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Study of Groundwater Fluctuation in Semi-Arid Region of Kadegaon Taluka Sangli, Maharashtra - A Case Study

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Abstract

The water present in the ground changes its levels for many reasons. The groundwater level mainly changes due to natural phenomena and human activities. A natural phenomenon refers to the precipitation and the infiltration of water, whereas manmade activities refer to groundwater used for the supply system of water. Some groundwater sources are heavily used for water supply, but some sources have very little use. Some wells are referred to as monitoring wells, which are used to maintain the records of the groundwater level fluctuation. This recorded data can be used for the detailed study of groundwater fluctuations. The data can be recorded at 30min intervals or on a daily basis. Daily basis recorded data is used for a long period of time. Also, water level changes can be referred to as short-term changes and long-term changes. Short term changes can be observed when the water level readings are recorded many times a day. While the long-term changes can be observed by the data collected for many years. There are so many factors that can affect water levels in the aquifer changes over time. The groundwater levels are majorly affected by the three main factors, 1) change in the volume of water available in the aquifer, 2) change in atmospheric pressure 3) Changes caused by aquifer deformation.

Keywords*: - Groundwater, Precipitation, Infiltration, Groundwater Level fluctuation etc.*

INTRODUCTION

Year by year the water is becoming the scare source all over the world. Water resources available on earth are in two forms, namely surface water and groundwater. According to the study of scientists, the total volume of the groundwater is only 0.65% of the total water available globally.

There are many areas in our country facing scarcity of water, which is due to the lack of proper planning of the groundwater development, resulting in the fall of water levels and drying of wells. The over-exploration of groundwater in certain parts of the country may also lower the groundwater table, which requires scientific resource management and conservation (N.J.Shrimali1 et. al.2008).

The source of water available below the surface of the earth can be used as the prime source of water for the water supply system, majorly for agriculture and used for domestic use and commercial use. Groundwater has crucial importance and value for human life and economic development. The groundwater has a major contribution to the earth's water circulatory system, known as the hydrologic cycle. The groundwater has its presence in the permeable geologic strata known as aquifers, i.e., geologic formations having voids in its structure that can store and transmit water. The movement of groundwater in the geologic formations is considered as groundwater flow. This flow rate is fast enough to supply an adequate amount of water to wells nearby (T.S. Anuraga et al., 2006).

Keeping in mind the growing rate of the population and its result, the needs of society could not be satisfied by the available surface water resources. Due to anthropogenic activities, the surface water resources become polluted. Thus the man has started a massive search for other water resources. Such massive mining of groundwater has leads to the drastic decline of groundwater table. Thus the groundwater has become a precious resources for agriculture and domestic use.

Hence in order to ensure a sensible use of groundwater the proper evaluation and management is required. Sometimes, the use of groundwater is faster than the natural replenishment of the water or the groundwater recharge, leading to the lowering of the groundwater table. Thus, in this situation, a serious problem occurs, resulting in shallow wells' drying and an increase in the pumping head in the deeper wells and bore wells. An efficient model or strategy needs to be developed to use groundwater and surface water for a better future of human life.

To develop such a model or strategy, quantitative and qualitative estimation of the available water resources is to be done. The realistic assessment of the groundwater and surface water resources will help develop such models.

The groundwater is mainly extracted for agricultural use to meet full crop water requirements, and there is neither water logging nor excessive lowering of the groundwater table. The prime necessity is to keep the groundwater reservoir in a dynamic equilibrium state over time and the fluctuation of groundwater levels to be kept in the particular range over the monsoon and non-monsoon seasons. (A.G.S. Reddy July 2012).

The precise assessment of groundwater recharge and discharge is quite difficult, as a direct measurement technique is not possible yet. Hence the methods used for the assessment of the groundwater resource are indirect methods.

***Objective*:** To calculate seasonal variation of groundwater level fluctuation in semi-arid region.

STUDY AREA

The study area lies in west a part of Maharashtra state bounded by Latitude 17^{O} 08’ 29” N to 17^{O} 25’ 34” N and Longitude 74^{O} 14’ 52” E to 74^{O} 31’ 41” E. falling partially survey of India topographical sheet no 47 K – 7, 10, on the scale 1:50,000 (Fig. 1) it covers total area of 560 km² and perimeter of 125 km includes district Sangli in Maharashtra. This district experiences a tropical wet-dry climate characterized by alternating wet and dry spells.

The study area receives rainfall during South-West monsoon from June to September. The distribution of rainfall isn't even all over the study area. The typical annual rainfall increases from 1038 mm within the western side to 288 mm within the east side. The rainfall is scattered. The numbers of rainy days during a season are less. It has been observed that about 20% rainfall is received during post-monsoon and by thunder showers within the month of May. The situation of rain-gauge stations are shown in (Fig. 2).

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The table 1 shows the latitude, longitude, altitude and sample size of the rain gage stations. The temperature may rise to 42ºC in summer and should fall down to 8ºC during winter. The wet and dry seasons generally occur between July and October and between January and May, respectively. The climate of the region is defined as subtropical with hot and dry weather in the summer. The main cause of annual rainfall variability in Western Maharashtra is the changing position of synoptic systems. The details of rain gauge stations are given in Table 1.

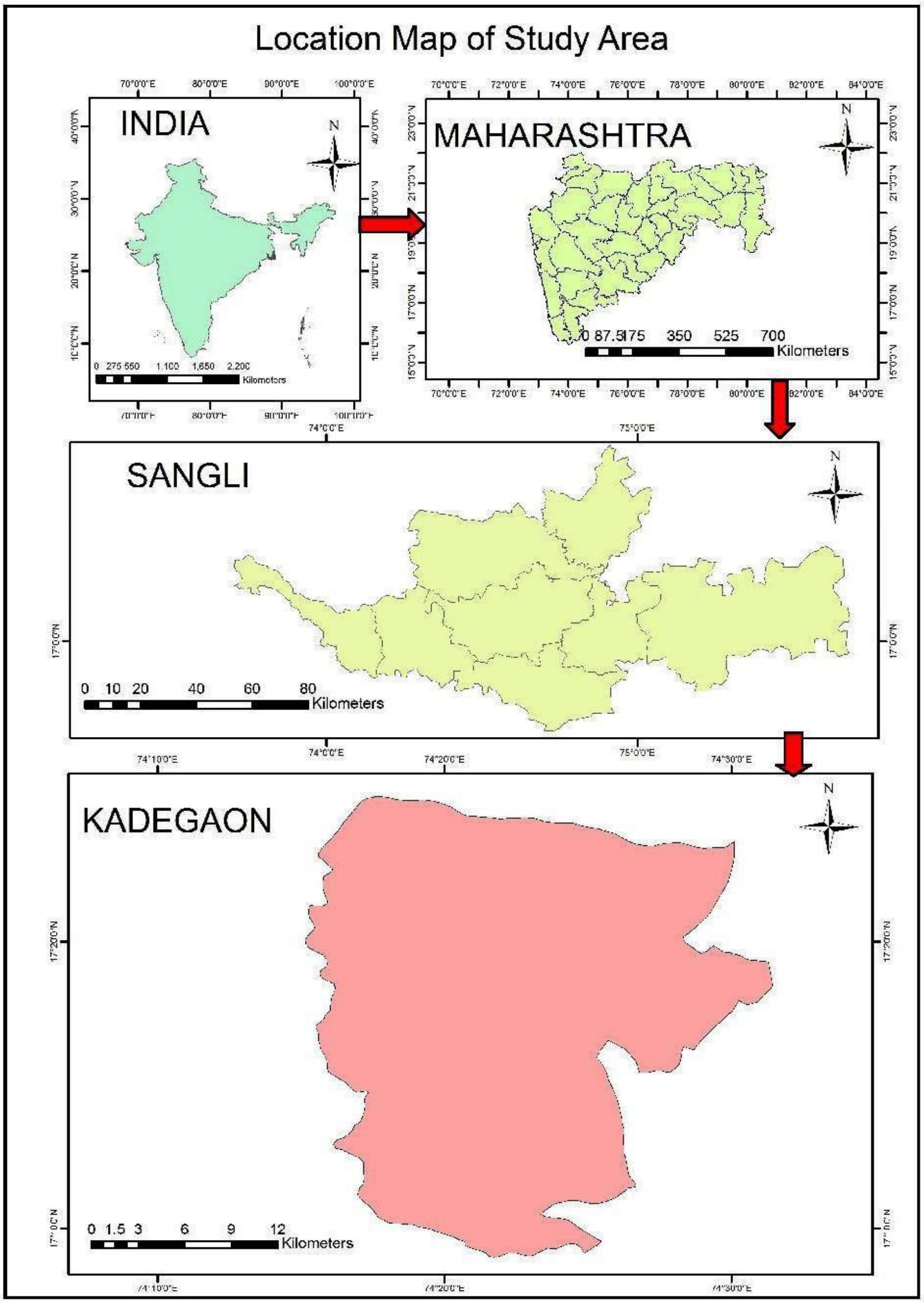

Fig. 1: Location Map of Study Area

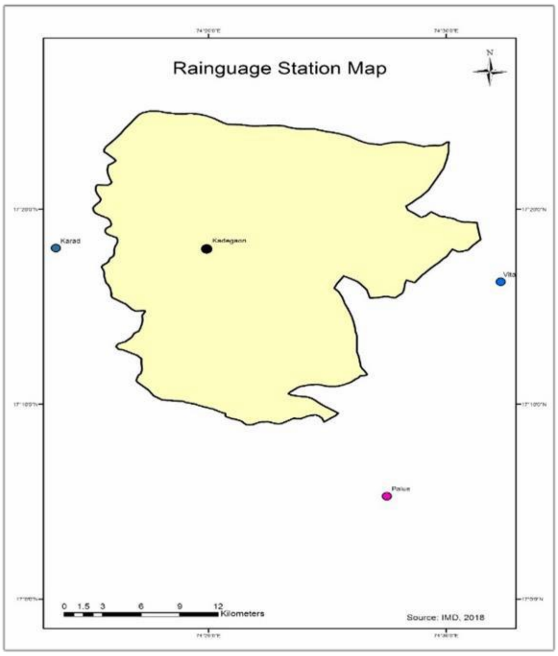

Fig. 2: Location of Rain Gauge Stations

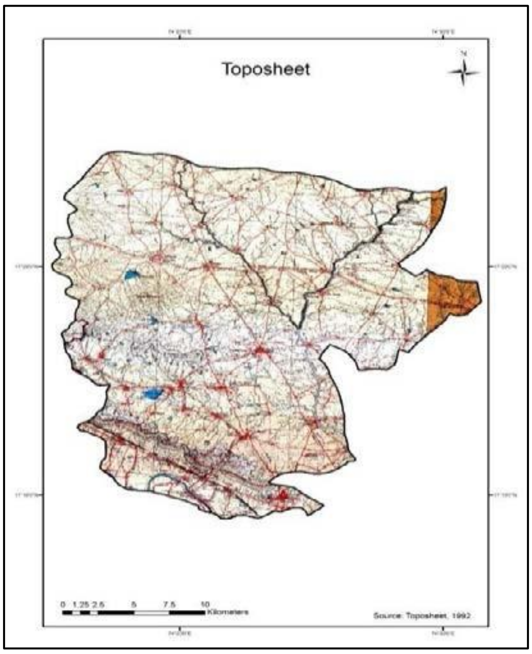

Fig. 3: Toposheet of Kadegaon Taluka

Table 1: Locations of Rain Gauge Stations

Sr. No.	Rain gauge Station	Latitude	Longitude	Sample Size (Year)	Altitude (m)
1	Kadegaon	74°19'56.40"E	17°18'7.58"N	22	675
2	Karad	74°13'33.01"E	17°18'11.73"N	22	580
3	Palus	74°27'27.12"E	17°5'29.28"N	22	570
4	Vita	74°32'16.04"E	17°16'27.70"N	22	680

Geology of the Region

The geology of the region is dominated by basaltic rock. Study area has experienced plenty of tectonic movements in the past, as evidenced by varying folds, faults and lineament association with hills positioned on the western side of the study area. The region is roofed by basaltic flows associated with the volcanic activity of Deccan from the Cretaceous to the Eocene age. We generally exhibit a phase like topography and are therefore referred to as Deccan Trap. These flows vary within the thickness of the independent flow from a couple of meters to 40 meters. They extend for a considerable distance. Basaltic lava flows are almost uniform in mineralogical and chemical composition. Basaltic flow are often categorized as Compact, fine-grained, massive basalt and vesicular, amygdaloidal basalt, the vesicles are stuffed with secondary minerals like quartz, chalcedony and calcite, etc. Comparatively soft, friable rocks are easier to break. The boundary of the basalt flows determined on the premise of the existence of red beds, change of the jointing and weathering pattern, ropey surface etc. The formation of a flat surface at different altitudes is another criterion that may be used for the identification of various basaltic flows. Such flat surfaces may be taken as flow tops. Basaltic flows are usually separated by red to brown colored clay rocks referred to as 'red beds.' The thickness of the red bed ranges from some centimeters to more than 2 meters. It also gradational relationship with the highest section of underlying flow (Fig. 3). These rocks possess negligible primary porosity but are cause to be porous and permeable because of secondary porosity by fracturing and weathering (Zende A.M. et. al., 2012).

In high rainfall are and under good drainage condition on weathering of basalt, laterite is formed. During weathering process silica, alkalis and alkaline earths have been leached away leaving alumina, iron, manganese and titanium. Laterite shows vermiculite or pisolitic structure. Alluviums deposited are more or less stratified deposits of gravel, sand, silt and clays deposited by streams and river. In these districts alluvial deposits are well developed along the bank of the most rivers. They vary in thickness from few meters along warna, Morna, Yerala, Agrani, Man and Bor rivers to 10.00 to 30.1 meters along Krishna river. These deposits commonly show features like graded beading, current bedding and cross bedding. At the bottom of those deposits fine graded sand and silt is present alongside kankar nodules locally referred to as Mann.

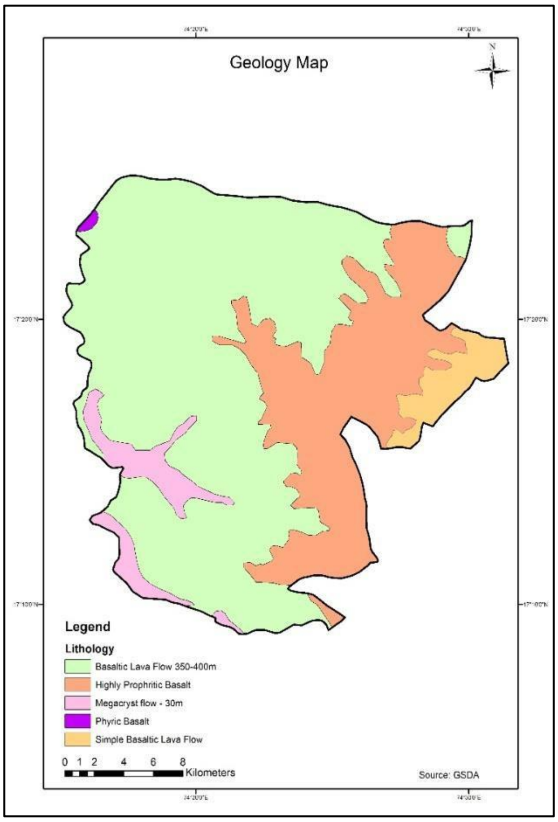

Fig. 4: Geology of the Kadegaon Tahsil

METHODOLOGY FOR GROUND WATER STUDY

To study the ground water of the region, ground water level in different dug wells and bore wells located in the basin has been considered. There are about 2 bore wells and 8 dug wells situated in the study area (Fig. 4). To know the overall behavior of groundwater table fluctuation, pre-monsoon and post-monsoon water levels with respect to ground level have been observed. The data collected for 22 years from 1998 to 2019.

These pre and post monsoon water levels are plotted and compared with the overall groundwater level fluctuation of weighted mean rainfall. Rain guage stations at Karad, Kadegaon, Palus, and Khanapur (Vita) considered for collection of rainfall for 22 years from 1998 to 2019. Kadegaon rain guage station is central part of Kadegaon tahsil while Karad, Khanapur (Vita) and Palus are outside the tahsil boundary. Location of rain gauge stations are shown in (Fig. 2). The details of groundwater monitoring wells are given in table 2 and 3.

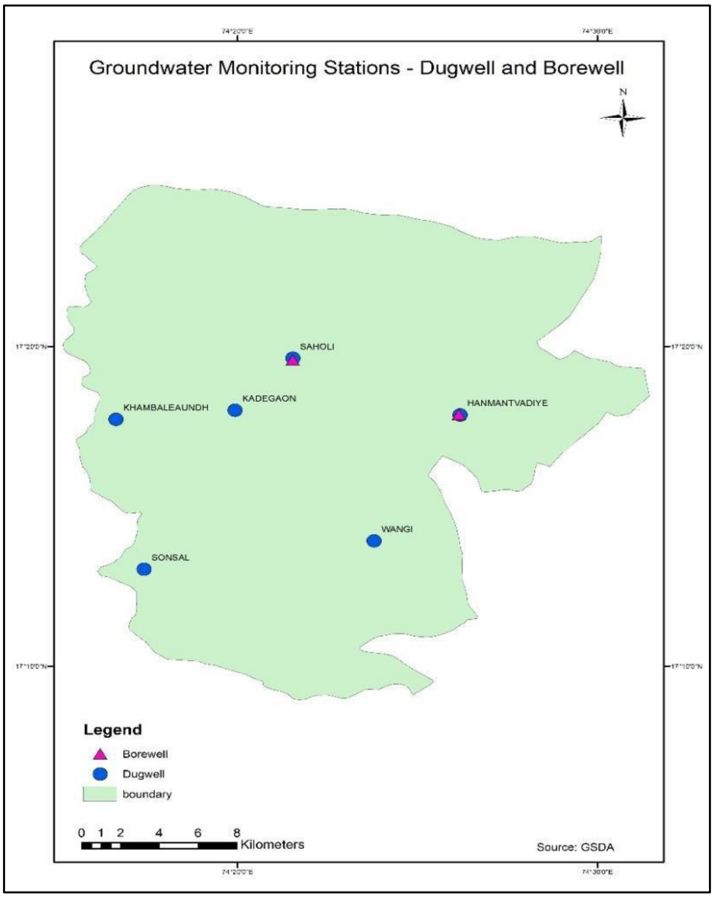

Fig. 5: Groundwater Monitoring Stations in Kadegaon Tahsil

Table 2: Details of Groundwater Monitoring Wells – Bore Well

BW ID	Name of Village	Latitude	Longitude	Altitude (m)
B1	Hanmant Vadiye	17°17'55" N	74°26'20" E	619
B2	Soholi	17°19'35" N	74°21'36" E	642

Table 3: Details of Groundwater Monitoring Wells – Dug Well

DW ID	Name of Village	Latitude	Longitude	Altitude (m)
D1	Hanmant vadiye	17° 17' 54" N	74° 26' 09" E	641
D2	Kadegaon	17° 18' 02" N	74° 19' 54" E	666
D3	Khambale aundh	17° 17' 46" N	74° 16' 37" E	841
D4	Soholi	17° 19' 40" N	74° 21' 31" E	654
D5	Sonsal	17° 13' 03" N	74° 17' 22" E	747
D6	Wangi	17° 17' 41" N	74° 18' 10" E	630

For the calculation of seasonal variation in dugwell and bore well pre-monsoon and post monsoon groundwater level are monitored for last 22 years (1998-2019). The details are shown in Table 4 for dugwell for locations A) Kadegaon, B) Hanmant Vadiye, C) Soholi, D) Khambale Aundh, E) Sonsal, F) Wangi respectively. Also, the details are shown in Table 5 for Borewell for locations A) Hanmant Vadiye, B) Soholi respectively.

Table 4: Details of Seasonal Groundwater Variation of Dug Well
A) Dug Well No.1 at Kadegaon

Year	WMR Rainfall in (mm)	Pre-Monsoon WLS in (m)	Post-Monsoon WLS in (m)	Seasonal Variation in (m)
1998	356	14.3	13.7	0.6
1999	368	12.9	12	0.9
2000	401	12.6	11.9	0.7
2001	425	11.8	10.1	1.7
2002	388.04	12.4	10.6	1.8
2003	288.23	12.8	11.6	1.2
2004	736	13.8	9	4.8
2005	920	12.7	8.5	4.2
2006	1038.4	13.4	4.6	8.8
2007	820	11.1	7.5	3.6
2008	710	11.3	7	4.3
2009	758	10.6	6.4	4.2
2010	635	11.5	7.6	2.9
2011	453.3	10.2	8.2	2
2012	425.2	11.6	8.1	3.5
2013	434.7	12.1	8.4	3.7
2014	622.9	12	8.7	3.3
2015	443.3	11.8	9.5	2.3
2016	505.7	11.6	9.1	2.5
2017	549.6	10.9	8.6	2.3
2018	496.5	11.3	9.2	2.1
2019	867.4	12.1	8.3	3.8

B) Dug Well No. 2 at Hanmant vadiye

Year	WMR Rainfall in mm	Pre-monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	9.5	8.5	1
1999	368	9.8	7.2	2.6
2000	401	8.7	7.4	1.3
2001	425	9.8	9.0	0.8
2002	388.04	8.7	6.2	2.5
2003	288.23	9.5	6.7	2.8
2004	736	9.6	2.6	7
2005	920	6.7	2.9	3.8
2006	1038.4	6.3	2.5	3.8
2007	820	5	3.3	1.7
2008	710	6.1	3.3	2.8
2009	758	4.3	3.1	1.2
2010	635	7.4	5.3	2.1
2011	453.3	6.6	4.8	1.8
2012	425.2	8.3	6.3	2
2013	434.7	7.1	6.2	0.9
2014	622.9	7.8	4.2	3.6
2015	443.3	6.3	4.8	1.5
2016	505.7	8.3	5.1	3.2
2017	549.6	6.7	4.2	2.5
2018	496.5	7.9	3.7	4.2
2019	867.4	6.2	2.4	3.8

C) Dug Well No. 3 at Soholi

Year	WMR Rainfall in mm	Pre-monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	12.2	8.4	3.8
1999	368	13.3	7.2	6.1
2000	401	12.6	7.6	5
2001	425	11.7	8.6	3.1
2002	388.04	13.8	8.1	5.7
2003	288.23	11.1	10	1.1
2004	736	14.2	7.1	7.1
2005	920	13.7	8.5	5.2
2006	1038.4	11.3	7.5	3.8
2007	820	10.9	8.5	2.4
2008	710	13.3	8.3	5
2009	758	10.5	7.6	2.9
2010	635	12.5	7.2	5.3
2011	453.3	13.7	9.5	4.2

2012	425.2	11.6	9.8	1.8
2013	434.7	10.8	7.8	3
2014	622.9	9.8	8.2	1.6
2015	443.3	11.3	7.6	3.7
2016	505.7	10.5	8.5	2
2017	549.6	12.5	7.9	4.6
2018	496.5	10.1	8.2	1.9
2019	867.4	12.2	7.8	4.4

D) Dug Well No. 4 Khambale Aundh

Year	WMR Rainfall in mm	Pre-monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	14.2	7.9	6.3
1999	368	13.8	8.3	5.5
2000	401	12.9	8.5	4.4
2001	425	14.1	7.8	6.3
2002	388.04	14.2	9.4	4.8
2003	288.23	14.1	14	0.1
2004	736	14.1	6.4	7.7
2005	920	8.55	3.3	5.25
2006	1038.4	13.1	6.6	6.5
2007	820	6.99	2.6	4.39
2008	710	11.4	4.4	7
2009	758	7.3	3.9	3.4
2010	635	9.8	4.3	5.5
2011	453.3	8.7	3.2	5.5
2012	425.2	10.5	6.9	3.6
2013	434.7	11.7	7.2	4.5
2014	622.9	9.5	5.4	4.1
2015	443.3	8.7	3.9	4.8
2016	505.7	10.3	8.4	1.9
2017	549.6	11.5	9.2	2.3
2018	496.5	8.5	6.1	2.4
2019	867.4	8.9	5.3	3.6

E) Dug Well No. 5 at Sonsal

Year	WMR Rainfall in mm	Pre-Monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	10.8	9.8	1
1999	368	10.6	8.7	1.9
2000	401	9.8	8.2	1.6
2001	425	9.5	8.9	0.6
2002	388.04	10.1	8.7	1.4

2003	288.23	10.2	11.1	-0.9
2004	736	10.8	13.1	-2.3
2005	920	3.3	3.7	-0.4
2006	1038.4	2.2	3.8	-1.6
2007	820	3.65	2.5	1.15
2008	710	2.3	2.2	0.1
2009	758	3.5	2.4	1.1
2010	635	6.7	4.3	2.4
2011	453.3	8.9	5.8	3.1
2012	425.2	9.2	6.4	2.8
2013	434.7	9.5	5.2	4.3
2014	622.9	6.4	4.9	1.5
2015	443.3	9.2	6.6	2.6
2016	505.7	10.4	7.2	3.2
2017	549.6	7.8	5.1	2.7
2018	496.5	8.5	4.2	4.3
2019	867.4	6.3	3.9	2.4

F) Dug Well No. 6 at Wangi

Year	WMR Rainfall in mm	Pre-monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	9.4	8.4	1
1999	368	89	7.4	1.5
2000	401	10.1	8.2	1.9
2001	425	9.8	7.6	2.2
2002	388.04	10.3	9.2	1.1
2003	288.23	9.2	9.8	-0.6
2004	736	7.3	5.9	1.4
2005	920	7.9	6.5	1.4
2006	1038.4	8.2	6.4	1.8
2007	820	7.1	6.7	0.35
2008	710	8.2	6.4	1.75
2009	758	6.0	4.6	1.4
2010	635	8.4	6.4	2
2011	453.3	7.9	6.2	1.7
2012	425.2	8.6	5.9	2.7
2013	434.7	7.4	6.2	1.2
2014	622.9	7.2	6.3	0.9
2015	443.3	8.9	6.9	2
2016	505.7	7.4	5.4	2
2017	549.6	6.9	6.2	0.7
2018	496.5	8.2	7.1	1.1
2019	867.4	6.2	5.9	0.3

Table 5: Details of Seasonal Groundwater Variation of Borewell

A) Bore well no 1at Hanmant Wadiye

Year	WMR Rainfall in mm	Pre-monsoon WLS in m	Post-monsoon WLS in m	Seasonal Variation in m
1998	356	9.1	6.2	2.9
1999	368	9.5	5.8	3.7
2000	401	8.9	5.2	3.7
2001	425	8.8	6.1	2.7
2002	388.04	6.8	5.2	1.6
2003	288.23	8.7	9.0	-0.3
2004	736	7.9	4.0	3.9
2005	920	5.8	2.2	3.6
2006	1038.4	4.8	2.8	2.0
2007	820	4.4	2.5	1.9
2008	710	4.7	4.6	0.1
2009	758	3.8	2.6	1.2
2010	635	4.6	3.8	0.8
2011	453.3	8.4	5.9	2.5
2012	425.2	8.7	5.3	3.4
2013	434.7	7.1	4.5	2.6
2014	622.9	8.3	5.2	3.1
2015	443.3	8.7	4.9	3.8
2016	505.7	7.5	5.9	1.6
2017	549.6	8.2	4.8	3.4
2018	496.5	7.6	5.3	2.3
2019	867.4	6.4	4.2	1.2

B) Bore well No. 2 at Soholi

Year	WMR Rainfall in mm	Pre-Monsoon WLS in m	Post-Monsoon WLS in m	Seasonal Variation in m
1998	356	38.5	30.2	8.3
1999	368	40.2	29.4	10.8
2000	401	32.7	23.8	8.9
2001	425	18.5	11.5	7.0
2002	388.04	19.7	16.8	2.9
2003	288.23	50.9	43.1	7.8
2004	736	51.6	27.2	24.4
2005	920	20.8	8.0	12.8
2006	1038.4	19.0	8.9	10.1
2007	820	17.9	9.0	8.9
2008	710	24.1	24.2	-0.1
2009	758	20.6	18.2	2.3
2010	635	22.1	17.4	4.7
2011	453.3	27.5	22.2	5.3
2012	425.2	32.4	28.9	3.5

2013	434.7	28.3	19.8	8.5
2014	622.9	22.1	18.4	3.7
2015	443.3	27.5	21.7	5.8
2016	505.7	25.4	20.5	4.9
2017	549.6	29.3	21.8	7.5
2018	496.5	32.4	22.2	10.2
2019	867.4	23.2	17.8	5.4

GRAPHICAL ANALYSIS

The output of all study is summarized in terms of graphs. These graphs include the Water levels measured with respect to ground at pre and post monsoon period stage, number of years and Weighted Mean Rainfall. The Fig. 5 to Fig. 10 Represents the ground water level fluctuation of Dug Well in pre-monsoon and post monsoon. The graph shows that the decreasing trend for dug well for pre-monsoon (May) at all stations, Kadegaon, Khambale Aundh, Hanmant Vadiye, Sonsal, Wangi and Soholi. The graph shows that the decreasing trend for dug well for post-monsoon (October) at all stations, Kadegaon, Khambale Aundh, Hanmant Vadiye, Sonsal, Wangi and Soholi. The Fig. no 11 and Fig. no 12 Represents the ground water level fluctuation of Bore well in pre monsoon and post monsoon season. The graph shows that the decreasing trend for Bore well for pre-monsoon (May) at stations Hanmant Vadiye, and Soholi. The graph shows that the decreasing trend for Bore well for post-monsoon (October) at stations Hanmant Vadiye, and Soholi.

RESULTS AND DISCUSSION

The groundwater fluctuation observed in all groundwater monitoring stations. The details of seasonal variations are as follows:

1. **For Dugwell:** At Kadegaon, minimum 0.6m (1998) and maximum 4.8m (2004); at Hanmant Vadiye, minimum 0.8m (2001) and maximum 4.2m (2018); at Soholi, minimum 1.1m (2003) and maximum 6.1m (1999); at Khambale Aundh, minimum 0.1m (2003) and maximum 7.0m (2008); at Sonsal, minimum -2.3m (2004) and maximum 4.3m (2018); at Wangi, minimum -0.06m (2003) and maximum 2.7m (2012).

2. **For Bore well:** At Hanmant Vadiye, minimum -0.3m (2003) and maximum 3.9m (2004); at Soholi, minimum -0.01m (2008) and maximum 24.4m (2004). While considering all groundwater dugwell monitoring stations seasonal variation, the minimum -2.3m (2004) at Sonsal and maximum 7.0m (2008) at Khambale

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Aundh. In general the depth to water level in Kadegaon taluka ranges from -2.3m to 7.0m B.G.L. (Below Ground Level). In low laying areas along drainage streams banks mainly in central of the taluka, the water table is shallow between 2 to 7 m BGL.The depth of water level for borewell in southwestern parts of the taluka varies between -0.3m to 24.4m BGL. In general the depth of water levels broadly follows the surface topography and the drainage pattern in the area. Ground water table in the catchment of Kadegaon tahsil increase from 1m to 7m Below Ground Level (BGL) during period of 1998 to 2019.

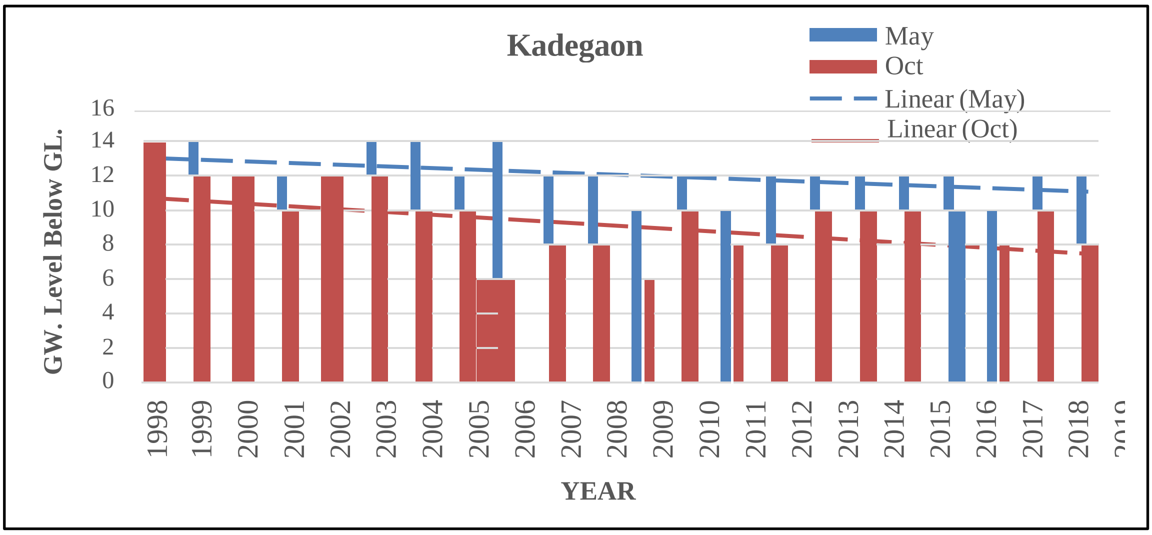

Fig. 6: Graphical Representation of Dug Well at Kadegaon

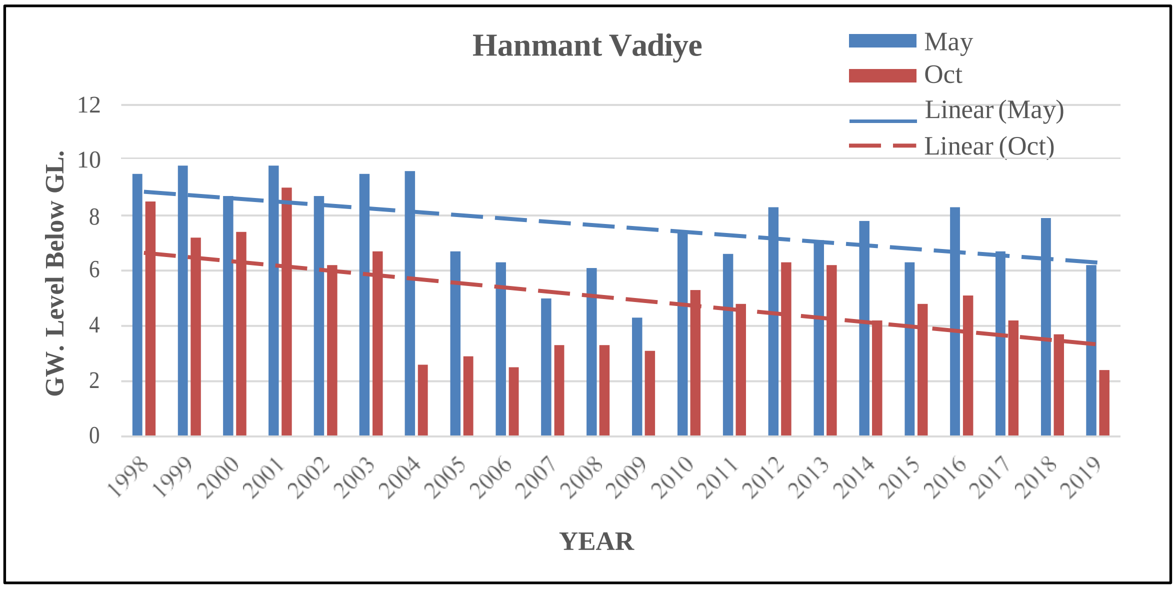

Fig. 7: Graphical Representation of Dug Well at Hanmant Vadiye

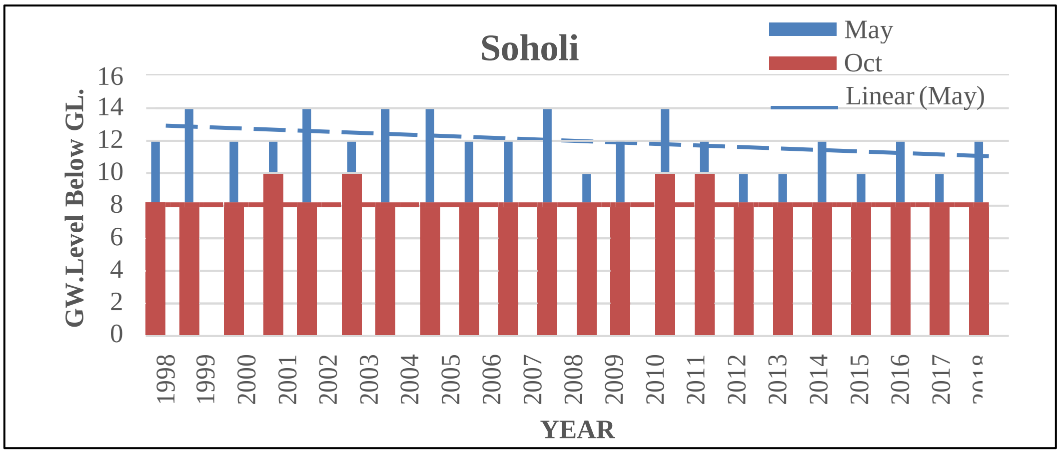

Fig. 8: Graphical Representation of Dug Well at Soholi

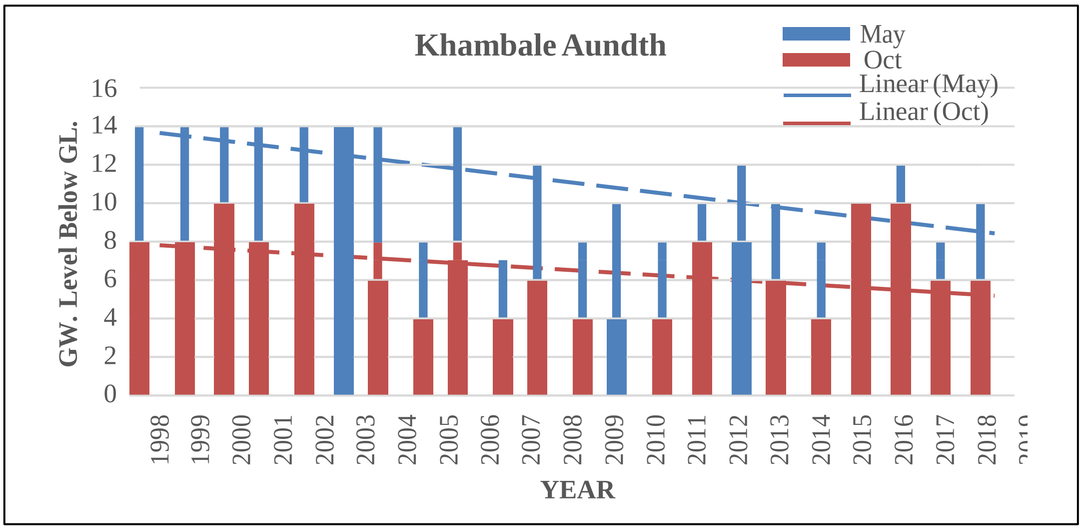

Fig. 9: Graphical Representation of Dug Well at Khambale Aundh

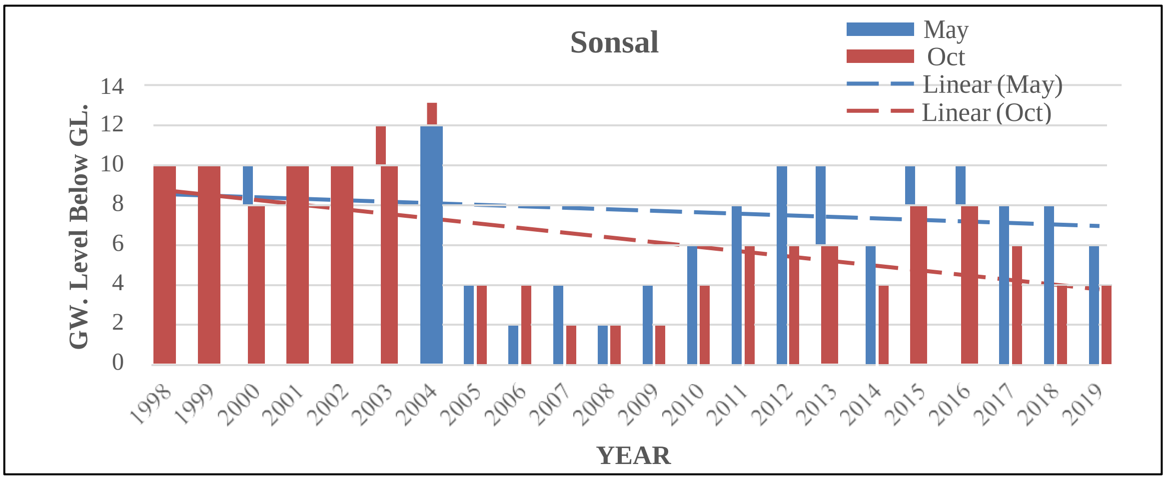

Fig. 10: Graphical Representation of Dug Well at Sonsal

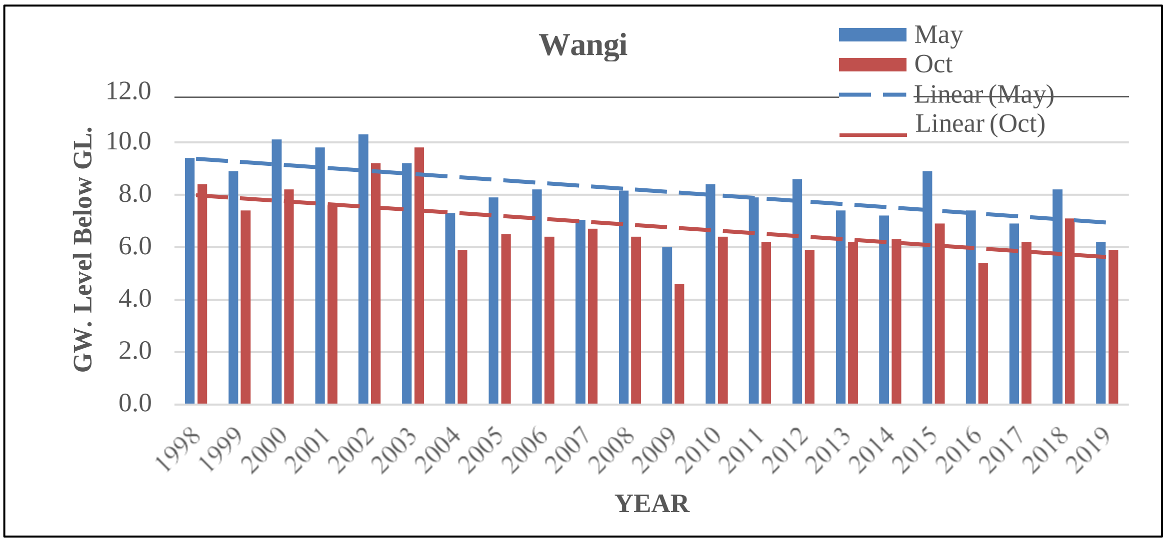

Fig. 11: Graphical Representation of Dug Well at Wangi

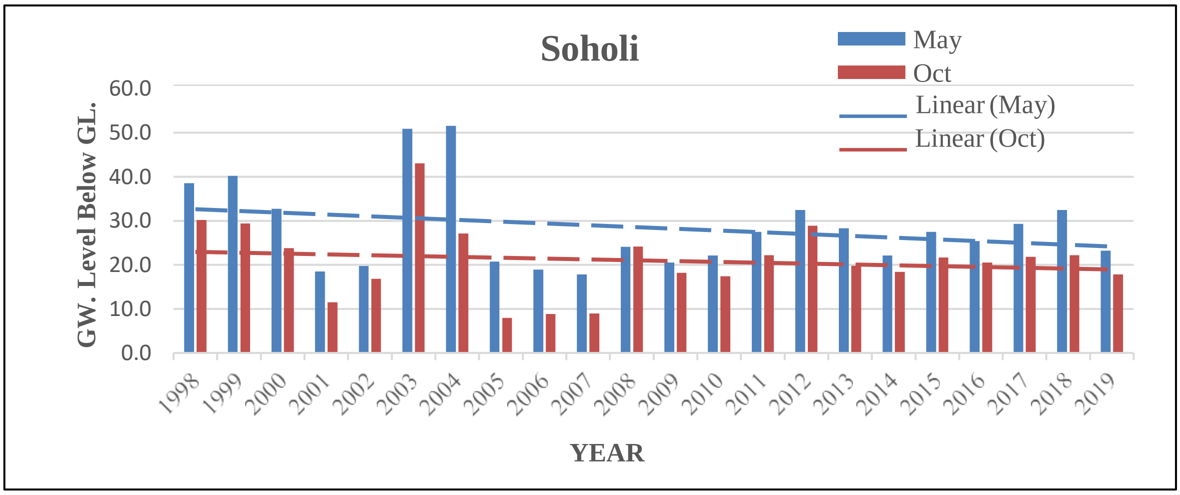

Fig. 12: Graphical Representation of Bore Well at Soholi

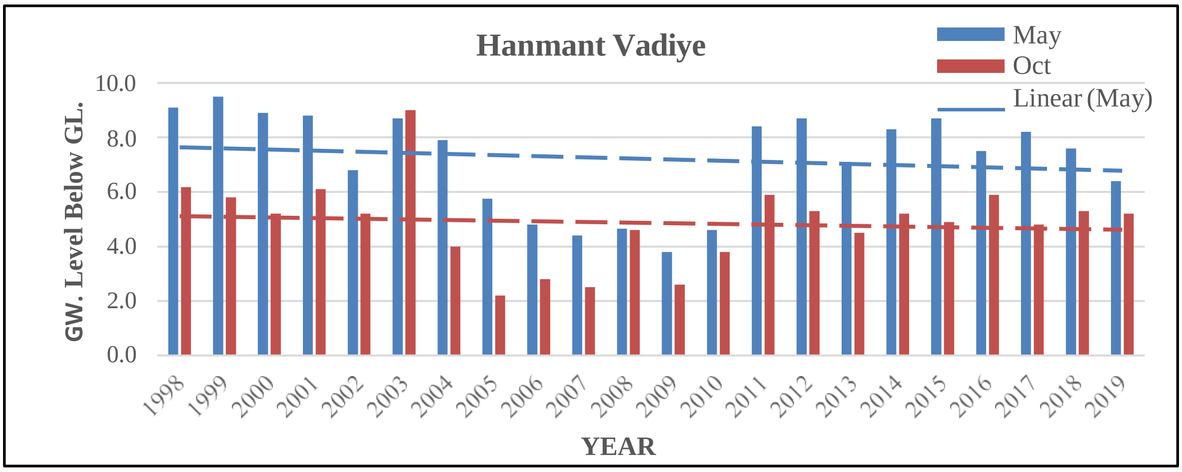

Fig. 13: Graphical Representation of Dug Well at Hanmant Vadiye

CONCLUSIONS

The groundwater fluctuations have been derived for the entire Kadegaon taluka and it has been decreasing 1m to 7 m below ground level, whereas rainfall intensity was slightly increasing. Due to lack of water harvesting structures, rainfall directly converts into a runoff. All Dugwell and Borewell monitoring stations show a decreasing trend in pre and post-monsoon season, groundwater level fluctuation for 22 years (1998-2019). According to Fig. 6 to Fig. 13, clearly shows the decreasing trend for all monitoring stations indicates groundwater recharge is continuously increasing in a proper manner, which helps to meet the water demand for various sectors.

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