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SYSTEMATIC APPROACH TO PROVIDE COMPREHENSIVE SOLUTION FOR GROUNDWATER MANAGEMENT IN INDIA

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Abstract: *India's groundwater is a valuable resource. However, the amount of exploitation of an increasing number of aquifers is becoming unsustainable. If current trends continue, in 20 years about 60% of all India's aquifers will be in a critical condition says a World Bank report, Deep Wells and Prudence. The efficiency of agriculture, long-term food security, livelihoods, and economic growth will all be seriously impacted by this. The majority of the world's groundwater is used in India. Over a fifth of the world's groundwater is used annually, or 230 cubic kilometers, according to estimates. Groundwater is used to supply 85% of drinking water and more than 60% of irrigated agriculture.*

India was chosen as the study area because the management of water resources in this basin has a significant impact on the production of agriculture, energy, and drinking water. Groundwater level, temperature, and gridded monthly rainfall data were all examined for India in the year 2021.

In this study, we describe a concept for a groundwater monitoring system that is predicated on a set of circumstances. A set of well-liked data-driven models will be used by the suggested system to deliver solutions included in this is Random Forest (RF). This paper will discuss the future groundwater level in India and will discuss the feasibility and competence of this model. This system will employ the models to produce a simplified prediction of groundwater level.

Index Terms - groundwater, agriculture, aquifers, feasibility, Random Forest

I. INTRODUCTION

In India's rural areas, groundwater has become the main democratic water source and means of reducing poverty. It is the most preferred source of water in India to fulfill the requirements of diverse user sectors because to its almost universal availability, dependability, and low capital cost. India's economy has grown significantly, and ground water has been a key factor in the country's socio economic development.

Due to heavy use and extraction over the past 20 years, the water level has been fast declining in some regions of the nation. The country of India has a rapidly growing population and changing lifestyles, which have enhanced domestic water demand. The need for water in the sector also rises. We need a monitoring system to ensure the areas that would be impacted by future water scarcity in order to protect the water for the future. A typical task for accomplishing this objective, particularly in rural areas, is accurate and dependable groundwater level prediction.

This project mainly relies on the idea of machine learning. It is all about the field of study that gives computer the capability to learn without being programmed explicitly. The process will be identified using the data-driven model without being sure of the correct input and output. We will move on to the following step after verifying all the information about groundwater, such as rainfall amounts, climatic conditions, water level, and so forth. Random Forest is a type of data-driven model (RF). This is a well-known machine learning method and data driven model. The process will start and continue based on the past groundwater data.

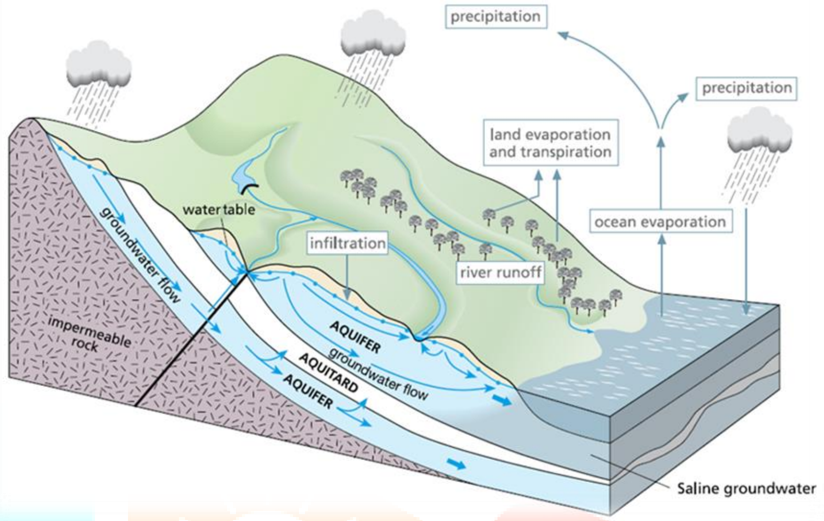

Figure 1: The function of groundwater in the wider hydrological system.

An aquitard, a semi-permeable layer, and an impervious rock layer are shown above a shallow aquifer in Figure 1 and a deeper aquifer, respectively. In order to maintain aquatic ecosystems, groundwater is essential. It offers a consistent outflow to wetlands, rivers, and streams that supports flows during dry weather and droughts. When it's dry, groundwater in some lowland catchments can supply more than 90% of a river's flow. 30% of the river flow may have flowed through rocks as groundwater, even in upland catchments where groundwater storage is confined. (3) (https://portals.iucn.org/)

II. METHOD AND RELATED WORK

2.1 Modeling Techniques

Popular machine-learning algorithm Random Forest is a part of the supervised learning methodology. It can be applied to ML issues involving both classification and regression. It is built on the idea of ensemble learning, which is a method of integrating various classifiers to address difficult issues and enhance model performance. This decision tree ensemble makes use of random feature selection and bootstrapping. This research is a suitable choice for random forest because of how effectively it handles big datasets.

An ensemble technique known as RF classifier trains several decision trees concurrently with bootstrapping, aggregation, and bagging. Bootstrapping describes the parallel training of many individual decision trees on various subsets of the training dataset using various subsets ofthe available characteristics. Bootstrapping m akes ensuring that every decision tree in the random forest is distinct, which lowers the RF classifier's total variance. RF classifier exhibits strong generalisation since it aggregates individual trees decisions into the fi nal determination. In terms of accuracy, RF classifier typically outperforms the majority of other classificati on techniques without experiencing over fitting problems.

2.2 Process

Random Forest Algorithm includes the following steps to accomplish the prediction.

Random Forest Algorithm
To generate *c* classifiers:
for i =1 to c **do**
  Randomly sample the training data D with replacement to produce D_i
  Createa root node, N_i containing D_i
  Call BuildTree(N_i)
end for
BuildTree(N):
if *N* contains instances of only one class **then**
  return
else
  Randomly select x% of the possible splitting features in *N*
  Select the feature *F* with the highest information gain to split on
  Create f child nodes of N ,N_1, ... N_f, where F has f possible values(F_1,....F_f)
 for i =1 to f **do**
  Set the contents of N_i to D_i ,where D_i is all instances in N that match F_i
  Call BuildTree(N_i)
 end for
end if

We can understand the working of Random Forest algorithm with the help of following steps.
Step 1 : First, start with the selection of random samples from a given dataset.
Step 2 :Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree.
Step 3 : In this step, voting will be performed for every predicted result.
Step 4 : At last, select the most voted prediction result as the final prediction result.

2.3 Overview of the Project

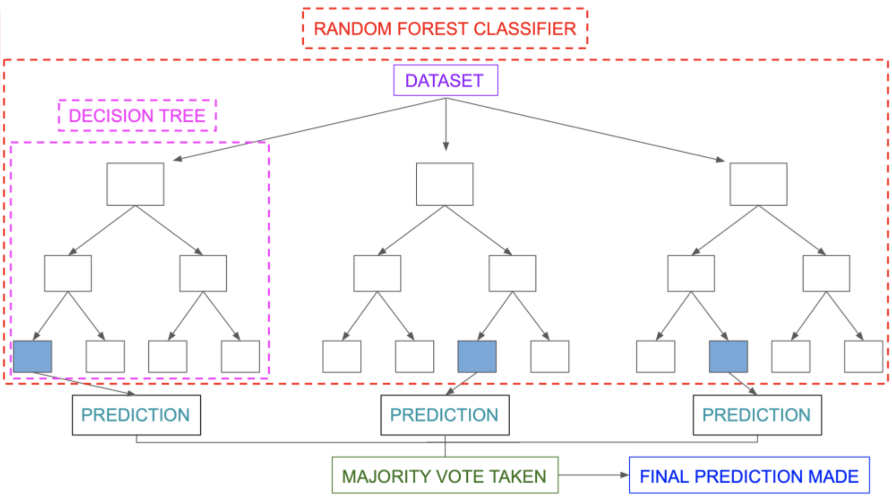

Figure 2:Random Forest Classifiers(https://www.section.io/)

According to Fig. 2, Random Forest is a form of supervised learning algorithm that uses ensemble techniques (bagging) to address classification and regression issues. During training, the algorithm builds a large number of decision trees and outputs the mean/mode of each tree's forecast.

III. STUDY AREA AND DATA

3.1 Study Area

India is the chosen country for study. Fig 3 displays the groundwater levels in India decomposed by region. Due to this, issues with water supply exhaustion for agricultural and environmental uses have become severe predictions of the future developments in groundwater levels are so urgently needed. For irrigation planning in this area, a short term groundwater level forecast is crucial, especially during the dry season when plants consume a lot of water and there isn't enough surface water (4)

The goal of this study was to analyse the characteristics of the drought in India using meteorological and hydrological data. Since the management of water resources in this basin is crucial for irrigation, electricity production, and the provision of drinking water, India was chosen as the research region. The analysis of meteorological drought geographical and temporal variation, evaluation of hydrological drought occurrence, drought prediction, and suggestion of appropriate mitigation measures were the goals of this work.

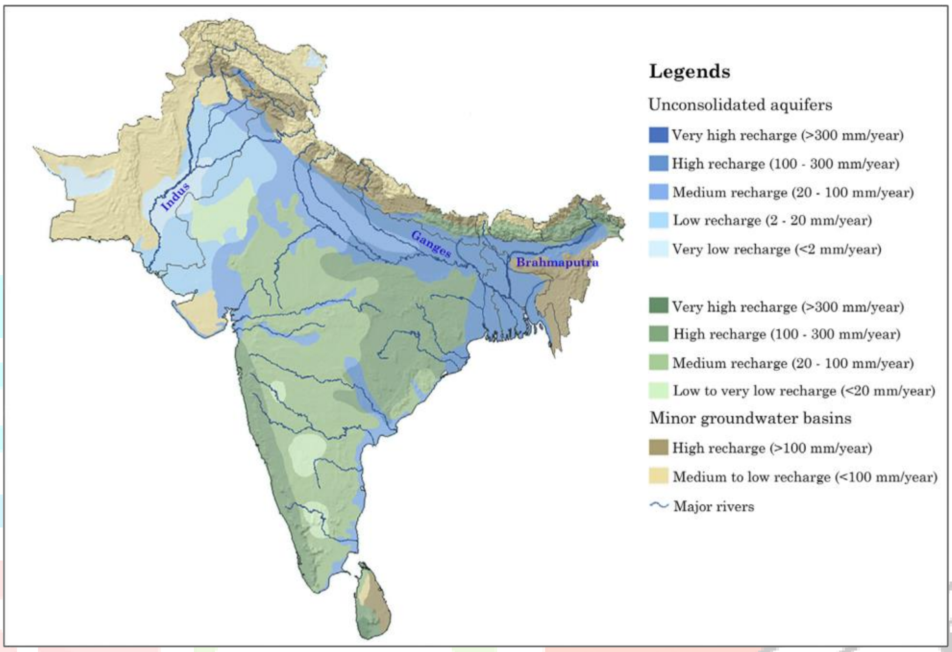

Figure 3: Study area India.(5)

Rainfall and other sources, such as canal seepage return flow from irrigation, seepage from water bodies, and artificial recharge owing to water conservation structures, all contribute to the annual replenishable ground water resource. Rainfall contributes 67% of the nation's annual replenishable groundwater resource, compared to 33% from all other sources combined. In the states of Andhra Pradesh, Delhi, Haryana, Jammu &Kashmir, Jharkhand, Punjab, Tamil Nadu, Uttar Pradesh, Uttaranchal, and UT of Pondicherry, other sources such as canal seepage, return flow from irrigation, seepage from water bodies, etc. contribute more than 33% of the annual replenishable resources.

Since the southwest monsoon contributes the majority of the nation's rainfall, around 73% of the nation's annual replenishable groundwater recharge occurs during the Kharif growing season. The net ground water available for use over the entire nation is 399 bcm after accounting for 34 bcm of natural discharge. There is a 231 bcm annual ground water flow, of which 213 bcm is used for irrigation and 18 bcm is used for domestic and industrial use.

In comparison to the national average of 8%, ground water plan for domestic and industrial purposes is more than 15% in the states of Chhattisgarh, Delhi, Goa, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Kerala, and the north-eastern states of Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, as well as in the union territories of Dadra & Nagar Haveli, Daman & Diu, La Table 1 shows how (https://indiawris.gov.in/) are represented.

Table 1:State-Wise Ground Water Resources Availability, Utilization and Stage of Development, India(https://indiawris.gov.in/)

Sl. No.	States / Union Territories	Annual Replenishable Ground Water Resource					Natural Discharge during non-monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Projected Demand for Domestic and Industrial uses up to	Ground Water Availability for future irrigation	Stage of Ground Water Development (%)
		Monsoon Season		Non-monsoon Season		Total								
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources				Irrigation	Domestic and industrial uses	Total			
	States													
1	Andhra Pradesh	16.04	8.93	4.20	7.33	36.50	3.55	32.95	13.88	1.02	14.90	2.67	17.65	45
2	Arunachal Pradesh	1.57	0.00009	0.98	0.0002	2.56	0.26	2.30	0.0008	0	0.0008	0.009	2.29	0.04
3	Assam	23.65	1.99	1.05	0.54	27.23	2.34	24.89	4.85	0.59	5.44	0.98	19.06	22
4	Bihar	19.45	3.96	3.42	2.36	29.19	1.77	27.42	9.39	1.37	10.77	2.14	16.01	39
5	Chhattisgarh	12.07	0.43	1.30	1.13	14.93	1.25	13.68	2.31	0.48	2.80	0.70	10.67	20
6	Delhi	0.13	0.06	0.02	0.09	0.30	0.02	0.28	0.20	0.28	0.48	0.57	0.00	170
7	Goa	0.22	0.01	0.01	0.04	0.29	0.02	0.27	0.04	0.03	0.07	0.04	0.19	27
8	Gujarat	10.59	2.08	0.00	3.15	15.81	0.79	15.02	10.49	0.99	11.49	1.48	3.05	76
9	Haryana	3.52	2.15	0.92	2.72	9.31	0.68	8.63	9.10	0.35	9.45	0.60	-1.07	109
10	Himachal Pradesh	0.33	0.01	0.08	0.02	0.43	0.04	0.39	0.09	0.03	0.12	0.04	0.25	30
11	Jammu & Kashmir	0.61	0.77	1.00	0.32	2.70	0.27	2.43	0.10	0.24	0.33	0.42	1.92	14
12	Jharkhand	4.26	0.14	1.00	0.18	5.58	0.33	5.25	0.70	0.38	1.06	0.56	3.99	20
13	Karnataka	8.17	4.01	1.50	2.25	15.93	0.63	15.30	9.75	0.97	10.71	1.41	6.48	70
14	Kerala	3.79	0.01	1.93	1.11	6.84	0.61	6.23	1.82	1.10	2.92	1.40	3.07	47
15	Madhya Pradesh	30.59	0.96	0.05	5.59	37.19	1.86	35.33	16.08	1.04	17.12	1.74	17.51	48
16	Maharashtra	20.15	2.51	1.94	8.36	32.96	1.75	31.21	14.24	0.85	15.09	1.51	15.10	48
17	Manipur	0.20	0.005	0.16	0.01	0.38	0.04	0.34	0.002	0.0005	0.002	0.02	0.31	0.65
18	Meghalaya	0.79	0.03	0.33	0.005	1.15	0.12	1.04	0.00	0.002	0.002	0.10	0.94	0.18
19	Mizoram	0.03	0.00	0.02	0.00	0.04	0.004	0.04	0.00	0.0004	0.0004	0.0008	0.04	0.90
20	Nagaland	0.28	0.00	0.08	0.00	0.36	0.04	0.32	0.00	0.009	0.009	0.03	0.30	3
21	Orissa	12.81	3.56	3.58	3.14	23.09	2.08	21.01	3.01	0.84	3.85	1.22	16.78	18
22	Punjab	5.98	10.91	1.36	5.54	23.78	2.33	21.44	30.34	0.83	31.16	1.00	-9.89	145
23	Rajasthan	8.76	0.62	0.26	1.92	11.56	1.18	10.38	11.60	1.39	12.99	2.72	-3.94	125
24	Sikkim	-	-	-	-	0.08	0.00	0.08	0.00	0.01	0.01	0.02	0.05	16
25	Tamil Nadu	4.91	11.96	4.53	1.67	23.07	2.31	20.76	16.77	0.88	17.65	0.91	3.08	85
26	Tripura	1.10	0.00	0.92	0.17	2.19	0.22	1.97	0.08	0.09	0.17	0.20	1.69	9
27	Uttar Pradesh	38.63	11.95	5.64	20.14	76.35	6.17	70.18	45.36	3.42	48.78	5.30	19.52	70
28	Uttaranchal	1.37	0.27	0.12	0.51	2.27	0.17	2.10	1.34	0.05	1.39	0.06	0.68	66
29	West Bengal	17.87	2.19	5.44	4.86	30.36	2.90	27.46	10.83	0.81	11.65	1.24	15.33	42
	Total States	**247.87**	**69.51**	**41.84**	**73.15**	**432.43**	**33.73**	**398.70**	**212.37**	**18.05**	**230.41**	**29.09**	**161.06**	**58**
	Union Territories													
1	Andaman & Nicobar	-	-	-	-	0.330	0.005	0.320	0.000	0.010	0.010	0.008	0.303	4
2	Chandigarh	0.016	0.001	0.005	0.001	0.023	0.002	0.020	0.000	0.000	0.000	0.000	0.020	0
3	Dadra & Nagar Haveli	0.059	0.005			0.063	0.003	0.060	0.001	0.008	0.009	0.008	0.051	14
4	Daman & Diu	0.006	0.002	0.000	0.001	0.009	0.0004	0.008	0.007	0.002	0.009	0.003	-0.002	107
5	Lakshadweep	-	-	-	-	0.012	0.009	0.004	0.000	0.002	0.002	-	-	63
6	Pondicherry	0.057	0.067	0.007	0.029	0.160	0.016	0.144	0.121	0.030	0.151	0.031	-0.008	105
	Total Union Territories	**0.138**	**0.075**	**0.012**	**0.031**	**0.597**	**0.036**	**0.556**	**0.129**	**0.052**	**0.181**	**0.050**	**0.365**	**33**
	Grand Total	**248.01**	**69.59**	**41.85**	**73.18**	**433.02**	**33.77**	**399.25**	**212.50**	**18.10**	**230.59**	**29.14**	**161.43**	**58**

3.2 Data

According to previous studies, climatic conditions and hydrological variables may have an impact on groundwater level. Examples include surface stream flow and precipitation (temperature, evaporation, etc.). But there weren't many data for these factors accessible in the research area. Additionally, several hydrological variables were given. With the help of those facts, we will carry on with the prediction process. Prior to that, they have to be cleaned and trained on the algorithm.

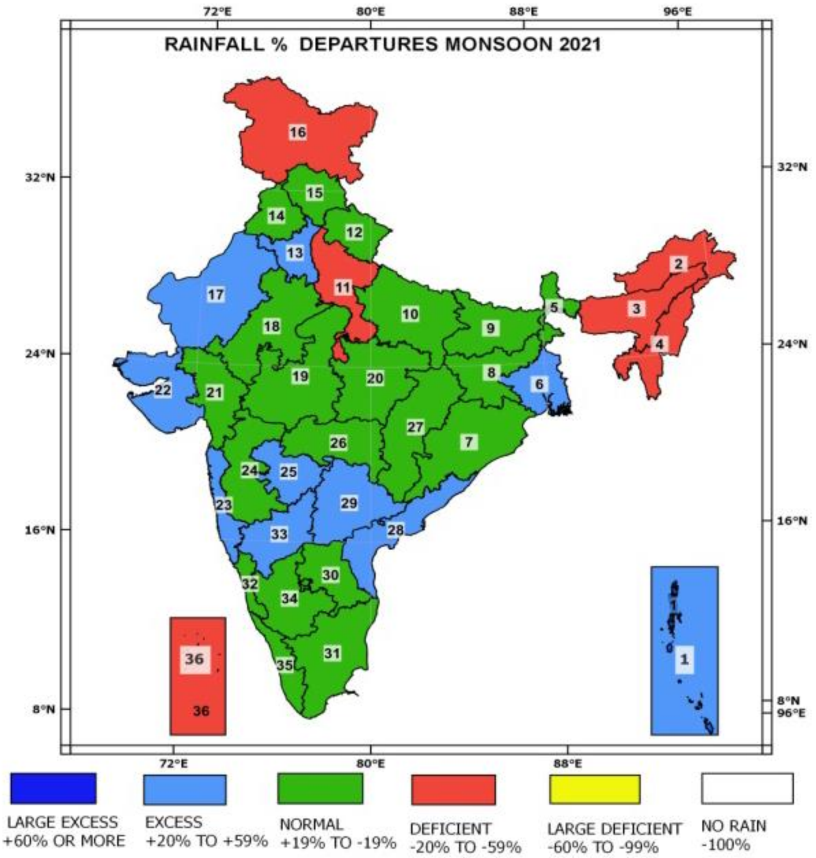

Figure 4: Rainfall over India on 2021

IV. MODEL DEVELOPMENT

4.1 Determining the model's structure

In order to select an appropriate set of inputs for the data-driven models, the input structure for both examined sites was determined using the cross-correlation method. The most popular analytical methodology for selecting appropriate inputs in hydrology may be this approach. Random Forest (RF) were used for the development process because they provide outcomes in a straightforward graphical manner.

Bagging = Bootstrap + Aggregation Bootstrap

Indicates that each RF tree is trained on a subset of the observations rather than the entire set of observation The selected portion is referred to as the bag, and the remainder as Out of Bag samples. The results from var ious trees are pooled once they have all been trained on various bags. The aggregation process aids in lowering variance.

4.2 Model Utilization

The algorithm for the model RF was implemented in Python. Python is a powerful programming language that aids developers in accomplishing goals with less code. A "forest" is created by growing and combining various decision trees using the Random Forest (RF) supervised machine learning technique. RF is a method of group learning that uses bagging. Because this model has the characteristics listed below when modeling the response variable using permutation accuracy, RF determines the significance of the predictor variables.

In order to comprehend the structure of the data, perform clustering, and find outliers, RF can identify the proximity between pairs of data points [13]. Due to the enormous number of trees that are developed, RF has a restricted generalization error (actual population error) and is not overfitted. [14]

V. METEOROLOGICAL INDICES

5.1 Climatic Parameters

Temperature

Beginning in the second week of November, the cold season is marked by a sharp decline in daytime and nighttime temperatures. The typical daily maximum and lowest temperatures range from 21.3°C to 7.3°C in January, the coldest month. When western disturbances sweep across North India in the winter, minimum temperatures can occasionally drop to below the freezing point of water. The temperature begins to increase rather significantly towards the middle of March. These are the hottest months: May and June. June has warmer nights despite May having higher daytime temperatures. From April the hot wind known locally as 'loo' blows and the weather is unpleasant. The highest temperature in May and June occasionally reaches 46 or 47°C. Probability% Annual Rainfall in mm 10% 922 20% 840 30% 778 40% 718 50% 664 With the onset of the monsoon 60% 618 70% 562 80% 520 90% 476 Towards the close of June or the start of July, the area's daytime temperatures significantly decline while the nighttime temperatures stay high. Probability of exceed Normal RF 58% 7. The nighttime temperatures in October are colder than they are during the monsoon season.

Humidity

The majority of the year, the air over Delhi is dry. The monsoon season has significant levels of humidity. The driest months are April and May, with relative humidity levels averaging around 30% in the mornings and less than 20% in the afternoons.

Cloudiness

Particularly in July and August during the monsoon, skies are frequently gloomy and substantially obscured. The remaining months of the year feature clear or sparsely cloudy skies. However, because of western disturbances, the skies turn gloomy throughout the months of January, February, and early March.

Winds

In general, winds are mild in the post-monsoon and winter seasons. Summer and monsoon seasons are when they are at their strongest. With the exception of the monsoon season, winds are typically from the west or northwest and tend to be more brisk in the late afternoon. In the monsoon season, easterly and southeasterly winds are more frequent.

Rain based drought indices

- SPI (Standardized Precipitation Index, McKee et al. 1993, 1995
- DI (Deciles Index), Gibbs and Maher, 1967
- PN (Percent of Normal Index), Willeke et al. (1994)
- CZI (China-Z Index), Wu et al. (2001)
- MCZI (Modified CZI), Wu et al. (2001)
- EDI (Effective drought Index), Byun and Wilhite (1999)
- RAI (Rainfall Anomaly Index), van Rooy (1965)
- ZSI (Z-score Index), Palmer (1965)(https://agrimetsoft.com/)

In general, drought is a complex phenomenon that has affected more people during the last century than any other natural disaster (Below, 2007). A number of techniques have been employed as drought assessment tools, including Drought Indices, stream flow measurements, and water storage reductions. Around the world, drought conditions and severity are frequently measured using drought indices (Keyantash and Dracup, 2002; Salehnia et al., 2017). Planning and managing water resources in a river basin requires research on drought characteristics such as severity, duration, and frequency (Dodangeh, 2017).

VI. RESULTS AND ANALYSIS

In order to evaluate the generalizability of the trained models, these models were used to forecast rainfall, temperature, and groundwater level over a certain period of time. The models' predictions were successfully confirmed and the findings are transparent. In the upcoming years, predictions for several years will be generated using data from the preceding year and a trained model.

6.1 Rainfall

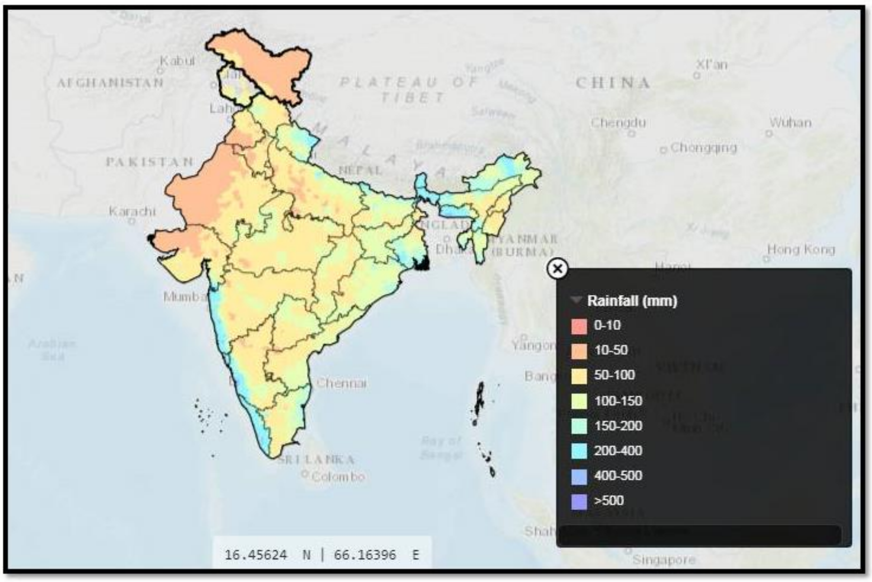

Figure 5: Rainfall map for 2021

The amount of rainfall during the season was above average. The regional distribution of rainfall (mm) for the season is depicted in Fig. 5. Arunachal Pradesh, Jharkhand, Bihar, Gangetic West Bengal, Odisha, Jammu & Kashmir and Ladakh, Uttarakhand, Konkan & Goa, Coastal Karnataka, Kerala, and both islands all saw more than 350 mm of rain in their respective regions. More than 450 mm of rain dropped in parts of Arunachal Pradesh, Assam, Meghalaya, Sub-Himalayan West Bengal, Sikkim, Odisha, Gangetic West Bengal, Jharkhand, Bihar, and Kerala islands**.**. More than 650 mm of rain occurred in parts of Arunachal Pradesh, Assam, Meghalaya, Sub-Himalayan West Bengal, Sikkim, Kerala, and both islands.

The regional distribution of the seasonal rainfall anomaly (mm) is depicted in Fig. 5. Except for the far northeastern region, Jammu & Kashmir, Ladakh, Odisha, Tamil Nadu, Puducherry & Karaikal, and a few pockets, the country's overall rainfall anomaly was positive. Arunachal Pradesh, Gangetic West Bengal, Odisha, Jharkhand, Bihar, East Uttar Pradesh, Uttarakhand, East Madhya Pradesh, Chhattisgarh, the entire west coast, and both islands all saw positive rainfall anomalies of over 100 mm. Over the Gangetic West Bengal, Odisha, Jharkhand, Bihar, East and West Uttar Pradesh, Uttarakhand, Chhattisgarh, entire west coast, and both islands, positive rainfall anomaly of more than 150 mm was seen.. Over regions of Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, Assam & Meghalaya, the magnitude of the negative rainfall anomaly exceeded 150 mm. All of the districts appear to have experienced significant rainfall excess during the time.

The average rainfall for the season was 68% of the LPA. In January, it was 117% of its LPA, while in February, it was 32% of its LPA. The sub-divisions of peninsular India, the western portion of central India, and both islands, in general, experienced considerable amounts of excess or excess rainfall, while the remaining sub-divisions received small amounts of deficient or inadequate rainfall.

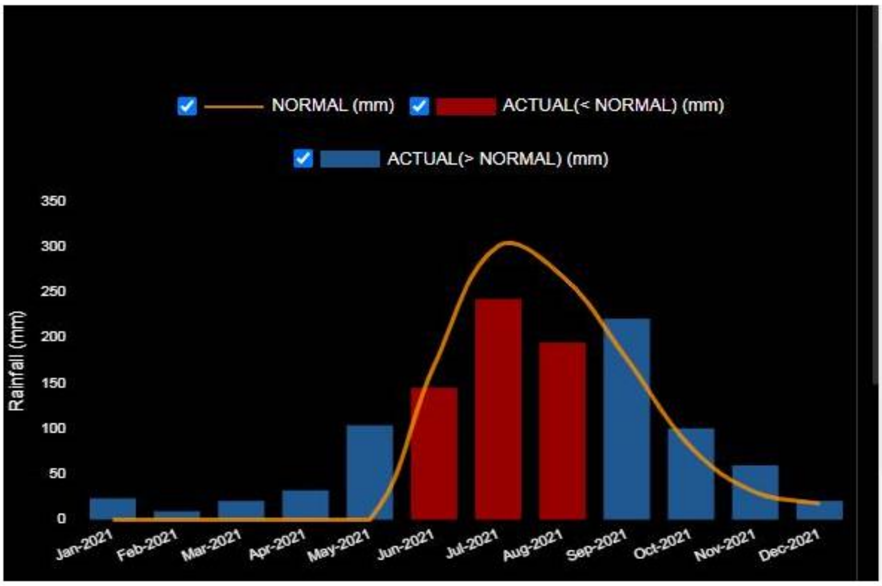

Figure 6: Monthly Rainfall from Jan 2021 to Dec 2021

The distribution of rainfall in India from January through December 2021 is shown in Fig. 6. Each month between January and December 2021, however, received less than equal to 250mm, which is below the average of 50mm (Figure6).The rainfall activity over the country as a whole was above normal (105% of LPA) during the year. Out of 36 meteorological subdivisions, 18 received excess rainfall, 13 received normal rainfall and remaining 5 subdivisions received deficient rainfall. At the end of year, of the four homogeneous regions, South Peninsular India received 129% of its LPA, central India received 110% of its LPA, and Northwest India received 97 % of its LPA while East & Northeast India received 89% of its LPA rainfall.(https://mausam.imd.gov.in/)

6.2 Temperature

India is a vast nation that may be divided into six major subcategories according to the Koppen climate classification. The summer season, the winter season, and the rainy season can all be used to classify the nation's annual temperature. The maximum temperature during the summer on the Indian Subcontinent can reach 44 degrees Celsius. Several states in the country go through hot climate that reach the average temperature of 45 degree Celsius. The amount of rain in the nation varies geographically, and here too, some regions have hot and humid weather while other areas have frigid breezes. However, the average temperature in the country cannot be as high as the summers. Winters are milder and pleasant, with an average temperature of 25 degrees Celsius in several states. Extreme cold weather, with lows below zero, can be found in the northeastern and northern regions of the nation.

India includes a remarkable variety of climates, from tropical to subtropical, and the Himalayas experience an alpine environment. The delightful winter season, which lasts from November to February, may be experienced in South India's Karnataka, Kerala, Tamil Nadu, Telangana, and Andhra Pradesh. Maximum temperatures range from 17 to 20 degrees Celsius. The Western Indian states of Maharashtra, Gujarat, and Haryana also have nice winter weather. Due to their proximity to the Himalayas, the northern Indian states frequently endure significant snowfall and very low temperatures. Even in the eastern states, the cold can be extreme at times. (www.mapsofindia.com)

While the desert region of India has relatively little rainfall, the majority of other portions of India, especially south India, receives substantial rainfall. The rains start in June and persist until September. In this region of the country, the Himalayas experience spring and fall, which are both very nice. Indian summers are really hot. From April to June, they start. During these months, the typical temperature might range from 40 to 45 degrees Celsius. India's average temperature for 2021 was 25.93 degrees Celsius, a little increase from 25.78 degrees Celsius the year before. In that year, the minimum temperature was 20.9 °C. (https://www.statista.com)

Figure 7: Annual temperature year of 2021

Figure 7 displays, correspondingly, the mean seasonal maximum and minimum temperature anomalies.

The country's annual mean temperature was 0.44°C warmer than the 1981–2010 average, making 2021 the fifth-warmest year on record since 1901. It should be noted that 11 of the 15 warmest years occurred during the last 15 years (2007-2021). Additionally, with anomalies of 0.34°C / 0.37°C above average, the most recent decade (2011-2020/2012-2021) was the warmest decade ever recorded. The yearly mean temperature increased by 0.63°C/100 years between 1901 and 2021, with the highest temperature growing by 0.99°C/100 years and the minimum temperature increasing by a comparatively smaller 0.26°C/100 years. (https://mausam.imd.gov.in/)

6.3 Groundwater level

Groundwater is a shared resource used by millions of farmers throughout the nation, and it is still the main supply of drinking water for rural communities. Additionally, it supports business applications. In order to meet the needs for water supply from competing sectors while avoiding overexploitation and the attendant economic and environmental harm, groundwater must be recognized, quantified, and managed. Due to the scarcity of water supplies and the rising demand for these vital resources, this is necessary. In order for the community and stakeholders to monitor and manage groundwater as a common resource, groundwater management with participation is intended to represent a significant advancement in community-based ground water management. (http://cgwb.gov.in/)

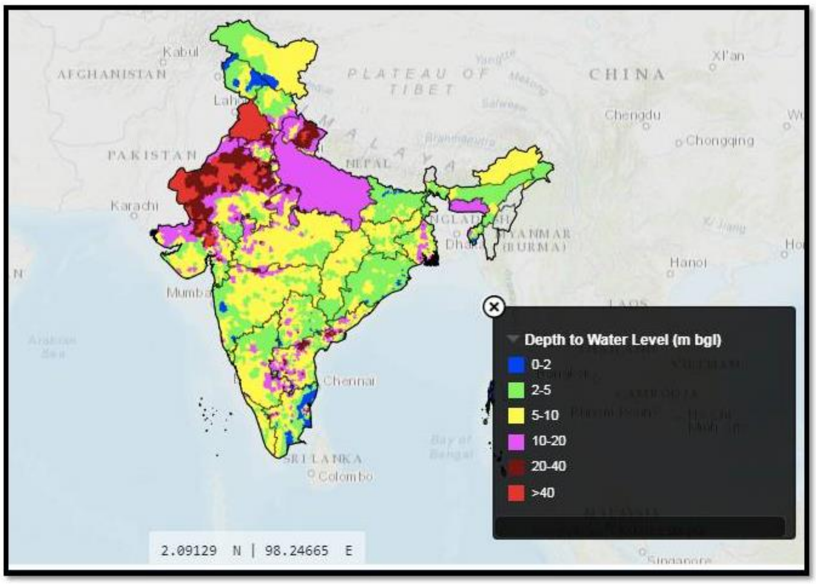

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Figure 8:India's 2021 Groundwater level Map

Although groundwater is a resource that can occasionally be restored, its accessibility varies throughout time and space. Technically defined, "dynamic ground water" refers to the amount of ground water that is regularly replenished and generally accessible in areas with changing water levels.

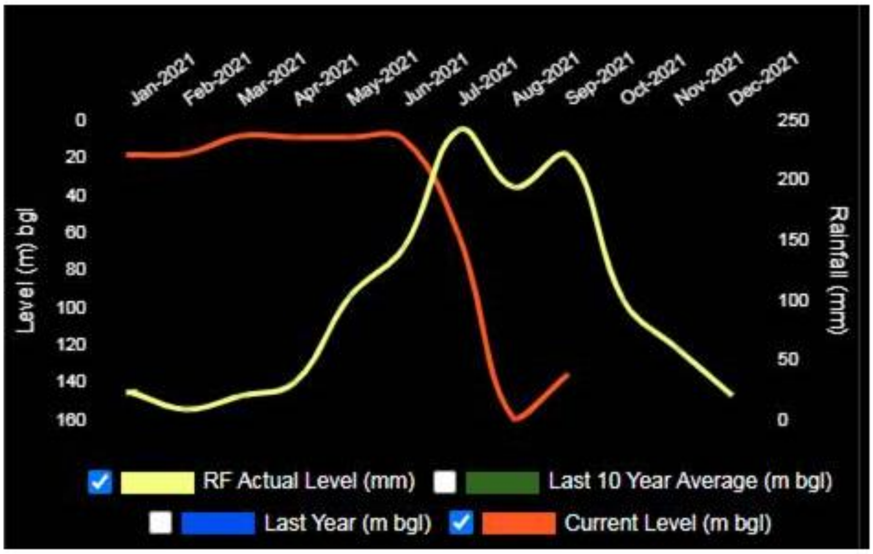

Figure 9: Monthly Groundwater level Jan 2021 to Dec 2021

Figure 9 depicts the observed groundwater level for the subdivision in India from January to December 2021.

VII. CONCLUSION

In environments where conditions are constantly changing, monitoring groundwater levels is an important concern. Whether drought or a decrease in pumpage can be forecast early will depend on how early groundwater researchers can react. Timely data can be made available due to advancements in wireless networking infrastructure. To develop a comprehensive, precise, and implementable solution for the real-time groundwater monitoring issue, all of the system's components must be planned and effectively integrated into one another. The resolution suggested in this report immediately addresses a significant groundwater research topic and serves as a case study for more extensive future environmental monitoring research.

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