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Central Ground Water Board

Ministry of Water Resources,
River Development & Ganga Rejuvenation
Government of India

GROUND WATER YEAR BOOK
2014-15
ANDHRA PRADESH

By

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Southern Region, Hyderabad
January, 2016

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GROUND WATER YEAR BOOK
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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 for preparation of sustainable development plan for the country. Central Ground Water Board has been monitoring ground water regime since 1969. During the year 2014-15, 44 new ground water monitoring wells were established forming a network of 881 operational ground water monitoring wells including 772 dug wells 109 piezometers as on 31-3-2015. These stations are being monitored four times a year viz., May, August, November and January to study the seasonal and long term changes. Water samples are collected during May and chemical analysis has been carried.

The ground water level monitoring, carried out by Central Ground Water Board, Southern Region, Hyderabad during 2014-15 has been compiled in the form of Ground Water Year Book. It outlines the behavior of ground water levels 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. A. B. Kawade, Scientist-C, Sri. P.Sudhakar, Scientist-C (HM), and Sri.K.Maruthi Prasad Scientist-B(Hydrochemistry) are commendable in preparation of the Report. The efforts of Sri.G.Y.Setty, Scientist-D and S.Renuka, Scientist-B(GP) of Report Processing Section are also appreciated in scrutiny, processing and issuance of the report.

It is hoped that this 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 **(A. D. Rao)**
19.01.2016 **REGIONAL DIRECTOR**

EXECUTIVE SUMMARY

Central Ground Water Board, under Ministry of Water Resources, Government of India, is carrying out Ground water Regime monitoring all over the country for generating historical data base to study the changes in ground water regime which plays crucial role for estimation of ground water resource (both dynamic and static).

In Andhra Pradesh, a total of 881 (772 dug wells and 109 Piezometers) Ground Water Monitoring wells are present as on 31-03-2015. The Water levels were monitored four times during May, 2014, August, 2014 November, 2014 and January, 2015. This report pertains to ground water monitoring carried out during all the four monitoring periods during AAP 2014-15. It depicts the ground water level scenario in the State and describes the regional behaviour of water levels during the period.

During the year 2014, the State had received annual rainfall of 741 mm, about22% less than normal against the normal rainfall of 952mm. It is normal to deficit in all the districts of the state. The deficit rainfall was recorded in Rayalaseem region and it was excess in the remaining districts. Highest annual rainfall of 1268 mm was recorded in Srikakulam district and lowest of 434 mm was recorded in YSR Kaddapa district. Monthly rainfall ranges from 0.5 mm in January to 149 mm in October month. July to November are the rainiest months of the year.

In general, the water levels are deep in the month of May and shallow during November. Water level rise takes place during August, November and January depending on the monsoon rainfall and level of ground water development. During the year 2014-15, the water level vary between -0.14 m agl to 40.03 m bgl during pre-monsoon and -0.17 m bgl to 45.01 m bgl during post-monsoon. The depth to water level of 2-5and 5-10 m bgl are more prevalent in the State during pre and post-monsoon.Number of wells with depth to water level in the range of 0-2 m bgl has increased from 15.92% in May 2014 to 45.2% in November 2014. Deep water levels (20-40 m bgl) were observed in 0.65% of the wells during May, 2014 and reduced to 0.25 % during November, 2014.

Rise in water level was observed in 64.14% of the wells during May, 2014 in comparison with May 2013 and 31.28% of the wells shows fall. When compared with mean of pre-monsoon water levels of last decade May (2004-2013), withMay2014 rise was observed in 61.15% of the wells and fall in 38.5% of the wells. Water level rise of more than 4 m was observed in 2.72% of the wells and fall of more than 4 m was observed in 1.53% of the wells.

Rise in water level was observed in November 2014 when compared to November, 2013 in 20.0 % of the wells and fall in 78.0% of wells. Maximum rise was observed in 0-2 m range in 19.1 % of wells, maximum fall was in 0-2 m range in 55.87 %of wells.

Water level fluctuation between May 2014 and November 2014indicates that rise of water levels was observed in 74.38% of the wells. This can be attributed to the normal to excess rainfall recorded in the state. Water level fluctuation during November 2014 with reference to decadal mean of November (2004-2013) shows fall in water levels in 69.95% of the wells. Rise was also noticed in 70.83% of wells when compared the water levels of May, 2014 to January, 2015. Rise

in29.45% and fall in 68.72% of the wells was observed from the fluctuation between Jan 2015and Jan 2014.

Water table elevation follows the topography which ranges from <10 m in east to >900 m in south and west. The general gradient is from west to east.

In May 2014, the area under water logging (0-2m bgl) was 16360 sq.km. i.e. 10% of the total area and the area under prone to water logging (2-3 m bgl) is 7894 sq.km i.e 4.8% of the area of the state. During the post-monsoon Nov 2014, the area under water logging was 31290 sq.km. i.e 19.1% of the total area and area under prone to water logging (2 to 3 m bgl) is 22210sq.km. i.e 13.6 % of the total area of the state. The water logged area has increased from 10% to 19.1 % from pre-monsoon to post-monsoon period. The area under prone to water logging has increased from 4.8% to 13.6% from May to November.

Monitored 617 ground water monitoring wells in Andhra Pradesh to assess the quality of shallow ground water during May, 2014. In general pH is in the range of 6.8 to 9.3. Electrical conductivity is beyond 3000 micromhos/cm in 15.6% of the samples. In general it is in the range of 750-3000 micromhos/cm. Only 4.4% of the samples have chloride concentration beyond BIS permissible limit. In general it is in the range of 50 to 500 mg/L. Fluoride exceeds the BIS permissible limit of 1.5 mg/L in 9.2% of the samples. In general it is in the range of 0.3 to 1.0 mg/L. Ground water in Majority of the locaion fall in C_2S_1 class followed by C_3S_1 , C_3S_2 C_3S_3, C_4S_4, C_1S_1, C_4S_3, C_4S_2 and C_2S_2 classes. Dominant Water types of the state are Na-Cl, Na-HCO3, Na-Ca-Cl-HCO3 and Na-Mg-HCO3 type.Most of the samples are suitable for livestock and poultry consumption. Highest Electrical Conductivity (12040 μS/cm) found at Guttalaumadivrm of Prakasam district, mostly saline water intrusion. Highest Chloride (3226 mg/L) found at Marteru of West Godavari district, and also indicative of Saline water intrusion. Highest Nitrate (1095 mg/L) found at Guttalaumadivrm of Prakasam district and Fluoride (5.4 mg/L) at Sitapalli of East Godavari district.

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1.0 INTRODUCTION

Central Ground Water Board has taken up the task of all complex issues of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity. A network of national hydrograph Stations (NHS) are being monitored on long term basis since 1969 through dug wells and piezometers in order to arrive at proper parametric indices of evaluation and judicious development of ground water resources and to study its long term behavior. A historical database on the ground water levels and water quality has been developed over a period of time since 1969.

The monitoring programme mainly comprises measurement of water levels and temperatures, four times in a year during May, August, November and January and collection of water samples for chemical analysis during May. As on 01.04.2014, 879 monitoring wells were in operation. (Dug wells-756 & piezometers-123).

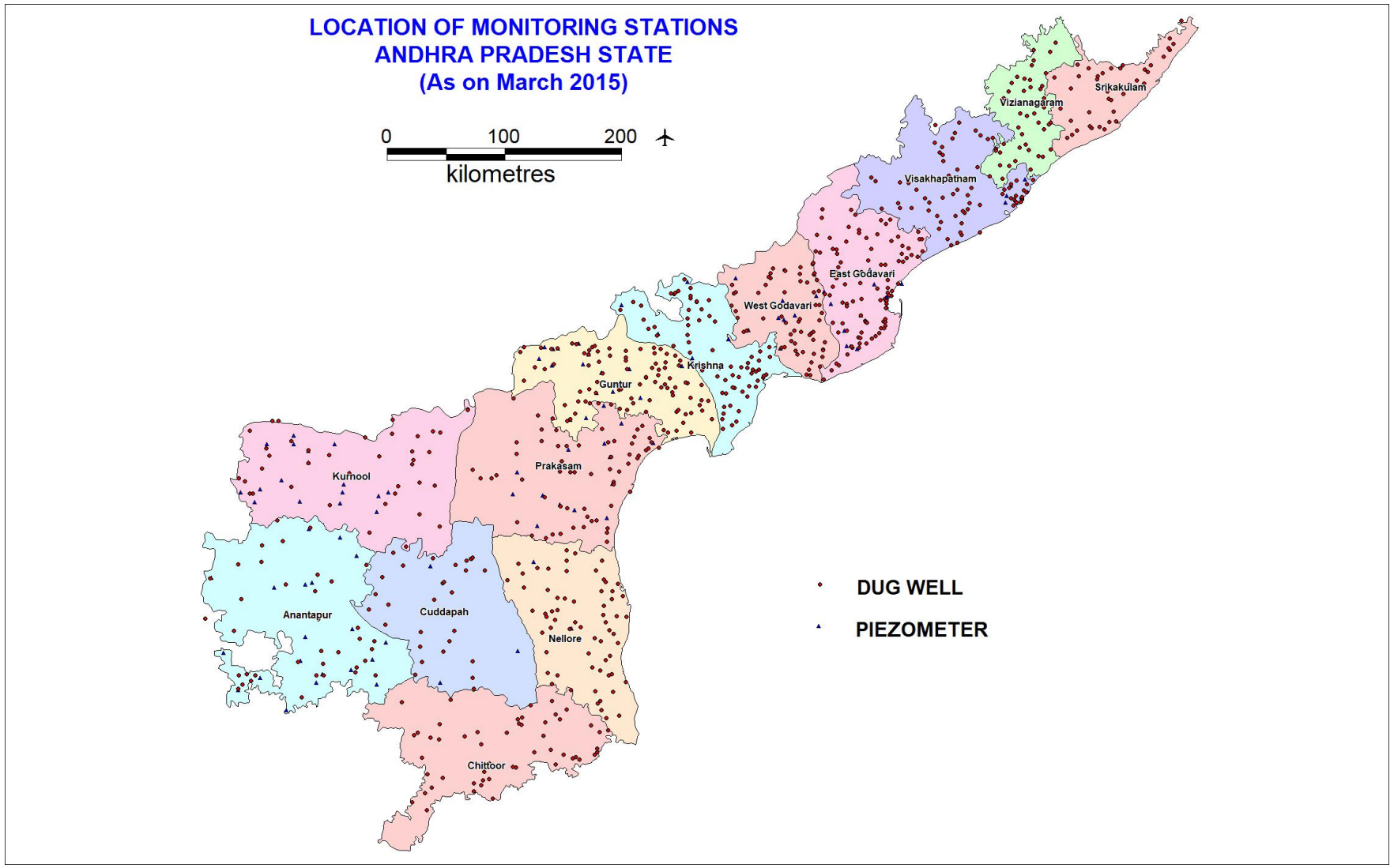
During the year 2014-15, 26 Dug wells and 16 Piezometers are abandoned and 44 new monitoring wells (43 Dug wells and 1 Piezometers) are established forming a network of 881wells including 772 Dug wells and 109 Piezometers (as on 31-3-2015). The dug wells tapping unconfined aquifers are used for domestic purpose by local populace. Some of these are community wells and the rest belong to individuals. The piezometers tapping unconfined and confined aquifers are constructed under various projects and exploration programmes by the department. The location of ground water monitoring wells are shown in the Fig.1.1

1.1 LOCATION AND EXTENT

Andhra Pradesh is the fourth largest State in India covering geographical area of 1,63, 900 sq.km. It lies between north latitudes 12° 14’ and 19° 54’ and, east longitudes 76° 50’ and 86° 50’. The State is bounded on the east by 970 km long coastline of Bay of Bengal, on the south by Tamil Nadu and Karnataka States, on the west by Karnataka State and on the north by Telangana, Madhya Pradesh, Chhattisgarh and Orissa States. Administratively, the State is divided into 13 districts and 1128 mandals. Based on geographical position, the State is divided in to two regions viz., Coastal and Rayalaseema regions. The Coastal Andhra region comprises nine districts namely Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam and Nellore districts. The Rayalaseema region is comprised of four districts viz., Kurnool, Kadapa, Anantapur and Chittoor districts.

The ground water year book for the year 2014-15 depict the ground water level scenario in the State and describes the regional behaviour of water levels. The wells are distributed more or less uniformly over the State covering 17 major and minor river basins.

Fig.1.1


LOCATION OF MONITORING STATIONS
ANDHRA PRADESH STATE
(As on March 2015)
0
100
200
kilometres
Srikakulam
Vizianagaram
Visakhapatnam
East Godavari
West Godavari
Krishna
Guntur
Prakasam
Kurnool
Anantapur
Cuddapah
Nellore
Chittoor
DUG WELL
PIEZOMETER

2. PHYSIOGRAPHY, DRAINAGE AND SOIL

2.1 PHYSIOGRAPHY

Physiographically, Andhra Pradesh is divided into three distinct zones, viz., Coastal Plains, Eastern Ghats and Western Pedeplains. The landforms, altitude and drainage pattern are different in each zone. The first two units stretch from Northeast to Southwest in a narrow strip while the western pedeplains occupy rest of the area.

2.1.1 COASTAL PLAINS

The coastal plains stretch from Kalingapatnam (Srikakulam district) in the north to Pulicot (Nellore district) in the south along a narrow strip, which broadens in the middle along Godavari - Krishna deltas (80 sq.km). The altitude of coastal plain ranges from sea level at the coast to 150 - 200 mamsl on the west.

2.1.2 EASTERN GHATS

The Eastern Ghats follow the Coastal Plains stretching closely from one end to the other 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 elevation of 600 to 1200 mamsl. The Nallamala, Erramala, Seshachalam, Velikonda and Palakonda hills falling in Rayalaseema region, cover southern section of Ghats**.**

2.1.3 WESTERN PEDEPLAINS

The physiographic unit western pedeplain occur in parts of Rayalaseema region (Kurnool and Anantapur districts) exhibits rolling topography with flat to undulating tracts. The elevation varies from 150 to 600 m amsl except at places where it is overlain by basaltic lava flows (600 to 900 mamsl).

2.2 DRAINAGE

The State is drained by 40 major and minor rivers. The important rivers are Godavari, Krishna, Pennar, Palar, Vamsadhara, and Nagavalli. Godavari and Krishna rivers and their tributaries drain the northern and central part and Pennar River drains the southern part of the state before confluence Bay of Bengal. 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, Nagavalli, Sarada, Yeleru, Gundlakamma, Palleru, Kurieru, Swarnamukhi and inter stream areas between Krishna and Godavari basins. 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 deltas as well as coastal plains. Most of the smaller streams feed innumerable tanks.

The Tungabhadra, Vedavati, Hindri, and Paleru rivers drain the northen part of the state. River Penna flows across southern part of the state with its tributaries Chitravati, Papaghni 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 deltas of rivers are very extensive and characterized 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 Eleru drains East Godavari district while Yerrakalave, Tammileru drain West Godavari district. Nellore district is drained by Pennar, Swarnamukhi and Arani rivers.

2.3 SOIL

The following wide variety of soil occur in the State;
Red soil,
Lateritic soil,
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 occur in Krishna and Guntur districts. Red earths with loamy soil and red sandy loamy soil and lateritic soil occur in Prakasam and Nellore districts. Black cotton soil is predominant in parts of Kadapa, Kurnool and Anantapur districts in Rayalaseema region, red loamy soil occur in parts of Chittoor and Kadapa districts. Red earths are predominant in Anantapur district.

3.0 HYDROMETEOROLOGY

3.1 Climate

The climate is tropical in nature and is influenced by topographical variations and maritime influence. 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) is given in the Table-3.1.

Table-3.1
Agro-climatic classification (Agricultural Department)

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

3.2 Rainfall Analysis

3.2.1 Rainfall Analysis - 2014

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 952mm. 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 574 mm in Anantapur district to 1166 mm in Srikakulam district(Fig 3.2).

- The mean annual rainfall during 2014 is 741 mm. Season-wise rainfall is 441.5 mm, 194.8 mm, 1.5 mm and 102.7 mm in monsoon (June-Sept), post-monsoon (Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively, contributing 60% of annual rainfall in SW monsoon, 26% in north-east and 14% in non-monsoon seasons. The annual (2014) rainfall ranges from 434 mm in Cuddapah district (deficit by 40%) to 1268 mm (excess by 9%) in Srikakulam district. Annual rainfall was deficit by 22%. Monthly mean rainfall ranges from 0.5 mm in January to 148.6 mm in October.

Table 3.2 District wise monthly Rainfall(2014)

		JAN		FEB		MAR		APR		MAY		JUNE		JULY	
No	**DISTRICT**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**
1	ANANTAPUR	0	2.4	0	3.6	15.1	5.2	15.2	21	69.6	56.7	60	55.2	36.3	64.3
2	CHITTOOR	0.5	7.5	1	7.4	11.9	8.4	2.5	29.8	64.7	67.2	72.8	66.8	56.7	100.1
3	CUDDAPAH	0	1.9	0	2.3	7.7	4.2	6.5	19.2	22.2	47.6	46.8	69.8	49.5	101.1
4	EAST GODAVARI	0.3	5.9	0	9	0	10.5	0	25.4	119.9	75.3	18.1	131.9	154.3	206.4
5	GUNTUR	0	5.3	2.4	7.9	0.3	6.7	0.3	16.7	65.2	58.4	19.1	90.2	130.5	147.3
6	KRISHNA	0	4.6	3	6.2	0	7.8	0	18.5	89.1	46.8	24.3	120.9	143.3	216.6
7	KURNOOL	0	1.1	1.1	1.9	19.7	4.9	7.7	19.9	48.9	51.7	83.2	80.5	113.8	115.8
8	NELLORE	0.9	15.6	2.4	11.4	0.6	5.6	9.3	17.4	22.5	51.4	42.5	53.4	62	91.2
9	PRAKASAM	0.6	7.9	0.9	8.8	3.8	8.6	7.8	17.6	25.6	52.3	15.1	64.3	102.3	99.3
10	SRIKAKULAM	0	7.4	0	18.3	31.7	15	9.1	29.4	194.8	63.9	65.9	145	246.6	190.2
11	VISHAKHAPATNAM	2	8.3	0	11.2	15.8	14.6	26.8	50.5	109.1	96.6	65.6	132.6	136.1	178.2
12	VIZIANAGARAM	0	8.2	1.2	14.7	23.2	14.7	7.1	37.3	148.2	90.7	85.4	140.7	173.9	181.5
13	WEST GODAVARI	2.2	6	0.7	10.4	1.1	8.4	4.5	20.8	127.8	55.8	17.3	135.8	257	240.2
	State Average	**0.5**	**6.3**	**1.0**	**8.7**	**10.1**	**8.8**	**7.4**	**24.9**	**85.2**	**62.6**	**47.4**	**99.0**	**127.9**	**148.6**

		AUG		SEP		OCT		NOV		DEC		ANNUAL		
	DISTRICT	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**Act.**	**Nor.**	**DEP(%)**
1	ANANTAPUR	71.2	74.5	46	128.8	107.5	115	13.6	35.3	3.3	11.6	438	574	**-24%**
2	CHITTOOR	112.6	110.2	72.3	140	125.1	167.2	55.3	137.3	20.7	58.4	596	900	**-34%**
3	CUDDAPAH	89.4	108.6	82.6	124.6	96.9	137.3	26.7	77.2	5.7	24.4	434	718	**-40%**
4	EAST GODAVARI	100.5	188.4	124.3	177.2	89.5	199	24	69.8	1.3	7.8	632	1107	**-43%**
5	GUNTUR	116.9	155.4	144.7	150.1	149.6	143.9	51.7	75.8	0.1	14.5	681	872	**-22%**
6	KRISHNA	99.2	194.2	109.3	169.7	115.2	164.2	31	66.1	0.3	12.1	615	1028	**-40%**
7	KURNOOL	152.9	124.3	95.1	139.6	80.4	105.6	23.3	28.4	1.8	6.6	628	680	**-8%**
8	NELLORE	122.9	95	70.9	112.8	157.1	248.2	130.9	283.9	80.1	107.2	702	1093	**-36%**
9	PRAKASAM	67.2	95.9	78	123	103.1	181.9	83.2	115	9.6	32.1	497	807	**-38%**
10	SRIKAKULAM	263.4	202.4	229.9	208.1	219.2	211.4	6.9	69.8	0	4.9	1268	1166	**9%**
11	VISHAKHAPATNAM	239.7	178.2	146.8	185.4	330.8	204.3	9.2	59.2	0.1	4.3	1082	1123	**-4%**
12	VIZIANAGARAM	286.3	194.8	176.1	209.1	284.3	188.1	9.6	56.3	0	6.1	1195	1142	**5%**
13	WEST GODAVARI	160.9	227.8	202.5	180.1	72.7	197.8	10.7	66.7	2.1	11.7	860	1162	**-26%**
	State Average	**144.9**	**150.0**	**121.4**	**157.6**	**148.6**	**174.1**	**36.6**	**87.8**	**9.6**	**23.2**	**740.5**	**951.7**	**-22%**

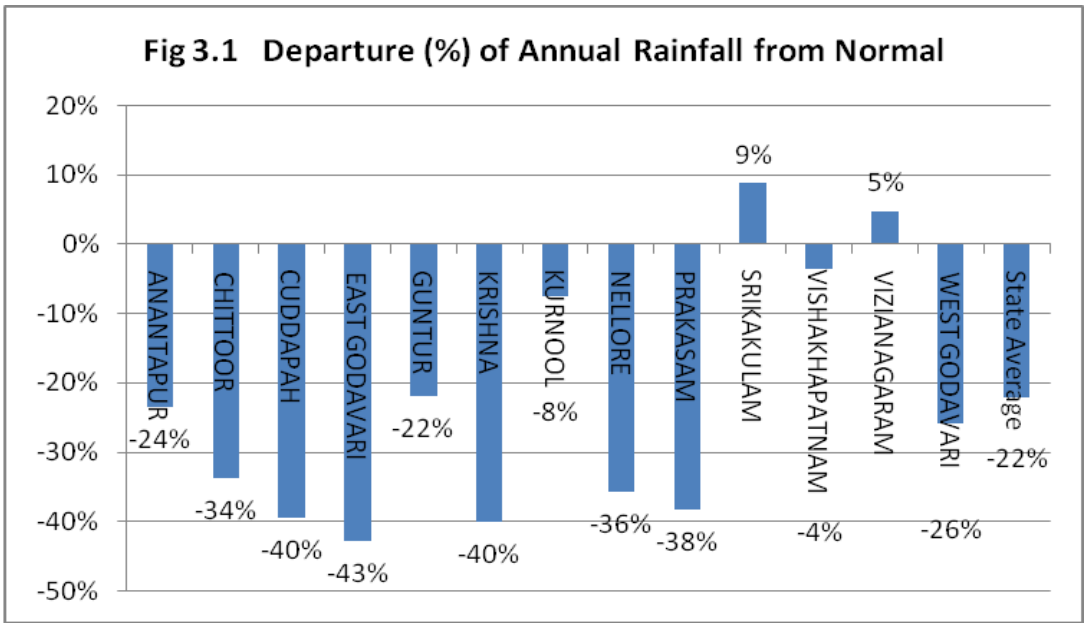
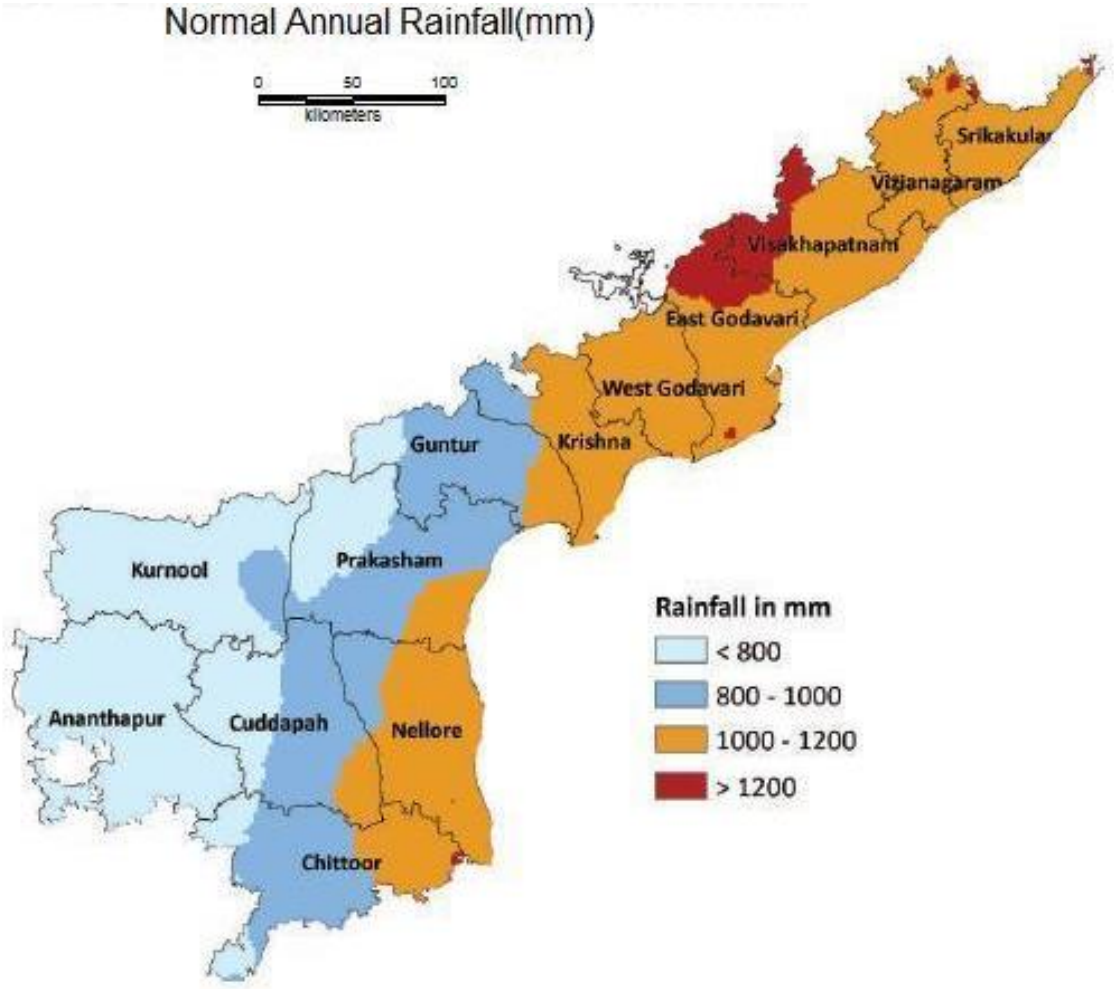


Fig 3.1 Departure (%) of Annual Rainfall from Normal
20%
10%
0%
-10%
-20%
-30%
-40%
-50%
ANANTAPUR
-24%
CHITTOOR
-34%
CUDDAPAH
-40%
EAST GODAVARI
-43%
GUNTUR
-22%
KRISHNA
-40%
KURNOOL
-8%
NELLORE
-36%
PRAKASAM
-38%
SRIKAKULAM
9%
VISHAKHAPATNAM
-4%
VIZIANAGARAM
5%
WEST GODAVARI
-26%
State Average
-22%

Fig.3.2


Normal Annual Rainfall(mm)
0
50
100
kilometers
Srikakulam
Vizianagaram
Visakhapatnam
East Godavari
West Godavari
Krishna
Guntur
Prakasham
Nellore
Kurnool
Cuddapah
Ananthapur
Chittoor
Rainfall in mm
< 800
800 - 1000
1000 - 1200
> 1200

3.2.2 Rainfall analysis - May 2014

District-wise rainfall data for the period Jun'12 - May'13, Jun'13-May'14, decadal mean (Jun-May) of 2004-2013 and normals of June – May and the departure of Jun'13-May'14 rainfall with all the rest of the periods are given in the Table-3.3**.** The thematic maps are prepared using departure values. (Fig 3.3, 3.4 and 3.5).

Departure of rainfall during June 2013 - May 2014 from June 2012-May 2013 rainfall

The thematic map depicting departure of rainfall during Jun'13-May'14 from Jun'12-May'13 rainfall (Fig.3.3) is prepared and correlated the water level fluctuations during May 2014-May 2013. The state has received 1007 mm of rainfall during Jun'13 to May'14 (Table-3.3), which is 6% less than that of during same period previous year, 0.4% more than the decadal mean(2004-2013) and 6% more than the normal. During the same period, last year, 1070 mm of rainfall was recorded. The departure in percentage ranges from -26% (East Godavari) to 18.4% (Kadapa district).

Table - 3.3
Rainfall distribution and Its variability

S No	District	Rainfall(Mm)				Departure of June'13-May'14 Rainfall From		
		June'13 - May'14	Jun'12 - May'13	Decadal Mean	Normal	June'12 - May'13	Decadal Mean (June-May)	Normal (June-May)
1	Anantapur	542	481	633	573	12.7%	-14.4%	-5.4%
2	Chittor	793	1002	991	898	-20.9%	-20.0%	-11.8%
3	Cuddapah	654	552	702	717	18.4%	-6.8%	-8.8%
4	East Godavari	1141	1540	1182	1106	-25.9%	-3.5%	3.1%
5	Guntur	1098	1040	937	872	5.5%	17.2%	25.9%
6	Krishna	1251	1512	1161	1027	-17.3%	7.7%	21.8%
7	Kurnool	686	627	741	680	9.4%	-7.5%	0.9%
8	Nellore	802	910	1105	1092	-11.8%	-27.4%	-26.5%
9	Prakasam	932	875	862	806	6.5%	8.2%	15.7%
10	Srikakulam	1578	1285	1194	1165	22.8%	32.2%	35.4%
11	Vishakhapatnam	1237	1195	1155	1121	3.5%	7.1%	10.4%
12	Vizianagaram	1116	1262	1203	1140	-11.6%	-7.3%	-2.2%
13	West Godavari	1256	1627	1169	1160	-22.8%	7.4%	8.3%
	State Mean	1007	1070	1003	950	-5.9%	0.4%	5.9%
Source: India Meteorological Department, GOI								

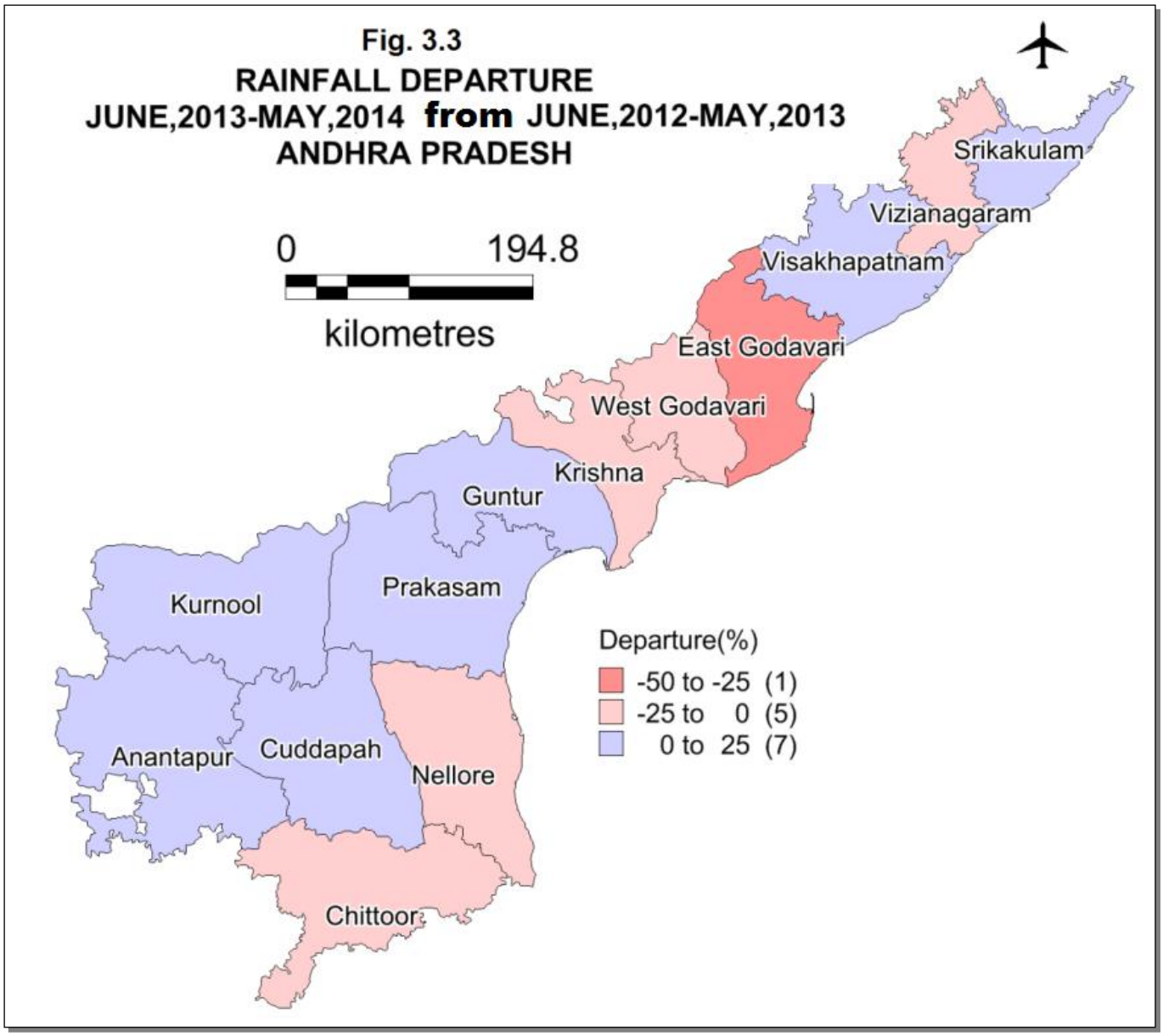
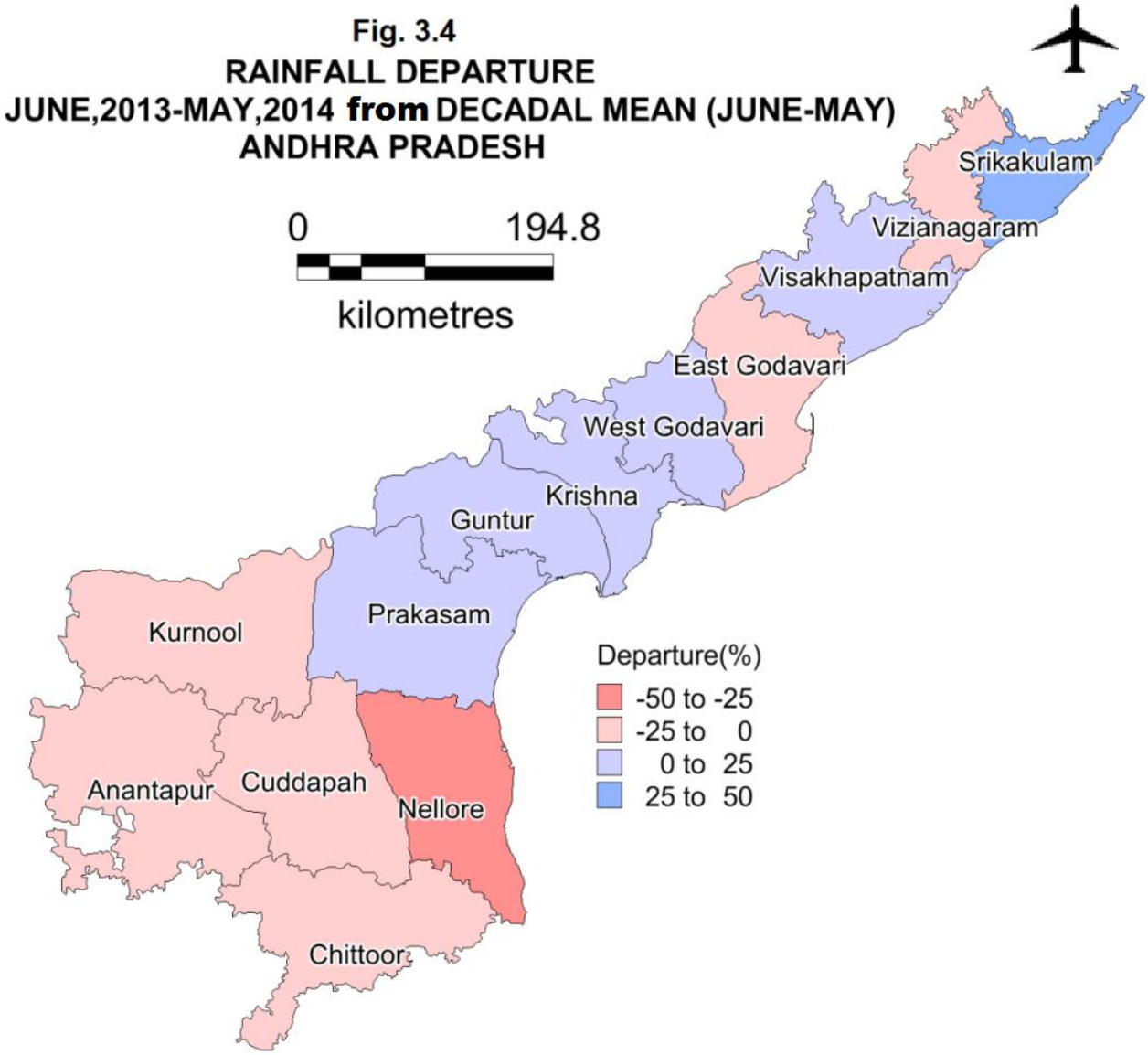


Fig. 3.3
RAINFALL DEPARTURE
JUNE,2013-MAY,2014 from JUNE,2012-MAY,2013
ANDHRA PRADESH
0
194.8
kilometres
Srikakulam
Vizianagaram
Visakhapatnam
East Godavari
West Godavari
Krishna
Guntur
Prakasam
Kurnool
Anantapur
Cuddapah
Nellore
Chittoor
Departure(%)
-50 to -25 (1)
-25 to 0 (5)
0 to 25 (7)

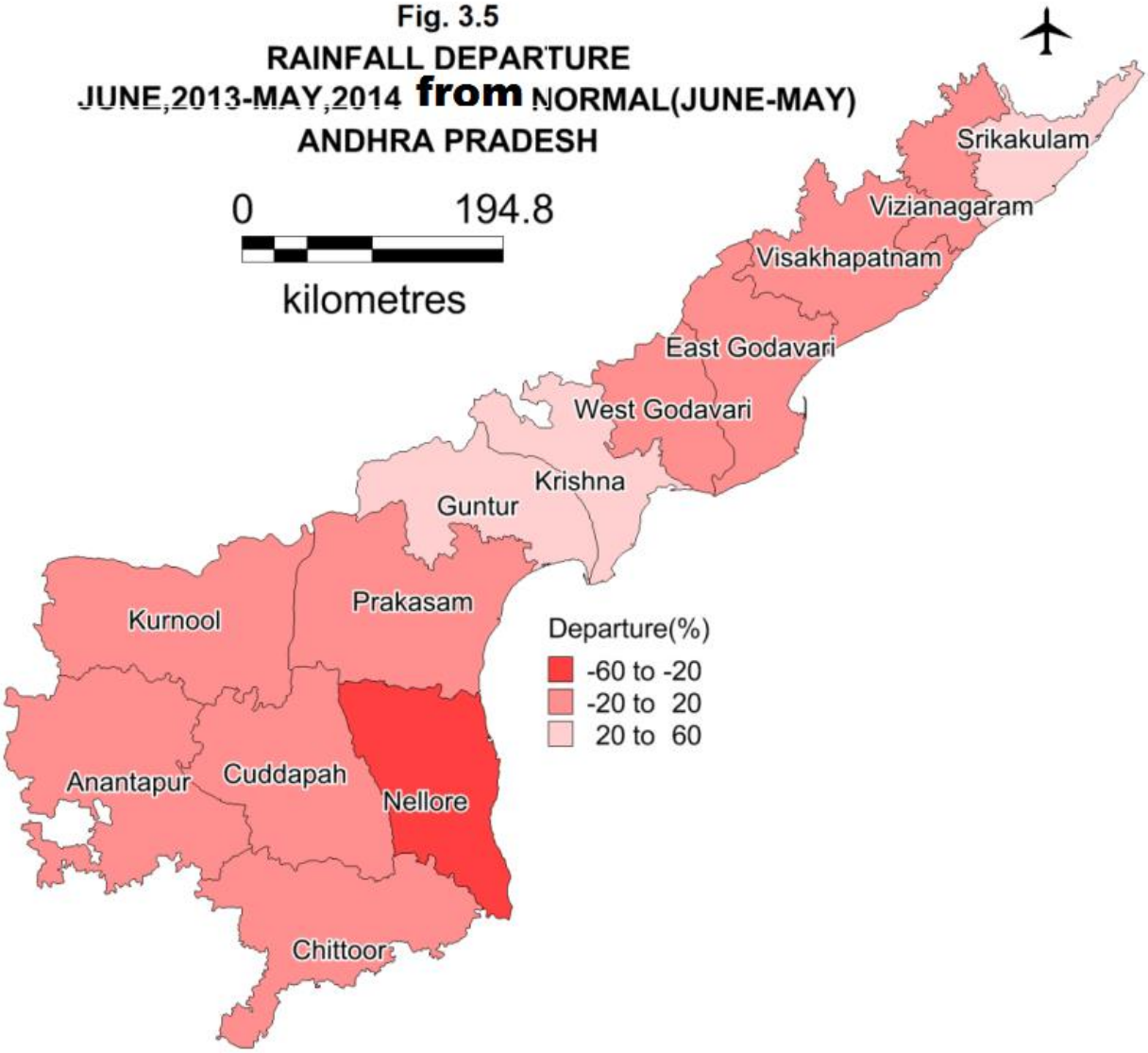
Departure of rainfall during June 2013-May 2014 from decadal mean rainfall 2004-2013 (Jun-May)

Thematic map depicting departure of Jun'13-May'14 rainfall from decadal mean rainfall (Fig 3.4) (Jun-May) is prepared and correlated with water level fluctuations of May, 2014 with respect to decadal mean (May). The decadal mean rainfall (Table-3.3) of is 1003 mm. The departure in percentage ranges from -27% (Nellore district) to 32.2% (Srikakulam district).



Departure of rainfall during June 2013-May 2014 from normalrainfall

Thematic map depicting (Fig. 3.5) departure of Jun'13-May'14 rainfall from normals of the same period is prepared and correlated with depth to water level map during May, 2014. During the period Jun'13-May'14 the state has received 6% more rainfall than normal. It ranges from -27% (Nellore district) to +35% (Srikakulam district). Deficit rainfall was observed only in Nellore district. Rest of the state has received normal to excess rainfall.



3.2.3 Rainfall - August 2014

The rainfall data of India Meteorological Department and Weekly Weather reports have been used to analyze the rainfall for the period Jun 2004 to Aug 2014. District-wise rainfall data for the period Jun'13-Aug'13, Jun'14-Aug'14, decadal mean (Jun-May) of 2004-2013 and normals of Jun – May and the departure of Jun'14-Aug'14 rainfall from rest of all the periods has been furnished in the Table-3.4. The departure values are used to prepare the thematic maps (Fig.3.6, 3.7 and 3.8).

Table - 3.4

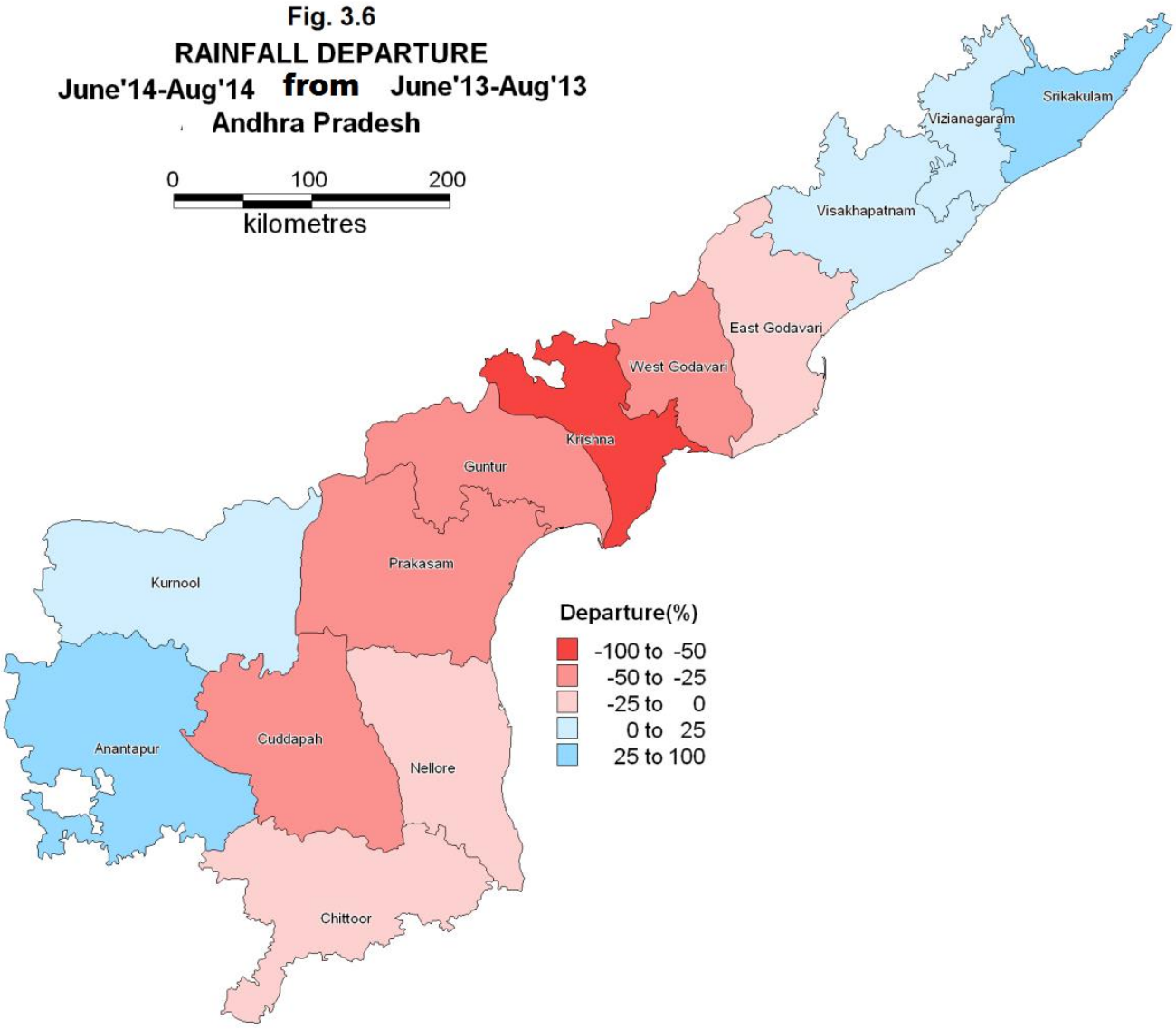
RAINFALL AND ITS VARIABILITY IN ANDHRA PRADESH
Aug'14

S NO	DISTRICT	RAINFALL(mm)				Departure of JUNE'14-Aug'14 rainfall from		
		JUNE'14 - AUG'14	JUN'13 - AUG'13	DECADAL MEAN (JUNE-AUG)	NORMAL	JUNE'13 - AUG'13	DECADAL MEAN (June-Aug)	NORMAL (June-Aug)
1	Anantapur	168	124	234	194	35.4%	-28.5%	-13.7%
2	Chittor	242	277	312	277	-12.6%	-22.4%	-12.6%
3	Cuddapah	186	270	267	280	-31.3%	-30.4%	-33.6%
4	East Godavari	273	328	520	527	-16.9%	-47.5%	-48.2%
5	Guntur	267	445	433	393	-40.1%	-38.4%	-32.2%
6	Krishna	267	550	563	532	-51.5%	-52.6%	-49.8%
7	Kurnool	303	302	337	321	0.3%	-10.1%	-5.5%
8	Nellore	227	280	242	240	-18.7%	-5.9%	-5.1%
9	Prakasam	185	358	272	260	-48.4%	-32.1%	-28.9%
10	Srikakulam	576	450	556	538	28.1%	3.5%	7.1%
11	Vishakhapatnam	441	419	465	489	5.3%	-5.1%	-9.7%
12	Vizianagaram	546	444	547	517	22.8%	-0.3%	5.5%
13	West Godavari	435	605	601	604	-28.1%	-27.6%	-27.9%
	STATE MEAN	**317**	**373**	**411**	**398**	**-15.2%**	**-23.1%**	**-20.4%**

Source: India Meteorological Department, GOI

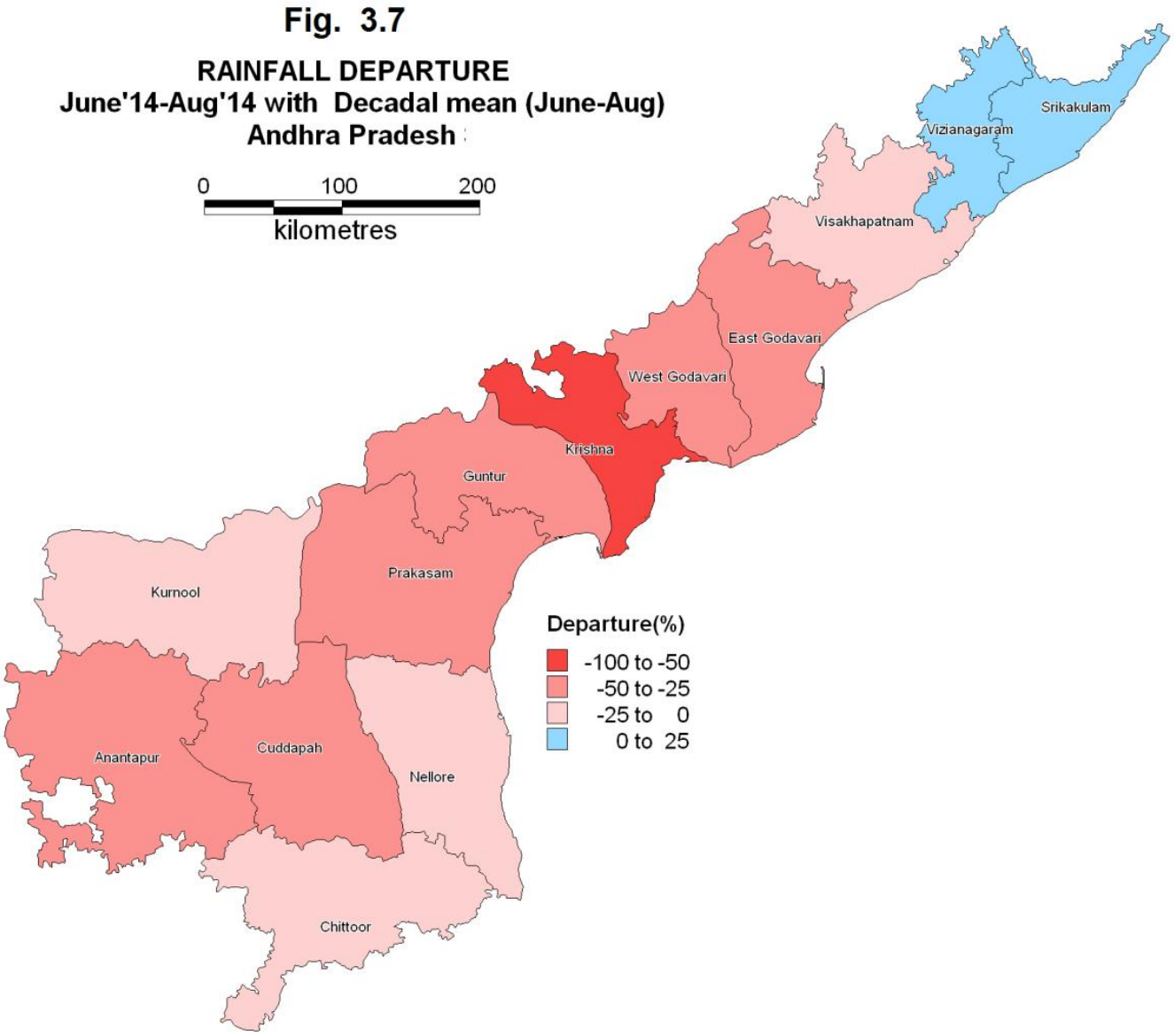
Departure of rainfall during June to August 2014 from June – August 2013

The thematic map (Fig.3.6) depicting departure of rainfall during Jun'14-Aug'14 from Jun'13-Aug'13 is prepared and correlated with water level fluctuation map during May 2014-Aug 2013. The state has received 317 mm of rainfall during Jun'14 to Aug'14 (Table-3.5) which is 15.2% less than the rainfall received during the same period previous year. The state received about 373 mm of rainfall during the same period last year. The departure in percentage ranges from –48.4% (Prakasam district) to 35.4% (Anantapur district). Anantapur, Kurnool, Srikakulam, Vizianagaram and Visakhaptnam districts have received more rainfall than the same period previous year.



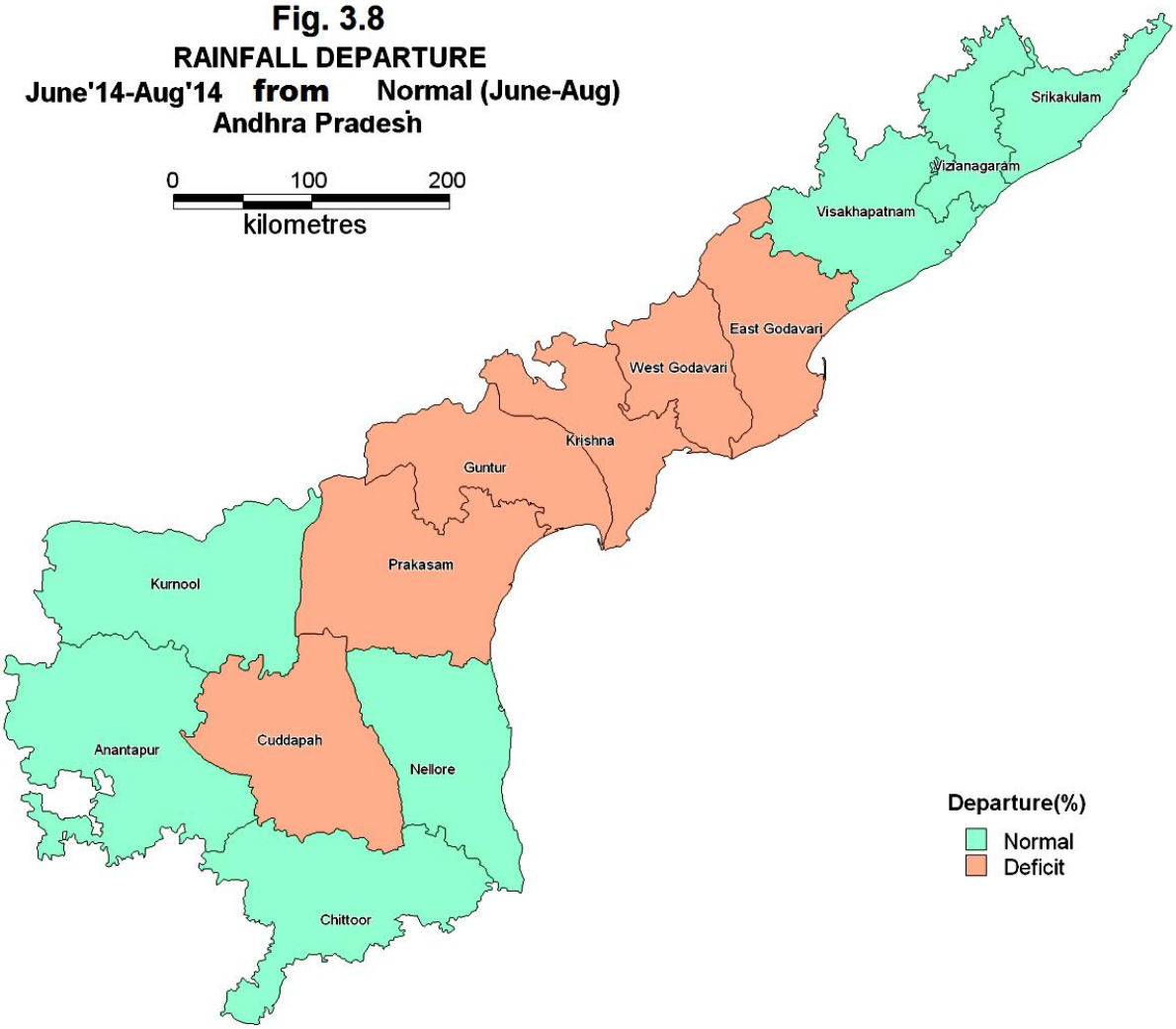
Departure of rainfall during June to August, 2014 from decadal mean (2004-13)

The thematic map (Fig.3.7) depicting departure of Jun'14-Aug'14 rainfall from decadal mean (Jun-May) is prepared and correlated with the water level fluctuation map of Aug 2014 with respect to decadal mean. The decadal mean rainfall (Jun-May) of the state is 411 mm (Table-3.5). The departure in percentage ranges from -52.6% (Krishna district) to 3.5% (Srikakulam district). Except Srikakulam and Vizainagaram districts, entire state has received less rainfall than the decadal mean (23% less).



Departure of rainfall during June to August 2014 from normal rainfall

Thematic map (Fig.3.8) depicting departure of Jun'14-Aug'14 rainfall from normals of the same period is prepared correlated with the depth to water level map of Aug, 2014. During the period Jun'14-Aug'14, 20% less rainfall than the normal was recorded(Table-3.5). It ranges from – 49.8% (Krishna district) to 7.1% (Srikakulam district). Rainfall was deficit in the State except Kurnool, Anantapur, Nellore, Chittoor, Srikakulam, Vizianagaram and Visakhaparnam districts.



3.2.4 Rainfall – November, 2014

The rainfall data of India Meteorological Department and weekly weather reports have been used to analyze the rainfall for the period June, 2004 to Oct, 2014. District-wise rainfall data for the period Jun'13- Oct'13, Jun'14- Oct'14, decadal mean (June - Oct) of 2004-2013 and normals of Jun – Oct and the departure of Jun'14- Oct'14 rainfall from rest of all the periods is given in the The departure values are used to prepare the thematic maps given in (Fig 3.9, 3.10 & 3.11).

Table – 3.5

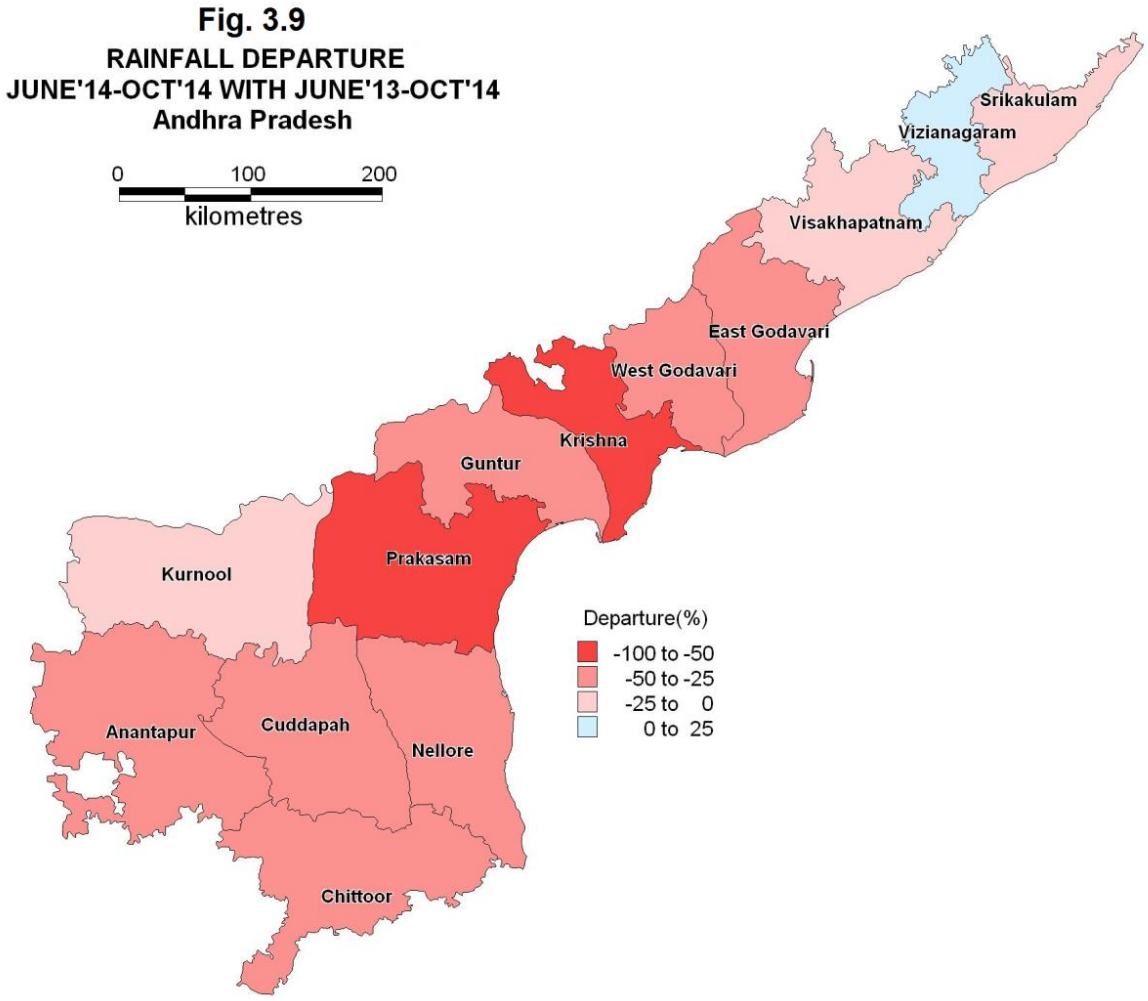
RAINFALL AND ITS VARIABILITY IN ANDHRA PRADESH
(In support of Nov14 NHS Report)

S No	District	Rainfall(Mm)				Departure Of June'14-Oct'14 Rainfall From		
		June'14 - Oct'14	Jun'13 - Oct'13	Decadal Mean (June-Oct)	Normal	June'13 - Oct'13	Decadal Mean (June-Oct)	Normal (June-Oct)
1	Anantapur	321	436	466	438	-26.4%	-31.1%	-26.7%
2	Chittor	440	633	632	584	-30.6%	-30.5%	-24.8%
3	Cuddapah	365	595	504	541	-38.6%	-27.5%	-32.5%
4	East Godavari	487	968	957	903	-49.7%	-49.1%	-46.1%
5	Guntur	561	967	754	687	-42.0%	-25.6%	-18.4%
6	Krishna	491	1070	947	866	-54.1%	-48.1%	-43.2%
7	Kurnool	479	607	600	566	-21.2%	-20.2%	-15.4%
8	Nellore	455	608	635	601	-25.1%	-28.3%	-24.2%
9	Prakasam	366	849	604	564	-56.9%	-39.5%	-35.2%
10	Srikakulam	1025	1304	984	957	-21.4%	4.2%	7.1%
11	Vishakhapatnam	919	1004	887	879	-8.5%	3.6%	4.6%
12	Vizianagaram	1006	907	930	914	10.9%	8.2%	10.0%
13	West Godavari	710	1074	990	982	-33.9%	-28.2%	-27.6%
	STATE MEAN	587	848	761	729	-30.8%	-22.9%	-19.6%

Source: India Meteorological Department, GOI

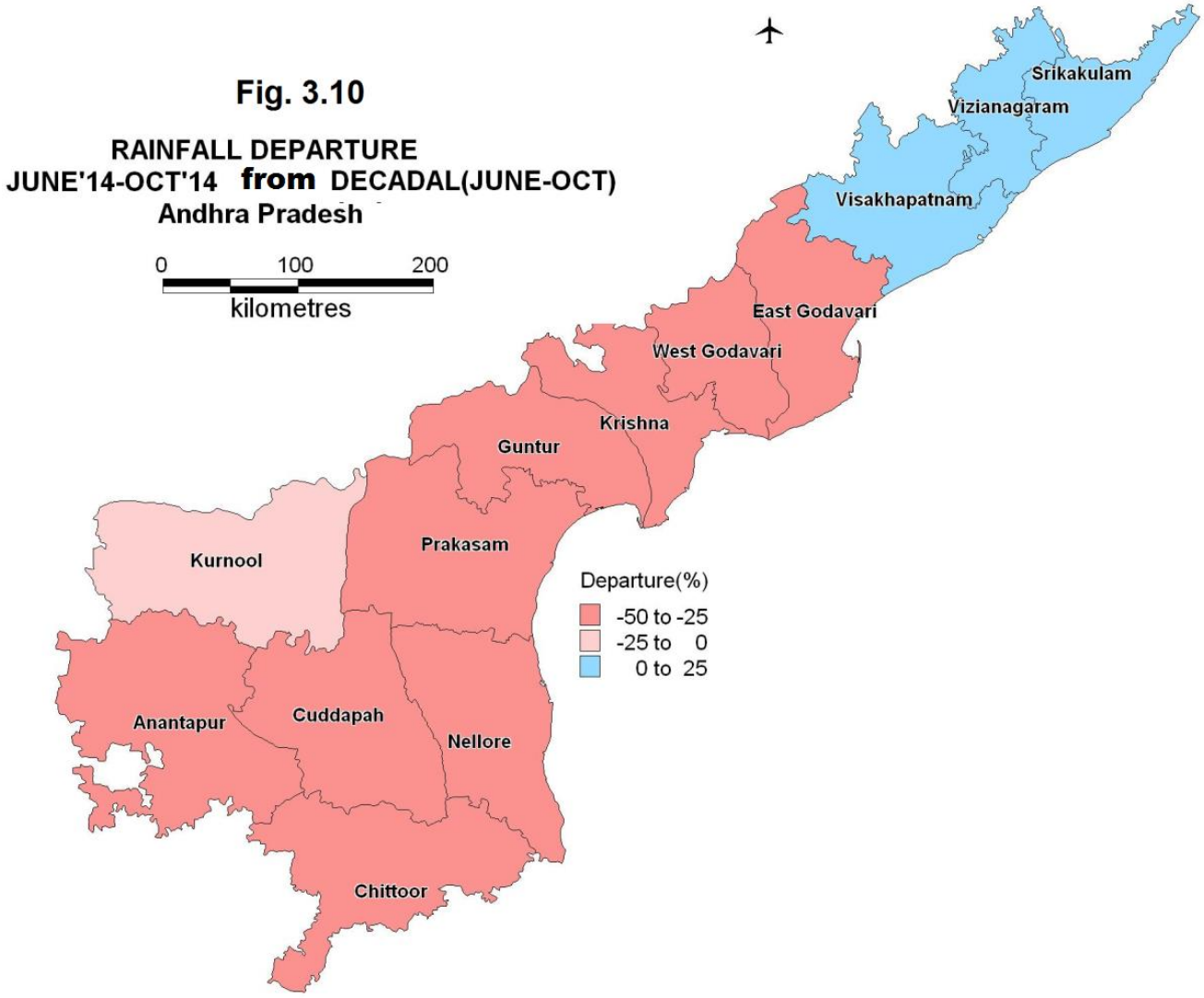
Departure of rain fall during June to October, 2014 from June to October, 2013

Thematic map depicting (Fig.3.9) departure of Jun'14- Oct'14 rainfall from Jun'13- Oct'13 rainfall is prepared to correlate with the water level fluctuation map of May, 2014 – Nov, 2014. The state has received 587 mm of rainfall during od Jun'14 to Oct'14which is 31% less than the rainfall received during the same period previous year, which was 848 mm. The departure in percentage ranges from –56.9% (Prakasam district) to 10.9% (Vizianagaram district).



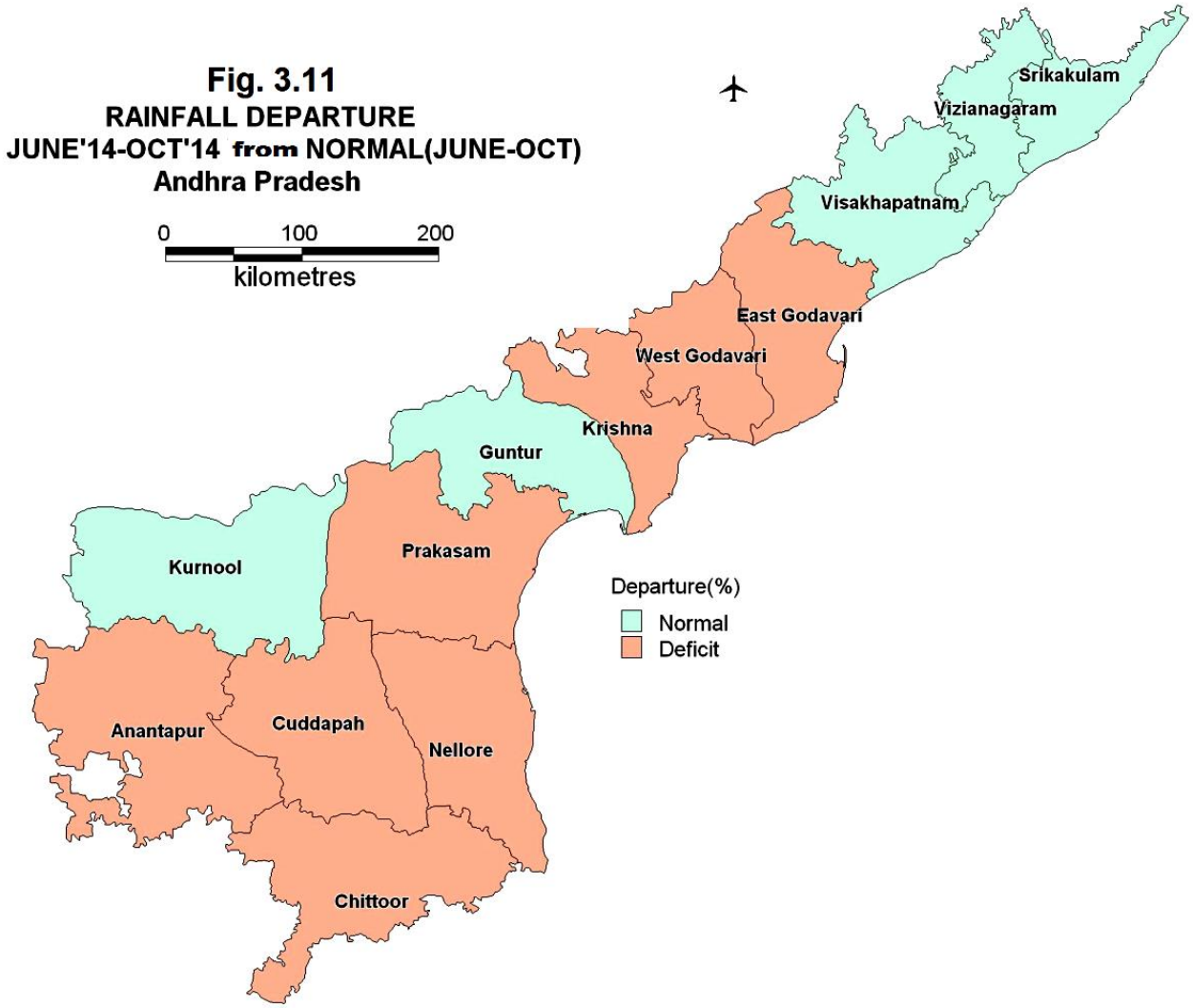
Departure of rainfall during June to October, 2014 from decadal mean - June to October - 2004-13

Departure of Jun'14- Oct'14 rainfall from decadal mean rainfall (Jun- Oct) is depicted in the **Fig 3.10.** Water level fluctuation map of Nov, 2014 from decadal mean (Nov) is correlated with departure of rainfall from decadal mean. The state has received 23% less rainfall than the decadal mean (June-Oct), which was 761 mm. The departure in percentage ranges from -49.1% (East Godavari district) to 8.2% (Vizianagaram district).



Departure of rainfall during June to October, 2014 from normal (June to October)

Departure of Jun'14- Oct'14 rainfall from normals of the same period is depicted in the Fig. 3.11. water level map of Nov, 2014 is correlated with departure of Jun'14- Oct'14 rainfall from normal. During the period Jun'14- Oct'14, the state has received 20% less than the normal rainfall, which was 729 mm. It ranges from –-46.1% in East Godavari district to 10% in Vizianagaram district.



3.2.5 Rainfall Analysis - January - 2015

Rainfall data of India Meteorological Department and Weekly Weather reports have been used to analyze the rainfall for the period Jan 2004 to Dec 2014. District-wise rainfall data for the period Jan'13-Dec'13, Jan'14- Dec'14 and decadal mean (Jan-Dec) of 2004-13, normals of Jan – Dec and the departure of Jan'14-Dec'14 rainfall from rest of all the periods are given in the Table-3.6. The thematic maps depicting departure of rainfall during Jan'14- Dec'14 from Jan'13-Dec'13, decadal mean and normals of the same period are presented in the Fig.3.12, 3.13 & 3.14.

Table 3.6

RAINFALL DISTRIBUTION AND ITS VARIABILITY IN ANDHRA PRADESH

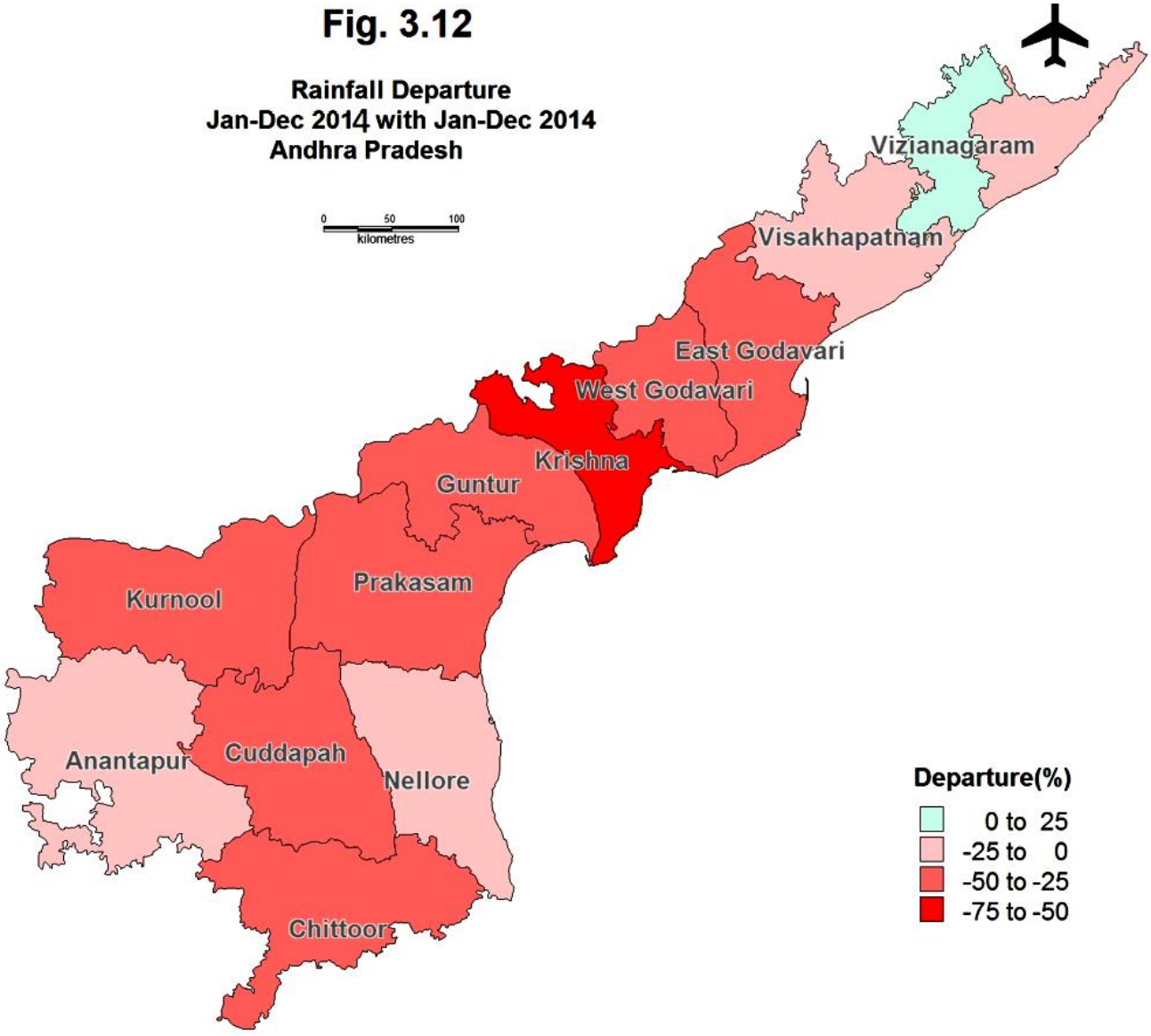
(JAN 2004 TO DEC 2014)

S NO	DISTRICT	RAINFALL(mm)				Departure of Jan'14-Dec'14 rainfall from		
		Jan'14 - Dec'14	Jan'13 - Dec'13	DECADAL MEAN (2004-13)	NORMAL Jan-Dec	FROM LAST YEAR SAME PERIOD	FROM DECADAL MEAN	FROM NORMALS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	ANANTAPUR	438	501	642	573	-13%	-32%	-24%
2	CHITTOR	596	856	989	898	-30%	-40%	-34%
3	Y S R KADAPA	434	689	698	717	-37%	-38%	-39%
4	EAST GODAVARI	632	1120	1186	1106	-44%	-47%	-43%
5	GUNTUR	681	1162	951	872	-41%	-28%	-22%
6	KRISHNA	615	1317	1183	1027	-53%	-48%	-40%
7	KURNOOL	581	917	748	680	-37%	-22%	-14%
8	S P S NELLORE	702	872	1103	1092	-19%	-36%	-36%
9	PRAKASAM	497	986	890	806	-50%	-44%	-38%
10	SRIKAKULAM	1268	1438	1208	1165	-12%	5%	9%
11	VISHAKHAPATNAM	1082	1165	1148	1121	-7%	-6%	-3%
12	VIZIANAGARAM	1195	1028	1178	1140	16%	1%	5%
13	WEST GODAVARI	860	1184	1189	1160	-27%	-28%	-26%
	STATE MEAN	**737**	**1018**	**1009**	**950**	**-27.6%**	**-26.9%**	**-22%**

Source: India Meteorological Department, GOI

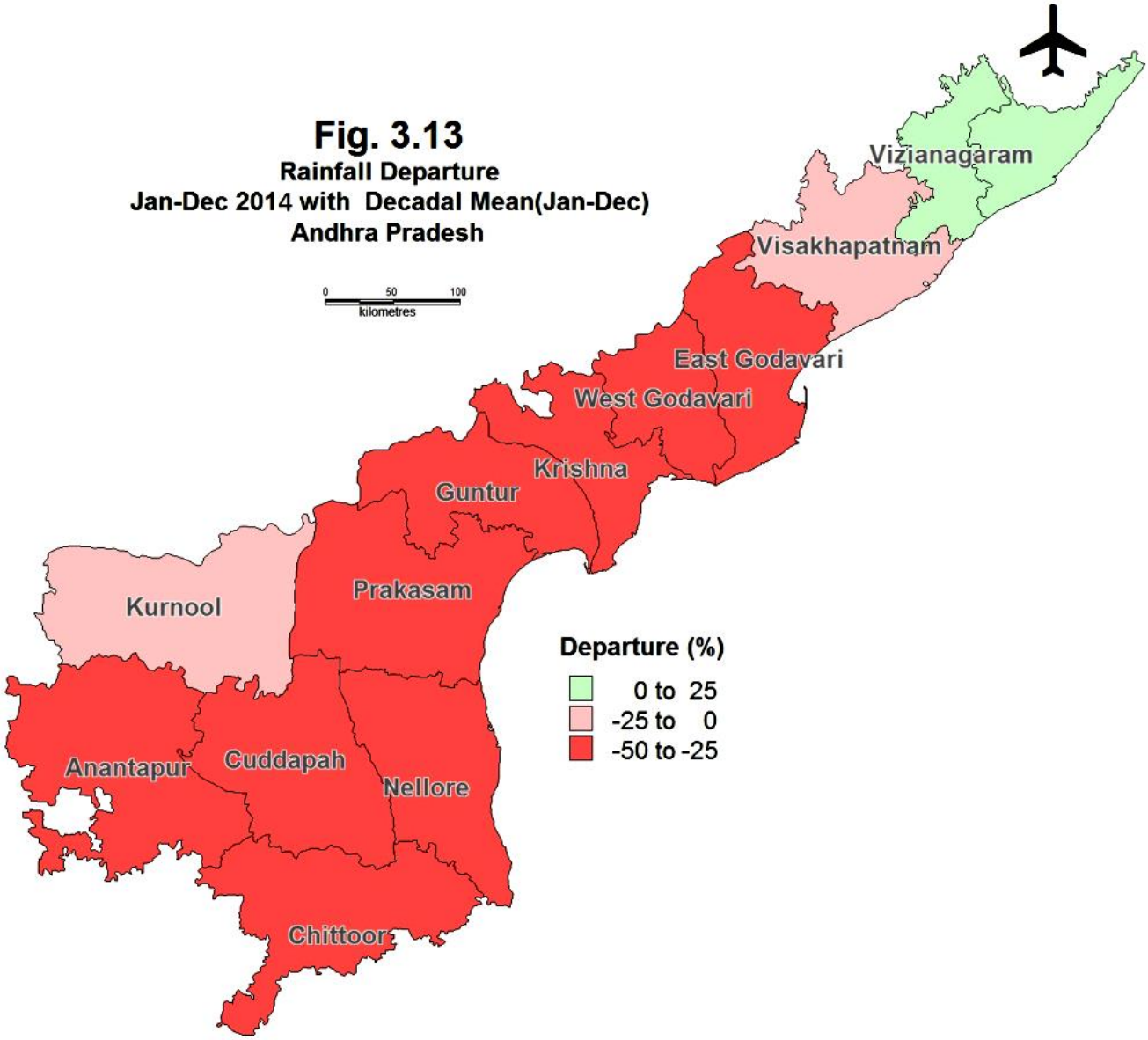
Departure of rain fall during Jan to Dec 2014 from Jan-Dec 2013

Thematic map depicting departure of rainfall during Jan'14- Dec'14 from Jan'13-Dec'13 rainfall is presented in the Fig.3.12. Water level fluctuation of Jan 2014-Dec, 2014 is correlated with departure of rainfall (Jan'14- Dec'14) from rainfall Jan'13-Dec'13. The state has received 737 mm of rainfall duringd Jan'- Dec'14 , which is 28% less (1018 mm) than the rainfall during the same period previous year **(**Table-3.6). The departure in percentage ranges from -53% in Krishna district to 16% in Vizianagaram district.



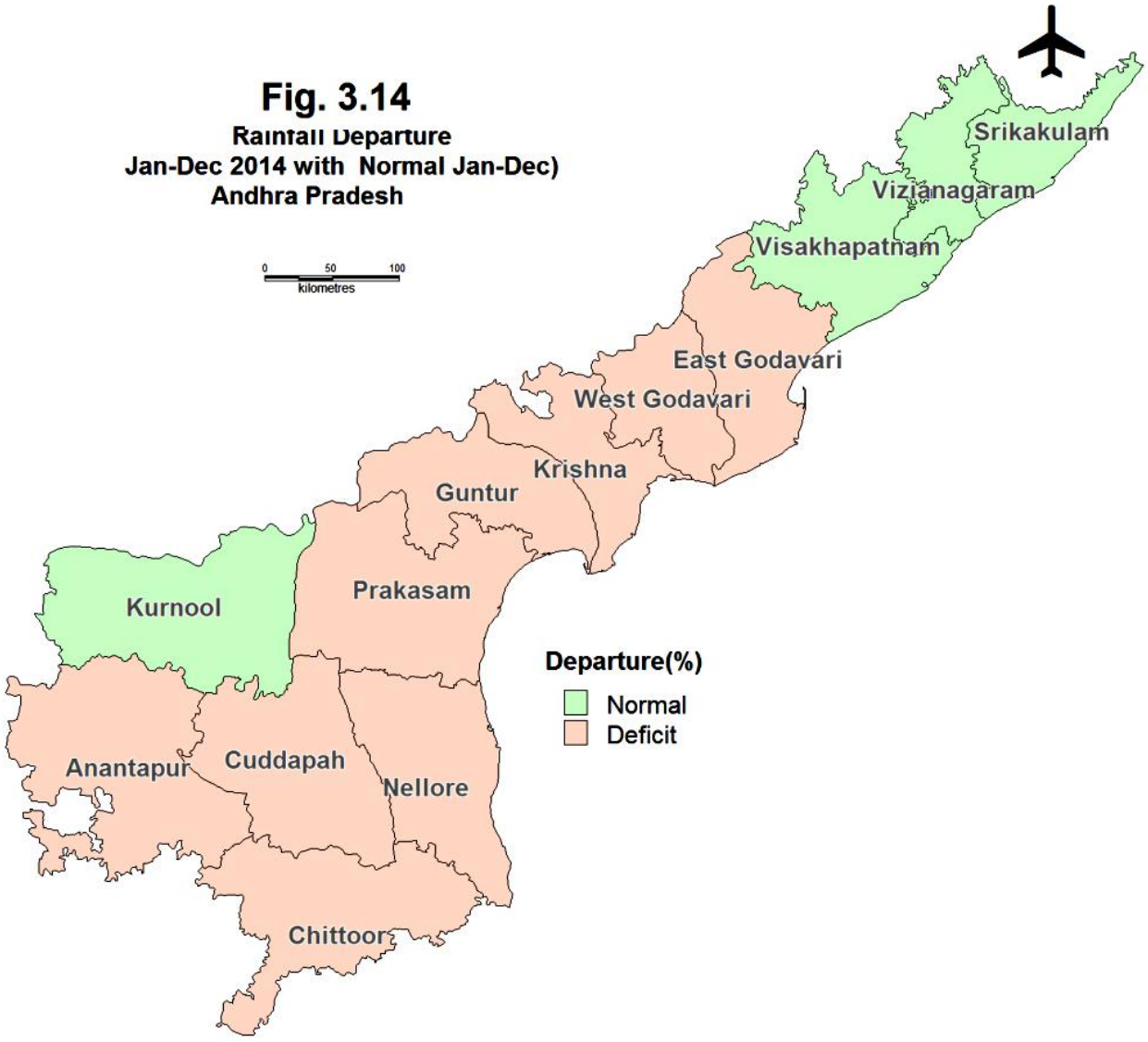
Departure of rain fall during Jan to Dec 2014 from decadal mean rainfall Jan-December

Themaic map depicting departure of Jan'- Dec'14 rainfall from decadal mean rainfall (Jan-Dec) is presented in the Fig 3.13. Water level fluctuation map of Jan, 2015 with respect to Decadal mean (Jan) is correlated with departure of Jan'- Dec'14 rainfall from decadal mean. The decadal mean rainfall (Jan-Dec) of the state is 1009 mm. During the period Jan' to Dec, 2014 the state has received 27% less rainfall than the decadal mean (Jan-Dec). The departure in percentage ranges from -48% in Krishna district to 5% in Visakhapatnam district. Except Srikakulam and Vizainagaram districts, less rainfall than the decadal mean has been recorded.



Departure of rain fall during Jan to Dec 2014 from normals of the same period

Thematic map depicting departure of Jan'14- Dec'14 rainfall from normals of the same period is presented in the Fig.3.14. Depth to water level data of Jan, 2015 is correlated with rainfall departure during Jan'- Dec'14 from normals. During the period Jan'14- Dec'14, the state has received deficit rainfll, 22% less than the normal. It ranges from –43% in East Godavari district to 9% in Srikakulam district. Deficit rainfall was recorded except Kurnool, Srikakulam, Vizianagaram and Visakhaparnam districts.



4.0 GEOLOGY

A wide variety of geological formations occur in Andhra Pradesh, ranging from the oldest Archaean crystalline rocks to Recent alluvium. The geological set up and principal aquifer systems are presented in the Fig.4.1 & 4.2 respectively. Major part of the State is underlain by gneissic complex with a structural fill of sedimentary rocks and basin-fill of meta-sedimentary rocks. The gneissic complex is overlain by basaltic lava flows in the northwestern part and is intruded by several younger rocks; granites, dolerites and pegmatites, etc.

4.1 Archaeans and Lower Pre-Cambrians

Peninsular gneiss, which is predominant rock type of Archaean, is dominant in Rayalaseema region. 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. Dharwars, comprising amphibolites, gneisses, schists, and quartzites occur as narrow isolated bands within granites in Chittoor, Anantapur, Kurnool, Kadapa, Nellore, 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 Cuddapah Super Group of rocks occur in parts of Krishna, Kurnool, Prakasam, Guntur, Nellore, Kadapa, Chittoor and Anantapur districts. These rocks, forming a crescent shaped Cuddapah basin, cover an area of 42,100 sq.km. Kurnools occur in Kundair valley and Palnad tract. Sullavais are exposed in Godavari valley. Gondwana Formations, comprising lower group of rocks, the Talchirs, Barakars and Kamthis and upper group of rocks, the Maleris, Kotas and Chikialas, occupy parts of West Godavari district. The Gondwana formations, of alluvial and lacustrine sediments are exposed in lower reaches of Godavari valley. Gondwanas also occur as disconnected outcrops along the coast from Tuni in East Godavari district to Satyavedu in Chittoor district.

4.3 Deccan Trap 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 limestone and sandstone, 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

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 Prakasam and Nellore districts.

4.5 Recent To Sub-Recent 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 between 60 m and 100 m.

Fig.4.1

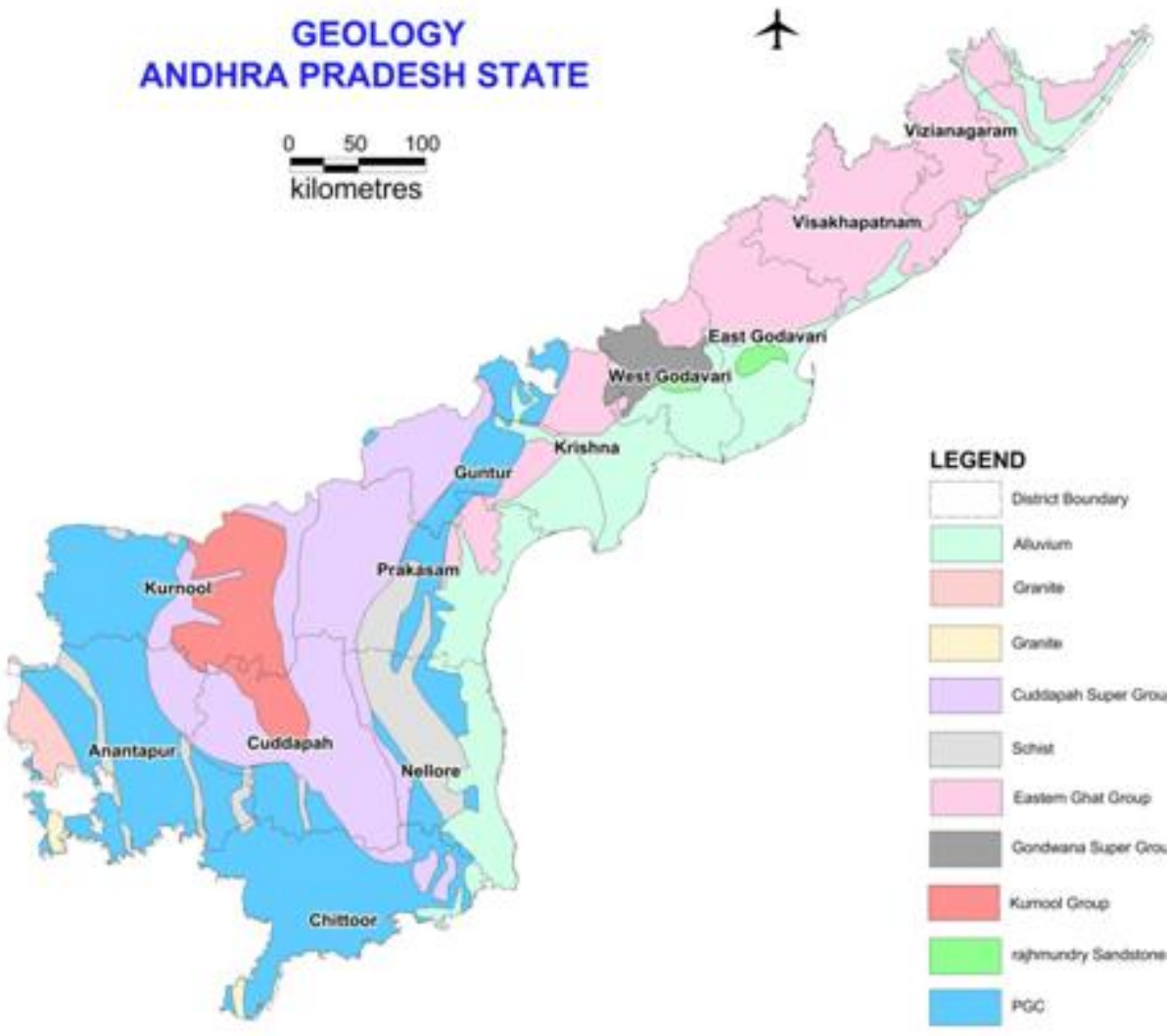
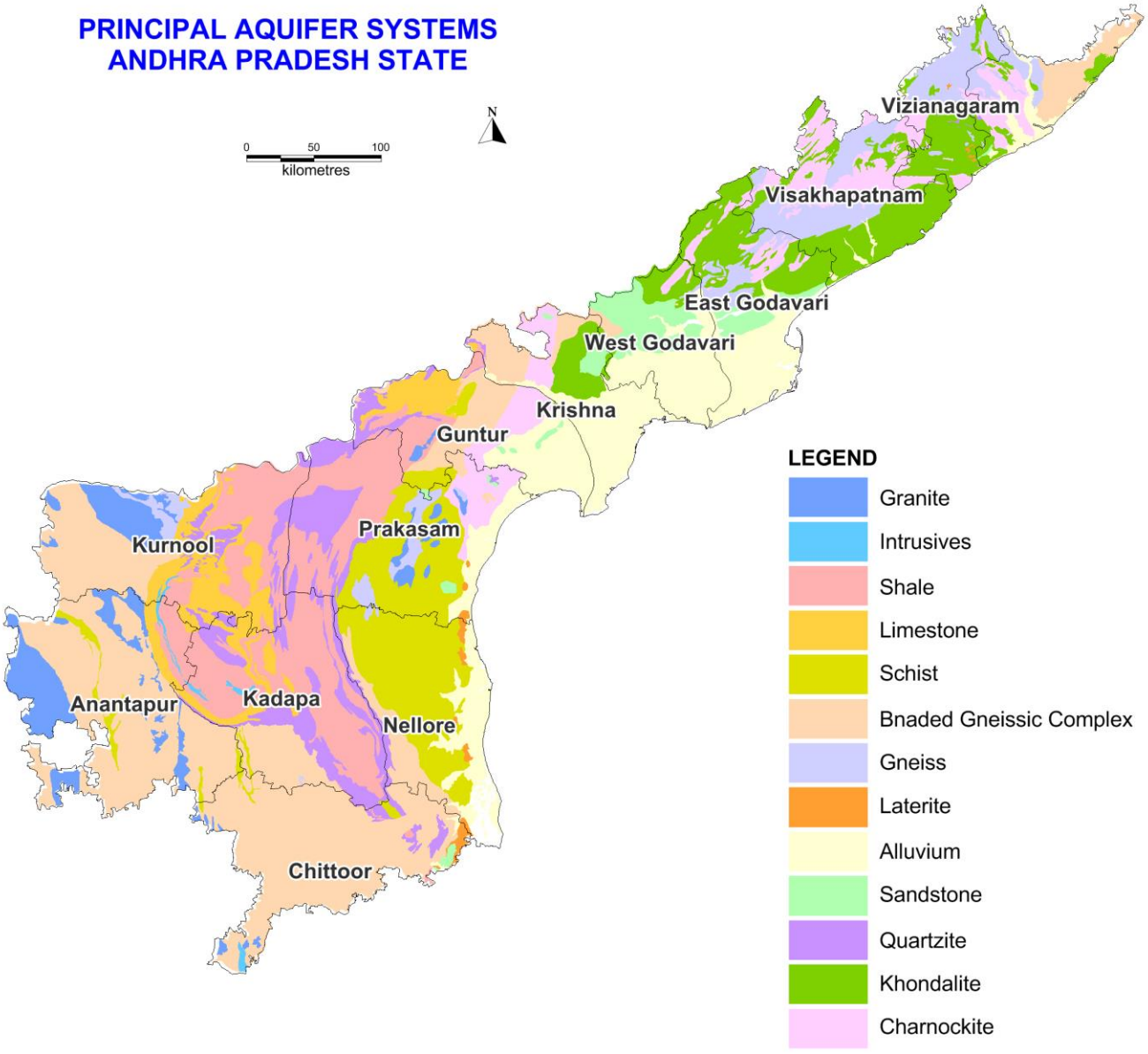


Fig.4.2


PRINCIPAL AQUIFER SYSTEMS
ANDHRA PRADESH STATE
N
0 50 100
kilometres
Vizianagaram
Visakhapatnam
East Godavari
West Godavari
Krishna
Guntur
Prakasam
Kurnool
Anantapur
Kadapa
Nellore
Chittoor
LEGEND
Granite
Intrusives
Shale
Limestone
Schist
Bnaded Gneissic Complex
Gneiss
Laterite
Alluvium
Sandstone
Quartzite
Khondalite
Charnockite

5.0 GROUND WATER REGIME MONITORING

The lithounits, ground water point of view, are classified into three groups, namely;

i) Consolidated formations
ii) Semi-Consolidated formations
iii) UnConsolidated formations

i) The Consolidated formations occupy about 83% of the area. They comprise rocks of Archaean age, limestones, quartzites and slates of pre-Cambrian age and massive Deccan Traps of Cretaceous to Eocene age. Weathered and fractured zones form the principal aquifer system. Vesicular zones, inter and infra-trappean contacts constitute aquifer system in Deccan Traps. Fractures and cavernous zones are the main aquifers in limestone formations. The aquifer system extends down to 100 mbgl in general and 150 mbgl at places.

ii) Semi-consolidated formations comprise Gondwana sandstones & shales, inter and infra-trappean and Rajahmundry sandstones. Coarse grained sandstone down to 700 mbgl form the main aquifer system.

iii) Unconsolidated formations consists of river and coastal alluvium of Sub-Recent to Recent age. Sand layers forms the main aquifer system in unconsolidated formations and are generally confined to shallow depth of 30mbgl.

5.1 Monitoring Methodology

Ground water regime is monitored through a network of dug wells and piezometers. The dug wells, which are owned by government and non-government agencies and individual users, are located in the shallow aquifer system. Piezometers (basically bore wells/tube wells) constructed exclusively for ground water regime monitoring purpose by Central Ground Water Board, tapping shallow and deeper aquifers separately. The ground water regime is monitored manually during the following periods, every year.

i) 1st to 10th January
ii) 20th to 30th May
iii) 20th to 30th August
iv) 1st to 10th November.

5.1.1 Participatory Ground water Monitoring

Under Participatory Ground water Monitoring Programme, weekly water level measurements are initiated in phases involving local people as observers to record the periodic and short term changes in ground water regime. A total of 190 observers are engaged since May, 2005.

5.1.2 Ground Water Quality monitoring

Chemical Quality of Ground Water is monitored once in a year from the monitoring wells (dug wells) in the month of May. The effect of geogenic, anthropogenic factors on ground water in different hydrogeological environments are being studied by quality monitoring over a period of time.

5.2 Database on Ground Water Monitoring Wells

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

5.3 Distribution of Ground Water Monitoring Wells

The distribution and density of monitoring wells is presented in the following sections.

5.3.1 Area represented by Ground Water Monitoring Wells (as on 01.04.2015)

As on 31.03.2014

Highest representation of one well per 76 sq.km was noticed in Vishakhapatnam district. Lowest of one well per 428 sq.km in YSR Kadapa district.
For the State, it was one well per 182 sq.km.

As on 01.04.2015

Highest representation of one well per 80 sq.km was observed in Vishakhapatnam district, Lowest of one well per 440 sq.km in YSR Kadapa district.
For the state it was one well per 182 sq.km. (Table-5.1).

Table-5.1
Distribution of National Ground Water Monitoring Stations
Andhra Pradesh during 2013 & 2014 (Area in sq.km)

Sl. No.	District	Area	As on 31.3.2014		As on 31.3.2015	
			Total GWMW	Area Represented	Total GWMW	Area Represented
1	Anantapur	19123	61	313	56	341
2	Chittoor	15224	53	287	50	304
3	East Godavari	10800	102	105	113	96
4	Guntur	11400	108	106	108	106
5	Krishna	8700	71	123	78	111
6	Kurnool	17700	61	290	58	305
S7	Prakasam	17600	74	238	67	263
8	SPS Nellore	13100	65	201	75	175
9	Srikakulam	5800	42	138	42	138
10	Visakhapatnam	6500	86	76	81	80
11	Vizianagaram	11200	46	243	44	254
12	West Godavari	7700	74	104	74	104
13	YSR Kadapa	15421	36	428	35	440
	Total	16026	879	182	881	182

5.3.2 Distribution of Ground Water Monitoring Wells - Basin-wise

The Godavari, Krishna, Mahanadi and Cauvery are the major river basins in the State. The basin wise distribution of network stations are 86 in Godavari, 254 in Krishna, 310 in Pennar and 195 in Mahanadi basins (Table-5.2).

Table-5.2
Basin-wise Distribution of Monitoring Wells, Andhra Pradesh

District	Godavari	Krishna	Penna	Vamsadhara	Total
Anantapur		13	43		56
Chittoor			50		50
East Godavari	65			48	113
Guntur		64	44		108
Kadapa			35		35
Krishna		78			78
Kurnool		39	19		58
Nellore			67		67
Prakasam		1	73		75
Srikakulam				42	42
Visakhapatnam	13			68	81
Vizianagaram				44	44
West Godavari	13	61			74
TOTAL	86	254	310	195	881

5.3.3 Distribution of ground water monitoring wells: District-wise & Aquifer-wise

Out of 881 existing monitoring wells as on 31.3.2015, 533 wells are located in hard rock formations, 348 in soft rocks including 220 wells in alluvial area. The district-wise distribution of monitoring wells in the three aquifer/litho units is given in Table-5.3.

TABLE - 5.3
Aquifer-wise monitoring stations in Andhra Pradesh as on March 2015

DISTRICT	AL	BGC	CK	GN	GR	KH	LS	LT	QZ	SC	SH	ST	Total
Anantapur		38			15						3		56
Chittoor	1	44						4	1				50
East Godavari	62		6	11		25						9	113
Guntur	26	21	21		2		21		2	8	3	4	108
Kadapa		8					2		3	3	19		35
Krishna	42	16	8			10	1					1	78
Kurnool		19		3	9		14		4		9		58
Nellore	19	7						6		35			67
PRAKASAM	14	3	10	7	7			2	3	16	10	3	75
Srikakulam	6	18	10	6		2							42
Visakhapatnam	3		10	22		46							81
Vizianagaram			8	14		20		1	1				44
West Godavari	47	2		1		8		1				15	74
Total	220	176	73	64	33	111	38	14	14	62	44	32	881

6.0 GROUND WATER LEVEL SCENARIO

Ground Water Level Monitoring is a scientific surveillance system to observe the periodic and long-term changes in ground water regime. The water level data collected over a period of time provides information about changes in ground water levels with progressive ground water development or with input in to the ground water system brought in by natural and artificial recharge and surface water irrigation system.

The establishment of ground water monitoring network provides information on ground water regime with a fair degree of accuracy. The scenario of ground water levels is studied periodically in the State based on the data generated and analysis of historical data. The status of monitoring wells as on March, 2014 and 2015 and number of wells established, abandoned during 2014 are given in the Table – 6.1.

Table - 6.1
Status of National Ground Water Monitoring Wells in Andhra Pradesh

Sl. No	District	No. wells as on March-14			No. wells Established during 2014-15			No. of wells Abandoned during 2014-15			No. of wells as on March-15		
		DW	PZ	Total	DW	PZ	Total	DW	PZ	Total	DW	PZ	Total
1	Anantapur	41	20	61	0	0	0	5	0	5	36	20	56
2	Chittoor	52	1	53	0	0	0	2	1	3	50	0	50
3	Cuddapah	33	3	36	0	0	0	10	0	1	32	3	35
4	East Godavari	87	15	102	12	0	12	0	1	1	99	14	113
5	Guntur	89	19	108	6	0	6	3	3	6	92	16	108
6	Krishna	64	7	71	7	1	8	0	1	1	71	7	78
7	Kurnool	37	24	61	4	0	4	2	5	7	39	19	58
8	Nellore	63	2	65	4	0	4	1	1	2	65	2	67
9	Prakasam	58	16	74	5	0	5	2	2	4	61	14	75
10	Srikakulam	42	0	42	0	0	0	0	0	0	42	0	42
11	Vizianagaram	46	0	46	0	0	0	2	0	2	44	0	44
12	Visakhapatnam	82	4	86	0	0	0	5	0	5	77	4	81
13	West Godavari	62	12	74	5	0	5	3	2	5	64	10	74
Total		756	123	879	43	1	44	26	16	42	772	109	881

6.1 Depth to Water Level

Periodic monitoring of water levels generally indicates water levels are deeper during pre-monsoon in the month of May and shallow during post-monsoon (November) in the same year. The water level measurements carried out during the month of August reveal the transient phase of southwest monsoon. Water level data during November show the effects of both southwest and northeast monsoons. Thematic maps depicting depth to water level in respect of May, August, November 2014 and January 2015(unconfined aquifers) are generated using GEMS software.

6.1.1 Depth to water level- MAY, 2014

Map depicting depth to water level during May, 2014 is shown in the Fig.6.1.The percentage of wells in different water level ranges is presented in the Fig.6.2 & Table-6.2. An analysis of depth to water level data of 766 wells during May, 2014 is summarised as follows;

1. Water levels vary between -0.09(West Godavari district) and 23.78 m.bgl (Prakasham district).
2. Depth to water level of 0 to 10 m bgl is more prevalent in 82% of wells.
3. Shallow water levels of less than 2 m bgl are noticed in very small areas in Coastal Region and in Anantpur and Kurnool districts of Rayalaseema Region in 15.92% of wells.
4. Water level range of 2 to 5 m bgl is observed mostly in Coastal Region and as small isolated areas in Rayalaseema Region in 45.82% of wells.
5. 5 to 10 m bgl range is observed as major parts in Nellore and Prakasham districts of Coastal area and Rayalaseema Region in 30.41% of wells.
6. Depth to water level varying between 10 and 20 m bgl (7.18% of wells) is observed as small isolated patches in coastal region except Vizianagaram, East Godavari and Srikakulam districts and in Rayalaseema Region. It is also observed as major parts in Chittoor district.
7. Deeper water levels of 20 to 40 m bgl (0.65% of wells) are noticed as small patches in Prakasham, Visakhapatnam and Guntur districts in Coastal Region and in Chittoor and Kadapa districts in Rayalaseema Region.

Fig.6.1

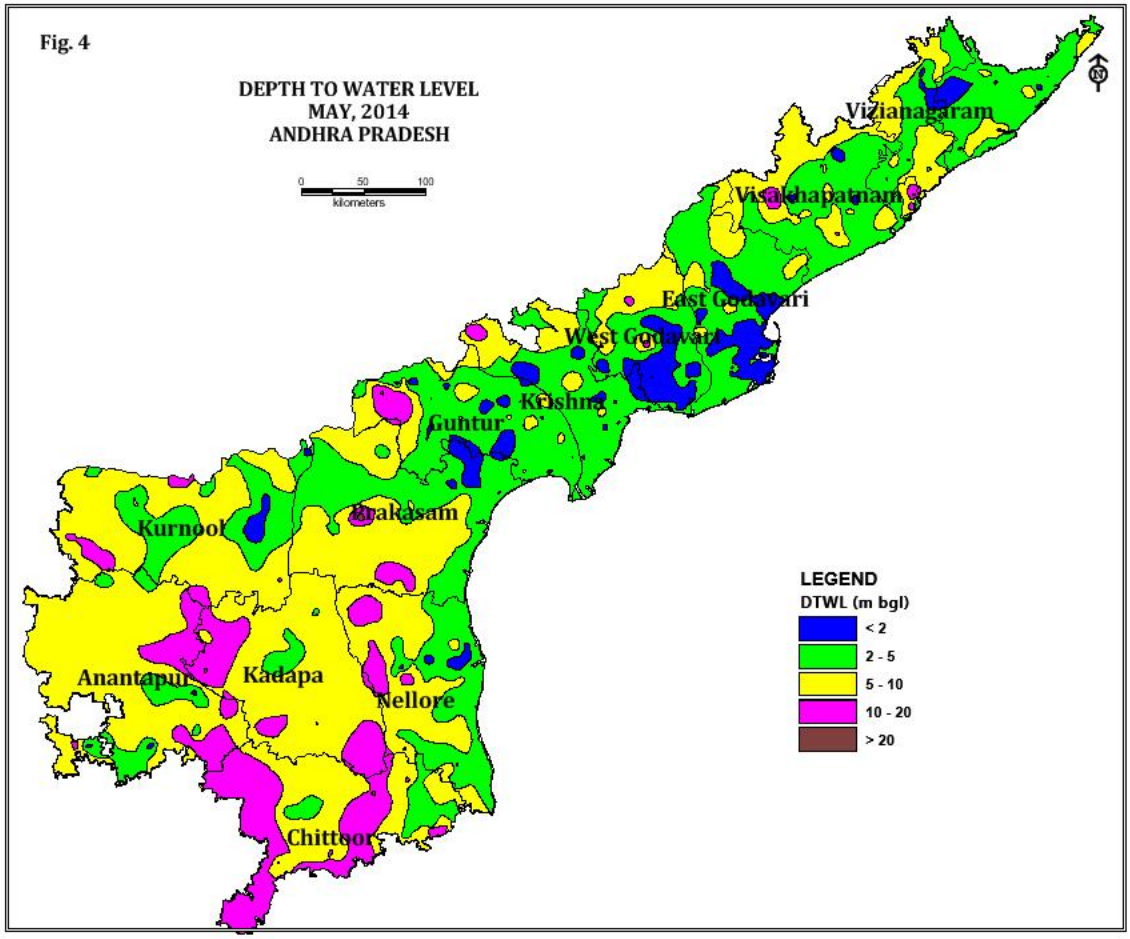
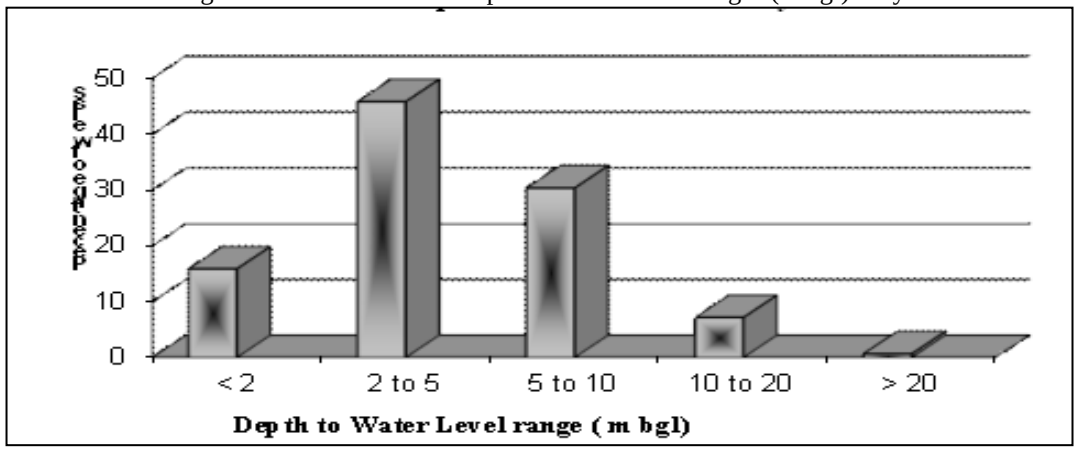


Table-6.2
Percentage of Wells in different Depth to Water level Ranges (m bgl) May - 2014

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	40	1.05	15.2	5	12.5	4	(10.0%)	23	(57.5%)	23	(57.5%)	0	1.92	0	0
2	Chittoor	52	2.34	21.25	0	0	12	(23.08%)	21	(40.38%)	21	(40.38%)	1	0	0	0
3	East Godavari	89	0.51	8.852	34	38.2	44	(49.44%)	18	(54.55%)	0	0	0	0	0	0
4	Guntur	93	0.66	21.12	17	18.28	57	(61.29%)	11	(12.36%)	2	(2.15%)	1	1.08	0	0
5	Krishna	64	0.27	13.39	10	15.63	39	(60.94%)	16	(17.20%)	2	(13.13%)	1	0	0	0
6	Kurnool	43	0.35	12.03	4	9.3	14	(32.56%)	13	(20.31%)	4	(9.3%)	0	0	0	0
7	Nellore	63	0.6	14.6	6	9.52	28	(44.44%)	21	(48.84%)	5	(7.94%)	0	0	0	0
8	Prakasham	65	0.4	23.78	4	6.15	36	(55.38%)	24	(38.1%)	2	(3.08%)	1	1.54	0	0
9	Srikakulam	41	0.41	9.74	5	12.2	24	(58.54%)	22	(33.85%)	0	0	0	0	0	0
10	Visakhapatnam	80	0.82	21.5	7	8.75	43	(53.75%)	12	(29.27%)	3	(3.75%)	1	1.25	0	0
11	Vizianagaram	46	0.77	9.75	7	15.22	23	40.35	16	16	0	0	0	0	0	0
12	West Godavari	57	0.09	13.75	23	40.35	21	(36.82%)	10	(17.54%)	3	(5.26%)	0	0	0	0
13	YSR Kadapa	33	2.77	20.7	0	0	6	(18.18%)	18	(54.55%)	8	(24.24%)	1	3.03	0	0
Total State		766	0.09	23.78	122		351		233		55		5			

Table-6.2
Percentage of Wells in different Depth to Water level Ranges (m bgl) May - 2014



6.1.2 DEPTH TO WATER LEVEL - AUGUST, 2014

Map depicting depth to water level during August, 2014 is shown in the Fig.6.3. **A**nalysis of depth to water level data of 766 wells during May, 2014 reveals the following:

1. Depth to water level of 0 - 10 m bgl is predominant in major part (91 %) of the state.
2. Water levels vary between -0.03 m.bgl (Kurnool district) and 39.5 m.bgl (Guntur district).
3. The percentage of wells in different water level ranges is presented in the Table–6.3 and Fig.6.4.Shallow water levels of less than 2 m bgl are noticed mostly in Visakhapatnam, Srikakulam, East Godavari, West Godavari and as small areas in Guntur and Kurnool districts representing 32.85% of wells.
4. 2 to 5 m bgl range is observed in 35.49 % of wells covering mostly coastal region and as smaller areas in Rayalseema region.
5. Depth to water levels varying between 5 and 10 m bgl are observed in major parts of Rayalseema region and as small patches in parts of Coastal region covering 23.03% of wells.
6. 10 and 20 m bgl range is noticed in Rayalseema region representing 7.85% of wells.
7. Deeper water level of 20 - 40 m bgl is noticed in 0.78% of wells in Kadapa district.

Fig.6.3

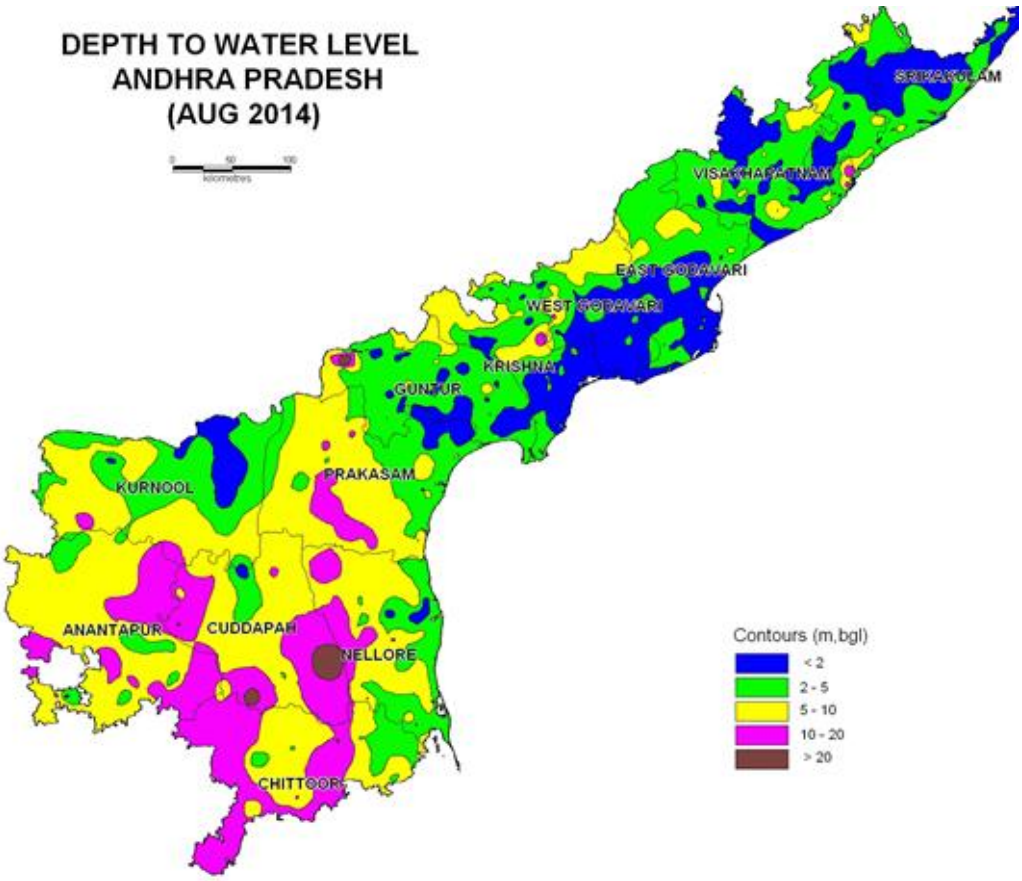
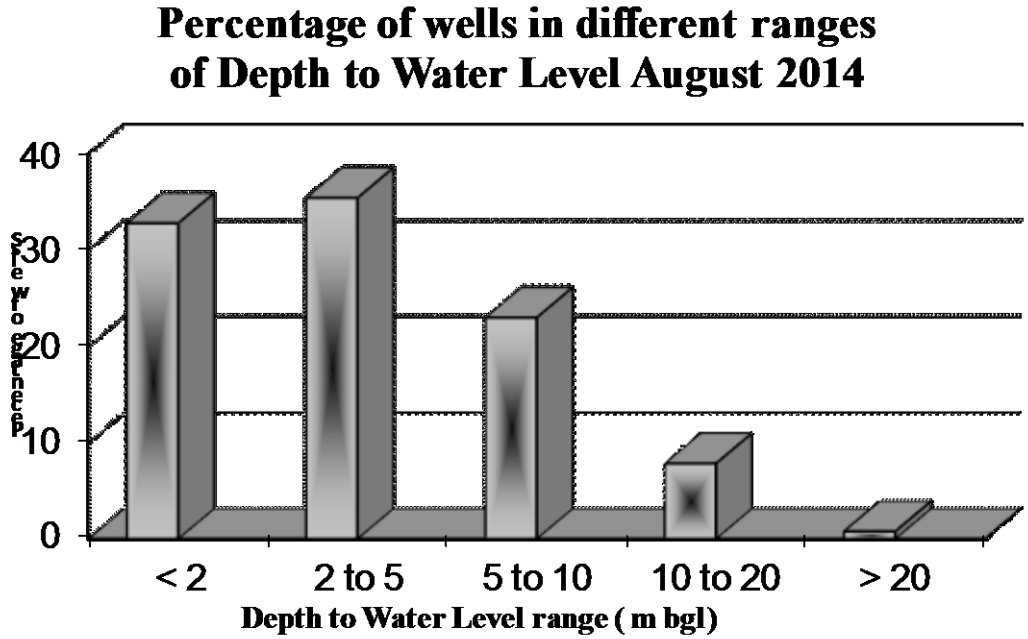


Table – 6.3

Percentage of Wells in different Ranges of Depth to Water level August-2014

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water Table (m bgl) in Ranga of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	40	0.48	18.0	3	7.5	6	15	19	47.5	12	30	0	0	0	0
2	Chittoor	50	1.4	21.3	1	2	6	12	21	42	21	42	1	2	0	0
3	East Godavari	34	3.2	47.6	0	0	3	8.8	15	44.1	15	44.1	0	0	1	2.9
4	Guntur	95	0.14	6.85	58	61	29	30.5	8	8.4	0	0	0	0	0	0
5	Krishna	102	0.14	39.5	36	35.3	46	45.1	13	12.7	6	5.9	1	1	0	0
6	Kurnool	72	-.2	17.7	30	41.7	25	34.7	12	16.7	5	6.9	0	0	0	0
7	Nellore	45	1.18	18.6	4	8.9	12	26.7	21	46.7	8	17.8	0	0	0	0
8	Prakasham	57	1.12	17.0	3	5.3	28	49.1	15	26.3	11	19.3	0	0	0	0
9	Srikakulam	65	-0.2	32.3	7	10.8	16	24.6	34	52.3	7	10.8	1	1.5	0	0
10	Visakhapatnam	42	0.19	8.4	19	45.2	18	42.9	5	11.9	0	0	0	0	0	0
11	Vizianagaram	74	0.05	18.05	38	51.3	22	29.7	11	14.9	3	4.05	0	0	0	0
12	West Godavari	48	0.48	9.9	26	54.2	17	35.4	5	10.4	0	0	0	0	0	0
13	YSR Kadapa	61	0.3	13.3	36	59	9	14.8	12	19.7	4	6.6	0	0	0	0
Total State		785	-0.2	47.6	261		237		191				3		1	

Fig.6.4



6.1.3 **Depth to water level - November, 2014**

Map depicting depth to water level during August, 2014 is shown in the Fig.6.5.
Analysis of depth to water level data of 801 wells during November, 2014 reveals the following:

1. Depth to water level of 0 - 10 m bgl is predominant in the state.

2. Water levels vary between -0.05 m.bgl (Kurnool district) and 27.85 m.bgl (Prakasham district). Shallow water level zone, less than 2 m bgl, spread along the coast and as small isolated patches in Rayalseema region representing 45.2% of wells.

3. 2 to 5 m bgl range is observed all the districts in 33.96 % of wells.

4. Water levels varying between 5 and 10 m bgl are registered in major parts `of Anantpur, Nellore, Prakasham and YSR Kadapa districts and as small isolated areas in coastal region covering 18.98% of wells.

5. Water level ranging 10 and 20 m bgl is noticed mostly in Rayalseema region in 6.62% of wells.

8. Deeper water levels of 20 and 40 m bgl are observed in parts of YSR Kadapa, Prakasham and West Godavari districts representing 0.25% of wells.

The percentage of wells in different water level ranges is presented in the Fig.6.6 and Table–6.4.

Fig.6.5

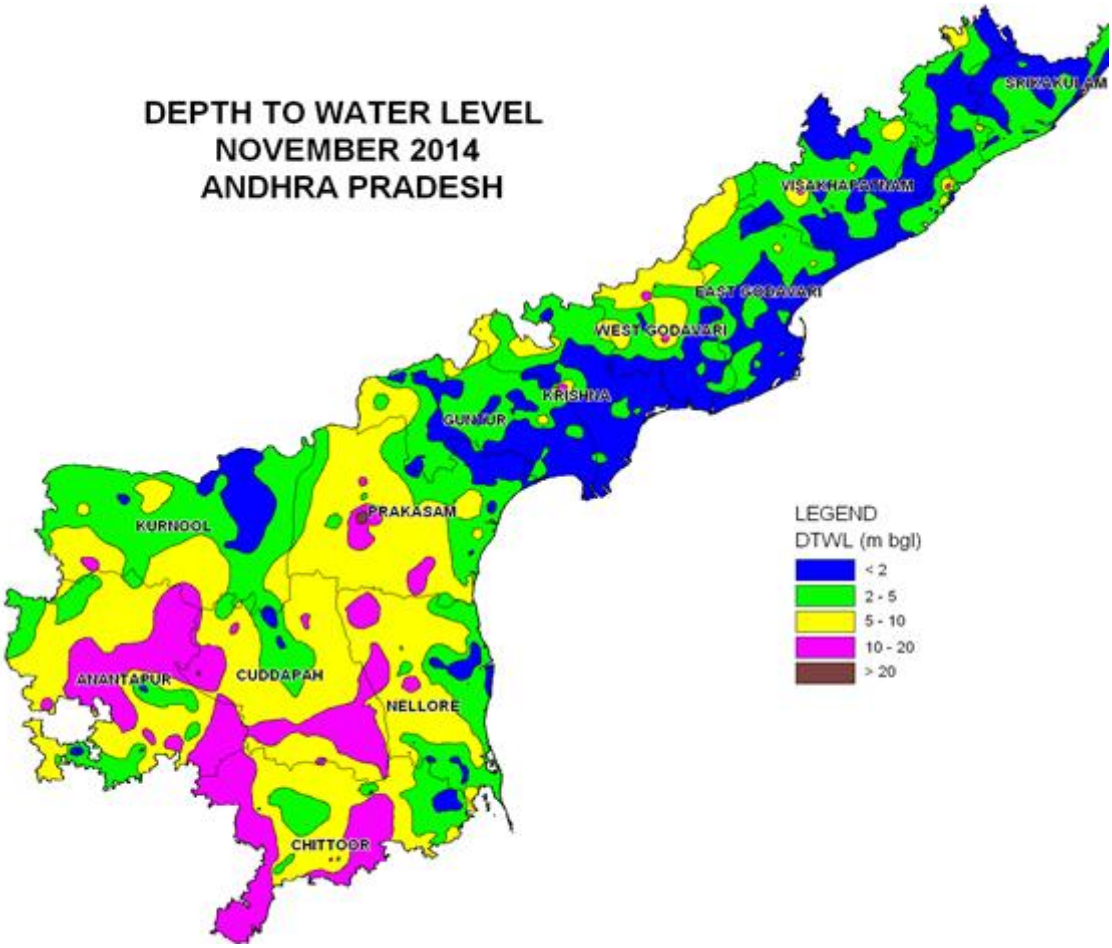

DEPTH TO WATER LEVEL
NOVEMBER 2014
ANDHRA PRADESH
SRIKAKULAM
VISAKHAPATNAM
EAST GODAVARI
WEST GODAVARI
KRISHNA
GUNTUR
PRAKASAM
KURNOOL
CUDDAPAH
ANANTAPUR
NELLORE
CHITTOOR
LEGEND
DTWL (m bgl)
< 2
2 - 5
5 - 10
10 - 20
> 20

Fig.6.6

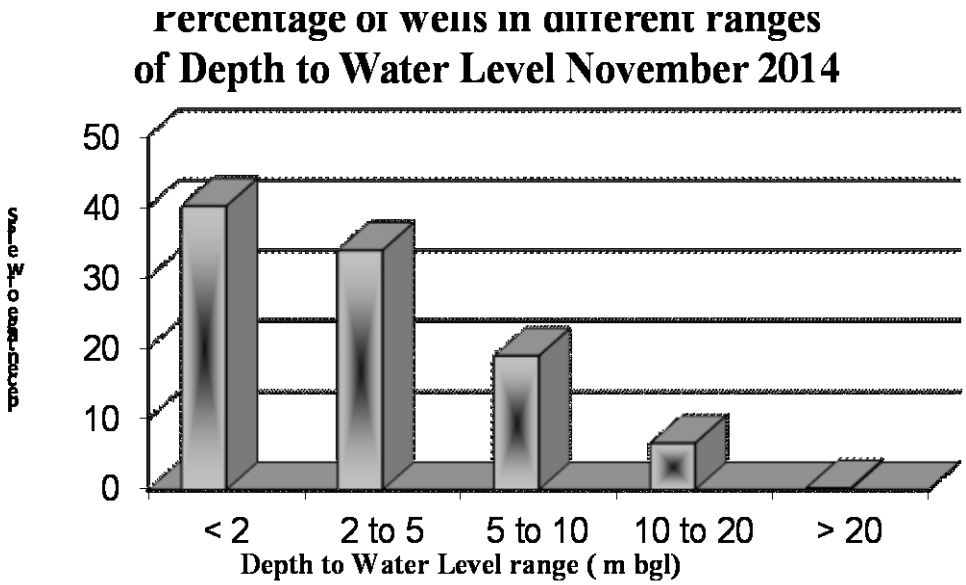

Percentage of Wells in different ranges
of Depth to Water Level November 2014
50
40
30
20
10
0
< 2
2 to 5
5 to 10
10 to 20
> 20
Depth to Water Level range (m bgl)

Table-6.4
Percentage of Wells in different Ranges of Depth to Water level
November-2014

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		Percentage of Wells Showing Depth to Water Table (m bgl) in Range of											
					0.0 - 2.0		2.0 - 5.0		5.0- 10.0		10.0 - 20.0		20.0 - 40.0		> 40.0	
			Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
1	Anantapur	44	0.65	18	5	11.36	9	20.45	19	43.18	11	25	0	0	0	0
2	Chittoor	49	0.67	19	6	12.24	15	30.61	14	28.57	14	28.57	0	0	0	0
3	East Godavari	34	0.5	20.7	2	5.88	6	17.65	14	41.18	11	32.35	1	2.94	0	0
4	Guntur	105	0.2	8.58	54	51.43	40	38.1	11	10.48	0	0	0	0	0	0
5	Krishna	95	0.06	9.99	50	52.63	38	40	7	7.37	0	0	0	0	0	0
6	Kurnool	69	0.31	16.29	39	56.52	25	36.23	3	4.35	2	2.9	0	0	0	0
7	Nellore	46	-0.05	12.03	12	26.09	21	45.65	12	26.09	1	2.17	0	0	0	0
8	Prakasham	63	0.17	14.6	11	17.46	20	31.75	26	41.27	6	9.52	0	0	0	0
9	Srikakulam	70	0.01	27.85	14	20	24	34.29	27	38.57	4	5.71	1	1.43	0	0
10	Visakhapatnam	42	0.37	5.38	25	59.52	15	35.71	2	4.76	0	0	0	0	0	0
11	Vizianagaram	77	0.14	12.35	42	54.55	27	35.06	6	7.79	2	2.6	0	0	0	0
12	West Godavari	44	0.42	7.15	29	65.91	13	29.55	2	4.55	0	0	0	0	0	0
13	YSR Kadapa	63	0.37	15.8	33	52.38	19	30.16	9	14.29	2	3.17	0	0	0	0
State Total		801	-0.05	27.85	322	45.2	272	33.96	152	18.98	53	6.62	2	0.25	0	0

6.1.4 Depth to Water Level January, 2015

Analysis of depth to water level data of 792 wells during January, 2014 reveals the following:

1. Water levels vary between -0.04 m.bgl (Prakasham district) and 20.70 m.bgl (Kadapa district).
2. In general depth to water level of 0 - 10 m bgl is predominant in the state.

Shallow water levels of less than 2 m bgl are noticed mostly in coastal region and asmall parts in Rayalseema which represents 27.27% of wells.

3. Depth to water level ranging from 2 to 5 m bgl is observed in all the districts and predominantly observed in coastal region which represents 43.68% of wells.
4. 5 and 10 m bgl range is observed in major parts of Anantpur, Nellore, Prakasham and YSR Kadapa districts of Rayalseema region and in small parts of all the districts of Coastal region of Andhra Pradesh covering 21.46% of wells.
5. Water levels varying between 10 and 20 m bgl are noticed in Rayalseema region representing 7.45% of wells.
6. Deeper water levels of 20 and 40 m bgl are noticed in small parts of YSR Kadapa district representing 0.12% of wells.

Map depicting depth to water level during January, 2014 is shown in the Fig.6.8 and percentage of wells in different water level ranges is presented in the Fig.6.7 & Table–6.4.

Fig.6.7

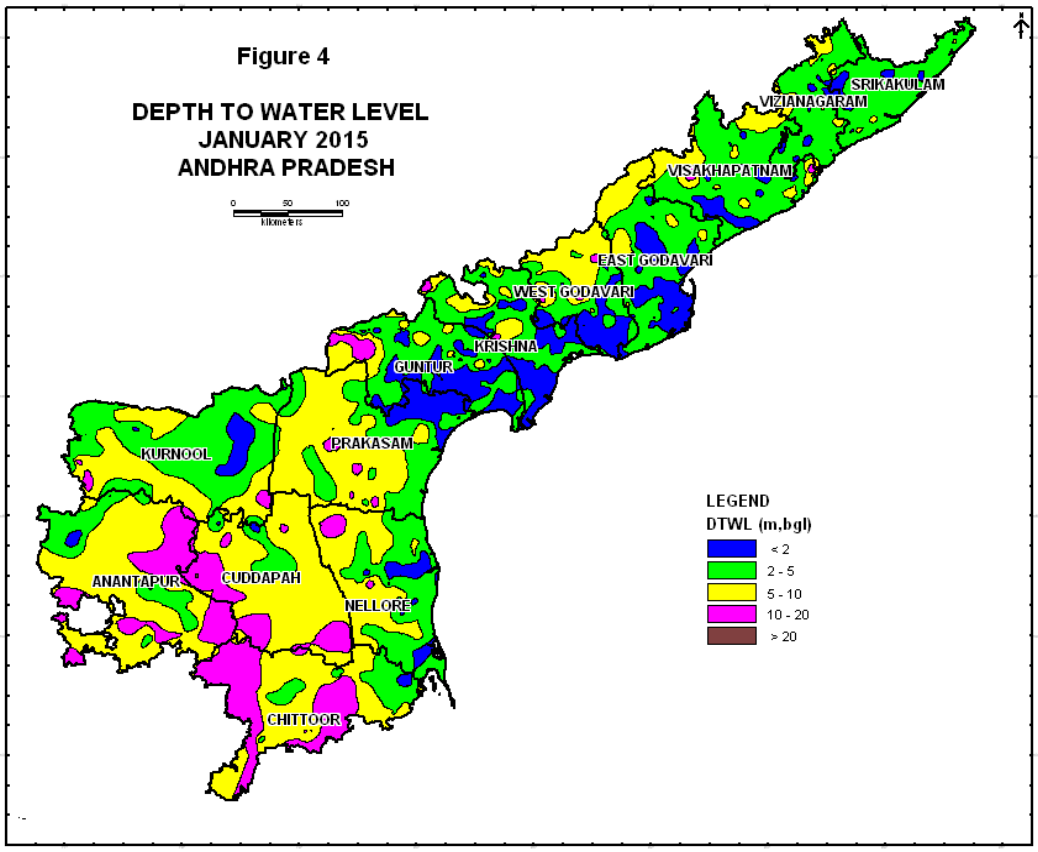


Fig.6.8

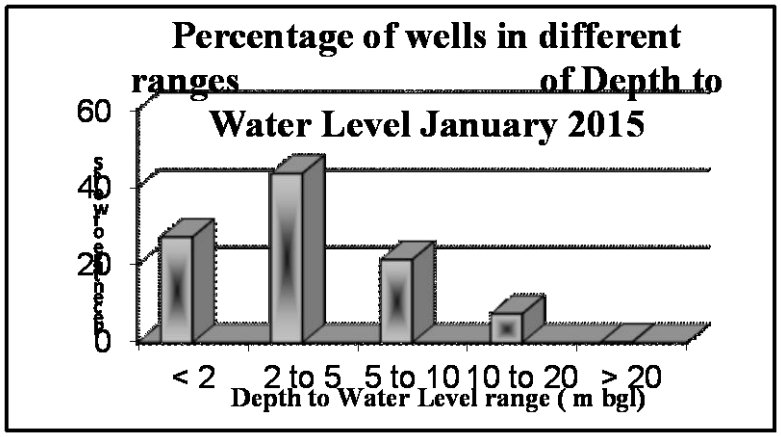


Table-6.5

Percentage of Wells in different Ranges of Depth to Water level January-2015

Sl. No	District	No of Wells Analysed	Depth to Water Table (m bgl)		No and Percentage of Wells Showing Depth to Water level (m bgl)											
					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	Anantapu	38	0.6	18	4	10.	6	15.	18	47.	1	26.	0	0	0	0
2	Chittoor	49	0.9	18.	3	6.1	13	26.	18	36.	1	30.	0	0	0	0
3	East	101	0.1	8.9	34	33.	55	54.	12	11.	0	0	0	0	0	0
4	Guntur	98	0.2	17	40	40.	43	43.	10	10.	5	5.1	0	0	0	0
5	Krishna	71	0.3	16.	26	36.	35	49.	8	11.	2	2.8	0	0	0	0
6	Kurnool	41	0.4	12.	8	19.	19	46.	10	24.	4	9.7	0	0	0	0
7	Nellore	66	0.3	15.	14	21.	27	40.	23	34.	2	3.0	0	0	0	0
8	Prakasha	70	-	17.	18	25.	30	42.	17	24.	5	7.1	0	0	0	0
9	Srikakula	42	0.9	6.5	7	16.	30	71.	5	11.	0	0	0	0	0	0
1	Visakhapa	78	0.4	17.	21	26.	40	51.	15	19.	2	2.5	0	0	0	0
1	Vizianagar	44	1.0	7.9	11	25	28	63.	5	11.	0	0	0	0	0	0
1	West	61	0.4	16.	28	45.	16	26.	14	22.	3	4.9	0	0	0	0
1	YSR	33	0.7	20.	2	6.0	4	12.	15	45.	1	33.	1	3.	0	0
State Total		792	- 0.0	20. 7	216	27. 27	346	43. 68	170	21. 46	59	7.4 5	1	0. 12	0	0

6.2 Frequency Distribution of Depth to Water Level

The categorization of depth to water levels (district-wise) with its percentages during May 2014, August 2014, November 2014 and January 2015 are given in the Table- 6.2 - 6.5. An analysis of water level data reveals the following observations (Table-6.6).

Table-6.6
Frequency Distribution of Depth to Water Level

Range-depth to water level (mbgl)	May,2014(%)	Nov,2014(%)	Remarks	
< 2	15.92	40.2	% of wells in < 2mbgl range increased	Impact of good monsoon from pre-monsoon to post-monsoon
2 - 5	45.82	33.96	% of wells in 2-5mbgl range reduced	Marginal decrease in percentage of wells in categories 2-5, 5-10 10-20 mbgl depth to water level.
5 - 10	30.41%	18.98	% of wells in 5-10mbgl range reduced	
10 - 20	7.18	6.62	% of wells in 10-20mbgl range reduced	

6.3 Water Table Elevation

Maps depicting water table elevation during pre (May, 2014) and post (November, 2014) monsoon are presented in the Fig.6.9 and 6.10. A perusal of the maps reveals that water table generally follows the topography. The elevation of water table ranges from <10 (zero) m amsl in eastern part of the area to >600 mamsl in southern part of the State. However, in Eastern Ghats it varies from 500 - 926 mamsl. The general gradient is from west to east. Hydraulic gradient ranges from 8 m/1km in southwestern part of Chittoor district to as low as 0.5 m/1km in Godavari valley (Highly permeable area), with general gradient of 2 m/km. In Eastern Ghats the hydraulic gradient ranges from 20 m/1km to as much as 50 m/1km.

Fig.6.9

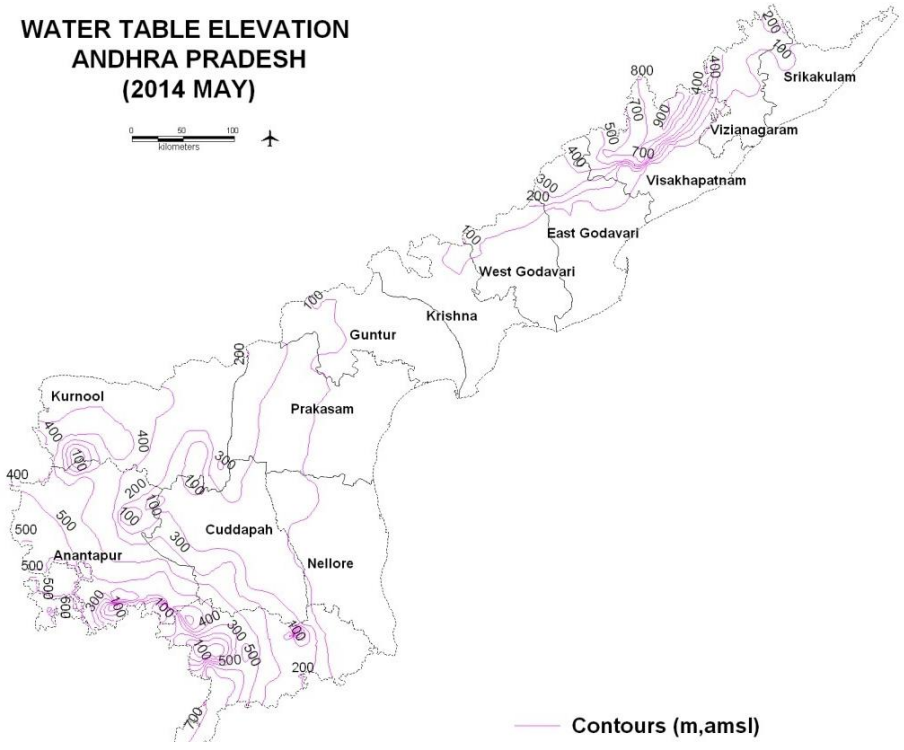
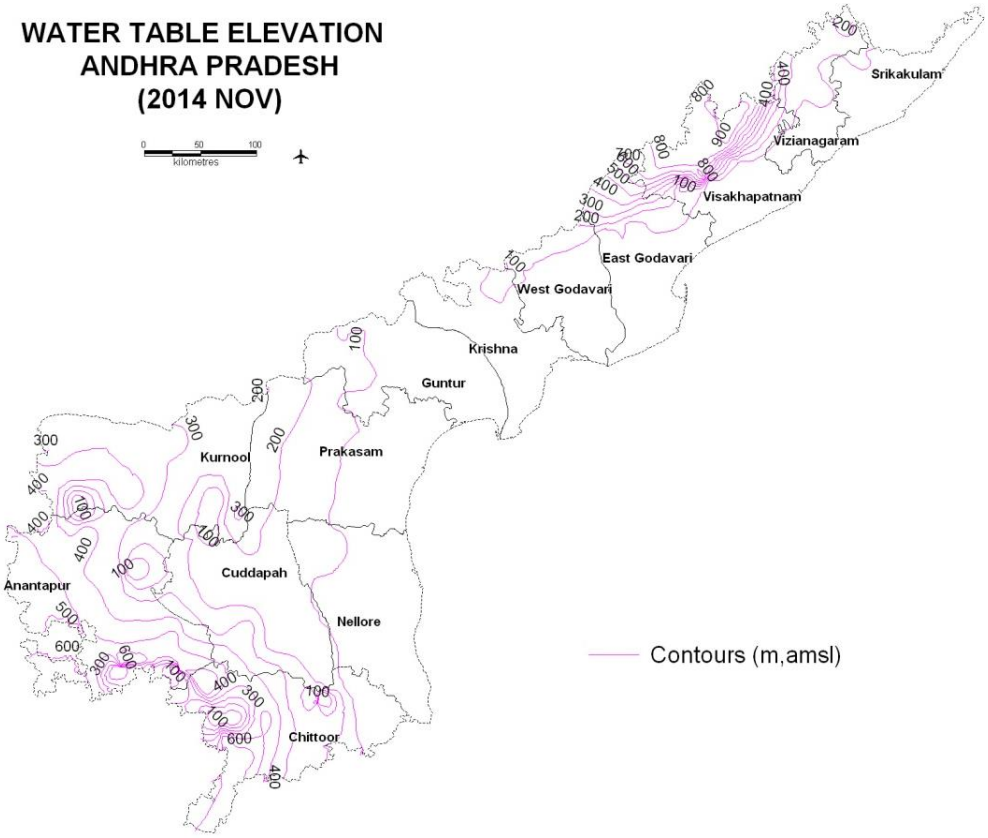


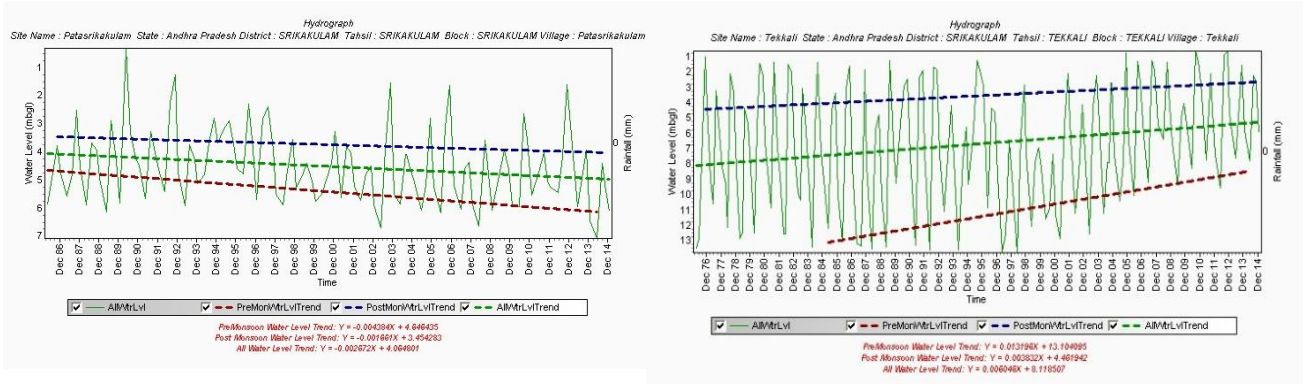
Fig.6.10



6.4. Hydrographs

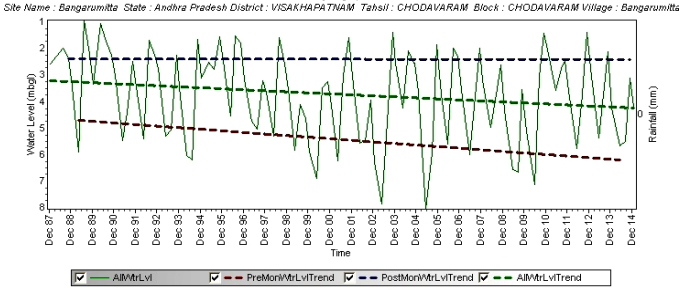
Hydrograph is a graphic display of water-level fluctuations over a period of time due to recharge and discharge. An analysis of long term water level data for the last 15 to 25 years, indicate the annual and seasonal significant trends. It depends on recharge factors such as rainfall, seepage from canals, irrigated area, water storage bodies etc. The fluctuations are observed to be high along drainage divides, upland areas and in chronically drought-affected areas. The fluctuations are minimum/low in low-lying, canal command and in coastal alluvial areas. The hydrographs of select observation wells and water level trends during pre & post monsoon are depicted in the Fig.6.11. to 6.13.

Fig.6.11
Hydrographs of select National Ground Water monitoring wells



Hydrograph

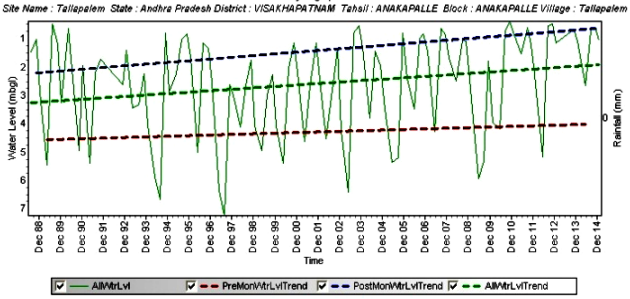
Site Name : Bangarumitta State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : CHODAVARAM Block : CHODAVARAM Village : Bangarumitta



PreMonsoon Water Level Trend: Y = -0.004932X + 4.709891
Post Monsoon Water Level Trend: Y = -0.000194X + 2.378545
All Water Level Trend: Y = -0.003195X + 3.208796

Hydrograph

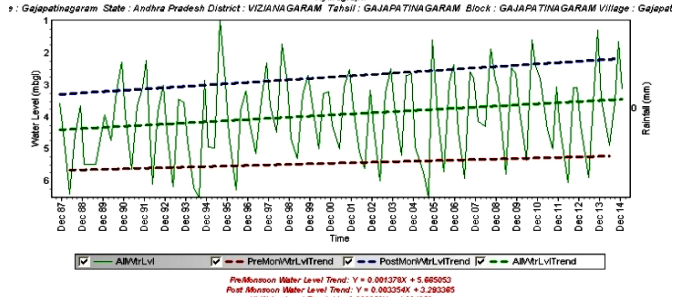
Site Name : Tallapalem State : Andhra Pradesh District : VISAKHAPATNAM Tahsil : ANAKAPALLE Block : ANAKAPALLE Village : Tallapalem



PreMonsoon Water Level Trend: Y = 0.001813X + 4.576120
Post Monsoon Water Level Trend: Y = 0.004958X + 2.216327
All Water Level Trend: Y = 0.004260X + 3.259008

Hydrograph

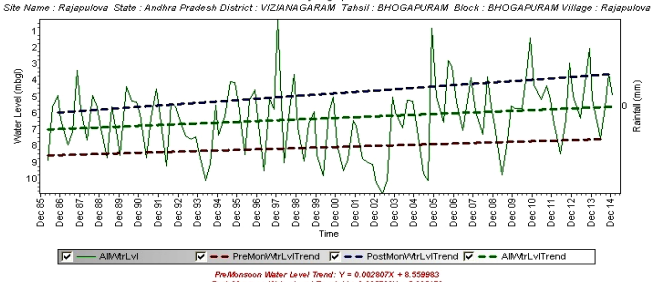
e : Gajapatinagaram State : Andhra Pradesh District : VIZIANAGARAM Tahsil : GAJAPATINAGARAM Block : GAJAPATINAGARAM Village : Gajapat



PreMonsoon Water Level Trend: Y = 0.001378X + 5.685053
Post Monsoon Water Level Trend: Y = 0.003354X + 3.293365
All Water Level Trend: Y = 0.002660X + 4.384263

Hydrograph

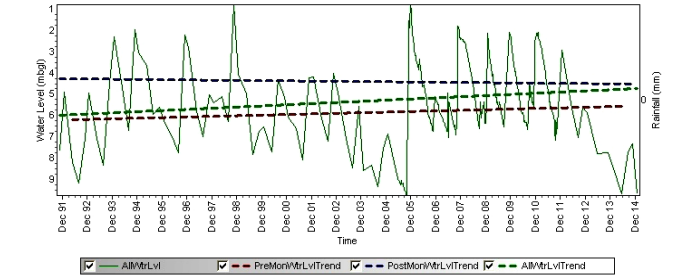
Site Name : Rajapulova State : Andhra Pradesh District : VIZIANAGARAM Tahsil : BHOGAPURAM Block : BHOGAPURAM Village : Rajapulova



PreMonsoon Water Level Trend: Y = 0.002807X + 8.559983
Post Monsoon Water Level Trend: Y = 0.006733X + 5.936172
All Water Level Trend: Y = 0.004112X + 7.005771

Hydrograph

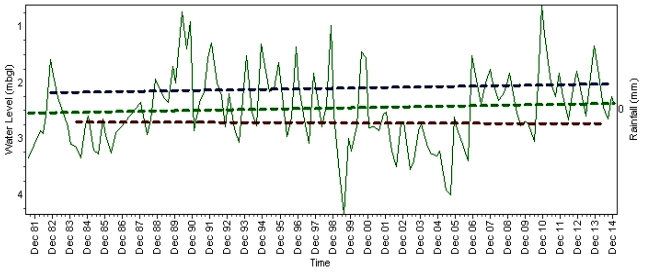
Site Name : Botla Gudur State : Andhra Pradesh District : PRAKASAM Tahsil : PAMURU Block : PAMURU Village : Botla Gudur



PreMonsoon Water Level Trend: Y = 0.002367X + 8.203455
Post Monsoon Water Level Trend: Y = -0.000873X + 4.270040
All Water Level Trend: Y = 0.004474X + 5.970908

Hydrograph

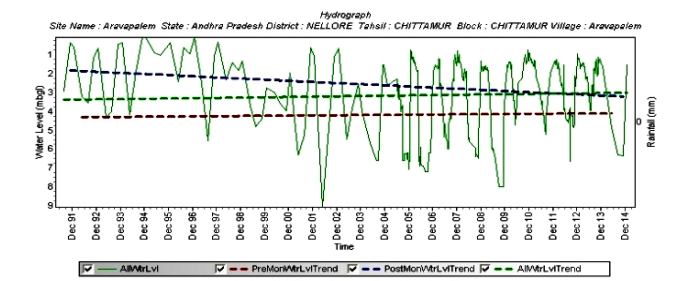
Site Name : Chirala State : Andhra Pradesh District : PRAKASAM Tahsil : CHIRALA Block : CHIRALA Village : Chirala



PreMonsoon Water Level Trend: Y = -0.000117X + 2.699882
Post Monsoon Water Level Trend: Y = 0.000367X + 2.174112
All Water Level Trend: Y = 0.000428X + 2.552561

Hydrograph

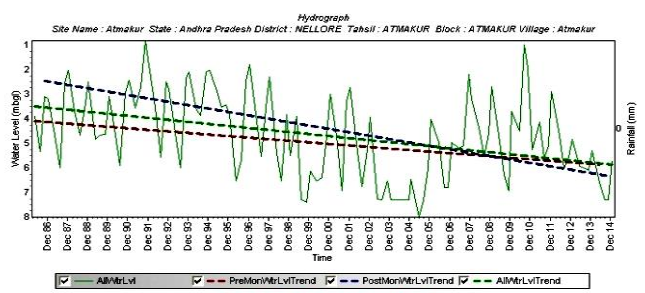
Site Name : Aravapalem State : Andhra Pradesh District : NELLORE Tahsil : CHITTAMUR Block : CHITTAMUR Village : Aravapalem



PreMonsoon Water Level Trend: Y = 0.000078X + 4.329234
Post Monsoon Water Level Trend: Y = -0.004927X + 1.859896
All Water Level Trend: Y = 0.001260X + 3.374585

Hydrograph

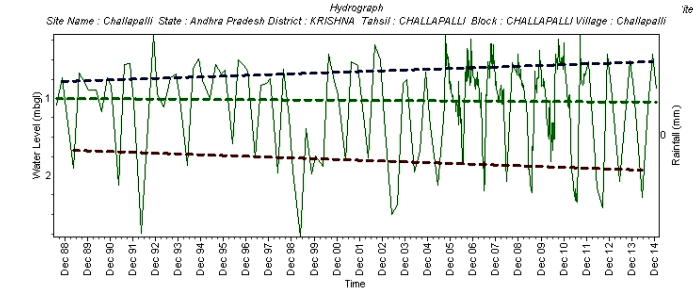
Site Name : Atmakur State : Andhra Pradesh District : NELLORE Tahsil : ATMAKUR Block : ATMAKUR Village : Atmakur



PreMonsoon Water Level Trend: Y = -0.005124X + 4.104997

Hydrograph

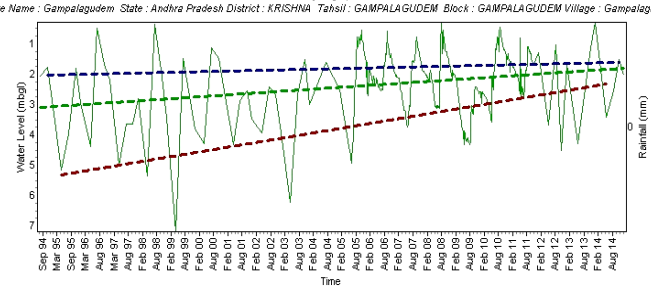
Site Name : Challapalli State : Andhra Pradesh District : KRISHNA Tahsil : CHALLAPALLI Block : CHALLAPALLI Village : Challapalli



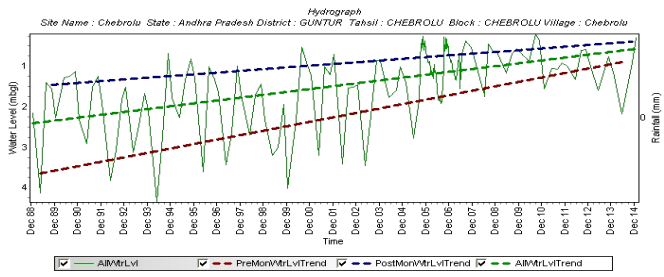
PreMonsoon Water Level Trend: Y = -0.000850X + 1.672285
Post Monsoon Water Level Trend: Y = 0.000838X + 0.777504
All Water Level Trend: Y = -0.000167X + 0.994984

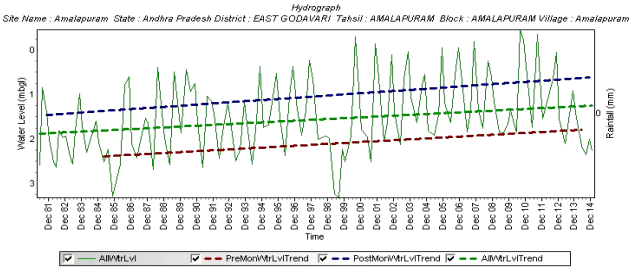
Hydrograph

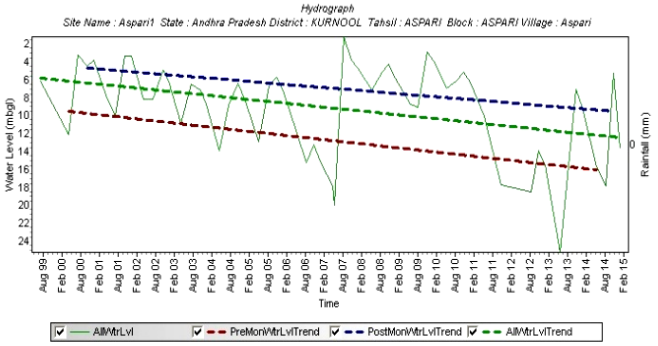
ite Name : Gampalagudem State : Andhra Pradesh District : KRISHNA Tahsil : GAMPALAGUDEM Block : GAMPALAGUDEM Village : Gampalagudei

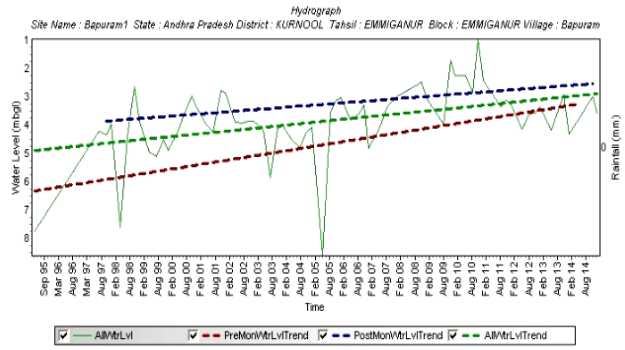


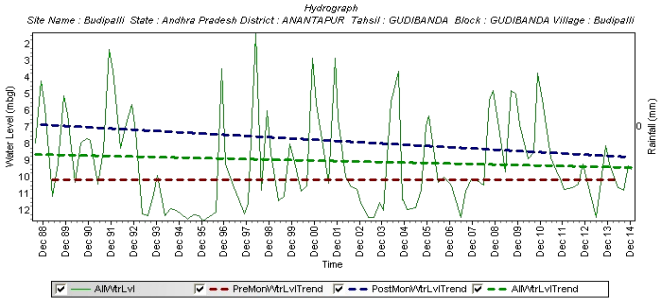
PreMonsoon Water Level Trend: Y = 0.012902X + 5.322813
Post Monsoon Water Level Trend: Y = 0.001712X + 2.010866
All Water Level Trend: Y = 0.005278X + 3.096813

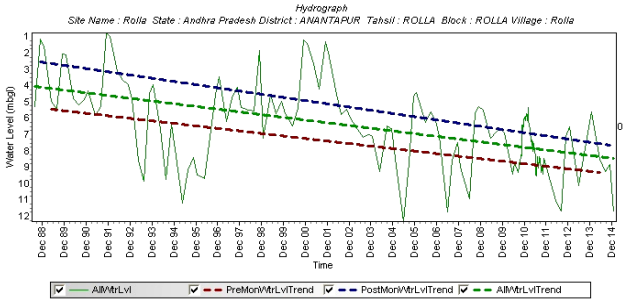

Hydrograph
Site Name : Chebrolu State : Andhra Pradesh District : GUNTUR Tahsil : CHEBROLU Block : CHEBROLU Village : Chebrolu
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.009012X + 3.639516
Post Monsoon Water Level Trend: Y = 0.003524X + 1.463690
All Water Level Trend: Y = 0.005979X + 2.494142

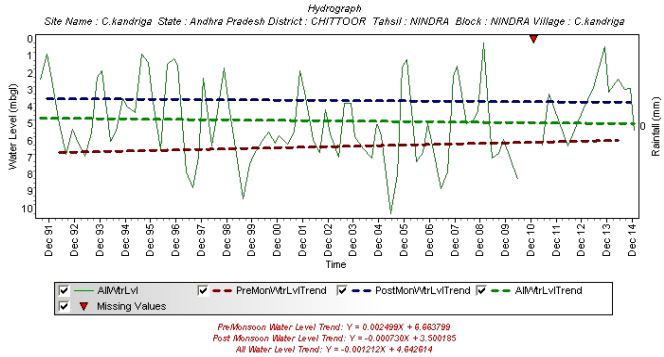

Hydrograph
Site Name : Amalapuram State : Andhra Pradesh District : EAST GODAVARI Tahsil : AMALAPURAM Block : AMALAPURAM Village : Amalapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.001719X + 2.398004
Post Monsoon Water Level Trend: Y = 0.002103X + 1.449057
All Water Level Trend: Y = 0.001537X + 1.885262


Hydrograph
Site Name : Aspari1 State : Andhra Pradesh District : KURNOOL Tahsil : ASPARI Block : ASPARI Village : Aspari
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.037824X + 9.558548
Post Monsoon Water Level Trend: Y = -0.029336X + 4.658055
All Water Level Trend: Y = -0.036169X + 5.762466


Hydrograph
Site Name : Bapuram1 State : Andhra Pradesh District : KURNOOL Tahsil : EMMIGANUR Block : EMMIGANUR Village : Bapuram
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = 0.013332X + 6.326806
Post Monsoon Water Level Trend: Y = 0.006498X + 3.853789
All Water Level Trend: Y = 0.009502X + 4.891330


Hydrograph
Site Name : Budipalli State : Andhra Pradesh District : ANANTAPUR Tahsil : GUDIBANDA Block : GUDIBANDA Village : Budipalli
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000029X + 10.123974
Post Monsoon Water Level Trend: Y = -0.006151X + 6.823348
All Water Level Trend: Y = -0.002432X + 8.623429


Hydrograph
Site Name : Rolla State : Andhra Pradesh District : ANANTAPUR Tahsil : ROLLA Block : ROLLA Village : Rolla
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.012747X + 5.445446
Post Monsoon Water Level Trend: Y = -0.016112X + 2.558264
All Water Level Trend: Y = -0.013818X + 4.053254


Hydrograph
Site Name : C.kandriga State : Andhra Pradesh District : CHITTOOR Tahsil : NINDRA Block : NINDRA Village : C.kandriga
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
Missing Values
PreMonsoon Water Level Trend: Y = 0.002499X + 6.663799
Post Monsoon Water Level Trend: Y = -0.000730X + 3.500185
All Water Level Trend: Y = -0.001212X + 4.642614

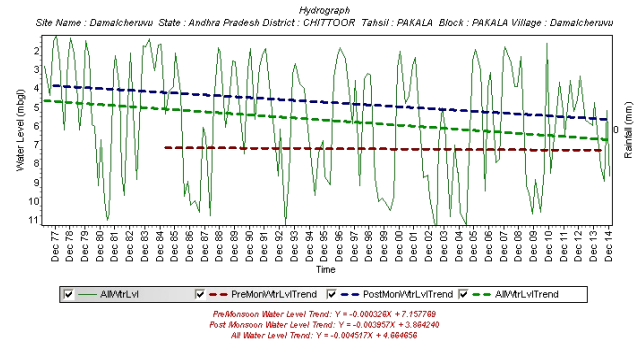

Hydrograph
Site Name : Damalcheruvu State : Andhra Pradesh District : CHITTOOR Tahsil : PAKALA Block : PAKALA Village : Damalcheruvu
Water Level (mbgl)
Rainfall (mm)
Time
AllMtrLvl
PreMonMtrLvlTrend
PostMonMtrLvlTrend
AllMtrLvlTrend
PreMonsoon Water Level Trend: Y = -0.000326X + 7.157769
Post Monsoon Water Level Trend: Y = -0.003957X + 3.864240
All Water Level Trend: Y = -0.004517X + 4.664656

Fig.6.12

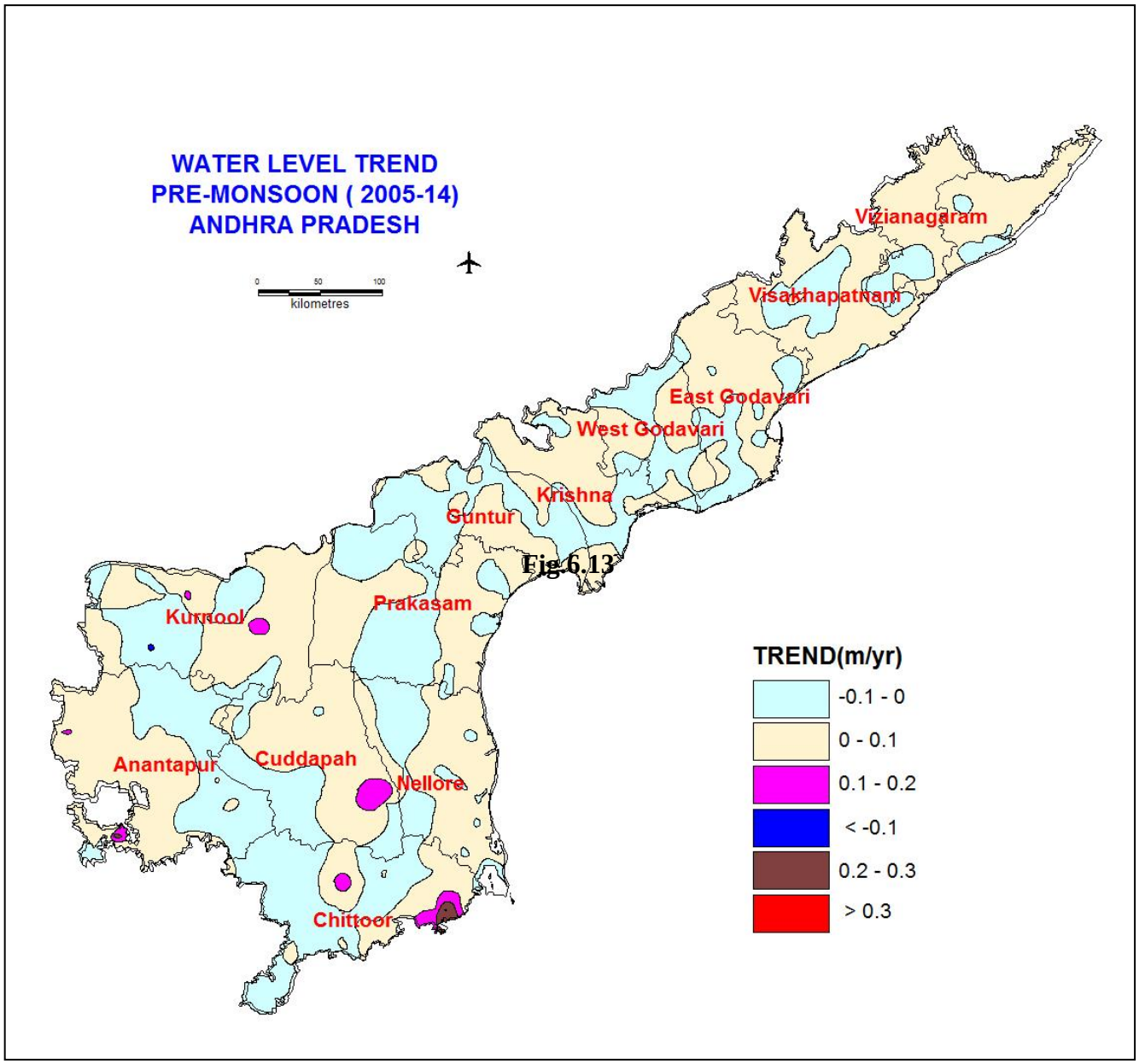
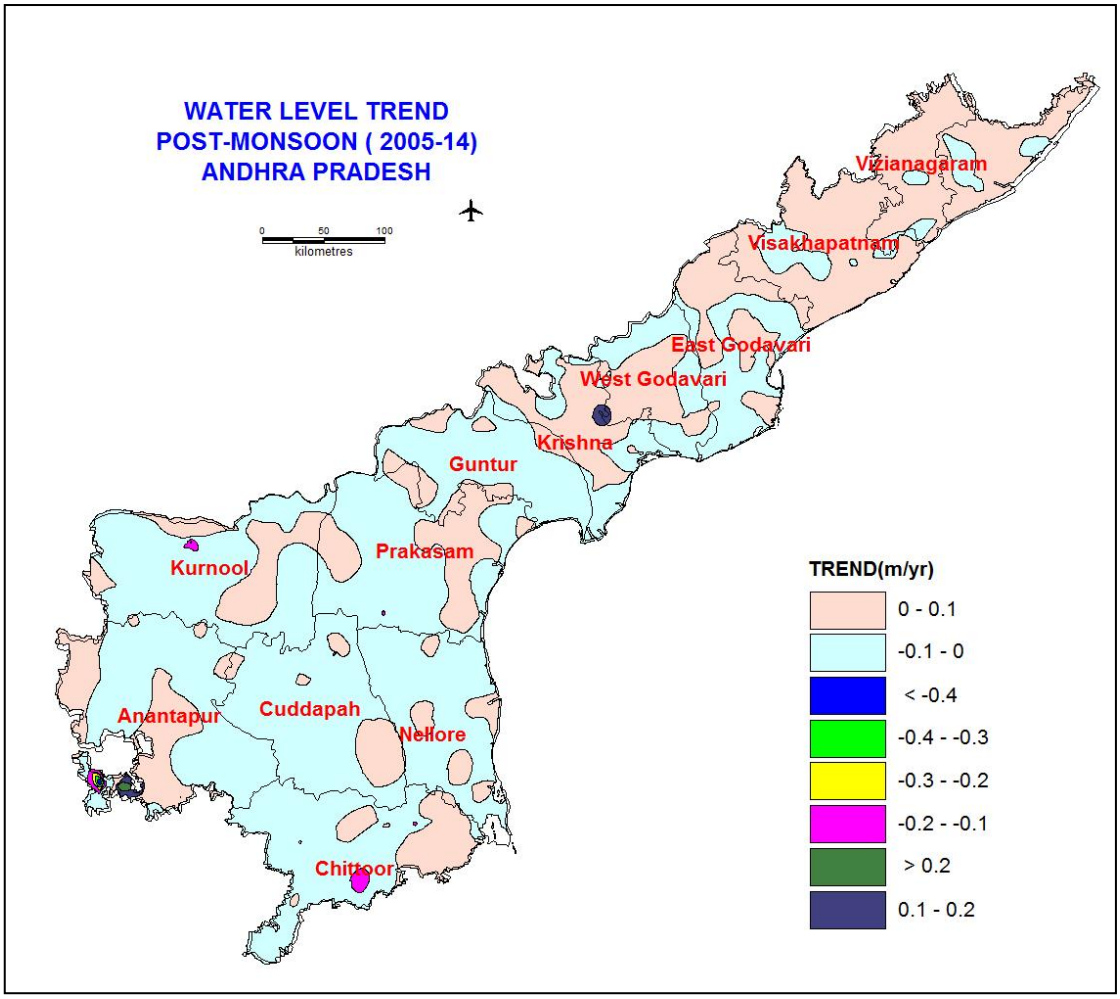


Fig.6.13

Fig.6.13



6.5 Water Level Fluctuation

6.5.1 May, 2014 with reference to May, 2013

Map depicting water level fluctuations during May, 2014 with reference to May, 2013 is shown in the Fig.6.14. Fluctuation and frequency distribution of different ranges are shown in the Fig. 6.15 and Table-6.7. Rise in water levels is predominant in the State. An analysis of water level data of 569 wells reveals that rise is recorded in 64.14% of wells (365), fall in 31.28% of wells (178), while no fluctuation is observed in 4.56 % of wells (26)

Rise of <2 m is recorded in 49.56% of wells, 2-4 m in 10.72% of wells and >4 m is registered in 3.86% of wells. Whereas fall of <2 m is observed in 25.48% of wells, 2-4 m in 4.56%of wells and >4 m is registered in 1.23% of wells. Rise of >4 m is ubiquitous in Guntur district (9.21 % of wells) while fall of >4 m is predominent in Chittoor district (10.0%).

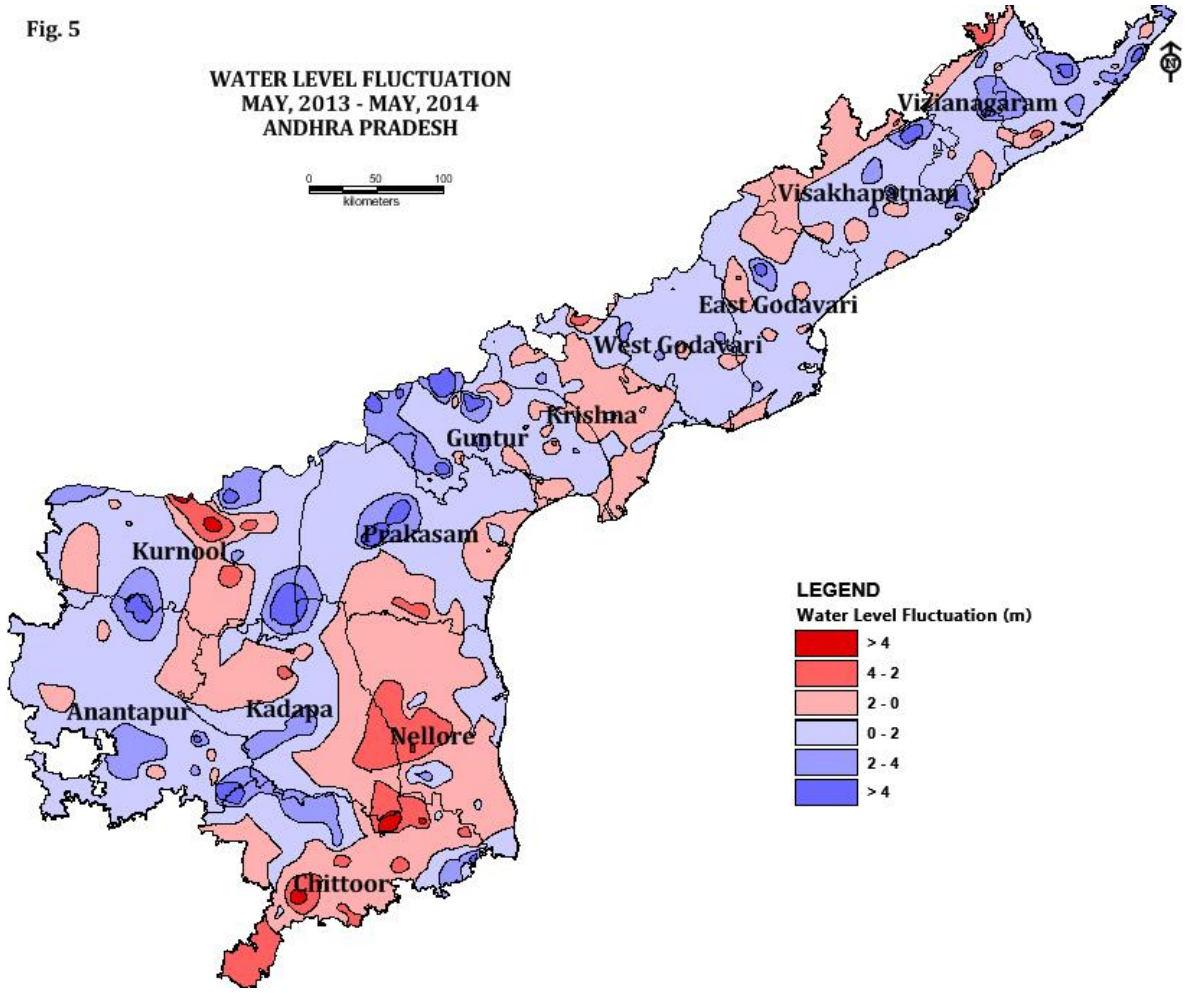
Rise in Water Levels

The rise in the water level between May 2014 and May 2013 is generalized as follows

1. Out of 365 wells registered a rise in water levels, less than 2 m rise is recorded in 77.26% of wells, 2 to 4 m in 16.71% of wells while more than 4 m is recorded in 6.03% of wells.
2. Less than 2 m rise (77.26% of wells) is observed in major parts of East Godavari, West Godavari, Guntur, Vizianagarm, Prakasham, Anantpur, and Kurnool districts.

3. Rise of 2-4 m (16.71% of wells) is observed as small areas in Coastal and Rayalaseema Region.
4. More than 4 m rise (6.03% of wells) is observed as small isolated areas Rayalaseema Region except Cudappah district and in parts of Vishakapatnam, East Godavari and Guntur districts.

Fig.6.14



Fall In Water Levels

The fall in the water level during May, 2014 with reference to May, 2013 is generalized as follows;

1. Out of 178 monitoring wells that have registered fall in water levels, less than 2 m fall is observed in 81.46% of wells, 2-4 m in 14.60% of wells and more than 4 m is registered in 3.93% of wells.
2. Less than 2 m fall is observed in considerable areas in Nellore, Prakasham, Krishna and Rayalaseema region and as small isolated patches in coastal districts(81.46% of wells).
3. Fall of 2-4 m is noticed as small parts in Rayalaseema Region except Anantpur and in Coastal Region except West Godavari district (14.60% of wells).
4. Fall of more than 4 m is observed as small parts in Rayalaseema Region except Anantpur and in Nellore district(3.93% of wells).

Fig.6.15

Categorisation of fluctuation of water levels (May 2013 - May 2014)

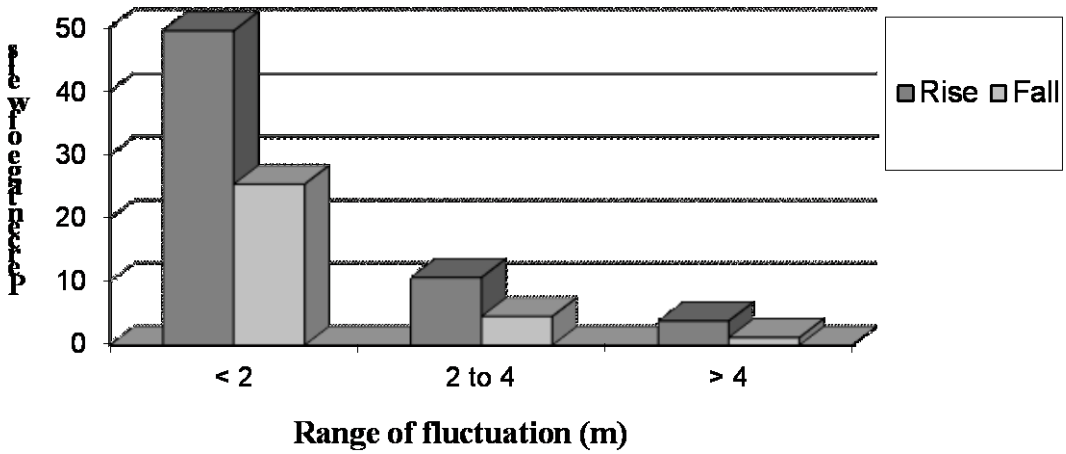


Table-6.7

Fluctuation and frequency distribution of different ranges - May, 2014 Vs May, 2013

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells/ Percentage Showing Fluctuation										Total W
			Rise		Fall		Rise						Fall				
							0 to 2		2 to4		>4		0 to 2		2 to 4		>4		
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%	Rise
1	Anantapur	35	0.14	17.8	0.34	1.95	16	45.71	5	14.29	3	8.57	6	17.14	0	0	0		24
2	Chittoor	40	0.07	6.16	.006	10.72	7	17.5	3	7.5	1	2.5	12	30.0	7	17.5	4	10.0	11
3	East Godavari	58	0.03	5.51	0.04	3.61	42	72.41	3	5.17	1	1.72	10	17.24	2	3.45	0	0	46
4	Guntur	76	0.01	11.16	0.04	3.49	42	55.26	6	7.89	7	9.21	20	26.32	1	1.32	0	0	55
5	Krishna	48	0.07	3.47	0.03	3.54	20	41.67	2	4.17	0	0	24	50.0	1	2.08	1	3.23	22
6	Kurnool	31	0.44	6.96	0.4	5.14	13	41.94	6	19.35	2	6.4	5	16.13	2	6.45	1	2.22	21
7	Nellore	45	0.04	2.88	0.02	4.28	13	28.89	2	4.44	0	0	23	51.11	5	11.11	0	0	15
8	Prakasham	48	0.15	9.95	0.04	2.53	28	58.53	1	2.08	2	4.17	11	22.92	3	6.25	0	0	31
9	Srikakulam	34	0.16	9.08	0.15	3.83	16	47.06	8	23.53	3	8.82	6	17.65	1	2.94	0	0	27
10	Visakhapatnam	59	0.04	9.74	0.15	2.34	32	54.24	8	13.56	2	3.39	12	20.34	2	3.34	0	0	42
11	Vizianagaram	38	0.13	5	0.11	3.06	22	57.89	7	18.42	1	2.63	7	18.42	1	2.63	0	0	30
12	West Godavari	34	0.06	2.64	0.1	1.88	24	70.59	5	14.71	0	0	4	11.76	0	0	0	0	29
13	YSR Kadapa	23	0.22	3.11	0.67	4.21	7	30.43	5	21.74	0	0	5	21.74	1	4.35	1	4.35	12
Total State		569	0.01	17.8	0.02	10.72	282		61		22		145		26		7		365

6.5.2 August, 2014 with reference to May,2014

Map depicting water level fluctuations during August 2014 with reference to May, 2014 is shown in the Fig.6.16. Fluctuation and frequency distribution of different ranges are shown in the Fig. 6.17 and Table-6.8. Rise is predominant in the State. An analysis of water level data of 739 wells reveals that rise is recorded in 60.89% of wells (450), fall in 33.01% of wells (244), while no fluctuation is observed in 6.1% of wells (45).

Water level rise of less than 2 m is recorded in 44.51% of wells, 2-4 m in 12.44% of wells and 4 m is recorded in 3.92% of wells. Water level fall of less than 2 m is recorded in 28.95% of wells, 2-4 m in 2.84% and more than 4 m is registered in 1.21% of wells. Rise of more than 4 m is recorded in highest percentage (11.36%) of wells in Vizianagaram district while fall of more than 4 m is registered highest in Chittoor district (5.77% of wells).

RISE OF WATER LEVELS

The rise in the water level during August 2014 with respect to May 2014 is generalized as follows;

Out of the 450 wells that have registered a rise in water levels,

1. Less than 2 m is mostly observed in Coastal region except Nellore and Prakasam districts and smaller parts of Rayalseema (73.11% of wells).
2. Rise of 2-4 m is observed in Visakhapatnam, Srikakulam districts and in smaller parts of Kurnool and Kadapa districts of Rayalseema (20.44% of wells).
3. Rise of more than 4 m is observed in smaller parts of Visakhapatnam, Kurnool and Kadapa districts(6.44% of wells).

FALL OF WATER LEVELS

The fall in water level during May, 2014 with respect to August, 2014 is generalised as follows;

Out of 244 wells that have registered fall in water levels,

1. Fall in water levels of less than 2 m is observed in Nellore and Prakasam districts of Coastal and Rayalseema region (87.7% of wells).
2. Fall of 2-4 m is mostly observed as isolated patches in parts of Prakasam, Kadapa, Anantapur and Chittoor districts(8.6% of wells).
3. Fall of more than 4 m is observed in Anantapur and Chittoor districts of Rayalseema (3.68% of wells).

Fig.6.16

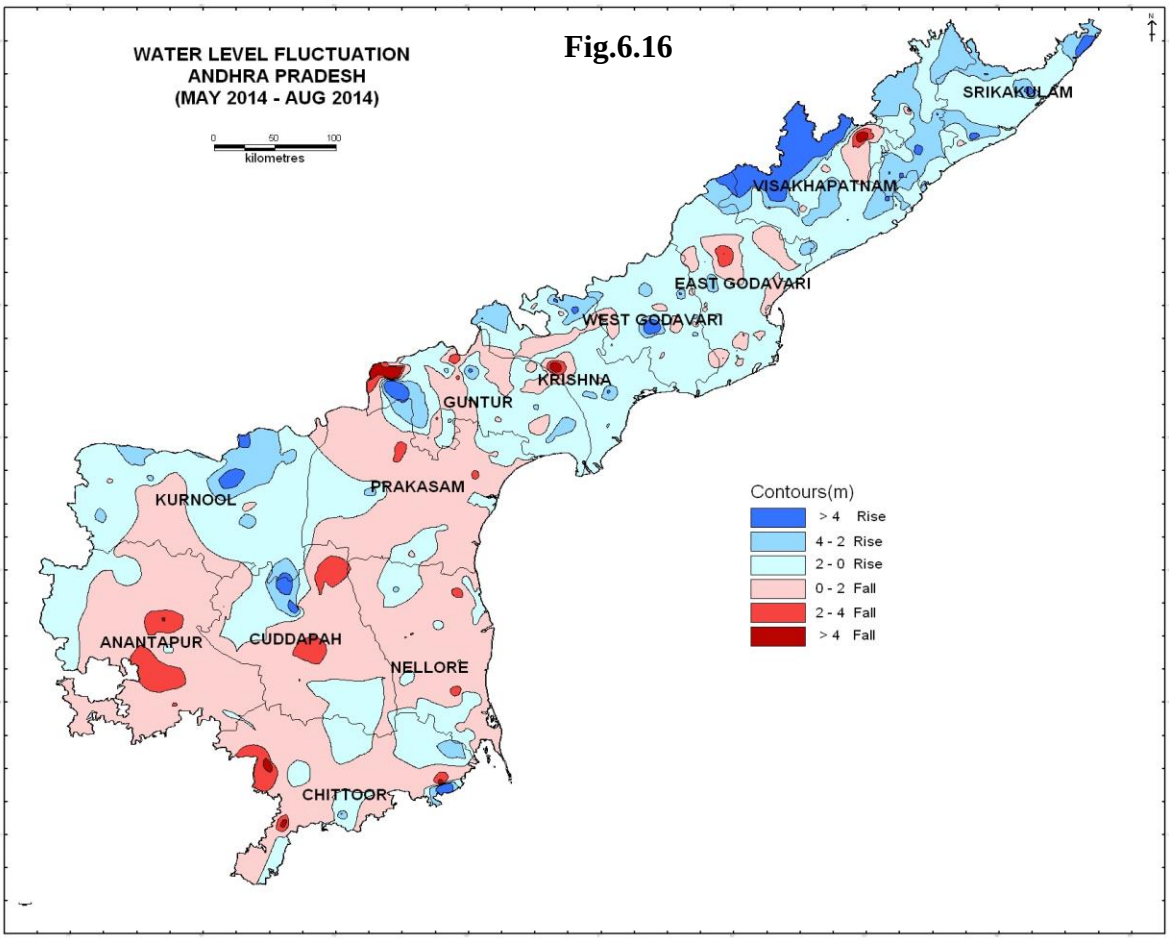


Fig.6.17

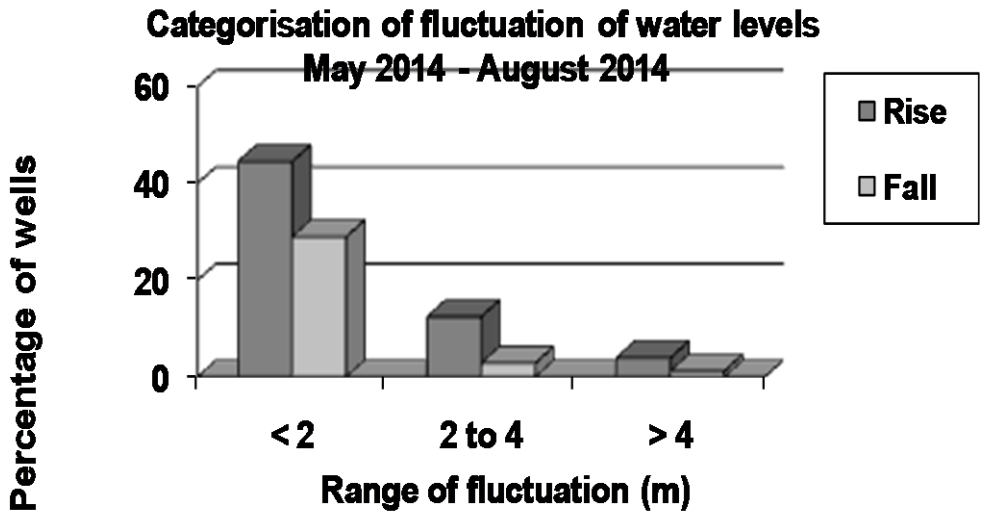


Table-6.8
Fluctuation and frequency distribution of different ranges of Fluctuations
May, 2014 Vs August, 2014

l. No	District	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	35	0.2	1.4	0.15	4.2	5	14.3	0	0	0	0	23	66	3	8.6	1	2	5	27
2	Chittoor	52	0.01	7.9	0.26	5.6	13	25	2	3.8	2	3.8	19	37	0	0	3	5	17	22
3	East Godavari	88	0.02	3.8	0.02	4.1	46	52.3	8	9.1	0	0	31	35	1	1.1	1	1	54	33
4	Guntur	85	0.01	8.6	0.02	18.4	45	52.9	7	8.2	0	0	25	29	3	3.5	2	2	54	30
5	Krishna	63	0.03	5.3	0.16	6.8	45	71.4	5	7.9	2	2.3	8	13	0	0	1	1	54	9
6	Kurnool	41	0.1	5.4	0.1	1.4	22	53.7	9	21.9	4	6.4	7	17	0	0	0	0	33	7
7	Nellore	62	0.07	2.3	0.01	2.8	14	22.6	1	1.6	2	4.9	35	57	4	6.5	0	0	15	39
8	Prakasham	65	0.08	2.9	0.1	2.7	15	23.1	1	1.5	0	0	42	65	3	4.6	0	0	16	45
9	Srikakulam	41	0.02	8.3	0.32	0.3	22	53.7	13	32	0	0	1	2.4	0	0	0	0	39	1
10	Visakhapatnam	76	0.1	8.9	0.02	7.6	40	52.6	22	29	6	7.9	5	6.6	1	1.3	1	1	68	7
11	Vizianagaram	44	0.27	5.3	3.2	3.2	18	40.9	20	45.5	5	11.4	0	0	1	2.3	0	0	43	1
12	West Godavari	54	0.03	8.6	0.03	2.6	40	74.1	4	7.4	2	3.7	7	13	1	1.9	0	0	46	8
13	YSR Kadapa	33	0.01	6.1	0.09	3.8	4	12.12	0	0	2	6.0	11	33	4	12.1	0	0	6	15
Total		739	0.01	8.9	0.01	18.4	329		92		29		214		21		9		450	244

6.5.3 **November 2014 with reference to May 2014**

Map depicting water level fluctuations during November, 2014 with reference to May, 2014 is shown in the Fig.6.18. Rise in water levels is predominant in the state. Categorization of water level fluctuation and frequency distribution of different ranges are shown in the Fig. 6.19 and Table-6.9. An analysis of data of 730 wells reveals that water level rise is recorded in 74.38% of wells (543), fall is recorded in 20.95% of wells (153), while in the rest, 4.67% of wells (34) no fluctuation is recorded.

Rise of less than 2 m is recorded in 48.9% of wells, 2-4 m in 18.63% of wells and more than 4 m is recorded in 6.85% of wells. Fall of less than 2 m is recorded in 17.67% of wells 2-4 m in 1.78% and more than 4 m is registered in 1.51% of wells. Rise of >4m is registered maximum in Kurnool district (21.43% of wells) while fall of >4m is observed maximum in Anantapur district (7.89%) wells.

RISE IN WATER LEVELS

The rise in water level during November, 2014 with reference to May, 2014 is generalised as follows;
Out of the 543 wells that have registered a rise in water levels,

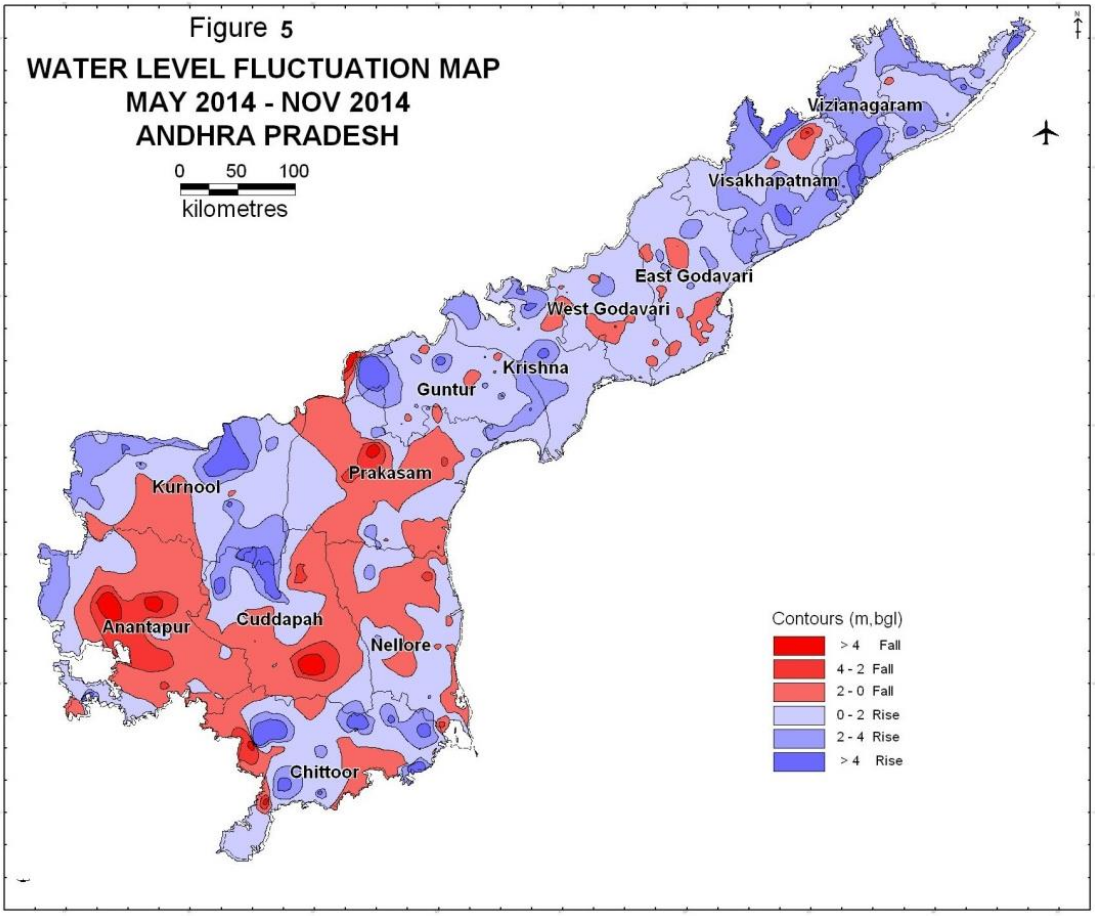
1. Rise of <2 m is mostly observed in Coastal region and as smaller parts in Rayalseema (65.75% of wells).
2. Rise of 2-4 m is mostly observed in Vizianagaram, Visakhapatnam, Srikakulam districts and as smaller parts in all districts of Rayalseema(25.05% of wells).
3. Rise more than 4 m is observed as smaller parts in all the districts except East Godavri, West Godavari, Nellore and Prakasham(9.21% of wells)

FALL IN WATER LEVELS

The fall in water level during November, 2014 with reference to May, 2014 is generalised as follows;
Out of the 153 wells that have registered fall in water levels,

1. Fall in water levels of less than 2 m is observed mostly in Anantapur and Vizianagaram districts and as smaller parts in all other districts(84.3% of wells).
2. Fall of 2-4 m is mostly observed as isolated patches in Anantapur, Kadapa, East Godavari, Nellore, Prakasham and West Godavari districts in 8.5% of wells.
3. Fall of more than 4 m is observed in Anantapur and Chittoor and Prakasham districts of Rayalseema(7.2% of wells).

Fig.6.18



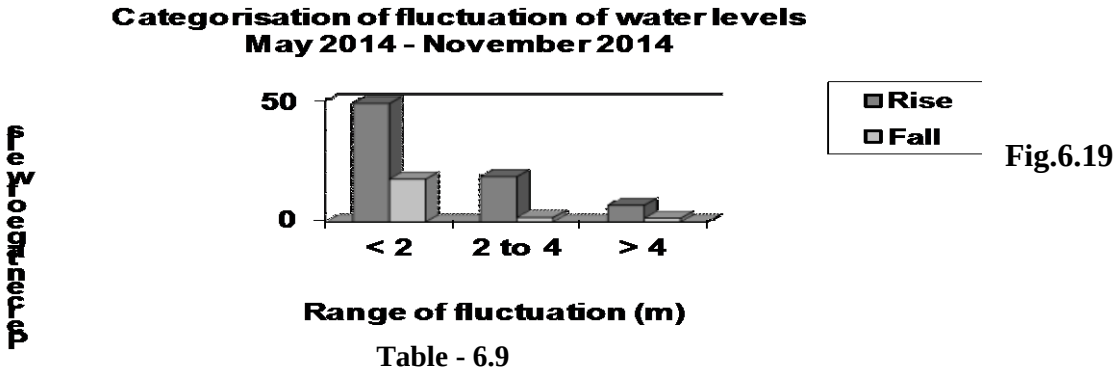


Fig.6.19

Table - 6.9

Fluctuation and frequency distribution of different Fluctuation ranges

November, 2014 Vs May, 2014

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	38	0.04	5.5	0.15	6.6	9	23.7	1	2.6	2	5.3	19	50	2	5.3	3	7.9	12	24
2	Chittoor	49	0.1	11.2	0.4	5.3	15	30.6	6	12.2	9	18.4	9	18.4	0	0	2	4.1	30	11
3	East Godavari	88	0.04	3.96	0.02	2.04	50	56.8	11	12.5	0	0	26	29.5	1	1.1	0	0	61	27
4	Guntur	87	0.07	14.2	0.05	6.14	59	67.8	15	17.2	5	5.8	7	8.1	0	0	1	1.2	79	8
5	Krishna	60	0.14	7.81	0.09	0.79	40	66.6	14	23.3	4	6.8	2	3.3	0	0	0	0	58	2
6	Kurnool	42	0.2	5.95	0.12	1.2	16	38.1	9	21.4	9	21.4	7	16.7	0	0	0	0	34	7
7	Nellore	59	0.06	3.17	0.06	3.14	26	44.1	3	5.1	0	0	19	32.2	2	3.4	0	0	29	21
8	Prakasham	60	0.15	3.65	0.04	5.6	26	43.3	5	8.3	0	0	20	33.3	3	5	2	3.3	31	25
9	Srikakulam	41	0.27	7.28	0.07	0.31	21	51.2	15	36.6	3	7.3	2	4.9	0	0	0	0	39	2
10	Visakhapatnam	74	0.02	9.15	0.01	4.52	31	41.9	27	36.5	11	14.9	4	5.4	0	0	1	1.4	69	5
11	Vizianagaram	44	0.02	6.10	-	-	18	40.9	22	50	4	9.1	0	0	0	0	0	0	44	0
12	West Godavari	55	0.04	3.60	0.1	4.4	40	72.7	6	10.9	0	0	6	10.9	2	3.6	1	1.8	46	9
13	YSR Kadapa	33	0.27	8.10	0.35	6.59	6	18.2	2	6.1	3	9.1	8	24.2	3	9.1	1	3.1	11	12
Total State		730	0.02	14.2	0.01	6.6	357	48.9	136	18.6	50	6.8	129	17.7	13	1.8	11	1.5	543	153

6.5.4 January, 2015 with reference to May, 2014

Water level Fluctuation during January, 2015 with reference to May, 2014 is depicted in the Fig.6.20 and its categorization is furnished in the Table-6.10 & Fig.6.21. Perusals of the maps and analysis of data of 727 wells reveals that rise of water level is predominant in the State. Rise is recorded in 70.83% of wells (515), fall is registered in 25.58% of wells (186), and no fluctuation is observed in 3.57% of wells (26).

Rise of less than 2 m is recorded in 56.53% of wells, 2-4 m in 9.76% of wells and more than 4 m is recorded in 4.54% of wells. Fall of less than 2 m is recorded in 20.77% of wells, 2-4 m in 3.57% of wells and more than 4 m is registered in 1.241% of wells. Rise of more than 4 m is recorded maximum in Chittoor district (14.29% of wells) while water level fall of more than 4 m is registered maximum in Anantapur district (9.38%) wells.

RISE IN WATER LEVELS

The rise in water level during May 2014 and January2015 is generalised as follows,
Out of 515 wells that have registered a rise in water levels,

1. 2 m is mostly observed in Coastal region and small parts of Rayalseema region(79.80% of wells).
2. 2-4 m is observed in in smaller parts in all districts of Rayalseema and Coastal regions(3.78% of wells).
3. More than 4 m is observed as smaller areas in all the district except East Godavri district(6.40% of wells).

FALL IN WATER LEVELS

The fall in water level during May 2014 with reference to January2015 is generalised as follows;

The fall in water level during May, 2014 and January,2015 is generalised as follows;
Out of the 186 wells that have registered fall in water levels,

1. less than 2 m is observed mostly in Anantapur, East Godavari, West Godavari and Srikakulam districts and as smaller parts in all other districts(81.18% of wells)

2. 2-4 m is mostly observed as isolated patches covering Anantapur and YSR Kadapa districts(13.97% of wells).
3. More than 4 m is observed in Anantapur, Chittoor and Kadapa districts (4.83% of wells).

Fig.6.20

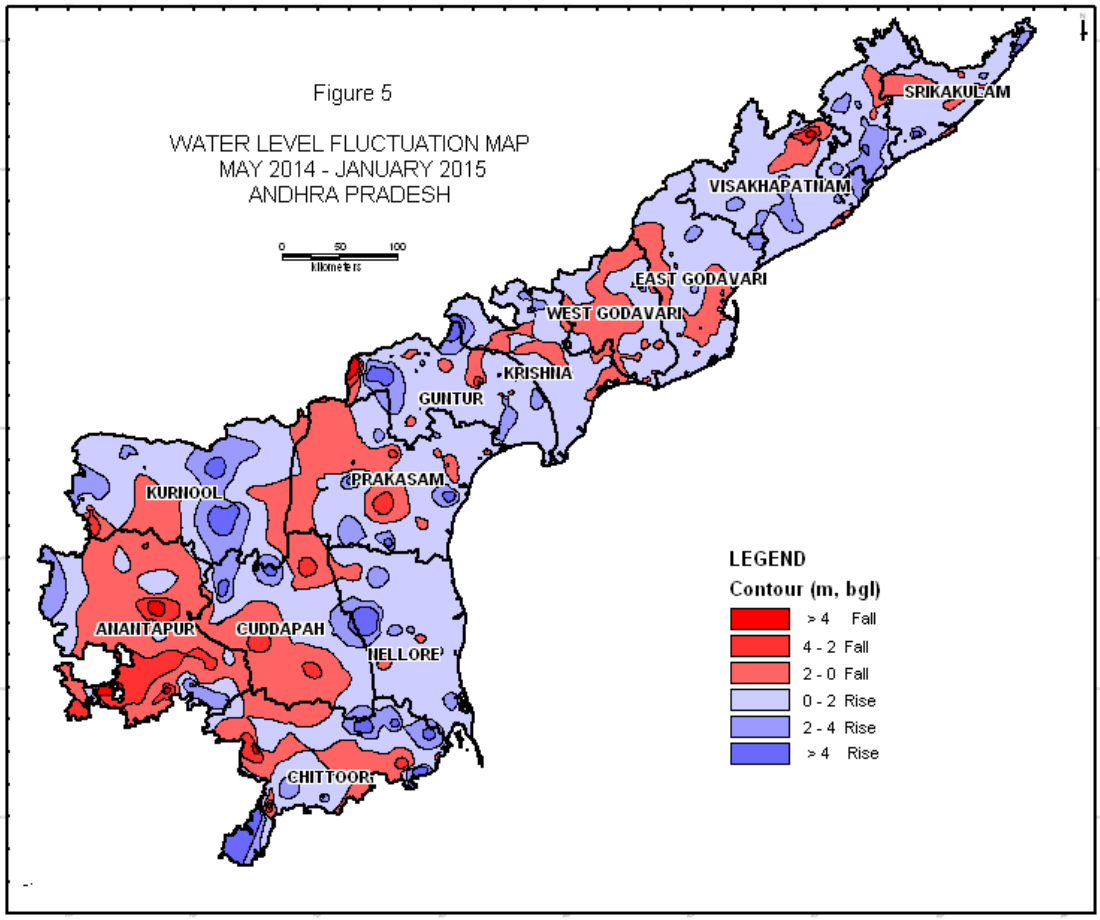


Fig.6.21

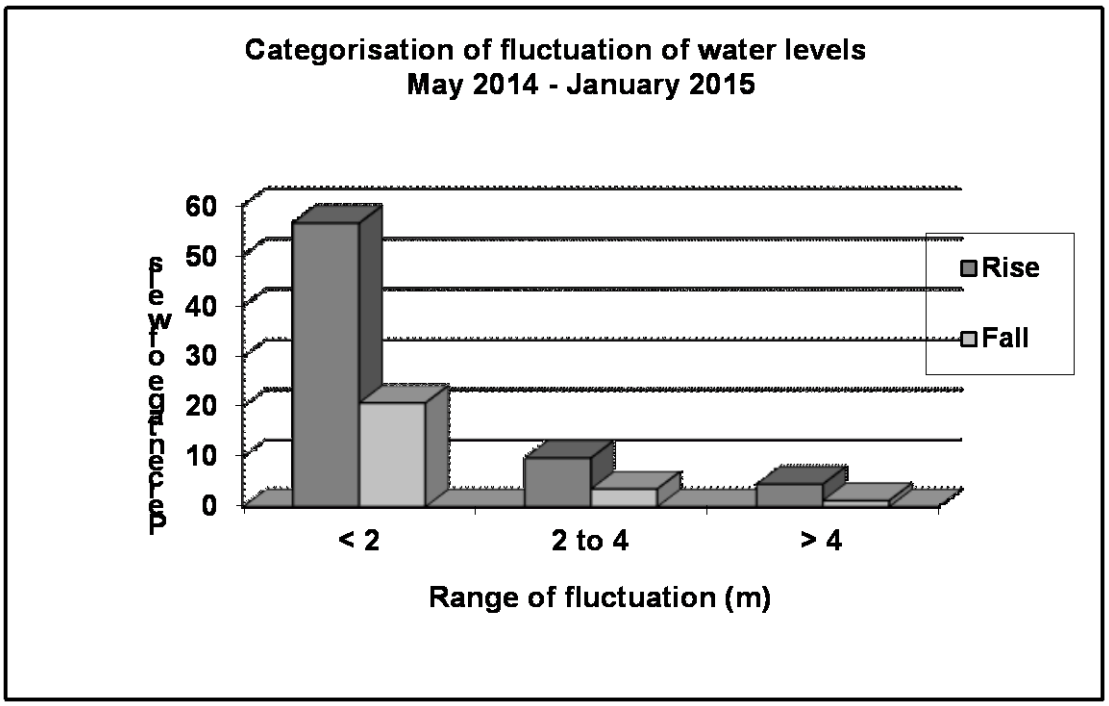


Table-6.10
District Wise Fluctuation & Frequency Distribution of Ranges
May, 2014 to January, 2015

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	32	0.3	4.64	0.05	6	6	18.75	4	12.5	1	3.13	12	37.5	6	18.75	3	9.38	11	21
2	Chittoor	49	0.02	10.33	0.04	5.3	16	32.65	4	8.16	7	14.29	11	22.45	1	2.04	2	4.08	27	14
3	East Godavari	84	0.05	3.15	0.02	2.13	43	51.19	4	4.76	0	0	33	39.29	2	2.38	0	0	47	35
4	Guntur	91	0.02	5.45	0.07	7.45	64	70.33	10	10.99	4	4.4	11	12.09	0	0	2	2.2	78	13
5	Krishna	64	0.11	7.6	0.02	1.76	48	75	2	3.13	2	3.13	12	18.75	0	0	0	0	52	12
6	Kurnool	37	0.03	5.37	0.16	3.04	18	48.65	7	18.92	3	8.11	7	18.92	2	5.41	0	0	28	9
7	Nellore	62	0.07	7.95	0.07	0.62	50	80.65	6	9.68	1	1.61	4	6.45	0	0	0	0	57	4
8	Prakasham	63	0.03	6.72	0.05	3.57	37	58.73	5	7.94	3	4.76	7	11.11	6	9.52	0	0	45	13
9	Srikakulam	41	0.09	6.07	0.02	1.35	23	56.1	2	4.88	2	4.88	14	34.15	0	0	0	0	27	14
10	Visakhapatnam	76	0.01	6.19	0.26	5.9	47	61.84	13	17.11	5	6.58	6	7.89	3	3.95	1	1.32	65	10
11	Vizianagaram	44	0.02	4.92	0.1	1.02	24	54.55	12	27.27	2	4.55	6	13.64	0	0	0	0	38	6
12	West Godavari	52	0.05	4.7	0.05	2.3	28	53.85	0	0	1	1.92	21	40.38	2	3.85	0	0	29	23
13	YSR Kadapa	32	0.08	5.65	0.35	6.16	7	21.88	2	6.25	2	6.25	7	21.88	4	12.5	1	3.13	11	12
Total State		727	0.01	10.33	0.02	7.45	411	56.53	71	9.76	33	4.54	151	20.77	26	3.57	9	1.24	515	186

6.5.5 Water Level Fluctuation – November 2014 with reference to November 2013

Water level fluctuation during November, 2014 with reference to November 2013 is depicted in the Fig.6.22 and its categorization is furnished in the Table-6.10 & Fig.6.23. Perusal of the maps and analysis of water level data of 605 wells reveals;

- Fall is predominant in the State
- Rise is recorded in 20.0% of wells (121)
- Fall is recorded in 78.00% of wells (472)
- No fluctuation in 2.0% of wells (12)

Rise of less than 2 m is recorded in 19.01% of wells; 2-4 m in 0.66% of wells and more than 4 m is recorded in 0.33% of wells. Fall of less than 2 m is recorded in 55.87% of wells, 2-4 m in 13.55% and fall of more than 4 m is registered in 8.6% of wells.

RISE IN WATER LEVELS

The rise in water level during November, 2014 with reference to November 2013 is generalized as follows;

Out of 121 wells that have registered rise;

1. less than 2 m rise is mostly observed as small isolated patches in all districts of Andhra Pradesh state (95.04% of wells)
2. Rise of 2-4 m is observed as small patches in East Godavari and Kurnool districts (3.3% of wells).
3. More than 4 m rise is observed as smaller areas in Chittoor and Kurnool districts(61% of wells).

FALL IN WATER LEVELS

The fall in water level during November, 2014 with reference to November, 2013 is generalized as follows;

Out of the 472 wells that have registered fall in water levels;

1. Fall of less than 2 m is observed predominantly in all the districts(71.61% of wells).
2. Fall of 2-4 m is mostly observed as isolated patches in all the districts(17.37% of wells).
3. Fall of more than 4 m is observed as small isolated patches in all the districts except Kurnool, Srikakulam and Vizianagaram districts(11.01% of wells).

Fig.6.22

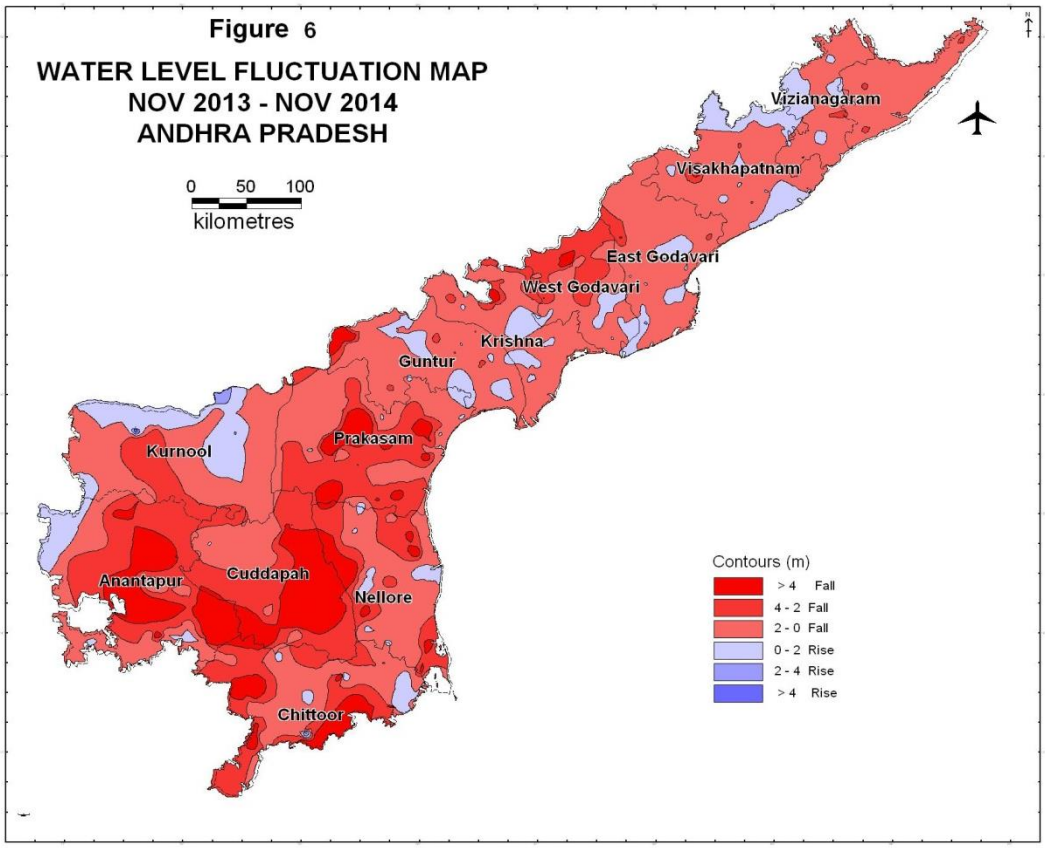


Fig.6.22

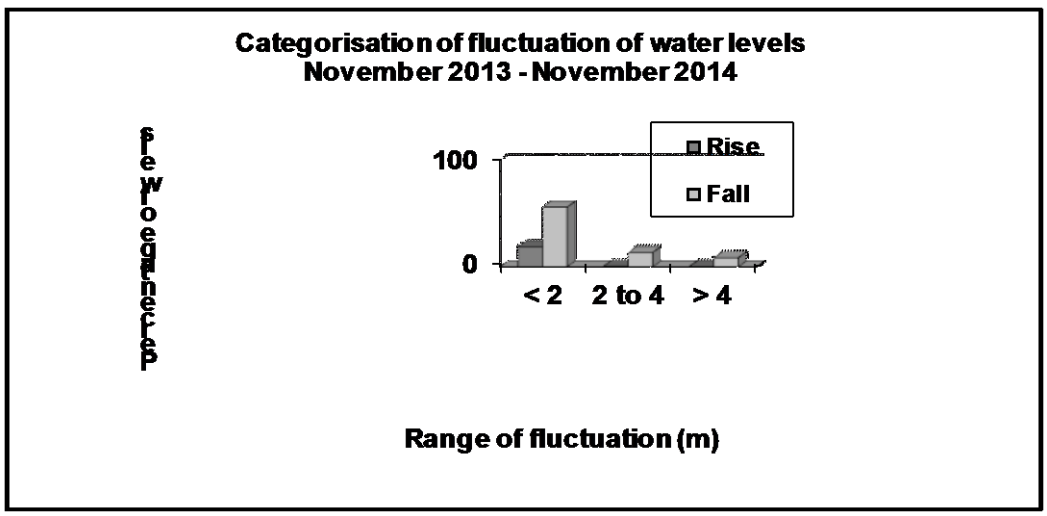


Table – 6.11
District wise fluctuation and frequency distribution of different ranges of fluctuation
November, 2014 - November, 2013

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	37	0.45	1.40	0.20	8.00	3	8.11	0	0.00	0	2.50	12	32.43	6	16.22	13	35.14	3	31
2	Chittoor	40	0.09	4.20	0.14	10.70	8	20.00	0	0.00	1	0.00	15	37.5	8	20.00	8	20	9	31
3	East Godavari	76	0.10	2.33	0.02	4.40	13	17.11	2	2.63	0	0.00	55	72.37	3	3.95	1	1.32	15	59
4	Guntur	76	0.03	1.51	0.02	8.94	16	21.05	0	0.00	0	0.00	50	65.79	8	10.53	2	2.69	16	60
5	Krishna	46	0.01	1.69	0.09	6.75	12	26.09	0	0.00	0	0.00	30	65.22	3	6.52	1	2.17	12	34
6	Kurnool	33	0.20	6.20	0.05	3.20	8	24.24	2	6.06	1	3.03	18	54.55	4	12.12	0	0	11	22
7	Nellore	44	0.13	1.09	0.02	7.20	8	18.18	0	0.00	0	0.00	17	38.64	8	18.18	7	15.9	8	32
8	Prakasham	49	0.15	0.85	0.01	17.99	6	12.24	0	0.00	0	0.00	16	32.65	15	30.61	10	20.4	6	41
9	Srikakulam	39	0.02	0.10	0.11	2.87	2	5.13	0	0.00	0	0.00	33	84.62	4	10.26	0	0	2	37
10	Visakhapatnam	56	0.01	1.77	0.02	5.25	17	30.36	0	0.00	0	0.00	33	58.93	4	7.14	1	1.79	17	38
11	Vizianagaram	49	0.02	0.57	0.01	3.36	11	26.83	0	0.00	0	0.00	28	68.29	2	4.88	0	0	11	30
12	West Godavari	42	0.05	0.75	0.02	8.50	10	23.81	0	0.00	0	0.00	22	52.38	7	16.67	3	7.14	10	32
13	YSR Kadapa	26	0.11	0.11	0.10	8.74	1	3.85	0	0.00	0	0.00	9	34.62	10	38.46	6	23.08	1	25
Total State		605	0.01	6.20	0.01	17.99	115	19.01	4	0.66	2	0.33	338	55.87	82	13.55	52	8.6	121	472

6.5.6 Water Level Fluctuation During January, 2015 with reference to January 2014

Fluctuation of water levels during January 2015 with reference to January 2014 is depicted in the Fig.6.24. The categorization of water level fluctuation is shown in the Fig.6.25 and furnished in the Table-6.11. Perusal of the map and analysis of water data of 713 wells reveals that

- Water level fall is predominant in the State.
- Rise is recorded in 29.45% of wells (210).
- Fall is registered in 68.72% of wells (490).
- While no fluctuation is recorded in 1.82% of wells (13).

Rise of less than 2 m is recorded in 26.08% of wells.
2-4 m in 2.24% of wells and
Rise of more than 4 m is recorded in 1.12% of wells.
Fall of less than 2 m is recorded in 50.63% of wells.
Fall of 2-4 m in 11.22% and of more than 4 m is registered in 6.88% of wells.

Water level rise of more than 4 m is recorded maximum in Chittoor district while fall of more than 4 m is registered maximum in Kadapa district.

RISE IN WATER LEVELS

The rise in water level during January 2015 with reference to January 2014 is generalised as follows;

Out of the 210 wells that have registered rise

1. Rise of less than 2 m is mostly observed in Srikakulam, Visakhapatnam and Vizianagaram districts and as smaller isolated patches in all other districts 88.57% of wells.

2. Rise of 2-4 m is observed as small isolated patches in Anantapur and Vizianagaram districts (7.61% of wells).
3. Rise of more than 4 m is observed as small isolated areas covering Chittoor and Prakasam districts (3.8% of wells).

4. **FALL IN WATER LEVEL**

The fall in water level during January 2015 with reference to January 2014 is generalised as follows;

1. Out of the 490 wells that have registered fall in water levels;
2. Less than 2 m is observed predominantly in all the districts (73.67% of wells). Fall of 2-4 m is mostly observed in all the districts (16.32% of wells).
3. Fall of more than 4 m is observed as small isolated patches in all the districts except Srikakulam and Vizianagaram (10.0% of wells).

Fig.6.24

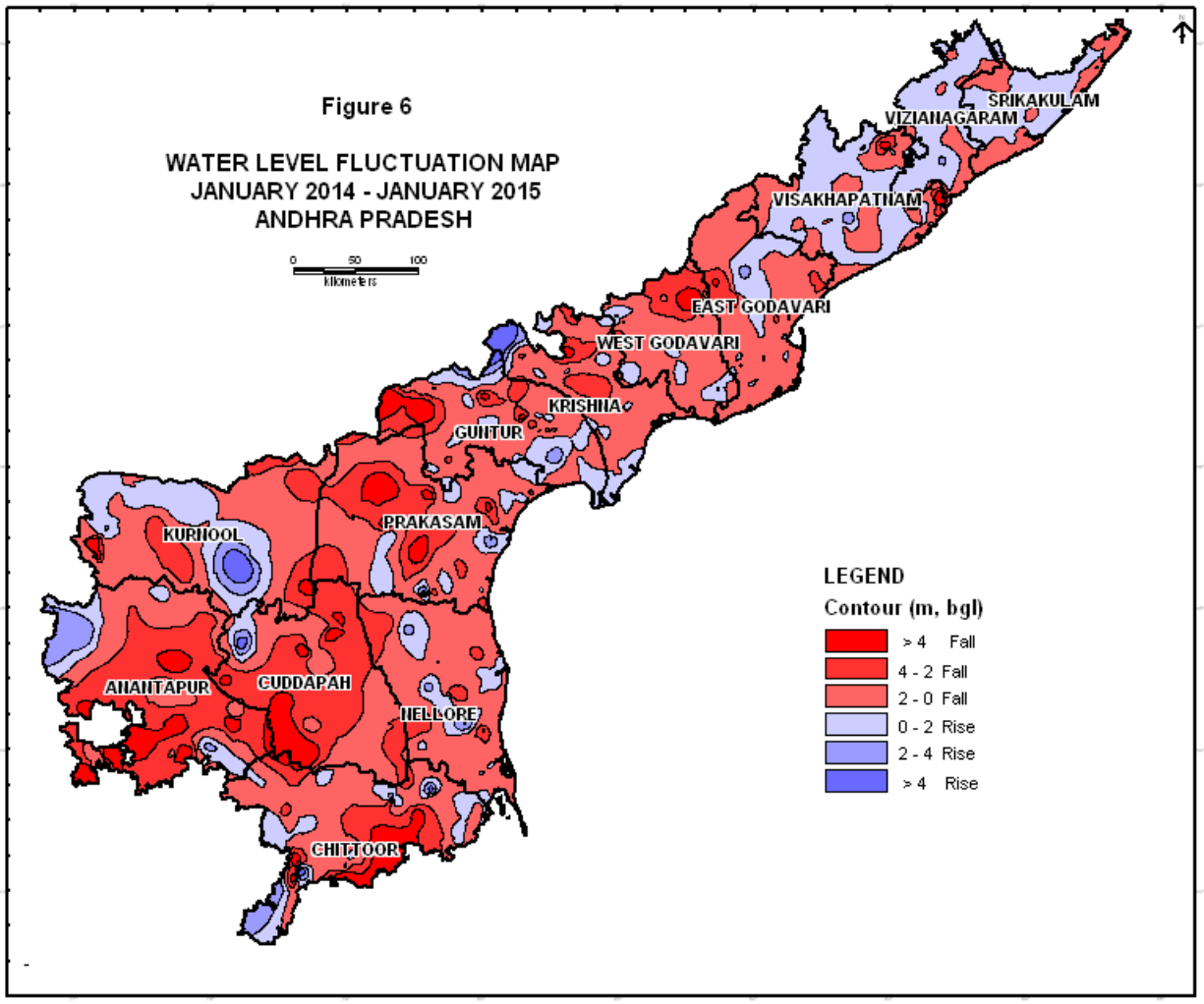


Fig.6.25

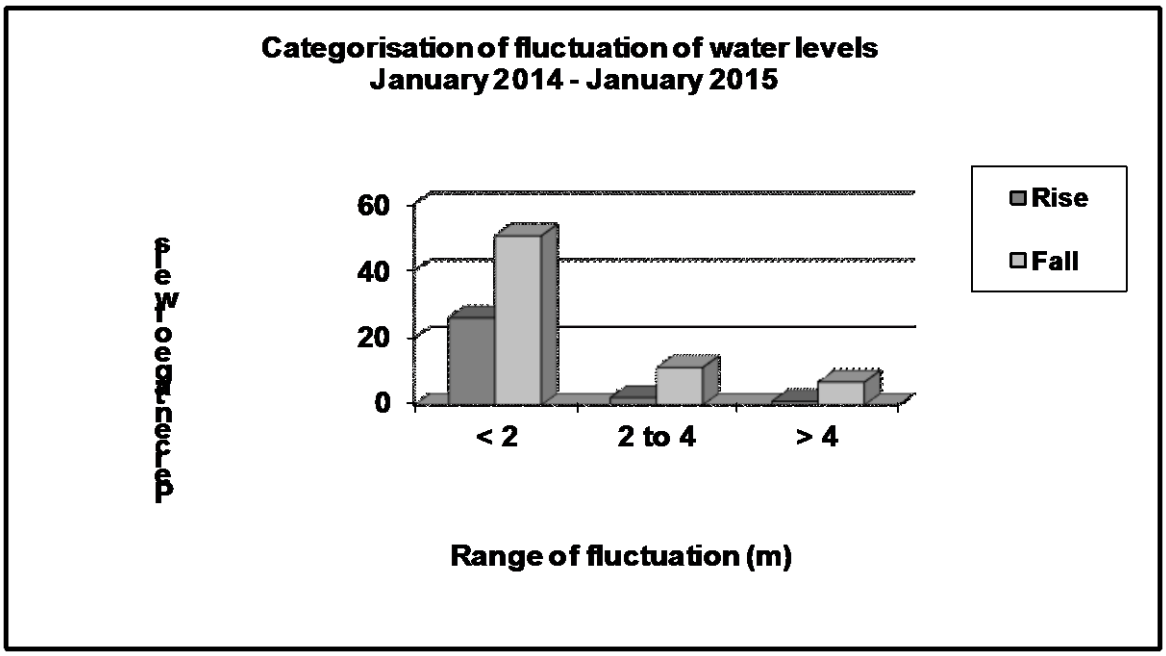


Table – 6.11
District wise fluctuation and frequency distribution of different water level ranges
January, 2015 and January, 2014

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	37	0.08	3.45	0.19	8.25	4	10.81	3	8.11	0	0.00	12	32.43	10	27.03	8	21.62	7	30
2	Chittoor	46	0.04	5.84	0.05	6.42	9	19.57	2	4.35	2	4.35	15	32.61	6	13.04	8	17.39	13	29
3	East Godavari	87	0.02	2.72	0.02	4.70	17	19.54	1	1.15	0	0.00	57	65.52	9	10.34	2	2.3	18	68
4	Guntur	92	0.04	3.18	0.01	9.10	20	21.74	1	1.09	0	0.00	56	60.87	10	10.87	5	5.43	21	71
5	Krishna	57	0.25	7.60	0.02	4.90	8	14.04	0	0.00	1	1.75	40	70.18	5	8.77	2	3.51	9	47
6	Kurnool	35	0.05	6.70	0.15	10.80	9	25.71	1	2.86	1	2.86	17	48.57	4	11.43	3	8.57	11	24
7	Nellore	62	0.08	4.30	0.03	4.43	13	20.97	2	3.23	1	1.61	37	59.68	8	12.90	1	1.61	16	46
8	Prakasham	63	0.01	5.39	0.01	6.85	13	20.63	0	0.00	2	3.17	29	46.03	11	17.46	6	9.52	15	46
9	Srikakulam	39	0.01	0.97	0.03	1.60	19	48.72	0	0.00	0	0.00	18	46.15	0	0.00	0	0	19	18
10	Visakhapatnam	75	0.01	3.62	0.02	13.24	37	49.33	2	2.67	0	0.00	32	42.67	2	2.67	2	2.67	39	36
11	Vizianagaram	41	0.06	3.08	0.08	1.94	28	68.29	3	7.32	0	0.00	10	24.39	0	0.00	0	0	31	10
12	West Godavari	47	0.20	2.15	0.01	15.92	9	19.15	1	2.13	0	0.00	27	57.45	6	12.77	2	4.26	10	35
13	YSR Kadapa	32	5.65	5.65	0.06	7.94	0	0.00	0	0.00	1	3.13	11	34.38	9	28.13	10	31.25	1	30
Total State		713	0.01	7.60	0.01	15.92	186	26.08	16	2.24	8	1.12	361	50.63	80	11.22	49	6.88	210	490

6.5.7 Water Level Fluctuation during May, 2014 - Decadal Mean of May 2004-2013

Fluctuation of water levels during May, 2014 with reference to decadal mean of May-2004-2013 is depicted in the Fig.6.26. The categorization of water level fluctuation is shown in the Fig.6.27 and furnished in the Table-6.12. Perusal of the map and analysis of water level data of 587 wells reveals that a general rise in about 61.15% of wells(359) while the rest of 38.5% of wells (226) recorded significant fall.

- Rise of less than 2 m is recorded in 47.87% of wells

- 2-4 m in 10.56% of wells and
- more than 4 m is recorded in 2.72% of wells.
- Fall of less than 2 m is recorded in 31.34% of wells
- 2-4 m in 5.62% and fall of more than 4 m is registered in 1.53% of wells. Rise of more than 4 m is recorded maximum in Srikakulam district fall of more than 4 m is registered maximum in Chittoor district (7.5%).

DECADAL RISE IN WATER LEVELS

Rise of water levels during May, 2014 with respect to decadal of May (2004-13) is generalized as follows;

Out of the 359 wells that have registered rise in water levels;

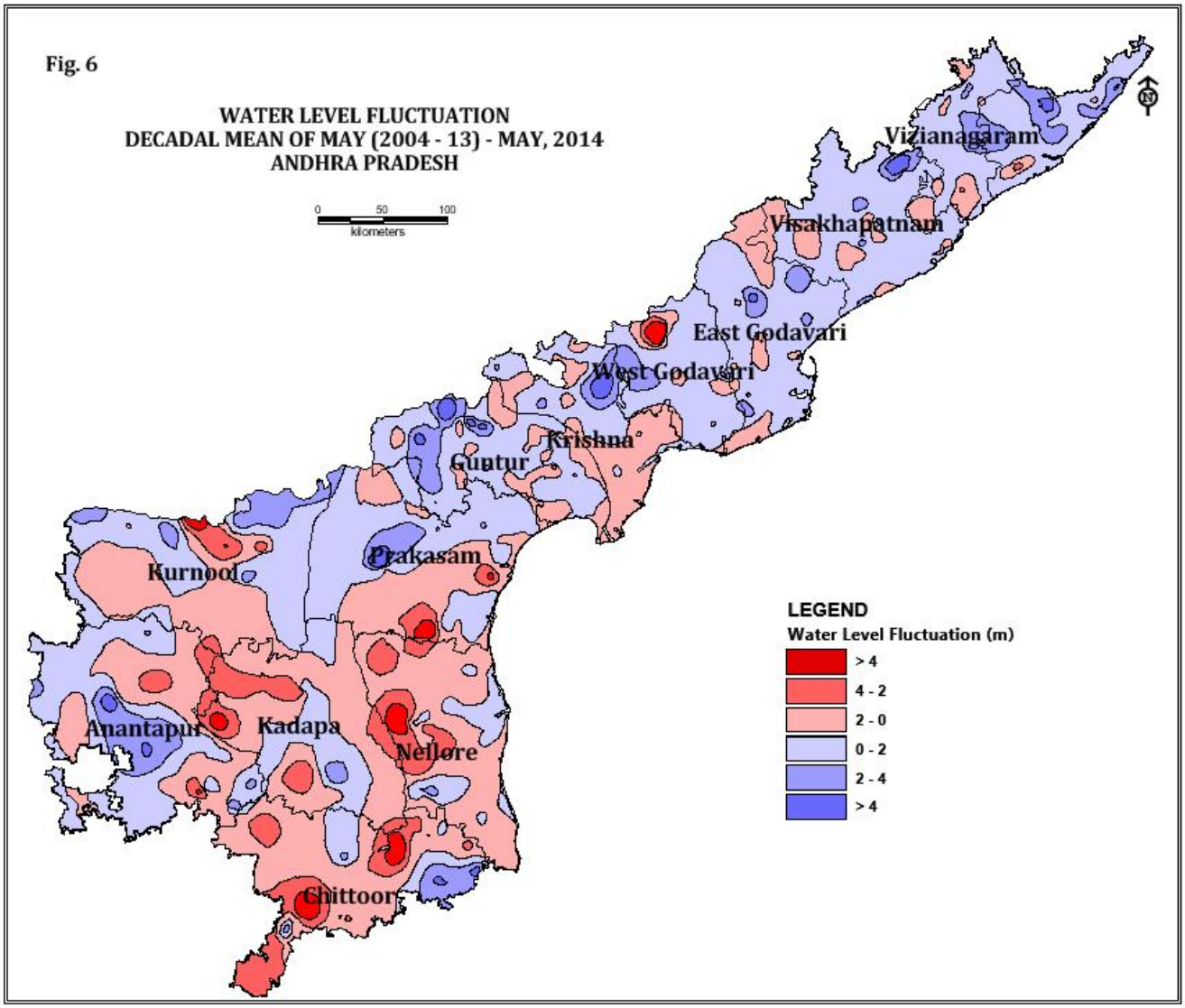
1. Rise of less than 2 m is observed in major parts of all districts (78.27% of wells).
2. Rise of 2-4 m is observed in smaller parts of all districts (17.27% of wells).
3. More than 4 m rise is observed as small parts in all districts of Coastal region except West Godavari and Nellore and as smaller areas in Anantpur and Chottoor districts(4.46% of wells)

DECADAL FALL IN WATER LEVELS

Fall of water levels during May, 2014 with respect to decadal of May (2004-13) is generalized as follows;

Out of the 226 wells that have registered fall in water levels,

Fig.6.26



1. Fall of less than 2 m is noticed in major parts of Nellore and Krishna districts, parts of Rayalaseema region and as smaller parts in Coastal region (81.41% of wells).
2. Fall of 2-4 m and >4m are noticed in small parts of Nellore and Prakasam districts and Rayalaseema in 14.6% and 3.99% of wells respectively.

Fig.6.27

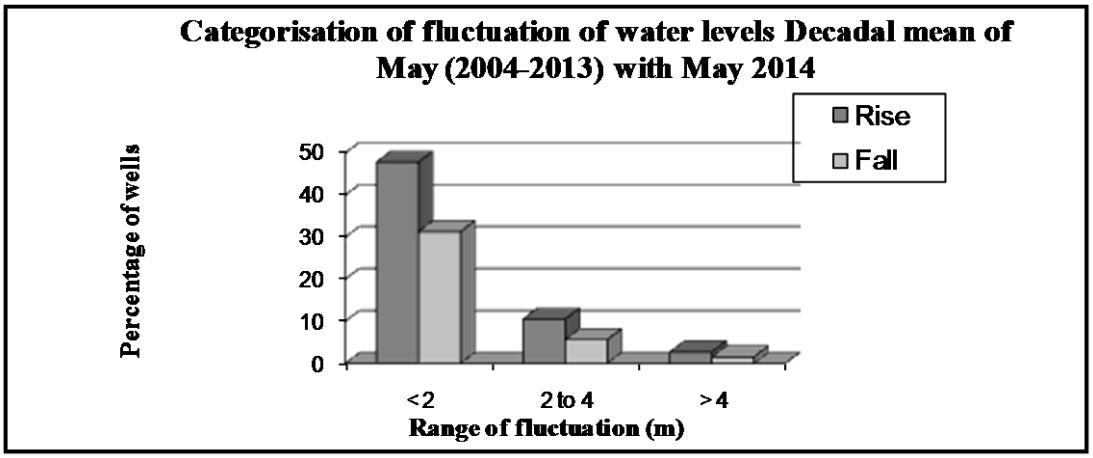


Table – 6.12
District wise fluctuation and frequency distribution of different water level ranges
Decadal Mean of May (2004-13) -May 2014

Sl. 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				
			Minimum	Maximum	Minimum	Maximum	0 to 2	2 to 4	> 4	0 to 2	2 to 4	> 4	Rise	Fall
1	Anantpur	37	0.57	5.53	0.12	4.75	9 24.32	7 18.92	2 5.41	13 35.14	3 8.11	1 2.70	18	17
2	Chittoor	40	0.1	6.16	0.22	8.76	4 10.00	4 10.00	2 5.00	19 47.50	8 20.00	3 7.50	10	30
3	Cuddapah	24	0.16	3.51	0.28	5.8	8 33.33	2 8.33%	0 0.00	9 37.50	4 16.67	1 4.17	10	14
4	East Godavari	62	0.03	4.87	0.24	3.61	44 70.97	5 8.06	1 1.61	10 16.13	2 3.23	0 0.00	50	12
5	Guntur	77	0	6.65	0.02	3.49	43 55.84	4 5.19	4 5.19	24 31.17	2 2.60	0 0.00	51	26
6	Krishna	49	0.03	6.19	0.03	1.66	21 42.86	2 4.08	1 2.04	25 51.02	0 0.00	0 0.00	24	25
7	Kurnool	33	0.34	3.59	0.11	3.45	16 48.48	7 21.21	0 0.00	8 24.24	2 6.06	0 0.00	23	10
8	Nellore	46	0.04	2.88	0.01	4.28	12 26.09	2 4.35	0 0.00	25 54.35	6 13.04	1 2.17	14	32
9	Prakasham	49	0.11	9.95	0.07	6.14	22 44.90	4 8.16	1 2.04	17 34.69	3 6.12	2 4.08	27	22
10	Srikakulam	34	0.16	9.08	0.48	3.53	19 55.88	8 23.53	2 5.88	4 11.76	1 2.94	0 0.00	29	5
11	Visakhapatnam	63	0.04	9.74	0.07	2.22	38 60.32	5 7.94	2 3.17	17 26.98	1 1.59	0 0.00	45	18
12	Vizianagaram	38	0.13	4.21	0.25	2.67	22 57.89	6 15.79	1 2.63	8 21.05	1 2.63	0 0.00	29	9
13	West Godavari	35	0.06	3.76	0.06	12.77	23 65.71	6 17.14	0 0.00	5 14.29	0 0.00	1 2.86	29	6
	Total	**587**	**0**	**9.95**	**0.01**	**12.77**	**281**	**62**	**16**	**184**	**33**	**9**	**359**	**226**

6.5.8 WATER LEVEL FLUCTUATION – AUGUST, 2014 WITH REFERENCE TO DECADAL MEAN OF AUGUST (2004-2013)

Water level fluctuation during August, 2014 with reference to decadal mean(2004-2013) is depicted in the Fig.6.28 and categorization of water level fluctuation is shown in the Fig.6.29 and in the Table-6.13. Perusal of the map and analysis of water level data of 371 wells reveals

- A general fall in water levels in 55.79% of wells.
- 44.2% of wells (164) registered rise while fall is recorded in 55.79% of wells (207).
- Rise of less than 2 m is recorded in 37.19% of wells,
- 2-4 m rise in 5.39% of wells and more than 4 m is recorded in 1.61% of wells.
- Fall of less than 2 m is recorded in 36.65% of wells
- 2-4 m fall is registered in 14.01% and more than 4 m in 5.12% of wells.
- Rise of more than 4 m is recorded maximum in East Godavari district while fall of more than 4 m is recorded maximum in Kadapa district.

DECADAL RISE IN WATER LEVELS

The rise water level during August, 2014 with reference to Decadal mean of August (2004-13) is generalized as follows;

1. Out of the 164 wells that have registered a rise in water levels, 84.14% of wells recorded water level rise of less than 2 m, 12.19% of wells in the range of 2 to 4 m while the rest 3.65% of wells recorded water level rise of more than 4 m.
2. Water level rise of less than 2 m is observed mostly in Visakhapatnam, Srikakulam, Prakasam districts and as isolated patches in rest of the state (84.14% of wells).
3. Rise of 2-4 m is observed as small isolated patches in Kurnool, Prakasam, and West Godavari districts(12.19% of wells).
4. Rise of more than 4 m is observed as small isolated patches in Kurnool, Prakasam, and West Godavari districts (3.65% of wells).

DECADAL FALL IN WATER LEVELS

The fall in water level during August, 2014 with reference to Decadal mean of August (2004-13) is generalized as follows;

Out of 207 wells that have registered fall in water levels,

1. fall of less than 2 and 2-4 m is noticed in all the districts of Rayalseema and Coastal region in 65.7% and 25.12% of wells respectively.
2. Fall of more than 4 m is noticed predominantly in all the districts of Rayalseema and as small isolated patches in Coastal region (9.17% of wells).

Fig.6.28

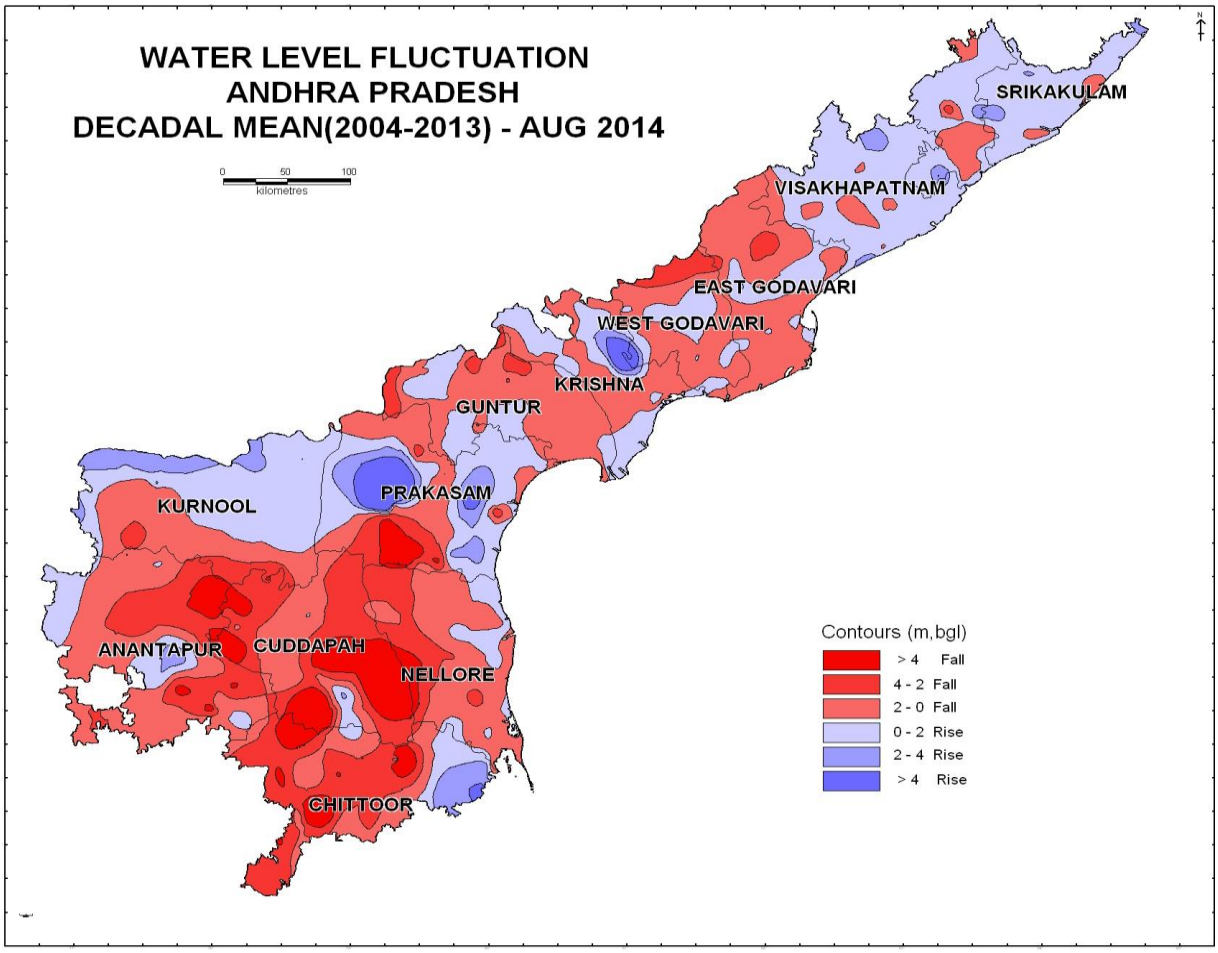


Fig.6.29

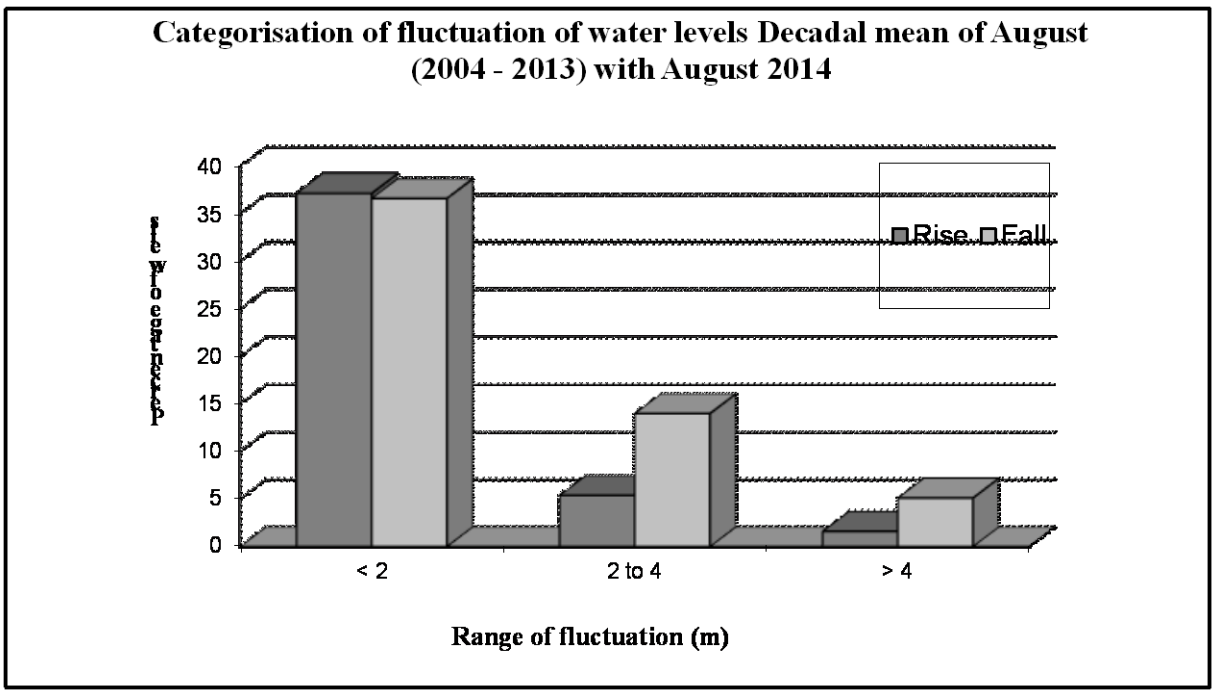


Table – 6.13

District wise fluctuation and frequency distribution of different water level ranges

Decadal Mean August(2004-2013) August 14

Sl. No	District	N796o of Wells	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		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	28	0.05	3.6	0.16	4.9	5	18	1	3.6	0	0	10	35.7	9	32.1	3	11	6	22
2	Chittoor	30	0.05	4.3	0.09	10.1	3	10	2	6.7	1	3.3	8	26.7	10	33.3	6	20	6	24
3	East Godavari	36	0.2	2.3	0.01	3.1	8	22.2	1	2.8	0	0	23	63.9	4	11.1	0	0	9	27
4	Guntur	41	0.02	1.4	0.09	3.8	15	36.7	0	0	0	0	20	48.8	6	14.6	0	0	15	26
5	Krishna	24	0.03	11.7	0.08	2.4	8	33.3	0	0	2	8.3	12	50.0	2	8.3	0	0	10	14
6	Kurnool	24	0.06	3.7	0.52	4.6	12	50	6	25	0	0	4	16.7	1	4.2	1	4	18	6
7	Nellore	31	0.02	1.5	0.18	4.4	9	29	0	0	0	0	17	54.8	4	12.9	1	3	9	22
8	Prakasham	36	0.02	19.8	0.05	5.2	10	27.8	2	5.6	2	5.6	13	36.1	6	16.7	3	8	14	22
9	Srikakulam	22	0.01	2.5	0.49	0.8	18	81.8	2	9.1	0	0	2	9.1	0	0	0	0	20	2
10	Visakhapatnam	36	0.1	4.0	0.01	1.8	24	66.7	4	11.1	0	0	8	22.2	0	0	0	0	28	8
11	Vizianagaram	23	0.24	4.1	0.1	3.5	13	56.5	1	4.4	1	4.4	7	30.4	1	4.4	0	0	15	8
12	West Godavari	19	0.02	1.6	0.21	3.1	10	52.6	0	0	0	0	7	36.8	2	10.5	0	0	10	9
13	YSR Kadapa	21	0.08	2.4	0.43	18.3	3	14.3	1	4.8	0	0	5	23.8	7	33.3	5	24	4	17
Total State		371	0.01	19.8	0.01	18.3	138		20		6		136		52		19		164	207

6.5.9 Water Level Fluctuation: November, 2014 with reference to Decadal Mean of November(2004-2013)

Water level fluctuation during November, 2014 with reference to decadal mean of November (2004-2013) is depicted in the Fig.6.30 and categorization of water level fluctuation is shown in the Fig.6.31 and in the Table-6.14. Perusal of the map and analysis of water level data of 619 wells reveals the following;

A general fall in about 69.95% of wells analyzed.
Rise is registered in 29.73% of wells (184) while fall in 69.95% of wells (433) and 0.032% of wells (2) shows no change in fluctuation.

- less than 2 m rise is recorded in 27.79% of wells
- Rise of 2-4 m is recorded in 1.62% of wells
- More than 4 m rise in 0.32% of wells
- Fall of less than 2 m is recorded in 47.5% of wells
- 2-4 m fall in 14.22% and 4 m is registered in 8.24% of wells

Rise of more than 4 m is recorded maximum in Anantapur district while fall of more than 4 m is registered maximum in Kadapa district.

RISE IN WATER LEVELS

The rise of water levels during November, 2014 with reference to decadal mean of November (2004-2013)is generalised as follows;

Out of the 184 wells that have registered a rise in water levels;

Rise of less than 2 m is observed mostly in Visakhapatnam and Vizianagaram districts and as isolated patches in rest of the state(93.47% of wells).

Rise of 2-4 m is observed as small isolated patches covering Kurnool, Visakhapatnam, Anantapur and Chittoor districts(5.43% of wells).
Rise of more than 4 m is observed as small patches in Anantapur, Chittoor and Visakhapatnam districts (1.1% of wells).

FALL IN WATER LEVELS

The fall of water levels during November, 2014 with reference to decadal mean of November (2004-2013)is generalised as follows;

Out of the 433 wells that have registered fall in water levels

Fall of less than 2 & 2-4 m is mostly noticed in all the districts in 57.89% and 20.32% of wells respectively.
Fall of more than 4 m is registered as small isolated patches in all the districts except Kurnool, Srikakulam, Visakhapatnam and Vizianagaramd in 11.78% of wells.

Fig.6.30

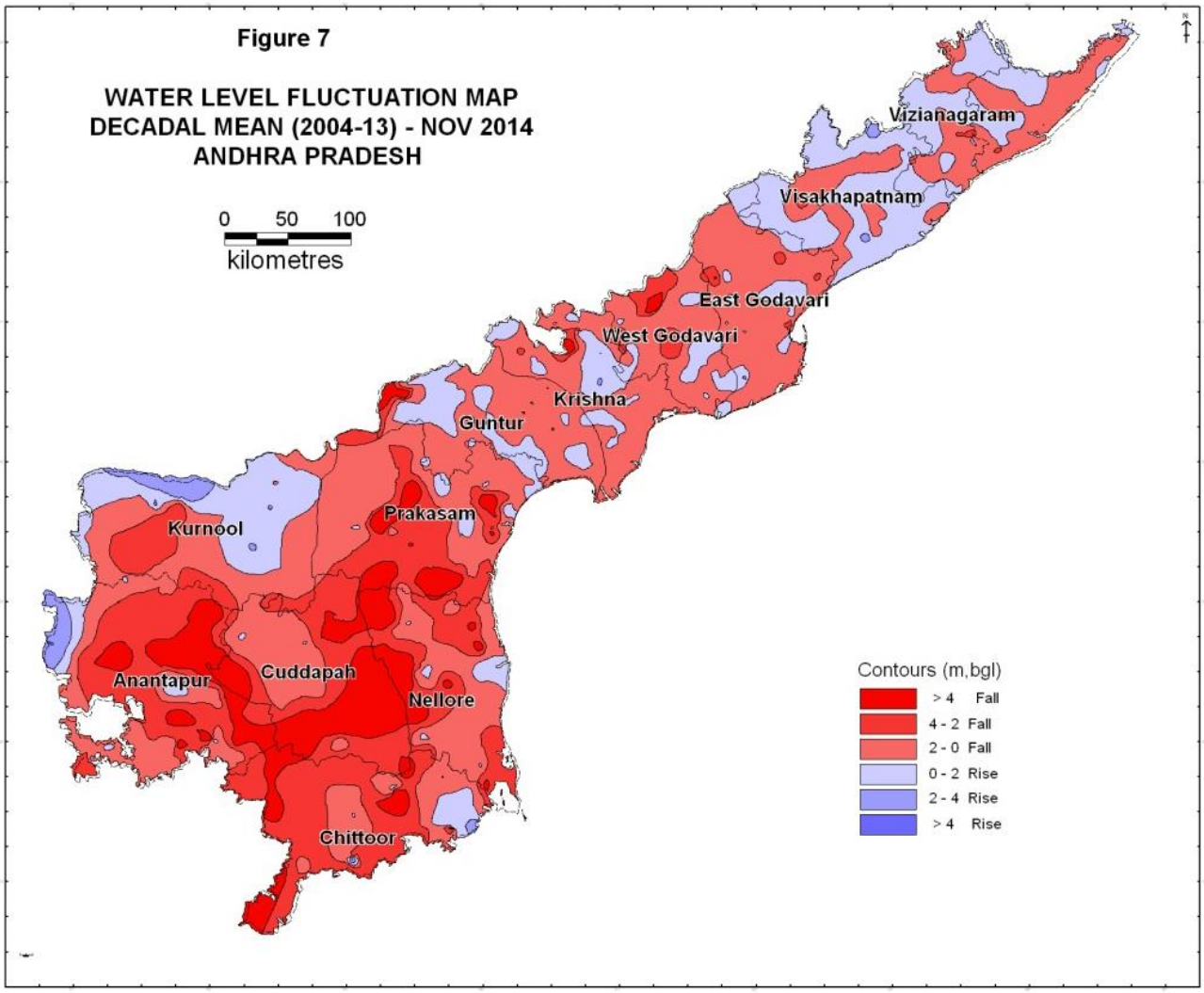


Fig.6.31

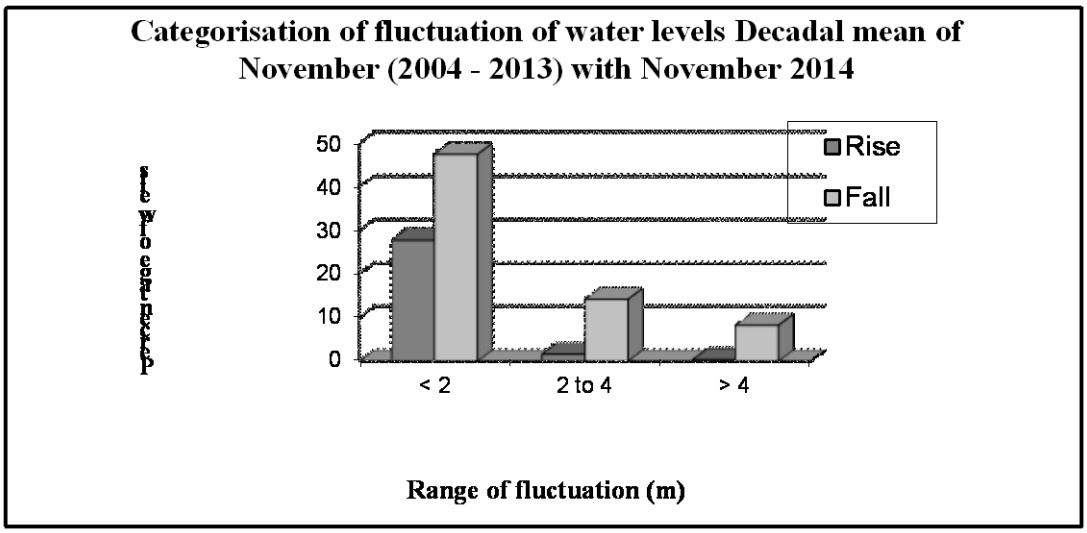


Table – 6.14
Fluctuation and frequency distribution of different water level ranges
November, 2014 - Decadal Mean of November (2004-2013)

Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No.	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	39	0.14	4.03	0.65	8	4	10.26	1	2.56	1	2.56	11	28.21	13	33.33	9	23.08	6	33
2	Chittoor	40	0.06	4.2	0.11	5.71	7	17.5	1	2.5	1	2.5	11	27.5	11	27.5	9	22.5	9	31
3	East Godavari	27	0	0.13	0.1	9.85	2	7.41	0	0	0	0	8	29.63	7	25.93	10	37.04	2	25
4	Guntur	77	0.01	2.33	0.04	4.4	16	20.78	1	1.3	0	0	51	66.23	8	10.39	1	1.3	17	60
5	Krishna	78	0.02	1.51	0.02	6.45	22	28.21	0	0	0	0	50	64.1	4	5.13	2	2.56	22	56
6	Kurnool	48	0.01	2.01	0.04	6.75	14	29.17	1	2.08	0	0	30	62.5	2	4.17	1	2.08	15	33
7	Nellore	34	0.07	2.88	0.07	3.4	13	38.24	4	11.76	0	0	12	35.29	5	14.71	0	0	17	17
8	Prakasham	45	0.21	1.09	0.02	8.78	8	17.78	0	0	0	0	16	35.56	12	26.67	7	15.56	8	35
9	Srikakulam	52	0.31	1.46	0.07	15.52	7	13.46	0	0	0	0	20	38.46	15	28.85	10	19.23	7	45
10	Visakhapatnam	39	0.02	0.85	0.01	2.87	14	35.9	0	0	0	0	23	58.97	2	5.13	0	0	14	25
11	Vizianagaram	56	0.01	2.35	0.03	2.89	33	58.93	2	3.57	0	0	19	33.93	2	3.57	0	0	35	21
12	West Godavari	41	0.01	1.23	0	3.36	19	46.34	0	0	0	0	20	48.78	2	4.88	0	0	19	22
13	YSR Kadapa	43	0.05	1.15	0.02	11.83	13	30.23	0	0	0	0	23	53.49	5	11.63	2	4.65	13	30
Total State		619	0	4.2	0	15.52	17	27.79	10	1.62	2	0.32	294	47.5	88	14.22	51	8.24	184	433

6.5.10 Water Level Fluctuation: January, 2015 with reference to decadal mean of January (2005-2014)

Water level fluctuation during January, 2014 with reference to decadal mean of January(2004-2013) is depicted in the Fig.6.30 and categorization of water level fluctuation is shown in the Fig.6.31 and in the Table-6.15. Perusal of the map and analysis of water level data of 736 wells reveals the following;

A general fall in water levels in 62.63% of wells.
Rise is registered in 37.09% of wells (273 no.)
Fall is observed in 62.63% of wells (461) and 0.31% of wells (2.) shows no change in fluctuation.

Water level rise of less than 2 m is recorded in 33.42% of wells.
Rise of 2-4 is recorded m in 2.71% of wells and more than 4 m in 0.95% of wells.
Fall of less than 2 m is registered in 43.75% of wells.
2-4 m fall is registered in 11.14% more than 4 m in 7.74% of wells.

Rise of more than 4 m is recorded maximum in Krishna district (3.17% of wells) while fall of more than 4 m is registered maximum in Kadapa district (33.33% of wells).

DECADAL RISE IN WATER LEVELS

The rise during January, 2015 with reference to decadal mean of January (2005-14) is generalised as follows;

Out of the 273 wells that have registered a rise;

- Water level rise of less than 2 m is predominantly observed in Visakhapatnam, Srikakulam and Vizianagaram districts and as isolated patches in rest of the state in 90.1% of wells.
- Rise of 2-4 m is observed as small isolated patches in all districts Kadapa. in 7.32% of wells.
- Rise of more than 4 m is observed as small isolated patches in Guntur, Krishna, Kurnool, Nellore, Prakasham and Srikakulam districts in 2.56% of wells.
-

DECADAL FALL IN WATER LEVELS

The fall during January, 2015 with reference to decadal mean of January (2005-14) is generalised as follows;

Out of the 461 wells that have registered fall in water levels,

- Fall of less than 2 m is mostly noticed in all the districts in 69.84% of wells.
- Fall of 2-4 and more than 4 m is noticed as isolated patches in all the districts except Vizianagaram and Srikakulam districts in 17.78 & 12.36% of wells.

Fig.6.30

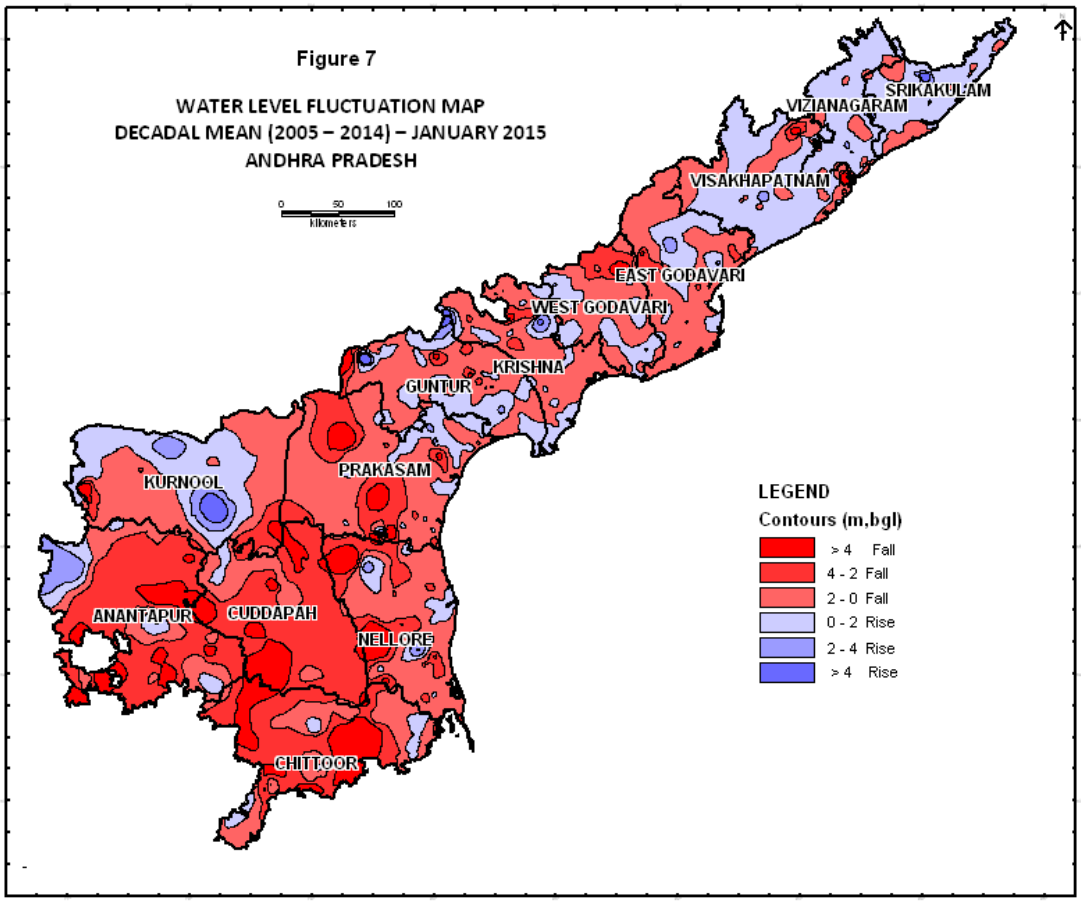


Fig.6.31

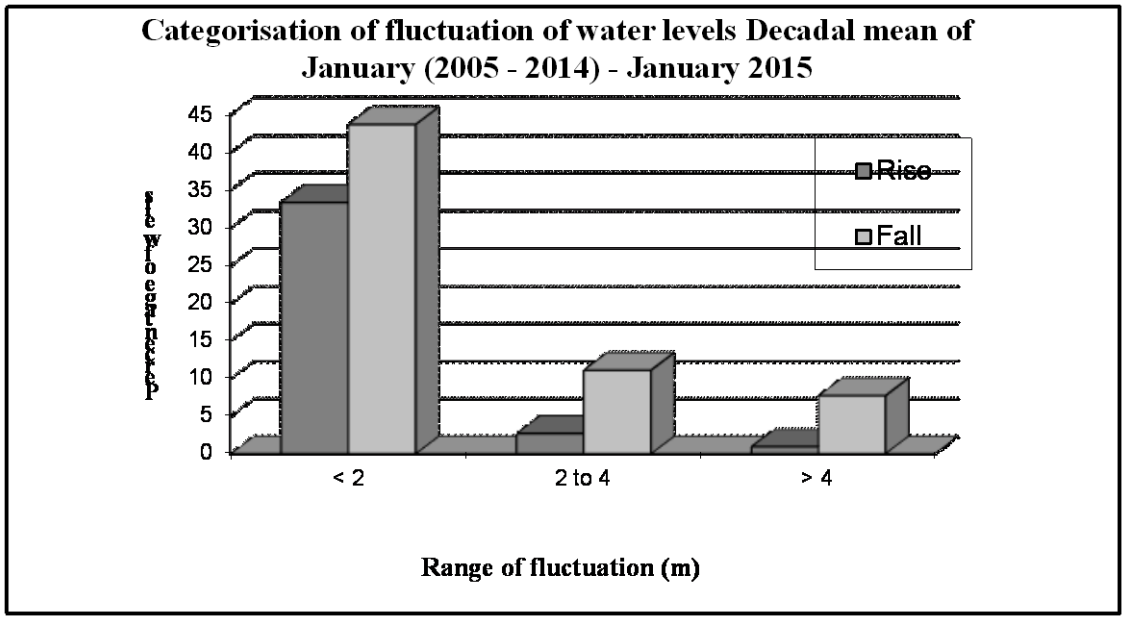


Table – 6.15
District wise fluctuation and frequency distribution of different water level ranges
January 2015 - Decadal mean of January (2005-2014)

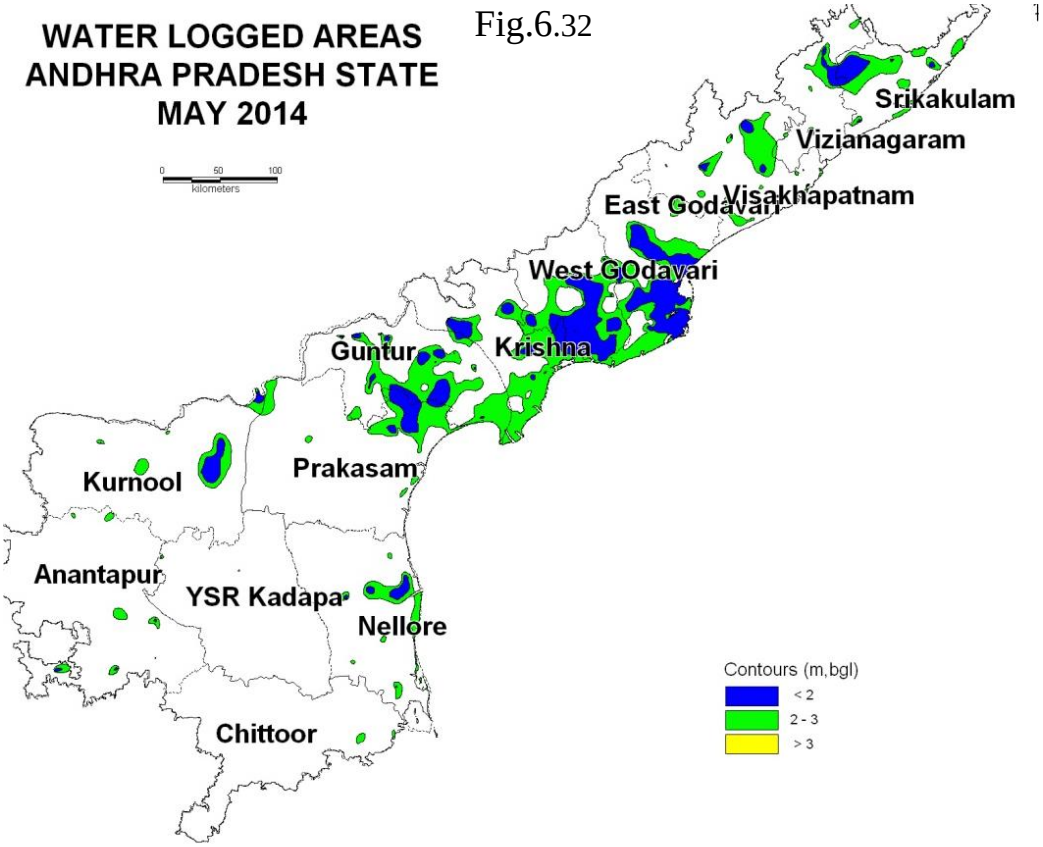
Sl. No	District	No of Wells Analysed	Range of Fluctuation (m)				No of Wells / Percentage Showing Fluctuation												Total No.	
			Rise		Fall		Rise						Fall							
							0 to 2		2 to 4		> 4		0 to 2		2 to 4		> 4		Rise	Fall
			Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%		
1	Anantapur	38	0.16	3.45	0.16	8.25	4	10.53	3	7.89	0	0	9	23.68	13	34.21	9	23.68	7	31
2	Chittoor	47	0.12	3.93	0.06	6.56	7	14.89	1	2.13	0	0	15	31.91	13	27.66	11	23.4	8	39
3	East Godavari	89	0.01	3.42	0	4.7	18	20.22	3	3.37	0	0	61	68.54	5	5.62	2	2.25	21	68
4	Guntur	92	0.04	9.08	0.01	7.27	29	31.52	1	1.09	1	1.09	53	57.61	5	5.43	3	3.26	31	61
5	Krishna	63	0.04	6.78	0.01	4.9	13	20.63	1	1.59	2	3.17	42	66.67	3	4.76	2	3.17	16	47
6	Kurnool	36	0.03	6.7	0.04	10.8	17	47.22	1	2.78	1	2.78	10	27.78	4	11.11	3	8.33	19	17
7	Nellore	62	0.05	4.3	0.03	8.45	12	19.35	1	1.61	1	1.61	29	46.77	12	19.35	7	11.29	14	48
8	Prakasham	64	0.03	5.39	0.13	8.41	16	25	2	3.13	1	1.56	30	46.88	9	14.06	6	9.38	19	45
9	Srikakulam	42	0.02	8.66	0.03	1.6	26	61.9	1	2.38	1	2.38	14	33.33	0	0	0	0	28	14
10	Visakhapatnam	77	0.04	3.62	0.02	13.24	50	64.94	2	2.6	0	0	21	27.27	2	2.6	2	2.6	52	25
11	Vizianagaram	44	0.02	3.08	0.04	1.94	33	75	3	6.82	0	0	8	18.18	0	0	0	0	36	8
12	West Godavari	49	0.1	2.15	0.04	12.63	19	38.78	1	2.04	0	0	24	48.98	3	6.12	1	2.04	20	28
13	YSR Kadapa	33	0.6	0.81	0.11	9.18	2	6.06	0	0	0	0	6	18.18	13	39.39	11	33.33	2	30
Total State		736	0.01	9.08	0	13.24	246	33.42	20	2.71	7	0.95	322	43.75	82	11.14	57	7.74	273	461

6.6 Water Logged and Areas Prone to Water Logging

6.6.1 Water Logged Area
Pre-monsoon - May 2014

Demarcation of water logged and area prone to water logging during pre-monsoon, May 2014 is presented in the Fig.6.32. Water logged areas are observed in smaller extents mainly in parts of East Godavari, West Godavari, Krishna, Prakasam, Guntur, Visakhapatnam, Srikakulam, Nellore and Kurnool districts of the state. The total water logged area during pre-monsoon is 16,360 sq.km. viz about 10% of the total area of the State.

Fig.6.32



Post-monsoon Period - November, 2014

Water logged area and area prone to water logging during post-monsoon (November, 2014) is presented in Fig.6.33. Water logged areas with less than 2 mbgl depth to water levels are observed in all the coastal districts, and as small patches in Rayalaseema, and Nellore districts. The total water logged area during the post-monsoon is 31,290 sq.km viz about 19% of the total area of the State. The water logged area has increased from 10% to 20% of the total area of the state.

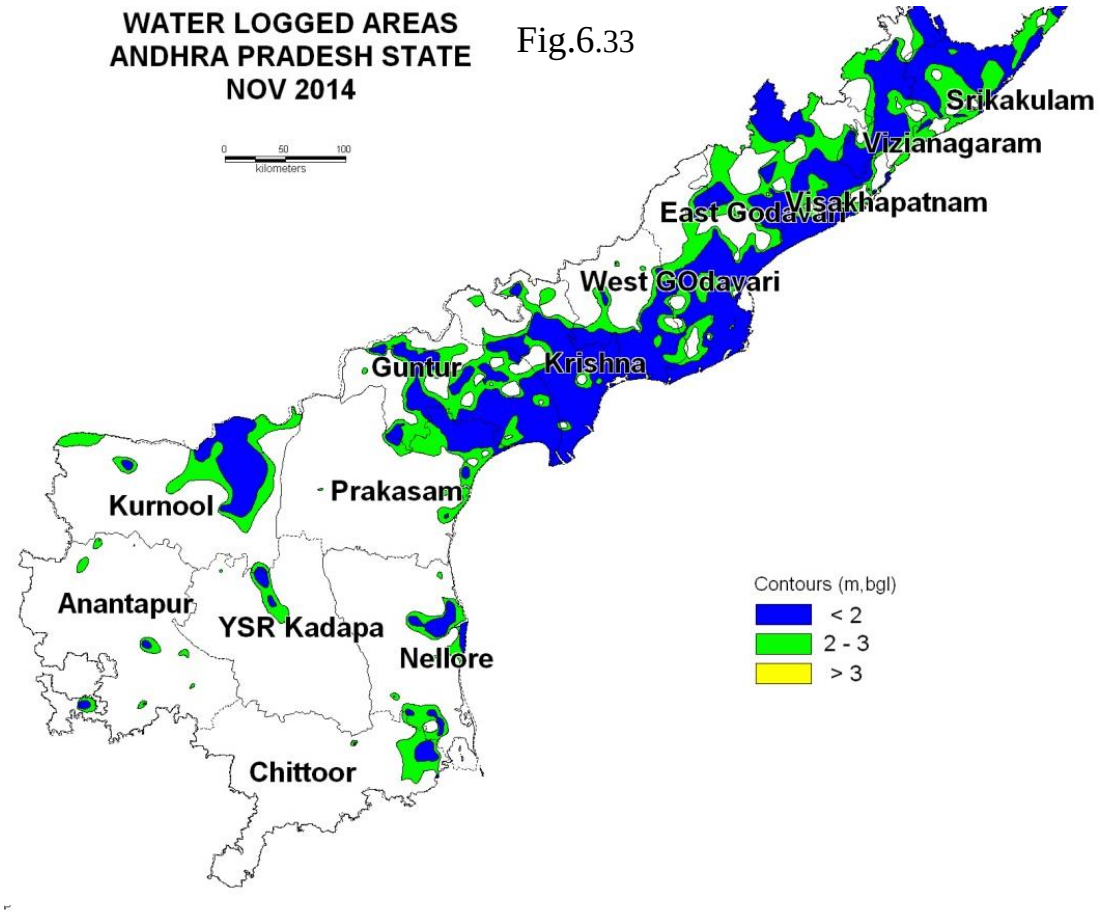


Fig.6.33

6.6.2 Area Prone to Water Logging - Pre-monsoon – May, 2014

A perusal of the Fig.6.32 shows that during pre-monsoon (May, 2014), the area prone to water logging with depth to water level 2 to 3 mbgl are mostly observed in parts of coastal districts, and as small patches in Rayalaseema and Nellore district. The total area prone to water logging during pre-monsoon is 7,894 Sq. km viz about 4.8% of the total area of the State.

Area Prone to Water Logging - Post-monsoon-November ,2014

A perusal of the map (Fig.6.33) reveals that the area prone to water logged with water level less between 2 to 3 m is observed as small patches in all the districts and as major portion in coastal districts. The total area under prone to water logging during post monsoon is 22,210 sq.km represent 13.6% of total geographical area of the State. The area prone to water logged has increased from 4.8% to 13.6% of the total area of the state.

7.0 GROUND WATER QUALITY

The ground water occurrence and availability is largely governed by the state of cementation and compaction of formation, which control the pore volume. A sizable proportion of population is dependent on ground water for drinking and other household utilities besides its use in irrigation at large in Telangana State. Due to limited cost effective treatment options for polluted ground water, the affected resource is generally lost for drinking and other utilities.

The quality of ground water in some parts of the country, particularly shallow ground water, is changing as a result of human activities. Ground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which ground water flows screen out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations. But freedom from bacterial pollution alone does not mean that the water is fit to drink. Many unseen dissolved mineral and organic constituents are present in ground water in various concentrations. Most are harmless or even beneficial; though occurring infrequently, others are harmful, and a few may be highly toxic.

Water is a solvent and dissolves minerals from the rocks with which it comes in contact. Ground water may contain dissolved minerals and gases that give tangy taste enjoyed by many people. Without these minerals and gases, the water would taste flat. The most common dissolved mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate, and sulfate. In water chemistry, these substances are called common constituents.

Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1,000 mg/L (milligrams per liter). Water with a few thousand mg/L of dissolved minerals is classed as slightly saline, but it is sometimes used in areas where less-mineralized water is not available. Water from some wells and springs contains very large concentrations of dissolved minerals and cannot be tolerated by human and animals or plants.

Ground water studies are incomplete until understanding both the physical and chemical dynamics of the system. In ground water studies, the physical characteristics of the flow system tell us the potential for ground water to move from one place to another. Chemistry tells us where it went and what it did along the way. This area of research, known as hydro-geochemistry, allows researchers to determine the time and source of recharge, estimate how long the water has been in the aquifer (residence time), identify the mineralogy of the aquifer material, examine the degree of mixing between waters of various sources and evaluate what types of chemical processes have occurred during the it's journey through the system. This information provides a broad, more regionally extensive understanding of groundwater systems. Furthermore, this improved knowledge can be used to create more comprehensive management and conservation plans, and more equitable groundwater regulations.

With rapid growth of population, the development and use of ground water for domestic, irrigation and industrial purposes has increased too many fold. At the same time, this vital resource is polluted anthrophogenically in the process, to such an extent it is rendered unsuitable for above purposes, in certain areas. The sources of groundwater contamination are varied in addition to natural processes, human physical activity may eventually cause groundwater quality problems. Once the pollution has entered the sub-surface environment, it may remain concealed for many years and dispersed over wide areas of ground water

aquifers. `The vulnerability of contamination or potential sources of contamination underscores the need for a systematic inventory/study. Because natural dilution is slow, artificial flushing is expensive and treatment is impractical, the effects of such pollution may continue for indefinite period. It is an indispensable part of any comprehensive groundwater protection strategy by which the potential threats can be evaluated and measures can be designed and implemented scientifically for the benefit of the society.

In this context the evaluation of ground water in terms of physical, chemical and bacteriological characteristics is important to determine its suitability for drinking, irrigation and industrial uses and to remedial measures to protect it from further deterioration. A data base on ground water quality is generated by monitoring the observation wells.

7.1 QUALITY OF SHALLOW GROUNDWATER

The chemical composition of groundwater mainly depends on the composition of the initial pore water; the composition of infiltrating water and subsurface inflow that replaces the pore water; the composition and physical properties of the soil and rock; the chemical interaction between rock, pore water, and infiltrating water; and microbiological processes. From the moment rain falls on the ground and begins to infiltrate and pass through the soil and rock, the water dissolves the host materials, and minerals are added to the groundwater flowing through. In general, the amount of total dissolved solids (TDS) increases with the residence time of groundwater. The dissolved constituents in groundwater take part in the geochemical cycle, which starts with the weathering of rocks. Weathering breaks up rock minerals and released elements react with water and enter into solution. In addition, the vegetative litter releases organic and mineral substances to the soil and groundwater as part of the biochemical cycle. The disintegration of rocks by physical weathering increases the infiltration capacity and the surface area of the contact between rock and air and rock and water. Chemical weathering is most active above the water table, in the unsaturated zone

Rainwater infiltrates into the soil and interacts with carbon dioxide in soils to become acidic. This acidic water then comes in contact and dissolves minerals in the soil. Eventually the water becomes neutral to mildly alkaline. This process is even more enhanced when cation exchange (in the case of calcium for sodium) takes place. Ground water interacts with the soils and other materials as it flows through them, becoming more mineralized over time, and distance. Some earth material, such as glacial tills or marine shales, contains soluble minerals that dissolve relatively rapidly in groundwater and can cause deterioration of groundwater quality at a shallow depth.

Water that contains a lot of calcium and magnesium is said to be hard. The hardness of water is expressed in terms of the amount of calcium carbonate-the principal constituent of limestone-or equivalent minerals that would be formed if the water is evaporated. Water is considered as soft if it contains 0 to 60 mg/L of hardness, moderately hard from 61 to 120 mg/L, hard between 121 and 180 mg/L, and very hard if more than 180 mg/L. Very hard water is not desirable for many domestic uses; it will leave a scaly deposit on the inside of pipes, boilers, and tanks. Hard water can be softened at a fairly reasonable cost, but it is not always desirable to remove all the minerals that make water hard. Extremely soft water is likely to corrode metals, although it is preferred for laundering, dish washing, and bathing.

In recent years, the growth of industry, technology, population, and water use has increased the stress upon both our land and water resources. Locally, the quality of ground water has been degraded. Municipal and industrial wastes and chemical fertilizers, herbicides, and pesticides not properly contained have entered the soil, infiltrated some aquifers, and degraded the ground-water quality. Other pollution problems include sewer leakage, faulty septic-tank operation, and landfill leachates. In some coastal areas, intensive pumping of fresh ground water has caused salt water to intrude into fresh-water aquifers. In recognition of the potential for pollution, biological and chemical analyses are made routinely on municipal and industrial water supplies. Central, State, and local agencies are taking steps to increase water-quality monitoring. Analytical techniques have been refined so that early warning can be given, and plans can be implemented to mitigate or prevent water-quality hazards.

A network of monitoring wells has been periodically monitored for water quality determination. This monitoring is intended to provide scientific information regarding the variability of chemical constituents within aquifers in the state. During May, 2014 (pre-monsoon), 617 samples were collected from Ground Water Monitoring Wells (GWMW) to assess the quality of ground water from shallow aquifers in the state of Andhra Pradesh. Water to be used for drinking and domestic purposes should be chemically safe and free from undesirable physical properties such as temperature, colour, turbidity and unpleasant taste or odour. The potability of ground water is judged based on drinking water specifications of Bureau of Indian Standards (BIS)-IS-10500(2003): 2012.

pH

pH is the most common measure of the acidity/alkalinity balance in a solution. It is a measure of the availability of hydrogen ions (H+) in solution, also known as "protons"; this is why pH is sometimes referred to as an indicator of the "proton acidity" of a groundwater. In formal terms, pH is defined as the negative logarithm (to base 10) of the hydrogen ion activity (in moles/liter). Values commonly fall in the range between 0 to 14, normally reported without units. The pH of ground waters are varying from 6.84 to 9.29. On the observation made, found 67(10.9%) locations crossed the BIS limits.

Electrical conductivity (EC)

Although strictly termed "specific electrical conductance" in practice the term "conductivity" is very widely used. The ability of given water to conduct electricity is directly proportional to the amount of dissolved, charged species (ions) which it contains. Conductivity values are normally expressed in the units of microsiemens per centimeter (μS/cm), or else for more saline waters, in millisiemens per centimeter (mS/cm). (1 mS/cm = 1000 μS/cm) at 25ºC. By use of an empirical factor, Electrical conductivity enables a rough estimate to be made of the dissolved mineral content of water samples. Electrical conductivity varying from 58 to 12040 μS/cm at 25^0C (Fig.7.1) EC in proportion to Total Dissolved Solids (TDS), exceeds BIS permissible limit of 3000 micromhos /cm in 15.6% of the samples in the state.

Chloride

Main natural source of Chloride is Halite dissolution. Small amounts occur naturally in rainfall. Pollutant Cl^- is very common, and occurs in human, animal and industrial wastes. Chloride is very conservative chemically, and is therefore a good groundwater tracer, unlike sulphate, for instance, which is retarded by reactions. Chloride occurs in all natural waters in varying concentrations. The chloride content increase as the soluble mineral

content increases. Chlorides in reasonable concentrations are not harmful to human beings. At concentrations above 1000 mg/L water acquires salty taste which is objectionable to many people. Only 4.4% of the samples of the state have chloride concentration beyond BIS permissible limit (Fig.7.2).

Fig.7.1

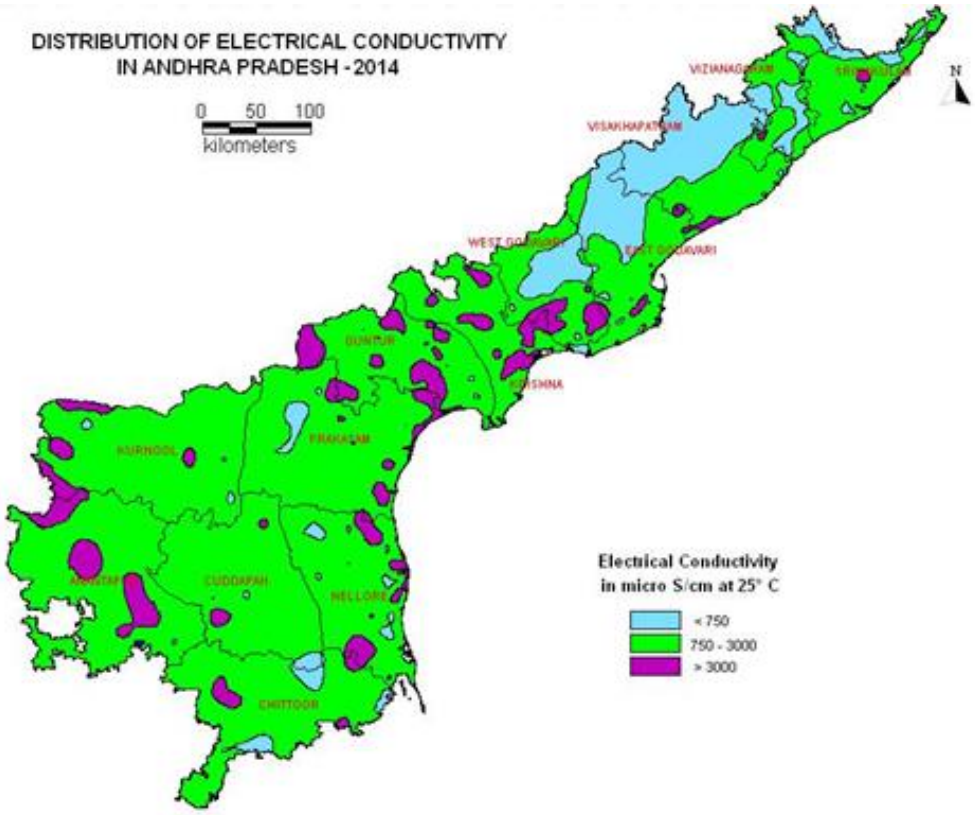
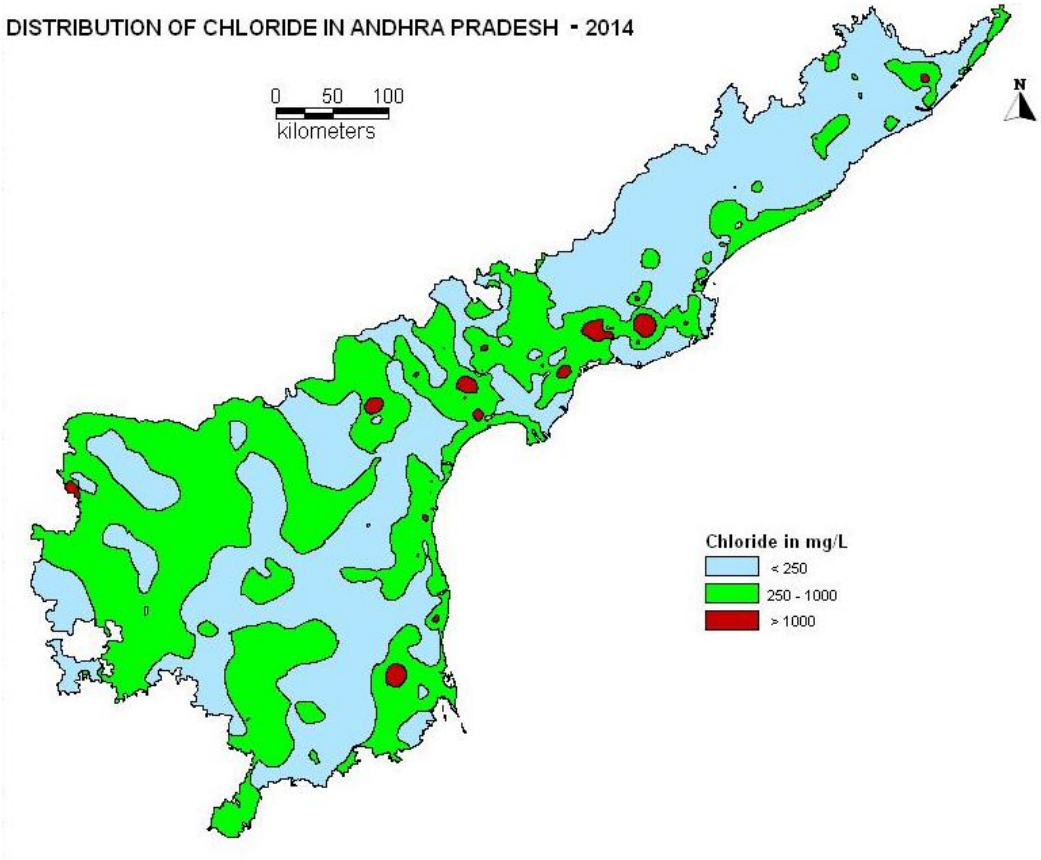


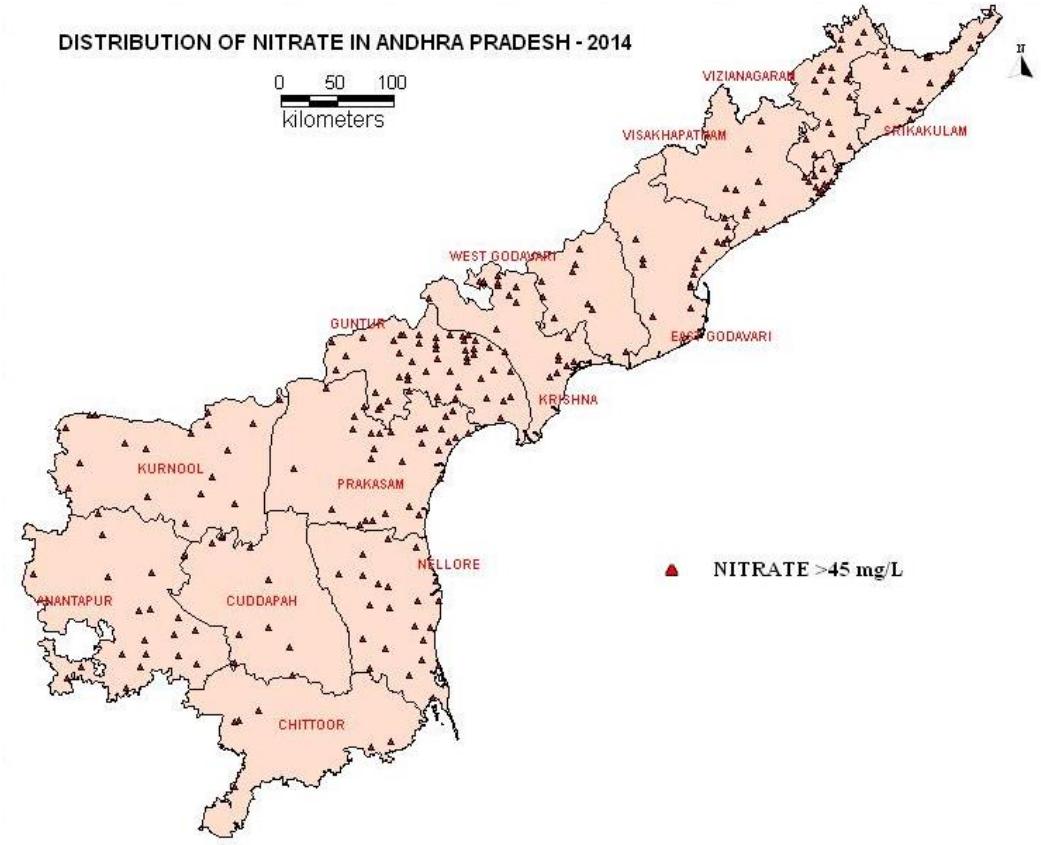
Fig.7.2



Nitrate

The presence of high nitrate concentration would normally indicate pollution of ground water at some state of its history. Since presence of excess nitrate ions is deleterious to human health, their occurrence in ground water is a matter of great concern. The leaching of nitrate from agriculture land has been a major research topic in recent years. Although commercial fertilizers are suspected to be a major source of nitrate in ground water, researchers have also identified natural organic nitrogen, livestock, septic tanks and atmospheric inputs as contributing factors. Nitrate exceeds the BIS permissible limit of 45 mg/L in 41.3% of the samples. The average Nitrate concentration (76 ppm) is much higher than BIS recommended. Distribution of Nitrate in Andhra Pradesh is shown in the Fig.7.3.

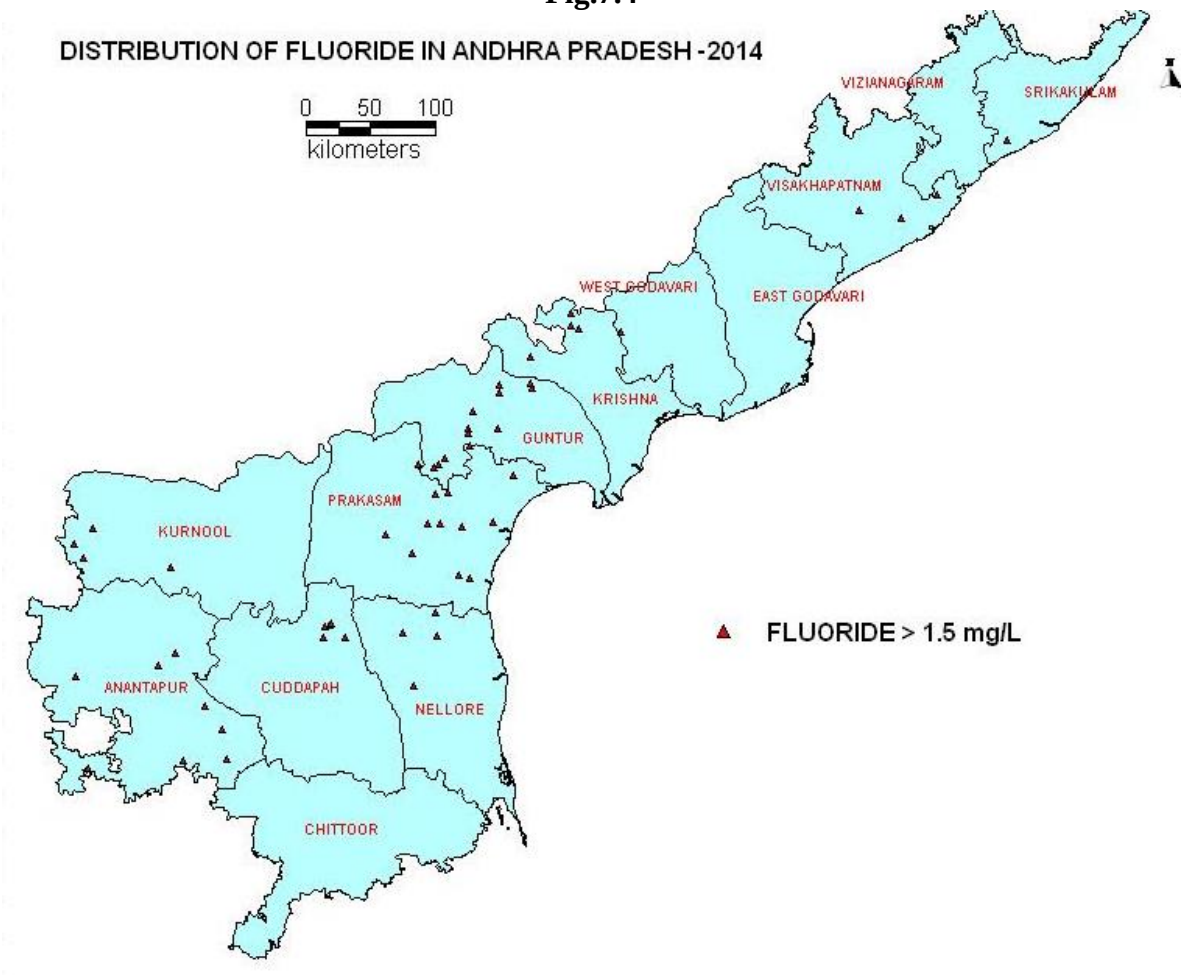
Fig.7.3



Fluoride

It is a minor constituent of natural water, but plays an important role in assessing the quality of water for domestic use. Deleterious effects of fluoride on human system are well known. Fluoride acts as two edged sword. It is beneficial when present in concentrations of 0.8-1.0mg/L for calcification of dental enamel especially for the children below 8 years of age. Below this limit it can cause dental carries. It can cause dental fluorosis if present in excess of 1.5mg/L and if such water consumed for long. Fluoride exceeds the BIS permissible limit of 1.5 mg/L in 9.2% of the samples of the state. The distribution of Fluoride in Andhra Pradesh is shown in the Fig.7.4.

Fig.7.4



7.2 Quality of ground water for drinking purpose

The hydro chemical data is compared with the drinking water quality standards set by Bureau of Indian Standards to assess the suitability of ground water from shallow aquifers in Andhra Pradesh, for drinking purposes. The minimum, maximum and average concentrations of various chemical parameters in ground water in the state are presented in the Table-7.1 and unsuitability of the ground water from shallow aquifers for drinking purposes with reference to chemical parameters is presented in the Table-7.2. Spatial distribution of electrical conductivity, chloride, nitrate and fluoride in the state are shown in the Fig.7.1 to 7.4. In general, the ground water from shallow aquifers in the state is alkaline in nature and average p^H value is 8.02.

Electrical conductivity in the state varies from 58 to 12040 µs/cm at 25^0C with an average value of 1789 µs/cm at 25^0C. In Krishna district the average value of EC is highest followed by Guntur and Kurnool, in all 15.6% of samples are beyond permissible limit of BIS. It is also evident from the Fig.1 that majority of samples have EC values between 750-3000µs/ cm.

Chloride Content in shallow ground water varies from 7.1 to 3226 mg/L. 4.4% of samples in the state exceeds the BIS permissibility. Highest percent of samples in West Godavari and Krishna districts are unsuitable for drinking. It is evident from Fig.7.2 that chloride value is less than 250 mg/L in majority of samples.

The average Nitrate content in ground water is 76 mg/L. 41.3% of samples are exceeding the BIS permissible limit indicating the anthropogenic contamination. Highest percent of samples in Anathapur, Kurnool and Guntur districts are unfit for drinking.

Fluoride content in the state varies from traces to 5.4 mg/L, with an average of 0.64 mg/L. 9.2% of samples exceeds BIS permissibility. Highest percent of samples in Ananthapu and followed by Kadapa and Prakasam districts are unfit for drinking.

Table-7.1
Conceentration of Chemical Parameters in Ground Water in Andhra Pradesh
(Minimum, Maximum and Average)

District	Maxima Minima Average	pH	EC µs/cm at 25^0C	Cl	NO3	F
				mg/L		
ANDHRA PRADESH	Maxima	9.29	12040	3226	1095	5.4
	Minima	6.84	58	7.1	0.0	0.00
	Average	8.02	1789	301	76	0.64
Srikakulam	Maxima	8.89	4860	1347	232	2.7
	Minima	7.52	260	35	0.90	0.04
	Average	8.17	1250	225	54	0.42
Vizianagaram	Maxima	8.98	4313	1064	248	1.4
	Minima	7.39	270	18	0.00	0.20
	Average	8.14	1115	195	51	0.61
Visakhapatnam	Maxima	9.08	3960	752	565	2.7
	Minima	7.54	58	7.1	0.00	0.00
	Average	8.12	1068	145	63	0.49
East Godavari	Maxima	8.78	5170	1198	283	1.4
	Minima	7.57	108	11	0.00	0.03
	Average	8.13	1462	261	49	0.35
West Godavari	Maxima	9.29	11510	3226	149	2.6
	Minima	7.98	198	21	1.00	0.02
	Average	8.64	1993	441	26	0.31
Krishna	Maxima	8.22	9200	2056	189	3.3
	Minima	7.34	770	64	0.91	0.02
	Average	7.86	2486	415	51	0.51
Guntur	Maxima	8.30	7864	2.56	829	3.1
	Minima	6.90	555	50	0.40	0.04
	Average	7.88	2221	367	122	0.72
Prakasam	Maxima	9.04	12040	2730	1095	5.4
	Minima	7.35	364	14	0.0	0.02
	Average	8.05	2069	338	114	1.06
Nellore	Maxima	8.26	5730	1588	287	3.8
	Minima	7.40	389	7.1	0.34	0.02
	Average	8.03	1686	282	52	0.63
Chittoor	Maxima	8.70	4284	1021	180	1.5
	Minima	7.10	271	32	0.00	0.10
	Average	7.68	1609	292	30	0.53
YSR Kadapa	Maxima	8.72	3430	581	518	2.01
	Minima	7.20	551	28	2.0	0.19
	Average	87.82	1818	265	76	0.85
Anathapur	Maxima	8.57	5370	993	590	4.0
	Minima	6.84	560	16	6.00	0.05
	Average	7.76	2074	281	163	1.07
Kurnool	Maxima	8.24	8940	1560	699	3.1
	Minima	6.90	265	32	0.88	0.09
	Average	7.92	2178	368	129	0.82

Table- 7.2
Unsuitability of Samples With Respect To Different Chemical Constituents.

District	Total Samples	% of Samples Unsuitable			
		EC	Cl	NO3	F
Srikakulam	37	5.4	2.7	43.2	2.7
Vizianagaram	42	7.1	2.4	45.2	0.0
Visakhapatnam	62	4.8	0.0	37.1	4.8
East Godavari	57	12.3	3.5	28.1	0.0
West Godavari	39	23.1	15.4	23.1	2.6
Krishna	61	29.5	6.6	32.8	6.6
Guntur	82	23.2	6.1	56.1	13.4
Prakasam	58	17.2	5.2	51.7	24.1
Nellore	61	16.1	4.8	35.5	6.5
Chittore	31	9.7	3.2	22.6	0.0
Kadapa	22	9.1	0.0	36.4	22.7
Ananthapur	32	15.6	0.0	62.5	28.1
Kurnool	33	15.2	3.0	57.6	15.2
Andhra Pradesh	617	15.6	4.4	41.3	9.2

7.3 Quality for irrigation

The most extensive use of ground water in the world is for the irrigation consumption. The chemical quality of ground water is an important factor to be considered in evaluating its usefulness for irrigation as poor quality ground water may cause salinity, specific ion toxicity or infiltration problem in soil. Such effect of irrigation may adversely affect crop production. Successful usage of water for irrigation depends on many factors not directly associated with water consumption.

In addition to the quality of water used for irrigation purposes, it is also important to know nature of soil, nature of crop, climate condition. In arid regions soil of heavy texture and of high pH, usually develop alkalinity and salinity problems much more quickly than the light sandy soils. Besides texture, permeability, drainage, water table, calcium status and pH are other factors, which govern the effect of the water on the properties of the soil. Some crops are more tolerant to saline water than others. In areas of good rainfall even low quality of water can be used with advantage as number of irrigations would be small and high rainfall will have moderate effect by leaching salts.

Water quality constraints in irrigation can be examined using a number of empirical indices that have been established on the basis of field experience and experiments. Each has been useful but none has been entirely satisfactory because of the wide variability in field condition.

US salinity laboratory classification

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

$$SAR = (Na^{+})/Sqrt\{(Ca^{+2}+Mg^{+2})/2\}$$

Where concentrations are expressed in meq/L

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

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

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

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

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

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

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

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

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

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

US salinity diagram (Fig.7.5) indicating irrigation suitability of ground water in the state reveals that 32.6% of water samples are falling in C_2S_1 class. 32% are C_3S_1 class, 18.3% in C_3S_2 class. 3.7% in C_3S_3 and 3.2% of samples falling in C_4S_4 class Remaining samples are falls in C_1S_1, C_4S_3, C_4S_2 and C_2S_2 classes respectively. The district wise US salinity diagrams are given in the Fig.7.5A-J.

Trilinear diagram for suitability of ground water for the state and district wise are presented in the Fig.7.6 and 7.6A-J.

Fig.7.5

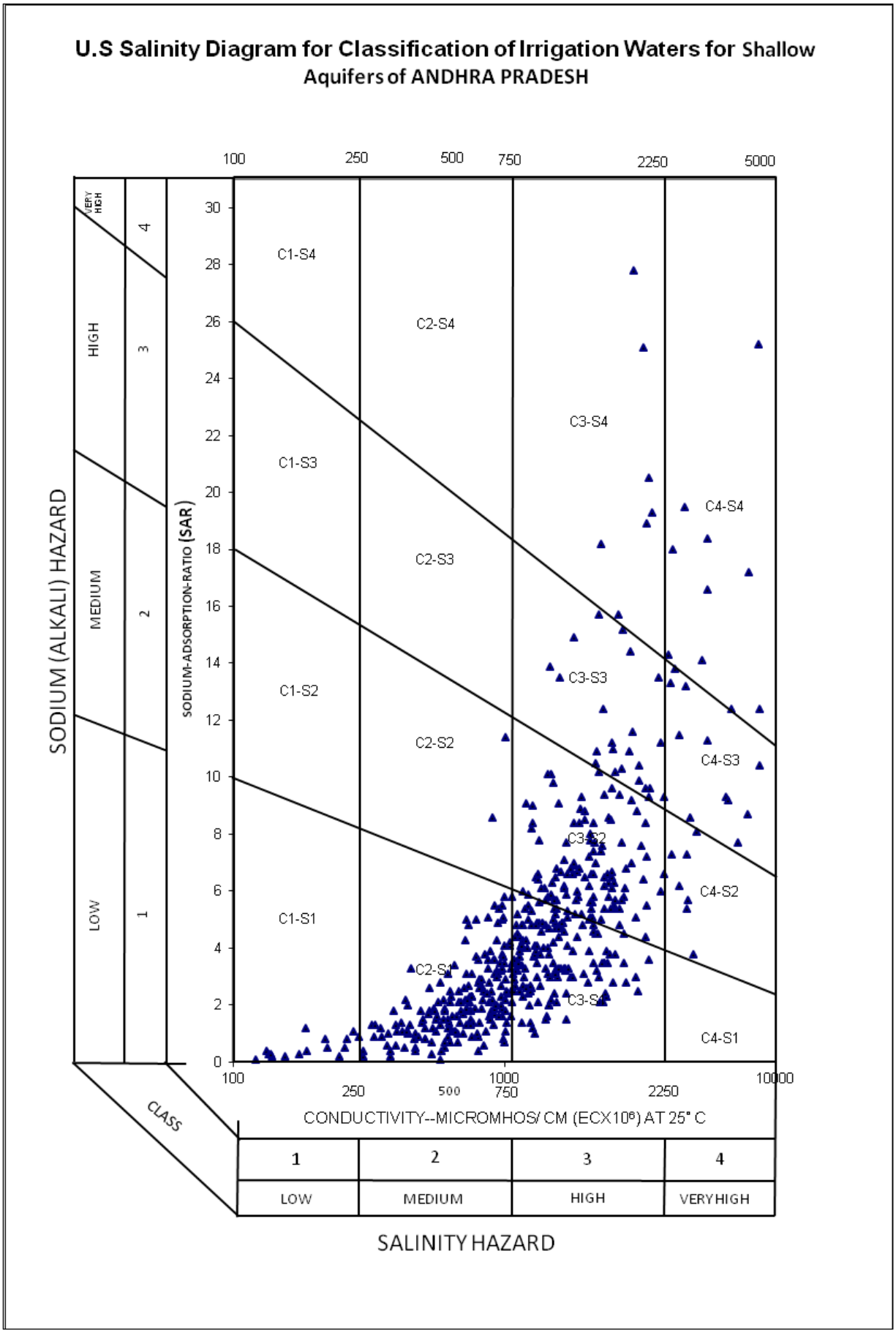
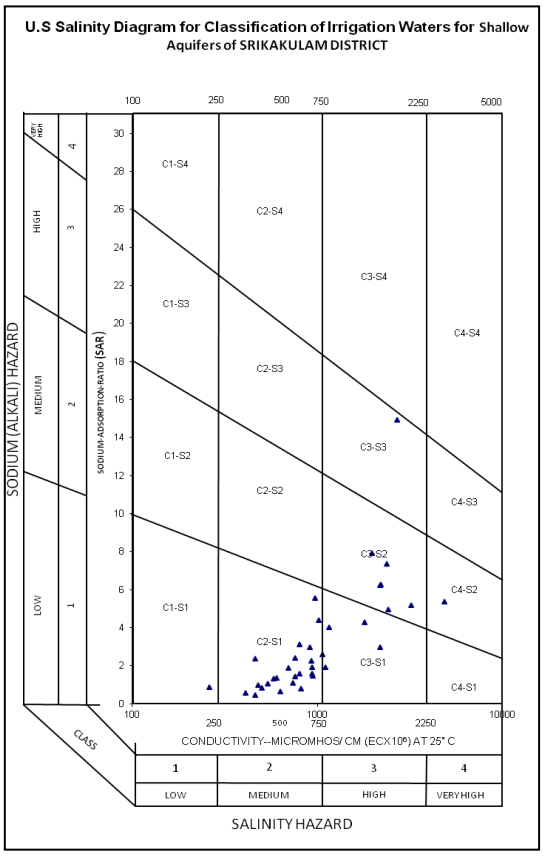
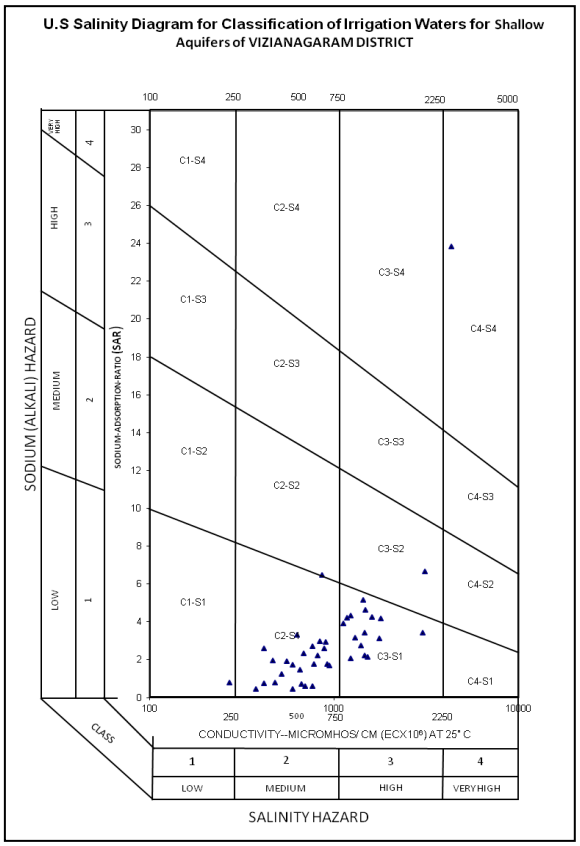
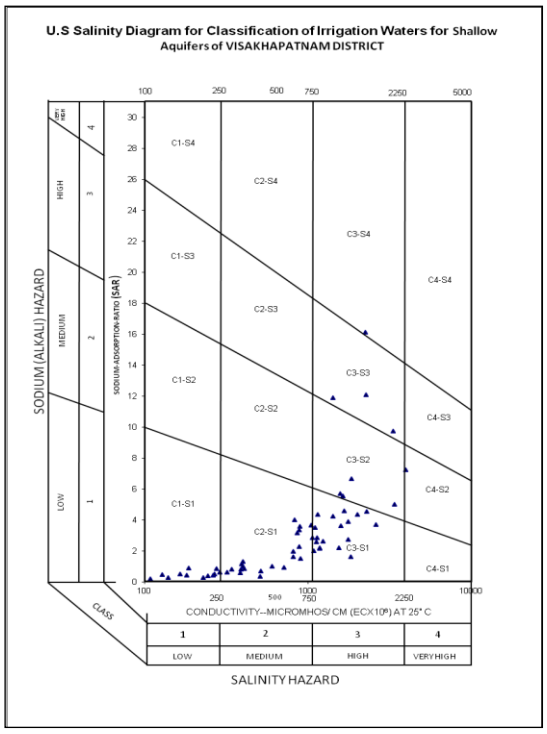
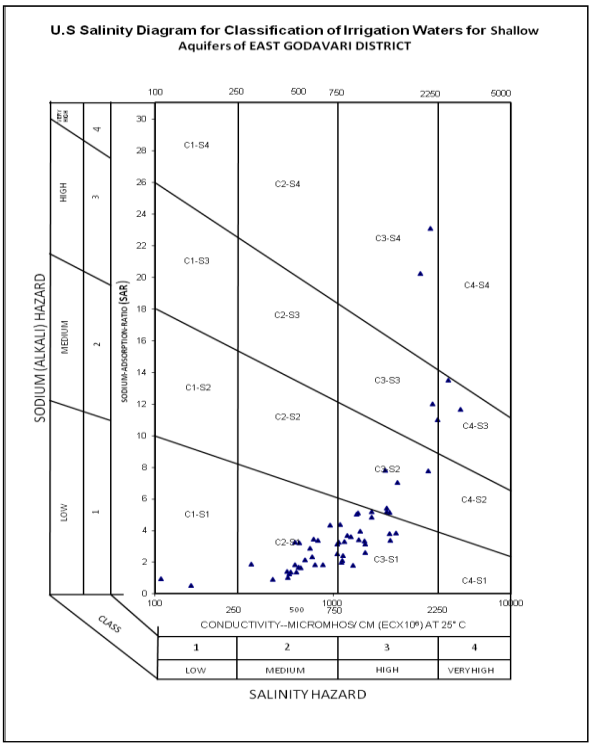


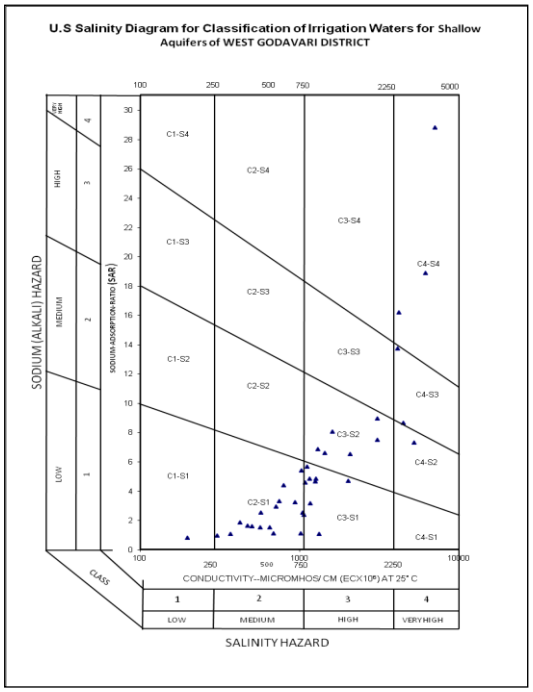
Fig.7.5A-J

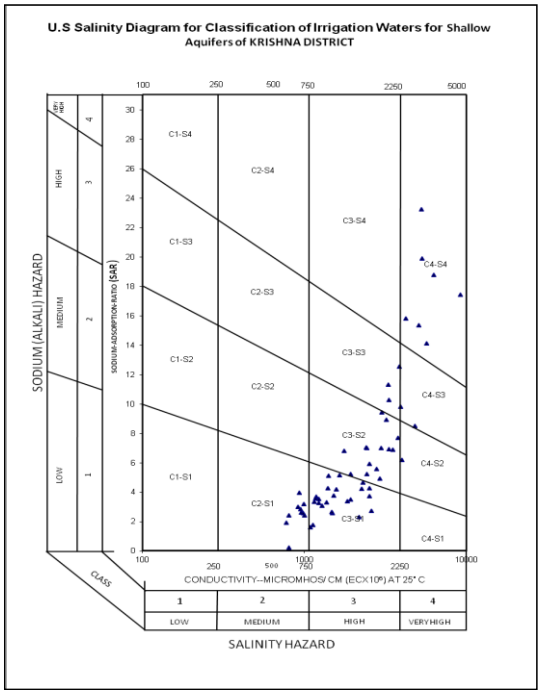

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow
Aquifers of SRIKAKULAM DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4

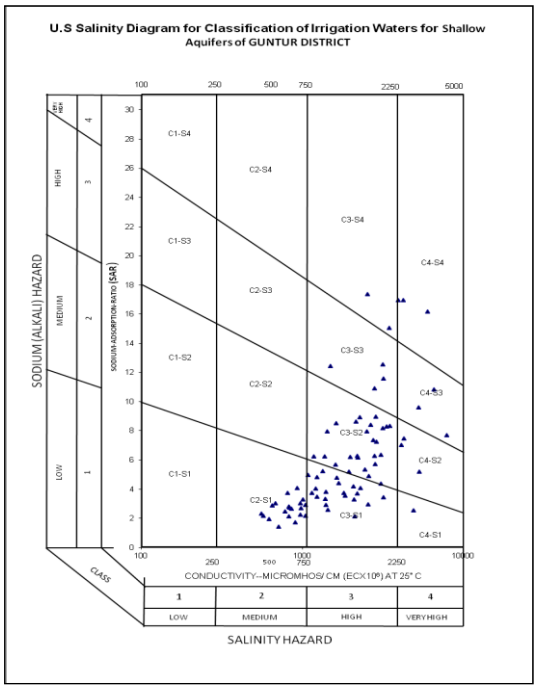

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow
Aquifers of VIZIANAGARAM DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4

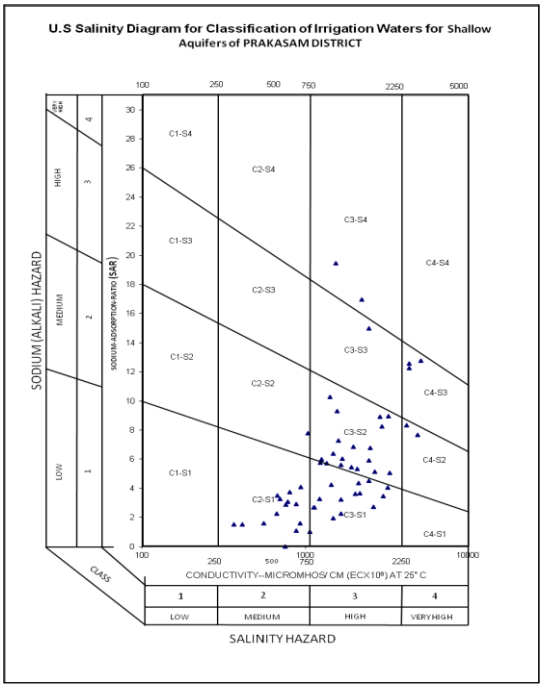

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow
Aquifers of VISAKHAPATNAM DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4

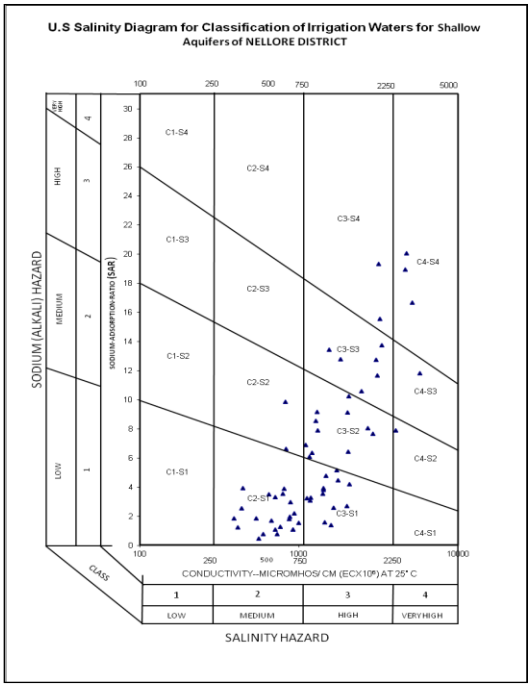

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow
Aquifers of EAST GODAVARI DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4

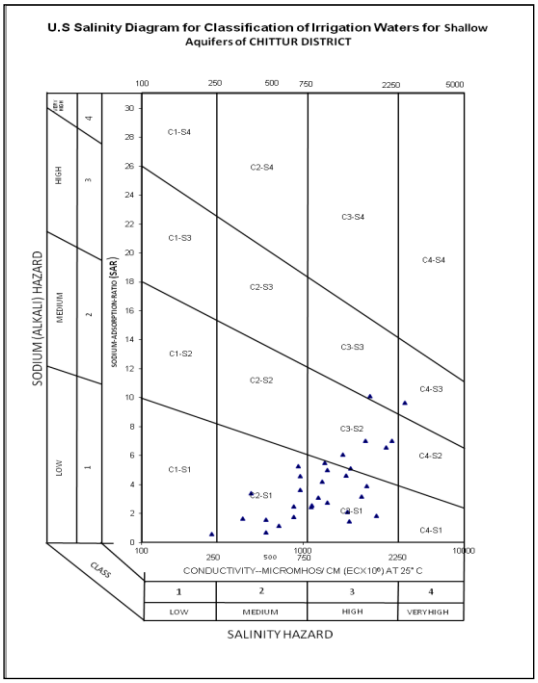

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of WEST GODAVARI DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of KRISHNA DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of GUNTUR DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of PRAKASAM DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S1
C1-S2
C1-S3
C1-S4
C2-S1
C2-S2
C2-S3
C2-S4
C3-S1
C3-S2
C3-S3
C3-S4
C4-S1
C4-S2
C4-S3
C4-S4


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of NELLORE DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S4
C2-S4
C3-S4
C4-S4
C1-S3
C2-S3
C3-S3
C4-S3
C1-S2
C2-S2
C3-S2
C4-S2
C1-S1
C2-S1
C3-S1
C4-S1


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of CHITTUR DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S4
C2-S4
C3-S4
C4-S4
C1-S3
C2-S3
C3-S3
C4-S3
C1-S2
C2-S2
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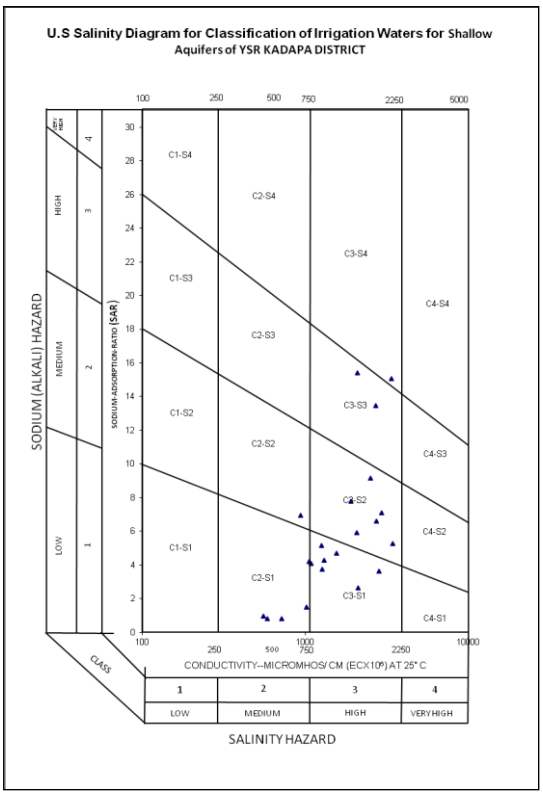
C1-S1
C2-S1
C3-S1
C4-S1


U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of YSR KADAPA DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S4
C2-S4
C3-S4
C4-S4
C1-S3
C2-S3
C3-S3
C4-S3
C1-S2
C2-S2
C3-S2
C4-S2
C1-S1
C2-S1
C3-S1
C4-S1

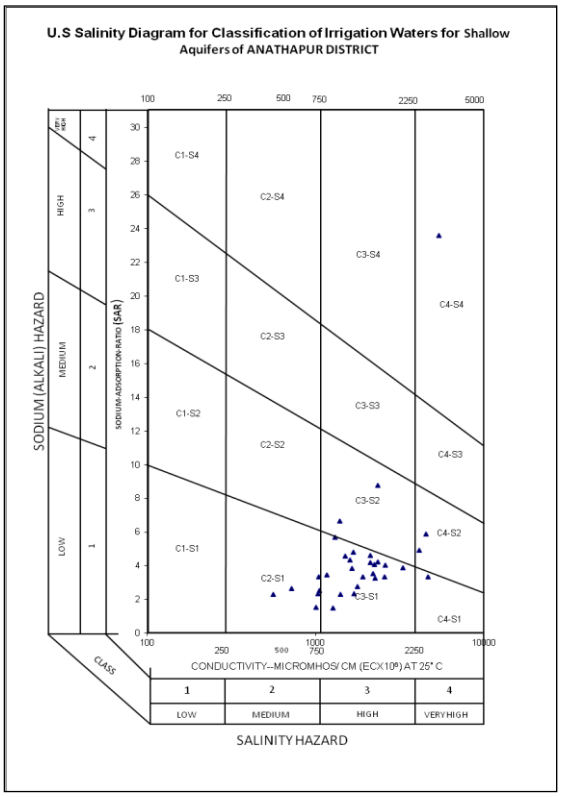

U.S Salinity Diagram for Classification of Irrigation Waters for Shallow Aquifers of ANATHAPUR DISTRICT
SODIUM (ALKALI) HAZARD
SODIUM-ADSORPTION-RATIO (SAR)
CONDUCTIVITY--MICROMHOS/ CM (ECX10⁶) AT 25° C
SALINITY HAZARD
CLASS
LOW
MEDIUM
HIGH
VERY HIGH
C1-S4
C2-S4
C3-S4
C4-S4
C1-S3
C2-S3
C3-S3
C4-S3
C1-S2
C2-S2
C3-S2
C4-S2
C1-S1
C2-S1
C3-S1
C4-S1

Fig.7.5J

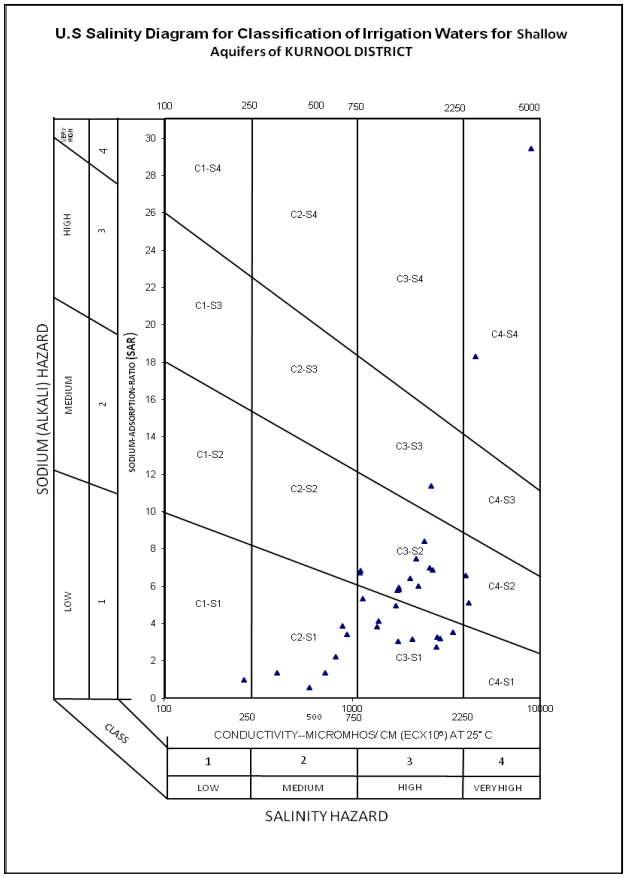


Fig.7.6

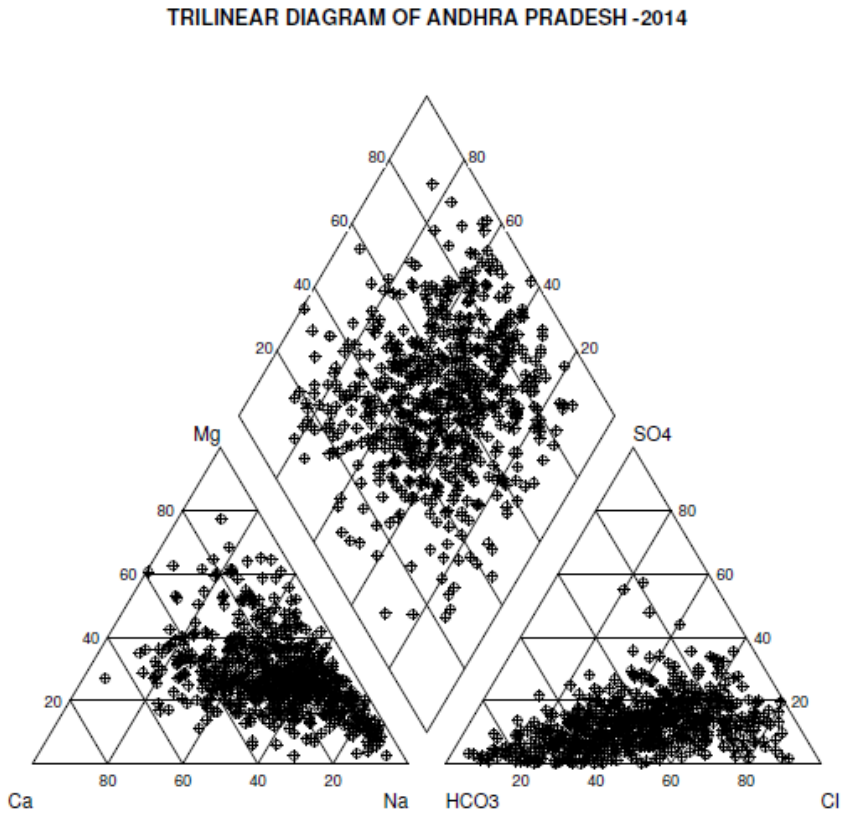
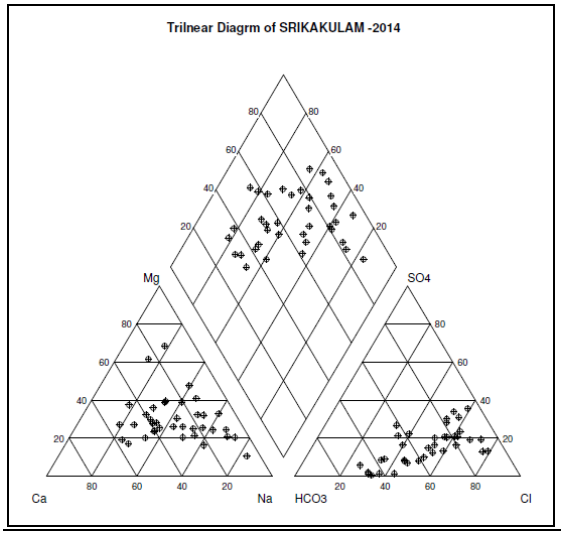
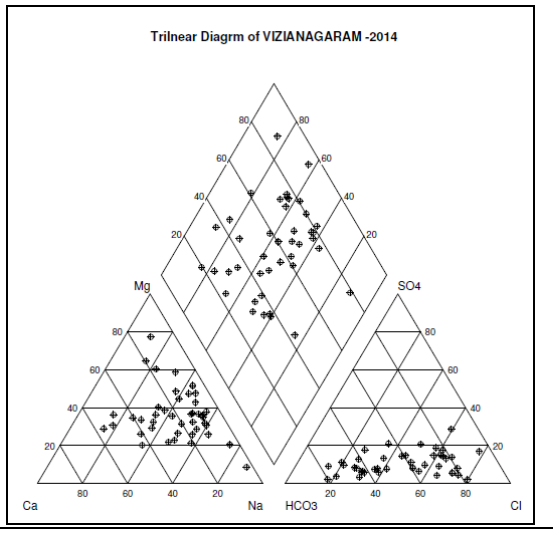
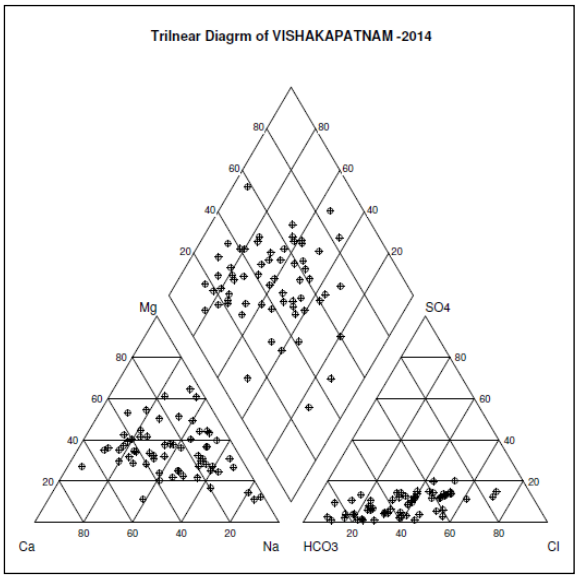
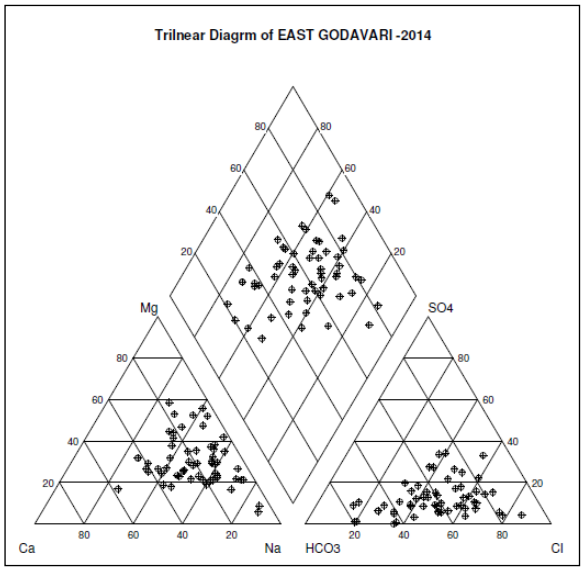


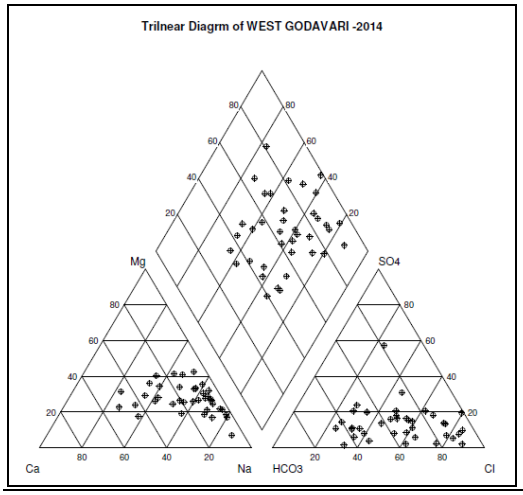
Fig.7.6A-J

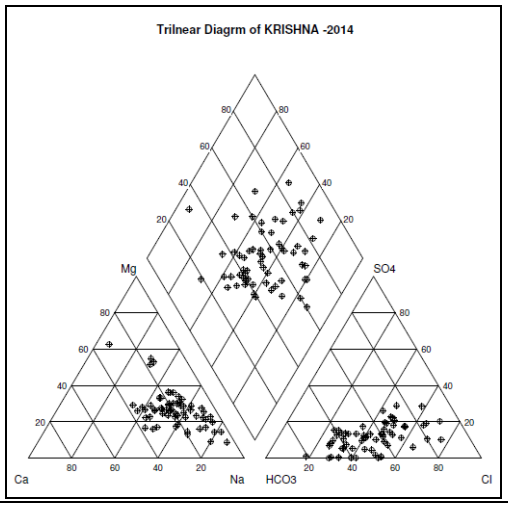

Trilnear Diagrm of SRIKAKULAM -2014
Mg
SO4
Ca
Na
HCO3
Cl

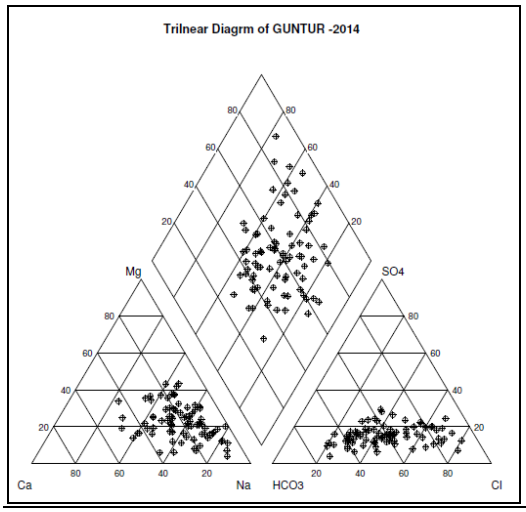

Trilnear Diagrm of VIZIANAGARAM -2014
Mg
SO4
Ca
Na
HCO3
Cl

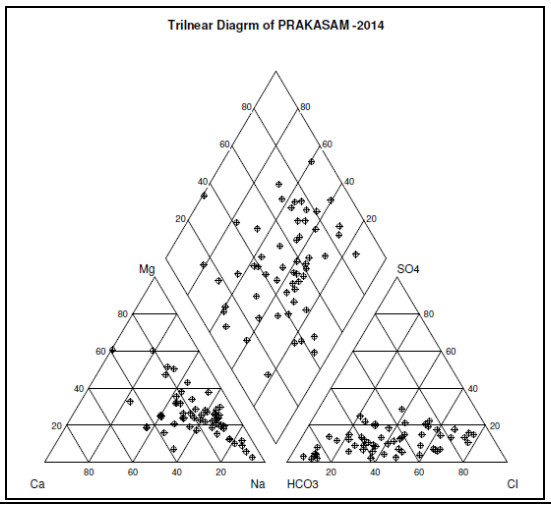

Trilnear Diagrm of VISHAKAPATNAM -2014
Mg
SO4
Ca
Na
HCO3
Cl

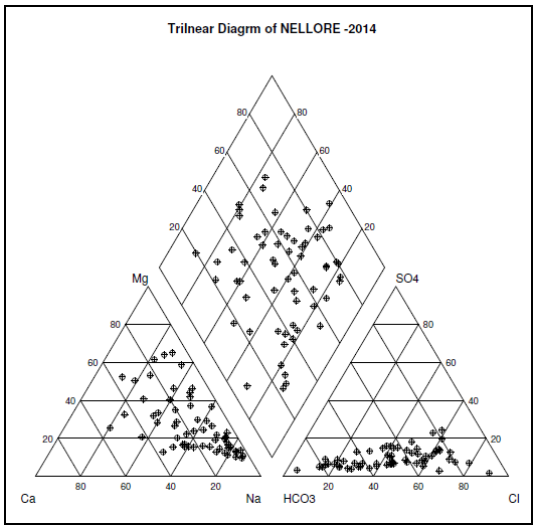

Trilnear Diagrm of EAST GODAVARI -2014
Mg
SO4
Ca
Na
HCO3
Cl

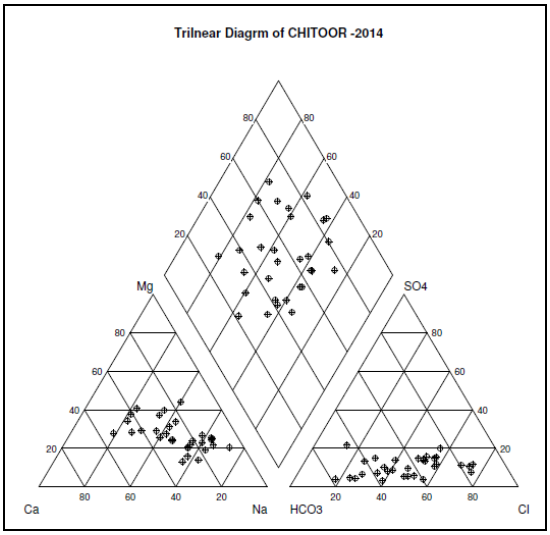

Trilnear Diagrm of WEST GODAVARI -2014
Mg
SO4
Ca
Na
HCO3
Cl

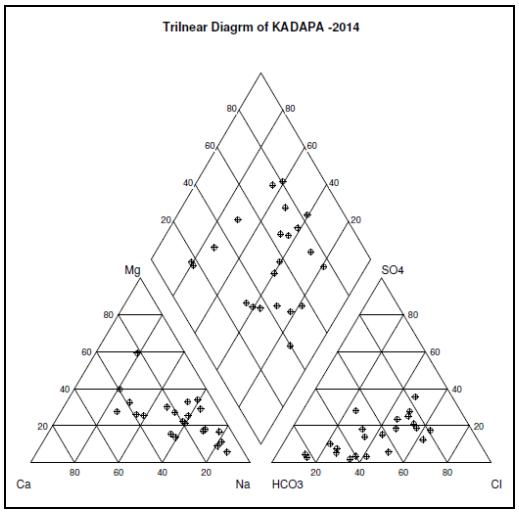

Trilnear Diagrm of KRISHNA -2014
Mg
SO4
Ca
Na
HCO3
Cl

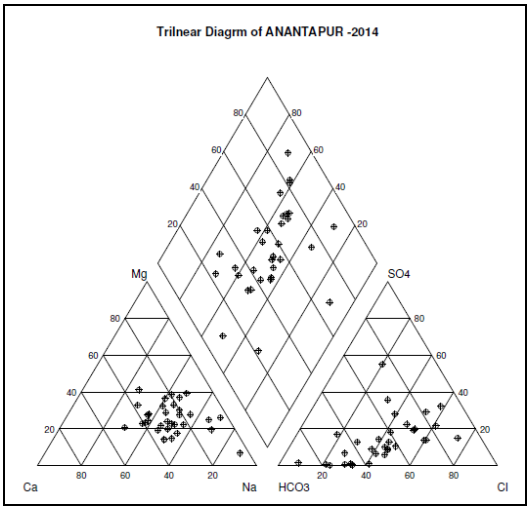

Trilnear Diagrm of GUNTUR -2014
Mg
SO4
Ca
Na
HCO3
Cl

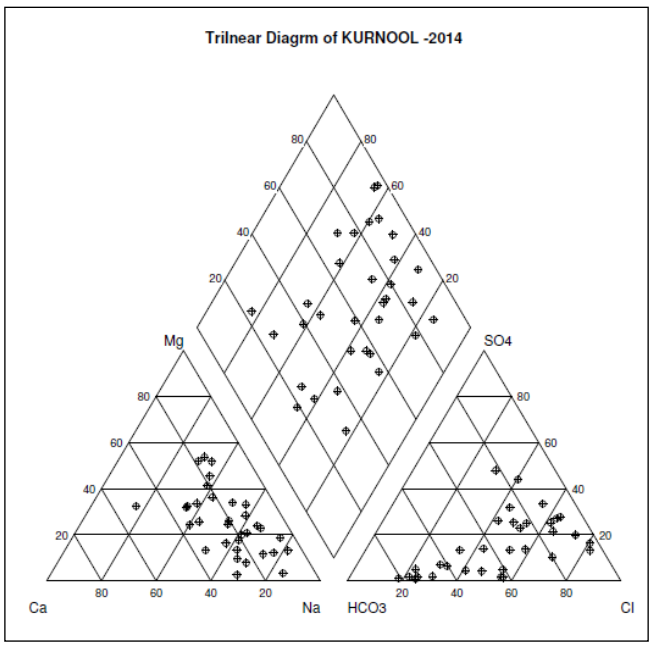

Trilnear Diagrm of PRAKASAM -2014
Mg
SO4
Ca
Na
HCO3
Cl


Trilnear Diagrm of NELLORE -2014
Mg
SO4
Ca
Na
HCO3
Cl


Trilnear Diagrm of CHITOOR -2014
Mg
SO4
Ca
Na
HCO3
Cl







7.4 WATER QUALITY FOR LIVE STOCK AND POULTRY

Though there was no Livestock standards regulated in India, basing on FAO and other international organizations standards classified the water quality for Livestock and Poultry. One of the important parameter is Salinity/Electrical Conductivity, which moderately shows the suitability of most of the samples in usable. Magnesium and Nitrate are other important parameters to be considered for the usage of ground water for the livestock. Magnesium is with in the range specified. Nitrate is suitable for the live stock, except in one case. The guide for usage of saline water for live stock and poultry purpose is given in the Table-7.3 &5.

Table- 7.3
Guide for use of saline water
for livestock and poultry and no of samples in limits

Soluble salt content	Rating	No of samples in the range	Uses
< 1 000 mg/Litre (<1.5 dS/m)	Excellent	345	Excellent for all classes of livestock and poultry
1 000-3 000 mg/Litre (1.5-5 dS/m)	Very satisfactory	250	Satisfactory for all classes of livestock. May cause temporary mild diarrhoea in livestock not accustomed to them. Those waters approaching the upper limits may cause some watery droppings in poultry.
3 000-5 000 mg/Litre (5-8 dS/m)	Satisfactory for livestock Unfit for poultry	18	Satisfactory for livestock but may be refused by animals not accustomed to it. If sulphate salts predominate, animals may show temporary diarrhoea. Poor waters for poultry, often causing watery faeces, increased mortality and decreased growth especially in turkeys.
5 000-7 000 mg/Litre (8-11 dS/m)	Limited use for livestock Unfit for poultry	3	This water can be used for livestock except for those that are pregnant or lactating. It may have some laxative effect and may be refused by animals until they become accustomed to it. It is unsatisfactory for poultry
7 000-10 000 mg/Litre (11-16 dS/m)	Very limited use	1	Considerable risk for pregnant and lactating cows, horses, sheep and for the young of these species. It may be used for older ruminants or horses. Unfit for poultry and probably swine.
> 10 000 mg/Litre (> 16 dS/m)	Not recommended	0	This water is unsatisfactory for all classes of livestock and poultry.

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

Table-7.4
Suggested Limits For Magnesium In Drinking Water For Livestock[1]

Livestock	No of Samples within the range	Magnesium (mg/L)	Concentration (me/l)
Poultry[2]	615	<250	<21
Swine[2]	615	<250	<21
Horses	615	<250	<21
Cows (lactating)	615	<250	<21
Ewes with lambs	615	<250	<21
Beef cattle	616	<400	33
Adult sheep on dry feed	617	<500	41

[1] Adapted from Australian Water Resources Council (1969).
[2] The tolerance of swine and poultry for magnesium is unknown but could well be less than 250 mg/L.

Table-7.5

Guide for usage of waters containing nitrate for livestock

Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO3-N)**	As Nitrate, NO3	No samples in the range	Comments
Less than 100	<440	603	Experimental evidence indicates this water should not harm livestock or poultry.
100 to 300	440 – 1320	14	This water by itself should not harm livestock or poultry. If hays or silages contain high levels of nitrate this water may contribute significantly to a nitrate problem in cattle, sheep, or horses.
More than 300	> 1320	0	This water could cause typical nitrate poisoning in cattle, sheep, or horses, and its use for these animals is not recommended. Because this level of nitrate contributes to the salts content in a significant amount, use of this water for swine or poultry should be avoided.

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

**** The values shown include nitrate and nitrite nitrogen. In no case should the waters contain more than 50 ppm nitrite nitrogen (NO2N) because of the greater toxicity of the nitrite form.***

*****1 ppm of nitrate nitrogen is equivalent to 4.4 ppm of nitrate (NO3).***

7.5 Over view of ground water quality

- Monitored 617 ground water monitoring wells in Andhra Pradesh to assess the quality of shallow ground waterduring May, 2014.
- In general pH is in the range of 6.8 to 9.3.
- Electrical conductivity is beyond 3000 micromhos/cm in 15.6% of the samples. In general it is in the range of 750-3000 micromhos/cm.
- Alkalinity exceeds BIS limit of 600 mg/L in 72 samples.
- Sodium is in the range of 0.2 - 2387 mg/L.
- Potassium is in the range of traces to 650 mg/L. In general it is in the range of 3 to 25 mg/L.
- Only 4.4% of the samples have chloride concentration beyond BIS permissible limit. In general it is in the range of 50 to 500 mg/L.
- Sulphate exceeds the BIS permissible limit of 400 mg/L in 3.1% of the samples. In general it is in the range of 5 to 50 mg/L.
- Fluoride exceeds the BIS permissible limit of 1.5 mg/L in 9.2% of the samples. In general it is in the range of 0.3 to 1.0 mg/L.
- Majority of the wells in the state fall in water samples are falling in C_2S_1 class and followed by C_3S_1 , C_3S_2 C_3S_3, C_4S_4, C_1S_1, C_4S_3, C_4S_2 and C_2S_2 classes.
- Dominant Water types of the state are Na-Cl, Na-HCO3, Na-Ca-Cl-HCO3 and Na-Mg-HCO3 type.
- Most of the samples are suitable for livestock and poultry consumption.
- Highest Electrical Conductivity (12040 μS/cm) found at Guttalaumadivrm of Prakasam district, mostly saline water intrusion.
- Highest Hardness (2500 mg/L) found at Marteru of West Godavari district.
- Highest Chloride (3226 mg/L) found at Marteru of West Godavari district, and also indicative of Saline water intrusion.
- Highest Sulphate (1286 mg/L) found at Gulyam-DW of Kurnool district.
- Highest Nitrate (1095 mg/L) found at Guttalaumadivrm of Prakasam district.
- Highest Fluoride (5.4 mg/L) found at Sitapalli of East Godavari district.

CONSERVE WATER FOR THE FUTURE

CENTRAL GROUND WATER BOARD
Ministry of Water Resources,
River Development & Ganga Rejuvenation
Govt. of India

Southern Region
GSI Post, Bandlaguda
Hyderabad – 500 068
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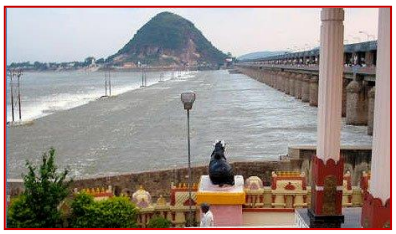

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