A Statistical Hydrometeorological Analysis of North Gujarat Region

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Abstract— Meteorology is the key driving force of hydrology along time, from the immediate states and processes until the monthly, yearly, seasonal and sometimes multiyear sequences. Meteorology influences much of the hydrological flows and storages. The Mehsana district area has been facing severe water scarcity due to scanty precipitation and intensive agriculture during the last few years. The present study shows that the average rainfall in the Mehsana district is around 743 mm and the average depth to water level in this region is very deep particularly during pre-monsoon, where the water level lies below 25m at almost all the places. Groundwater level varies from 20.16 mm to 174.70 mm in the Mehsana region which shows very high difference in underground water level at various places in the study area. Hydrometeorology study indicates that uncontrolled extraction of groundwater is the only cause leads to unpredictable relation between precipitation and ground water level.

Key words: Hydrometeorological, precipitation

I. INTRODUCTION

Hydro-meteorological feedbacks and feed forwards can be enhanced through the characteristics of the geographic interface, such as the land use, landscape structures, biology of the cover, and water storage abilities. The ability to observe and predict hydrometeorology extremes associated with heavy precipitation and floods is crucial in our ability to understand the water cycle and provide advance warning to potentially hazardous situations. Heavy precipitation influences ecosystems, agriculture, infrastructure and water resources, thus impacting society.

To prepare a sustainable management strategy for groundwater development, it is important to understand the fluctuation of groundwater levels with reference to natural or artificial recharge in space and time domain. The rainfall comprises an important component of the water cycle and is the prime source of groundwater recharge [4]. The climate change likely to impact rainfall patterns leading to higher uncertainty and difficulties in management of both water scarcity and flood events [5].

There is irregular trend of water source through precipitation whereas on the other side, there has been a steady systematic lowering of water table resulting in depletion. Uneven distribution of rainfall and unplanned management of the existing water resources leads to severe water crises in the study area which falls in semi arid region. Considering these issues, the research work helps to determine the present status of groundwater level and rainfall intensity variations in the study area. It deals with the scientific study of the interaction between meteorological and hydrologic phenomena including the occurrence and motion of atmospheric water and subsurface water.

The aim of this paper is to assess the precipitation and groundwater level scenario in the semi arid region to establish the graphical presentation of relationship between precipitation and groundwater level.

II. STUDY AREA

Mahesana falls in semi-arid region as the tropic of cancer passes through the district. Geologically speaking, a subtropical climatic condition prevails in the study area. Mehsana district occupies 4393.74 sq.km area between 23°15´ and 23°53´ North latitudes and 72°07´ and 72°46´ East longitudes in the northern part of Gujarat state. The maximum temperature ranges from 36˚ C to 47˚ C and the minimum temperature varies from 14˚ C to 31˚ C. The mean daily temperature during the summer fluctuates from 33˚ to 43˚ C and the mean daily temperature during winter varies from 15˚C to 31˚C.

The Mehsana district receives scanty rains as the area is situated on north part of Gujarat which belongs plain topography. About 96 % of the annual rainfall in the district is received during the south-west monsoon during June to September. The rainfall is also very less, varying from 700 mm to 1000 mm with average of 827 mm (CGWB Report, 2014) and the district has extreme climate. A general review of rainfall stations indicates that the precipitation is mostly uncertain and unevenly distributed in the region.

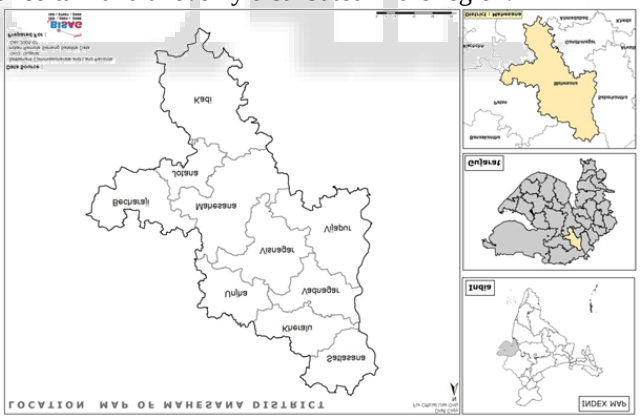

Fig. 1: Location Map of Study Area

III. METHODOLOGY

Water is very useful parameter of the environment because it is connected with the soil, drainage streams, river, reservoirs, catchment, basin, vegetation, and atmosphere [1]. For establishing the relation between Hydrometeorological parameters, two inputs are essential for this study (a) Precipitation data (b) Groundwater level data. Precipitation data was collected from State Water Data Center, Gandhinagar of last 14 years (2001- 20) recorded at 15 raingauge stations across the district. For analyzing the average depth to water level, and its variability in the study area, the groundwater level (GWL) data of 03 years (2012-2014) was recorded at different hydrological stations was

procured from the Central Ground Water Board (CGWB). The average rainfall and groundwater level for the last consecutive three years (2012-2014) were determined and analysed. The groundwater level fluctuation was analysed with the average value of the concerned year. The methodology flow chart is shown in figure 2. The groundwater data and the rainfall data assorted on monthly basis were analysed for their long - term pattern, and were interpreted graphically to understand the dynamics of the groundwater level and rainfall. The average water level depths and average rainfall recorded for 03 and 12 years respectively were used to indicate the current trend. The map showing location of 15 raingauge stations is generated in ArcGIS environment as shown in figure 3. The results were used to make the clear understanding of relation between precipitation and groundwater level in all aspects.

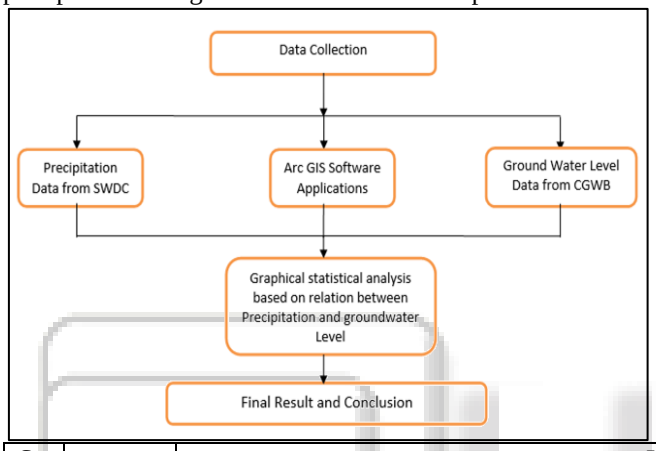

Fig. 2: Flow chart showing the methodology

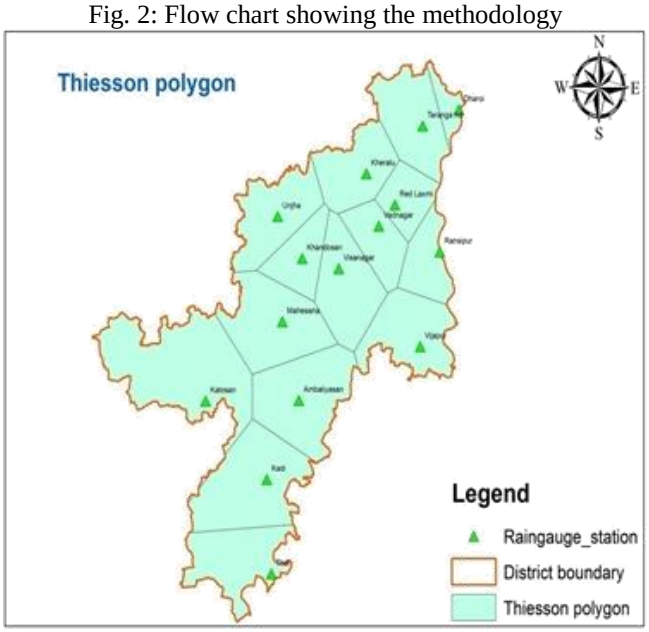

Fig. 3: Raingauge Station Location (Source: SWDC & BISAG, Gandhinagar)

Following Table 1 indicates the average value of fourteen years data from 2001 to 2014 for the Mehsana district.

Sr. No.	Taluka	Years														Total	Avg.
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
1	Visnagar	865	211	719	479	1335	1711	882	582	486	706	856	254	540	515	10141	724.36
2	Vadnagar	623	278	985	845	995	1574	981	429	370	489	622	385	554	635	9765	697.50
3	Kheralu	663	258	868	608	1105	1489	1020	531	282	508	456	327	956	533	9614	686.71
4	Satlasana	908	437	720	636	1090	1898	899	464	408	914	780	560	1050	675	11439	817.07
5	Vijapur	537	241	696	353	1257	1230	1225	501	572	651	883	688	857	800	10491	749.36
6	Kadi	498	384	1440	567	1966	1595	969	957	623	1449	697	454	1308	952	13859	989.93
7	Mehsana	382	491	257	797	1323	1282	711	558	692	695	943	441	1086	744	10402	743.00
8	Unjha	360	625	180	614	983	1322	716	385	345	628	610	323	1212	1263	9566	683.29
9	Bechraji	294	428	283	556	1209	1141	864	491	215	700	599	211	881	634	8506	607.57

Table 1: Rainfall Data for the Year 2001 - 2014

(Rainfall values are in millimeter, Source: SWDC, Gandhinagar,)

Looking to the current data of rain fall in different blocks of Mehsana district, Kadi, Satlasana, Vijapur and Mehsana gets more precipitation as compare to other blocks. Kadi records the highest rainfall as 989.93 mm whereas Bechraji receives the lowest rainfall as 607.57 mm in the Mehsana district – average of last fourteen years. All remaining blocks gets rainfall between 600 mm to 850 mm. so most of the blocks come under semi-arid region with higher order. Vadnagar, Kheralu, Unjha and Becharaji blocks have comparatively less rainfall as 724.36mm, 686.71 mm, 683.29 mm and 607.57 mm as an average of last fourteen years and leads to severe groundwater depletion and water contamination. Vadnagar and Kheralu blocks were declared as dark zones by government before three years and no electricity connection was issued for two years, but looking to the demands from farmers for new electricity connection

& due to political influence, it was again permitted for water extraction from the bore well since 2013.

A. Relation between Rainfall and Groundwater Level:

The rise and fall of water levels depend upon the amount, duration and intensity of rainfall, depth of weathering, specific yield of the formation and the general slope of the terrain towards drainage channels and various other factors. Precipitated water that reaches the ground surface may be partially discharged into streams as surface runoff or partially infiltrate into the ground. If water supplies are not continually provided from either a rainfall or other sources of recharge, the groundwater level would gradually decrease due to deeper percolation or evapotranspiration.

The groundwater level may be changed due to the recharge from adjacent surface watersheds. Pumping more groundwater than usual from a local aquifer or regional aquifers can drastically lower the water elevation in wells. The fluctuation of groundwater level may be different in magnitude for different locations depending on the abstraction and recharge. The measurement and monitoring of water level in wells is a basic task for proper assessment and management of ground water resources. The observed last three years data of groundwater level and rainfall recorded in Mehsana region is as under:

Sr. No.	Taluka/ Block	2012		2013		2014	
		GWL (mt)	Rainfall (mm)	GWL (mt)	Rainfall (mm)	GWL (mt)	Rainfall (mm)
1	Visnagar	45.22	254	44.03	540	48.92	515
2	Vadnagar	105.11	385	104.27	554	95.94	635
3	Kheralu	171.35	327	174.70	956	172.39	533
4	Satlasana	20.16	560	21.98	1050	22.14	675
5	Vijapur	71.48	688	71.02	857	67.31	800
6	Kadi	96.28	454	95.09	1308	90.55	952
7	Mehsana	38.56	441	37.82	1086	54.06	744
8	Unjha	53.03	323	51.78	1212	80.49	1263
9	Becharaji	70.97	211	78.76	881	85.08	634

Table 2: Comparison of Groundwater Level And Rainfall

The relationship between groundwater level and rainfall recorded in Mehsana district is shown for all nine blocks as shown in figure 4 to figure 12 :

Visnagar Block:

The groundwater level in Visnagar block varies from 44.03 to 48.92 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

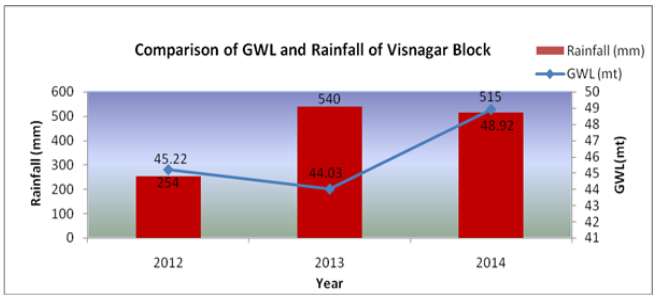

Fig. 4: Comparison of GWL and Rainfall of Visnagar Block

Vadnagar Block:

The groundwater level in Vadnagar block varies from 95.94 to 105.11 m below the ground level. From the observed data, it reveals that there was inverse relation between rainfall and groundwater level. The observation indicates over exploitation of groundwater for various purposes.

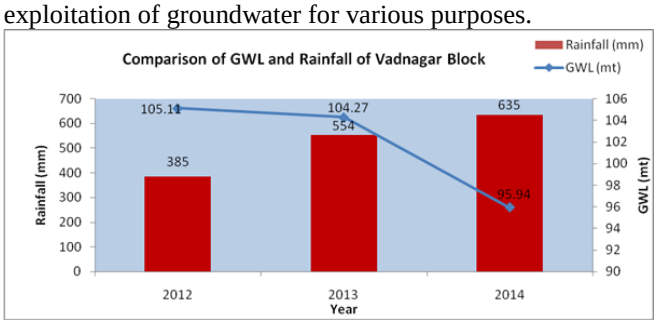

Fig. 5: Comparison of GWL and Rainfall of Vadnagar Block

Kheralu Block:

The groundwater level in Kheralu block varies from 171.35 to 174.70 m below the ground level. From the observed data, it reveals that there was increase in rainfall along with increase in groundwater level. It shows that rainfall was the reason for the fluctuation in water level.

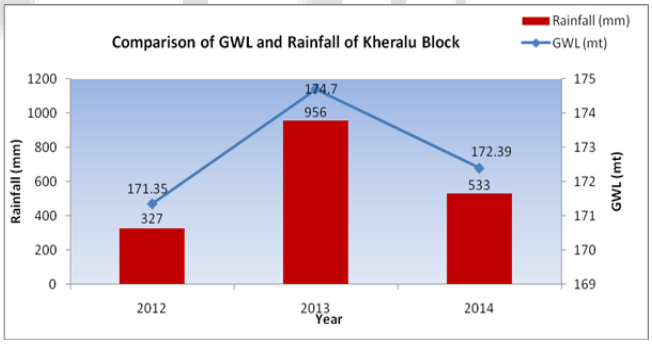

Fig. 6: Comparison of GWL and Rainfall of Kheralu Block

Satlasana Block:

The groundwater level in Satlasana block varies from 20.16 to 22.14 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

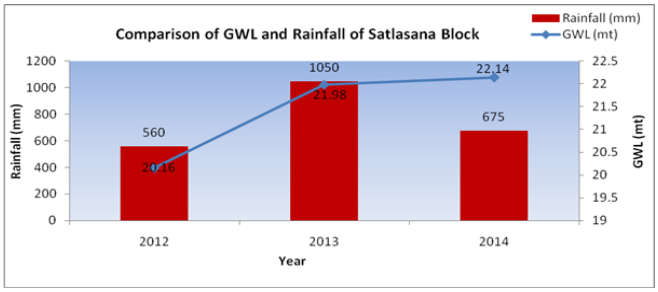

Fig. 7: Comparison of GWL and Rainfall of Satlasana Block

Vijapur Block:
The groundwater level in Vijapur block varies from 67.31 to 71.48 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

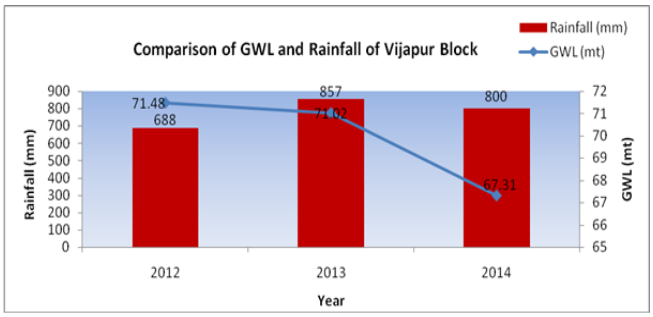

Fig. 8: Comparison of GWL and Rainfall of Vijapur Block

Kadi Block:
The groundwater level in Kadi block varies from 90.55 to 96.28 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

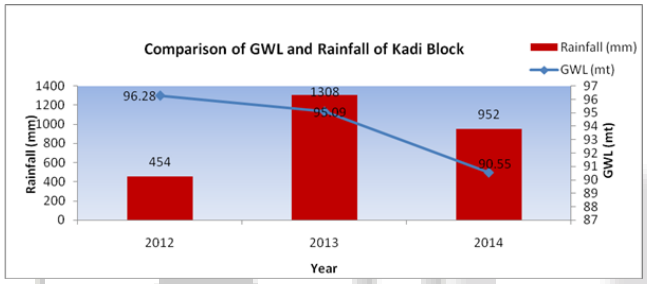

Fig. 9: Comparison of GWL and Rainfall of Kadi Block

Mehsana Block:
The groundwater level in Mehsana block varies from 37.82 to 54.06 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

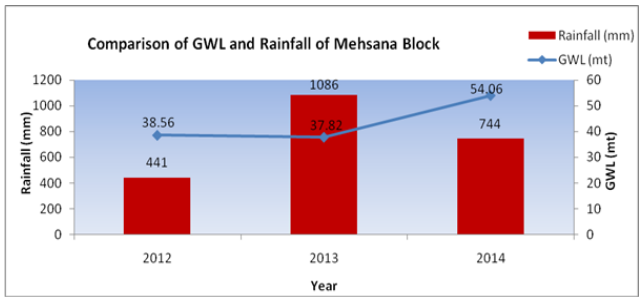

Fig. 10: Comparison of GWL and Rainfall of Mehsana Block

Unjha Block:
The groundwater level in Unjha block varies from 51.78 to 80.49 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

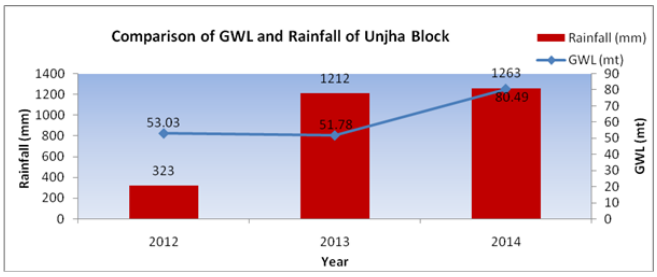

Fig. 11: Comparison of GWL and Rainfall of Unjha Block

Becharaji Block:
The groundwater level in Becharaji block varies from 70.97 to 85.08 m below the ground level. From the observed data, it reveals that there was fluctuation in groundwater level irrespective of rainfall. It shows that rainfall was not the only reason for the fluctuation in water level.

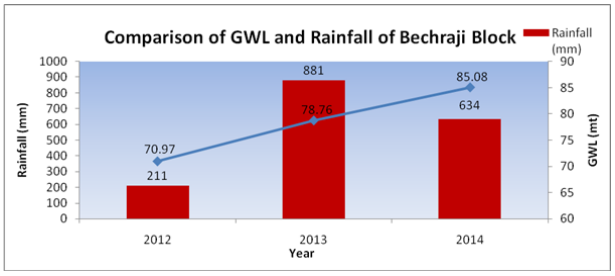

Fig. 12: Comparison of GWL and Rainfall of Becharaji Block

In general, it is observed that rainfall is not leading to increase the groundwater level because of overexploitation of groundwater for various purposes like agricultural, domestic, industrial, forest etc. hence the rainfall – groundwater level relation is remains in fluctuation.

IV. Conclusions

The erratic nature of rainfall distribution within monsoon months from June to September makes the region adversely affected by meteorological drought and water scarcity which is above the expectation. The present study showed that the average rainfall in the Mehsana district is around 750 mm as per the study and the average depth to water level in this region is very deep particularly during pre-monsoon, where the water level lies below 25 m at almost all the places. It can be inferred that Vadnagar and Kheralu blocks are the regions having very deep water level ranges 95.94 m to 174.70 m, which are more prone to drought like conditions due to a constant decline in the water level, whereas Satlasana block shows the high water level as compare to other blocks ranges 20.16 m to 22.14 m due to hilly region. It is also observed that no specific relation is observed in fluctuation between rainfall and water level for last three years available data.

Acknowledgments

The authors are grateful to state water data centre (SWDC), Gandhinagar for providing rainfall data and Bhaskaracharya Institute for Space Application and Geo-informatics (BISAG), Gandhinagar for technical support in GIS environment for analysis purpose.

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