 5	5.8 5	5.8 6	5.83
Max.	5.9 0	5.8 8	5.8 8	5.8 8	5.8 8	5.9 0	5.9 1	5.9 2	5.9 2	5.9 1	5.9 0	5.9 0	5.9 4	5.9 2	5.9 2	5.9 3	5.9 4	5.9 7	5.9 7	5.9 7	5.9 7	5.9 7	5.9 5	5.94
25% Percentile	5.8 6	5.8 6	5.8 5	5.8 4	5.8 4	5.8 1	5.8 1	5.8 4	5.8 3	5.8 3	5.8 5	5.8 9	5.9 3	5.9 2	5.8 7	5.8 1	5.8 1	5.7 9	5.8 5	5.8 5	5.9 0	5.9 4	5.9 1	5.94
75% Percentile	5.8 6	5.8 6	5.8 7	5.8 7	5.8 5	5.8 4	5.8 4	5.8 6	5.8 5	5.8 5	5.8 6	5.9 1	5.9 4	5.9 6	5.8 8	5.8 6	5.8 5	5.8 3	5.8 7	5.8 7	5.9 2	5.9 4	5.9 4	5.97
<b>Central Tendency</b>																								
Mean	5.8 6	5.8 6	5.8 6	5.8 6	5.8 4	5.8 3	5.8 3	5.8 5	5.8 4	5.8 4	5.8 6	5.8 9	5.7 9	5.7 4	5.7 0	5.6 6	6.0 1	5.8 2	5.8 7	5.8 6	5.9 1	5.9 3	5.5 7	5.95
Median	5.8 6	5.8 6	5.8 6	5.8 6	5.8 4	5.8 3	5.8 3	5.8 5	5.8 4	5.8 4	5.8 6	5.9 0	5.9 4	5.9 3	5.8 8	5.8 4	5.8 4	5.8 1	5.8 6	5.8 6	5.9 1	5.9 4	5.9 3	5.96
<b>Variability</b>																								
Range	0.0 6	0.0 6	0.0 5	0.0 4	0.1 0	0.1 1	0.1 1	0.1 0	0.1 0	0.0 9	0.0 9	0.1 2	4.3 8	4.5 5	4.5 0	1.1 8	0.1 4	0.1 4	0.1 4	0.1 3	0.1 2	0.1 2	0.1 9	0.00
Variance	0.0 0	1.1 4	1.6 1	1.5 4	1.5 8	1.4 6	0.0 5	0.0 0	0.0 0	0.0 0	0.0 0	0.9 7	0.00											
Std. Deviation	0.0 2	0.0 2	0.0 2	0.0 1	0.0 4	0.0 3	0.0 3	0.0 2	0.0 3	0.0 2	0.0 2	0.0 3	1.0 7	1.2 7	1.2 4	1.2 6	1.2 1	0.2 2	0.0 3	0.0 4	0.0 3	0.0 3	0.9 9	0.04

Similar to water level data, as per the program design, at the beginning of the program in the year 2020, attempt has been made to collate the existing data / information on ground water quality for the GP from all sources. Incidentally, there was no ground water quality data available for the GP. In order to assess the ground water quality, as per the Atal Jal protocol, annual water quality monitoring has been initiated and in the pre-monsoon period of year 2022, initially only two water quality samples were collected from the Bore well/Dug well/ and Piezometers. The samples were analyzed for 14 basic chemical parameters as per the protocol. Subsequently 5 samples were collected across the GP in the year 2023 and 2024 and analyzed. Based on the analytical results of ground water quality, attempt has been made to compare the major elements affecting the human health between the year 2023 and 2024, the analytical results are presented in Table 3 and pictorially shown in Fig 9.

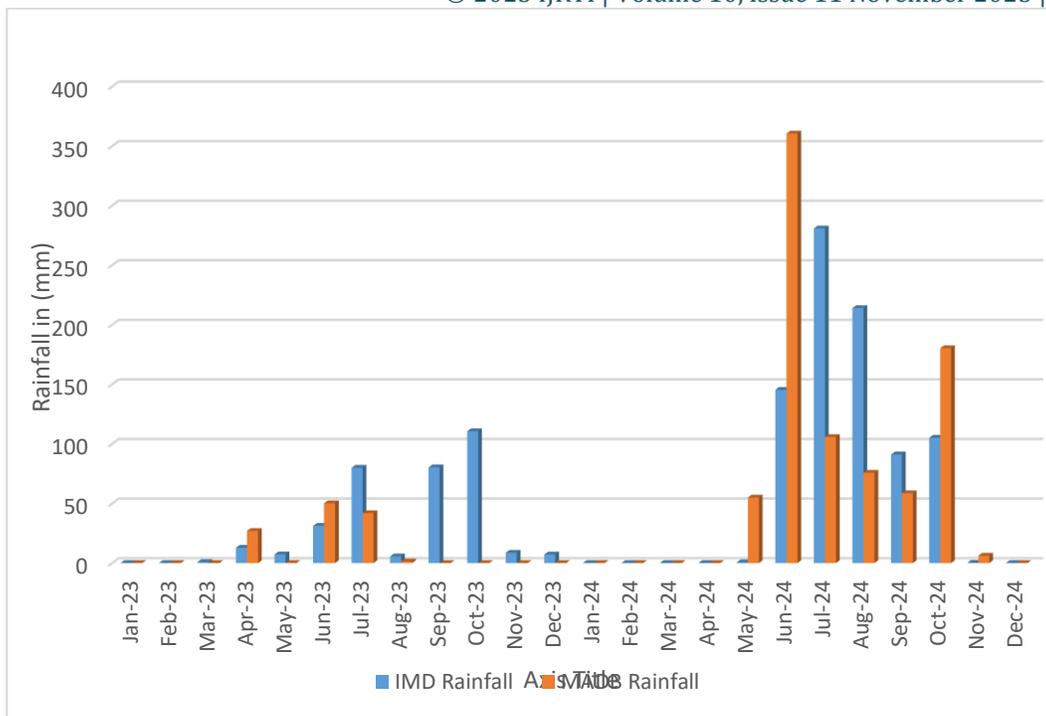
From the map, in general, it may be observed that nearly all the critical chemical constituents affecting the human health are absent in Katarkhatav and are above the permissible limit of drinking water and hence the ground water is potable. Groundwater quality varies, with one samples showing very good quality and two samples showing good quality. As a conclusion, groundwater quality issues haven't been identified in the Gram Panchayat, making it potentially suitable for drinking, domestic, and irrigation purposes. The water quality status is also available for public viewing through a mobile app, with a screenshot provided below.



**Figure 9: Electrical conductivity, Nitrate and Fluoride comparison map**

#### Rainfall monitoring-data collection and analysis

Under Atal Jal, one mechanical rain gauge has been installed in the gram panchayat to monitor the rainfall, monitoring is being carried out on daily basis and a register is maintained in the GP. it is one of the important parameters in preparation of Water Budget / Security Plans in Atal Bhujal Yojana. The rainfall data helps in the estimation of Water Availability, which gives an account of the status of Water Resources in each Gram Panchayat. At the same time, the rainfall data helps in arriving at runoff and planning supply side interventions. Rainfall is the major source of water for irrigation and hence quantitative assessment of rainfall helps in planning the crops. Maintaining a regular data /record of rainfall will also help in the year-on-year updating of Water Security Plans. The monthly data has been plotted as a bar graph as shown in Fig.10



**Figure 10: Bar graph of monthly rainfall (Atal Jal) Gridded data (IMD) (May 2022-Apr 2025)**

### Observations and Discussion

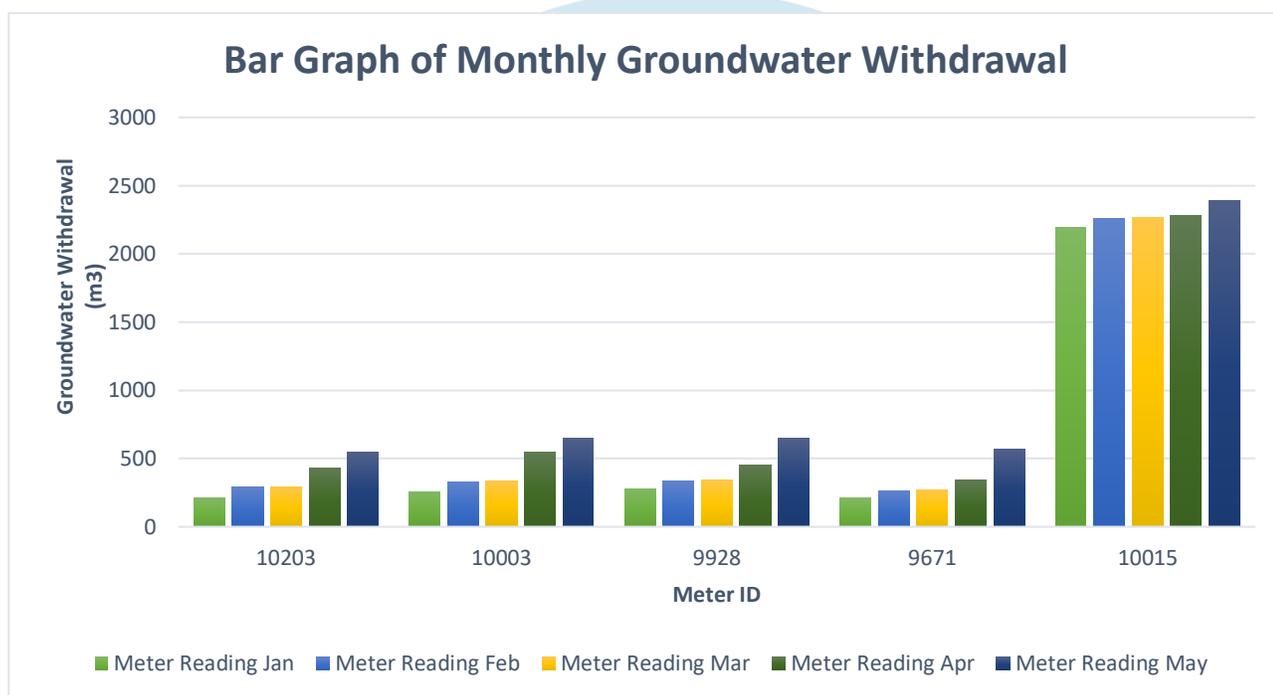
Various interventions, taken up as part of the Central and State Government Schemes such as MGNREGS, PMKSY, State Schemes etc. have succeeded in replenishment of groundwater resources to some extent and consequent rise in groundwater levels in some areas of the Maharashtra State of India. However, there is still no significant improvement in the existing groundwater management practices or in the status of groundwater resources at Block/District levels in major parts of the State. This could be due to various reasons, including lack of scientific data/knowledge at appropriate levels in various interventions, unscientific location of recharge/ harvesting structures, focus on issues other than groundwater, lack of attention to prioritization of the water-stressed areas etc. Analysis of the efforts made so far indicate that the emphasis has been on measures aimed at increasing the availability of groundwater (supply side measures) rather than reducing the demand (demand side measures). In general, there has been limited community involvement in planning, execution and maintenance of structures constructed under such schemes. There are, however, some instances where community and stakeholders' participation in groundwater management has been able to make a significant positive impact on the groundwater regime. In recent years, there have been several promising attempts at groundwater management with community participation in different parts of the state. These include the Agriculture department's integrated water Management Programme (IWMP), Jalyukt shivarand water budget-based holistic water management in Hiwre Bazaar village in Maharashtra. These pilot initiatives have demonstrated how demand for groundwater can be reduced if timely information on groundwater availability is provided to communities, multiple agencies work together and communities are engaged in the planning process. Most of these success stories of participatory groundwater management are community driven and self-financed which, at times, become a bottleneck in replicating such initiatives elsewhere. 6. With time, the government and policy makers have recognized the potential of community led groundwater management and the need to

institutionalise such initiatives through convergence of Govt. initiatives with emphasis on demand side management and behavioral change for ensuring the long-term sustainability of groundwater in the country. The Atal Bhujal Yojana is a major step in this direction. The planning process at the GP level is started with awareness creation and sensitization of the local communities, followed by the measurement of groundwater levels and rainfall. The equipment for measurement (Digital Water Level Recorders, Hand held tapes / sounders, simple rain gauges and water quality testing kits) are procured by the State Program Management Units, Maharashtra (SPMUs). Digital Water Level Recorders (DWLRs) are installed in earmarked piezometers / dug wells to have continuous record of data. Katakarkhatav Gram Panchayat have one DWLR, the data from which will be received at different levels including the MIS of Atal Jal and NWIC. Volunteers from the Gram Panchayats will be identified and trained by the District Implementation Partners (DIP), Satara in data collection. There will be one hand held tape / sounders, rain gauge and water quality testing kit for Katakarkhatav. The data collected made available to the public by the GP by displaying it at prominent places in the GP (Panchayat Office of Katakarkhatav Schools etc.). The data collected by volunteers and received from DWLRs will be analysed, interpreted and published as a report at Block Level of Khatav. This data would serve as a valuable input for water budgeting and preparation of Water Security Plans. This data will also be suitably disclosed to the general public in order to make them aware about the groundwater situation in their village area. Standard guidelines on operation, maintenance and data acquisition from these equipment have been circulated to the all GPs of Satara.

Monsoon months (June–Sept) receive the highest rainfall. July is the wettest month in both years. Winter and early summer months (Jan–May, Oct–Dec) show minimal rainfall. 2023 and 2024 show similar seasonal patterns, with only slight variations in magnitude. The total annual rainfall increased significantly from 337.52 mm in 2023 to 787.04 mm in 2024, an increase of 449.82 mm. In 2023, 58.43% of the total rainfall occurred during the monsoon period, while in 2024, monsoon rainfall accounted for 71.41% of the annual total. Although total annual rainfall increased in 2024, the percentage contribution from the monsoon decreased by about 12.98%. Ground water withdrawals are often estimated by indirect methods in absence of direct metering of water wells. It is essential to measure the volume of ground water on daily/ yearly basis for water budgeting as well as for control and regulatory purpose. This also helps in planning the irrigation as per the crop water requirements. To understand the ground water dynamics especially in terms of discharge, volume of groundwater Withdrawn should be precisely recorded at Gram Panchayat level which can also be used to work out the water budget and decide the management interventions. Taking regular, reliable and accurate measurements of flow / volume of ground water taken out is one of the best ways to plan the irrigation and ensure food security. In order to achieve the set target, water flow meter has been installed at the level of Gram Panchayat to estimate the Ground water withdrawal and the regular data is being collected farmers/ FLW/CRPs/volunteers. Presently groundwater data is being collected on monthly basis from 5 nos. of water flow meter.

## Monthly groundwater withdrawal in the gram panchayat

The monthly groundwater withdrawal, from Jan 2025 to May 2025 is given in the fig. 11, From the figure it can be seen that the maximum groundwater withdrawal is in the months of Jan 2025 to May 2025. Bar chart of monthly GW withdrawal is given in the fig10.



**Figure 11 : Bar Graph of monthly groundwater withdrawal**

Three monitoring stations are fitted water flow meter has been used to estimate the groundwater draft in Rabi and Kharif season through Unit Draft method. Methodology for groundwater draft estimation is given in table 8 and estimated seasonal draft is given in table 8. In the paper, unit draft method has been used to estimate the GW withdrawal in the GP. However, as per the guideline circulated for analysis of water flow meter data, the crop duty method can also be used to arrive at total GW withdrawal depending upon the availability.

### Preparation and implementation of water security plan

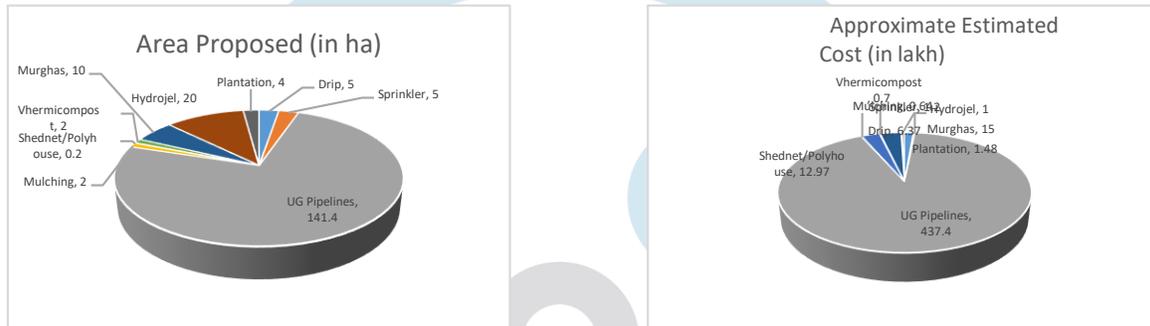
This section details are given for proposed demand and supply side interventions in WSP and implementation of such interventions in the gram panchayat, through convergence of existing state or central governments scheme or incentive fund utilization under the Atal Bhujal Yojana. The key information includes area of GP which is likely to be covered under the interventions, tentative cost of implementation and anticipated water savings in case of demand side measures and water conservation/recharge in case of supply side measures.

### Water security plan-proposal (As per approved WSP 2024-25)

Water security plan is an outcome of the participatory groundwater management approach which specifies the investments and action to be taken at GP level under demand management and to create additional water storages/conservation structures. The plan has been worked out with the active involvement of community,

VWSC members, DIP/DPMU. At GP level multiple meetings and training program conducted to sensitize the villagers about the process of water budgeting, water availability and water utilization in the gram panchayat and based on that, a participatory water security plan has been prepared. The proposed plan has been shared with the different line departments for implementation of WSP at GP level. The details of interventions proposed under WSP are given in the table 14 & 15.

**Figure 13: Demand side interventions -distribution of Area and Cost**



**Figure 13: Supply side interventions –cost distribution**

By implementing both demand and supply-side interventions, it is anticipated that groundwater management in the Gram Panchayat will significantly improve. The demand-side measures are expected to save approximately 226.9 ham of water, whereas about 7.6 ham of water will be recharged into the groundwater by artificial recharge structures.

The implementation of demand-side interventions through convergence and incentive fund utilization, at the gram panchayat level has resulted in a water savings of 16.41 (ham). Since 92.98 ha area has already been covered with micro irrigation system, therefore total 678 ha area in the GP is covered with efficient irrigation system. Under Supply side intervention, the total annual GW recharge is 0.94 ham.

## Conclusion and Recommendations

Groundwater supplies more than 85 % of rural India's domestic and agricultural water needs, which is depleting fast in many areas due to its large-scale withdrawal (Bhalerao and Kelkar 2013). The stress on groundwater in most of the rural areas of Maharashtra state can be ascribed to changes in the precipitation pattern and exploitation. Recharge enhancement with subsurface storage is a known technology and has already successfully been implemented in many countries at different scales (Tuinhof et al. 2002). The basic requirements for recharging the ground water reservoir are availability of non-committed surplus monsoon run off in space and time, Identification of suitable hydrogeological environment and sites for creating sub surface reservoir through cost effective artificial recharge techniques. A Recharge Shaft is one of the key recharging measures used for direct recharging of an Aquifer. It is an efficient and cost-effective option appropriate for augmenting the recharge into the phreatic aquifers where water levels are much deeper and the aquifer zones are

overlain by strata having low permeability like tightly jointed massive basalt or almost impermeable strata like amygdaloidal basalt. Its relevance is particularly pronounced in areas where the stream flows are available during the monsoon and limited post monsoon periods.

There is need to establish mechanism and train the Community Resource Parsons (CRP) to continue water level and quality monitoring and update the water security plan at frequent interval by involving the community and VWSC members. The understanding developed from the analytical results as discussed above shall be used in future planning including GP wise annual / seasonal ground water resource estimation as well in day to day management of ground water.

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