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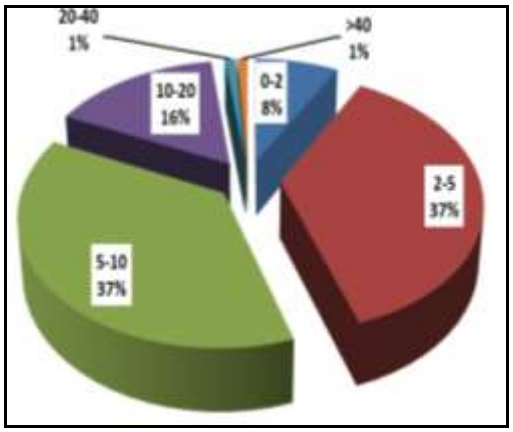
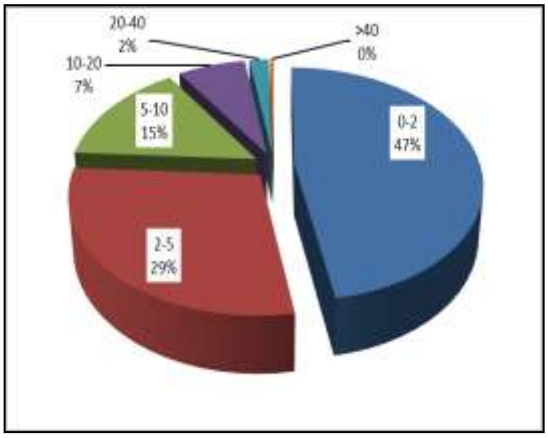
Central Ground Water Board

Ministry of Jal Shakti
Department of Water Resources,
River Development & Ganga Rejuvenation
Govt. of India

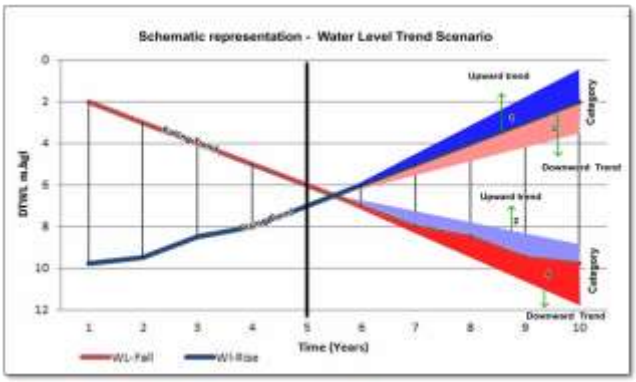
GROUND WATER YEAR BOOK
2019-20
ANDHRA PRADESH



MAY 2019 WATER LEVEL



NOVEMBER 2019 WATER LEVEL



Southern Region, Hyderabad
June, 2020

Central Ground Water Board
Ministry of Jal Shakti
Departmernt of Water Resources,
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GROUND WATER YEAR BOOK
2019-2020
ANDHRA PRADESH STATE

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GROUND WATER YEAR BOOK
2019-20
ANDHRA PRADESH STATE

CONTENTS

Annexure:

Annexure	Title
I.	District-wise Status of Monitoring wells in May 2019
II.	District-wise Status of Monitoring wells in Aug 2019
III.	District-wise Status of Monitoring wells in Nov 2019
IV.	District-wise Status of Monitoring wells in January 2020
V.	Distribution Of Percentage Of Wells –DTWL in May 2019
VI.	Distribution Of Percentage Of Wells –DTWL in August 2019
VII.	Distribution Of Percentage Of Wells –DTWL in November 2019
VIII.	Distribution Of Percentage Of Wells –DTWL in January 2020
IX.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From May 2019 to August 2019).
X.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From May 2019 to November 2019).
XI.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From May, 2019to January 2020).
XII.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From May, 2018 to May, 2019).
XIII.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From August 2018 to August 2019).
XIV.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From November 2018 to November 2019)
XV.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other (From January 2019 to January 2020)
XVI.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other from Decadal mean of May(2009-2018) to May 2019
XVII.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other from Decadal mean of August(2009-2018) to August 2019
XVIII.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other from Decadal mean of November(2009-2018) to November 2019
XIX.	Fluctuation and Frequency Distribution from Different Ranges from One Period to other from Decadal mean (January-2010-2019) to January-2020
XX.	District wise summarized chemical composition of ground water from GWMS during Pre-monsoon season-2019 (May)

FOREWORD

The historical ground water level monitoring data is useful in understanding changes in ground water regime in time and space and for preparation of sustainable development plan for the state. Central Ground Water Board has been monitoring ground water regime since 1969. As on 31-3-2020, a total of 838 operational ground water monitoring wells (GWMS) (DW: 674, Pz: 164) are in operation. These stations are being monitored four times a year viz., May, August, November and January to study the seasonal and long term changes. The water samples are collected during May for chemical analysis.

The ground water level monitoring carried out by Central Ground Water Board, Southern Region, and Hyderabad during 2019-20 is compiled in the form of Ground Water Year Book. It outlines the ground water level behaviour in the current year with reference to the corresponding periods of previous year and also with last decadal mean. It also elaborates the chemical quality of ground water.The water level data of Groundwater and Water Audit Department of Andhra Pradesh state has also been considered to study the water level behavior. It also elaborates the chemical quality of ground water.

The sincere efforts made by **Ms. Caroline Louis Sc-B, Ms. Reshma S.Pillai Sc-B and Ms T.Sabna Sc-B** in preparation of the report are commendable. The effort from officers of chemical laboratory namely Shri Y. Satyakumar and Shri Punith Raj TS who analyzed the samples and contributed ground water quality chapter is note worthy.

It is hoped that the Ground Water Year Book will be quite useful as baseline information for planners, administrators and researchers involved in ground water development and management in the state of Telangana.

Hyderabad **(D Subba Rao)**
Dated: 29.06.2020 **Regional Director**

Executive Summery

Andhra Pradesh State with geographical area of 1.63 lakh sq.km is governed administratively by 13 districts. The total population of the State is 4.96 crores with a decadal growth of 9.2%. It lies between North Latitude 12° 37' and 19° 09' and East Longitude 76° 45'and 84° 47'. The State is mainly drained by Godavari, Krishna, Pennar, Vamsadhara, Nagavalli, Gundlakamma rivers. The major part of the state is underlain by gneissic complex with a structural fill of sedimentary formations and basin-fill of meta-sedimentary formations and meta-sediments. During the year 2019, the state received annual rainfall in the range of 662 mm (Anantapuramu district) to 1336.2 mm (Srikakulam district) with an annual rainfall of 963 mm.

As part of National Ground Water Monitoring Programme, Central Ground Water Board (CGWB) is carrying out ground water regime monitoring four times a year (January, May (pre monsoon), August and November (post monsoon)) and ground water quality monitoring once in the year (May). Ground Water Year Book is prepared by integrating data generated from CGWB and Ground Water Department, Govt. of Andhra Pradesh. As on 31.03.2020 Central Ground Water Board, Southern Region monitors 674 dug wells and 164 piezometers in order to depict the changes in ground water regime of the state in different seasons.

During may 2019, 82 % area of the state is having depth to water level within 10mbgl and 92% area in the state having depth to water level within 10mbgl during post monsoon 2019. During pre monsoon deeper water levels of more than 10 m are noticed in Rayalaseema region and Prakasam districts, where ground water is the main source for irrigation. In the state about 98% of the area experienced rise in seasonal water levels in post monsoon compared to the pre-monsoon period.

Annual water level fluctuation of premonsoon has shown a fall in water levels for 59 % of the area, predominantly in Rayalaseema region. During post-monsoon about 90% area of the state experienced rise in annual water level fluctuation because of the excess rainfall in 2019 monsoon in comaprision with 2018 monsoon. 82% of the area experienced fall of water level in decadal mean water level fluctuation of 2009-2018 with respect to May 2019, whereas 68% of the area experienced rise in decadal mean water level of 2009-2018 with respect to November 2019.

Ground water quality of 593 samples collected during may 2019 were analysed for 14 parameters namely pH, EC (in µS/cm at 25 ° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3, F and TDS. The spatial variation of TDS, Chloride, Fluoride and Nitrate concentration and the suitability of water for drinking purposes is assessed as per BIS guidelines and for irrigation as per USSL and RSC are also discussed.

GROUND WATER YEAR BOOK
(2019-2020)
ANDHRA PRADESH

1. INTRODUCTION

Central Ground Water Board has taken up the task of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity in the state. In order to arrive at proper parametric indices of evaluation and judicious development of ground water resources, the Board is monitoring a National Network of Hydrograph Stations (NHS) on long term basis since 1969 through a network of wells (Dug wells and Piezometers) for studying its long term behaviour due to influence of rainfall and ground water development. A historical database on the ground water levels and water quality has been developed over a period of time since the year 1969.

The monitoring mainly comprises measurement of water levels and temperature, four times in a year viz., in the months of May (pre-monsoon), August (mid-monsoon), November (post-monsoon) and January and collection of water samples during May every year, for chemical analysis. As on 31-03-2019, there were 864 operational Ground Water Monitoring Wells (GWMS) (699 dug wells and 165 piezometers). During the year (2019-20), 34 Ground water monitoring wells (33 Dug wells and one PZ) were abandoned and 7 ground water monitoring wells were established. As on March 2020, the status of monitoring stations is 838 wells, out of which, 674 are Dug wells and 164 Piezometers.

The dug wells tapping unconfined aquifers are mostly confined to village limits, which are used for domestic purpose. Some of these are community wells and the rest belong to private individuals. The piezometers tapping unconfined and confined aquifers constructed under various projects and exploration programs by the department are monitored manually four times a year. The location of network of monitoring wells is presented in the **Fig.1.1.**

1.1 Location and Extent

Andhra Pradesh State is the 7th largest state in India covering geographical area of 1,63,000 Km^2. It lies between NL 12° 37’ and 19° 09’ and EL 76° 45’ and 84° 47’. The State is bordered on the east by Bay of Bengal (~970 km), south by Tamilnadu and Karnataka, west by Karnataka and Telangana and north by Telangana, Chattisgarh and Orissa states.

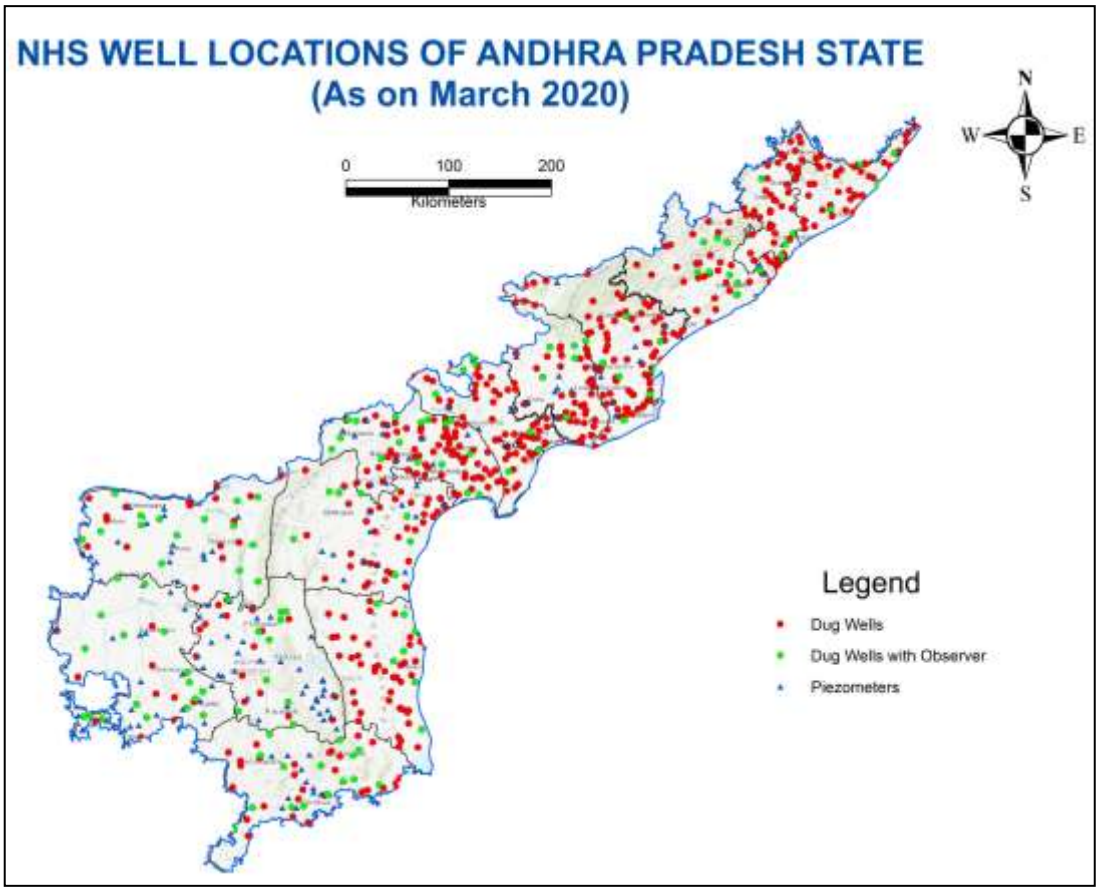


Fig.1.1: Location of GWMS in Andhra Pradesh State (as on 31st March, 2020)

Administratively, the State is divided into 13 districts (Srikakulam, Vizianagaram, Vishakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam, SPS Nellore, YSR Kadapa, Kurnool, Anantapur and Chittoor) and governed by 670 revenue mandals (mandals) with 17398 revenue villages. Total population of the state (2011 census) is ~4.96 Crores (with male-female ratio of 997) of which 90 % lives in rural area and 10% in urban area. The density of population varies from188 persons/km^2 in YSR Kadapa to 518 persons/km^2 in Krishna district (average density: 304 persons/km^2). The overall growth in total population during decade is ~9.2 % (2001 to 2011 census) (**DES, Govt of Andhra Pradesh, 2015**). The present ground water year book (2018–19) depicts the ground water **l**evel scenario in the State and describes the behaviour of water levels during the period. The piezometric data of Ground Water Department, Govt of A.P. is also integrated in order to have realistic water level scenario.

2. PHYSIOGRAPHY, DRAINAGE AND SOIL

2.1 Physiography

Physiographically, Andhra Pradesh State can be divided into three distinct zones, viz., Coastal plains, Eastern Ghats and Western pediplains. The first two zones stretch from north-east to south-west in a narrow strip while 3rd zone occupy rest of the area. The elevation ranges from 0 to > 600 m above mean sea level (a.msl) (**Fig.2.1**).

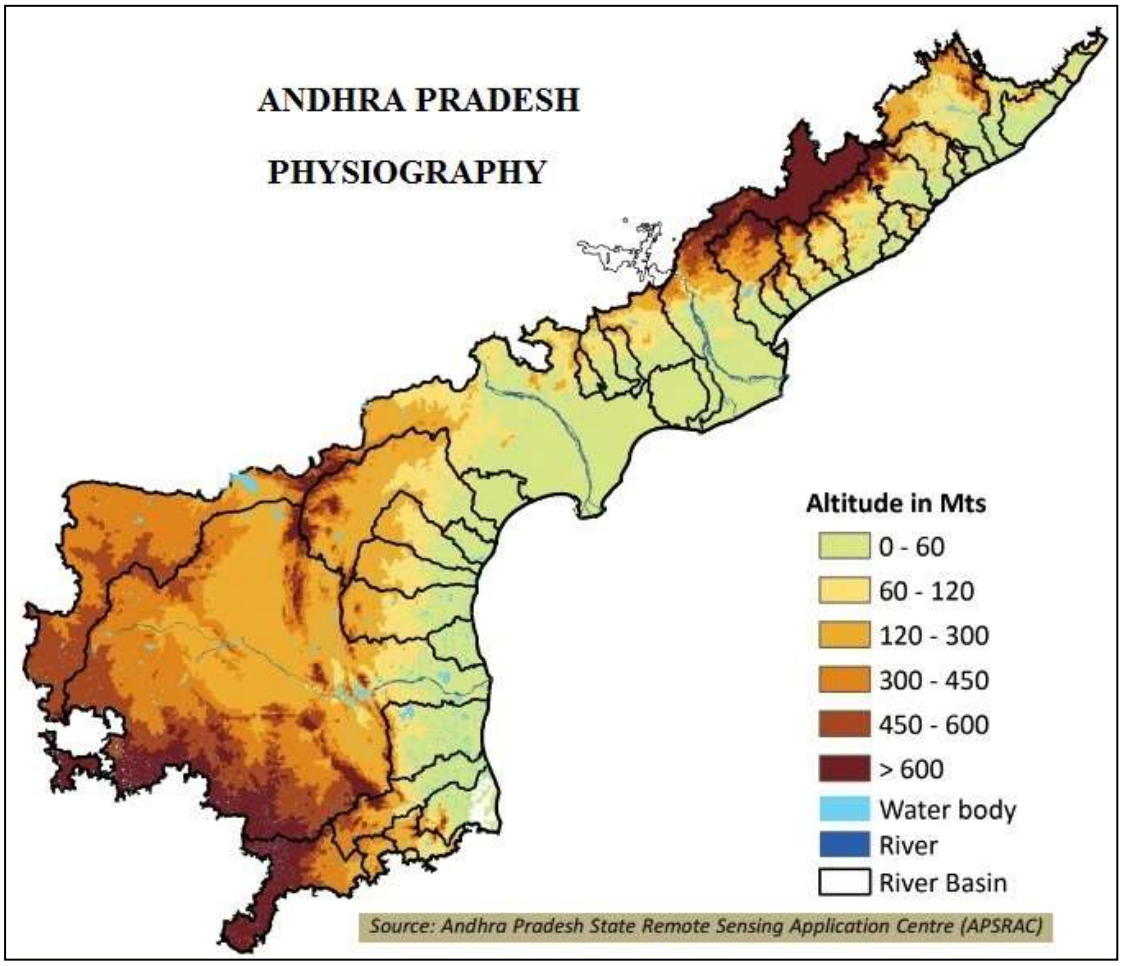


Fig.2.1: Physiography map of Andhra Pradesh (after APRAC-2014)

2.1.1 Coastal Plains

The coastal plains stretch from Kalingapatnam (Srikakulam district) in north to Pulicat (Nellore district) in south along a narrow strip, which broadens in the middle along Godavari-Krishna deltas (up to 80 km^2). The altitude of coastal plains ranges from sea level at the coast to 150-200 m amsl on the west. The area has rich agricultural land owing to two deltas.

2.1.2 Eastern Ghats

The Eastern Ghats follow the Coastal Plains stretching closely from one end to other end except in area between the Godavari and Krishna rivers. The hill ranges trend in NE - SW direction in the north and in N-S direction in the south and attain an elevation of 600 to 1200 m amsl. The Nallamala, Erramala, Seshachalam, Velikonda and Palakonda hills falling in Rayalaseema region, cover southern section of Ghats**.**

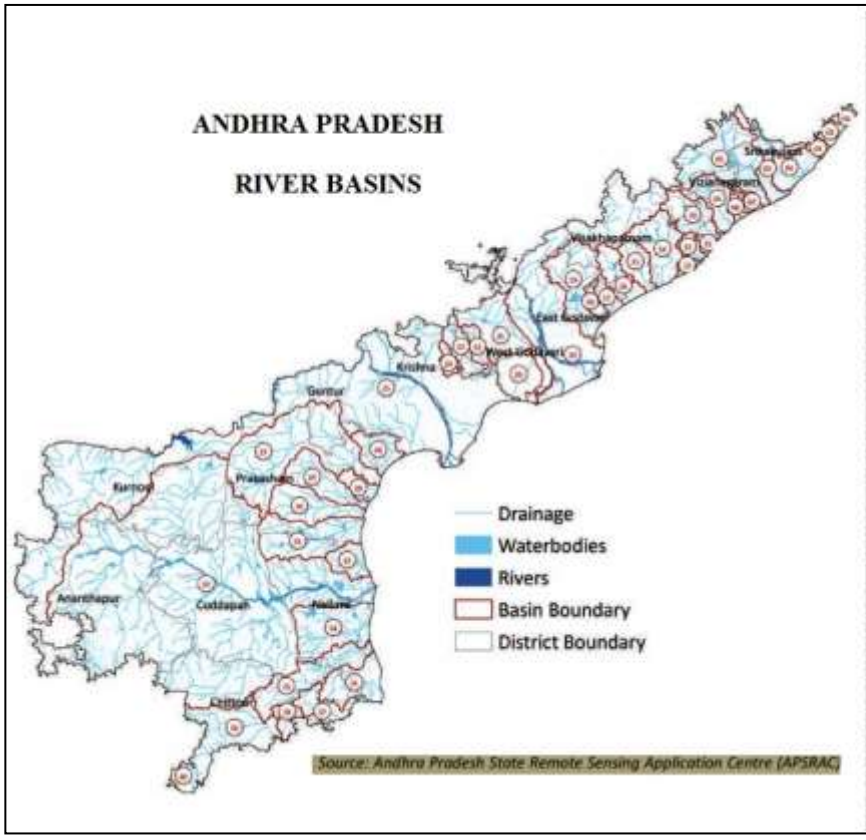
2.1.3 Western Pediplains

A major part of State covering parts of Rayalaseema region (Kurnool and Anantapur districts), fall in this category. The pediplains show rolling topography with flat to undulating tracts. This plateau in the interior of the State extends largely between elevations of 150 to 600 m amsl except at places where the elevation ranges from 600 to 900 m amsl.

2.2 Drainage

Godavari and Krishna rivers and their tributaries drain the northern and central part and Pennar river drains in southern part of state before joining Bay of Bengal (**Fig. 2.2**). There are 3 major basins and 11 medium river basins in the state. The major river basins are Godavari, Krishna and Pennar and medium basins are Vamsadhara, Nagavali, Sarada, Yeleru, Gundlakamma, Paleru (A), Manneru, Uppateru, Swarnamukhi, Palar and minor drainages between Musi and Gundlakamma river. The drainage pattern is generally dendritic with wide valleys in western peniplain. The drainage in Eastern Ghat is coarse and dendritic with steep and narrow valleys. Youthful streams and valleys mark the eastern coastal tract intersected by innumerable feeder and distributary canal system. The mature river courses of Godavari, Krishna and Pennar meanders through the vast areas and are covered by deltas as well as coastal plains. The deltas of rivers are very extensive and characterized by considerable thickness of alluvial material.

Most of the smaller streams feed innumerable tanks. River Penna flows across the southern part of the state with its tributaries Chitravati, Papaghni, Kundu, Sagileru and Cheyyeru and drains major part of Rayalaseema region and Nellore district of coastal region. The drainage basins are characterized by undulating topography comprising a series of ridges and valleys intersperse by hill ranges. Vamsadhara and Nagavalli rivers with their distributaries drain the northeastern part of the state in Srikakulam district. Visakhapatnam district is mostly drained by local rivulets like Sarada. River Yeleru drains most of the East Godavari district while Yerrakalava, Tammileru drain West Godavari district. Nellore district is drained by Pennar, Swarnamukhi and Araniar rivers.



Basin Code	Name of River Basin
01	Bahuda
02	Mahendratanya
03	Pundiminor Basin
04	Noupada Minor Drainages
05	Vamsadara
06	Nagavali
07	Peddagedda
08	Kandivalasagedda
09	Champavathi
10	Gosthani
11	Mathurvada
12	Narvagedda
13	Anakapalli
14	Sarada
15	Varaha
16	Thandava
17	Pampa
18	Suddagedda
19	Yeleru
20	Godavari Basin
21	Yerrakalva
22	Tammileru
23	Ramileru
24	Budameru
25	Krishna Basin
26	Romperu
27	Gundlakamma
28	Minor Drainages between Musi & Gundlakamma
29	Musi (A) - K11
30	Paleru (A)
31	Manneru
32	Kandaleru
33	Pennar Basin
34	Upputeru
35	Swarnamukhi
36	Kalangi Basin
37	Araniar Basin
38	Kushustali
39	Palar
40	Ponnair

Fig.2.2: Drainage and River sub-basin map of Andhra Pradesh State. (After APRAC-2014)

2.3 Soils

The State has a wide variety of soils viz., Red soil, Laterite, Black Cotton soil, Deltaic Alluvium soil, Coastal soil and Saline soil. Red clayey soils occur predominantly in Srikakulam, Visakhapatnam, East Godavari and West Godavari districts in coastal region. Black cotton soil commonly occurs in Krishna and Guntur districts. Red earths with loamy sub-soil and red sandy loamy soil occur in Prakasam and Nellore districts and Laterite soils in Nellore and Prakasam districts. Black cotton soil occurs in part of Kadapa, Kurnool and Anantapur district and red loamy soils occur in parts of Chittoor and Kadapa districts. Red earths are predominant in Anantapur district. Soil map of AP is given in **Fig. 2.3.**

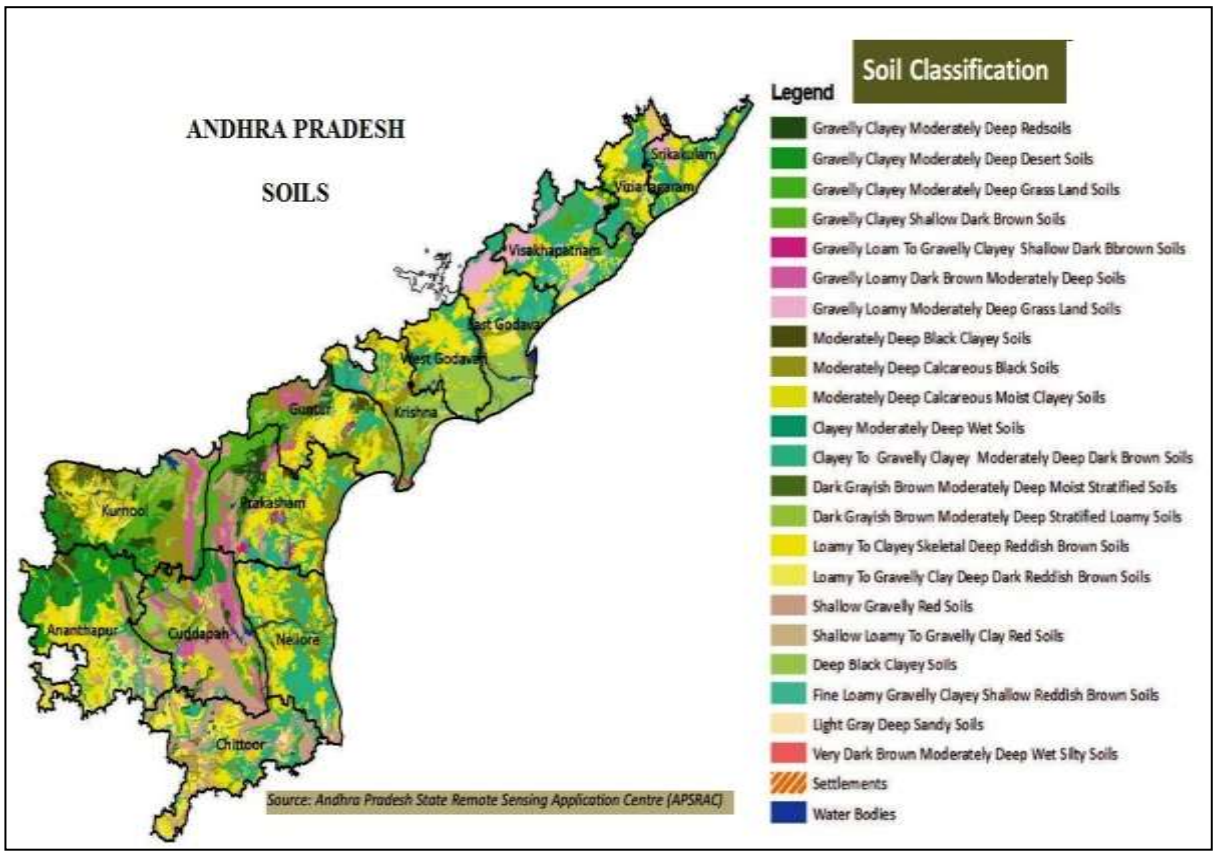


Fig.2.3: Soil Map of Andhra Pradesh (after APSRAC-2014)

3. HYDROMETEOROLOGY

3.1 Climate

The climate of the state is tropical in nature and is influenced by the topographical variations and maritime influence. The Deccan Plateau has more of a temperate climate than the coastal belt. The Eastern Ghats in Vishakhapatnam and its neighborhood play a significant role, which acts as a barrier to easterly winds in association with depression from Bay of Bengal during the southwestern monsoon. The Agro-climatic classification (Agricultural Department) of the state is given below.

Region	Classification
Rayalaseema	Scarce rainfall zone
Plateau	Southern zone
	Krishna – Godavari Zone
Coastal	North Coastal zone
Andhra Pradesh	South Coastal zone
	High Altitude
	Tribal Zone
	Scarce Rainfall Zone

3.2 Rainfall Analysis – 2019

District-wise monthly, seasonal, annual and normal rainfall and departure from normal is given in the **Table-3.1**. The district-wise departure from normal is depicted in **Fig. 3.1**. The salient features of rainfall analysis are given below:The normal annual rainfall of the state is 950 mm. Season-wise normal rainfall is 555 mm, 285 mm, 15 mm and 95 mm in southwest monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 58% of annual in southwest monsoon, 30% of annual rainfall in northeast monsoon and 12% in non-monsoon season. Annual normal rainfall ranges from 573 mm in Anantapur district to 1165 mm in Srikakulam district.

The mean annual rainfall in the year 2019 of the state is 963 mm. Season-wise rainfall is 618 mm, 276 mm, 12 mm and 57 mm in southwest monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively contributing 64% of annual rainfall in southwest monsoon, 29% of annual rainfall in northeast monsoon and 7 % in non-monsoon season. The annual (2019) rainfall ranges from 662 mm in Anantapar district

(16 % above normal) to 1336.2 mm (15 % above normal) in Srikakulam district. Annual rainfall was 1 % above the normal in 2019 in the sate. Monthly mean rainfall ranges from 1.3 mm in February to 241 mm in September.

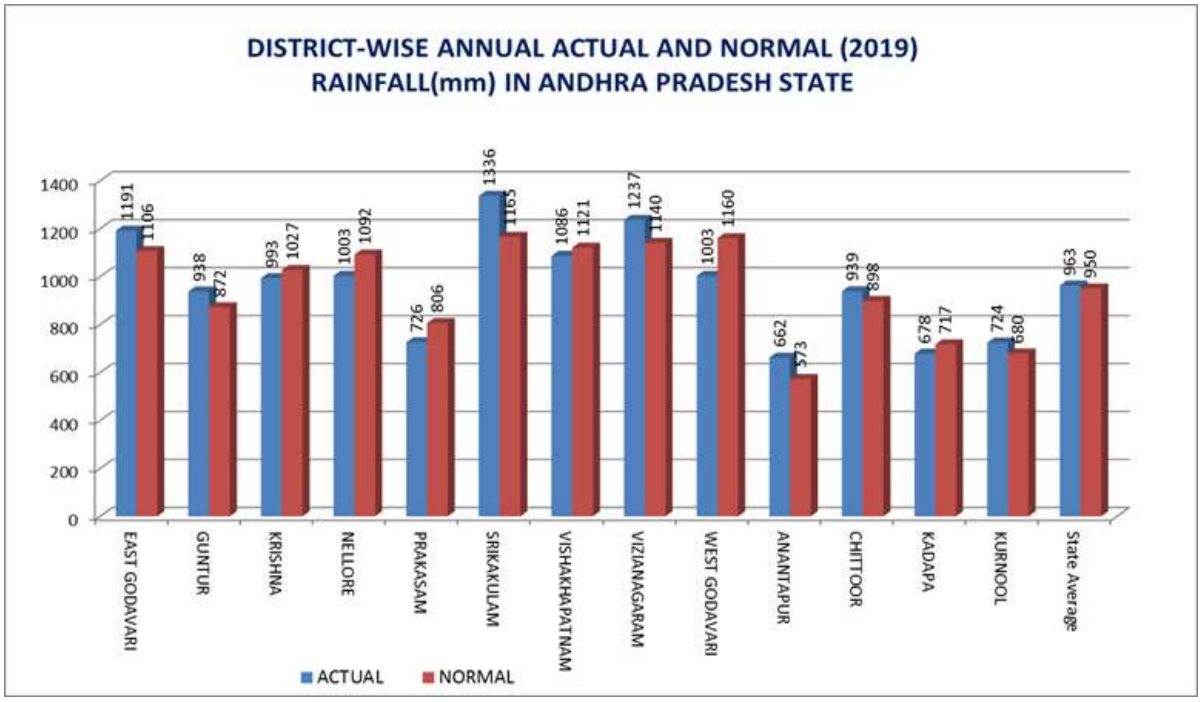


Fig.3.1: District-wise Annual Actual and Normal (2019) rainfall.

Southwest monsoon (June - September) performance:

Southwest monsoon was normal in the state. In Coastal Andhra Pradesh, East Godavari (24% above normal, 872.4 mm, the highest rainfall of the state) and Guntur (24% above normal, 675.4 mm) districts were in Excess rainfall category and the remaining districts had normal rainfall. Nellore with 364.4 mm (3% above normal) rainfall was the lowest rainfall district of Andhra Pradesh. All four districts of Rayalseema region had normal rainfall, with Kurnool having the highest rainfall (535.6 mm, 16% above normal) and Ananthapur the lowest (382.4 mm, 18% above normal).

Significant weather events in 2019:

During cyclone Fani coastal districts Srikakulam and Vizianagaram received rainfall from 2nd to 4th May. Srikakulam district received heavy to very heavy rainfall. Highest rainfall 182 mm recorded at Ichchapuram in Srikakulam district on 3rd May.

The rainfall received during the period January to December 2019 is compiled and analysed for correlating with water levels monitored during the period May 2019, August 2019, November 2019 and January 2020. Isohytel map of Andhra Pradesh State (Normal annual rainfall in mm) is depicted in **Fig.3.2.** The data is presented in **Table-3.2 to 3.5** and depicted in **Fig. 3.3 to 3.10.**

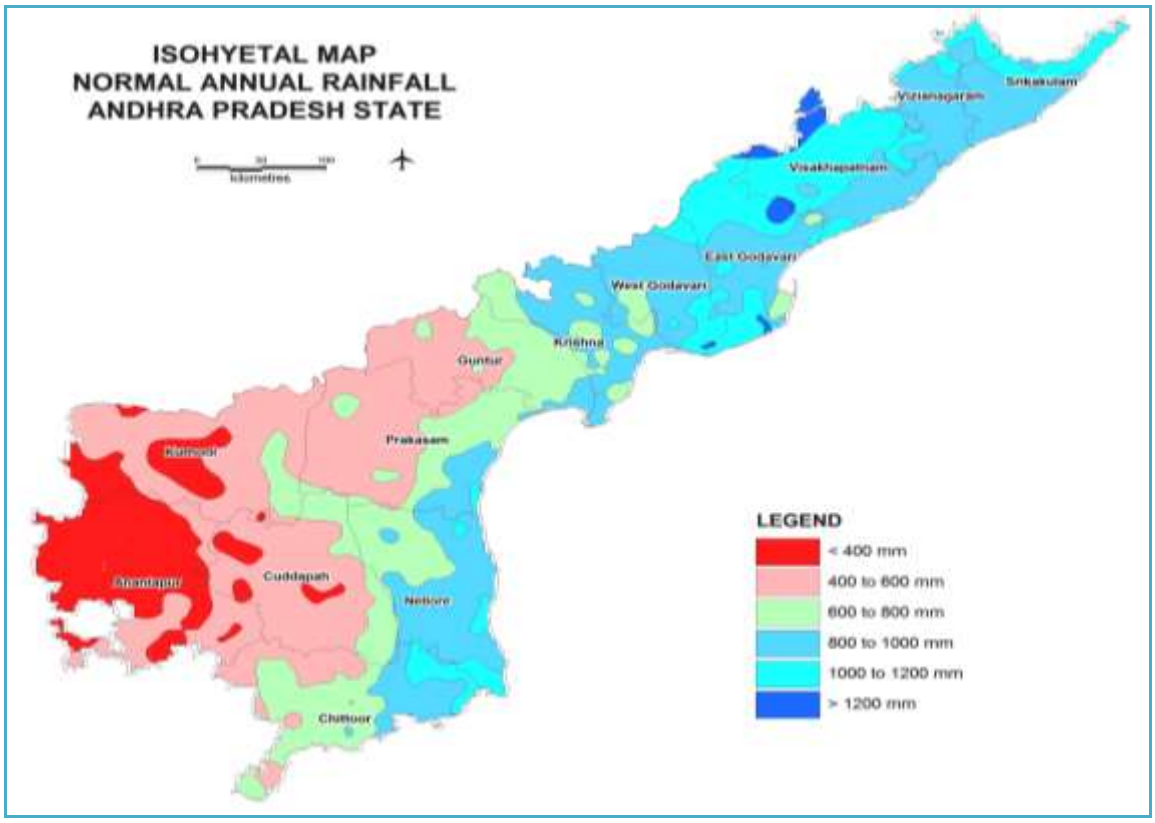


Fig.3.2: Isohytel map of Andhra Pradesh State (Normal annual rainfall in mm).

Table-3.1: Monthly Actual and Normal (2019) rainfall (mm) in Andhra Pradesh State

		JAN		FEB		MAR		APR		MAY		JUNE		JULY	
S No	DISTRICT	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR
1	**EAST GODAVARI**	4.1	6	0	10.1	13.3	11.3	33.7	22.8	2.6	75.3	97.6	131.9	275.4	206.4
2	**GUNTUR**	25.7	5.5	0.4	7.7	0.6	7.7	6.8	15	17.8	58.4	82.4	90.2	157.9	147.3
3	**KRISHNA**	18.2	4.6	5.9	6.3	14.5	8.7	16.7	16.9	15.2	46.8	57.1	120.9	218.7	216.6
4	**NELLORE**	7.9	15.7	3.3	11.6	0	6	24.2	15.2	12.5	51.4	21.3	53.4	106.9	91.2
5	**PRAKASAM**	15	7.9	0.4	8.8	2.2	10.5	27.1	14.9	19.4	52.3	51.7	64.3	124.8	99.3
6	**SRIKAKULAM**	0	7.9	1.6	18.1	5.7	17.2	8.6	26.3	135.1	63.9	72.8	145	176.2	190.2
7	**VISHAKHAPATNAM**	0.3	8.8	1	10.8	15.9	17.6	40.8	44.7	54.5	96.6	92	132.6	138.7	178.2
8	**VIZIANAGARAM**	0	8.7	0.5	14.4	16.9	17.7	26.6	32.3	43	90.7	88.1	140.7	175.5	181.5
9	**WEST GODAVARI**	13.4	6.1	0.5	10.7	2.2	8.7	5.3	19	4.4	55.8	54.2	135.8	231.4	240.2
10	**ANANTAPUR**	10.6	3	1	3.3	0	6.1	13.2	18.9	47.6	56.7	52.3	55.2	30.1	64.3
11	**CHITTOOR**	9.6	7.7	2.3	7.6	0	10.1	12.1	25.6	30	67.2	56.4	66.8	86.8	100.1
12	**KADAPA**	14.8	1.9	0.4	2.4	0	4.7	13.3	17.3	17.8	47.6	35	69.8	67.5	101.1
13	**KURNOOL**	17.1	1.2	0.2	1.9	0.4	5.7	5.4	18.3	36.3	51.7	71.7	80.5	76.9	115.8
	State Average	**10.5**	**6.5**	**1.3**	**8.7**	**5.5**	**10.2**	**18**	**22.1**	**33.6**	**62.6**	**64**	**99**	**143.6**	**148.6**

		AUG		SEP		OCT		NOV		DEC		ANNUAL		
S No	DISTRICT	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	ACT	NOR	DEP(%)
1	**EAST GODAVARI**	275.8	188.4	223.6	177.2	256.7	199	7.1	69.8	1.3	7.8	1191	1106	8%
2	**GUNTUR**	181.6	155.4	253.5	150.1	202.7	143.9	6.4	75.8	2.1	14.5	937.9	871.5	8%
3	**KRISHNA**	192	194.2	265.4	169.7	182.8	164.2	5.1	66.1	1.8	12.1	993.4	1027.1	-3%
4	**NELLORE**	88	95	148.4	112.8	335.7	248.2	104.9	283.9	150.2	107.2	1003	1091.6	-8%
5	**PRAKASAM**	94.4	95.9	132.9	123	217.1	181.9	11.4	115	29.4	32.1	725.8	805.9	-10%
6	**SRIKAKULAM**	249.2	202.4	319.2	208.1	359.5	211.4	1.1	69.8	7.2	4.9	1336	1165.2	15%
7	**VISHAKHAPATNAM**	167.2	178.2	303.3	185.4	264.9	204.3	6.2	59.2	1.3	4.3	1086	1120.7	-3%
8	**VIZIANAGARAM**	233.4	194.8	309.6	209.1	342	188.1	0.1	56.3	0.8	6.1	1237	1140.4	8%
9	**WEST GODAVARI**	269.6	227.8	253	180.1	165	197.8	4.1	66.7	0	11.7	1003	1160.4	-14%
10	**ANANTAPUR**	70.1	74.5	229.9	128.8	179.6	115	12.7	35.3	14.7	11.6	661.8	572.7	16%
11	**CHITTOOR**	144.9	110.2	228.4	140	226.6	167.2	41.7	137.3	100	58.4	938.8	898.2	5%
12	**KADAPA**	102.3	108.6	209.1	124.6	155.4	137.3	28	77.2	34.6	24.4	678.2	716.9	-5%
13	**KURNOOL**	132.5	124.3	254.5	139.6	119.6	105.6	5.4	28.4	4	6.6	724	679.6	7%
	State Average	**169.3**	**150**	**240.8**	**157.6**	**231.4**	**174.1**	**18**	**87.8**	**26.7**	**23.2**	**962.8**	**950**	**1%**

3.2.1 May, 2019

The rainfall data collected from India Meteorological Department and compiled from weekly weather reports has been used to analyse the rainfall for the period June 2018 to May 2019. **Table-3.2** gives the district-wise rainfall data for the period June 2017 to May 2018, June 2018 to May 2019 and normal for June to May and the departure of June 2018 to May 2019 rainfall with other periods. The departure values are used to prepare the graphs and presented in **Fig-3.3** and **Fig-3.4.**

Table-3.2: Salient Features of Rainfall and its Variability in Andhra Pradesh State.

S NO	DISTRICT	Rainfall (June'18-May'19)	Rainfall (June'17-May'18)	Normal Rainfall (June-May)	Departure from Annual (%)	Departure from Normal (%)	Remark
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	362	622	552	-41.8%	-34.4%	Deficit
2	Chittoor	524	1079	934	-51.4%	-43.9%	Deficit
3	Cuddapah	326	843	700	-61.3%	-53.4%	Deficit
4	East Godavari	795	1115	1218	-28.7%	-34.7%	Deficit
5	Guntur	660	796	847	-17.1%	-22.1%	Deficit
6	Krishna	969	953	1033	1.7%	-6.2%	Normal
7	Kurnool	376	723	670	-48.0%	-43.9%	Deficit
8	Nellore	515	940	1080	-45.2%	-52.3%	Deficit
9	Prakasam	433	634	871	-31.7%	-50.3%	Deficit
10	Srikakulam	1301	1375	1162	-5.4%	12.0%	Normal
11	Vishakhapatnam	830	935	1202	-11.2%	-30.9%	Deficit
12	Vizianagaram	949	1178	1131	-19.4%	-16.1%	Normal
13	West Godavari	1113	1025	1153	8.6%	-3.5%	Normal
	STATE MEAN	**704**	**940**	**966**	**-25.1%**	**-27.1%**	**Deficit**

Source: India Meteorological Department, GOI

3.2.1.1 Rainfall Departure of June'18 -May'19 from Normal Rainfall of Same Period

Fig.3.3 gives departure of June'18 - May'19 rainfall from normal of the same period. During the period June'18 - May'19, the state has received 27.1 % less rainfall than normal, which is 704 mm. It ranges from -53.4% in Kadapa district to 12.1% in Srikakulam district. The state has received normal rainfall in Krishna, Srikakulam, Vizianagaram, West Godavari district, whereas deficit rainfall in the remaining districts.

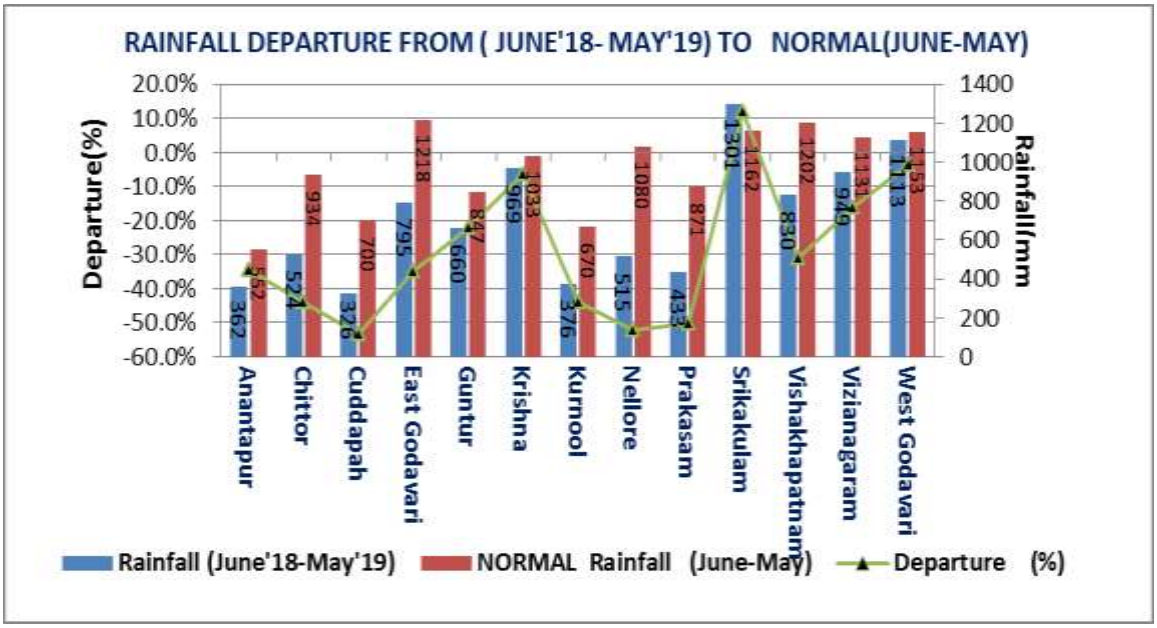


Fig.3.3: Rainfall Departure of June '18- May'19 from Normal of same Period.

3.2.2.2 Rainfall Departure of June'18 -May'19 from June'17 -May'18

Fig. 3.4 gives departure of June'18 - May'19 rainfall from June'17 - May'18 rainfall. **Table 3.2** indicates that state has received 704 mm of rainfall during the period June'18 - May'19**,** which is 25.1% less than the rainfall received during June'17 - May'18. The departure in percentage ranges from -61.3 % in Kadapa district to 8.6% in West Godavari district.

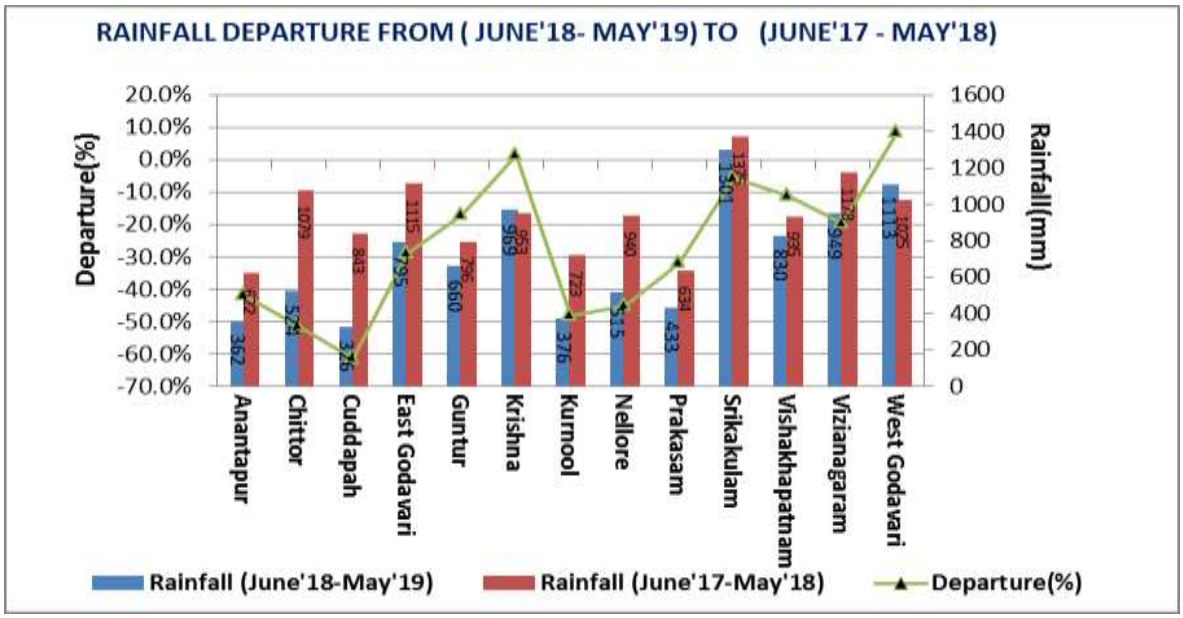


Fig.3.4: Rainfall Departure of June '18- May'19 from Normal of same Period.

3.2.2 August 2019

Table-3.3 gives the district-wise rainfall data for the period June-August 2018, June-August 2019, normal of June-August and the departure of June- August, 2019 rainfall with other periods. The departure values are used to prepare the graphs and presented in **Fig.3.5 and Fig.3.6.**

Table-3.3: Salient Features of Rainfall and its Variability in Andhra Pradesh State.

S NO	DISTRICT	Rainfall (mm) (June'19-August'19)	Rainfall (June'18-August'18)	Normal Rainfall (June-August)	Departure from Annual (%)	Departure from Normal (%)	REMARK
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	153	131	220	16.8%	-30.5%	Deficit
2	Chittoor	288	178	298	61.8%	-40.3%	Deficit
3	Cuddapah	205	109	280	88.1%	-26.8%	Deficit
4	East Godavari	649	778	565	-16.6%	14.9%	Normal
5	Guntur	422	457	379	-7.7%	11.3%	Normal
6	Krishna	468	681	521	-31.3%	-10.2%	Normal
7	Kurnool	281	184	329	52.7%	-14.6%	Normal
8	Nellore	216	146	229	47.9%	-5.7%	Normal
9	Prakasam	271	179	255	51.4%	6.3%	Normal
10	Srikakulam	498	674	509	-26.1%	-2.2%	Normal
11	Vishakhapatnam	398	531	523	-25.0%	-23.9%	Deficit
12	Vizianagaram	497	545	502	-8.8%	-1.0%	Normal
13	West Godavari	555	923	607	-39.9%	-8.6%	Normal
	STATE MEAN	**377**	**424**	**401**	**-11.1%**	**-6.1%**	**Normal**

Source: India Meteorological Department, GOI

3.2.2.1 Rainfall Departure of June - August'19 from Normal Rainfall of Same Period:

Fig 3.5 gives departure of June - August'19 rainfall from normal of the same period. During the period June - August'19, the state has received 6.1% less rainfall than normal. It ranges from -40.3% in Chittoor district to 14.9% in East Godavari district. The state has

deficit rainfall in Chittoor, Anantapur, Cuddapah and Vishakhapatnam districts and normal rainfall in the remaining districts.

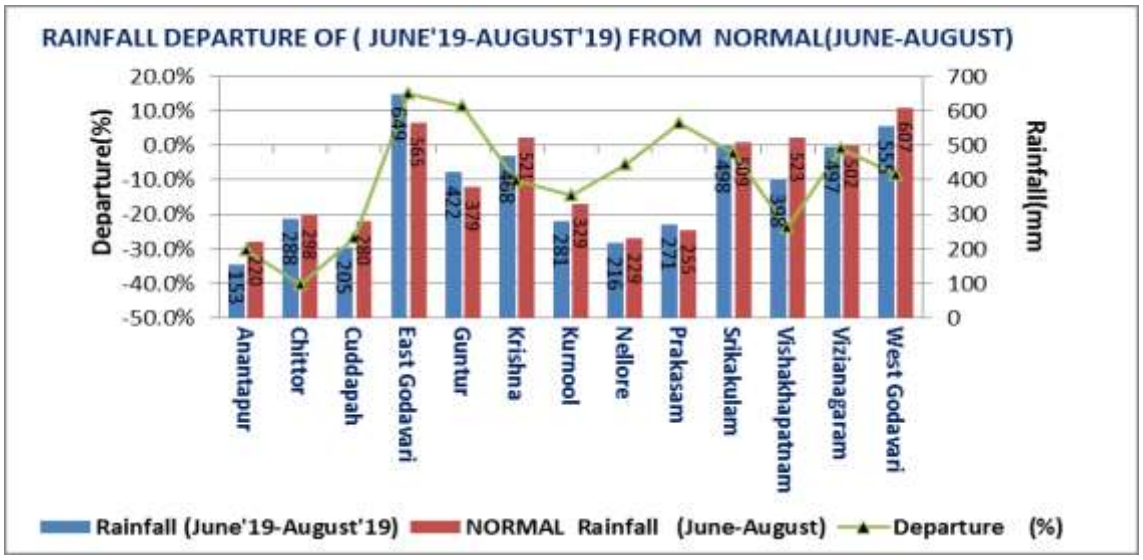


Fig.3.5: Rainfall Departure of June- August'19 from Normal of same Period.

3.2.2.2 Rainfall Departure of June- August'19 from June - August'18.

Fig 3.6 gives departure of June- August'19 rainfall from June to August'18 rainfall. **Table 3.3** indicates that state has received 377 mm of rainfall during the period June – August 2019, which is 11.1% less than the rainfall received during same period in 2018. The departure percentage ranges from - 39.9% in West Godavari district to 88.1 % in Cuddapah district.

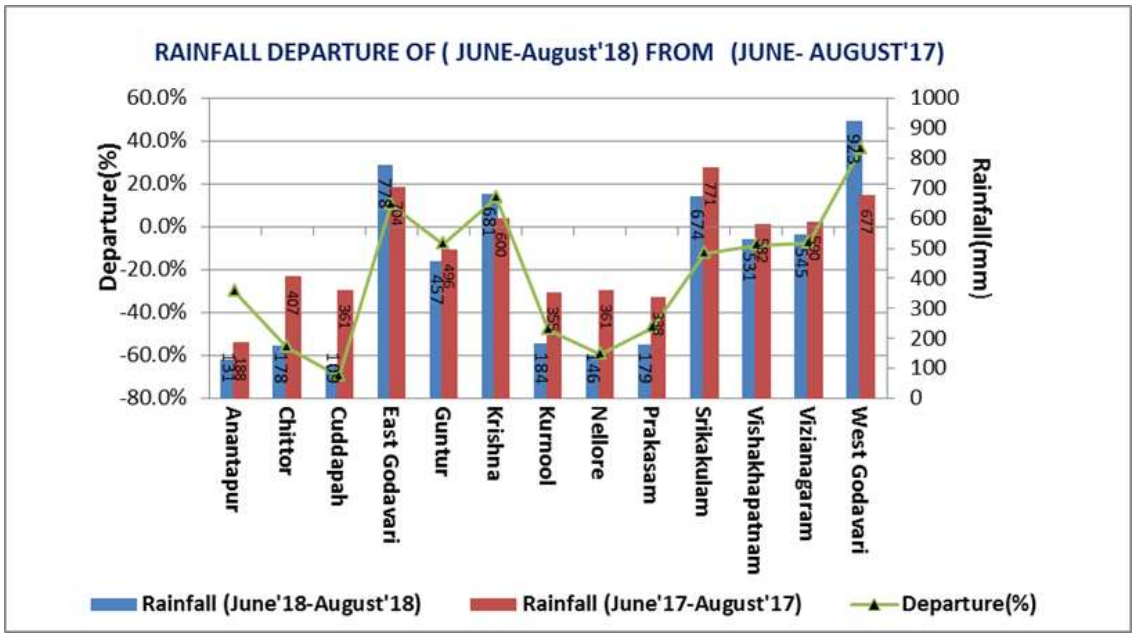


Fig.3.6 Rainfall Departure of June- August'19 from June to August'18:

3.2.3 November 2019

Table 3.4 gives the district-wise rainfall data for the period June-October 2019, June-October 2018, normal for June-October and the departure of June- October 2019 rainfall from normal and previous year (2018) for same period. The departure values are used to prepare the graphs as shown in **Fig-3.7** and **Fig-3.8**.

Table-3.4: Salient Features of Rainfall and its Variability in Andhra Pradesh State.

S No	District	Rainfall (mm) (June'19-December'19)	Rainfall (mm) (June'18-December'18)	Normal Rainfall (mm) (June-December)	Departure (%) from 2018	Departure (%) from Normal	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	562	284	438	97.9%	28.3%	Excess
2	Chittoor	743	351	584	111.7%	27.2%	Excess
3	Cuddapah	569	242	541	135.2%	5.2%	Normal
4	East Godavari	1129	911	903	23.9%	25.0%	Excess
5	Guntur	878	541	687	62.3%	27.8%	Excess
6	Krishna	916	768	866	19.3%	5.8%	Normal
7	Kurnool	655	315	566	107.9%	15.7%	Normal
8	Nellore	700	245	601	185.7%	16.5%	Normal
9	Prakasam	621	307	564	102.3%	10.1%	Normal
10	Srikakulam	1177	1086	957	8.4%	23.0%	Excess
11	Vishakhapatnam	966	710	879	36.1%	9.9%	Normal
12	Vizianagaram	1149	775	914	48.2%	25.7%	Excess
13	West Godavari	973	1015	982	-4.1%	-0.9%	Normal
	STATE MEAN	**849**	**581**	**729**	**46.1%**	**16.5%**	**Normal**

Source: India Meteorological Department, GOI

3.2.3.1 Rainfall Departure of June - October'19 from Normal Rainfall of Same Period:

Fig.3.7 gives departure of June - October'19 rainfall from normal of the same period. **Table 3.4** indicates that the state has received 16.5 % more rainfall than normal during June – october2019. It ranges from -0.9% in West Godavari district to 28.3% in Anantapur district. The state has received excess rainfall in Anantapur, Guntur, Chittoor, Srikakulam, East Godavari, Vizianagaram and normal rainfall in the remaining districts.

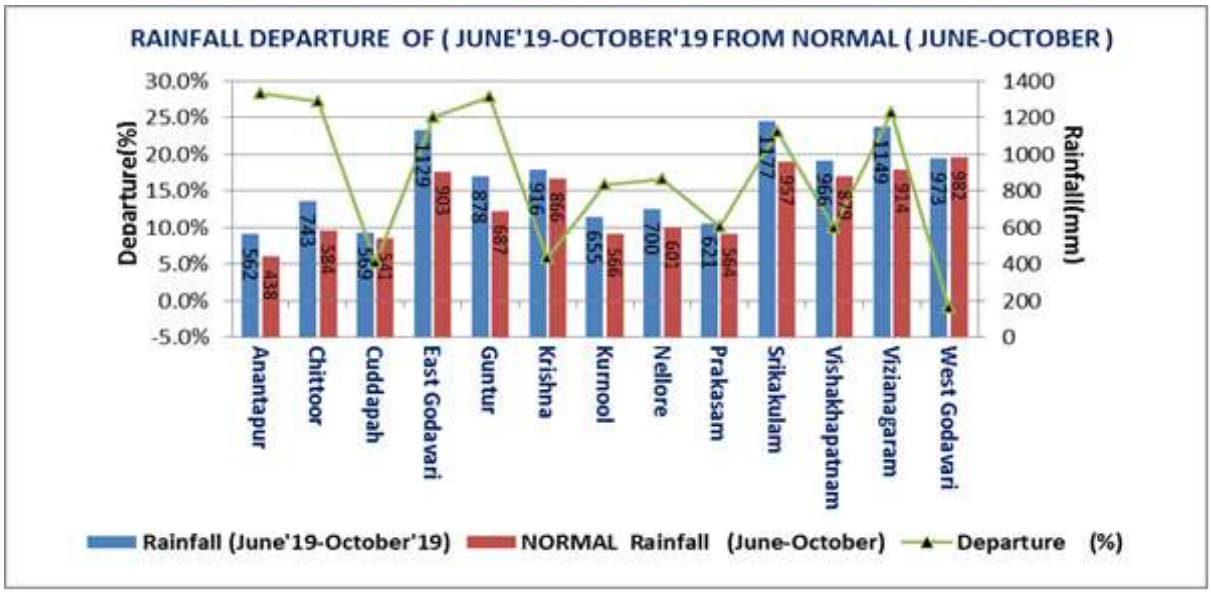


Fig.3.7: Rainfall Departure of June- October'19 from Normal of same Period.

2.2 Rainfall Departure of June- October'19 from June - October'18.

Fig.3.8 gives departure of June- October'19 rainfall from June to October'18 rainfall. **Table 3.4** indicates that state has received 849 mm of rainfall during the period June – October, 2019, which is 46.1% more than the rainfall received during June to October, 2018. The departure percentage ranges from - 4.1 % in West Godavari district to 185.7 % in Nellore district.

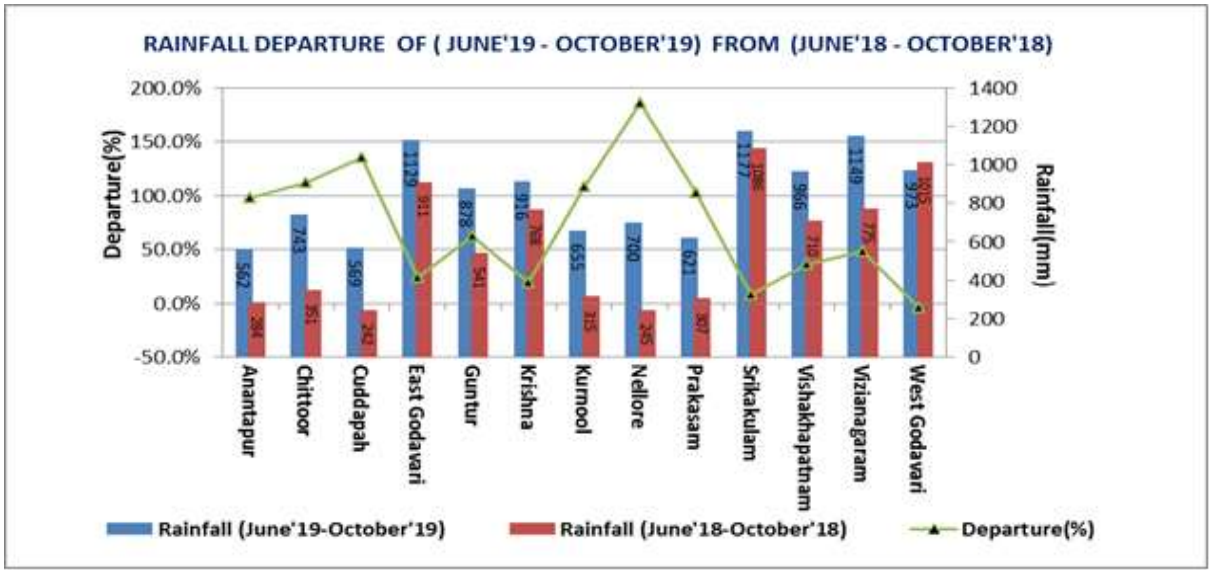


Fig.3.8: Rainfall Departure of June- October'19 from June to October'19

3.2.4 Januray 2020

Table 3.5 gives the district-wise rainfall data for the period June-December 2019, June-December 2018, normal for June-December and the departure of June- December 2019 rainfall from normal and previous year (2018) for same period. The departure values are used to prepare the graphs as shown in **Fig-3.9 and Fig-3.10.**

Table-3.5: Salient Features of Rainfall and its Variability in Andhra Pradesh State.

S No	District	Rainfall (mm) (June'19-December'19)	Rainfall (mm) (June'18-December'18)	Normal Rainfall (mm) (June-December)	Departure (%) from 2018	Departure (%) from Normal	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	589	289	485	103.8%	21.4%	Excess
2	Chittoor	885	470	780	88.3%	13.5%	Normal
3	Cuddapah	632	280	981	125.7%	-35.6%	Deficient
4	East Godavari	1138	998	777	14.0%	46.5%	Excess
5	Guntur	887	609	944	45.6%	-6.0%	Normal
6	Krishna	923	898	601	2.8%	53.6%	Excess
7	Kurnool	665	316	712	110.4%	-6.6%	Normal
8	Nellore	955	467	992	104.5%	-3.7%	Normal
9	Prakasam	662	370	1032	78.9%	-35.9%	Deficient
10	Srikakulam	1185	1150	942	3.0%	25.8%	Excess
11	Vishakhapatnam	974	718	977	35.7%	-0.3%	Normal
12	Vizianagaram	1150	862	1060	33.4%	8.4%	Normal
13	West Godavari	977	1087	643	-10.1%	51.9%	Excess
	STATE MEAN	**894**	**655**	**840**	**36.5%**	**6.4%**	**Normal**

Source: India Meteorological Department, GOI

3.2.4.1 Rainfall Departure of June - December'19 from Normal Rainfall for Same Period:

Figure 3.9 gives departure of June - December'19 rainfall from normal of the same period. **Table 3.5** indicates that the state has received 6.4 % more rainfall than normal during June – December 2019. It ranges from -35.9% in Prakasam district to 53.6% in Krishna district. The state has received excess rainfall in Anantapur, East Godavari, Krishna Srikakulam and

West Godavari districts, Deficient rainfall in Prakasam & Cuddapah districts and normal rainfall in remaining districts. Southwest Monsoon was normal in the state.

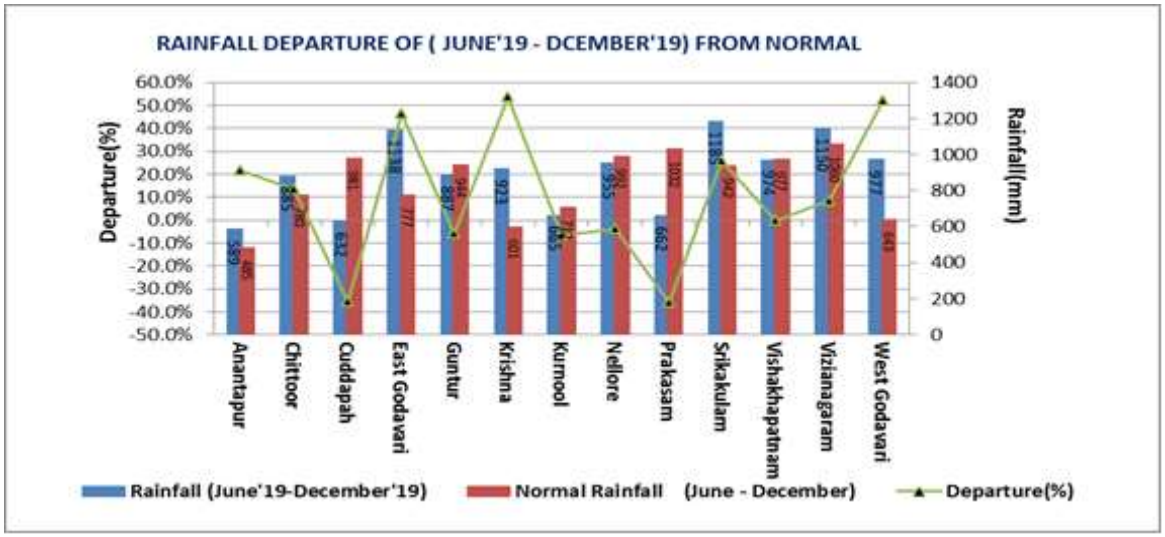


Fig.3.9: Rainfall Departure of June- December'19 from Normal of same Period.

3.2.4.2 Rainfall Departure of June- December'19 from June - December'18.

Figure 3.10 gives departure of June - December'19 rainfall from June - December'18 rainfall. **Table 3.5** indicates that state has received 894 mm of rainfall during the period June - December' 2019, which is 36.5 % more than the rainfall received during June - December' 2018. The departure in percentage ranges from -10.1 % in West Godavari district to 125.7% in Cuddapah district.

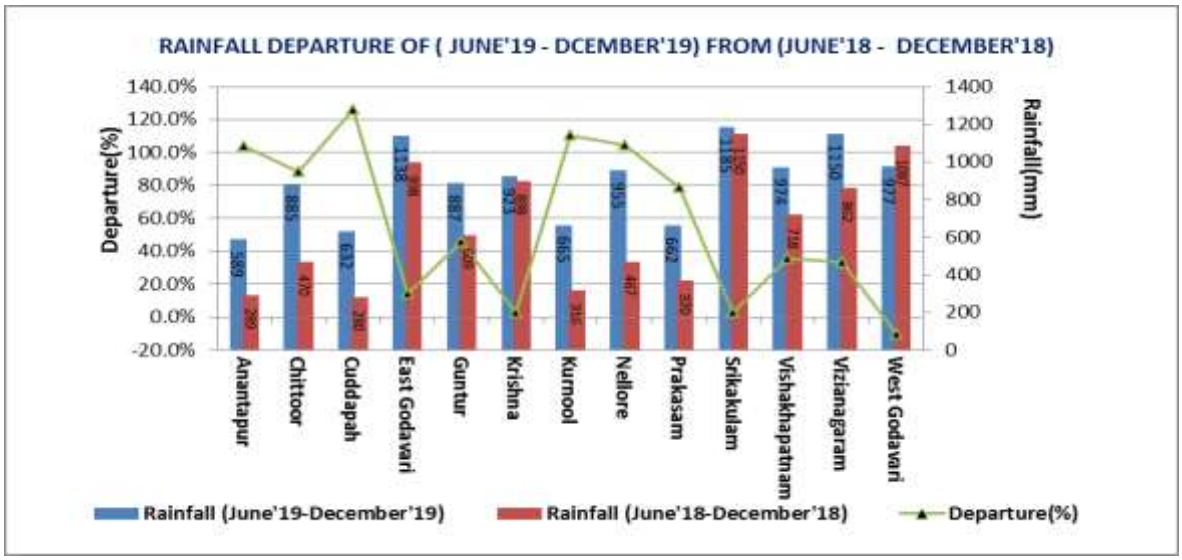


Fig.3.10: Rainfall Departure of June- December'19 from June to December'18

4. GEOLOGY

A wide variety of geological formations occur in Andhra Pradesh State, ranging from the oldest Archaean crystalline formations to recent alluvium. The geological set up and hydrogeological map is presented in the **Fig.4.1** and **4.2** respectively. A major part of the area is underlain by gneissic complex with a structural fill of sedimentary formations and basin-fill of meta-sedimentary formations. The gneissic complex is overlain by basaltic lava flows in the northwestern part and is intruded by several younger rocks namely granites, dolerites, pegmatites and quartzite etc.

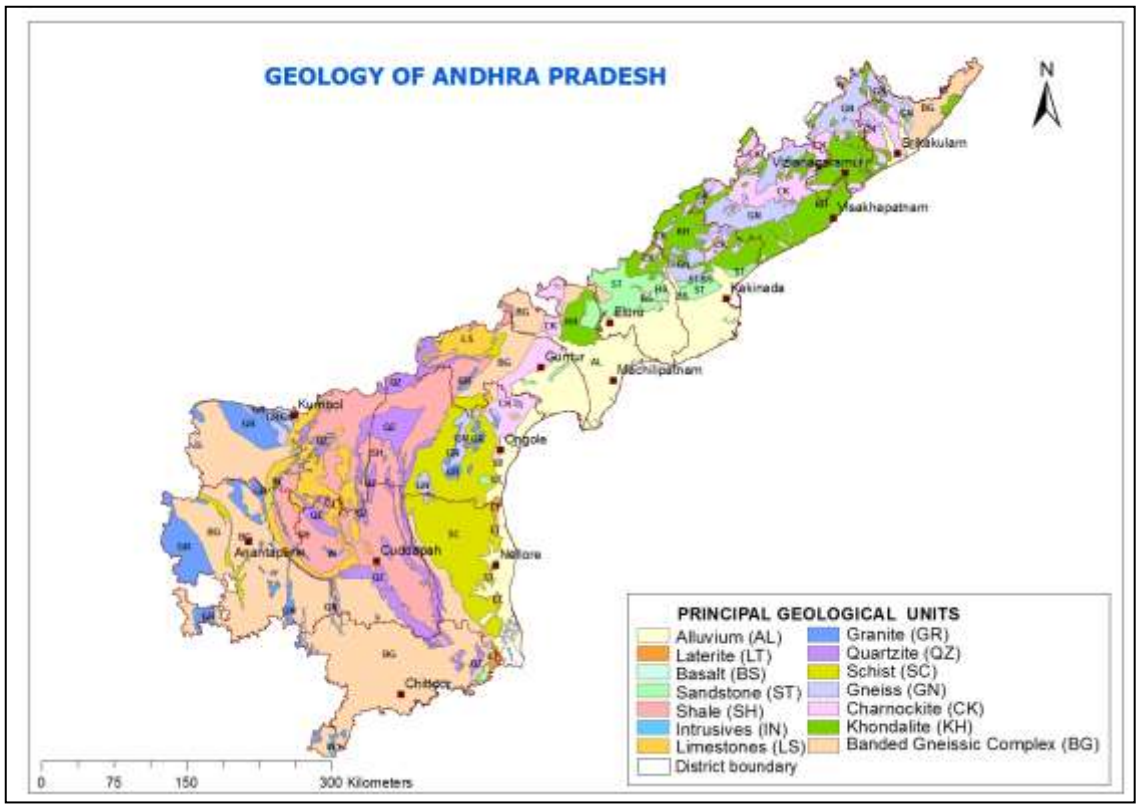


Fig.4.1: Geology of Andhra Pradesh State

4.1 Archaeans and Lower Pre-Cambrians

Peninsular gneisses of Archaean age are dominant rock types in Rayalaseema region of the State. Dharwars, comprising amphibolites, gneisses, schists, and quartzites occur as narrow isolated bands within granites in Chittoor, Anantapur, Kurnool, Kadapa, Nellore and Prakasam districts. The Charnockites and Khondalites occur in an extensive belt in Srikakulam, Vizianagaram, and Visakhapatnam districts and in upland areas of East Godavari

and West Godavari districts. The Charnockite bands also occur as narrow patches adjoining Coastal alluvium in Krishna, Guntur and Prakasam districts.

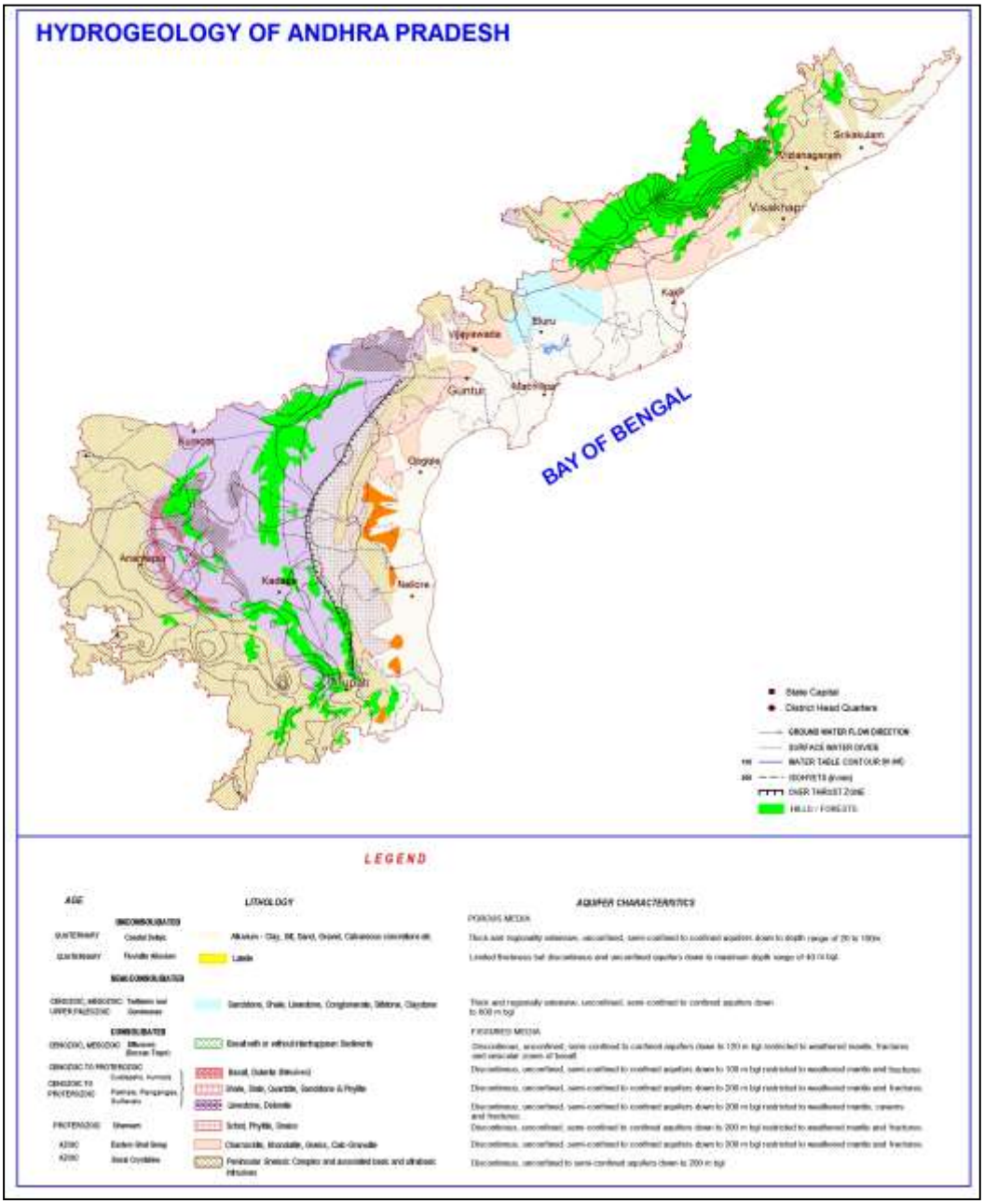


Fig.4.2: Hydrogeology map of Andhra Pradesh State.

4.2 Upper Pre-Cambrian to Early Pre-Cambrian

The group includes Kadapas and Kurnools comprising shales, limestones, dolomites, sandstones and conglomerates. The crescent shaped Kadapa Super Group covering ~42,100 Km^2 occur in parts of Krishna, Kurnool, Prakasam, Guntur, Nellore, Kadapa, Chittoor and

Anantapur districts. Kurnools occur in Kundair valley and Palnad tract. Gondwanas also occur as disconnected outcrops along the coast from Tuni in East Godavari district to Satyavedu in Chittoor district.

4.3 Deccan Traps (Basalt) and Associated Rocks

Deccan traps, the horizontally disposed lava flows are confined to Minor outcrops near Rajahmundry on either banks of the river Godavari. The thickness of individual flow varies between few meters to as much as 30 m. Inter-trappean beds comprising limestones, cherts and sandstones occur between trap flows near Rajahmundry. Infra-trappean beds, comprising deposits of limestones and sandstones, underlie the trap flows. These are exposed in an area covering a stretch of 6 km from Pangidi in West Godavari district to Kateru in East Godavari district.

4.4 Tertiary Formations (Miocene-Pliocene)

The formation of this group is locally known as Rajahmundry formation. It constitutes mainly Sandstones occurring from Eluru to Rajahmundry as isolated out crops dipping gently towards the coast. Sandstones of equivalent age occur along the southern coast in Chittoor, Prakasam and Nellore districts. They are highly potential from ground water point of view.

4.5 Quaternary Formations

Alluvium, beach sands, Laterite soils etc. belong to this group. Beds of clay, sand, gravel and boulders stretch along the coast except near Visakhapatnam. This distribution is not only confined to deltas but also extends deep inland in narrow patches along river courses of Godavari, Krishna, Pennar and Vamsadhara. The alluvial deposits attain a thickness of more than 600 m in East and West Godavari districts sloping towards the coast. In Srikakulam and Visakhapatnam districts, the thickness varies up to 20 m.

5. GROUND WATER RESOURCES (2016-2017)

The dynamic ground water resource potential of the state has been estimated as per the methodology given by the Ground Water Estimation Committee 1997 (GEC 1997).

As per the latest estimates (March 2017), The net ground water availability in the state is 20.15 BCM out of which the total draft for all uses (Domestic, Industrial and Irrigation) is 8.9 BCM. Net ground water available for future use is 11.25 BCM. The stage of development is 44.15%. Out of 670 mandals, over-exploited (OE) mandals are 45, critical mandals are 24, semi-critical mandals are 60 and safe mandals are 541 (including saline mandals 81). Comparatively high ground water development is observed in Anantapur (88.9%) and Kadapa (68.7%) districts. Ground water development is low in Vizianagaram and East Godavari districts (21%). More mandals from Rayalaseema regions falls under OE, Critical and Semi Critical category than Coastal region mandals. The categorization of mandals is depicted in **Fig.5.1**.

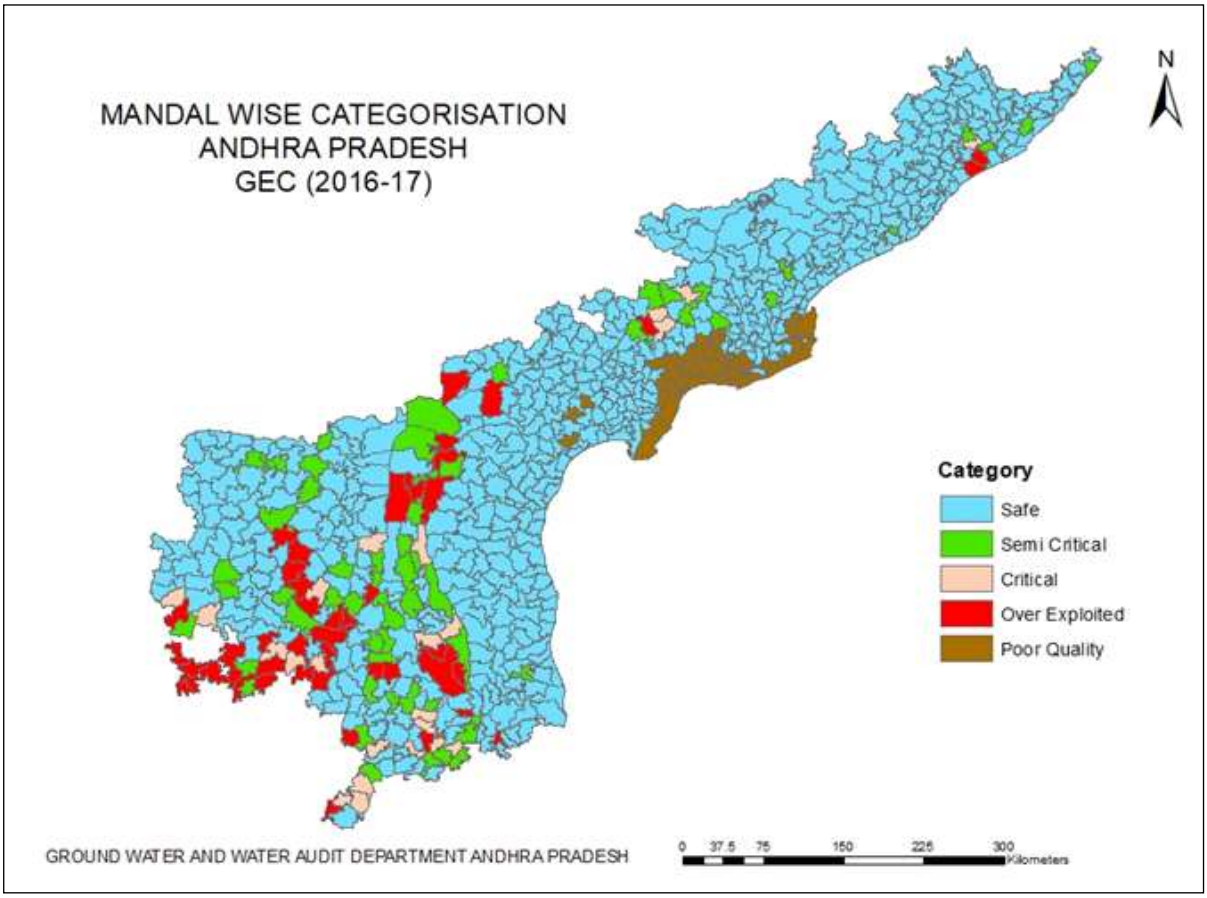


Fig.5.1: Categorization of Mandals (as on March, 2017), Andhra Pradesh State.

6. GROUND WATER REGIME MONITORING

Ground water level monitoring is a scientific surveillance system to establish the periodic and long-term changes in ground water regime. The water level data over a period of time provides information on changes in ground water levels with progressive ground water development by natural and artificial recharge/surface water irrigation system.

Monitoring of a network of ground water monitoring wells provides periodical information on ground water regime scenario with a fair degree of accuracy in different hydrogeological environments in the area.

Ground water occurrence point of view State litho units are grouped into following 3 groups.

i) Consolidated Formations
ii) Semi-consolidated Formations
iii) Unconsolidated Formations

6.1 Consolidated formations: Crystalline rocks of Archaean age, metasedimentary rocks of Kadapa and Kurnools and basalts lava flows of Deccan traps are included in these formations occupying ~83% of the area. These rocks generally lack primary porosity and secondary porosity is developed due to weathering, fracturing, development of solution cavities and channels and interconnection of vesicles. In these rocks depth of weathering varies from 5 to 10 m bgl (occasionally up to 20 m) and majority of fractures occur within 100 m depth. In these rocks dug wells/ dug cum bore wells and bore wells are the most prevalent abstraction structures. Ground water yield from these rocks varies from 0.1 lps to 3 lps.

In Khondalite formations, depth of weathering varies from 10-40 mbgl with yields of 0.5-2 lps. Consolidated meta-sedimentary formations (Kadapa and Kurnool rocks and equivalents) have undergone great deal of compaction, metamorphism, thereby reducing primary porosity. Occurrence of ground water in these formations is restricted to structural features like folds, faults, lineaments, fractures, fissures, solution cavities and channels etc. Depth of weathering in these formation ranges from 5-10 m bgl and yield varies from 0.01-19 lps (general 1-5 lps). Relatively Kurnool group of rocks are more potential than other Kadapas (general yield 5-10 lps).

6.2 Semi-consolidated formations: Semi-consolidated formations are represented by rocks belonging to Gondwana formations (sandstones) and Rajahmundry sandstones. The yield of these formations ranges from 10-70 lps.

6.3 Unconsolidated formations: Un-consolidated formations are represented by coastal alluvium, deltaic alluvium and inland river alluvium. Ground water occurs under water table and confined conditions. Water quality in deeper aquifers is of poor quality. In deltaic areas of Godavari, Krishna and Pennar, yield varies from 0.7-30 lps and Godavari deltas. Ground water quality is of potable nature in paleo channels.

6.4 Monitoring Methodology

Ground water regime is monitored through a network of dug wells and piezometers known as Ground Water Monitoring Station (GWMS). The dug wells, which are owned by government, non-government agencies and individual users, are tapped in the shallow aquifer system. Piezometers (basically bore wells/tube wells) are constructed exclusively for ground water regime monitoring under Hydrology Projected. Some of the exploratory wells/ observatory wells drilled under and exploratory drilling programme of Central Ground Water Board are converted to piezometers for regular monitoring.

The network of observation wells are monitored 4 times a year by the officials of Central Ground Water Board during the following periods.

Period	**Date**
January	1st to 10th of the month
May (Pre-monsoon)	20th to 30th of the month
August (Mid-monsoon)	20th to 30th of the month
November (Post-monsoon)	1st to 10th of the month

6.4.1 Participatory Ground water Monitoring

Weekly water level measurements are initiated in phases involving local people as observers under participatory ground water monitoring programme, to observe micro-level changes in ground water regime. Participatory observers from the local area where GWMS is there are engaged since May, 2005 and as on 31st March, 2020, 128 no's of GWMS are monitored though participatory approach (**Table-6.1**).

6.4.2 Chemical Quality Monitoring

The chemical quality of ground water is monitored (dug wells/Piezometers) once in the month of May (pre-monsoon season) to observe the effect of geogenic, anthropogenic contamination of ground water in different hydrogeological environments over a period of time.

6.5 Maintenance of Database on Ground Water Monitoring Wells

The database on water levels and chemical quality is entered in the GEMS, developed over a period of time since 1969. The database is maintained in Oracle using GEMS (Ground water Estimation and Management System) software, which is adopted by all ground water agencies in the country.

6.6 Distribution of Ground Water Monitoring Wells

The distribution and density of monitoring wells in the State; distribution in river basins, aquifer systems and canal command areas are summarized in the following session.

6.6.1 District-Wise Distribution of Ground Water Monitoring Wells`

Total 838 GWMS are monitored in the state (DW: 674 (80 %) and Pz: 164(20%) and density varies from 111 Km^2/well (East Godavari) to 321 Km^2/well in Kurnool district (**Table-6.1**).

6.6.2 Aquifer-Wise Distribution of Ground Water Monitoring Wells

Out of 838 GWMS, 649 wells are located in hard rocks, 189 wells in soft rocks. District wise and aquifer wise distribution of GWMS is given in **Table-6.2.** About 24.6 % of

GWMS are located in Banded Gneissic complex , followed by Alluvium formations (22.5 %), followed by Khondalite rocks (8 %).

Table-6.1: District-wise Distribution of GWMS, Andhra Pradesh State (As on March, 2020).

S.No.	District	Area (Km2)	No of GWMS			No of Participatory observers	Density of Network stations (sq. km. per well)		
			DW	Pz	Total	Nos	Dug wells	Piezo meters	combined stations
1	Anantapur	19130	27	33	**60**	17	709	580	319
2	Chittoor	15152	44	15	**59**	15	344	1010	257
3	Kadapa	15359	84	12	**96**	8	183	1280	160
4	East Godavari	10807	84	13	**97**	15	129	831	111
5	Guntur	11391	24	39	**63**	10	475	292	181
6	Krishna	8727	65	7	**72**	8	134	1247	121
7	Kurnool	17658	35	20	**55**	17	505	883	321
8	Nellore	13076	57		**57**	7	229	0	229
9	Prakasam	17626	49	13	**62**	7	360	1356	284
10	Srikakulam	5837	51		**51**	4	114	0	114
11	Vishakhapatnam	11161	48		**48**	2	233	0	233
12	Vizianagaram	6539	55	3	**58**	12	119	2180	113
13	West Godavari	7742	51	9	**60**	6	152	860	129
	Total	**160205**	**674**	**164**	**838**	**128**	238	977	191

Nine Dug wells and One Piezometers are transferred from erstwhile Telangana state to Andhra Pradesh.

Table 6.2: Aquifer-Wise Distribution of Ground Water Monitoring Wells

	Alluvium		BGC		Basalt		Charnokite		Gneiss		Granite		Khondalite		Lime stone		Laterite		Quartzite		Schist		Shale		Sand stone		Total
District	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**Pz**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	**Dw**	**PZ**	
Anantapur			15	27							12	4												2			60
Chittoor	2		38	15													4										59
Kadapa			6	3		1									1	5			2	1	1		14	29			63
East Godavari	40	6	12	1	1		7		6		1		15	1											1	5	96
Guntur	26		14	3			19	1			1				11	4			2	1	5	2	3	1	3	1	97
Krishna	37	2	14	1			6	1					6	2		1									2		72
Kurnool			10	8					1	3	4	4			8	4			3				9	1			55
Nellore	16		6		1		1										6		1		24				2		57
Prakasam	10	2	2	1	2	2	9	2	5	2			1								9	4	11				62
Srikakulam	11		26				5		6				3														51
Vizianagaram							11		19				18														48
Visakhapatnam	1						21		16				16	3	1												58
West Godavari	32	4	4		1								4												10	5	60
Grand Total	**175**	**14**	**147**	**59**	**5**	**3**	**79**	**4**	**53**	**5**	**18**	**8**	**63**	**6**	**21**	**14**	**10**	**0**	**8**	**2**	**39**	**6**	**37**	**33**	**18**	**11**	**838**

7. ANALYSIS OF WATER LEVELS

The ground water levels observed over a period of time provide valuable information on behaviour of the ground water regime, which is constantly subjected to changes due to recharge and discharge phenomena. A balance between these two factors results in the decline or rise in the ground water storage. When the recharge exceeds discharge there will be a rise in the ground water storage and vice versa. The decline in water level may be due to increase in draft (for different purposes) or decrease in precipitation (less recharge to ground water). On the other hand a rise in water level may be due to an increase in rainfall and/or due to changes in irrigation practices. The dug wells tap the phreatic aquifer mostly limited to a depth of 20 m. The depth of piezometers which are tapping both the phreatic and deeper aquifers varies from 20 to 100 m. Hence the water level recorded in the piezometers may not be the same as that of dug wells for a particular period though both the structures are in the same place. In this report the water level data collected from un-confined aquifers (shallow depth) is presented. An attempt is also made to interpret the piezometric data generated by SGWD and CGWB and piezometric maps of May and Nov 2019 are prepared. The data from GWMS for the year 2019-20 was analyzed and for every set of measurements, write up and maps were prepared and are presented here under various paragraphs. The purpose of water level data analysis is

i) Four measurements of depth to water level give an overall idea regarding the ground water level in the state during the year of measurement.

ii) The fluctuation in comparison to the same month in the previous year gives an idea about the change in the ground water level for a particular period with respect to that of the level during the same month in the previous year. This gives an idea about the change in the amount of draft and rainfall between the two years.

iii) The water level fluctuation during the pre-monsoon period in comparison to last year gives an idea about the seasonal fluctuation, which ultimately reflects the change in dynamic ground water resources.

iv) The water level fluctuation during a particular month of measurement with reference to the decadal mean for the same months gives an idea of the behaviour of the ground water level on long-term basis.

7.1 Depth to Water Levels

7.1.1 Depth to Water Levels (May, 2019)

The depth to water level during May, 2019 based on analysis of water level data of 720 wells is generalized and given below. Distribution of wells in different depth ranges is depicted in pie diagram **Fig-7.1** and depth to water level map is given in **Fig-7.2**

Analysis of depth to water level data of 720 wells **(Annexure - V**) shows water levels vary between 0.31 m.bgl (Guntur district) and 60 m.bgl (YSR Kadapa district). Water level of less than 2 m bgl is recorded in 8% of wells, between 2-5 m bgl in 37% of wells, between 5-10 m bgl in 37% of wells, between 10-20 m bgl in 16% of wells, between 20-40 m bgl in 1% of wells and > 40 m bgl in 1% of wells. Depth to water level map of May, 2019 (**Fig.5**) shows that, Shallow water levels of less than 2 m bgl are noticed as small scattered patches in Srikakulam, Nellore, Kurnool, Ananthpur, Prakasam, Krishna, West Godavari, East Godavari, Guntur and Visakhapatnam covering an area of 8% (55 wells). Water level 2 to 5 m bgl is covered in 37% of the area (267 wells), mainly in Srikakulam, Krishna, East Godavari and Guntur. Area-wise 37% of the state is covered by depth to water level of 5 to 10 m bgl (267 wells), predominantly in southern part of the state. Water level 10 to 20 m bgl is covered in 16% of the area (117 wells). Water level 20 to 40 m covers about 1% of the state (10 wells) noticed mostly in Anathpur, Cuddapah, Prakasam and, Krishna, Guntur districts. Deeper Water levels of more than 40 m covers about 1% of the state (4 wells) in Cuddapah and Prakasam districts.

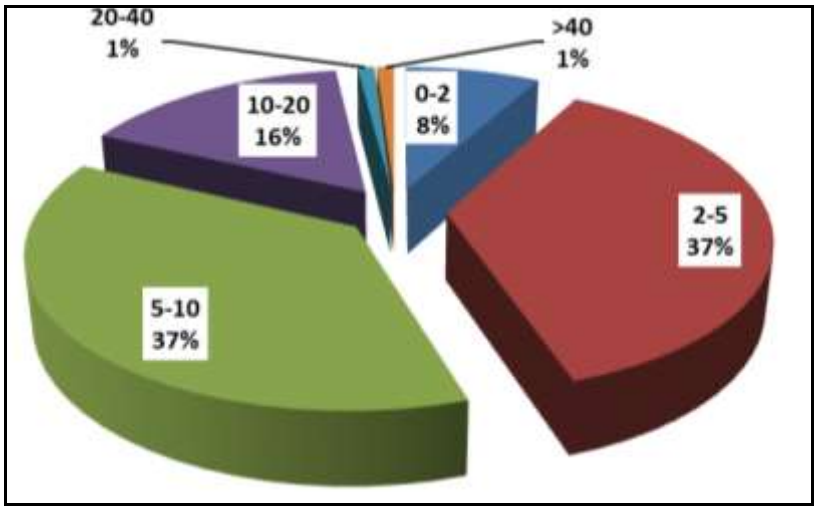


Fig.3: Percentage of wells in different depth ranges of DTW-May 2019

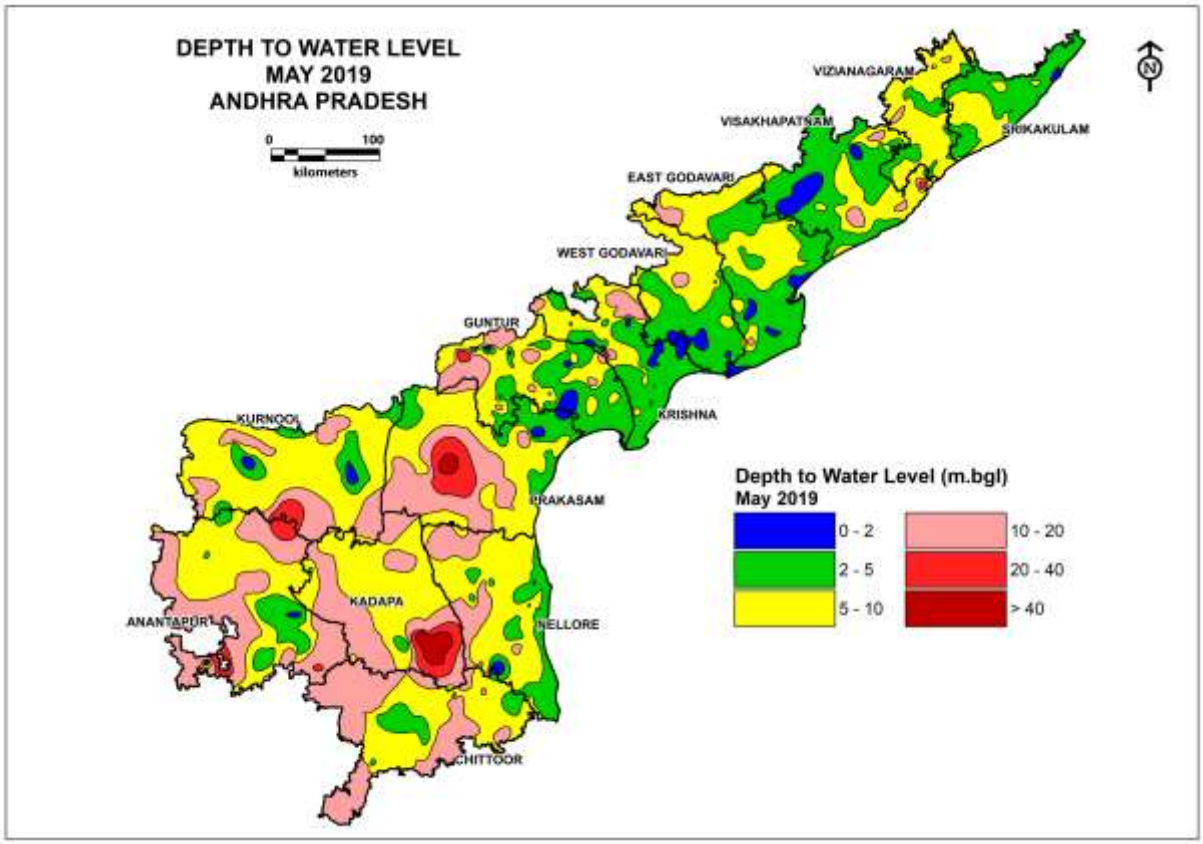


Fig-7.2: Depth to water level, May, 2019in Andhra Pradesh state

7.1.2 Depth to Water Levels –August, 2019 (Mid-monsoon Season)

The depth to water level during August, 2019 based on analysis of water level data of 727 wells is generalized and given below. Distribution of wells in different depth ranges is depicted in pie diagram Fig.7.3. and depth to water level map is given in Fig 7.4.

Water level of less than 2 m bgl is recorded in 26% of wells, between 2-5 m bgl in 30% of wells, between 5-10 m bgl in 28% of wells, between 10-20 m bgl in 13% of wells, between 20-40 m bgl in 2% of wells and > 40 m bgl in 1% of wells. Depth to water level map of August, 2019 (**7.4.**) shows that, Shallow water levels of less than 2 m bgl are noticed as small scattered patches in Visakhapatnam, Srikakulam, Krishna, West Godavari, East Godavari, Guntur, Vizianagaram and Kurnool covering an area of 13% (188 wells). Water level of 2 to 5 m bgl is covered in 25 % of the area (218 wells), mainly in Visakhapatnam, Srikakulam, Krishna, West Godavari, East Godavari, Guntur, Vizianagaram, Kurnool and as small patches in all other districts. Area-wise 32% of the state is covered by depth to water level of 5 to 10 m bgl (207 wells), predominantly in southern part of the state and in some parts of

Visakhapatnam and Vizianagaram districts. Water level of 10 to 20 m bgl is covered in 22% of the area (96 wells). Water level of 20 to 40 m covers about 7% of the state (13 wells) noticed mostly in Cuddapah, Anantapur, Prakasam, Chittoor, Kurnool, West Godavari, Krishna and Guntur districts. Deeper Water levels of more than 40 m covers about 3% of the state (5 wells) in Cuddapah, Chittoor, Anantapur and Prakasam districts.

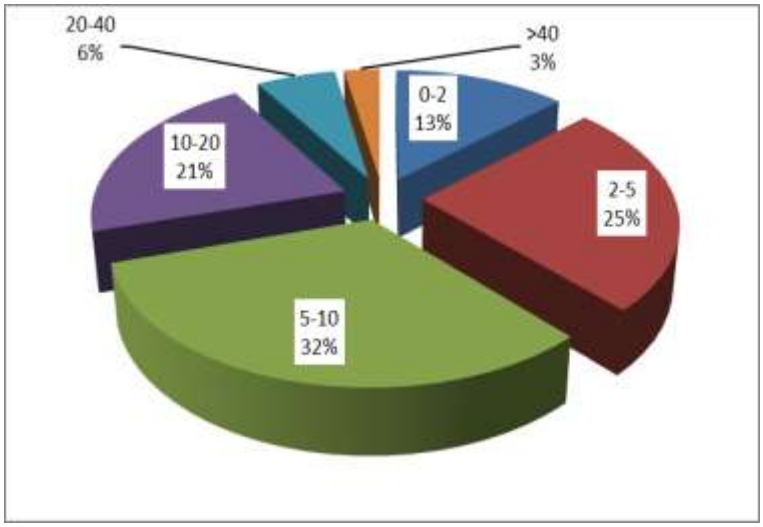


Fig.7.3: Percentage of wells in different depth ranges of DTW-August 2019

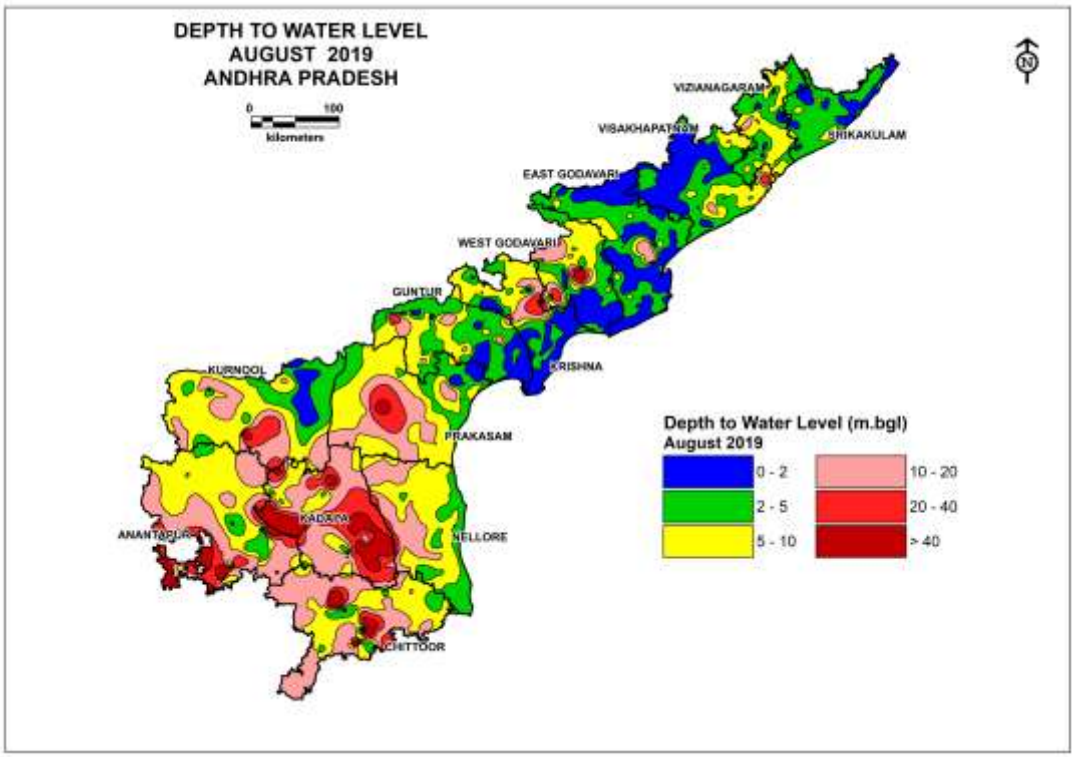


Fig.7.4: Depth to water level August, 2019 in Andhra Pradesh state

7.1.3 Depth to Water Levels - Post-Monsoon Season (November, 2019)

The depth to water level during November, 2019 based on analysis of water level data of 710 wells is generalized and given below. Distribution of wells in different depth ranges is depicted in pie diagram **Fig.7.5**. and depth to water level map is given in **Fig 7.6**.

Analysis of depth to water level data of 710 wells **(Annexure - VII**) shows water levels vary between -0.64 m.bgl (Prakasam district) and 65.86 m.bgl (Cuddapah district). The average water level of the state is 3.5 m bgl. Water level of less than 2 m bgl is recorded in 48 % of wells, between 2-5 m bgl in 29% of wells, between 5-10 m bgl in 15% of wells, between 10-20 m bgl in 7% of wells, between 20-40 m bgl in 2% of wells and in the rest 0.4 % of wells depth to water level more than 40 m bgl is registered. Depth to water level map of November, 2019 (**Fig.5**) shows that , Shallow water levels of less than 2 m bgl are noticed mainly in central and northern part covering an area of 29% (343 wells). Water level 2 to 5 m bgl is covered in 37% of the area (203 wells). Area-wise 25% of the state is covered by depth to water level of 5 to 10 m bgl (103 wells). Water level 10 to 20 m bgl is covered in 7% of the area (47 wells). Deeper water levels of more than 20 m covers about 2% of the state (14 wells) noticed mostly in Cuddapah, Prakasam, and Krishna districts.

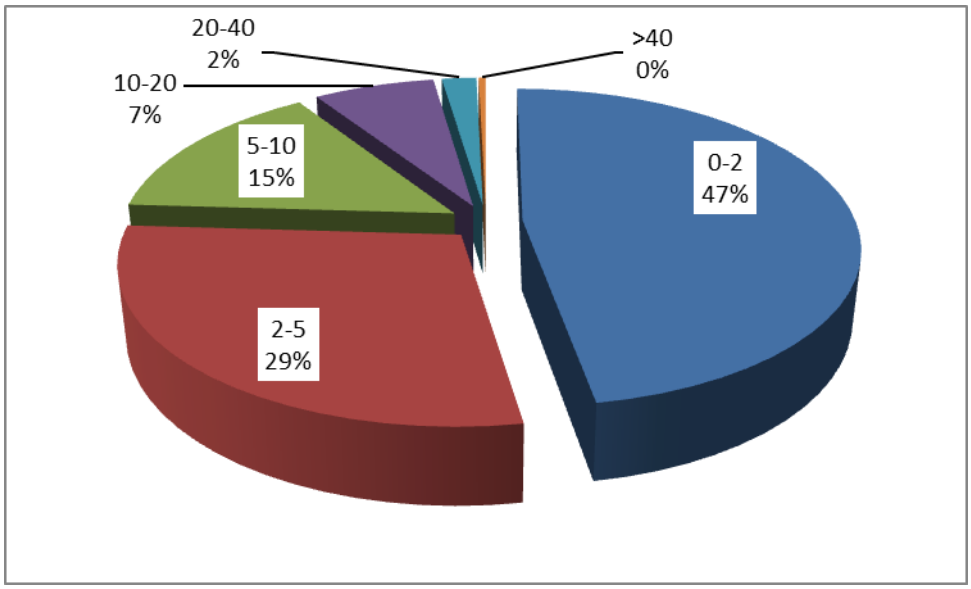


Fig.7.5: Percentage of wells in different depth ranges of DTW-November 2019

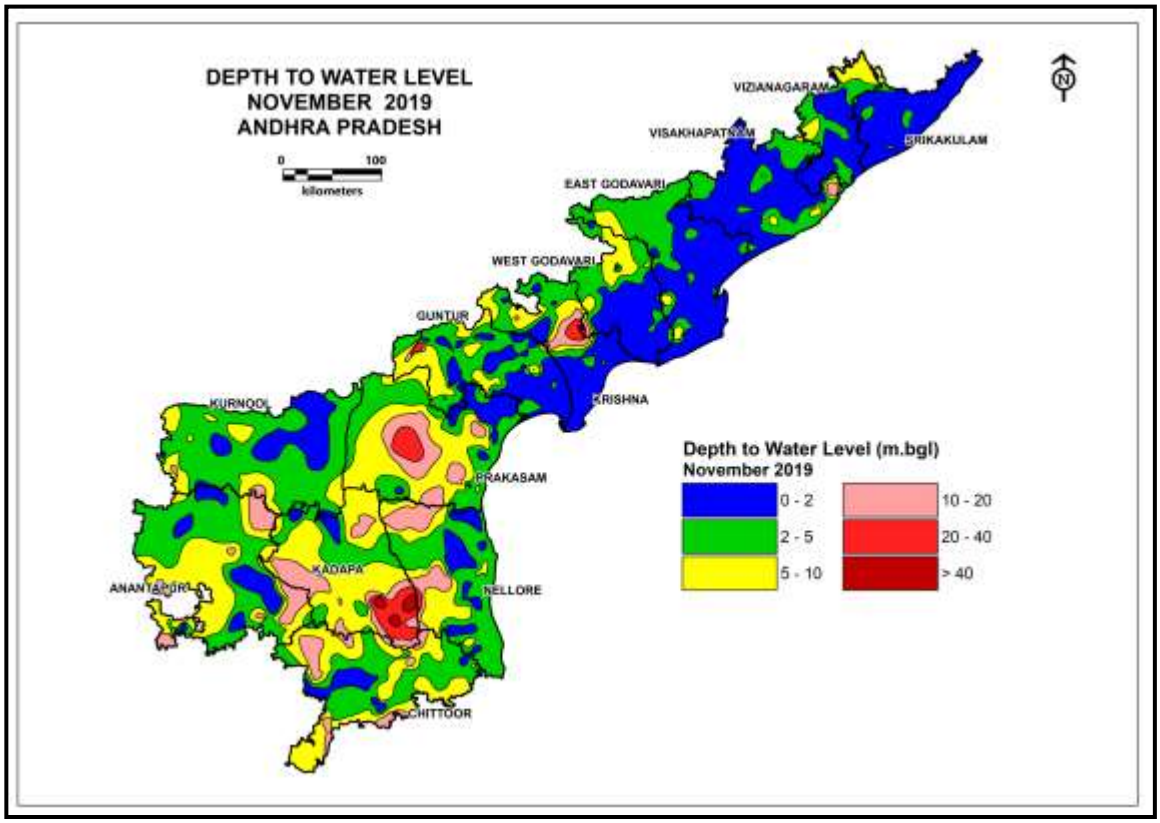


Fig.7.6: Depth to water level November, 2019 in Andhra Pradesh state

7.1.4 Depth to Water Levels (January, 2020)

The depth to water level during January, 2019 based on analysis of water level data of 714 wells is generalized and given below. Distribution of wells in different depth ranges is depicted in pie diagram **Fig-7.7**. and depth to water level map is given in **Fig-7.8**.

Analysis of depth to water level data of 714wells **(Annexure - VIII**) shows water levels vary between 0.1 m.bgl (Prakasam district) and 58.4 m.bgl (Kadapa district). Water level of less than 2 m bgl is recorded in 32 % of wells, between 2-5 m bgl in 40% of wells, between 5-10 m bgl in 18% of wells, between 10-20 m bgl in 7% of wells, between 20-40 m bgl in1% of wells and in the rest 1 % of wells depth to water level more than 40 m bgl is registered. Depth to water level map of January 2020 (**Fig-7.8**.) shows that, Shallow water level of less than 2m bgl is covered in 16% area (232 wells) of West Godavari, East Godavari, Nellore and Vishakhapatnam districts. Water level 2 to 5 m bgl is covered in 47% of the area (289 wells). Area wise 28% of the state is covered by depth to water level of 5 to 10 m bgl (131 wells). Water level 10 to 20 m

bgl is covered in 9% of the area (48 wells). Deeper water levels of more than 20 m covers about 1% of the state (10 wells) noticed mostly in Kadapa, Prakasam, Guntur and Krishna districts.

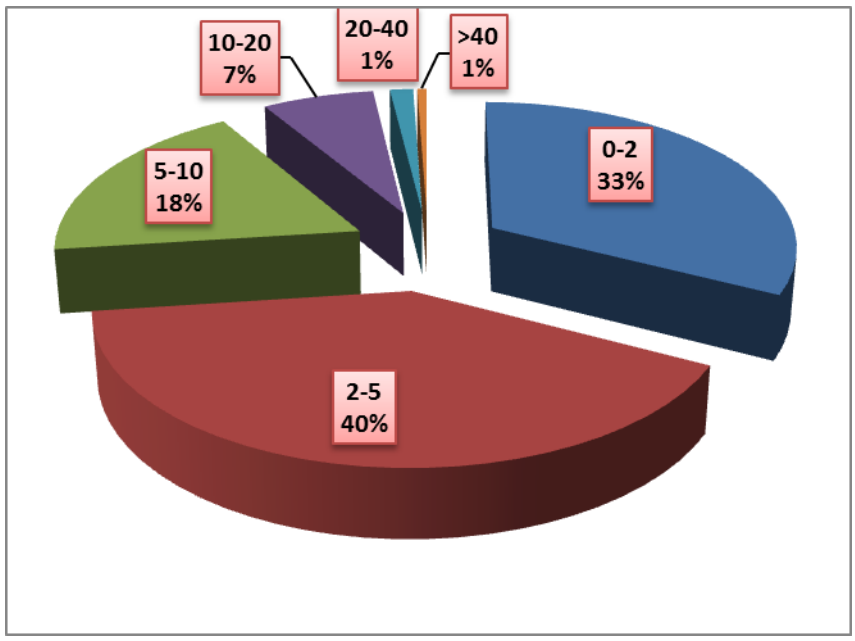


Fig.7.7: Percentage of wells in different depth ranges of DTW-January 2020

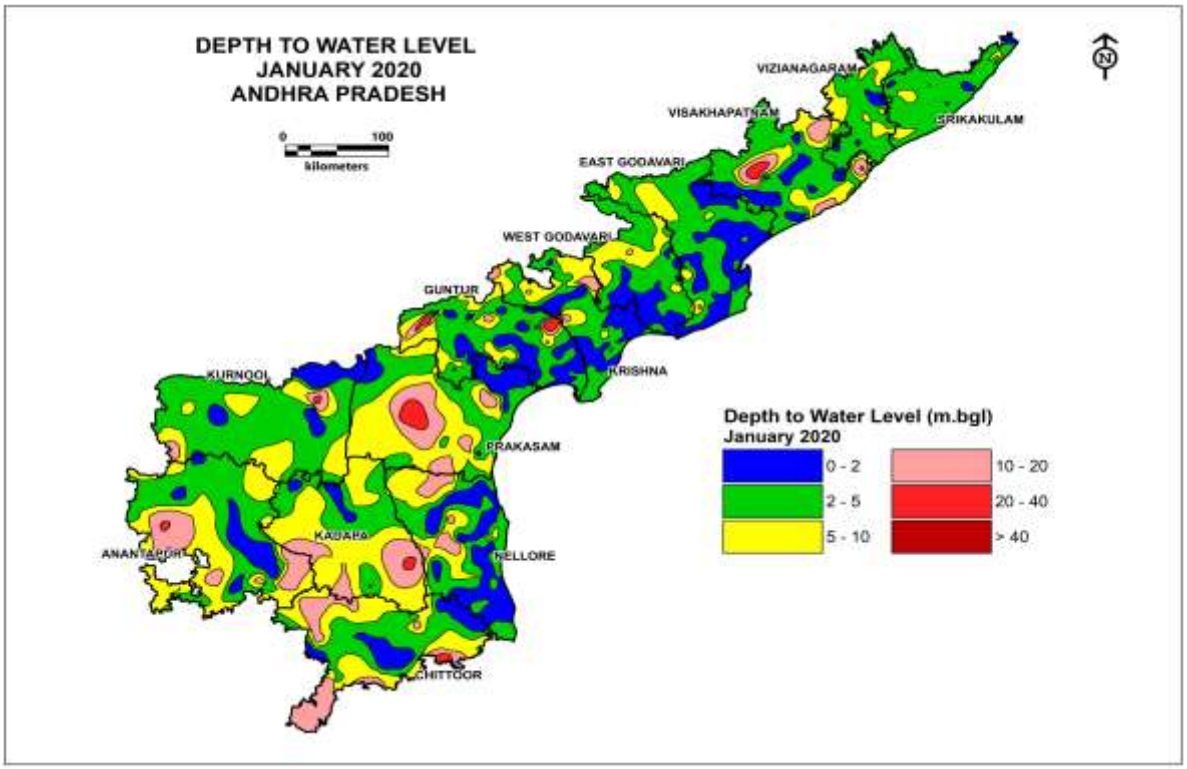


Fig.7.8: Depth to water level January, 2020 in Andhra Pradesh state

7.2 Integrated Depth to Water Level (GWD and CGWB)

The water level data of monitoring stations (Piezometers only) of Central Ground Water Board and Groundwater and Water Audit Department of Andhra Pradesh state are considered together to analyze the water level data of the monitoring stations in the state.

7.2.1 May 2019 (Pre-monsoon)

Water level data from a total of 1294 station, out of which, 1229 stations of State GWD and 58 of CGWB are utilized for preparing the depth to water level map **(Fig 7.9)** and the depth to water levels and percentage of wells in different depth ranges in May 2018. Based on the tabulated **(Table 7.1)** results, it is inferred that, out of 1294 stations, depth to water level of 27 stations (2%) are in the range of 0 to 2 m bgl, 203 stations (16%) are in the range of 2 to 5 m bgl, 345stations (27%) are in the range of 5 to 10 m bgl, 353 stations (27%) are in the range of 10 to 20 m bgl, 243 stations (19%) are in the range of 20 to 40 m bgl and depth to water level of 123 stations (10%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 29 % of wells and shallow water level of less than 2 m bgl are observed in 2 % of wells. Area-wise, 31% of the state have deeper water levels(>20 m bgl) and only 1% of the area has shallow water levels. Medium range 5-20 m bgl is observed in 68% of the area.

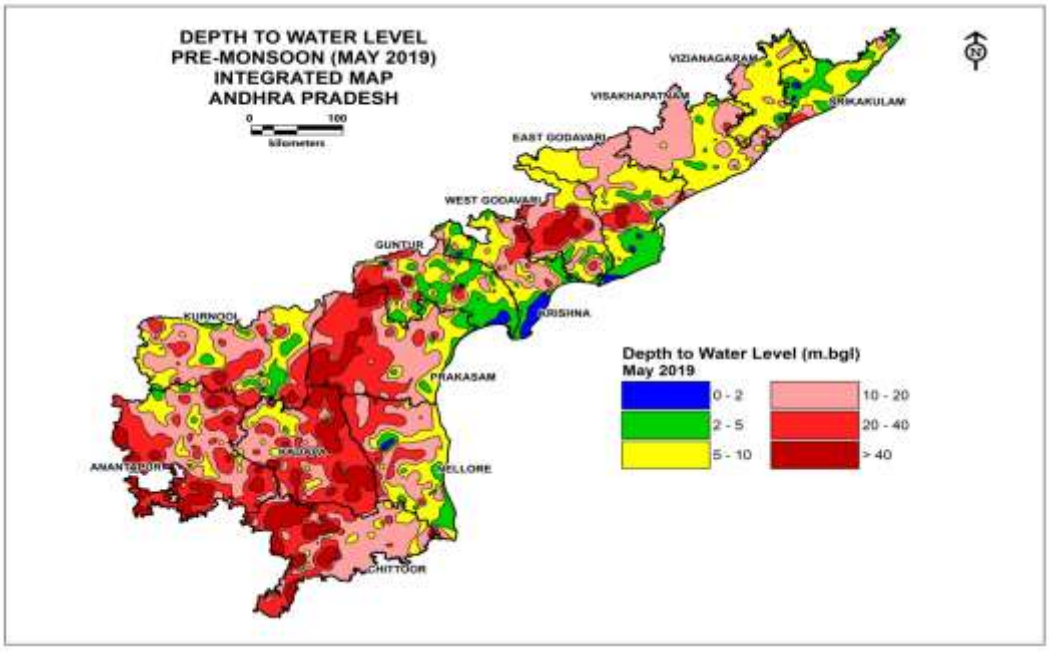


Fig 7.9 Depth To Water Level Map of May 2019 (Integrated data)

TABLE 7.1: Depth to water levels and percentage of wells in different depth ranges in May-2019															
S NO	**DISTRICT**	**NO OF WELLS**	**MIN**	**0 TO 2**	**% OF WELLS**	**2 TO 5**	**% OF WELLS**	**5 TO 10**	**% OF WELLS**	**10 TO 20**	**% OF WELLS**	**20 TO 40**	**% OF WELLS**	**> 40**	**% OF WELLS**
1	Anantapur	155	2.4	0	0%	6	4%	22	14%	46	30%	53	34%	28	18%
2	Chittoor	113	1.12	1	1%	3	3%	18	16%	42	37%	27	24%	22	19%
3	East Godavari	97	0.59	5	5%	27	28%	34	35%	16	16%	13	13%	2	2%
4	Guntur	127	0.57	7	6%	45	35%	33	26%	25	20%	9	7%	8	6%
5	Kadapa	116	3.318	0	0%	4	3%	16	14%	32	28%	33	28%	31	27%
6	Krishna	111	1.28	4	4%	23	21%	41	37%	28	25%	13	12%	2	2%
7	Kurnool	153	0.299	4	3%	33	22%	44	29%	40	26%	28	18%	4	3%
8	Nellore	93	0.832	2	2%	13	14%	30	32%	29	31%	17	18%	2	2%
9	Prakasam	100	2.404	0	0%	10	10%	15	15%	31	31%	30	30%	14	14%
10	Srikakulam	38	1.225	2	5%	15	39%	15	39%	5	13%	1	3%	0	0%
11	Visakhapatnam	75	2.018	0	0%	11	15%	31	41%	29	39%	4	5%	0	0%
12	Vizianagaram	45	1.691	1	2%	6	13%	27	60%	11	24%	0	0%	0	0%
13	West Godavari	71	1.86	1	1%	7	10%	19	27%	19	27%	15	21%	10	14%
14	**State Figures**	**1294**	**0.18**	**27**	2%	**203**	16%	**345**	27%	**353**	27%	**243**	19%	**123**	10%

7.2.2 Post-monsoon (November 2019)

The water level data of monitoring stations (Piezometers only) of Central Ground Water Board and State Ground Water Board are considered together to analyze the water level data of the monitoring stations in the state. Water level data from a total of 1294 station, out of which, 1229 stations of State GWD and 58 of CGWB are utilized for preparing the depth to water level map **(Fig 7.10)** and the depth to water levels and percentage of wells in different depth ranges in Nov 2019. Based on the tabulated results**(Table 7.2)**, it is inferred that, out of 1294 stations, depth to water level of 208 stations (16%) are in the range of 0 to 2 m bgl, 329 stations (26%) are in the range of 2 to 5 m bgl, 294 stations (23%) are in the range of 5 to 10 m bgl, 262 stations (20%) are in the range of 10 to 20 m bgl, 136 stations (11%) are in the range of 20 to 40 m bgl and 58 stations (5%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 16 % of wells and shallow water level of less than 2 m bgl are observed in 16% of wells Area-wise, 15% of the state have deeper water levels(>20 m bgl) and only 3% of the area has shallow water levels. Medium range 5-20 m bgl is observed in 82% of the area.. The increase in deeper water levels is mostly observed in southern parts of the state where less monsoon rainfall is received.

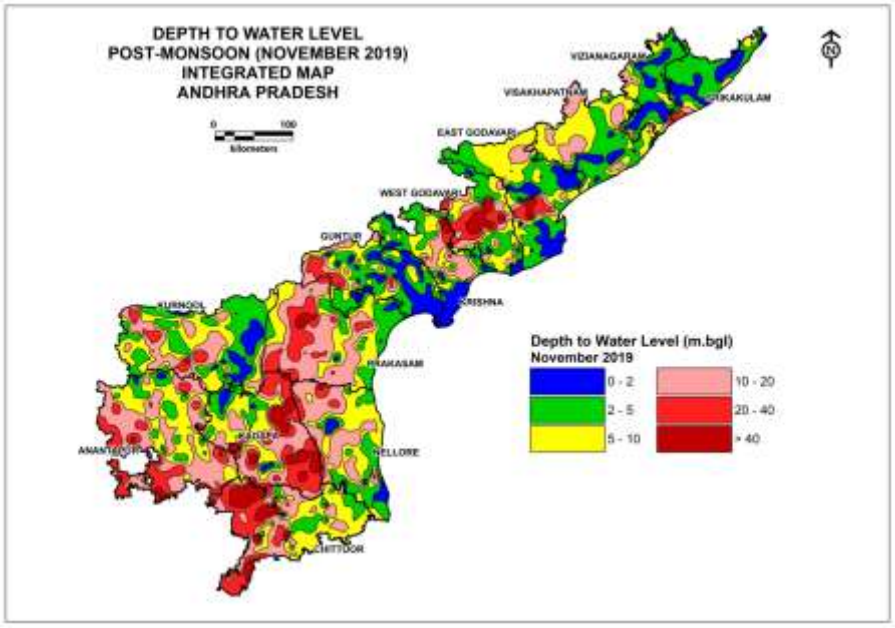


Fig 7.10 Depth To Water Level Map of Nov 2019 (Integrated data)

Table 7.2 : Depth to water levels and percentage of wells in different depth ranges in November 2019

S NO	DISTRICT	NO OF WELLS	MIN	0 TO 2	% OF WELLS	2 TO 5	% OF WELLS	5 TO 10	% OF WELLS	10 TO 20	% OF WELLS	20 TO 40	% OF WELLS	> 40	% OF WELLS
1	Anantapur	150	1.12	6	4%	21	14%	40	27%	45	30%	32	21%	6	4%
2	Chittoor	113	0.26	7	6%	21	19%	19	17%	34	30%	17	15%	15	13%
3	East Godavari	97	0.07	27	28%	32	33%	21	22%	7	7%	8	8%	2	2%
4	Guntur	126	0.37	45	36%	35	28%	24	19%	14	11%	6	5%	2	2%
5	Kadapa	116	0.18	6	5%	13	11%	33	28%	22	19%	25	22%	17	15%
6	Krishna	111	0.36	21	19%	32	29%	23	21%	24	22%	8	7%	3	3%
7	Kurnool	154	0	30	19%	55	36%	38	25%	23	15%	6	4%	2	1%
8	Nellore	92	0.43	9	10%	21	23%	30	33%	29	32%	2	2%	1	1%
9	Prakasam	99	0.87	7	7%	19	19%	19	19%	33	33%	19	19%	2	2%
10	Srikakulam	38	0.51	14	37%	19	50%	3	8%	1	3%	1	3%	0	0%
11	Visakhapatnam	76	0.25	15	20%	25	33%	23	30%	12	16%	1	1%	0	0%
12	Vizianagaram	45	0.387	17	38%	16	36%	8	18%	4	9%	0	0%	0	0%
13	West Godavari	70	1.33	4	6%	20	29%	13	19%	14	20%	11	16%	8	11%
14	**State Figures**	**1287**		**208**	16%	**329**	26%	**294**	23%	**262**	20%	**136**	11%	**58**	5%

7.3 Fluctuations with Pre-Monsoon Water Levels

7.3.1 Water Level Fluctuation- From May, 2019 to Aug 2019

Water level fluctuations during August 2019 from May 2019 are presented in **Annexure-IX.** Analysis of 697 wells shows that water level rise is recorded in 69% wells (478 nos) and fall is recorded in 16% wells (110). Spatial distribution is given in **Fig 7.11.** In the state about 77% of the area (478wells) experienced rise in water levels compared to the pre-monsoon period (May'19). Out of the 478 wells, 67 % of wells have recorded less than 2m rise, 23% of wells in the range of 2 to 4 m while 10% of wells recorded water level rise of more than 4 m. Rise in water level of less than 2 m is observed in all districts, mainly in the northern part of the state falling in Visakhapatnam, Srikakulam, Vizianagaram, Guntur, Krishna, Prakasam, East Godavari, West Godavari, Anantapur, Kurnool and Kadapa districts. Water level rise of 2-4 m is observed mainly in Prakasam, Kurnool, Srikakulam, Vizianagaram, Guntur, Krishna, East Godavari, Visakhapatnam and Vizianagaram districts. Rise of water level more than 4 m is significant and predominant in Visakhapatnam, East Godavari, Guntur, Prakasam, Kadapa, Chittoor and Kurnool districts.

In the state about 23% of the area (110 wells) experienced fall in water levels compared to the pre-monsoon period (May'19). Out of the 110 wells that have registered fall in water levels, 85% of wells have recorded less than 2 m fall, 12% of wells in the range of 2-4 m and the rest 4% wells registered water level fall of more than 4 m. Fall of more than 4 m is observed significantly as patches in parts of Kurnool, Kadapa, Chittoor and Anantapur districts. Fall of 0 to 2 m observed in all parts, mainly in southern part of the state in Kadapa, Chittoor, Kurnool, Nellore, Prakasam, Anantapur and Guntur districts.

The rainfall received during May 2019 to August 2019 is 6% less than the normal rainfall for the same period. In four districts, Anantapur, Chittoor, Kadapa and Vishakapatnam, deficit rainfall caused significant fall in groundwater levels.

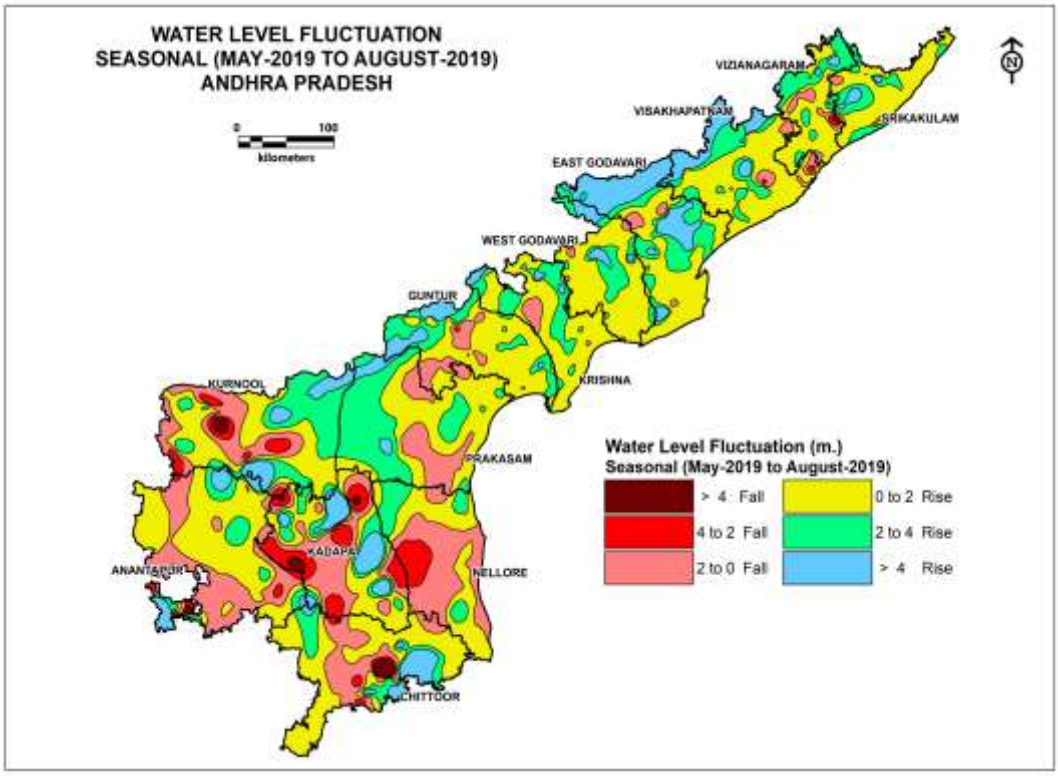


Fig 7.11: Water Level Fluctuation (From May 2019 to August 2019)

7.3.2 Water Level Fluctuation - from May, 2019 to Nov, 2019

The district-wise water level fluctuations from May 2019 to Nov 2019are presented in **Annexure-X** An analysis of 693 wells shows that water level rise is recorded in 91% wells (634 nos) and fall is recorded in 23% wells (16 nos). Rise in water levels is mainly due to normal rainfall received during the period June to October 2019 in north-coastal districts and fall in water levels is mainly due to less rainfall received specially in Rayalaseema region. Spatial distribution water level fluctuation is shown in **Fig 7.12.**

In the state about 98% of the area (634 wells) experienced rise in water levels compared to the pre-monsoon period (May'19). Out of the 634 wells, 37% of wells have recorded water level less than 2m and is observed in all districts especially in West Godavari, East Godavari, Krishna, Guntur, Prakasam, Chittoor and Prakasam districts. Water level rise of 2-4 m is observed in all the districts as patches. Rise of water level more than 4 m is significant and predominant in southern part of the state in Anantapur, Kurnool, Chittoor, Nellore, Kadapa, Prakasam districts and as patches Srikakulam and all other remaining districts. In the state about 2% of the area (16 wells) experienced fall in water levels compared to pre-monsoon period (May'19). Out of the 16 wells that have registered

fall in water levels, 81% of wells have recorded less than 2 m fall and 19 % of wells shows fall more than 4 m. Fall of more than 4 m is observed as small patches in parts of Cuddapah, Krishna and Chitoor districts. Fall of water level less than 2m observed mainly in southern part of the state in Kadapa, Nellore and Chittoor districts

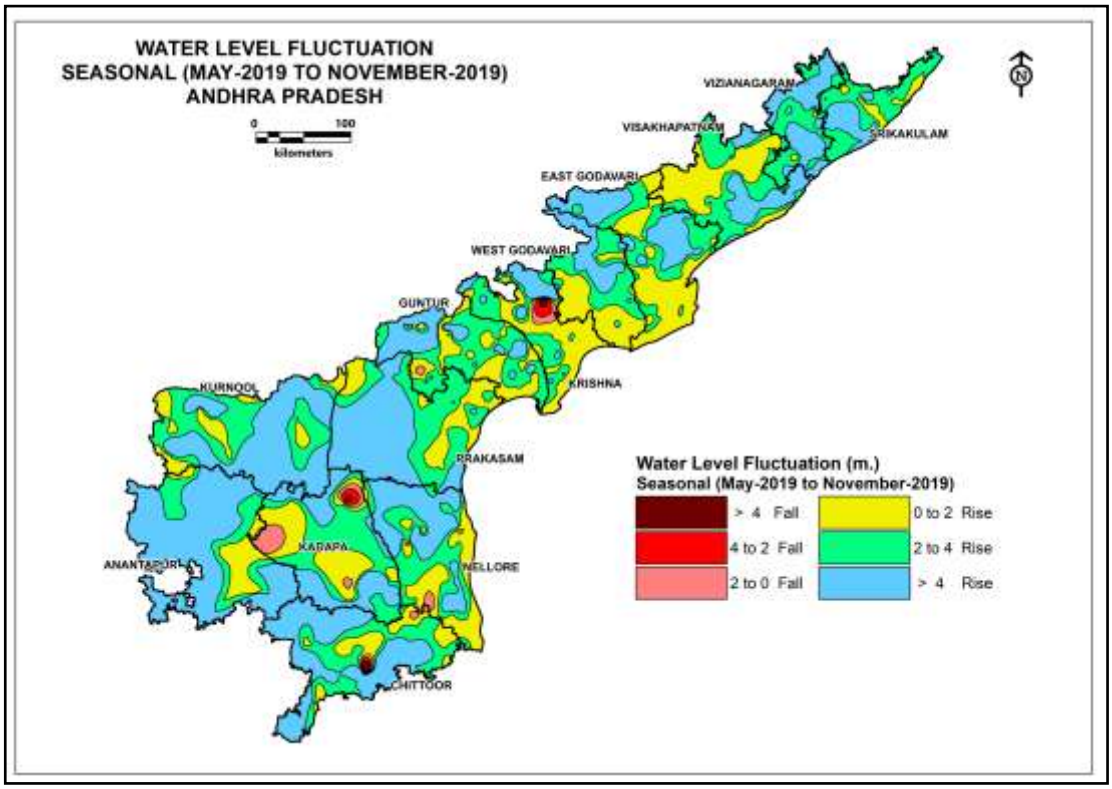


Fig 7.12 Water Level Fluctuation (From May 2019 to November 2019)

7.3.3 Water Level Fluctuation - from May, 2019 to January 2020

The district-wise water level fluctuations from May 2019 to Jan 2020 are presented in **Annexure-XI.** Analysis of 690 wells shows that water level rise is recorded in 90% wells (621 nos) and fall is recorded in 5% wells (33 nos).. Rise in water levels is mainly due to normal rainfall received during the period June to December 2019 in north-coastal districts and fall in water levels is mainly due to less rainfall received specially in Rayalaseema region. Spatial distribution of water level fluctuations is shown in **Fig 7.13.**

In the state about 98% of the area (621 wells) experienced rise in water levels compared to the pre-monsoon period (May'19). Out of the 621 wells, 63% of wells have recorded water level rise less than 2m and is observed in all districts. Water level rise of 2-4 m is observed in all the districts as patches. Rise of water level more than 4 m is significant and predominant in southern part of the state in Anantapur, Kurnool, Chittoor, Nellore, Kadapa, Prakasam districts and as patches in Srikakulam and all the other remaining districts

In the state about 2% of the area (33 wells) experienced fall in water levels compared to pre-monsoon period (May'19). Out of the 33 wells that have registered fall in water levels, 91% of wells have recorded less than 2m fall and 3% of wells shows fall more than 4m. Fall of water level less than 2m observed as small patches in Kadapa, Nellore, Kurnool, Guntur, Srikakulam and Chittoor districts.

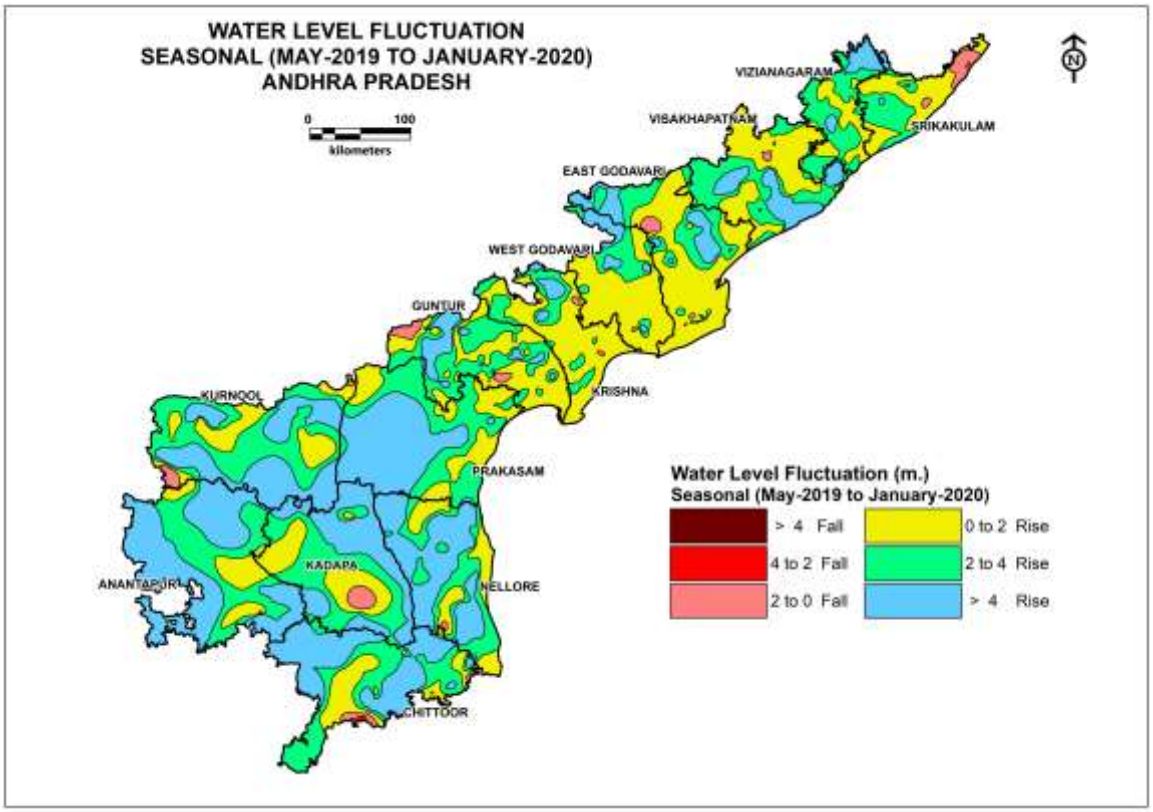


Fig 7.13: Water Level Fluctuation (From May 2019 to January 2020)

7.4 Annual Water Level Fluctuation

7.4.1 Water Level Fluctuation (From May 18 to May, 2019)

Water level fluctuation data of May 2019 with May 2018 is presented in **Annexure - XII.** An analysis of data of 689 wells shows that water level rise is recorded in 29% of wells (199), water level fall is recorded in 59 % of wells (405). The state has experienced fluctuation in the range of -2 to 2 m in about 65% of the wells. Spatial distribution of fluctuation is shown in **Fig 7.14.**

In the state about 29% of the area (199 wells) experienced rise in water levels compared with last year same period. Out of the 199 wells that have registered rise in water level, 81% of wells have recorded less than 2m. 13% of wells in the range of 2 to 4 m while the rest 6% of wells recorded water level rise of more than 4 m. Rise in water level less than 2 m is observed in small parts in all districts. Water level rise of 2-4 m is observed in small

patches all districts except Srikakulam, Vizianagaram, Vishakapatnam, Kadapa and Chittoot districts. Rise of Water level more than 4 m is observed in small parts of Guntur, Krishna, Nellore, Prakasam, and Anantapur districts.

In the state about 59% of the area (405 wells) experienced fall in water levels compared with last year same period (May 2018). Out of the 405 wells that have registered fall in water levels, 70% of wells have recorded less than 2 m, 18% of wells in the range of 2-4 m and the rest 12% wells registered more than 4 m. Fall of more than 4 m is observed significantly observed in Southern districts and small isolated patches in all other districts. Fall of 2 to 4 m is concentrated mainly in southern districts. Fall of 0 to 2 m is observed mainly in Guntur, Kadapa, Prakasam, Chittoor, Kurnool, Nellore Anantapur, Visakhapatnam, Vizianagaram, and small areas in all other districts.

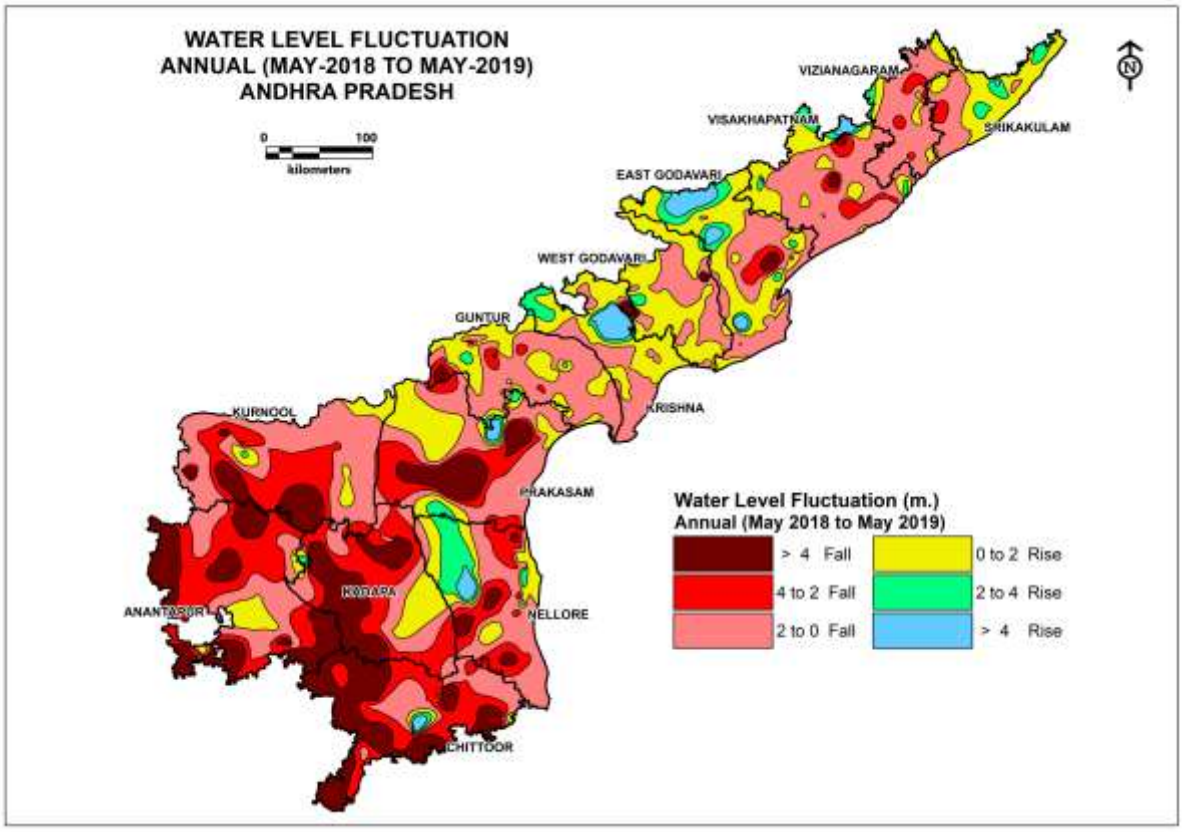


Fig.7.14: Water Level Fluctuations from May-2018 to May-2019

7.4.2 Water Level Fluctuation (August-2019 from August-2018)

Water level fluctuation data of August 2018 from August 2017 is presented in **Annexure-XIII.** Analysis of data of 682 wells shows that water level rise is recorded in 24% of wells (166), water level fall is recorded in 67% of wells (455). The state has experienced

fluctuation in the range of -2 to 2 m in about 66% of the wells. Spatial distribution of fluctuation is shown in **Fig 7.15.**

In the state about 21% of the area (166 wells) experienced rise in water levels compared with last year same period. Out of the 166 wells that have registered rise in water level, 83% of wells have recorded less than 2m. 10% of wells in the range of 2 to 4 m. while the rest 7% of wells recorded water level rise of more than 4 m. Rise in water level less than 2 m. is observed in all districts, mainly in Kurnool, Anantapur, Nellore, Prakasam, Visakhapatnam, East Godavari, West Godavari, Krishna, Chittoor and Guntur districts. Water level rise of 2-4 m is observed as small patches in Nellore, Anantapur, Prakasam, Guntur, Krishna, East Godavari and West Godavari districts. Rise of Water level more than 4 m is observed mainly in Krishna, Nellore, Prakasam, Krishna, Kurnool, Kadapa and Anantapur districts.

In the state about 79% of the area (455 wells) experienced fall in water levels compared with August-2018. Out of the 455 wells that have registered fall in water levels, 69% of wells have recorded less than 2 m, 19% of wells in the range of 2-4 m. and the rest 12% wells registered more than 4 m. Fall of more than 4 m. is observed significantly in southern part of the state in parts of Kadapa, Prakasam, Chittoor, Kurnool, Nellore Anantapur, Krishna, West Godavari, Visakhapatnam and Vizianagaram districts. Fall of 2 to 4 m. is concentrated mainly in Kadapa, Kurnool, Anantapur, Chittoor, Nellore, Srikakulam, Visakhapatnam, Vizianagaram, Guntur, Krishna and Prakasam districts. Fall of 0 to 2 m is observed in all districts.

Annual rainfall of 18-19 is ~25% less than the preceding year annual rainfall (17-18), because of which fall in water levels is recorded in 73% of wells when compared for annual fluctuation.

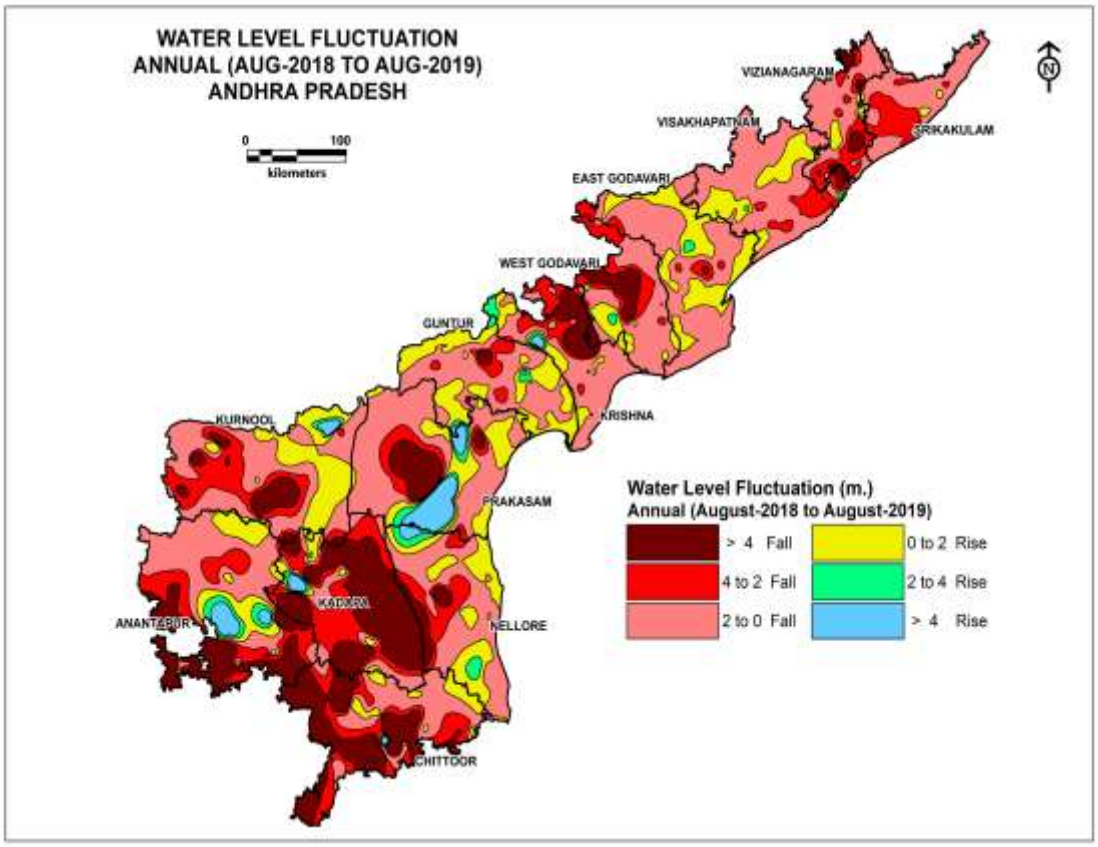


Fig. 7.15: Water Level Fluctuations (August 2018 from August 2019)

7.4.3 Water Level Fluctuations (November 2019 from November 2018)

The district-wise water level fluctuations from November 2017 to November 2018 are presented in **Annexure-XIV.** An analysis of data of 689 wells shows that water level rise is recorded in 83% of wells (574), water level fall is recorded in 12% of wells (81). Spatial distribution of water level fluctuations is presented in **Fig 7.16.**

In the state about 90% of the area (574 wells) experienced rise in water levels compared with last year same period. Out of the 574 wells that have registered rise in water level, 70 % of wells have recorded water level less than 2m. 19% of wells in the range of 2 to 4 m. while 11% of wells recorded water level rise of more than 4 m. Rise in water level less than 2 m. is observed predominantly in all the districts. Water level rise of 2-4 m. is observed as small patches in all districts. Rise of Water level more than 4 m. is observed mainly in southern districts Anantapur, Kurnool, Nellore, Kadapa, Prakasam and Chittoor districts. All the districts predominantly shows rise in water level due to good rainfall.

In the state about 10% of the area (81 wells) experienced fall in water levels compared with last year same period (November -2018). Out of the 81 wells that have

registered fall in water levels, 74% of wells have recorded less than 2 m, 7% of wells in the range of 2-4 m and the rest 19% wells registered more than 4 m. Fall of more than 4 m is observed significantly as small patches in parts of Prakasam, Nellore, Cuddapah, Krishna, West Godavari, Kurnool and Chittoor districts. Fall of 2 to 4 m is observed mainly in Cuddapah, Nellore, Prakasam, Chittoor, Anantapur, Krishna and West Godavari districts. Fall of 0 to 2 m is observed as very small scattered patches in all districts.

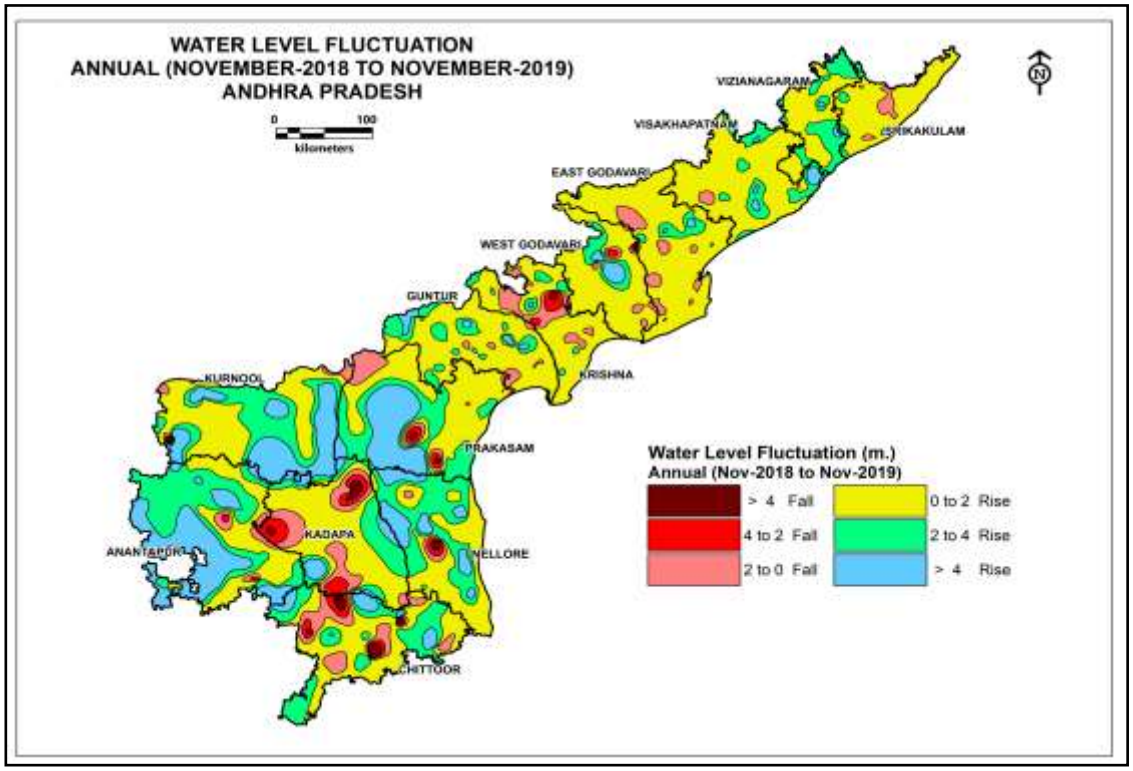


Fig.7.16 : Water Level Fluctuations (November 2019 from November 2018)

7.4.4 Water Level Fluctuations (January-2020 from January-2019)

The district-wise water level fluctuations from January 2019 to January 2020 are presented in **Annexure-XV.** Analysis of data of 689 wells shows that water level rise is recorded in 68% of wells (466), water level fall is recorded in 28% of wells (196). Spatial distribution of water level fluctuations is given in **Fig 7.17.**

In the state about 82% of the area (466 wells) experienced rise in water levels compared with last year same period. Out of the 466 wells that have registered rise in water level, 69 % of wells have recorded water level less than 2m. 17% of wells in the range of 2 to 4 m. while 14% of wells recorded water level rise of more than 4m. Rise in water level less than 2 m is observed predominantly in all the districts. Water level rise of 2-4 m is observed as small patches in all districts. Rise of Water level more than 4m is observed mainly in

southern districts Anantapur, Kurnool, Nellore, Kadapa, Prakasam and Chittoor districts. All the districts predominantly shows rise in water level due to good rainfall.

In the state about 18% of the area (196 wells) experienced fall in water levels compared with last year same period (January 2020). Out of the 196 wells that have registered fall in water levels, 92% of wells have recorded less than 2 m, 4% of wells in the range of 2-4 m and the rest 4% wells registered more than 4 m. Fall of more than 4 m is observed significantly as small patches in parts of Nellore, Anantapur, Chittoor and Kurnool districts. Fall of 2 to 4 m is observed mainly in Kadapa, Chittoor, Anantapur and Nellore districts. Fall of 0 to 2 m is observed as very small scattered patches in all districts.

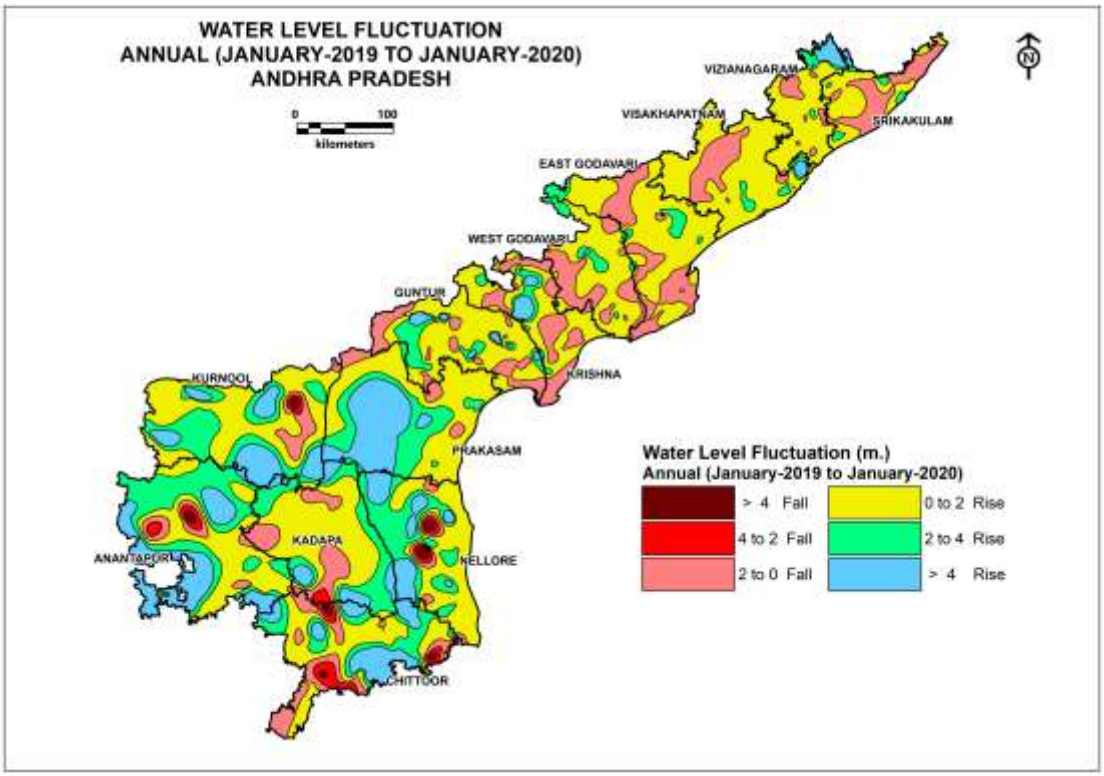


Fig. 7.17: Water Level Fluctuations (January, 2020 from January, 2019).

7.5 Decadal Water Level Fluctuations

7.5.1 Water Level Fluctuations-Decadal mean of May (2009-18) to May 2019

Water level fluctuation data of May 2019 from Decadal Mean of May (2009-2018) is presented in **Annexure - XVI** Analysis of data of 713 wells shows that water level rise is recorded in 28% wells (198 wells), water level fall is recorded in 72% wells (513 wells). Water Level Fluctuations from Decadal Mean of May (2009-2018) to May-2019 is depicted in **Fig. 7.18**.

Area-wise, 18% of the state experienced water levels rise compared with the decadal mean of May (2009-18). Out of 198 wells, water level rise of less than 2 m is recorded in 85% wells, in the range of 2-4 m in 9% wells. Rise of water level more than 4 m is observed in 6% of the wells, covering only 1% of the area and observed in Krishna, Anantapur, Srikakulam, Vishakapatnam and Vizianagaram districts. Rise in water level of less than 2 m is observed as small patches in Anantapur, Kurnool and small parts in north coastal districts. Water level rise of 2-4 m is observed in Srikakulam, Vishakapatnam, Vizianagaram and Krishna districts.

In the state about 82% of the area experienced fall in water levels compared with decadal mean (2009-2018). Out of the 513 wells that have registered fall in water levels, 67% have recorded less than 2 m, 24% in the range of 2-4 m and 10% wells registered water level fall of more than 4 m. Fall of less than 2 m is observed in major parts in all districts. Fall of 2 to 4 m is observed in major parts in southern districts and small parts in nortrh coastal districts. Fall of more than 4 m is observed significantly in parts of Prakasam, Anantapur, Kadapa, Chittoor, Guntur and Krishna districts.

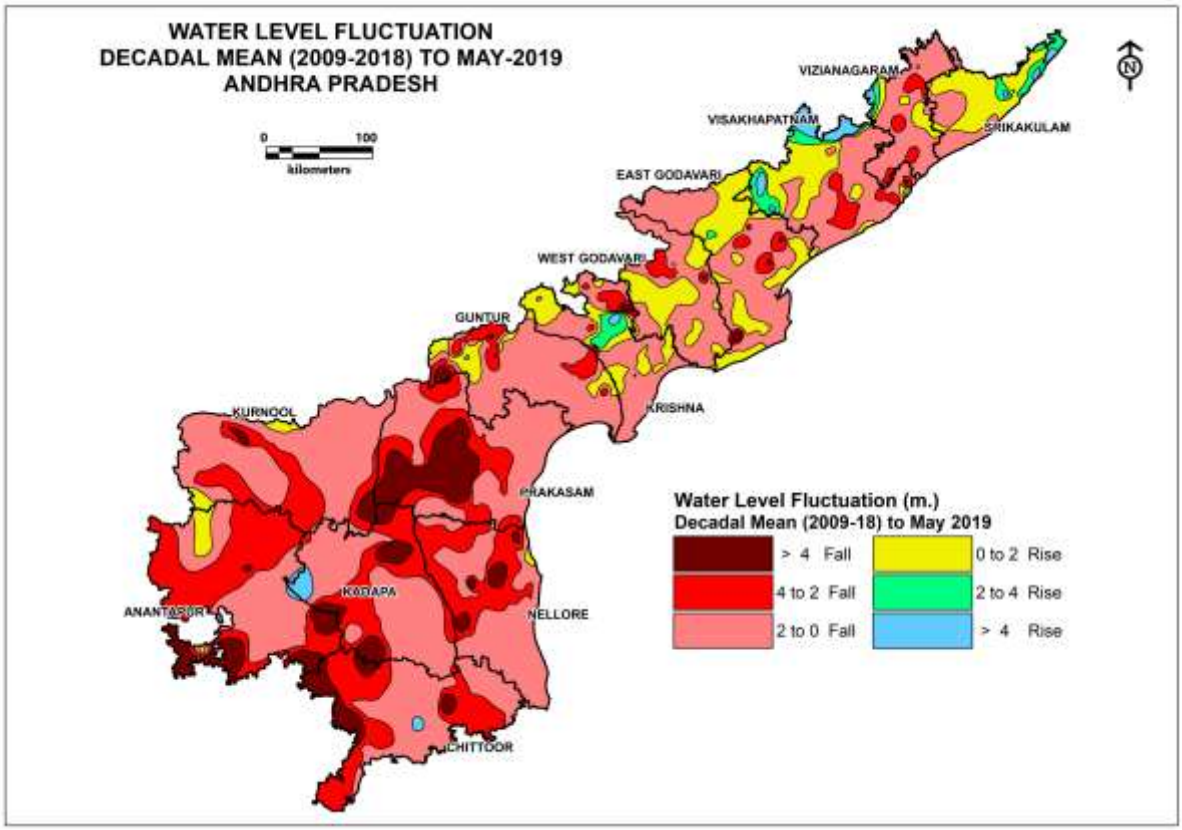


Fig.7.18: Water Level Fluctuations - Decadal Mean of May (2008-2017) to May-2018

7.5.2 Water Level Fluctuations-Decadal Mean of August (2009-2018) to August 2019

Water level fluctuation of August, 2018 from Decadal mean of August (2009-2018) is presented in **Annexure-XVII.** **S**patial distribution of fluctuation is presented in **Fig 7.19**. Analysis of data of 715 wells shows that water level rise is recorded in 32% wells (230 wells), water level fall is recorded in 68% wells (483 wells).

Area-wise, 29% of the state experienced water levels rise compared with the decadal mean of August (2009-18). Out of 230 wells, water level rise of less than 2 m is recorded in 86% wells, in the range of 2-4 m in 11% wells. Rise of water level more than 4 m is observed in 3% of the wells, covering only less than 1% of the area and observed in Chittoor, Krishna and West Godavari districts. Rise in water level of less than 2 m is observed predominantly in Anantapur, Kurnool, Vishakhapatnam, East Godavari, Kadapa, Chittoor, Guntur, Srikakulam and West Godavari. Water level rise of 2-4 m is observed in Anantapur, Prakasam, Kadapa, Kurnool, Guntur, Krishna, West Godavari and Srikakulam districts.

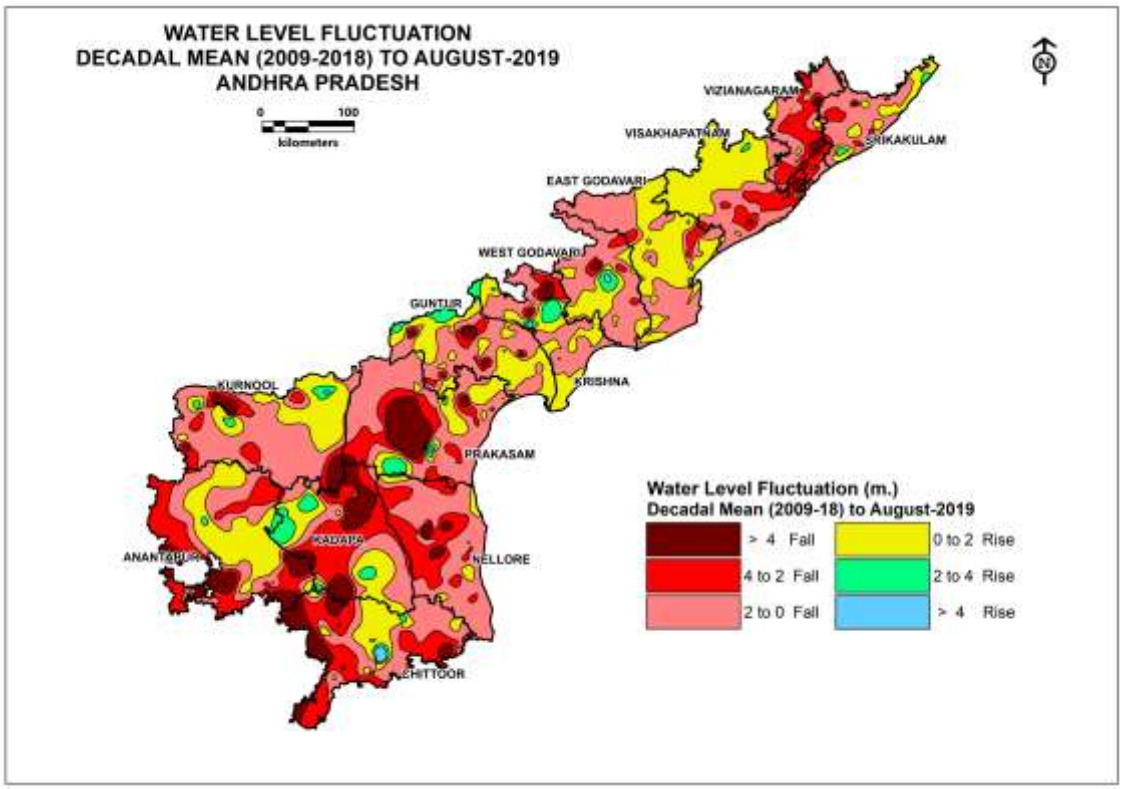


Fig. 7.19: Water Level Fluctuation - Decadal Mean (2009-2018) to August-2019.

In the state about 71% of the area experienced fall in water levels compared with decadal mean (2009-2018). Out of the 483 wells that have registered fall in water levels, 62%

have recorded less than 2 m, 27% in the range of 2-4 m and 11% wells registered water level fall of more than 4 m. Fall of less than 2 m is observed in all districts. Fall of 2 to 4 m is observed mainly in Kadapa, Anantapur, Kurnool, Chittoor, Nellore, Prakasam Srikakulam, Visakhapatnam and Vizianagaram districts. Fall of more than 4 m is observed significantly in parts of Prakasam, Anantapur, Kadapa, Chittoor, Guntur, Krishna, Visakhapatnam and Vizianagaram districts.

7.5.3 Water Level Fluctuation-Decadal Mean of Nov (2009-2018) to Nov, 2019

District-wise water level fluctuations from decadal mean of Nov (2009-18) to Nov 2019 is presented in **Annexure-XVIII.** Spatial distribution of fluctuations as **Fig 7.20**. Analysis of data of 701 wells shows that water level rise is recorded in 71% wells (496 wells), water level fall is recorded in 29% wells (204 wells).

Area-wise, 68% of the state experienced water level rise compared with the decadal mean of November (2009-18). Out of 701 wells, water level rise of less than 2 m is recorded in 84% wells, in the range of 2-4 m in 13% wells. Rise of water level more than 4 m. is observed in 3% of the wells, covering small patches in West Godavari, Prakasam, Nellore, Kurnool and Chittoor districts. Rise in water level of less than 2 m is observed in all the districts. Water level rise of 2-4 m is observed significantly in parts of Anantapur, Kurnool, Cuddapah, Srikakulam, Chittoor and Vizianagaram districts.

In the state about 32% of the area experienced fall in water levels compared with decadal mean (2009-2018). Out of the 204 wells that have registered fall in water levels, 70% have recorded less than 2 m, 16% in the range of 2-4 m. and 14% wells registered water level fall of more than 4 m. Fall of less than 2 m. is observed as small patches in all districts. Fall of 2 to 4 m. is observed mainly in Cuddapah, Nellore, Anantapur, Prakasam and Chittoor districts. Fall of more than 4 m. is observed significantly in parts of Prakasam, Kadapa, Chittoor and Nellore districts.

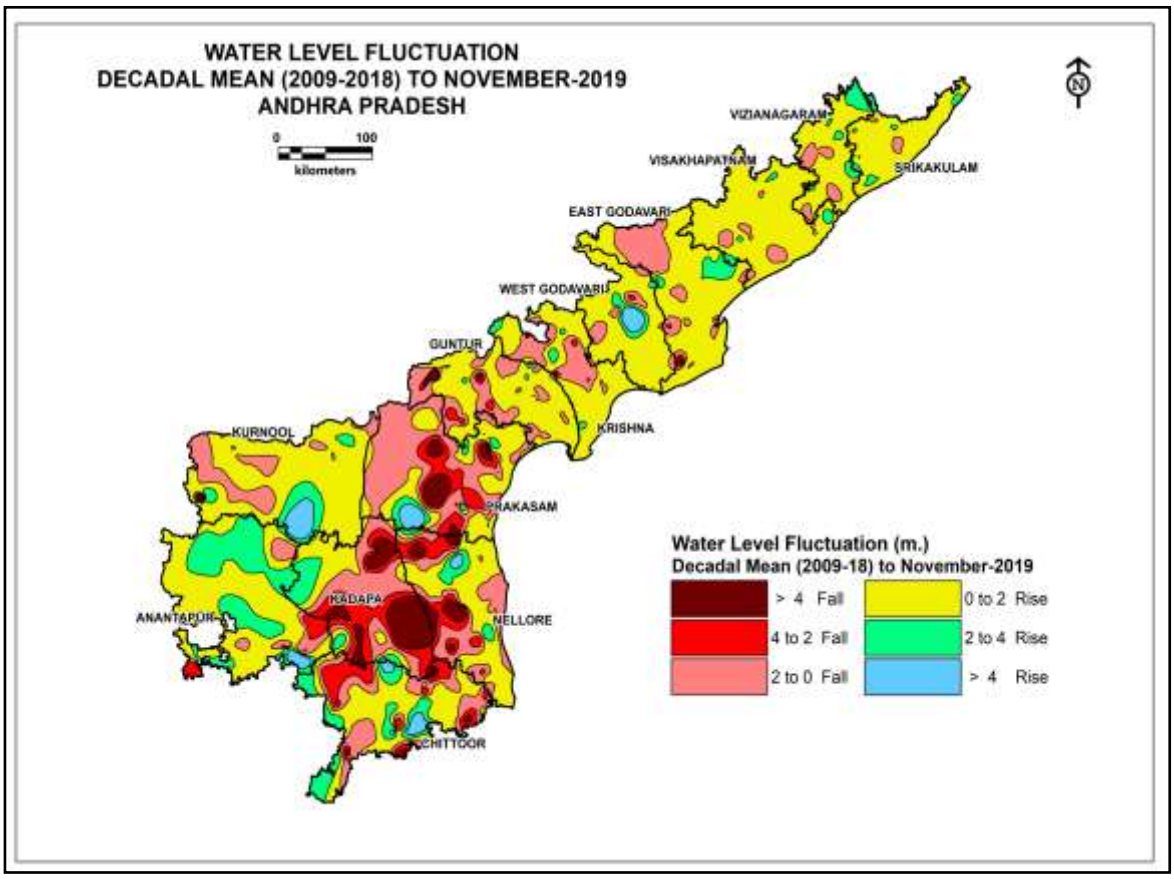


Fig. 7.20: Water Level Fluctuation - Decadal Mean (2009-2018) to November-2019

7.5.4 Water Level Fluctuation- Decadal Mean (2010-2019) to January 2020

District-wise water level fluctuations from decadal mean of Jan (2009-18) to Jan 2019 is presented in **Annexure-XIX.** Analysis of data of 704 wells shows that water level rise is recorded in 61% wells (430wells), water level fall is recorded in 39% wells (273 wells). Spatial distribution of water level fluctuations is presented in **Fig 7.21.**

Area-wise, 61% of the state experienced water level rise compared with the decadal mean of January (2010-19). Out of 704 wells, water level rise of less than 2 m is recorded in 81% wells, in the range of 2-4 m in 14% wells. Rise of water level more than 4m is observed in 5% of the wells, covering small patches in Prakasam, Nellore, Kurnool, Ananthpur, Kadapa and Chittoor districts. Rise in water level of less than 2 m is observed in all the districts. Water level rise of 2-4 m is observed significantly in parts of Anantapur, Kurnool, Kadapa, Srikakulam, Chittoor and Vizianagaram districts.

In the state about 39% of the area experienced fall in water levels compared with decadal mean (2010-2019). Out of the 204 wells that have registered fall in water levels, 80% have recorded less than 2 m, 11% in the range of 2-4 m. and 9% wells registered water level fall of more than 4 m. Fall of less than 2 m is observed as small patches in all districts. Fall of

2 to 4 m is observed mainly in Kadapa, Nellore, Anantapur, Prakasam, Kurnool, East Godavari and Chittoor districts. Fall of more than 4 m. is observed significantly in parts of Prakasam, Kadapa, Chittoor and Nellore districts.

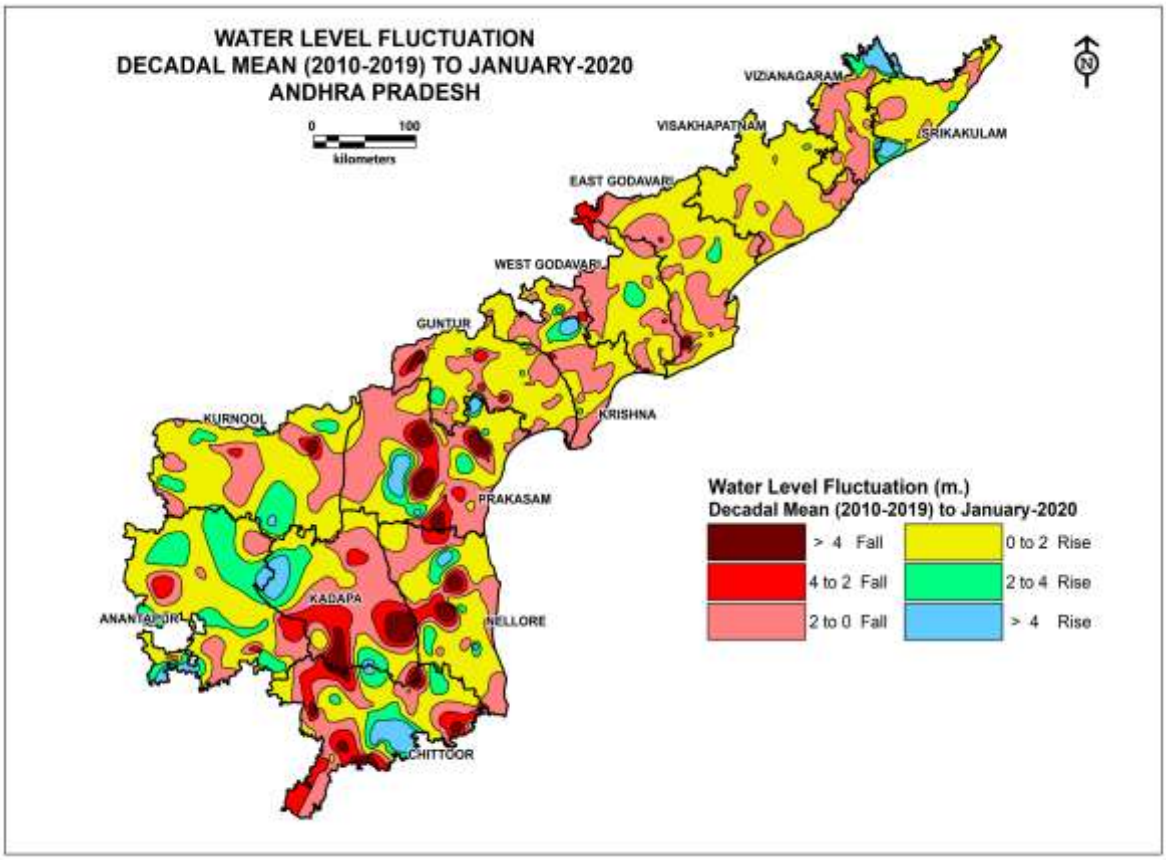


Fig. 7.21: Water Level Fluctuation - Decadal Mean (2010-2019) to January-2020

7.6 Aquifer wise water levels

Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in all the formations except in intrusives. Deepest water levels are observed alluvium, limestone and banded gneissic complex.During post-monsoon season, shallowest water levels are observed in all formations except in intrusives and laterites. Deepest water levels are observed in gneiss, granite, limestone, quartz and sandstone. Aquifer wise water level scenario is presented in **Table-7.3.**

Table-7.3: Aquifer wise Minimum, Maximum and Average values of water levels, Andhra Pradesh State.

Principle Aquifer	Pre-monsoon May 2019			Post-monsoon Nov 2019		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Alluvium	0.31	23.8	3.88	0.02	23.3	2.04
Branded gneissic complex	0.64	23.4	7.99	0.1	18.15	4.55
Chanrockite	2.46	33	11.23	0.74	24.8	8.57
Gneiss	1.21	14.9	5.32	0.1	14.12	2.19
Granite	0.8	14.2	6.27	0.17	7.8	2.07
Khondalite	0.83	18.44	9.52	0.33	12.76	4.28
Limestone	2.11	30.1	6.71	0.1	28.5	3.11
Laterite	0.55	39.5	8.57	0.2	39.5	4.65
Quartzite	2.05	10.52	6.80	0.18	9.54	3.26
Schist	1.05	13.44	7.11	0.63	11.21	4.27
Shales	2.6	23.97	9.04	0.27	17	6.42
Sandstone	3.3	68.53	17.58	0.32	65.86	12.91

7.7 Long-term Water Level trends:

7.7.1 Pre-monsoon trend map:

It is inferred from the pre-monsoon water level trend map that the falling trend in water level of 0-4 m/yr. is observed in 86% of the area and rising trend of 0-3 m / yr. in water level is observed in 14% of the area in the state. Falling trend is recorded at 100 locations and 82 locations have recorded rising trend during May. Falling trend of 0 to 1 m/yr. is more prevalent all the districts. The falling trend of 1 to 2 m/yr is observed in parts of Anantapur, Kurnool, Kadapa, Prakasam, Krishna, Nellore and West Godavari districts as small patches. Falling trend of more than 2 m/yr. is restricted to few locations in Anantapur, Prakasam, Nellore,Krishna and West Godavari districts. Rising trend of 0 to 1 m/yr. is predominant in north coastal districts, Chittoor and small areas in all other districts. Falling trend ranges from 0.003 m/yr. to 3.864 m/yr while rising trend ranges from 0.001 to 2.61 m/yr.

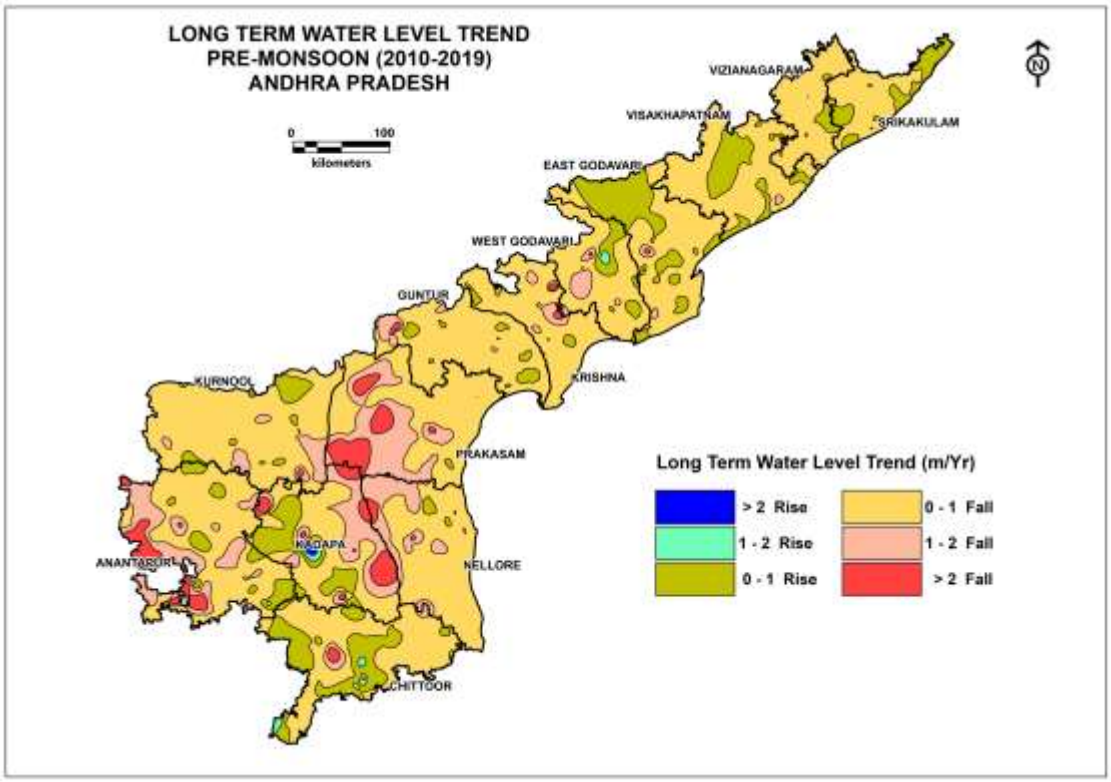


Fig-7.22 Long term water level trend – Pre-monsoon period (2010-2019)

7.7.2 Post-monsoon trend map:

It is inferred from the post-monsoon water level trend map that the falling trend in water level of 0-3.6 m/yr. is observed in 58% of the area and rising trend of 0-2 m / yr. in water level is observed in 42% of the area in the state. Falling trend is recorded at 140 locations and 86 locations have recorded rising trend. Falling trend of 0 to 1 m/yr. is more prevalent in all the districts except Chittoor and Visakhapatnam, where relatively less areas area seen. The falling trend of 1 to 2 m/yr also observed as small patches in all the districts. Falling trend of more than 2 m/yr. is restricted to few locations in all the Kurnool, Kadapa, Chitoor, Srikakulam and Anathpur districts. Rising trend of 0 to 1 m/yr. is predominant in the districts. Falling trend ranges from 0.001 m/yr. to 3.6 m/yr., while rising trend ranges from 0.001 to 3.81 m/yr. Season wise area under Fall and Rise with percentages is given below.

Criteria	Fall	Rise	Fall in % of area	Rise in % of area
	Area (sq.km.)		(%)	
Pre-monsoon	141267	35336	58%	42%
Post-monsoon	23007	69119	86%	14%

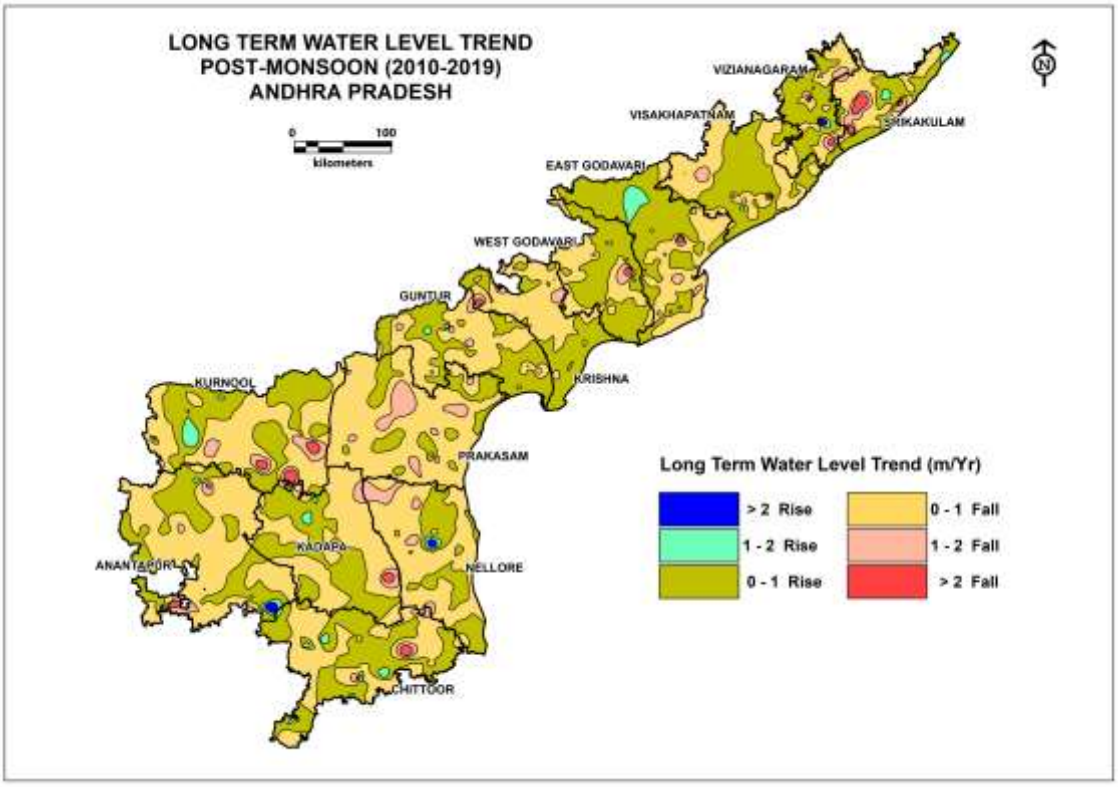


Fig -7.23 Long term water level trend Post-monsoon period (2010-2019)

7.8 Long term water level scenario

To study the change in Ground water scenario, the pre and post monsoon long term water level trend data of 10 years (2010 – 2019) is compared with pre and post monsoon water level trend data of last five years (2015-2019). The change in water level trends in last five years is categorized into 4 categories, represented in Table-7.4 and Fig:7.24

Table-7.4 Categorization of Water Level Scenario

Water level Trend	Category	Description
Rising	1	Areas with rising trend showing further improvement (increase in rising rate) in water level trends in last five years
	2	Areas with falling trend, showing improvement (fall in declining rate) in water level trends in last five years
Declining	3	Areas with rising trends, showing decline (fall in rising rate) in water level trends in last five years.
	4	Areas with falling trend showing further decline (increase in falling rate) in water level trends in last five years

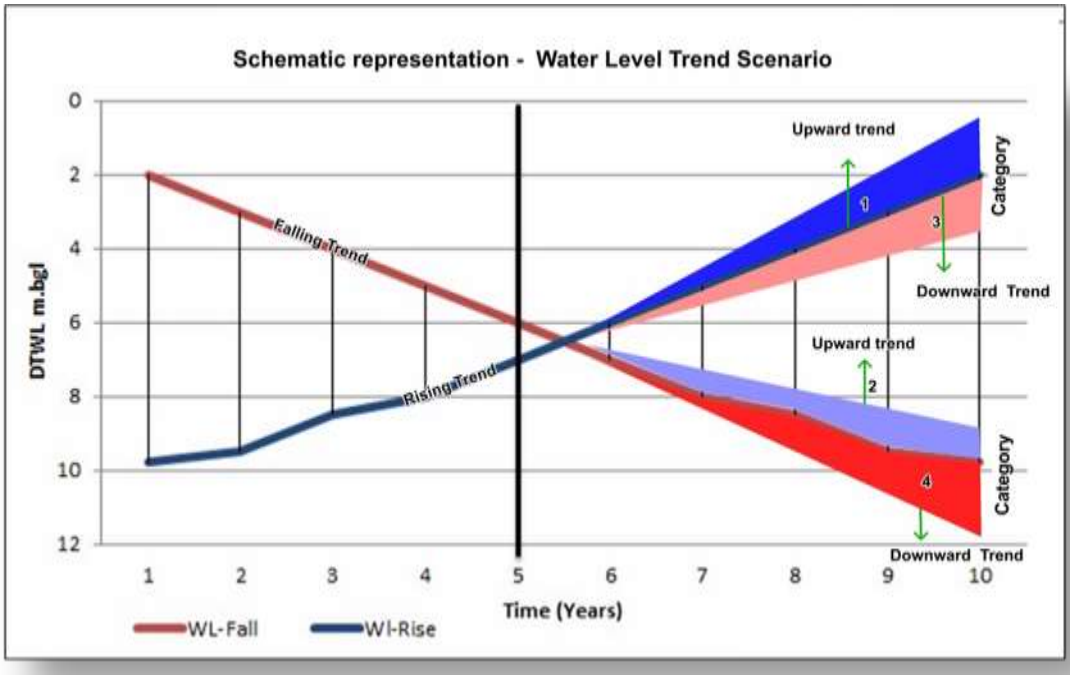


Fig.7:24 Schematic representation of water level trend scenario

During pre-monsoon 54% area of the state shows improvement in water levels (Category -1 & 2) and 46 % of the area shows decline in water level trends (Category - 3 & 4). Improvement in last five years is observed in West Godavari (72%), Krishna (71%), Nellore (69%), Prakasam (65%), Vizianagaram (63%), Guntur (59%), Kurnool (57%), Cuddapah (55%) and Anantapur (53%) districts, whereas in major parts of Vishakhapatnam (68%), Chittoor (64%), East Godavari (63%) and Srikakulam (60%) districts, decline in water level trend is observed. It is further observed that long term 10 years falling trend further declined in last 5 years in 36% area of the state ranging from 53% in Chittoor to 22% in West Godavari district(Fig-7:25 & Table-7.5).

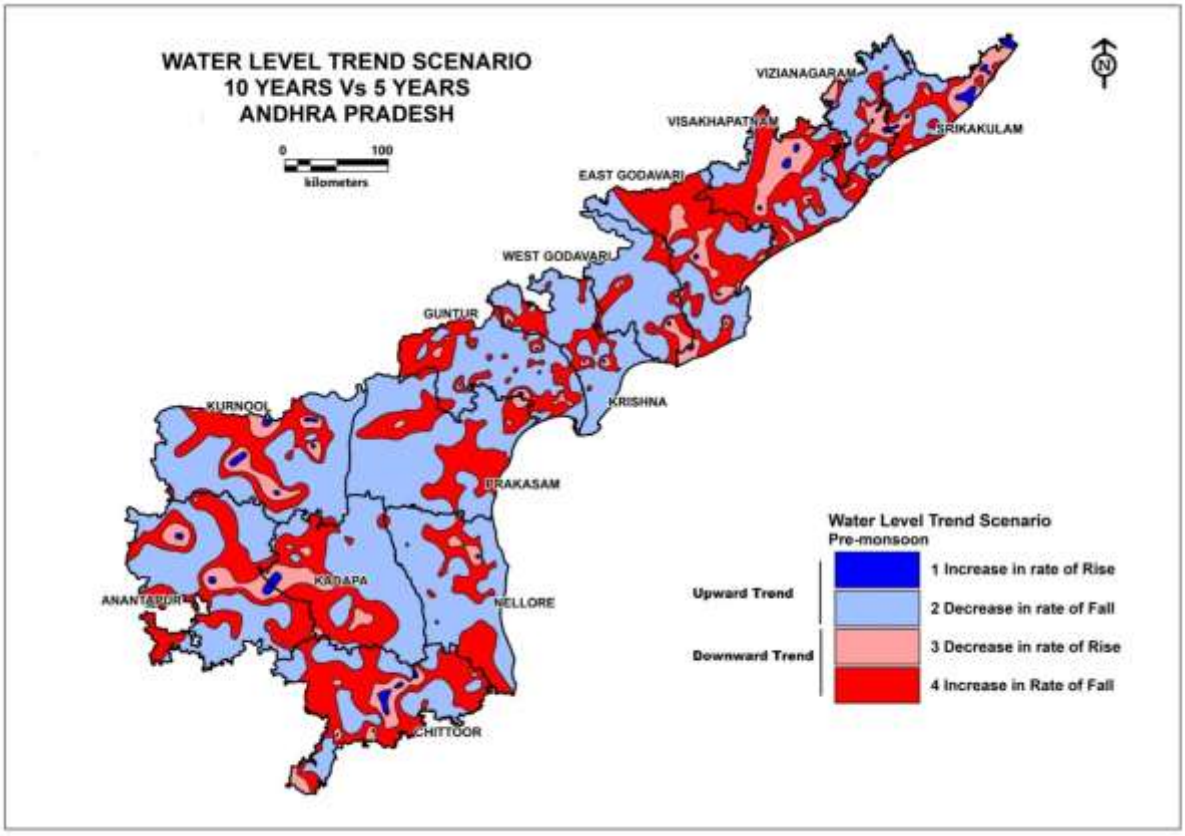


Fig-7.25 Pre monsoon Water Level Trend Scenario

Table-7.5 District wise Water Level Trend Scenario

District	Category-1		Category-2		Category-3		Category-4		Rise		Fall	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Anantapur	1%	6%	51%	42%	7%	22%	41%	30%	53%	48%	47%	52%
Chittoor	1%	2%	35%	27%	11%	25%	53%	46%	36%	30%	64%	70%
Cuddapah	1%	5%	54%	37%	10%	28%	35%	30%	55%	42%	45%	58%
East Godavari	1%	10%	36%	21%	16%	44%	47%	25%	37%	31%	63%	69%
Guntur	1%	9%	58%	48%	6%	16%	36%	27%	59%	57%	41%	43%
Krishna	0%	19%	71%	34%	2%	21%	27%	27%	71%	52%	29%	48%
Kurnool	2%	5%	55%	55%	12%	13%	32%	27%	57%	60%	43%	40%
Nellore	0%	2%	69%	50%	3%	15%	29%	33%	69%	52%	31%	48%
Prakasam	0%	4%	65%	51%	2%	8%	33%	36%	65%	56%	35%	44%
Srikakulam	7%	16%	33%	33%	25%	24%	34%	27%	40%	49%	60%	51%
Visakhapatnam	1%	7%	31%	21%	17%	37%	52%	35%	32%	28%	68%	72%
Vizianagaram	1%	12%	62%	26%	11%	31%	26%	31%	63%	37%	37%	63%
West Godavari	0%	11%	71%	34%	7%	27%	22%	28%	72%	45%	28%	55%
Total	**1%**	**8%**	**53%**	**37%**	**10%**	**24%**	**36%**	**31%**	**54%**	**45%**	**46%**	**55%**

During post-monsoon 45% area of the state shows improvement in water levels and 55% of the area shows decline in water level trends. Improvement in water level trends in last five years is observed in Kurnool (60%), Guntur (57%), Prakasam (56%), Krishna (52%), Nellore (52%), whereas declining trend is observed in major parts of Vishakhapatnam (72%), Chittoor (70%), East Godavari (69%), Vizianagaram (63%), Cuddapah (58%),West Godavari (55%), Anantapur (52%) and Srikakulam (51%) districts. It is further observed that long term 10 years falling trend further declined in last 5 years in 31% area of the state ranging from 46% in Chittoor to 25% in East Godavari district (Fig-7:26 & Table 7:5).

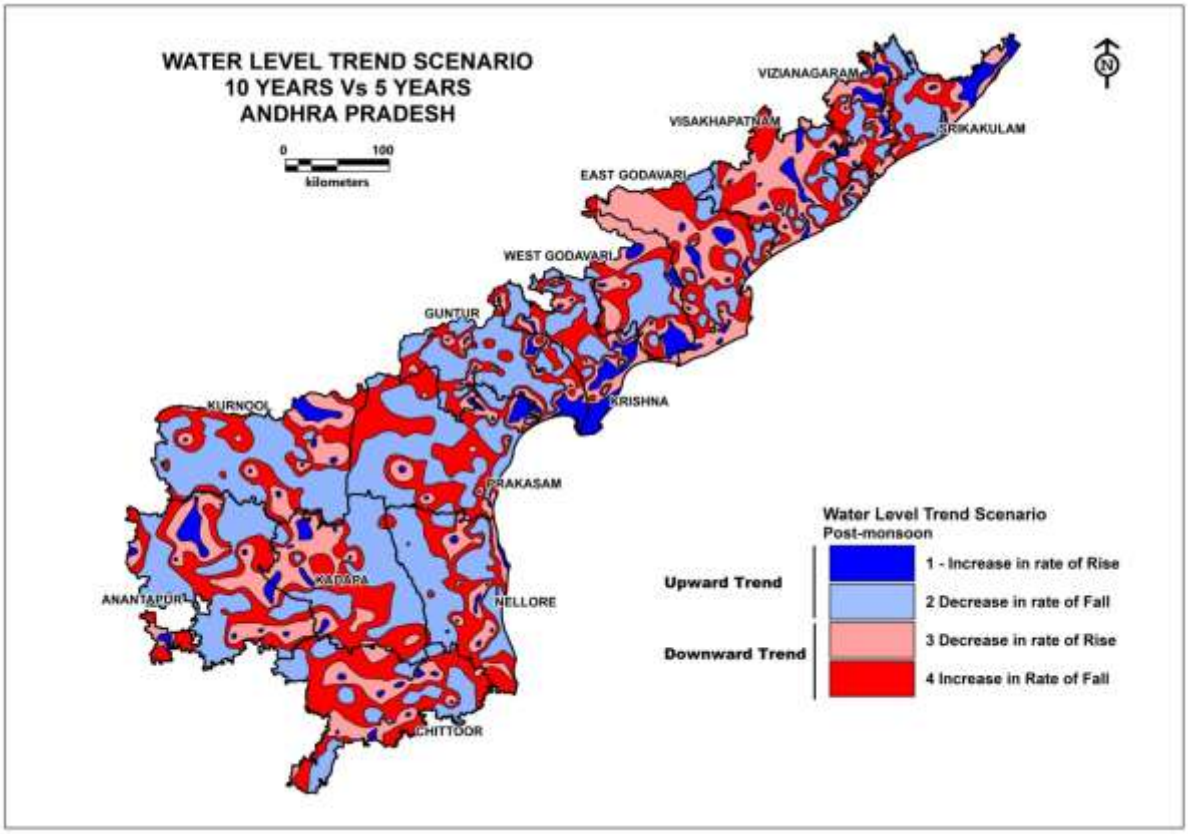


Fig.7:26 Post monsoon Water Level Trend Scenario

Rise in water levels in last five years can be attributed to improvement in medium and minor irrigation projects. Under rehabilitation of minor irrigation tanks, ~ 40.2 MCM of desiltation works completed under Neeru-Chettu program of Govt. of AP which facilitated accelerated ground water recharge. The Govt. of Andhra Pradesh had taken several initiatives in improving the surface water availability in various irrigation projects like Sir Arthur Cotton Barrage (GDS) in East Godavari, Tadipudi LI Scheme in West Godavari, Thotapalli Barrage Project in Vijayanagaram district and KC Canal modernisation project in Cuddapah district etc. These initiatives had sustained command area, which in turn reduced the stress on ground water system and resulted in rise in ground water levels in the State.

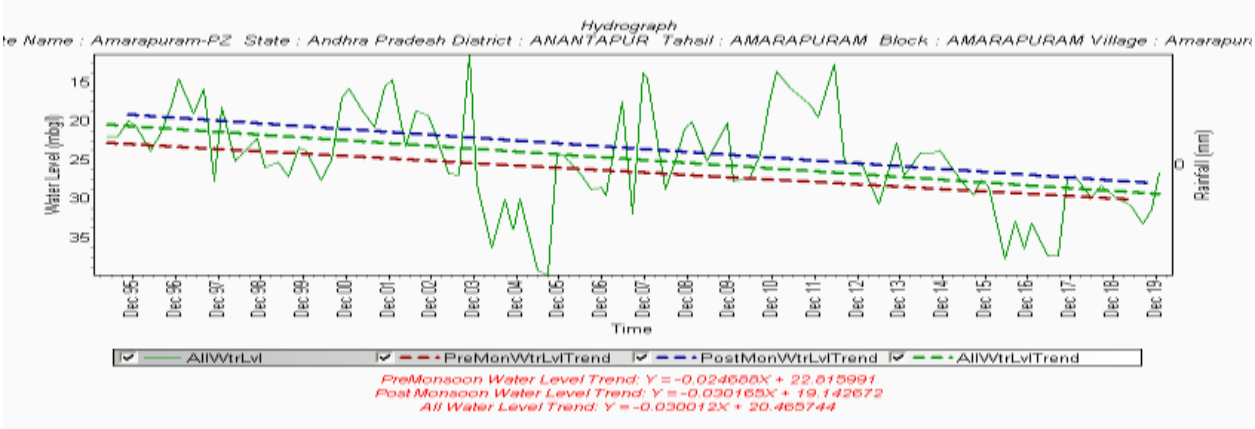
7.9 Hydrographs of water level

Total 26 hydrographs are generated (2 from each district) (**Fig. 7.27**). Out of 26, 10 wells show rising trends in both seasons, 11 shows falling trend in both season and rest shows mixed trend (**Table-7.6**).

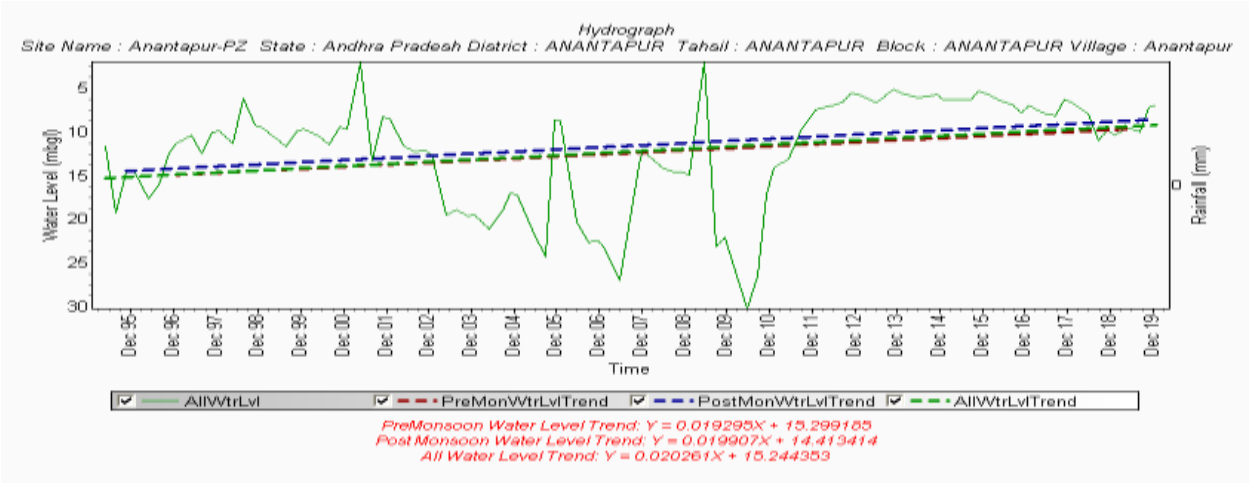
Table-7.6: Representative Hydrographs showing rising and falling trends in Andhra Pradesh State.

S. No.	Fig No.	Location	District	Pre (m/yr.)		Post (m/yr.)	
				Rise	Fall	Rise	Fall
1	7.24a	Amarapuram	Anantapur		0.024		0.030
2	7.24b	Anantapur	Anantapur		0.019		0.019
3	7.24c	Damalcheruvu	Chittoor	0.004			0.0005
4	7.24d	Battuvaripalli	Chittoor	0.004		0.0002	
5	7.24e	Muddireddipalli	Kadapa		0.008		0.017
6	7.24f	Anjaneyapuram	Kadapa	0.001			0.004
7	7.24g	Jaggampet	East Godavari	0.01		0.005	
8	7.24h	Gollaprolu	East Godavari	0.002		0.00008	
9	7.24i	Ipur	Guntur		0.0027		0.0033
10	7.24j	Guntur	Guntur	0.01		0.0068	
11	7.24k	Nuziveedu	Krishna	0.0048		0.0024	
12	7.24l	Gudivada	Krishna		0.00098		0.0017
13	7.24m	Gonegandla	Kurnool	0.0095		0.0022	
14	7.24n	Ahobilam	Kurnool		0.031		0.025
15	7.24o	Kadanothola	Nellore		0.007		0.00077
16	7.24p	Bata	Nellore		0.004		0.009
17	7.24q	Chirala	Prakasam		0.0021		0.002
18	7.24r	Chandalur	Prakasam		0.0093	0.0009	
19	7.24s	Ichapuram	Srikakulam	0.0007		0.0037	
20	7.24t	Barua	Srikakulam	0.0072		0.010	
21	7.24u	Narsipattanam	Vishakhapattanam	0.0001			0.0003
22	7.24v	Araku	Vishakhapattanam		0.0031		0.001
23	7.24w	Agraharam	Vizianagaram	0.0088		0.008	
24	7.24x	Garbham	Vizianagaram	0.0007			0.001
25	7.24y	Kovvur	West Godavari	0.00336		0.0026	
26	7.24z	Eluru	West Godavari		0.082		0.069

7.27a



7.27b



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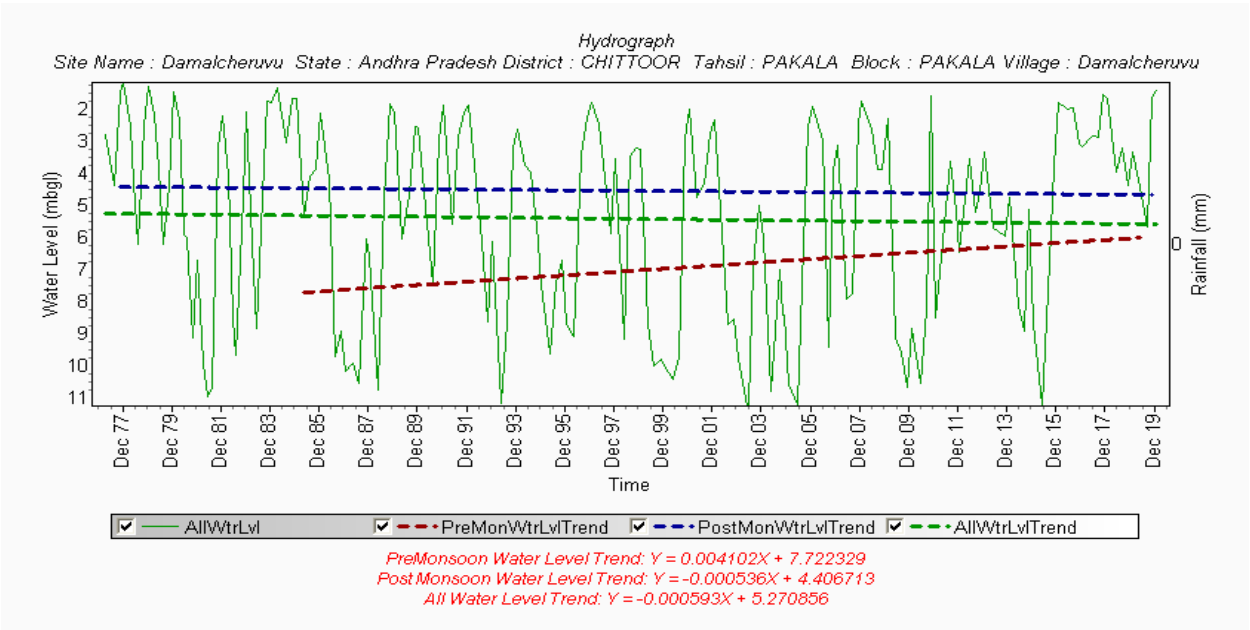
7.27c



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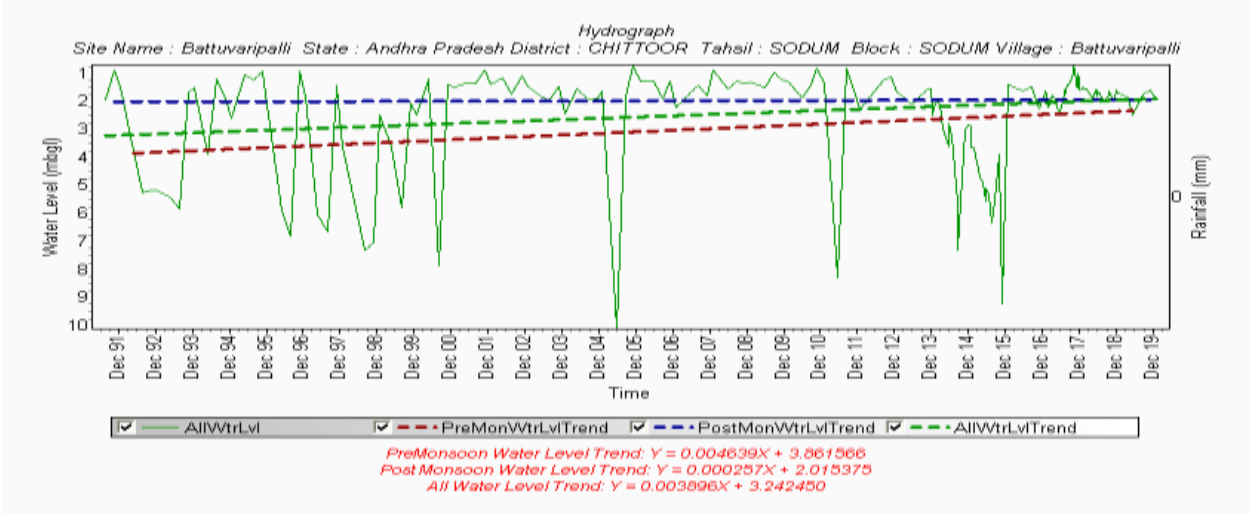

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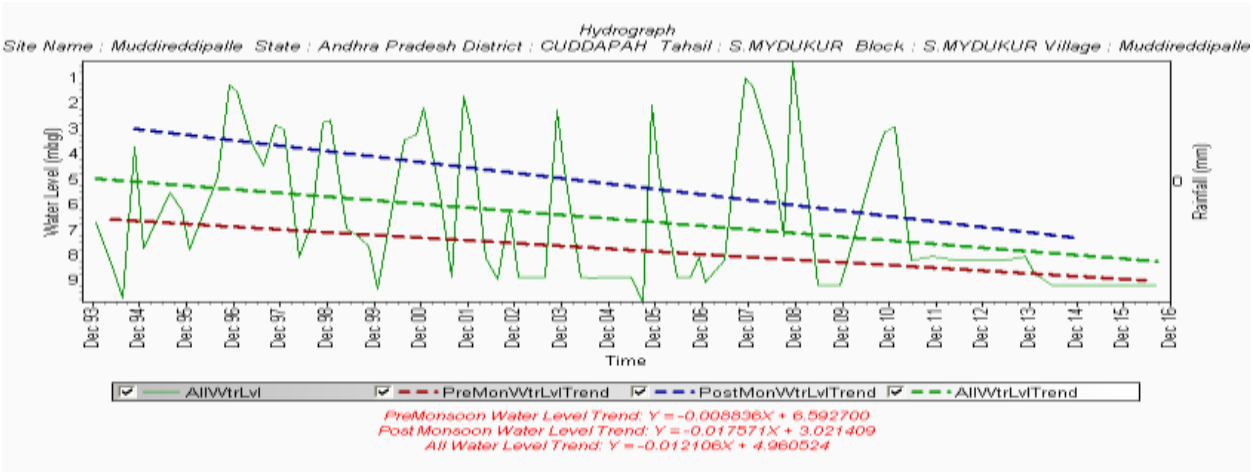

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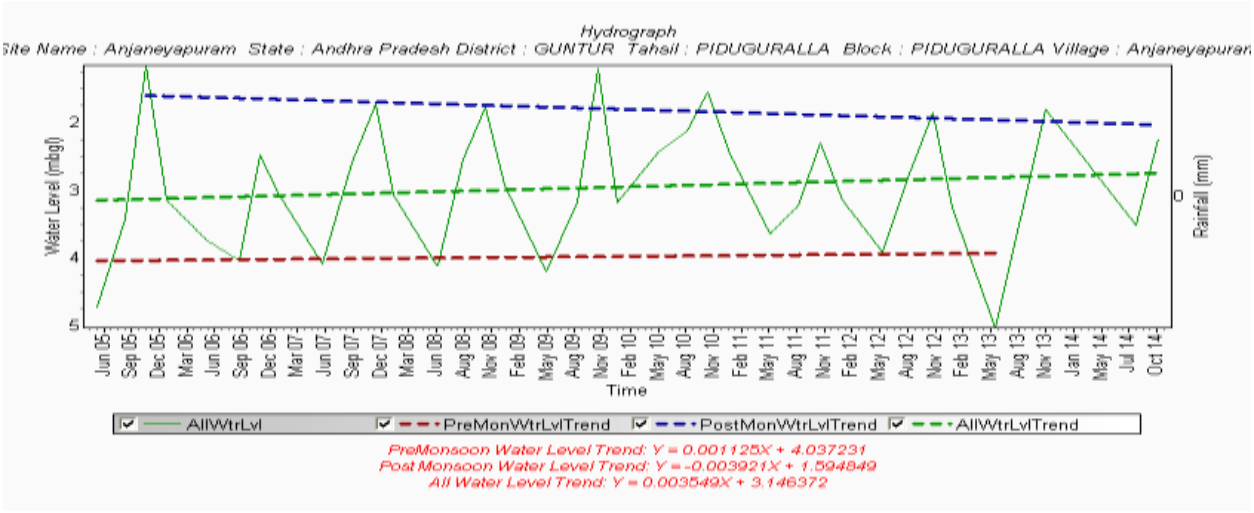

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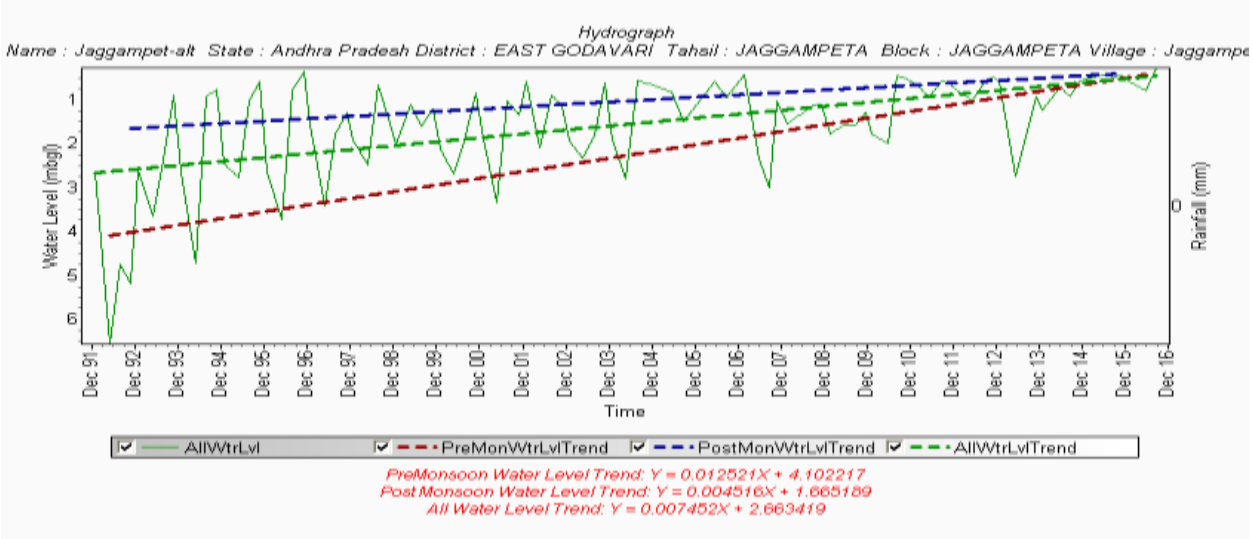
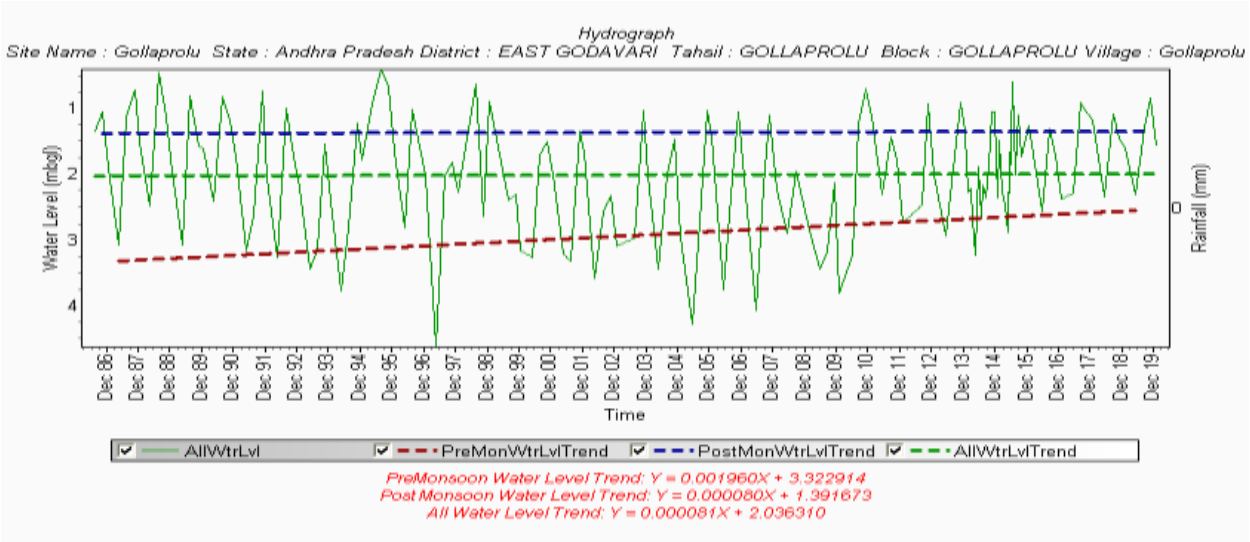
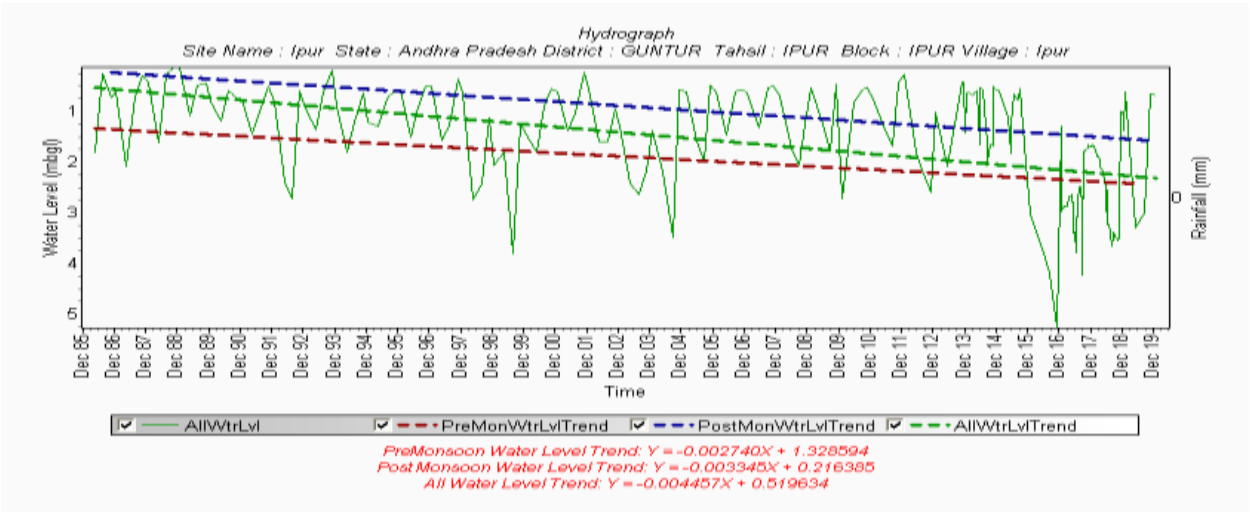


7.27h



7.27i



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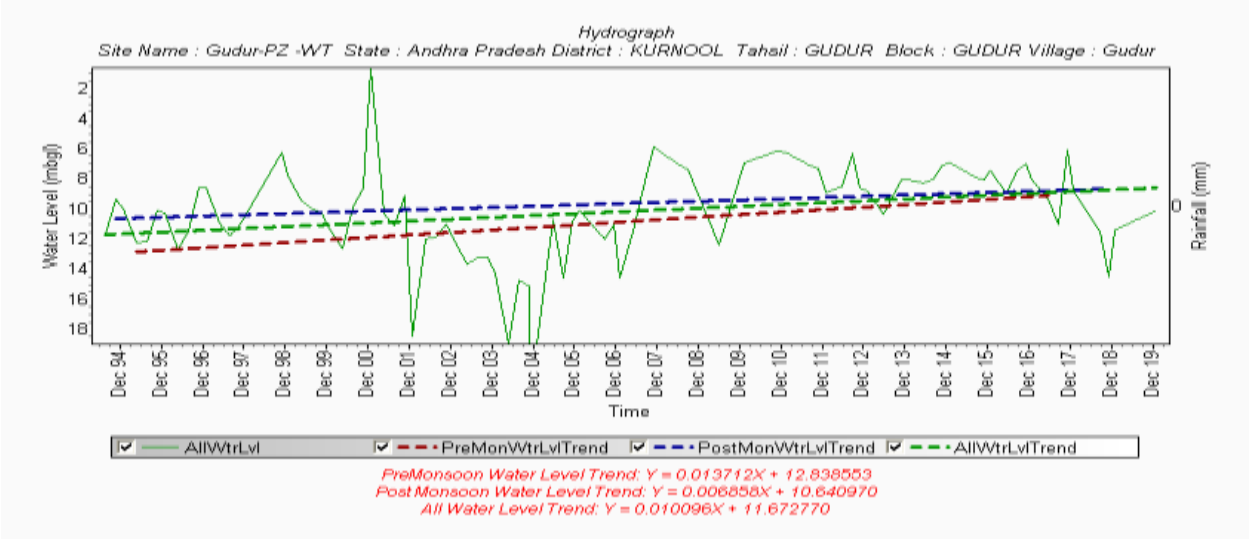

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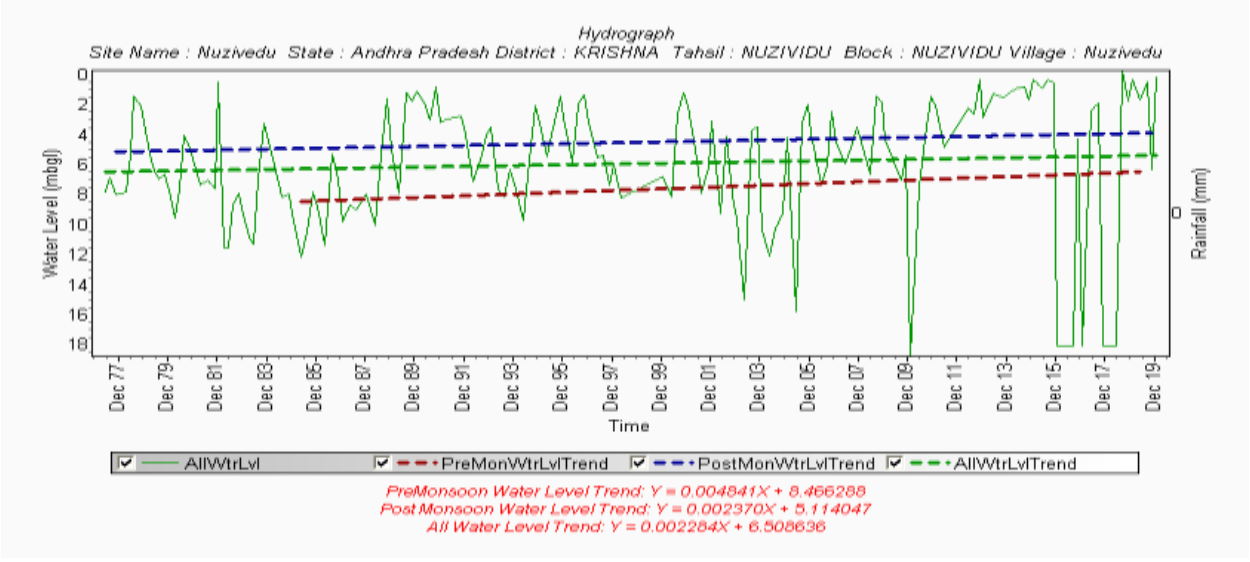

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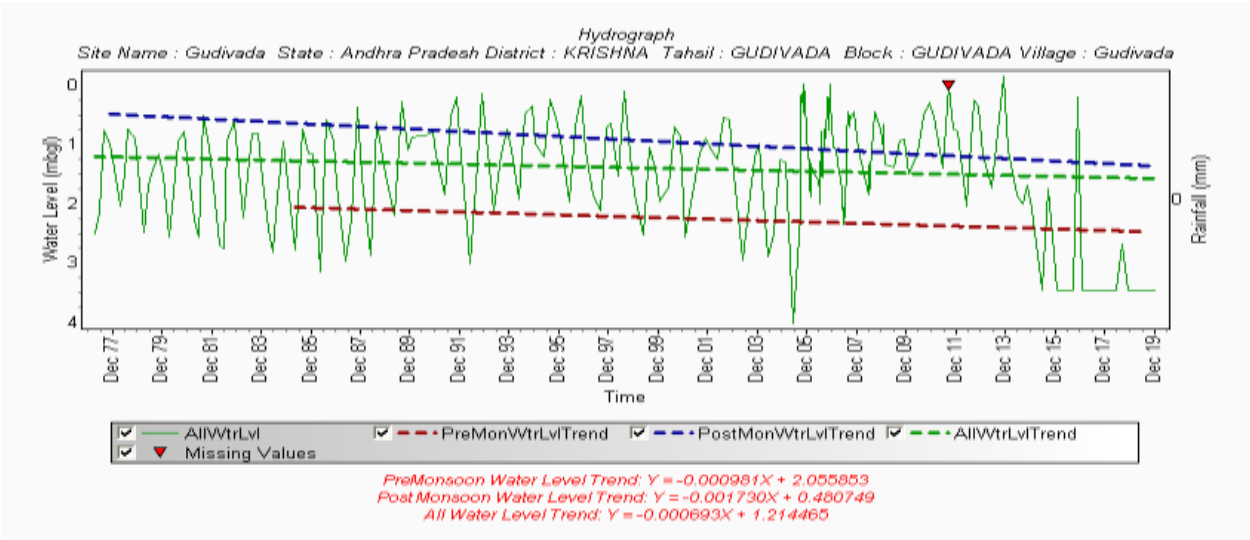

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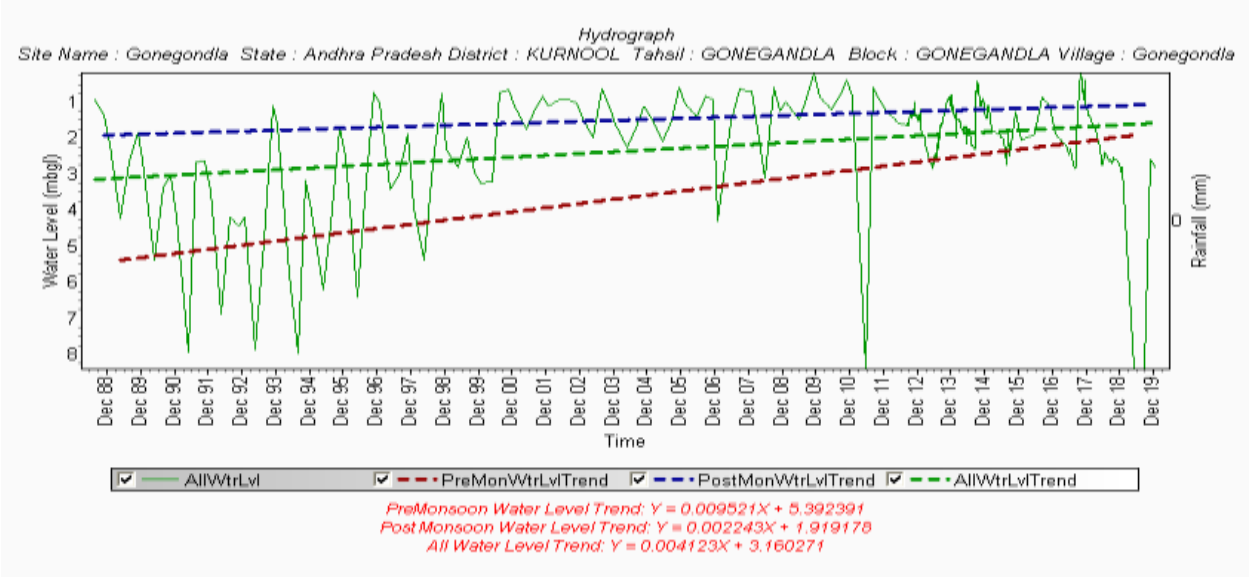

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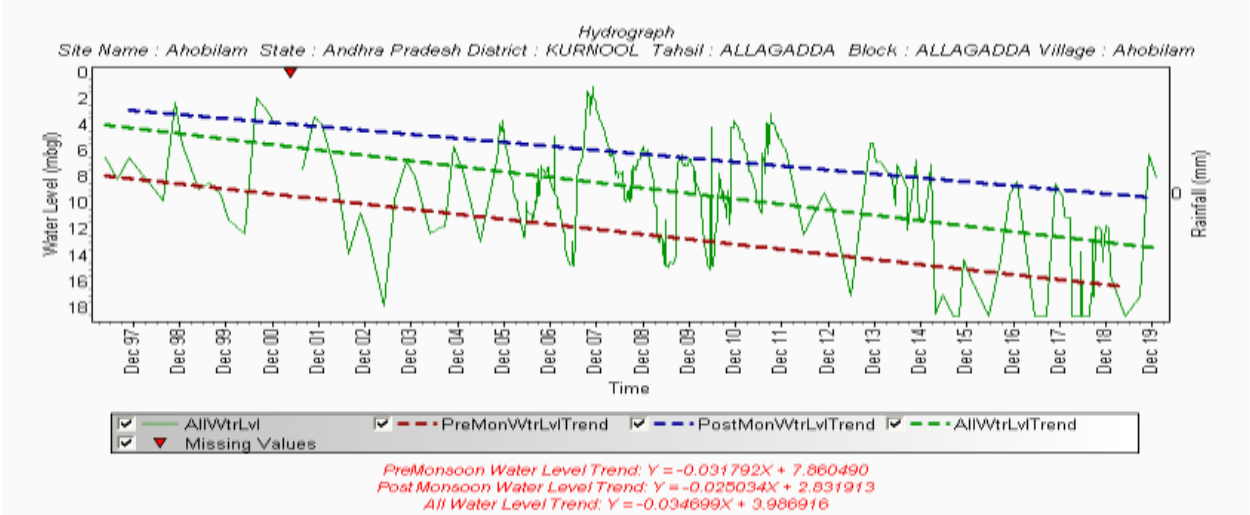

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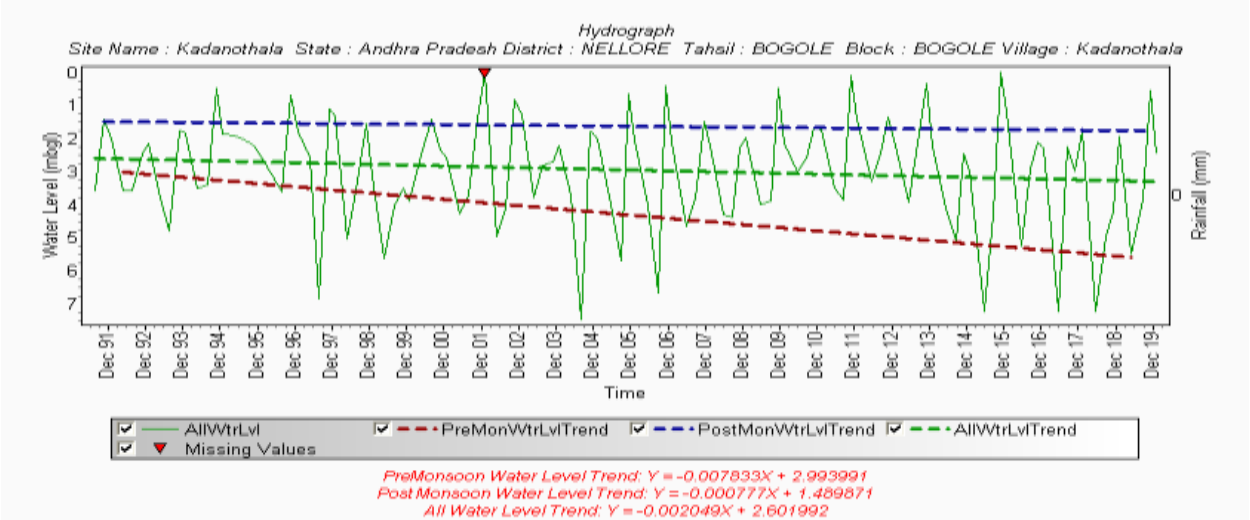

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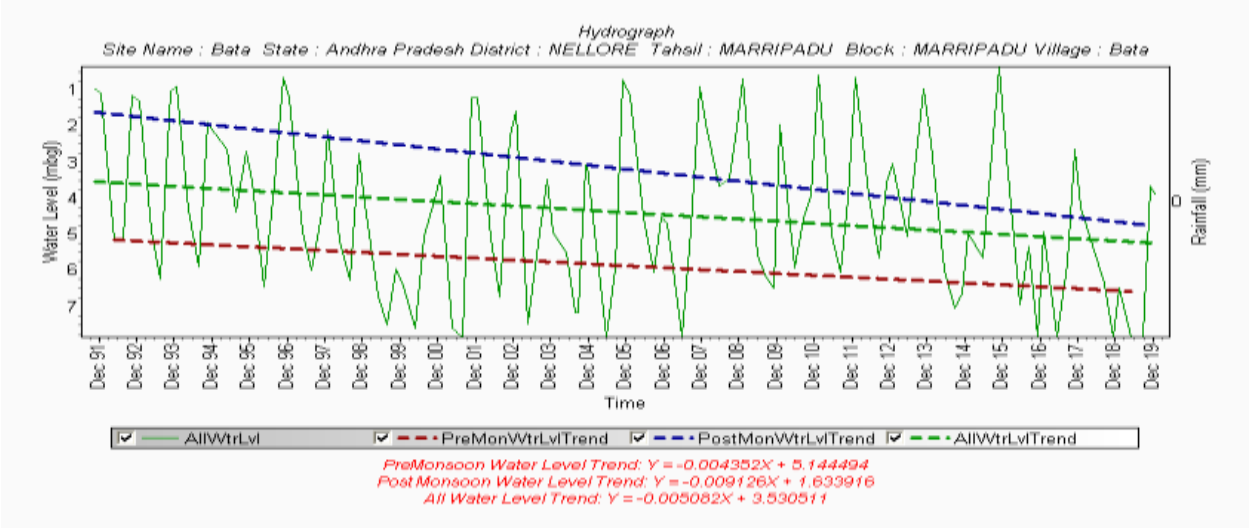

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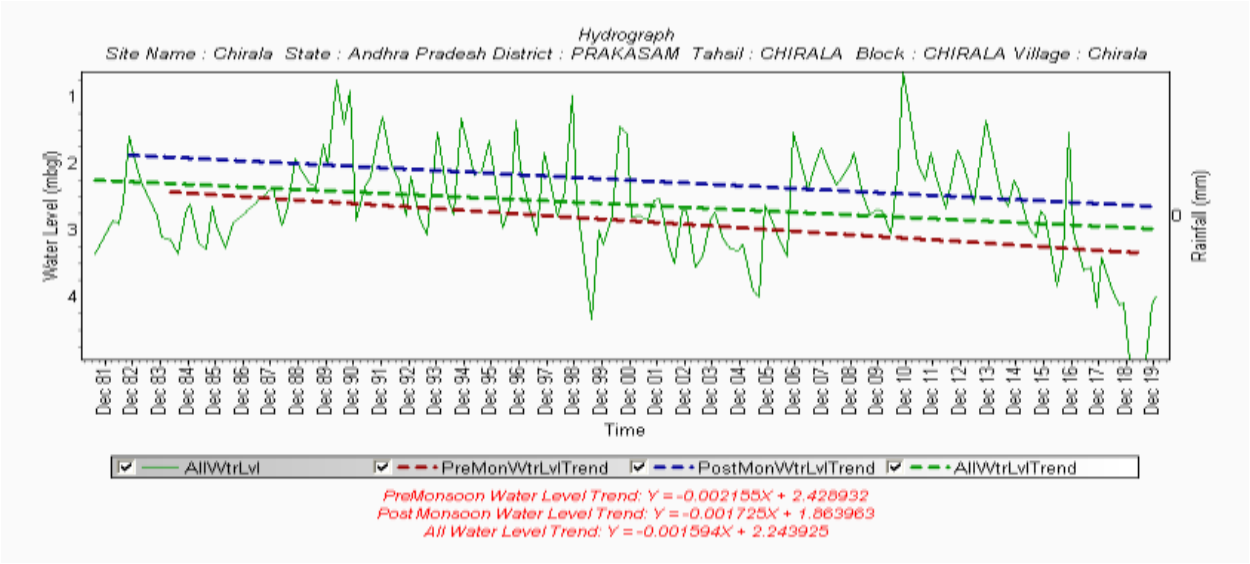

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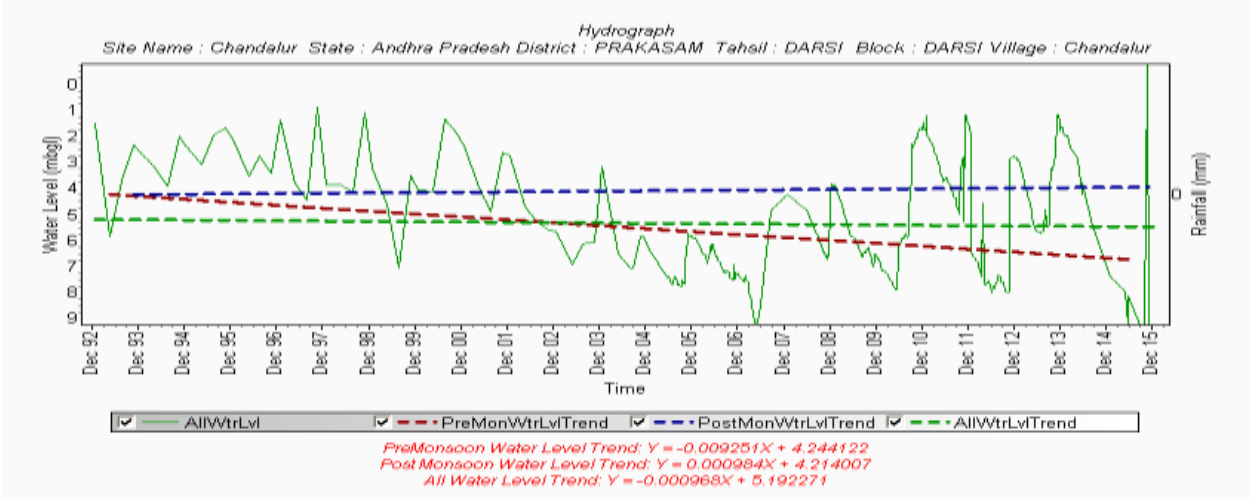
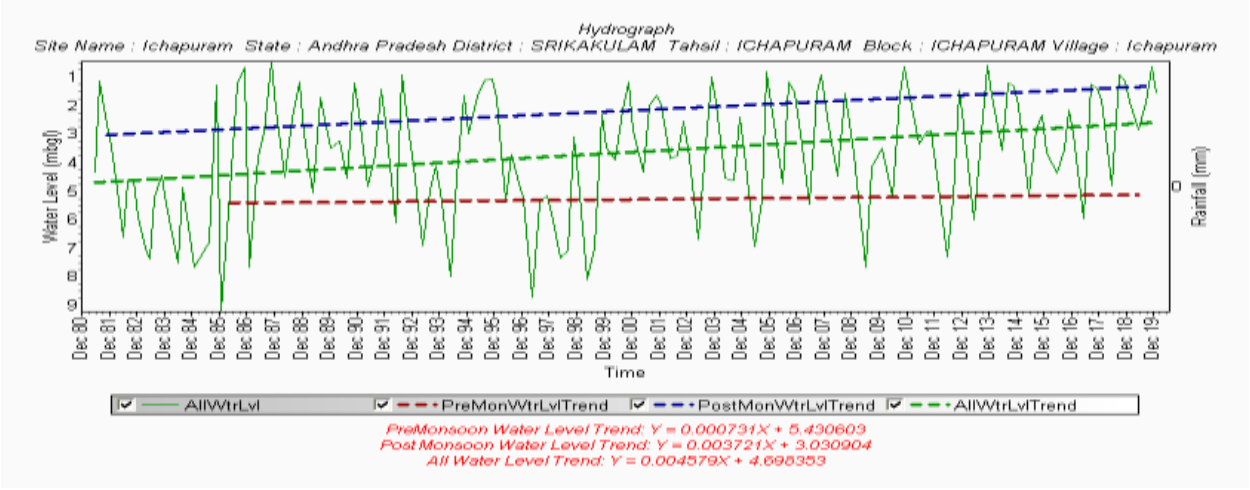


727s



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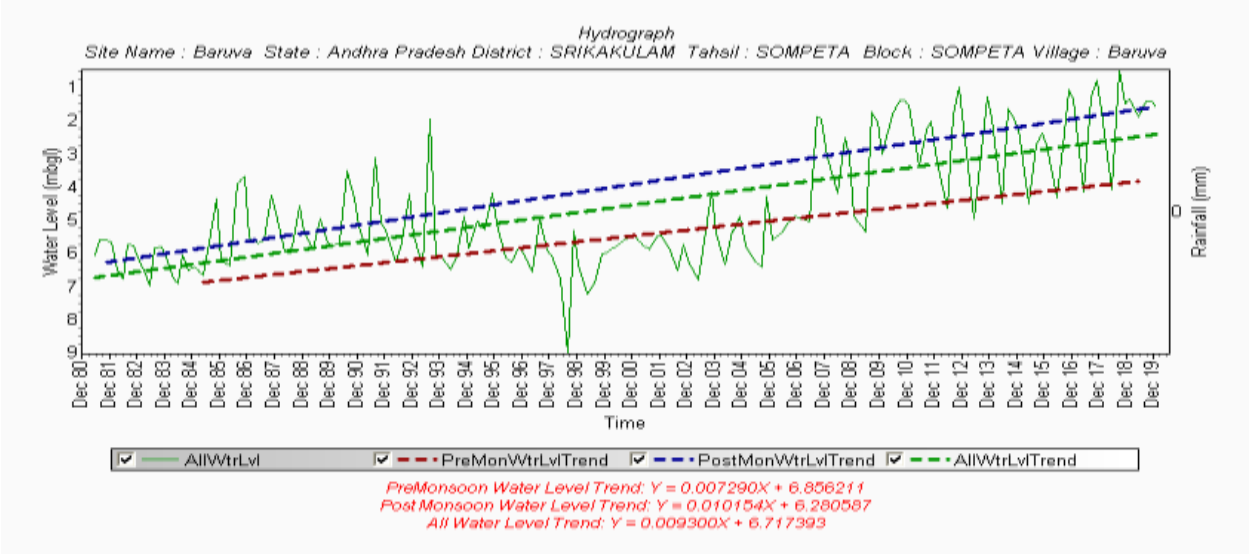
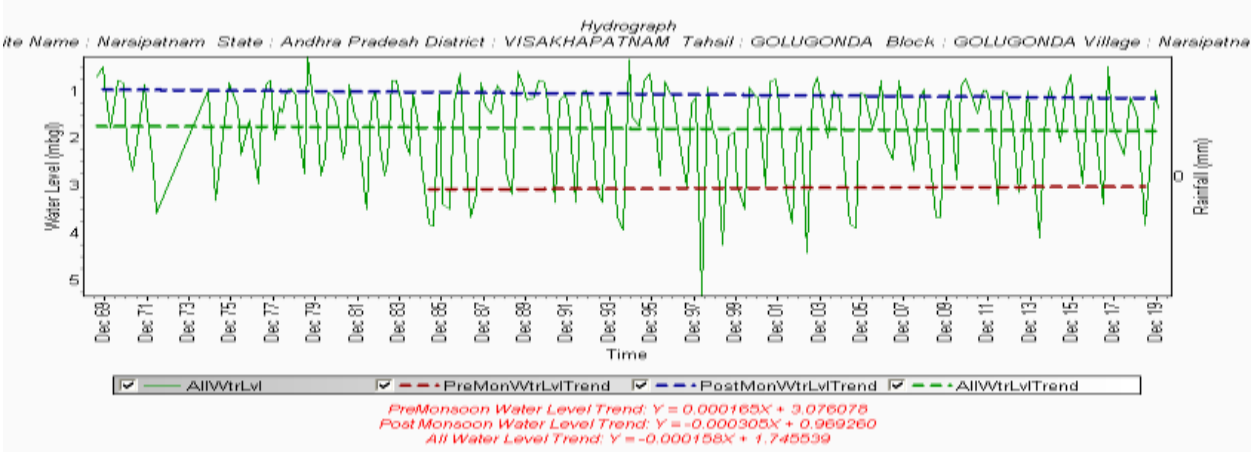


7.27u



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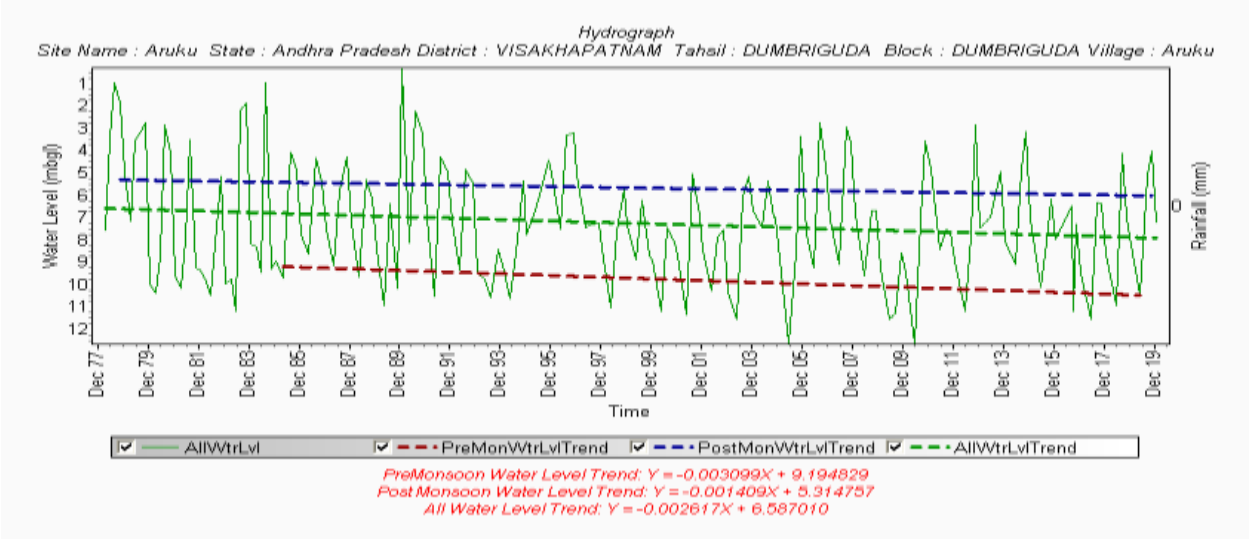

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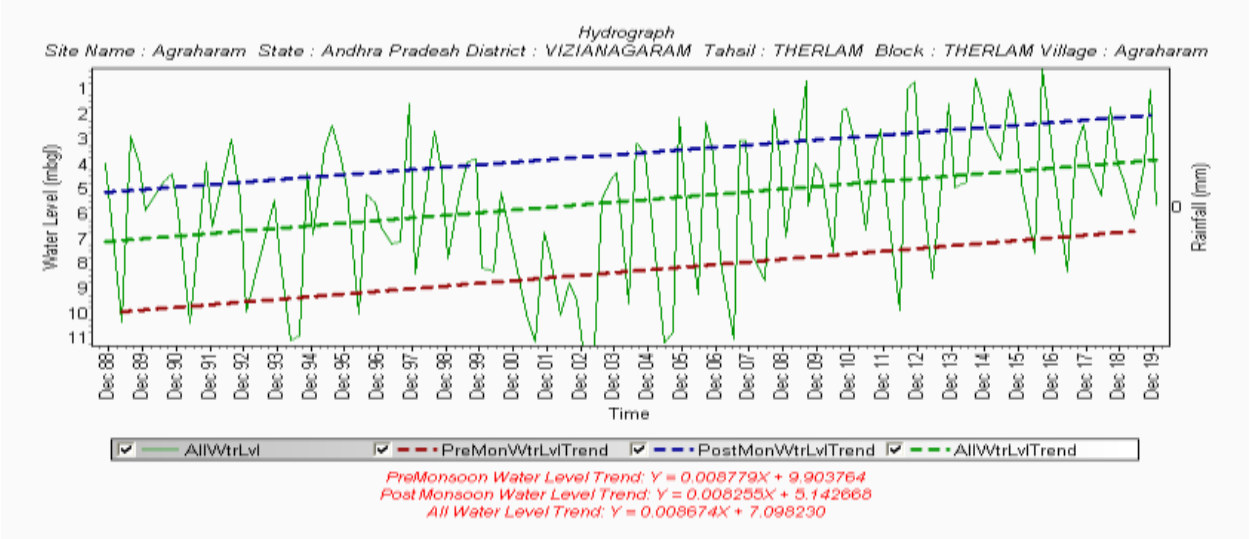

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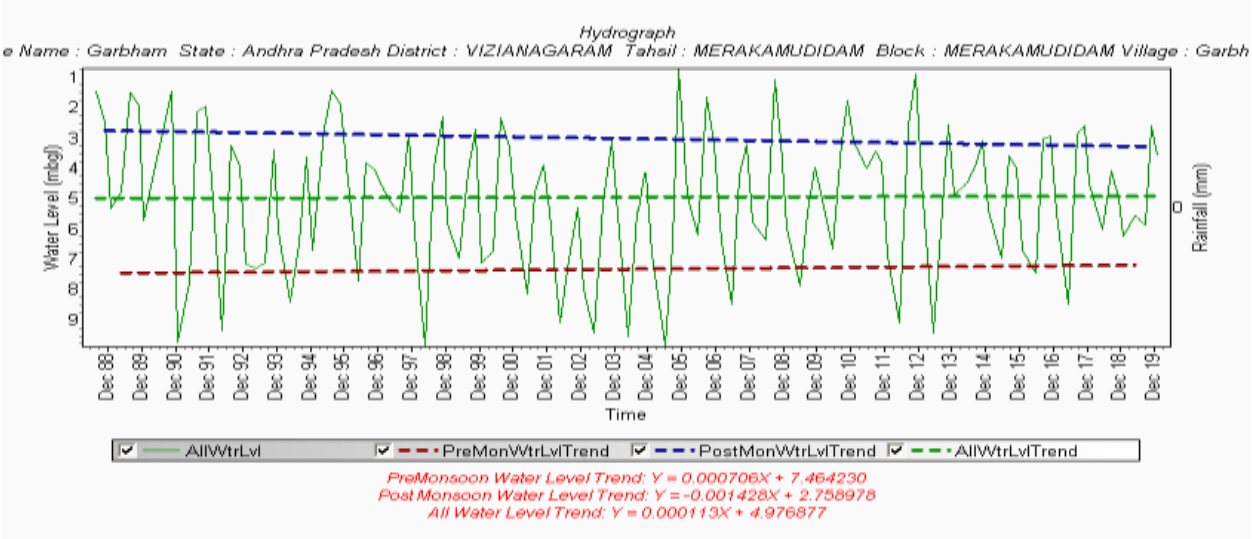
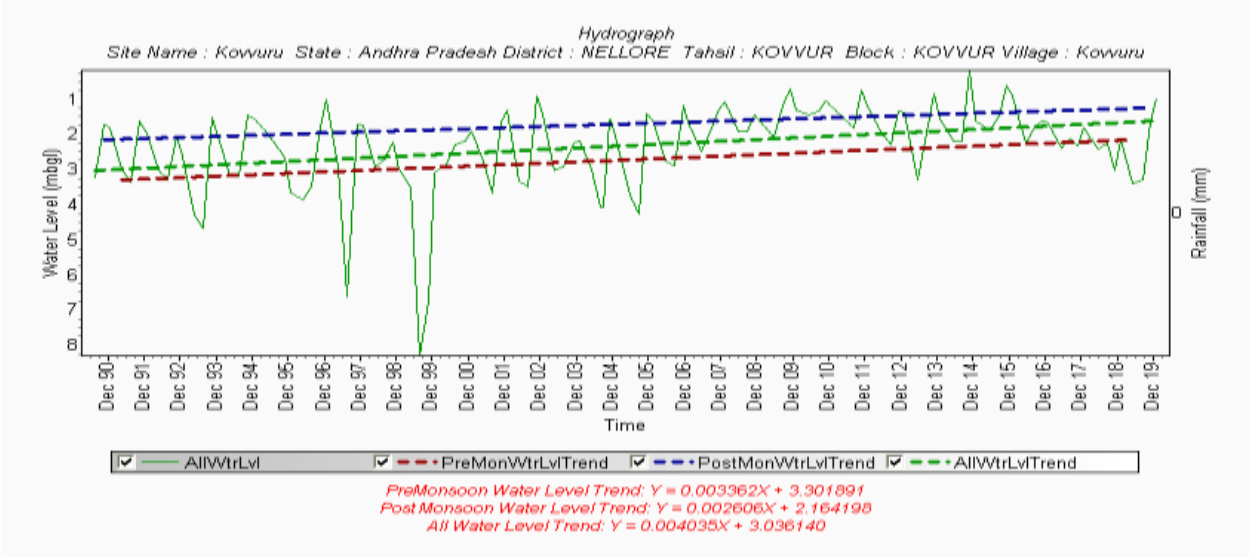


7.27y



7.27z

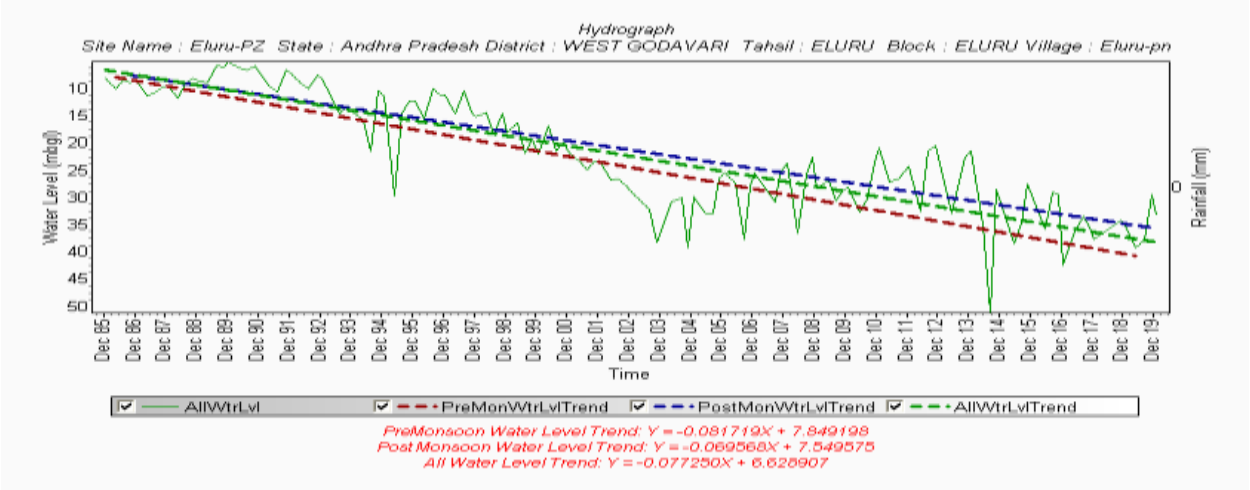


Fig.7.27 (7.24a to 7.24z): Representative Hydrographs of Andhra Pradesh State.

8. GROUND WATER QUALITY

Water is a universal solvent and therefore, chemical nature of groundwater forms the basis of interpretations of quality in relation to source, geology, climate and use.

8.1 Distribution of physico-chemical parameters

A total of **593** groundwater samples from shallow GWMS (both Dug Wells and Piezometers) were collected during pre-monsoon season of 2019 (May) for basic constituents (Fig.8.1 and Table-8.1). Samples are analyzed in the Regional Chemical Laboratory of CGWB, SR, (NABL Accredited). Sampling, preservation, and storage of groundwater have been carried out by following standard guidelines (APHA 2017, 23rd Edition). Fourteen major parameters such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Carbonate (CO_3^{2-}),Bicarbonate (HCO_3^{-}), Chloride (Cl^{-}), Sulphate (SO_4^{2-}), Nitrate (NO_3^{-}) and Fluoride (F-), were determined. District wise collection of samples during May-2019 is given in Table- 8.1.

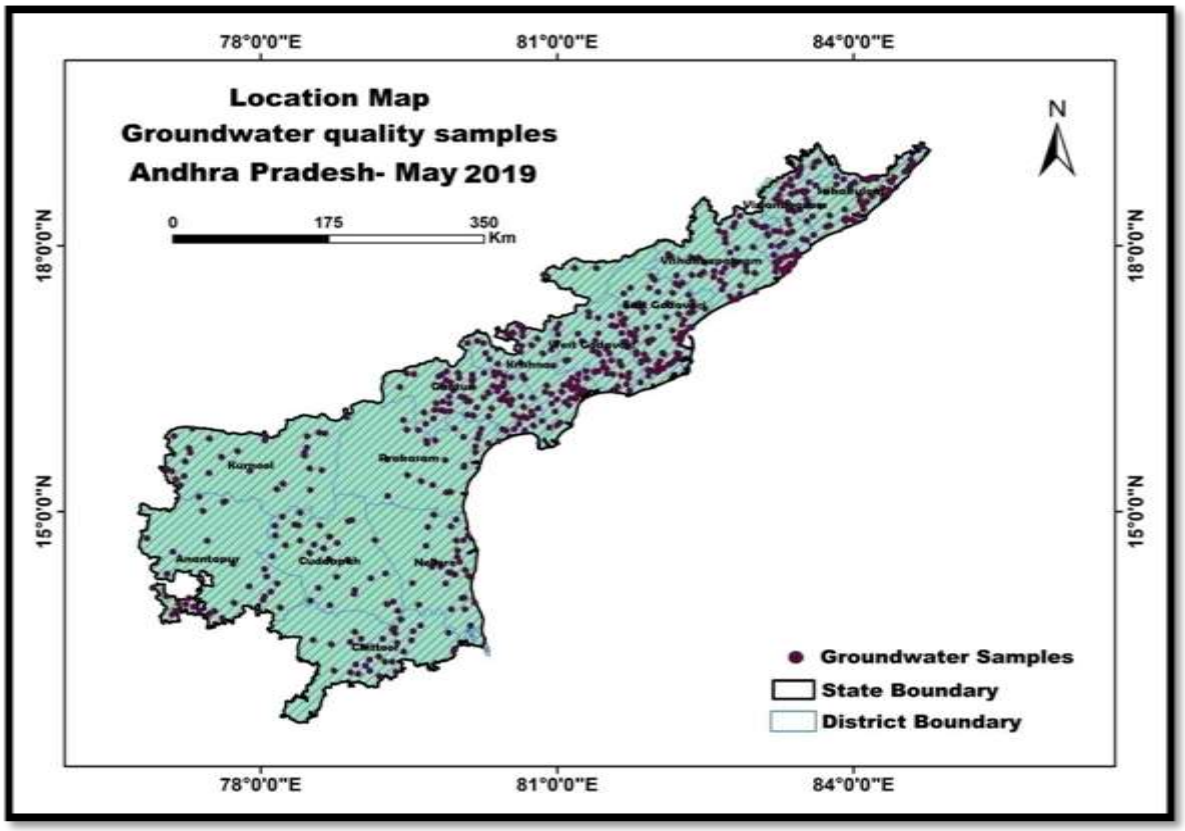


Fig.8.1: Location map of Ground water sampling sites in Andhra Pradesh.

Table-8.1: District wise collection of samples (May-2019)

S.No.	District	No. of Samples	S.No.	District	No. of Samples
1	ANANTAPUR	31	8	NELLORE	28
2	CHITTOOR	30	9	PRAKASAM	26
3	EAST GODAVARI	82	10	SRIKAKULAM	47
4	GUNTUR	73	11	VISAKHAPATNAM	59
5	KADAPA	32	12	VIZIANAGARAM	48
6	KRISHNA	54	13	WEST GODAVARI	53
7	KURNOOL	30		**GRAND TOTAL:**	**593**

8.1.1 pH- Hydrogen Ion Concentration

The hydrogen ion activity is a main variable of groundwater system because the hydrogen ion participates in most of the chemical reactions that affect water composition. In most natural waters pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. The pH value of a solution is the negative logarithm of concentration of hydrogen ions (H^+) in moles/liter. Pure water at 7 pH (at 25º C), contains equal proportion of H^+ and OH^- (hydroxyl) ions. The pH value is less than 7 if the H^+ ions exceed the OH^- ions, and it is more than 7 when OH^- ions exceed H^+ ions. In the ground waters of State, pH ranges from 6.52-8.95.In 7 samples {Akiveedu (8.53), Kanapuram (8.57), Pamulaparu (8.58), Cherukuwada (8.7)of West Godavari district, Varagami of Guntur district (8.6), Pithapuram of Visakhapatnam district (8.85), Jonnada of East Godavari district (8.95)}, pH is beyond permissible limit of BIS.

8.1.2 Electrical Conductivity (EC)

Electrical conductance (EC) of an electrolyte is the reciprocal of specific resistance and is expressed in µS/cm. Electrical conductivity normally, increases with flow and residence time in the aquifer and its determination shows, to what extent mineralization has taken place in the groundwater. In the study area, the EC value (µS/cm at 25°C) ranges from 50-25430. Highest EC is noticed at Jammalamadugu of Kadapa district. Overall (85.3%) EC is in the best range of 500-3000 µ S/cm and high ECs are detected in parts of Kurnool, Kadapa, Krishna, Guntur, East and West Godavari districts.

8.1.3 Total Dissolved Solids (TDS)

The concentration of TDS in groundwater depends upon nature of rock formation, depth through which water is passing, climate, geomorphology of the area at which water is

moving, porosity and permeability of rocks. Contamination of water by human and animal activities including sewage disposal and agricultural practices and mixing of different types of water also affects TDS.

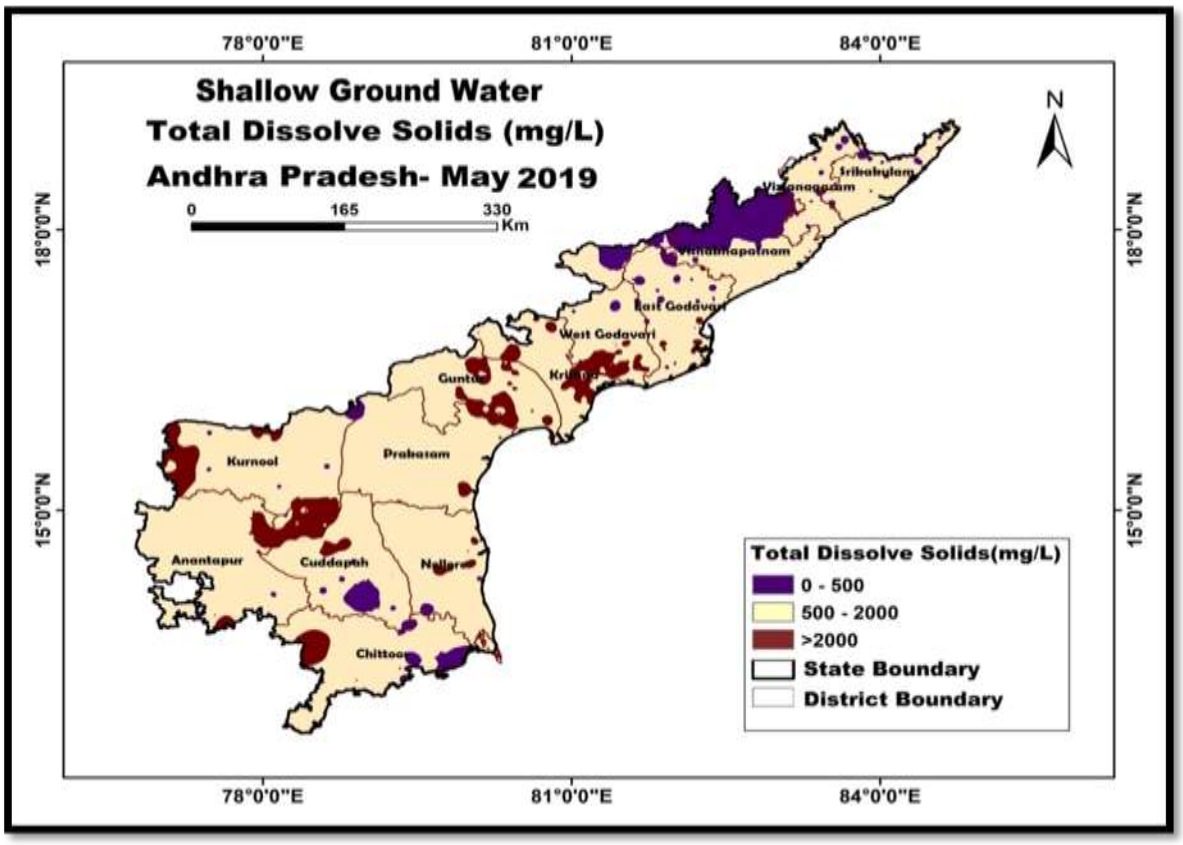


Fig.8.2: TDS Distribution in Shallow Ground waters of the State (May-2019).

In the state, concentration of TDS ranges from 30-15287mg/L (avg: 1180) and it is found that in 76 samples it is beyond permissible limit (2000 mg/L)**.**

8.1.4 Total Hardness (TH)

Total hardness is the capacity of water to neutralize soap and is the sum of $Ca^{2+}$and Mg^{2+}. Hardness is of two types, namely primary and secondary. In the state, Total Hardness ranges from 20-2525mg/L and it is found that in 131 samples Hardness is beyond permissible limits of BIS (600 mg/L).

8.1.5 Calcium (Ca^{2+})

In most of the naturally occurring groundwater, calcium is the main cation due to its abundance in earth's crust and high mobility (Hem, 1991). The principal sources of calcium in groundwater are minerals present in igneous rock, especially silicates, like pyroxenes, amphiboles, feldspars and sedimentary rocks like limestone, dolomite and gypsum. It is also

present in the form of adsorbed ions on negatively charged mineral surfaces in soils and rocks.

The concentration of calcium ranges from 4-393mg/L and it is found that in 35 samples, Ca is beyond permissible limit (200 mg/L). In almost all districts Ca is below permissible limit is and maximum of 393mg/L is detected in Badadanapalli of East Godavari district.

8.1.6 Magnesium (Mg^{2+})

Weathering of basic igneous rocks such as dunites, pyroxenites; volcanic rocks such as basalts; metamorphic rocks like amphibolites, talc and tremolite-schists; sedimentary rocks such as dolomite, gypsum etc are the main sources of Mg^{2+} in the groundwater (Karanth, 1987) and use of surface water for irrigation is another source of Mg^{2+} in the groundwater (Hem, 1991). In the state, as in most natural water, the magnesium concentration is much lower than the calcium concentration (Hem, 1991). It ranges from 1.22-386mg/L with an average of 54mg/L. Maximum concentration is detected in Prattipadu of Guntur district. It is found that in 72 samples, the Magnesium is beyond permissible limit (100 mg/L).

8.1.7 Sodium (Na^{+})

Silicate minerals such as albite, nepheline, sodalite, glaucophane, aegerine and other Na+ bearing minerals present in rocks are the main source of Na+ in the groundwater. The other sources are rainwater, dissolution of evaporate minerals, sodium disposal through sewage and industrial wastes (Handa, 1975). Certain clay minerals and zeolites can increase the sodium concentration in groundwater by Base Exchange reaction **(Karanth, 1987).** The concentration of Na^{+} ranges from below detectable limits to5313mg/L. With an average concentration of 220mg/L and highest is detected in Jammalamadugu of Kadapa district.

8.1.8 Potassium (K^{+})

The common source of K^{+} in groundwater is due to weathering of silicate minerals like orthoclase, microcline, nepheline, biotite, leucite etc. Dissolution of evaporites containing highly soluble sylvite and nitre in sedimentary rocks are the other sources of K^{+} in the ground waters **(Handa, 1975; Karanth, 1987).** Anthropogenic sources such as fertilizers, manure, human and animal wastes and intrusion of saline waters due to over pumping are some of the other sources of K^{+} in ground waters.

The concentration of K+ ranges from below detectable limits to 716mg/L. The average concentration is 40mg/L and the highest was detected in dug well of Kanchisamudram village (Ananthapur district).

8.1.9 Carbonate and Bicarbonate ($CO_3^{--}$and HCO_3)

The main sources of CO_3^- and HCO_3^- ion in the groundwater is dissolved CO_2 present in rainwater. When this rainwater enters soil, it dissolves more CO_2 from decaying organic matter present in soil **(Karanth, 1987).** An increase in temperature or decrease in pressure causes reduction in the solubility CO_2 in groundwater. Carbon dioxide mixed water, while passing through soil dissolves carbonate minerals and give bicarbonate.

The occurrence of carbonates in groundwater is mainly dependent on its pH. In groundwater, carbonates are generally present when pH of groundwater is above 8.3 and it is in traces or absent when pH of water is less than 8.3 (**Handa, 1975; Hem, 1991; Karanth, 1987).** Under normal conditions the bicarbonate concentration in groundwater ranges between 100 to 800 mg/L.

In the ground waters of State, the concentrations of bicarbonate ranges from 9.2 to 2837mg/L, with an Average concentration of 467mg/L and highest is detected in Donkapallisatram of Kadapa district.

8.1.10 Chloride (Cl^-)

Chloride in the form of chloride (Cl-) is one of the major in-organic anion in water and wastewater **(APHA, 2017).**

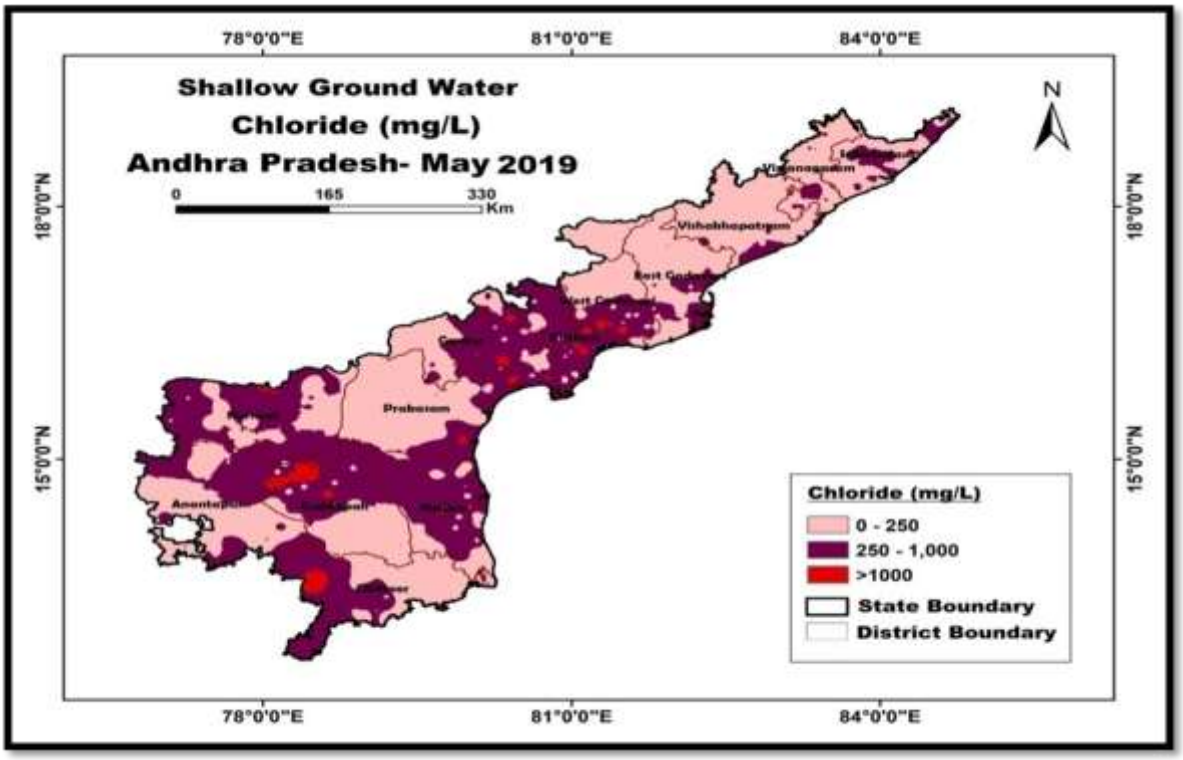


Fig. 8.3: Distribution of Chloride in Shallow Ground waters of the State (May-2019).

Hydrolysis of halite and related minerals, rainwater, irrigation and industrial effluents are the main sources of Cl^- in groundwater **(Handa, 1975).**Minerals like sodalite, mica, chlor-apatite, hornblende, etc are the other minor sources of chloride in groundwater **(Karanth, 1987).** Abnormal concentration of Cl^- in groundwater may results due to pollution of sewage wastes, planting of coconut trees **(Karanth, 1987).** In the ground waters of State, chloride concentration ranges from 3.5 to 5530 mg/L with an average of 304 mg/L and found that 29 samples are unsuitable for drinking purposes. Maximum concentration detected in Jammalamadugu of Kadapa district.

8.1.11 Sulphate (SO_4^{2-})

Sulphate (SO_4^{2-}) is widely distributed in native and may be present in natural waters in concentration ranging from a few to several thousand mg/L (APHA, 1998). The main sources of SO_4^{2-} in groundwater are sulphide minerals like pyrite, gypsum and anhydrite minerals found in sedimentary rocks (Karanth, 1987).

In the ground waters of the state, the concentration of sulphate ranges from 0.86-3029mg/L. Maximum concentration detected in Jammalamadugu of Kadapa district.

8.1.12 Nitrate (NO_3^-)

Nitrogen is present in atmosphere reacts with rainwater and forms nitrate and ammonium ions.

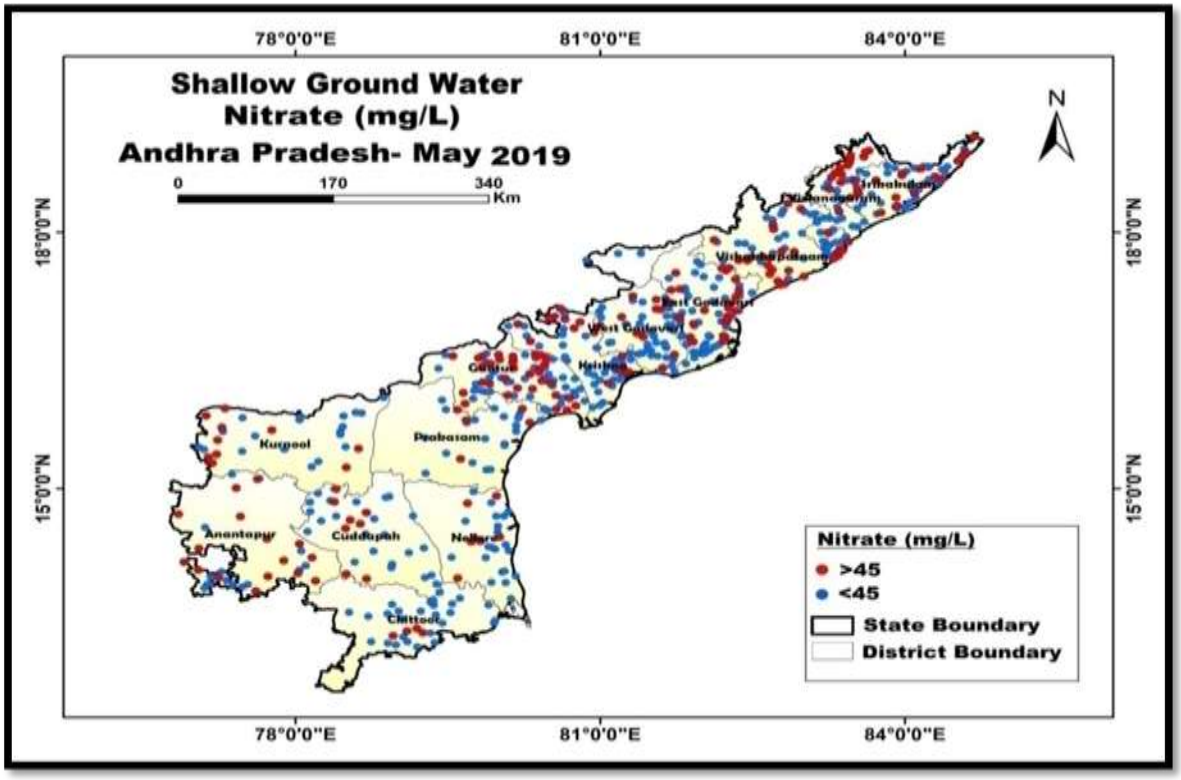


Fig.8.4: Point values of Nitrate in Shallow Ground waters of the State (May-2019).

The incidence of high nitrate in groundwater has been observed due topollution from anthropogenic sources, specially leaching from sewage/septic tanks **(Walker, 1973; Dudley, 1990).**

In the ground waters of State, the concentrations of Nitrate range from 0-622 mg/L. Maximum concentration detected in Badadanapalli of East Godavari district. It is found that out of 593 samples nearly 195 samples (32.9%) are unfit for human consumption. Point values of Nitrate are presented in **Fig.8.4**.

8.1.13 Fluoride (F^-)

The main sources of Fluoride in ground waters are Fluoride bearing minerals present in rocks like Fluorite (CaF_2), Apophyllite ($KCa_4Si_8O_{20}(F,OH)\ 8(H_2O)$, Fluoroapatite ($Ca_5(PO_4)_3F$), Cryolite ($Na_3AlF_6$), Villuanite as well as Fluoride replacing hydroxyl ion in the ferromagnesium silicates (amphiboles, micas) and soil consisting of clay minerals. Dissolution of F- bearing minerals, ion exchange and evaporative concentration can locally

account for high F- concentration in ground water. Weathering of rock and leachable Fluoride in an area are more important in deciding the presence of Fluoride in groundwater rather than presence of Fluoride bearing minerals in bulk rocks/soils (Ramesham and Rajagopalan 1985).

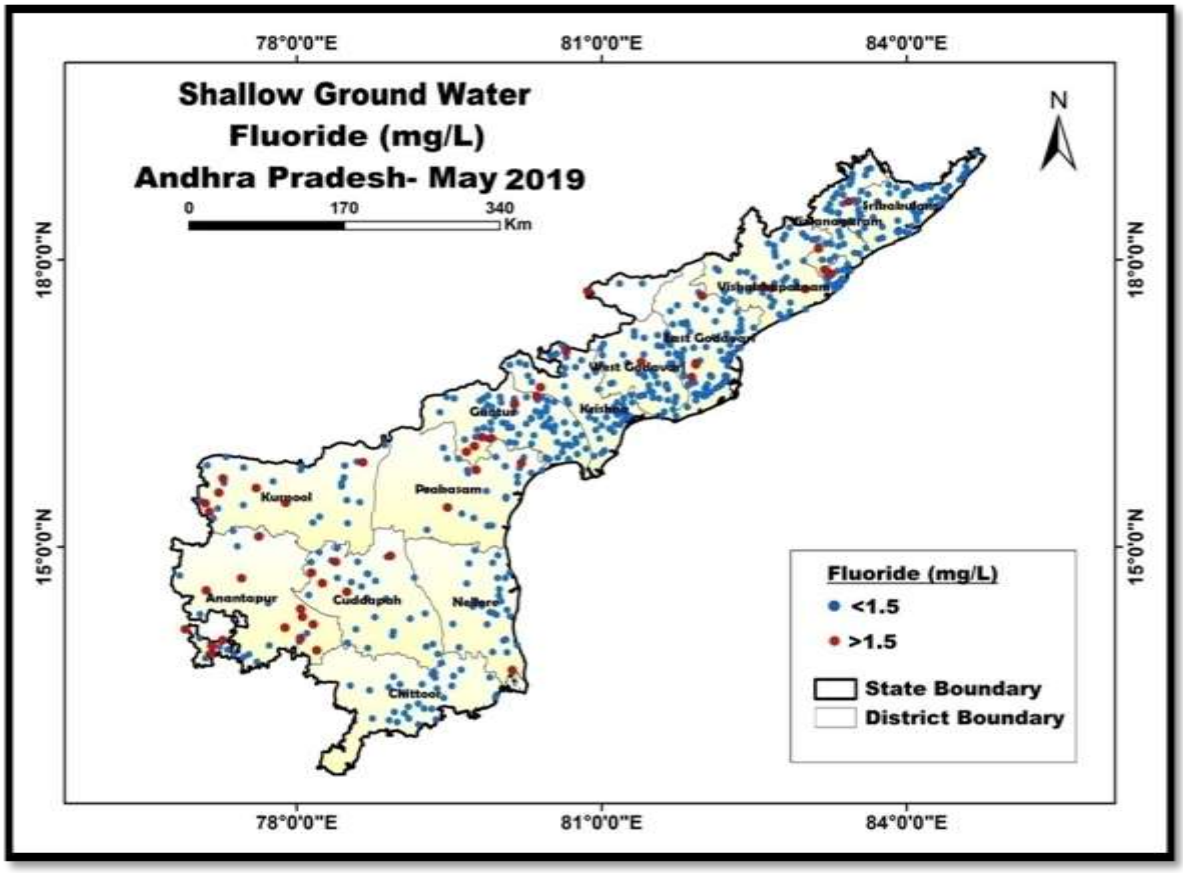


Fig.8.5: Point values of Fluoride in Shallow Ground waters of the state(May-2019).

In the ground waters of State, the concentrations of fluoride range from 0.04-4.61mg/L and maximum concentration is detected in Kalyandurg of Anantapur district. Out of 593 total samples, 49 (only 8.3%) are unfit for human consumption. Higher concentration of F (>1.5 mg/L) are detected in few more districts of the state**(Fig.8.5).**

8.2 Quality of ground water for drinking purpose

The hydro chemical data is compared with the drinking water quality standards set by Bureau of Indian Standards (BIS) to assess the suitability of ground water from shallow aquifers in Andhra Pradesh, for drinking purposes. The suitability of the ground water samples collected from shallow aquifers for drinking purposes with reference to chemical parameters is presented in Table 8.2.

Total Dissolved Solids(TDS) in 12.8% of samples is beyond permissible limit of BIS. Out of which, highest percent of samples in Krishna (29.6%), Kurnool (26.7) and Guntur (24.7%) districts are unsuitable for drinking with respect to TDS. Chloride Content in 4.9% of samples in the state exceeds the BIS permissibility. The Nitrate content in 32.9% of samples of the state is exceeding the BIS permissible value indicating the anthropogenic contamination. In the state w.r.t nitrate contamination, highest percent of samples in Ananthapur (51.6%), Guntur (46.6%), Visakhapatnam (45.8%), Vizianagaram (39.6%) Kurnool (36.7%) and Srikakulam (31.9%) districts are unfit for drinking.

Fluoride content in the state varies 0.04-4.61mg/L and maximum concentration is detected in Kalyandurg of Anantapur district. 8.3% of samples in the state exceed BIS permissible limit. Highest percent of samples in Anantapur (41.9%) followed by Kurnool (23.3%) districts are unfit for drinking.

Table- 8.2 Suitabilityof Samples with respect to different constituents (IS-10500: 2012) for drinking purpose

District	TH (600)	Ca (200)	Mg (100)	HCO_3 (600)	Cl (1000)	SO_4 (400)	NO_3 (45)	F (1.5)	TDS (2000)
% Samples Exceeding permissible limit									
Andhra Pradesh	**22.1**	**5.9**	**12.1**	**22.4**	**4.9**	**7.6**	**32.9**	**8.3**	**12.8**
Anantapur	**19.4**	**3.2**	**6.5**	**29**	**0**	**3.2**	**51.6**	**41.9**	**3.2**
Chittoor	**23.3**	**3.3**	**10**	**10**	**3.3**	**3.3**	**16.7**	**0**	**3.3**
East Godavari	**19.5**	**3.7**	**8.5**	**19.5**	**4.9**	**8.5**	**29.3**	**4.9**	**9.8**
Guntur	**41.1**	**11**	**21.9**	**41.1**	**6.8**	**12.3**	**46.6**	**6.8**	**24.7**
Kadapa	**25**	**6.3**	**18.8**	**12.5**	**9.4**	**9.4**	**21.9**	**15.6**	**12.5**
Krishna	**37**	**11.1**	**25.9**	**51.9**	**14.8**	**13**	**27.8**	**3.7**	**29.6**
Kurnool	**26.7**	**16.7**	**23.3**	**16.7**	**3.3**	**10**	**36.7**	**23.3**	**26.7**
Nellore	**17.9**	**10.7**	**3.6**	**21.4**	**10.7**	**14.3**	**21.4**	**3.6**	**14.3**
Prakasam	**7.7**	**0**	**3.8**	**26.9**	**3.8**	**0**	**19.2**	**15.4**	**15.4**
Srikakulam	**14.9**	**4.3**	**2.1**	**6.4**	**2.1**	**0**	**31.9**	**0**	**4.3**
Visakhapatnam	**13.6**	**1.7**	**10.2**	**18.6**	**0**	**0**	**45.8**	**6.8**	**1.7**
Vizianagaram	**6.3**	**4.2**	**2.1**	**0**	**0**	**2.1**	**39.6**	**6.3**	**0**
West Godavari	**20.8**	**1.9**	**13.2**	**20.8**	**3.8**	**17**	**20.8**	**1.9**	**17**

8.3 Quality of ground water for irrigation Purposes

The most extensive use of ground water in the world is for the irrigation consumption. The chemical quality of ground water is an important factor to be considered in evaluating its usefulness for irrigation as poor-quality ground water may cause salinity, specific ion toxicity or infiltration problem in soils. Such effect may adversely affect crop production.

Water quality constraints in irrigation can be examined using a number of empirical indices that have been established on the basis of field experience and experiments.

8.3.1 US salinity laboratory classification

The laboratory has constructed a diagram and described 16 classes with reference to Sodium Adsorption Ratio (SAR) as an index for sodium hazard and electrical conductivity as an index for salinity hazard. SAR is defined as

$$SAR = \frac{Na}{\sqrt{\frac{(Ca + Mg)}{2}}}$$

Where concentrations are expressed in meq/L.

The samples collected from the monitoring wells in Telangana fall in to 9 classes as described below.

C_1S_1: Low salinity and low sodium waters are good for irrigation and can be used with most of the crops with no restriction on use on most of the soils.

C_2S_1: Medium salinity and low sodium waters are good for irrigation and can be used on all most all soils with a little danger of development of harmful levels of exchangeable sodium if moderate amount of leaching occurs. Crops can be grown without any special consideration for salinity control.

C_3S_1: The high salinity and low sodium waters require good drainage. Crops with good salt tolerance should be selected.

C_3S_2: The high salinity and medium sodium waters require good drainage and can be used on coarse textured or organic soils having good permeability.

C_3S_3: These high salinity and high sodium waters require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendments make feasible the use of these waters.

C_4S_1: Very high salinity and low sodium waters are not suitable for irrigation unless the soil must be permeable and drainage must be adequate. Irrigation waters must be applied in excess to provide considerable leaching. Salt tolerant crops must be selected.

C_4S_2: Very high salinity and medium sodium waters are not suitable for irrigation on fine textured soils and low leaching conditions and can be used for irrigation on coarse textured or organic soils having good permeability.

C_4S_3: Very high salinity and high sodium waters produce harmful levels of exchangeable sodium in most soils and will require special soil management, good drainage, high leaching and organic matter additions. Gypsum amendment makes feasible the use of these waters.

C_4S_4: Very high salinity and very high sodium waters are generally unsuitable for irrigation purpose. These are sodium chloride type of waters and can cause sodium hazard. It can be used on coarse textured soils with very good drainage for very high salt tolerant crops. Gypsum amendments make feasible the use of these waters.

Fig. 8.6 shows the US salinity diagram of all water samples of the state. It is observed that 71% of water samples are falling in C_3S_1 class, 10.3% in C_2S_1 class, 3.4% of samples falling in C_3S_2 class and6.4%, 4.6%, 1.7%, 2.5%, samples falling in C_4S_2, C_4S_1, C_4S_3,C_1S_1respectively. Only one sample falls in C_4S_4 class.

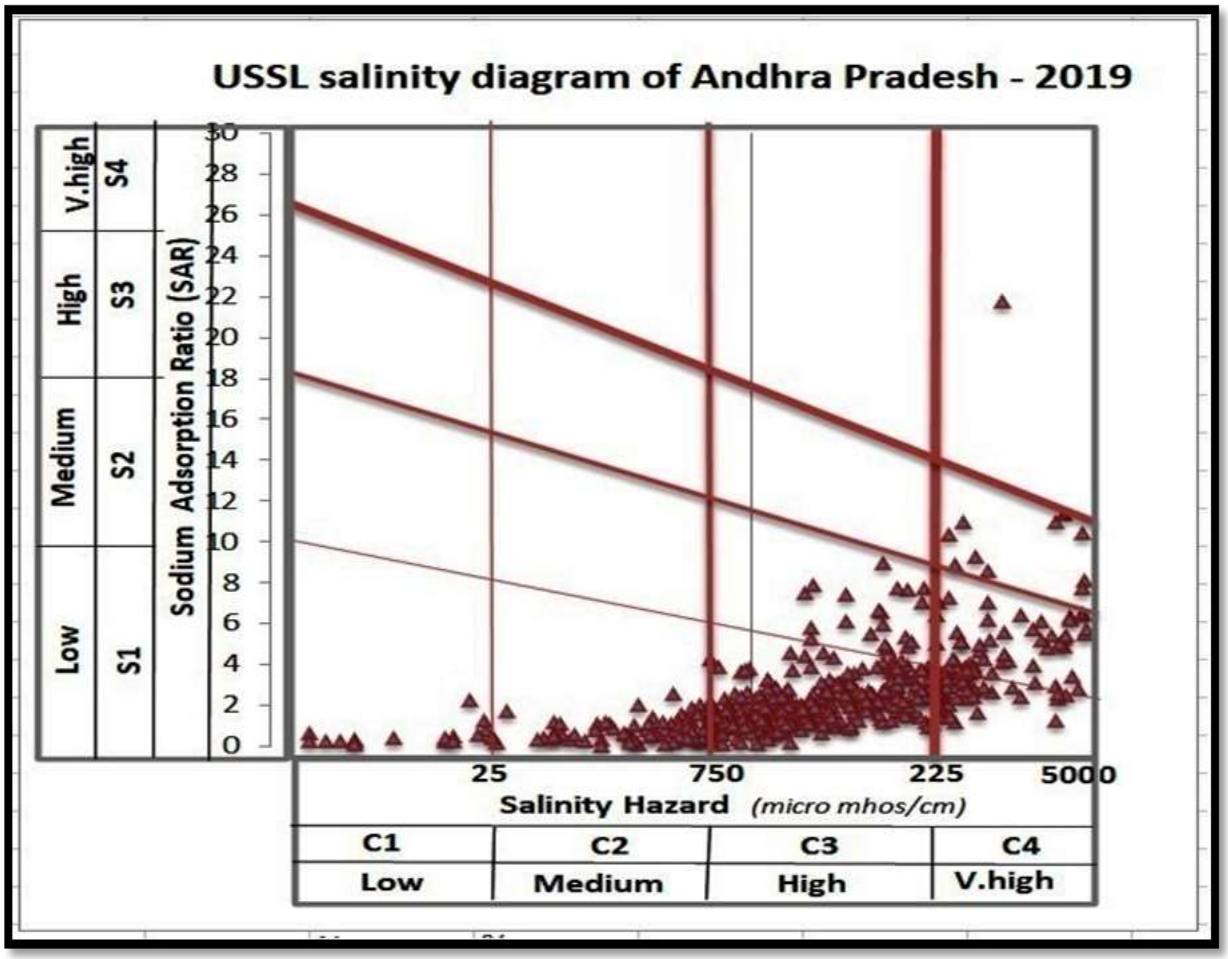


Fig. 8.6 U.S. Salinity diagram for classification of irrigation waters - shallow aquifers of Andhra Pradesh -2019.

8.3.2 Residual Sodium Carbonate (RSC)

The RSC is defined as the excess of carbonate and bicarbonate amount over the alkaline earths (Ca^{2+} and Mg^{2+}). Use of RSC beyond permissible limit (>2.5) adversely affects irrigation. The tendency of Ca^{2+} and Mg^{2+} to precipitate, as the water in the soil becomes more

concentrated, as a result of evaporation and plant transpiration, and gets fixed in the soil by the process of base exchange, thereby decreasing the soil permeability.

$$\mathbf{RSC = (CO_3^{2-} + HCO_3^{-})-(Ca^{2+}+Mg^{2+})}$$

Where concentrations are in meq/L.

Distribution of ground water in the state as per RSC given in **Table 8.3** reveals, majority of samples (77.23%) fall in Safe category (RSC < 1.25), 6.75 % samples in the Marginal category and remaining 16.02% samples in the Unsuitable category.

Table 8.3: **Classification of groundwater based on RSC.**

RSC	Category	No of samples	% of samples
<1.25	Safe	458	77.23
1.25 - 2.50	Marginal	40	6.75
> 2.50	Unsuitable	95	16.02

8.4 Water quality for livestock and poultry

Though there are no livestock standards regulated in India, basing on FAO and other international organizations standards, the water quality was classified for livestock and Poultry. One of the important parameter is Salinity/Electrical Conductivity, which moderately shows the suitability of most of the samples in usable. Magnesium and Nitrate are other important parameters to be considered for the usage of ground water for the livestock. **Tables 8.4** and **8.5** indicate water quality with respect to Nitrate and Salinity for livestock respectively.

8.5 Groundwater faecies

For identification of different water facies of groundwater, Piper diagram is widely used as it gives best graphical representation (**Hill, 1940; Piper 1944**). Groundwater can be grouped broadly into 10 types (**Fig.8.7**). Ground water from the state is mainly of Na-Mg-HCO_3-Cl and Na-Ca-HCO_3-Cl type followed by Na-Mg-Cl-HCO_3, Ca-Na-HCO_3-Cl type.

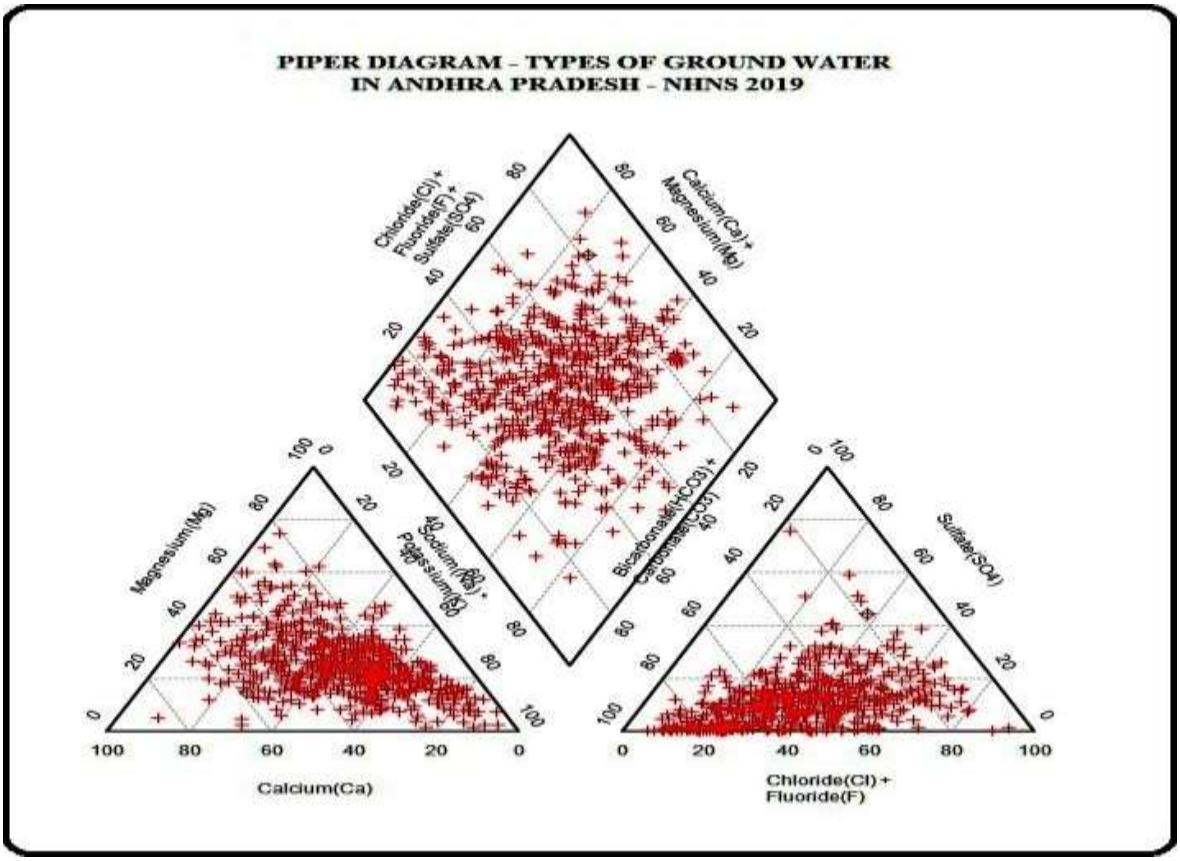


Fig.8.7: Ground water faecies (Piper Plot)-Shallow Ground Waters- Andhra Pradesh ,May-2019.

Table-8.4: Guide to use of waters containing Nitrate for livestock.

Nitrate-NO_3 (mg/L)	**No. of samples in the range**	**Comments**
<440	589	Experimental evidence indicates this water should not harm livestock or poultry.
440 – 1320	4	This water by itself should not harm livestock or poultry. If hays or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep, or horses.
> 1320	0	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, use of this water for swine or poultry should be avoided.

Source: Water Quality for Livestock and Poultry, FO-1864-GO. University of Minnesota, Extension Division, 1990.

Table-8.5 Use of ground water for livestock and poultry

Soluble salt content (TDS) [Electrical Conductivity(EC)]	Rating	No of samples in the range	Uses
< 1000 mg/L [<1.5 dS/m]	Excellent	339	Excellent for all classes of livestock and poultry
1000-3000 mg/L [1.5-5 dS/m]	Very satisfactory	222	Satisfactory for all classes of livestock. May cause temporary mild diarrhea in livestock not accustomed to them. Those waters approaching the upper limits may cause some watery droppings in poultry.
3000-5000 mg/L [5-8 dS/m]	Satisfactory for livestock Unfit for poultry	26	Satisfactory for livestock but may be refused by animals not accustomed to it. If Sulphate salts predominate, animals may show temporary diarrhea. Poor waters for poultry, often causing watery faeces, increased mortality and decreased growth especially in turkeys.
5000-7000 mg/L [8-11 dS/m]	Limited use for livestock Unfit for poultry	5	This water can be used for livestock except for those that are pregnant or lactating. It may have some laxative effect and may be refused by animals until they become accustomed to it. It is unsatisfactory for poultry
7000-10000 mg/L [11-16 dS/m]	Very limited use	1	Considerable risk for pregnant and lactating cows, horses, sheep and for the young of these species. It may be used for older ruminants or horses. Unfit for poultry and probably swine.
> 10000 mg/L [> 16 dS/m]	Not recommended	0	This water is unsatisfactory for all classes of livestock and poultry.

Source: FAO, 1985b, and Guyer, 1996.

9.0 SUM-UP

Central Ground Water Board, Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India, has been carrying out ground water regime studies all over the country for generating historical data base in order to establish dynamics of ground water regime which plays a crucial role for estimation of ground water resource.

Andhra Pradesh state covering ~1.63 lakh Km^2 lies between NL 12° 37' and 19° 09' and EL 76° 45' and 84° 47' and governed administratively by 13 districts. The total population of the state is ~4.96 crores and shown a decadal growth of 9.2 %. Drainage of the state can be divided into 3 major and 11 medium and ~60% of the soils are red in colour.

Forests occupy ~23% of the area and net sown area is ~38%. About 75% of the irrigation is contributed by ground water and the rest by surface water.

The mean annual rainfall in the year 2019 of the state is 963 mm. Season-wise rainfall is 618 mm, 276 mm, 12 mm and 57 mm in southwest monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively contributing 64% of annual rainfall in southwest monsoon, 29% of annual rainfall in northeast monsoon and 7 % in non-monsoon season. The annual (2019) rainfall ranges from 662 mm in Anantapar district (16 % above normal) to 1336.2 mm (15 % above normal) in Srikakulam district.

A major part of the state is underlain by gneissic complex with a structural fill of sedimentary formations and basin-fill of meta-sedimentary formations. The gneissic complex is overlain by basaltic lava flows in the northwestern part and is intruded by several younger rocks namely granites, dolerites, pegmatite's and quartzite etc.

The net ground water availability in the state is 20.15 BCM out of which the total draft for all uses (Domestic, Industrial and Irrigation) is 8.9 BCM. Net ground water available for future use is 11.25 BCM. The stage of development is 44.15%. Out of 670 mandals, over-exploited mandals are 45, critical mandals are 24, semi-critical mandals are 60 and safe mandals are 541 (including saline mandals 81).

Ground water monitoring is carried out as part of National ground water monitoring programme 4 times a year (January, May, August and November) and ground water quality once in a year (May). As on 31/03/2020, total of 838 (DW: 674and Pz: 164) Ground Water Monitoring Wells (GWMS) are in existence. There are 128 observers appointed to monitor GWMS on participatory mode (all dug wells).

Density of wells varies from 111 Km^2/well (East Godavari district) to 321 Km^2/well in Kurnool district with average of 191 Km^2/well. In the state, Soft rocks have 189 monitoring stations and hardocks have 649 monitoring stations.

In general, the water levels are deep during May and shallow during November months. During May (pre-monsoon season) water levels are in the range of 0.31 m bgl to 60 m bgl and water levels in the range of less than 10mbgl are more predominant and occupying ~82% of the area. Shallow water levels (0 to 2 m bgl) and deep water levels (>20 mbgl) occupy ~8 % and 2% of the area respectively.

During August (mid-monsoon season) water levels are in the range of 0.10 m bgl to 73.39 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~32% of the area followed by 2-5 mbgl (25% area). Shallow water levels less than 2 m occupy about 13% of the area. Water level 10 to 20 m bgl is covered in 21% of the area Deep water levels (>20 mbgl) occupy ~9 % of the area.

During November (post-monsoon season) water levels are in the range of 0.10 m bgl to 65.86 m bgl. Shallow water level range 0 to 2 m bgl is observed in 47% of the total area. Water levels in the range of 2-5 m bgl are occupying ~29 % of the area followed by 5-10 m bgl(15 % area). Deep water levels (>20 mbgl) occupy ~2 % of the area. Water levels are within 10 mbgl(91%) range in most of the area.

Area with deep water levels has changed from 9% in August to 2% in November. Area under shallow water levels changed from 8% in May to 47% in November.

During January-20, water levels are in the range of 0.1 m bgl to 58.4 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying 18 % of the area followed by 2-5 mbgl (40 % area). Shallow water levels (0-2 mbgl) occupy 33 % and deep water levels (>20 mbgl) occupy ~2 % of the area.

Integrated water level data from CGWB and GWD (Ground Water Department, Govt of Andhra Pradesh) has been considered to analyze water level scenario based on more dense data. Water level data from GWD is based on real-time monitoring of water level from DWLR of telemetry. Majority of water levels are in the range of 5 – 10m bgl in pre-monsoon and post-monsoon seasons. Deep water levels > 20 m bgl 29%has changed to 15% in post monsoon.

Water level fluctuation of August 2019 with pre-monsoon water level of May 2019 have shown fall in 23% of the area and rise in77% of the area. Maximum rise of 24.07 m in YSR Kadapa district and maximum fall of 4.86 m is also in YSR Kadapa district.

Water level fluctuation of Nov, 2019 with pre-monsoon water level of May, 2019 have shown fall in 2% of the area and rise in 98% of the area. Maximum rise of 36.69 m is in YSR Kadapa district and maximum fall is 10.2 m in Krishnar district.

Water level fluctuation of Jan, 2020 with pre-monsoon water level of May, 2019 have shown fall in 2% of the area and rise in 98% of the area. Maximum rise of 35.21 m in YSR Kadapa district and maximum fall is Kurnool district.

Annual water level fluctuation during May, 2019 from May, 2018 has shown fall in water levels in 59% of the area and rise in 41% of the area. Maximum rise of 16.38 m is observed in Krishna district and maximum fall is noticed in Prakasam district (20.28 m).

Annual water level fluctuation during Aug, 2019 from Aug, 2018 has shown fall in water levels in 21% of the area and rise in 79% of the area. Maximum fall is noticed in Prakasam district (19.18 m) and maximum rise of 33.82 m is observed in Prakasam districts.

Annual water level fluctuation during Nov-2019 from Nov, 2018 has shown fall in water levels in 10% of the area and rise in 90% of the area. The maximum rise of 16.41 m is recorded in Prakasam district and maximum fall of 10.80 m is recorded in Prakasam district.

Annual water level fluctuation during January-2020 from January-19 has shown fall in water levels in 18 % of the area and rise in 82% of the area. The maximum rise of 20.93 m recorded in Prakasam district and the maximum fall of 11.22 m is recorded in YSR Kadapa district.

Water levels during May-19, August-19, November-19 and January-20 as compared to decadal mean water levels, have shown fall in most of the wells during May'19 and Aug'19 and rise in most of the wells as well as in most of the area in Nov'19 and Jan'20 in comparison with decadal mean of corresponding water levels. The percentage of wells with fall in water levels in comparison with decadal mean of the respective months is 82%, 71%, 32% and 39% in May-19, August-19, November-19 and January-20 respectively.

Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in all the formations except in Intrusives. Deepest water levels are observed alluvium, Limestone and BGC. During post-monsoon season, shallowest water levels are observed in all formations except in Intrusives and Laterites. Deepest water levels are observed in Gneiss, Granite, Limestone, Quartz and Sandstone.

Based on long term water level trend maps, it is inferred that, during pre-monsoon season, rise in water level trend is observed in 14% of the area, fall in trend is observed in

86% of the area. During post-monsoon season, rise in water level trend is observed in 42% of the area, fall in trend is observed in 58% of the area.

Ground water quality is assessed during pre-monsoon season of 2019 by collecting 593 samples from both dug wells and piezometers and 14 parameters namely pH, EC (in µS/cm at 25 ° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3, F and TDS were analyzed as per standard guidelines laid down in APHA and suitability of ground water for drinking purposes is assessed as per BIS guidelines and for irrigation as per USSL and RSC.

Groundwater from the state is slightly acidic to alkaline in nature with pH in the range of 6.52-8.95. Electrical conductivity varies from 50-25430 µ Siemens/cm. Total Dissolved Solids (TDS) varies from 30-15287mg/l and in 76 samples (12%) it is beyond 2000 mg/l. Total hardness varies from 20-2525 mg/l and in 22 % of samples it is beyond 600 mg/l. Calcium varies from 4-393mg/L (in 6 % samples it is beyond permissible limits of BIS i.e., >200 mg/l) and magnesium varies from 1.22-386mg/ (in 12 % samples it is beyond permissible limits of BIS i.e., >100 mg/l). Sodium and potassium varies from BDL (Below detection Limit) to 5313 mg/l and BDL (Below detection Limit) to 716 mg/l respectively. The HCO_3 concentration varies from 9.2 to 2837mg/L,mg/l. Chloride and sulphate varies from 3.5 to 5530 mg/L and 0.86-3029mg/L respectively. NO_3 ranges from 0-622 mg/l and found that 33 % samples are unfit for human consumption (>45 mg/l). Fluoride concentration varies from 0.04-4.61mg/l and found that 8.3% samples are unfit for human consumption (beyond 1.5 mg/l).

As far as irrigation suitability of ground water is concerned it is found that majority of samples fall in C_3S_1 type of water. As per RSC classification of waters only 16.02% are unfit for irrigation. Ground water from the area is mainly of Na-Mg-HCO_3-Cl and Na-Ca-HCO_3-Cl type followed by Na-Mg-Cl-HCO_3, Ca-Na-HCO_3-Cl type.

Annexure-I: District wise Status of Ground water monitoring wells. May 2019(m bgl)

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on May 2019		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	32	33	65	32	33	65	10	0	10	0	0	0	0	0	0	0	0	0	32	33	65
2	Chittoor	45	15	60	24	12	36	21	01	22	0	2	2	0	0	0	0	0	0	45	15	60
3	Cuddapah	25	39	64	12	29	41	13	7	20	0	2	2	0	0	0	0	0	0	25	39	64
4	East Godavari	86	12	98	74	10	84	9	2	11	3	0	3	0	0	0	0	0	0	86	12	98
5	Guntur	84	13	97	70	13	83	10	3	13	0	1	1	0	0	0	0	0	0	84	13	97
6	Krishna	65	7	72	54	7	61	11	0	11	0	0	0	0	0	0	0	0	0	65	7	72
7	Kurnool	37	20	57	27	12	39	9	0	9	1	7	8	0	0	0	0	0	0	37	20	57
8	Nellore	57	0	57	31	0	31	26	0	26	0	0	0	0	0	0	0	0	0	57	0	57
9	Prakasam	49	13	62	22	8	30	27	4	31	0	1	1	0	0	0	0	0	0	49	13	62
10	Srikakulam	54	0	54	52	0	52	2	0	2	2	0	2	0	0	0	0	0	0	54	0	54
11	Visakhapatnam	58	3	61	58	3	61	2	0	2	0	0	0	0	0	0	0	0	0	58	3	61
12	Vizianagaram	51	0	51	48	0	48	1	0	1	2	0	2	0	0	0	0	0	0	51	0	51
13	West Godavari	54	9	63	44	8	52	7	1	8	3	0	3	0	0	0	0	0	0	54	9	63
	Total	**697**	**164**	**861**	**548**	**135**	**673**	**148**	**18**	**166**	**11**	**13**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	**697**	**164**	**861**

Annexure- II: District wise status of Ground water monitoring wells- August 2019(m bgl)

S. No	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on August 2019		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	32	33	65	23	26	49	9	0	9	1	7	8	0	0	0	0	0	0	32	33	65
2	Chittoor	45	15	60	24	14	38	21	0	21	0	1	1	0	0	0	0	0	0	45	15	60
3	Cuddapah	25	39	64	11	28	39	14	6	20	1	4	5	0	0	0	0	0	0	25	39	64
4	East Godavari	86	12	98	77	11	88	0	0	0	9	1	10	0	0	0	0	0	0	86	12	98
5	Guntur	84	13	97	76	9	85	5	1	6	4	3	7	0	0	0	0	0	0	84	13	97
6	Krishna	65	7	72	60	6	66	5	0	5	0	1	1	0	0	0	0	0	0	65	7	72
7	Kurnool	37	20	57	29	16	45	7	0	7	1	4	5	0	0	0	0	0	0	37	20	57
8	Nellore	57	0	57	33	0	33	24	0	24	0	0	0	0	0	0	0	0	0	57	0	57
9	Prakasam	49	13	62	24	8	32	25	0	25	0	5	5	0	0	0	0	0	0	49	13	62
10	Srikakulam	54	0	54	53	0	53	0	0	0	1	0	1	0	0	0	0	0	0	54	0	54
11	Visakhapatnam	58	3	61	58	3	61	0	0	0	0	0	0	0	0	0	0	0	0	58	3	61
12	Vizianagaram	51	0	51	51	0	51	0	0	0	0	0	0	0	0	0	0	0	0	51	0	51
13	West Godavari	54	9	63	51	7	58	1	1	2	2	1	3	0	0	0	0	0	0	54	9	63
	Total	**697**	**164**	**861**	**574**	**128**	**702**	**111**	**8**	**119**	**19**	**27**	**46**	**0**	**0**	**0**	**0**	**0**	**0**	**697**	**164**	**861**

Annexure- III: District wise status of Ground water monitoring wells- November 2019(m bgl)

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on November 2019		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	32	33	65	30	26	56	1	0	1	2	7	9	5	0	4	0	0	0	27	33	60
2	Chittoor	45	15	60	36	15	51	7	0	7	1	0	1	1	0	1	0	0	0	44	15	59
3	Cuddapah	25	39	64	18	29	47	5	6	11	1	4	5	1	0	1	0	0	0	24	39	63
4	East Godavari	86	12	98	79	8	87	0	1	1	0	2	2	2	0	2	0	0	0	84	12	96
5	Guntur	84	13	97	82	8	90	1	1	2	1	5	6	0	0	0	0	0	0	84	13	97
6	Krishna	65	7	72	59	4	63	4	1	5	2	2	4	0	0	0	0	0	0	65	7	72
7	Kurnool	37	20	57	35	15	50	2	0	2	0	5	5	2	0	2	0	0	0	35	20	55
8	Nellore	57	0	57	45	0	45	11	0	11	0	0	0	0	0	0	0	0	0	57	0	57
9	Prakasam	49	13	62	36	10	46	13	0	13	0	3	3	0	0	0	0	0	0	49	13	62
10	Srikakulam	54	0	54	51	0	51	0	0	0	2	0	2	3	0	3	0	0	0	51	0	51
11	Visakhapatnam	58	3	61	54	3	57	0	0	0	2	0	2	3	0	3	0	0	0	55	3	58
12	Vizianagaram	51	0	51	44	0	44	0	0	0	5	0	5	3	0	3	0	0	0	48	0	48
13	West Godavari	54	9	63	49	6	55	1	0	1	1	3	4	3	0	3	0	0	0	51	9	60
	Total	**697**	**164**	**861**	**618**	**124**	**742**	**45**	**9**	**54**	**17**	**31**	**48**	**18**	**0**	**23**	**0**	**0**	**0**	**674**	**164**	**838**

Annexure- IV: District wise status of Ground water monitoring wells- January 2020(m bgl)

S. No.	District	No of Stations to be monitored			No of Stations where WL data Recorded			No of Stations Monitored as Dry			No of Stations not Monitored due to Various Reasons			No of Stations Abandoned			No of Stations Established			No of Stations as on January 2020		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	27	33	60	25	33	58	0	0	0	2	0	2	0	0	0	0	0	0	27	33	60
2	Chittoor	44	15	59	36	13	49	6	0	6	2	2	4	0	0	0	0	0	0	44	15	59
3	Kadapa	24	39	63	21	29	50	3	5	8	0	5	5	0	0	0	0	0	0	24	39	63
4	East Godavari	84	12	96	79	10	89	0	0	0	5	2	7	0	0	0	0	0	0	84	12	96
5	Guntur	84	13	97	81	7	88	0	1	1	3	5	8	0	0	0	0	0	0	84	13	97
6	Krishna	65	7	72	62	4	66	2	0	2	1	3	4	0	0	0	0	0	0	65	7	72
7	Kurnool	35	20	55	35	19	54	0	0	0	0	1	1	0	0	0	0	0	0	35	20	55
8	Nellore	57	0	57	51	0	51	6	0	6	0	0	0	0	0	0	0	0	0	57	0	57
9	Prakasam	49	13	62	37	9	46	12	0	12	0	4	4	0	0	0	0	0	0	49	13	62
10	Srikakulam	51	0	51	49	0	49	0	0	0	2	0	2	0	0	0	0	0	0	51	0	51
11	Visakhapatnam	55	3	58	53	3	56	0	0	0	2	0	2	0	0	0	0	0	0	55	3	58
12	Vizianagaram	48	0	48	48	0	48	0	0	0	0	0	0	0	0	0	0	0	0	48	0	48
13	West Godavari	51	9	60	48	8	56	3	1	4	0	0	0	0	0	0	0	0	0	51	9	60
Total		674	164	838	625	135	760	32	7	39	17	22	39	0	0	0	0	0	0	674	164	838

Annexure- V: Distribution of percentage of wells-May 2019 (m bgl)

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	40	0.85	23.4	2	5	7	17.5	12	30	16	40	3	7.5	0	0
2	Chittoor	45	2.05	18.7	0	0	8	17.78	18	40	19	42.2	0	0	0	0
3	YSR Kadapa	31	2.55	60	0	0	2	6.45	13	41.94	12	38.7	1	3.23	3	9.68
4	East Godavari	87	0.45	11.4	14	16.09	44	50.57	26	29.89	3	3.45	0	0	0	0
5	Guntur	92	0.31	39.5	10	10.87	42	45.65	28	30.43	11	12	1	1.09	0	0
6	Krishna	67	0.94	23.8	8	11.94	33	49.25	18	26.87	7	10.5	1	1.49	0	0
7	Kurnool	43	0.55	35.93	3	6.98	7	16.28	22	51.16	10	23.3	1	2.33	0	0
8	Nellore	57	0.64	17	2	3.51	16	28.07	27	47.37	12	21.1	0	0	0	0
9	Prakasam	58	1.29	48.36	1	1.72	18	31.03	22	37.93	14	24.1	2	3.45	1	1.72
10	Srikakulam	43	1.7	9.8	5	11.63	26	60.47	12	27.91	0	0	0	0	0	0
11	Visakhapatnam	60	0.8	30.1	3	5	24	40	26	43.33	6	10	1	1.67	0	0
12	Vizianagaram	47	2.11	12.15	0	0	13	27.66	31	65.96	3	6.38	0	0	0	0
13	West Godavari	50	1.05	17.5	7	14	27	54	12	24	4	8	0	0	0	0
Total State		720	0.31	60	55	8%	267	37%	267	37%	117	16%	10	1%	4	1%

Annexure- VI: Distribution of percentage of wells- Aug 2019 (m bgl)

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) Range											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	42	1.08	28.5	4	9.52	6	14.29	14	33.33	13	31	5	11.9	0	0
2	Chittoor	43	1.13	18.15	3	6.98	7	16.28	16	37.21	17	39.5	0	0	0	0
3	YSR Kadapa	34	1.55	73.39	1	2.94	3	8.82	11	32.35	11	32.4	4	11.76	4	11.76
4	East Godavari	78	0.1	8.47	43	55.13	27	34.62	8	10.26	0	0	0	0	0	0
5	Guntur	89	0.1	39.5	24	26.97	34	38.2	23	25.84	7	7.87	1	1.12	0	0
6	Krishna	68	0.09	24.14	26	38.24	23	33.82	15	22.06	3	4.41	1	1.47	0	0
7	Kurnool	44	0.05	17.97	10	22.73	8	18.18	16	36.36	10	22.7	0	0	0	0
8	Nellore	56	2.12	17	0	0	18	32.14	25	44.64	13	23.2	0	0	0	0
9	Prakasham	57	0.85	46.15	5	8.77	13	22.81	22	38.6	15	26.3	1	1.75	1	1.75
10	Srikakulam	49	0.1	8.61	20	40.82	21	42.86	8	16.33	0	0	0	0	0	0
11	Visakhapatnam	65	0.15	32.97	17	26.15	22	33.85	21	32.31	4	6.15	1	1.54	0	0
12	Vizianagaram	51	0.49	11.09	9	17.65	21	41.18	19	37.25	2	3.92	0	0	0	0
13	West Godavari	51	0.1	12.2	26	50.98	15	29.41	9	17.65	1	1.96	0	0	0	0
Total State		727	0.1	73.39	188	26%	218	30%	207	28%	96	13%	13	2%	5	1%

Annexure-VII: Distribution of percentage of wells - November 2019

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	40	0.14	14.15	13	32.5	13	32.5	7	17.5	7	17.5	0	0	0	0
2	Chittoor	43	0.1	18.15	9	20.93	12	27.91	14	32.56	8	18.6	0	0	0	0
3	YSR Kadapa	34	0.5	65.86	3	8.82	8	23.53	6	17.65	8	23.53	6	17.65	3	8.82
4	East Godavari	83	0.1	11.31	58	69.88	21	25.3	3	3.61	1	1.2	0	0	0	0
5	Guntur	91	0.02	39.5	44	48.35	33	36.26	11	12.09	2	2.2	1	1.1	0	0
6	Krishna	66	0.15	28.5	38	57.58	18	27.27	7	10.61	1	1.52	2	3.03	0	0
7	Kurnool	44	0.2	12.2	12	27.27	20	45.45	9	20.45	3	6.82	0	0	0	0
8	Nellore	57	0.18	17	13	22.81	25	43.86	13	22.81	6	10.53	0	0	0	0
9	Prakasham	59	0.1	30.71	16	27.12	13	22.03	19	32.2	9	15.25	2	3.39	0	0
10	Srikakulam	44	0.41	3.92	39	88.64	5	11.36	0	0	0	0	0	0	0	0
11	Visakhapatnam	57	0.17	17.8	34	59.65	17	29.82	5	8.77	1	1.75	0	0	0	0
12	Vizianagaram	44	0.36	7.8	30	68.18	10	22.73	4	9.09	0	0	0	0	0	0
13	West Godavari	48	0.1	10.45	34	70.83	8	16.67	5	10.42	1	2.08	0	0	0	0
Total State		710	0.1	65.86	343	48%	203	29%	103	15%	47	7%	11	2%	3	0%

Annexure-VIII: Distribution of percentage of wells- January 2020

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Range of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0-20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	36	0.39	19.53	9	25	11	30.56	9	25	7	19.4	0	0	0	0
2	Chittoor	42	0.55	18.15	12	28.57	12	28.57	9	21.43	9	21.43	0	0	0	0
3	YSR Kadapa	36	1.05	58.4	5	13.89	6	16.67	10	27.78	7	19.44	5	13.89	3	8.33
4	East Godavari	84	0.05	11.25	41	48.81	37	44.05	4	4.76	2	2.38	0	0	0	0
5	Guntur	89	0.17	39.5	32	35.96	40	44.94	13	14.61	3	3.37	1	1.12	0	0
6	Krishna	66	0.1	23.38	26	39.39	29	43.94	6	9.09	4	6.06	1	1.52	0	0
7	Kurnool	45	0.15	40.9	8	17.78	24	53.33	10	22.22	2	4.44	0	0	1	2.22
8	Nellore	57	0.1	14.36	27	47.37	16	28.07	11	19.3	3	5.26	0	0	0	0
9	Prakasham	58	0.1	27.27	12	20.69	16	27.59	19	32.76	9	15.52	2	3.45	0	0
10	Srikakulam	45	0.79	6.55	9	20	29	64.44	7	15.56	0	0	0	0	0	0
11	Visakhapatnam	56	0.75	20.74	16	28.57	24	42.86	14	25	1	1.79	1	1.79	0	0
12	Vizianagaram	48	0.88	8.22	9	18.75	31	64.58	8	16.67	0	0	0	0	0	0
13	West Godavari	52	0.17	10.47	26	50	14	26.92	11	21.15	1	1.92	0	0	0	0
Total State		714	0.1	58.4	232	32%	289	40%	131	18%	48	7%	10	1%	4	1%

Annexure- IX: Fluctuation and Frequency distribution from different ranges from one period to other August 2019 from May 2019

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.02	9.01	0.01	1.7	14	35	5	12.5	1	2.5	11	27.5	0	0	0	0	20	11
2	Chittoor	43	0.09	6.93	0.17	2.3	16	37	1	2.33	2	4.69	4	9.3	1	2.33	0	0	19	5
3	YSR Kadapa	34	0.13	24.07	0.38	4.86	6	18	2	5.88	4	11.8	4	11.76	3	8.82	2	5.88	12	9
4	East Godavari	77	0.01	10.22	0.15	1.56	44	57	16	20.78	11	14.3	6	7.79	0	0	0	0	71	6
5	Guntur	87	0.09	12.48	0.01	2.6	47	54	16	18.39	6	6.9	12	13.79	3	3.45	0	0	69	15
6	Krishna	67	0.16	10.6	0.33	1.66	40	60	12	17.91	5	7.46	5	7.46	0	0	0	0	57	5
7	Kurnool	42	0.01	19.71	0.01	3.47	14	33	10	23.81	3	7.14	6	14.29	2	4.76	0	0	27	8
8	Nellore	56	0.03	3.72	0.07	2.53	13	23	3	5.36	0	0	13	23.21	2	3.57	0	0	16	15
9	Prakasam	57	0.18	4.45	0.13	2	11	19	7	12.28	1	1.73	11	19.3	0	0	0	0	19	11
10	Srikakulam	41	0.15	7	0.01	0.79	24	59	8	19.51	3	7.32	6	14.63	0	0	0	0	35	6
11	Visakhapatnam	59	0.01	8.34	0.1	4.27	33	56	10	16.95	6	10.1	7	11.8	2	3.39	1	1.69	49	10
12	Vizianagaram	45	0.19	5	0.17	4.05	24	53.33	10	22.22	4	8.89	6	13.33	0	0	1	2.22	38	7
13	West Godavari	49	0.02	8.27	0.38	0.55	34	69.39	9	18.37	3	6.12	2	4.09	0	0	0	0	46	2
Total State		697	0.01	24.07	0.01	4.86	320	67%	109	23%	49	10%	93	85%	13	12%	4	4%	478	110

Annexure- X: Fluctuation and Frequency distribution from different ranges from one period to other November 2019 from May 2019

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	39	0.16	17.41			8	21	3	7.69	27	69.23	0	0	0	0	0	0	38	0
2	Chittoor	43	0.11	11.21	0.4	6.75	12	28	13	30.23	10	23.26	1	2.33	0	0	1	2.33	35	2
3	YSR Kadapa	32	0.79	36.69	0.1	4.52	6	19	6	18.75	10	31.25	3	9.38	0	0	1	3.13	22	4
4	East Godavari	83	0.09	10.21	0.09	1.07	43	52	20	24.1	18	21.69	2	2.41	0	0	0	0	81	2
5	Guntur	89	0.11	10.69	0.06	0.4	33	37	30	33.71	21	23.6	3	3.37	0	0	0	0	84	3
6	Krishna	64	0.33	15.32	4.61	4.61	29	45	17	26.56	15	23.44	0	0	0	0	1	1.56	61	1
7	Kurnool	42	0.14	23.9			11	26	13	30.95	16	38.1	0	0	0	0	0	0	40	0
8	Nellore	57	0.35	7.55	0.29	0.88	16	28	11	19.3	16	28.07	3	5.26	0	0	0	0	43	3
9	Prakasham	57	0.08	17.65			17	30	19	33.33	8	14.04	0	0	0	0	0	0	44	0
10	Srikakulam	42	0.34	9.13			11	26	20	47.62	11	26.19	0	0	0	0	0	0	42	0
11	Visakhapatnam	56	0.1	12.3			17	30	16	28.57	23	14.07	0	0	0	0	0	0	56	0
12	Vizianagaram	41	1.02	8			5	12.2	14	34.15	22	53.66	0	0	0	0	0	0	41	0
13	West Godavari	48	0.2	11.27	1.95	1.95	28	58.33	10	20.83	9	18.75	1	2.08	0	0	0	0	47	1
Total State		693	0.08	36.69	0.06	6.75	236	51%	192	41%	206	7%	13	81%	0	0%	3	19%	634	16

Annexure- XI: Fluctuation and Frequency distribution from different ranges from one period to other January 2020 from May 2019

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	34	0.09	19.23	0.19	0.19	7	21	7	20.59	19	55.88	1	2.94	0	0	0	0	33	1
2	Chittoor	42	0.5	13.3	1.13	2.3	11	26	10	23.81	14	33.33	1	2.38	1	2.38	0	0	35	2
3	YSR Kadapa	34	0.13	35.21	0.33	0.9	5	15	6	17.65	16	47.06	2	5.88	0	0	0	0	27	2
4	East Godavari	82	0.05	7.72	0.1	1.47	52	63	13	15.85	10	12.2	7	8.54	0	0	0	0	75	7
5	Guntur	88	0.01	10.95	0.35	1.41	42	48	28	31.82	15	17.05	2	2.27	0	0	0	0	85	2
6	Krishna	65	0.11	13.37	0.14	0.46	39	60	13	20	8	12.31	3	4.62	0	0	0	0	60	3
7	Kurnool	41	0.31	10.3	0.03	4.97	13	32	11	26.83	14	34.15	2	4.88	0	0	1	2.44	38	3
8	Nellore	57	0.44	10.55	0.46	0.46	12	21	15	26.32	23	40.35	1	1.75	0	0	0	0	50	1
9	Prakasham	57	0.21	21.09	1.12	1.12	14	25	21	36.84	9	15.79	1	1.75	0	0	0	0	44	1
10	Srikakulam	42	0.03	4.49	0.49	1.39	27	64	7	16.67	3	7.14	4	9.52	0	0	0	0	37	4
11	Visakhapatnam	56	0.11	9.36	0.03	2.93	23	41	18	32.14	9	16.07	4	7.14	1	1.79	0	0	50	5
12	Vizianagaram	45	0.26	7.56	-	-	17	37.78	20	44.44	8	17.78	0	0	0	0	0	0	45	0
13	West Godavari	47	0.16	8.83	0.12	0.8	32	68.09	7	14.89	3	6.38	2	4.26	0	0	0	0	42	2
Total State		690	0.01	35.21	0.03	4.97	294	47%	176	28%	151	24%	30	91%	0	0%	1	3%	621	33

Annexure- XII: Fluctuation and Frequency distribution from different ranges from one period to other May 2019 from May 2018

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	39	0.04	1.03	0.11	16.63	4	10	0	0	0	0	7	17.95	16	41.03	9	23.1	4	32
2	Chittoor	44	2.67	6.75	0.10	13.07	0	0	1	2	1	2	11	25	10	22.73	11	25	2	32
3	YSR Kadapa	25	0.23	2.60	0.1	9.6	1	4	1	4	0	0	5	20	7	28	8	32	2	20
4	East Godavari	82	0.01	15.90	0.05	5.80	33	40	5	6	2	2	37	45.12	3	3.66	1	1.22	40	41
5	Guntur	92	0.02	4.59	0.03	4.76	20	22	2	2	1	1	54	58.7	5	5.43	2	2.19	23	61
6	Krishna	67	0.02	16.38	0.01	10.78	32	48	2	3	2	3	17	25.37	1	1.49	1	1.49	36	19
7	Kurnool	39	0.29	2.29	0.11	11.36	3	8	1	3	0	0	20	51.28	8	20.51	5	12.8	4	33
8	Nellore	50	1.27	9.48	0.16	4.90	2	4	4	8	1	2	15	30	7	14	4	8	7	26
9	Prakasam	53	0.03	7.39	0.08	20.28	8	15	2	4	1	2	17	32.08	2	3.77	4	7.5	11	23
10	Srikakulam	43	0.04	4.60	0.03	3.35	24	56	4	9	1	2	10	23.26	2	4.65	0	0	29	12
11	Visakhapatnam	60	0.05	6.65	0.05	5.90	12	20	1	2	3	5	33	55	6	10	2	3.33	16	41
12	Vizianagaram	47	0.02	0.59	0.02	3.52	7	15	0	0	0	0	32	68.09	7	14.89	0	0	7	39
13	West Godavari	48	0.06	3.40	0.02	7.26	16	16	2	4	0	0	25	52.08	0	0	1	2.08	18	26
Total State		689	0.01	16.38	0.01	20.28	162	81%	25	13%	12	6%	283	70%	74	18%	48	12%	199	405

Annexure- XIII: Fluctuation and Frequency distribution from different ranges from one period to other August 2019 from August 2018

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	42	0.09	8.27	0.23	12.63	6	14	0	0	2	5	14	33.33	8	19.05	9	21.5	8	31
2	Chittoor	41	0.10	8.57	0.01	7.76	6	15	1	2	1	2	12	29.27	3	7.32	9	22	8	24
3	YSR Kadapa	25	0.59	2.38	0.12	9.79	3	12	2	8	0	0	4	16	4	16	7	28	5	15
4	East Godavari	74	0.06	2.71	0.01	2.97	28	38	1	1	0	0	43	58.11	2	2.7	0	0	29	45
5	Guntur	85	0.14	4.87	0.03	7.64	22	26	2	2	2	2	48	56.47	9	10.59	1	1.18	26	58
6	Krishna	67	0.01	7.51	0.20	11.00	10	15	2	3	2	3	33	49.25	10	14.93	7	10.5	14	50
7	Kurnool	40	0.14	9.66	0.11	6.83	11	28	1	3	1	3	14	35	7	17.5	4	10	13	25
8	Nellore	55	0.03	3.27	0.13	9.14	14	25	2	4	0	0	16	29.09	6	10.91	1	1.82	16	23
9	Prakasam	57	0.05	33.82	0.11	19.18	13	23	1	2	2	4	18	31.58	1	1.75	3	5.26	16	22
10	Srikakulam	43	0.50	1.36	0.05	4.95	2	5	0	0	0	0	28	65.12	10	23.26	3	6.98	2	41
11	Visakhapatnam	59	0.06	7.30	0.02	6.05	9	15	3	5	1	2	28	47.46	12	20.34	3	5.08	13	43
12	Vizianagaram	48	0.05	2.79	0.02	5.89	6	13	1	2	0	0	25	52.08	11	22.92	5	10.4	7	41
13	West Godavari	46	0.02	2.63	0.01	10.62	8	17	1	2	0	0	29	63.04	5	10.87	3	6.54	9	37
Total State		682	0.01	33.82	0.01	19.18	138	83%	17	10%	11	7%	312	69%	88	19%	55	12%	166	455

Annexure- XIV: Fluctuation and Frequency distribution from different ranges from one period to other November 2019 from November 2018

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	39	0.12	9.07	2.63	2.84	15	38	5	13	16	41	0	0	2	5.13	0	0	36	2
2	Chittoor	43	0.11	10.43	0.40	8.74	14	33	13	30	3	7	5	11.63	0	0	4	9.3	30	9
3	YSR Kadapa	23	0.20	8.08	0.06	6.56	7	30	2	9	2	9	5	21.74	1	4.35	4	17.39	11	10
4	East Godavari	83	0.01	4.94	0.15	1.79	61	73	7	8	2	2	13	15.66	0	0	0	0	70	13
5	Guntur	88	0.01	8.78	0.05	0.66	62	70	10	11	8	9	6	6.82	0	0	0	0	80	6
6	Krishna	66	0.04	5.08	0.05	4.50	41	62	7	11	2	3	9	13.64	2	3.03	1	1.52	50	12
7	Kurnool	42	0.03	11.45	0.07	6.33	21	50	6	14	11	26	2	4.76	1	2.38	1	2.38	38	4
8	Nellore	57	0.29	7.55	0.30	4.99	22	39	16	28	8	14	1	1.75	0	0	1	1.75	46	2
9	Prakasham	56	0.08	16.41	0.02	10.80	24	43	11	20	3	5	4	7.14	0	0	2	3.57	38	6
10	Srikakulam	43	0.05	2.77	0.07	1.87	34	79	2	5	0	0	7	16.28	0	0	0	0	36	7
11	Visakhapatnam	56	0.03	9.40	0.32	0.37	36	64	11	20	7	13	2	3.57	0	0	0	0	54	2
12	Vizianagaram	44	0.08	5.37	0.09	0.09	25	57	16	36	2	5	1	2.27	0	0	0	0	43	1
13	West Godavari	49	0.14	6.78	0.03	8.73	37	76	3	6	2	4	5	10.2	0	0	2	4.08	42	7
Total State		689	0.01	16.41	0.02	10.80	399	70%	109	19%	66	11%	60	74%	6	7%	15	19%	574	81

Annexure-XV: Fluctuation and Frequency distribution from different ranges from one period to other January 2020 from January2019

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	35	0.26	10.57	0.01	5.02	13	37	7	20	11	31	3	8.57	0	0	1	2.86	31	4
2	Chittoor	42	0.05	13.30	0.18	9.70	16	38	4	10	8	19	6	14.29	2	4.76	3	7.14	28	11
3	YSR Kadapa	30	0.08	6.88	0.08	11.22	7	23	4	13	4	13	8	26.67	2	6.67	2	6.67	15	12
4	East Godavari	84	0.01	6.02	0.02	2.19	44	52	6	7	1	1	32	38.1	1	1.19	0	0	51	33
5	Guntur	87	0.03	9.34	0.06	1.14	51	59	6	7	8	9	20	22.99	0	0	0	0	65	20
6	Krishna	65	0.01	11.44	0.02	1.95	24	37	4	6	6	9	29	44.62	0	0	0	0	34	29
7	Kurnool	42	0.15	9.99	0.05	1.85	20	48	6	14	8	19	8	19.05	0	0	0	0	34	8
8	Nellore	57	0.13	9.05	0.39	5.88	23	40	15	26	10	18	3	5.26	0	0	2	3.51	48	5
9	Prakasham	58	0.02	20.93	0.03	2.97	26	45	9	16	6	10	4	6.9	1	1.72	0	0	41	5
10	Srikakulam	44	0.02	3.35	0.04	2.30	13	30	4	9	0	0	25	56.82	1	2.27	0	0	17	26
11	Visakhapatnam	53	0.03	8.18	0.01	4.06	28	53	6	11	2	4	16	30.19	0	0	1	1.89	36	17
12	Vizianagaram	44	0.14	7.16	0.02	1.09	27	61	5	11	2	5	10	22.73	0	0	0	0	34	10
13	West Godavari	48	0.02	4.90	0.04	1.92	28	58	3	6	1	2	16	33.33	0	0	0	0	32	16
Total State		689	0.01	20.93	0.01	11.22	320	69%	79	17%	67	14%	180	92%	7	4%	9	5%	466	196

Annexure- XVI: Fluctuation and Frequency distribution from different ranges from one period to other

May 2019 from Decadal mean of May (2009-18)

Mean (2009 May-2018 May) -May/ 2019																				
			Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
							Rise						Fall						Total No. of Wells	
			Rise		Fall		0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
Sl. No	District	No of Wells Analysed	Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	39	0.14	1.07	0.03	16.63	6	15	0	0	0	0	12	31	14	36	7	18	6	33
2	Chittoor	45	0.06	5.75	0.09	9.32	8	18	1	2	1	2.22	16	36	14	31	5	11	10	35
3	YSR Kadapa	26	0.3	6.59	0.38	9.68	2	8	2	8	1	3.85	13	50	5	19	3	12	5	21
4	East Godavari	87	0	3.43	0.01	5.98	32	37	2	2	0	0	42	48	6	7	4	5	34	52
5	Guntur	92	0.01	2.05	0.08	5.55	21	23	1	1	0	0	48	52	16	17	6	7	22	70
6	Krishna	67	0.02	4.56	0	6.4	18	27	1	1	1	1.49	39	58	6	9	2	3	20	47
7	Kurnool	42	0.09	2.77	0.1	5.81	9	21	1	2	0	0	21	50	8	19	3	7	10	32
8	Nellore	57	0.18	3.19	0.09	6.41	5	9	3	5	0	0	26	46	15	26	8	14	8	49
9	Prakasam	58	0.12	7.13	0.01	22.46	4	7	1	2	3	5.17	27	47	16	28	7	12	8	50
10	Srikakulam	43	0.01	5.3	0.11	2.19	24	56	3	7	4	9.3	10	23	1	2	0	0	31	11
11	Visakhapatnam	60	0.01	5.62	0.05	4.94	14	23	3	5	1	1.67	31	52	9	15	2	3	18	42
12	Vizianagaram	47	0.01	1.48	0.05	3.74	9	19	0	0	0	0	29	62	9	19	0	0	9	38
13	West Godavari	50	0.01	1.35	0	4.62	17	34	0	0	0	0	29	58	2	4	2	4	17	33
Total State		713	0	7.13	0	22.46	169	85%	18	9%	11	6%	343	67%	121	24%	49	10%	198	513

Annexure-XVII: Fluctuation and Frequency distribution from different ranges from one period to other

August 2019 from Decadal mean of Aug (2009-18)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	42	0.04	2.3	0.19	8.89	12	29	1	2	0	0	11	26	11	26	7	17	13	29
2	Chittoor	43	0.43	8.57	0.08	8.13	9	21	2	5	1	2.33	14	33	12	28	5	12	12	31
3	YSR Kadapa	25	1.17	3.59	0.21	9.87	2	8	6	24	0	0	7	28	5	20	5	20	8	17
4	East Godavari	78	0.06	2.11	0.06	3.84	38	49	2	3	0	0	31	40	6	8	0	0	40	37
5	Guntur	89	0.01	2.63	0.07	8.09	34	38	2	2	0	0	40	45	7	8	6	7	36	53
6	Krishna	68	0.04	5.69	0.01	6.18	19	28	4	6	1	1.47	33	49	7	10	4	6	24	44
7	Kurnool	43	0.06	4.23	0.31	7.36	13	30	3	7	1	2.33	12	28	9	21	5	12	17	26
8	Nellore	56	0.07	1.23	0.01	9.54	6	11	0	0	0	0	34	61	12	21	4	7	6	50
9	Prakasham	57	0.07	10.8	0.05	22.19	9	16	2	4	2	3.51	28	49	11	19	4	7	13	43
10	Srikakulam	48	0.04	3.95	0.03	4.83	11	23	2	4	0	0	25	34	8	23	2	8	13	35
11	Visakhapatnam	65	0.06	5.9	0.09	8.99	21	32	1	2	1	1.54	22	34	15	23	5	8	23	42
12	Vizianagaram	51	0.05	1.15	0.24	5.17	7	14	0	0	0	0	18	35	21	41	5	10	7	44
13	West Godavari	50	0.01	4.31	0.02	8.64	17	34	0	0	1	2	24	48	7	14	1	2	18	32
Total State		715	0.01	10.8	0.01	22.19	198	86%	25	11%	7	3%	299	62%	131	27%	53	11%	230	483

Annexure-XVIII: Fluctuation and Frequency distribution from different ranges from one period to other

November 2019 from Decadal mean of November (2009-18)

Mean (2009 NOV-2018 NOV) -NOV/ 2019																				
			Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
Sl. No	District	No of Wells Analysed	Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.17	6.17	0.19	3.85	19	48	9	23	5	12.5	4	10	3	8	0	0	33	7
2	Chittoor	43	0.1	6.18	0.18	5.46	17	40	6	14	2	4.65	7	16	6	14	5	12	25	18
3	YSR Kadapa	25	0.23	4.02	0.09	19.4	5	20	4	16	1	4	4	16	4	16	7	28	10	15
4	East Godavari	83	0.02	3.78	0.07	4.88	61	73	5	6	0	0	12	14	2	2	2	2	66	16
5	Guntur	91	0.01	2.59	0.01	15.31	54	59	6	7	0	0	26	29	3	3	2	2	60	31
6	Krishna	66	0.01	3.06	0.02	4.2	44	67	4	6	0	0	15	23	2	3	1	2	48	18
7	Kurnool	43	0.06	6.83	0	7.15	22	51	6	14	2	4.65	12	28	0	0	1	2	30	13
8	Nellore	57	0.04	4.88	0.06	6.6	26	46	4	7	1	1.75	16	28	4	7	6	11	31	26
9	Prakasham	59	0.01	6.88	0.11	16.58	23	40	3	5	2	3.39	18	31	8	14	5	8	28	31
10	Srikakulam	44	0.04	3.27	0.01	0.35	33	75	5	11	0	0	6	14	0	0	0	0	38	6
11	Visakhapatnam	57	0.09	3.28	0.11	0.6	46	81	3	5	0	0	8	14	0	0	0	0	49	8
12	Vizianagaram	44	0.18	3.85	0.05	1.55	29	66	6	14	0	0	9	20	0	0	0	0	35	9
13	West Godavari	49	0.04	8.2	0	6.97	40	82	2	4	1	2.04	5	10	0	0	1	2	43	6
Total State		701	0.01	8.2	0	19.4	419	84%	63	13%	14	3%	142	70%	32	16%	30	15%	496	204

Annexure- XIX: Fluctuation and Frequency distribution from different ranges from one period to other Jan, 2020 from Decadal mean of Jan (2010-19)

Decadal Mean (January 2010- January 2019) to January -2020																				
Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	36	0.02	6.08	0.01	3.71	13	36	11	31	3	8.33	7	19	2	6	0	0	27	9
2	Chittoor	42	0.2	7.57	0.01	7.81	14	33	6	14	3	7.14	8	19	5	12	6	14	23	19
3	YSR Kadapa	31	0.53	5.44	0.04	11.22	7	23	6	19	2	6.45	5	16	6	19	5	16	15	16
4	East Godavari	84	0.01	4.36	0.01	5.84	45	54	3	4	2	2.38	31	37	1	1	2	2	50	34
5	Guntur	89	0.02	2.59	0	10.61	52	58	6	7	0	0	25	28	4	4	2	2	58	31
6	Krishna	66	0.02	8.77	0	3.39	31	47	4	6	2	3.03	26	39	2	3	0	0	37	28
7	Kurnool	44	0.03	9.27	0.03	1.97	20	45	9	20	3	6.82	12	27	0	0	0	0	32	12
8	Nellore	57	0.02	5.21	0.07	6.78	28	49	6	11	2	3.51	16	28	2	4	3	5	36	21
9	Prakasham	58	0.01	10.7	0.03	11.1	20	34	3	5	4	6.9	21	36	4	7	6	10	27	31
10	Srikakulam	45	0.03	2	0.01	1.77	30	67	0	0	0	0	15	33	0	0	0	0	30	15
11	Visakhapatnam	56	0	2.52	0.05	2.52	36	64	1	2	0	0	17	30	2	4	0	0	37	19
12	Vizianagaram	48	0	6.99	0.12	2.42	25	52	2	4	1	2.08	19	40	1	3	0	0	28	20
13	West Godavari	48	0.01	3.46	0.02	2.14	27	56	3	6	0	0	17	35	1	2	0	0	30	18
Total State		704	0	10.7	0	11.22	348	81%	60	14%	22	5%	219	80%	30	11%	24	9%	430	273

Annexure- XX: District-wise summarized chemical composition of ground water from GWMS during Pre-monsoon season-2018 (May), Andhra Pradesh

DISTRICT	STATISTICS	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	NO3	SO4	F	TDS	Total Alkalinity
ANANTHAPUR	Maximum:	8.25	5500	780	240	141	527	716	0	1037	638	662	478	4.61	3813	850
	Minimum:	7.50	390	105	28	8.5	38	0.39	0	189	18	1.4	10	0.50	228	155
	Average:	7.90	1803	430	96	46	180	62	0	528	196	103	105	1.76	1110	432
CHITTOOR	Maximum:	8.20	6820	1490	313	173	880	219	0	939	1801	521	213	1.49	3934	770
	Minimum:	7.05	120	35	10	2.4	11	0.8	0	49	7.1	1.4	0.47	0.20	71	40
	Average:	7.71	1588	452	91	54	148	16	0	386	279	59	28	1	911	316
EAST GODAVARI	Maximum:	8.95	10650	1725	393	249	1272	653	570	1220	2233	1171	622	2.9	6612	1000
	Minimum:	7.02	240	85	14	7.3	0	0	0	31	11	0.86	0	0.25	135	25
	Average:	7.72	1687	430	87	52	167	40	10	468	223	91	42	0.67	992	383
GUNTUR	Maximum:	8.60	9949	2525	375	386	1293	360	46	1360	2198	922	560	2.23	5584	1115
	Minimum:	6.90	622	155	24	10	32	0.50	0	183	39	14	0	0.04	356	150
	Average:	7.65	2735	600	120	73	305	75	0.63	594	408	207	69	0.52	1621	487
KADAPA	Maximum:	8.49	25430	1600	381	225	5313	100	576	2837	5530	3029	381	3.2	15287	2325
	Minimum:	7.23	260	35	12	1.2	4.1	0.27	0	43	14	1.4	0.7	0.25	157	35
	Average:	7.88	2652	464	80	64	390	8.5	20	498	480	166	41	0.9	1547	408
KRISHNA	Maximum:	8.40	7800	1470	305	219	1182	297	0	1159	2084	780	183	2.1	4487	950
	Minimum:	6.52	794	200	40	10	21	0.43	0	43	50	4.3	0	0.12	474	35
	Average:	7.83	2955	627	125	76	358	68	0	618	549	173	31	0.59	1759	507
KURNOOL	Maximum:	8.21	7920	1760	393	238	1208	536	0	1287	2084	1300	564	2.9	4463	1055
	Minimum:	6.93	290	110	20	11	15	0.35	0	55	43	8.5	0.70	0.18	179	45
	Average:	7.68	2489	582	117	70	271	47	0	441	405	199	103	0.9	1483	362
NELLORE	Maximum:	8.37	6260	975	287	134	1085	159	0	848	1315	514	221	4.0	3455	695
	Minimum:	6.90	475	115	10	7.4	32	1.1	0	31	60	15	1.6	0.11	279	25
	Average:	7.52	2185	412	96	42	285	36	0	421	346	202	36	0.61	1301	345
PRAKASAM	Maximum:	8.16	6620	1250	164	214	915	235	0	1476	1595	394	258	3.4	3686	1210
	Minimum:	7.23	772	105	24	2.4	69	0.70	0	281	64	10	1.1	0.20	451	230
	Average:	7.63	2052	353	81	37	290	37	0	527	289	116	40	0.92	1213	432
SRIKAKULAM	Maximum:	7.80	5184	1175	234	149	493	159	0	695	1067	261	180	0.76	2758	570
	Minimum:	6.89	279	60	18	3.6	15	0	0	37	35	7.0	1.0	0.10	187	30
	Average:	7.27	1524	418	106	37	131	26	0	361	227	76	39	0.36	863	296
VISAKHAPATNAM	Maximum:	8.85	3870	1030	216	173	398	130	93	927	893	234	261	3.3	2142	760
	Minimum:	6.56	50	20	4.0	2.4	2.3	0	0	9.2	3.5	1.2	1.0	0.08	30	7.5
	Average:	7.62	1144	346	69	42	110	11	1.6	355	149	62	54	0.65	715	291
VIZIANAGARAM	Maximum:	8.02	2650	690	200	112	284	158	0	598	596	475	167	1.9	1490	490
	Minimum:	6.70	560	90	20	6.1	2.8	0.38	0	140	14	1.0	0.26	0.20	306	115
	Average:	7.50	1227	394	94	39	89	19	0	366	171	37	40	0.67	712	300
WEST GODAVARI	Maximum:	8.70	10410	1500	248	255	1776	473	240	1171	2521	1171	140	2.0	6118	960
	Minimum:	7.20	130	60	11	7.9	1.4	0.39	0	61	7.1	1.9	0.35	0.26	70	50
	Average:	7.84	2070	468	90	59	235	42	17	446	301	188	26	0.68	1223	365
STATE FIGURES	**Maximum:**	8.95	25430	2525	393	386	5313	716	576	2837	5530	3029	622	4.61	15287	2325
	Minimum:	6.52	50	20	4.0	1.2	0	0	0	9.2	3.5	0.86	0	0.04	30	7.5
	Average:	7.67	1995	466	97	54	220	40	4.2	467	304	128	49	0.71	1180	383

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