Central Ground Water Board

Ministry of Jal Shakti

Department of Water Resources,

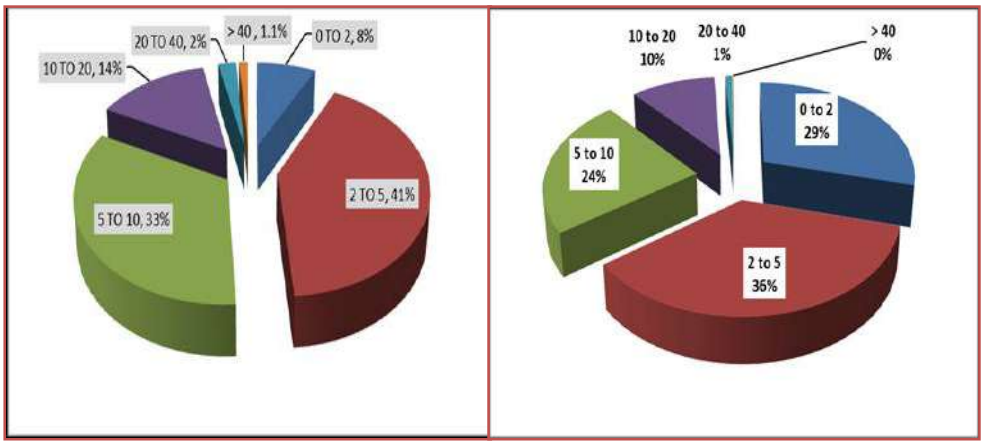
River Development & Ganga Rejuvenation

Govt. of India

GROUND WATER YEAR BOOK

2018-19

ANDHRA PRADESH



MAY 2018 WATER LEVEL

NOVEMBER 2018 WATER LEVEL

Southern Region, Hyderabad

August, 2019

Central Ground Water Board

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GROUND WATER YEAR BOOK
2018-2019
ANDHRA PRADESH STATE

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GROUND WATER YEAR BOOK

2018-19

ANDHRA PRADESH STATE

CONTENTS

Annexure:

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 31-3-2019, a total of 864 operational ground water monitoring wells (GWMS) (DW: 699, Pz: 165) are in operations. 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, Hyderabad during 2018-19 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 **Sri. G Praveen Kumar, Sc-C and Ms. Resma S Pillai, Sc-B** in preparation of the report are commendable. The efforts from officers of chemical laboratory namely Shri K. Bhaskar Reddy, Shri 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: 24-9-2019 **Regional Director**

EXECUTIVE SUMMARY

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 Longitude 12° 37' and 19° 09' and East Latitude 76° 45 ' and 84° 47'. The State is mainly drained by Godavari, Krishna, Pennar, Vamsadhara, Nagavalli, Gundlakamma rivers. A major part of the area is underlain by the rocks comprising and meta-sediments. During the year 2018, the state received annual rainfall in the range of 391 mm (Anantapuramu district) to 1301 mm (Srikakulam district) with average of 762 mm.

As part of National Ground Water Monitoring Programme, Central Ground Water Board (CGWB) is carrying out ground water regime monitoring 4 times a year (January, May, August and November) and ground water quality 1 time (May). As on 31.03.2019, total of 864 Ground Water Monitoring Wells are in existence while 142 wells are monitored on participatory mode. Ground water levels data base help in groundwater management particularly in the context of large scale contemplated surface water command areas in the state.Ground Water Year Book is compiled based on integrated data generated by CGWB and Ground Water Department, Govt. of Andhra Pradesh in order to have realistic ground water scenario.

Water level analysis shows that during pre-monsoon season, water levels are shallow in canal command areas particularly in deltaic areas and deep water level non-command areas. Annual water level fluctuation of May 2016 vs May 2017 has shown rise in water levels in 30 % of the area, predominantly in Rayalaseema districts, because of the excess rainfall in 2017 monsoon in comaprision with 2016 monsoon.

During May 2018, 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. Rise in water levels in Nov 2018 compared to May 2018 is observed in north-coastal districts fall is observed in Rayalaseema districts and Prakasam district due to less rainfall received specially in Rayalseema region. Shallow water level in the range of 0 to 2 m bgl observed in 5% of the area mostly in coastal belt and small parts of Kurnool district. that shallow water levels of less

than 2 m bgl are noticed as small scattered patches covering an area of 1% (26 wells) in Khammam, Warangal, Karimnagar, Adilabad, Nalgonda, Mahbubnagar and Ranga reddy Ground water quality of 623 samples collected during pre-monsoon season of 2018 were analysed for major constituents. Fluoride concentration varies from 0.1 to 4.04 mg/l and found that 9% samples are unfit for human consumption.

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 31-03-2018, there were 865 operational Ground Water Monitoring Wells (GWMS) (718 dug wells and 147 piezometers). During the year (2018-19), 19 Ground water monitoring wells (19 Dug wells) were abandoned and 18 new ground water monitoring wells (18 PZ) were established. As on March 2019, the status of monitoring stations is 864 wells, out of which, 699 are Dug wells and 165 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.

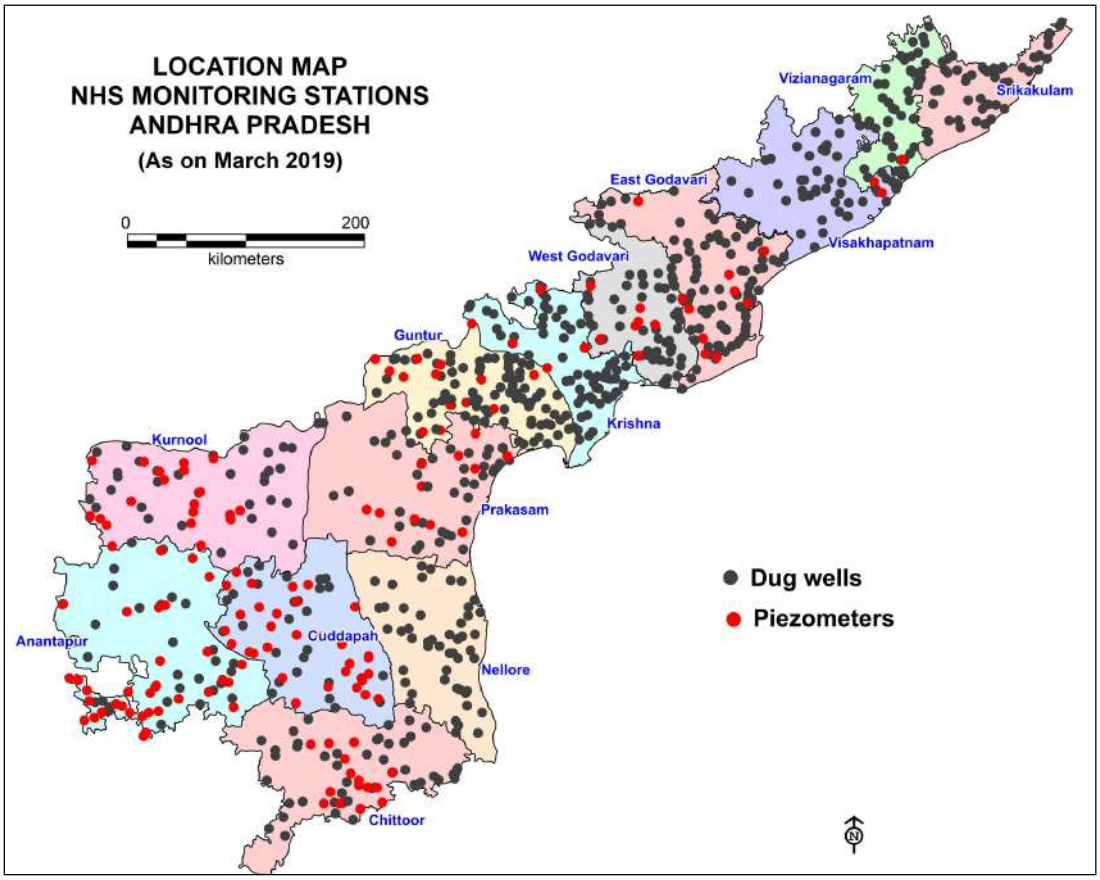


Fig.1.1: Location of GWMS in Andhra Pradesh State (as on 31st March, 2019)

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**).

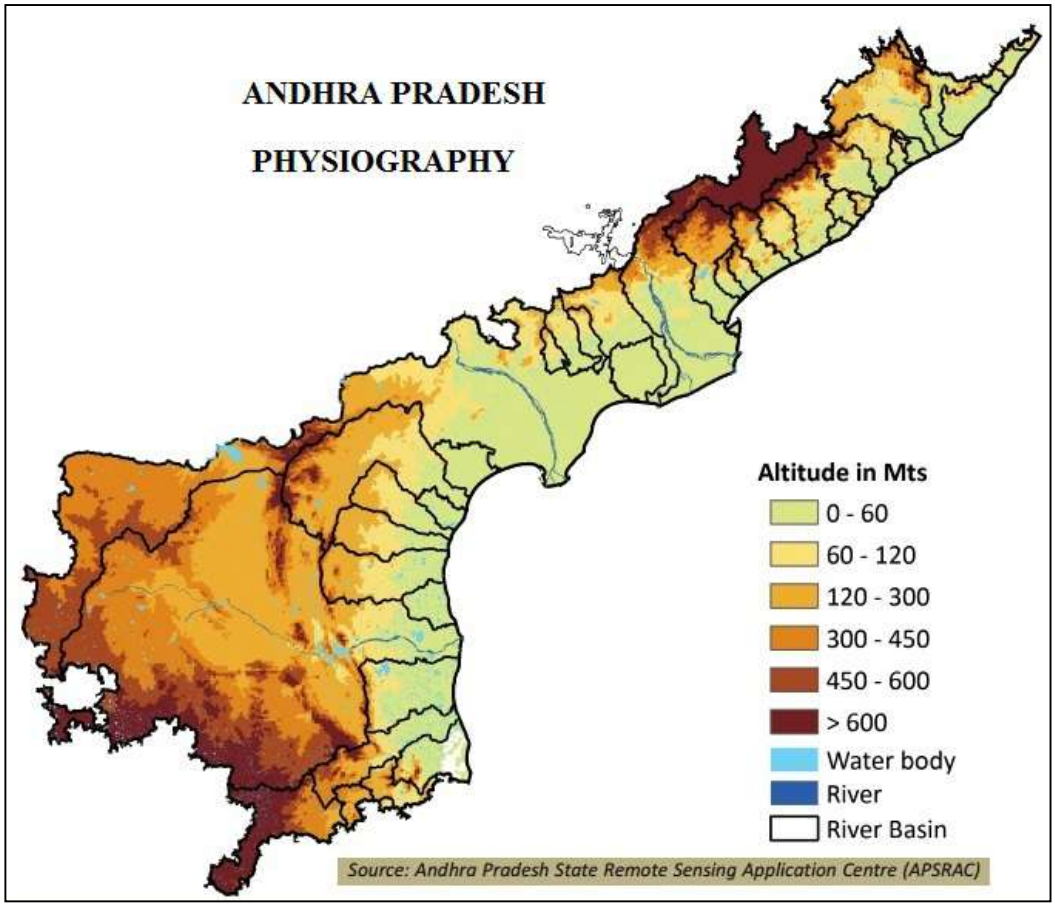


Fig.2.1: Physiography map of Andhra Pradesh (after APRAC-2014).

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**.**

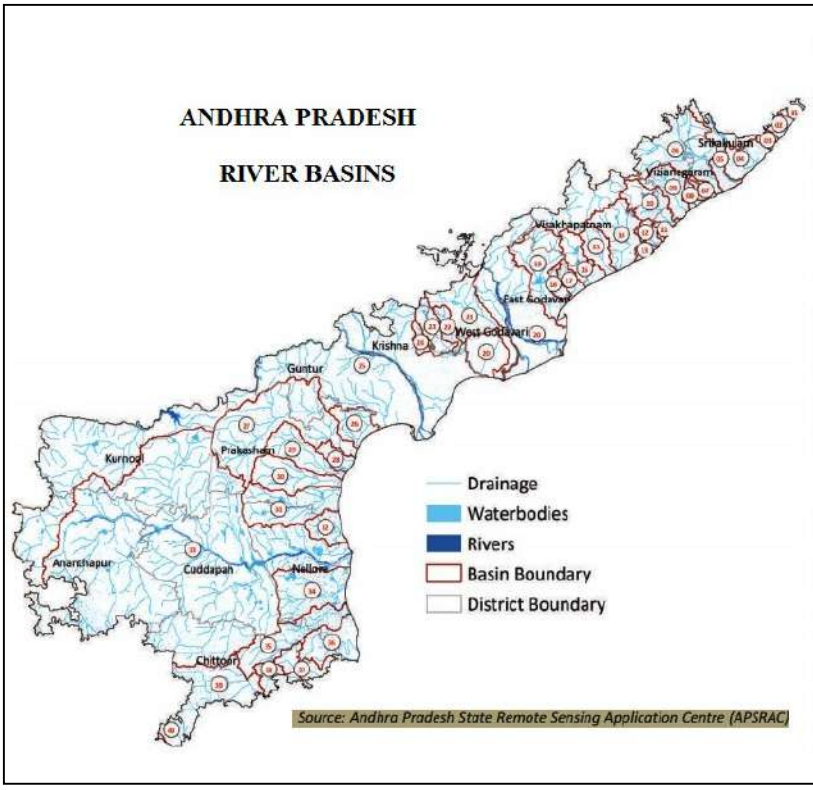
2.1.3 Western Pediplains

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	Anekapalli
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.**

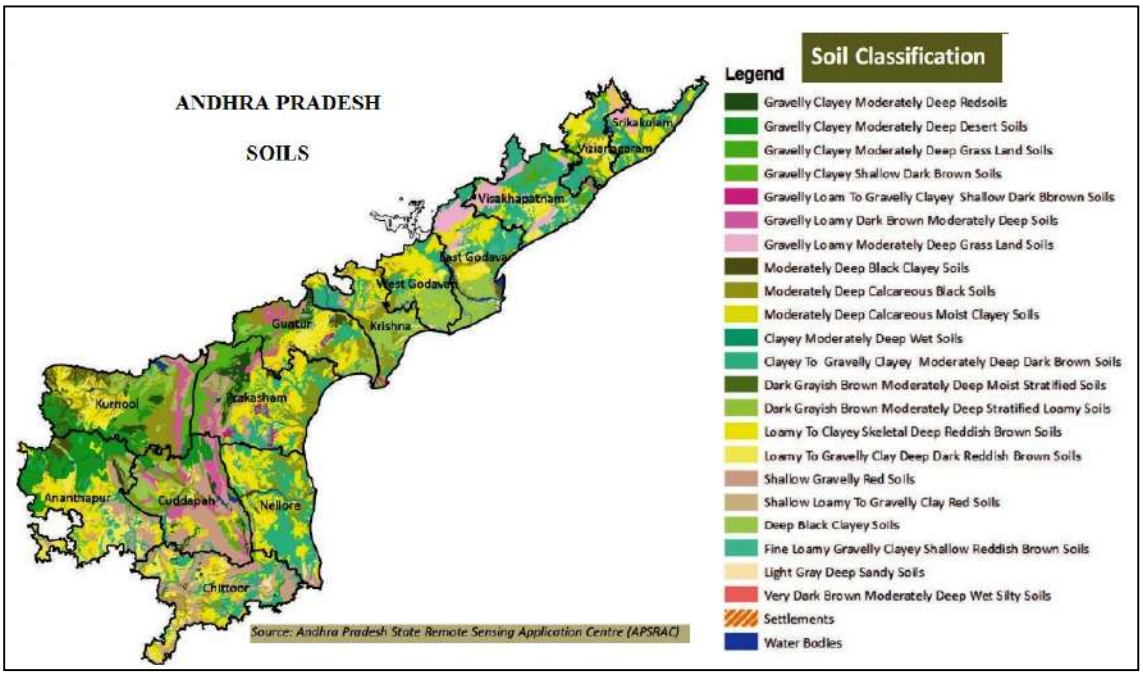


Fig.2.3: Soil Map of Andhra Pradesh (after APSRAC-2014).

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
	Scarce rainfall zone
	Southern zone
	Krishna – Godavari Zone
	North Coastal zone
	South Coastal zone
	High Altitude
	Tribal Zone
	Scarce Rainfall Zone

3.2 Rainfall Analysis – 2018

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 as under:

- The normal annual rainfall of the state is 950 mm. Season-wise normal rainfall is 573 mm, 267 mm, 15.4 mm and 101mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 58% of annual in SW monsoon, 30% of annual rainfall in north-east monsoon and 12% in non-monsoon season. Annual normal rainfall ranges from 552 mm in Anantapur district to 1218 mm in East Godavari district.
- The mean annual rainfall in the year 2018 of the state is 762 mm. Season-wise rainfall is 527 mm, 134 mm, 2.4 mm and 98 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively contributing 69% of annual rainfall in SW monsoon, 18% of annual rainfall in north-east monsoon and 13% in non-monsoon season. The annual (2018) rainfall ranges from 391 mm in Anantapar district (deficit by 32%)

to 1301 mm (excess by 12%) in Srikakulam district. During the year 2018, annual rainfall was deficit by 23% in the state. Monthly mean rainfall ranges from 0.75 mm in January to 179 mm in August.

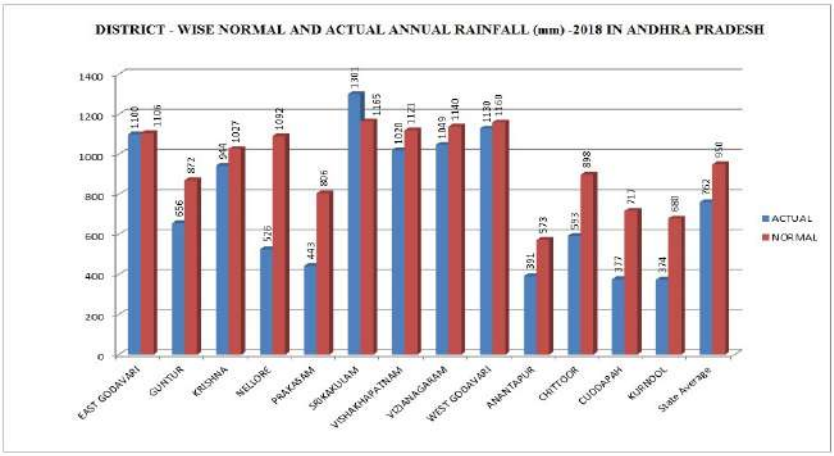


Fig.3.1: District-wise Annual Normal and Actual (2018) rainfall.

➢ The rainfall received during the period Jan, 2018 to Dec, 2018 is compiled and analyzed for correlating with water levels monitored during the period May, 2018, Aug, 2018, Nov,2018 and Jan, 2019. 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 the **Fig. 3.3 to 3.10.**

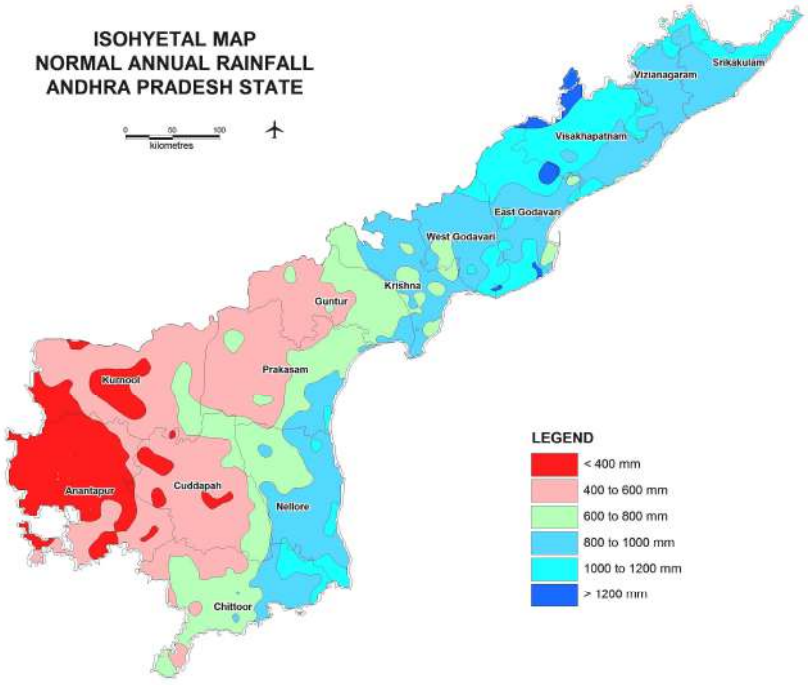


Fig.3.2: Isohytel map of Andhra Pradesh State (Normal annual rainfall in mm).

Table-3.1: Monthly Normal and Actual (2018) 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**	0	6	0	10.1	0	11.3	46	22.8	55.8	75.3	161.5	131.9	346.4	206.4
2	**GUNTUR**	0	5.5	0	7.7	1.7	7.7	14.1	15	31.8	58.4	111.6	90.2	134.9	147.3
3	**KRISHNA**	0	4.6	0.3	6.3	4.5	8.7	3.6	16.9	37.5	46.8	159.8	120.9	199.1	216.6
4	**NELLORE**	0.7	15.7	0.2	11.6	30.1	6	7.2	15.2	20.9	51.4	60.9	53.4	34	91.2
5	**PRAKASAM**	0	7.9	0	8.8	24.9	10.5	11.7	14.9	36.6	52.3	29	64.3	69.6	99.3
6	**SRIKAKULAM**	0	7.9	0	18.1	0.5	17.2	47.8	26.3	102.9	63.9	88.8	145	270.7	190.2
7	**VISHAKHAPATNAM**	0	8.8	0	10.8	1.2	17.6	109.6	44.7	108.6	96.6	161	132.6	175.5	178.2
8	**VIZIANAGARAM**	0	8.7	0	14.4	1.6	17.7	86.6	32.3	98	90.7	131.6	140.7	165.9	181.5
9	**WEST GODAVARI**	0	6.1	0	10.7	3.5	8.7	19.6	19	19.8	55.8	157.9	135.8	347	240.2
10	**ANANTAPUR**	0	3	3	3.3	19.5	6.1	15.7	18.9	63.8	56.7	74.8	55.2	20	64.3
11	**CHITTOOR**	0	7.7	14.4	7.6	28.5	10.1	10.9	25.6	68.5	67.2	71.8	66.8	46.9	100.1
12	**KADAPA**	0	1.9	2.2	2.4	56.1	4.7	4.3	17.3	34.8	47.6	34.8	69.8	15.7	101.1
13	**KURNOOL**	0	1.2	0.1	1.9	3	5.7	13.2	18.3	35.7	51.7	73.5	80.5	49.2	115.8
	State Average	**0**	**7**	**2**	**9**	**13**	**10**	**30**	**22**	**55**	**63**	**101**	**99**	**144**	**149**

		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**	270.1	188.4	106	177.2	26.7	199	9.1	69.8	78.2	7.8	**1099.8**	**1106**	**-1%**
2	**GUNTUR**	210.8	155.4	65.2	150.1	18.1	143.9	18.1	75.8	50.1	14.5	**656.4**	**871.5**	**-25%**
3	**KRISHNA**	321.7	194.2	57.1	169.7	30.7	164.2	28.2	66.1	101.4	12.1	**943.9**	**1027.1**	**-8%**
4	**NELLORE**	51.4	95	42	112.8	56.8	248.2	168	283.9	54	107.2	**526.2**	**1091.6**	**-52%**
5	**PRAKASAM**	80.7	95.9	84.8	123	42.4	181.9	52.6	115	10.5	32.1	**442.8**	**805.9**	**-45%**
6	**SRIKAKULAM**	314.4	202.4	195.5	208.1	216.9	211.4	0	69.8	63.3	4.9	**1300.8**	**1165.2**	**12%**
7	**VISHAKHAPATNAM**	194.1	178.2	146.2	185.4	32.9	204.3	8.1	59.2	82.5	4.3	**1019.7**	**1120.7**	**-9%**
8	**VIZIANAGARAM**	247.8	194.8	167.5	209.1	61.7	188.1	5.3	56.3	82.6	6.1	**1048.6**	**1140.4**	**-8%**
9	**WEST GODAVARI**	418.5	227.8	65	180.1	26.7	197.8	10.6	66.7	61.2	11.7	**1129.8**	**1160.4**	**-3%**
10	**ANANTAPUR**	35.8	74.5	105.1	128.8	48.4	115	4.7	35.3	0.3	11.6	**391.1**	**572.7**	**-32%**
11	**CHITTOOR**	58.9	110.2	113.3	140	59.7	167.2	106.2	137.3	13.6	58.4	**592.7**	**898.2**	**-34%**
12	**KADAPA**	58.1	108.6	94.7	124.6	37.6	137.3	33.3	77.2	5.3	24.4	**376.9**	**716.9**	**-47%**
13	**KURNOOL**	61.4	124.3	96.9	139.6	34.3	105.6	5.9	28.4	0.9	6.6	**374.1**	**679.6**	**-45%**
	State Average	**179**	**150**	**103**	**158**	**53**	**174**	**35**	**88**	**46**	**23**	**762**	**950**	**-23%**

3.2.1 May, 2018

3.2.1.1 Rainfall Analysis (June2017 - May2018 from June - 2016 to May - 2017 rainfall)

The rainfall data collected from India Meteorological Department and compiled from weekly weather reports has been used to analyze the rainfall for the period June 2017 to May 2018. **Table 3.2** gives the district-wise rainfall data for the period June 2016 – May2017, June 2017 – May 2018 and normal of June – May and the departure of June 2017- May 2018 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: District-wise rainfall (June'17-May'18) and its departure from normal and June'16-May'17

S NO	DISTRICT (erstwhile)	Rainfall (June'17-May'18)	Rainfall (June'16-May'17)	Normal Rainfall (June-May)	Departure (%) of (3) from (4)	Departure (%) of (3) from (5)	REMARK
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	602	343	573	75.5%	5.1%	Normal
2	Chittoor	1060	616	898	72.1%	18.0%	Normal
3	Kadapa	787	566	717	39.0%	9.8%	Normal
4	East Godavari	1115	994	1106	12.2%	0.8%	Normal
5	Guntur	794	895	872	-11.3%	-8.9%	Normal
6	Krishna	940	918	1027	2.4%	-8.5%	Normal
7	Kurnool	720	564	680	27.7%	5.9%	Normal
8	Nellore	910	489	1092	86.1%	-16.6%	Normal
9	Prakasam	609	531	806	14.7%	-24.4%	Deficit
10	Srikakulam	1374	939	1165	46.3%	17.9%	Normal
11	Vishakhapatna	1118	986	1121	13.4%	-0.2%	Normal
12	Vizianagaram	1177	1032	1140	14.1%	3.2%	Normal
13	West Godavari	1022	1074	1160	-4.8%	-11.9%	Normal
	STATE	**941**	**765**	**950**	**22.9%**	**-1.0%**	**Normal**

Source: India Meteorological Department, GOI

3.2.1.1 Rainfall Departure of June'17- May'18 from June'16-May'17

Figure 3.3 gives departure of Jun'17- May'18 rainfall from Jun '16 to May'17 rainfall. It is prepared to correlate with water level fluctuation map of May 2018 vs May 2017. **Table 3.2** indicates that state has received 941 mm of rainfall during the period June, 2017 – May, 2018, which is 22.9% more than the rainfall received during June, 2016 to May, 2017. The departure in percentage ranges from -11.3 % in Guntur district to 86.1% in Nellore district.

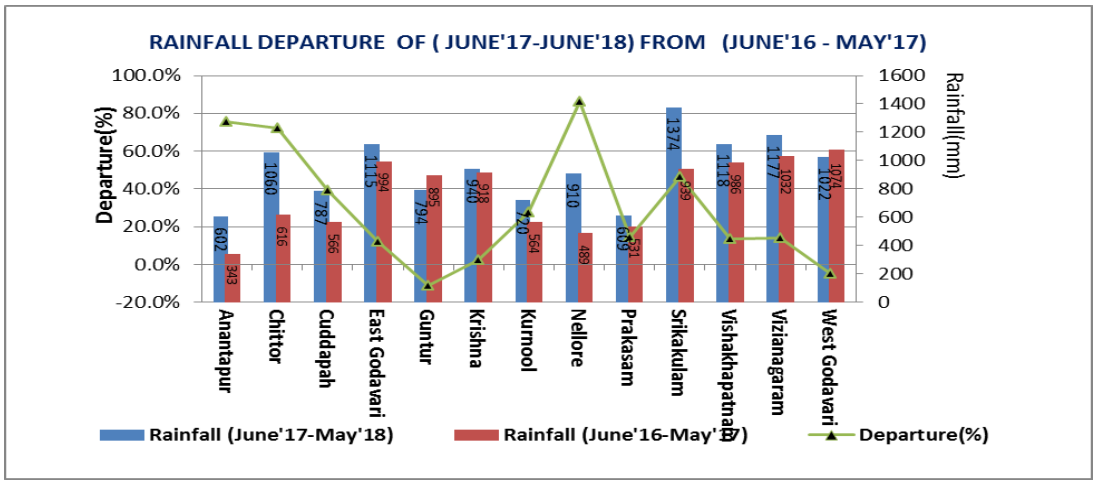


Fig.3.3: Rainfall Departure (June, 2017- May,2018 from June,2016-May,2017)

3.2.1.2 Departure of rainfall during June, 2017-May, 2018 from normal rainfall of same period

Figure 3.4 gives departure of Jun'17- May'18 rainfall from normal of the same period. It is prepared to correlate with depth to water level map of May 2018. During the period Jun'17- May'18, the state has received -1 % less rainfall than normal, which is 950 mm. It ranges from 24.4% in Prakasam district to 18% in Chittoor district. All the districts have received normal rainfall except Prakasam district, which has received deficit rainfall.

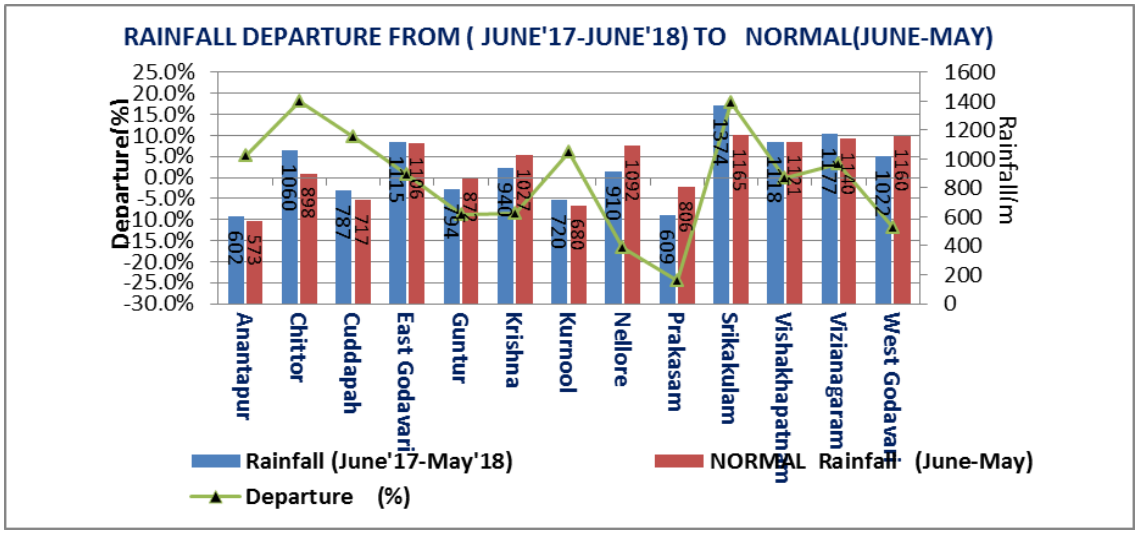


Fig.3.4: Rainfall Departure - June'17- May'18 from Normal of same Period.

3.2.2 August, 2018

The district wise rainfall for the period June, 2018 -August,2018 from June,2017 – August, 2017 is given in **Table-3.3** and different thematic maps are presented in **Fig.3.5 and 3.6**.

Table-3.3: District-wise rainfall (June'18-Aug'18) and its departure from normal and June'17-Aug'17

S NO	DISTRICT	Rainfall (June'18-August'18)	Rainfall (June'17-August'17)	Normal Rainfall (June-August)	Departure(%)	Departure (%)	REMARK
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	131	188	220	-30.3%	-40.5%	Deficit
2	Chittoor	178	407	298	-56.3%	-40.3%	Deficit
3	Kadapa	109	361	280	-69.8%	-61.1%	Deficit
4	East Godavari	778	704	565	10.5%	37.7%	Excess
5	Guntur	457	496	379	-7.9%	20.6%	Excess
6	Krishna	681	600	521	13.5%	30.7%	Excess
7	Kurnool	184	355	329	-48.2%	-44.1%	Deficit
8	Nellore	146	361	229	-59.6%	-36.2%	Deficit
9	Prakasam	179	338	255	-47.0%	-29.8%	Deficit
10	Srikakulam	674	771	509	-12.6%	32.4%	Excess
11	Vishakhapatnam	531	582	523	-8.8%	1.5%	Normal
12	Vizianagaram	545	590	502	-7.6%	8.6%	Normal
13	West Godavari	923	677	607	36.3%	52.1%	Excess
	STATE MEAN	**424**	**495**	**401**	**-14.2%**	**5.7%**	**Normal**

Source: India Meteorological Department, GOI

3.2.2.1 Departure of rainfall during June - 2018 to August - 2018 from June 2017 - August 2017

This map gives departure of June 18 - August'18 rainfall from June 17 to Aug 17 rainfall. It is prepared to correlate with water level fluctuation map of Aug 2018 from Aug 2017. **Table 3.3** indicates that state has received 424 mm of rainfall during the period Jun'18 to Aug'18, which is 14.2% less than the rainfall received during the same period last year.

The state received about 495 mm of rainfall during the same period last year. The departure in percentage ranges from -69.8% in Kadapa district to 13.5 % in Krishna district.

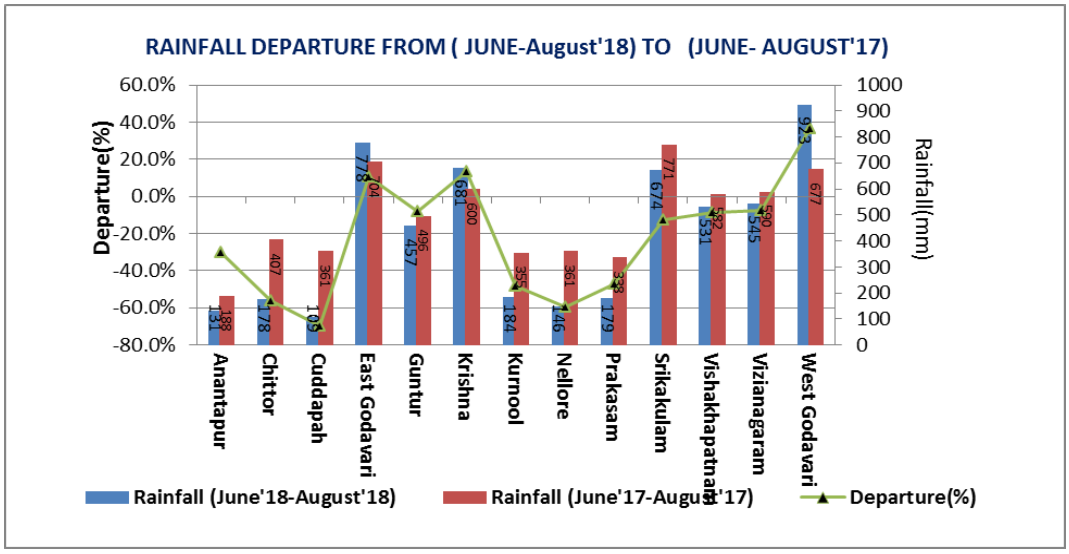


Fig.3.5: Rainfall Departure (June, 2018-Aug,2018 from June, 2017-Aug,2017).

3.2.2.2 Departure of rainfall during June, 2018 to August, 2018 from normal rainfall

This map gives departure of June 2018 to Aug 2018 rainfall with normal rainfall of the same period. It is prepared to correlate with depth to water level map of Aug 2018. During the period June 2018 to Aug 2018, the state has received 5.7 % more rainfall (424 mm) than normal rainfall (401 mm). It ranges from -61.1% in Kadapa to 52.1% in West Godavari district.

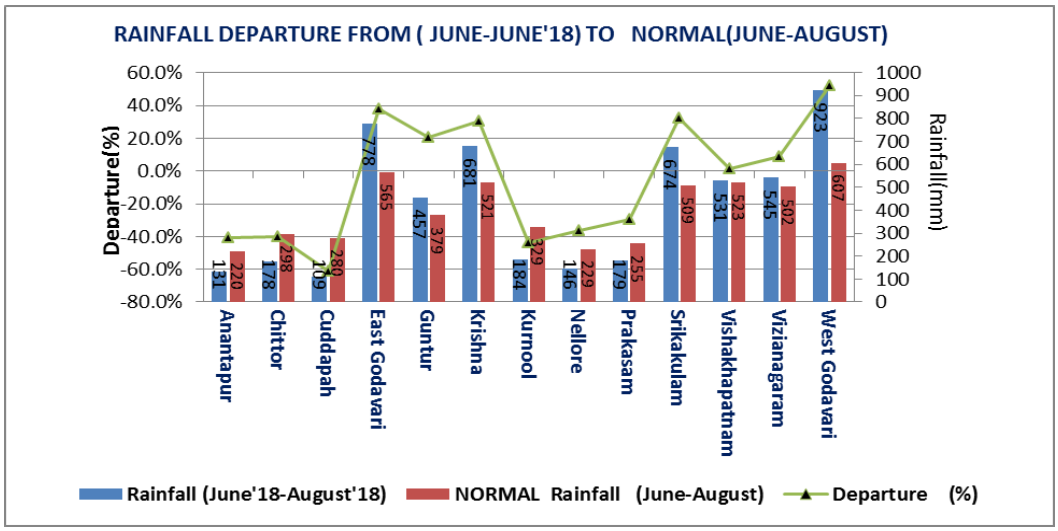


Fig.3.6: Rainfall Departure (June,2018 –Aug,2018 from Normal of the same Period).

3.2.3 November - 2018

The district wise rainfall for the period June, 2018 – October, 2018 from June,2017 – October, 2017 is given in **Table-3.4** and different thematic maps are presented in **Fig.3.7, and 3.8**.

Table-3.4: District-wise rainfall (June'18-Oct'18) and its departure from normal and June'17-Oct'17

S NO	DISTRICT	Rainfall (June'18-October'18)	Rainfall (June'17-October'17)	NORMAL Rainfall (June-October)	Departure (%)	Departure (%)	REMARK
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Anantapur	284	526	438	-46.0%	-35.2%	Deficit
2	Chittoor	351	836	584	-58.0%	-39.9%	Deficit
3	Kadapa	242	708	541	-65.8%	-55.3%	Deficit
4	East Godavari	911	1009	903	-9.7%	0.9%	Normal
5	Guntur	541	740	687	-26.9%	-21.3%	Deficit
6	Krishna	768	881	866	-12.8%	-11.3%	Normal
7	Kurnool	315	670	566	-53.0%	-44.3%	Deficit
8	Nellore	245	651	601	-62.4%	-59.2%	Deficit
9	Prakasam	307	550	564	-44.2%	-45.6%	Deficit
10	Srikakulam	1086	1116	957	-2.7%	13.5%	Normal
11	Vishakhapatnam	710	894	879	-20.6%	-19.2%	Deficit
12	Vizianagaram	775	957	914	-19.0%	-15.2%	Normal
13	West Godavari	1015	978	982	3.8%	3.4%	Normal
	STATE MEAN	**581**	**809**	**729**	**-28.2%**	**-20.4%**	**Deficit**

Source: India Meteorological Department, GOI

3.2.3.1 Departure of rainfall (June'18 to October'18 from June'17 to Oct'17)

It is prepared to correlate with water level fluctuation map of Nov 2018 from Nov 2017. **Table 3.7** indicates that state has received 581 mm of rainfall during the period June 2018 to Oct 2018, which is 28.2 % less than the rainfall received during the same period last year. The departure in percentage ranges from -65.8% in Kadapa district to 3.8 % in West Godavari district. The district-wise rainfall and its departure are given in Fig. 3.7.

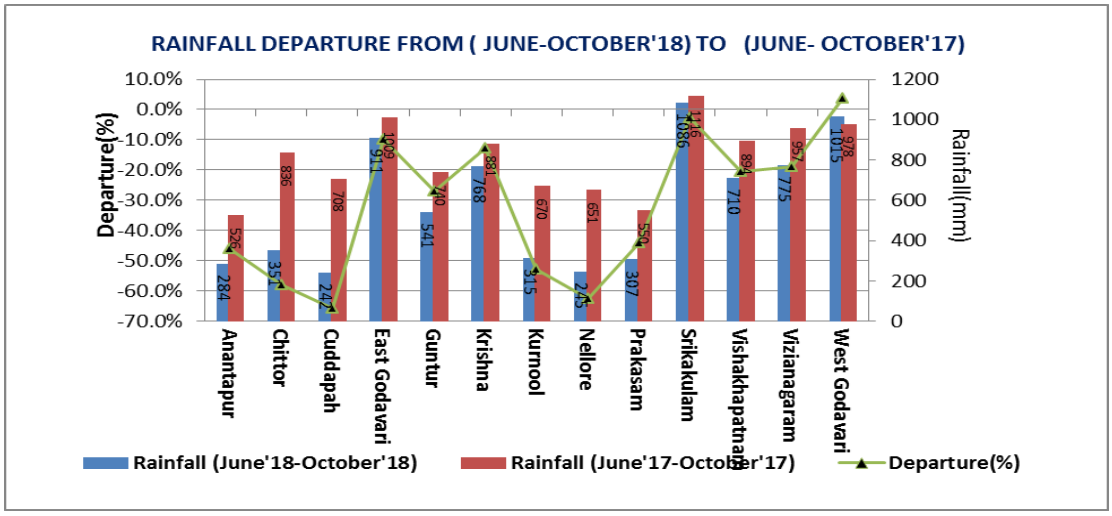


Fig.3.7: Rainfall Departure (June'18-Oct'18 from June'17-Oct'17).

3.2.3.2 Departure of rainfall June 2018 to October-2018 from normal rainfall (June-Oct)

It is prepared to correlate with depth to water level map of Nov 2018. During the period June 2018 to Oct 2018, the state has received 20.4 % less rainfall than normal which is 729 mm. It ranges from -59.2% in Nellore district to 13.5% in Srikakulam district. The state has received normal rainfall in Srikakulam, West Godavari, Krishna, East Godavari and Vizianagaram districts and deficit rainfall in the remaining districts. The district-wise rainfall and its departure are given in **Fig 3.8.**

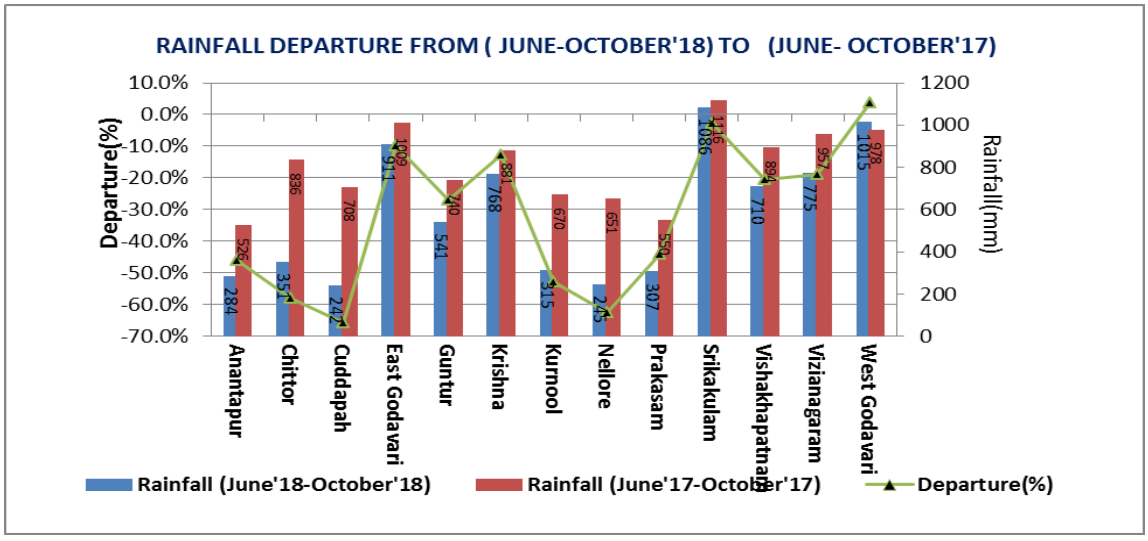


Fig.3.8: Rainfall Departure June'18 – Oct'18 from Normal of same Period.

3.2.4 January, 2019

The district wise rainfall for the period June, 2018 to Decemeber, 2018 and normal of same period is given in **Table-3.5** and different thematic maps are presented in **Fig.3.9** and **3.10**.

Table-3.5: District-wise rainfall (June'18-Dec'18) and its departure from normal and Jun'17-Dec'17.

DISTRICT	Rainfall (June'18-Dec'18)	Rainfall (June'17-Dec'17)	Normal Rainfall (June-Dec)	Departure (%)	Departure (%)	Remarks
(2)	(3)	(4)	(5)	(6)	(7)	(8)
Anantapur	289	535	485	-46.0%	-40.4%	Deficit
Chittoor	470	966	780	-51.3%	-39.7%	Deficit
Kadapa	280	745	981	-62.4%	-71.5%	Scanty
East Godavari	998	970	777	2.9%	28.4%	Excess
Guntur	609	748	944	-18.6%	-35.5%	Deficit
Krishna	898	898	601	0.0%	49.4%	Excess
Kurnool	316	671	712	-52.9%	-55.6%	Deficit
Nellore	467	873	992	-46.5%	-52.9%	Deficit
Prakasam	370	561	1032	-34.0%	-64.1%	Scanty
Srikakulam	1150	1223	942	-6.0%	22.1%	Excess
Vishakhapatnam	718	900	977	-20.2%	-26.5%	Deficit
Vizianagaram	862	992	1060	-13.1%	-18.7%	Normal
West Godavari	1087	982	643	10.7%	69.1%	Excess
STATE MEAN	**655**	**851**	**840**	**-23.0%**	**-22.1%**	**Deficit**

3.3.4.1 Departure of rainfall during June - 2018 to Dec -2018 from Jun-2017 to Dec-2017

Departure of June - December'18 rainfall from June to December'17 rainfall. indicates that state has received 655 mm of rainfall during the period June – December, 2018, which is 23% less than the rainfall received during June to December, 2017. The departure in percentage ranges from -62.4 % in Kadapa district to 10.7% in West Godavari district.

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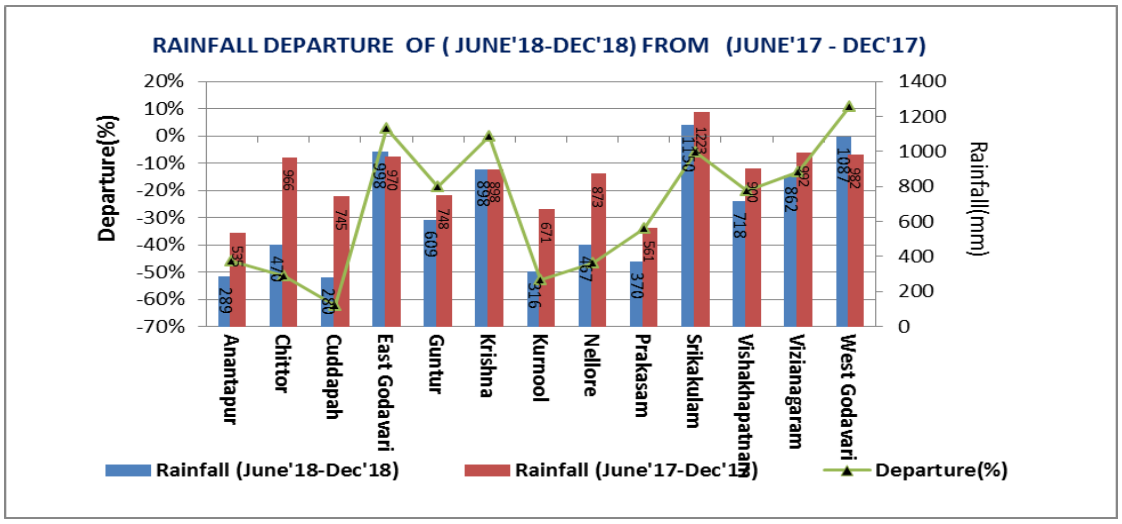


Fig.3.9: Rainfall Departure (June - 2018-Dec - 2018 from June - 2017-Dec - 2017).

3.2.4.2 Departure of rainfall during Jun, 2018 –Dec, 2018 from normal rainfall of the same period

Departure of June - December'18 rainfall from normal of the same period.. During the period June - December'18, the state has received 22.1 % less rainfall than normal, which is 840 mm. It ranges from -71.5% in Kadapa district to 69.1% in West Godavari district. The state has received normal rainfall only in Vizianagaram district and excess rainfall in East Godavari, West Godavari, Krishna and Srikakulam districts whereas deficit and scanty rainfall in the remaining districts.

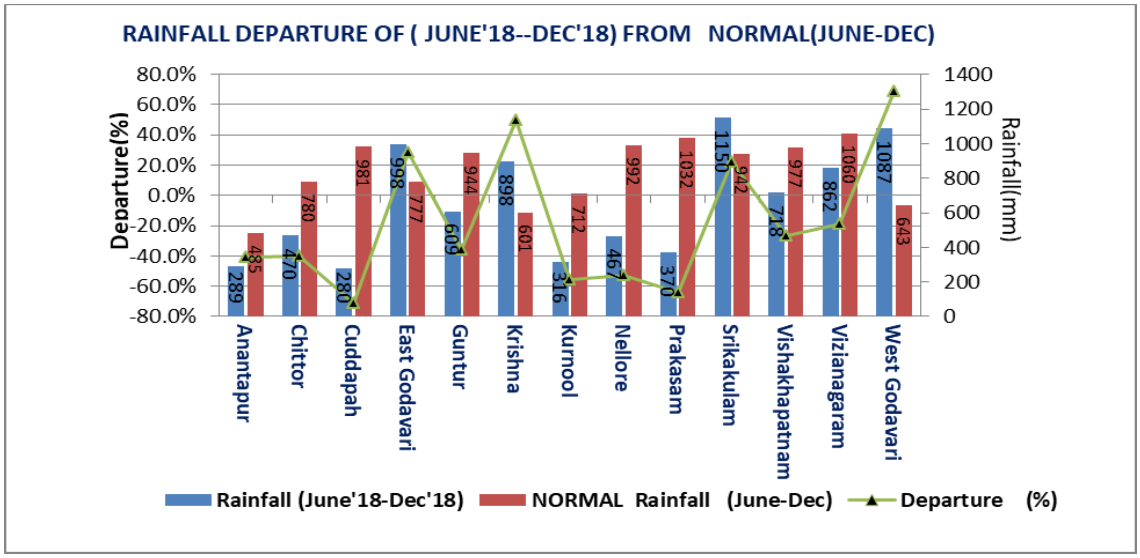


Fig.3.10 : Rainfall Departure (Jun - 2018- Dec - 2018 from Normal of same Period).

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.

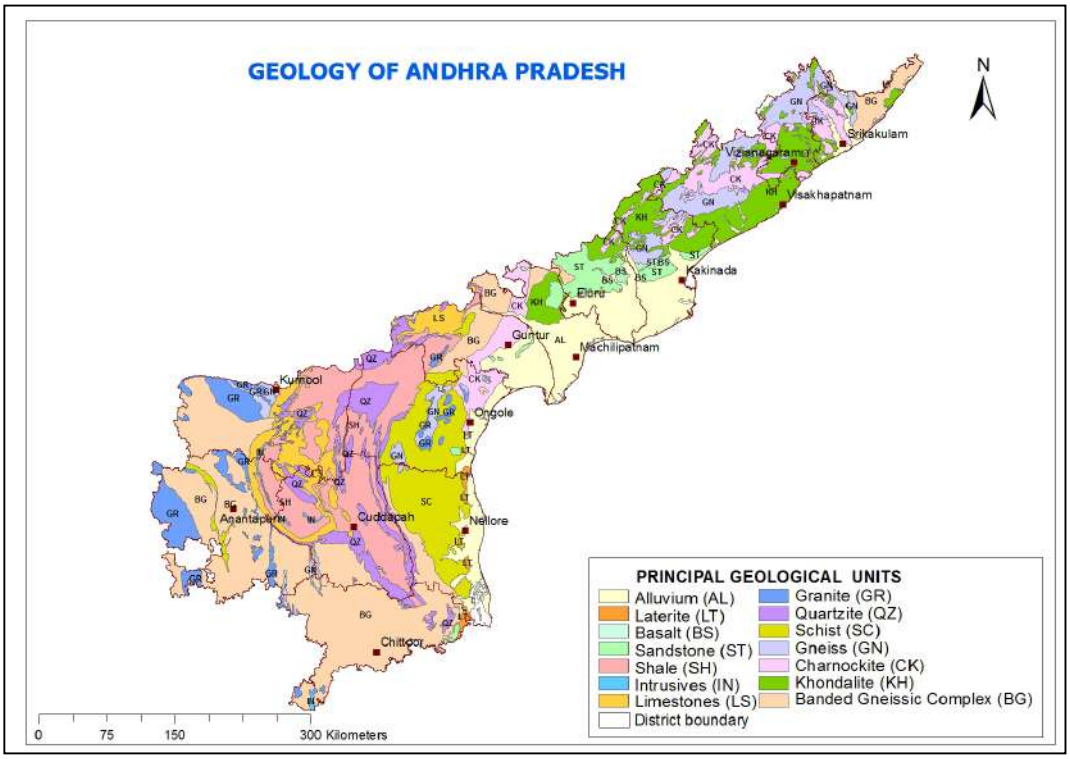


Fig.4.1: Geology of Andhra Pradesh State

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.

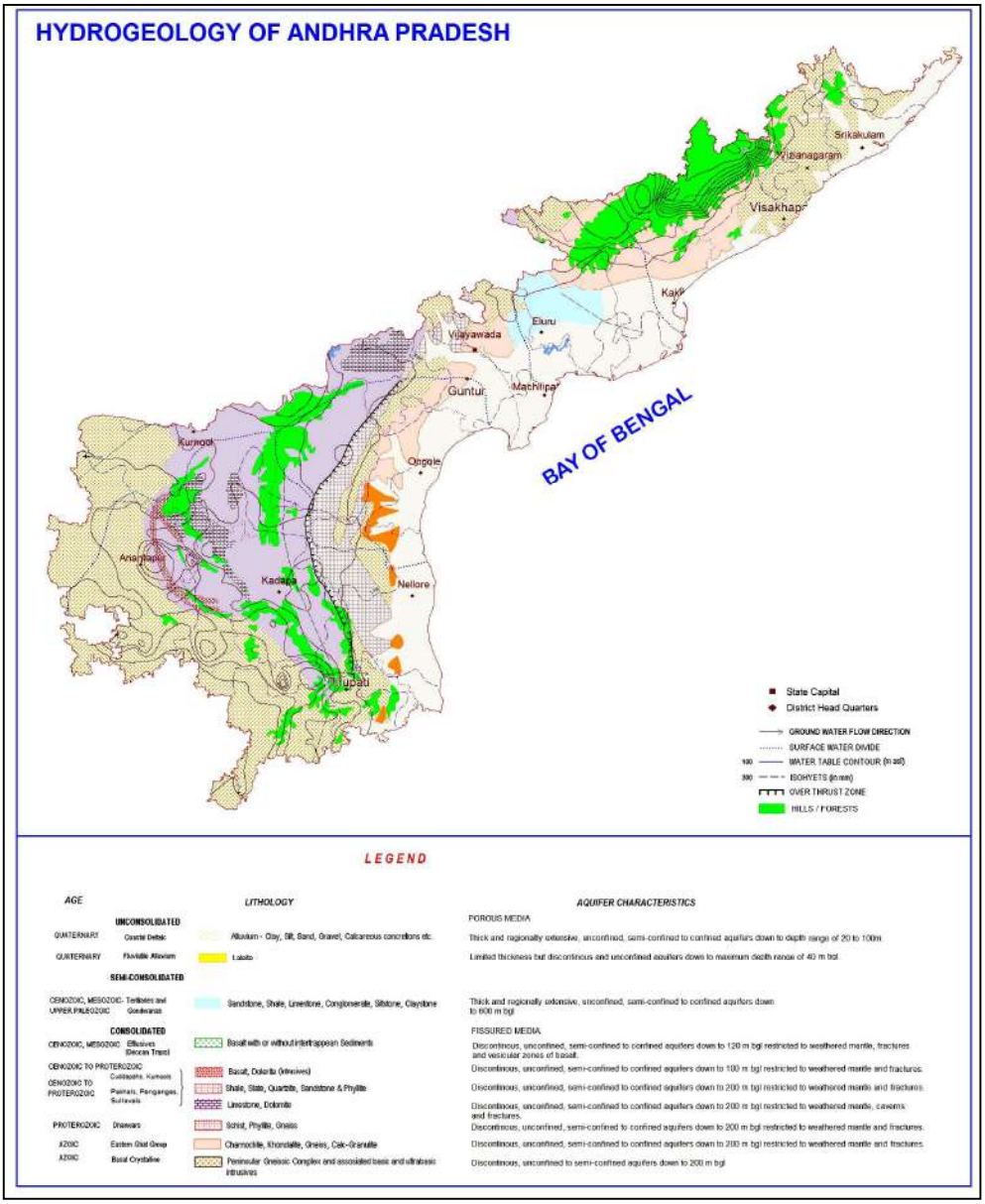


Fig.4.2: Hydrogeology map of Andhra Pradesh State.

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**.

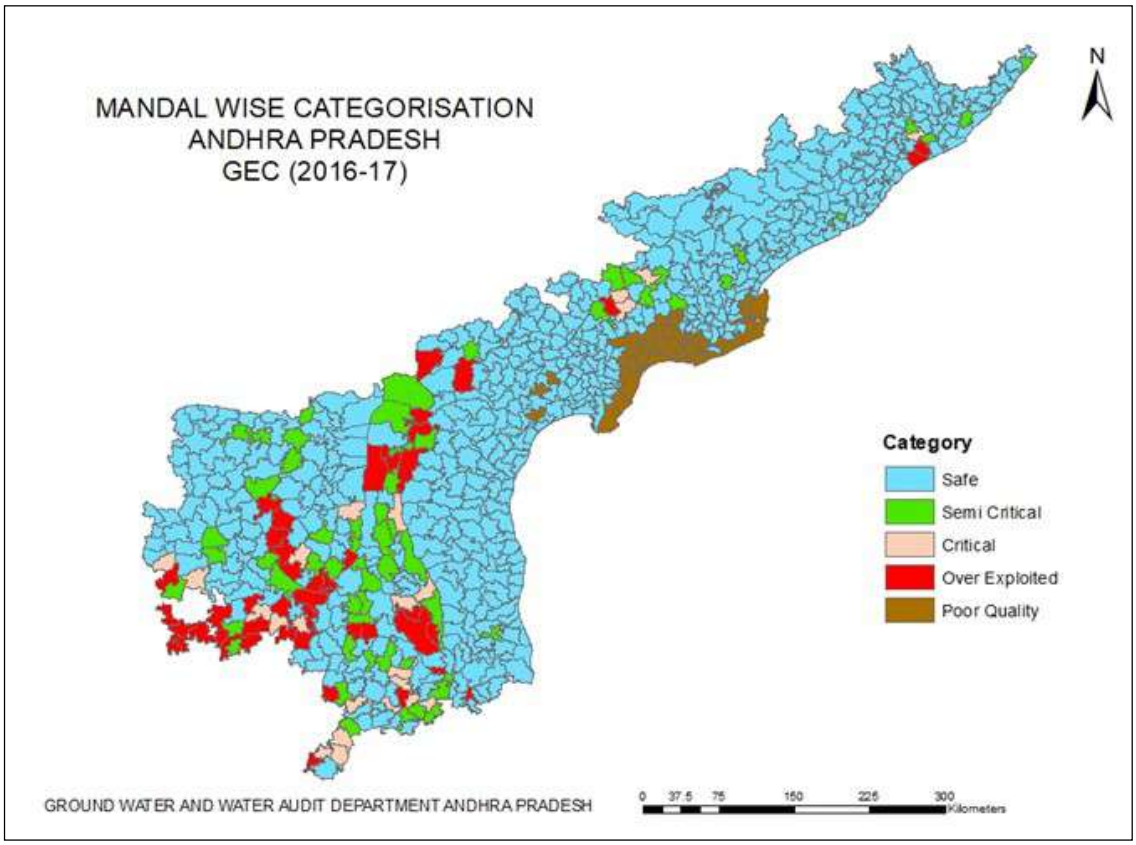


Fig.5.1: Categorization of Mandals (as on March, 2017), Andhra Pradesh State.

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, 2019, 142 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 864 GWMS are monitored in the state (DW: 699 (81 %) and Pz: 165 (19%) and density varies from 103 Km^2/well (East Godavari) to 310 Km^2/well in Kurnool district (**Table-6.1**).

6.6.2 Aquifer-Wise Distribution of Ground Water Monitoring Wells

Out of 864 GWMS, 677 wells are located in hard rocks, 187 wells in soft rocks. District wise and aquifer wise distribution of GWMS is given in **Table-6.2.** About 23.8 % of GWMS are located in Banded Gneissic complex , followed by Alluvium formations (23.3 %), followed by Khondalite rocks (10.3 %) .

Table-6.1: District-wise Distribution of GWMS, Andhra Pradesh State (As on March, 2019).

S.No.	District	Area (Km2)	No of GWMS			No of Participatory	Density of Network stations (sq. km. per well)		
							Dug wells	Piezo meters	
1	Anantapur	19130	32	33	65	18	598	580	294
2	Chittoor	15152	45	15	60	15	337	1010	253
3	Kadapa	15359	25	39	64	10	614	394	240
4	East Godavari	10807	92	13	105	13	117	831	103
5	Guntur	11391	84	13	97	17	136	876	117
6	Krishna	8727	65	7	72	10	134	1247	121
7	Kurnool	17658	37	20	57	17	477	883	310
8	Nellore	13076	57	0	57	7	229	Nil	229
9	Prakasam	17626	49	13	62	8	360	1356	284
10	Srikakulam	5837	52	0	52	4	112	Nil	112
11	Vishakhapatnam	11161	57	3	60	12	196	3720	186
12	Vizianagaram	6539	47	0	47	3	139	Nil	139
13	West Godavari	7742	57	9	66	8	136	860	117
	Total	**160205**	**699**	**165**	**864**	**142**	229	971	185

Table-6.2: Distribution of monitoring stations-Principal Aquifer-wise (as on March, 2019)

	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			20	27							12	4												2			65
Chittoor	2		39	15													4										60
Kadapa			7	3		1									1	5			2	1	1		14	29			64
East Godavari	44	6	5	1	1		8		7		1		18	1											8	5	105
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	5	4			9	4			3				9	1			57
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		28				5		5				3														52
Vizianagaram							10		18				19														47
Visakhapatnam	1						21		17				17	3	1												60
West Godavari	35	4	6		1								5												10	5	66
Grand Total	**173**	**14**	**149**	**59**	**5**	**3**	**77**	**4**	**53**	**5**	**19**	**8**	**68**	**6**	**22**	**14**	**10**	**0**	**8**	**2**	**38**	**6**	**37**	**32**	**25**	**11**	**864**

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 2018 are prepared. The data from GWMS for the year 2018-19 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, 2018)

The depth to water level during May, 2018 monitoring based on analysis of water level data of 795 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**.

An analysis of depth to water level data of 795 wells **(Annexure - V**) shows water levels vary between 0.09 m.bgl (Anantapur district) and 60.13 m.bgl (Chittoor district). The average water levels of the state is 6.95 m bgl ranging from 4.72 m bgl in East Godavari to 12.32 m bgl Kadapa district. An average of water level of less than 2 m bgl is recorded in 8 % of wells, between 2-5 m bgl in 41% of wells, between 5-10 m bgl in 33% of wells, between 10-20 m bgl in 14% of wells , between 20-40 m bgl in 2% of wells and in the rest 1.1% of wells depth to water level more than 40 m bgl is registered. Depth to water level map of May, 2018 (**Fig.7.2**) shows that , Shallow water levels of less than 2 m bgl are noticed as small scattered patches covering an area of 2% (60 wells) except in Kadapa and Prakasam. Water level 2 to 5 m bgl is covered in 32% of the area (329 wells). Area-wise 44% of the state is covered by depth to water level of 5 to 10 m bgl (266 wells). Water level 10 to 20 m bgl is covered in 18% of the area (113 wells). Deeper water levels of more than 20 m covers about 5% of the state (27 wells) noticed mostly in Kadapa and Anantapur districts .

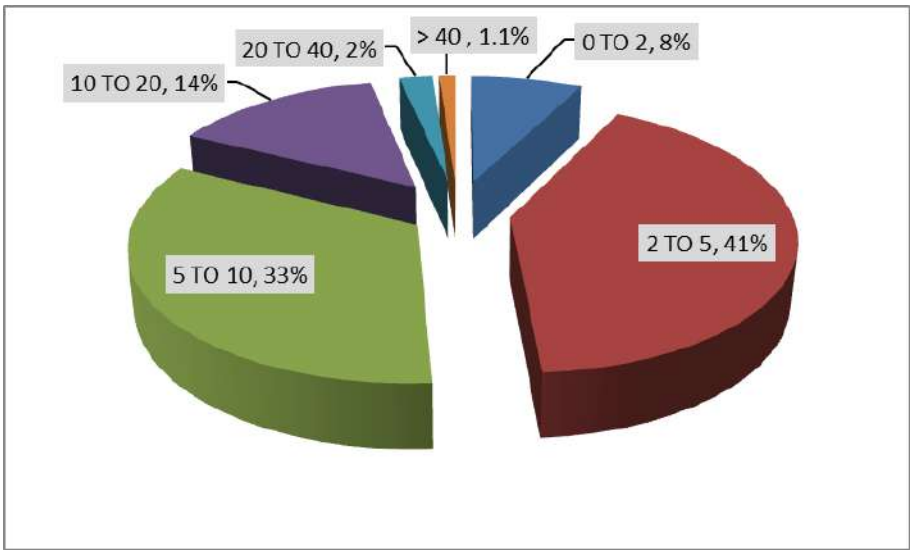


Fig-7.1: Percentage of wells in different depth ranges of DTW-May 2018

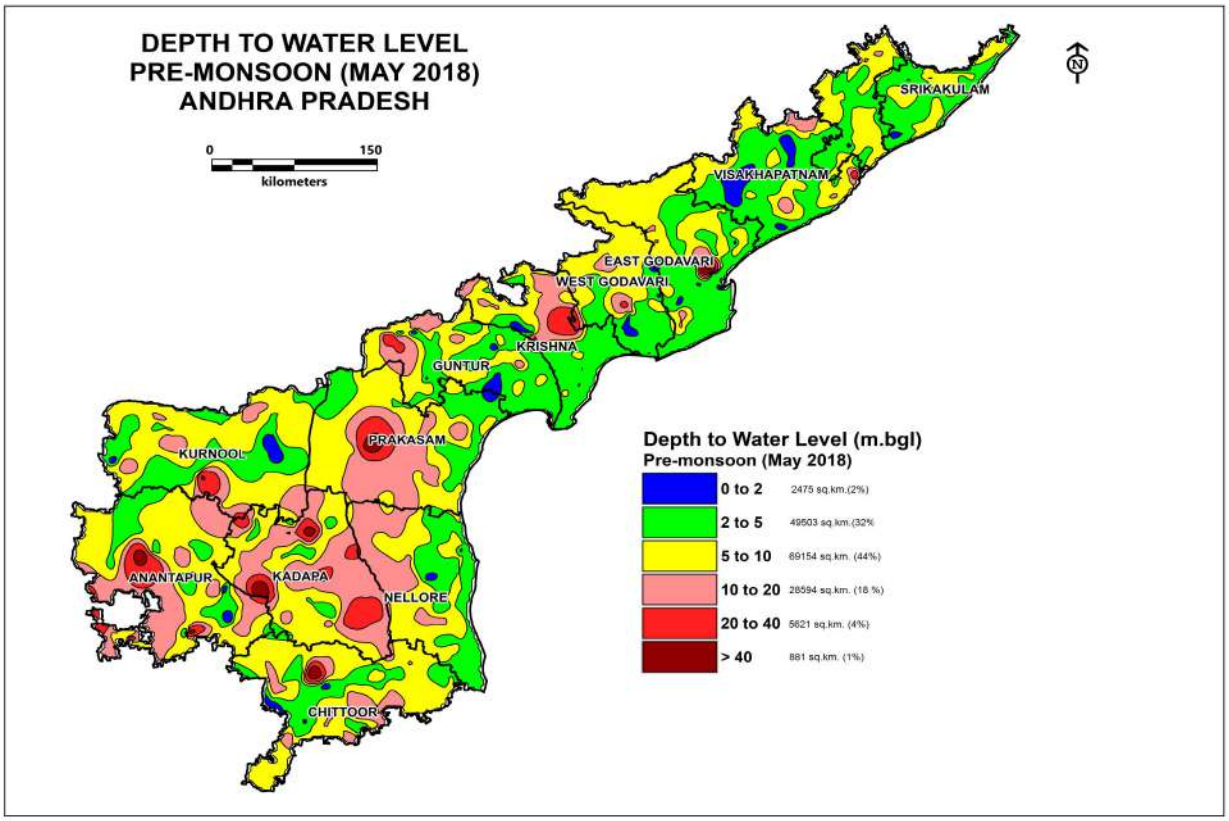


Fig-7.2: Depth to water level, May, 2018 in Andhra Pradesh state

7.1.2 Depth to Water Levels –August, 2018 (Mid-monsoon Season)

The depth to water level during August, 2018 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.7.3**. and depth to water level map is given in **Fig 7.4**.

An analysis of depth to water level data of 720 wells **(Annexure - VI)** shows water levels vary between 0.30 m.bgl (Krishna district) and 39.09 m.bgl (Prakasam district). The average water level of the state is 4.89 m bgl ranging from 1.50 m bgl in Srikakulam to 8.24 m bgl in Prakasam district. Water level of less than 2 m bgl is recorded in 35 % of wells, between 2-5 m bgl in 30% of wells, between 5-10 m bgl in 23% of wells, between 10-20 m bgl in 10% of wells, between 20-40 m bgl in 1% of wells and in the rest 1.1% of wells depth to water level more than 40 m bgl is registered. Depth to water level map of August, 2018 (**Fig.7.4**) shows that , Shallow water levels of less than 2 m bgl are noticed as scattered patches in northern part covering 19% of area (249 wells). Water level 2 to 5 m bgl is covered in 29% of the area (217 wells). Area-wise 36% of the state is covered by depth to water level

of 5 to 10 m bgl (165 wells). Water level 10 to 20 m bgl is covered in 15% of the area (72 wells). Deeper water levels of more than 20 m covers about 1% of the state (16 wells) noticed mostly in Kadapa, Prakasam, Anantapur, Visakhapatnam and Krishna districts.

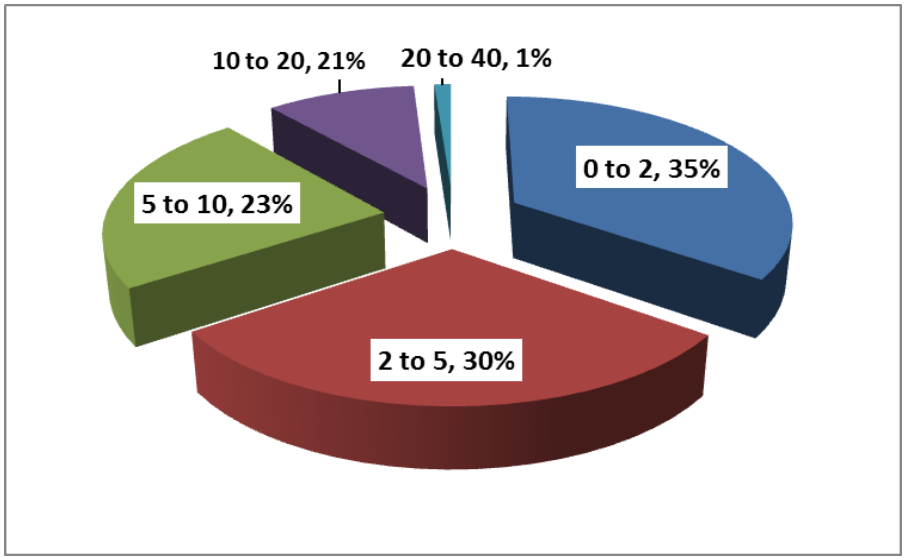


Fig.7.3: Percentage of wells in different depth ranges of DTW-August 2018

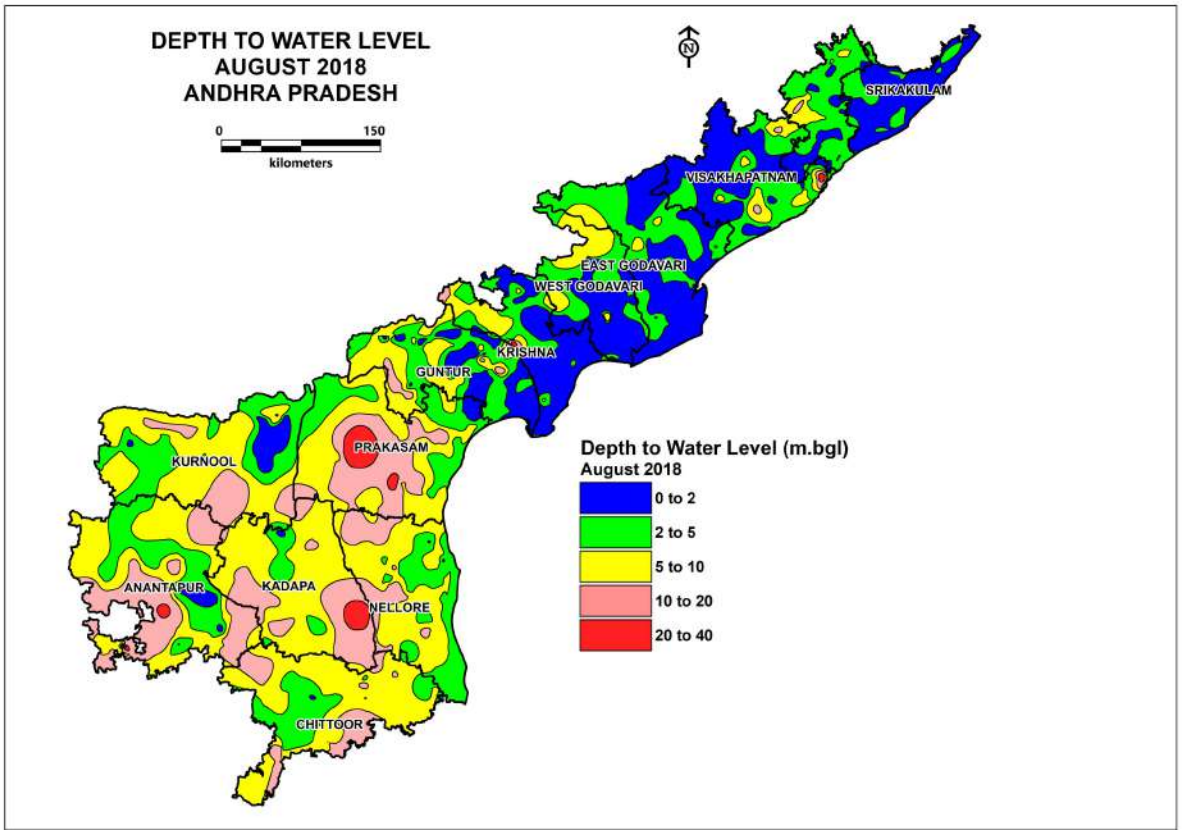


Fig.7.4: Depth to water level August, 2018 in Andhra Pradesh state

7.1.3 Depth to Water Levels - Post-Monsoon Season (November, 2018)

The depth to water level during November, 2018 based on analysis of water level data of 742 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**.

An analysis of depth to water level data of 742 wells **(Annexure - VII)** shows water levels vary between 0.33 m.bgl (West Godavari district) and 44.27 m.bgl (Prakasam district). The average water level of the state is 5.16 m bgl ranging from 1.97 m bgl in Srikakulam to 8.59 m bgl in Anantapur district. Water level of less than 2 m bgl is recorded in 29 % of wells, between 2-5 m bgl in 35% of wells, between 5-10 m bgl in 23% of wells, between 10-20 m bgl in 10% of wells, between 20-40 m bgl in 1% of wells and in the rest 0.90% of wells depth to water level more than 40 m bgl is registered. Depth to water level map of November, 2018 (**Fig.7.6**) shows that , Shallow water levels of less than 2 m bgl are noticed as scattered patches in central and northern part covering an area of 13% (218 wells). Water level 2 to 5 m bgl is covered in 36% of the area (262 wells). Area-wise 36% of the state is covered by depth to water level of 5 to 10 m bgl (174 wells). Water level 10 to 20 m bgl is covered in 14% of the area (76 wells). Deeper water levels of more than 20 m covers about 1% of the state (13 wells) noticed mostly in Prakasam, Anantapur, Visakhapatnam, West Godavari, Guntur and Krishna districts.

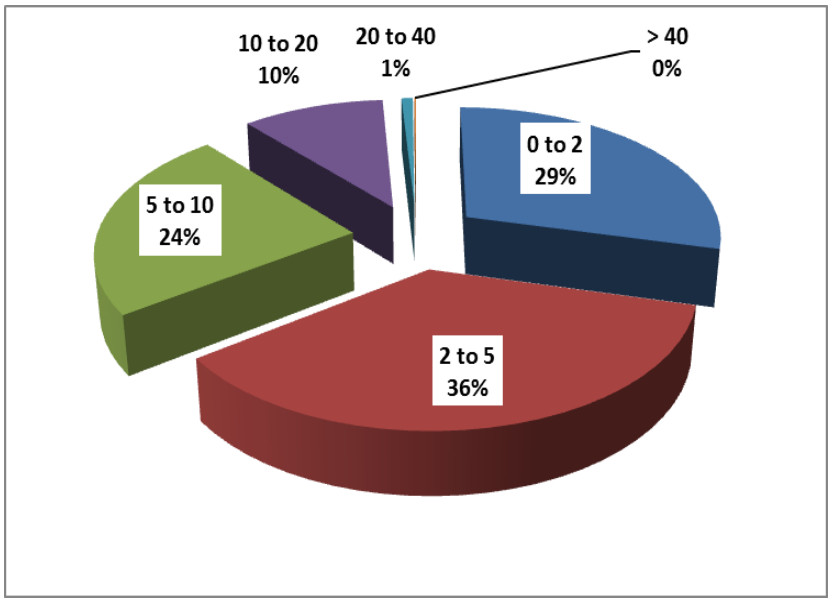


Fig.7.5: Percentage of wells in different depth ranges of DTW-November 2018

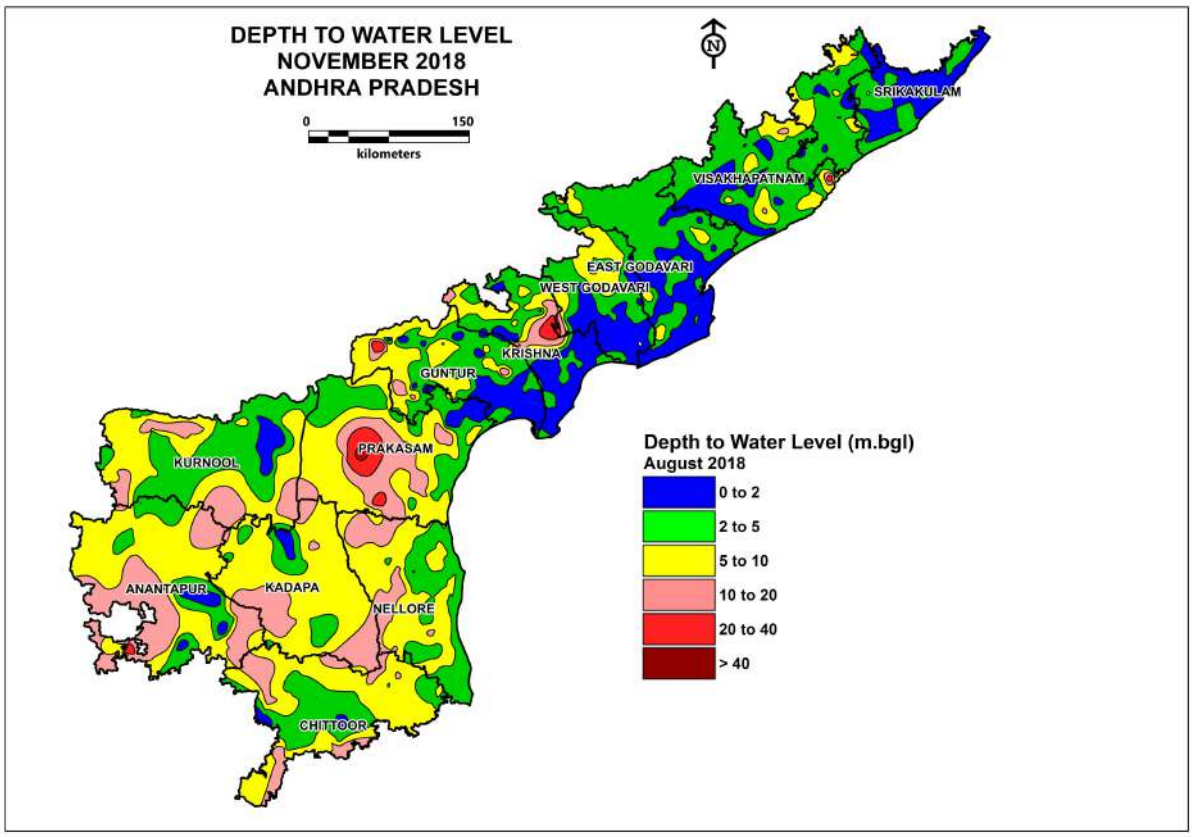


Fig.7.6: Depth to water level November, 2018 in Andhra Pradesh state

7.1.4 Depth to Water Levels (January, 2019)

The depth to water level during January, 2019 based on analysis of water level data of 730 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**.

An analysis of depth to water level data of 730 wells **(Annexure - VIII)** shows water levels vary between 0.19 m.bgl (Guntur district) and 50.01 m.bgl (YSR Kadapa district). Water level of less than 2 m bgl is recorded in 22 % of wells, between 2-5 m bgl in 40% of wells, between 5-10 m bgl in 26% of wells, between 10-20 m bgl in 11% of wells, between 20-40 m bgl in 1% of wells . Depth to water level map of January, 2019 (**Fig.7.8**) shows that , Shallow water levels of less than 2 m bgl are noticed as scattered patches in Krishna, West Godavari, East Godavari, Guntur and Visakhapatnam covering an area of 8% (164 wells). Water level 2 to 5 m bgl is covered in 35% of the area (286 wells), mainly in Srikakulam, East Godavari and Guntur. Area-wise 39% of the state is covered by depth to water level of 5 to 10 m bgl (190 wells),

predominantly in southern part of the state. Water level 10 to 20 m bgl is covered in 15% of the area (78 wells). Deeper water levels of more than 20 m covers about 2% of the state (12 wells) noticed mostly in Kadapa, Prakasam and Guntur districts.

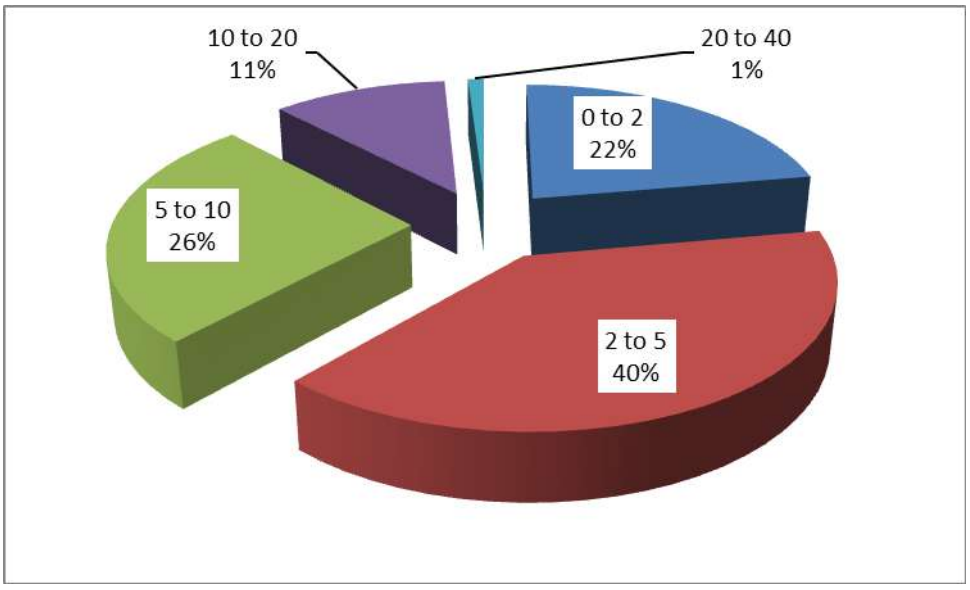


Fig.7.7: Percentage of wells in different depth ranges of DTW-January 2019

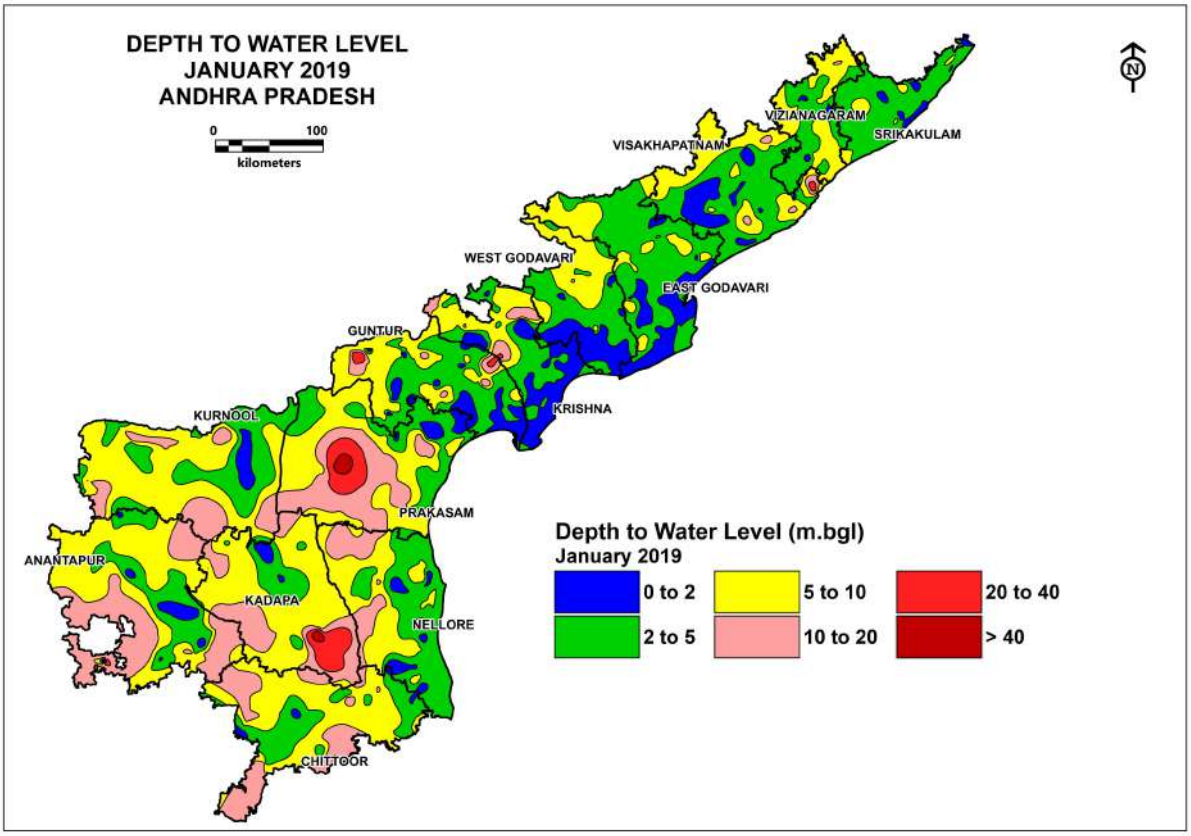


Fig.7.8: Depth to water level January, 2019 in Andhra Pradesh state

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 2018 (Pre-monsoon) Water level data from a total of 1288 station, out of which, 1225 stations of State GWD and 49 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 1274 stations, depth to water level of 52 stations (4%) are in the range of 0 to 2 m bgl, 255 stations (20%) are in the range of 2 to 5 m bgl, 387 stations (30%) are in the range of 5 to 10 m bgl, 358 stations (28%) are in the range of 10 to 20 m bgl, 163 stations (13%) are in the range of 20 to 40 m bgl and depth to water level of 59 stations (5%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 18 % of wells and shallow water level of less than 2 m bgl are observed in 4 % of wells. Area-wise, 18% of the state have deeper water levels(>20 m bgl) and only 2% of the area has shallow water levels. Medium range 5-20 m bgl is observed in 67% of the area.

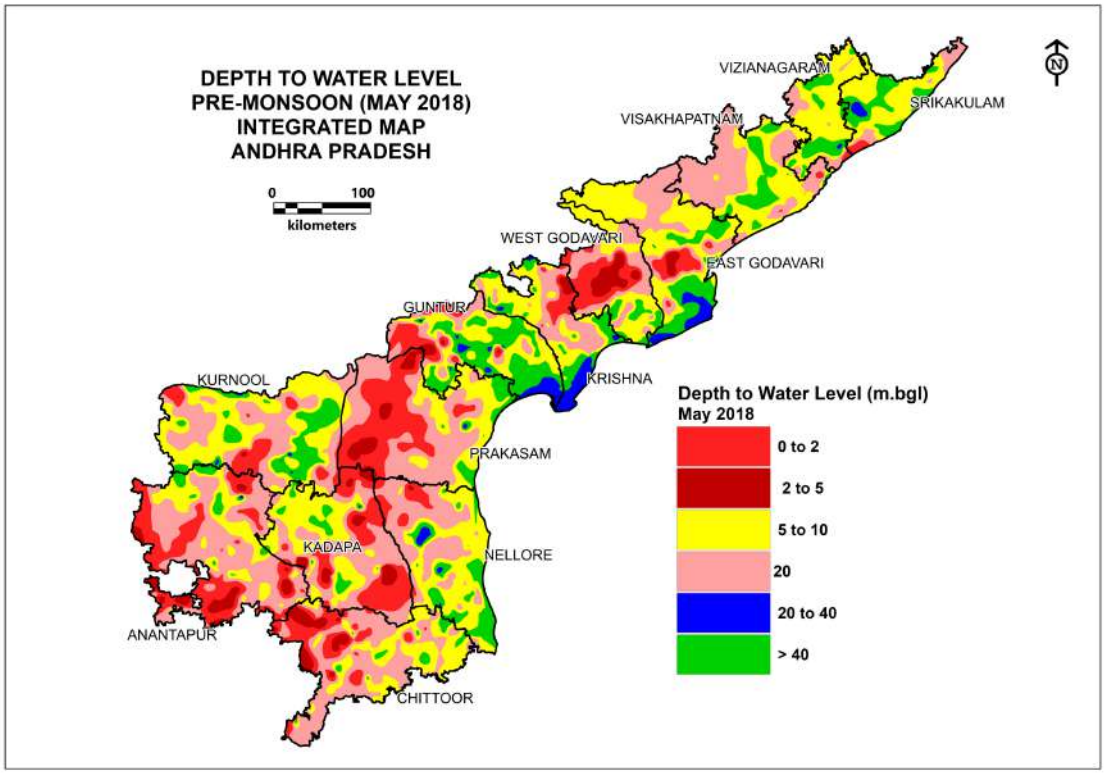


Fig 7.9 Depth To Water Level Map of May 2018 (Integrated data)

TABLE 7.1: Depth to water levels and percentage of wells in different depth ranges in May-2018

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	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	154	0.18	87.55	18.91	2	1%	8	5%	36	23%	52	34%	41	27%	14	9%
2	Chittoor	118	1.26	82.39	17.11	2	2%	13	11%	28	24%	49	42%	17	14%	9	8%
3	East Godavari	98	1.05	69.19	9.76	9	9%	28	29%	34	35%	14	14%	11	11%	2	2%
4	Guntur	129	0.4	61.85	9.81	11	9%	49	38%	34	26%	20	16%	10	8%	5	4%
5	Kadapa	105	1.62	89.28	17.15	1	1%	12	11%	36	34%	29	28%	19	18%	8	8%
6	Krishna	111	1.2	93.69	12.11	6	5%	21	19%	36	32%	33	30%	12	11%	3	3%
7	Kurnool	151	1.07	48.88	8.63	10	7%	39	26%	54	36%	35	23%	7	5%	2	1%
8	Nellore	96	0.38	43.42	9.43	5	5%	22	23%	33	34%	27	28%	5	5%	1	1%
9	Prakasam	100	1.21	66.4	18.37	1	1%	12	12%	16	16%	38	38%	21	21%	7	7%
10	Srikakulam	37	1.05	27.59	7.12	2	5%	15	41%	13	35%	7	19%	0	0%	0	0%
11	Visakhapatnam	72	1.22	32.6	9.37	2	3%	15	21%	26	36%	25	35%	4	6%	0	0%
12	Vizianagaram	45	1.67	17.87	7.07	1	2%	13	29%	21	47%	10	22%	0	0%	0	0%
13	West Godavari	72	2.24	76.78	20.16	0	0%	8	11%	20	28%	19	26%	16	22%	8	11%
14	**State Figures**	**1288**	**0.18**	**93.96**	**13.23**	**52**	**4%**	**255**	**20%**	**387**	**30%**	**358**	**28%**	**163**	**13%**	**59**	**5%**

7.2.2 Post-monsoon (November 2018)

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 1288 station, out of which, 1228 stations of State GWD and 49 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 2017. Based on the tabulated results**(Table 7.2)**, it is inferred that, out of 1277 stations, depth to water level of 133 stations (10%) are in the range of 0 to 2 m bgl, 249 stations (19%) are in the range of 2 to 5 m bgl, 341 stations (26%) are in the range of 5 to 10 m bgl, 307 stations (24%) are in the range of 10 to 20 m bgl, 160 stations (12%) are in the range of 20 to 40 m bgl and 87 stations (7%) are more than 40 m bgl. Deeper water level of more than 20 m bgl are observed in 19 % of wells and shallow water level of less than 2 m bgl are observed in 10 % of wells. Area-wise, 22% of the state have deeper water levels and only 5% of the area has shallow water levels. Medium range 5-20 m bgl is observed in 56% of the area. From pre-monsoon to post-monsoon, there is decrease from 67% to 56% in the medium range of depth to water levels (5-20 m bgl), there is increase from 18% to 22% in the deeper water level range and there is an increases from 2% to 5 % in shallow water levels. The increase in deeper water levels is mostly observed in southern parts of the state where less monsoon rainfall is received.

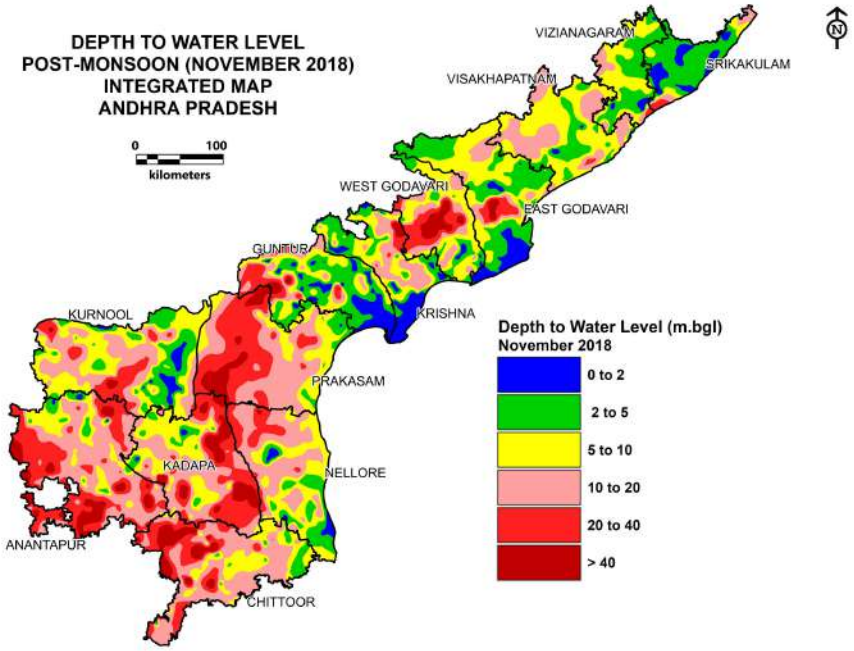


Fig 7.10 Depth To Water Level Map of Nov 2018 (Integrated data)

Table 7.2 : Depth to water levels and percentage of wells in different depth ranges in November-2018

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	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	154	0.31	89.30	21.40	3	2%	9	6%	24	16%	54	35%	44	29%	19	12%
2	Chittoor	118	0.53	96.86	20.12	4	3%	9	8%	25	21%	47	40%	14	12%	17	14%
3	East Godavari	98	0.14	68.89	7.58	19	19%	34	35%	28	29%	7	7%	8	8%	2	2%
4	Guntur	129	0.05	62.05	8.81	35	27%	31	24%	31	24%	15	12%	9	7%	5	4%
5	Kadapa	105	0.95	90.00	19.99	2	2%	10	10%	36	34%	21	20%	19	18%	16	15%
6	Krishna	111	0.47	85.98	9.70	19	17%	25	23%	28	25%	28	25%	7	6%	3	3%
7	Kurnool	151	0.40	52.00	8.70	18	12%	38	25%	53	35%	27	18%	12	8%	3	2%
8	Nellore	96	0.47	43.82	10.23	7	7%	16	17%	30	31%	36	38%	6	6%	1	1%
9	Prakasam	100	1.92	58.37	19.54	1	1%	11	11%	14	14%	32	32%	26	26%	13	13%
10	Srikakulam	37	0.76	28.40	4.18	14	38%	16	43%	6	16%	1	3%	0	0%	0	0%
11	Visakhapatnam	72	0.93	27.20	8.43	3	4%	18	25%	29	40%	19	26%	3	4%	0	0%
12	Vizianagaram	45	0.76	18.56	5.87	4	9%	19	42%	17	38%	5	11%		0%		0%
13	West Godavari	72	1.06	75.85	17.70	4	6%	13	18%	20	28%	15	21%	12	17%	8	11%
14	**State Figures**	**1288**	**0.05**	**96.86**	**13.39**	**133**	**10%**	**249**	**19%**	**341**	**26%**	**307**	**24%**	**160**	**12%**	**87**	**7%**

7.3 Fluctuations with Pre-Monsoon Water Levels

7.3.1 Water Level Fluctuation- From May, 2018 to Aug 2018

Water level fluctuations during August 2018 from May 2018 are presented in **Annexure-IX.** An analysis of 641 wells shows that water level rise is recorded in 74 % wells (476 nos). About 26% of wells (165 nos) have shown a fall in water level. Spatial distribution is given in **Fig 7.11.** The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in West Godavari and 37.3 m in Anantapur districts. The minimum and maximum fall in water level fluctuations is recorded in 0.02 m in Kurnool and 13.6 m in Anantapur district. Rise in water levels is in 74% of the wells covering northern part of the state. Water level fall is in 26% of the wells and fall of more than 4 m is as small patch in Anantapur and Kurnool districts. Rise of more than 4 m is recorded mainly in north coastal districts and western parts of West Godavari, Krishna and Guntur districts.

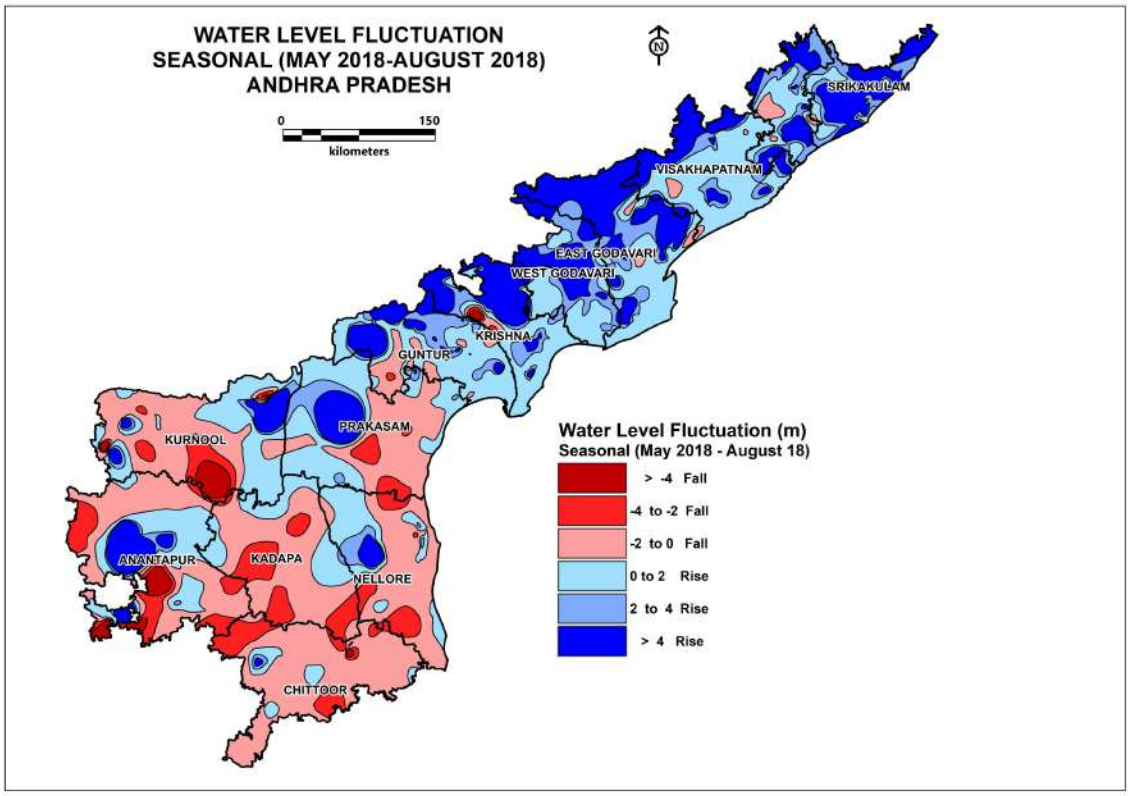


Fig 7.11: Water Level Fluctuation (From May 2018 to August 2018)

7.3.2 Water Level Fluctuation - from May, 2018 to Nov, 2018

The district-wise water level fluctuations from May 2018 to Nov 2018 are presented in **Annexure-X.** An analysis of 711 wells shows that water level rise is recorded in 70 % wells (496 nos) and 23% of wells (162 nos) have shown a fall in water level and 7% of wells (53 nos) have no fluctuation in water levels. Rise in water levels is mainly due to normal rainfall received during the period June to October 2018 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.**

The minimum and maximum rise in water level fluctuations is recorded as 0.02 m in SPS Nellore district and 32.7 m in East Godavari district. The minimum and maximum fall in water level fluctuations is recorded as 0.02 m in Visakhapatnam and 10.2 m in Chittoor district. In the state, rise of more than 4 m is observed in north-coastal districts. Water level fall of more than 4 m is observed in Rayalaseema districts and Prakasam district. Water levels rise in the ranges 0 to 2 m and 2 to 4 m is more prominently seen in about 62% and 23% of wells, respectively.

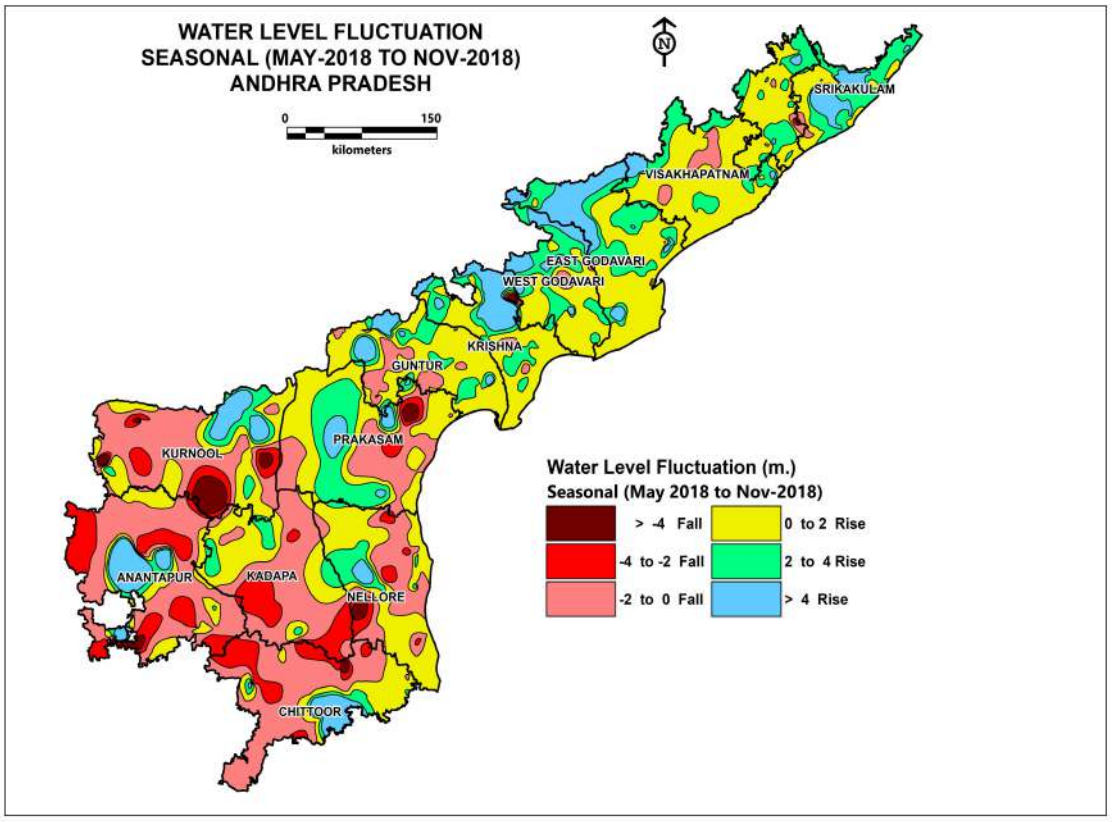


Fig 7.12 Water Level Fluctuation (Nov, 2018 from May, 2018)

7.3.3 Water Level Fluctuation - from May, 2018 to January 2019

The district-wise water level fluctuations from May 2018 to Jan 2019 are presented in **Annexure-XI.** An analysis of 690 wells shows that water level rise is recorded in 68 % wells (466 nos) and fall in water levels in 24% of wells (168 nos). Rise in water levels is mainly due to normal rainfall received during the period June to December 2018 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.**

The minimum and maximum rise in water level fluctuations is recorded as 0.02 m in East Godavari and 37.41 m in Anantapur district respectively. The minimum and maximum fall in water level fluctuations is recorded as 0.02 m in Visakhapatnam and 15.23 m in Prakasam district. In the state, rise of more than 4 m is observed in 32 wells (7% of total wells) predominantly in Anantapur, Nellore, Guntur Krishna, West Godavari and East Godavari, districts which is due to good rains. Water level fall of more than 4 m is observed in 18 wells in significant as patches in Rayalaseema districts, Nellore, Prakasam and Krishna districts.

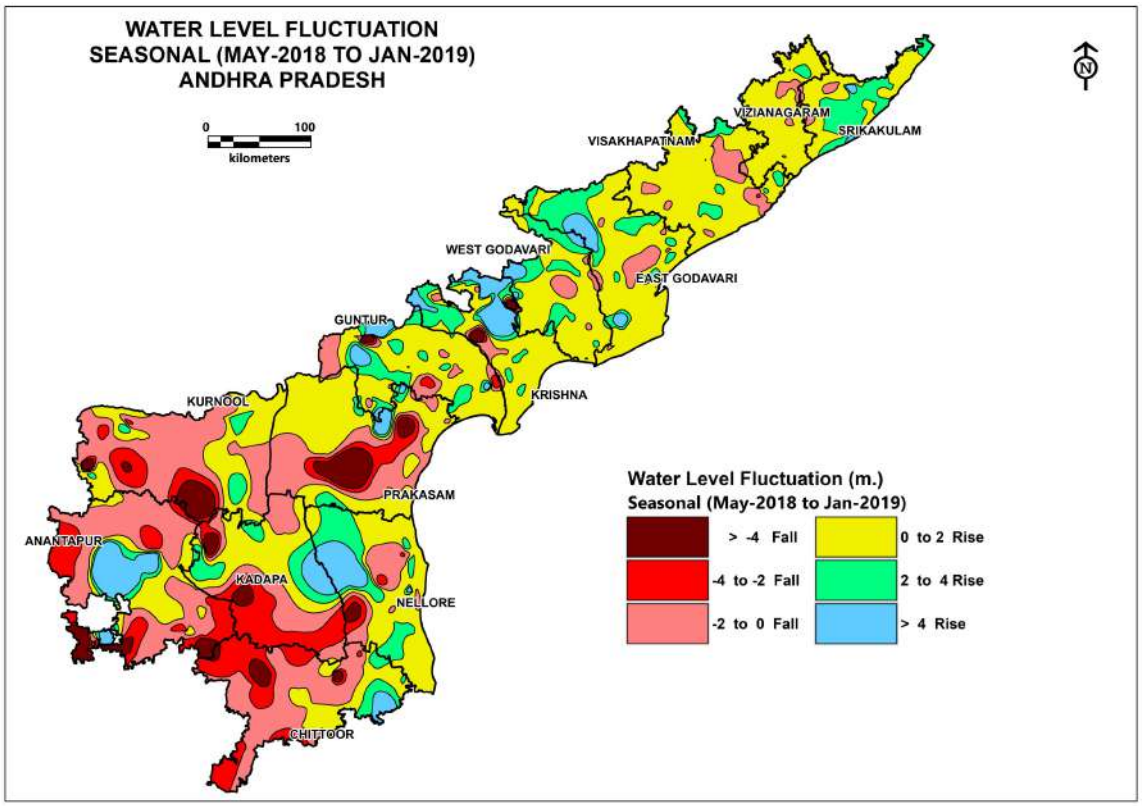


Fig 7.13: Water Level Fluctuation (May, 2018 to January, 2019)

7.4 Annual Water Level Fluctuation

7.4.1 Water Level Fluctuation (From May 17 to May, 2018)

Water level fluctuation data of May 2018 with May 2017 is presented in **Annexure - XII.** An analysis of data of 652 wells shows that water level rise is recorded in 66% of wells (431), water level fall is recorded in 34% of wells (221). This is mainly due to 1% less rainfall in 2017 monsoon compared to monsoon 2016. Spatial distribution of fluctuation is shown in **Fig 7.14.**

Area-wise, 70% of the state experienced water levels rise compared with the same period last year. Out of the 431 wells that have registered a rise in water levels, 71% of wells recorded water level rise of less than 2 m, 24% 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 of less than 2 m is observed mostly in Rayalaseema parts of the state. Water level rise of 2-4 m is observed in all the districts of the state except in Krishna and Visakhapatnam district, where it is insignificant. Rise of water level more than 4 m is observed as patches and is significant in Kadapa, Anantapur and Kurnool districts.

Area-wise, 30% of the state experienced water levels fall compared with the same period last year. Out of the 221 wells that have registered fall in water levels, 86% of wells have recorded less than 2 m fall, 8% of wells in the range of 2-4 m and the rest 6% wells registered water level fall more than 4 m. Fall of water level more than 4 m is more prominent in Anantapur, Chittoor and Kurnool Districts.

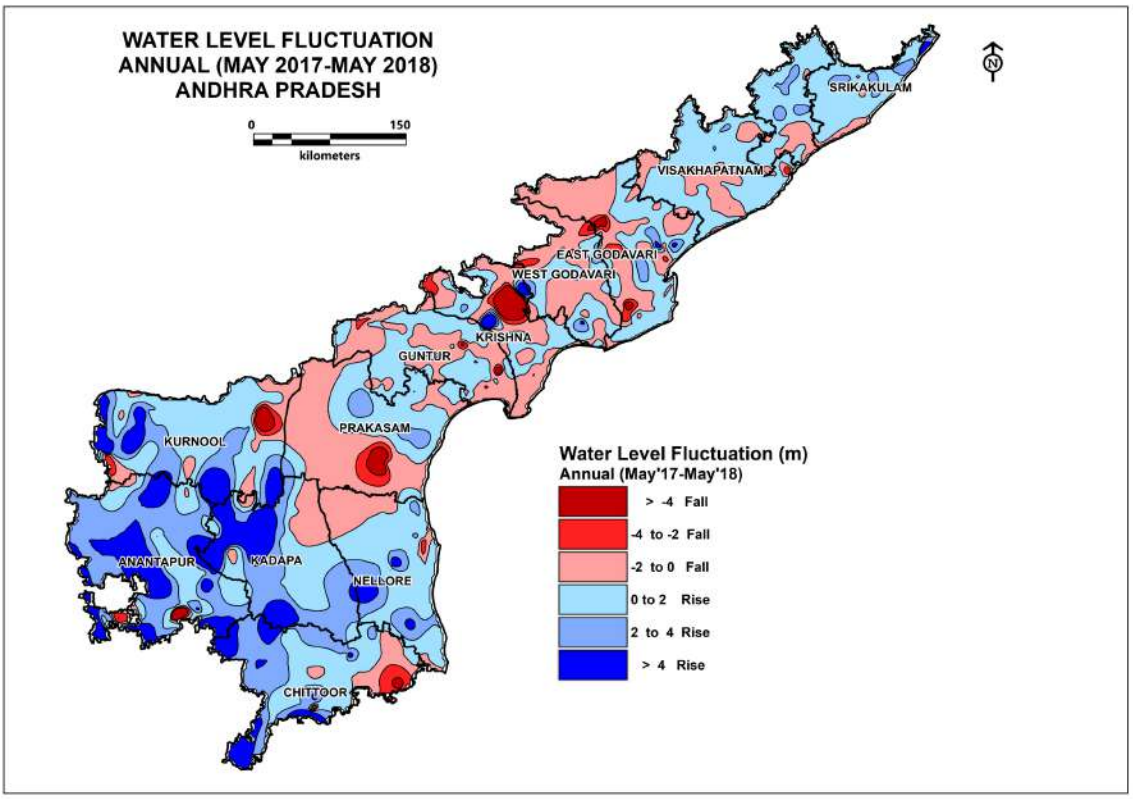


Fig.7.14: Water Level Fluctuations (May, 2018 from May,2017)

7.4.2 Water Level Fluctuation (August-2018 from August-2017)

Water level fluctuation data of August 2018 from August 2017 is presented in **Annexure-XIII.** An analysis of data of 647 wells shows that water level rise is recorded in 62% of wells (404), water level fall is recorded in 38% of wells (243). During the period June - August'18, the state has received 5.7 % more rainfall than normal. The state has experienced fluctuation in the range of -2 to 2 m in about 94% of the wells. Spatial distribution of fluctuation is shown in **Fig 7.15.**

65% of the area (404 wells) experienced rise in water levels compared with last year same period. 75% of wells have recorded less than 2m. 16% of wells in the range of 2 to 4 m while the rest 8.7% of wells recorded water level rise of more than 4 m. Rise in water level less than 2 m is observed in all the districts. Water level rise of 2-4 m is observed mainly in Anantapur, East Godavari, Guntur and as small areas in all other districts. Rise of Water level more than 4 m is observed mainly in Anantapur, Kadapa, Prakasam and Krishna districts.

35% of the area (243 wells) experienced fall in water levels compared with last year same period (August-2017). 81% of wells have recorded less than 2 m, 12% of wells in the

range of 2-4 m and the rest 7% wells registered more than 4 m. fall in water levels. Fall of more than 4 m is observed significantly as patches in parts of Prakasam, Guntur, Kurnool, Nellore and Chittoor districts. Fall of 2 to 4 m is observed in Anantapur, Nellore, Prakasam, Chittoor, Kurnool districts. Fall of 0 to 2 m is observed mainly in Visakhapatnam, Prakasam, Vizianagaram, Kurnool Nellore, Chittoor and small areas in all other districts.

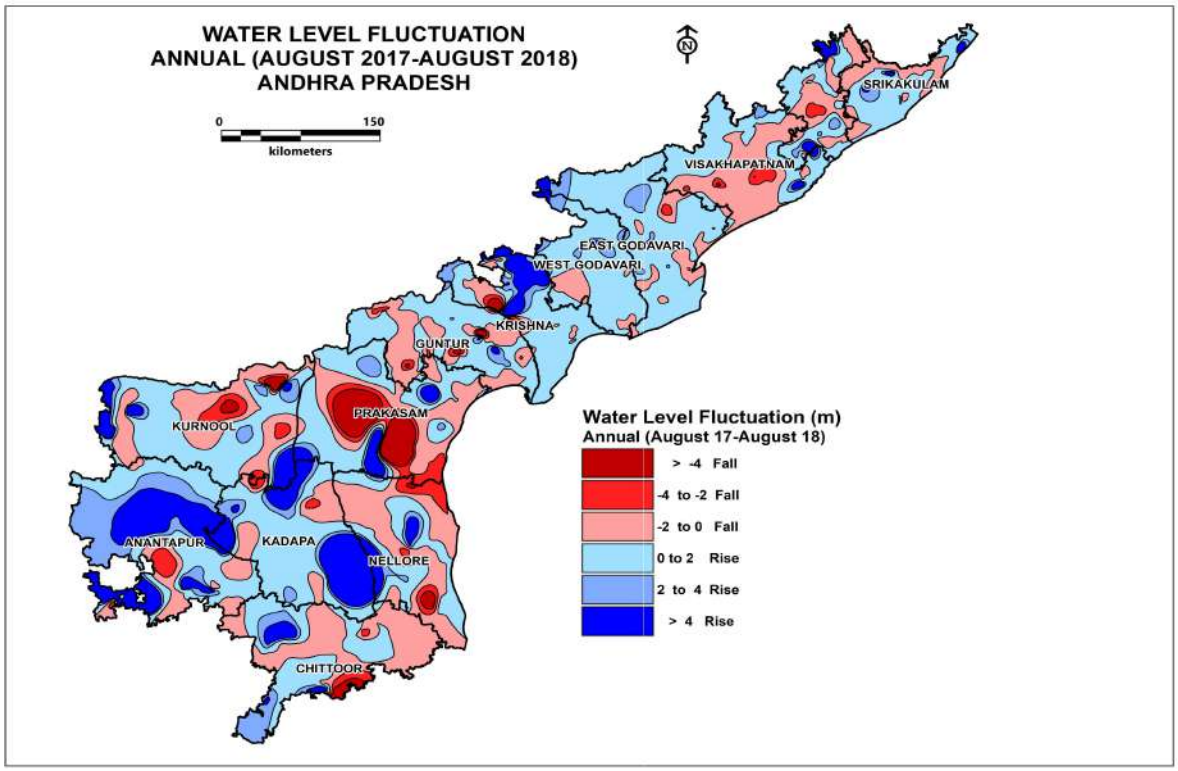


Fig. 7.15: Water Level Fluctuations (August 2017 from August 2018)

7.4.3 Water Level Fluctuations (November, 2018 from November, 2017)

The district-wise water level fluctuations from Nov 2017 to Nov 2018 are presented in **Annexure-XIV.** An analysis of data of 724 wells shows that water level rise is recorded in 31% of wells (227), water level fall is recorded in 67% of wells (477). Fall in water levels is mainly due to 28.2 % less rainfall than last year same period in the state i.e., June to October. Spatial distribution of water level fluctuations is presented in **Fig 7.16.**

22% of the area (227 wells) experienced rise in water levels compared with last year same period. 86% of wells have recorded less than 2m. 10% of wells in the range of 2 to 4 m while the rest 4% of wells recorded water level rise of more than 4 m. Rise in water level less than 2 m is observed in all the districts. Water level rise of 2-4 m is observed mainly in

Anantapur, East Godavari, Guntur and as small areas in all other districts. Rise of Water level more than 4 m is observed mainly in Anantapur, Kadapa, Prakasam and Krishna districts.

78% of the area (477 wells) experienced fall in water levels compared with last year same period (Nov-2017). 65% of wells have recorded less than 2 m, 19% of wells in the range of 2-4 m and the rest 16% wells registered more than 4 m. fall in water level. Fall of more than 4 m is observed significantly as patches in parts of Prakasam, Guntur, Kurnool, Nellore and Chittoor districts. Fall of 2 to 4 m is observed in Anantapur, Nellore, Prakasam, Chittoor, Kurnool districts. Fall of 0 to 2 m is observed mainly in Visakhapatnam, Prakasam, Vizianagaram, Kurnool Nellore, Chittoor and small areas in all other districts.

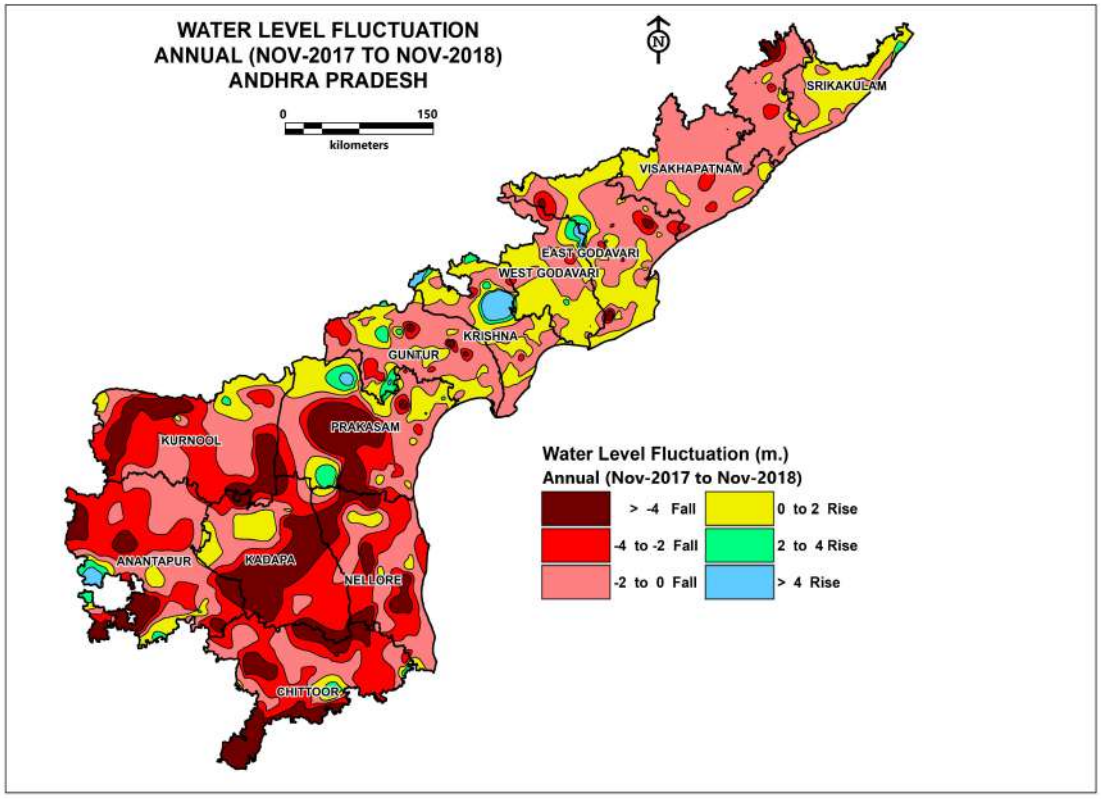


Fig.7.16 : Water Level Fluctuations (November,2018 from November,2017)

7.4.4 Water Level Fluctuations (January-2019 from January-2018)

The district-wise water level fluctuations from Jan 2018 to Jan 2019 are presented in **Annexure-XV.** An analysis of data of 706 wells shows that water level rise is recorded in 40% of wells (280), water level fall is recorded in 55% of wells (388). The state has experienced fluctuation in the range of -2 to 2 m in about 75% of the wells. Fall in water levels is mainly due to 23% less rainfall than last year same period in the state i.e., June to December. Spatial distribution of water level fluctuations is given in **Fig 7.17.**

27% of the area (280 wells) experienced rise in water levels compared with last year same period. 90% of wells have recorded less than 2m. 6% of wells in the range of 2 to 4 m while the rest 4% 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 Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur and Srikakulam districts. Water level rise of 2-4 m is observed as small patches in East Godavari, West Godavari, Srikakulam and Nellore districts. Rise of Water level more than 4 m is observed mainly in Krishna, Nellore, Prakasam, Guntur and Anantapur districts.

73% of the area (388 wells) experienced fall in water levels compared with last year same period (January-2018).65% of wells have recorded less than 2 m, 18% of wells in the range of 2-4 m and the rest 17% wells registered more than 4 m. Fall of more than 4 m is observed significantly as patches in parts of Kadapa, Prakasam, Chittoor, Kurnool, Nellore Anantapur and Guntur districts. Fall of 2 to 4 m is concentrated mainly in southern districts. Fall of 0 to 2 m is observed mainly in Kadapa, Prakasam, Chittoor, Kurnool, Nellore Anantapur, Visakhapatnam, Vizianagaram, and small areas in all other districts.

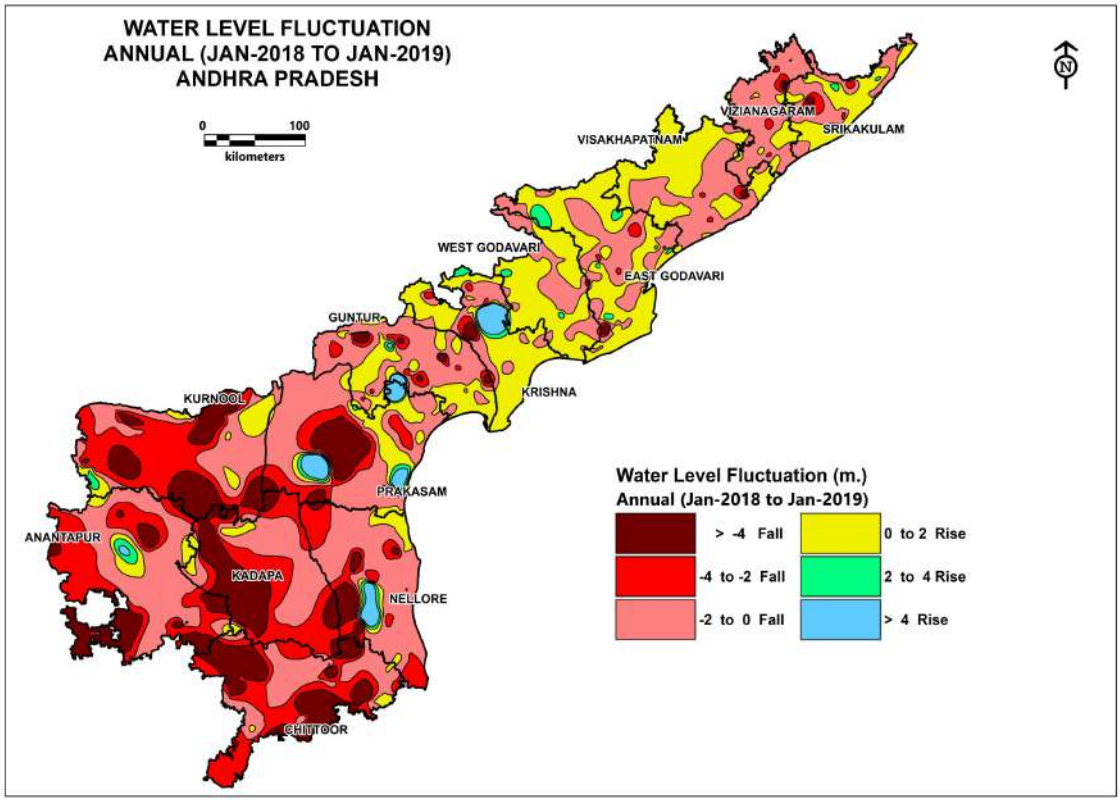


Fig. 7.17: Water Level Fluctuations (January, 2019 from January, 2018).

7.5 Decadal Water Level Fluctuations

7.5.1 Water Level Fluctuations-Decadal mean of May (2008-17) to May 2018

Water level fluctuation data of May 2018 from Decadal Mean of May (2008-2017) is presented in **Annexure - XVI.** An analysis of data of 630 wells shows that water level rise is recorded in 50% wells (315 no of wells), water level fall is recorded in 50% wells (315 no of wells). Water Level Fluctuations from Decadal Mean of May (2008-2017) to May-2018 is depicted in **Fig. 7.18**.

Area-wise, 61% of the state experienced water levels rise compared with the decadal mean of May (2008-17). Out of 315 wells, water level rise of less than 2 m is recorded in 55% wells, in the range of 2-4 m in 21% wells and rise of more than 4 m is recorded in 24% wells. Rise of water level more than 4 m is observed in 24% of the wells , covering only 14% of the area and as small patches in all the districts. Rise of more than 4 m is mainly observed in Rayalaseema districts and as small patches in other coastal districts.

Area-wise, 39% of the state experienced water levels fall compared with the decadal mean of May (2008-17). Out of the 315 wells that have registered fall in water levels, 70% have recorded less than 2 m fall, 18% in the range of 2-4 m and 11% wells registered water level fall of more than 4 m. Fall of more than 4 m is mainly observed in Kurnool, Anantapur, Nellore, Prakasam and Krishna districts.

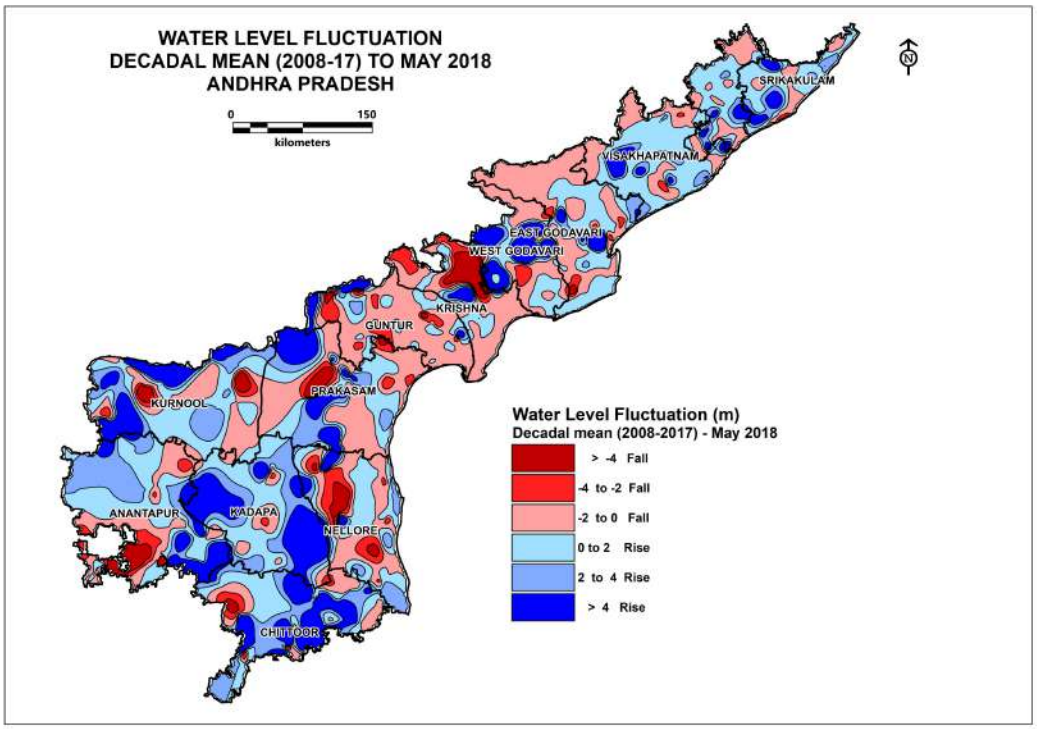


Fig.7.18: Water Level Fluctuations - Decadal Mean of May (2008-2017) to May-2018

7.5.2 Water Level Fluctuations-Decadal Mean of August (2008-2017) to August 2018

Water level fluctuation of August, 2017 from Decadal mean of August (2008-2017) is presented in **Annexure-XVII. S**patial distribution of fluctuation is presented in **Fig 7.19**. An analysis of 720 wells data shows that rise in water levels is observed in 375 wells (52% of wells) and fall in 345wells (48% of wells) .

Area-wise, 52% of the state experienced water levels rise compared with the decadal mean of May (2008-17). Out of 375 wells, water level rise of less than 2 m is recorded in 81% wells, in the range of 2-4 m in 12% wells. Rise of water level more than 4 m is observed in 6% of the wells, covering only 3% of the area and as small patches in Anantapur Krishna, Prakasam 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 mainly in Krishna, Chittoor, Anantapur and Kurnool districts.

Area-wise, 48% of the area experienced fall in water levels compared with decadal mean (2008-2017). Out of the 345 wells that have registered fall in water levels, 72% have recorded less than 2 m, 19% 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 in Prakasam, Kurnool, Nellore, Kadapa, Chittoor, Vizianagaram and small areas in all other districts. Fall of 2 to 4 m is observed as small patch in all the districts except Srikakulam district. Fall of more than 4 m is observed significantly in parts of Prakasam, Anantapur, Kadapa, Krishna, Kurnool, Nellore and Guntur districts.

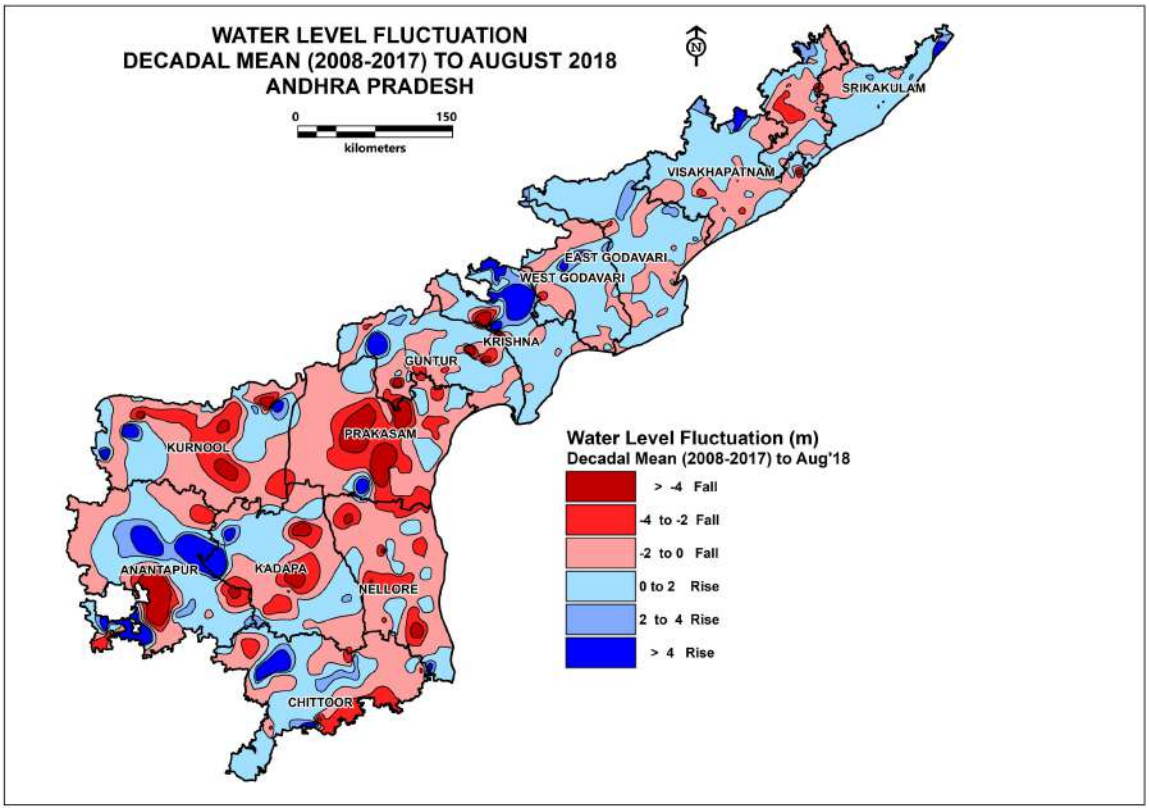


Fig. 7.19: Water Level Fluctuation - Decadal Mean (2008-2017) to August-2018

7.5.3 Water Level Fluctuation-Decadal Mean of Nov (2008-2017) to Nov, 2018

District-wise water level fluctuations from decadal mean of Nov (2008-17) to Nov 2018 is presented in **Annexure-XVIII. S**patial distribution of fluctuations as **Fig 7.20**. An analysis of 534 wells data shows that rise in water levels is observed in 136 wells (25%) and fall in 396 wells (74%)

Area-wise, 18% of the state experienced water levels rise compared with the decadal mean of May (2008-17).Water level rise of less than 2 m is recorded in 92% wells, in the range of 2-4 m in 6% wells. Rise of water level more than 4 m is observed in 2% of the wells, covering small patches in Kadapa, West Godavari, Prakasam 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 mainly in Kadapa, Srikakulam, and Chittoor and Anantapur districts.

Area-wise, 82% of the state experienced fall in water levels compared with decadal mean (2008-2017).65% have recorded less than 2 m, 20% in the range of 2-4 m and 15% wells registered water level fall of more than 4 m. Fall of less than 2 m is observed in all districts significantly. Fall of 2 to 4 m is observed mainly in Kadapa, Nellore, Chittoor,

Prakasam, Anantapur and Guntur districts. Fall of more than 4 m is observed significantly in parts of Prakasam, Anantapur, Kadapa, Krishna, Kurnool, Nellore and Guntur districts.

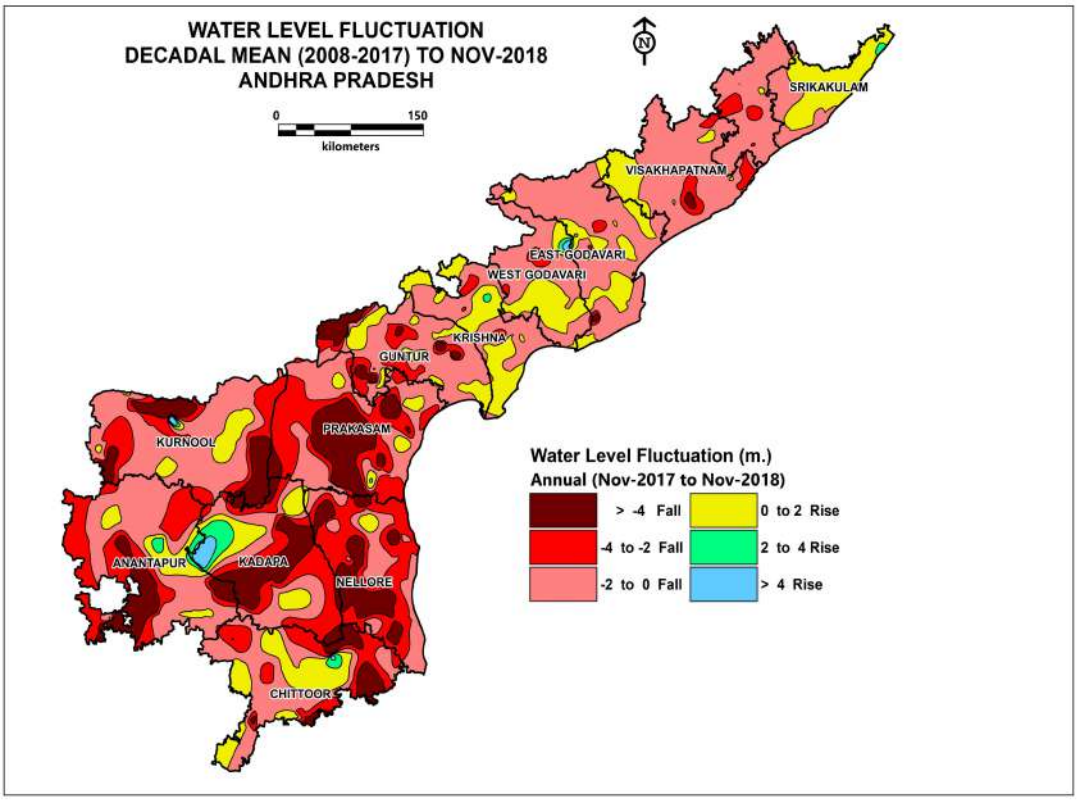


Fig. 7.20: Water Level Fluctuation - Decadal Mean (2008-2017) to November-2018

7.5.4 Water Level Fluctuation- Decadal Mean (2009-2018) to January 2019

District-wise water level fluctuations from decadal mean of Jan (2009-18) to Jan 2019 is presented in **Annexure-XIX.** An analysis of 719 wells shows that water level rise is recorded in 34 % wells (241 nos) and fall in water levels in 66% of wells (477 nos). Spatial distribution of water level fluctuations is presented in **Fig 7.21.**

Area-wise, 22% of the state experienced water levels rise compared with the decadal mean of January (2009-18).Rise of less than 2 m is recorded in 91% wells, in the range of 2-4 m in 7% wells. Rise of water level more than 4 m is observed in 2% of the wells, covering only 2% of the area and observed in Krishna, Anantapur Kurnool, Srikakulam and Kadapa districts. Rise in water level of less than 2 m is observed as small patches in Anantapur Krishna, Srikakulam, Visakhapatnam, West Godavari, Prakasam and Chittoor districts.

Area-wise, 78% of the state experienced fall in water levels compared with decadal mean (2009-2018). 63% of wells recorded less than 2 m, 20% in the range of 2-4 m and 17%

wells registered water level fall of more than 4 m. Fall of less than 2 m is observed in Vizianagaram, East Godavari, Prakasam, Guntur, Kurnool, Nellore, Kadapa, Chittoor, and small areas in all other districts. Fall of 2 to 4 m is observed as small patch in all the districts predominantly in southern districts. Fall of more than 4 m is observed significantly in parts of Prakasam, Anantapur, Kadapa, Krishna, Kurnool, Chittoor, Nellore and Guntur districts.

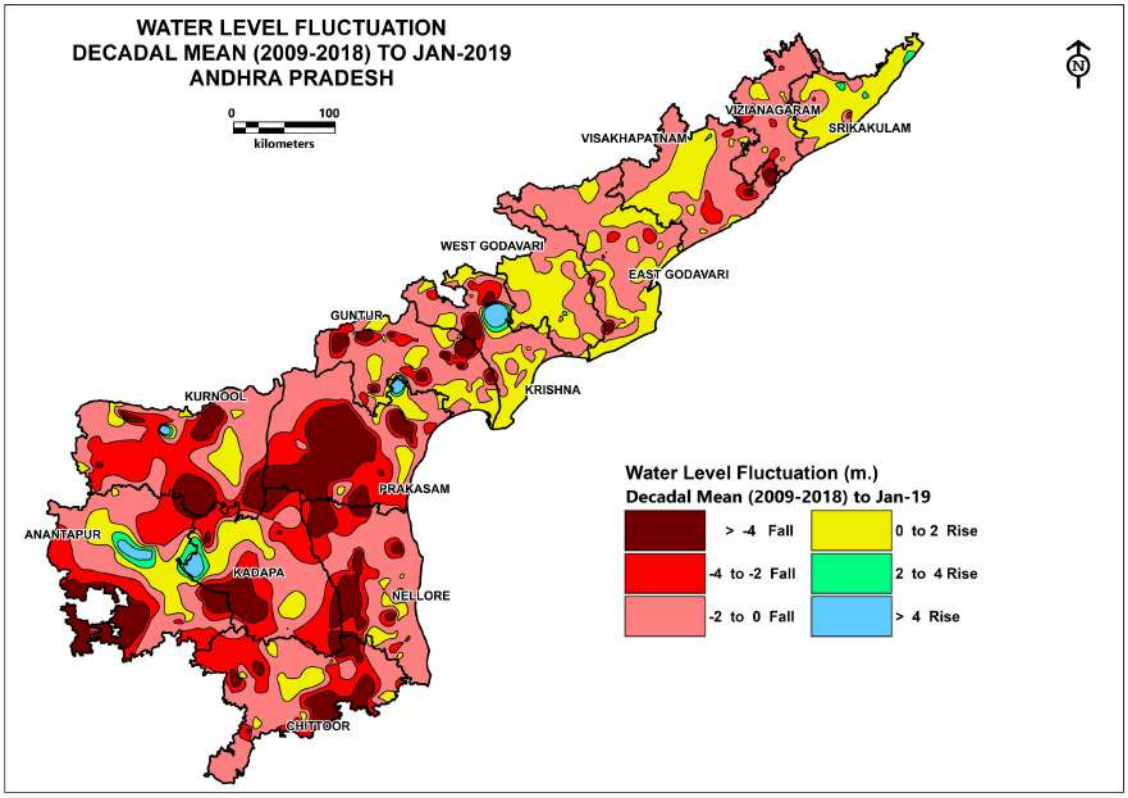


Fig. 7.21: Water Level Fluctuation - Decadal Mean (2009-2018) to January-2019

7.6 Aquifer wise water levels

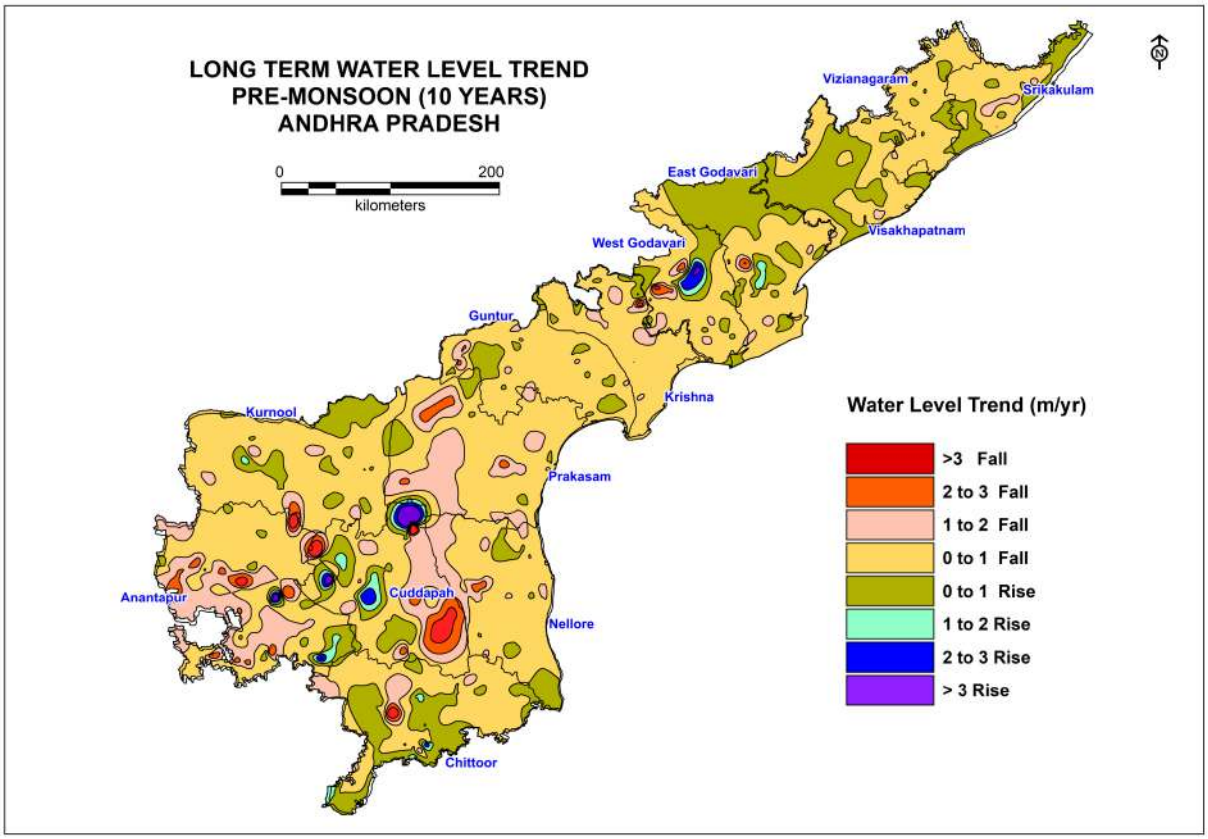
Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in all the formations except in Intrusives. Deepest water levels are observed alluvium, Limestone and BGC. During post-monsoon season, shallowest water levels are observed in all formations except in Intrusives and Laterites. Deepest water levels are observed in Gneiss, Granite, Limestone, Quartz and Sandstone. 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 2018			Post-monsoon Nov 2018		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Alluvium	0.41	22.85	3.94	-0.33	20.45	2.55
Branded gneissic complex	0.09	48.5	6.81	0	18.13	5.54
Chanrockite	0.96	14.9	4.82	0	14.08	2.91
Gneiss	0.38	14.2	5.46	0	14.5	4.02
Granite	2.75	46	8.25	0	35.75	7.79
Khondalite	1.2	32.6	6.75	0	28.5	4.39
Limestone	0.38	39.5	8.06	0.45	39.5	6.41
Laterite	3.66	10.52	6.61	3.4	10.51	6.16
Quartzite	2.35	9.37	5.92	1.08	13.42	6.22
Schist	1.85	17	8.53	0	24.5	7.64
Shales	2.9	49.3	8.17	0	44.27	6.98
Sandstone	1.54	18.05	6.22	0	13.35	4.43

7.7 Long-term Water Level trends:

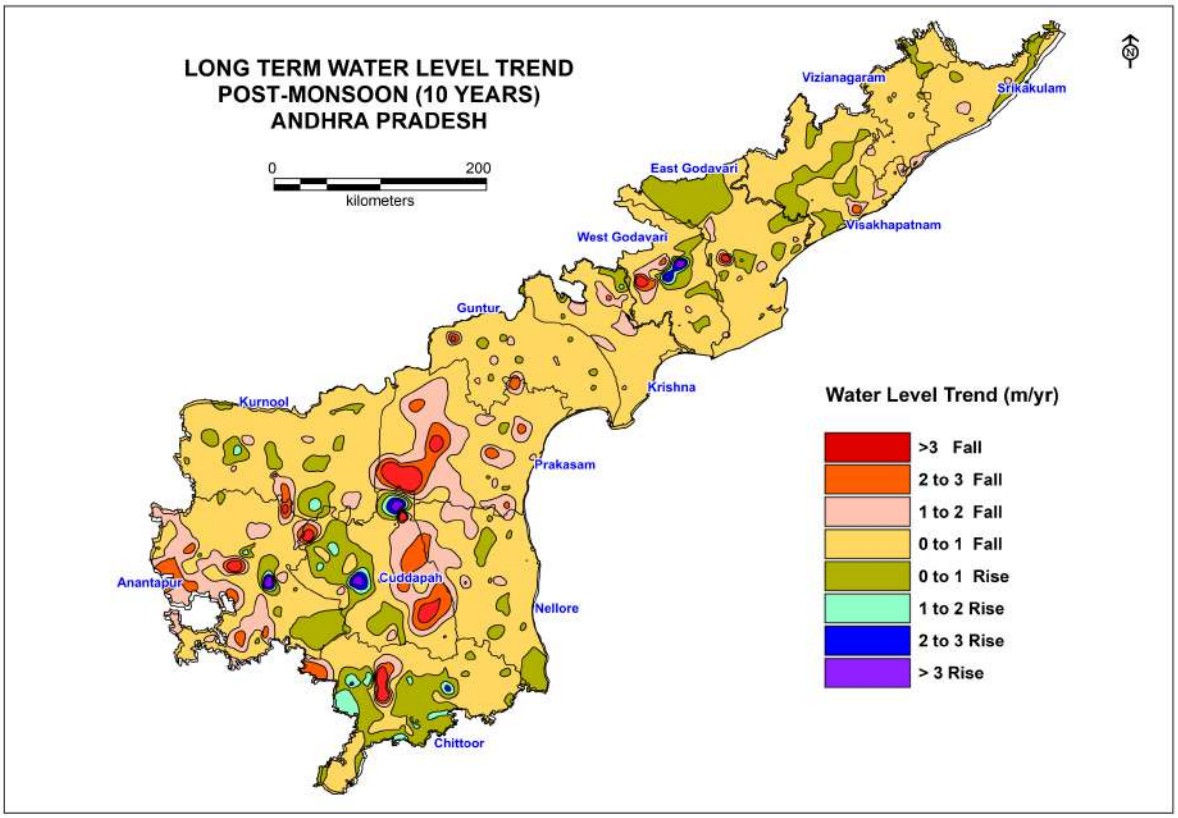
7.7.1 Pre-monsoon trend map: It is inferred from the pre-monsoon water level trend map that the falling trend in water level of 0-4 m/yr. is observed in 78% of the area and rising trend of 0-3 m / yr. in water level is observed in 22% of the area in the state. Falling trend is recorded at 344 locations and 159 locations have recorded rising trend during May. Falling trend of 0 to 1 m/yr. is more prevalent in Rayalaseema region and Prakasam, Nellore, Guntur, Krishna and West Godavari districts. The falling trend of 1 to 2 m/yr. is observed in Anantapur, Kurnool, Kadapa, Prakasam, Krishna and West Godavari districts as small patches. Falling trend of more than 2 m/yr. is restricted to few locations in Anantapur, Prakasam, 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 4.12 m/yr., while rising trend ranges from 0.001 to 3.0 m/yr. More than 1 m / yr. rise is seen in Anantapur and Chittoor districts. The district-wise trend analysis is given in **Table 7.4**.



7.22 Long term water level trend – Pre-monsoon period (1999-2018)

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 0-4.5 m/yr. is observed in 77% of the area and rising trend of 0-2 m / yr. in water level is observed in 23% of the area in the state. Falling trend is recorded at 569 locations and 165 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. is observed in Anantapur, Kurnool, Praksam, Guntur, Krishna , Krishna and West Godavari districts as small patches. Falling trend of more than 2 m/yr. is restricted to few locations in all the Kurnool, Prakasam, Guntur, Krishna West Godavari and Visakhapatnam districts. Rising trend of 0 to 1 m/yr. is predominant in Chittoor and Visakhapatnam and restricted to few locations in all other districts. Falling trend ranges from 0.001 m/yr. to 4.52 m/yr., while rising trend ranges from 0.001 to 2.28 m/yr. More than 1 m / yr. rise is seen as small patch in Chittoor district. The district-wise trend analysis with salient features is given in **Table 7.4.** 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	127626	35336	78%	22%
Post-monsoon	136952	26017	84%	16%



7.23 Long term water level trend Post-monsoon period (1999-2018)

TABLE 7.4 : Analysis of Trend values of Water Levels (1999-2018) in Andhra Pradesh

	Pre-monsoon (May)						Post-monsoon (Nov)					
	Rising trend (m/yr.)			Falling trend (m/yr.)			Rising trend (m/yr.)			Falling trend (m/yr.)		
DISTRICT	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**	**No of Locations**	**Minimum trend value**	**Maximum trend value**
ANANTAPUR	12	0.002	3.089	31	0.024	3.009	15	0.018	1.364	37	0.04	2.41
CHITTOOR	21	0.015	1.076	12	0.026	0.486	28	0.007	2.283	16	0.01	0.53
KADAPA	6	0.085	0.695	16	0.009	1.802	13	0.001	0.384	15	0.03	0.78
EAST GODAVARI	13	0.026	0.622	39	0.007	1.277	12	0.007	0.366	79	0.00	1.56
GUNTUR	16	0.005	0.317	56	0.010	1.365	11	0.000	0.212	85	0.01	3.70
KRISHNA	5	0.001	0.164	42	0.003	3.428	2	0.048	0.157	70	0.00	2.21
KURNOOL	8	0.010	0.201	21	0.004	3.075	13	0.001	0.900	33	0.01	3.82
NELLORE	5	0.060	0.772	30	0.015	2.487	10	0.056	0.936	41	0.03	0.91
PRAKASAM	4	0.008	0.135	32	0.019	4.412	5	0.074	0.253	50	0.04	4.52
SRIKAKULAM	13	0.003	0.520	15	0.009	0.544	12	0.003	0.524	27	0.02	0.97
VISAKHAPATNAM	36	0.001	0.857	13	0.004	0.920	26	0.001	0.519	34	0.01	4.33
VIZIANAGARAM	11	0.018	0.258	19	0.010	0.582	5	0.013	0.106	37	0.00	1.01
WEST GODAVARI	9	0.061	0.497	18	0.003	2.653	13	0.008	0.624	45	0.02	2.31
TOTAL	**159**	**0.001**	**3.089**	**344**	**0.003**	**4.412**	165	0.00005	2.283	569	0.0004	4.52

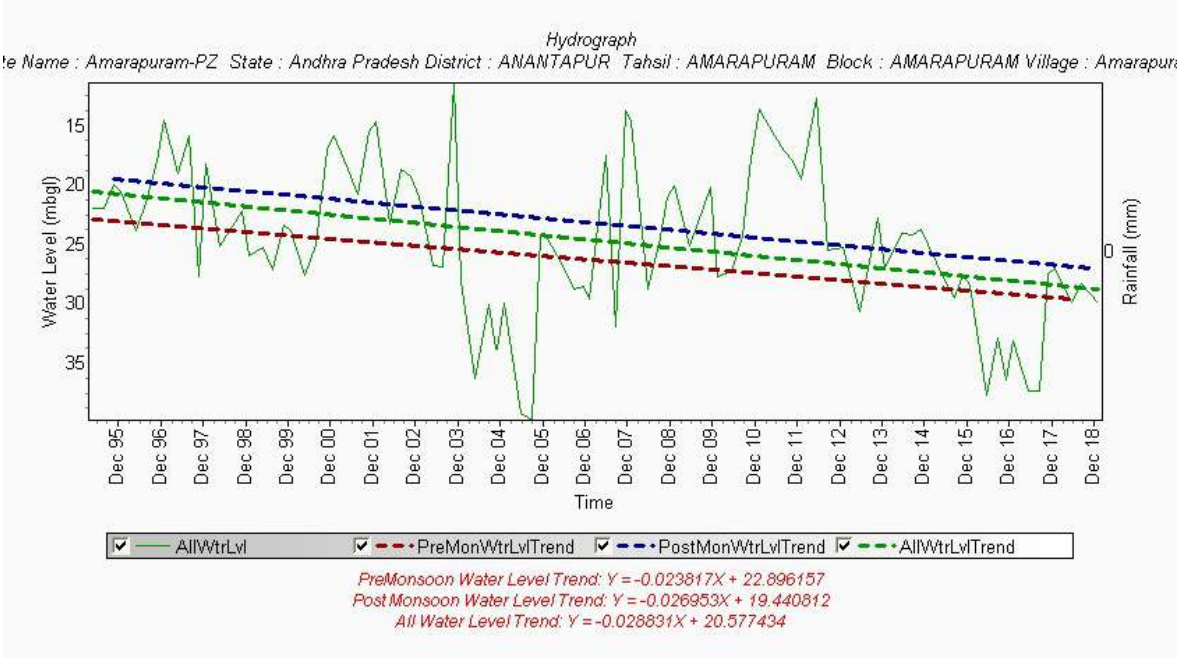
7.8 Hydrographs of water levels

Total 26 hydrographs are generated (2 from each district) (**Fig. 7.24**). Out of 26, 8 wells show rising trends in both seasons, 11 shows falling trends in both season and rest shows mix trends (**Table-7.5**).

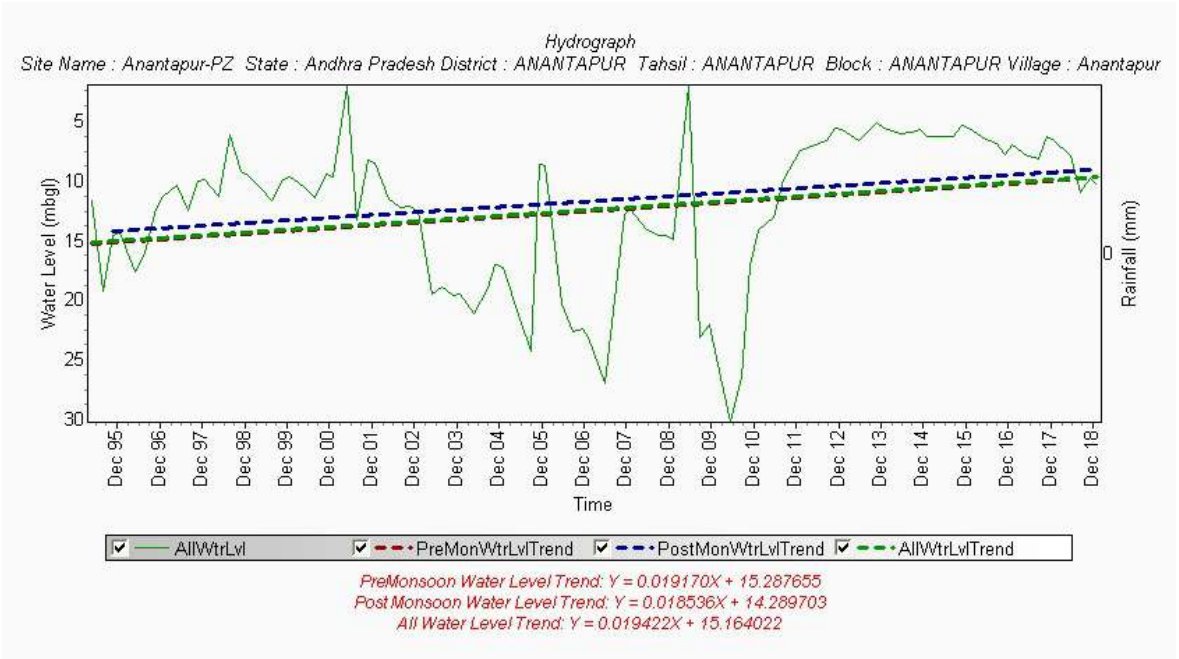
Table-7.5: Representative Hydrographs showing rising and falling trends in Andhra Pradesh State.

S. No.	Fig No.	Location	District	Pre (m/yr.)		Post (m/yr.)	
				Rise	Fall	Rise	Fall
1	7.24a	Amarapuram	Anantapur		0.2858		0.3234
2	7.24b	Anantapur	Anantapur	0.230		0.222	
3	7.24c	Damalcheruvu	Chittoor	0.026			0.018
4	7.24d	Battuvaripalli	Chittoor	0.0562		0.0017	
5	7.24e	Muddireddipalli	Kadapa		0.105		0.204
6	7.24f	Anjaneyapuram	Kadapa		0.00012		0.756
7	7.24g	Jaggampet	East Godavari	0.15		0.054	
8	7.24h	Gollaprolu	East Godavari	0.022			0.002
9	7.24i	Ipur	Guntur		0.030		0.043
10	7.24j	Guntur	Guntur	0.015			0.014
11	7.24k	Nuziveedu	Krishna	0.094		0.028	
12	7.24l	Gudivada	Krishna		0.001		0.0063
13	7.24m	Gonegandla	Kurnool	0.136		0.030	
14	7.24n	Ahobilam	Kurnool		0.362		0.324
15	7.24o	Kadanothola	Nellore		0.0094	0.020	
16	7.24p	Bata	Nellore		0.039		0.117
17	7.24q	Chirala	Prakasam		0.017		0.013
18	7.24r	Chandalur	Prakasam		0.1104	0.0117	
19	7.24s	Ichapuram	Srikakulam		0.0042	0.041	
20	7.24t	Barua	Srikakulam	0.076		0.120	
21	7.24u	Narsipattanam	Vishakhapattanam	0.003			0.003
22	7.24v	Araku	Vishakhapattanam		0.033		0.021
23	7.24w	Agraharam	Vizianagaram	0.100		0.092	
24	7.24x	Garbham	Vizianagaram		0.014		0.007
25	7.24y	Kovvur	West Godavari	0.030		0.027	
26	7.24z	Eluru	West Godavari		0.987		0.868

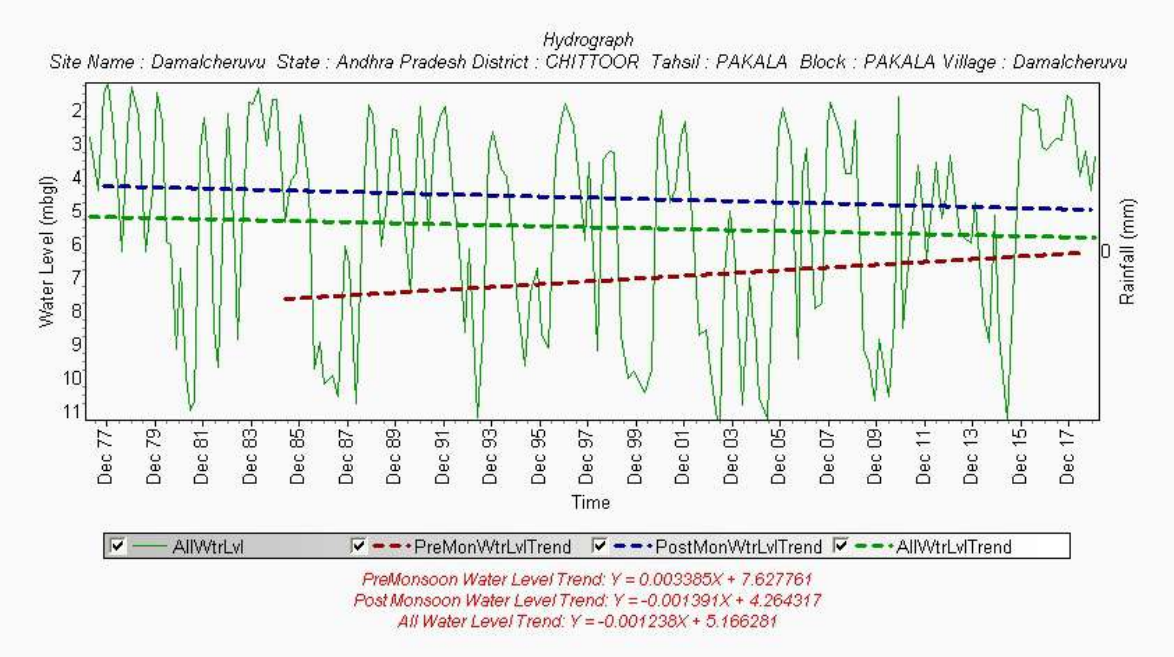
7.24a


Hydrograph
e Name : Amarapuram-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : AMARAPURAM Block : AMARAPURAM Village : Amarapura
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.023817X + 22.896157
Post Monsoon Water Level Trend: Y = -0.026953X + 19.440812
All Water Level Trend: Y = -0.028831X + 20.577434

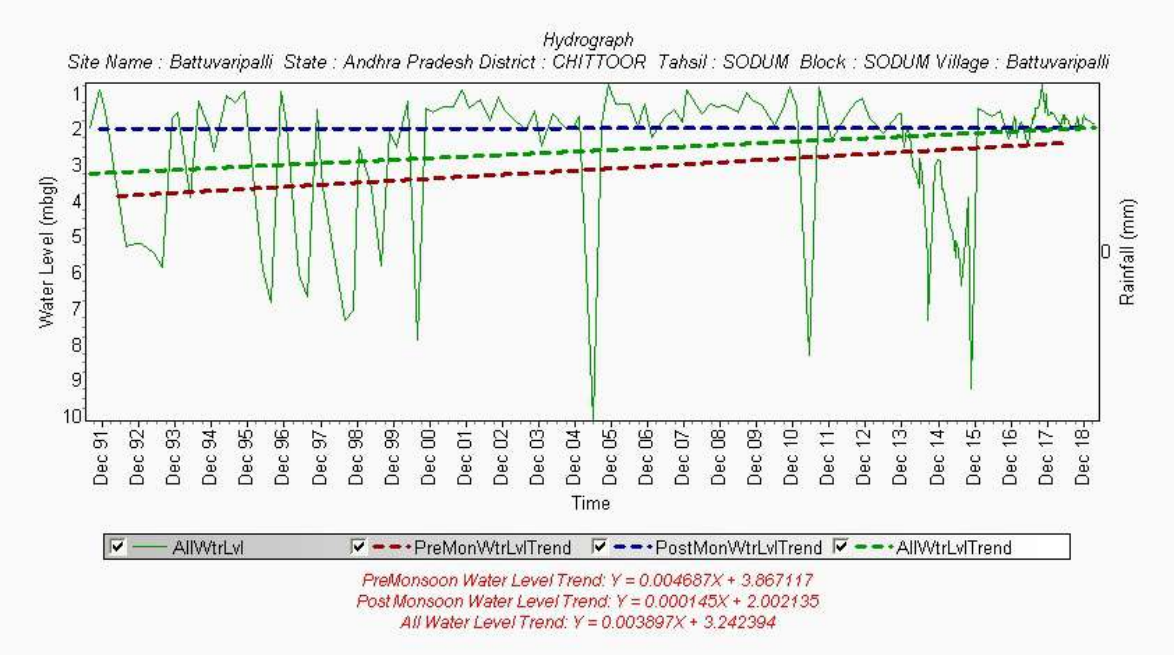
7.24b


Hydrograph
Site Name : Anantapur-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : ANANTAPUR Block : ANANTAPUR Village : Anantapur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.019170X + 15.287655
Post Monsoon Water Level Trend: Y = 0.018536X + 14.289703
All Water Level Trend: Y = 0.019422X + 15.164022

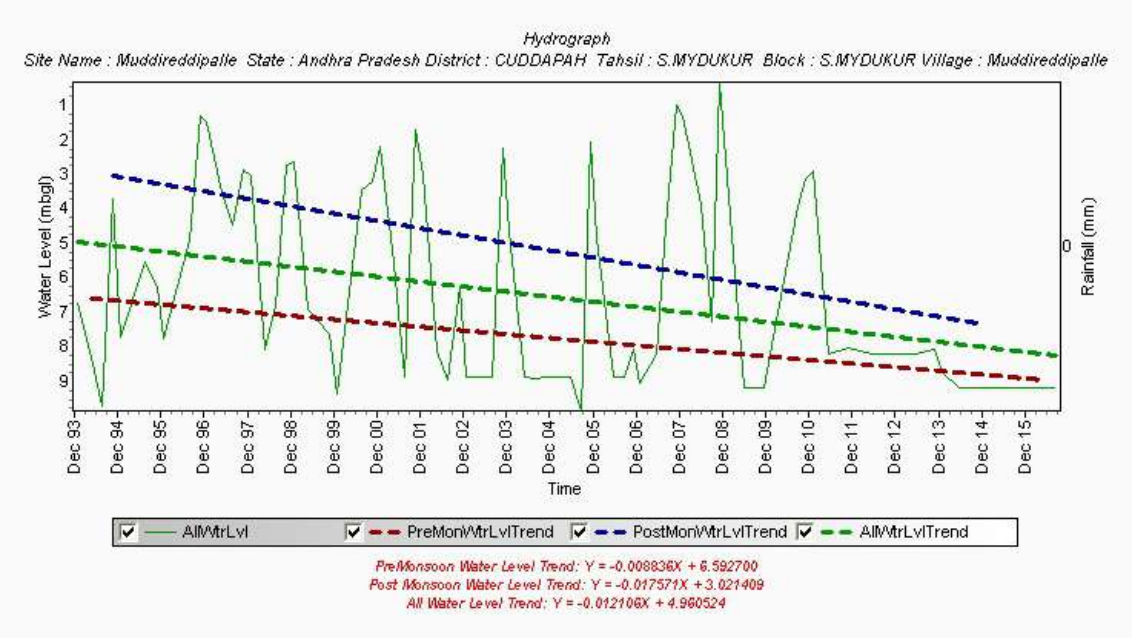
7.24c


Hydrograph
Site Name : Damalcheruvu State : Andhra Pradesh District : CHITTOOR Tahsil : PAKALA Block : PAKALA Village : Damalcheruvu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.003385X + 7.627761
Post Monsoon Water Level Trend: Y = -0.001391X + 4.264317
All Water Level Trend: Y = -0.001238X + 5.166281

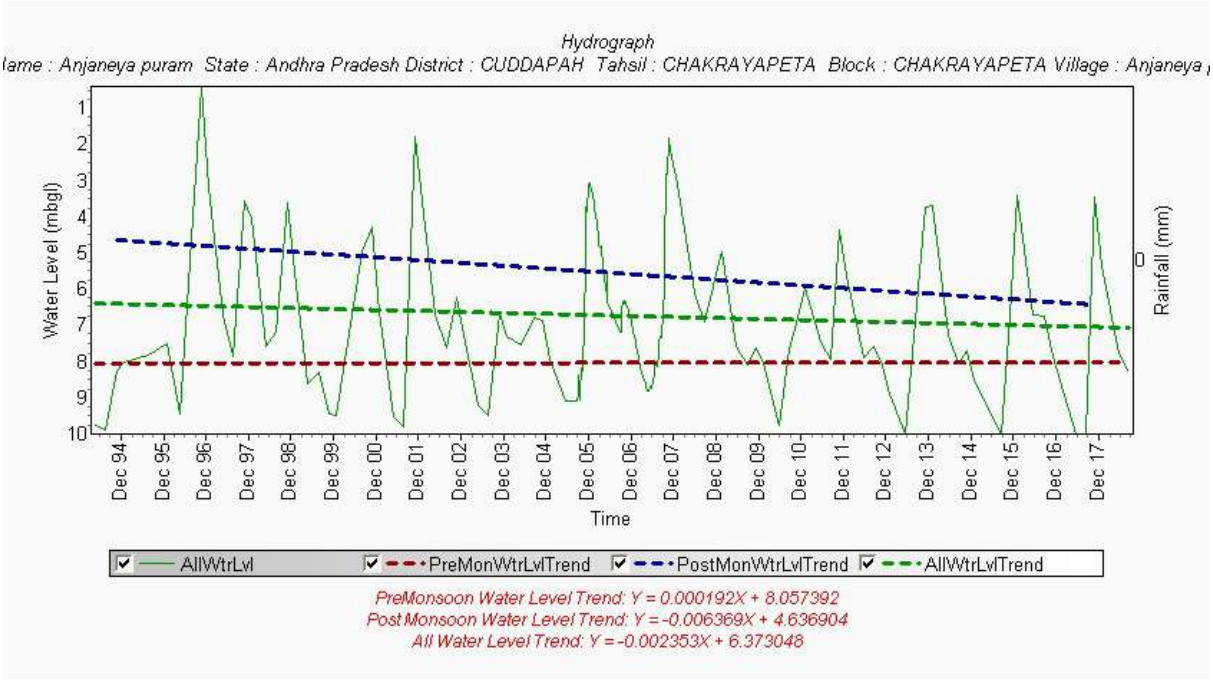
7.24d


Hydrograph
Site Name : Battuvaripalli State : Andhra Pradesh District : CHITTOOR Tahsil : SODUM Block : SODUM Village : Battuvaripalli
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.004687X + 3.867117
Post Monsoon Water Level Trend: Y = 0.000145X + 2.002135
All Water Level Trend: Y = 0.003897X + 3.242394

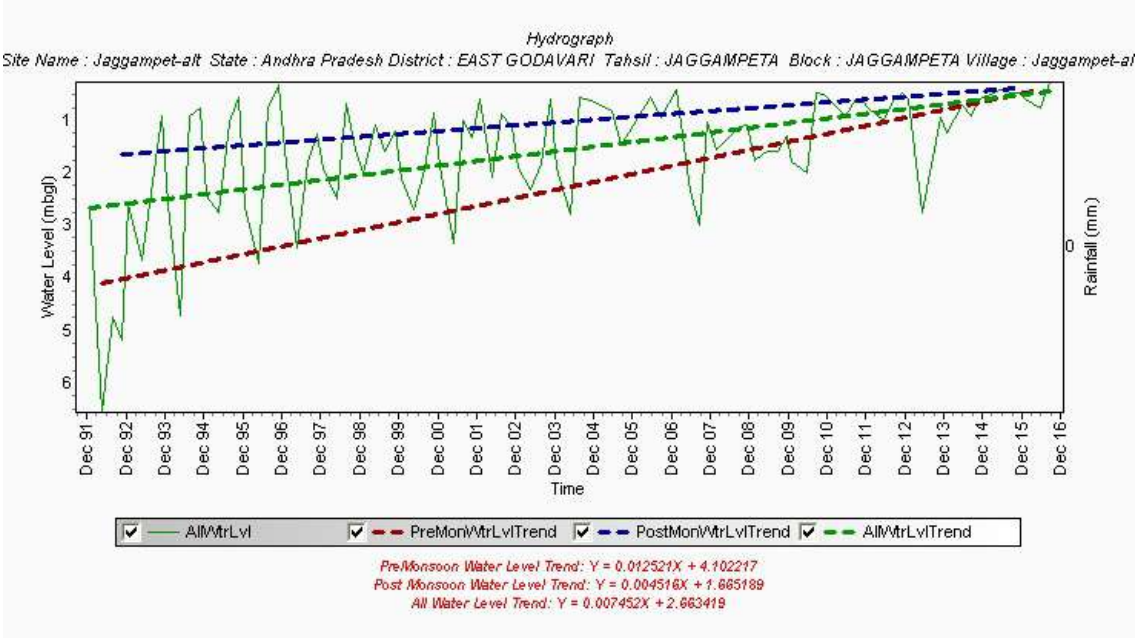
7.24e


Hydrograph
Site Name : Muddireddipalle State : Andhra Pradesh District : CUDDAPAH Tahsil : S.MYDUKUR Block : S.MYDUKUR Village : Muddireddipalle
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.008836X + 6.592700
Post Monsoon Water Level Trend: Y = -0.017571X + 3.021409
All Water Level Trend: Y = -0.012106X + 4.960524

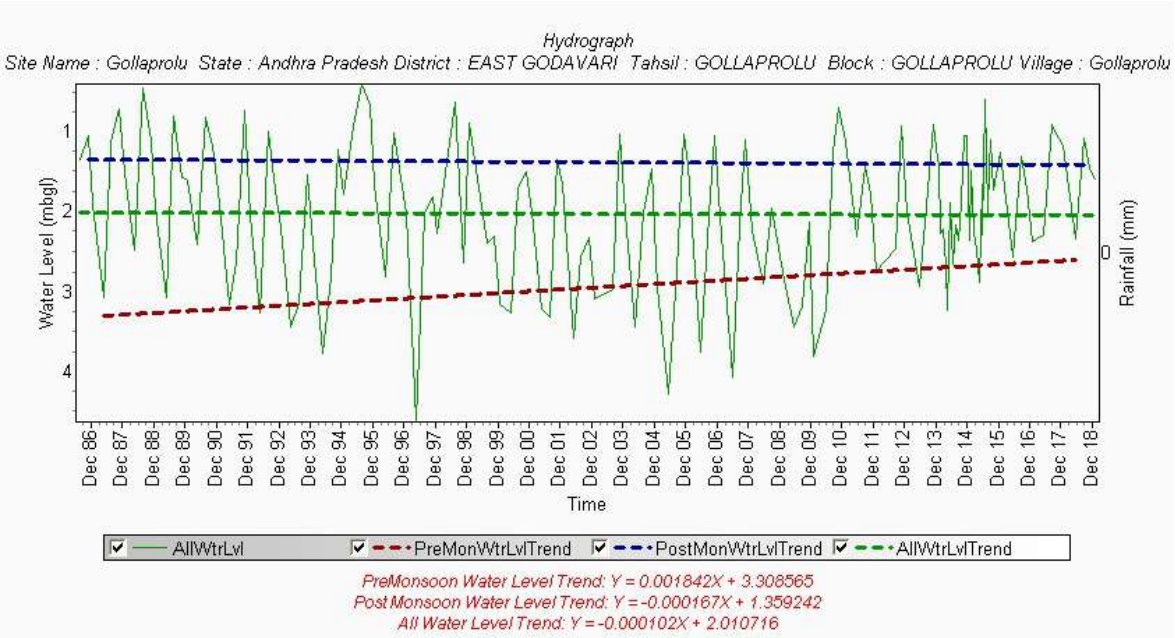
7.24f


Hydrograph
lame : Anjaneya puram State : Andhra Pradesh District : CUDDAPAH Tahsil : CHAKRAYAPETA Block : CHAKRAYAPETA Village : Anjaneya
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000192X + 8.057392
Post Monsoon Water Level Trend: Y = -0.006369X + 4.636904
All Water Level Trend: Y = -0.002353X + 6.373048

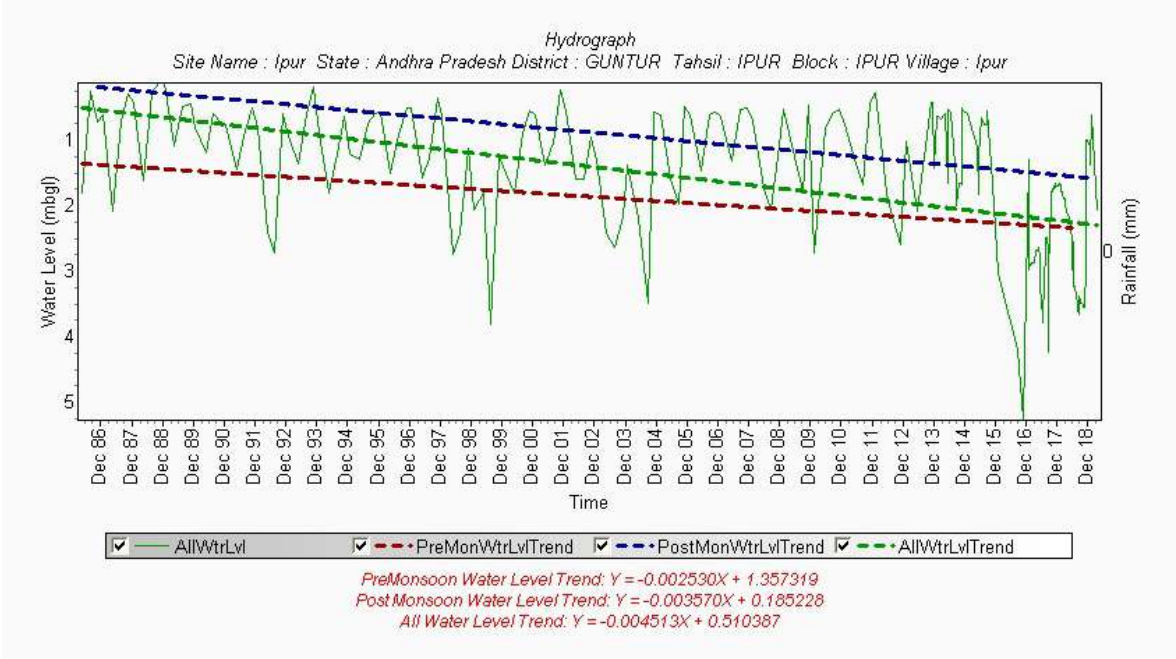
7.24g


Hydrograph
Site Name : Jaggampet-alt State : Andhra Pradesh District : EAST GODAVARI Tahsil : JAGGAMPETA Block : JAGGAMPETA Village : Jaggampet-al
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.012521X + 4.102217
Post Monsoon Water Level Trend: Y = 0.004516X + 1.665189
All Water Level Trend: Y = 0.007452X + 2.663419

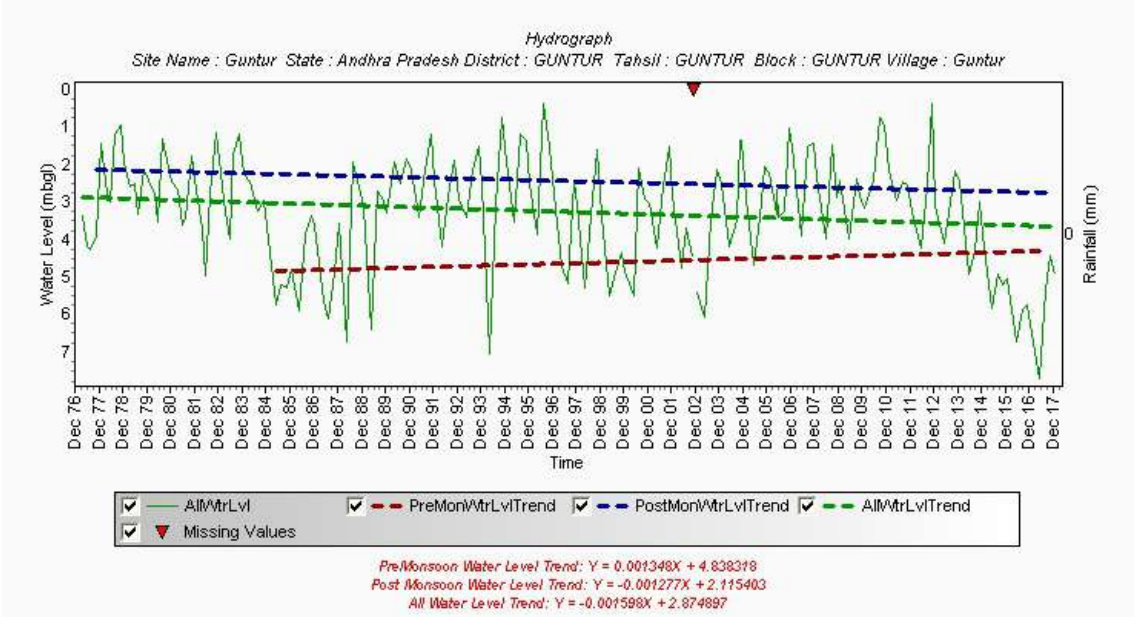
7.24h


Hydrograph
Site Name : Gollaprolu State : Andhra Pradesh District : EAST GODAVARI Tahsil : GOLLAPROLU Block : GOLLAPROLU Village : Gollaprolu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001842X + 3.308565
Post Monsoon Water Level Trend: Y = -0.000167X + 1.359242
All Water Level Trend: Y = -0.000102X + 2.010716

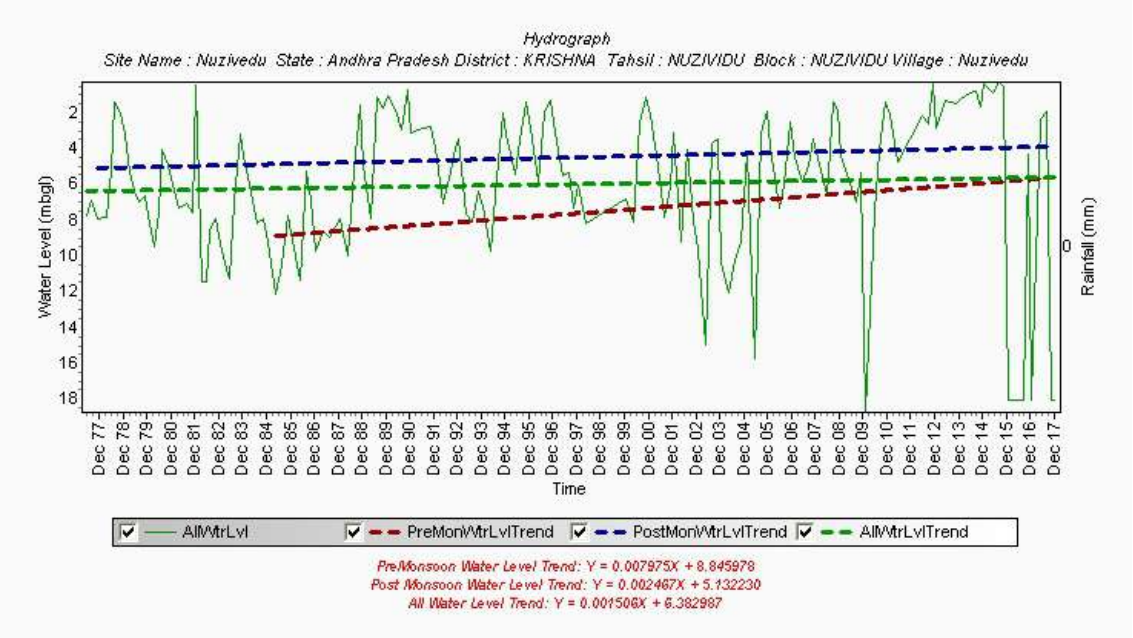
7.24i


Hydrograph
Site Name : Ipur State : Andhra Pradesh District : GUNTUR Tahsil : IPUR Block : IPUR Village : Ipur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002530X + 1.357319
Post Monsoon Water Level Trend: Y = -0.003570X + 0.185228
All Water Level Trend: Y = -0.004513X + 0.510387

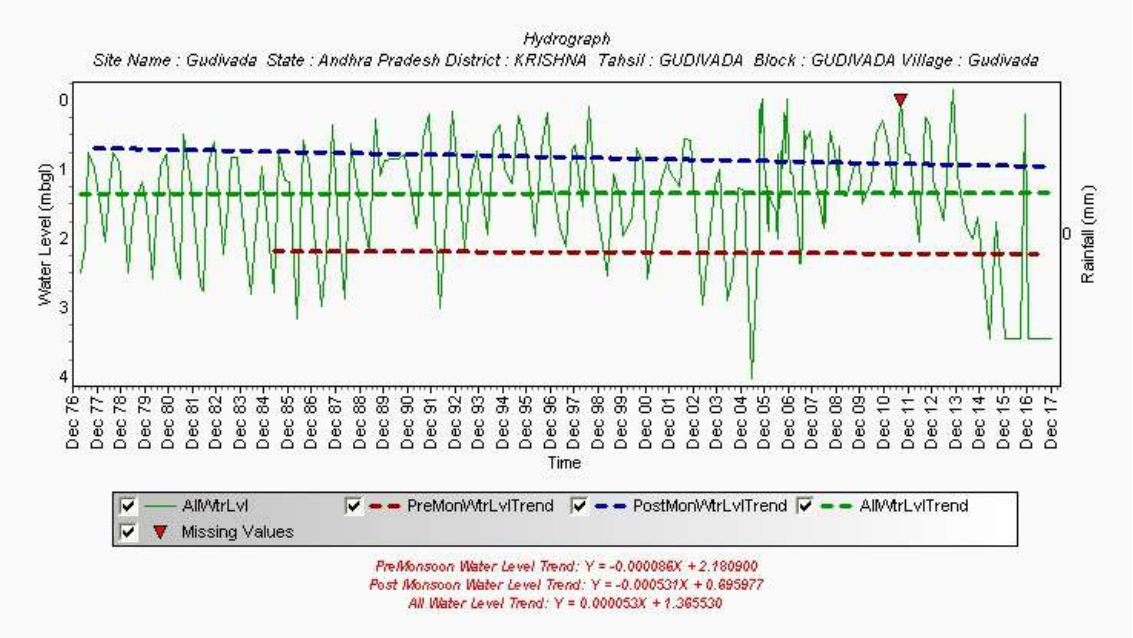
7.24j


Hydrograph
Site Name : Guntur State : Andhra Pradesh District : GUNTUR Tahsil : GUNTUR Block : GUNTUR Village : Guntur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.001348X + 4.838318
Post Monsoon Water Level Trend: Y = -0.001277X + 2.115403
All Water Level Trend: Y = -0.001598X + 2.874897

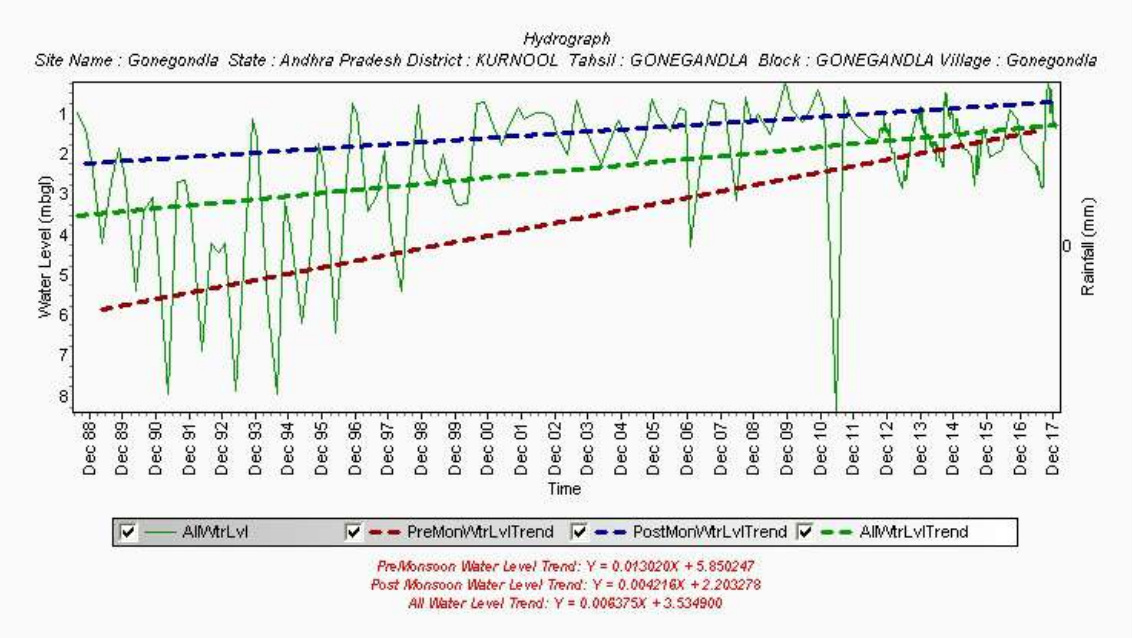
7.24k


Hydrograph
Site Name : Nuzivedu State : Andhra Pradesh District : KRISHNA Tahsil : NUZIVIDU Block : NUZIVIDU Village : Nuzivedu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.007975X + 8.845978
Post Monsoon Water Level Trend: Y = 0.002467X + 5.132230
All Water Level Trend: Y = 0.001506X + 6.382987

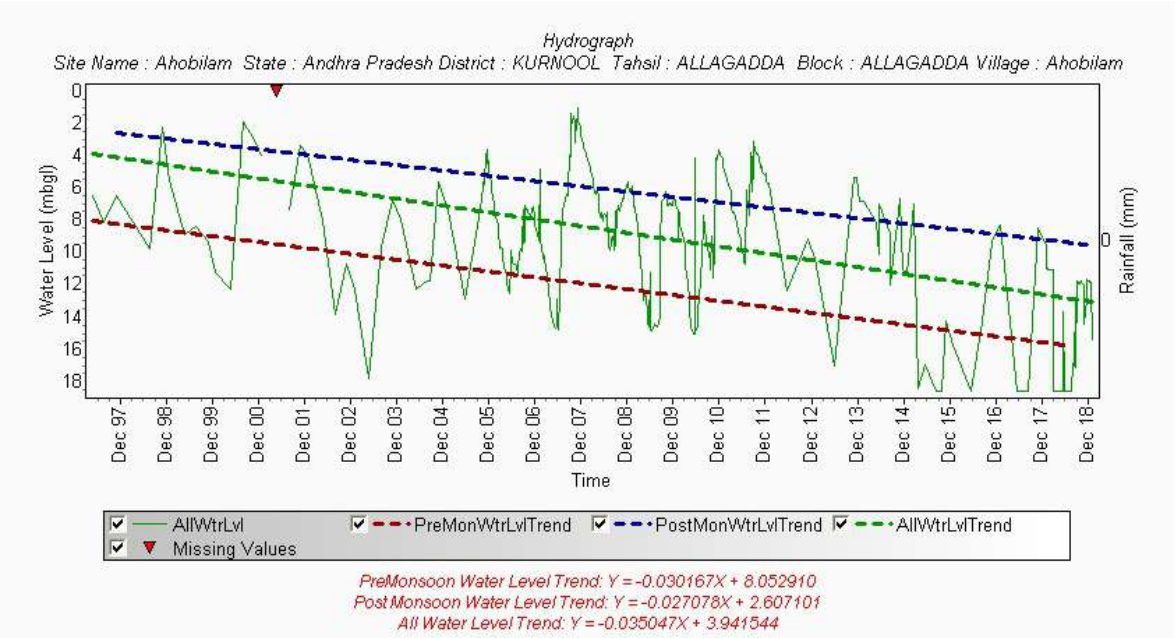
7.24l


Hydrograph
Site Name : Gudivada State : Andhra Pradesh District : KRISHNA Tahsil : GUDIVADA Block : GUDIVADA Village : Gudivada
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.000086X + 2.180900
Post Monsoon Water Level Trend: Y = -0.000531X + 0.695977
All Water Level Trend: Y = 0.000053X + 1.365530

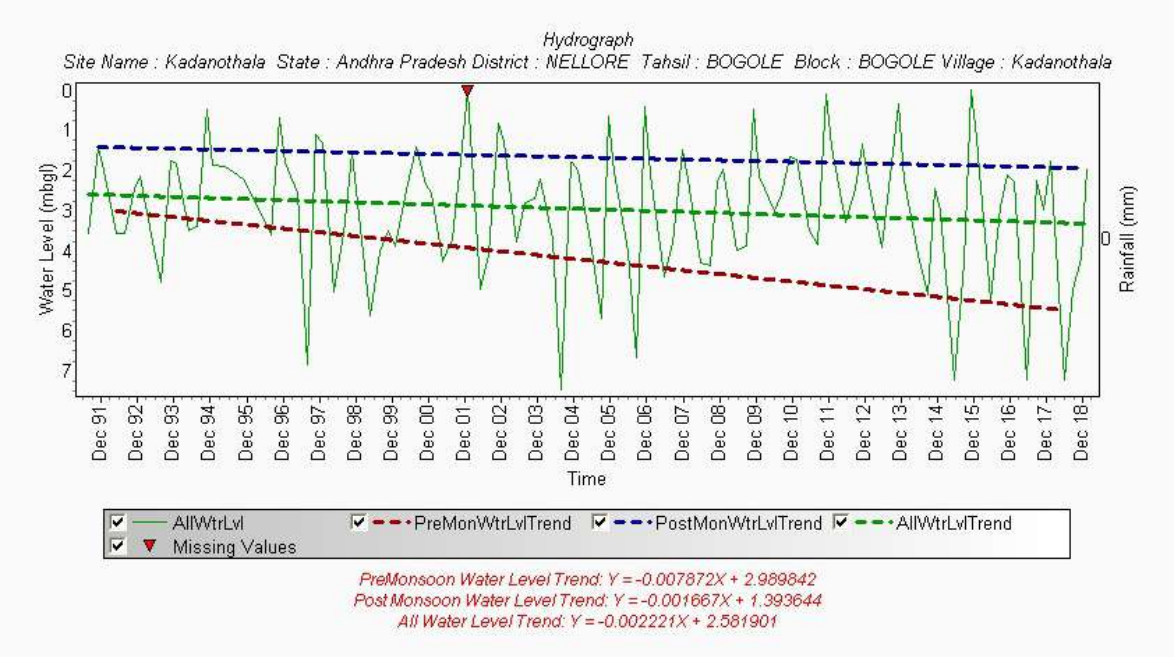
7.24m


Hydrograph
Site Name : Gonegondla State : Andhra Pradesh District : KURNOOL Tahsil : GONEGANDLA Block : GONEGANDLA Village : Gonegondla
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.013020X + 5.850247
Post Monsoon Water Level Trend: Y = 0.004216X + 2.203278
All Water Level Trend: Y = 0.006375X + 3.534900

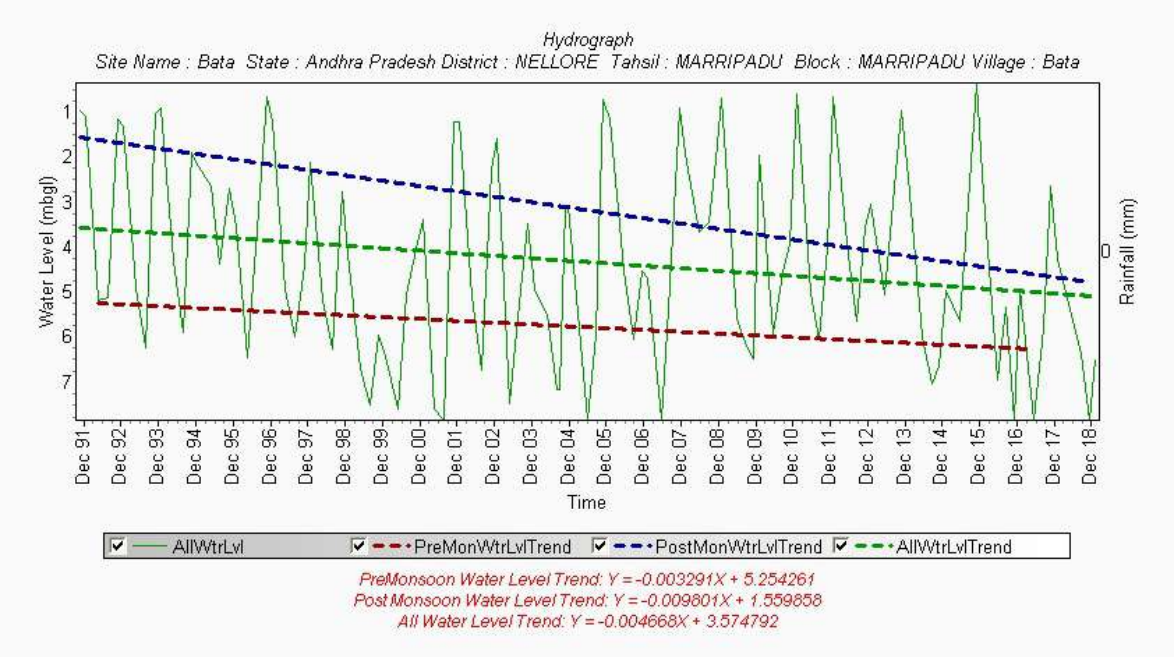
7.24n


Hydrograph
Site Name : Ahobilam State : Andhra Pradesh District : KURNOOL Tahsil : ALLAGADDA Block : ALLAGADDA Village : Ahobilam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.030167X + 8.052910
Post Monsoon Water Level Trend: Y = -0.027078X + 2.607101
All Water Level Trend: Y = -0.035047X + 3.941544

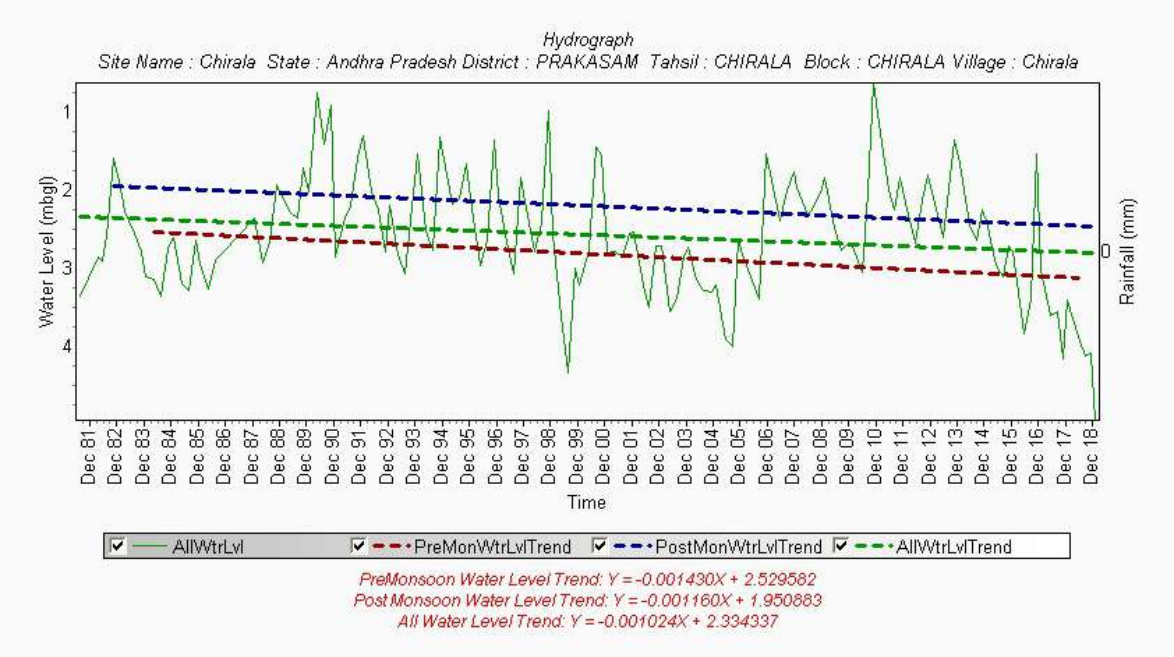
7.24o


Hydrograph
Site Name : Kadanothala State : Andhra Pradesh District : NELLORE Tahsil : BOGOLE Block : BOGOLE Village : Kadanothala
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.007872X + 2.989842
Post Monsoon Water Level Trend: Y = -0.001667X + 1.393644
All Water Level Trend: Y = -0.002221X + 2.581901

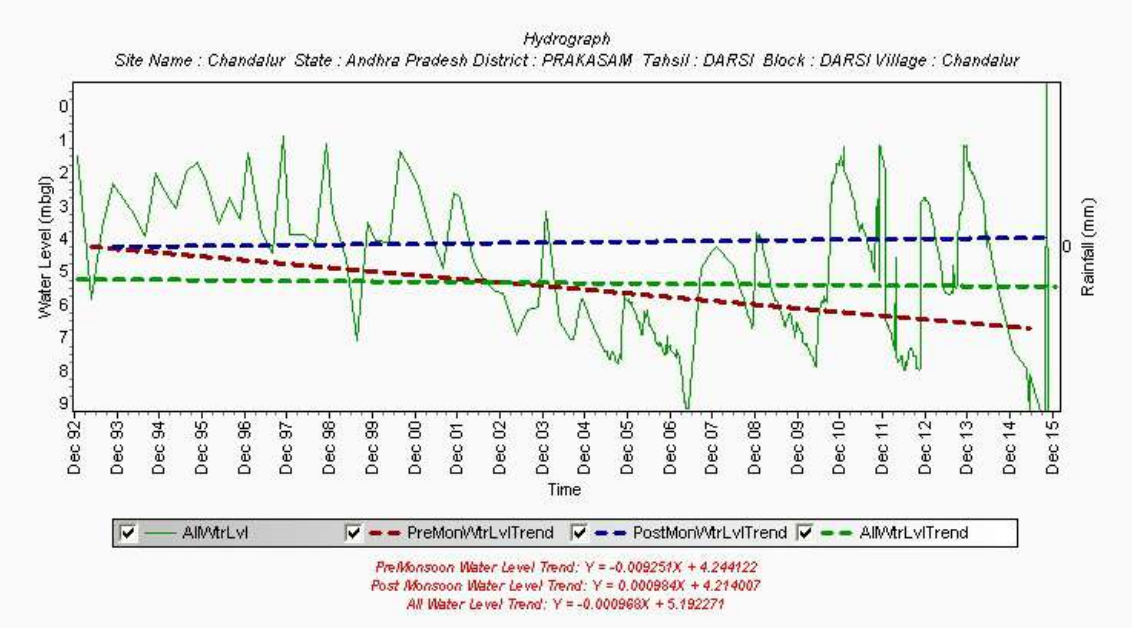
7.24p


Hydrograph
Site Name : Bata State : Andhra Pradesh District : NELLORE Tahsil : MARRIPADU Block : MARRIPADU Village : Bata
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.003291X + 5.254261
Post Monsoon Water Level Trend: Y = -0.009801X + 1.559858
All Water Level Trend: Y = -0.004668X + 3.574792

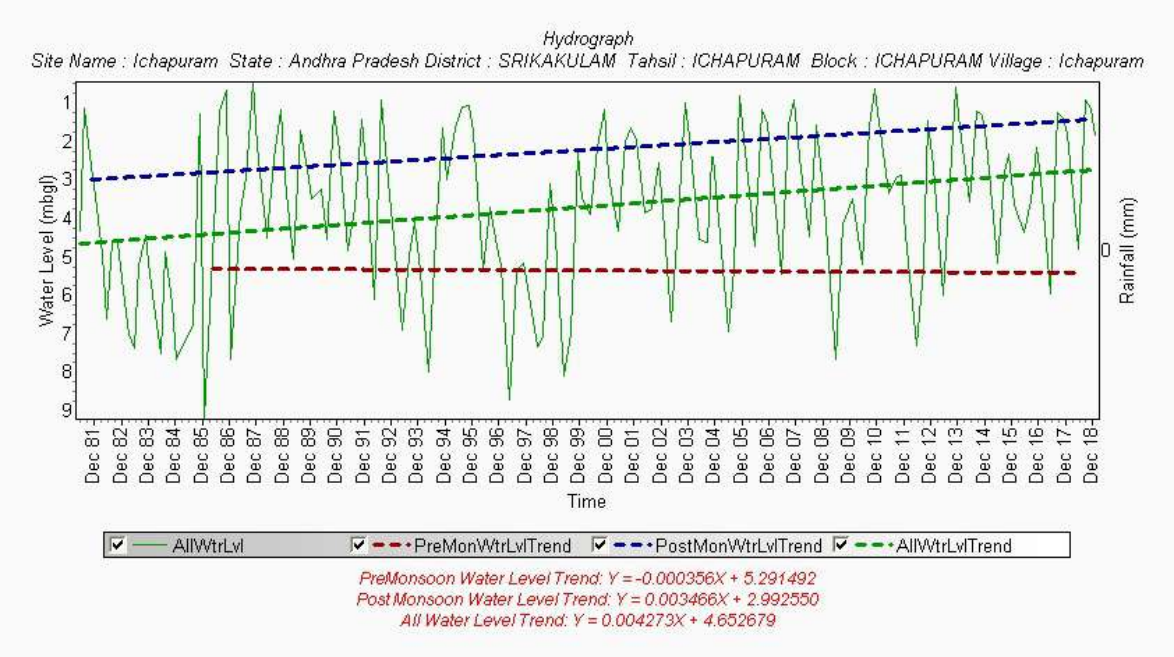
7.24q


Hydrograph
Site Name : Chirala State : Andhra Pradesh District : PRAKASAM Tahsil : CHIRALA Block : CHIRALA Village : Chirala
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001430X + 2.529582
Post Monsoon Water Level Trend: Y = -0.001160X + 1.950883
All Water Level Trend: Y = -0.001024X + 2.334337

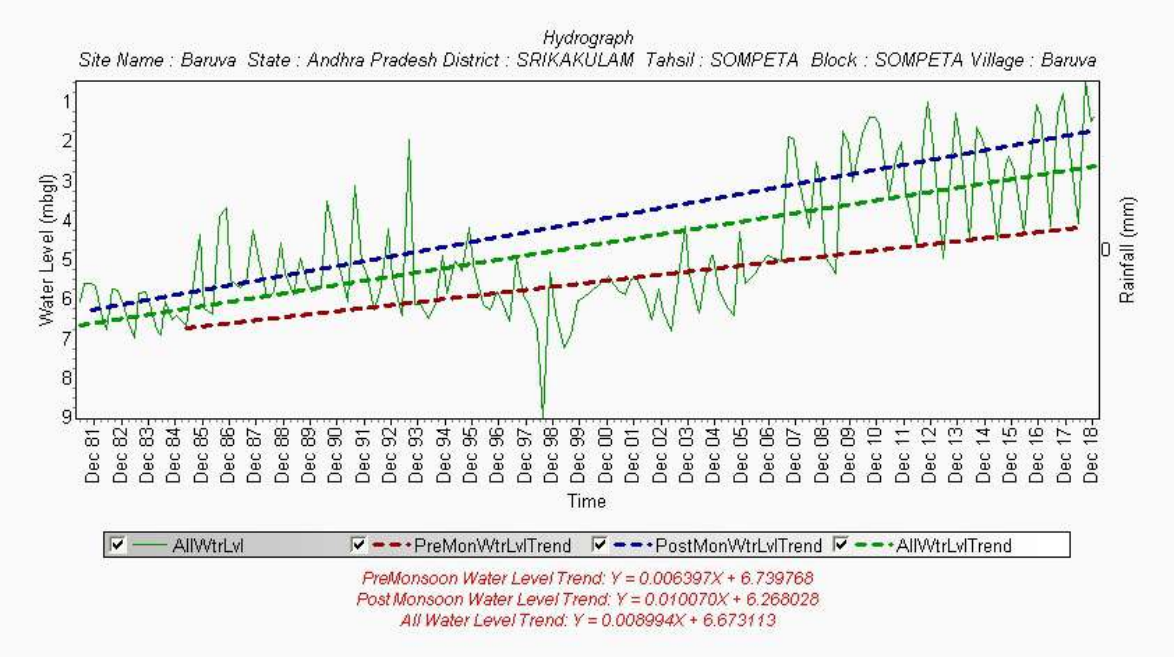
7.24r


Hydrograph
Site Name : Chandalur State : Andhra Pradesh District : PRAKASAM Tahsil : DARSI Block : DARSI Village : Chandalur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.009251X + 4.244122
Post Monsoon Water Level Trend: Y = 0.000984X + 4.214007
All Water Level Trend: Y = -0.000968X + 5.192271

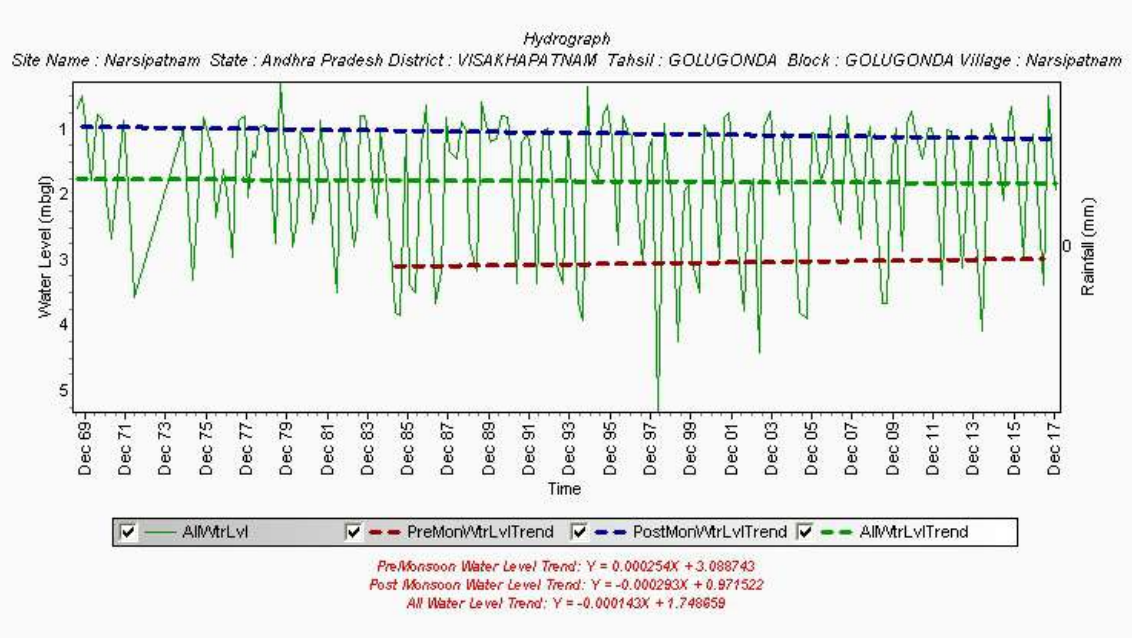
7.24s


Hydrograph
Site Name : Ichapuram State : Andhra Pradesh District : SRIKAKULAM Tahsil : ICHAPURAM Block : ICHAPURAM Village : Ichapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000356X + 5.291492
Post Monsoon Water Level Trend: Y = 0.003466X + 2.992550
All Water Level Trend: Y = 0.004273X + 4.652679

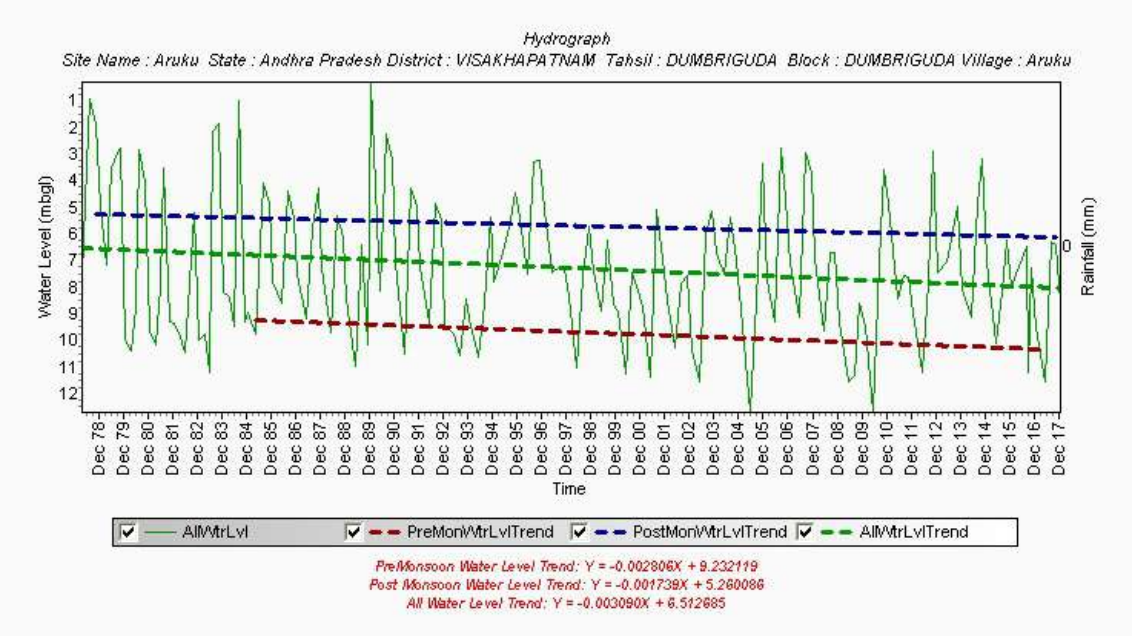
7.24t


Hydrograph
Site Name : Baruva State : Andhra Pradesh District : SRIKAKULAM Tahsil : SOMPETA Block : SOMPETA Village : Baruva
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.006397X + 6.739768
Post Monsoon Water Level Trend: Y = 0.010070X + 6.268028
All Water Level Trend: Y = 0.008994X + 6.673113

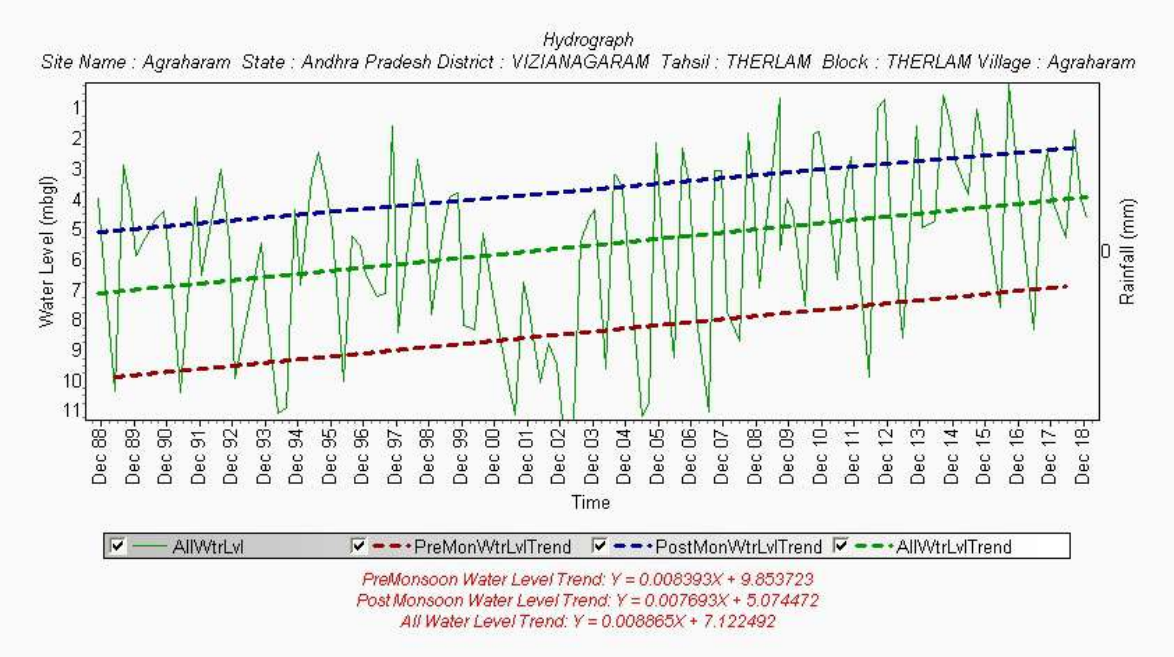
7.24u


Hydrograph
Site Name : Narsipatnam State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : GOLUGONDA Block : GOLUGONDA Village : Narsipatnam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000254X + 3.088743
Post Monsoon Water Level Trend: Y = -0.000293X + 0.971522
All Water Level Trend: Y = -0.000143X + 1.748659

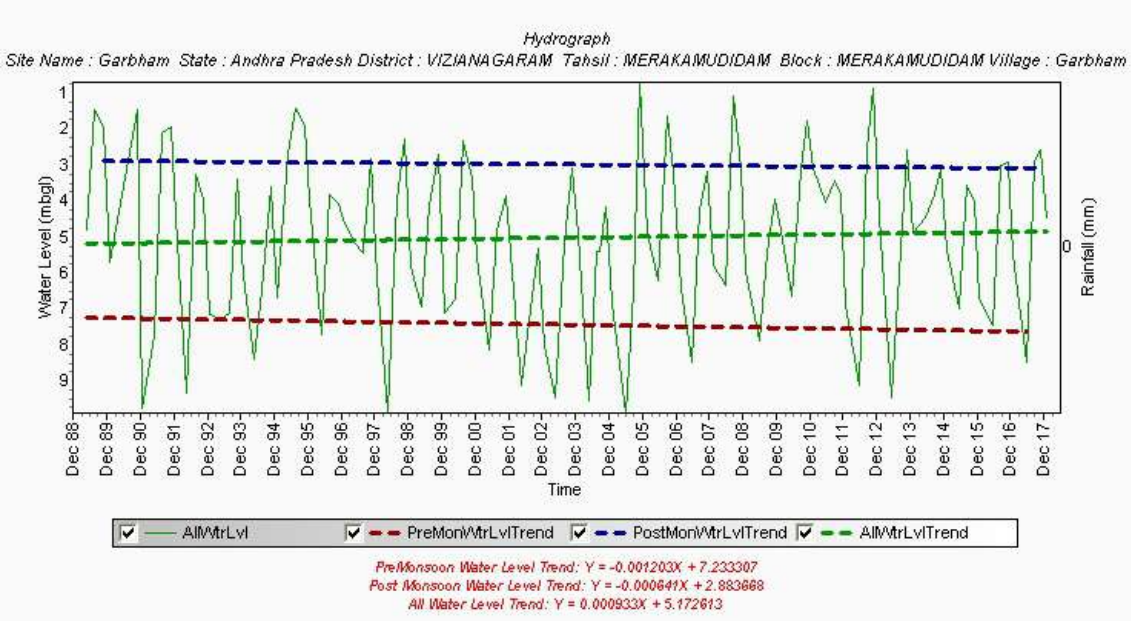
7.24v


Hydrograph
Site Name : Aruku State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : DUMBRIGUDA Block : DUMBRIGUDA Village : Aruku
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002806X + 9.232119
Post Monsoon Water Level Trend: Y = -0.001739X + 5.260086
All Water Level Trend: Y = -0.003090X + 6.512685

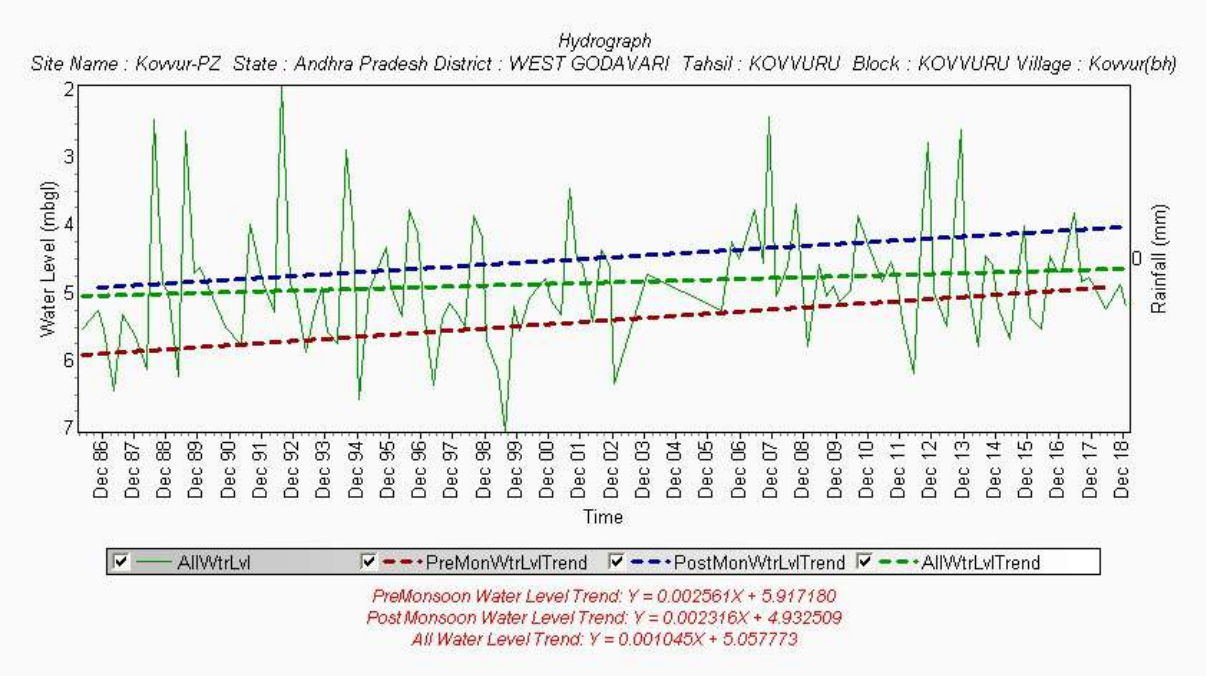
7.24w


Hydrograph
Site Name : Agraharam State : Andhra Pradesh District : VIZIANAGARAM Tahsil : THERLAM Block : THERLAM Village : Agraharam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.008393X + 9.853723
Post Monsoon Water Level Trend: Y = 0.007693X + 5.074472
All Water Level Trend: Y = 0.008865X + 7.122492

7.24x


Hydrograph
Site Name : Garbham State : Andhra Pradesh District : VIZIANAGARAM Tahsil : MERAKAMUDIDAM Block : MERAKAMUDIDAM Village : Garbham
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001203X + 7.233307
Post Monsoon Water Level Trend: Y = -0.000641X + 2.883668
All Water Level Trend: Y = 0.000933X + 5.172613

7.24y



7.24z

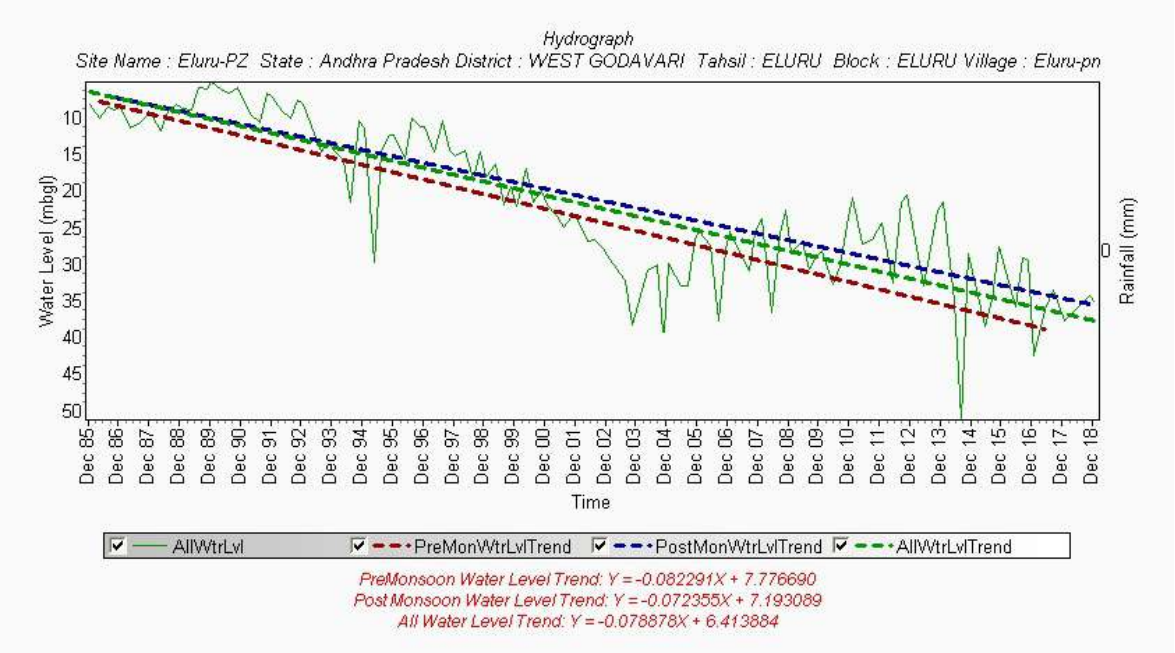


Fig.7.24 (7.24a to 7.24z): Representative Hydrographs from Andhra Pradesh State.

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 623 groundwater samples from shallow GWMS (both Dug Wells and Piezometers) were collected during pre-monsoon season of 2018 (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 1998). 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-2018 is given in Table- 8.1.

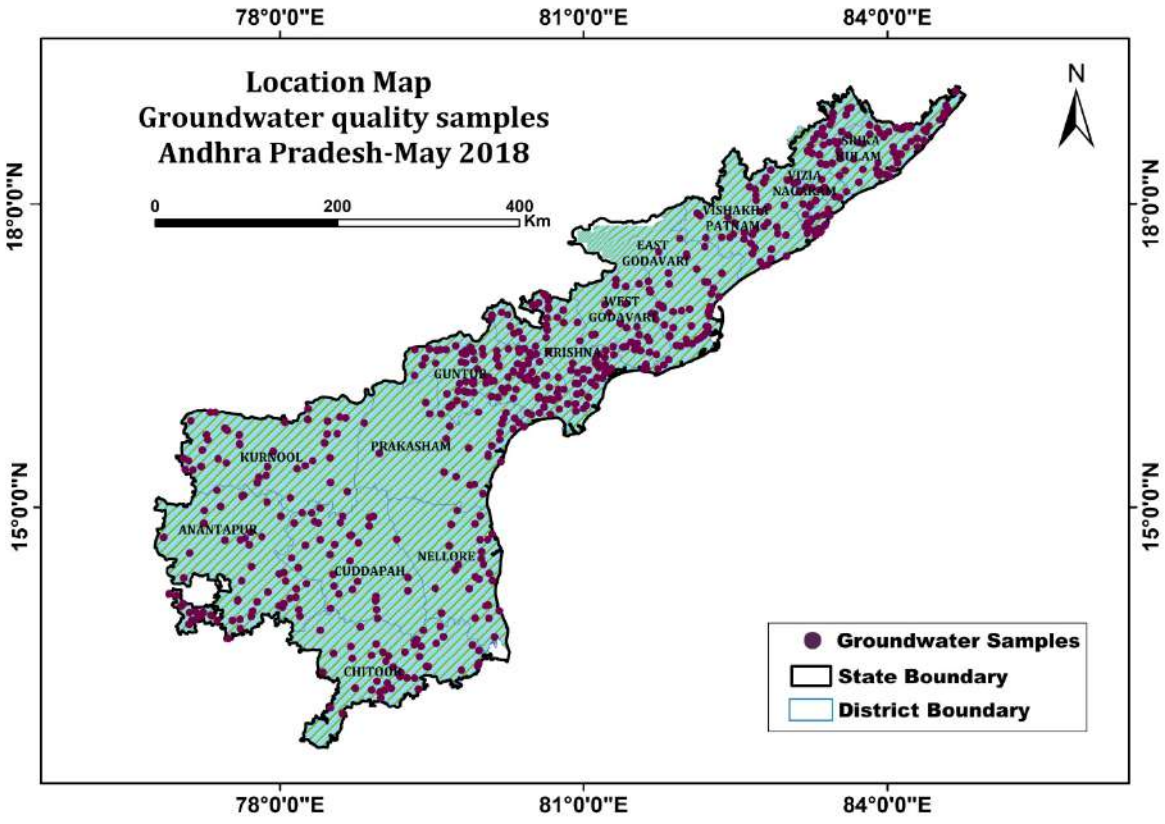


Fig.8.1: Location of Ground water sample sites in Andhra Pradesh

Table-8.1: District wise collection of samples (May-2018)

S.No.	District	Samples		S.No.	District	Samples
		Normal				Normal
1	ANANTAPUR	57		8	NELLORE	26
2	CHITTOOR	44		9	PRAKASAM	27
3	CUDAPAH	36		10	SRIKAKULAM	49
4	EAST GODAVARI	45		11	VISAKHAPATNAM	57
5	GUNTUR	94		12	VIZIANAGARAM	48
6	KRISHNA	63		13	WEST GODAVARI	34
7	KURNOOL	43	TOTAL:			**623**

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 6.3- 8.69. In 4 samples (Ayyavaripalli of Kadapa district, Kakinada of East Godavari district and K. Agraharam of Krishna district, Nandikotkur of Kurnool district), 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 40-20000. Highest EC is noticed at Jammalamadugu of Kadapa district. Overall (85.2%) 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.

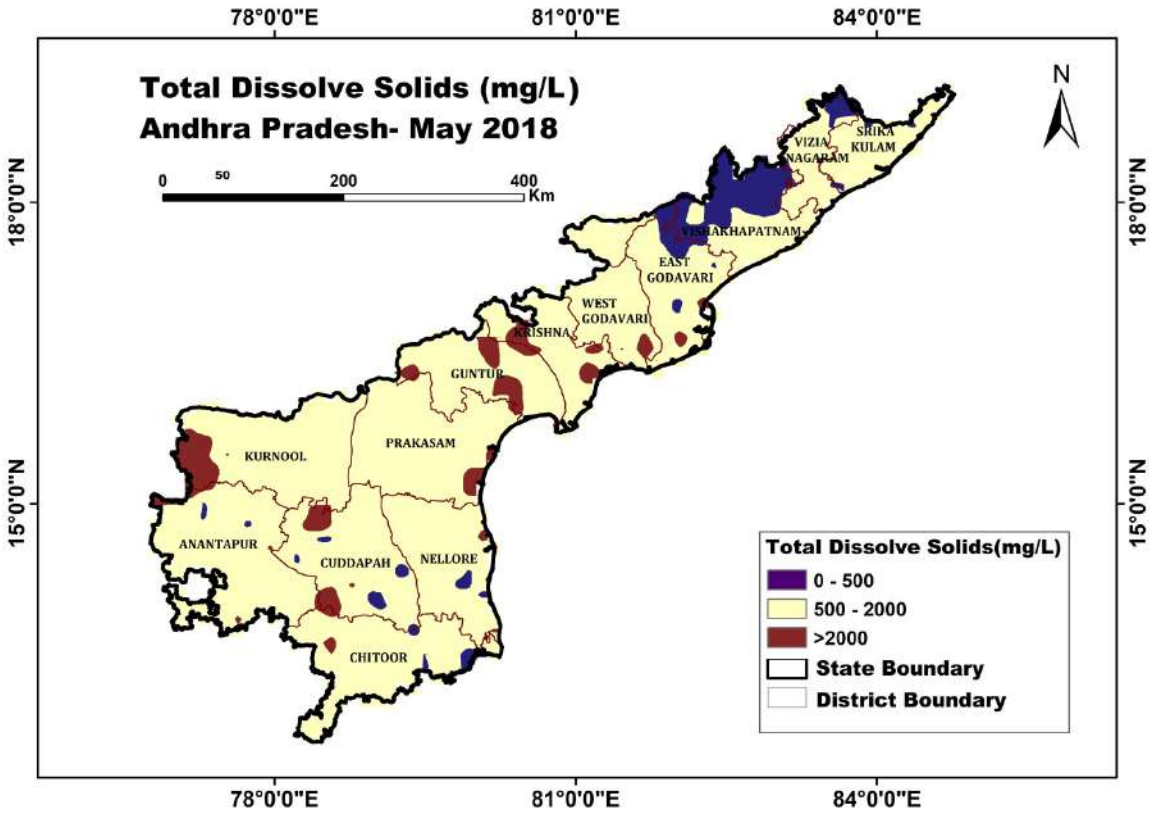


Fig.8.2: Distribution of TDS (May-2018).

In the state, concentration of TDS ranges from 25-12592 mg/L (avg: 1153) and it is found that in 79 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 20-3800 mg/L and it is found that in 144 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 2-721 mg/L and it is found that in 39 samples, Ca is beyond permissible limit (200 mg/L). In almost all districts Ca is below permissible limit is and maximum of 661 mg/L is detected in Nadupur of Krishna 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 2.44-778.3 mg/L with an average of 62.2 mg/L. Maximum concentration is detected in Gulyam of Kurnool district. It is found that in 88 samples, Mg is beyond permissible limit (100 mg/L).

8.1.7 Sodium (Na^{+})

Silicate minerals such as albite, nepheline, sodalite, glaucophane, Aegerion 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 1.0 to 4200 mg/L. With an average concentration of 201 mg/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 600 mg/L. The average concentration is 37.3 mg/L and the highest was detected in dug well of Adoni Kota Veerabhadraswamigudi village (Kurnool 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 12 to 1464 mg/L, with an Average concentration of 436 mg/L and highest is detected in Nadupur of Krishna 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, 1995).** 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, chloro-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 7.0 to 4857 mg/L with an average of 317 mg/L and found that 31 samples are unsuitable for drinking purposes. Maximum concentration detected in Narasimhapuram of West Godavari district.

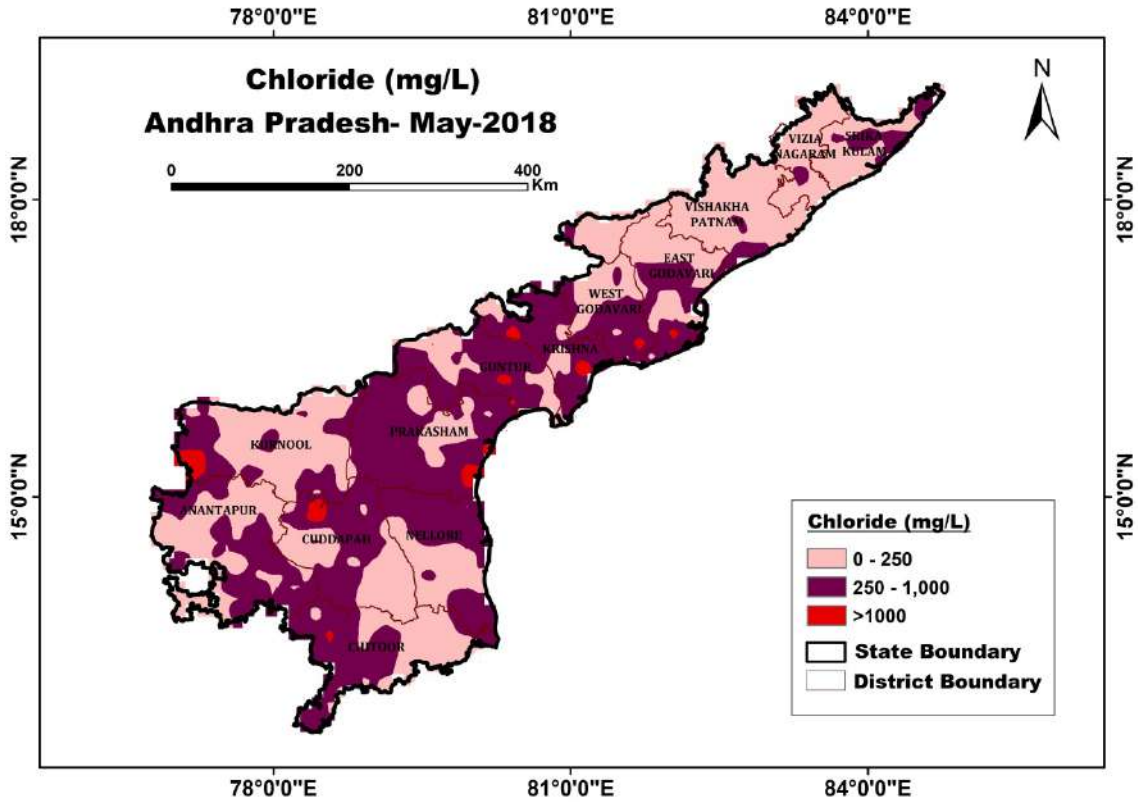


Figure 8.3 : Distribution of Chloride in ground water (May-2018).

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 1-2774 mg/L. Maximum concentration detected in Gulyam of Kurnool district.

8.1.12 Nitrate (NO_3^-)

Nitrogen is present in atmosphere reacts with rainwater and forms nitrate and ammonium ions. The incidence of high nitrate in groundwater has been observed due to

pollution 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 0-991 mg/L. Maximum concentration detected in Gulyam of Kurnool district. It is found that out of 600 samples nearly 229 samples (36.8%) are unfit for human consumption. A point value of Nitrate is presented in **Fig.8.4**.

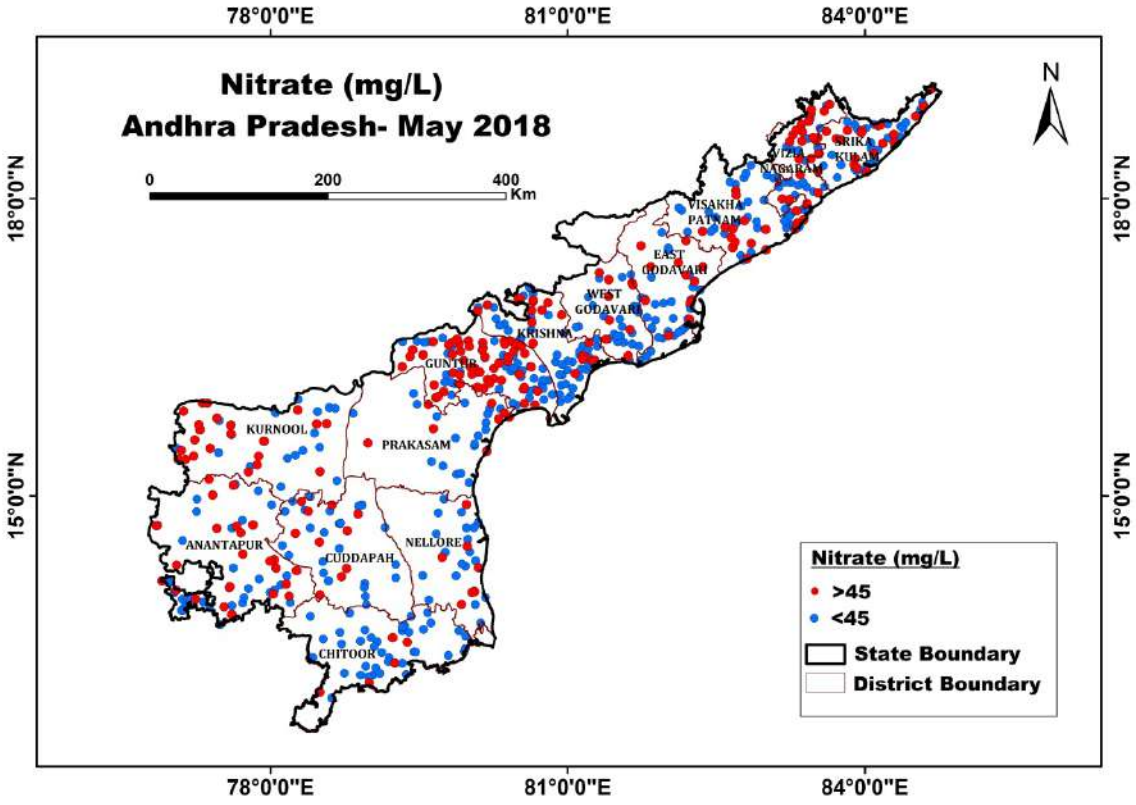


Fig.8.4: Point values of Nitrate in ground water (May-2018).

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).

In the ground waters of State, the concentrations of fluoride range from 0.1-4.04 mg/L and maximum concentration is detected in Kalyandurg of Anantapur district. Out of 600 total samples, 58 (only 9.3 %) are unfit for human consumption. Higher concentration of F (>1.5 mg/L) are detected in few districts of the state **(Fig.8.5).**

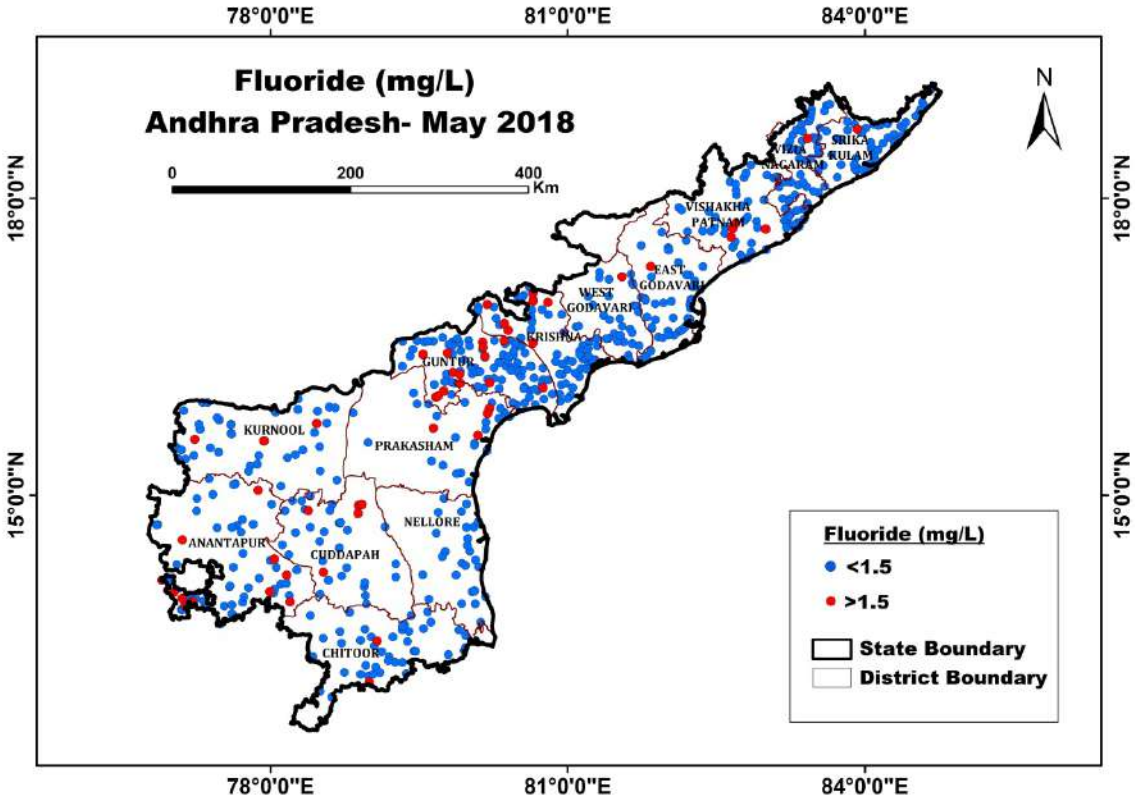


Fig.8.5: Point values of Fluoride in ground water (May-2018).

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 12.7 % of samples is beyond permissible limit of BIS. Out of which, highest percent of samples in Guntur (23.4%), Krishna (22.2%) and Kadapa (19.4%) districts are unsuitable for drinking with respect to TDS. Chloride Content in 5.0% of samples in the state exceeds the BIS permissibility. The Nitrate content in 36.8% of samples of the state is exceeding the BIS permissible value indicating the anthropogenic contamination, which is more than the previous year. In the state w.r.t nitrate contamination,

highest percent of samples in Guntur (55.3%), Kurnool (51.2%) and Vizianagaram (47.9%) districts are unfit for drinking.

Fluoride content in the state varies 0.1-4.04 mg/L and maximum concentration is detected in Kalyandurg of Anantapur district. 9.3% of samples in the state exceed BIS permissible limit. Highest percent of samples in Anantapur (28.2%) followed by Prakasam (18.5%) districts are unfit for drinking.

Table- 8.2 Suitability of 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	**23.1**	**6.3**	**14.1**	**18.9**	**5.0**	**2.9**	**36.8**	**9.3**	**12.7**
Anantapur	28.1	8.8	14.0	12.3	0.0	0.0	42.1	22.8	7.0
Chittoor	11.4	4.5	6.8	11.4	2.3	0.0	11.4	4.5	2.3
Kadapa	13.9	8.3	13.9	11.1	8.3	5.6	27.8	16.7	19.4
East Godavari	24.4	2.2	20.0	28.9	6.7	2.2	26.7	2.2	13.3
Guntur	36.2	8.5	23.4	36.2	6.4	9.6	55.3	14.9	23.4
Krishna	36.5	11.1	25.4	39.7	9.5	3.2	30.2	11.1	22.2
Kurnool	32.6	14.0	11.6	11.6	4.7	7.0	51.2	7.0	11.6
Nellore	19.2	3.8	11.5	23.1	7.7	3.8	26.9	0.0	15.4
Prakasam	22.2	3.7	18.5	14.8	11.1	0.0	33.3	18.5	18.5
Srikakulam	16.3	2.0	6.1	4.1	2.0	0.0	38.8	2.0	8.2
Visakhapatnam	7.0	0.0	3.5	8.8	0.0	0.0	31.6	7.0	1.8
Vizianagaram	6.3	0.0	0.0	0.0	0.0	0.0	47.9	2.1	0.0
West Godavari	29.4	11.8	20.6	23.5	11.8	0.0	26.5	2.9	17.6

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 Absorption Ratio (SAR) as an index for sodium hazard and electrical conductivity as an index for salinity hazard. SAR is defined as

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

Concentrations are expressed in meq/L.

The samples collected from the monitoring wells in Andhra Pradesh 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 amendments make 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. 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 57.1% of water samples are falling in C_3S_1 class, 13.2% in C_2S_1 class, 12.5% of samples falling in C_4S_2 class. 5.9%, 4.7% and 2.7%, samples falling in C_3S_2, C_4S_1 and C_4S_3 respectively. The remaining samples falls in C_1S_1 (2.6%), C_4S_4 (0.9%), and C_3S_3 (0.3%) classes.

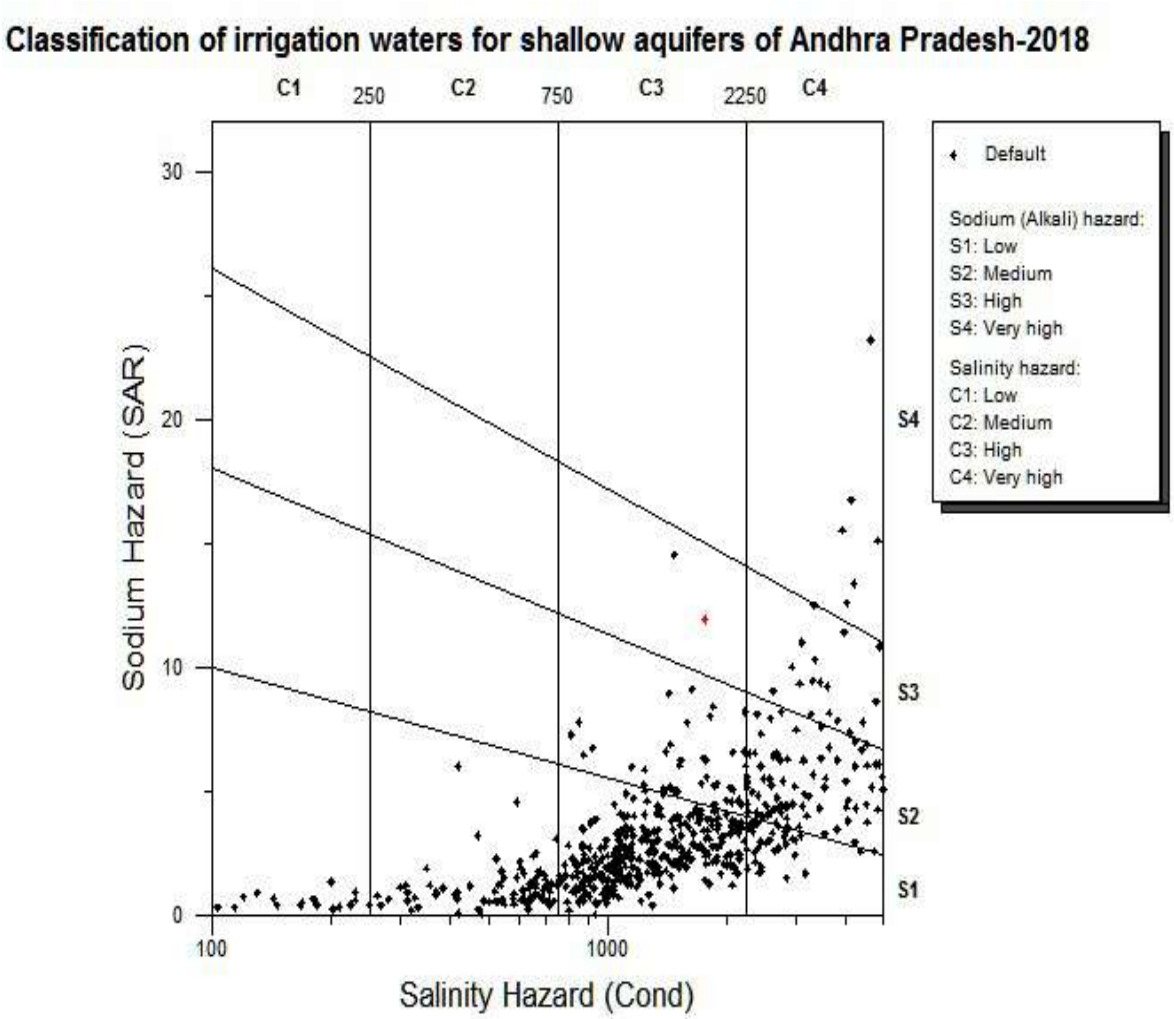


Fig. 8.6 U.S. Salinity diagram for classification of irrigation waters for shallow aquifers of Andhra Pradesh -2018

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.

Distribution of ground water in the state as per RSC given in **Table 8.3** and it reveals, majority of samples (86.2%) fall in safe class (RSC < 1.25), 4.8% in marginal category and remaining 9.0% in not suitable category.

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

RSC	Category	No of samples	% of samples
<1.25	Safe	537	86.2
1.25 - 2.50	Marginal	30	4.8
> 2.50	Not Suitable	56	9.0

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. Nitrate is other important parameter to be considered for the usage of ground water for the livestock. **Tables 8.4, 8.5** show water quality in relation to salinity and nitrate for livestock.

Table-8.4 Use of ground water for livestock and poultry

Soluble salt content	Rating	No of samples in the range	Uses
< 1000 mg/Litre (<1.5 dS/m)	Excellent	333	Excellent for all classes of livestock and poultry
1000-3000 mg/Litre (1.5-5 dS/m)	Very satisfactory	262	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/Litre (5-8 dS/m)	Satisfactory for livestock Unfit for poultry	17	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 fasces, increased mortality and decreased growth especially in turkeys.

5000-7000 mg/Litre (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/Litre (11-16 dS/m)	Very limited use	4	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/ liter (> 16 dS/m)	Not recommended	2	This water is unsatisfactory for all classes of livestock and poultry.

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

Table-8.5 Guide to use of waters containing nitrates for livestock.

Nitrate, NO_3 (mg/L)	No samples in the range	Comments
<440	611	Experimental evidence indicates this water should not harm livestock or poultry.
440 - 1320	12	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.

**** The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO_2-N) because of the greater toxicity of the nitrite form.***

*****1 ppm of nitrate nitrogen is equivalent to 4.4 ppm of nitrate (NO_3).***

8.5 Groundwater facies

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 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.

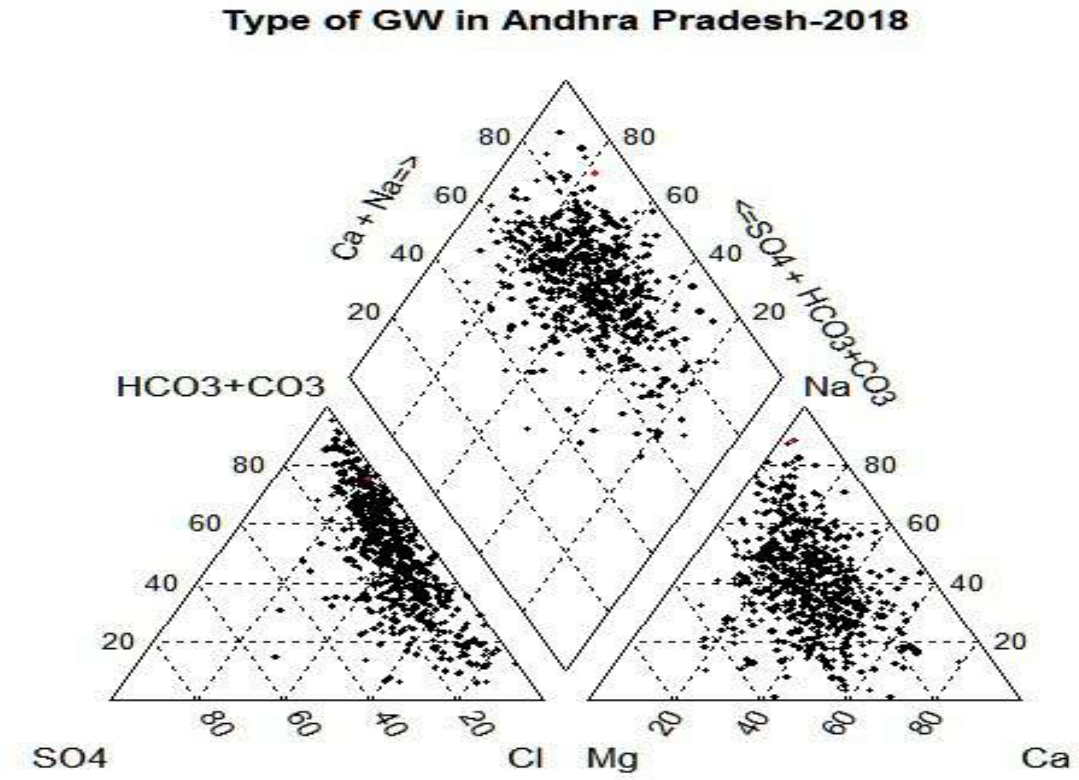


Fig.8.7: Ground water facies (Piper Plot)-May-2018.

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 2018 of the state is 762 mm. Season-wise rainfall is 527 mm, 134 mm, 2.4 mm and 98 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively contributing 69% of annual rainfall in SW monsoon, 18% of annual rainfall in north-east monsoon and 13% in non-monsoon season. The annual (2018) rainfall ranges from 391 mm in Anantapur district (deficit by 32%) to 1301 mm (excess by 12%) 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 31/03/2019, total of 864 (DW: 699 and Pz: 165) Ground Water Monitoring Wells (GWMS) are in existence. There are 142 observers appointed to monitor GWMS on participatory mode (all dug wells).

Density of wells varies from 103 Km^2/well (East Godavari district) to 310 Km^2/well in Kurnool district with average of 185 Km^2/well. In the state, Soft rocks have 187 monitoring stations and hardocks have 677 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 0.09 m bgl to 60.13 m bgl and water levels in the range of less than 10m.bgl are more predominant occupying ~78% of the area. Shallow water levels (0 to 2 m bgl) and deep water levels (>20 mbgl) occupy ~2 % and 5% of the area respectively.

During August (mid-monsoon season) water levels are in the range of 0.30 m bgl to 39.09 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~36% of the area followed by 2-5 mbgl (29% area). Shallow water levels less than 2 m occupy about 19% of the area. Water level 10 to 20 m bgl is covered in 15% of the area Deep water levels (>20 mbgl) occupy ~1 % of the area.

During November (post-monsoon season) water levels are in the range of 0.33 m bgl to 44.27 m bgl. Shallow water level range 0 to 2 m bgl is observed in 13% of the total area. Water levels in the range of 2-5 m bgl are occupying ~36 % of the area followed by 5-10 m bgl mbgl (36 % area). Deep water levels (>20 mbgl) occupy ~1 % of the area. Majority of water levels are in the range of 2 to 10 m bgl(72%).

Area with deep water levels has changed from 5% in May to 1 % in November. Area under shallow water levels changed from 2% in May to 13% in Nov .

During January-19, water levels are in the range of 0.19 m bgl to 50 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~39 % of the area followed by 2-5 mbgl (35 % area). Shallow water levels (0-2 mbgl) occupy ~8 % 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. The range of water level in pre-monsoon ranges from 0.18 m bgl (Anantapur district) to 93.96 m bgl (Krishna district). In post-monsoon season it ranges from 0.05 m in Guntur district) to 96.86 m bgl (Chittoor district). Majority of water levels are in the range of 5 – 10 m bgl in pre-monsoon and post-monsoon seasons. Deep water levels (> 20 m bgl) remained same in both the seasons. Shallow water levels have increased from 4% to 10% from pre to post-monsoon season due to monsoon rains.

Water level fluctuation of Aug, 2018 with pre-monsoon water level of May, 2018 have shown fall in 42% of the area and rise in 58% of the area. Maximum rise of 37.3 m in Anantapur district and maximum fall of 13.6 m is also in Anantapur district.

Water level fluctuation of Nov, 2018 with pre-monsoon water level of May, 2018 have shown fall in 36% of the area and rise in 64% of the area. Maximum rise of 32.7 m is in East Godavari district and maximum fall is 10.2 m in Chittoor district.

Water level fluctuation of Jan, 2019 with pre-monsoon water level of May, 2018 have shown fall in 37% of the area and rise in 63% of the area. Maximum rise of 37.41 m in Anantapur district and maximum fall is 15.23 m in Vishakhapatnam district

Annual water level fluctuation during May, 2018 from May, 2017 has shown fall in water levels in 70% of the area and rise in 30% of the area. Maximum rise of 15.8 m is observed in Kurnool district and maximum fall is noticed in Anantapur district (20 m).

Annual water level fluctuation during Aug, 2018 from Aug, 2017 has shown fall in water levels in 35% of the area and rise in 65% of the area. Maximum fall is noticed in Prakasam district (34.4 m) and maximum rise of 23 m is observed in Prakasam districts.

Annual water level fluctuation during Nov-2018 from Nov,2017 has shown fall in water levels in 78 % of the area and rise in 22% of the area. The maximum rise of 16.2 m is recorded in Krishna district and maximum fall of 18.81 m is recorded in Anantapur district.

Annual water level fluctuation during January-2019 from January-18 has shown fall in water levels in 73 % of the area and rise in 27% of the area. The maximum rise of 66.9 m recorded in Prakasam district and the maximum fall of 16.31 m is recorded in Anantapur district.

Water levels during May-18, August-18, November-18 and January-19 as compared to decadal mean water levels, have shown rise in most of the wells during May'18 and Aug'18 and fall in most of the wells as well as in most of the area in Nov'18 and Jan'19 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 39%, 48%, 82% and 78% in May-18, August-18, November-18 and January-19 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 22% of the area, fall in trend is observed in 78% of the area. During post-monsoon season, rise in water level trend is observed in 23% of the area, fall in trend is observed in 77% of the area.

Ground water quality is assessed during pre-monsoon season of 2018 by collecting 623 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 6.3 to 8.69. Electrical conductivity varies from 40-20000 µ Siemens/cm. Total Dissolved Solids (TDS) varies from 25-12592 mg/l and in 79 samples it is beyond 2000 mg/l (12.6 %). Total hardness varies from 20-3800 mg/l and in 23 % of samples it is beyond 600 mg/l. Calcium and magnesium varies from 2 to 721 mg/l (in 6 % samples it is beyond permissible limits of BIS i.e., >200 mg/l) and 2.44 to 778 mg/l (in 14 % samples it is beyond permissible limits of BIS i.e., >100 mg/l). Sodium and potassium varies from 1 - 4200 mg/L and BDL (Below detection Limit) to 600 mg/l respectively. The HCO_3 concentration varies from 12 to 1464 mg/l. Chloride and sulphate varies from 7 to 4857 mg/l and 1 to 2774 mg/l respectively. NO_3 ranges from 0 to 991 mg/l and found that 37 % samples are unfit for human consumption (>45 mg/l). Fluoride concentration varies from 0.1 to 4.04 mg/l and found that 9% 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 9 % 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 2018. Andhra Pradesh

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 May2018		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	35	33	68	31	29	60	2	3	5	1	1	2	1	0	1	0	0	0	34	33	67
2	Chittoor	48	10	58	33	14	47	11	0	11	2	1	3	2	0	2	0	5	5	46	15	61
3	Cuddapah	28	26	54	23	22	45	3	2	5	1	2	3	1	0	1	0	0	0	27	26	53
4	East Godavari	87	12	99	75	10	85	10	3	13	4	0	4	0	0	0	0	0	0	87	12	99
5	Guntur	85	13	98	77	10	87	8	1	9	0	2	2	0	0	0	0	0	0	85	13	98
6	Krishna	67	7	74	51	6	57	15	0	15	1	1	2	0	0	0	0	0	0	67	7	74
7	Kurnool	38	19	57	34	12	46	4	0	4	0	7	7	0	0	0	0	0	0	38	19	57
8	Nellore	59	1	60	29	0	29	22	0	22	8	1	9	1	1	2	0	0	0	58	0	58
9	Prakasam	50	14	64	27	8	35	21	1	22	2	5	7	0	1	1	0	0	0	50	13	63
10	Srikakulam	53	0	53	50	0	50	1	0	1	0	0	0	2	0	2	1	0	1	52	0	52
11	Visakhapatnam	63	3	66	54	3	57	3	0	3	0	0	0	6	0	6	0	0	0	57	3	60
12	Vizianagaram	51	0	51	47	0	47	1	0	1	0	0	0	3	0	3	0	0	0	48	0	48
13	West Godavari	54	9	63	49	6	55	7	2	9	1	1	2	0	0	0	0	0	0	54	9	63
	Total	**718**	**147**	**865**	**580**	**120**	**700**	**108**	**12**	**120**	**20**	**21**	**41**	**16**	**2**	**18**	**1**	**5**	**6**	**703**	**150**	**853**

ANNEXURE II - District wise status of Ground water monitoring wells- August 2018

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 Aug 2018		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	34	33	67	30	29	59	3	0	3	1	4	5	0	0	0	0	0	0	34	33	67
2	Chittoor	46	15	61	33	14	47	10	1	11	3	0	3	0	0	0	0	0	0	46	15	61
3	Kadapa	27	26	53	20	22	42	7	3	10	0	1	1	0	0	0	0	0	0	27	26	53
4	East Godavari	93	13	106	85	12	97	0	0	0	8	1	9	0	0	0	0	0	0	93	13	106
5	Guntur	85	13	98	80	10	90	2	0	2	3	3	6	0	0	0	0	0	0	85	13	98
6	Krishna	67	7	74	62	4	66	3	0	3	2	3	5	0	0	0	0	0	0	67	7	74
7	Kurnool	38	19	57	34	12	46	4	0	4	0	7	7	0	0	0	0	0	0	38	19	57
8	Nellore	58	0	58	40	0	40	17	0	17	1	0	1	0	0	0	0	0	0	58	0	58
9	Prakasam	50	13	63	27	10	37	23	1	24	0	2	2	0	0	0	0	0	0	50	13	63
10	Srikakulam	52	0	52	50	0	50	0	0	0	2	0	2	0	0	0	0	0	0	52	0	52
11	Visakhapatnam	57	3	60	57	3	60	**0**	**0**	0	**0**	**0**	0	**0**	0	0	0	0	0	57	3	60
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	57	9	66	**53**	**4**	57	**0**	**1**	1	**5**	**4**	9	**0**	**0**	0	**1**	**0**	1	58	9	67
	Total	**712**	**151**	**863**	**619**	**120**	739	**69**	**6**	75	**25**	**25**	50	**0**	**0**	0	**1**	**0**	1	713	151	864

ANNEXURE III - District wise status of Ground water monitoring wells- November 2018

S. No.	District	No of Stations to be monitored			No of Stations where WL data			No of Stations Monitored as			No of Stations not Monitored			No of Stations Abandoned			No of Stations Established			No of Stations as on Jan 2019		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	34	33	67	26	31	57	5	0	5	3	2	5	0	0	0	0	0	0	34	33	67
2	Chittoor	46	15	61	35	15	50	10	0	10	1	0	1	1	0	1	0	0	0	45	15	60
3	Kadapa	27	26	53	20	22	42	5	2	7	2	2	4	1	0	1	0	6	6	26	32	58
4	East Godavari	93	13	106	90	11	101	1	1	2	2	1	3	0	0	0	0	0	0	93	13	106
5	Guntur	85	13	98	79	8	87	3	1	4	3	4	7	2	0	2	0	0	0	83	13	96
6	Krishna	67	7	74	63	5	68	2	1	3	2	1	3	0	0	0	0	0	0	67	7	74
7	Kurnool	38	19	57	36	18	54	2	0	2	0	1	1	0	0	0	0	1	1	38	20	58
8	Nellore	58	0	58	39	0	39	18	0	18	1	0	1	1	0	1	0	0	0	57	0	57
9	Prakasam	50	13	63	28	7	35	21	1	22	1	5	6	1	0	1	0	0	0	49	13	62
10	Srikakulam	52	0	52	52	0	52	0	0	0	0	0	0	0	0	0	0	0	0	52	0	52
11	Visakhapatnam	57	3	60	57	3	60	0	0	0	0	0	0	0	0	0	0	0	0	57	3	60
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	58	9	67	55	6	61	2	1	3	1	2	3	0	0	0	0	0	0	58	9	67
	Total	**713**	**151**	**864**	**628**	**126**	**754**	**69**	**7**	**76**	**16**	**18**	**34**	**6**	**0**	**6**	**0**	**7**	**7**	**707**	**158**	**865**

ANNEXURE IV - District wise status of Ground water monitoring wells- January 2019

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	34	33	67	26	29	55	5	0	5	1	4	5	2	0	2	0	0	0	32	33	65
2	Chittoor	45	15	60	35	15	50	10	0	10	0	0	0	0	0	0	0	0	0	45	15	60
3	Kadapa	26	32	58	19	28	47	6	3	9	0	1	1	1	0	1	0	7	7	25	39	64
4	East Godavari	93	13	106	92	12	104	0	1	1	0	0	0	1	0	1	0	0	0	92	13	105
5	Guntur	83	13	96	79	8	87	3	1	4	1	4	5	0	0	0	1	0	1	84	13	97
6	Krishna	67	7	74	57	5	62	6	0	6	2	2	4	2	0	2	0	0	0	65	7	72
7	Kurnool	38	20	58	32	16	48	4	3	7	1	1	2	1	0	1	0	0	0	37	20	57
8	Nellore	57	0	57	43	0	43	14	0	14	0	0	0	0	0	0	0	0	0	57	0	57
9	Prakasam	49	13	62	25	8	33	23	4	27	0	1	1	1	0	1	1	0	1	49	13	62
10	Srikakulam	52	0	52	50	0	50	0	0	0	2	0	2	0	0	0	0	0	0	52	0	52
11	Visakhapatnam	57	3	60	53	3	56	1	0	1	3	0	3	0	0	0	0	0	0	57	3	60
12	Vizianagaram	48	0	48	44	0	44	1	0	1	2	0	2	1	0	1	0	0	0	47	0	47
13	West Godavari	58	9	67	56	8	64	1	0	1	0	1	1	1	0	1	0	0	0	57	9	66
	Total	**707**	**158**	**865**	**611**	**132**	**743**	**74**	**12**	**86**	**12**	**14**	**26**	**10**	**0**	**10**	**2**	**7**	**9**	**699**	**165**	**864**

ANNEXURE V - Distribution of percentage of wells , May, 2018 (m bgl).

S NO	DISTRICT	NO OF WELLS	MIN	MAX	AVERAGE	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	SRIKAKULAM	50	1.52	10.30	4.99	2	4%	25	50%	22	44%	1	2%	0	0%	0	0%
2	VIZIANAGARAM	48	1.42	12.00	5.25	2	4%	21	44%	23	48%	2	4%	0	0%	0	0%
3	VISAKHAPATNAM	60	0.38	32.60	5.56	7	12%	25	42%	22	37%	5	8%	1	2%	0	0%
4	EAST GODAVARI	91	0.78	21.90	4.72	11	12%	49	54%	26	29%	4	4%	1	1%	0	0%
5	WEST GODAVARI	58	0.73	44.78	5.55	13	22%	23	40%	15	26%	6	10%	0	0%	1	2%
6	KRISHNA	72	0.75	37.24	6.83	3	4%	37	51%	18	25%	11	15%	3	4%	0	0%
7	GUNTUR	96	0.41	39.50	5.63	9	9%	49	51%	28	29%	8	8%	2	2%	0	0%
8	PRAKASAM	56	2.25	49.30	8.03	0	0%	20	36%	20	36%	15	27%	0	0%	1	2%
9	NELLORE	51	1.37	17.00	6.80	2	4%	18	35%	20	39%	11	22%	0	0%	0	0%
10	CHITTOOR	58	0.87	60.13	8.75	4	7%	17	29%	21	36%	15	26%	0	0%	1	2%
11	KADAPA	48	2.78	54.87	12.32	0	0%	13	27%	14	29%	13	27%	6	13%	2	4%
12	ANANTAPUR	60	0.09	48.50	11.41	3	5%	14	23%	19	32%	17	28%	4	7%	3	5%
13	KURNOOL	47	0.38	41.90	6.93	4	9%	18	38%	18	38%	5	11%	1	2%	1	2%
	STATE FIGIURES	**795**	**0.09**	**60.13**	**6.95**	**60**	**8%**	**329**	**41%**	**266**	**33%**	**113**	**14%**	**18**	**2%**	**9**	**1.1%**

ANNEXURE VI - Distribution of percentage of wells , Aug, 2018 (m bgl).

S NO	DISTRICT	NO OF WELLS	MINIMUM	MAXIMUM	AVERAGE	0 - 2 m	% OF WELLS	2 - 5 m	% OF WELLS	5 - 10 m	% OF WELLS	10 - 20 m	% OF WELLS	20 - 40 m	% OF WELLS	> 40 m	% OF WELLS
1	ANANTAPUR	43	0.72	22.73	8.19	5	12%	12	28%	12	28%	11	26%	3	7%	3	7%
2	CHITTOOR	43	1.94	15.12	7.24	1	2%	11	26%	21	49%	9	21%	0	0%	0	0%
3	KADAPA	29	1.7	24.38	8.15	1	3%	5	17%	15	52%	7	24%	1	3%	1	3%
4	EAST GODAVARI	83	0.07	10	2.05	56	67%	20	24%	5	6%	0	0%	0	0%	0	0%
5	GUNTUR	91	-0.11	15.3	3.90	30	33%	36	40%	18	20%	6	7%	0	0%	0	0%
6	KRISHNA	67	-0.3	25.4	2.75	42	63%	13	19%	8	12%	2	3%	1	1%	1	1%
7	KURNOOL	44	-0.11	15.38	5.86	8	18%	12	27%	16	36%	7	16%	0	0%	0	0%
8	NELLORE	56	1.9	17	6.53	2	4%	21	38%	23	41%	10	18%	0	0%	0	0%
9	PRAKASAM	61	0.61	39.09	8.24	2	3%	17	28%	25	41%	16	26%	2	3%	2	3%
10	SRIKAKULAM	45	0.22	4.9	1.50	33	73%	11	24%	0	0%	0	0%	0	0%	0	0%
11	VISAKHAPATNAM	60	0.15	28.2	3.87	20	33%	26	43%	9	15%	3	5%	1	2%	1	2%
12	VIZIANAGARAM	48	0.3	10.49	3.20	16	33%	23	48%	8	17%	1	2%	0	0%	0	0%
13	WEST GODAVARI	50	-0.2	9.73	2.09	33	66%	10	20%	5	10%	0	0%	0	0%	0	0%
	STATE FIGURES	**720**	**-0.30**	**39.09**	**4.89**	**249**	**35%**	**217**	**30%**	**165**	**23%**	**72**	**10%**	**8**	**1%**	**8**	**1.1%**

ANNEXURE VII - Distribution of percentage of wells , November, 2018 (m bgl).

S NO	DISTRICT	NO OF WELLS	MINIMUM	MAXIMUM	AVERAGE	0 - 2 m	% OF WELLS	2 - 5 m	% OF WELLS	5 - 10 m	% OF WELLS	10 - 20 m	% OF WELLS	20 - 40 m	% OF WELLS	> 40 m	% OF WELLS
1	ANANTAPUR	41	0.55	35.75	8.59	5	12%	6	15%	17	41%	11	27%	1	2%	1	2%
2	CHITTOOR	45	0.96	15.12	6.98	3	7%	14	31%	20	44%	8	18%	0	0%	0	0%
3	KADAPA	29	0.82	13	6.91	3	10%	7	24%	12	41%	7	24%	0	0%	0	0%
4	EAST GODAVARI	88	0.24	12.2	2.65	45	51%	36	41%	5	6%	2	2%	0	0%	0	0%
5	GUNTUR	96	0.28	39.5	4.44	27	28%	37	39%	23	24%	7	7%	1	1%	1	1%
6	KRISHNA	67	0	20.45	3.45	33	49%	21	31%	8	12%	3	4%	1	1%	1	1%
7	KURNOOL	46	0.09	16.4	6.12	9	20%	13	28%	17	37%	7	15%	0	0%	0	0%
8	NELLORE	55	1.98	17.3	6.73	2	4%	21	38%	20	36%	12	22%	0	0%	0	0%
9	PRAKASAM	55	1	44.27	7.77	4	7%	16	29%	18	33%	14	25%	1	2%	2	4%
10	SRIKAKULAM	45	0.25	5.13	1.97	28	62%	16	36%	1	2%	0	0%	0	0%	0	0%
11	VISAKHAPATNAM	61	0.68	27.2	4.43	17	28%	23	38%	17	28%	3	5%	1	2%	1	2%
12	VIZIANAGARAM	48	0.67	11.18	3.65	12	25%	29	60%	6	13%	1	2%	0	0%	0	0%
13	WEST GODAVARI	66	-0.33	28.5	3.37	30	45%	23	35%	10	15%	1	2%	1	2%	1	2%
	STATE FIGURES	742	**-0.33**	**44.27**	**5.16**	**218**	**29%**	**262**	**35%**	**174**	**23%**	**76**	**10%**	**6**	**1%**	**7**	**0.9%**

ANNEXURE VIII - Distribution of percentage of wells, January 2019

Sl. No	District	No of Wells Analyzed	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	41	0.75	22.7	7	17	7	17	11	27	15	37	1	2	0	0
2	Chittoor	45	1.12	18.15	5	11	10	22	21	46	9	20	0	0	0	0
3	YSR Kadapa	31	0.6	50.01	2	6	7	22	11	35	7	23	3	10	1	3
4	East Godavari	91	0.35	10.2	36	40	41	45	13	14	1	1	0	0	0	0
5	Guntur	92	0.19	39.5	21	23	41	45	22	23	6	7	2	2	0	0
6	Krishna	67	0.3	22.75	26	39	23	34	10	14	7	10	1	1	0	0
7	Kurnool	45	0.32	16.1	6	30	15	33	17	38	7	16	0	0	0	0
8	Nellore	57	0.71	17	8	14	24	42	18	32	7	12	0	0	0	0
9	Prakasam	60	0.47	48.2	4	7	20	33	19	32	14	23	2	3	1	2
10	Srikakulam	46	1.18	7.3	11	24	29	63	6	13	0	0	0	0	0	0
11	Visakhapatnam	57	0.53	29.92	13	23	25	43	15	26	3	5	1	2	0	0
12	Vizianagaram	44	1.36	11.75	5	11	22	50	16	36	1	2	0	0	0	0
13	West Godavari	54	0.3	15.37	20	37	22	40	11	20	1	2	0	0	0	0
Total State		**730**	**0.19**	**50.01**	**164**	**22%**	**286**	**40%**	**190**	**26%**	**78**	**11%**	**10**	**1%**	**2**	

ANNEXURE IX - Fluctuation and Frequency distribution from different ranges from one period to other Aug, 2018 from May, 2018

S NO	DISTRICT	TOTAL NO OF WELLS MONITORED	FALL	% OF WELLS FALL	MINIMUM	MAXIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	41	22	54%	-13.60	-0.10	-2.42	15	68%	4	18%	3	14%	19	46%	0.04	37.30	4.32	12	63%	2	11%	4	21%
2	CHITTOOR	34	28	82%	-6.22	-0.06	-1.27	23	82%	3	11%	2	7%	6	18%	0.09	7.32	1.60	5	83%	0	0%	1	17%
3	KADAPA	23	19	83%	-3.40	-0.10	-1.58	12	63%	7	37%	0	0%	4	17%	0.45	1.60	1.06	4	100%	0	0%	0	0%
4	EAST GODAVARI	79	5	6%	-0.83	-0.09	-0.55	5	100%	0	0%	0	0%	74	94%	0.30	16.38	2.61	39	53%	24	32%	11	15%
5	GUNTUR	89	17	19%	-3.17	-0.04	-1.06	14	82%	3	18%	0	0%	72	81%	0.08	12.12	2.01	46	64%	19	26%	6	8%
6	KRISHNA	64	3	5%	-7.35	-0.80	-3.57	1	33%	1	33%	1	33%	61	95%	0.21	18.35	3.81	27	44%	19	31%	14	23%
7	KURNOOL	39	18	46%	-7.47	-0.02	-2.01	12	67%	2	11%	4	22%	21	54%	0.02	9.18	1.86	15	71%	2	10%	4	19%
8	NELLORE	36	23	64%	-3.99	-0.03	-1.22	19	83%	4	17%	0	0%	13	36%	0.01	9.14	2.33	7	54%	4	31%	2	15%
9	PRAKASAM	36	21	58%	-3.10	-0.03	-1.03	19	90%	2	10%	0	0%	15	42%	0.16	10.21	1.79	11	73%	3	20%	1	7%
10	SRIKAKULAM	44	0	0%	-0.60	-0.07	-0.27	0	0%	0	0%	0	0%	44	100%	0.72	9.50	3.57	10	23%	19	43%	15	34%
11	VISAKHAPATNAM	59	3	5%	-2.55	-0.70	-1.20	3	100%	0	0%	0	0%	56	95%	0.04	7.45	1.82	38	68%	13	23%	5	9%
12	VIZIANAGARAM	48	5	10%	-0.04	-0.04	-0.04	4	80%	1	20%	0	0%	43	90%	0.04	6.01	2.43	18	42%	19	44%	6	14%
13	WEST GODAVARI	49	1	2%	0.00	0.00	0.00	1	100%	0	0%	0	0%	48	98%	0.01	8.15	2.09	29	60%	14	29%	5	10%
	STATE FIGURES	641	**165**	**26**	**-13.60**	**0.00**	**-1.25**	**128**	**78%**	**27**	**16**	**10**	**6%**	**476**	**74%**	**0.01**	**37.30**	**2.41**	**261**	**55%**	**138**	**29**	**74**	**16%**

ANNEXURE X - Fluctuation and Frequency distribution from different ranges from one period to other Nov, 2018 from May, 2018

DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MINIMUM	MAXIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
		FALL IN WL											RISE IN WL										
ANANTAPUR	40	25	63%	-6.90	-0.05	-1.99	14	56%	8	32%	2	8%	13	33%	0.02	32.70	4.85	8	62%	1	8%	4	31%
CHITTOOR	44	25	57%	-10.22	-0.03	-1.59	17	68%	7	28%	1	4%	10	23%	0.15	11.02	3.22	5	50%	2	20%	3	30%
KADAPA	26	16	62%	-3.60	-0.10	-1.52	11	69%	5	31%	0	0%	8	31%	0.87	3.04	2.19	3	38%	5	63%	0	0%
EAST GODAVARI	85	3	4%	-0.59	-0.07	-0.33	3	100%	0	0%	0	0%	81	95%	0.02	18.54	2.03	53	65%	19	23%	9	11%
GUNTUR	91	18	20%	-2.32	-0.03	-0.85	17	94%	1	6%	0	0%	69	76%	0.02	10.45	1.64	55	80%	9	13%	5	7%
KRISHNA	67	3	4%	-6.49	-1.01	-3.13	2	67%	0	0%	1	33%	62	93%	0.20	16.27	2.94	31	50%	18	29%	13	21%
KURNOOL	41	23	56%	-8.42	-0.10	-1.87	17	74%	2	9%	4	17%	18	44%	0.06	8.98	2.52	11	61%	3	17%	4	22%
NELLORE	51	18	35%	-4.88	-0.08	-1.52	13	72%	4	22%	1	6%	20	39%	0.01	7.40	1.61	13	65%	6	30%	1	5%
PRAKASAM	51	12	24%	-5.64	-0.13	-1.38	10	83%	1	8%	1	8%	22	43%	0.06	7.35	2.00	16	73%	2	9%	4	18%
SRIKAKULAM	44	2	5%	-0.21	-0.03	-0.12	2	100%	0	0%	0	0%	42	95%	0.30	9.21	3.20	12	29%	17	40%	13	31%
VISAKHAPATNAM	60	9	15%	-1.89	-0.02	-0.56	9	100%	0	0%	0	0%	51	85%	0.02	6.62	1.47	41	80%	7	14%	3	6%
VIZIANAGARAM	48	3	6%	-2.55	-0.11	-1.00	2	67%	1	33%	0	0%	45	94%	0.11	4.56	1.78	28	62%	15	33%	2	4%
WEST GODAVARI	63	5	8%	-0.41	-0.41	-0.41	5	100%	0	0%	0	0%	55	87%	0.09	7.55	2.88	31	56%	11	20%	13	24%
STATE FIGURES	711	**162**	**23%**	**-10.22**	**-0.02**	**-1.25**	**122**	**75%**	**29**	**18%**	**10**	**6%**	**496**	**70%**	**0.01**	**32.70**	**2.49**	**307**	**62%**	**115**	**23%**	**74**	**15%**

ANNEXURE XI - Fluctuation and Frequency distribution from different ranges from one period to other Jan, 2019 from May, 2018

Sl. No	District	No of Wells Analyzed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
							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	40	0.13	37.41	0.39	7.97	7	18	1	3	4	10	15	37	7	18	4	10	12	26
2	Chittoor	44	0.03	9.7	0.12	8.95	9	20	3	7	1	2	15	34	5	11	2	5	13	22
3	YSR Kadapa	25	0.17	2.71	0.1	9.55	4	16	5	20	0	0	6	24	6	24	2	8	9	14
4	East Godavari	85	0.02	18.76	0.11	1.5	57	67	16	19	4	4	8	9	0	0	0	0	77	8
5	Guntur	91	0.05	10.67	0.02	8.91	53	58	13	14	4	4	12	13	4	4	1	1	70	17
6	Krishna	67	0.02	17.75	0.1	10.97	37	55	10	15	8	11	3	5	1	1	2	3	55	6
7	Kurnool	39	0.52	4.68	0.05	9.6	10	26	5	13	1	2	16	41	2	5	3	7	16	21
8	Nellore	50	0.12	8.84	0.1	4.88	19	38	8	16	5	10	4	8	2	4	1	2	32	7
9	Prakasam	54	0.03	9.46	0.03	15.23	16	29	3	6	2	3	11	20	1	1	3	5	21	15
10	Srikakulam	43	0.07	7.5	0.05	0.78	17	40	18	42	4	9	4	9	0	0	0	0	39	4
11	Visakhapatnam	57	0.03	3.68	0.02	2.23	37	65	7	13	0	0	12	21	1	2	0	0	44	13
12	Vizianagaram	44	0.03	3.25	0.03	1.2	32	73	4	9	0	0	6	13	0	0	0	0	36	6
13	West Godavari	51	0.02	5.48	0.07	1.77	32	62	8	16	2	4	9	18	0	0	0	0	42	9
Total State		**690**	**0.02**	**37.41**	**0.02**	**15.23**	**330**	**71%**	**101**	**22%**	**35**	**7%**	**121**	**72%**	**29**	**17%**	**18**	**11%**	**466**	**168**

ANNEXURE XII - Fluctuation and Frequency distribution from different ranges from one period to other May, 2018 from May, 2017

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	46	5	11%	-20.01	-0.01	-4.90	3	60%	0	0%	2	40%	41	89%	0.06	7.75	3.06	12	29%	22	54%	7	17%
2	CHITTOOR	37	9	24%	-7.91	-0.22	-2.41	6	67%	1	11%	2	22%	28	76%	0.13	6.72	2.18	16	57%	10	36%	2	7%
3	KADAPA	33	3	9%	-2.96	-0.91	-1.76	2	67%	1	33%	0	0%	30	91%	0.10	11.63	4.13	8	27%	14	47%	8	27%
4	EAST GODAVARI	80	42	53%	-14.05	-0.91	-1.26	35	83%	5	12%	2	5%	38	48%	0.03	5.80	1.01	33	87%	4	11%	1	3%
5	GUNTUR	88	37	42%	-7.16	-0.01	-1.23	33	89%	1	3%	3	8%	51	58%	0.04	3.75	0.85	48	94%	3	6%	0	0%
6	KRISHNA	58	31	53%	-2.84	-0.07	-0.94	27	87%	4	13%	0	0%	27	47%	0.04	6.73	0.78	25	93%	1	4%	1	4%
7	KURNOOL	44	10	23%	-8.00	-0.03	-2.10	8	80%	0	0%	2	20%	34	77%	0.23	15.80	2.69	20	59%	10	29%	4	12%
8	NELLORE	29	7	24%	-3.19	-0.01	-0.59	6	86%	1	14%	0	0%	22	76%	0.10	4.90	1.65	14	64%	8	36%	0	0%
9	PRAKASAM	35	21	60%	-7.17	-0.05	-0.89	19	90%	1	5%	1	5%	14	40%	0.22	3.25	1.43	10	71%	4	29%	0	0%
10	SRIKAKULAM	48	8	17%	-1.76	-0.08	-0.53	8	100%	0	0%	0	0%	40	83%	0.01	8.00	1.43	30	75%	9	23%	1	3%
11	VISAKHAPATNAM	57	20	35%	-6.50	-0.04	-1.05	17	85%	1	5%	2	10%	37	65%	0.03	6.60	1.00	34	92%	2	5%	1	3%
12	VIZIANAGARAM	48	12	25%	-1.98	-0.10	-0.45	12	100%	0	0%	0	0%	36	75%	0.07	4.05	1.27	27	75%	9	25%	0	0%
13	WEST GODAVARI	49	16	33%	-2.43	-0.09	-0.81	14	88%	2	13%	0	0%	33	67%	0.04	4.31	0.94	27	82%	6	18%	0	0%
	STATE FIGIURES	652	**221**	**34%**	**-20.01**	**-0.01**	**-0.92**	**190**	**86%**	**17**	**8%**	**14**	**6%**	**431**	**66%**	**0.01**	**15.80**	**1.43**	**304**	71%	**102**	**24%**	**25**	**6%**

ANNEXURE XIII - Fluctuation and Frequency distribution from different ranges from one period to other Aug, 2018 from Aug, 2017

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MINIMUM	MAXIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	Anantapur	41	9	22%	-0.16	-6.68	-1.84	7	78%	1	11%	1	11%	32	78%	0.19	23.27	3.84	10	31%	13	41%	9	28%
2	Chittoor	35	19	54%	-0.05	-6.52	-1.45	15	79%	2	11%	2	11%	16	46%	0.08	4.92	1.57	12	75%	3	19%	1	6%
3	Kadapa	23	6	26%	-0.01	-2.80	-0.84	5	83%	1	17%	0	0%	17	74%	0.03	23.07	3.69	10	59%	4	24%	3	18%
4	East Godavari	81	16	20%	-0.03	-3.57	-0.99	13	81%	3	19%	0	0%	65	80%	0.03	3.12	0.75	58	89%	7	11%	0	0%
5	Guntur	88	34	39%	-0.02	-8.26	-1.78	26	76%	2	6%	6	18%	54	61%	0.01	6.67	1.04	46	85%	7	13%	1	2%
6	Krishna	62	11	18%	-0.03	-7.58	-1.53	9	82%	1	9%	1	9%	51	82%	0.06	12.02	2.03	36	71%	6	12%	8	16%
7	Kurnool	40	17	43%	-0.03	-8.59	-1.70	12	71%	3	18%	2	12%	23	58%	0.09	8.33	2.05	15	65%	4	17%	4	17%
8	Nellore	39	25	64%	-0.14	-5.85	-1.35	18	72%	5	20%	2	8%	14	36%	0.06	3.83	1.12	11	79%	3	21%	0	0%
9	Prakasam	40	22	55%	-0.02	-34.42	-2.86	18	82%	2	9%	2	9%	18	45%	0.01	5.59	1.57	12	67%	3	17%	3	17%
10	Srikakulam	43	15	35%	-0.02	-1.65	-0.54	15	100%	0	0%	0	0%	28	65%	0.15	4.98	1.25	22	79%	4	14%	2	7%
11	Visakhapatnam	57	38	67%	-0.03	-4.35	-0.99	32	84%	4	11%	2	5%	19	33%	0.02	5.90	1.30	15	79%	2	11%	2	11%
12	Vizianagaram	48	23	48%	-0.20	-3.81	-1.16	19	83%	4	17%	0	0%	25	52%	0.06	5.38	1.39	18	72%	5	20%	2	8%
13	West Godavari	50	8	16%	-0.03	-1.61	-0.43	8	100%	0	0%	0	0%	42	84%	0.02	3.50	0.84	37	88%	5	12%	0	0%
	State Figures	647	243	38%	-0.01	-34.42	-1.34	197	81%	28	12%	18	7%	404	62%	0.01	23	1.7	302	75%	66	16	35	**8.7%**

ANNEXURE XIV - Fluctuation and Frequency distribution from different ranges from one period to other Nov, 2018 from Nov, 2017

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MINIMUM	MAXIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	Anantapur	40	32	80%	-0.15	-18.81	-3.72	12	38%	9	28%	11	34%	7	18%	0.11	5.19	1.56	4	57%	2	29%	1	14%
2	Chittoor	44	37	84%	-0.15	-10.38	-3.53	13	35%	10	27%	14	38%	4	9%	0.03	3.10	1.61	2	50%	2	50%	0	0%
3	Kadapa	28	23	82%	-0.02	-11.03	-3.71	8	35%	5	22%	10	43%	5	18%	0.13	3.37	1.16	4	80%	1	20%	0	0%
4	East Godavari	87	53	61%	-0.02	-7.34	-1.05	46	87%	5	9%	2	4%	32	37%	0.02	5.27	0.62	30	94%	1	3%	1	3%
5	Guntur	94	61	65%	-0.01	-6.32	-1.35	48	79%	10	16%	3	5%	30	32%	0.02	6.20	1.09	24	80%	4	13%	2	7%
6	Krishna	67	27	40%	-0.01	-3.12	-0.78	25	93%	2	7%	0	0%	38	57%	0.05	16.27	1.30	33	87%	3	8%	2	5%
7	Kurnool	45	40	89%	-0.03	-11.07	-3.26	14	35%	15	38%	11	28%	5	11%	0.44	2.27	1.26	4	80%	1	20%	0	0%
8	Nellore	48	41	85%	-0.15	-16.59	-3.51	16	39%	13	32%	12	29%	5	10%	0.30	1.36	0.86	5	100%	0	0%	0	0%
9	Prakasam	55	33	60%	-0.35	-17.78	-3.33	15	45%	10	30%	7	21%	18	33%	0.07	4.95	1.15	14	78%	3	17%	1	6%
10	Srikakulam	45	18	40%	-0.01	-1.17	-0.45	18	100%	0	0%	0	0%	26	58%	0.06	3.47	0.68	24	92%	2	8%	0	0%
11	Visakhapatnam	61	48	79%	-0.03	-4.73	-0.93	44	92%	3	6%	1	2%	13	21%	0.01	1.60	0.51	13	100%	0	0%	0	0%
12	Vizianagaram	47	40	85%	-0.08	-4.90	-1.44	31	78%	6	15%	3	8%	7	15%	0.01	2.10	0.71	6	86%	1	14%	0	0%
13	West Godavari	63	24	38%	-0.08	-3.47	-1.03	21	88%	2	8%	1	4%	37	63%	0.02	5.98	0.97	33	89%	2	5%	2	5%
	State Figures	**72**	**47**	**66%**	**-0.01**	**-18.81**	**-2.16**	**311**	**65**	**90**	**19**	**75**	**16**	**227**	**31%**	**0.01**	**16**	**1.0**	**196**	**86**	**22**	**10**	**9**	**4.0**

ANNEXURE XV - Fluctuation and Frequency distribution from different ranges from one period to other Jan, 2019 from Jan, 2018

Sl. No	District	No of Wells Analyzed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
							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	41	0.09	4.64	0.20	16.31	2	5	0	0	1	2	15	37	6	15	15	36	3	36
2	Chittoor	45	0.03	2.53	0.22	13.55	3	7	2	4	0	0	17	38	8	18	11	24	5	36
3	YSR Kadapa	26	0.10	1.52	0.52	10.89	5	19	0	0	0	0	6	23	6	23	7	26	5	19
4	East Godavari	86	0.03	5.66	0.03	6.33	47	55	4	5	1	1	27	31	6	7	1	1	52	34
5	Guntur	90	0.06	4.83	0.03	8.81	31	34	0	0	1	1	41	45	7	8	7	7	32	55
6	Krishna	66	0.02	17.75	0.02	12.02	44	67	1	2	1	2	10	15	3	3	2	3	46	15
7	Kurnool	43	0.28	4.68	0.04	9.80	5	12	1	2	1	2	15	35	10	23	8	18	7	33
8	Nellore	55	0.03	5.88	0.13	9.09	7	13	0	0	1	2	28	51	9	16	6	10	8	43
9	Prakasam	59	0.01	66.90	0.01	9.62	13	22	1	2	4	7	18	30	5	8	6	10	18	29
10	Srikakulam	43	0.08	3.70	0.03	4.90	24	56	2	5	0	0	13	30	2	4	2	4	26	17
11	Visakhapatnam	56	0.03	1.91	0.03	5.51	29	52	0	0	0	0	21	37	3	5	1	2	29	25
12	Vizianagaram	44	0.05	2.62	0.10	3.70	13	30	1	2	0	0	26	59	4	9	0	0	14	30
13	West Godavari	52	0.01	3.90	0.09	2.60	31	60	4	8	0	0	15	28	1	2	0	0	35	16
Total State		**706**	**0.01**	**66.90**	**0.01**	**16.31**	**254**	**90%**	**16**	**6%**	**10**	**4%**	**252**	**65%**	**70**	**18%**	**66**	**17%**	**280**	**388**

ANNEXURE XVI - Fluctuation and Frequency distribution from different ranges from one period to other May, 2018 from Decadal mean of May(2008-17)

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	ANANTAPUR	48	16	33%	-27.24	-0.17	-5.26	6	38%	5	31%	5	31%	32	67%	0.12	11.55	2.94	15	47%	10	31%	7	22%
2	CHITTOOR	45	14	31%	-5.02	-0.35	-1.74	11	79%	2	14%	1	7%	31	69%	0.01	17.34	5.10	11	35%	7	23%	13	42%
3	KADAPA	29	6	21%	-2.44	-0.37	-1.57	3	50%	3	50%	0	0%	23	79%	0.41	20.10	4.61	8	35%	8	35%	7	30%
4	EAST GODAVARI	67	40	60%	-16.37	-0.37	-1.67	29	73%	8	20%	3	8%	27	40%	0.07	28.04	3.44	18	67%	4	15%	5	19%
5	GUNTUR	81	55	68%	-6.33	-0.02	-1.41	40	73%	11	20%	4	7%	26	32%	0.00	14.83	2.13	18	69%	5	19%	3	12%
6	KRISHNA	53	41	77%	-13.09	-0.07	-2.24	29	71%	6	15%	6	15%	12	23%	0.11	7.87	2.46	7	58%	3	25%	2	17%
7	KURNOOL	40	17	43%	-16.02	-0.08	-2.19	14	82%	1	6%	2	12%	23	58%	0.11	11.60	3.60	13	57%	3	13%	7	30%
8	NELLORE	46	29	63%	-7.69	-0.03	-2.35	15	52%	7	24%	7	24%	17	37%	0.05	9.32	3.18	7	41%	6	35%	4	24%
9	PRAKASAM	48	31	65%	-8.22	-0.11	-2.12	19	61%	7	23%	5	16%	17	35%	0.05	11.85	4.67	5	29%	6	35%	6	35%
10	SRIKAKULAM	36	14	39%	-2.94	-0.07	-0.86	13	93%	1	7%	0	0%	22	61%	0.12	7.55	2.50	14	64%	3	14%	5	23%
11	VISAKHAPATNAM	58	20	34%	-5.72	-0.01	-1.31	15	75%	4	20%	1	5%	38	66%	0.01	15.52	2.01	27	71%	7	18%	4	11%
12	VIZIANAGARAM	37	15	41%	-1.84	-0.15	-0.76	15	100%	0	0%	0	0%	22	59%	0.04	9.56	2.44	13	59%	4	18%	5	23%
13	WEST GODAVARI	42	17	40%	-5.95	-0.10	-1.87	12	71%	3	18%	2	12%	25	60%	0.01	37.22	6.11	17	68%	0	0%	8	32%
	STATE FIGIURES	630	**315**	**50%**	**-27.24**	**-0.02**	**-1.44**	**221**	**70%**	**58**	**18%**	**36**	**11%**	**315**	**50%**	**0.00**	**28.04**	**2.56**	**173**	55%	**66**	**21%**	**76**	**24%**

ANNEXURE XVII - Fluctuation and Frequency distribution from different ranges from one period to other Aug, 2018 from Decadal mean of Aug (2008-17)

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	Anantapur	44	18	41%	-0.08	-8.531	-2.44	11	61%	3	17%	4	22%	26	59%	0.14	13.37	2.52	15	58%	6	23%	5	19%
2	Chittoor	43	22	51%	-0.23	-5.585	-1.90	13	59%	7	32%	2	9%	21	49%	0.00	5.67	1.97	10	48%	8	38%	2	10%
3	Kadapa	29	11	38%	-0.19	-6.656	-2.22	7	64%	2	18%	2	18%	18	62%	0.05	8.01	1.47	14	78%	3	17%	1	6%
4	East Godavari	83	35	42%	-0.03	-3.840	-0.79	32	91%	3	9%	0	0%	48	58%	0.07	2.74	0.82	43	90%	5	10%	0	0%
5	Guntur	91	43	47%	-0.08	-7.690	-1.58	34	79%	3	7%	6	14%	48	53%	0.01	4.84	0.99	44	92%	3	6%	1	2%
6	Krishna	67	12	18%	-0.20	-7.590	-2.01	8	67%	2	17%	2	17%	55	82%	0.05	6.50	1.51	44	80%	3	5%	8	15%
7	Kurnool	44	27	61%	-0.04	-6.463	-1.93	16	59%	7	26%	4	15%	17	39%	0.23	6.09	1.80	13	76%	2	12%	2	12%
8	Nellore	57	48	84%	-0.04	-5.405	-1.59	33	69%	11	23%	4	8%	9	16%	0.03	3.70	1.25	8	89%	1	11%	0	0%
9	Prakasam	60	46	77%	-0.05	-34.535	-2.71	25	54%	17	37%	4	9%	14	23%	0.00	4.80	1.27	10	71%	0	0%	3	21%
10	Srikakulam	44	8	18%	-0.02	0.065	-0.29	8	100%	0	0%	0	0%	36	82%	0.07	4.63	1.12	30	83%	5	14%	1	3%
11	Visakhapatnam	60	32	53%	-0.02	0.028	-1.02	28	88%	3	9%	1	3%	28	47%	0.03	3.49	0.85	25	89%	3	11%	0	0%
12	Vizianagaram	48	30	63%	-0.03	0.059	-1.28	23	77%	6	20%	1	3%	18	38%	0.06	2.87	0.96	15	83%	3	17%	0	0%
13	West Godavari	50	13	26%	-0.02	0.028	-0.66	12	92%	1	8%	0	0%	37	74%	0.03	4.07	0.84	33	89%	3	8%	1	3%
	State Figures	720	**345**	**48%**	**-0.23**	**0.07**	**-1.57**	**250**	**72%**	**65**	**19%**	**30**	**9%**	**375**	**52%**	**0.00**	**13.37**	**1.34**	**304**	**81%**	**45**	**12%**	**24**	**6%**

ANNEXURE XVIII - Fluctuation and Frequency distribution from different ranges from one period to other Nov,2018 from Decadal mean of Nov (2008-17)

S NO	DISTRICT	TOTAL MONITORED	NO OF WELLS FALL	% OF WELLS FALL	MAXIMUM	MINIMUM	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS	NO OF WELLS RISE	% OF WELLS RISE	MIN	MAX	AVERAGE	0 TO 2 m	% OF WELLS	2 TO 4 m	% OF WELLS	>4 m	% OF WELLS
			FALL IN WL											RISE IN WL										
1	Anantapur	32	25	78%	-21.20	-0.014	-3.26	12	48%	7	28%	6	24%	7	22%	0.05	3.35	0.93	6	86%	1	14%	0	0%
2	Chittoor	35	23	66%	-10.15	-0.074	-3.17	10	43%	5	22%	8	35%	12	34%	0.07	4.41	1.02	11	92%	0	0%	1	8%
3	Kadapa	21	14	67%	-6.13	-0.302	-3.12	5	36%	4	29%	4	29%	7	33%	0.08	6.51	2.27	4	57%	2	29%	1	14
4	East Godavari	64	41	64%	-7.83	-0.022	-1.07	35	85%	3	7%	3	7%	23	36%	0.01	1.56	0.36	23	100%	0	0%	0	0%
5	Guntur	71	55	77%	-18.37	-0.049	-2.18	35	64%	11	20%	9	16%	16	23%	0.03	1.64	0.45	16	100%	0	0%	0	0%
6	Krishna	44	27	61%	-4.98	-0.002	-1.08	21	78%	5	19%	1	4%	17	39%	0.07	2.11	0.59	16	94%	1	6%	0	0%
7	Kurnool	34	26	76%	-7.19	-0.114	-2.81	14	54%	5	19%	7	27%	8	24%	0.20	0.79	0.36	8	100%	0	0%	0	0%
8	Nellore	36	35	97%	-9.77	-0.415	-3.52	11	31%	13	37%	11	31%	1	3%	1.68	1.68	1.68	1	100%	0	0%	0	0%
9	Prakasam	38	32	84%	-16.96	-0.134	-3.67	15	47%	6	19%	11	34%	6	16%	0.08	9.93	2.77	3	50%	2	33%	1	17
10	Srikakulam	33	11	33%	-0.99	-0.090	-0.39	11	100%	0	0%	0	0%	22	67%	0.02	2.90	0.63	20	91%	2	9%	0	0%
11	Visakhapatnam	47	40	85%	-4.92	-0.009	-1.33	30	75%	9	23%	1	3%	7	15%	0.01	0.57	0.23	7	100%	0	0%	0	0%
12	Vizianagaram	35	33	94%	-3.16	-0.080	-1.20	26	79%	7	21%	0	0%	1	3%	0.25	0.25	0.25	2	200%	0	0%	0	0%
13	West Godavari	44	34	77%	-3.66	-0.024	-0.64	31	91%	3	9%	0	0%	9	20%	0.13	6.14	1.21	8	89%	0	0%	1	11
	State Figures	534	**396**	**74%**	**-21.20**	**-0.002**	**-2.11**	**256**	**65%**	**78**	**20%**	**61**	**15%**	**136**	**25%**	**0.01**	**9.93**	**0.98**	**125**	**92%**	**8**	**6%**	**4**	**3%**

ANNEXURE XIX - Fluctuation and Frequency distribution from different ranges from one period to other Jan, 2019 from Decadal mean of Jan (2009-18)

Sl. No	District	No of Wells Analyzed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
							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	%		
1	Anantapur	38	0.05	5.92	0.03	10.48	7	18	0	0	2	5.26	11	29	10	26	8	21	9	29
2	Chittoor	45	0.07	2.35	0.03	6.34	6	13	3	7	0	0	16	36	13	29	7	16	9	36
3	YSR Kadapa	26	0.13	5.25	0.03	7.02	6	23	3	12	1	3.85	3	12	8	31	5	19	10	16
4	East Godavari	91	0.02	2.04	0	5.73	39	43	1	1	0	0	45	49	4	4	2	2	40	51
5	Guntur	92	0.01	1.61	0.06	15.92	24	26	0	0	0	0	45	49	9	10	14	15	24	68
6	Krishna	67	0	7.52	0.03	11.79	28	42	0	0	1	1.49	28	42	5	7	5	7	29	38
7	Kurnool	45	0.04	6.14	0.07	7.35	12	27	1	2	1	2.22	15	33	10	22	6	13	14	31
8	Nellore	57	0.04	1.26	0.12	9.4	10	18	0	0	0	0	25	44	9	16	13	23	10	47
9	Prakasam	60	0.23	2.64	0.04	18.98	6	10	2	3	0	0	22	37	13	22	17	28	8	52
10	Srikakulam	44	0.07	4.09	0.08	3.55	27	61	4	9	1	2.27	11	25	1	2	0	0	32	12
11	Visakhapatnam	57	0.07	2.88	0.02	12.74	18	32	1	2	0	0	28	49	8	14	2	4	19	38
12	Vizianagaram	44	0.18	1.17	0.03	3.31	9	20	0	0	0	0	29	66	5	11	0	0	9	34
13	West Godavari	53	0.06	2.36	0.02	5.67	27	51	1	2	0	0	23	43	1	2	1	2	28	25
Total State		**719**	**0**	**7.52**	**0**	**18.98**	**219**	**91%**	**16**	**7%**	**6**	**2%**	**301**	**63%**	**96**	**20%**	**80**	**17%**	**241**	**477**

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

District	Min/Max/Avg	pH	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	F	TDS
			→					in mg/L					←
	Min	6.3	20	2	2.4	1	0	12	7	0	0	0.1	25
	Max	8.69	3800	721	778	4200	600	1464	4857	2774	991	4.04	12592
	Avg	7.6	493	95.2	62.2	201.1	37.3	436.8	317	108.5	63.6	0.8	1153.2
	Min	6.5	50	12	4.88	11	0	61	11	4.8	0	0.32	85
	Max	8.25	1800	289	299.33	334	598	952	773	302	909	4.04	3160
	Avg	7.64	484.18	97.95	58.31	146.49	36.04	432.95	228.51	69.64	115.12	1.23	1017.9
	Min	7.14	35	6	2.44	10	0.78	31	14	3.4	0	0.22	64
	Max	8.18	1410	305	166.68	480	190	793	1347	150	222	2.13	2749
	Avg	7.68	423.41	90.43	48.09	130.66	17.48	382.11	234.86	53.21	27.21	0.76	835.80
	Min	7.17	55	12	3.69	23	0.78	49	7	0	1	0.28	125
	Max	8.69	1800	329	238.06	4200	90	1403	4857	1800	636	3.14	1259.2
	Avg	7.88	441.81	81.14	58.26	292.78	17.47	410.31	382.44	134.83	79.06	0.89	1355.7
	Min	6.7	75	2	9.78	1	1	49	11	1.5	0.2	0.2	146
	Max	8.56	1500	240	248.08	1838	208	1116	3049	450	166	1.67	6356
	Avg	7.62	459.56	77.96	64.44	197.04	36.47	468.27	312.98	76.65	33.59	0.54	1078.9
	Min	6.94	175	14	7.43	46	2	214	64	10	0	0.13	374
	Max	8.26	3300	501	546.95	1046	400	1074	2552	680	670	3.25	6081
	Avg	7.55	623.14	117.96	79.95	265.32	68.88	541.66	407.29	172.41	98.88	0.90	1541.3
	Min	6.37	90	10	7.45	23	0.78	311	46	1	0	0.17	360

	Max	8.19	3400	721	389.28	2400	500	1464	3403	2210	249	4	8729
	Avg	7.52	625.40	113.79	83.03	288.79	64.24	590.83	466.89	146.14	40.70	0.73	1547.2
	Min	6.3	115	2	2.62	16	0.39	140	21	11	0	0.26	207
	Max	8.12	3800	561	778.31	2599	600	976	3687	2774	991	3	11474
	Avg	7.51	616.28	122.19	75.71	265.51	32.50	390.77	373.09	275.51	114.07	0.80	1493.7
	Min	6.89	110	24	6.18	28	0.7	37	32	3.8	0.8	0.1	220
	Max	7.79	1020	228	150.94	906	150	811	1305	407	198	1.5	3270
	Avg	7.44	430.58	86.54	52.19	221.42	29.67	394.27	340.73	102.99	37.27	0.53	1111.4
	Min	6.89	215	16	12.24	60	0	232	85	22	0.6	0.12	471
	Max	7.75	1890	261	311.33	1000	190	976	2411	387	431	2.64	4611
	Avg	7.40	531.30	85.15	77.52	292.44	37.76	457.78	457.41	128.63	64.87	0.90	1423.5
	Min	7.05	65	16	4.9	7	1	55	7	2	1	0.2	114
	Max	8.1	1200	216	214.11	515	250	634	1390	317	304	1.53	2745
	Avg	7.56	404.69	86.08	46.18	115.22	28.80	314.24	235.67	50.84	52.80	0.50	807.5
	Min	7.07	20	2	2.44	1	0.78	12	7	0	0	0.16	25
	Max	8.25	730	132	139.88	836	104	1409	851	185	166	2.5	2781
	Avg	7.78	309.91	56.77	40.91	108.14	11.70	343.91	140.96	41.63	38.07	0.66	647.6
	Min	7.15	70	12	9.74	8	0.8	85	11	3	0	0.24	99
	Max	7.99	820	176	99.88	202	156	580	617	163	218	1.9	1345
	Avg	7.52	356.35	78.42	39.07	87.75	21.59	328.56	155.19	40.94	47.42	0.64	671.23
	Min	7.24	150	32	9.81	20	3.9	146	18	7.2	0	0.15	231
	Max	8.05	2350	353	376.64	1224	340	1275	2942	398	272	1.55	5226
	Avg	7.68	591.03	119.44	71.24	223.59	41.65	488.97	431.03	82.42	34.46	0.38	1302.3

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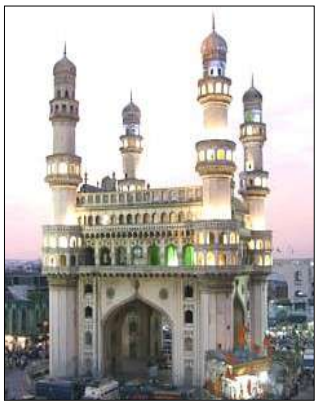

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