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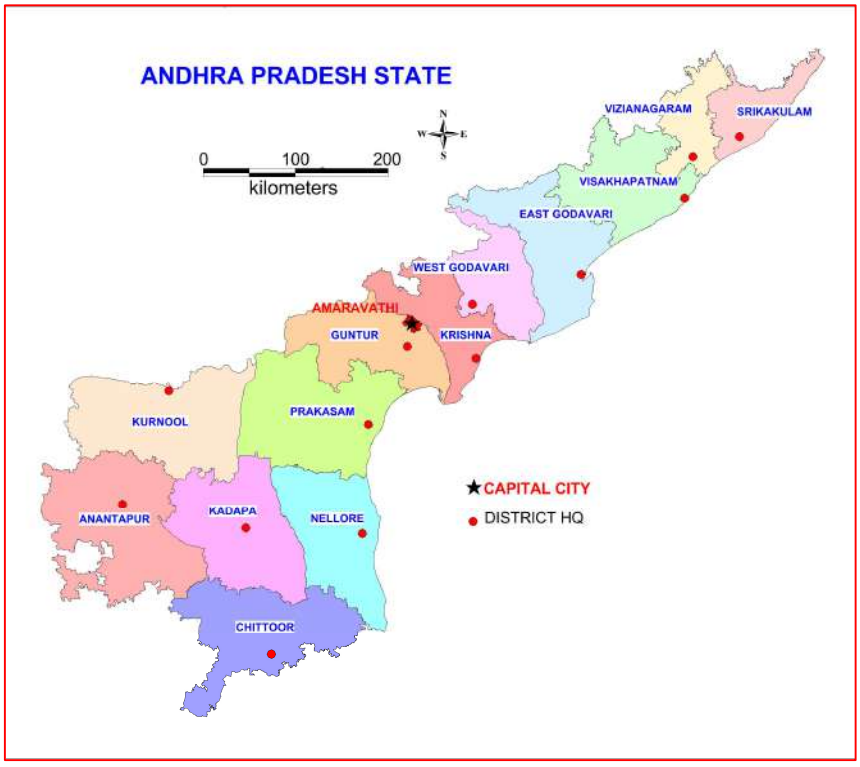
Central Ground Water Board

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

GROUND WATER YEAR BOOK
2016-17
ANDHRA PRADESH STATE



Southern Region, Hyderabad
September, 2017

Central Ground Water Board
Ministry of Water Resources,
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GROUND WATER YEAR BOOK
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ANDHRA PRADESH STATE

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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 31-3-2017, a total of 855 operational ground water monitoring wells (GWMS) (DW: 742, Pz: 113) 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 2016-17 is compiled in the form of Ground Water Year Book. It outlines the ground water level behavior 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 sincere efforts made by **Sri. P.Sudhakar, Scientist-D (HM)** in preparation of the report is commendable. The effort from officers of chemical laboratory namely Shri K. Bhaskar Reddy, Shri K. Maruthi Prasad and Shri Y. Satyakumar who analyzed the samples and contributed technically is note worthy. Shri GRC Reddy, Scientist-D and S.Renuka, Scientist-B (GP) of Report Processing Section in scrutiny, processing and issuance of the report are also appreciated.

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 Andhra Pradesh.

Hyderabad **(D Subba Rao)**
Dated: 4-10-2017 **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%. The State is mainly drained by Godavari, Krishna, Pennar, Vamsadhara, Nagavalli, Gundlakamma rivers. A major part of the area is underlain by gneissic complex while the balance area is covered by sedimentary and alluvial formations. During the year 2016, the state received annual average rainfall of 845 mm, which is 11 % less than the normal i.e., 950 mm. The district mean rainfall ranges from 395 mm (Anantapuramu) to 1158 mm (Vizianagaram).

Ground water monitoring is carried out as part of National ground water monitoring programme four times a year (January, May, August and November) and ground water quality one time (May). As on 31.03.2017, total of 855 Ground Water Monitoring Wells (GWMS) are in existence while 159 observers are observing water levels on participatory mode.

Aquifer-wise water level analysis shows that during both pre and post-monsoon seasons, shallow water levels are observed in alluvial formations all along the coast, which is due to canal command and low ground water development. Deeper water levels observed in Shales, falling in drought affected areas, can be attributed to low rainfall and high ground water utilisation.

Ground water levels are shallow in north coastal districts and deep in Rayalaseema, upland tracts of Prakasam and West Godavari districts. As on November, 2016 (post monsoon), deeper water levels of more than 20 m are observed in Prakasam, Kurnool and YSR Kadapa districts which is due to deficient rainfall, and long term water level falling trend is also observed in all the seasons.

Ground water quality is assessed during pre-monsoon season of 2016 by collecting 684 samples. Nitrate contamination owing its origin to anthropogenic is seen all over the state, with an average concentration of 66 mg/l and 40% of samples exceeding BIS permissible limits. High concentrations of fluoride (>1.5 mg/l) are detected as isolated patches in the state, except in Srikakulam and SPS Nellore districts.

GROUND WATER YEAR BOOK
(2016–2017)
ANDHRA PRADESH STATE

1. INTRODUCTION

Central Ground Water Board has taken up the task of complex issues of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity. 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-.2017, there were 855 operational Ground Water Monitoring Wells (GWMS (742 dug wells and 113 piezometers). During the year (2016-17), 23 Ground water monitoring wells (22 Dug wells and 1 Piezometers) were abandoned and 30 new ground water monitoring wells (19 DW and 11 PZ) were established.

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 programmes 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 east by Bay of Bengal (~970 km), on south by

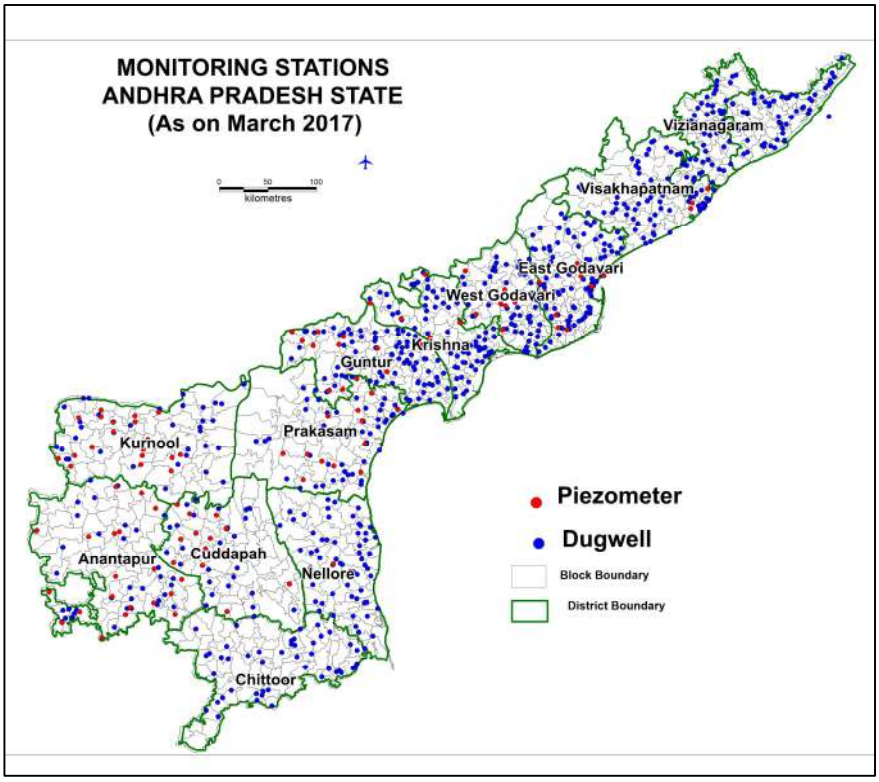


Fig.1.1: Location of GWMS in Andhra Pradesh State (as on 31st March, 2017).

Tamilnadu and Karnataka, on west by Karnataka and Telangana and on north by Telangana, Chattisgarh and Orissa states (**DES, Govt of AP, 2015**).

Administratively, the State is divided into 13 districts (Srikakulam, Vizianagar, Vishakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasham, SPS Nellore, YSR Cuddapah, Kurnooll, Ananthapuramu 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 from 188 persons/km^2 in YSR Cuddapaha 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 (2016–17) depicts the ground water **l**evel scenario in the State and describes the behaviour of water levels during the period. The observation wells are distributed more or less uniformly over the State.

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**).

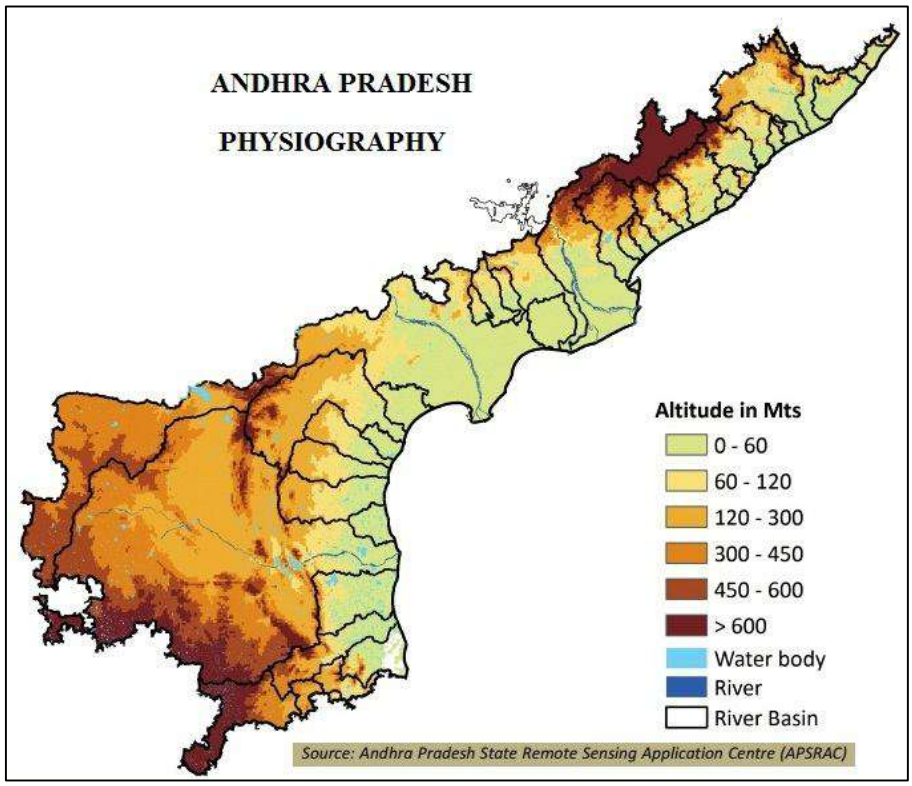


Fig.2.1: Physiography map of AP (after APRAC-2014).

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**.**

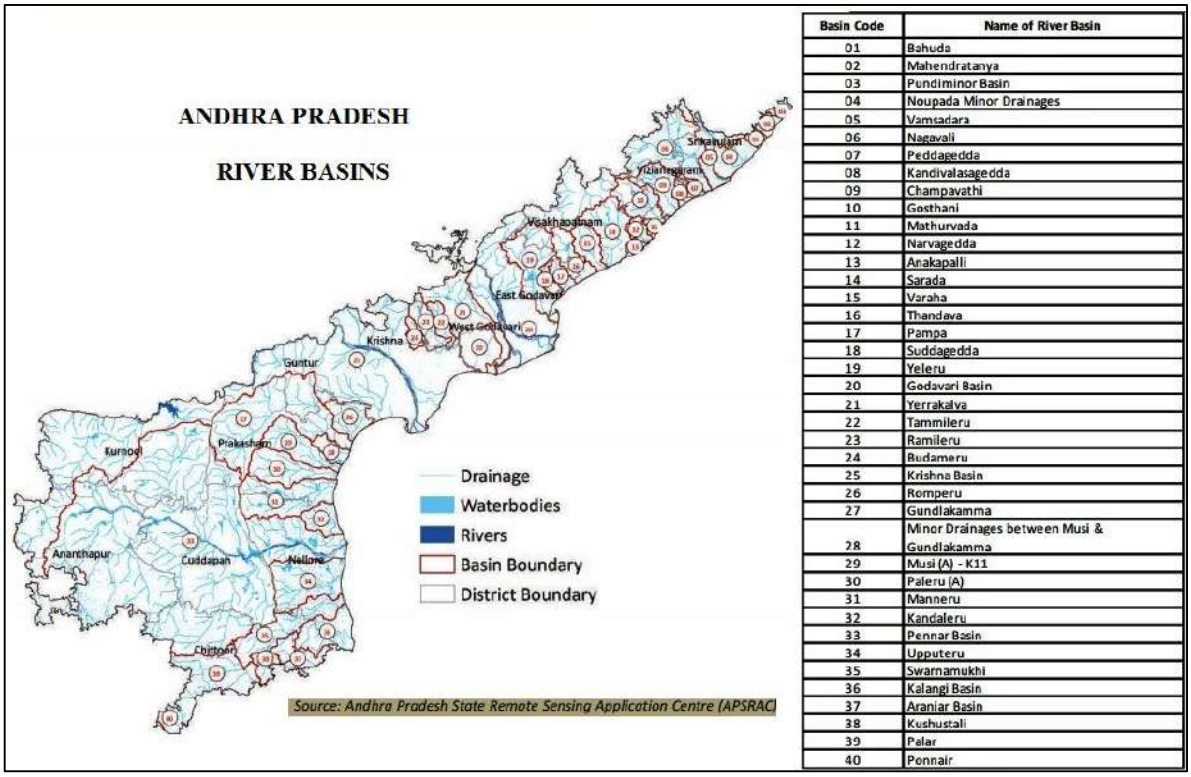
2.1.3 Western Pedeplains

A major part of State covering parts of Rayalaseema region (Kurnool and Anantapur districts), fall in this category. The pedeplains show rolling topography with flat to undulating tracts. This plateau in the interior of the State extends largely between elevation 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 peneplain. 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 distributory canal system. The mature river courses of Godavari, Krishna and Pennar meanders through the vast areas covered by delats as well as coastal plains. 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 charecterised by undulating topography comprising a series of ridges and valleys intersperse by hill ranges. The seltas of rivers are very extensive and charecterised by considerable thichness of alluvial material. Vamsadhara and Nagavalli rivers with their distributaries drain the northeastern part of the state in Srikakulam district. Visakhapatnam district is mostly drained by local rivulets like Sarada. River Yeleru drains most of the East Godavari district while Yerrakalava, Tammileru drain West Godavari district. Nellore district is drained by Pennar, Swarnamukhi and Araniar rivers.



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

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

2.3 Soils

The State has a wide variety of soils viz., Red soil, Laterite, Black Cotton soil, Deltaic Alluvium soil, Coastal soil and Saline soil. Red clayey soil 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.**

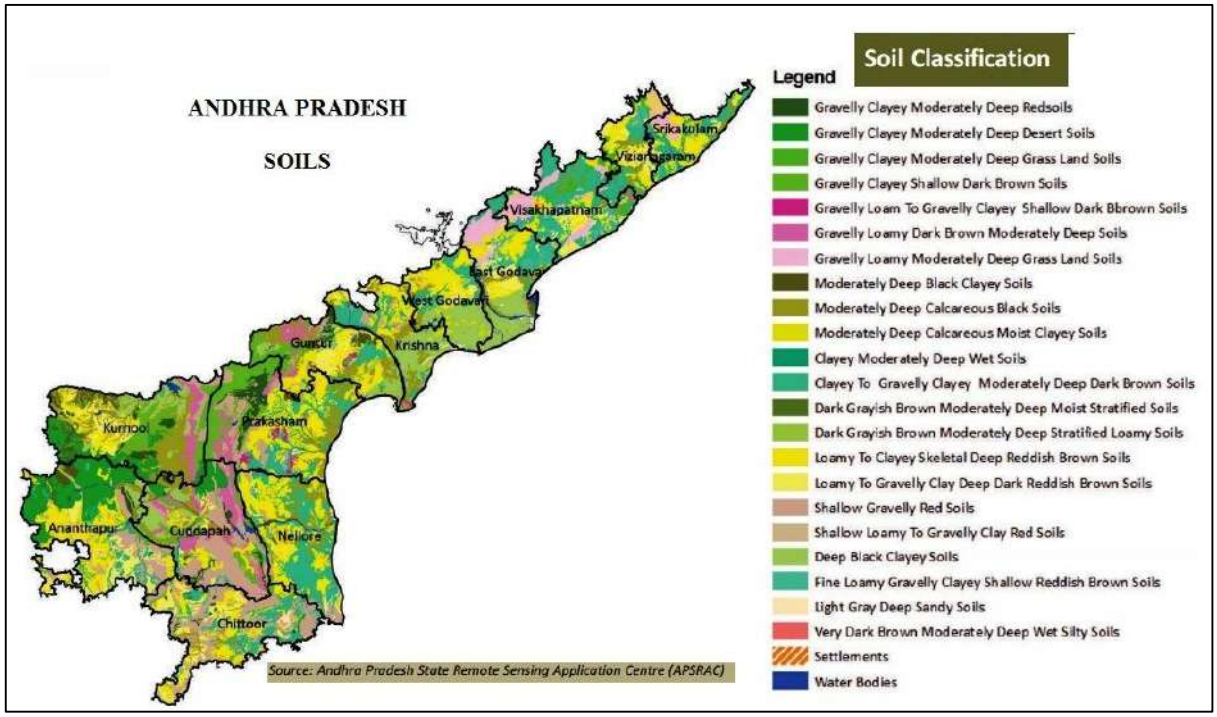


Fig.2.3: Soil Map of AP (after APSRAC-2014).

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 in the **Table-3.1**.

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

3.2 Rainfall Analysis - 2016

District-wise monthly, seasonal, annual and normal rainfall and departure from normal is given in the Table-3.2. 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 is 951 mm. Season-wise normal rainfall is 555 mm, 285 mm, 9.8 mm and 96.3mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, 58% of annual rainfall occur in SW monsoon, 30% in north-east and 12% in non-monsoon seasons. Annual normal rainfall ranges from 341 mm in Atmakur mandal, Anantapuramu district to 1623 mm in Munchingipattu mandal, Visakhapatnam district(Fig 3.2).

- The mean annual rainfall during 2016 is 845 mm. Season-wise rainfall is 623 mm, 99 mm, 4 mm and 119 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 73.7% of annual rainfall in SW monsoon, 11.7% in north-east and 14.6% in non-monsoon seasons. The annual (2016) rainfall ranges from 595 mm in SPS Nellore district (deficit by 46%) to 966 mm (more by 11%) in Guntur district. Annual rainfall was deficit in SPS Nellore, Prakasam, Anantapur and Chittoor districts. In all other districts is was normal. Monthly mean rainfall ranges from 0.8 mm in February to 196 mm in September.

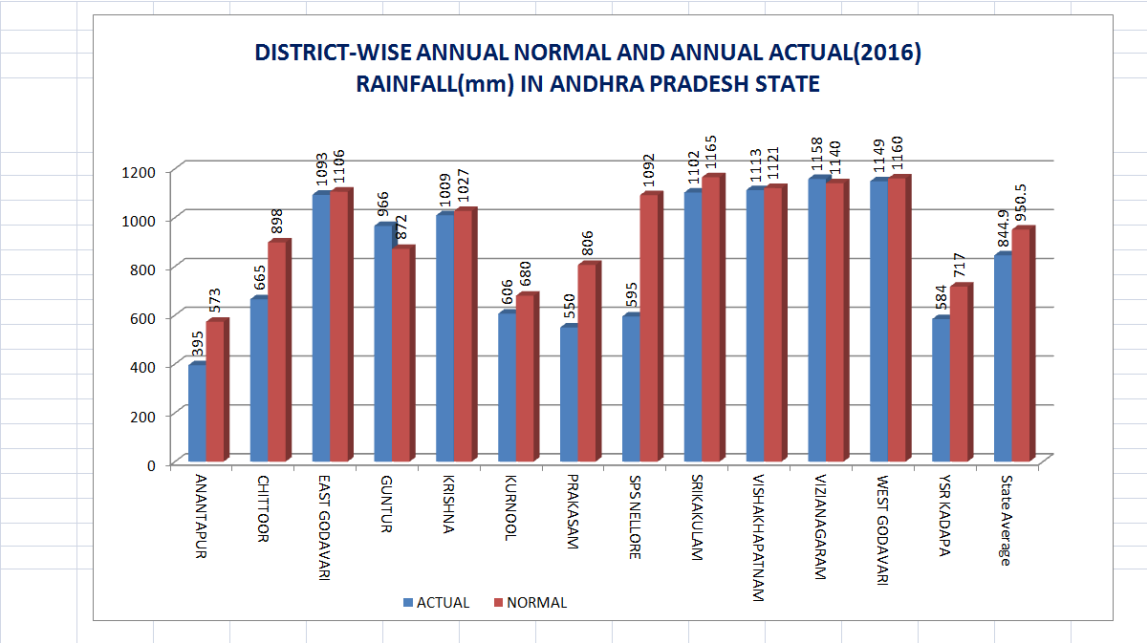


Fig.3.1: District-wise Annual Normal and Actual (2016) rainfall.

The rainfall received during the period Jan, 2015 to Dec, 2016 is compiled and analysed for correlating with water levels monitored during the period May, 2016, Aug, 2016, Nov,2016 and Jan, 2017. The data is presented in **Table-3.2 to 3.5** and depicted in the **Fig. 3.3 to 3.10.**

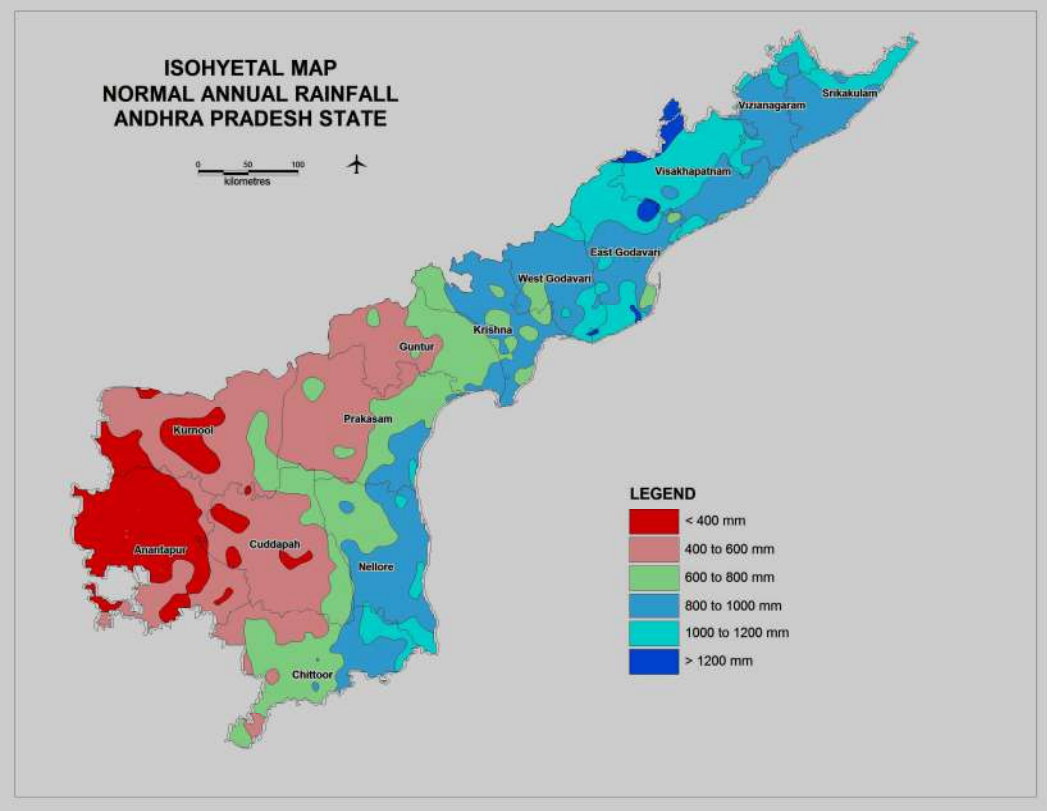


Fig.3.2: Isohytel map of Andhra Pradesh State (Normal annual rainfall in mm).

Table-3.1: Monthly Normal and Actual (2016) rainfall (mm) in Andhra Pradesh State.

		JAN		FEB		MAR		APR		MAY		JUNE		JULY	
S No	**DISTRICT**	ACTUAL	NORMAL	ACTUAL	NORMAL	ACTUAL	NORMAL	ACTUAL	NORMAL	ACTUAL	NORMAL	ACTUAL	NORMAL	ACTUAL	NORMAL
1	ANANTAPUR	9.8	3	0	3.3	0.1	6.1	0.5	18.9	94.8	56.7	96.9	55.2	108	64.3
2	CHITTOOR	2.9	7.7	0	7.6	3	10.1	0.4	25.6	107.3	67.2	137.4	66.8	154	100.1
3	EAST GODAVARI	1.9	6	0.1	10.1	0.3	11.3	0	22.8	121.4	75.3	266.3	131.9	211	206.4
4	GUNTUR	0.2	5.5	0	7.7	0	7.7	0.2	15	112.8	58.4	199.6	90.2	88	147.3
5	KRISHNA	1	4.6	0	6.3	1.1	8.7	0	16.9	115.2	46.8	308.9	120.9	113	216.6
6	KURNOOL	4.2	1.2	0	1.9	0.6	5.7	0.5	18.3	71.1	51.7	151	80.5	131	115.8
7	PRAKASAM	0.4	7.9	0	8.8	5.4	10.5	0.1	14.9	58.7	52.3	100.4	64.3	60	99.3
8	SPS NELLORE	7	15.7	0	11.6	0	6	0.6	15.2	123.4	51.4	88.5	53.4	68	91.2
9	SRIKAKULAM	1.2	7.9	6.4	18.1	8.3	17.2	8.4	26.3	189.6	63.9	185.9	145	156	190.2
10	VISHAKHAPATNAM	0.4	8.8	3.7	10.8	13	17.6	10.8	44.7	160	96.6	189.3	132.6	200	178.2
11	VIZIANAGARAM	0.3	8.7	0	14.4	13.5	17.7	14.7	32.3	156.5	90.7	200.3	140.7	204	181.5
12	WEST GODAVARI	1.1	6.1	0	10.7	2.7	8.7	0	19	101.4	55.8	333.3	135.8	173	240.2
13	YSR KADAPA	14.7	1.9	0	2.4	0.1	4.7	0.1	17.3	47.7	47.6	133.9	69.8	137	101.1
	State Average	**3.5**	**6.5**	**0.8**	**8.7**	**3.7**	**10.2**	**2.8**	**22.1**	**112.3**	**62.6**	**184.0**	**99.0**	**138.7**	**148.6**

		AUG		SEP		OCT		NOV		DEC		ANNUAL		
S No	**DISTRICT**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**DEP(%)**
1	ANANTAPUR	13	74.5	44	128.8	5.3	115	2.6	35.3	19.6	11.6	395	573	**-31%**
2	CHITTOOR	22	110.2	46	140	33	167.2	11.6	137.3	147.5	58.4	665	898	**-26%**
3	EAST GODAVARI	153	188.4	256	177.2	69	199	10.2	69.8	4	7.8	1093	1106	**-1%**
4	GUNTUR	194	155.4	290	150.1	71.5	143.9	1.9	75.8	7.6	14.5	966	872	**11%**
5	KRISHNA	174	194.2	201	169.7	76	164.2	8.8	66.1	10.3	12.1	1009	1027	**-2%**
6	KURNOOL	72	124.3	163	139.6	9	105.6	2.2	28.4	1.6	6.6	606	680	**-11%**
7	PRAKASAM	92	95.9	147	123	14	181.9	10.9	115	60.9	32.1	550	806	**-32%**
8	SPS NELLORE	25	95	62	112.8	29	248.2	32.2	283.9	159	107.2	595	1092	**-46%**
9	SRIKAKULAM	111	202.4	294	208.1	104	211.4	36.9	69.8	0.7	4.9	1102	1165	**-5%**
10	VISHAKHAPATNAM	148	178.2	284	185.4	95	204.3	7.3	59.2	1.1	4.3	1113	1121	**-1%**
11	VIZIANAGARAM	127	194.8	335	209.1	104	188.1	2	56.3	0.6	6.1	1158	1140	**2%**
12	WEST GODAVARI	162	227.8	316	180.1	46	197.8	9.4	66.7	3.9	11.7	1149	1160	**-1%**
13	YSR KADAPA	59	108.6	110	124.6	12.4	137.3	2.2	77.2	66.7	24.4	584	717	**-19%**
	State Average	**104.0**	**150.0**	**196.0**	**157.6**	**51.4**	**174.1**	**10.6**	**87.8**	**37.2**	**23.2**	**845**	**951**	**-11%**

3.2.1 May, 2016

3.2.1.1 Rainfall Analysis (June, 2015 to May,2016 from June, 2014 to May,2015 rainfall)

The district wise rainfall for the period June,2015 to May, 2016 from June, 2014 to May, 2015 is given in **Table-3.3** and different thematic maps are presented in **Fig.3.3, and 3.4**.

Table-3.2: District-wise rainfall (June'15-May'16) and its departure from normal and June'14-May'15

S NO	DISTRICT	Rainfall (JUNE'15 - MAY'16)	Rainfall (JUNE'14-MAY'15)	NORMAL Rainfall (JUNE-MAY)	Departure (%) FROM JUNE'14-MAY'15	Departure from NORMAL	REMARK
1	Anantapur	662	487	573	36.1%	15.7%	Normal
2	Chittor	1353	721	898	87.6%	50.6%	Excess
3	East Godavari	1158	563	1106	105.8%	4.7%	Normal
4	Guntur	789	651	872	21.3%	-9.5%	Normal
5	Krishna	965	576	1027	67.5%	-6.0%	Normal
6	Kurnool	479	664	680	-27.9%	-29.5%	Deficit
7	Prakasam	653	499	806	30.8%	-19.0%	Normal
8	SPS Nellore	751	751	1092	0.1%	-31.2%	Deficit
9	Srikakulam	1095	1104	1165	-0.8%	-6.0%	Normal
10	Vishakhapatnam	1166	1056	1121	10.4%	4.0%	Normal
11	Vizianagaram	1168	1105	1140	5.7%	2.4%	Normal
12	West Godavari	1117	765	1160	46.0%	-3.7%	Normal
13	YSR Cuddapah	965	499	717	93.5%	34.6%	Excess
	STATE MEAN	**948**	**726**	**950**	**30.5%**	**-0.3%**	**Normal**

The figure 3.3 gives departure of Jun,2015- May,2016 rainfall with Jun,2014 to May,2015 rainfall. It is prepared to correlate with water level fluctuation map of May, 2016 from May, 2015. **Table 3.3** indicates that state has received 948 mm of rainfall during the period Jun'15- May'16, which is 30.5 % more than the rainfall received during Jun '14 to May'15. The departure in percentage ranges from -28 % in Kurnool district to 106 % in East Godavari district.

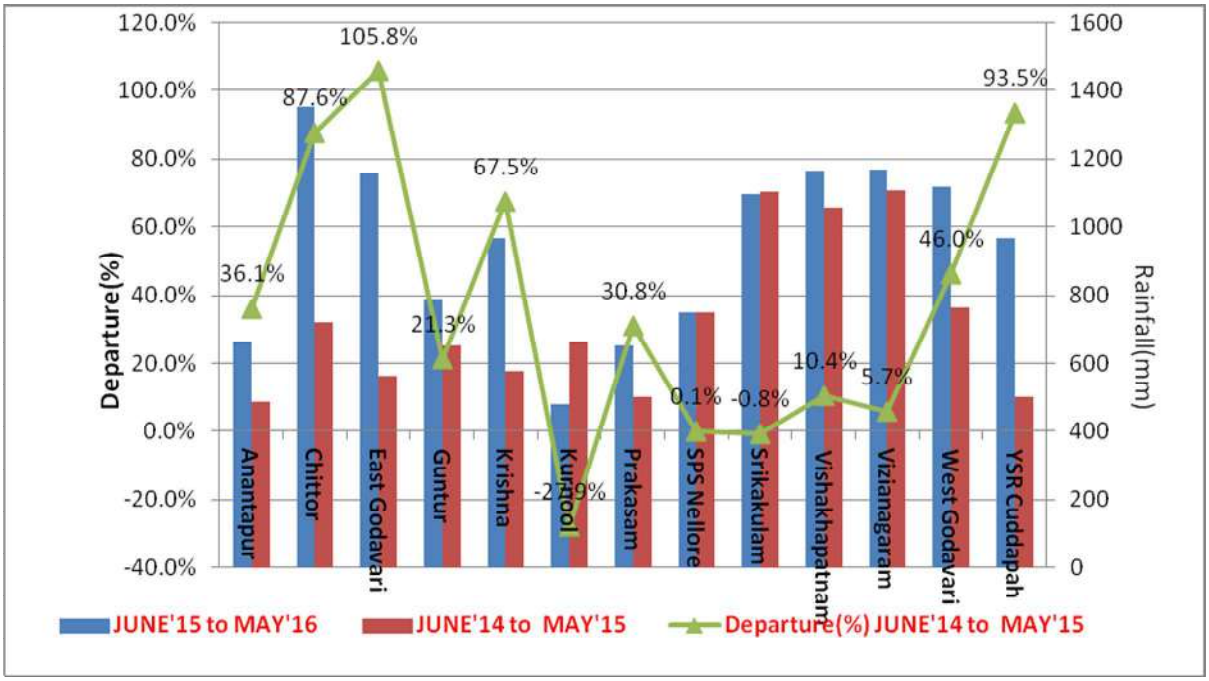


Fig.3.3: Rainfall Departure (June,2015- May,2016 from June,2014-May,2015)

3.2.1.2 Departure of rainfall during June, 2015-May, 2016 from normal rainfall of same period

The figure 3.4 gives departure of Jun, 2015- May, 2016 rainfall with normal of the same period. It is prepared to correlate with depth to water level map of May, 2016. During the period Jun,2015- May,2016, the state has received 0.3 % less rainfall than normal rainfall, which is 950 mm. It ranges from –31.2% in SPS Nellore district to 50.6 % in Chittoor district. Kurnool and SPS Nellore districts received deficit rainfall. Chittoor, and YSR Kadapa districts have received excess rainfall. All other distrifcts received normal rainfall.

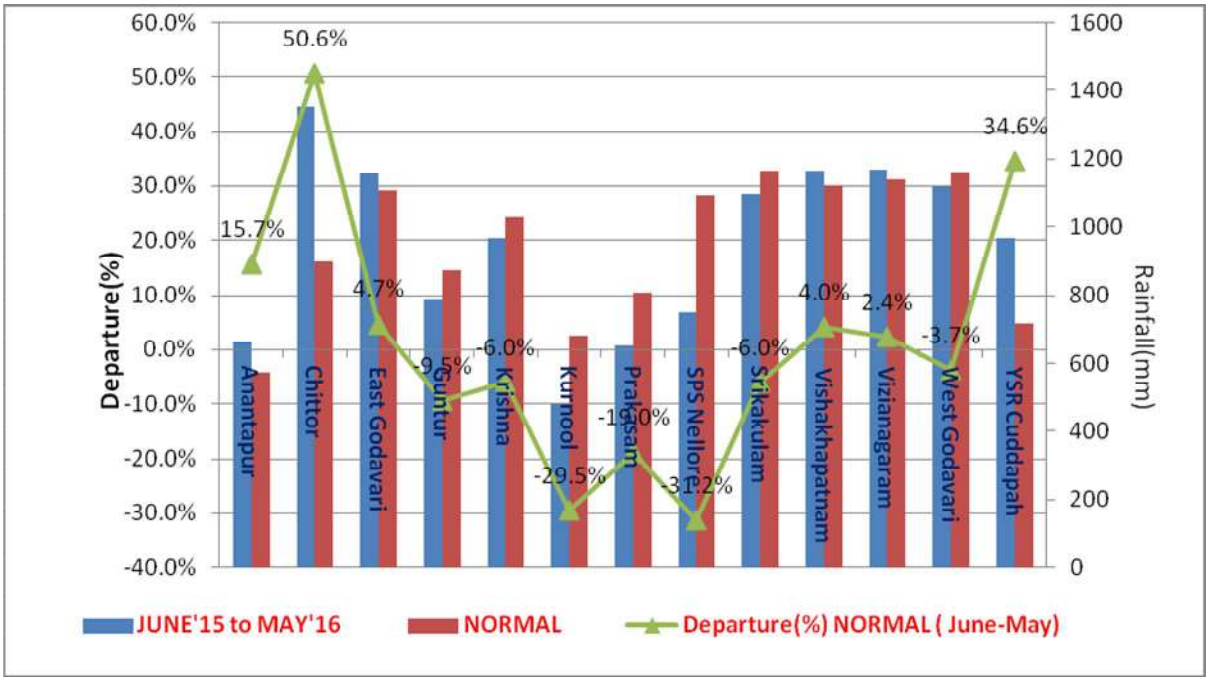


Fig.3.4: Rainfall Departure - Jun'15- May'16 from Normal of same Period.

3.2.2 August, 2016

The district wise rainfall for the period June,2016 -August,2016 from June,2015 – August, 2015 is given in **Table-3.4** and different thematic maps are presented in **Fig.3.5, and 3.6**.

Table-3.3: District-wise rainfall (June'15-Aug'16) and its departure from normal and June'14-Aug'15

		RAINFALL(mm)			DEPARTURE(%)		
S NO.	DISTRICT	JUNE'16-AUG'16	JUNE'15-AUG'15	NORMAL	JUNE'15-AUG'15	NORMAL	REMARK
1	Anantapur	218	179	194	21.80%	12.40%	NORMAL
2	Chittor	313	269	277	16.40%	13.00%	NORMAL
3	YSR Kadapah	330	258	280	27.90%	18.10%	NORMAL
4	East Godavari	630	657	527	-4.10%	19.60%	EXCESS
5	Guntur	482	422	393	14.20%	22.70%	EXCESS
6	Krishna	596	546	532	9.20%	12.10%	NORMAL
7	Kurnool	354	170	321	108.20%	10.40%	NORMAL
8	SPS Nellore	182	237	240	-23.20%	-24.00%	DEFICIT
9	Prakasam	252	262	260	-3.80%	-2.90%	NORMAL
10	Srikakulam	453	539	538	-16.00%	-15.70%	NORMAL
11	Vishakhapatnam	537	648	489	-17.10%	9.80%	NORMAL
12	Vizianagaram	531	619	517	-14.20%	2.70%	NORMAL
13	West Godavari	668	648	604	3.10%	10.60%	NORMAL
	STATE MEAN	**427**	**420**	**398**	**1.70%**	**7.30%**	NORMAL

3.2.2.1 Departure of rainfall during June, 2016 to August, 2016 from June, 2015-August, 2015

The figure 3.5 gives departure of rainfall with June,2015 to Aug,2015 rainfall. It is prepared to correlate with water level fluctuation map of Aug, 2016 with Aug, 2015. **Table 3.4** indicates that state has received 427 mm of rainfall during the period Jun,2016 to Aug,2016, which is 1.7 % more than the rainfall received during the same period last year. The state received about 420 mm of rainfall during the same period last year. The departure in percentage ranges from -23.2% in SPS Nellore district to 108% in Kurnool district.

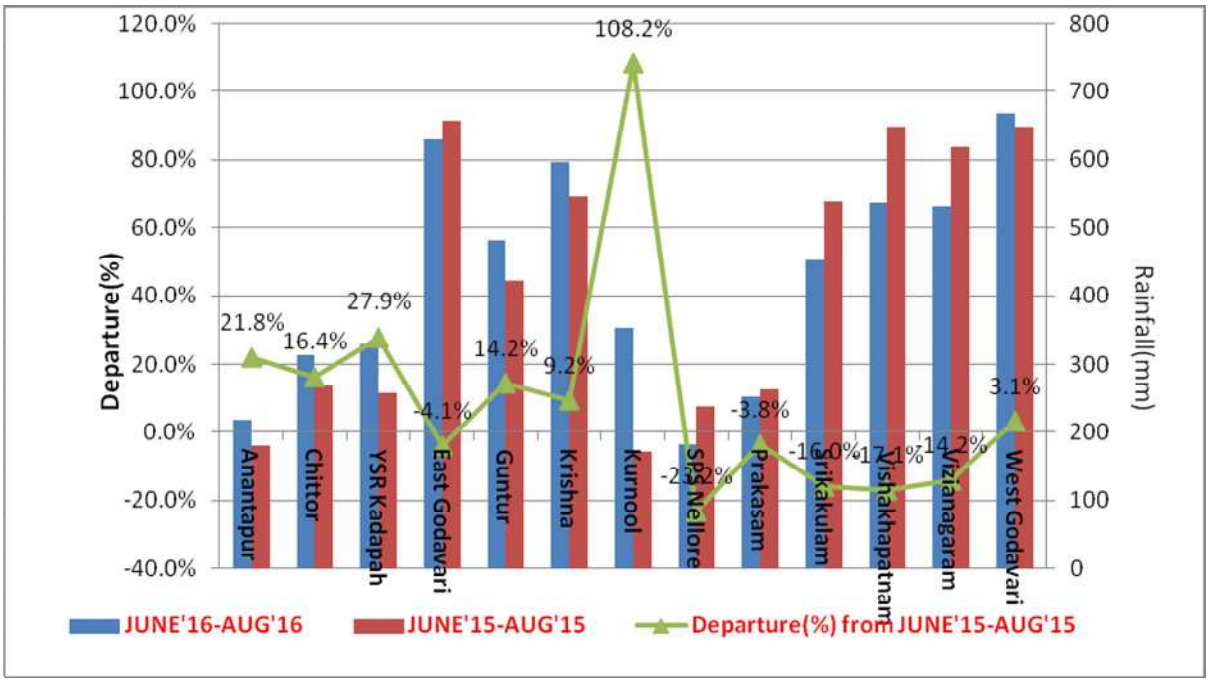


Fig.3.5: Rainfall Departure (June,2016-Aug,2016 from June, 2015-Aug,2015).

3.2.2.2 Departure of rainfall during June, 2016 to August, 2016 from normal rainfall

The figure 3.6 gives departure of June 2016 to Aug 2016 rainfall with normal rainfall of the same period. It is prepared to correlate with depth to water level map of Aug 2016. During the period June 2016 to Aug 2016, the state has received 7.3 % more rainfall than normal rainfall. It ranges from -24% in SPS Nellore to 22.7% in Guntur district. The deficit rainfall is observed only in SPS Nellore district and in the rest it received normal rainfall except in Guntur and East Godavari district where in it was excess rainfall.

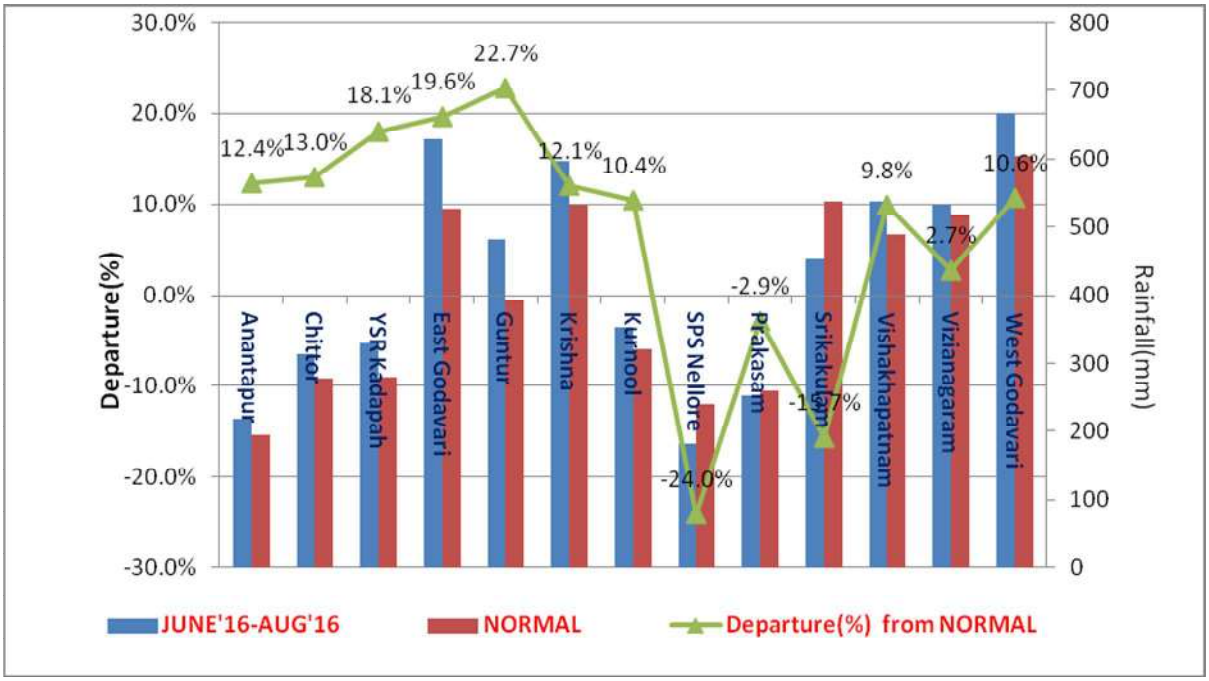


Fig.3.6: Rainfall Departure (June,2016 –Aug,2016 from Normal of the same Period).

3.2.3 November, 2016

The district wise rainfall for the period June, 2016 – October, 2016 from June,2015 – October, 2015 is given in **Table-3.5** and different thematic maps are presented in **Fig.3.7, and 3.8**.

3.2.3.1 Departure of rainfall (June,2016 to October,2016 from June,2015 to Oct, 2015)

The **figure 3.7** gives departure of Jun, 2016 to Oct, 2016 rainfall with June,2015 to Oct,2015 rainfall. It is prepared to correlate with annual water level fluctuation of Nov 2016. **Table 3.5** indicates that state has received 674 mm of rainfall during the period Jun, 2016 to Oct, 2016, which is 3.4 % more than the rainfall received during the same period last year. The state received about 652 mm of rainfall during the same period last year. The departure in percentage ranges from -37.6% in Anantapur district to 41.5% in Guntur district.

Table-3.5: District-wise rainfall (June'15-Oct'16) and its departure from normal and June'15-Oct'15

S NO	DISTRICT	Rainfall (JUNE'16 - OCT'16)	Rainfall (JUNE'15-OCT'15)	NORMAL Rainfall (JUNE-OCT)	Departure (%) JUNE'15-OCT'15	Departure from NORMAL	REMARK
1	Anantapur	267.2	428	438	-37.6%	-39.0%	Deficit
2	Chittor	392.4	553	584	-29.0%	-32.8%	Deficit

3	Cuddapah	452.3	479	541	-5.6%	-16.5%	Normal
4	Kurnool	526	378	566	39.2%	-7.0%	Normal
5	East Godavari	955.3	910	903	5.0%	5.8%	Normal
6	Guntur	843.1	596	687	41.5%	22.7%	Excess
7	Krishna	872.9	751	866	16.2%	0.8%	Normal
8	Nellore	272.5	421	601	-35.3%	-54.6%	Deficit
9	Prakasam	413.4	443	564	-6.7%	-26.8%	Deficit
10	Srikakulam	850.9	808	957	5.3%	-11.1%	Normal
11	Vishakhapatnam	916.3	852	879	7.5%	4.3%	Normal
12	Vizianagaram	970.3	941	914	3.1%	6.1%	Normal
13	West Godavari	1030.3	918	982	12.2%	5.0%	Normal
	STATE MEAN	**674**	**652**	**729**	**3.4%**	**-7.6%**	**Normal**

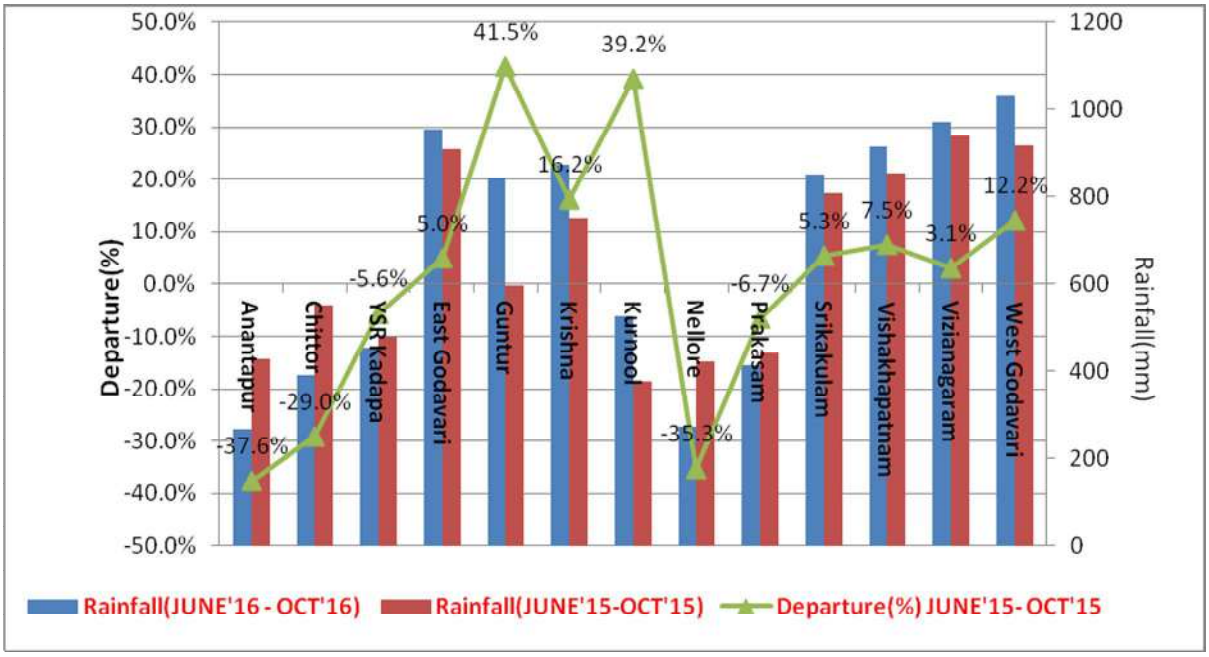


Fig.3.7: Rainfall Departure (June, 2016-Oct.2016 from June.2015-Oct.2015).

3.2.3.2 Departure of rainfall (June to October-2016 from normal rainfall (June-Oct))

The **figure 3.8** gives departure of June, 2016 to Oct, 2016 rainfall with normal rainfall of the same period. It is prepared to correlate with depth to water level map of Nov, 2016. During the period June, 2016 to Oct, 2016, the state has received 3.1 % less rainfall than normal rainfall. It ranges from -54.6% in Prakasam to 6.1% in Vizianagaram district. The deficit rainfall is observed in Anantapur, Chittoor, Nellore and Prakasam district and excess in only Guntur district.

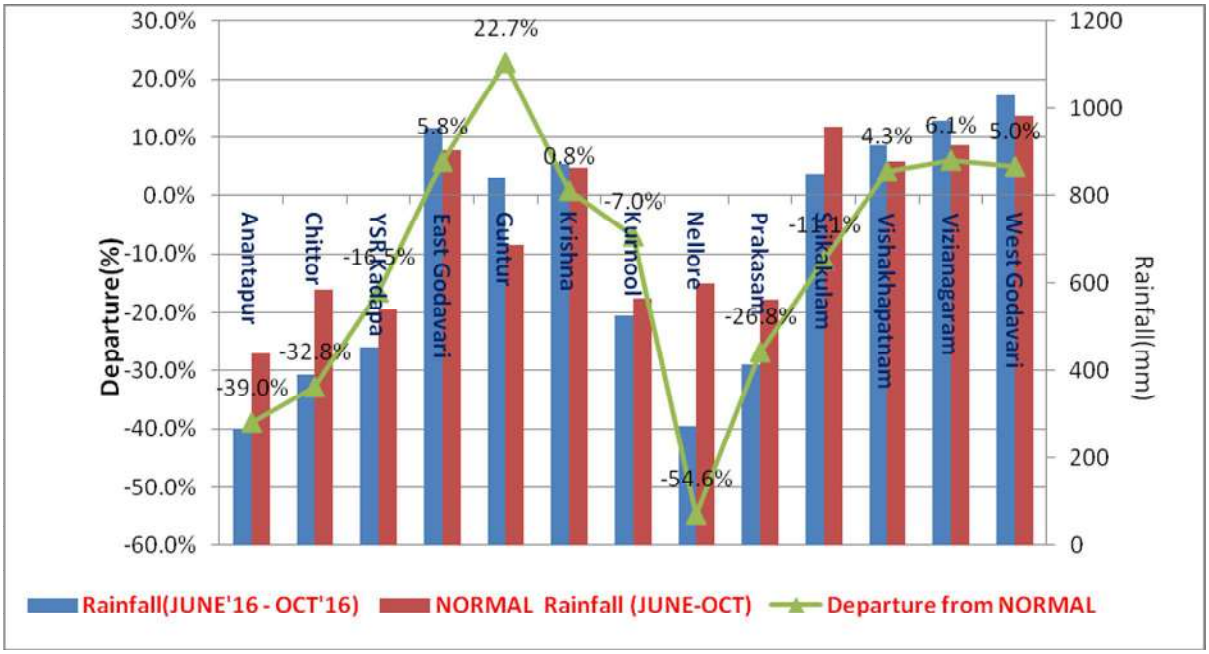


Fig.3.8: Rainfall Departure (June, 2016 - Oct, 2016 from Normals of same Period).

3.3.4 January, 2017

The district wise rainfall for the period June, 2016 to Decemeber, 2016 and normals of same period is given in **Table-3.6** and different thematic maps are presented in **Fig.3.9 and 3.10**.

Table-3.6: District-wise rainfall (Jun'16-Dec'16) and its departure from normal and Jun'15-Dec'15.

S NO	DISTRICT	Rainfall (JUNE'16 - DEC'16)	Rainfall (JUNE'15-DEC'15)	NORMAL Rainfall (JUNE-DEC)	Departure (%) FROM JUNE'15-DEC'15	Departure from NORMAL	REMARK
1	Anantapur	289.4	557.2	485	-48.1%	-40.3%	Deficit
2	Chittor	551.5	1239.8	780	-55.5%	-29.3%	Deficit
3	East Godavari	969.5	1033.8	981	-6.2%	-1.1%	Normal
4	Guntur	852.6	675.4	777	26.2%	9.7%	Normal
5	Krishna	892	847.6	944	5.2%	-5.5%	Normal
6	Kurnool	529.8	402.3	601	31.7%	-11.8%	Normal
7	Prakasam	485.2	588.7	712	-17.6%	-31.8%	Deficit
8	SPS Nellore	463.7	1294.6	992	-64.2%	-53.2%	Deficit
9	Srikakulam	888.5	880.8	1032	0.9%	-13.9%	Normal
10	Vishakhapatnam	924.7	977.7	942	-5.4%	-1.9%	Normal
11	Vizianagaram	972.9	982.7	977	-1.0%	-0.4%	Normal
12	West Godavari	1043.6	1011.8	1060	3.1%	-1.6%	Normal
13	YSR Kadapa	521.2	902.5	643	-42.2%	-18.9%	Normal
	STATE MEAN	**722**	**877**	**840**	**-17.6%**	**-14.1%**	**Normal**

Source: India Meteorological Department, GOI

3.3.4.1 Departure of rainfall during Jun,2016 to Dec,2016 from Jun,2015 to Dec,2015

The figure 3.9 gives departure of rainfall of June, 2016 to Dec, 2016 from June, 2015 to Dec, 2015 rainfall. It is prepared to correlate with water level fluctuation map of Jan, 2017 with Jan, 2016. **Table 3.6** indicates that state has received 722 mm of rainfall during the period Jun,2016 to Oct, 2016, which is 17.6 % less than the rainfall received during the same period last year. The state received about 877 mm of rainfall during the same period last year. The departure in percentage ranges from -64.2% in SPS Nellore district to 31.7% in Kurnool district.

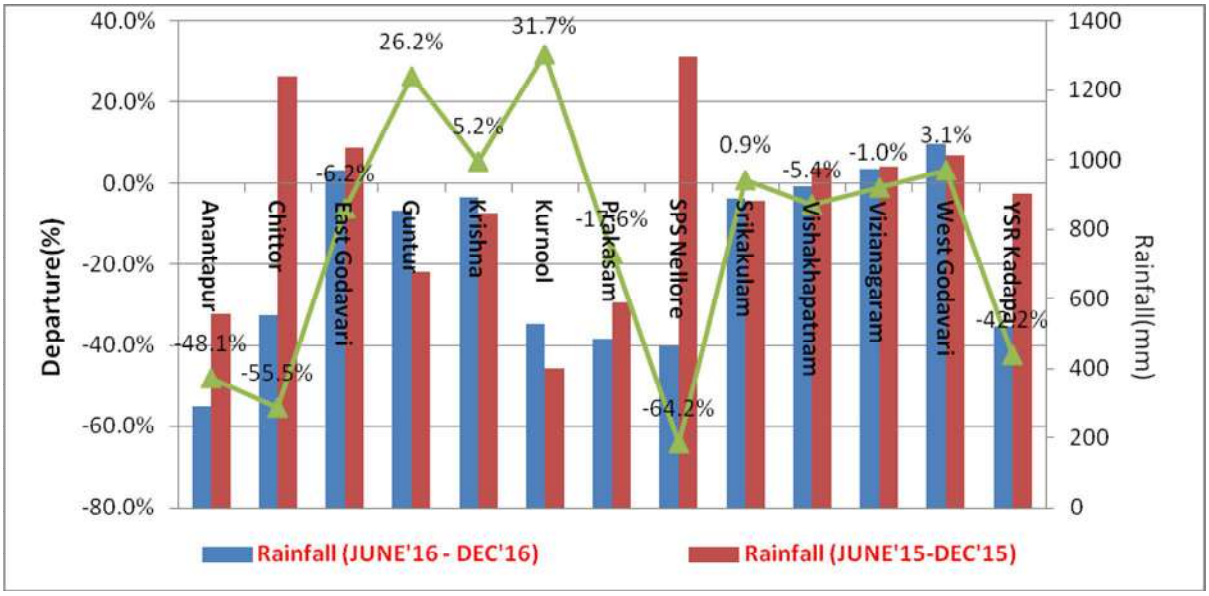


Fig.3.9: Rainfall Departure (June,2016-Dec,2016 from June,2015-Dec,2015).

3.3.4.2 Departure of rainfall during Jun, 2016 –Dec, 2016 from normal rainfall of the same period

The figure 3.10 gives departure of June 2016 - Dec 2016 rainfall with normal rainfall of the same period. It is prepared to correlate with depth to water level map of Jan 2017. During the period June, 2016 – Dec, 2016 the state has received 14.1 % less rainfall than normal rainfall. It ranges from -53.2% in SPS Nellore to 9.7 % in Guntir district. The deficit rainfall is observed in Anantapur, Chittoor, SPS Nellore and Prakasam district.

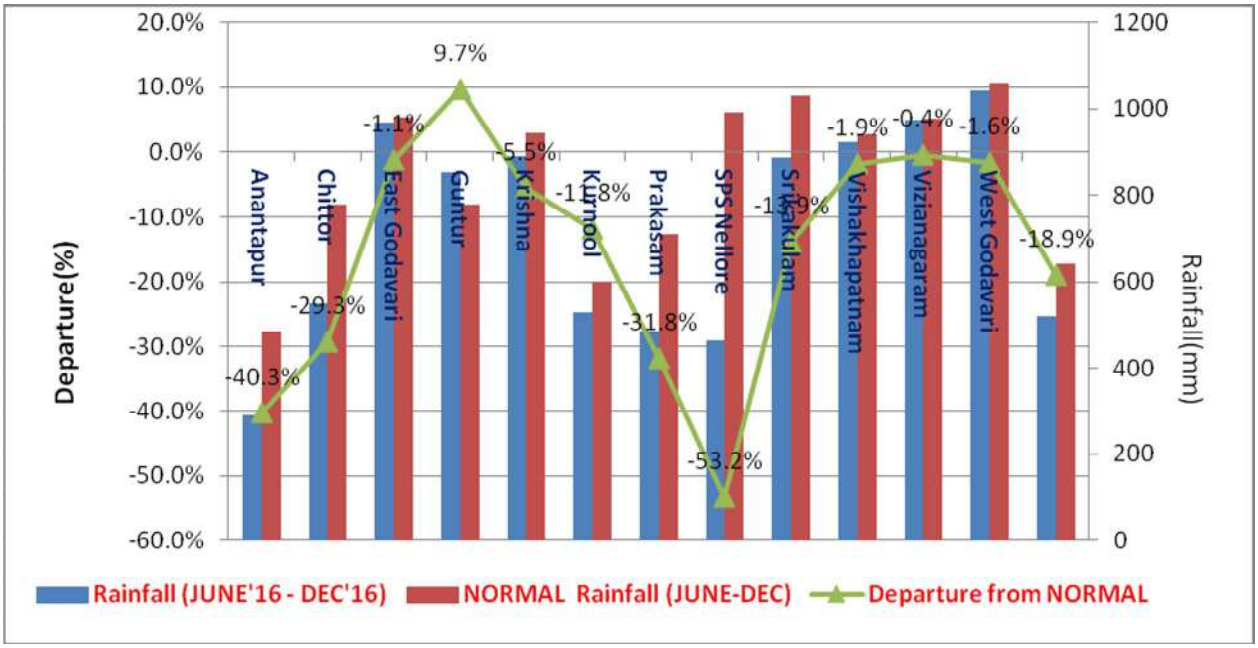


Fig.3.10 Rainfall Departure (Jan,2016- Dec,2016 from Normals of same Period).

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.

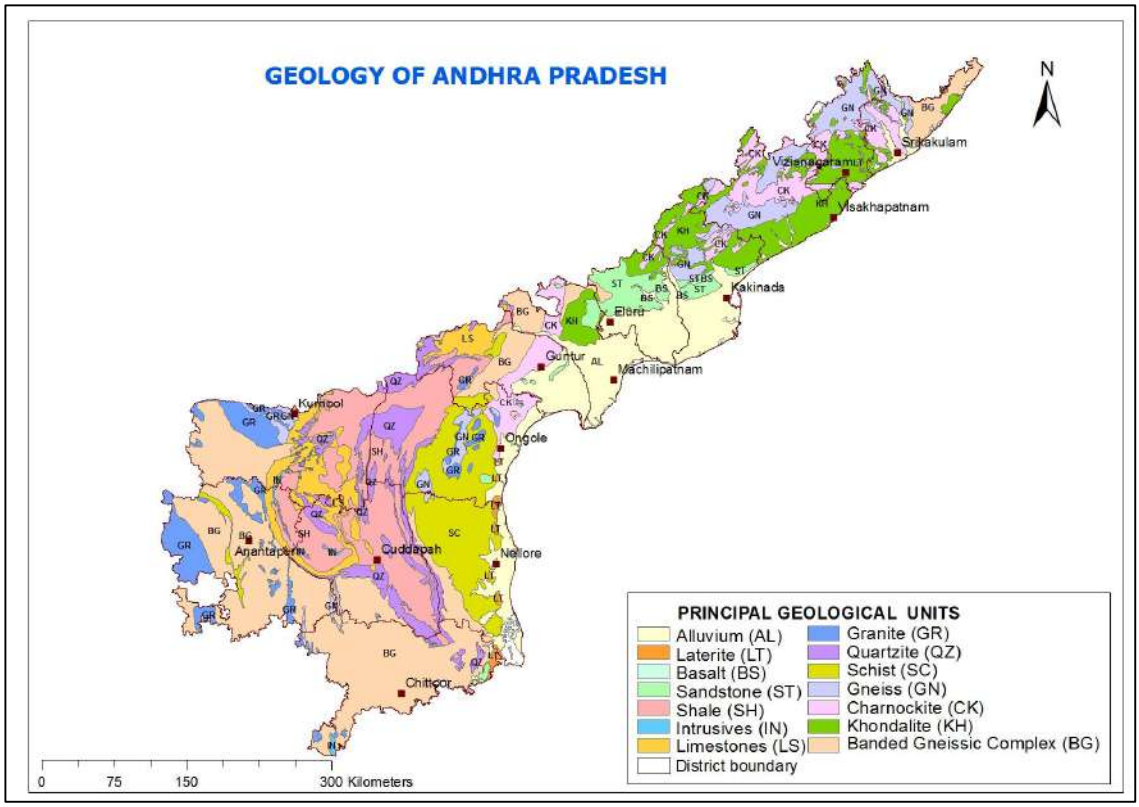


Fig.4.1: Geology of Andhra Pradesh State.

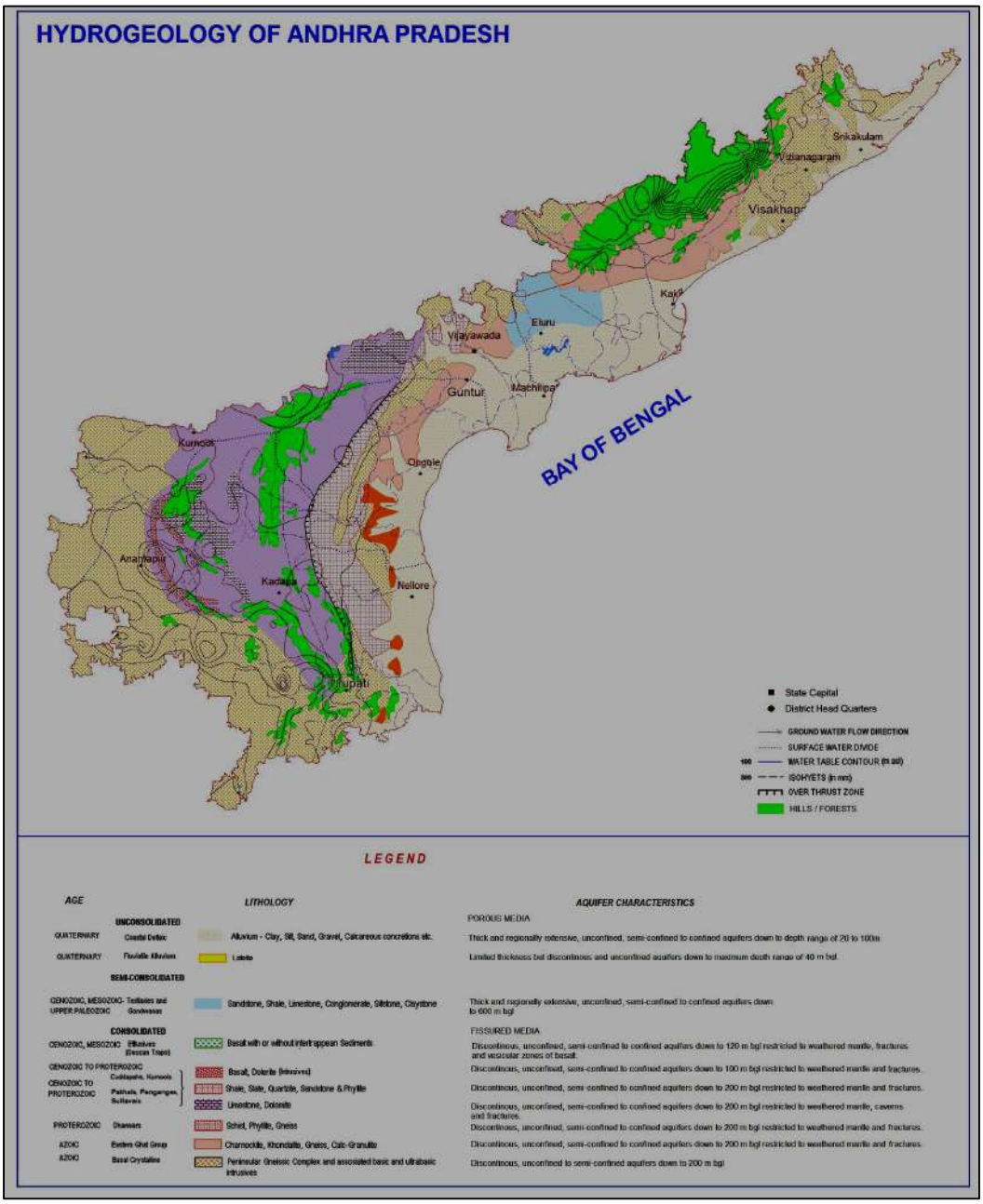


Fig.4.2: Hydrogeology map of Andhra Pradesh State.

4.1 Archaeans and Lower Pre-Cambrians

Peninsular gneisses of Archaean age are dominant rock types in Rayalseema 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.

4.2 Upper Pre-Cambrian to Early Pre-Cambrian

The group includes Cuddapahs, Pakhals, Pengangas, Kurnools and Sullavais comprising shales, limestones, dolomites, sandstones and conglomerates. The crescent shaped Cuddapah 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 metres 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 (2012-2013)

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 2013), the annual replenishable ground water resources are 20387 MCM, natural discharge during non-monsoon period is 1913 MCM, net ground water availability is 18474 MCM, annual gross ground water draft is 8104 MCM, allocation for future domestic and industrial use is 1644 MCM and net ground water availability for future irrigation use is 10210 MCM. The average stage of ground water development is 44 %.

Out of 670 mandals, 61 fall under over-exploited category, 17 falls under critical, 54 under semi-critical and rest 538 under safe category (this includes 73 poor quality mandsls (41 Fully and 32 partly). More mandals from Rayalseema regions falls under OE, C and SC category than Coastal region mandals. The categorization of mandals is depicted in **Fig.5.1**.

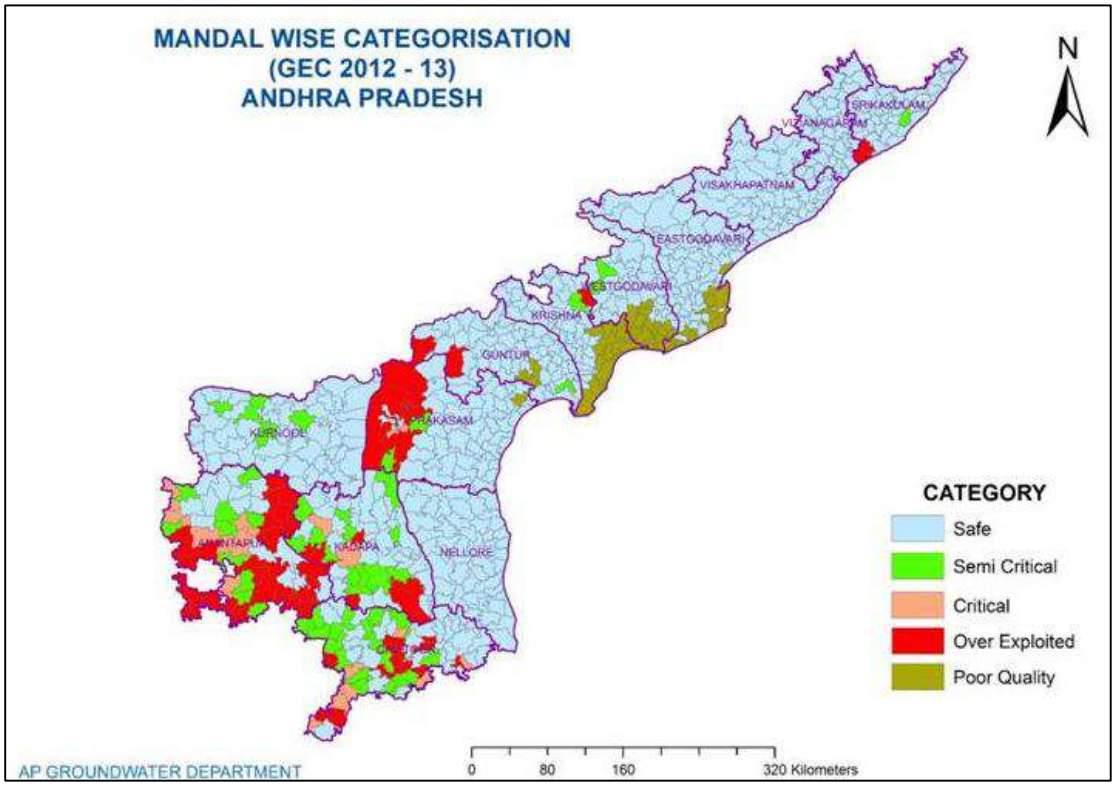


Fig.5.1: **Categorization of Mandals (as on March, 2013), Andhra Pradesh State.**

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 in to 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 Cuddapah 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 (occassionaly up to 20 m) and majority of fractuires occur with in 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 (Cuddapah and Kurnool rocks and equivalents) has 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 Cuddapahs (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 from 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 and in coastal areas it is shallow and brackish or saline in nature. Water quality in deeper aquifers from Nellore and Krishna district is of poor quality.In deltaic areas of Godavari, Krishna and Pennar, yield varies from 0.7-30 lps and Godavari deltas yields are relatively better than Krishna and Pennar. Ground water quality is of potable nature in paleochannels.

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) constructed exclusively for ground water regime monitoring under Hydrology Projectd. Some of the exploratory wells/ onservatory 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 theres are engaged since May, 2005 and as on 31st March, 2017 , 159 nos 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 on 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, 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 the following session.

6.6.1 District-Wise Distribution of Ground Water Monitoring Wells

Total 855 GWMS are monitored in the state (DW: 742 (87 %) and Pz: 113 (13%) and density varies from 101 Km^2/well (East Godavari) to 375 Km^2/well in Cuddaph district (**Table-6.1** and **Fig.1.1**).

6.6.2 Aquifer-Wise Distribution of Ground Water Monitoring Wells

Out of 855 GWMS, 610 wells are located in hard rocks, 245 wells in soft rocks. District wise and aquifer wise distribution of GWMS is given in **Table-6.2.** About 25 % of GWMS are located in Alluvium rocks followed by Banded Gneissic comples (20 %), followed by Khondalite rocks (12 %) etc.

Table-6.1: District-wise Distribution of GWMS, Andhra Pradesh State (As on March, 2017).

S. No.	District	Area (Km2)	No of GWMS			No of Participatory observeres	Density of Net work
			DW	Pz	Total	Nos	Km^2/well
1	Anantapur	19130	36	20	56	18	342
2	Chittor	15152	48	0	48	15	316
3	Cuddapah	15359	28	13	41	11	375
4	East Godavari	10807	94	13	107	12	101
5	Guntur	11391	85	13	98	18	116
6	Krishna	8727	69	7	76	12	115
7	Kurnool	17658	39	19	58	18	304

8	Nellore	13076	59	1	60	7	218
9	Prakasam	17626	52	14	66	13	267
10	Srikakulam	5837	54	0	54	4	108
11	Vishakhapatnam	11161	67	4	71	25	157
12	Vizianagaram	6539	51	0	51	3	128
13	West Godavari	7742	60	9	69	8	112
	Total	160205	742	113	855	164	**187 (Avg)**

Table-6.2: Distribution of monitoring stations-Principal Aquifer-wise (as on March, 2017).

S NO	**DISTRICT**		**AL**	**BG**	**CK**	**GN**	**GR**	**IN**	**KH**	**LS**	**LT**	**QZ**	**SC**	**SH**	**ST**	**TOTAL**
1	Ananthapur	DW		23			12							1		36
		PZ		14			4							2		20
2	CHITTOOR	DW	1	43							3	1				48
		PZ														0
3	East Godawari	DW	52		5	9			23						5	94
		PZ	10												3	13
4	Guntur	DW	26	18	18		1			10		1	6	2	3	85
		PZ		3	1					5		1	2		1	13
5	Kadapa	DW		7						1		3	2	15		28
		PZ		1				1		3		1		7		13
6	Krishna	DW	40	12	6				8	1					2	69
		PZ	1	1	1				3					1		7
7	Kurnool	DW		11		1	4			10		3		10		39
		PZ		7		3	5			4						19
8	Nellore	DW	15	7							5		32			59
		PZ											1			1
9	Prakasham	DW	13	2	7	4	3					2	11	7	3	52
		PZ	2	1	2	1	4				1		2	1		14
10	Srikakulam	DW	8	24	11	8			3							54
		PZ														0
11	Vijayanagaram	DW			11	19			20						1	51
		PZ							4							4
12	Vishakapatnam	DW	1		8	23			35							67
		PZ														0
13	West Godawari	DW	40	1					10						9	60
		PZ	5												4	9
	TOTAL	DW	**195**	**148**	**66**	**64**	**20**		**99**	**22**	**8**	**10**	**51**	**35**	**23**	**742**
		PZ	**18**	**27**	**4**	**4**	**13**	**1**	**7**	**12**	**1**	**2**	**5**	**11**	**8**	**113**

(Note:AL: Alluvium, BGC-Banded Gneissic complex, CK-Charnokite, Gn-Gneiss, Gr-Granite, Kh-Kondalite, LS-Limestone, LT-Laterite, Qz-Quartzite,SC-Schists, SH-Shale, ST-Sandstone).

7. ANALYSIS OF WATER LEVELS

The ground water levels observed over a period of time provides 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 are tapping the phreatic aquifer which is 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. The data from GWMS for the year 2016-17 was analysed 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, 2016)

An analysis of depth to water level data of 775 wells **(Annexure-V**) shows, water levels in the range of -0.80 (Krishna district) to 49.3 m bgl (Prakasam district). The spatial distribution of depth to water level is shown in **Fig 7.1**. One well in Krishna district shows artesian condition. Shallow water level in the range of 0 to 2 m bgl covers an area of about 4035 Km^2 (3 % of state area) and mostly observed in coastal area and parts of Chittoor district. Water levels in the range of 2 to 5 m are more predominant occupying 54840Km^2 (34% of area). Water levels in the range of 5 to 10 m occupy about 72850 Km^2 (46% of area). Water levels between 10-20 m bgl cover about 24960 Km^2 of state area (16 %) mostly in Anantapur, Prakasam and Kurnool districts. Deep water levels of more than > 20 mbgl covers about 2% of the total geographical area respectively, covering Rayalseema region of the state.

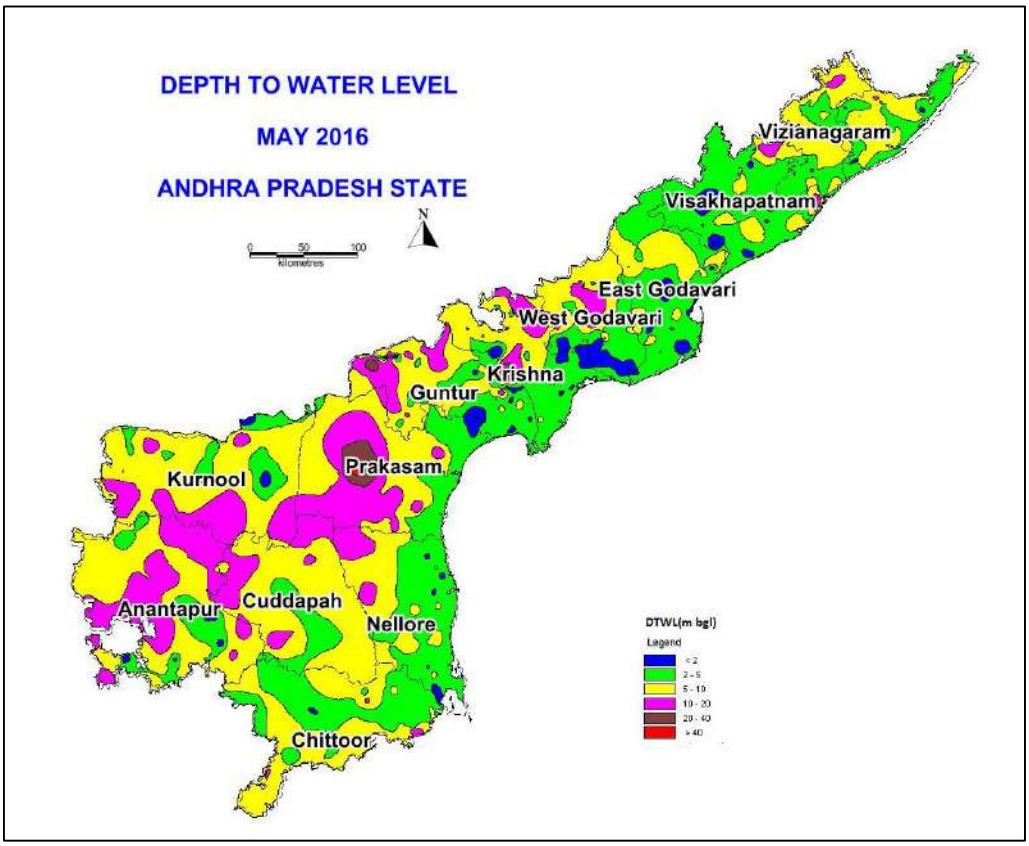


Fig.7.1: Distribution of water levels, Premonsoon season (May, 2016).

7.1.2 Depth to Water Levels –August, 2016 (Mid-monsoon Season)

An analysis of depth to water level data of 784 wells **(AnnexureVI)** shows, water levels are in the range of -1.1 (East Godavari district) 49.3 mbgl(Prakasam district). The spatial distribution of water level is shown in **Fig 7.2**. One well located in Krishna district shown artesian condition (-1.1 m). Shallow water level in the range of 0 to 2 m bgl covers an area of about 22,090 Km^2 (14% of state area) and mostly observed in north coastal districts and small parts of Kurnool, Chittoor and Nellore districts in 30% of the wells. Water levels in the range of 2 to 5 m occupies about 49,950 Km^2 areas (31% of the total geographical area of the state), occupying mostly eastern and northern part of the State in 35% of the wells. During August, majority of the water levels are in the range of 5 to 10 m bgl occupying about 55,570 Km^2areas (35%) in 26% of the wells. Water levels between 10-20 m bgl cover about 20,610 $Km^2$of state area(13 %) in 7% of the wells. Deep water levels more than > 20 mbgl covers about 7.3 % of the total geographical area respectively, covering parts of Kadapa, Anantapur and Kurnool districts in 1.38% of the wells.

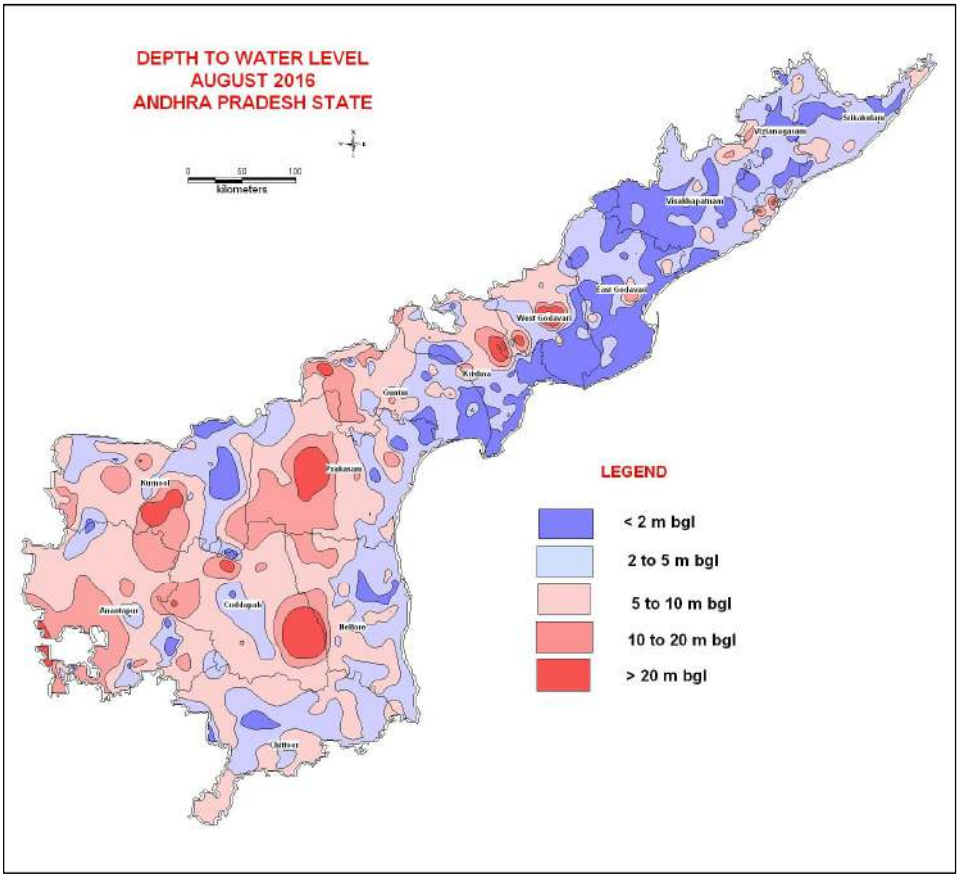


Fig.7.2: Depth to Water Levels in August, 2016(Mid-monsoon season).

7.1.3 Depth to Water Levels - Post-Monsoon Season (November, 2016)

An analysis of depth to water level data of 775 wells **(Annexure-VII**) shows, water levels are in the range of -0.30 (Krishna district) 48.5 mbgl(Prakasam district). The spatial distribution of water level is shown in **Fig 7.3**. One well located at in Krishna district shown artesian condition. Shallow water level in the range of 0 to 2 m bgl covers an area of about 20,990 Km^2 (13% of state area) and mostly observed in coastal belt and small parts of Kurnool district (262 wells). Water levels in the range of 2 to 5 m occupies about 56,910 Km^2 areas (36% of the total geographical area of the state), occupying entire State except parts of southern areas of the state. During August water levels are in the range of 5-10 m bgl is observed in about 26 % of the wells and 10-20m in 7.2 % of the wells. Deep water levels of >20 mbgl is observed in only 1.1% of the wells covering parts of Kadapa, Anantapur, Prakasam and Kurnool districts.

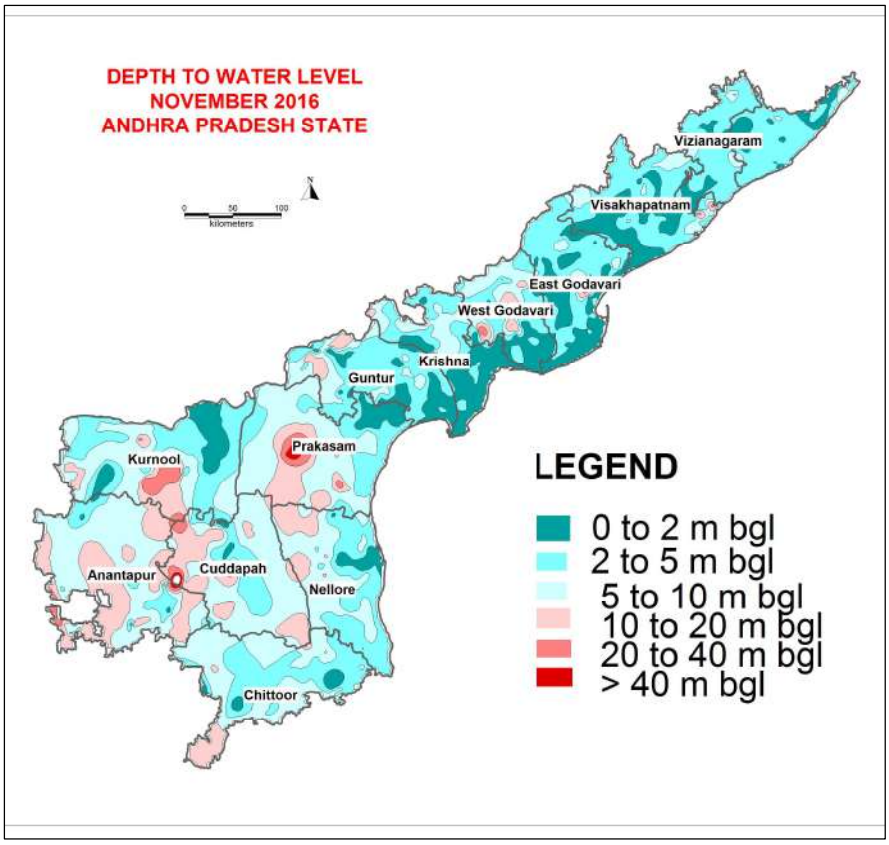


Fig.7.3: Depth to Water Levels – Nov, 2016(Post-monsoon season)

7.1.4 Depth to Water Levels (January, 2017)

An analysis of depth to water level data of 777 wells **(Annexure-VIII**) shows, water levels are observed in the range of -0.75 m bgl (Krishna district) to 49.3 mbgl (Prakasam district). The spatial distribution of water level is shown in **Fig 7.4.** Shallow water levels (<

2m) are observed in 21%(163 nos) of the monitored wells and deep water levels (>20 m) are observed in 1.16% (9 nos) of the wells.

Shallow water level (0 to 2 m bgl) covers an area of about 11760 Km^2 (8 % of state area) and mostly observed in coastal parts of the state (except Prakasam district) and also in western parts of Kurnool district. Depth to water levels in the range of 2 to 5 m bgl in 56,560 sq.km. , 5-10 m bgl in 52,770 sq.km. and 10-20 m bgl in 21,840 sq.km. Deep water levels more than 20 m bgl covers about 5128 km^2. in 5 % of the total geographical area covering mostly in small patches in Nellore and Prakasam districts.

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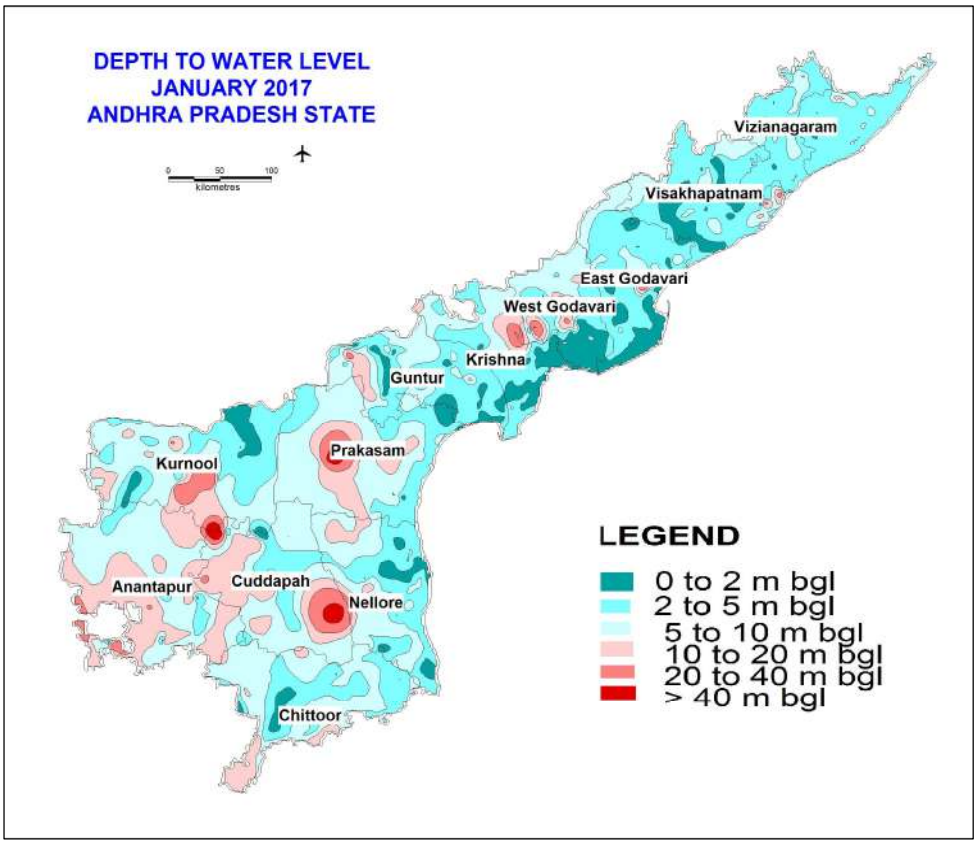

Fig.7.4: Depth to Water Levels- January, 2017.

7.2 Fluctuations with Premonsoon water Levels

7.2.1 Water Level Fluctuation- Aug 2016 from May, 2016

Water level fluctuations during August 2016 with respect to May 2016 are presented in **Annexure-IX.** An analysis of 773 wells shows that water level rise is recorded in 71 % wells (546 nos) covering an area of about 75% of the total geographical area. About 23% of wells (176) have shown a fall in water level covering an area of about 25% of the total geographical area and 51 wells have no rise or fall in water levels. Rise in water levels is

mainly due to monsoon rainfall. The spatial distribution of water level fluctuation is shown in Fig 7.5. In the state about 119564 km^2 area shown a rise in water levels in the range of < 2 to > 4 m and in rest of the area i.e 40336 Km^2 water level fluctuations have shown a fall in the range of < 2 to > 4 m. Water level fall of more than 4 m is recorded mostly Nellore and Prakasam districts while rise of more than 4 m is recorded mainly in Anantapur, Kurnool , Krishna and western parts of East, West Godavari and Srikakulam districts.

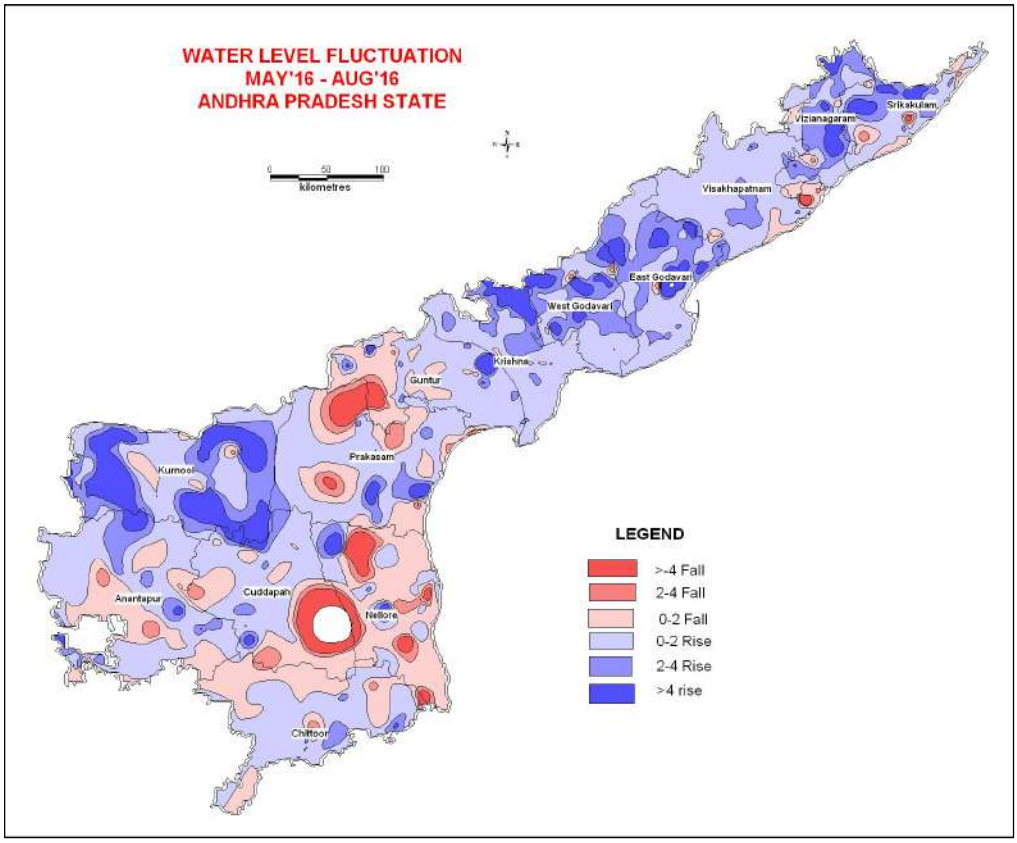

Fig 7.5 Water Level Fluctuation (August 2016 from May 2016)

7.2.2 Water Level Fluctuation - Nov, 2016 from May, 2016

Water level fluctuations during November 2016 with respect to May 2016 are presented in **Annexure-X.** An analysis of 764 wells shows that water level rise is recorded in 75 % wells (573 nos) covering an area of about 72% of the total geographical area. About 21% of wells (162) have shown a fall in water level covering an area of about 25% of the total geographical area and 29 wells have no rise or fall in water levels. Rise in water levels is mainly due to monsoon rainfall. The spatial distribution is given in **Fig 7.6.**

The minimum and maximum rise in water level fluctuations is recorded as 0.03 m in Vizianagaram and West Godavari and 29.3 m in Guntur districts respectively. The minimum and maximum fall in water level fluctuations is recorded as 0.01 m in Chittoor, East Godavari

and Visakhapatnam districts and 42.6 m in Visakhapatnam district. In the state about 115727 km^2 area shown a rise in water levels in the range of < 2 to > 4 m and in rest of the area i.e 44473 Km^2 water level fluctuations have shown a fall in the range of < 2 to > 4 m. Water level fall of more than 4 m is recorded mostly in Nellore, Chittoor and Prakasam districts while rise of more than 4 m is recorded mainly in Kurnool and western parts of all the districts except Visakhapatnam and Rayalaseema districts

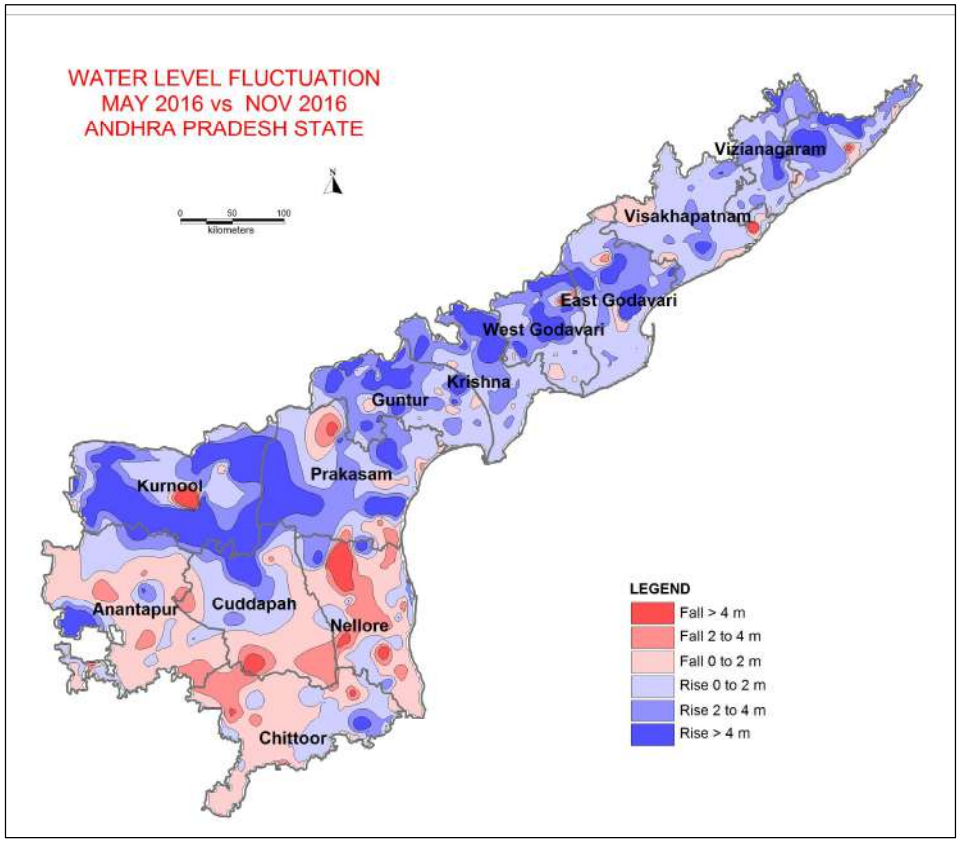

Fig 7.6 Water Level Fluctuation (Nov, 2016 from May, 2016)

7.2.3 Water Level Fluctuation - January 2017 from May, 2016

Water level fluctuations during Jan 2017 with respect to May 2016 are presented in **Annexure-XI.** An analysis of 764 wells shows that water level rise is recorded in 66% wells (503 nos) and water level fall is recorded in 30% wells (228 nos) and no change in water level in 33 wells. Fluctuation ranges from , rise 0.02(East Godavari and Visakhapatnam district) m to 21.5(Guntur and Krishna district) and fall 0.01 m (Krishna district) to 42.6 m(Visakhapatnam district).

Rise in water levels is observed in 52,928 sq.km.(34% of the state area). Fall in water levels is observed in 1,00,130 sq.km.(65% of the state area). In the Kadapa, Prakasam, SPS

Nellore, Anantapuramu and Chittoor districts water level in Jan 2017 have been deeper than the pre-monsoon water levels of May 2016. This is due to deficit rainfall during monsoon 2016. The spatial distribution of fluctuation of water level is presented in **Fig 7.7.**

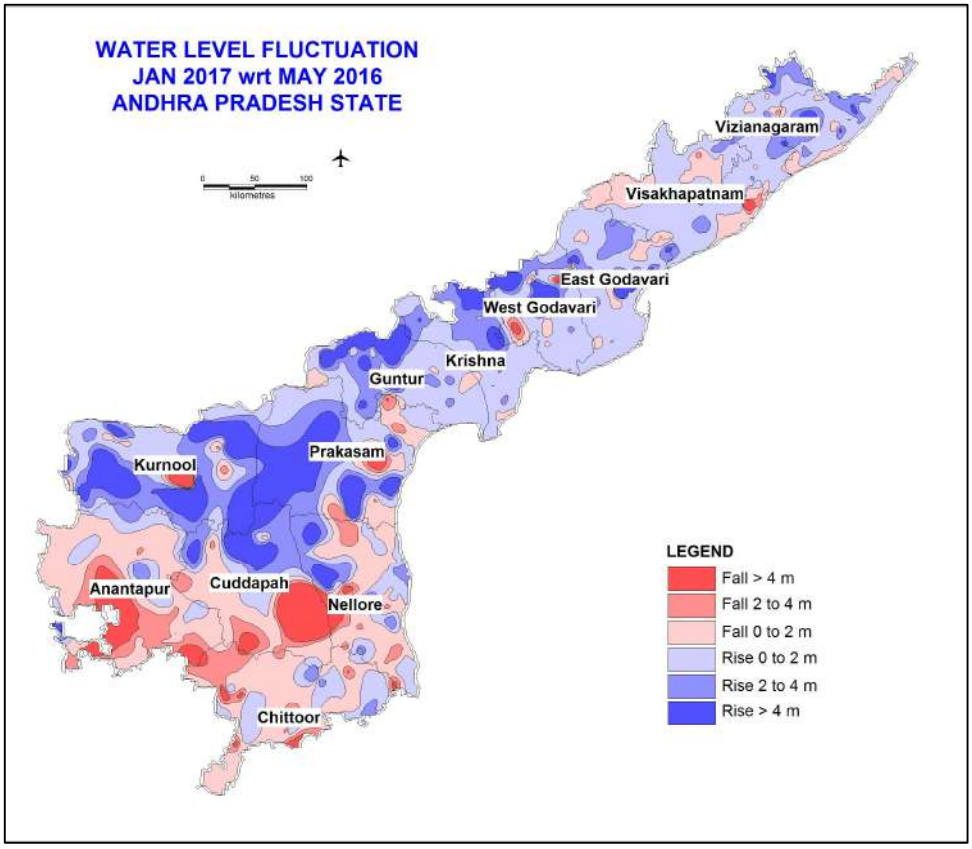

Fig 7.7 Water Level Fluctuation (January, 2017 from May, 2016)

7.3 Annual Water Level Fluctuation

7.3.1 Water Level Fluctuation (May, 2016 from May, 2015)

Water level fluctuations during May-2016 with respect to May 2015 are presented in **Annexure-XII.** An analysis of 733 wells shows that water level rise is recorded in 310 wells covering(42 % of the area) and 374 wells have shown a fall in water level (51% of the area) and 49 wells (6%) have no rise or fall in water levels. Rise in water levels is mainly due to recharge during pre-monsoon showers. The areal distribution of water level fluctuiation is shown in Fig 7.8.

About 84740 $km^2$of the area covering Coastal tract, western parts of Anantapur, Chittoor, Nellore and Kadapa district, and parts of western parts of Visakhapatnam water level fluctuations have shown a rise in the range of < 2 m, 2-4 m and > 4 m.

In the state about 75160 km^{2}area covering western parts of all the districts except Rayalaseema districts of the state shown a fall in water levels in the range of < 2 m, 2-4 m and > 4 m

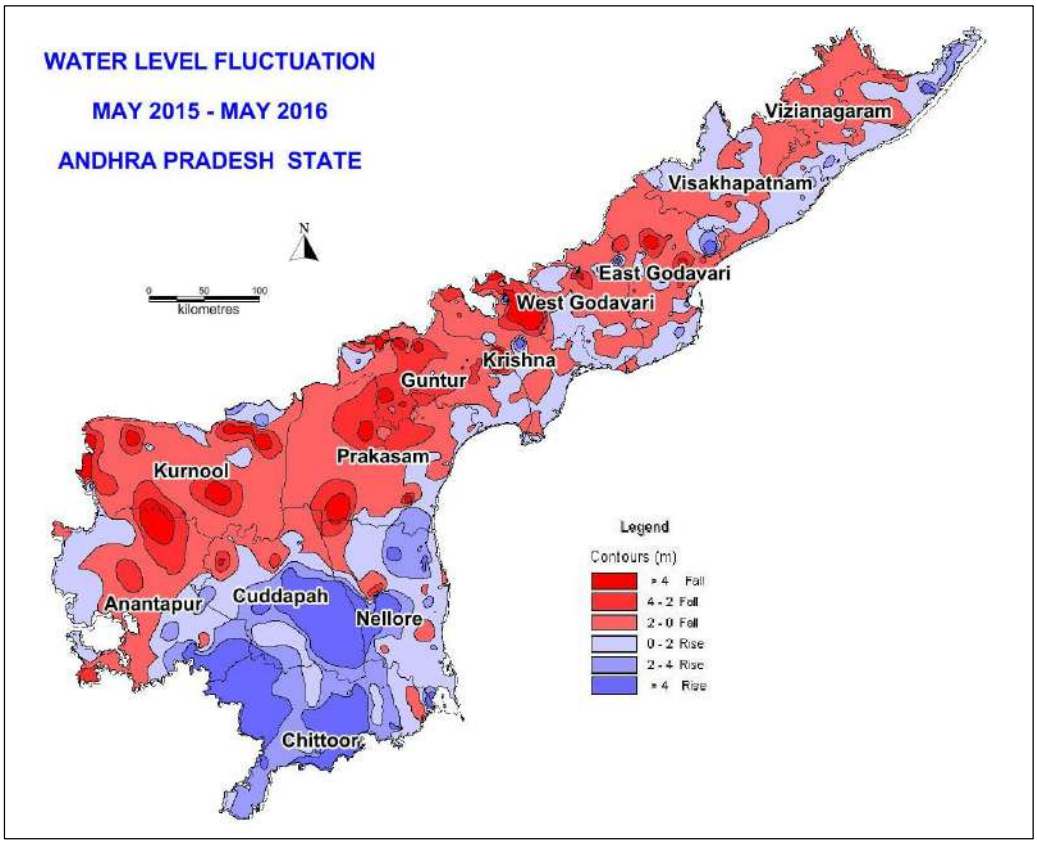

Fig.7.8: Water Level Fluctuations (May, 2016 from May, 2015)

7.3.2 Water Level Fluctuation (August-2016 from August-2015)

Water level fluctuation data of August 2016 with respect to August 2015 is presented in **Annexure-XIII.** An analysis of 747 wells shows that water level rise is recorded in 47% wells (348 nos) covering an area of about 43 % of the total geographical area. About 50% of the wells (372) have shown a fall in water level covering 57% of the area. About 27 wells have shown neither rise nor fall in water levels. The spatial distribution of fluctuation is shoiwn in in **Fig 7.9.**

In the state about 68656 km^{2}area shown a rise in water levels in the range of < 2 to > 4 m and in about 91244 of the area, water level fluctuations have shown a fall in the range of < 2 to > 4 m. Water level fall of more than 4 m is recorded mainly in Prakasam and Guntur

districts. Water level rise of more than 4 m is recorded mainly in Chittoor, Kurnool, Anantapuram and YSR Kadapa districts. Anantapuram and YSR Kadapa districts.

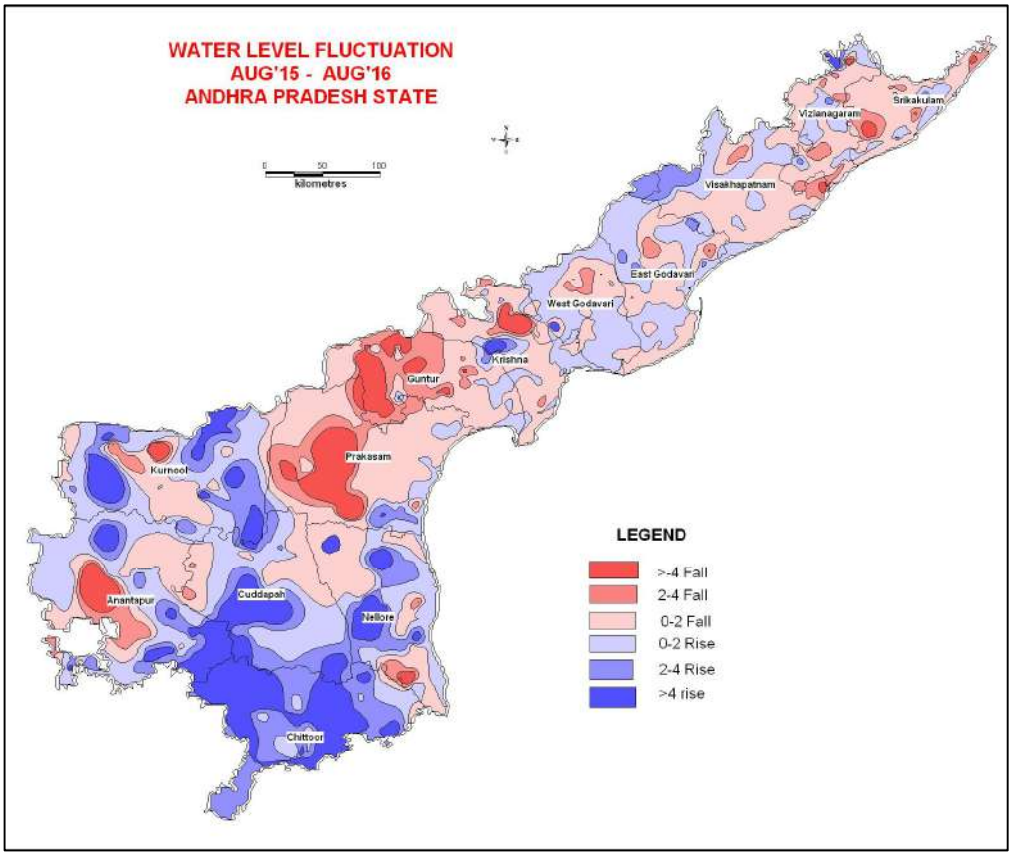

Fig. 7.9: Water Level Fluctuations (August 2016 from August 2015)

7.3.3 Water Level Fluctuations (November, 2016 from November, 2015)

Water level fluctuation data of Nov 2016 from Nov 2015 is presented in **Annexure-XIV.** An analysis of 723 wells shows that water level rise is recorded in 42% wells (304 nos) covering an area of about 45 % of the total geographical area. About 54% of the wells (393 nos) have shown a fall in water level covering 55% of the area. About 26 wells have shown neither rise nor fall in water levels. The spatial distribution of fluctuation is shown in **Fig 7.10.**

The minimum and maximum rise in water level fluctuations is recorded as 0.01 m in East Godavari district and 20.2m in Guntur districts respectively.The minimum and maximum fall in water level fluctuations is recorded in 0.01 m Vishakhapattanam and West Godavari district and 44.8 m in Vishakhapattanam district respectively.In the state about

72570 km^2area shown a rise in water levels in the range of < 2 to > 4 m and in about 87630 of the area, water level fluctuations have shown a fall in the range of < 2 to > 4 m.

Water level fall of more than 4 m is recorded mainly in Nellore, Kadapa and Anantapur districts. Water level rise of more than 4 m is recorded in parts of Chittoor, Kurnool and Guntur districts.

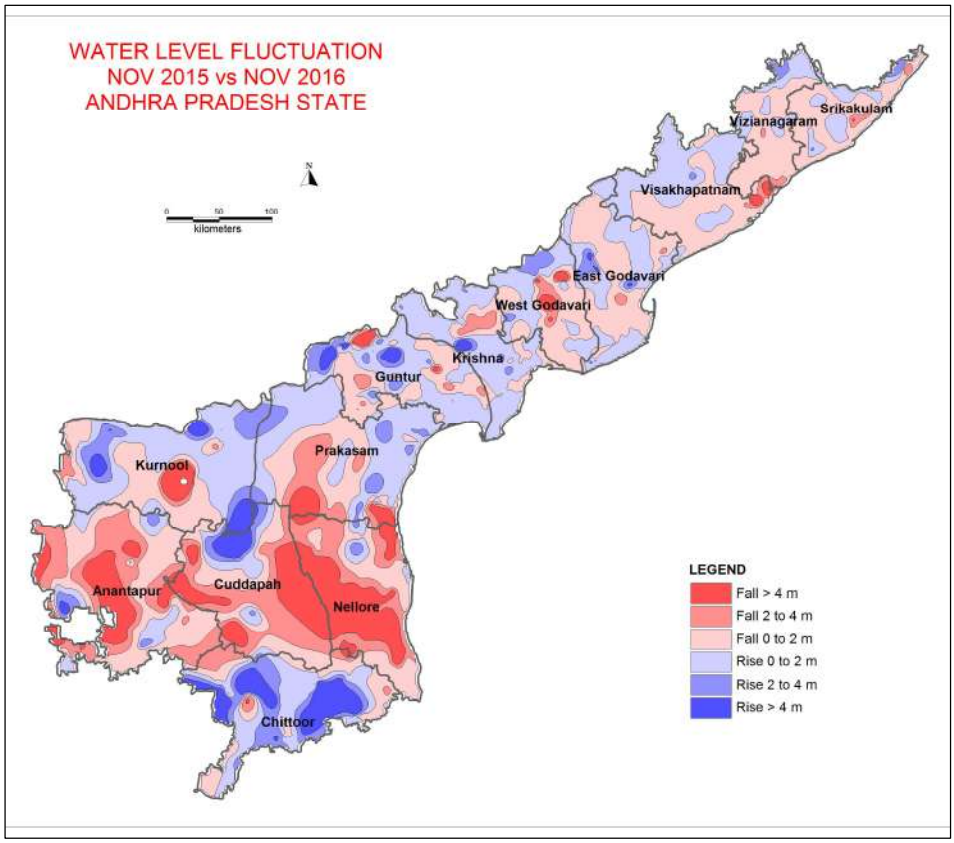

Fig. 7.10 : Water Level Fluctuations (November,2016 from November,2015)

7.3.4 Water Level Fluctuations (January-2017 from January-2016)

Water level fluctuations during Jan 2017 with respect to Jan 2016 are presented in **Annexure-XV.** An analysis of 742 wells shows that water level rise is recorded in 37% wells (274 nos) and water level fall is recorded in 60% wells (447 nos) and no change in water level in 21 wells. Fluctuation ranges from , rise 0.01(East Godavari Dt) m to 27.8(Guntur Dt.) and fall 0.01 m (Guntur Dt.) to 45.1 m(YSR Kadapa dt.).

Rise in water levels is observed in 52928 sq.km.(34% of the state area). Fall in water levels is observed in 100130 sq.km.(65% of the state area). In Kadapa, Prakasam, Nellore and Chittoor district the fall in water levels in comparison with Jan 2016 was observed

which was due to less rainfall during monsoon 2016. This is due to deficit rainfall during monsoon 2016. The spatial distribution of fluctuation of water level is shown in **Fig 7.11.**

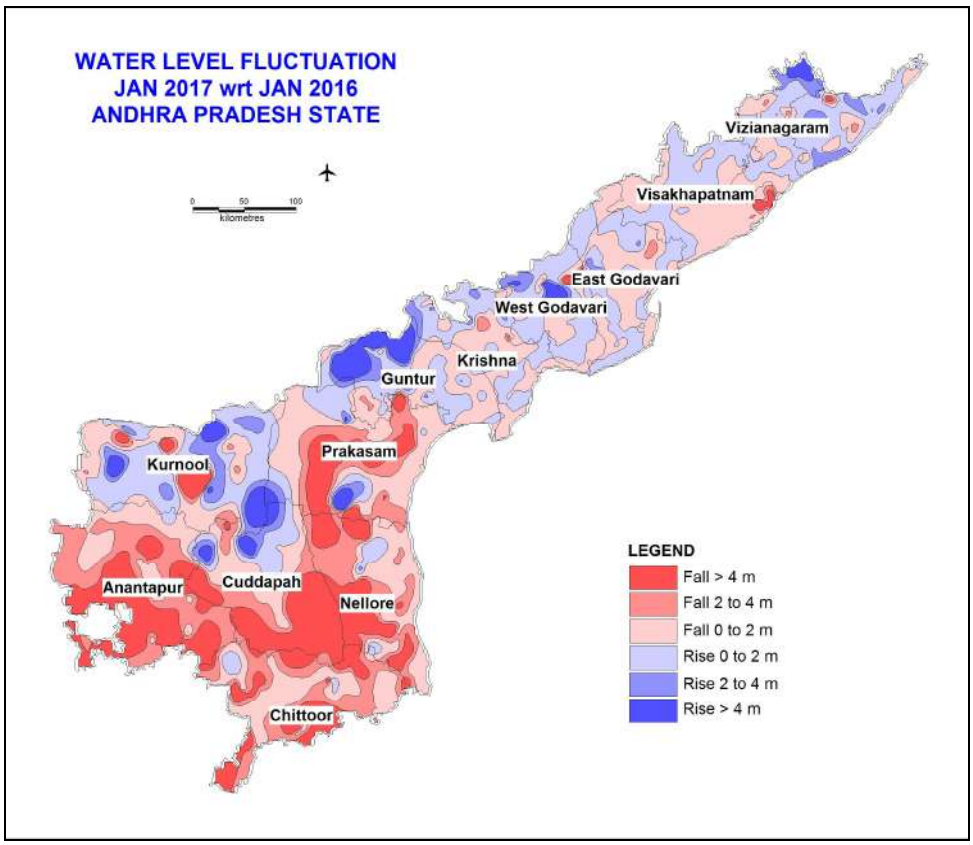

Fig. 7.11: Water Level Fluctuations (January, 2017 from January, 2016).

7.4 Decadal Water Level Fluctuations

7.4.1 Water Level Fluctuations (May 2016 from Decadal mean of May(2006-15))

Water level fluctuation of May, 2016 with decadal means of May (2006-2015) is presented in **Annexure-XVI. The spatial distribution od fluctuation is shown in Fig 7.12.** An analysis of 748 wells data shows a rise in water levels in 304 wells and fall in 437 wells covering an area of 84740 km^2 (53 %) and 75160 km^2 (47%) respectively. This fall in water levels with respect to decal mean is mainly due to less rainfall in northern parts of the state. Perusal of the map shows a general fall in water levels in major part of the state.

About 84740 $km^2$of the area covering Anantapur, Chittoor, Nellore and Kadapa district, and parts of Visakhapatnam water level fluctuations have shown a rise in the range of < 2 m, 2-4 m and > 4 m. In the state about 75160 km^2area covering Kurnool, Prakasam, Guntur, Krishna, West Godavari, East Godavari and northern parts of Visakhapatnam and

Viziangaram districts of the state shown a fall in water levels in the range of < 2 m, 2-4 m and > 4 m.

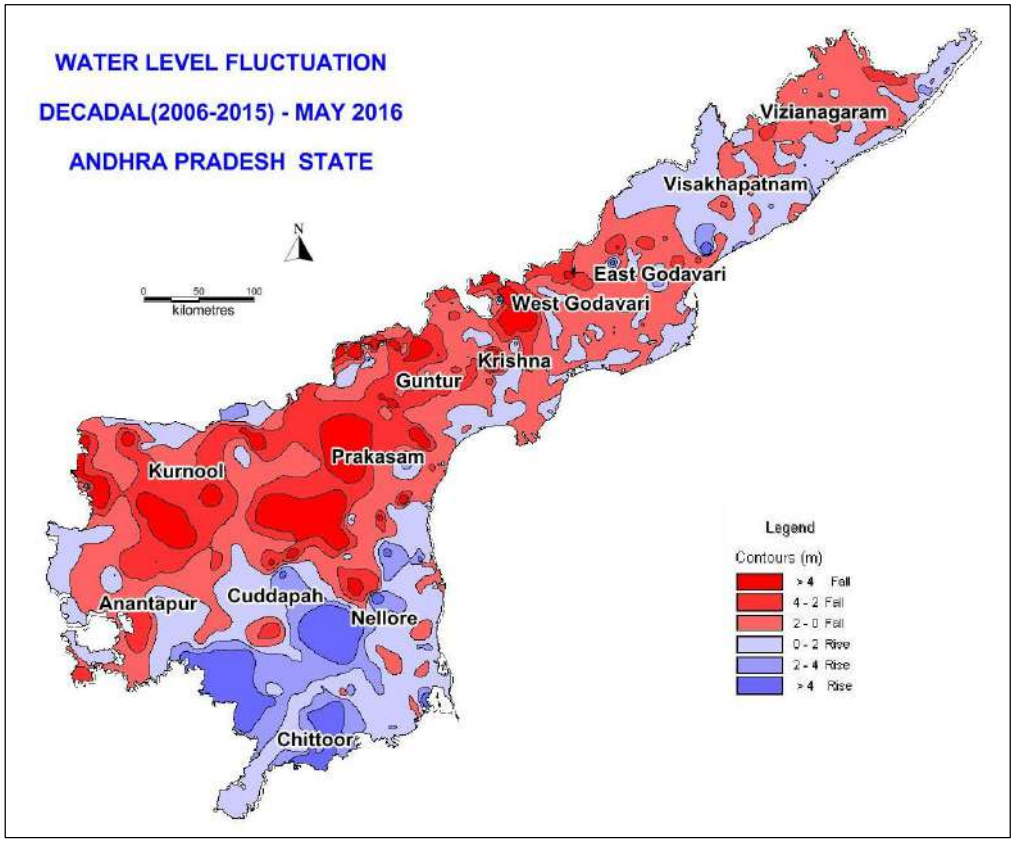

Fig.7.12: Water Level Fluctuations (May, 2016 from Decadal Mean of May (2006-2015))

7.4.2 Water Level Fluctuations (August,2016 from Decadal Mean of August (2006-2015))

Water level fluctuation of August, 2016 from Decadal mean of August, (2006-2015) is presented in **Annexure-XVII.** The spatial distribution of fluctuation is shown in **Fig 7.13**.

An analysis of 762 wells data shows that rise in water levels is observed in 335 wells (44%) and fall in 416 wells (55%) covering an area of 48.4% and 51.5% respectively. Perusal of the map shows a general fall in water levels in major part of the state.

In the state about 77490 km^2area shown a rise in water levels and in about 82410 km^2 of the area, water level fluctuations have shown a fall in water levels. Perusal of the map shows that fall of more than 4 m is observed in Prakasam, Guntur and Krishna and also as

isolated patches in Anantapur and Kurnool districts.Rise of water level more than 4 m is observed in Chittoor, Kadapa and SPS Nellore districts.

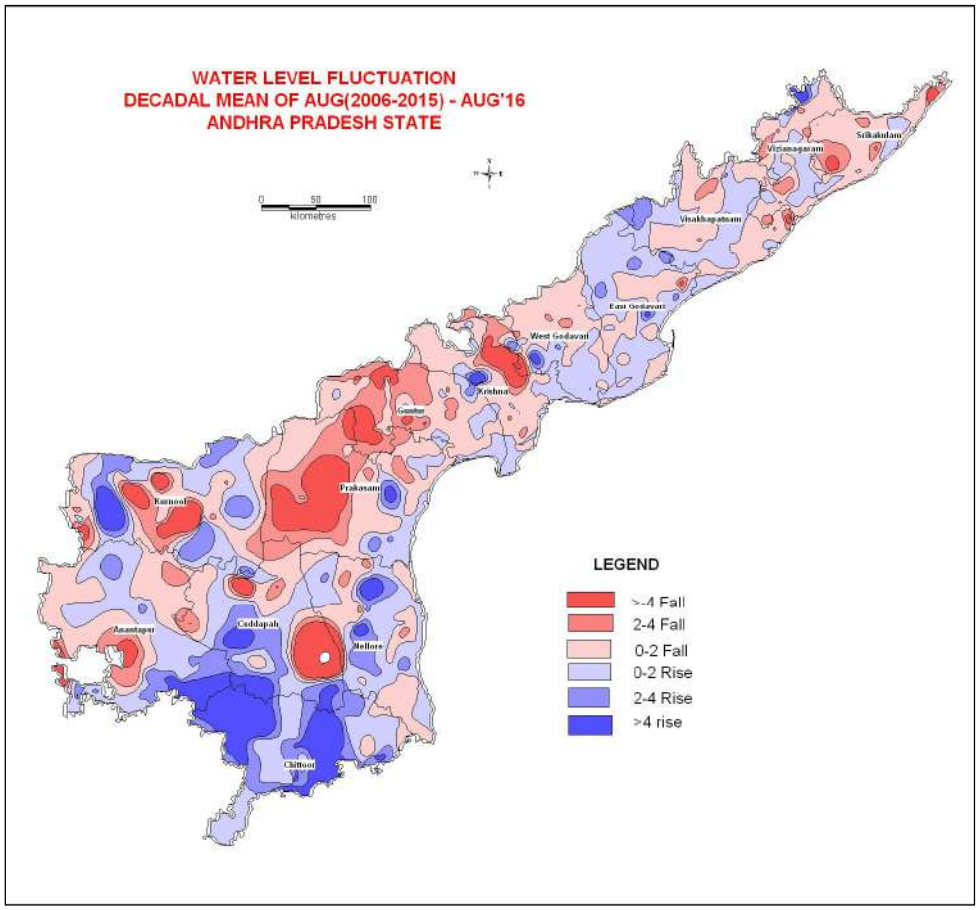

Fig. 7.13: Water Level Fluctuations, August , 2016 from Decadal Mean of August (2006-2015)

7.4.3 Water Level Fluctuation- Nov, 2016 from Decadal Mean of Nov (2006-2015)

Water level fluctuation of Nov, 2016 with Decadal mean of Nov (2006-2015) is presented in **Annexure-XVIII** and the spatial distribution of fluctuation is shown in **Fig 7.14**. An analysis of 757 wells data shows that fall in water levels is observed in 525 wells (69%) and rise in 231 wells (31%) covering an area of 32% and 68% respectively. Perusal of the map shows a general fall in water levels in major part of the state.

In the state about 50828 km^2area shown a rise in water levels in the range of < 2 to > 4 m and in about 109372 km^2 of the area, water level fluctuations have shown a fall in the range of < 2 to > 4 m. Perusal of the map shows that fall of more than 4 m is observed in some parts of Rayalaseema region, Prakasam and SPS Nellore districts. Rise of more than 4 m is observed in some parts of Chittoor duistrits.

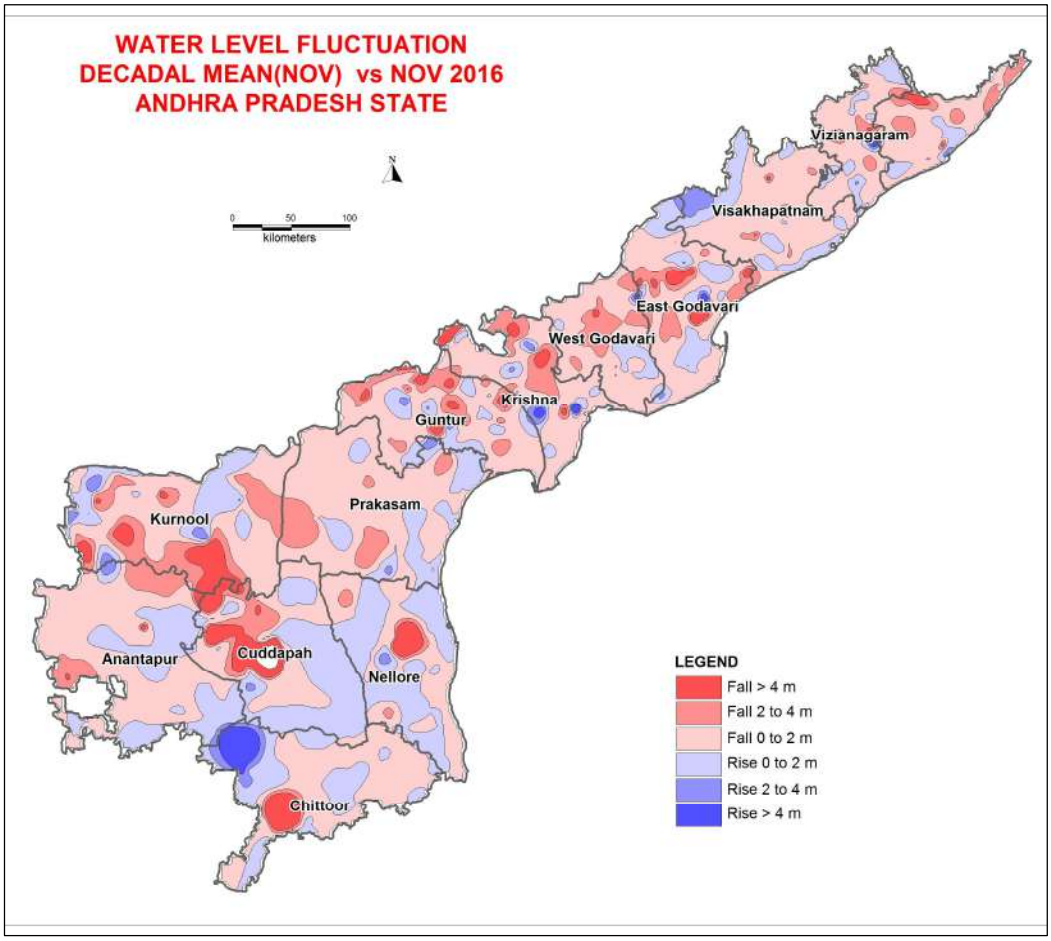

Fig. 7.14: Water Level Fluctuations (Nov, 2016 from Decadal Mean of Nov (2006-2015))

7.4.4 Water Level Fluctuation- January, 2017 from Decadal Mean of Jan (2007-16)

Water level fluctuations during Jan 2017 with Decadal mean of Jan(2007-2016)are presented in **Annexure-XIX.** An analysis of 759 wells shows that water level rise is recorded in 29% wells (224 nos) and water level fall is recorded in 70% wells (534 nos) and no change in water level in 1 well. Fluctuation ranges from , rise 0.01(SPS Nellore district) m to 6.02 m(Guntur district.) and fall 0.01 m (Chittoor ,East Godavari and West Godavari district.) to 43.6 m(YSR Kadapa district.). Rise in water levels is observed in 64360 sq.km.(42% of the state area). Fall in water levels is observed in 88730 sq.km.(58% of the state area). In Kurnool, Kadapa and Chittoor districts, rise in water levels is observed in Jan 2017 in comparison with decadal mean (Jan). The fall of more than 4 m is observed in parts of Anantapur, Kadapa , SPS Nellore and Prakasam district. The spatial distribution of fluctuation of water level is shown in **Fig 7.15**.

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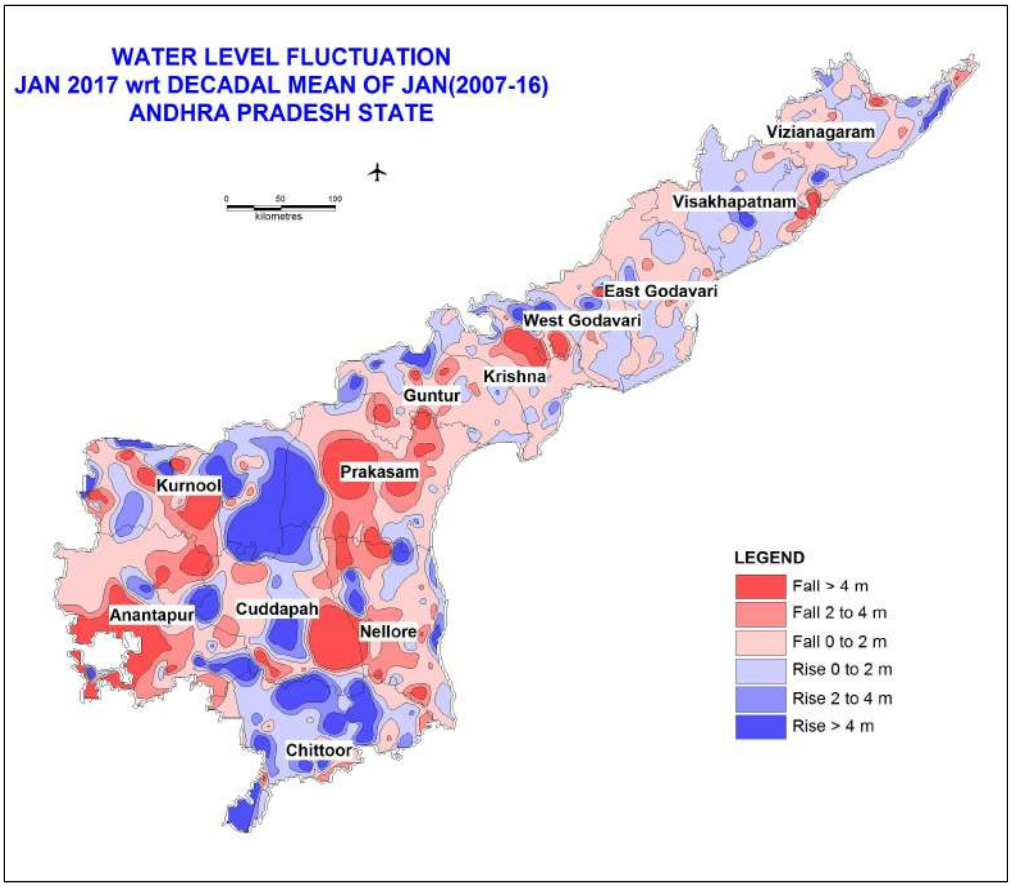


Fig. 7.15: Water Level Fluctuations (Jan, 2017 from Decadal Mean of Jan (2007-16))

7.5 Aquifer wise water levels

Aquifer wise water level analysis shows that during pre-monsoon season shallowest water levels are observed in alluvial formations and deepest in shale formations. During post-monsoon season, shallowest and deepest water levels are observed in Khondalite and Limestone(79.7 m). Aquifer wise water level scenario is presented in **Table-7.1.**

Table-7.1: Aquifer wise Minimum, Maximum and Average values of water levels, Andhra Pradesh State.

		May-16				Nov-16			
S NO	AQUIFER	MIN	MAX	AVG	COUNT	MIN	MAX	AVG	COUNT
1	GRANITE	0.7	14.5	7.8	26	0.3	37.7	6	31
2	INTRUSIVES	0	0	0	0	22.6	22.6	22.6	1
3	SHALES	2.1	49.3	10	36	0.3	45.2	8.1	42
4	LIMESTONE	0.3	39.5	9.6	30	-0.1	79.7	10.2	33
5	SCHIST	0.7	29.5	7.3	54	-0.2	22	3.7	51
6	GNIESS	1	12.2	5.7	64	1.5	22.4	5.9	69
7	LATRITE	1.5	13.3	5.3	10	0.6	7.2	2.6	8
8	ALLUVIUM	-0.8	19.8	3.4	187	0.2	11.9	3.3	203
9	SANDSTONE	0.8	18.1	6.2	28	0.7	37.6	7.1	27

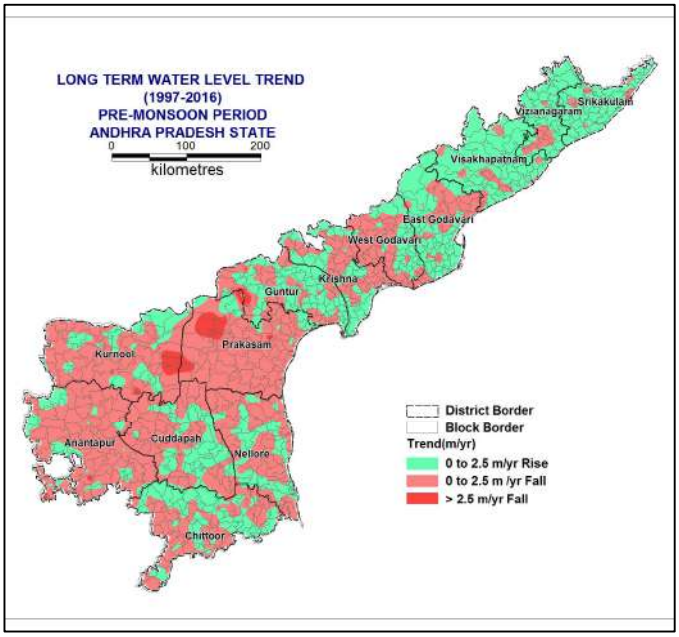
10	QUARTZITE	1.8	11.3	6.5	12	1.1	48.5	9.7	9
11	KHONDALITE	-0.7	22.3	5.6	93	-0.3	21.8	5.1	96
12	CHANROCKITE	0.9	38.1	5.4	66	0.7	14.8	4.8	65
13	BRANDED GNIESSIC COMPLEX	-0.8	18.6	6.4	154	0.1	32.2	4.2	171

7.6 Long-term Water Level trends:

7.6.1 Long term water level trend based on maps

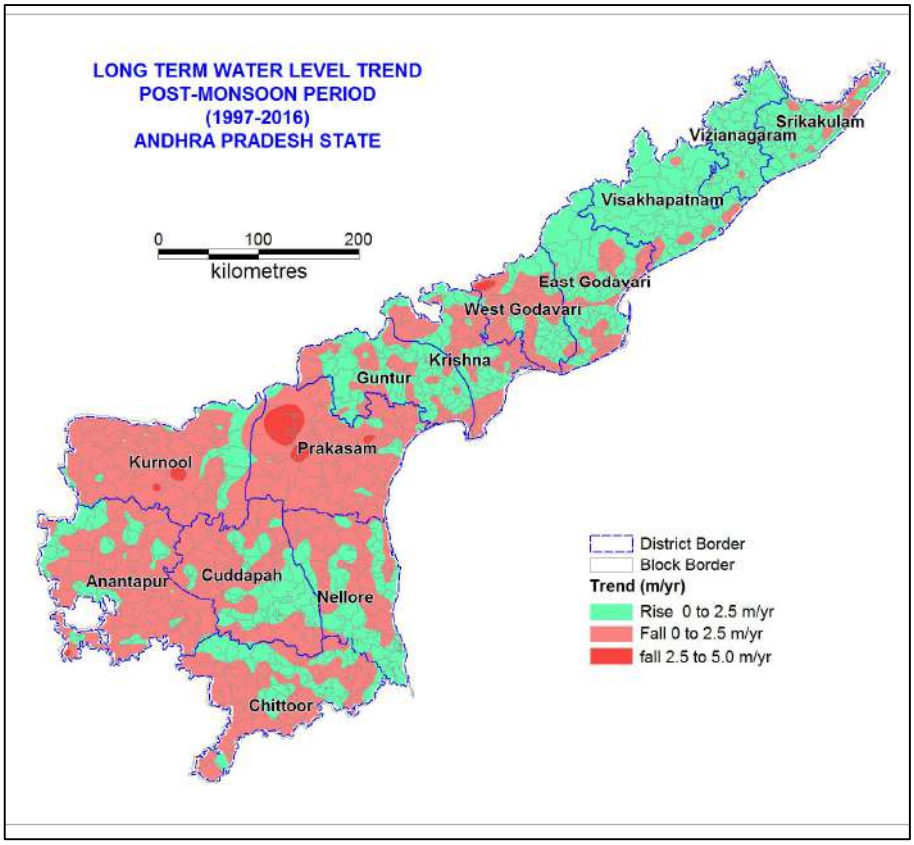
The long term water level trend is depicted in maps of pre-monsoon, post-monsoon and annual of water level based on data from 1997-2016. Pre and post monsoon fallows the same trend.

Pre-monsoon trend map: It is inferred from the pre-monsoon water level trend map that the fall in water level trend of 0-2.5 m/yr is more prevalent in the southern districts of the state along with parts of East , West Godavari and Krishna district. The trend of more than 2.5 m/yr fall is observed in Prakasam and Kurnool districts as small patch**.(Fig 7.16).** The rise in water level trend (0 to 2.5 m/yr) is prvlent in parts of Srikakulam , Vizianagaram and Visakhapatnam districts and in some parts of East Godavari and West Godavari districts. Fall in water level trend is observed in some parts of the districts comprising Anantapur, YSR Kadapa, Chittoor, Kurnool, Prakasam districts. Ground water is the main source of irrigation. In parts of East and West Godavari districts, fall in trend is noticed , which is due to expoitation of ground water.



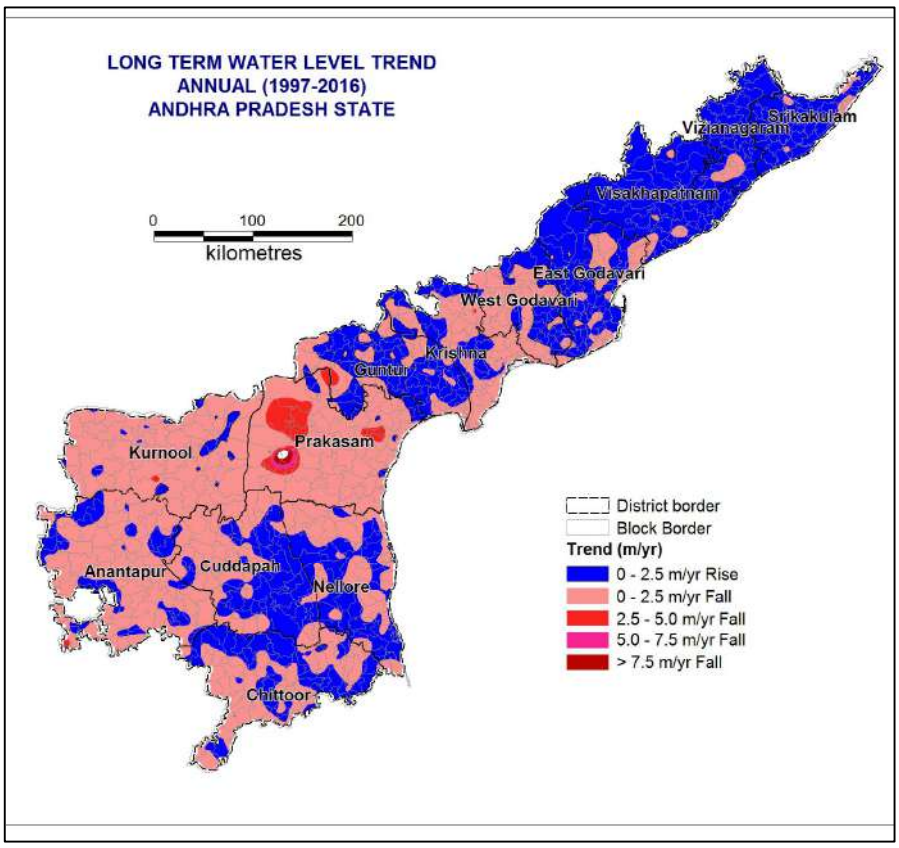
7.16 Long term water level trend – Pre-monsoon period (1997-2016)

Post-monsoon trend map: It is inferred from the post-monsoon water level trend map that the fall in water level trend of 0-2.5 m/yr is more prevalent in the southern districts of the state along with parts of West Godavari and Krishna district. The falling trend of more than 2.5 m/yr is observed in Prakasam and Kurnool districts as small patch**.(Fig 7.17).** Rise in water level trend of 0 to 2.5 m/yr is prevalent in Srikakulam, Vizainagaram and Visakhapatnam districts and some parts of East Godavari district.



7.17 Long term water level trend Post-monsoon period(1997-2016)

Annual trend map: It is inferred from the annual water level trend map that the fall in water level trend of 0-2.5 m/yr is more prevalent in the Prakasam, anantapur, Kurnool and parts of West Godavari and Krishna districts of the state. The rise in water level trend of 0 to 2.5 m/yr is prevalent in Srikakulam, Vizianagaram, Visakhapatnam districts and also in some parts of East and West Godavari, Guntur, Chittoor and SPS Nellore districtgs.The falling trend of more than 2.5 m/yr is observed in Prakasam districts as small patch**.(Fig 7.18)**



7.18 Long term water level trend - Annual(1997-2016)

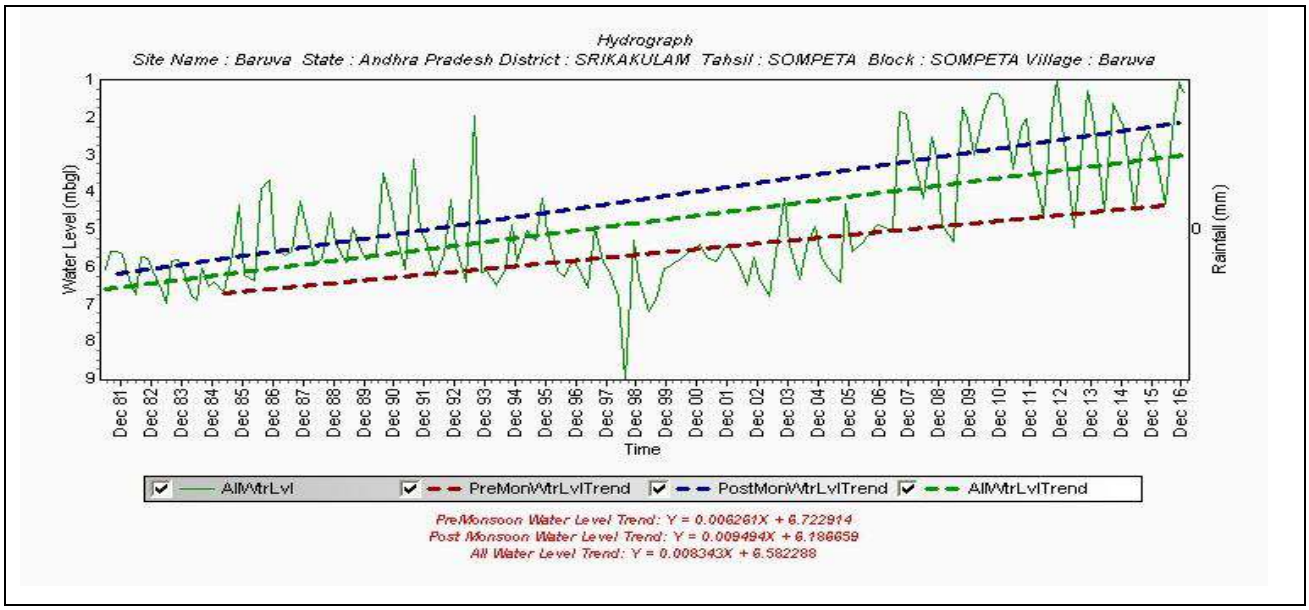
7.6.2 Hydrographs of water levels

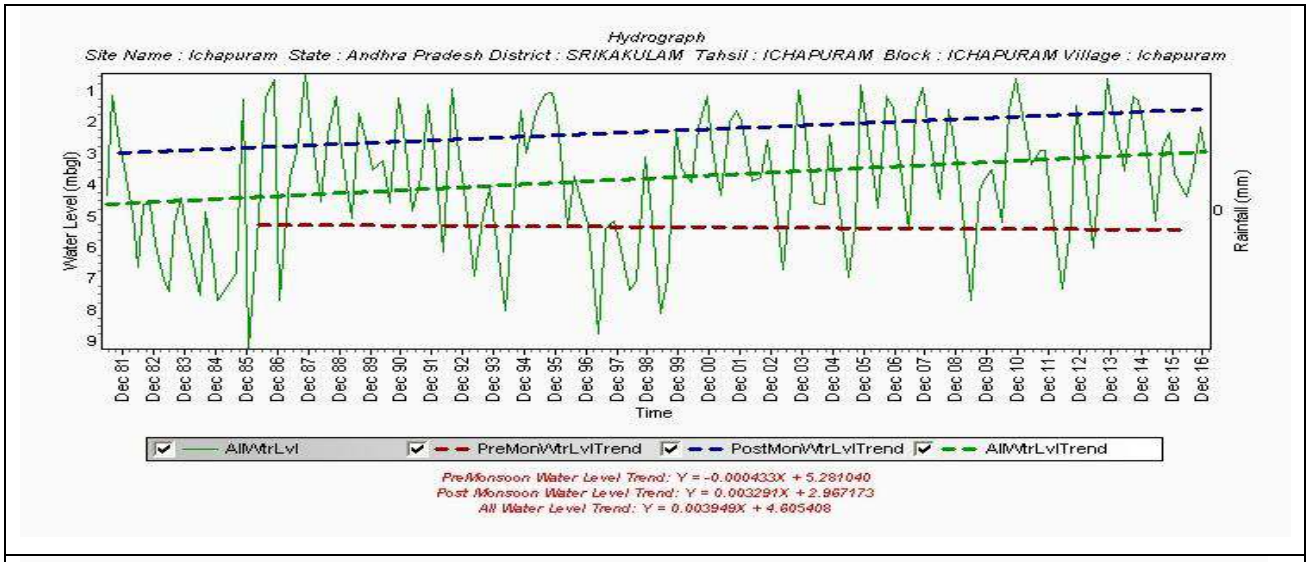
Total 26 hydrographs are generated (2 from each district) (**Table-7.2 and Fig. 7.19**). Out of 26, 7 wells shows rising trends in both seasons, 8 shows falling trends in both season and rest shows mix trends (**Table-7.2**).

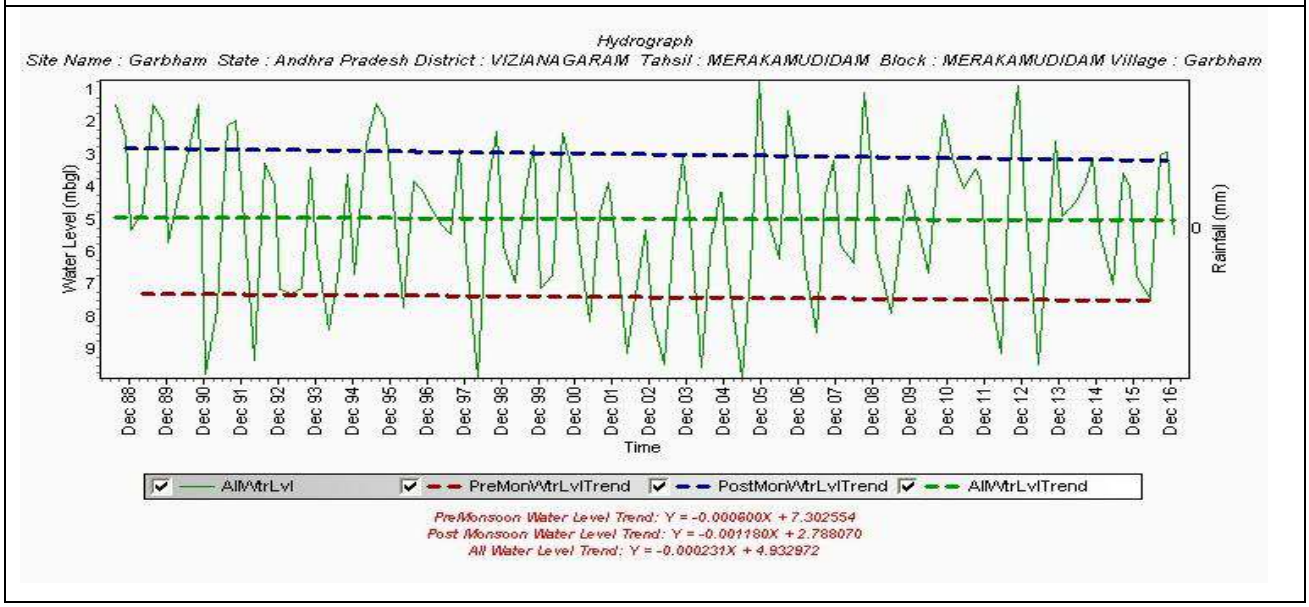
Table-7.2: Representative Hydrographs showing rising and falling trends in Andhra Pradesh State.

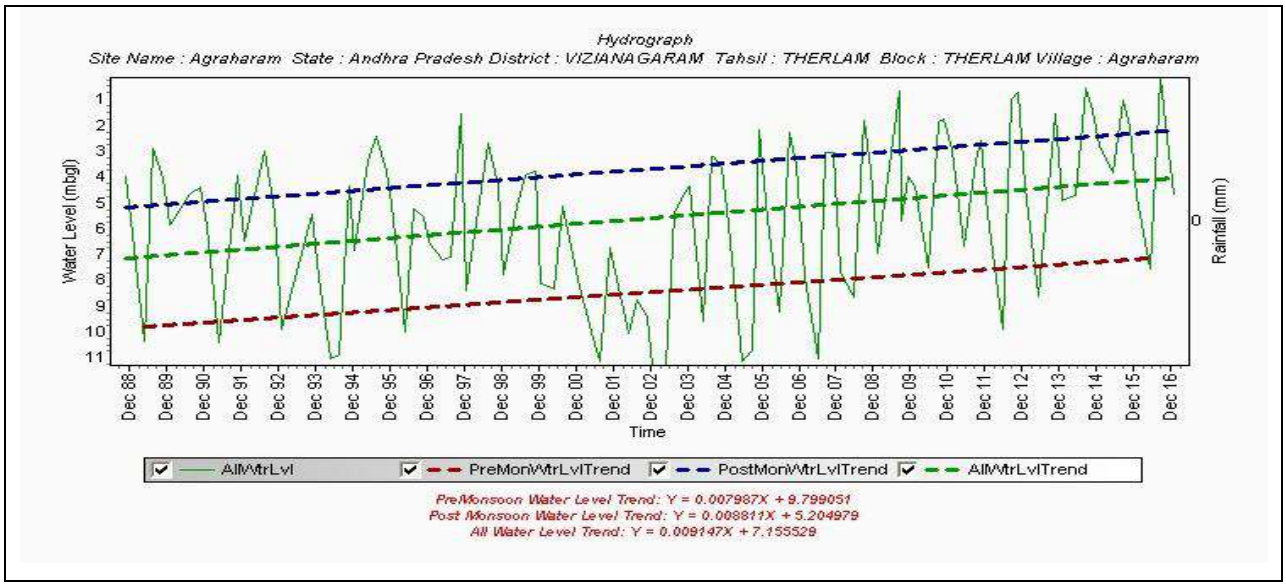
S. No.	Location	District	Pre (m/yr)		Post (m/yr)	
			Rise	Fall	Rise	Fall
1	Amarapurama	Anantapur		0.168		0.276
2	Anatapur	Anantapur	0.168		0.18	
3	Damalcheruvu	Chittoor	0.0048			0.024
4	Battuvaripalli	Chittoor	0.0192			0.0276
5	Muddireddipalli	Cuddapah		0.096		0.204
6	Anjaneyapuram	Cuddapah	0.24			0.108
7	Jaggampet	East Godavari	0.144		0.048	
8	Gollaprolu	East Godavari	0.018			0.0036

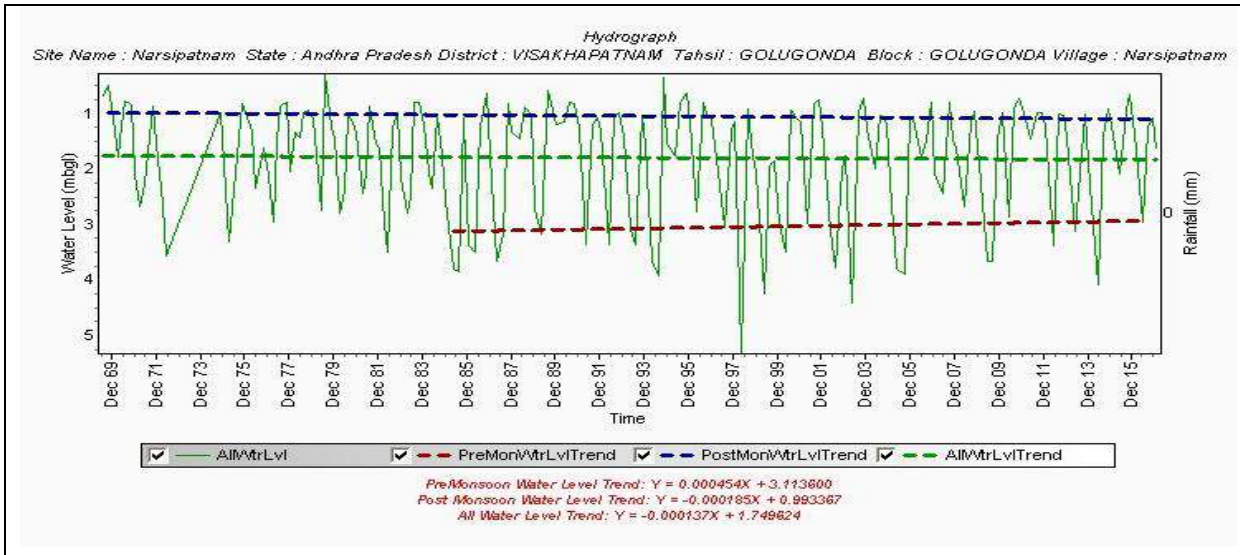
9	Ipur	Guntur		0.00216		0.036
10	Guntur	Guntur	0.0348			0.0084
11	Nuziveedu	Krishna	0.0732		0.084	
12	Gudivada	Krishna	0.0048		0.0012	
13	Gonegandla	Kurnool	0.072			0.0096
14	Ahobilam	Kurnool		0.168		0.144
15	Kadanothola	Nellore		0.048	0.0156	
16	Bata	Nellore		0.0228		0.0096
17	Chirala	Prakasam		0.0084	0.0156	
18	Chandalur	Prakasam		0.1104	0.0108	
19	Ichapuram	Srikakulam		0.0048	0.036	
20	Barua	Srikakulam	0.072		0.108	
21	Narsipattanam	Vishakhapattanam	0.0048			0.0012
22	Araku	Vishakhapattanam		0.024		0.0192
23	Agraharam	Vizianagaram	0.0948		0.096	
24	Garbham	Vizianagaram		0.0072		0.0132
25	Kovvur	West Godavari	0.024		0.036	
26	Eluru	West Godavari		0.996		0.864

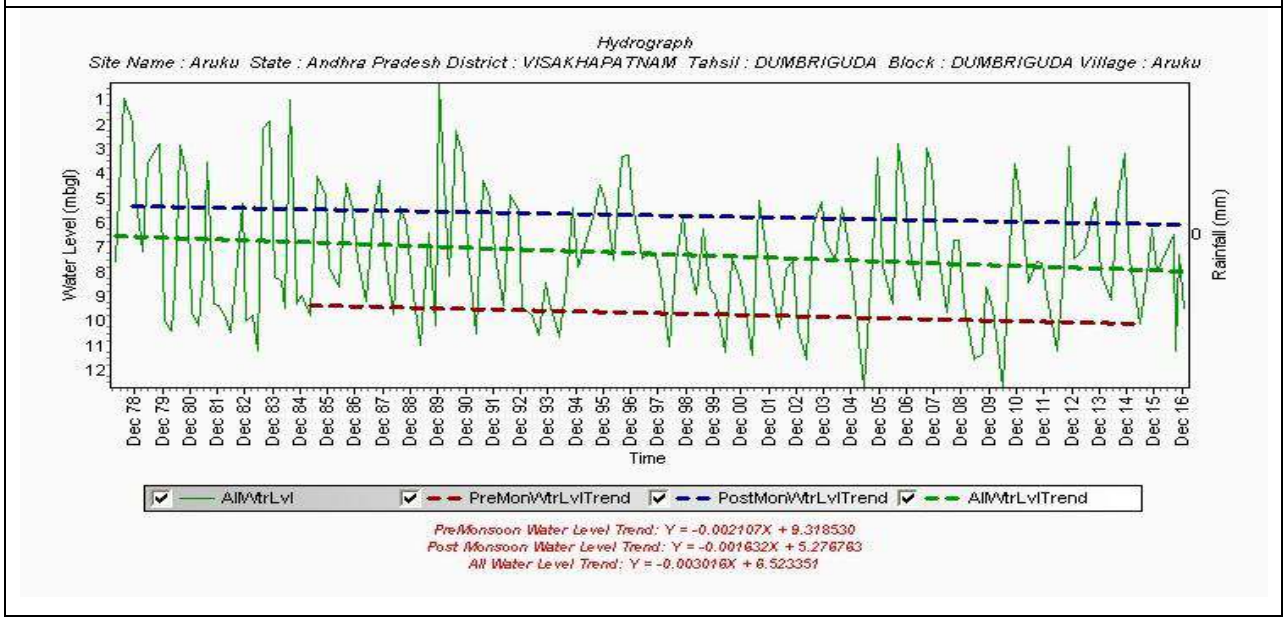


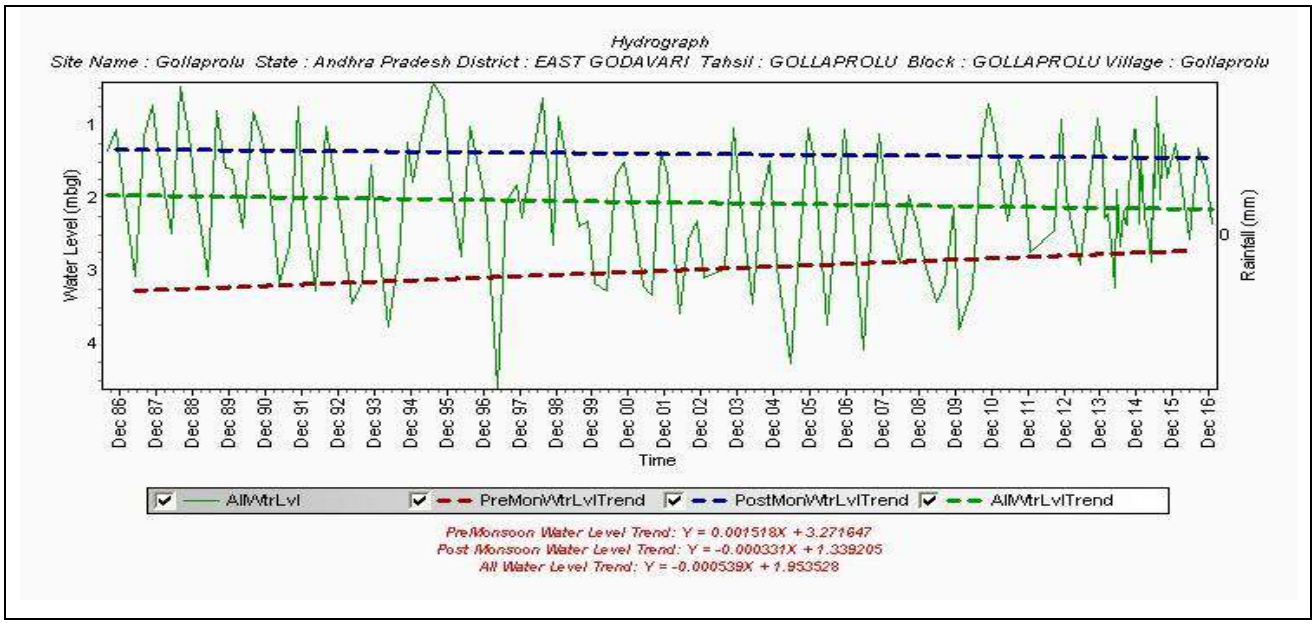

Hydrograph
Site Name : Ichapuram State : Andhra Pradesh District : SRIKAKULAM Tahsil : ICHAPURAM Block : ICHAPURAM Village : Ichapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000433X + 5.281040
Post Monsoon Water Level Trend: Y = 0.003291X + 2.967173
All Water Level Trend: Y = 0.003949X + 4.605408

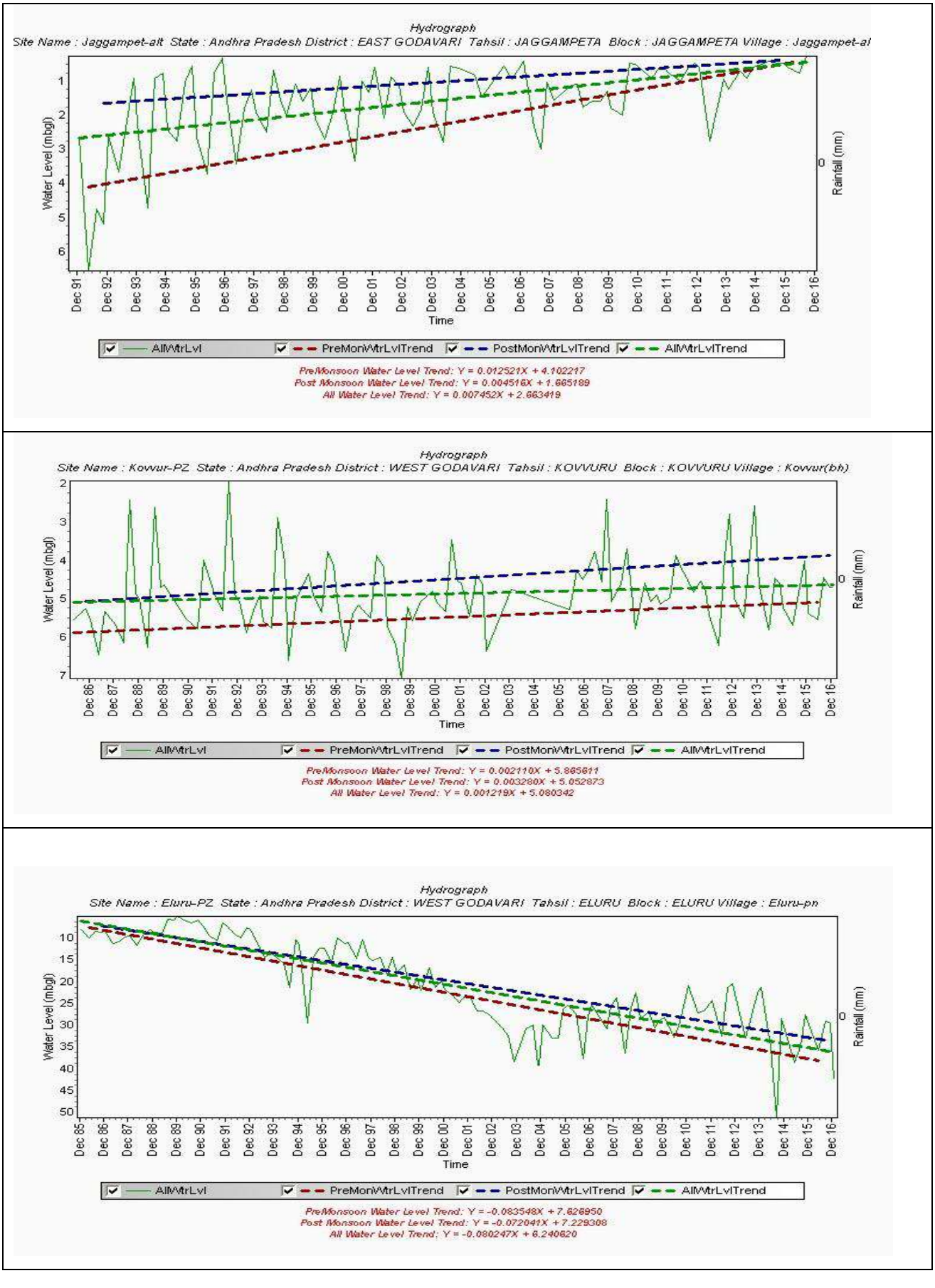

Hydrograph
Site Name : Garbham State : Andhra Pradesh District : VIZIANAGARAM Tahsil : MERAKAMUDIDAM Block : MERAKAMUDIDAM Village : Garbham
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000600X + 7.302554
Post Monsoon Water Level Trend: Y = -0.001180X + 2.788070
All Water Level Trend: Y = -0.000231X + 4.932972

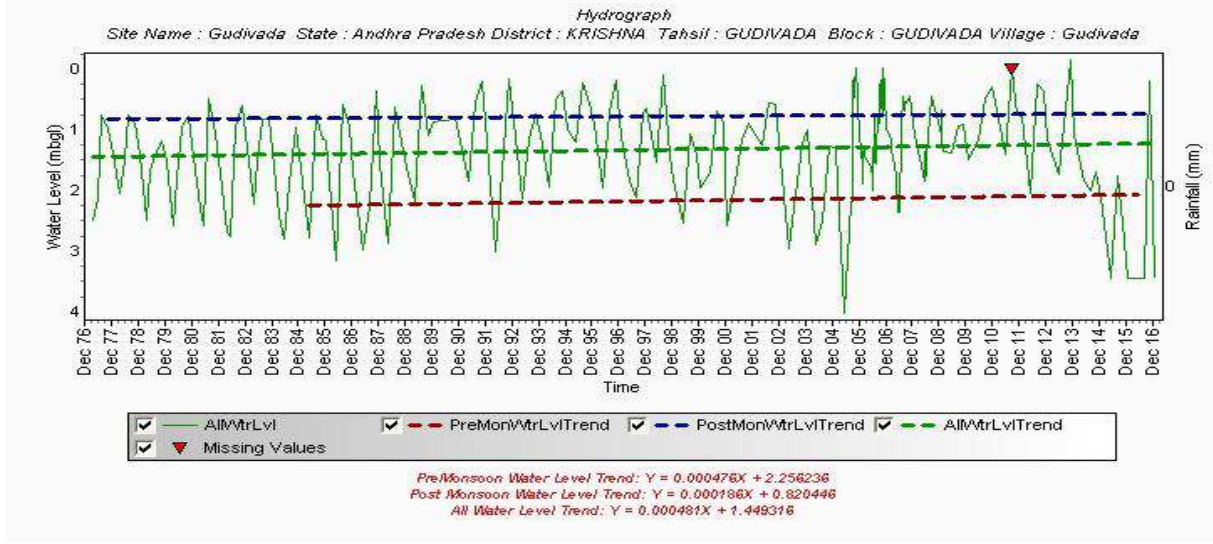

Hydrograph
Site Name : Agraharam State : Andhra Pradesh District : VIZIANAGARAM Tahsil : THERLAM Block : THERLAM Village : Agraharam
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.007987X + 9.799051
Post Monsoon Water Level Trend: Y = 0.008811X + 5.204979
All Water Level Trend: Y = 0.009147X + 7.155529

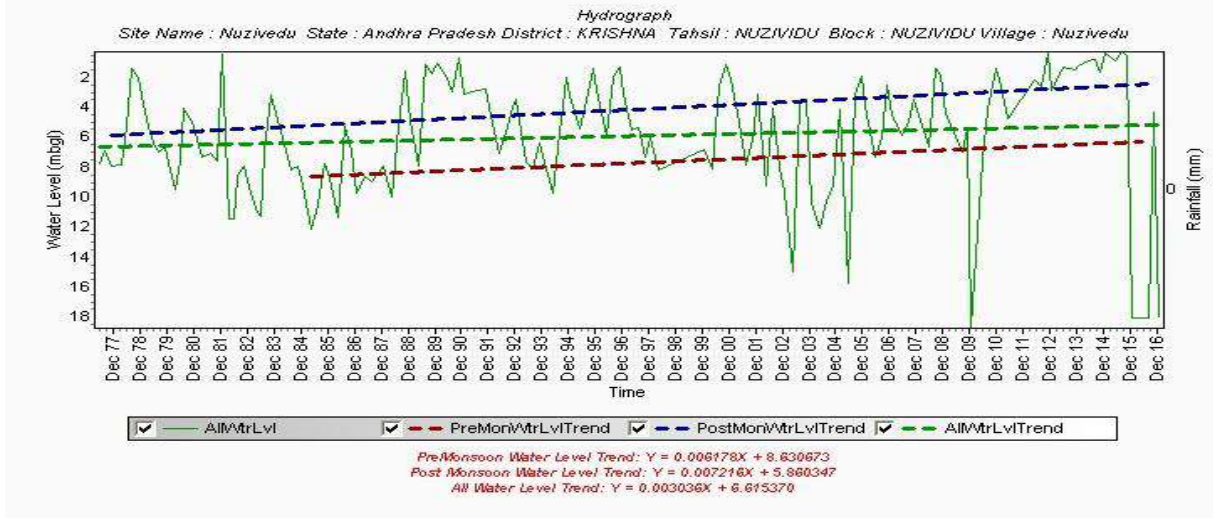

Hydrograph
Site Name : Narsipatnam State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : GOLUGONDA Block : GOLUGONDA Village : Narsipatnam
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000454X + 3.113600
Post Monsoon Water Level Trend: Y = -0.000185X + 0.993367
All Water Level Trend: Y = -0.000137X + 1.749624

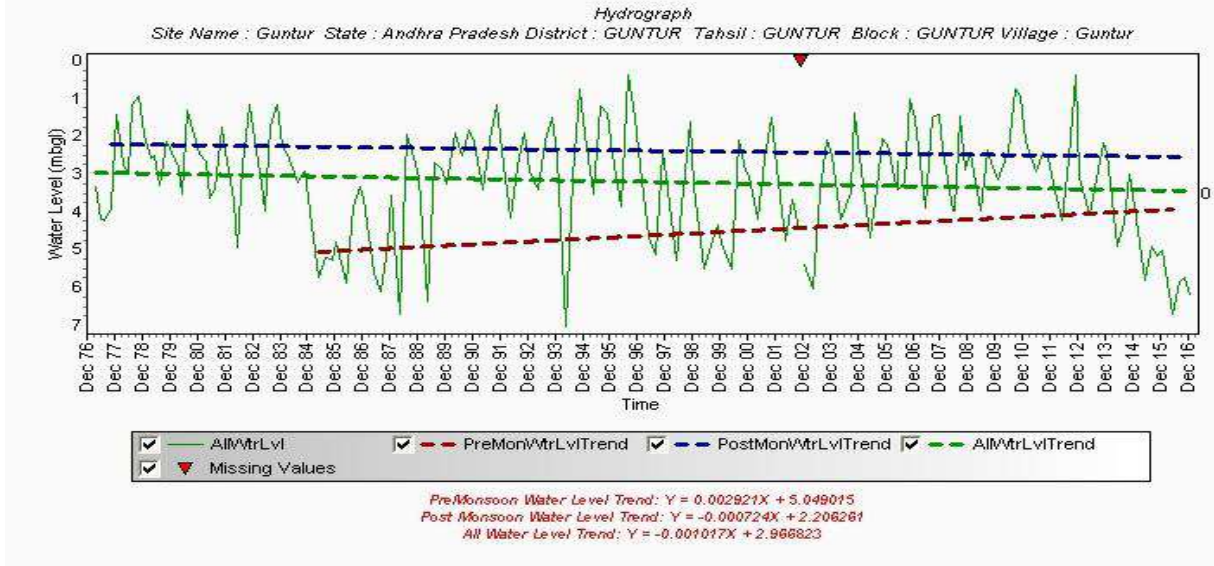

Hydrograph
Site Name : Aruku State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : DUMBRIGUDA Block : DUMBRIGUDA Village : Aruku
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.002107X + 9.318530
Post Monsoon Water Level Trend: Y = -0.001632X + 5.276763
All Water Level Trend: Y = -0.003016X + 6.523351

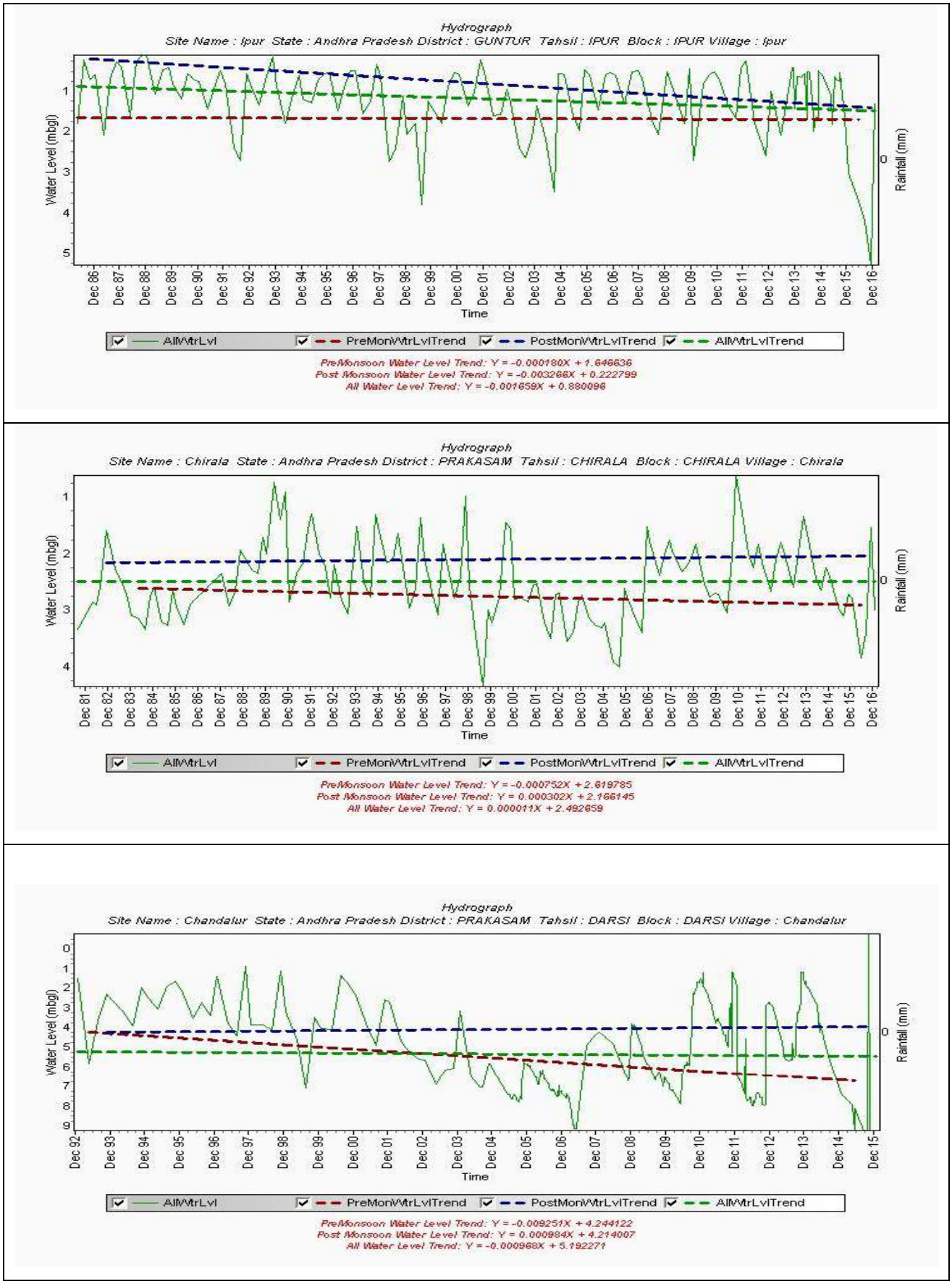

Hydrograph
Site Name : Gollaprolu State : Andhra Pradesh District : EAST GODAVARI Tahsil : GOLLAPROLU Block : GOLLAPROLU Village : Gollaprolu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001518X + 3.271647
Post Monsoon Water Level Trend: Y = -0.000331X + 1.339205
All Water Level Trend: Y = -0.000539X + 1.953528

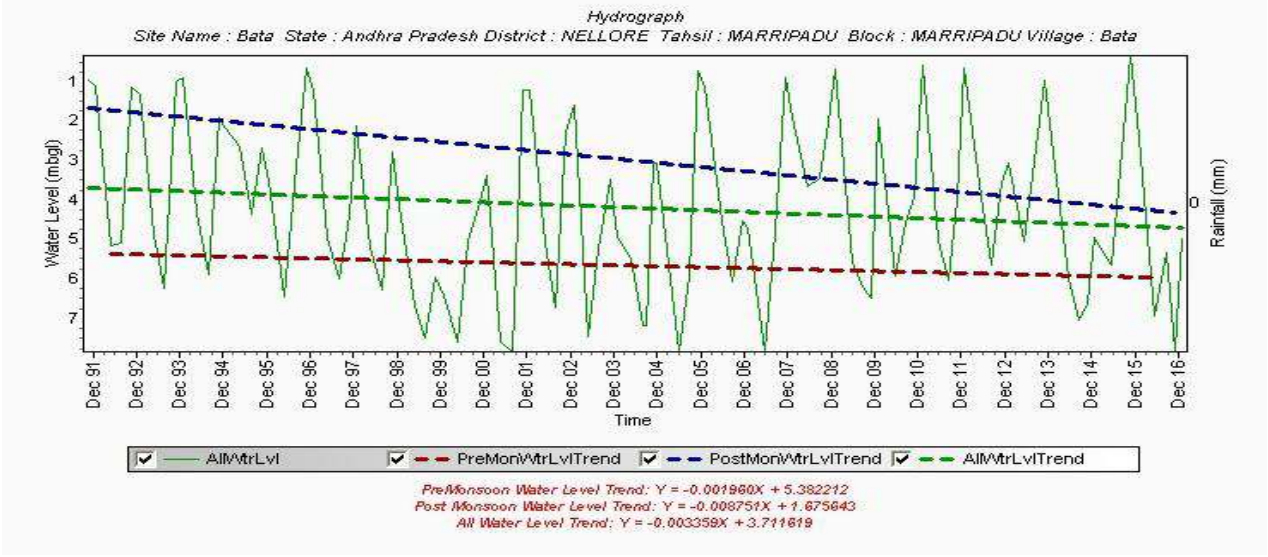

Hydrograph
Site Name : Jaggampet-alt State : Andhra Pradesh District : EAST GODAVARI Tahsil : JAGGAMPETA Block : JAGGAMPETA Village : Jaggampet-al
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.012521X + 4.102217
Post Monsoon Water Level Trend: Y = 0.004516X + 1.665189
All Water Level Trend: Y = 0.007452X + 2.663419
Hydrograph
Site Name : Kovvur-PZ State : Andhra Pradesh District : WEST GODAVARI Tahsil : KOVVURU Block : KOVVURU Village : Kovvur(bh)
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.002110X + 5.865611
Post Monsoon Water Level Trend: Y = 0.003280X + 5.052873
All Water Level Trend: Y = 0.001219X + 5.080342
Hydrograph
Site Name : Eluru-PZ State : Andhra Pradesh District : WEST GODAVARI Tahsil : ELURU Block : ELURU Village : Eluru-pn
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.083548X + 7.626950
Post Monsoon Water Level Trend: Y = -0.072041X + 7.229308
All Water Level Trend: Y = -0.080247X + 8.240620

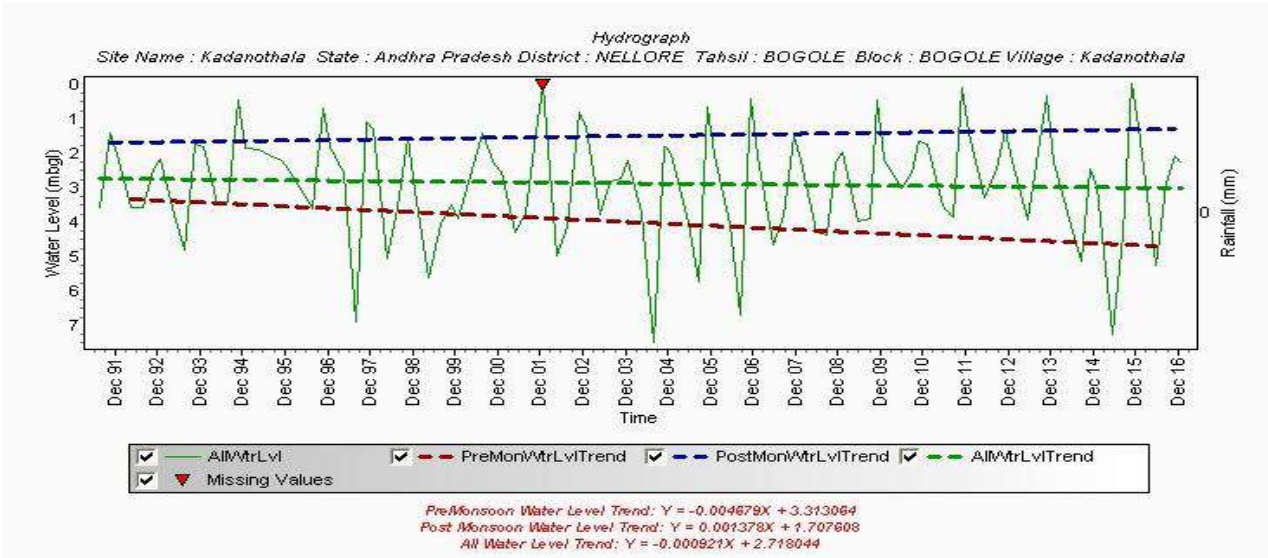

Hydrograph
Site Name : Gudivada State : Andhra Pradesh District : KRISHNA Tahsil : GUDIVADA Block : GUDIVADA Village : Gudivada
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.000476X + 2.256236
Post Monsoon Water Level Trend: Y = 0.000186X + 0.820446
All Water Level Trend: Y = 0.000481X + 1.449316

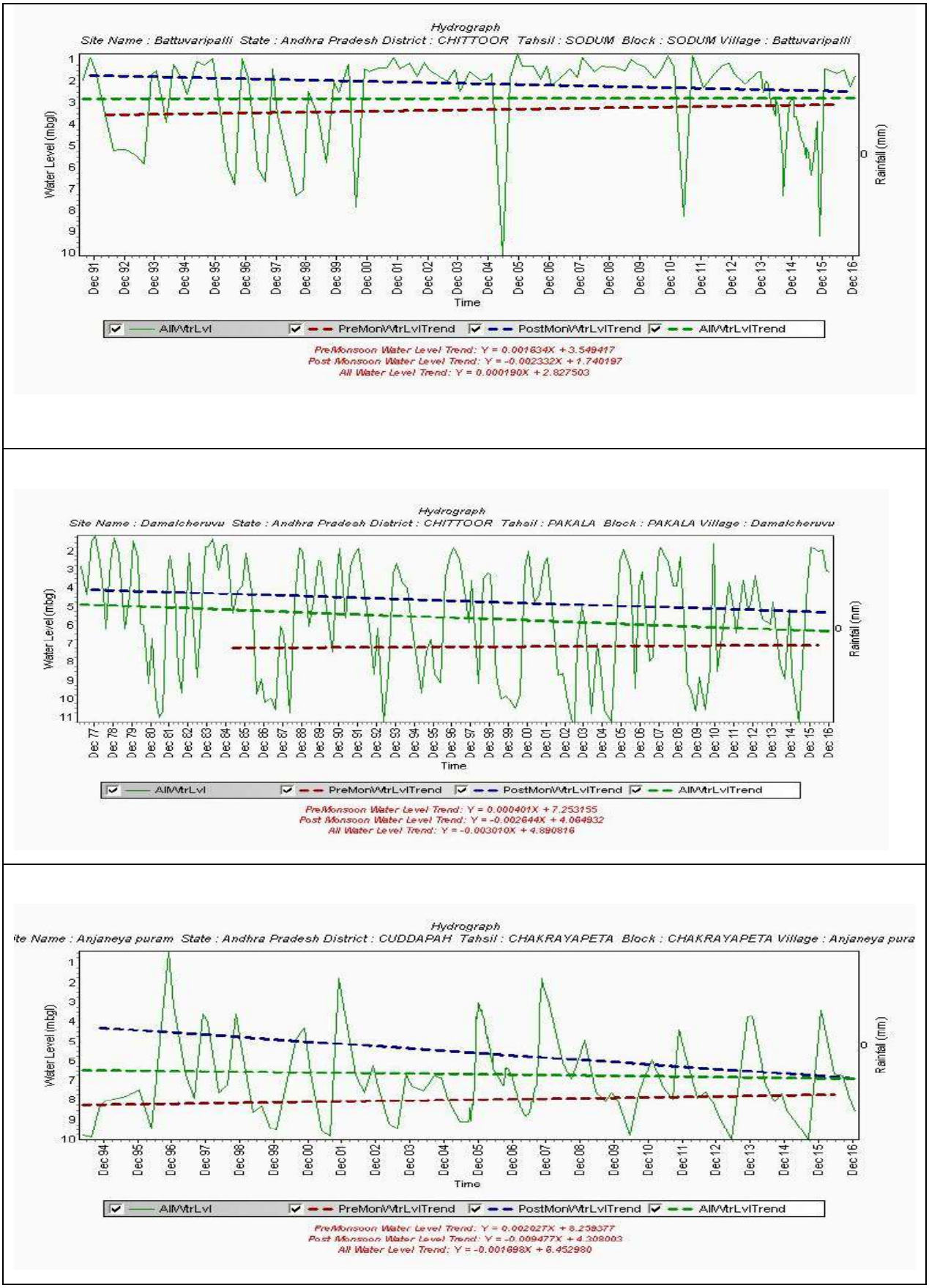

Hydrograph
Site Name : Nuzivedu State : Andhra Pradesh District : KRISHNA Tahsil : NUZIVIDU Block : NUZIVIDU Village : Nuzivedu
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.006178X + 8.630673
Post Monsoon Water Level Trend: Y = 0.007216X + 5.860347
All Water Level Trend: Y = 0.003036X + 6.615370

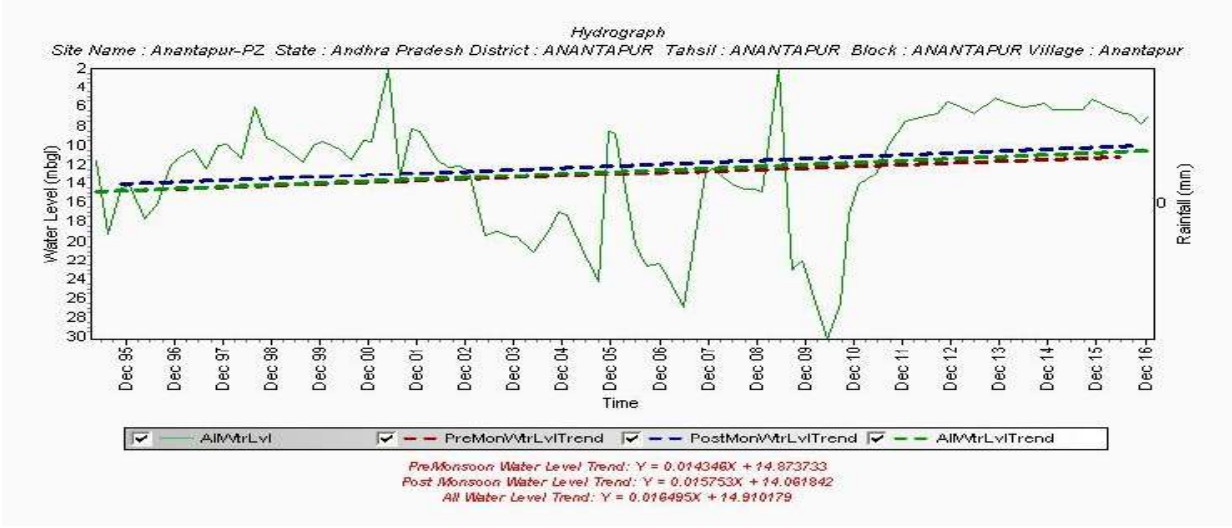

Hydrograph
Site Name : Guntur State : Andhra Pradesh District : GUNTUR Tahsil : GUNTUR Block : GUNTUR Village : Guntur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.002921X + 5.049015
Post Monsoon Water Level Trend: Y = -0.000724X + 2.206261
All Water Level Trend: Y = -0.001017X + 2.966823

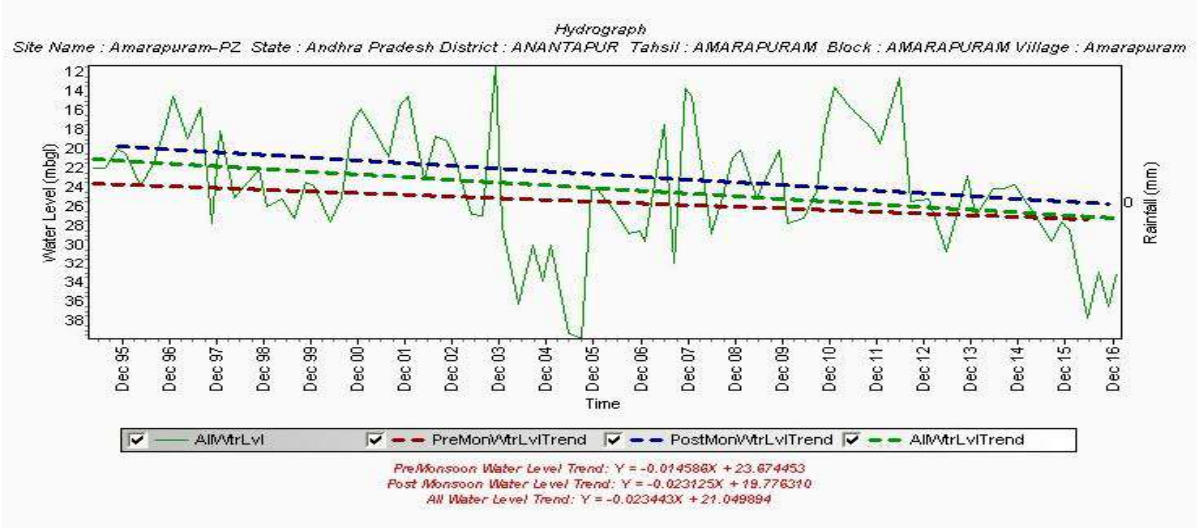

Hydrograph
Site Name : Ipur State : Andhra Pradesh District : GUNTUR Tahsil : IPUR Block : IPUR Village : Ipur
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000180X + 1.646636
Post Monsoon Water Level Trend: Y = -0.003266X + 0.222799
All Water Level Trend: Y = -0.001659X + 0.880096
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 = -0.000752X + 2.619785
Post Monsoon Water Level Trend: Y = 0.000302X + 2.166145
All Water Level Trend: Y = 0.000011X + 2.492659
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

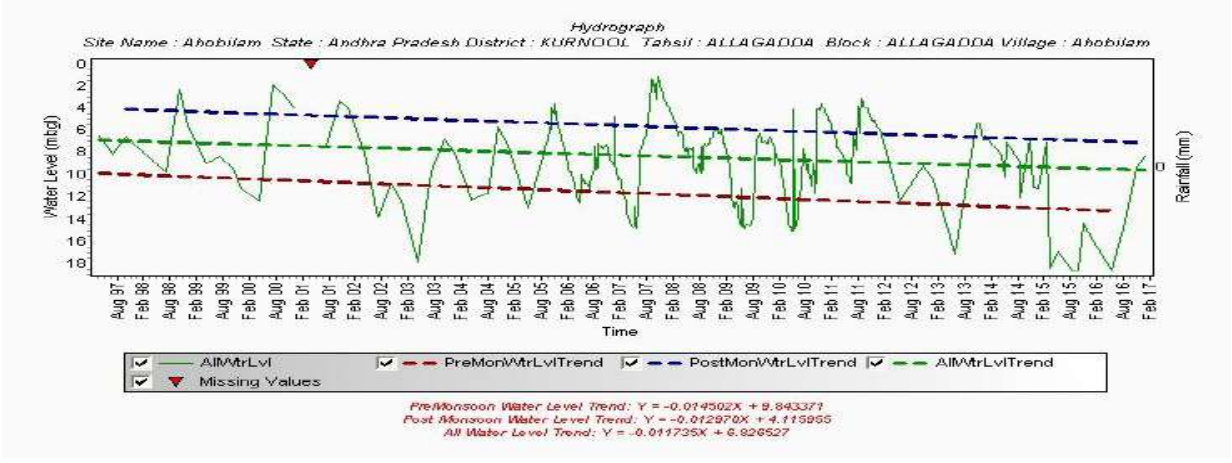

Hydrograph
Site Name : Bata State : Andhra Pradesh District : NELLORE Tahsil : MARRIPADU Block : MARRIPADU Village : Bata
Water Level (mbgl)
Rainfall (mm)
Time
AllWtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllWtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.001960X + 5.382212
Post Monsoon Water Level Trend: Y = -0.008751X + 1.675643
All Water Level Trend: Y = -0.003359X + 3.711619


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 = -0.004679X + 3.313064
Post Monsoon Water Level Trend: Y = 0.001378X + 1.707608
All Water Level Trend: Y = -0.000921X + 2.718044


Hydrograph
Site Name : Battuvaripalli State : Andhra Pradesh District : CHITTOOR Tahsil : SODUM Block : SODUM Village : Battuvaripalli
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMoniMtrLvlTrend
PostMoniMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001634X + 3.549417
Post Monsoon Water Level Trend: Y = -0.002332X + 1.740197
All Water Level Trend: Y = 0.000190X + 2.827503
Hydrograph
Site Name : Damalcheruvu State : Andhra Pradesh District : CHITTOOR Tahsil : PAKALA Block : PAKALA Village : Damalcheruvu
Water Level (mbg)
Rainfall (mm)
Time
AllMtrLvl
PreMoniMtrLvlTrend
PostMoniMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.000401X + 7.253155
Post Monsoon Water Level Trend: Y = -0.002644X + 4.064932
All Water Level Trend: Y = -0.003010X + 4.890816
Hydrograph
te Name : Anjaneya puram State : Andhra Pradesh District : CUDDAPAH Tahsil : CHAKRAYAPETA Block : CHAKRAYAPETA Village : Anjaneya pura
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMoniMtrLvlTrend
PostMoniMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.002027X + 8.258377
Post Monsoon Water Level Trend: Y = -0.009477X + 4.309003
All Water Level Trend: Y = -0.001698X + 8.452980


Hydrograph
Site Name : Anantapur-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : ANANTAPUR Block : ANANTAPUR Village : Anantapur
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.014346X + 14.873733
Post Monsoon Water Level Trend: Y = 0.015753X + 14.061842
All Water Level Trend: Y = 0.016495X + 14.910179


Hydrograph
Site Name : Amarapuram-PZ State : Andhra Pradesh District : ANANTAPUR Tahsil : AMARAPURAM Block : AMARAPURAM Village : Amarapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.014586X + 23.674453
Post Monsoon Water Level Trend: Y = -0.023125X + 19.776310
All Water Level Trend: Y = -0.023443X + 21.049894


Hydrograph
Site Name : Ahobilam State : Andhra Pradesh District : KURNOOL Tahsil : ALLAGADDA Block : ALLAGADDA Village : Ahobilam
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonWtrLvlTrend
PostMonWtrLvlTrend
AllMtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = -0.014502X + 9.843371
Post Monsoon Water Level Trend: Y = -0.012970X + 4.115955
All Water Level Trend: Y = -0.011735X + 6.926527

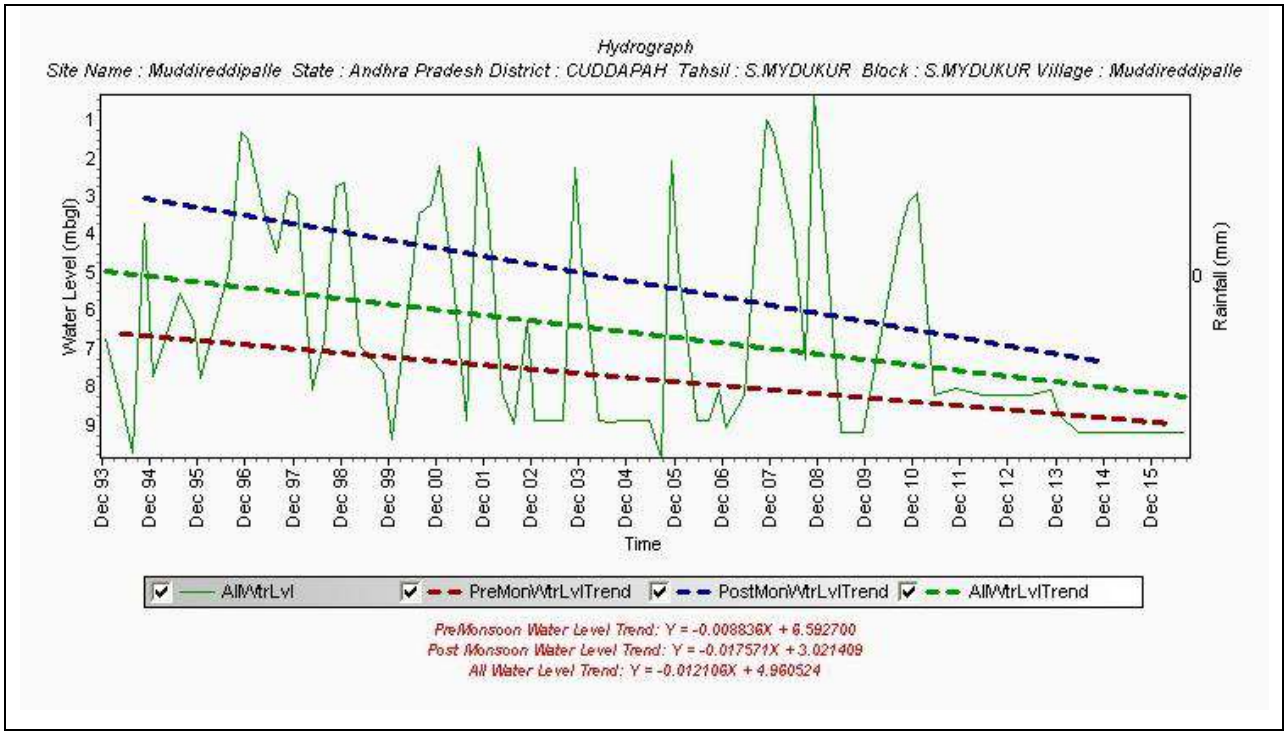


Fig.7.19: Representative Hydrographs from Andhra Pradesh State.

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. Total 684 groundwater samples were collected for normal analysis , Iron and Arsenic analysis from shallow GWMS (both DW and Pz) during pre-monsoon season of 2016 (May) and district wise number of samples analysed is given in **Table-8.1.**The samples are analyzed in the Chemical Laboratory of CGWB (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), bicarbonate (HCO_3^{-}), chloride (Cl), sulphate (SO_4^{2-}), nitrate (NO_3^{-}) and fluoride (F^{-}) were determined. The cation and anion balance are within acceptable limits of +/- 5% (**APHA, 1998**). District wise minimum, maximum and average data is given in **Annexure XXI.**

Table-8.1: District wise collection of samples (May-2016).

S.No.	District	samples		S.No.	District	samples
1	Anantapuramu	32		8	Nellore	24
2	Chittor	48		9	Prakasam	27
3	Cuddapah	23		10	Srikakulam	50
4	East Godavari	109		11	Vishakhapatnam	68
5	Guntur	81		12	Vizianagaram	51
6	Krishna	66		13	West Godavari	72
7	Kurnool	33			**Total**	**684**

8.1 Distribution of physico-chemical parameters and suitability for drinking purpose (as per BIS, 2012)

8.1.1 Hydrogen Ion Concentration (pH)

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(Gumma-Vizianagaram district) to 9.3 (Rachuru-West Godavari district). In 23 samples (9 from Srikakulam highest exceeded) pH is beyond permissible limits of BIS (**Annexure-XXI**).

8.1.2 Electrical Conductivity (EC)

Specific conductance (EC) of an electrolyte is the reciprocal of specific resistance and is expressed in µ S/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 values (µS/cm at 25 $^{\circ}$C) ranges from 60 to 13980 µS/cm, The Highest sample is Kanchikacherla of Krishna District may be due to Inland Salinity due to Black Cotton Soils of the area.

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. In the state, concentration of TDS ranges from 35-8511 mg/l (avg: 1099mg/L) and it is found that in 90 samples TDS is beyond drinking water standard limits (2000 mg/l) (**Fig.8.1**)

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 25-2600 mg/l and it is found that in 98 samples (14.4%), Total Hardness is beyond drinking water standard 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 concentrations of calcium in the state range from 4-46 mg/l and it is found that in 28 samples (4.1%), Calcium is beyond drinking water standard limits (200 mg/l).

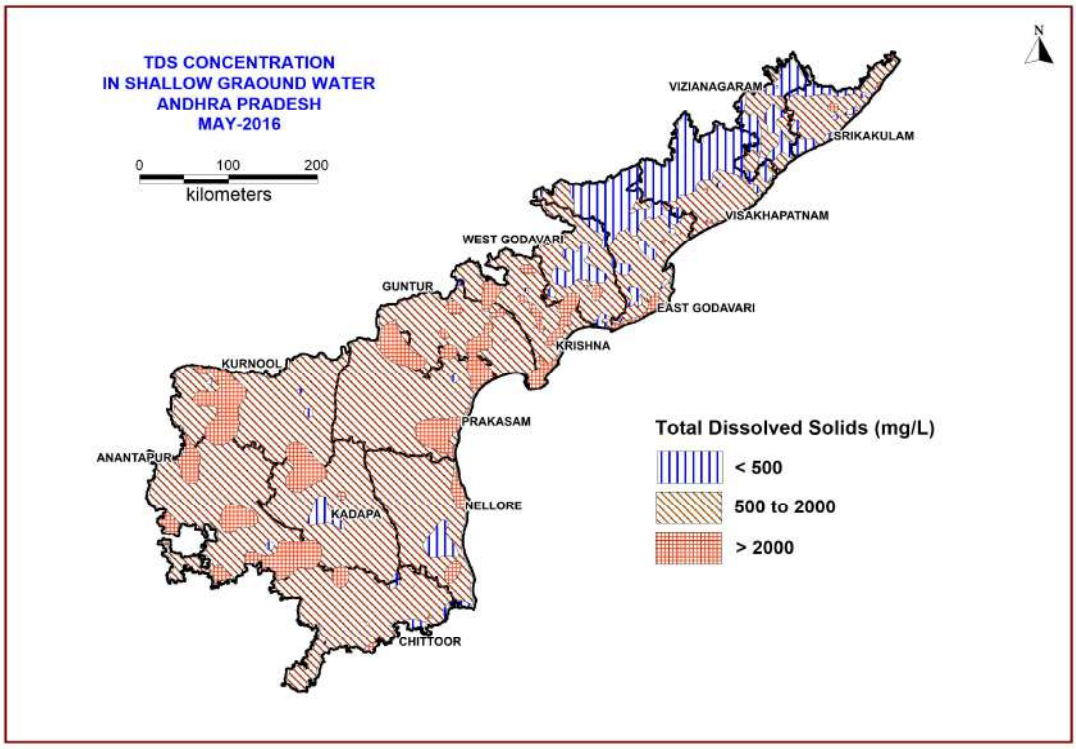


Fig.8.1: Distribution of TDS in Andhra Pradesh (May-2016).

8.1.6 Magnesium (Mg^{2+})

Weathering of basic igneous rocks such as dunites, pyroxenites; volcanic rocks such as basalts; metamorphic rocks like amphibolites, talc and tremolite-schists; sedimentary rocks such as dolomite, gypsum *etc* are the main sources of Mg^{2+} in the groundwater (**Karanth, 1987**) and use of surface water for irrigation is another source of Mg^{2+} in the groundwater (**Hem, 1991**). In the State, as in most natural water, the magnesium concentration is much lower than the calcium concentration (**Hem, 1991**). It ranges from 1.2-353 mg/l. In total 17 samples (2.5%), Magnesium is beyond permissible limit of BIS.

8.1.7 Sodium (Na^+)

Silicate minerals such as albite, nepheline, sodalite, glaucophane, aegerine and other Na^+ bearing minerals present in rocks are the main source of Na^+ in the groundwater. The other sources are rainwater, dissolution of evaporate minerals, sodium disposal through sewage and industrial wastes (**Handa, 1975**). Certain clay minerals and zeolites can increase the sodium concentration in groundwater by base exchange reaction (**Karanth, 1987**). The concentration of Na^+ in the state ranges from 0.5 to 2325 mg/l. Maximum concentration of 2325 mg/l is detected in Kanchikacherla well (Krishna district).

8.1.8 Potassium (K^+)

The common source of K^+ in groundwaters is 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 concentrations of K^+ in ground water ranges from below detectable limits to 450 mg/l. Maximum concentration of 450 mg/l is noticed in Rachuru well (West Godavari 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 and 800 mg/l.

In the ground waters of State, the concentrations of bicarbonate ranges from nil to 1330 mg/l. Maximum concentration of 1330 mg/l is detected in Inovolu well (Guntur district). In 55 samples (8.1%) bicarbonate concentration is beyond maximum permissible limits of BIS

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 chloride 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 5.3 to 2801 mg/l. Highest concentration is detected at at Kanchikacherla of Krishna District and found that 29 samples are unsuitable for drinking purposes. **Areal distribution of chloride is depicted in Fig. 8.2.**

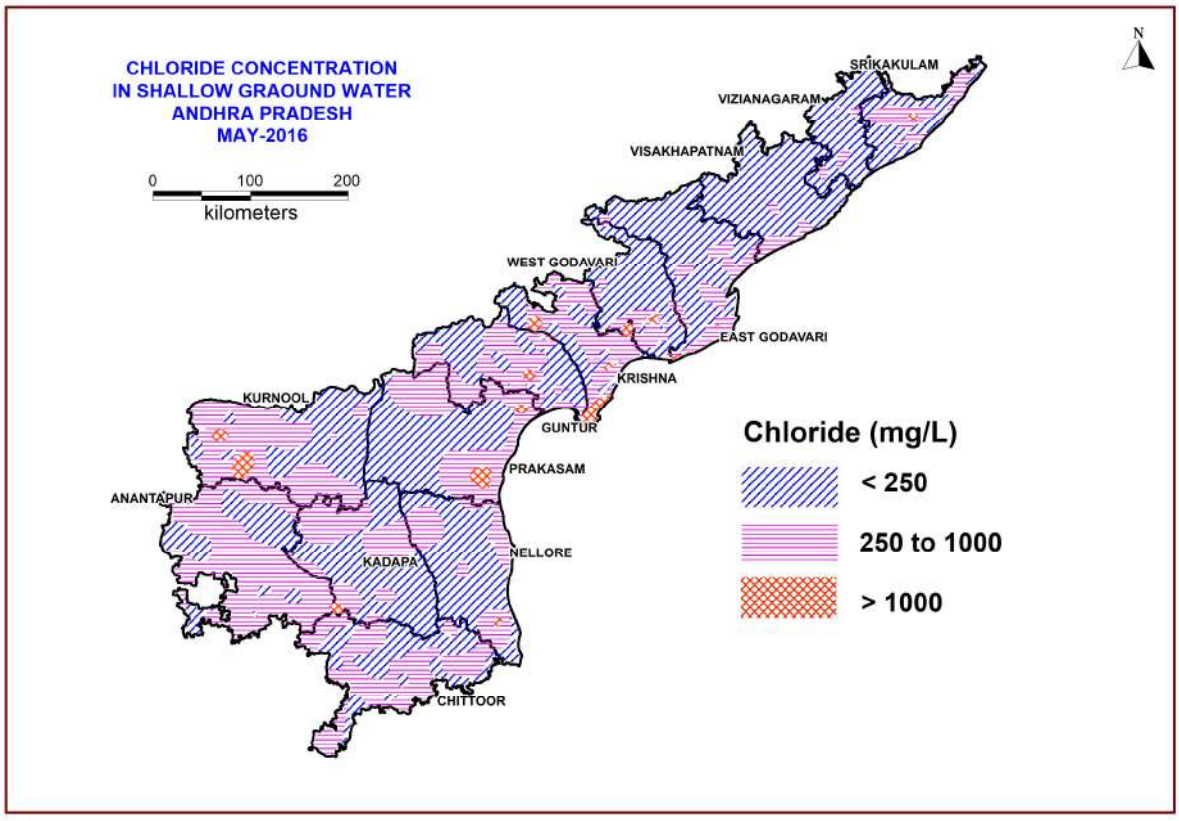


Fig.8.2: Distribution of Chloride in Andhra Pradesh (May-2016).

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 and other sources of Sulphate in groundwater (**Karanth, 1987**).

In the ground waters of state, the concentrations of sulphate range from 0-3130 mg/l and found that 46 samples are unsuitable for drinking purposes. Maximum concentration of 3130 mg/l is noticed in Karamchedu well (Prakasam district). **Areal distribution of Sulphate is depicted in Fig. 8.3.**

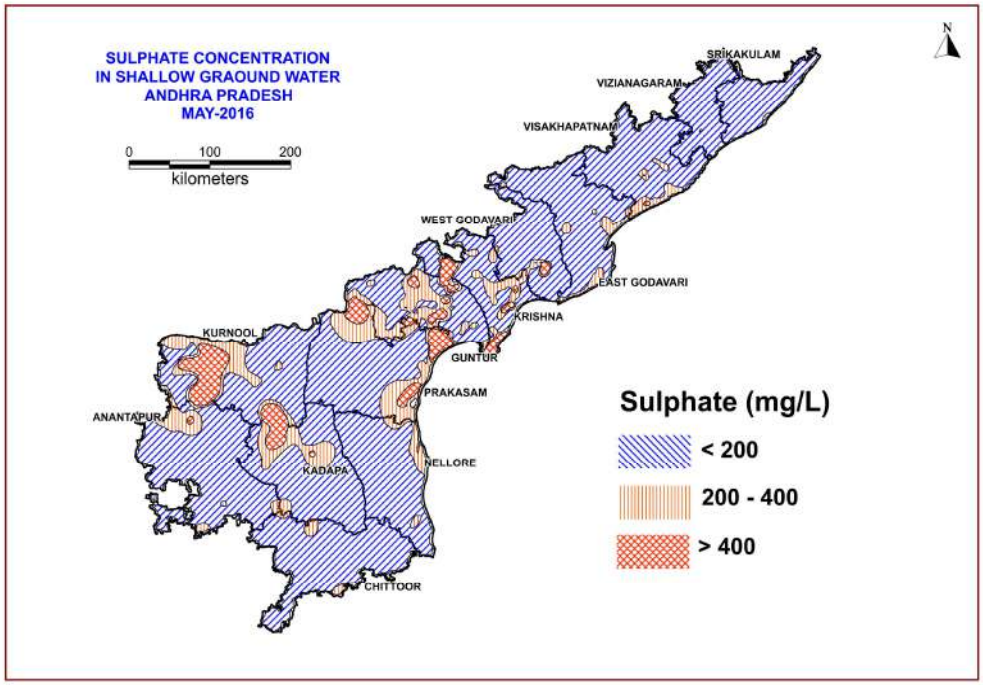


Fig.8.3: Distribution of Sulphate in Andhra Pradesh (May-2016).

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 0-1119 mg/l. Maximum concentration of 1119 mg/l is noticed in Nallacherla well (Anathapur district). It is found that 283 samples (40%) are unfit for human consumptions. **Distribution of nitrate is presented in Fig.8.4**.

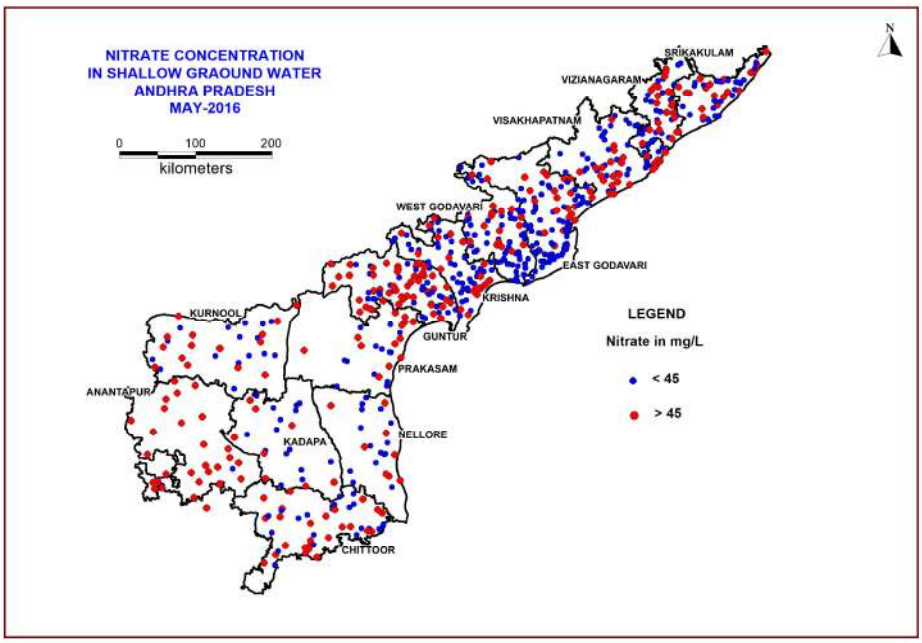


Fig.8.4: Distribution of Nitrate in Ground Water-Andhra Pradesh (May-2016).

8.1.13 Fluoride (F^-)

The main sources of F^- in ground waters are F^- bearing minerals present in rocks like fluorite (CaF_2), apophyllite ($KFCa_4(Si_4O_{20})8H_2O$), fluoroapatite ($Ca_3(PO_4)_3F$), cryolite (Na_3AlF6), villuanite as well as F^- 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 F^- in an area are more important in Deciding the presence of F^- in groundwater rather than presence of F^- bearing minerals in bulk rocks/soils (**Ramesham and Rajagopalan 1985**). Other causes of high F- in ground water are alkaline nature, high $HCO3^-$, high TDS and longer residence time in an aquifer (**Madhnure, et al., 2007**).

In the ground waters of state, the concentrations of fluoride range from 0.06 to 5.2 mg/l and maximum concentration of 5.2 is detected in Kanigiri well (Prakasam district). Over all 55 samples (8.1%) are unfit for human consumption. Higher concentration of F (>1.5 mg/l) are detected in most of districts, except Srikakulam and Nellore district (**Fig.8.5)**.

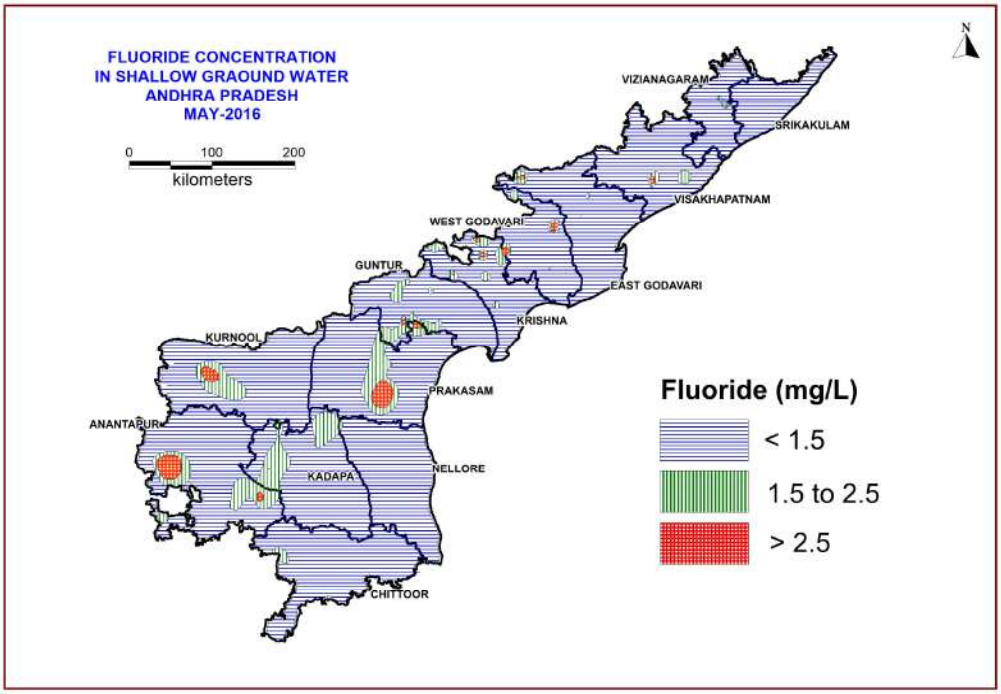


Fig.8.5: Distribution of Fluoride in ground water in Andhra Pradesh (May-2016).

8.2 Suitability for Irrigation Purposes

Productivity and quality of agricultural crops is largely depends on quality of groundwater supplied for its irrigation (**US Salinity Laboratory Staff, 1973**). In order to find out suitability of groundwater for irrigation, EC along with Na^+ plays an important role. The salts present in soil affects the growth of plants, along with soil structure, permeability and aeration. Timely supply of water to crops helps is better yield but on other hand its excessive use results in gradual accumulation of soluble salts in the soils, particularly when the soils has low permeability and less sufficient drainage facilities (**Handa, 1975**).

8.2.1 USSL Salinity Classification (USSL)

US Salinity Laboratory's diagram, which is based on EC and sodium adsorption ration (SAR), is widely used for assessing groundwater suitability for irrigational use.

Irrigation water classification based on US Salinity Laboratory Staff (**1954**) is given in **Table 8.3 and Fig.8.6.**

The sixteen classes in the diagram indicates the extent that water can affect the soil in terms of sodium hazard as low (S_1), medium (S_2), high (S_3) and very high (S_4) and similarly salinity hazard as a low (C_1), medium (C_2), high (C_3) and very high (C_4).

S_1 type can be used for irrigation on almost all soils with little danger of developing harmful levels of exchangeable sodium (KGS, 1998). S_2 type will present an appreciable sodium

hazard in certain fine-textured soils especially poorly leached soils. Such water may be used safely on coarse-textured or organic soils having good permeability. S_3 type may produce harmful levels of exchangeable sodium in most soils and will require good drainage, leaching and addition of organic matter. S_4 type is generally unsatisfactory for irrigation unless special action is taken, such as addition of gypsum to the soil.

C_1 type can be used for irrigation of almost all crops on most soils with little likelihood that soil salinity will develop. C_2 type can be used if a moderate amount of leaching occurs. Crops of moderate salt tolerance can be irrigated with C_2 type water without special practices. C_3 type cannot be used on soils of restricted drainage. C_4 type is not suitable for irrigation water under ordinary circumstances. It can be used only on crops, which are tolerant to salt and when special practices are adopted (**US Salinity Laboratory Staff, 1954**).

Perusal of **Fig.8.6** indicates that groundwater falls in 8 classes' *viz.* C_2-S_1, C_3-S_1 and C_3-S_2 and C_1-S_1, C_3-S_3, C_4-S_3, C_4-S_2, C_4-S_4 and majority of samples fall in C_2-S_1 and C_3-S_1 type of water.

Table 8.2: Classification of Irrigation water based on EC and SAR (USSL, 1954).

S. NO.	Class	EC and SAR	Remarks
1	C_1S_1	< 250 µS/cm and SAR < 10	Low salinity and low sodium hazard
2	C_2S_2	< 250 – 750 µS/cm and SAR < 18	Medium salinity and medium sodium hazard
3	C_3S_3	< 750- 2250 µS/cm and SAR < 26	High salinity and high sodium hazard
4	C_4S_4	< 2250-5000 µS/cm and SAR > 26	Very high salinity and very high sodium hazard

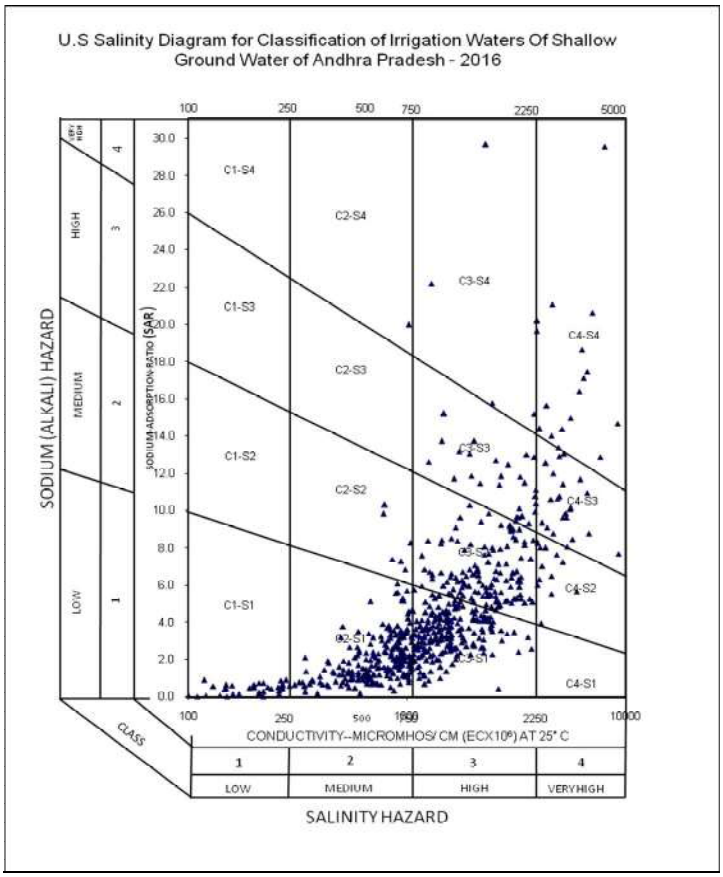


Fig.8.6: USSL Diagram, May-2016.

8.2.2 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 from the State as per RSC given in **Table 8.3** and it reveals, majority of samples (78 %) fall in safe class (RSC < 1.25), 7 % in marginal category and remaining 15 % in not suitable category.

Table 8.3: Classification of ground water based on RSC.

Sl no	RSC	Category	No of samples	% of samples
1	<1.25	Safe	501	73.6
2	> 1.25 < 2.50	Marginal	73	10.7
3	> 2.50	Not Suitable	107	15.7

8.3 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 from the state can be grouped broadly into 9 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 and Ca-Na-HCO_3-Cl type (**Fig.8.7**).

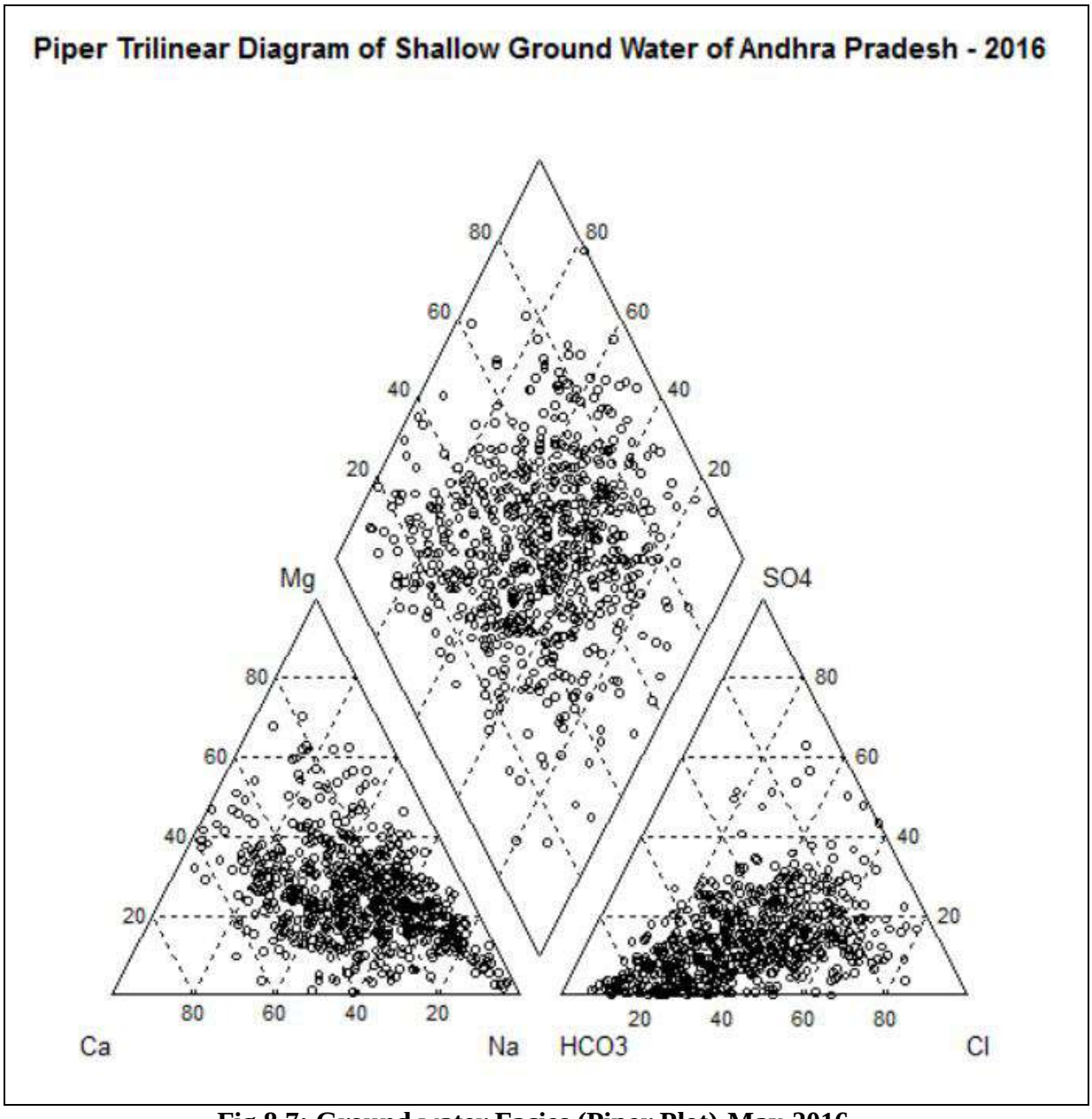


Fig.8.7: Ground water Facies (Piper Plot)-May-2016.

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 irrigation are contributed by ground water and rest by surface water.

During the year 2016, State received annual rainfall in the range of 341 mm (Atmakur mandal in Anantapuramu district) to 1623 mm in Munchingipattu mandal in Visakhapatnam district with an average annual rainfall of 845 mm which is 11 % of less than the normal rainfall i.e., 950 mm and drought conditions occurred in 4 districts namely Anantapuramu, Chittoor, SPS Nellore and Prakasam districts. South-west monsoon season (June-Sept) contributes 74% of rainfall, north-east monsoon (Oct-Dec) contributes 12% and non-monsoon contributes about 14% of annual rainfall in the State.

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 annual replenishable ground water resources are 20,387 MCM, natural discharge during non-monsoon period is 1,913 MCM, net ground water availability is 18,474 MCM, annual gross ground water draft is 8,104 MCM, allocation for future domestic and industrial use is 1,644 MCM and net ground water availability for future irrigation use is 10,210 MCM. The average stage of ground water development is 44% and out of 670 mandals , 61 fall under over-exploited category, 17 falls under critical, 54 under semi-critical and rest 538 under safe category including 73(41 Full, 32 Partial) mandals of poor-quality.

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 1 time (May). As on 31/03/2017, total of 855 (DW: 742 and Pz: 113) Ground Water

Monitoring Wells (GWMS) are in existence. There are total 164 parahydrogeologist are appointed to monitor GWMS on participatory mode (all dug wells).

Density of wells varies from 101 Km^2/well (East Godavari district)) to 375 Km^2/well in YSR Kadapa district with average of 187 Km^2/well. Hard rock aquifers (BGC) have high no of wells (610 wells).

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 -0.80 m bgl to 49.3 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~46% of the area followed by 10-20 mbgl. Shallow water levels (0 to 2 m bgl) and deep water levels (>20 mbgl) occupy ~3 % and 2% of the area respectively.

During August (mid-monsoon season) water levels are in the range of -1.1 m bgl to 49.3 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~35% of the area followed by 2-5 mbgl (31% area). Moderately deep water levels (10-20 mbgl) occupy ~13% and deep water levels (>20 mbgl) occupy ~7.3 % of the area.

During November (post-monsoon season) water levels are in the range of -0.3 m bgl to 48.5 m bgl. Shallow water level range 0 to 2 m bgl is observed in 13% of the total area. Water levels in the ranges of 2-5 m bgl are more predominant occupying ~36 % of the area followed by 5-10 m bgl mbgl (33 % area). Moderately deep water levels (10-20 mbgl) occupy ~12 % and deep water levels (>20 mbgl) occupy ~6 % of the area.

Pre-dominant water level range changed from 5-10 m bgl in May to 2-5 m bgl in November due to monsoon rains. Percentage of wells in the range 0-2 m bgl is changed from 3% in May to 13% in November due to monsoon rains.

During January-17, water levels are in the range of -0.75 m bgl to 49.3 m bgl and water levels in the range of 2-5 m bgl are more predominant occupying ~38 % of the area followed by 5-10 mbgl (36 % area). Shallow water levels (0-2 mbgl) occupy ~8 % and deep water levels (>20 mbgl) occupy ~4 % of the area.

Water level fluctuation of Aug, 2016 with pre-monsoon water level of May, 2016 have shown fall in 25% of the aera and rise in 75% of the area. Maximum rise of 11.37m in West Godavari district and maximum fall of 42.6 m in Visakhapatnam and YSR Kadapa distirct.

Water level fluctuation of Nov, 2016 with pre-monsoon water level of May, 2016 have shown fall in 28% of the aera and rise in 72% of the area. Maximum rise of 29.3 m in Guntur district and maximum fall of 42.6m in Visakhapatnam distirct.

Water level fluctuation of Jan, 2017 with pre-monsoon water level of May, 2016 have shown fall in 34% of the aera and rise in 66% of the area. Maximum rise of 21.52 m in Guntur district and maximum fall of 42.6 m in Visakhapatnam distirct

Annual water level fluctuation during May,2016 from May, 2015 have shown fall in water levels in 54% of the area and rise in 46% of the area. Maximum rise of 42.0 m is observed in YSR Kadapa district and maximum fall is noticed in Guntur district (32.42 m).

Annual water level fluctuation during Aug,2016 from Aug, 2015 have shown fall in water levels in 57% of the area and rise in 53% of the area. Maximum fall is noticed in Prakasam and Guntur district (32.42 m). Miminim rise of >4 m is observed in Anantapur, Chittoor, Kurnool and Kadapa districts.

Annual water level fluctuation during Nov-2016 from Nov,2015 have shown fall in water levels in 55 % of the area and rise in 45% of the area. The minimum (0.01 m) and maximum rise (20.2 m) recorded in East Godavari and Guntur district respectively. Maximum fall of > 4 m is recorded in SPS Nellore and Anantapur districts.

Annual water level fluctuation during January-2017 from January-16 have shown fall in water levels in 65 % of the area and rise in 35% of the area. The minimum (0.01 m) and maximum rise (27.8 m) recorded in East Godavari and Guntur district respectively. The minimum (0.01 m) and maximum fall (45.1 m) recorded in Guntur, Krishna and YSR Kadapar district respectively.

Water levels during May-16, August-16, November-16 and January-17 as compared to decadal mean water levels, have shown fall in most of the wells as well as in most of the area. The percentage of wells with fall in water levels in comparison with decadal mean of the respective months is 58.4%, 54.6%, 69.4% and 70% in May-16, August-16, November-16 and January-17 respectively.

Aquifer wise water level analysis shows that during pre-monsoon season water levels are shallowest (-0.8 m bgl) in Khondalite and Alluvium and deepest (49.3 mbgl) in Shales. During pre-monsoon season shallowest (-0.3 m bgl) in Khondalite and deepest (79.7 m in Limestone.

Long-term water levels trends in representative 26 wells have shown rising trends in both seasons in 7 wells. In 8 wells falling trends in both seasons are observed. During pre-monsoon season rise of 0.0048 to 0.24 m and fall of 0.00216 to 0.996 m is observed. During post-monsoon season rise of 0.0012 to 0.18 m and fall of 0.002 to 0.864 m is observed. Based on lond term water level trend maps, it is inferred that, pre-monsoon water level trend of 0-

2.5 m/yr is more prevalent in the southern districts of the state along with parts of East , West Godavari and Krishna district. The trend of more than 2.5 m/yr is observed in Prakasam and Kurnool districts as small patch. Post-monsoon water level trend map that the fall in water level trend of 0-2.5 m/yr is more prevalent in the southern districts of the state along with parts of East, West Godavari and Krishna district. The trend of more than 2.5 m/yr is observed in Prakasam and Kurnool districts as small patch. Annual water level trend map shows that the fall in water level trend of 0-2.5 m/yr is more prevalent in the Prakasam, anantapur, Kurnool and parts of West Godavari and Krishna districts of the state. The trend of more than 2.5 m/yr is observed in Prakasam districts as small patch**.**

Ground water quality is assessed during pre-monsoon season of 2016 by collecting 684 samples from both dug wells and peizometers 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, % Na and RSC.

Groundwater from the state is slightly acidic to alkaline in nature with pH in the range of 6.3 - 9.3 (Avg: 7.9). Electrical conductivity varies from 60-13980 (avg: 1818) µ Siemens/cm. Total Dissolved Solids (TDS) varies from 35-8511 and in 90 samples it is beyond 2000 mg/l (6.75 %). Total hardness varies from 25-2600 mg/l and in 14.4 % of samples it is beyond 600 mg/l. Calcium and magnesium varies from 40 - 460 mg/l (avg: 75) (in 4.1 % samples it is beyond permissible limits of BIS i.e., >200 mg/l) and 1.2 - 353 mg/l (avg: 48) (in 2.5% samples it is beyond permissible limits of BIS i.e., >100 mg/l). Sodium and potassium varies from 0.5 - 2325 and BDL to 450 mg/l. The HCO_3 concentration varies from nil to 1330 mg/l. Chloride and sulphate varies from 5.3 – 2801 and 0 to 3130 mg/l and found that in 29 and 46 samples it its beyond permissible limits of BIS respectively. NO_3 ranges from 0-1119 mg/l and found that 40 % samples are unfit for human consumptions (>45 mg/l). Fluoride concentration varies from 0.06 – 5.2 mg/l (Kanigiri in Prakasam district) and found that 8.1% samples are unfit for human consumptions (beyond 1.5 mg/l).

As for as irrigation suitability of ground water is concerned it is found that majority of samples fall in C_2-S_1 type of water. As per RSC classification of water 15.7 % are unfit for irrigation. Ground water from the area is mainly of Na-Mg-HCO3-Cl and Na-HCO3-cl type followed by Na-Mg-Cl-HCO_3 and Ca-Na-HCO_3-Cl type.

ANNEXURE I - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- MAY,2016

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 2016		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	35	20	55	31	19	50	4	0	4	1	1	2	0	0	0	1	0	1	36	20	56
2	Chittoor	47	0	47	46	0	46	1	0	1	0	0	0	0	0	0	0	0	0	47	0	47
3	Cuddapah	32	3	35	20	3	23	12	0	12	0	0	0	0	0	0	0	0	0	32	3	35
4	East Godavari	95	13	108	87	11	98	6	2	8	1	0	1	0	0	0	0	0	0	95	13	108
5	Guntur	90	13	103	72	11	83	17	2	19	0	0	0	1	0	1	0	0	0	89	13	102
6	Krishna	70	7	77	54	5	59	16	0	16	0	2	2	0	0	0	0	0	0	70	7	77
7	Kurnool	39	18	57	39	19	58	0	0	0	0	0	0	0	0	0	0	1	1	39	19	58
8	Nellore	61	2	63	50	2	52	4	0	4	5	0	5	2	0	2	0	0	0	59	2	61
9	Prakasam	53	14	67	29	10	39	17	2	19	6	2	8	1	0	1	0	0	0	52	14	66
10	Srikakulam	45	0	45	53	0	53	2	0	2	0	0	0	0	0	0	10	0	10	55	0	55
11	Visakhapatnam	**69**	**4**	73	66	4	70	**0**	**0**	0	**1**	**0**	1	**2**	0	2	**0**	0	0	67	4	71
12	Vizianagaram	**47**	**0**	47	51	0	51	**0**	**0**	0	**0**	**0**	0	**1**	0	1	6	0	6	51	0	51
13	West Godavari	**62**	**9**	71	51	8	59	**9**	**1**	10	**1**	**0**	1	**1**	0	1	**0**	0	0	61	9	70
	Total	**745**	**103**	**848**	**649**	**92**	**741**	**88**	**7**	**95**	**15**	**5**	**20**	**8**	**0**	**8**	**17**	**1**	**18**	**754**	**104**	**858**

ANNEXURE II - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- AUG,2016

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			No of Stations Abandoned			No of Stations Established			No of Stations as on AUG 2016		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	36	20	56	32	20	52	3	0	3	1	0	1	0	0	0	0	0	0	36	20	56
2	Chittoor	47	0	47	45	0	45	2	0	2	0	0	0	0	0	0	1	0	1	48	0	48
3	Cuddapah	32	3	35	22	2	24	7	0	7	0	1	1	3	0	3	0	0	0	29	3	32
4	East Godavari	95	13	108	90	12	102	1	0	1	4	1	5	0	0	0	0	0	0	95	13	108
5	Guntur	89	13	102	78	12	90	7	0	7	0	0	0	4	0	4	0	0	0	85	13	98
6	Krishna	70	7	77	60	3	63	9	0	9	0	4	4	1	0	1	0	0	0	69	7	76
7	Kurnool	39	19	58	36	16	52	3	1	4	0	2	2	0	0	0	0	0	0	39	19	58
8	Nellore	59	2	61	55	1	56	1	0	1	1	0	1	1	1	2	0	0	0	58	1	59
9	Prakasam	52	14	66	41	14	55	11	0	11	0	1	1	0	0	0	1	0	1	53	14	67
10	Srikakulam	55	0	55	50	0	50	0	0	0	4	0	4	1	0	1	0	0	0	54	0	54
11	Visakhapatnam	**67**	**4**	71	64	3	67	**0**	**1**	1	**3**	**0**	3	**0**	0	0	**0**	0	0	67	4	71
12	Vizianagaram	**52**	**0**	52	51	0	51	**0**	**0**	0	**1**	**0**	1	**0**	0	0	0	0	0	52	0	52
13	West Godavari	**61**	**9**	70	51	5	56	**0**	**1**	1	**2**	**3**	5	**0**	0	0	**0**	0	0	61	9	70
	Total	**754**	**104**	**858**	**675**	**88**	**763**	**44**	**3**	**47**	**16**	**12**	**28**	**10**	**1**	**11**	**2**	**0**	**2**	**746**	**103**	**849**

ANNEXURE III - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- NOV, 2016

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 NOV 2016		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	36	20	56	30	20	50	5	0	5	1	0	1	0	0	0	0	0	0	36	20	56
2	Chittoor	48	0	48	47	0	47	1		1	0	0	0	0	0	0	0	0	0	48	0	48
3	Cuddapah	29	3	32	19	12	31	9	1	10	0	0	0	1	0	1	0	10	10	28	13	41
4	East Godavari	95	13	108	88	13	101	3	0	3	3	0	3	1	0	1	0	0	0	94	13	107
5	Guntur	85	13	98	83	10	93	1	0	1	1	3	4	0	0	0	0	0	0	85	13	98
6	Krishna	69	7	76	62	3	65	2	0	2	5	4	9	0	0	0	0	0	0	69	7	76
7	Kurnool	39	19	58	35	18	53	2	1	3	2	0	2	0	0	0	0	0	0	39	19	58
8	Nellore	58	1	59	49	0	49	6	0	6	4	1	5	0	0	0	0	0	0	58	1	59
9	Prakasam	53	14	67	39	11	50	10	1	11	3	2	5	0	0	0	0	0	0	53	14	67
10	Srikakulam	54	0	54	54	0	54	0	0	0	0	0	0	0	0	0	0	0	0	54	0	54
11	Visakhapatnam	**67**	**4**	71	67	3	70	**0**	**1**	1	**0**	**0**	0	**0**	0	0	**0**	0	0	67	4	71
12	Vizianagaram	**52**	**0**	52	51	0	51	**1**	**0**	1	**0**	**0**	0	**0**	0	0	0	0	0	52	0	52
13	West Godavari	**61**	**9**	70	55	0	55	**4**	**0**	4	**1**	**0**	1	**1**	0	1	**0**	0	0	60	9	69
	Total	**746**	**103**	**849**	**679**	**90**	**769**	**44**	**4**	**48**	**20**	**10**	**30**	**3**	**0**	**3**	**0**	**10**	**10**	**743**	**113**	**856**

ANNEXURE IV - DISTRICT WISE STATUS OF GROUND WATER MONITORING WELLS- JAN, 2017

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 Jan 2017		
		DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total	DW	Pz	Total
1	Anantapur	36	20	56	28	20	48	8	0	8	0	0	0	0	0	0	0	0	0	36	20	56
2	Chittoor	48	0	48	45	0	45	3	0	3	0	0	0	0	0	0	0	0	0	48	0	48
3	Cuddapah	28	13	41	20	11	31	7	2	9	1	0	1	0	0	0	0	0	0	28	13	41
4	East Godavari	94	13	107	87	13	100	3	0	3	4	0	4	0	0	0	0	0	0	94	13	107
5	Guntur	85	13	98	84	10	94	1	0	1	0	3	3	0	0	0	0	0	0	85	13	98
6	Krishna	69	7	76	64	5	69	5	0	5	0	2	2	0	0	0	0	0	0	69	7	76
7	Kurnool	39	19	58	36	18	54	3	1	4	0	0	0	0	0	0	0	0	0	39	19	58
8	Nellore	58	1	59	53	1	54	4	0	4	1	0	1	0	0	0	0	0	0	58	1	59
9	Prakasam	53	14	67	37	14	51	11	0	11	5	0	5	0	0	0	0	0	0	53	14	67
10	Srikakulam	54	0	54	53	0	53	1	0	1	0	0	0	0	0	0	0	0	0	54	0	54
11	Visakhapatnam	**67**	**4**	71	66	3	69	**1**	**1**	2	**0**	**0**	0	**0**	0	0	**0**	0	0	67	4	71
12	Vizianagaram	**52**	**0**	52	51	0	51	**0**	**0**	0	**0**	**0**	0	**1**	0	1	0	0	0	51	0	51
13	West Godavari	**60**	**9**	69	55	9	64	**5**	**0**	5	**0**	**0**	0	**0**	0	0	**0**	0	0	60	9	69
	Total	**743**	**113**	**856**	**679**	**104**	**783**	**52**	**4**	**56**	**11**	**5**	**16**	**1**	**0**	**1**	**0**	**0**	**0**	**742**	**113**	**855**

ANNEXURE V - DISTRIBUTION OF PERCENTAGE OF WELLS , MAY, 2016 (m bgl).

Sl. No.	District Name	No. of wells analyzed	Depth to water Table (mbgl)		No of Wells/% of wells showing depth to water level (m bgl) in the range of											
			Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Anantapur	41	0.65	18.00	4	10	9	22	17	41	11	27	0		0	
2	Chittoor	47	1.62	12.00	3	6	22	47	19	40	3	6	0		0	
3	Kadapa	33	2.55	17.73	0		6	18	19	58	8	24	0		0	
4	East Godavari	85	-0.70	10.20	15	18	49	58	20	24	1	1	0		0	
5	Guntur	103	0.28	39..50	12	12	35	34	40	39	13	13	3	3	0	
6	Krishna	72	-0.80	19.84	9	13	32	44	19	27	12	17	0		0	
7	Kurnool	48	0.75	18.63	4	8	12	25	21	44	11	23	0		0	
8	Nellore	54	0.71	17.00	6	11	26	48	20	37	2	4	0		0	
9	Prakasam	61	1.67	49.30	1	2	23	38	22	36	13	21	1	2	1	2
10	Srikakulam	49	0.85	10.82	4	8	26	53	17	35	2	4	0		0	
11	Visakhapatnam	70	0.45	22.25	11	16	39	55	15	21	4	6	1	1	0	
12	Vizianagaram	51	1.41	12.20	1	2	25	49	22	43	3	6	0		0	
13	West Godavari	61	0.58	17.50	12	20	29	48	12	20	8	13	0		0	
	Total	775	-0.80	49.30	82	10.6	333	43	263	34	91	11.7	5	0.6	1	0.13

ANNEXURE VI - DISTRIBUTION OF PERCENTAGE OF WELLS, AUG, 2016 (m bgl).

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	42	0.3	15.7	7	17	9	21	17	41	9	21	0	0	0	0
2	Chittoor	47	0.59	14.5	6	13	21	45	18	38	2	5	0	0	0	0
3	East Godavari	100	-1.1	9.1	62	62	32	32	6	6	0	0	0	0	0	0
4	Guntur	99	0.38	39.5	23	23	31	31	31	31	13	13	1	1	0	0
5	Krishna	71	-0.79	20.1	26	37	23	32	17	24	4	5	1	1	0	0
6	Kurnool	44	-0.09	22	7	16	17	39	14	31	5	11	1	2	0	0
7	Nellore	59	0.75	12.3	5	8	28	47	22	37	4	6	0	0	0	0
8	Prakasham	64	0.33	49.3	3	5	20	31	28	44	11	17	1	1	1	1
9	Srikakulam	47	0.16	8.95	15	32	25	53	7	15	0	0	0	0	0	0
10	Visakhapatnam	67	0.51	45.2	25	37	30	45	8	12	2	2	1	1	1	1
11	Vizianagaram	51	-0.01	11.05	23	45	23	45	3	5	2	4	0	0	0	0
12	West Godavari	60	0.29	9.97	32	53	13	21	15	25	0	0	0	0	0	0
13	YSR Kadapa	33	-0.14	47.45	2	6	6	18	18	55	5	15	1	3	1	3
Total State		784	-1.1	49.3	236	30	278	35.4	204	26	57	7.2	6	0.76	3	0.38

ANNEXURE VII - DISTRIBUTION OF PERCENTAGE OF WELLS, NOV, 2016 (m bgl).

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	42	1.17	16.4	5	12	10	24	16	38	11	26	0	0	0	0
2	Chittoor	47	-0.06	12.07	3	7	19	40	21	45	4	9	0	0	0	0
3	YSR Kadapa	30	0.78	20.7	4	13	5	17	12	40	8	27	1	3	0	0
4	East Godavari	97	0.09	0.1	56	57	36	37	5	5	0	0	0	0	0	0
5	Guntur	94	0.35	19.3	29	30	45	48	16	17	4	4	0	0	0	0
6	Krishna	70	-0.3	19.35	38	54	20	28	9	13	3	4	0	0	0	0
7	Kurnool	47	0.15	22	10	21	20	42	12	25	4	8	1	2	0	0
8	Nellore	55	0.75	12.45	8	14	19	35	23	42	5	10	0	0	0	0
9	Prakasham	61	0.72	48.5	9	15	19	31	22	36	9	15	1	2	1	2
10	Srikakulam	50	0.45	7.29	21	42	26	52	3	6	0	0	0	0	0	0
11	Visakhapatnam	71	0.56	45.2	29	40	27	38	13	18	0	0	1	1	1	1
12	Vizianagaram	52	0.75	11.65	18	35	28	54	4	7	2	3	0	0	0	0
13	West Godavari	59	-0.19	16.99	32	54	15	25	8	14	4	7	0	0	0	0
Total State		775	-0.3	48.5	262	34	289	37	164	21	54	7	4	0.5	2	0.25

ANNEXURE VIII - DISTRIBUTION OF PERCENTAGE OF WELLS, JAN, 2017 (m bgl).

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	43	0.79	20.14	4	9	6	13	18	41	14	32	1	2	0	0
2	Chittoor	48	0.83	15.12	7	14	17	35	20	41	4	8	0	0	0	0
3	YSR Kadapa	29	0.17	47.45	1	3	7	24	13	44	6	20	1	3	1	1
4	East Godavari	96	0.57	9.1	34	35	54	56	8	8	0	0	0	0	0	0
5	Guntur	89	0.56	25.18	17	19	49	55	19	21	3	3	1	1	0	0
6	Krishna	72	-0.75	20.48	20	27	31	43	14	19	6	8	1	1	0	0
7	Kurnool	49	0.79	22	8	16	16	32	19	38	5	10	1	2	0	0
8	Nellore	59	0.84	12	11	18	22	37	23	38	3	5	0	0	0	0
9	Prakasham	60	1.3	49.3	4	6	19	31	26	43	10	16	0	0	1	1
10	Srikakulam	50	1.01	12.02	7	14	32	64	9	18	2	4	0	0	0	0
11	Visakhapatnam	71	0.55	42.2	19	26	32	45	16	22	2	3	1	1	1	1
12	Vizianagaram	51	0.73	11.18	5	9	34	66	11	21	1	2	0	0	0	0
13	West Godavari	60	-0.13	16.99	26	43	18	30	11	18	5	8	0	0	0	0
Total State		777	-0.75	49.3	163	21	337	43	207	27	61	8	6	0.8	3	0.4

ANNEXURE IX - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2016 FROM MAY, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.05	9.75	0.06	4.71	19	46	6	15	2	5	9	22	2	5	1	2	27	12
2	Chittoor	47	0.04	8.44	0.02	4.65	24	51	6	13	1	2	12	26	1	2	2	4	31	15
3	East Godavari	100	100	0.15	0.96	4.75	56	56	27	27	13	13	1	1	1	1	1	1	96	3
4	Guntur	98	98	0.02	0.03	7.42	51	52	4	4	4	4	24	24	3	3	1	1	59	28
5	Krishna	70	70	0.18	0.15	0.26	36	51	10	14	10	14	4	6	0	0	0	0	56	4
6	Kurnool	43	0.05	9.13	0.38	4.15	17	40	6	14	14	14	1	2	1	2	1	2	37	3
7	Nellore	58	0.03	6.1	0.04	11.8	11	19	2	3	2	3	30	51	5	9	7	12	15	42
8	Prakasham	63	0.03	11.17	0.13	8.3	17	27	7	11	2	3	17	27	3	5	4	6	26	24
9	Srikakulam	46	0.15	7.32	0.05	5.65	20	43	10	22	8	17	5	11	2	4	1	2	38	8
10	Visakhapatnam	64	0.09	4.45	0.03	42.6	37	58	10	16	1	1	12	19	2	3	1	1	48	15
11	Vizianagaram	50	0.02	8.05	0.1	2.63	17	34	16	32	9	18	6	12	1	2	0	0	42	7
12	West Godavari	60	0.03	11.37	0.95	5.01	33	55	17	28	6	10	2	3	1	1	1	1	56	4
13	YSR Kadapa	33	33	0.13	0.02	42	11	33	2	6	2	6	8	25	2	6	1	3	15	11
Total State		773	0.02	11.37	0.02	42.6	349		123		74		131		24		21		546	176

ANNEXURE X - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2016 FROM MAY, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.04	8.94	0.04	4.5	12	30	1	2	3	7	14	34	7	17	1	2	16	22
2	Chittoor	46	0.08	7.67	0.01	5.15	12	26	2	4	2	4	23	50	4	8	3	6	16	30
3	YSR Kadapa	30	0.17	6.91	0.55	5.14	6	20	3	10	3	10	6	20	4	13	1	3	12	11
4	East Godavari	97	0.08	7.46	0.01	4.52	51	52	25	26	11	11	5	5	1	1	1	1	87	7
5	Guntur	94	0.05	29.3	0.15	4	43	45	22	23	21	22	5	5	1	1	0	0	86	6
6	Krishna	69	0.16	14.62	0.19	0.55	30	43	22	32	12	17	3	4	0	0	0	0	64	3
7	Kurnool	46	0.06	10.01	1.4	3	17	37	5	11	19	41	1	2	2	4	0	0	41	3
8	Nellore	54	0.15	5.45	0.03	12.3	9	17	6	11	2	4	19	35	12	22	5	10	17	36
9	Prakasham	60	0.14	7.55	0.11	4.98	18	30	11	18	8	13	9	15	4	7	2	3	37	15
10	Srikakulam	48	0.28	7.43	0.05	5.62	12	25	22	46	9	18	4	8	0	0	1	2	43	5
11	Visakhapatnam	68	0.04	5.46	0.01	42.6	45	66	10	15	3	4	9	13	0	0	1	1	58	10
12	Vizianagaram	51	0.03	6.37	0.09	1.25	25	49	16	31	6	11	4	8	0	0	0	0	47	4
13	West Godavari	60	0.03	11.2	0.13	7.07	31	52	8	13	10	17	8	13	0	0	2	3	49	10
Total State		764	0.28	29.3	0.01	42.6	311		153		109		110		35		17		573	162

ANNEXURE XI - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2017 FROM MAY, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.12	5.67	0.03	5.94	7	17	1	2	1	2	16	39	9	21	4	9	9	29
2	Chittoor	47	0.13	6.9	0.03	6.45	16	34	2	4	1	2	20	42	2	4	6	12	19	28
3	YSR Kadapa	29	0.15	7.33	0.12	42	2	7	1	3	6	20	11	37	3	10	2	7	9	16
4	East Godavari	96	0.02	4.93	0.04	5.22	58	60	16	16	5	5	13	13	0	0	1	1	79	14
5	Guntur	89	0.07	21.52	0.22	1.72	47	53	19	21	11	12	9	10	0	0	0	0	77	9
6	Krishna	71	0.06	13.1	0.01	0.69	37	52	14	19	7	10	7	9	0	0	0	0	58	7
7	Kurnool	48	0.09	10.32	0.12	3.86	14	29	9	18	12	25	6	12	4	8	0	0	35	10
8	Nellore	58	0.04	7.31	0.12	10.94	10	17	9	15	3	5	18	31	10	17	8	13	22	36
9	Prakasham	59	0.08	12.32	0.18	7.47	15	25	7	12	7	11	13	22	6	10	4	6	29	23
10	Srikakulam	48	0.05	5.7	0.03	6.07	20	41	10	20	5	10	11	22	1	2	1	2	35	13
11	Visakhapatnam	68	0.02	3.48	0.02	42.6	38	55	4	6	0	0	20	29	3	4	2	2	42	25
12	Vizianagaram	50	0.22	5.21	0.11	2.71	29	58	10	20	3	6	7	14	1	2	0	0	42	8
13	West Godavari	60	0.03	7.55	0.08	7.07	35	58	9	15	3	5	6	10	2	3	2	3	47	10
Total State		764	0.02	21.52	0.01	42.6	328		111		64		157		41		30		503	228

ANNEXURE XII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER MAY, 2016 FROM MAY, 2015

S.No.	District Name	No. of wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Anantapur	38	0.06	7.07	0.08	8.19	11	29	5	13	4	10	9	24	5	13	1	3	20	15
2	Chittoor	45	0.32	13.25	0.46	3.25	8	18	11	24	21	47	3	7	1	2	0		40	4
3	Cuddapah	34	0.11	42	0.34	4.90	6	18	6	18	7	20	2	6	1	3	1	3	19	4
4	East Godavari	80	0.02	9.80	0.02	6.62	18	22	5	6	1	1	46	57	5	6	2	2	24	53
5	Guntur	99	0.02	2.37	0.05	32.42	19	19	1	1	0		44	44	18	18	11	11	20	73
6	Krishna	70	0.01	12	0.03	17.15	19	27	0		2	3	31	44	9	13	7	10	21	47
7	Kurnool	43	0.08	4.08	0.10	8.18	3	7	3	7	1	2	18	48	5	12	8	18	7	34
8	Nellore	52	0.10	7.93	0.04	3.68	22	42	8	15	8	15	8	16	2	4	0		38	10
9	Prakasam	60	0.01	3.48	0.03	21.03	16	27	3	5	0		19	32	10	17	4	6	19	33
10	Srikakulam	40	0.02	6.67	0.05	3.28	22	55	2	5	2	5	10	25	2	5	0		26	12
11	Visakhapatnam	70	0.05	3.52	0.04	3.20	36	51	5	7	0		27	39	2	3	0		41	29
12	Vizianagaram	45	0.12	3.55	0.01	3.70	11	24	1	2	0		30	67	2	4	0		12	32
13	West Godavari	57	0.04	7.07	0.03	5.48	20	35	0		3	5	26	45	0		2	3	23	28
	Total	**733**	**0.01**	**42.0**	**0.01**	**32.42**	**211**		**50**		**49**		**276**		**62**		**36**		**310**	**374**

ANNEXURE XIII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2016 FROM AUG, 2015

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.05	6.73	0.09	2.96	15	37	4	10	9	22	8	20	3	7	0	0	28	11
2	Chittoor	47	0.28	12.85	0.05	1.10	7	15	12	25	22	47	4	8	0	0	0	0	41	4
3	East Godavari	93	0.02	3.83	0.02	4.14	47	50	8	9	0	0	34	36	3	3	1	1	55	38
4	Guntur	95	0.02	5.67	0.04	12.60	17	18	1	1	1	1	40	42	21	22	12	12	19	73
5	Krishna	70	0.06	10.85	0.02	17.75	20	28	0	0	2	3	34	48	8	11	3	4	22	45
6	Kurnool	42	0.11	6.60	0.08	1.41	17	40	4	10	11	26	9	21	0	0	0	0	32	9
7	Nellore	55	0.14	6.40	0.10	4.15	21	38	5	9	7	12	18	33	0	0	1	1	33	19
8	Prakasham	59	0.20	4.09	0.05	17.00	10	17	4	7	1	2	28	47	7	12	5	8	15	40
9	Srikakulam	41	0.05	4.23	0.05	5.40	11	26	1	2	1	2	22	53	3	7	3	7	13	28
10	Visakhapatnam	67	0.01	3.91	0.03	45.15	17	25	4	6	0	0	36	53	5	7	4	6	21	45
11	Vizianagaram	46	0.15	7.39	0.01	4.06	13	28	3	6	1	2	19	41	9	20	1	2	17	29
12	West Godavari	59	0.01	5.03	0.01	2.62	32	54	1	2	1	1	23	40	2	3	0	0	34	25
13	YSR Kadapa	33	0.35	7.74	0.14	2.06	5	15	5	15	8	24	5	15	1	3	0	0	18	6
Total State		747	0.01	12.85	0.01	45.15	232		52		64		280		62		30		348	372

ANNEXURE XIV - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2016 FROM NOV, 2015

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.05	4.59	0.07	6.23	6	15	0		1	2	13	32	10	25	7	17	7	30
2	Chittoor	46	0.34	11.40	0.05	4.45	13	29	5	11	11	24	14	30	2	4	1	2	29	17
3	YSR Kadapa	24	0.11	3.88	0.32	10.13	4	17	2	8	0	0	5	21	5	21	5	21	6	15
4	East Godavari	89	0.01	4.89	0.02	2.88	34	38	2	2	2	2	45	50	2	2	0	0	38	47
5	Guntur	94	0.02	20.20	0.03	9.73	34	36	10	11	6	6	38	40	3	3	3	3	50	44
6	Krishna	69	0.10	10.16	0.05	3.83	42	61	5	7	1	1	14	20	3	4	0	0	48	17
7	Kurnool	42	0.02	6.55	0.02	3.50	17	40	5	12	3	7	11	26	3	4	0	0	25	14
8	Nellore	43	0.21	3.08	0.10	11.71	1	2	2	5	0	0	13	30	9	20	18	42	3	40
9	Prakasham	59	0.05	4.35	0.03	6.15	19	32	8	14	2	3	18	30	4	7	4	7	29	26
10	Srikakulam	41	0.04	3.67	0.02	4.45	11	27	3	7	0	0	22	53	1	2	1	2	14	24
11	Visakhapatnam	71	0.03	2.75	0.01	44.80	18	25	1	1	0	0	45	63	3	4	3	4	19	51
12	Vizianagaram	46	0.02	3.75	0.03	3.15	10	22	1	2	0	0	32	69	3	6	0	0	11	35
13	West Godavari	59	0.03	11.20	0.01	14.60	20	34	3	5	2	3	30	50	1	2	2	3	25	33
Total State		723	0.01	20.20	0.01	44.80	229		47		28		300		49		44		304	393

ANNEXURE XV - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2017 FROM JAN, 2016

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	40	0.24	0.43	0.03	9.60	2	5	0	0	0	0	9	22	13	32	15	37	2	37
2	Chittoor	47	0.08	1.66	0.20	9.90	5	10	0	0	0	0	18	38	10	21	14	10	5	42
3	YSR Kadapa	29	0.40	5.50	0.05	45.1	3	10	1	3	2	7	6	20	6	20	10	34	6	22
4	East Godavari	92	0.01	6.52	0.02	2.74	37	40	2	2	2	2	47	51	1	1	0	0	41	48
5	Guntur	86	0.03	27.80	0.01	3.66	28	32	7	8	6	7	40	46	4	6	0	0	41	44
6	Krishna	72	0.03	2.84	0.01	3.57	33	45	6	8	0	0	25	34	2	2	0	0	39	27
7	Kurnool	45	0.03	9.42	0.05	12.70	15	33	6	13	4	9	12	26	3	6	3	6	25	18
8	Nellore	58	0.89	3.00	0.05	9.80	2	3	1	1	0	0	23	39	16	27	16	27	3	55
9	Prakasham	57	0.07	10.17	0.06	9.62	4	7	3	5	2	3	24	42	11	19	11	19	9	46
10	Srikakulam	41	0.05	3.92	0.10	5.60	19	46	9	21	0	0	11	26	1	2	1	2	28	13
11	Visakhapatnam	71	0.05	4.40	0.02	42.72	17	23	1	1	1	1	45	63	2	2	4	5	19	51
12	Vizianagaram	45	0.04	4.30	0.02	2.54	23	51	3	6	1	2	16	35	2	4	0	0	27	18
13	West Godavari	59	0.03	7.64	0.01	13.32	25	42	1	1	3	5	23	38	1	1	2	3	29	26
Total State		742	0.01	27.80	0.01	45.10	213		40		21		299		72		76		274	447

ANNEXURE XVI - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER MAY, 2016 FROM DECADAL MEAN OF MAY(2006-15)

District Name	No of Wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
		Rise		Fall		Rise						Fall						Rise	Fall
		Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
Anantapur	40	0.22	7.12	0.24	9.12	15	37	3	7	3	7	9	22	8	20	2	5	21	19
Chittoor	45	0.19	7.75	0.15	1.70	15	35	12	27	13	29	4	9	0		0		40	4
Cuddapah	34	0.26	12.45	0.18	6.59	8	23	4	11	4	12	8	23	6	18	2	6	16	16
East Godavari	83	0.03	8.63	0.01	4.39	20	24	2	2	2	2	52	63	6	7	1	1	24	59
Guntur	103	0.11	4.49	0.02	31.75	20	19	0		1	1	42	41	19	18	18	17	21	79
Krishna	71	0.01	10.57	0.02	13.89	16	22	1	1	1	1	31	44	13	18	9	12	18	53
Kurnool	47	0.02	3.88	0.10	7.78	7	17	3	6	0		16	34	9	19	11	23	11	36
Nellore	52	0.02	6.83	0.06	6.03	21	40	7	13	4	8	15	29	3	5.	2	3	32	20
Prakasam	60	0.14	3.54	0.01	21.03	12	20	2	3	0		23	38	14	23	9	15	14	46
Srikakulam	40	0.06	3.60	0.01	3.04	16	40	4	10	0		15	37	5	12	0		20	20
Visakhapatnam	70	0.01	3.93	0.01	3.69	44	63	6	8	0		18	25	2	3	0		50	20
Vizianagaram	45	0.06	2.06	0.02	2.75	16	36	1	2	0		25	55	3	7	0		17	28
West Godavari	58	0.03	5.46	0.01	8.58	18	31	0		2	3	34	59	1	2	2	3	20	37
Total	**748**	**0.01**	**0.26**	**0.01**	**31.75**	**229**		**45**		**30**		**292**		**89**		**56**		**304**	**437**

ANNEXURE XVII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER AUG, 2016 FROM DECADAL MEAN OF AUG(2006-15)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.22	4.6	0.29	4.87	15	36	9	22	2	5	7	17	6	15	1	2	26	14
2	Chittoor	47	0.31	8.73	0.11	2.41	12	25	12	25	16	34	5	10	1	2	0	0	40	6
3	East Godavari	93	0.02	3.74	0.03	4.63	53	57	7	7	0	0	30	32	2	2	1	1	60	33
4	Guntur	98	0.01	5.67	0.02	14.55	16	16	0	0	1	1	42	42	23	23	14	14	17	79
5	Krishna	71	0.07	9.11	0.05	14.63	17	24	0	0	2	2	38	53	8	11	6	8	19	52
6	Kurnool	44	0.14	4.1	0.01	11.17	13	30	8	18	1	2	13	29	6	13	3	6	22	22
7	Nellore	59	0.01	6.6	0.05	3.96	25	42	5	8	2	3	21	35	5	8	0	0	32	26
8	Prakasham	63	0.05	5.97	0.03	17.99	13	20	2	3	1	1	24	38	12	19	8	12	16	44
9	Srikakulam	41	0.08	1.77	0.03	6.12	8	19	0	0	0	0	25	61	5	12	3	7	8	33
10	Visakhapatnam	67	0.03	2.91	0.01	15.15	31	46	2	3	0	0	28	41	4	6	2	3	33	34
11	Vizianagaram	46	0.05	6.18	0.05	3.63	14	30	1	2	1	1	19	41	11	23	0	0	16	30
12	West Godavari	59	0.01	2.27	0.02	3.27	30	50	1	1	0	0	24	40	4	6	0	0	31	28
13	YSR Kadapa	33	0.42	5.2	0.63	29.28	8	24	4	12	3	9	8	24	4	12	3	9	15	15
Total State		762	0.01	9.11	0.01	29.28	255		51		29		284		91		41		335	416

ANNEXURE XVIII - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER NOV, 2016 FROM DECADAL MEAN OF NOV(2006-15)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation													
			Rise		Fall		Rise						Fall						Total No. of Wells	
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	41	0.07	4.97	0.16	6.88	7	17	1	2	1	2	11	27	13	31	8	19	9	32
2	Chittoor	47	0.03	11.4	0.01	4.79	15	32	8	17	5	10	12	25	5	11	2	4	28	19
3	YSR Kadapa	30	0.13	2.56	0.05	7.96	5	16	1	3	0	0	11	37	5	16	8	27	6	24
4	East Godavari	97	0.04	5.95	0.05	5.38	35	36	1	1	1	1	56	58	3	3	1	1	37	60
5	Guntur	94	0.01	1.72	0.06	11.21	26	27	0	0	0	0	53	56	11	11	4	4	26	68
6	Krishna	70	0.04	3.38	0.01	6.12	29	41	1	1	0	0	33	47	5	7	2	3	30	40
7	Kurnool	46	0.1	3.18	0.07	9.9	17	37	2	4	0	0	15	32	8	17	4	9	19	27
8	Nellore	54	0.01	2.43	0.12	8.21	8	15	3	5	0	0	27	50	10	18	6	11	11	43
9	Prakasham	61	0.02	2.35	0.03	24.25	13	21	2	3	0	0	27	44	9	15	10	16	15	46
10	Srikakulam	41	0.15	2.95	0.09	4.57	5	12	1	2	0	0	32	78	1	2	2	4	6	35
11	Visakhapatnam	71	0	2.14	0.01	44.8	18	25	1	1	0	0	47	66	3	4	2	3	19	52
12	Vizianagaram	46	0.01	2.8	0.02	3.16	6	13	1	2	0	0	34	73	5	10	0	0	7	39
13	West Godavari	59	0.01	4.37	0.04	13.72	16	27	1	2	1	2	35	59	3	5	2	3	18	40
Total State		757	0.01	11.4	0.01	44.8	200		23		8		393		81		51		231	525

ANNEXURE XIX - FLUCTUATION AND FREQUENCY DISTRIBUTION FROM DIFFERENT RANGES FROM ONE PERIOD TO OTHER JAN, 2017 FROM DECADAL MEAN OF JAN(2007-16)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4			
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise	Fall
1	Anantapur	42	0.43	0.94	0.12	11.53	5	12	0	0	0	0	10	24	15	35	12	28	5	37
2	Chittoor	48	0.08	4.84	0.01	5.9	15	31	3	6	1	2	20	41	7	15	2	4	19	29
3	YSR Kadapa	29	0.06	1.87	0.15	43.63	9	31	0	0	0	0	5	17	8	27	6	20	9	19
4	East Godavari	96	0.06	3.07	0.01	3.33	35	36	3	3	0	0	55	59	3	3	0	0	38	58
5	Guntur	89	0.02	6.02	0.04	6.86	19	21	1	1	1	1	54	60	10	11	4	5	21	68
6	Krishna	72	0.05	2.45	0.05	11.74	14	19	1	1	0	0	48	66	6	8	3	4	15	57
7	Kurnool	48	0.09	3.68	0.12	10.93	12	25	4	8	0	0	17	35	11	22	4	8	16	32
8	Nellore	59	0.01	1.77	0.1	6.79	13	22	0	0	0	0	18	30	20	33	8	13	13	46
9	Prakasham	59	0.47	2.37	0.25	24.98	2	3	1	1	0	0	26	44	16	27	14	23	3	56
10	Srikakulam	41	0.18	4.24	0.01	6.5	17	41	1	2	0	0	19	46	2	5	2	4	18	23
11	Visakhapatnam	71	0.01	2.45	0.01	40.46	25	35	2	3	0	0	36	50	5	7	3	4	27	44
12	Vizianagaram	45	0.07	3.19	0.03	3.34	13	29	1	2	0	0	29	64	2	5	0	0	14	31
13	West Godavari	60	0.03	4.79	0.01	11.16	25	41	0	0	1	1	28	46	4	6	2	3	26	34
Total State		759	0.01	6.02	0.01	43.63	204		17		3		365		109		60		224	534

Annexure XXI District -wise summarised chemical composition of ground water from GWMS during Pre-monsoon season-2016 (May), Andhra Pradesh

DISTRICT	Statistic	pH (6.5-8.5)	EC	TH (600)	Ca (300)	Mg (100)	Na	K	HCO3 (600)	Cl (1000)	SO_4 (400)	NO_3 (45)	F (1.5)	TDS (2000)
SRIKAKULAM	Min	7.2	265	40	4.0	7.3	16	0.39	24	18	4.8	0.0	0.12	154
	Max	9.5	4608	1300	224	180	600	350	610	1276	292	250	1.3	2686
	Average	8.1	1220	277	50	37	144	30	195	233	73	50	0.37	740
VIZIANAGARAM	Min	6.3	146	60	6.0	6.1	6.9	0.00	61	14	0.00	0.0	0.13	87
	Max	9.1	2716	840	152	175	460	240	561	574	222	270	2.0	1456
	Average	7.7	1027	253	47	33	99	29	249	142	53	45	0.59	600
VISAKHAPATNAM	Min	7.3	60	25	4.0	2.4	0.50	1.0	12	5.3	0.48	0.0	0.06	35
	Max	8.6	4330	860	204	141	711	120	659	865	588	342	3.7	2623
	Average	8.1	1109	282	51	38	116	16	262	121	90	51	0.61	655
EAST GODAVARI	Min	7.2	160	45	4.0	3.6	2.8	0.00	0	11	0.32	0.03	0.08	89
	Max	9.3	7670	1400	220	207	1110	450	927	1914	704	340	1.7	4472
	Average	7.9	1412	335	62	44	154	28	347	216	83	32	0.38	832
WEST GODAVARI	Min	7.0	130	50	14	3.6	6.9	0.98	67	7.1	2.7	0.19	0.06	80
	Max	8.7	11930	1350	180	219	2060	450	769	2198	2040	95	3.5	7234
	Average	8.1	1475	331	62	43	167	30	369	209	100	26	0.46	864
KRISHNA	Min	7.4	650	85	14	4.9	15	0.00	287	43	2.1	0.00	0.06	380
	Max	8.7	13980	1900	230	334	2325	400	1208	2801	2242	256	3.3	8511
	Average	8.0	2888	530	98	69	383	62	607	469	209	48	0.70	1719
GUNTUR	Min	7.2	680	25	4.0	3.6	60	1.0	159	39	4.0	1.0	0.08	422
	Max	8.4	9300	2600	460	353	1300	380	1330	1914	1410	660	3.6	5517
	Average	7.9	2353	410	73	55	326	65	540	292	237	99	0.81	1478
PRAKASAM	Min	7.3	808	30	8.0	2.4	80	1.0	232	43	31	0.10	0.15	466
	Max	9.0	10300	1900	320	292	1600	198	952	2269	3130	477	5.2	6714
	Average	8.1	3011	503	80	73	450	35	453	495	351	74	0.98	1843
NELLORE	Min	7.0	342	70	12	3.6	40	2.0	79	25	1.0	1.5	0.08	221
	Max	8.2	5400	1120	76	238	920	160	1086	1106	404	176	1.5	3070

	Statistic	pH (6.5-8.5)	EC	TH (600)	Ca (300)	Mg (100)	Na	K	HCO3 (600)	Cl (1000)	SO_4 (400)	NO_3 (45)	F (1.5)	TDS (2000)
	Average	7.8	1511	266	37	42	223	26	437	191	101	43	0.48	930
CHITTOOR	Min	7.0	80	25	6.0	1.2	6.0	0.98	12	14	0.00	0.00	0.08	46
	Max	8.2	5420	1260	272	163	655	160	952	1531	330	694	1.6	3110
	Average	7.6	1731	465	109	47	182	17	424	277	74	81	0.74	1047
KADAPA	Min	7.1	650	90	22	7.3	22	0.00	201	35	0.08	1.5	0.22	383
	Max	8.4	6010	1780	440	214	1091	200	598	1078	618	881	2.5	3777
	Average	7.6	1915	432	91	50	226	25	455	266	113	105	0.95	1157
ANATHAPUR	Min	7.3	220	75	18	4.9	14	1.0	98	14	1.9	2.6	0.09	126
	Max	8.1	5190	1280	392	129	613	400	952	773	424	1119	4.1	3436
	Average	7.7	2531	544	145	44	290	70	567	346	94	267	1.1	1603
KURNOOL	Min	7.2	580	165	28	6.1	6.7	1.0	61	25	1.1	1.5	0.09	319
	Max	8.4	12370	1620	456	219	2290	120	854	1897	2845	623	3.1	7787
	Average	7.9	2681	548	130	54	350	23	386	394	350	97	0.86	1643
ANDHRA PRADESH	**Min**	**6.3**	**60**	**25**	**4.0**	**1.2**	**0.50**	**0.00**	**0.00**	**5.3**	**0.00**	**0.00**	**0.06**	**35**
	Max	**9.5**	**13980**	**2600**	**460**	**353**	**2325**	**450**	**1330**	**2801**	**3130**	**1119**	**5.2**	**8511**
	Average	**7.9**	**1818**	**383**	**75**	**48**	**223**	**36**	**398**	**266**	**138**	**66**	**0.64**	**1099**

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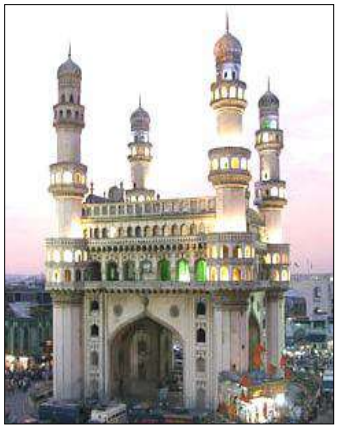

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