International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 03 | Mar 2022 www.irjet.net p-ISSN: 2395-0072

Impact of Rainfall on Ground Water Level Fluctuations in the State of Uttarakhand, India

Ravi Kant Bhardwaj[1], Shivangi Sharma[2]

[1]*College of Technology, GBPUA&T, Pantnagar, India*
[2]*School of Agro & Rural Technology, IIT Guwahati, India*

Abstract - *Water is significant normal assets on soil which cater for all human endeavours. Groundwater is the foremost vital and reliable fresh water resource globally even in areas with excessive rainfall patterns and ample surface water. The present study is used to evaluate the impact of rainfall on ground water level fluctuations based on the data analysed over a period of 10 years from 2011 to 2020 for the state of Uttarakhand in the northern part of India. These data were analysed for the precipitation variation and groundwater variation. The examination too outlined that, the precipitation is impacting the groundwater level of the consider range as the rain more often than not begun in September and ended in December. Be that as it may, there are small events of rain within the rest of the months all through the year. The most extreme water level too was found amid January to February. The water table begins to decrease from June to August and comes to its most reduced level ordinarily from August to September. The result too outlines that, groundwater level diminished day by day due to fumble and excessive withdrawal from water system divisions and household employments.*

***Key Words*: Rainfall, Groundwater, Fluctuations, Uttarakhand**

1.INTRODUCTION

India is among the countries having the greatest number of rivers, but all the requirement of water in agricultural, industrial or domestic purposes cannot be fulfilled with only surface water. Groundwater is also one of the most significant drinking and domestic water resource worldwide, but the surge in urbanization and industrialization have overexploited this precious resource, causing a dramatic rise in its demand [1]. In many parts of India, groundwater has been extensively utilized for agricultural, industrial and domestic purposes [2]. Almost 250 billion cubic meters (BCM) of groundwater is extracted in India out of which more than 85% consumed for agricultural activities on yearly basis [3].

In simple terms, groundwater can be thought of the water which in present below the earth surface within soil pores and cracks in rocks. Groundwater constitutes a significant part of the hydrological cycle and is formed as precipitation or the water stored in surface bodies infiltrates or seeps into the ground. By natural discharge, groundwater from aquifers enters springs, surface water sources, seepage areas or to the sea [4]. Groundwater can be dynamically replenished depending on the nature of various parameters like climatic factors, hydrogeological and topographical constraints [5]. Uttarakhand is third largest dependent (more than 65%) on groundwater for its irrigation purposes in the country [6]. Moreover, springs, which are basically points of discharge of underground water sources to the surface is one of the major domestic sources of water for the people of this region.

Uttarakhand is situated in the Himalayan foothills and majority of the area of the State falls under hilly terrain (about 86%) expect for Haridwar, Udham Singh Nagar and some parts of Dehradun district. In hilly terrains, groundwater primarily occurs in fractures and fissures; and emerges as springs. The state possesses a diverse hydrogeological set-up and is distinctively divided into two regimes namely, the Himalayan mountain belt and the Gangetic alluvial plain.

Marechal *et al.* reported a rapid increase in the number of mechanized tube wells which has resulted in highest number of pump sets installations in the country. Moreover, groundwater irrigated land area has increased by 105% in contrast with the area of surface water irrigated area remained just 28% over the same period of two decades [7].

Singhal *et al.* accessed the availability of groundwater and its development in the district of Uttarakhand and estimated that the recharge rate in the water bearing formations of the region was about 19% followed by a stage of about 164% for groundwater development. These results suggested that there was a critical over- exploitation of groundwater in that region [8].

The aim of this present study is to evaluate the impact of rainfall of groundwater level fluctuations in Uttarakhand, India due to rapid increase in population rise, tourism and other socioeconomic growth in the state. This will further boost the need for groundwater management research as the findings will provide some insight towards sustainable utilization of this precious resources and its management in order to avoid their shortage or decline.

1.1 Study Area

The study area is the state of Uttarakhand which lies in the northern region of the country between $28^{0}43'$ N to $31^{0}28'$

N latitude and $77^{0}34'$ E to $81^{0}03'$ E longitude. The state is adjacent to Uttar Pradesh in the southern part and Himachal Pradesh in the northwest and shares international boundary with China and Nepal. It has a total geographical area of 53,483 km^2 [9] with a population of about 10.09 million and population density of 189 per km^2 as per census report of 2011 [10].

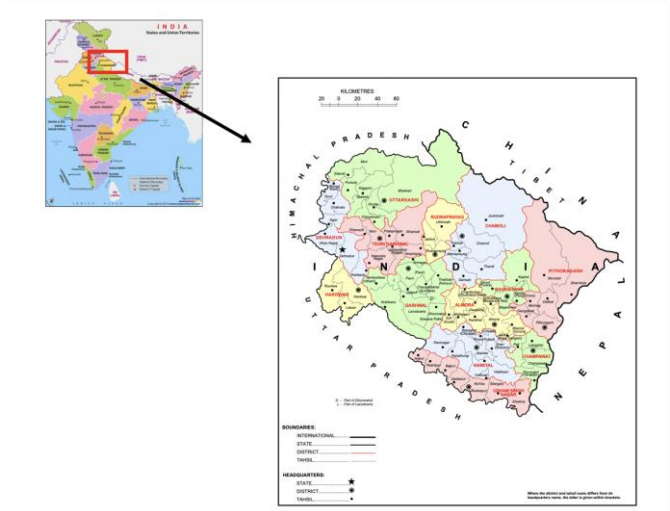

Chart -1: The study area map indicates the districts for which the data was collected

In Uttarakhand, the topography ranges from sub-tropical forests at lower altitudes to glaciers at higher altitudes due to its location on the southern slope of the Himalayas. Uttarakhand falls under Montane, also known as alpine, climate regions. The climate of Uttarakhand is temperate with seasonal variation in temperature but also affected by tropical monsoons. The temperature falls with elevation in altitude. January is the coldest month, with daily high temperatures below freezing and near 21° C in the southeast. July is the hottest month in the north, with 7° C to around 21° C daily. While in the southeast, May is warmest month, with daily temperature ranging from 38° C to the low of 27° C. Summer is the driest part of the year with afternoon relative humidity between 30% to 45% and morning relative humidity from 50% to 70% in southern part. In these parts the relative humidity ranges between 80% and 90% in the morning and 50% and 70% in the afternoon.

The state receives the average precipitation of around 1300 mm, mostly brought by southwest monsoon which blows from July through September. In general, the year is divided into four seasons. The winter season from December to February is followed by pre- monsoon or hot weather season from March to May. June to September constitutes the southeast monsoon season and period of October and November is of post monsoon season [11].

The nature of water bearing formations falls under multi-aquifer system in plain areas whereas fissures, joints and fractures in metamorphic and crystalline igneous rocks are the major water sources in hilly terrains. The water levels in these aquifers ranges from 20 m bgl (meters below ground level) to about 100 m bgl and is safely utilized for drinking, irrigation and domestic purposes. Between pre and post monsoon seasons the groundwater fluctuates typically between 2 m to 4 m.

2. Methodology

2.1 Data Collection and Data Quality

The groundwater level data for the thirteen districts of the Uttarakhand state were collected from Central Ground Water Board (CGWB), Ministry of Jal Shakti, Department of Water Resources, River development and Ganga Rejuvenation, Government of India for the period of 2011 to 2020 were sorted and arranged in an Excel sheet. So also, the Evapotranspiration and rainfall data for the same years were collected and sorted in the same format above. The map of the study area obtained from Uk.gov.in website of National Informatics Centre Uttarakhand was used to locate the districts/stations. All the data was found to be homogeneous and the missing values obtained were less than 5% for the period 2011 to 2020, the missing values in the data series were estimated using various types of weighting methods such as inverse, distance, correlation, and normal ratio.

3. Results and Discussions

3.1 Rainfall Variation

The below figures indicate the monthly variation in rainfall in the thirteen districts of the state over a period of 10 years from 2011 to 2020. The months from May to September experiences the maximum rainfall during the rainy season. The months from October to April observes the minimum rainfall and sometimes very little or no rainfall. The results of the study entail that, the maximum rainfall in Almora was recorded in August, 2011, Champawat August, 2011, Bageshwar July, 2018, Dehradun August, 2012, Chamoli July, 2018, Garhwal August, 2014, Pithoragarh July, 2018, Haridwar July, 2018, Nainital July, 2016, Rudraprayag July, 2016, Uttarakashi August, 2012, Tehri Garhwal August, 2012 and Udham Singh Nagar August, 2012.

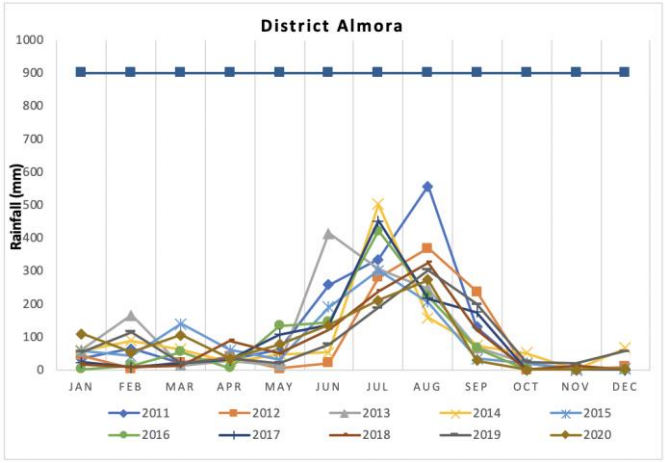

Chart -1: Monthly variations in rainfall in the district of Almora (2011-2020)

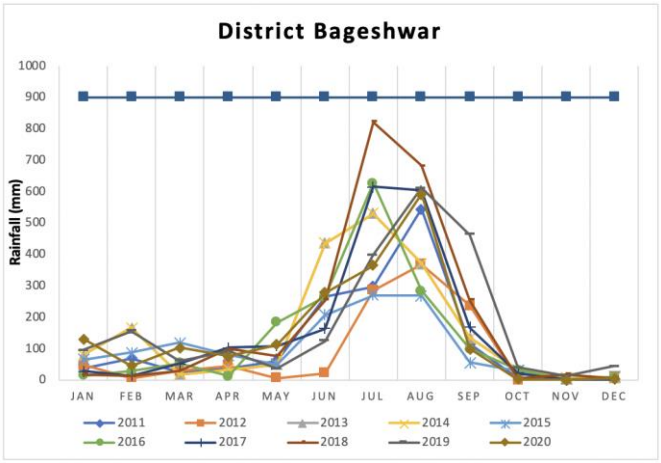

Chart -4: Monthly variations in rainfall in the district of Bageshwar (2011-2020)

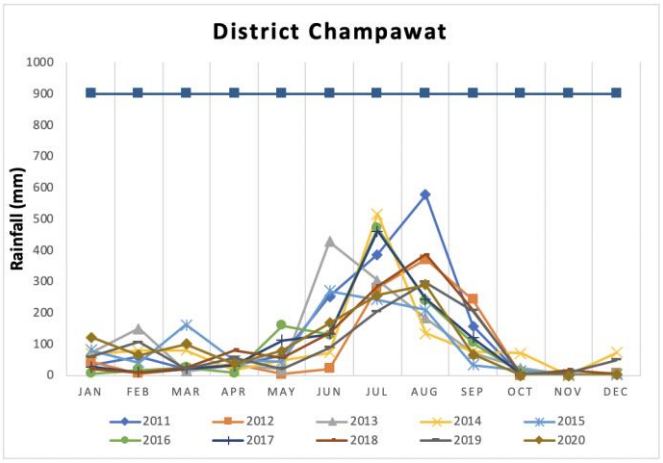

Chart -2: Monthly variations in rainfall in the district of Champawat (2011-2020)

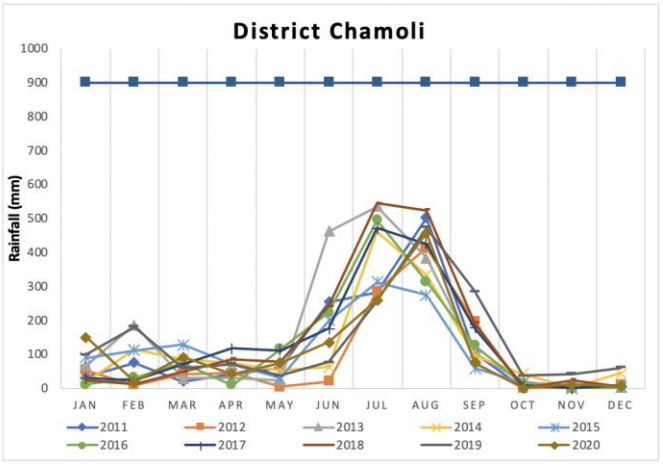

Chart -5: Monthly variations in rainfall in the district of Chamoli (2011-2020)

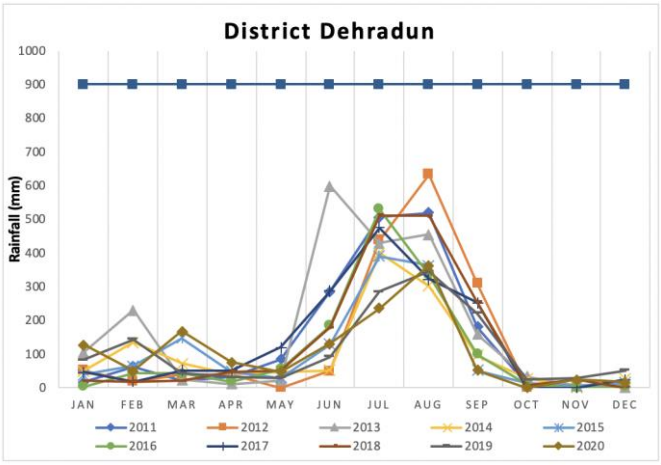

Chart -3: Monthly variations in rainfall in the district of Dehradun (2011-2020)

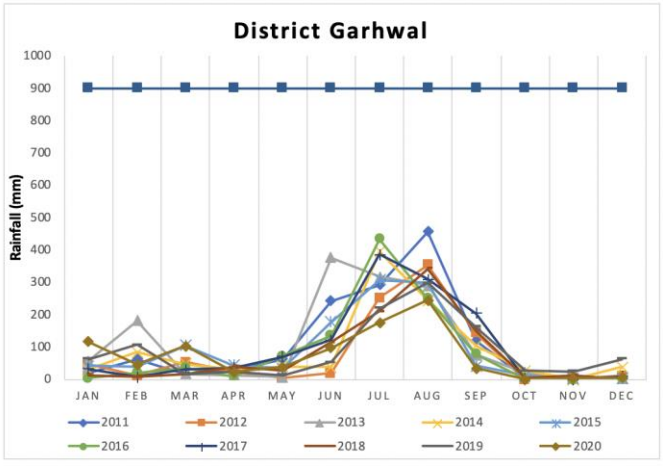

Chart -6: Monthly variations in rainfall in the district of Garhwal (2011-2020)

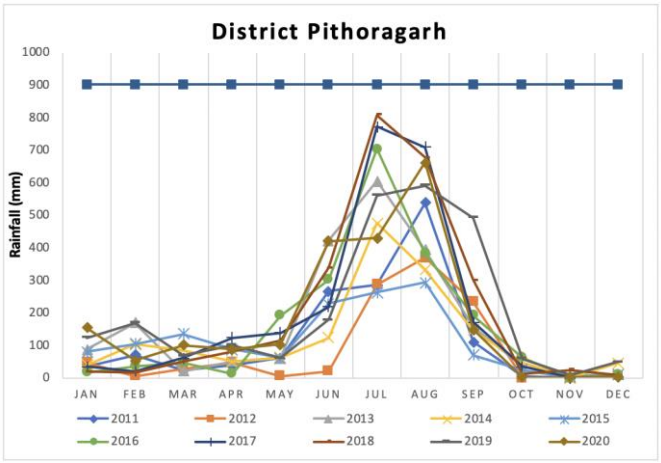

Chart -7: Monthly variations in rainfall in the district of Pithoragarh (2011-2020)

The maximum annual rainfall recorded in Almora was 1499.55 mm in 2011, Bageshwar 2263.35 mm in 2018, Champawat 1228.49 mm in 2014, Chamoli 1858.15 mm, Dehradun 20178.94 mm in 2013, Garhwal 1355.34 mm in 2013, Haridwar 1545.92 mm in 2013, Nainital 1694.08 mm in 2013, Pithoragarh 2455.27 mm in 2019, Rudraprayag 1991.07 mm in 2013, Tehri Garhwal 1539.46 mm in 2013, Udham Singh Nagar 1758.85 mm in 2018 and Uttarakashi 1815.85 mm in 2013. It further indicated that Uttarakhand state received an excessive rainfall in the year 2013, as each district recorded higher values for rainfall. Pithoragarh received the highest rainfall of 2455.27 mm in 2019 and Uttarakashi received the lowest rainfall of 849.61 mm in 2011. While the average rainfall received was recorded at Rudarprayag (1398 mm) in 2020.

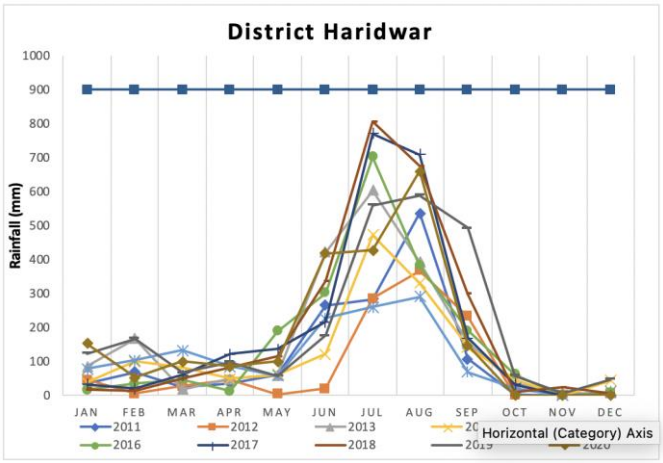

Chart -8: Monthly variations in rainfall in the district of Haridwar (2011-2020)

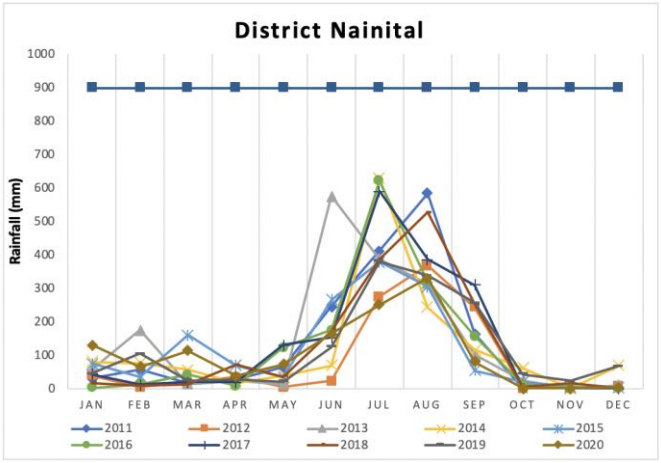

Chart -9: Monthly variations in rainfall in the district of Nainital (2011-2020)

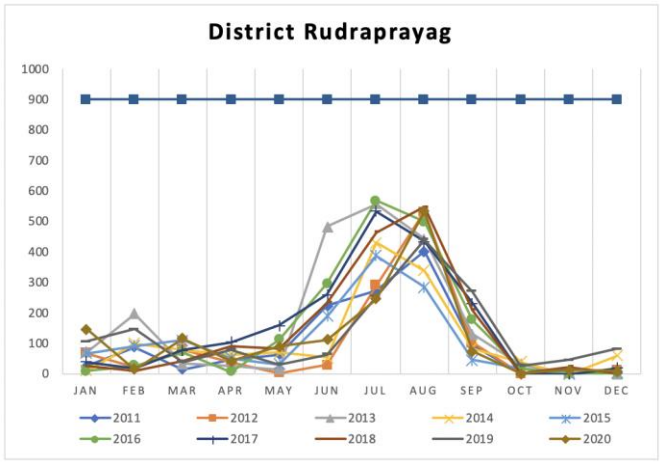

Chart -10: Monthly variations in rainfall in the district of Rudraprayag (2011-2020)

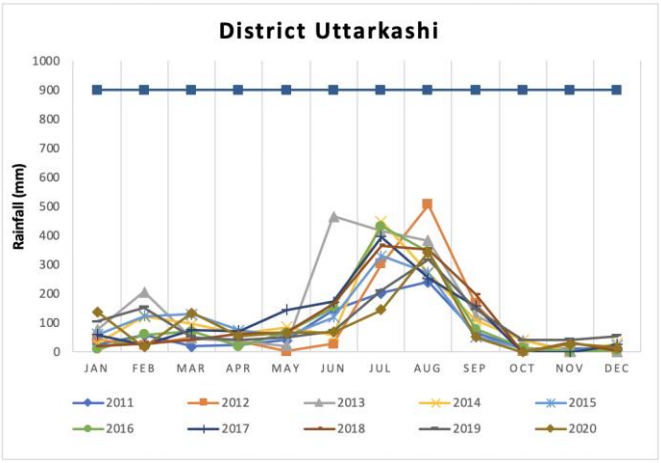

Chart -11: Monthly variations in rainfall in the district of Uttarkashi (2011-2020)

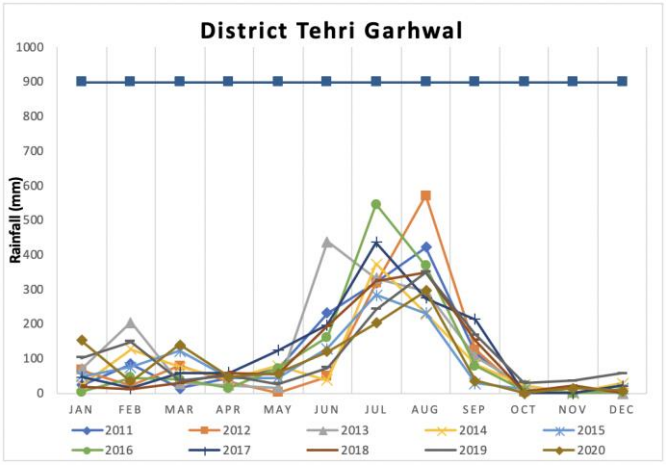

Chart -12: Monthly variations in rainfall in the district of Tehri Garhwal (2011-2020)

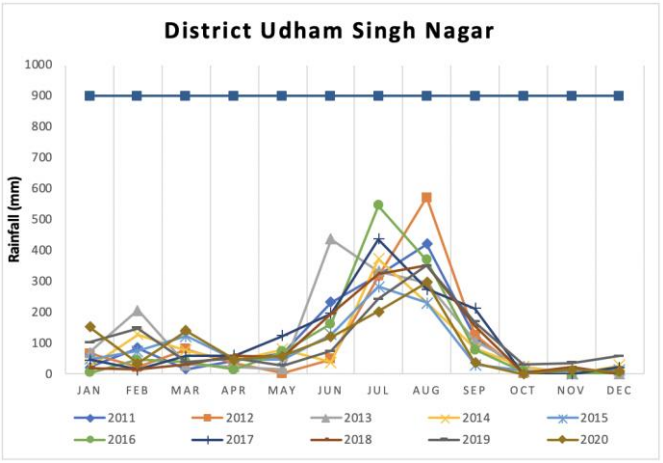

Chart -13: Monthly variations in rainfall in the district of Udham Singh Nagar (2011-2020)

The minimum annual rainfall was recorded at Uttarkashi (849.61 mm) in 2011 while Garhwal is the district that has the lowest rainfall in the state as the table above shows. The study result also shows that the rainfall has decreased in the area since from 2011 to 2020, but the decrease is not linearly. There is a wide variation of the rainfall in the study area depending upon the area and the year.

3.2 Rainfall Variation

The result of the analysis suggests that, annual rainfall of the state has increased but the increase is not linear and decreased in 2020 over the period of study as recorded in Table 1. Similarly, the above (Figure 9) illustrates the trends in the groundwater table of the study area during 2011 to 2020. The result showed that the minimum water table was in 2016 and maximum was in 2018 due to increase in rainfall. The result indicated the good relationship between these parameters as the fluctuation curve indicated which was abiding by the nature of the rainwater of the area. The highest deflection occurred from April to July, and the water table slowly increased until it reached the minimum during August to November it maintained an average level until February.

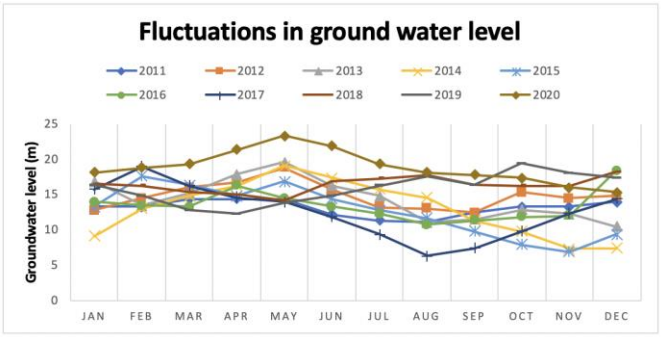

Chart -14: Ground water level fluctuations for the state of Uttarakhand over a period of 10 years (2011-2020)

The water table starts to decreases till the heavy rain will start again in May. However, the overall yearly water table result indicating decline in groundwater level trend is due to unsustainable withdrawal of groundwater for domestic and irrigation purposes as the state used groundwater for water supply, this were played a vital role in water level fluctuation in Uttarakhand, India.

Table -1: Yearly rainfall (mm) of thirteen districts of Uttarakhand, India (2011-2020)

Year	Almora	Bageshwar	Chamoli	Champawat	Dehradun	Garhwal	Haridwar	Nainital	Pithoragarh	Rudarprayag	Tehri Garhwal	US Nagar	Uttarakashi
2011	1499.45	1448.93	1381.99	1579.84	1735.8	1299.7	1317.74	1602.85	1429.24	1240.34	1336.57	1713.22	849.61
2012	1034.66	1044.91	1080.72	1025.61	1594.6	908.92	1039.98	1014.09	1045.76	1176.36	1277.02	973.17	1166.88
2013	1348.57	1849.09	1858.15	1299.49	2078.94	1355.34	1545.92	1694.08	2008.58	1991.07	1539.46	1633.69	1815.85
2014	1189.69	1387.08	1389.79	1228.49	1251.04	1073.06	1144.87	1450.18	1502.95	1330	1124.82	1227.49	1341.71
2015	1083.84	1230.25	1301.63	1141.07	1301.77	1099.51	1079.33	1397.53	1348.89	1285.33	1032.92	1349.53	1251.02
2016	1076.48	1593.34	1420.6	1169.91	1330.98	1038.29	1137.59	1470.21	1951.69	1792.29	1339.85	1433.99	1251.57
2017	1170.29	1866.41	1619.5	1155.77	1651.17	1200.19	1113.3	1661.37	2278.26	1879.16	1443.97	1622.14	1377.22
2018	1001.51	2263.35	1785.56	1224	1649.49	932.29	1404.64	1500.02	2441.29	1735.62	1225.37	1758.85	1334.52
2019	1118.96	2115.42	1685.14	1117.88	1385.3	1062.42	1125.06	1446.81	2455.27	1589.99	1325.14	1488.82	1281.04
2020	1033.11	1790.74	1326.53	1180.44	1292.28	878.41	1161.97	1243.17	2153.47	1398.91	1107.03	1319.16	1055.65

4. Conclusions

The study results illustrate that, the maximum rainfall occurred during June to September, and little rainfall was recorded during January to March. The water table fluctuation was recorded monthly, and analysis showed that, precipitation have an influence in recharge of the water table in Uttarakhand, India. The water table elevated during April to May due to the recharge by the listed parameters and usually declined from June to August. The lowest level of groundwater level fluctuation was found to be from August to September. The result of this study entails that the groundwater level fluctuations in Uttarakhand is dependent solidly on rainfall pattern. The findings of this research can provide some information to the government for water management and for predicting future climatic events.

REFERENCES

[1] N. Adimalla, R. Dhakate, A. Kasarla, and A. K. Taloor, "Appraisal of groundwater quality for drinking and irrigation purposes in Central Telangana, India," Groundw. Sustain.

Dev., vol. 10, no. 126, p. 100334, 2020, doi: 10.1016/j.gsd.2020.100334.

[2] M. R. Khan, C. I. Voss, W. Yu, and H. A. Michael, "Water Resources Management in the Ganges Basin: A Comparison of Three Strategies for Conjunctive Use of Groundwater and Surface Water," Water Resour. Manag., vol. 28, no. 5, pp. 1235–1250, 2014, doi: 10.1007/s11269-014- 0537-y.

[3] A. Gulati, B. Sharma, P. Banerjee, and G. Mohan, "Nabard Research Study-6," 2019.

[4]. Julie Trottier and Paul Slack, "Managing Water Resources, Past and Present," 2004.

[5] T. Anamika Shalini, "Groundwater Level and Rainfall Variability Trend Analysis using GIS in parts of Jharkhand state (India) for Sustainable Management of Water Resources," Int. Res. J. Environ. Sci. Int. Sci. Congr. Assoc., vol. 1, no. 4, pp. 24–31, 2012, [Online]. Available:

[6] V. Dhawan, "Water and Agriculture in India: Background paper for the South Asia expert panel during the Global Forum for Food and Agriculture - (GFFA) 2017," OAV - Ger. Asia- Pacific Bus. Assoc., pp. 1–25, 2017, [Online]. Available: https://www.oav.de/fileadmin/user_upload/ 5_Publikationen/5_Studien/170118_Study_W ater_Agriculture_India.pdf.

[7] J. C. Maréchal, B. Dewandel, S. Ahmed, L. Galeazzi, and F. K. Zaidi, "Combined estimation of specific yield and natural recharge in a semi- arid groundwater basin with irrigated agriculture," J. Hydrol., vol. 329, no. 1–2, pp. 281–293, 2006, doi: 10.1016/j.jhydrol.2006.02.022.

[8] D. C. Singhal, M. Israil, V. K. Sharma, and B. Kumar, "Evaluation of groundwater resource and estimation of its potential in Pathri Rao watershed, district Haridwar (Uttarakhand)," Curr. Sci., vol. 98, no. 2, pp. 162–170, 2010.

[9] K. Division et al., "Geographic Location :," no. 1, pp. 1–4, 2000.

[10] R. Males, R. Females, U. Males, and U. Females, "Uttarakhand Profile Uttarakhand Profile," Literacy, vol. 2011, pp. 1–2, 2011.

[11] C. Of, "CLIMATE OF UTTARAKHAND," India Meteorological Department, Pune, Page no. 21.

BIOGRAPHIES

Ravi Kant Bhardwaj, College of Technology, GBPUA&T, Pantnagar, India

Shivangi Sharma, School of Agro & Rural Technology IIT Guwahati, India