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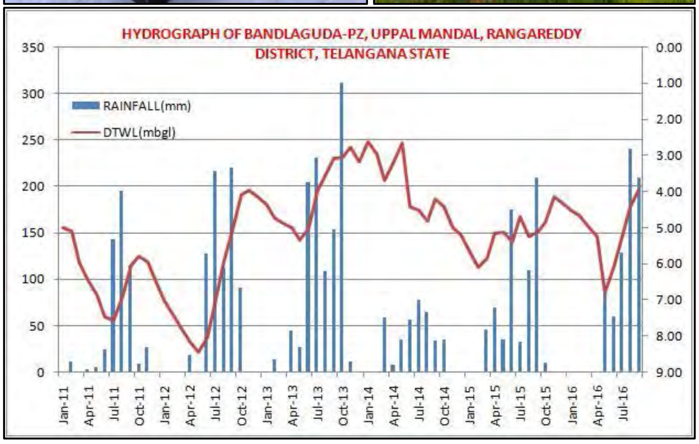
Central Ground Water Board

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

GROUND WATER YEAR BOOK
2015-16
TELANGANA STATE



Southern Region, Hyderabad
October, 2016

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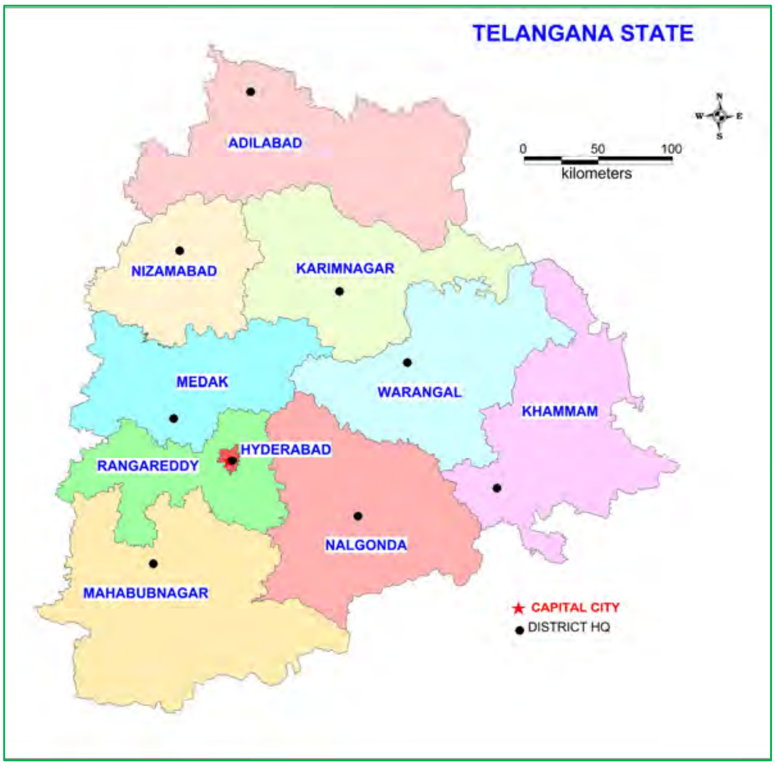

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GROUND WATER YEAR BOOK
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FOREWORD

The historical ground water level monitoring data is useful in understanding changes in ground water regime in time and space and for preparation of sustainable development plan for the state. Central Ground Water Board has been monitoring ground water regime since 1969. During the year 2015-16, 53 new ground water monitoring wells were established and 23 wells were abandoned due to various reasons. As on 31-3-2016, total 766 operational ground water monitoring stations (GWMS) (Dug wells: 354 & Piezometer wells: 412) are in operation. These stations are being monitored four times a year viz., May, August, November and January to study the seasonal and long term changes. The water samples are collected during May for chemical analysis.

The ground water level monitoring carried out by Central Ground Water Board, Southern Region, Hyderabad during 2015-16 is compiled in the form of Ground Water Year Book. It outlines the ground water level behavior in the current year with reference to the corresponding periods of previous year and also with last decadal mean. It also elaborates the chemical quality of ground water.

The sincere efforts made by **Dr. Pandith Madhnure, Scientist-D, Sri. P.Sudhakar, Scientist-D (HM)** in preparation of the report is commendable. The effort from officers of chemical laboratory namely Sh. K. Bhaskar Reddy, Sh. K. Maruthi Prasad and Sh Y. Satyakumar who analyzed the samples and contributed technically is note worthy. Sh. GRC Reddy, Scientist-D, Smt. S.Renuka, Scientist-B (GP) and Sh. B.J. Madhusudhan, AHg of Report Processing Section in scrutiny, processing and issuance of the report are also appreciated.

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

Hyderabad **(A. D. RAO)**
Dated: 31/10/2016 **REGIONAL DIRECTOR**

EXECUTIVE SUMMARY

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

Telangana State covering ~1.12 lakh Km^2 lies between NL 15° 48′ and 19° 54′ and EL 77° 12 ′ and 81° 50 and governed administratively by 10 districts. The total population of the state is ~3.5 crores and shown a decadal growth of 13.6 %. Drainage of the state can be divided into 2 major and 11 sub-basins and ~60% of the soils are red in colour.

Forests occupy ~24% of the total area and ~43% is under cultivation. About 75% of irrigation is contributed by ground water and remaining by surface water.

During the year 2015, State received annual rainfall of in the range of 472 mm (Mahabubnagar district) to 997 mm in Khammam district with average of 710 mm, i.e., 25 % less than the normal rainfall (939 mm) and drought conditions occurred in 5 districts (Nizamabad, Medak, Rangareddy, Mahabubnagar and Hyderabad). South-west monsoon season (June-Sept) contributes 80% of rainfall, north-east monsoon (Oct-Dec) contributes 13%, winter rainfall contributes 1% and summer contributes ~6% of rainfall in the state.

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

The annual replenishable ground water resources are 14744 MCM, natural discharge during non-monsoon period is 1354 MCM, net ground water availability is 13390 MCM. The annual gross ground water draft is 7766 MCM, allocation for future domestic and industrial use is 1554 MCM and net ground water availability for future irrigation use is 4823 MCM. The average stage of ground water development is 58% and 46 mandals categorized as over-exploited, 12 mandals as critical, 74 mandals as semi-critical and remaining 311 mandals as safe category.

Ground water monitoring is carried out 4 times in a year (January, May, August and November) and ground water quality one time (May). As on 31/03/2016, total of 766 Ground Water Monitoring Stations (GWMS) (Dug wells: 354 and Piezometer wells: 412) exist.

There are 148 parahydrogeologists who are appointed to monitor GWMS on participatory mode (all dug wells).

Density of monitoring wells varies from 1 well per 8 Km^2 (Hyderabad) to 1 well per 222 Km^2 in Mahabubnagar district with average of 1 well per 146 Km^2. Hard rock aquifers (BGC) have maximum number of wells i.e., 575 and charnokite have only one well. In Krishna basin maximum wells i.e., 420 wells when compared to Godavari basin i.e., 346 wells are in existence.

The water levels are deep during May when compared to November. During May 2015 (pre-monsoon season) water levels are in the range of 0.33 m bgl to 46.10 m bgl with the range of 5-10 m bgl more predominant (~48%) of the area. Shallow water levels in the range of 2-5 m bgl and deep water levels >20 mbgl occupy ~9 % and 4% of the total area respectively.

During August 2015 (mid-monsoon season) water levels are in the range of 0.1 m bgl to 50.98 m bgl with the range of 5-10 m bgl more predominant occupying ~33% of the area followed by 2-5 mbgl (30% area). Moderate deep water levels (10-20 mbgl) occupy ~24% and deep water levels (>20 mbgl) occupy ~6 % of the area.

During November 2015 (post-monsoon season) water levels are in the range of 0.07 m agl to 59.4 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~37 % of the area followed by 2-5 mbgl (29 % area). Moderate deep water levels (10-20 mbgl) occupy ~5 % and deep water levels (>20 mbgl) occupy ~8 % of the area.

During January 2016, water levels are in the range of 0.3 m bgl to 69.5 m bgl and water levels in the range of 5-10 m bgl are more predominant occupying ~42 % of the area followed by 10-20 mbgl (31 % area). Shallow water levels (2-5 mbgl) occupy ~19 % and deep water levels (>20 mbgl) occupy ~8 % of the area.

Annual water level fluctuation during May-2015 Vs May-14 have shown fall in water levels in 89% of the area due to less rainfall (-49%) than the previous year. Maximum rise of 19.2 m is observed in Adilabad district and maximum fall is noticed in Rangareddy district (36.82m) and all districts excluding Khammam have shown fall in water levels.

Annual water level fluctuation during Aug-2015 Vs Aug-14 have shown fall in water levels in 68 % of the area due to less rainfall (-30%) than the normal rainfall during the period. Maximum rise > 4 m is recorded in Adilabad, Warangal, Khammam and Mahabubnagar district and maximum fall > 4 m is noticed in all districts excluding Khammam and Hyderabad districts.

Annual water level fluctuation during Nov-2015 Vs Nov-2014 have shown fall in water levels in 62 % of the area. The minimum (0.06 m) and maximum rise (24.35 m) recorded in Warangal and Rangareddy districts respectively. The minimum (0.01 m) and maximum fall (30.8 m) recorded in Warangal and Mahabubnagar districts respectively.

Annual water level fluctuation during January-2016 Vs January-15 have shown fall in water levels in 83 % of the area. The minimum (0.01 m) and maximum rise (16.33 m) recorded in Khammam and Nalgonda district respectively. The minimum (0.01 m) and maximum fall (47.00 m) recorded in Khammam and Medak districts respectively.

Water levels during May-15, August-15, November-15 and January-16 as compared to decadal water levels, have shown fall in most of the wells as well as most of the area, due to less rainfall during these months.

Aquifer wise water level analysis shows that during pre-monsoon season water levels are shallowest (0.3 m bgl) and deepest (40.5 mbgl) in banded gneissic complex (BGC). Deepest water levels (46.1 mbgl) during pre-monsoon season are recorded in basalt formation and during post-monsoon season in BGC (59.4 mbgl).

Out of representative 20 wells, the long-term water levels trend in 9 wells have shown rising trend in both seasons and in 8 wells, falling trend in both seasons. In 2 wells rising trend, during pre-monsoon season and falling trend in post-monsoon season were observed and 1 well shows falling trend during pre monsoon and rising trend during post-monsoon season. During pre-monsoon season rise of 0.01 to 0.7 m and fall of 0.02 to 0.2 m is observed and in post-monsoon season rise of 0.007 to 0.6 m and fall of 0.01 to 0.13 m is observed.

Ground water quality is assessed during pre-monsoon season of 2015 by collecting 311 samples from both dug wells and peizometer wells and 16 parameters namely pH, EC (in µS/cm at 25°C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3, F, TDS, Fe and As were analyzed as per standard guidelines laid down in APHA and suitability of ground water for drinking purposes is assessed as per BIS guidelines and for irrigation as per USSL, Percent Na and RSC.

Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 6.6-8.6. Electrical conductivity varies from 127 to 8526 µs/cm and overall EC are in the range of 750-2250 µs/cm. Total Dissolved Solids (TDS) varies from 75 to 5139 and in 21 samples (6.75 %) it is beyond permissible limit of BIS (2000 mg/l). Total hardness varies from 40-3080 mg/l and in 17 % of samples, it is beyond 600 mg/l. Calcium varies from 6-728 mg/l and in 3 % samples it is beyond permissible limits of BIS i.e., >200 mg/l. Magnesium varies from 1 to 306 mg/l and in 9% samples it is beyond permissible limits of

BIS i.e., >100 mg/l. Sodium and potassium varies from 2 to 1656 and <1 to 550 mg/l. The anions like CO_3, HCO_3 varies from below detectable limit to 96 and 18 to 1403 mg/l respectively. Chloride and sulphate varies from 7-1772 and 0 to 845 mg/l and found that in 2 % of samples it is beyond permissible limits of BIS. NO_3 ranges from 1-993 mg/l and found that 44 % samples are unfit for human consumption (>45 mg/l). Fluoride concentration varies from 0.1-3.83 mg/l (Malkapur in Nalgonda district) and found that 14 % samples are unfit for human consumption (beyond 1.5 mg/l). It is also observed that majority of samples having high concentration of F (>1.5 mg/l) (14 nos out of 44) are from Nalgonda district. Iron concentration in 12.9% samples exceeds permissible limit of 1mg/l. Arsenic concentration varies from BDL to 17ppb, which is well within permissible limit of 50ppb. Over all the ground water is potable for livestock and poultry.

Ground water is mostly suitable for irrigation and majority of samples fall in C_3-S_1 type of water (high salinity low sodium hazard). As per RSC and Percent Na classification of water, 8% and 10% samples are unfit for irrigation respectively. Ground water from the area is mainly of Ca-HCO_3-Cl and Ca-Na-CHO_3-Cl type followed by Ca-HCO_3, Ca-Cl and Ca-Na-Cl type.

The correlation plot of F^+ vs. pH^- (r^2=0.03), F^- vs. Na (r^2=0.05) and F^- vs. HCO_3 (r^2=0.1) shows a weak degree of positive correlations and plot between F^- vs. Ca^{2+} shows weak negative correlation (r^2=0.01).

GROUND WATER YEAR BOOK
(2015–2016)
TELANGANA STATE

1. INTRODUCTION

Central Ground Water Board has taken up the task of complex issues of ground water management, development, augmentation, protection and regime monitoring both in terms of quality and quantity. In order to arrive at proper parametric indices of evaluation and judicious development of ground water resources, the Board is monitoring National Hydrograph Stations (NHS) on long term basis since 1969 through a network of wells (Dug wells and Piezometers) for studying its long term behaviour due to influence of rainfall and ground water development. A historical database on the ground water levels and water quality has been developed over a period of time since1969.

The ground water regime monitoring mainly comprises measurement of water levels and temperature, four times in a year viz., in the months of May (pre-monsoon), August (mid-monsoon), November (post-monsoon) and January and collection of water samples during May every year, for chemical analysis. As on 31-03-2016, there were 766 operational Ground Water Monitoring Stations (GWMS) (Shallow aquifer: 659 and Deeper aquifer: 107) (354 dug wells and 412 piezometers). During the year (2015-16), 23 Ground water monitoring wells (15 Dug wells and 8 Piezometers) are abandoned and 56 new ground water monitoring wells (DW: 9 and Pz: 44) are established.

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

1.1 Location and Extent

Telangana State is the **29th State** (Act, 2014) formed in India covering geographical area of 1,12,077 Km^2 (after transferring 327 villages from Khammam district to residual Andhra Pradesh). It lies between NL 15° 48' and 19° 54' and EL 77° 12 ' and 81° 50 '. The state is bordered by The states of Maharashtra, Chattisgarh to the north, Karnataka to the west and Andhra Pradesh to the south, east and north-east.

Administratively, the state is divided into 10 districts (Adilabad, Karimnagar, Nizamabad, Warangal, Khammam, Nalgonda, Medak, Ranga Reddy, Hyderabad and Mahabubnagar) and governed by 459 revenue mandals (blocks/tahsils) with 10,434 revenue villages. Total population of the state is ~3.5 Crores with sex ratio of 988 (2011 census), of which 61 % lives in rural area and 39% in urban area. The density of population varies from 170 persons/km^2 in Adilabad to 19,717 persons/km^2 in Hyderabad district (average density: 312 persons/km^2). The decadal growth in population is ~13.6 % (2001 to 2011 census).

The present ground water year book (2015–16) depicts the ground water level scenario in the state and describes the behaviour of water levels during the period. The observation wells are distributed more or less uniformly over the state.

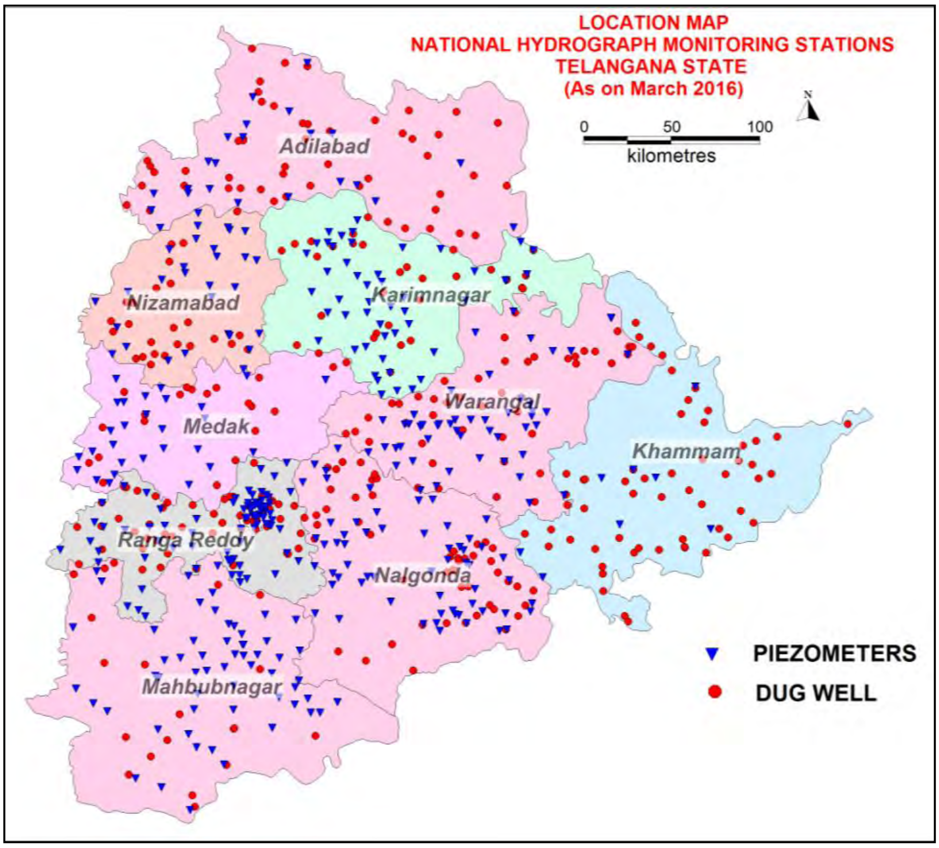


Fig.1.1: Location of GWMS in Telangana State (as on 31st March, 2016).

2. PHYSIOGRAPHY, DRAINAGE, SOIL, AGRICULTURE, LAND UTILIZATION AND IRRIGATION

2.1 Physiography

Physiographically, Telangana state is occupied by western pediplains except a fringe of Eastern Ghats in the northeastern part of Khammam district. A major part of the state is occupied by western Pediplains.The pediplains depict rolling topography with flat to undulating tracts. The state extends largely between elevations of 150 to 600 m amsl except at places where it is overlain by basaltic lava flows, the elevation of which ranges from 600 to 900 m a msl.

2.2 Drainage

The state is drained by two major rivers namely, Godavari and Krishna and their tributaries before entering into the state of Andhra Pradesh and finally to Bay of Bengal. There are 2 major basins and 13 sub basins in the state.

The major river basins are Godavari basin with 8 sub-basins namely, lower Godavari, Maneru, Manjira, middle Godavari, Penganga, Pranhita, Sabari and Wardha and Krishna basin with 5 sub basins namely, lower Bhima, lower Krishna, Munneru, Musi and Paleru (**Fig.2.1**). Apart from these, there are 2 other basins namely Tammileru and Yerrakalva lying between Godavari and Krishna covering very small area. The River Godavari with its tributaries viz., Pranahita, Pedda Vagu, Manjira, Maner, Kinnerasani, Sileru and Pamuleru drain whole of northern Telangana. The Tungabhadra, Musi, Paleru and Maneru rivers drain southern part of the state.

The pattern of drainage is generally dendritic with wide valleys in western pediplain. Drainage of the Eastern Ghat is coarse and dendritic with steep and narrow valleys. Most of the smaller streams feed innumerable tanks.

2.3 Soils

The soil has been classified based on color, texture, formation, physical, chemical and morphological properties of the formation. The state has a wide variety of soils viz., red soil, lateritic soils and black cotton soils. ~ 60 % of the state is occupied by red soils with loamy sub-soils covering entire Nalgonda district, a major part of Mahabubnagar, Waranagal, Karimnagar and Nizamabad districts. Black cotton soil commonly occurs in Adilabad and Nizamabad districts. Laterite soil occurs in western part of Ranga Reddy and Medak districts.

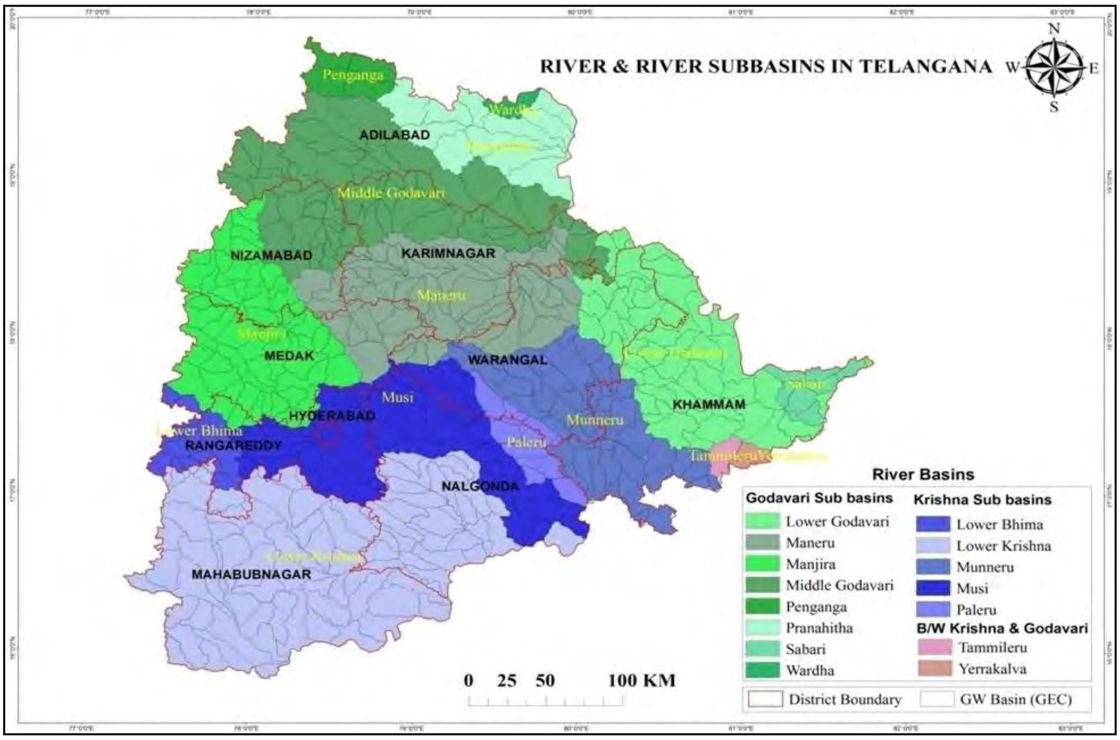


Fig.2.1: Drainage and River sub-basin map of Telangana state.

2.4 Agriculture and Land utilization

Agriculture plays an important role in the economy of state and sustainable growth in agriculture continues to be core agenda of the Government and occupies center stage with 3 thrust areas viz, i) to promote inclusive growth ii) to enhance rural income and iii) to sustain food security. ~55.5% of state population is dependent on some form or the other farm activity for livelihood. Share of agriculture in state GSDP is 9.3% (2014-15).

Forest occupy ~23.9 % of states geographical area and ~43.2% of the total area is under cultivation, 8.36% is current fallow lands, 7.8% is put to non-agricultural uses, 5.36% is barren and uncultivable and 6.24% falls under other fallow lands and remaining under culturable waste etc. (**Fig.2.2**)

2.5 Irrigation

The gross area irrigated in the state during 2013-14 is 31.64 lakh hectares which is increased by 23.74 % from 2012-13. The net area irrigated is 22.89 lakh hecates during the 2013-14 which increased by 29% from previous year. In the state there are 12.83 lakh irrigation sources (Bore wells/Tube wells 6.53 lakhs and Dug wells:6.3 lakhs) and 0.5 lakh surface flow and lift irrigation schemes (**Fig.2.3**). Ground water contributes ~75% of gross irrigated area and 25 % by surface water (tanks, canals and lift irrigation).

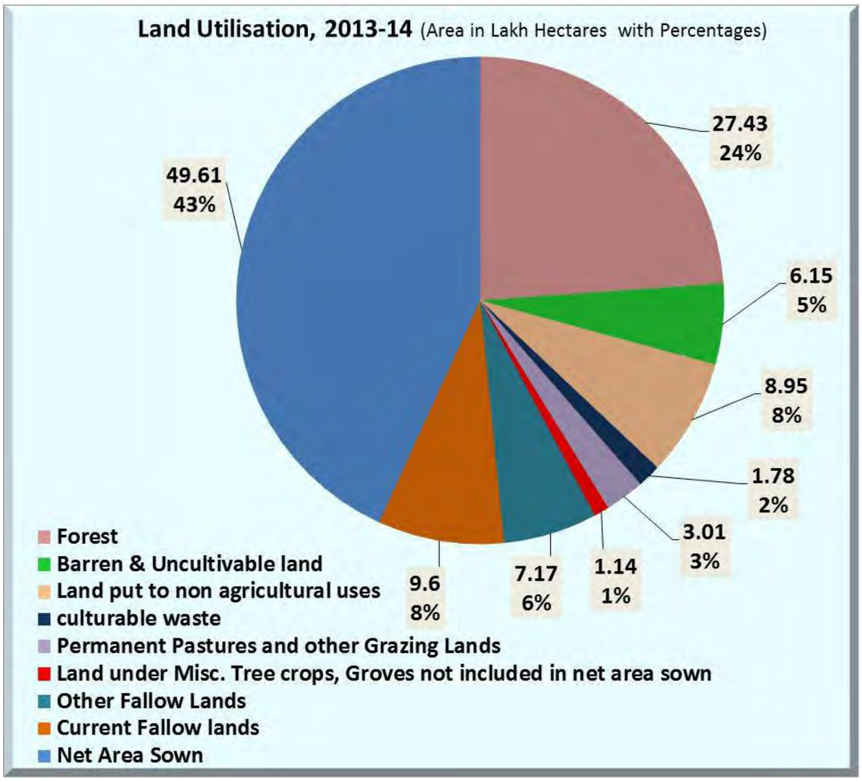
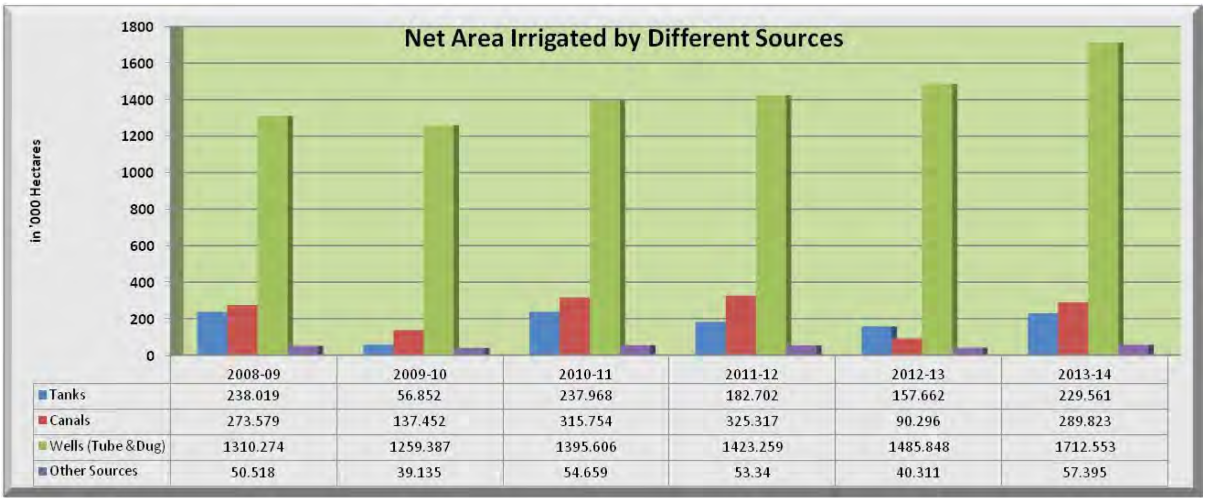


Fig.2.2: Land Utilization in Telangana state (2013-14) (area in lakh hectares with percentage).



	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Tanks	238.019	56.852	237.968	182.702	157.662	229.561
Canals	273.579	137.452	315.754	325.317	90.296	289.823
Wells (Tube &Dug)	1310.274	1259.387	1395.606	1423.259	1485.848	1712.553
Other Sources	50.518	39.135	54.659	53.34	40.311	57.395

Fig.2.3: Year wise net area irrigated by different sources in Telangana state.

3. HYDROMETEOROLOGY

3.1 Climate

Telangana state is geographically located in semi-arid region and has predominantly hot and dry climate. Summer starts in March and high temperature is observed in May with average temperature of 42° C. Monsoon starts in the month of June and lasts until September. As per agricultural department (Govt of Telangna), state can be divided into following 4 sub zones.

- North Telangana Zone
- Southern Telengana Zone
- High Altitude and
- Tribal Zone.

3.2 Rainfall Analysis-2015

District-wise monthly, seasonal and annual rainfall of both normal and actual of the year 2015 is compiled from daily and weekly weather reports of India Meteorological Department (IMD) and presented in **Table-3.1** and depicted in **Fig.3.1.** The salient features are given below.

- The normal annual rainfall of The state is 939 mm of which SW monsoon (June-September) contributes 80% (749 mm), NE monsoon (Oct-Dec) contributes 13% (120 mm), winter contributes 1% (12 mm) and summer contributes 6 % (58 mm) of the rainfall. Annual normal rainfall ranges from 732 mm in Mahabubnagar district to 1121 mm in Adilabad district **(Fig.3.2).**
- During the year 2015, state received 25 % less rainfall (710 mm) than normal rainfall of which SW monsoon (June-September) contributed 79 % (558.5 mm), NE monsoon (Oct-Dec) contributed 4 % (30.4 mm), winter contributed 1% (11 mm) and summer contributed 16 % (110 mm) of the rainfall.
- Drought conditions occurred in 5 districts namely Nizamabad, Medak, Mahabubnagr, Hyderabad and Rangareddy.
- Actual Annual rainfall in 2015 ranges from 472 mm (Deficit by 35 %) in Mahabubnagar district to 997 mm (deficit by 9 %) in Khammam district.
- Monthly mean rainfall ranged from 0.0 mm in February to 198.7 mm in June.

The rainfall received during the period Jan 2005 to Dec 2015 is compiled and analysed for correlating with water levels monitored during the period May 2015 to Jan 2016. The data is presented in **Table-3.2 to 3.5** and depicted in the **Fig. 3.3 to 3.10.**

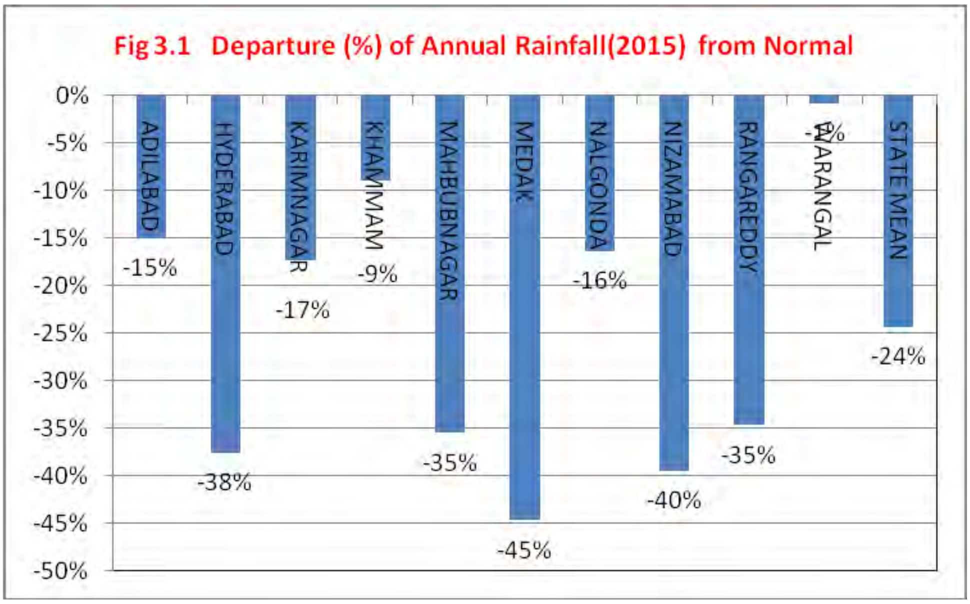


Fig.3.1: Annual departure of rainfall (2015) from normal rainfall (%).

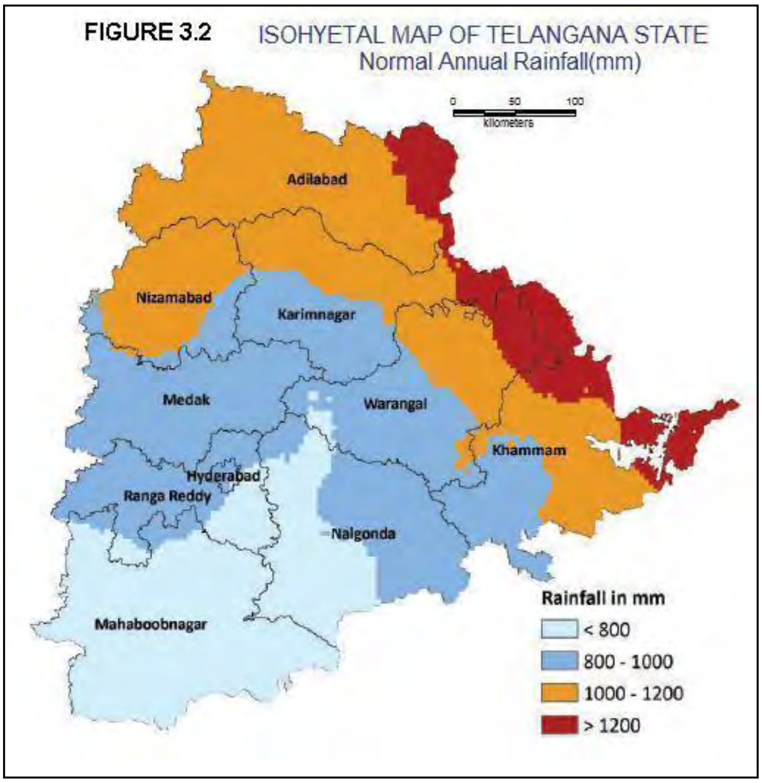


Fig.3.2: Isohytel map of Telangana state (Normal annual rainfall in mm).

Table-3.1: Monthly normal and actual rainfall (mm) during 2015 in Telangana State.

	JAN		FEB		MAR		APR		MAY		JUNE		JULY	
District	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**	**ACTUAL**	**NORMAL**
Adilabad	36.4	7.4	0	7.1	59.5	9.7	49.2	14.2	32.9	18.2	279	178.4	145	317.4
Hyderabad	0.1	5.9	0	7.3	20.8	12.6	56.7	22.7	6	33.8	126.9	110.7	38.9	176.8
Karimnagar	31.9	10.7	0	5.5	38.8	10.2	53.6	17.2	16.2	24	209.6	153.2	92.2	257.3
Khammam	1.9	4.2	0	7.4	6.7	8.8	46.6	26.4	31.3	52.6	398.1	150.3	98.2	282.8
Mahbubnagar	3.9	1.8	0	2.8	24	4.9	53.8	17.9	18.1	34.1	70.3	91.1	33.2	161.6
Medak	8.5	6.5	0	4.4	46.3	8.9	52.1	20.1	19.2	28	105	138.2	40.9	229.4
Nalgonda	0	3.9	0	4.5	3.2	8.4	42.6	16.4	19.7	28.7	160.5	103.2	64.8	154.7
Nizamabad	15.1	7.9	0	4.1	40.2	7.1	83.3	14.4	25.6	24.5	155.5	161.3	63.4	289.4
Rangareddy	7.1	3.1	0	4	40	6.6	77	22.6	19.3	34.6	107.1	109.4	46.3	190.6
Warangal	6.2	8.3	0	7.8	29.6	10.2	72.5	17.3	16.1	28.7	375.4	147.6	102.5	271.2
State Mean	**11.1**	**6.0**	**0.0**	**5.5**	**30.9**	**8.7**	**58.7**	**18.9**	**20.4**	**30.7**	**198.7**	**134.3**	**72.5**	**233.1**
	AUG		**SEP**		**OCT**		**NOV**		**DEC**		**ANNUAL**			
Adilabad	169.3	291.7	172	171.4	5	83	0	14.8	4.2	7.3	953	1121	**-15%**	
Hyderabad	74.3	190.5	129.2	165.5	77.7	95.6	0.5	23.7	0	6.4	531	852	**-38%**	
Karimnagar	142.5	226.7	212.5	163.1	13.3	85.9	0	20.8	0.4	5.9	811	981	**-17%**	
Khammam	194.8	256.4	196.8	170.9	14.3	106.9	8.4	24.5	0	4.5	997	1096	**-9%**	
Mahbubnagar	107.9	158.2	117	148.8	39	85.4	0.5	21.2	4.2	3.8	472	732	**-35%**	
Medak	100.2	211.1	109.7	165.2	28.3	86.6	0	19.3	0	4.8	510	923	**-45%**	
Nalgonda	164.4	147.2	144.8	149.6	29.1	105.8	7.3	32	0.2	6.6	637	761	**-16%**	
Nizamabad	158.2	296.5	92	172.9	26.4	91.3	0.1	17.1	0.6	5.5	660	1092	**-40%**	
Rangareddy	120.9	176.5	110.8	177.2	21	94.5	0.1	19.1	0.6	4.3	550	843	**-35%**	
Warangal	175.4	222.3	179.2	155.5	22.2	88.9	0.7	22.9	0.1	7.2	980	988	**-1%**	
State Mean	**140.8**	**217.7**	**146.4**	**164.0**	**27.6**	**92.4**	**1.8**	**21.5**	**1.0**	**5.6**	**710**	**939**	**-24%**	

Table-3.2: Rainfall and its variability in Telangana state.

District	Rainfall (mm)				Departure of June 2014 to May 2015 with		
	June-13 To May-14	June-14 To May-15	Decadal mean (2006-15)	Normal	June-13-May-14	Decadal mean (June-May)	Normal (June-May)
Adilabad	1689	893	1053	1120	-47.1%	-15.2%	-20.3%
Hyderabad	1090	584	859	851	-46.4%	-32.0%	-31.4%
Karimnagar	1487	729	1065	980	-51.0%	-31.5%	-25.6%
Khammam	1522	808	1280	1095	-46.9%	-36.9%	-26.2%
Mahbubnagar	987	573	696	731	-41.9%	-17.7%	-21.6%
Medak	1145	498	828	922	-56.5%	-39.9%	-46.0%
Nalgonda	1140	521	712	761	-54.3%	-26.8%	-31.5%
Nizamabad	1425	637	952	1092	-55.3%	-33.1%	-41.7%
Rangareddy	1024	612	818	842	-40.2%	-25.2%	-27.3%
Warangal	1467	711	1060	987	-51.5%	-32.9%	-28.0%
STATE MEAN	**1298**	**657**	**932**	**938**	**-49.4%**	**-29.6%**	**-30.0%**
Source: IMD, Govt of India							

3.2.1 May-2015

3.2.1.1 Rainfall Analysis (June2014-May 2015 vs. June2013-May2014 rainfall)

The thematic map depicting departure of rainfall during June 2014-May2015 from June2013-May2014 rainfall is given in **Fig. 3.3**. Water level fluctuation during May, 2015 Vs May 2014, is correlated with departure of rainfall. The rainfall recorded during June'14 to May'15 is 657 mm which is 49 % less than rainfall received during the previous year (2013-14) and 30 % less than the decadal mean (2006-2015). The departure ranges from -56 % in Medak district to -40 % in Rangareddy district.

3.2.1.2 Departure of rainfall during June 2014-May 2015 vs. decadal mean rainfall 2006-2015 (June-May)

Rainfall departure of June2014-May2015 with decadal mean rainfall (June-May) is prepared to correlate with water level fluctuation of May 2015 with Decadal mean (May) (**Fig-3.4**). Decadal mean rainfall (June-May) of the state is 932 mm.The actual rainfall during June 2014 - May 2015 is 657 mm and it ranges from -40 % (Medak district) to -15% (Adilabad district).

3.2.1.3 Departure of rainfall during June 2014-May 2015 vs. normal rainfall of same period

Rainfall departure of June2014-May2015 with normals of the same period is prepared to correlate with water level fluctuation of May 2015 (**Fig-3.5**). During this period,the state received -30% rainfall than normal rainfall and it ranges from -46 % (Medak district) to -20 % (Adilabad district) and deficient rainfall is observed all over the state.

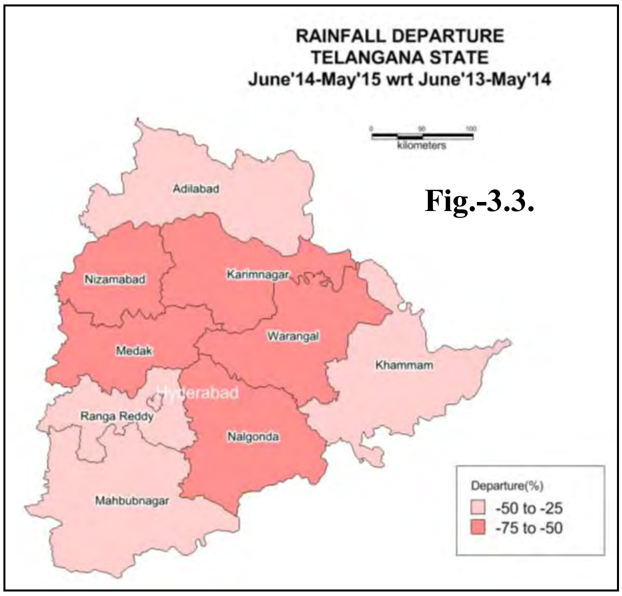


Fig.-3.3.

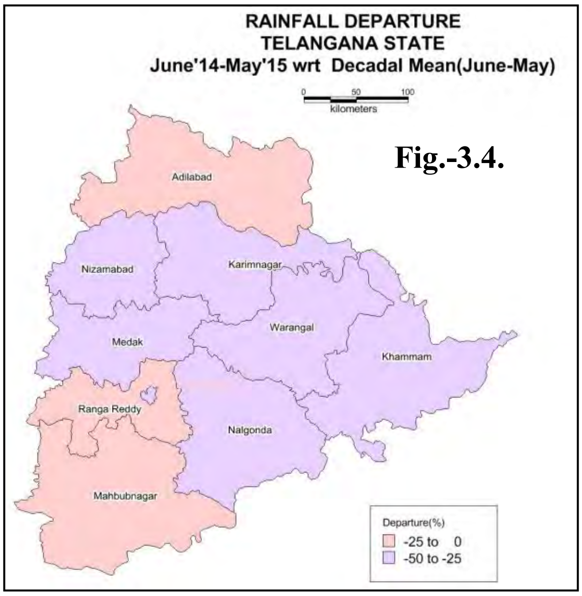


Fig.-3.4.

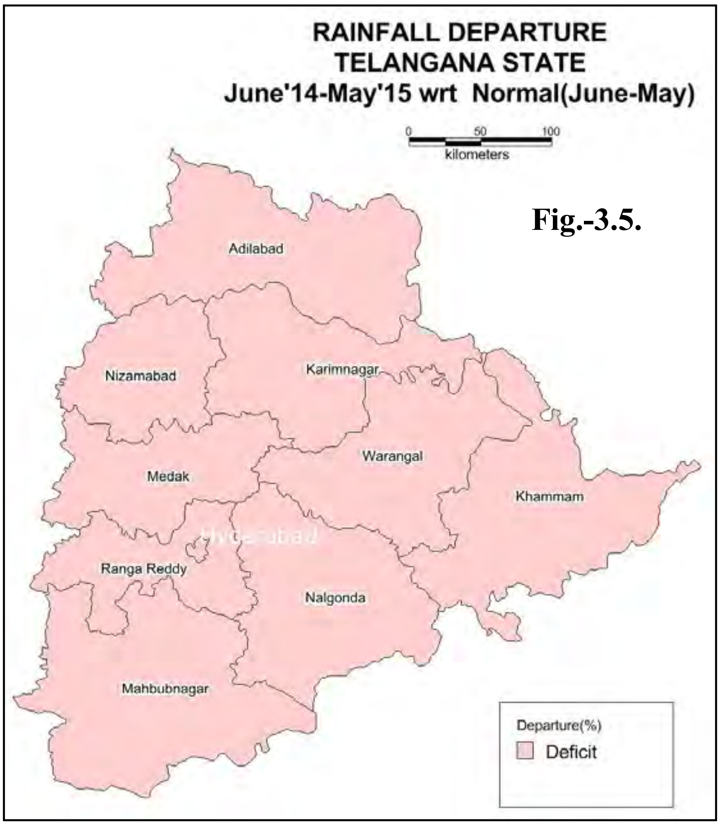


Fig.-3.5.

3.2.2 August, 2015

The district wise rainfall for the period June-August 2015 Vs June-August 2014, decadal mean and normal is given in **Table-3.3** and thematic maps are presented in **Fig.3.6, 3.7 and 3.8**.

Table-3.3: Rainfall and its variability in Telangana state

District	Rainfall (mm)				Departure of June15 to August15 rainfall with		
	June-14 to Aug-14	June-15 to Aug-15	Decadal mean (June-Aug) (2006-15)	Normal (June – Aug)	June-14-August-14	Decadal mean (June-Aug)	Normal (June-Aug)
Adilabad	461	593	703	788	29%	-16%	-25%
Hyderabad	327	240	508	478	-27%	-53%	-50%
Karimnagar	449	444	663	637	-1%	-33%	-30%
Khammam	437	691	778	690	58%	-11%	0%
Mahbubnagar	327	211	372	411	-35%	-43%	-49%
Medak	278	246	503	579	-12%	-51%	-57%
Nalgonda	226	389	338	405	72%	15%	-4%
Nizamabad	373	377	649	747	1%	-42%	-50%
Rangareddy	331	274	463	477	-17%	-41%	-42%
Warangal	428	653	674	641	53%	-3%	2%
STATE MEAN	**364**	**412**	**565**	**585**	**13%**	**-27%**	**-30%**
Source: IMD, Govt of India							

3.2.2.1 Departure of rainfall during June2015 to August 2015 vs. June2014- August2014

Departure of June2015-Aug 2015 rainfall from June 2014- Aug-2014 rainfall is depicted in the **Fig.3.6.** During June15 to August15, state received rainfall of 412 mm (Table-3.3) which is 13 % more than the rainfall during the same period of previous year (364 mm). The departure ranges from -35% in Mahabubnagar district to + 72 % in Nalgonda district.

3.2.2.2 Departure of rainfall during June2015 to August2015 vs. decadal mean (June-Aug) (2006-2015)

Departure of June2015 to August 2015 rainfall from decadal mean (June-August) is depicted in the **Fig.3.7**. Water level fluctuation map of August 2015 with decadal mean (August) is correlated with departure of rainfall. Decadal mean rainfall (June-August) of the state is 565 mm (Table-3.3) and it ranges from -53 % in Hyderabad district to +15 % in Nalgonda district.

3.2.2.3 Departure of rainfall during June to August, 2015 vs. normal rainfall of the same period

Departure of June2015 to August 2015 rainfall from normals of the same period is depicted in the **Fig.3.8** and correlated with depth to water levels of August-2015.

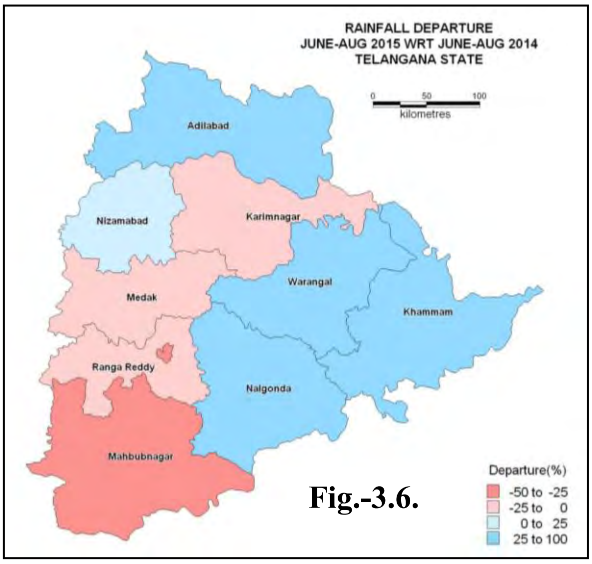


Fig.-3.6.

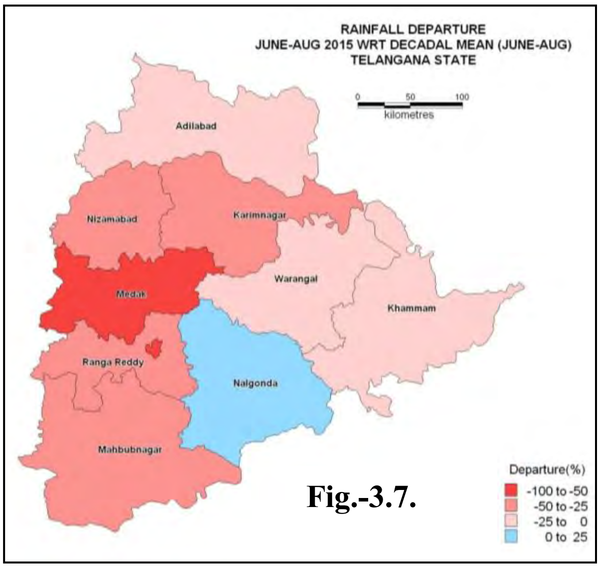


Fig.-3.7.

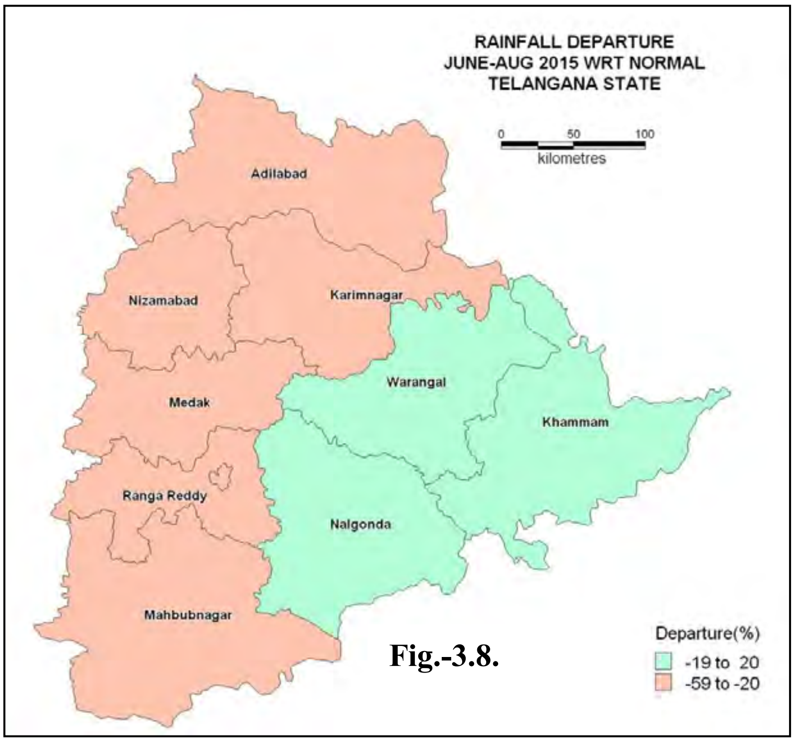


Fig.-3.8.

It ranges from -57 % in Medak district to 2 % in Warangal district.

3.2.3 November, 2015

The district wise rainfall for the period June to October-2015, June to October-2014,decadal mean(June to October-2006-15) and normal is given in **Table-3.4** and thematic maps are presented in **Fig.3.9, 3.10 and 3.11**.

Table-3.4: Rainfall and its variability in Telangana State (Source: IMD, Govt of India).

District	Rainfall (mm)				Departure of June-15 to October-15 with		
	June-14 to Oct-14	June-15 to Oct-15	Decadal mean (2006-15)	Normal	June-14-Oct-14	Decadal mean (June-Oct)	Normal (June-Oct)
Adilabad	707	770	1013	1042	8.8%	-24.0%	-26.1%
Hyderabad	447	447	765	739	0.0%	-41.6%	-39.5%
Karimnagar	584	670	984	886	14.7%	-31.9%	-24.4%
Khammam	707	902	1151	967	27.6%	-21.6%	-6.8%
Mahbubnagar	455	367	631	645	-19.4%	-41.8%	-43.1%
Medak	354	383	738	831	8.1%	-48.1%	-53.9%
Nalgonda	440	564	616	661	28.3%	-8.4%	-14.6%
Nizamabad	456	496	894	1011	8.7%	-44.5%	-51.0%
Rangareddy	452	406	719	748	-10.1%	-43.5%	-45.7%
Warangal	576	855	975	886	48.6%	-12.3%	-3.4%
STATE MEAN	**518**	**586**	**849**	**842**	**13.2%**	**-30.9%**	**-30.4%**

3.2.3.1 Departure of rainfall during June2015 to October 2015 vs. June2014 to October2014

Departure of June 2015 to October 2015 rainfall from June 2014 to October 2014 rainfall is depicted in the **Fig.3.9.** Water level fluctuation during November 2015 Vs November 2014 is correlated with departure of rainfall. During this period the state received 586 mm rainfall, which is 13% more than the rainfall of same period of previous year (518 mm). It ranges from -19.4 % in Mahabubnagar to + 48.6 % in Warangal district.

3.2.3.2 Departure of rainfall during June 2015 to October 2015 vs. decadal mean of same period

Departure of June2015 to October 2015 rainfall from decadal mean (June-October) is depicted in the **Fig.3.10**. Water level fluctuation map of November-2015 with decadal mean is correlated with departure of rainfall. Overall it is 849 mm (Table-3.4) and it ranges from -48 % in Medak district to -8.4 % in Nalgonda district.

3.2.3.3 Departure of rainfall during June 2015 to October2015 from normal rainfall (June-October)

Departure of June 2015 to October 2015 rainfall from normals of the same period is depicted in the **Fig.3.11** and correlated with depth to water levels of November 2015. Overall the state received 586 mm, which is -30 % than the normal rainfall during the same period. It ranges from -54 % in Medak district to -3.4 % in Warangal district.

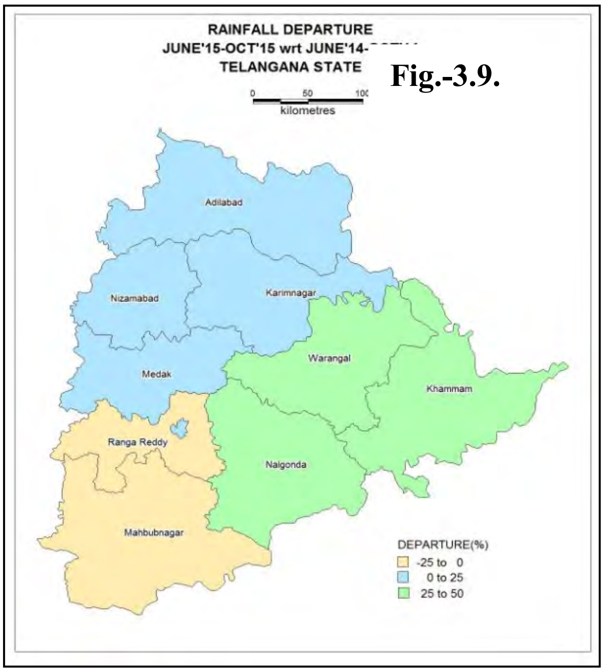


Fig.-3.9.

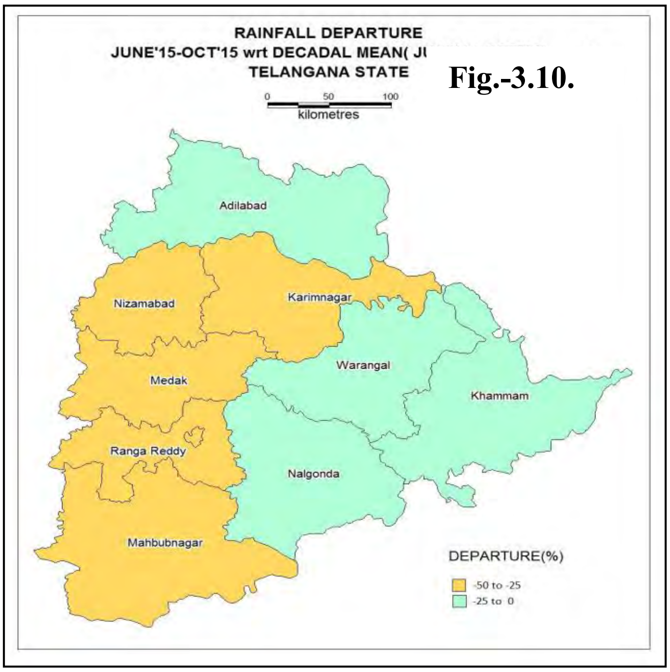


Fig.-3.10.

Fig.-3.11.

3.3.4 January, 2016

The district wise rainfall for the period January 2015 to December 2015 with reference to January 2014 to December 2014, decadal mean of January to December (2006-15) and normals of same period is given in **Table-3.5** and different thematic maps are presented in **Fig.3.12, 3.13 and 3.14**.

Table-3.5: Rainfall and its variability in Telangana State (Source: IMD, Govt of India).

District	Rainfall (mm)				Departure of Jan 15 to Dec-15 with			Remarks
	Jan-14 to Dec-14	Jan-15 to Dec-15	Decadal mean (2006-15)	Normal Jan-Dec	previous year	Decadal mean (Jan-Dec)	Normal (Jan-Dec)	
Adilabad	861	953	1007	1120	11	-5	-15	Normal
Hyderabad	608	531	833	851	-13	-36	-38	Deficit
Karimnagar	733	811	1022	980	11	-21	-17	Normal
Khammam	820	997	1247	1095	22	-20	-9	Normal
Mahabubnagar	601	472	671	731	-21	-30	-35	Deficit
Medak	512	510	785	922	0	-35	-45	Deficit
Nalgonda	543	637	704	761	17	-10	-16	Normal
Nizamabad	647	660	928	1092	2	-29	-40	Deficit
Rangareddy	601	550	784	842	-8	-30	-35	Deficit
Warangal	740	880	1077	987	32	-9	-1	Normal
STATE MEAN	**667**	**710**	**906**	**938**	**7**	**-22**	**-24**	Deficit

3.3.4.1 Departure of rainfall during January 2015 to December2015 vs. Jan14 to Dec-14

Departure of January 2015 to December2015 from Janary2014 to December 2014 rainfall is depicted in the **Fig.3.12.** During this period the state received 710 mm rainfall, which is 7 % more than the rainfall of same period in previous year (667 mm). It ranges from -21 % in Mahabubnagar to + 32 % in Warangal district.

3.3.4.2 Departure of rainfall during January15 to December15 vs. decadal mean of same period

Departure of January15 to December 15 rainfall vs. decadal mean (Jan-Dec-2006-15) is depicted in the **Fig.3.13**. Water level fluctuation of Jan-16 with decadal mean is correlated with departure of rainfall. Overall it is 906 mm (Table-3.5) and it ranges from -36 % in Hyderabad district to -5 % in Adilabad district.

3.3.4.3 Departure of rainfall during January 2015 to December2015 vs. normal rainfall of same period

Departure of January2015 to December2015 rainfall vs. normals of the same period is depicted in the **Fig.3.14.** It ranges from -45 % in Medak district to -1 % in Warangal district.

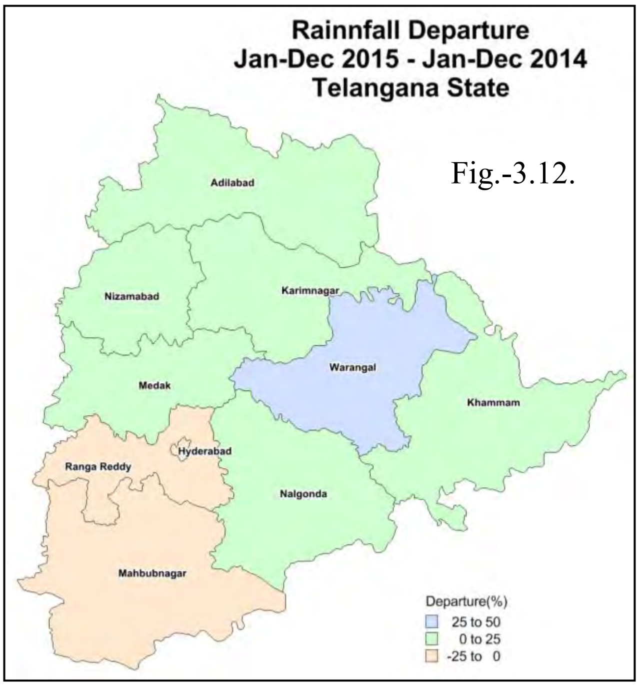


Fig.-3.12.

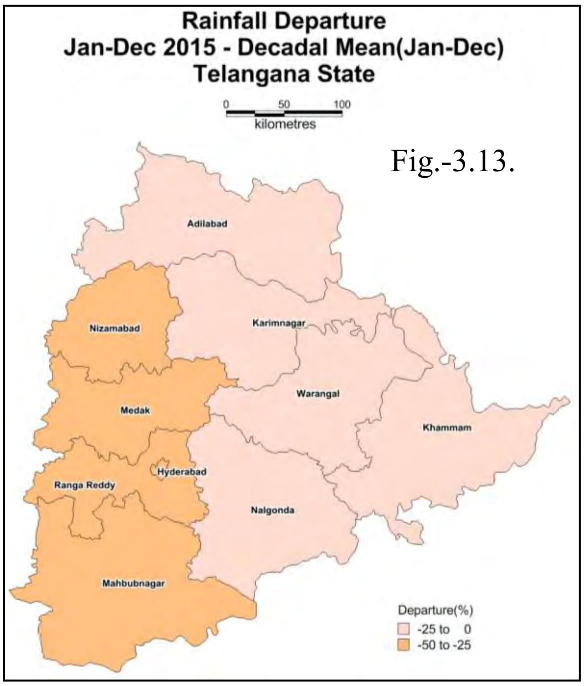


Fig.-3.13.

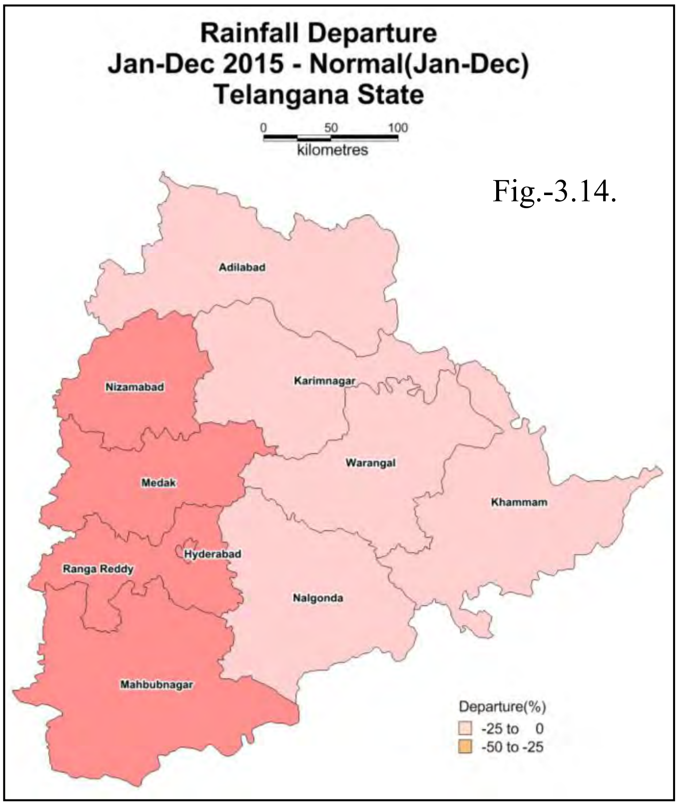


Fig.-3.14.

4. GEOLOGY

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

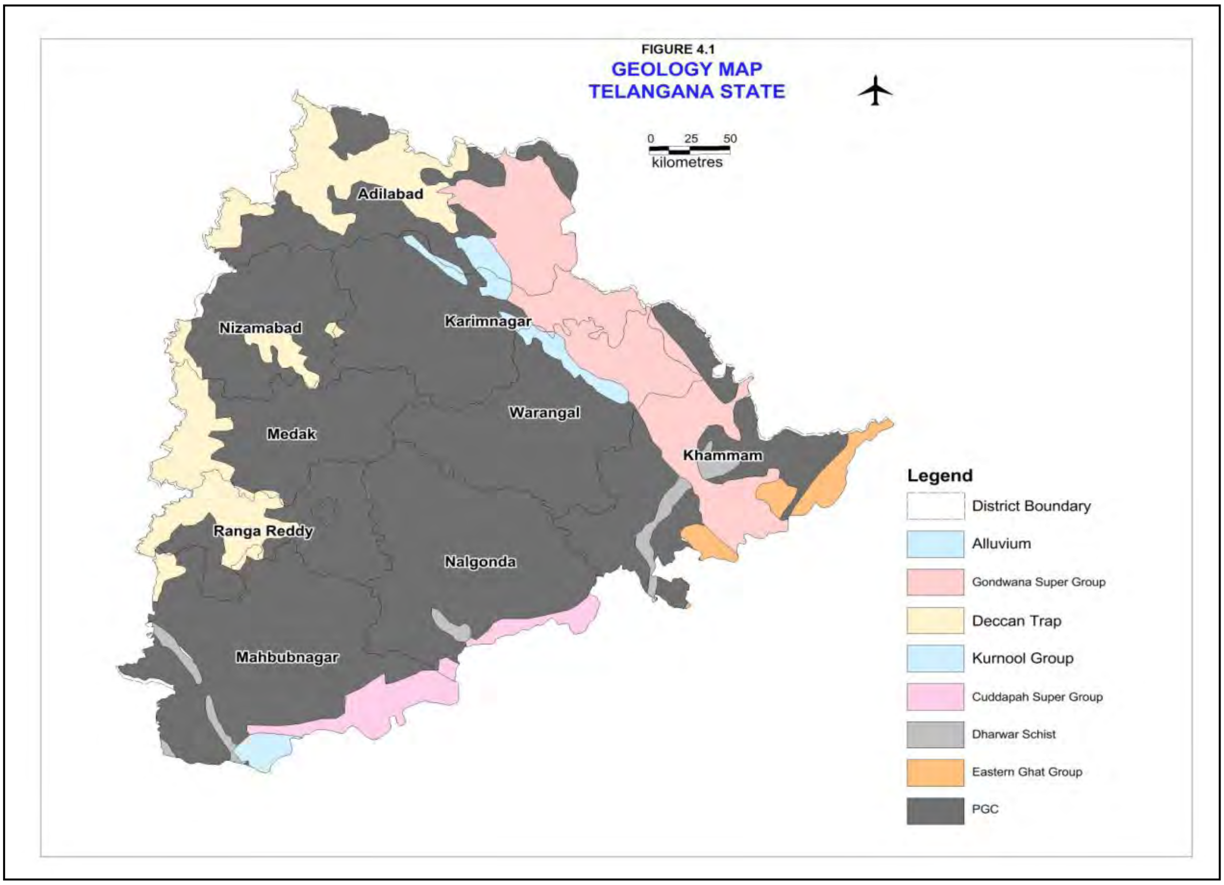


Fig.4.1: Geology of Telangana state.

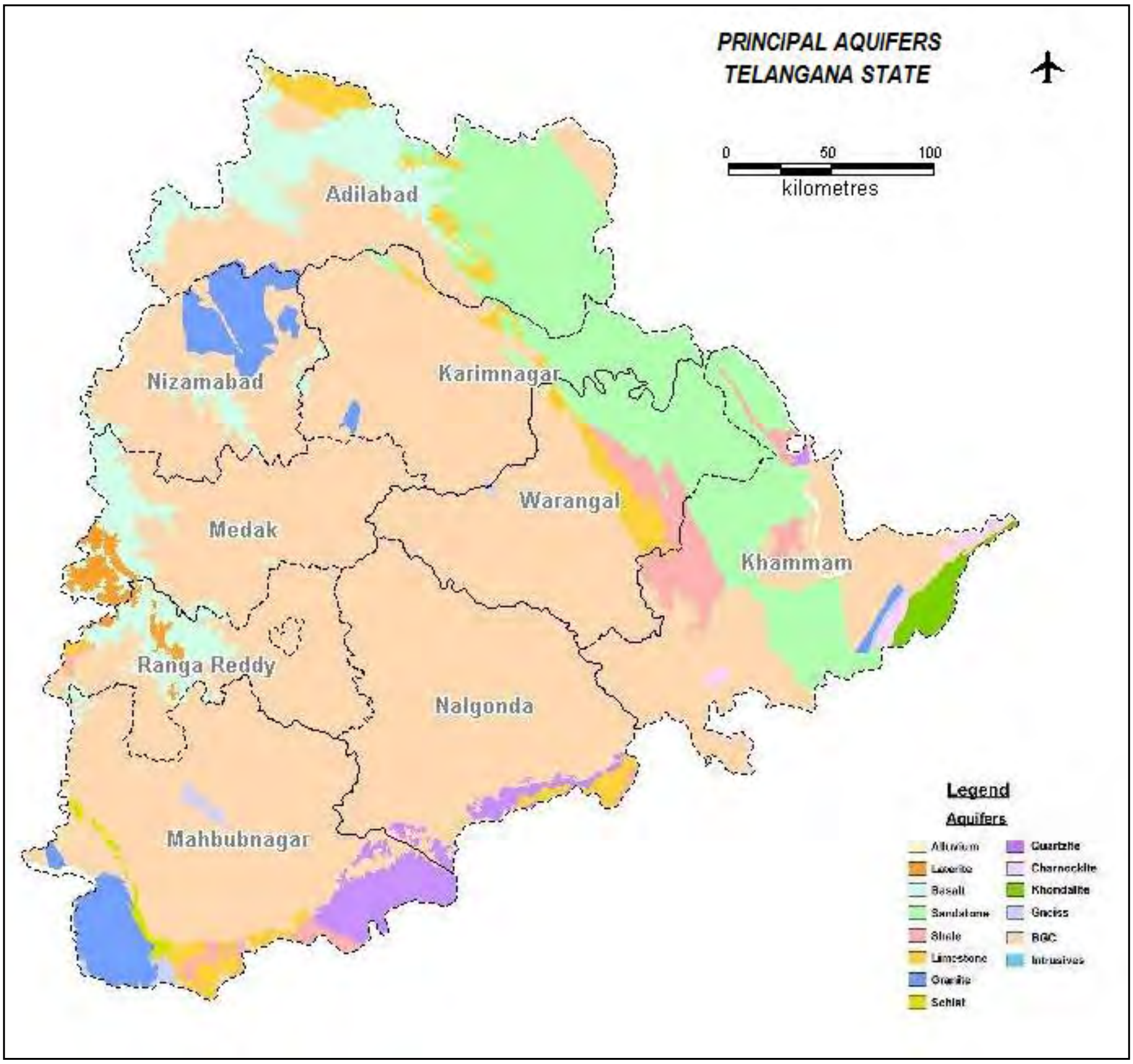


Fig.4.2: Principal Aquifers of Telangana state.

4.1 Archaean and Lower Protorozoic

Peninsular gneisses of Archaean age are dominant rock types in Telangana state. It is intruded by closepet granite and dolerite dykes. Dharwars, comprising amphibolites, gneisses, schists, and quartzites occur as narrow isolated bands within granites in Mahabubnagar, Nalgonda, Khammam, Warangal, Karimnagar and Adilabad districts.

4.2 Middle to Upper protorozoic

The group includes Cuddapahs, Pakhals, Pengangas, Kurnools and Sullavais comprising shales, limestones, dolomites, sandstones and conglomerates. The Cuddapah Super Group of rocks and Kurnool group of rocks occur in parts of Nalgonda and Mahabubnagar districts. The Pengangas, which are considered as equivalent of Pakhals, are exposed in Adilabad district. Bheema group of rocks consisting of flaggy massive and argillaceous limestones occur along western border of Rangareddy district. Sullavais sandstones overlie Pakhals and Penganga rocks consisting shales, limestones, sandstones and conglomerates occur in Adilabad, Karimnagar and Warangal districts.

4.3 Gondwana Super Group

Fresh water fluvial sediments of Gondwana Super group rocks (Upper Carboniferous to Lower Cretaceous), comprising lower group of rocks occur along NW-SE trending Pranhita-Godavari valley extending in Adilabad, Karimnagar and Warnagal districts. Lower Gondwanas are well developed in Godavari valley and sub-divided into Talchirs, Barakars, Barren measures and Kamthis consisting mainly conglomerates, sandstones, shales occassionaly clays in parts of Khammam district. The upper Gondwana is sub-divided into Maleru, Kota, Gangapur and Chikiala formations consisting of sandstones, conglomerates and clays.

4.4 Deccan Traps (Basalt)

Horizontal to sub-horizontal disposed lava flows of the Deccan traps covering ~8210 Km^2 occur in parts of Adilabad (4187 Km^2), Nizamabad(701 Km^2), Medak (1513 Km^2), Ranga Reddy (1680 Km^2)and Mahbubnagar districts (128 Km^2). The thickness of individual flow varies between a few metres to as much as 30 m with total thickness to more than 200 m at places. They overlie Archaean group of rocks except in Ranga reddy district where they overlay Bheema Group of rocks. Inter-trappean beds comprising limestone, chert and sandstone occur between trap flows near Vikarabad and Adilabad.

4.5 Quaternary Depostis

Sub-recent deposits represented by laterite capping occur in Medak and Rangareddy districts at places with thickness up to 30 m. They cover about 916 Km^2 area in the state (Medak: 609 Km^2 and Rangareddy 307 Km^2).

5. GROUND WATER RESOURCES (2012-2013)

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

As per the latest estimates (March 2013), the annual replenishable ground water resources are 14744 MCM, natural discharge during non-monsoon period is 1354 MCM, net ground water availability is 13390 MCM.The annual gross ground water draft is 7766 MCM, allocation for future domestic and industrial use is 1554 MCM and net ground water availability for future irrigation use is 4823 MCM. The average stage of ground water development is 58%.

Out of 443 mandals, 46 categorised as over-exploited, 12 categorised as critical, 74 categorised as semi-critical and remaining 311 as safe category. The categorization of mandals is depicted in **Fig.5.1**.

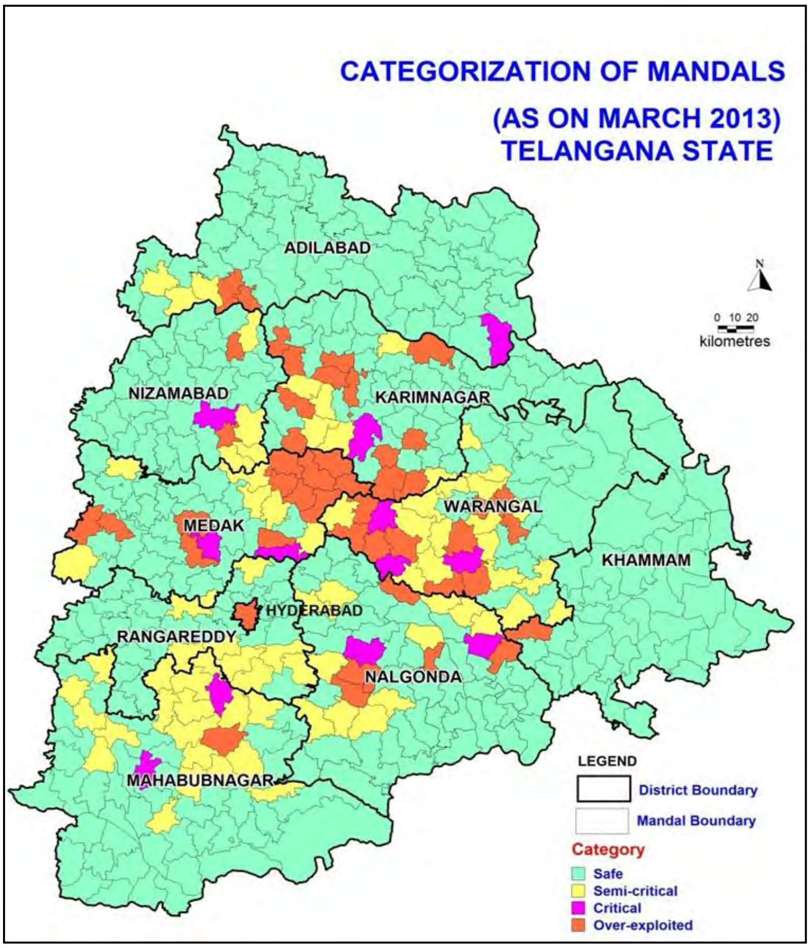


Fig.5.1: Categorization of mandals (as on 2013), Telangana state.

6. GROUND WATER REGIME MONITORING

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

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

Ground water occurrence point of view, litho units of the state are grouped into following 3 groups.

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

6.1 Consolidated formations

Crystalline rocks of Archaean age, metasedimentary rocks of Cuddapahs, Kurnools and basaltic lava flows of Deccan traps are included in these formations. The crystalline rocks which occupy ~83 % of area, generally lack primary porosity and secondary porosity is developed due to weathering, fracturing, development of solution cavities and channels and interconnection of vesicles. In these rocks, depth of weathering varies from 3 to 20 m bgl and majority of fractures occur within 100 m depth. In these rocks dug wells/ dug cum bore wells and bore wells are the most prevalent abstraction structures. Ground water yield from these rocks varies from 0.1 lps to 5 lps.

Pakhals, Penganga and Sullavais are relatively poor to moderate potential aquifers and basalts are hard and compact and possess meagre primary porosity (by virtue of interconnected vesicles). Fractures in basalts are developed due to columnar joints and tectonic activities. Yield of ground water in these rocks varies from 0.1 to 3 lps and potential zones exists down to 38-200 m depth.

6.2 Semi-consolidated formations

Semi-consolidated formations are represented by rocks belonging to Gondwana formations. The Talchirs, Barakaras and Kamthis formations yield more ground water (up to 60 lps). At some place auto flows are encountered.

6.3 Unconsolidated formations

Unconsolidated formations are represented by river alluvium and occur along the major river Godavari and river Krishna and their tributaries in the state.

6.4 Monitoring Methodology

Ground water regime is monitored through a network of dug wells and piezometers known as Ground Water Monitoring Stations (GWMS). The dug wells, which are owned by government and non-government agencies and individual users,tap shallow aquifers. Piezometers (basically bore wells/tube wells) constructed exclusively for ground water regime monitoring under Hydrology Project tap both shallow and deeper aquifers. Some of the exploratory wells/ observatory wells drilled under exploratory drilling programme of CGWB tapping deeper aquifers are converted to piezometers for regular monitoring.

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

Period	**Date**
January	1st to 10th of the month
May (Pre-monsoon)	21st to 30th of the month
August (Mid-monsoon)	21st to 30th of the month
November (Post-monsoon)	1st to 10th of the month

6.4.1 Participatory Ground water Monitoring

To observe micro-level changes in ground water regime, weekly measurements are initiated in phases involving local people as observers under participatory ground water monitoring programme. Participatory observers are engaged since May, 2005, from the local area where GWMS are existing and as on 31st March 2016, 148 nos of GWMS are monitored though participatory approach (**Table-6.1**).

6.4.2 Chemical Quality Monitoring

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

6.5 Maintenance of Database on Ground Water Monitoring Wells

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

6.6 Distribution of Ground Water Monitoring Wells

The distribution and density of monitoring wells in The state; distribution in river basins, aquifer systems and canal command areas are summarized below.

6.6.1 District-Wise Distribution of Ground Water Monitoring Wells

Total 766 GWMS are monitored in the state (Du wells: 353 (46%) and Piezometer wells: 413 (54%)) and density varies from one wells for 8 Km^2 (Hyderabad) to one wells for 222 Km^2 in Mahabubnagar district (**Table-6.1** and **Fig.1.1**).

Table-6.1: Distribution of GWMS, Telangana State (As on March, 2016).

S. No.	District	Area (Km2)	No of GWMS			No of Participatory observers	Density of Net work
			DW	Pz	Total	Nos	Km^2/well
1	Adilabad	16105	51	25	76	17	212
2	Hyderabad	217	7	21	28	6	8
3	Karimnagar	11823	30	54	84	9	140
4	Khammam	13266	56	13	69	29	192
5	Mahabubnagar	18432	20	63	83	14	222
6	Medak	9699	22	29	51	14	190
7	Nalgonda	14240	50	68	118	18	120
8	Nizamabad	7956	25	27	52	10	153
9	Ranga reddy	7493	46	60	106	17	71
10	Warangal	12846	46	53	99	14	130
	Total	**112077**	**353**	**413**	**766**	**148**	**146 (Average)**

6.6.2 Basin-wise distribution of Ground Water Monitoring Wells

The Godavari and Krishna are the major river basins in the state. The number of network stations located in Godavari and Krishna basins is 346 (45%) and 420 (55%) respectively. The district-wise and basin-wise distribution of monitoring wells is given in the **Table-6.2**.

6.6.3 Aquifer-Wise Distribution of Ground Water Monitoring Wells

Out of 766 GWMS, 652 (85%) wells are located in hard rocks, 114(15%) wells in soft rocks. District-wise and aquifer-wise distribution of GWMS is given in**Table-6.3.** Majority of

GWMS (75%) are located in Banded Gneissic complex(BGC) rocks followed by Sandstone (11%), and basalt rocks (6.7%) etc.

Table-6.2: District-wise and Basin-wise distribution of GWMS, Telangana state

S. No.	District	Basin		Total
		Godavari	Krishna	
1	Adilabad	76	0	76
2	Hyderabad	0	28	28
3	Karimnagar	84	0	84
4	Khammam	36	33	69
5	Mahabubnagar	0	83	83
6	Medak	49	2	51
7	Nalgonda	0	118	118
8	Nizamabad	52	0	52
9	Ranga reddy	12	94	106
10	Warangal	37	62	99
	Total	**346**	**420**	**766**

Table-6.3: District-wise and Principal Aquifer-wise Distribution of monitoring stations, Telangana state (as on March, 2016).

District	Principal Aquifer Systems										
	BGC	BS	CK	GN	GR	LS	LT	QZ	SH	ST	Total
Adilabad	36	18	0	0	1	5	0	0	0	16	76
Hyderabad	28	0	0	0	0	0	0	0	0	0	28
Karimnagar	63	0	0	0	0	1	0	0	0	20	84
Khammam	41	0	1	0	1	0	0	0	2	24	69
Mahabubnagar	73	0	0	3	2	4	0	1	0	0	83
Medak	33	13	0	0	0	0	5	0	0	0	51
Nalgonda	117	0	0	0	0	0	0	1	0	0	118
Nizamabad	35	1	0	0	16	0	0	0	0	0	52
Ranga reddy	75	19	0	0	0	1	11	0	0	0	106
Warangal	74	0	0	0	0	1	0	0	2	22	99
Total	**575**	**51**	**1**	**3**	**20**	**12**	**16**	**2**	**4**	**82**	**766**

(Note: BGC-Banded Gneissic complex, BS-Basalt, CK-Charnokite, Gn-Gneiss, Gr-Granite, LS-Limestone, Qz-Quartzite,SH-Shale, ST-Sandstone).

7. ANALYSIS OF WATER LEVELS

The ground water levels observed over a period of time provides valuable information on behaviour of the ground water regime, which is constantly subjected to changes due to recharge and discharge phenomena. Balance between recharge and discharge results in decline or rise in the ground water storage. When the recharge exceeds discharge there will be a rise in the ground water storage and vice versa. The decline in water level may be due to increase in draft (for different purposes) or decrease in precipitation (less recharge to ground water). On the other hand a rise in water level may be due to an increase in rainfall and/or due to changes in irrigation practices. The dug wells are tapping the phreatic aquifer which is mostly limited to a depth of 20 m. The depth of piezometers which are tapping both the phreatic and deeper aquifers varies from 20 to 100 m. Hence the water level recorded in the piezometers may not be the same as that of dug wells for a particular period though both the structures are in the same place. In this report the water level data collected from shallow aquifers (tapping weathered zone and first fracture zone) are presented in detail. Water levels tapping deeper fractures are discussed separately. The data from GWMS for the year 2015-16 was analysed and for every set of measurements, write up and maps were prepared and are presented here under various paragraphs. The purpose of water level data analysis is

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

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

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

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

7.1 Depth to Water Levels (May-2015 – Pre-monsoon season)

- An analysis of depth to water level data of 564 wells **(Annexure-1**) shows, water levels in the range of 0.33 (Rangareddy district) to 46.1mbgl (Medak district) (**Fig.7.1**).
- Shallow water level in the range < 2 m bgl covers an area of about 361 Km^2 (0.3% of state area) and mostly observed in Khammam and Adilabad districts.
- Water levels in the range of 2 to 5 m occupies about 10340 Km^2 area (~9% of the total geographical area of The state), occupying mostly eastern part of the state.
- Majority of the water levels are in the range of 5 to 10 m bgl occupying about 56,130 Km^2 area (48.3%) and represented by 41.7 % wells.
- Water levels between 10-20 m bgl covers about 44,300 Km^2 (38.1%) representing 35.1% wells.
- Deep water levels in the range of 20-40 m bgl and > 40 m bgl covers about 3.7% and <0.1% of the total geographical area respectively, representing 5 % and 0.5 % of the total wells respectively, covering mostly Hyderbad, Rangareddy and Medak districts.

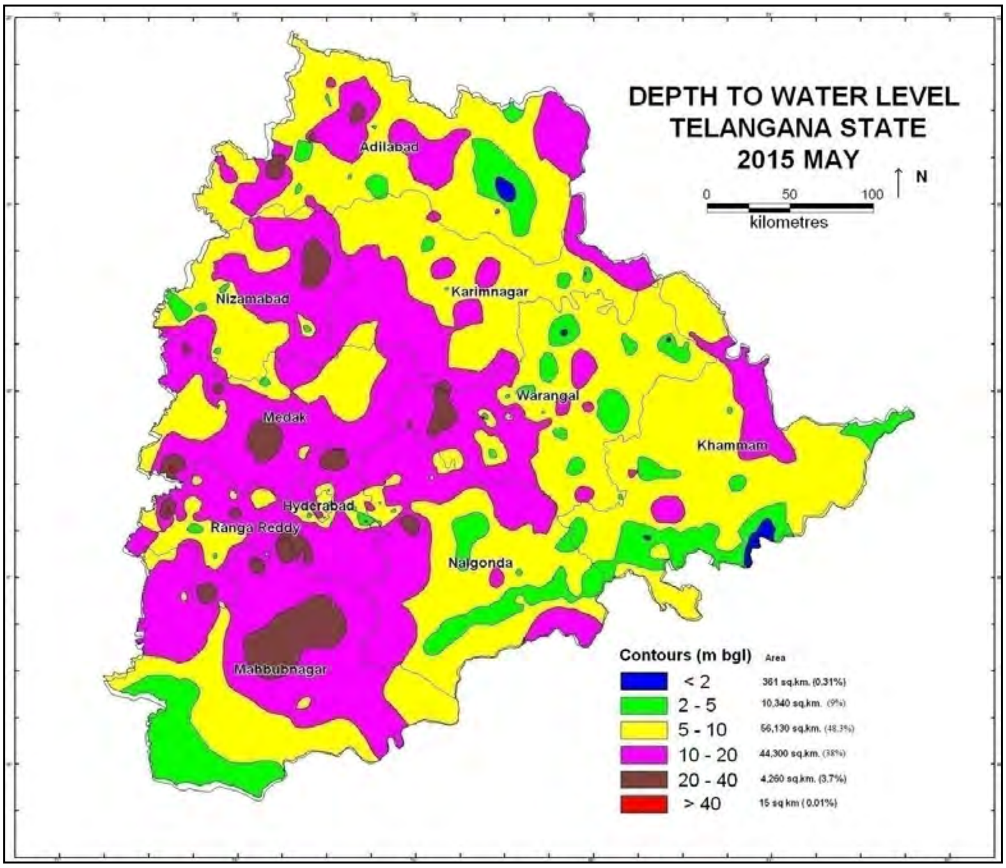


Fig.7.1: Distribution of water levels, Premonsoon -2015 (May).

7.2 Depth to Water Levels (August-2015-Mid-monsoon Season)

An analysis of depth to water level data of 607 wells **(Annexure-2**) shows, water levels in the range of 0.10 (Rangareddy district) 50.98 mbgl (Mahabubnagar district). The depth to water levels are summarized below and presented in **Fig. 7.2.**

- One well located at Projcet Nagar in Khammam district shown artesian conditions (-0.08 m).
- Shallow water level in the range of < 2 m bgl covers an area of about 8911 Km^2 (7.7 % of state area) and mostly observed in Adilabad, Warangal, Khammam and Mahabubnagar districts.
- Water levels in the range of 2 to 5 m occupies about 34420 Km^2 area (29.6 % of the total geographical area of The state), occupying mostly eastern and northern part of the state.
- Majority of the water levels are in the range of 5 to 10 m bgl occupying about 37860 Km^2 areas (32.5 %) and represented by 32 % of wells.
- Water levels between 10-20 m bgl cover about 27490 Km^2 of state area (23.6% of The state area) are represented by 24 % of wells.
- Deep water levels in the range of 20-40 m bgl and > 40 m bgl covers about 5.36 % and 1.2 % of the total geographical area respectively, covering mostly Medak, Hyderabad, Ranga Reddy, and Mahabubnagar districts.

7.3 Depth to Water Levels (November-2015-Post-Monsoon)

An analysis of depth to water level data of 599 wells **(Annexure-3**) shows, water levels in the range of 0.21 m (Rangareddy district) 59.38 mbgl (Mahabubnagar district). The depth to water levels are summarized below and presented in **Fig.7.3.**

- One well located at Projcet Nagar in Khammam district shown artesian conditions (-0.073 m).
- Shallow water level in the range of < 2 m bgl covers an area of about 844 Km^2 (0.73 % of state area) and mostly observed in Adilabad, Warangal, Khammam districts.
- Water levels in the range of 2 to 5 m occupies about 33,690 Km^2area (28.97 % of the state area) in Adilabad, Warangal, Khammam and as small patches in Mahabubnagar district.
- Majority of the water levels are in the range of 5 to 10 m bgl occupying about 42,990 Km^2areas (36.96 % of the state area).

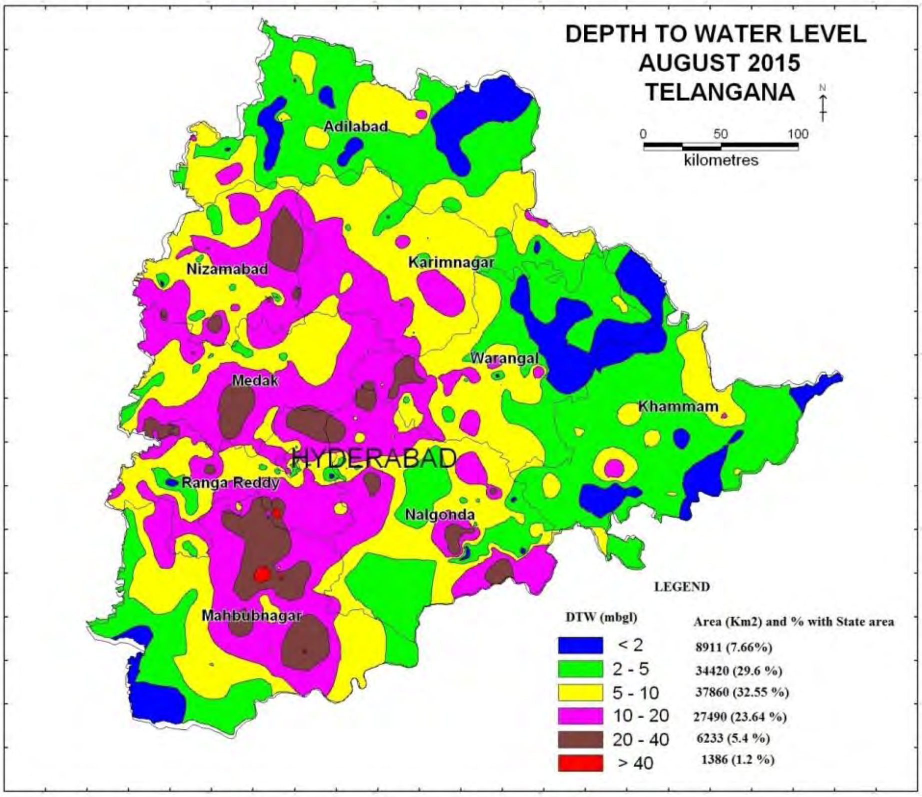


Fig.7.2: Depth to Water Levels-August 2015.

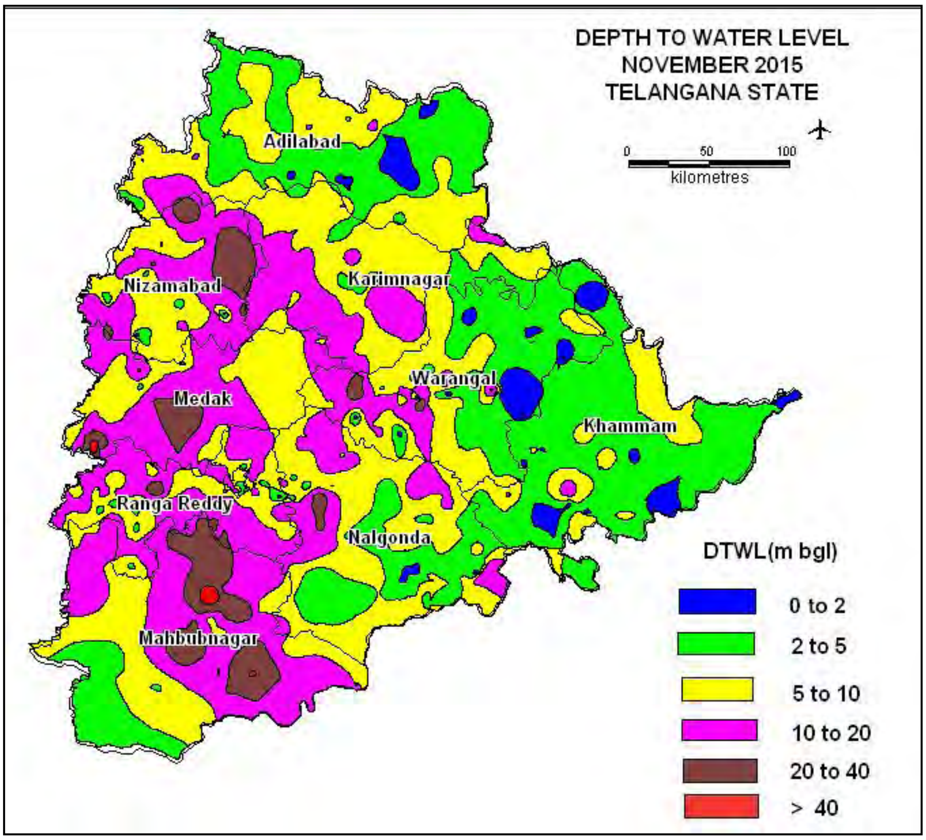


Fig.7.3: Depth to Water Levels-November2015

- Water levels between 10-20 m bgl cover about 30,060 Km^2 (4.6%) of state area.
- Deep water levels in the range of 20-40 mbgl and > 40 mbgl covers about 4.6 % and 2.89 % of the total geographical area respectively, covering mostly Medak, Hyderabad, Rangareddy, Nizamabad and Mahabubnagar districts.

7.4 Depth to Water Levels (January-2016)

An analysis of depth to water level data of 602 wells **(Annexure-4**) shows, water levels in the range of 0.30 m (Rangareddy district) 69.5 m bgl (Medak district). The depth to water levels during January 2016 are summarized below and presented as in **Fig.7.4.**

- Shallow water level in the range of < 2 m bgl covers an area of about 528 Km^2 (0.45 % of state area) falling in Adilabad and Khammam districts.
- Water levels in the range of 2 to 5 m occupies about 21850 Km^2area (18.8 % of area) covering Adilabad, Warangal, Khammam, eastern part of Nalgonda and in south-western part of Mahabubnagar district.
- Majority of the water levels are in the range of 5 to 10 m bgl occupying about 48690 Km^2area (42 % of The state area).
- Water levels between 10-20 m bgl cover about 36190 Km^2 of state area (31% of state area).
- Deep water levels in the range of 20-40 m bgl and > 40 m bgl covers about 6.5% and 1.2 % of the area respectively, covering mostly Medak, Hyderabad, Rangareddy, , Nizamabad and Mahabubnagar districts.

7.5 Annual Water Level Fluctuation

7.5.1 Water Level Fluctuation (May 2015 Vs May 2014)

Water level fluctuation data of May 2015 Vs May 2014 is presented in **Annexure-5.** Areal distribution of fluctualtion map is presented in **Fig.7.5.** An analysis of 511 wells shows that water level rise is recorded in 62 wells (11%) covering an area of about 10.5%. ~89 % of the area have shown a fall in water level representing 85.93 % wells (440 wells), while in the rest, 1.95 % wells (9 wells) no fluctuation is recorded. Fall in water levels is mainly due to less rainfall (-49%) than the previous year.

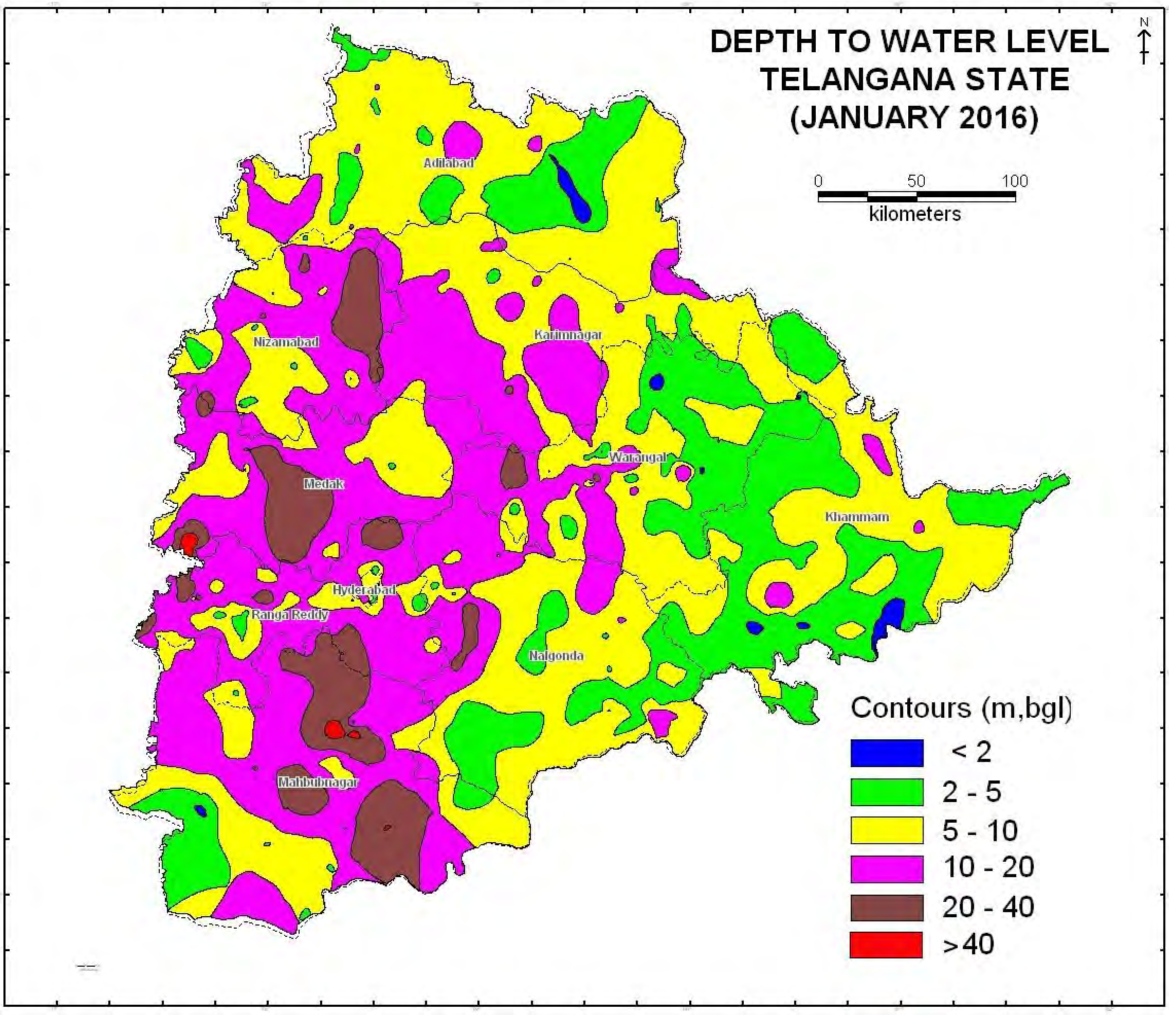


Fig.7.4: Depth to Water Levels – January 2016.

Water level rise of more than 4 m is recorded maximum in Rangareddy and Nalgonda districts while water level fall of more than 4 m is recorded in Nizamabad, Nalgonda, Mahabubnagar and Medak districts.

Rise in Water Levels:

1. During May 2015, the minimum rise in water level of 0.01 m in Warangal district and maximum of 19.23 m in Adilabad district is observed.
2. Medak district have shown a very negligible rise in water levels as compared to other districts (Min 0.2 and Max 0.41 m).
3. Water level rise of < 2 m is recorded in 69% wells(43 wells out of 62) covering about 9 % of total geographical area, falling in northern part of Kammam, Adilabad, eastern part of Warangal, western part of Mahabubnagar district and in patches in all the districts of the state.

4. 2 to 4 m and > 4 m rise in water levels is observed in 15%(9 wells) and 16%(10wells) of wells, covering about 0.8% and 0.7% geographical area respectively.

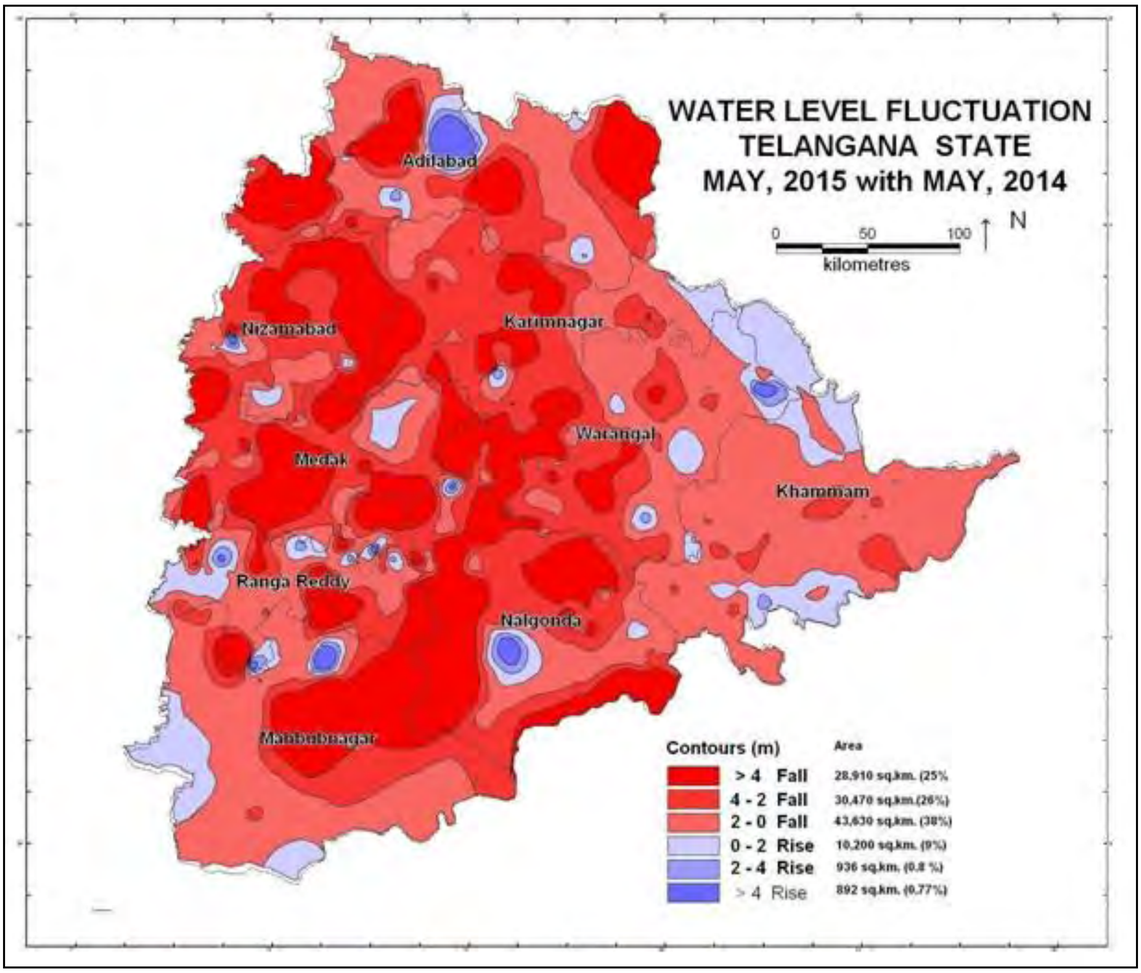


Fig.7.5: Water level Fluctuation May 2015 Vs May 2014.

Fall in Water Levels:

1. During the period an appreciable fall in water levels is observed with minimum 0.02 m (Khammam) and maximum 36.82 m (Rangareddy district) covering about 1,03,010 Km^2 area (89%).
2. Fall in water levels < 2 m are observed in all districts of Telangana state covering an area about 43,630 km^2 (38%). This range is observed in 40.7% of wells.
3. Water level fall between 2 to 4 m is noticed in all districts of Telangana state covering an area about 30,470 km^2 (26%). This range is observed in 31.6% of wells.
4. More than 4 m water level fall is observed in all districts of Telangana state except Khammam district covering an area about 28,910 km^2 (25%). This range is observed in 27.7 % of wells.

7.5.2 Water Level Fluctuation (August 2015 vs. August 2014)

Water level fluctuation data of August 2015 with respect to August 2014 is presented in **Annexure-6** and areal distribution of fluctualtion map is presented in **Fig.7.6.**

- An analysis of 522 wells shows that water level rise is recorded in 33.3 % wells (174) covering an area of about 32 % of the total geographical area.
- About 68 % of the area has shown a fall in water level representing 66.7 % wells (342) and 6 wells shown no fluctuation.
- Fall in water levels is mainly due to less rainfall (-30 %) than the normal rainfall in the period.
- Water level rise of more than 4 m is recorded maximum mainly in Adilabad, Warangal, Khammam and western part of Mahabubnagar, while water level fall of more than 4 m is recorded mainly in most of the districts, excluding Khammam, Hyderabad.

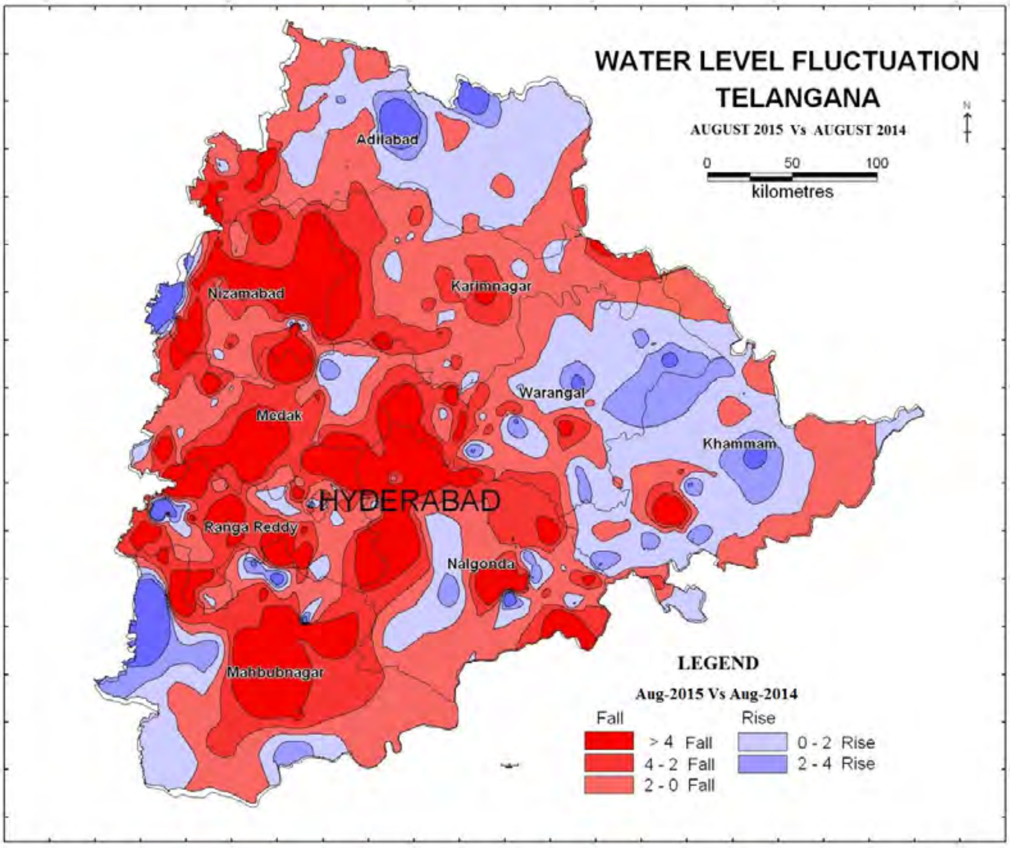


Fig. 7.6: Water Level Fluctuation- August 2015 Vs August 2014.

7.5.3 Water Level Fluctuations (November-2015 Vs November-2014)

Water level fluctuation data of November 2015 with respect to November 2014 is presented in **Annexure-7** and areal distribution of fluctualtion map is presented in **Fig.7.7.**

An analysis of 549 wells shows that water level rise is recorded in 150 wells covering an area of about 28 %. ~62 % of the areas have shown a fall in water level (388 wells) and 11 wells shows no fluctuation.

- The minimum and maximum rise in water level fluctuations is recorded as 0.06 m in Warangal district and 24.35 m in Ranga Reddy district.
- The minimum and maximum fall in water level fluctuations is recorded as 0.01 m in Warangal district and 30.8 m in Mahabubnagar districts.
- In the state about 32,160 km^2area shown a rise in water levels in the range of < 2 to > 4 m and in about 84,140 km^2 of the area, water level fluctuations have shown a fall in the range of < 2 to > 4 m.
- Water level rise of more than 4 m is recorded maximum mainly in Nalgonda and Warangal districts, while water level fall of more than 4 m is recorded in all the districts except in Hyderabad and Khammam districts.

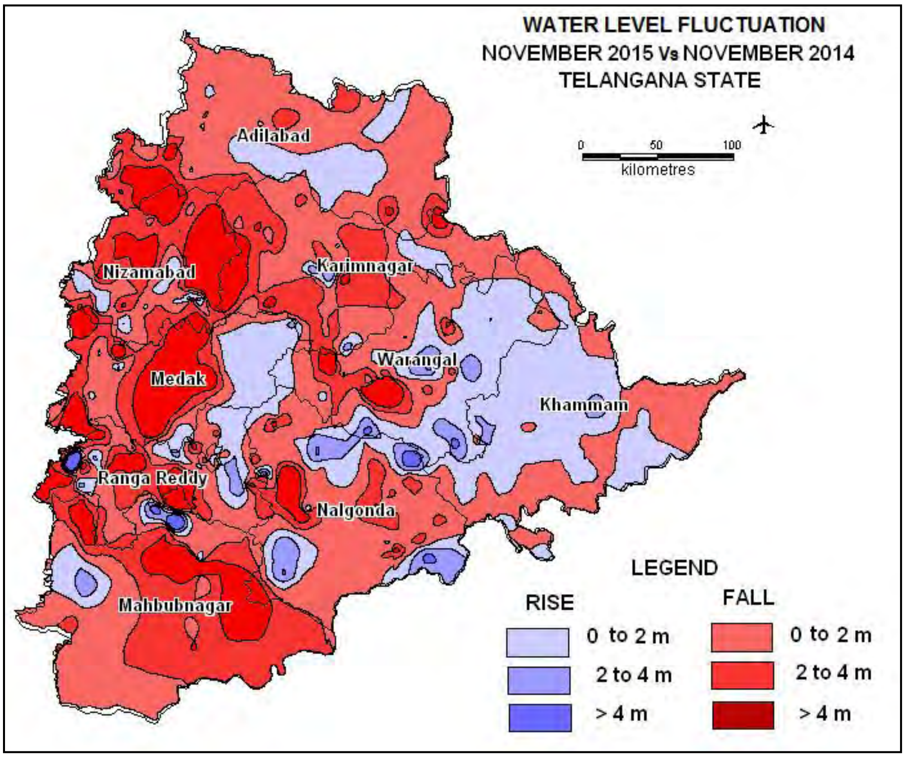


Fig. 7.7: Water Level Fluctuation-November-2015 Vs November-2014.

7.5.4 Water Level Fluctuation (January-2016 vs. January-2015)

Water level fluctuation data of January 2016 with respect to January 2015 is presented in **Annexure-8** and areal distribution of fluctualtion map is presented in **Fig.7.8.** An analysis of 546 wells shows that about 83% of the areas have shown a fall in water level representing

421 wells, rise is recorded in 109 wells covering an area of ~17 % and 16 wells shown neither rise nor fall in water levels during the period.

- The minimum and maximum fall in water level fluctuation is recorded as 0.01 m in Khammam district and 27.22 m in Mahabubnagar district.
- Maximum fall of > 4 m is observed in northern parts of Adilabad, in Nizamabad, central parts of Medak and eastern parts of Nalgonda districts
- 52% of the wells shows fall in water levels in the range of 0-2 m, 26% of the wells in 2-4 m range and 22% of the wells show fall more than 4m.
- The minimum and maximum rise in water level fluctuation is recorded as 0.01 m in Khammam district and 16.33 m in Nalgonda district.

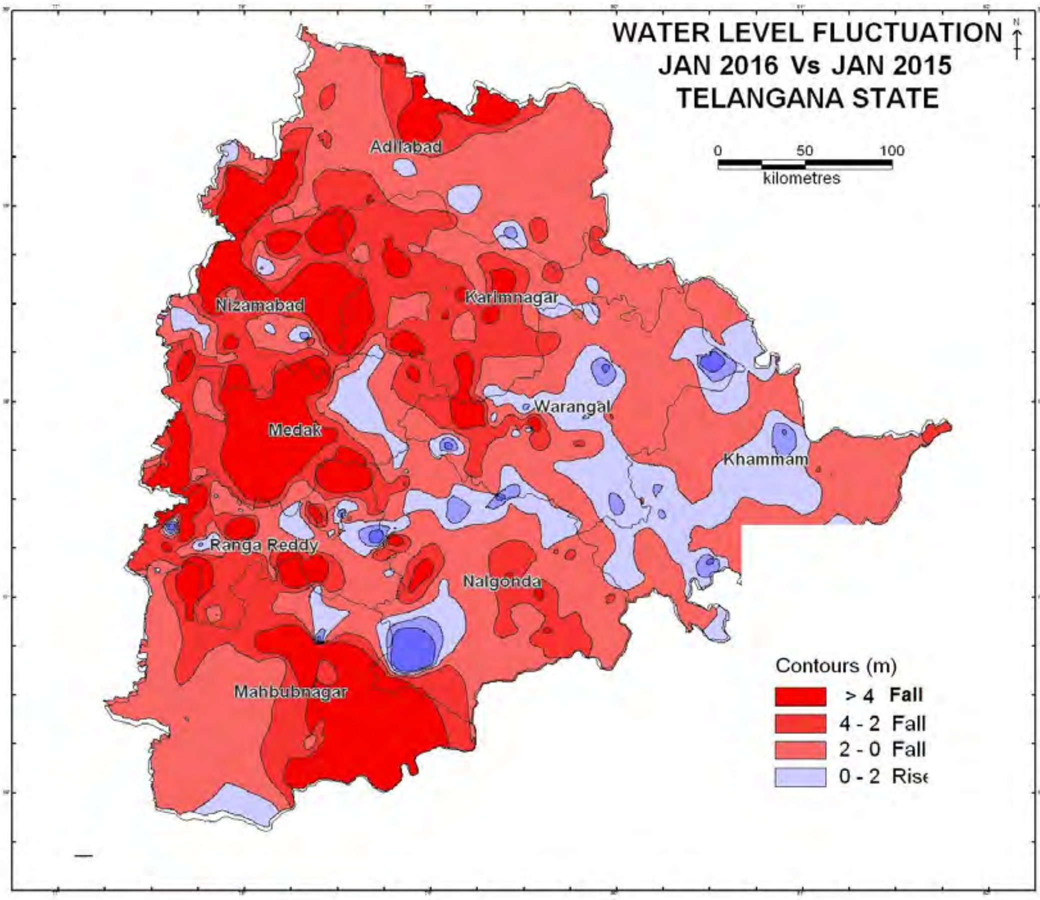


Fig. 7.8: Water Level Fluctuation - January-2016 Vs January-2015.

7.6 Decadal Water Level Fluctuation

7.6.1 Water Level Fluctuations-May-2015 vs. decadal mean of May (2005-14)

Water level fluctuation of May, 2015 with reference to Decadal mean of May (2005-2014) is presented in **Annexure-9** and areal distribution given in **Fig.7.9.** An analysis of 522 wells data shows a rise in water levels in 139 wells (26.6 %) and fall in 379 wells (72.6 %) covering an area of 25,555 km^2 (22 %) and 89,560 km^2 (76 %) respectively and remaining of the area no change is observed. This fall in water levels with respect to decadal mean is mainly due to less rainfall (-30 %) during the same period.

Perusal of the map shows a general fall in water levels. Water level rise of more than 4 m is recorded in Mahabubnagar, Nalgonda, Warangal and Rangareddy districts, while water level fall of more than 4 m is recorded in most of the districts except Khammam.

Decadal rise in water levels:

- During May 2015, the minimum rise in water level of 0.02 m in Medak district and maximum of 10.2 m in Mahabubnagar district is observed.
- Medak district have shown a very negligible rise in water levels as compared to other district (Min 0.02 and Max 1.55 m).
- Water level rise of <2 m is recorded in 19.4 % wells covering about 18 % of total geographical area (21510 Km^2) and it is mainly observed in Khammam, Mahabubnagar, Adilabad, Rangareddy and Nalgonda districts.
- 2 to 4 m and > 4 m rise in water levels is observed in 4.6 % and 2.5% of wells, covering about 3% and 1% geographical area respectively.

Decadal fall in water levels:

- During the period an appreciable fall in water levels are observed in ~ 89,560 Km^2 area (76%). The minimum fall of 0.02 m is observed in Medak district and maximum fall of 36.39 m in Ranga Reddy district.
- Fall in water levels of less than 2 m is observed in all districts of Telangana state covering an area about 52,760 km^2 (45%). This range is observed in 37.1% of wells.
- Water level fall between 2 to 4 m is noticed in all districts of Telangana state covering an area about 23,630 km^2 (20%). This range is observed in 20.2% of wells.
- More than 4 m water level fall is observed in all districts of Telangana State except Khammam district covering an area about 13,170 km^2 (11%). This range is observed in 15% of wells.

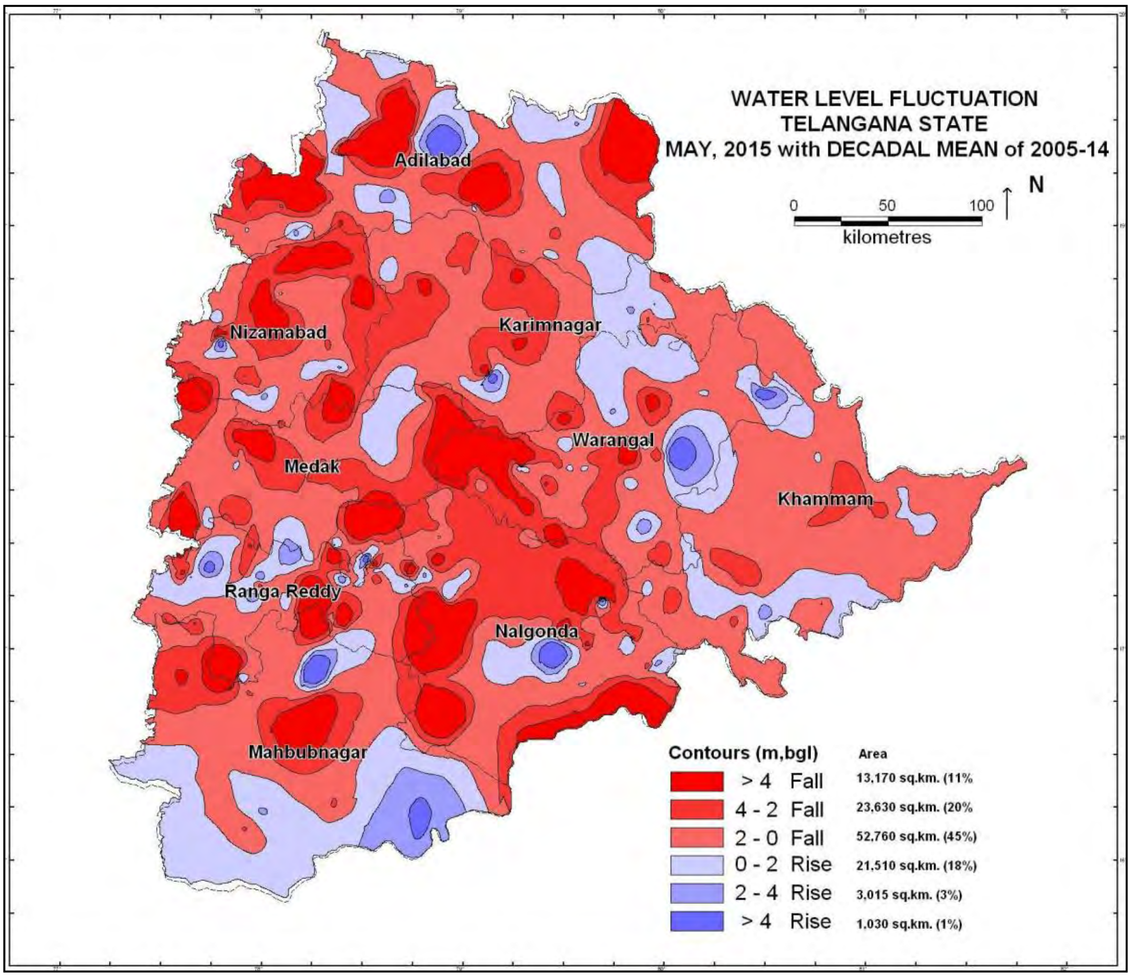


Fig.7.9: Water level Fluctuation –May-2015 Vs Decadal mean of May 2005-14.

7.6.2 Water Level Fluctuation-August-2015 with Decadal Mean of August 2005-14.

Water level fluctuation of August, 2015 with reference to Decadal means of August, (2005-2014) is presented in in **Annexure-10** and areal distribution given in **Fig.7.10.** An analysis of 532 wells data shows a rise in water levels in 129 wells (24.2 %) and fall in 403 wells (75.8 %) covering an area of 32564 km^2 (28 %) and 83736 km^2 (62 %) respectively. This fall in water levels with respect to decadal mean is mainly due to less rainfall (-27 %) during this period.

Perusal of the map shows a general fall in water levels in major part of The state. Water level rise of more than 4 m is recorded in south-western part of The state (Mahabubnagar) and north eastern parts of Warangal and Khammam districts.

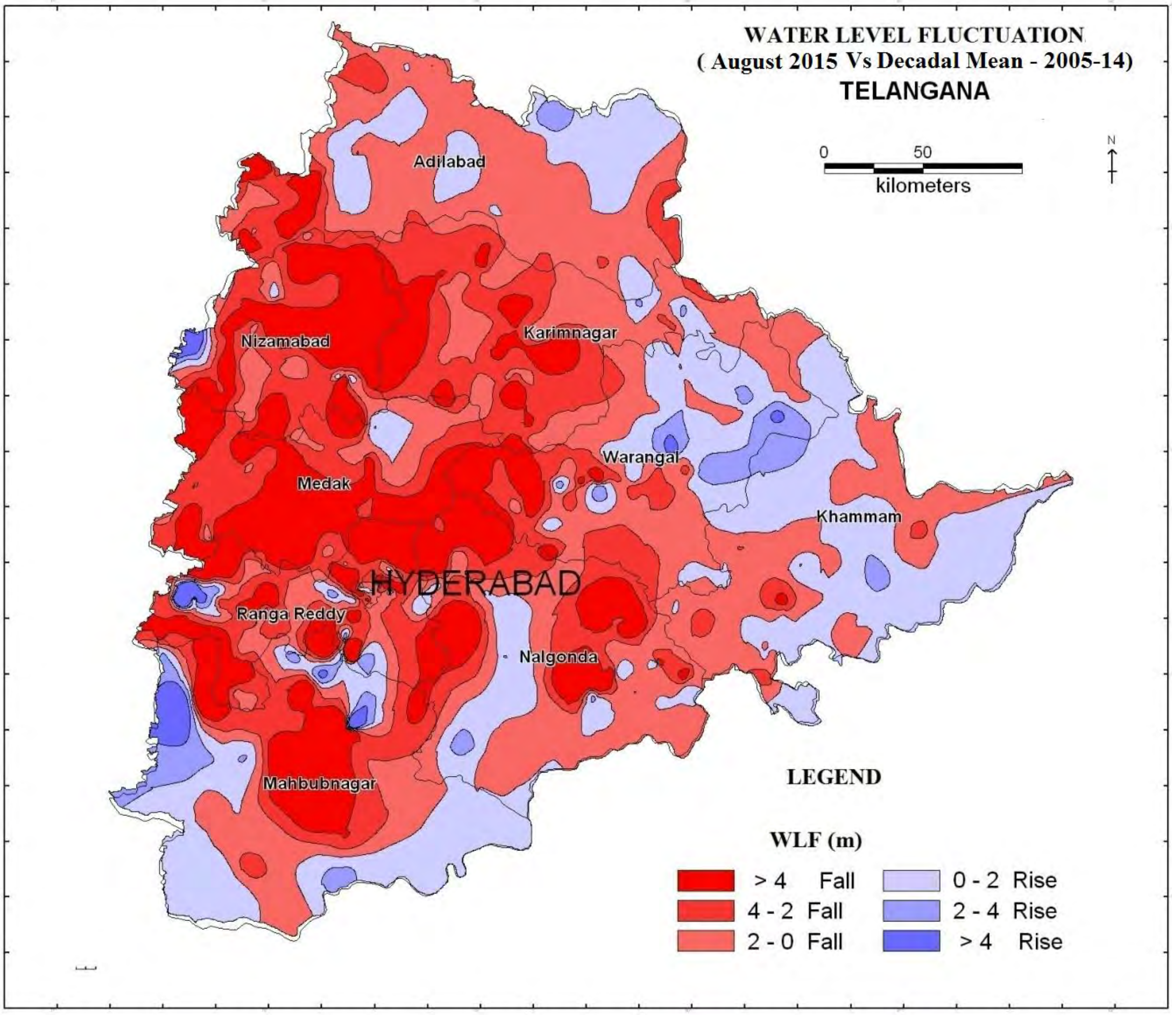


Fig. 7.10: Water level fluctuation (August 2015 Vs Decadal Mean August 2005-2014).

7.6.3 Water Level Fluctuation- November-2015 with Decadal Mean of November 2005-2014

Water level fluctuation of November, 2015 with reference to Decadal means of November, (2005-2014) is presented in in **Annexure-11** and areal distribution given in **Fig.7.11.** An analysis of 563 wells data shows a rise in water levels in 83 wells and fall in 476 wells covering an area of 15,960 km^2 (14 %) and 1,00,340 km^2 (86 %) respectively. This fall in water levels with respect to decal mean is mainly due to less rainfall (-31 %) during this period.

- The minimum and maximum rise in water level fluctuations is recorded as 0.03 m in Adilabad district and 21.45 m in Rangareddy district.

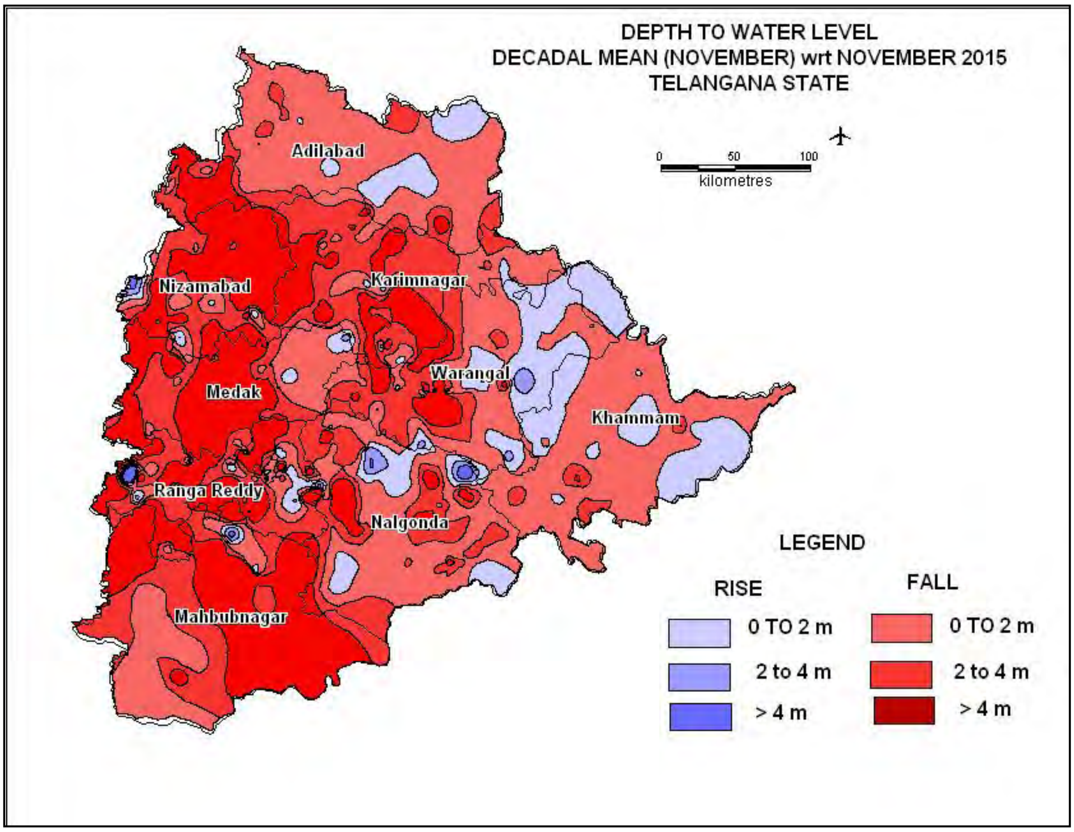


Fig. 7.11: Water Level Fluctuations, Nov-2015 Vs Decadal Mean (Nov 2005-2014)

- The minimum and maximum fall in water level fluctuations is recorded in 0.01 m Adilabad and Nalgonda districts and 33.12 m in Mahabubnagar district respectively.
- In The state about 15,960 km2 area shown a rise in water levels in the range of < 2 to > 4 m and in about 1,00,340 of the area, water level fluctuations have shown a fall in the range of < 2 to > 4 m.
- Perusal of the map shows a general fall in water levels in major part of The state except in eastern parts of Warangal and Khammam districts.

7.6.4 Water Level Fluctuation- January-2016 with Decadal Mean of January (2006-15)

Water level fluctuation of January-2016 with reference to decadal mean of January (2006-2015) is presented in in **Annexure-12** and areal distribution given in **Fig.7.12.**

An analysis of 557 wells data shows fall in 489 wells (93% of the area) and a rise in water levels in 66 wells (7% of the area) and 2 wells shown neither rise nor fall. This fall in water levels with respect to decadal mean is mainly due to less rainfall (-24 %) during this period.

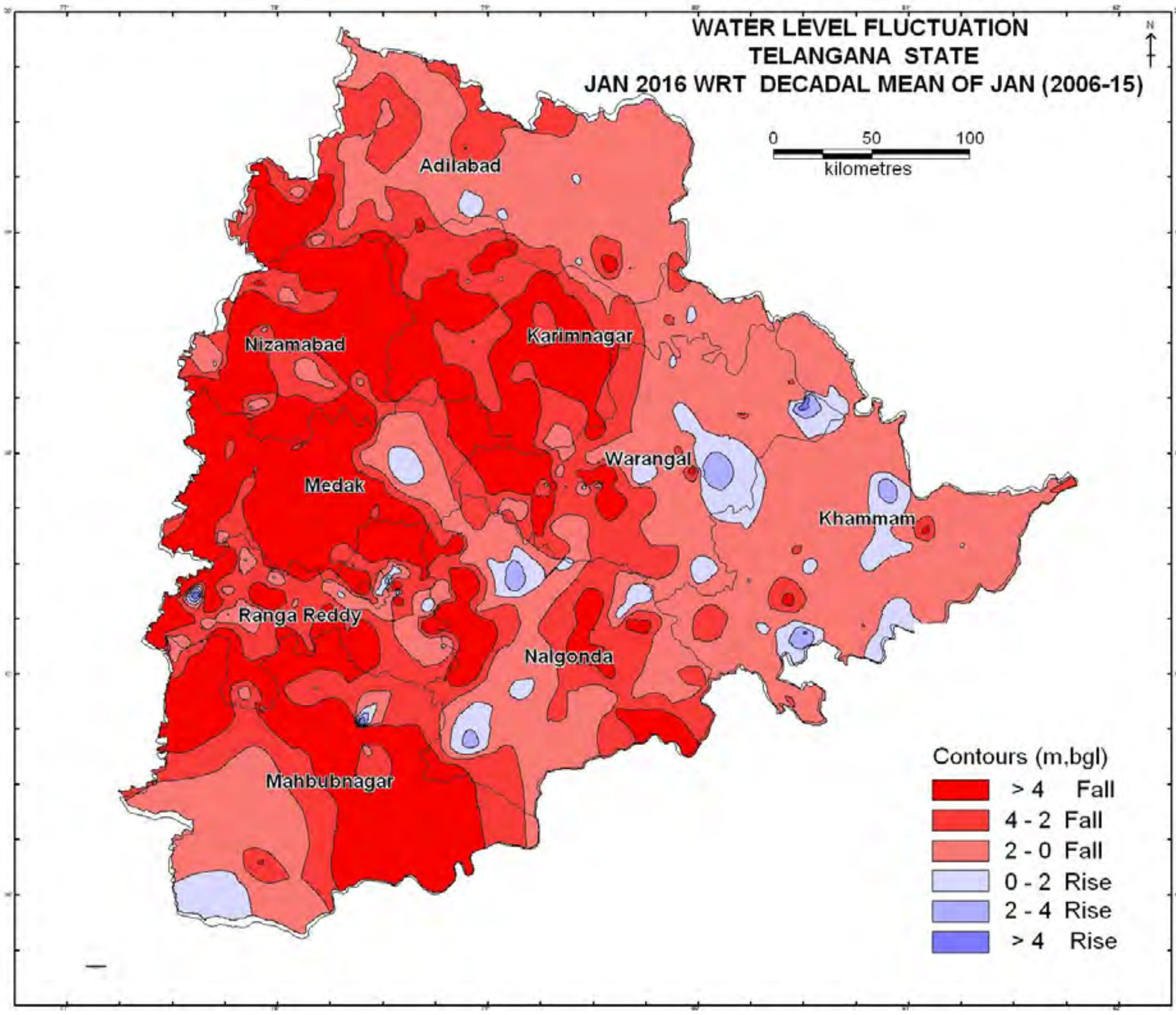


Fig. 7.12: Water Level Fluctuation, January 2016 Vs Decadal mean (January-2006-15).

- The minimum and maximum rise in water level fluctuations is recorded as 0.02 m in Khammam district and 9.10 m in Ranga Reddy district.
- The minimum and maximum fall in water level fluctuations is recorded as 0.01 m in Warangal district and 47.86 m in Medak district.
- Out of 489 wells, 39% of the wells shows fall in water levels in the range of 0-2 m, 27% of the wells in 2-4 m range and 34% of the wells show fall more than 4 m.

7.7 Aquifer wise water levels

Aquifer wise water level analysis shows that during pre-monsoon season water levels are shallowest (0.3 m bgl) and deepest (40.5 mbgl) in banded gneissic complex (BGC). Deepest water level (46.1 mbgl) during pre-monsoon season are noticed in basalt formation.

During post-monsoon season the deepest water level is in BGC (59.4 mbgl). Aquifer wise water level scenario is presented in **Table-7.1.**

Table-7.1: Aquifer wise distribution of water levels, Telangana State.

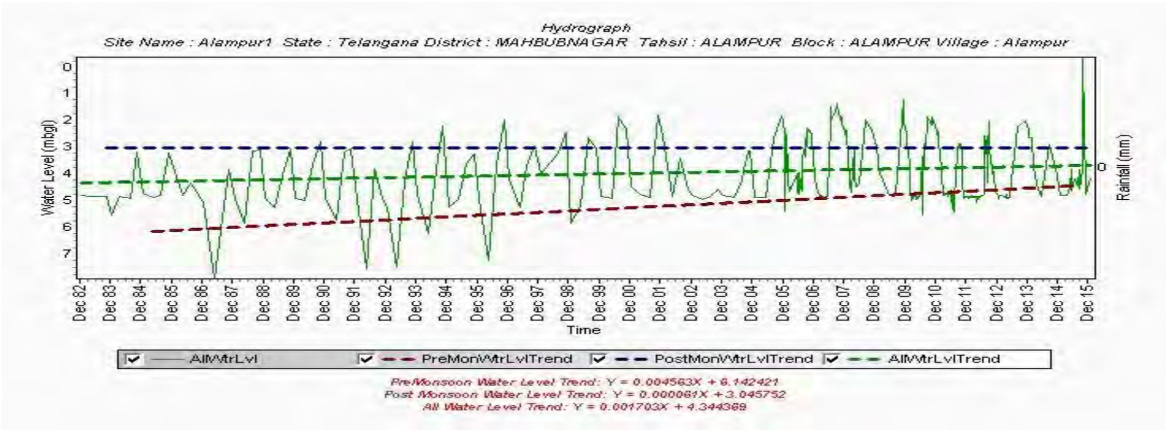
Aquifer Type	May-15				Nov-15			
	Min	**Max**	**Avg**	**Nos**	**Min**	**Max**	**Avg**	**Nos**
LT	6.4	18.3	12.6	13	7.5	18.8	14.1	15
BS	2.3	46.1	11.6	42	1.9	52.9	9.4	40
ST	0.5	16.9	6.6	54	-0.1	12.7	4.5	57
GR	3.7	27.4	11.6	15	3.5	34.5	13.1	14
QZ	7.5	10.6	9	2	7.4	14.4	10.9	2
LS	3.1	7.4	5.6	6	0.5	7.9	4.3	7
BG	0.3	40.5	10.4	426	0.2	59.4	9.3	457
GN	0	0	0	0	18.1	18.1	18.1	1
SH	7.5	14.8	10.2	3	2.8	6.9	4.4	3
SC	6.5	6.5	6.5	1	5.7	5.7	5.7	1
CK	3.7	3.7	3.7	1	1.9	1.9	1.9	1

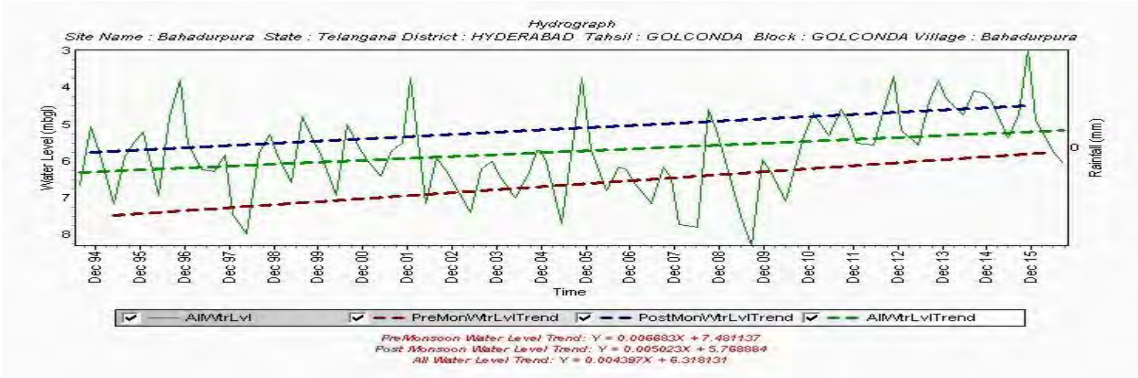
7.8 Long-term Water Level trends: A total 20 hydrographs are generated (2 from each district) by using the existing long term data (**Table-7.2 and Fig. 7.13**). Out of 20, 9 wells show rising trend in both seasons, 8 wells show falling trend in both seasons and 2 wells show rising trend during pre-monsoon season and falling trend in post-monsoon season and 1 well show falling trend during pre-monsoon and rising trend during post-monsoon season (**Table-7.2**).

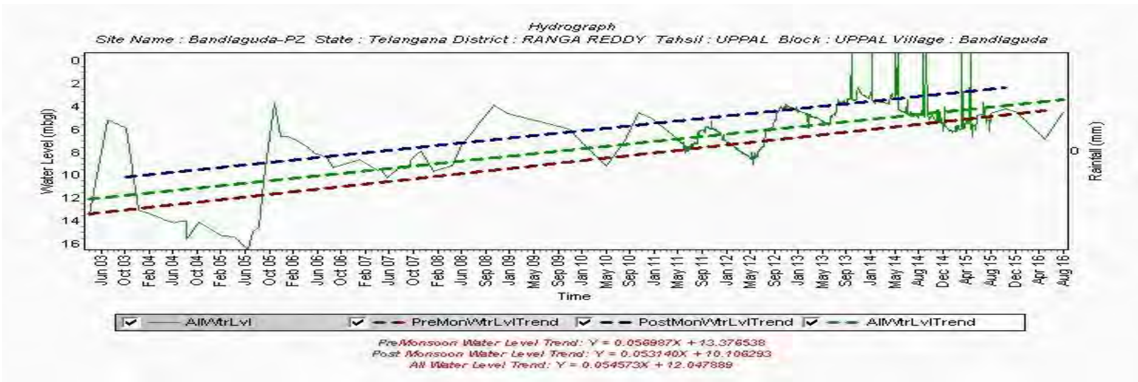
7.9 Water levels from deeper Aquifer: In addition to shallow ground water monitoring, a total of 107 piezometers are monitored representing deeper aquifers (**Annexure-13**). The minimum and maximum water levels during pre-mononsoon season varies from 2.93 (Rangareddy) to 91.86 m bgl (Nalgonda district). During post-monosoon season water levels varies from 0.45 (Adilabad) to 91.93 m bgl (Nalgonda district). In both seasons 1 well in Warangal district is in artesian condition.

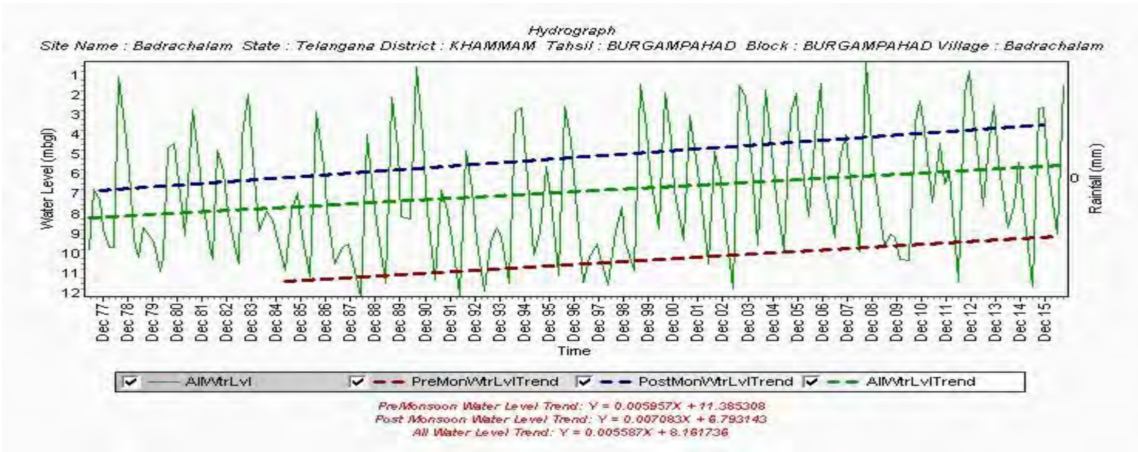
Table-7.2: Representative Hydrograph Stations showing rising and falling trends in Telangana State.

S. No.	Location	District	Pre (m/yr)		Post (m/yr)		Aquifer
			Rise	Fall	Rise	Fall	
1	Bhimavaram	Adilabad	0.012			0.033	Sandstone
2	Gudihatnur	Adilabad	0.05		0.03		Basalt
3	Bahadurpura	Hyderabad	0.08		0.06		BGC
4	Kutubshahi tombs	Hyderabad		0.15		0.13	BGC
5	Chigurmamidi	Karimnagar		0.06		0.041	BGC
6	Dharmapuri	Karimnagar		0.1		0.059	BGC
7	Bhadrachalam	Khammam	0.071		0.085		BGC
8	Kesavpuram	Khammam	0.027		0.053		BGC
9	Alampur	Mahabubnagar	0.055		0.007		Limestone
10	Bandrapal	Mahabubnagar	0.13		0.066		Granite
11	Nacharam	Medak	0.047			0.023	BGC
12	Narayankhed	Medak		0.035		0.039	BGC
13	Devarkonda	Nalgonda	0.3		0.12		BGC
14	Miryalguda	Nalgonda	0.05		0.03		BGC
15	Chinnkodapagal	Nizamabad		0.11		0.084	BGC
16	Dudgaon	Nizamabad		0.033		0.07	Granite
17	Vanasthalipuram	Ranga Reddy		0.055	0.2		BGC
18	Bandlaguda	Ranga Reddy	0.7		0.6		BGC
19	Govindraopet	Warangal		0.025		0.023	Sandstone
20	Katapuram	Warangal		0.2		0.015	Sandstone

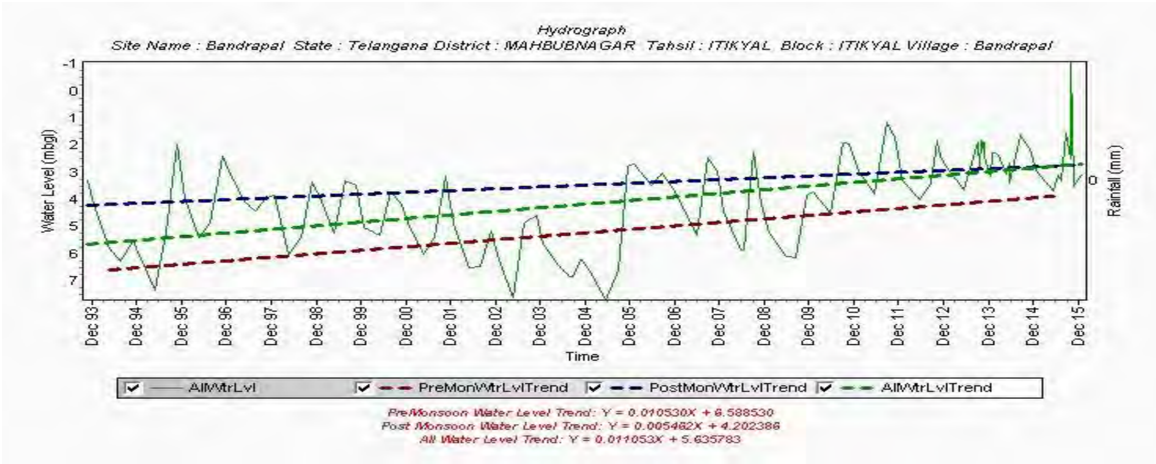


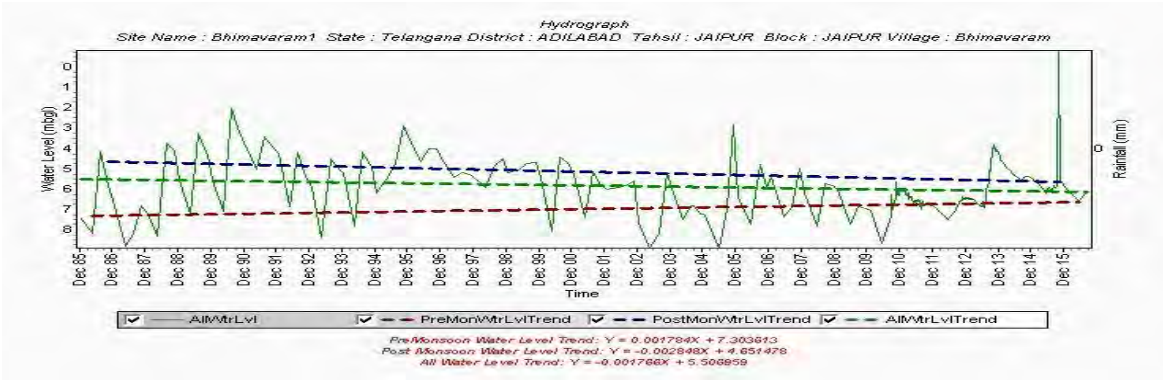


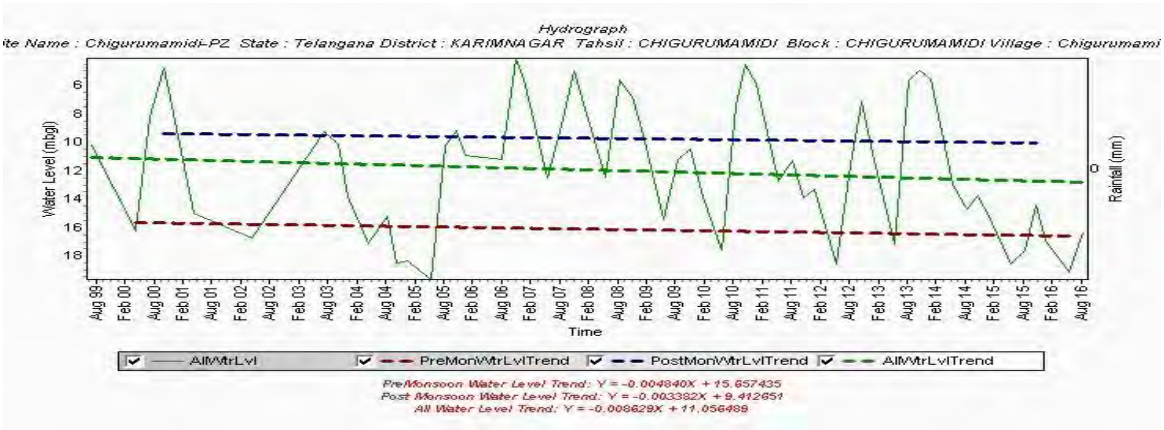


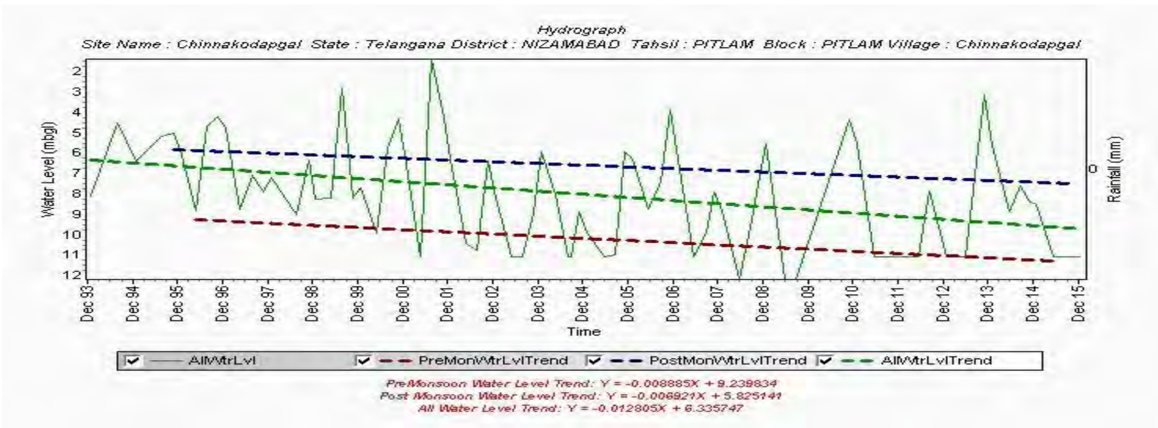


7.13 a Representative Hydrographs from Telengana State.

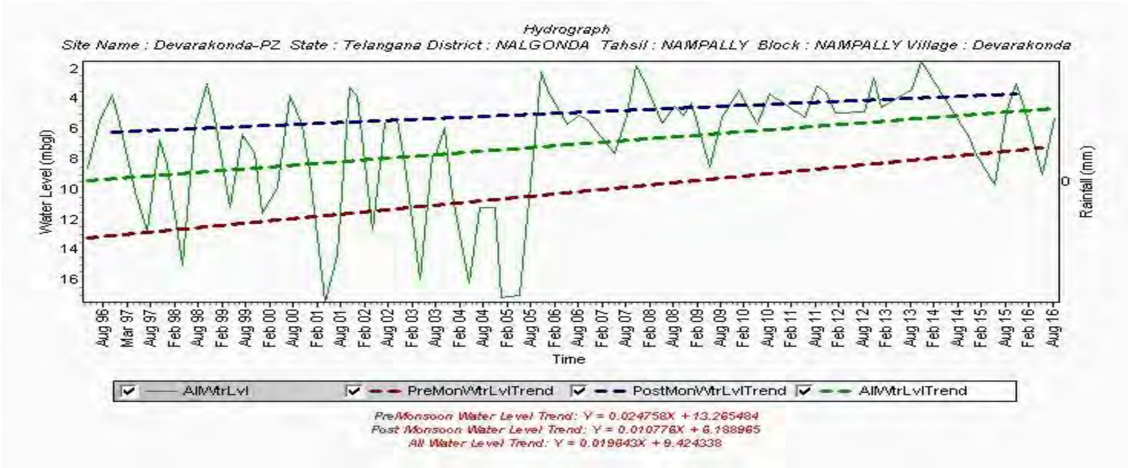


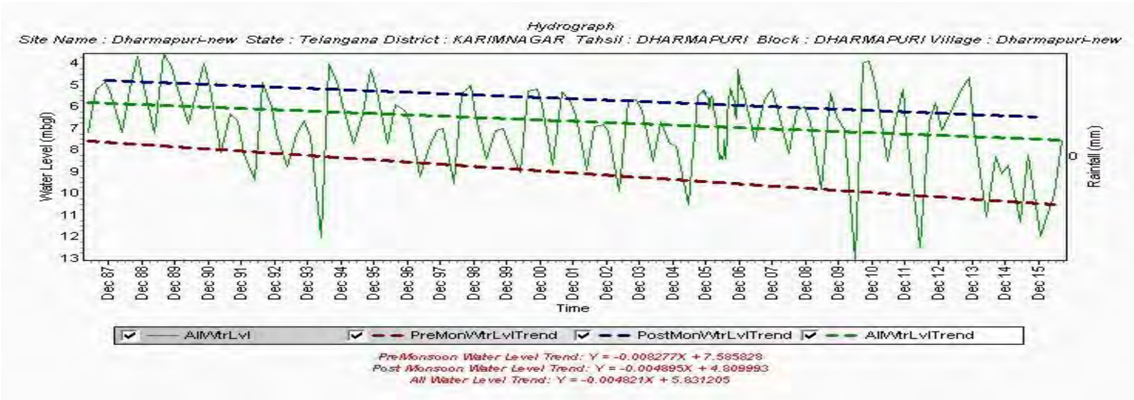


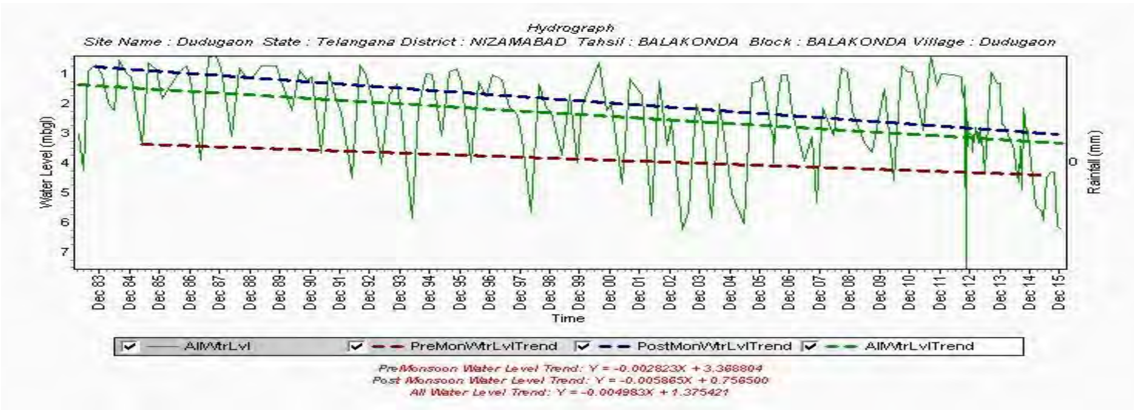


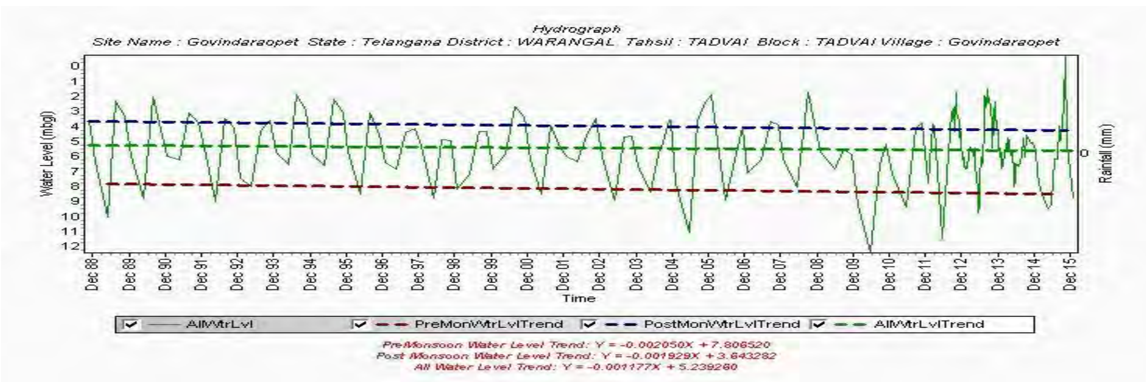


7.13b Representative Hydrographs from Telengana State.

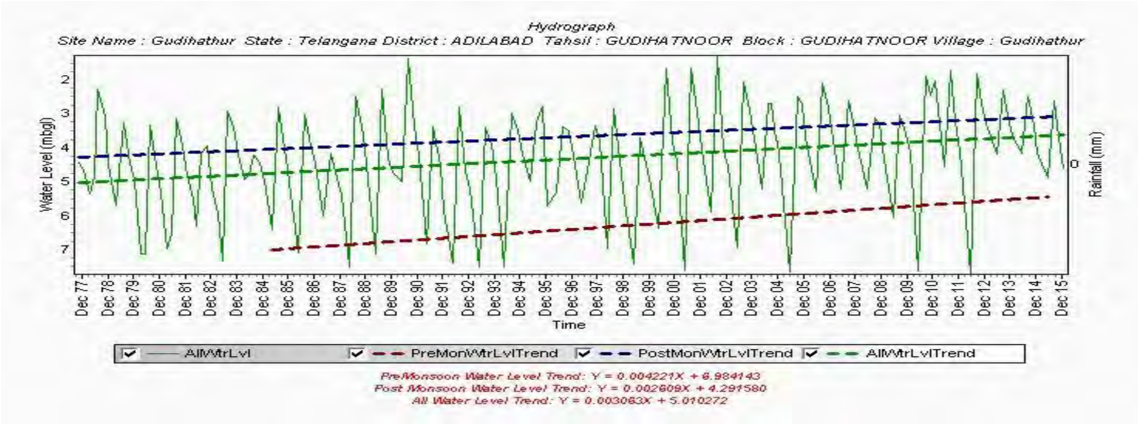


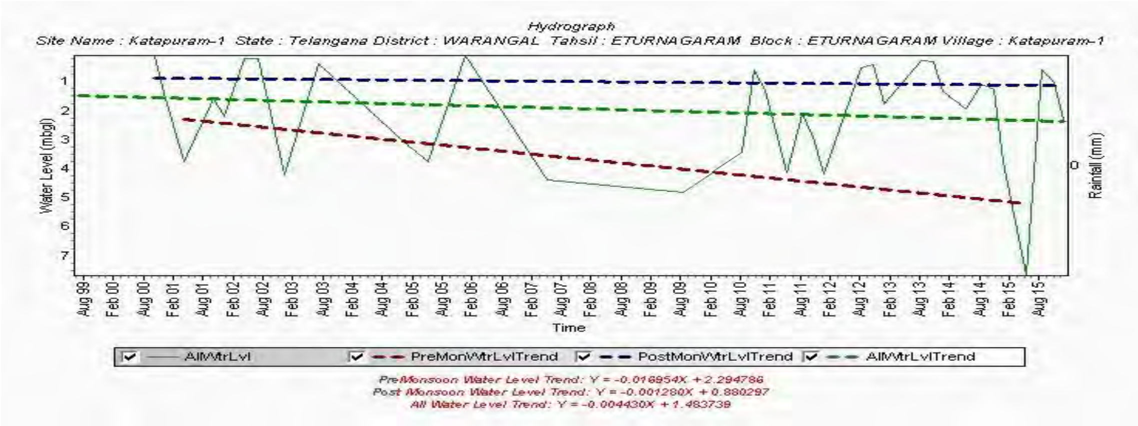


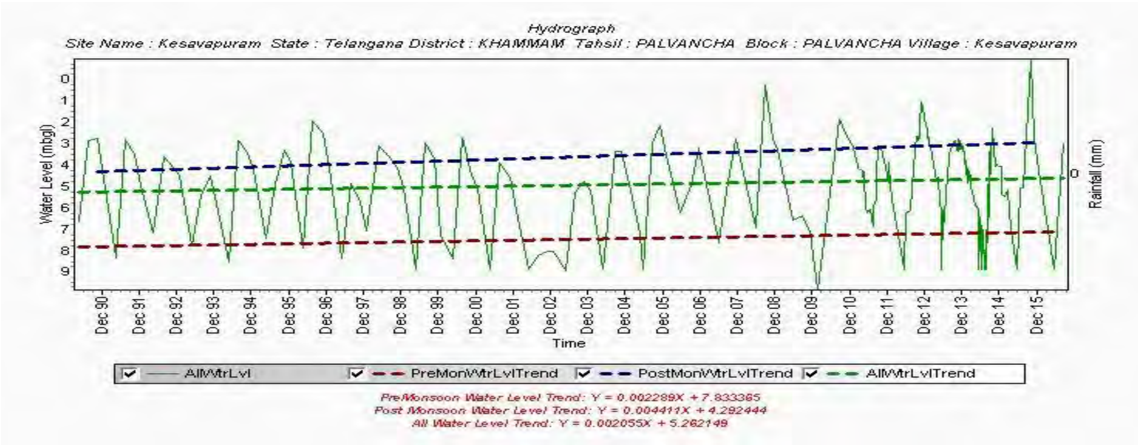


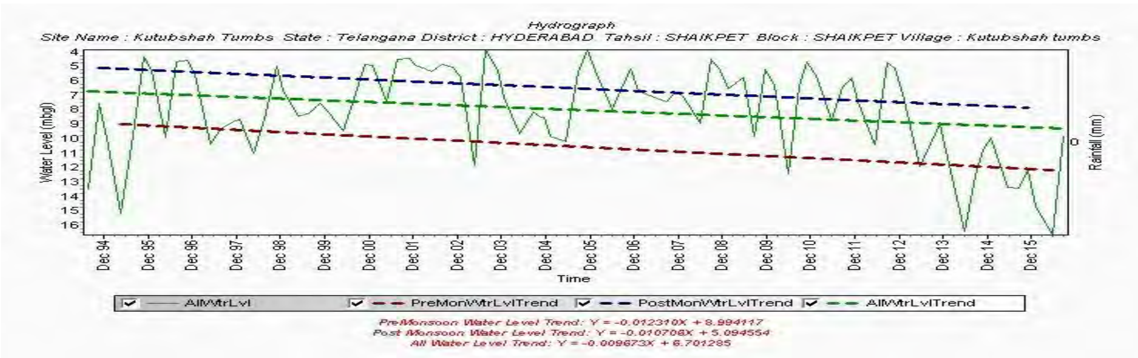


7.13c Representative Hydrographs from Telengana State.

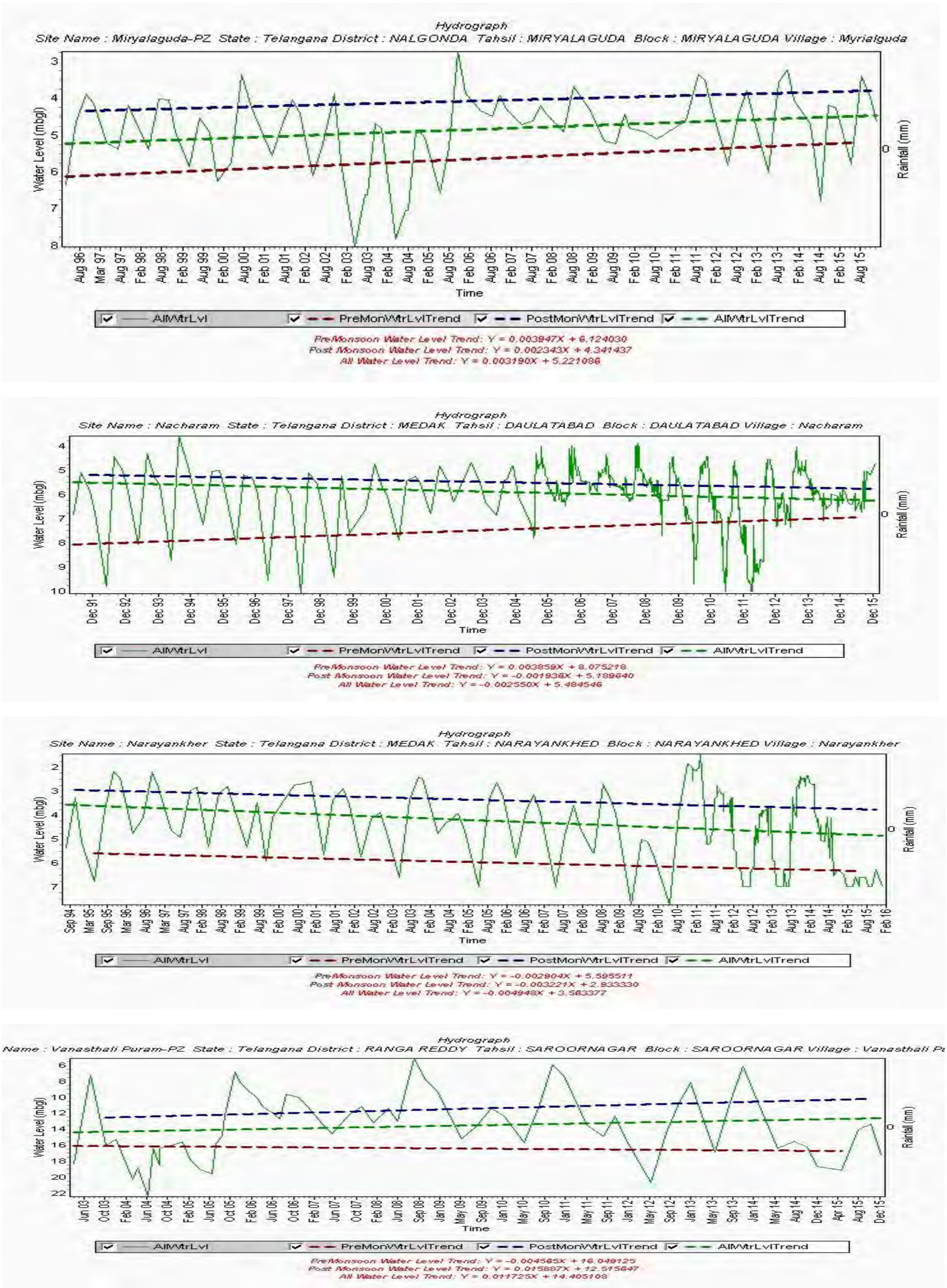








7.13d Representative Hydrographs from Telengana State.



7.13e Representative Hydrographs from Telengana State.

8. GROUND WATER QUALITY

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

8.1 Distribution of physico-chemical parameters

A total of 311 groundwater samples from shallow GWMS (both DW and Pz) were collected during pre-monsoon season of 2015 (May) for basic constituents, iron and arsenic (As) analysis (Fig.8.1 and Table-8.1). Samples are analyzed in the Regional Chemical Laboratory of CGWB, SR, (NABL Accredited). Sampling, preservation, and storage of groundwater have been carried out by following standard guidelines (APHA 1998). Sixteen major parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^2+), sodium (Na+), potassium (K+), carbonate (CO3), bicarbonate (HCO^{3-}), chloride (Cl), sulphate ($SO^4{}_2$-), nitrate (NO3-), fluoride (F-), iron and arsenic were determined. The cation and anion balance are within acceptable limits of +/- 5% (APHA, 1998). District wise minimum, maximum and average is given in Table- 8.2 and in detail in **Annexure-14**.

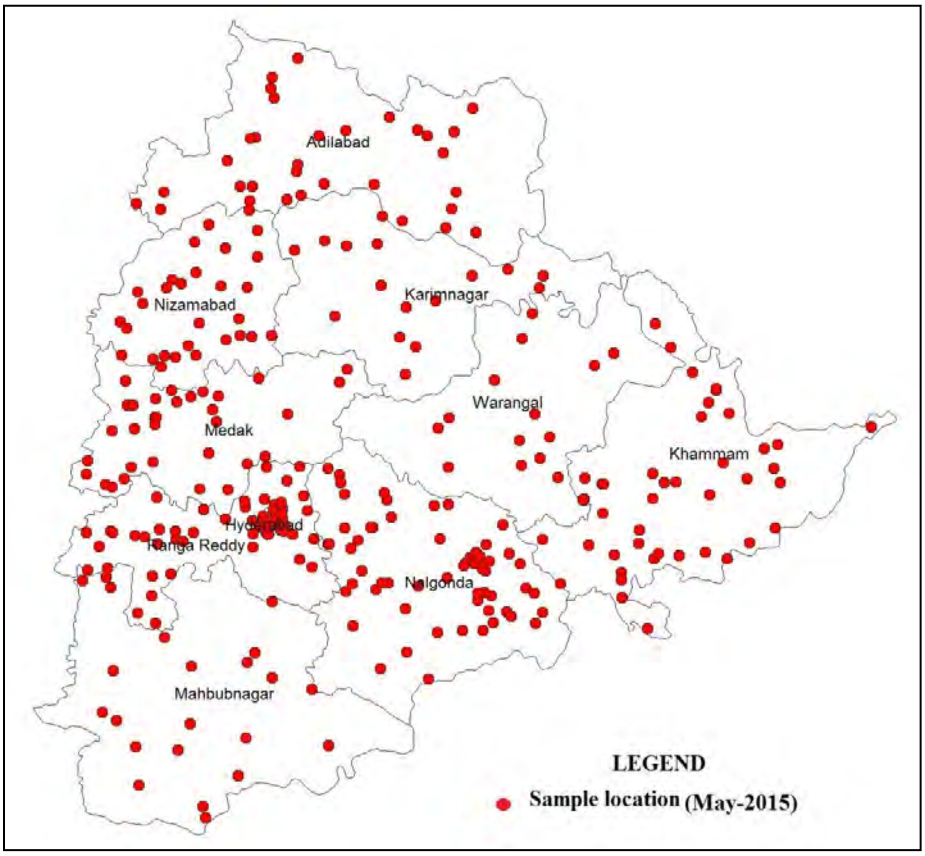


Fig.8.1: Location of Ground water sample sites in Telangana state.

Table-8.1: District wise collection of samples (May-2015).

S.No.	District	Samples		S.No.	District	Samples
		Normal				Normal
1	Adilabad	32		6	Medak	33
2	Hyderabad	14		7	Nalgonda	65
3	Karimnagar	16		8	Nizamabad	29
4	Khammam	44		9	Rangareddy	42
5	Mahbubnagar	22		10	Warangal	14

Table- 8.2 Statistical Analysis of for Various Parameters

District	Min/ Max/ Avg	pH	TH	Ca	Mg	HCO_3	Cl^-	SO_4	NO_3	F	TDS	As	Fe
			←					Mg/l					→
Telangana State	Min	6.6	40	6.0	1.2	18	7.1	0.0	0.06	0.05	75	0.0000	0.00
	Max	8.6	3080	728	306	1403	1773	845	993	3.8	5139	0.0174	7.9
	Avg	7.6	420	89	48	398	214	75	65	0.88	901	0.0008	0.68
Adilabad	Min	7.6	205	34	8.5	207	14	2.5	5.9	0.1	303	0.0021	0.00
	Max	8.6	740	190	141	1403	1773	400	229	2.5	5139	0.0031	0.99
	Avg	7.9	364	81	40	389	191	30	59	0.77	792	0.002	0.13
Hyderabad	Min	7.4	185	26	4.9	122	53	20	2.4	0.49	344	0.000	0.01
	Max	8.2	615	190	64	427	372	125	84	2.1	1085	0.000	7.1
	Avg	7.8	355	79	38	278	166	61	27	0.96	639	0.000	1.8
Karimnagar	Min	6.7	150	44	2.4	159	35	0.25	1.6	0.39	255	0.002	0.02
	Max	7.6	1020	316	145	561	787	178	227	2.7	2211	0.003	5.6
	Avg	7.2	468	121	40	443	183	21	89	1.2	841	0.003	0.48
Khammam	Min	6.8	50	8.0	4.9	18	11	0.48	0.06	0.05	75	0.002	0.01
	Max	8.0	960	180	191	848	1319	845	311	3.1	3504	0.005	7.9
	Avg	7.5	391	64	56	446	225	95	51	0.86	975	0.003	0.49
Mahabub-nagar	Min	7.3	165	18	15	128	35	3.4	3.1	0.25	250	0.002	0.20
	Max	8.5	915	224	178	763	468	400	260	2.4	1783	0.003	5.6
	Avg	7.7	514	99	65	442	223	115	85	0.72	1033	0.003	0.98
Medak	Min	6.8	40	6.0	3.6	67	7.1	0.48	0.62	0.05	125	0.002	0.06
	Max	8.4	920	200	131	1007	908	305	198	3.0	2464	0.004	7.6
	Avg	7.3	358	84	36	388	164	47	35	0.69	739	0.003	1.05
Nalgonda	Min	6.6	100	12	1.2	61	34	2.2	0.76	0.18	242	0.002	0.03
	Max	8.2	3080	728	306	927	1489	560	993	3.8	4399	0.017	0.93
	Avg	7.6	536	115	60	460	348	134	99	0.98	1310	0.005	0.17
Nizamabad	Min	6.8	100	8.0	4.9	110	11	0.96	0.62	0.09	123	0.002	0.01
	Max	8.4	985	208	162	1007	443	130	128	1.1	1351	0.004	5.0
	Avg	7.7	345	72	40	309	138	48	33	0.55	611	0.003	0.75
Ranga Reddy	Min	7.5	110	28	6.1	98	21	0.00	3.0	0.14	239	0.002	0.05
	Max	8.4	990	186	141	525	468	155	584	3.6	1747	0.003	6.7
	Avg	7.9	374	88	38	307	144	48	73	0.99	676	0.003	1.48
Warangal	Min	7.3	185	26	12	214	43	22	2.5	0.26	418	0.003	0.01
	Max	7.9	930	200	139	702	411	141	126	3.2	1488	0.003	0.33
	Avg	7.6	410	68	58	465	150	62	49	1.27	810	0.003	0.07

8.1.1 Hydrogen Ion Concentration (pH)

The hydrogen ion activity is a main variable of groundwater system because the hydrogen ion participates in most of the chemical reactions that affect water composition. In most natural waters pH value is dependent on the carbon dioxide-carbonate-bicarbonate equilibrium. The pH value of a solution is the negative logarithm of concentration of hydrogen ions (H+) in moles/liter. Pure water at 7 pH (at 25° C), contains equal proportion of H+ and OH- (hydroxyl) ions. The pH value is less than 7 if the H+ ions exceed the OH- ions, and it is more than 7 when OH- ions exceed H+ ions. In the ground waters of State, pH ranges from 6.6-8.6. In only 1 sample (Medaram, Adilabad district), pH is beyond permissible limit of BIS **(Annexure-15).**

8.1.2 Electrical Conductivity (EC)

Specific conductance (EC) of an electrolyte is the reciprocal of specific resistance and is expressed in μ S/cm. Electrical conductivity normally, increases with flow and residence time in the aquifer and its determination shows, to what extent mineralization has taken place in the groundwater. In the study area, the EC values (μS/cm at 25 °C) ranges from 127-8526.Highest EC is noticed at Medaram in Adilabad district. Overall EC is in the range of 750-2250 μ S/cm and high ECs are detected in eastern parts of Adilabad, Karimnagar, central part of Khammam and western parts of Nalgonda districts (Fig.8.2).

8.1.3 Total Dissolved Solids (TDS)

The concentration of TDS in groundwater depends upon nature of rock formation, depth through which water is passing, climate, geomorphology of the area at which water is moving, porosity and permeability of rocks. Contamination of water by human and animal activities including sewage disposal and agricultural practices and mixing of different types of water also affects TDS.

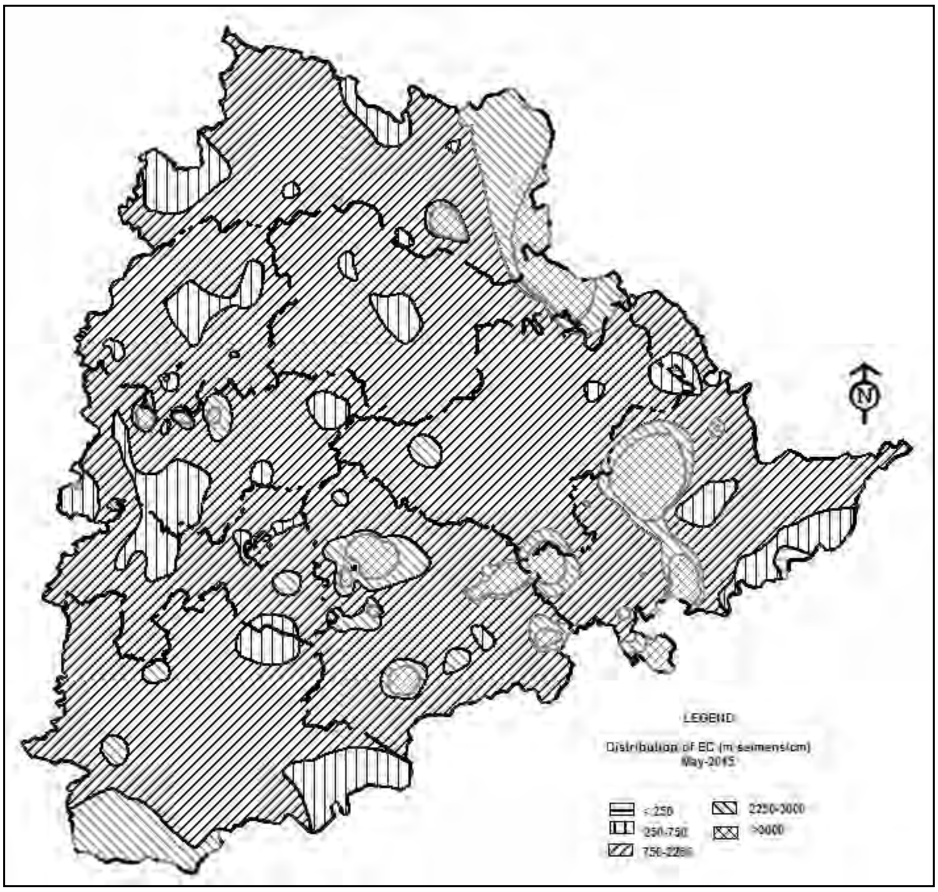


Fig.8.2: Distribution of EC (May-2015).

In The state, concentration of TDS ranges from 75-5139 mg/L (avg: 928) and it is found that in 44 samples it is beyond drinking water standard limit (2000 mg/l).

8.1.4 Total Hardness (TH)

Total hardness is the capacity of water to neutralize soap and is the sum of Ca2+and Mg2+. Hardness is of two types, namely primary and secondary. In The state, total hardness ranges from 40-3080 mg/L and it is found that in 53 samples, TH is beyond drinking water standard limits of BIS (600 mg/l).

8.1.5 Calcium (Ca^{2+})

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

The concentration of calcium ranges from 6-728 mg/l and it is found that in 9 samples, Ca is beyond drinking water standard limits (200 mg/l). In 4 districts Ca beyond permissible limits is detected and maximum of 728 is detected in Nalgonda district (Tummal penpahad).

8.1.6 Magnesium (Mg^{2+})

Weathering of basic igneous rocks such as dunites, pyroxenites; volcanic rocks such as basalts; metamorphic rocks like amphibolites, talc and tremolite-schists; sedimentary rocks such as dolomite, gypsum etc are the main sources of Mg2+ in the groundwater (Karanth, 1987) and use of surface water for irrigation is another source of Mg2+ in the groundwater (Hem, 1991). In The state, as in most natural water, the magnesium concentration is much lower than the calcium concentration (Hem, 1991). It ranges from 1-306 mg/L. Except Hyderabad, in all districts Mg is beyond permissible limits in 27 samples with maximum of 306 mg/l is detected in Nalgonda district (Tummal penpahad).

8.1.7 Sodium (Na^{+})

Silicate minerals such as albite, nepheline, sodalite, glaucophane, aegerine and other Na+ bearing minerals present in rocks are the main source of Na+ in the groundwater. The other sources are rainwater, dissolution of evaporate minerals, sodium disposal through sewage and industrial wastes (Handa, 1975). Certain clay minerals and zeolites can increase the sodium concentration in groundwater by Base Exchange reaction **(Karanth, 1987).** The concentration of Na^{+} ranges from 2 to 1656 mg/l. Maximum concentration of 1656 is detected in Medaram well (Adilabad district).

8.1.8 Potassium (K^{+})

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

The concentrations of K^+ ranges from below detectable limits to 550 mg/l. Maximum concentration of 550 mg/l are detected in Kethepally well (Nalgonda district).

8.1.9 Carbonate and Bicarbonate (CO_3^- and HCO_3)

The main sources of CO_3^- and HCO_3^- ion in the groundwater is dissolved CO2 present in rainwater. When this rainwater enters soil, it dissolves more CO2 from decaying organic matter present in soil **(Karanth, 1987).** An increase in temperature or decrease in pressure causes reduction in the solubility CO2 in groundwater. Carbon dioxide mixed water, while passing through soil dissolves carbonate minerals and give bicarbonate.

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

In the ground waters of State, the concentrations of bicarbonate ranges from 18-1403 mg/l. Maximum concentration of 1403 is detected in Medaram well (Adilabad district).

8.1.10 Chloride (Cl^-)

Chloride in the form of chloride (Cl-) is one of the major in-organic anion in water and wastewater **(APHA, 1995).** Hydrolysis of halite and related minerals, rainwater, irrigation and industrial effluents are the main sources of Cl- in groundwater **(Handa, 1975).** Minerals like sodalite, mica, chloro-apatite, hornblende, etc are the other minor sources of chloride in groundwater **(Karanth, 1987).** Abnormal concentration of Cl^- in groundwater may results due to pollution of sewage wastes, planting of coconut trees **(Karanth, 1987).**

In the ground waters of State, chloride concentration ranges from 7 to 1773 mg/l and found that 6 samples are unsuitable for drinking purposes. Maximum concentration of 1773 is detected in Medaram well (Adilabad district).

8.1.11 Sulphate (SO_4^{2-})

Sulphate (SO_4^{2-}) is widely distributed in native and may be present in natural waters in concentration ranging from a few to several thousand mg/l (APHA, 1998). The main sources of SO42- in groundwater are sulphide minerals like pyrite, gypsum and anhydrite minerals found in sedimentary rocks are other sources of SO_4^{2-} in groundwater (Karanth, 1987).

In the ground waters of State, the concentrations of sulphate range from 0-845 mg/l. Maximum concentration of 845 is detected in Madhira well (Khammam district).

8.1.12 Nitrate (NO_3^-)

Nitrogen is present in atmosphere reacts with rainwater and forms nitrate and ammonium ions. The incidence of high nitrate in groundwater has been observed due to pollution from anthropogenic sources, specially leaching from sewage/septic tanks **(Walker, 1973; Dudley, 1990).**

In the ground waters of State, the concentrations of nitrate range from 0-993 mg/l. Maximum concentration of 993 is detected in Tummala penpahad well (Nalgonda district). It is found that out of 311 samples nearly 137 samples (44%) are unfit for human consumption. Distribution of nitrate is presented in **Fig.8.3**.

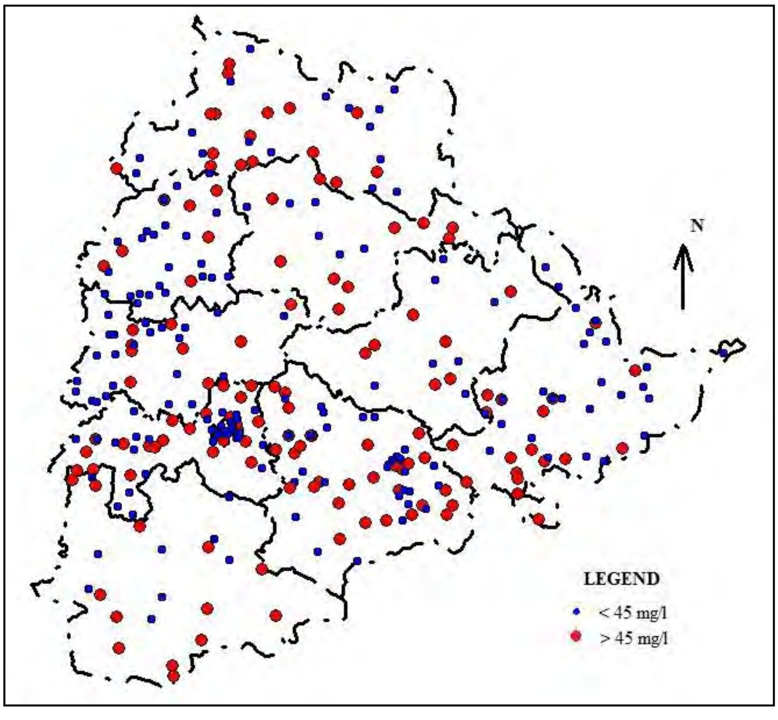


Fig.8.3: Distribution of nitrate in ground water (May-2015).

8.1.13 Fluoride (F^-)

The main sources of F^- in ground waters are F- bearing minerals present in rocks like fluorite (CaF^2), apophyllite ($KFCa4(Si_4O_20)8H_2O$), fluoroapatite ($Ca^3(PO_4)3F$), cryolite (Na_3AlF6), villuanite as well as F- replacing hydroxyl ion in the ferromagnesium silicates (amphiboles, micas) and soil consisting of clay minerals. Dissolution of F- bearing minerals, ion exchange and evaporative concentration can locally account for high F- concentration in ground water. Weathering of rock and leachable F- in an area are more important in deciding the presence of F- in groundwater rather than presence of F- bearing minerals in bulk rocks/soils (Ramesham and Rajagopalan 1985). Other causes of high F- in ground water are alkaline nature, high HCO3-, high TDS and longer residence time in an aquifer (**Madhnure, et al., 2007).**

In the ground waters of State, the concentrations of fluoride range from 0.1-3.8 mg/l and maximum concentration of 3.8 is detected in Malkapur piezometer wells (Nalgonda district). Over all 44 samples (14%) are unfit for human consumption. Higher concentration of F (>1.5 mg/l) are detected in all parts of The state **(Fig.8.4).**

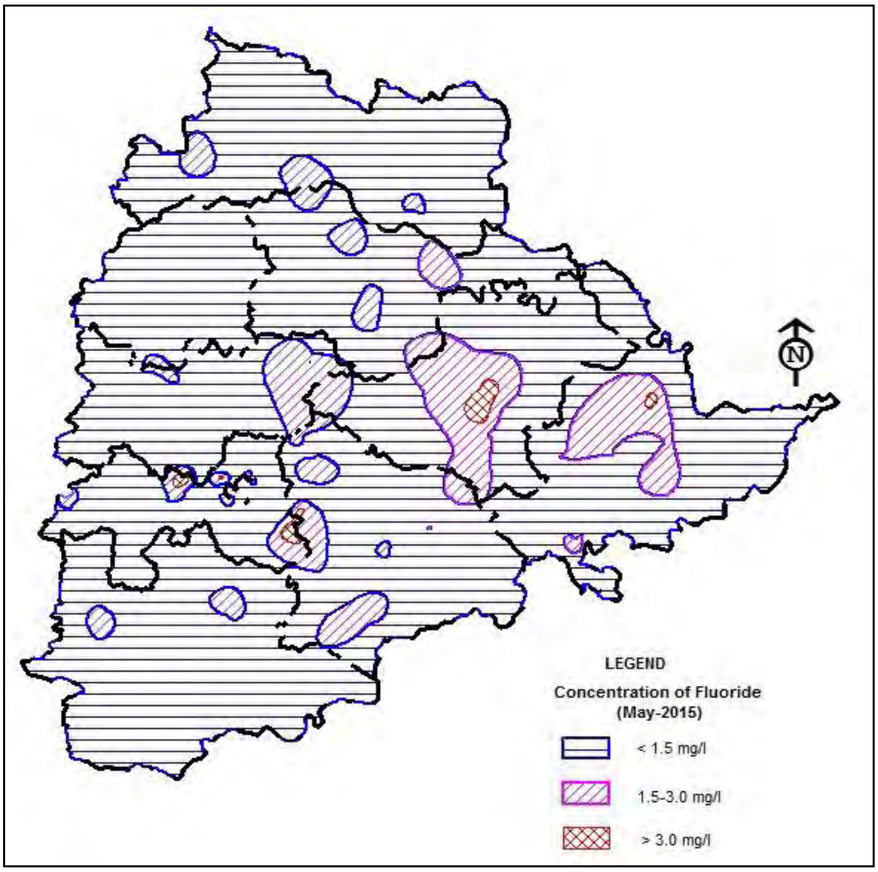


Fig.8.4: Distribution of Fluoride in ground water (May-2015).

8.1.14 Iron

Iron is a minor constituent of natural water, but plays an important role in assessing the quality of water for domestic use. Deleterious effects of Iron on human system are less. It is beneficial when present in concentrations of upto 0.3mg/l. Anaerobic groundwaters may contain iron (II) at concentrations of up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well, although turbidity and colour may develop in piped systems at iron levels above 0.05–0.1 mg/litre. It is an essential element in human nutrition.

Iron exceeds the BIS permissible limit of 1.0 mg/l in 12.9% of the samples of The state. The distribution of Iron in Telangana is shown in **Fig. 8.5**.

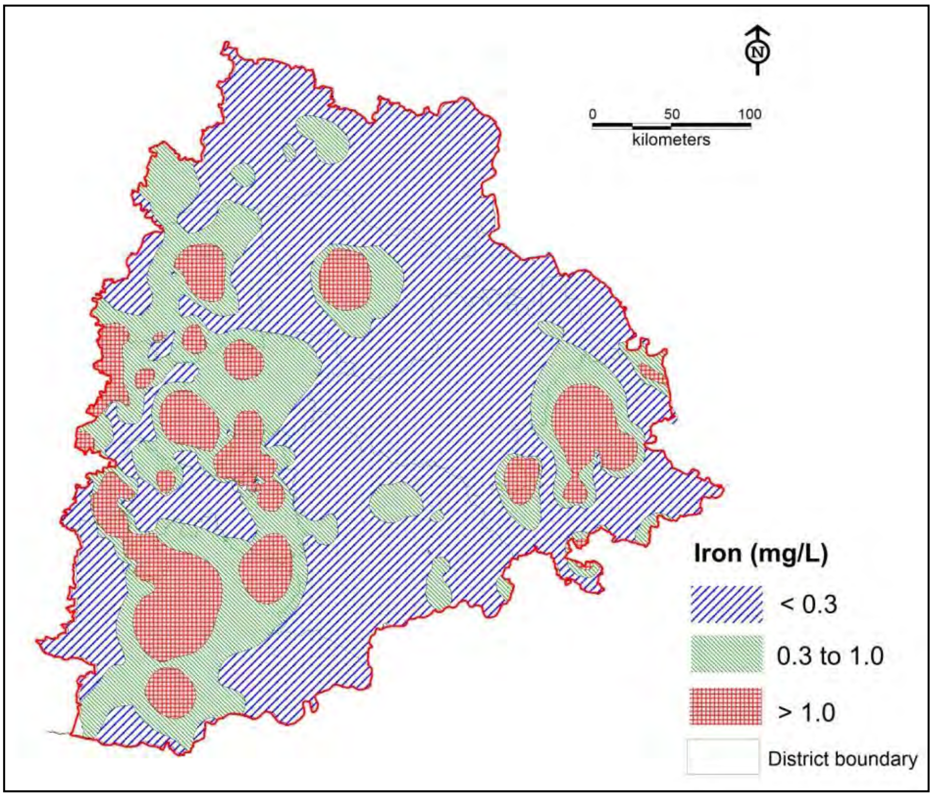


Fig. 8.5 Distribution of Iron in shallow ground water Telangana State – May 2015.

8.1.15 Arsenic

Arsenic is a trace element found at variable concentrations in the atmosphere, soils and rocks, natural waters and organisms. Arsenic has long been recognized as a toxin and carcinogen. It occurs in two oxidation states in water. As per BIS, acceptable concentration is 0.01 mg/l (10 ppb) and maximum permissible limit is 0.05 mg/l (50 ppb).

Arsenic in ground water of State varies from BDL to 10 ppb out of 309 samples and falls within permissible limits of BIS. Only in 2 samples (both in Nalgonda district) namely Kudakuda (12 ppb) and Suryapet (17 ppb) it is beyond acceptable limits but within maximum permissible limits of BIS.

8.2 Quality of ground water for drinking purpose

The hydrochemical data is compared with the drinking water quality standards set by Bureau of Indian Standards (BIS) to assess the suitability of ground water from shallow aquifers in Telangana, for drinking purposes. The suitability of the ground water samples collected from shallow aquifers for drinking purposes with reference to chemical parameters is presented in Table 8.3.

Electrical conductivity in 7.7% of samples is beyond permissible limit of BIS. Chloride Content in 1.9% of samples in the state exceeds the BIS permissibility. Highest percent of samples in Nizamabad (10.3%), Nalgonda (4.6%) and Khammam (4.5%) districts are unsuitable for drinking. The Nitrate content in 43.7% of samples in The state are exceeding the BIS permissible value indicating the anthropogenic contamination, which is less than the previous years. Highest percent of samples in Nizamabad (79.3%), Karimnagar (62.5%) and Nalgonda (52.3%) districts are unfit for drinking.

Fluoride content in the state varies from 0.05 to 3.8 mg/l, with an average of 0.88 mg/l. 14.5% of samples in the state exceed BIS permissible limit. Highest percent of samples in Karimnagar (25%), Nalgonda (21.5%) and followed by Ranga Reddy (16.7%) district are unfit for drinking.

Iron content in 12.9% of samples in the state exceed BIS permissible limit. Highest percent of samples in Hyderabad (35.7%), Ranga Reddy(31.0%) and followed by Medak (18.2%) district are unfit for drinking.

8.3 Quality of ground water 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 soils. Such effect may adversely affect crop production.

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

Table- 8.3 Suitability of Samples with respect to different constituents for drinking purpose (IS-10500: 2012)

District	BIS Standards	TH (600)	Ca (200)	Mg (100)	HCO3 (600)	Cl (1000)	SO4 (400)	NO3 (45)	F (1.5)	TDS (2000)	Iron (1.0)
		Mg/l									
Telangana State	% Samples exceeding	17.0	2.9	8.7	5.5	1.9	1.9	43.7	14.5	6.8	12.9
Adilabad	% Samples exceeding	6.3	0.0	3.1	3.1	3.1	0.0	50.0	9.4	3.1	0.0
Hyderabad	% Samples exceeding	21.4	0.0	0.0	0.0	0.0	0.0	14.3	7.1	0.0	35.7
Karimnagar	% Samples exceeding	18.8	6.3	6.3	0.0	0.0	0.0	62.5	25.0	6.3	6.3
Khammam	% Samples exceeding	18.2	0.0	11.4	11.4	4.5	2.3	40.9	15.9	9.1	11.4
Mahabub-nagar	% Samples exceeding	18.2	2.3	4.5	4.5	0.0	0.0	29.5	4.5	0.0	9.1
Medak	% Samples exceeding	9.1	0.0	4.5	4.5	0.0	0.0	20.5	6.8	6.8	18.2
Nalgonda	% Samples exceeding	26.2	9.2	16.9	9.2	4.6	7.7	52.3	21.5	18.5	0.0
Nizamabad	% Samples exceeding	48.3	17.2	37.9	13.8	10.3	13.8	79.3	0.0	20.7	13.8
Ranga Reddy	% Samples exceeding	9.5	0.0	4.8	0.0	0.0	0.0	47.6	16.7	0.0	31.0
Warangal	% Samples exceeding	4.8	0.0	4.8	0.0	0.0	0.0	16.7	9.5	0.0	0.0

8.3.1 US salinity laboratory classification

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

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

Where concentrations are expressed in meq/l.

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

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

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

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

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

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

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

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

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

Fig. 8.6 shows the US salinity diagram of all water samples of The state. It is observed that 35.2% of water samples are falling in C_2S_1 class, 48.6% in C_3S_1 class, 9.6% of samples falling inC_3S_2 class. 1.5% and 1.3%, samples falling in C_4S_3, and C_3S_3 respectively and remaining samples falls in C_1S_1, C_4S_2, C_4S_3, C_3S_4, C_2S_2 and C_4S_1 classes.

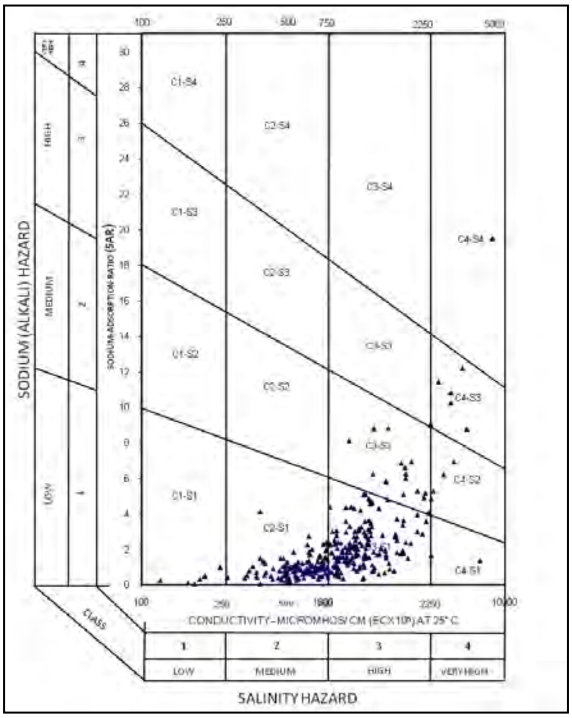


Fig. 8.6 U.S. Salinity diagram for classification of irrigation waters for shallow aquifers of Telangana State -2015

8.3.2 Residual Sodium Carbonate (RSC)

The RSC is defined as the excess of carbonate and bicarbonate amount over the alkaline earths (Ca^{2+} and Mg^{2+}). Use of RSC beyond permissible limit (>2.5) adversely affects irrigation. The tendency of Ca^{2+} and Mg^{2+} to precipitate, as the water in the soil becomes more concentrated, as a result of evaporation and plant transpiration, and gets fixed in the soil by the process of base exchange, thereby decreasing the soil permeability.

Distribution of ground water from The state as per RSC given in **Table 8.4** and it reveals, majority of samples (83 %) fall in safe class (RSC < 1.25), 9 % in marginal category and remaining 8 % in not suitable category.

Table 8.4: Classification of ground water based on RSC.

RSC	Category	No of samples
<1.25	Safe	257
> 1.25 < 2.50	Marginal	28
> 2.50	Not Suitable	26

8.3.3 Percent of Sodium (% Na)

Suitability of groundwater for irrigation purposes is assessed by using the percent of sodium (% Na) in water (**Wilcox, 1948, 1955**). Excess of sodium combining with carbonate will lead to formation of alkaline soils, if combined with chloride the saline soils are formed and either of the soils will not support growth of crops. As per the Indian standards, maximum of 60 % sodium is permissible for irrigation water and it is found that ~10% of samples are unfit for irrigation.

8.4 Water quality for livestock and poultry

Though there are no livestock standards regulated in India, basing on FAO and other international organizations standards, the water quality was classified for livestock and Poultry. One of the important parameter is Salinity/Electrical Conductivity, which moderately shows the suitability of most of the samples in usable. Magnesium and Nitrate are other important parameters to be considered for the usage of ground water for the livestock. Magnesium is also within the range specified. Tables 8.4, 8.5 and 8.6 show water quality in relation to salinity, magnesium and nitrate for livestock.

Table-8.5 Use of ground water for livestock and poultry

Soluble salt content	Rating	No of samples in the range	Uses
< 1 000 mg/litre (<1.5 dS/m)	Excellent	109	Excellent for all classes of livestock and poultry
1 000-3 000 mg/litre (1.5-5 dS/m)	Very satisfactory	178	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	17	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	5	This water can be used for livestock except for those that are pregnant or lactating. It may have some laxative effect and may be refused by animals until they become accustomed to it. It is unsatisfactory for poultry
7 000-10 000 mg/litre (11-16 dS/m)	Very limited use	2	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 recommende d	0	This water is unsatisfactory for all classes of livestock and poultry.

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

Table-8.6 Suggested limits for magnesium in drinking water for livestock

Livestock	No of Samples within the range	Magnesium (mg/l)	Concentration (me/l)
Poultry[2]	310	<250	<21
Swine[2]	310	<250	<21
Horses	310	250	<21
Cows (lactating)	310	250	<21
Ewes with lambs	310	250	<21
Beef cattle	311	400	33
Adult sheep on dry feed	311	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-8.7 Guide to use of waters containing nitrates for livestock.

Nitrate content* as parts per million (ppm) of nitrate nitrogen (NO_3-N)**	**Nitrate, NO_3**	**No samples in the range**	**Comments**
Less than 100	<440	309	Experimental evidence indicates this water should not harm livestock or poultry.
100 to 300	440 - 1320	2	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).***

8.5 Ground water facies

For identification of different water facies of groundwater, Piper diagram is widely used as it gives best graphical representation (**Hill, 1940; Piper 1944**). Groundwater can be grouped broadly into 9 types and 52 sub types (**Table-.8.8 and Fig.8.9**). Ground water from the area is mainly of Ca-HCO_3-Cl and Ca-Na-HCO_3-Cl type followed by Ca-HCO_3, Ca-Cl and Ca-Na-Cl type (**Fig.8.6**). It is found that ~9 % of samples fall in Mg-Ca-Na-Cl type, 6% each in Mg-Ca-Na-HCO_3 and Na-Mg-Ca-Cl type and 5% each in Ca-Mg-Na-HCO_3, Na-Mg-Cl and Mg-Na-Ca-HCO_3 type etc.

8.6 Interrelationships between Variables (Correlation Matrix)

Correlation between F^- and 4 major ions (pH, Ca^{2+}, Na^+ and HCO_3^-), is studied (**Fig.8.8 a-d)**. The correlation plot of F^+ vs. pH^- (r^2=0.03), F^- vs. Na (r^2=0.05) and F^- vs. HCO_3 (r^2=0.1) shows a weak degree of positive correlations. **Apambire *et al.* (1997**) and **Madhnure *et al.*** (2007) have also observed that Na^+ concentration increases with F^-, thereby increasing the solubility of fluorite mineral in water. Plot between F^- vs. Ca^{2+} shows weak negative correlation (r^2=0.01), which is an accordance with the proven hypothesis of F^- enrichment being facilitated by removal of Ca^{2+} through precipitation of calcite during water rock interaction (**Reddy, 2014**).

Table 8.8: Type of ground waters during May-2015,Telangana state.

S.No.	Water Type	Nos	S.No.	Water Type	Nos	S.No.	Water Type	Nos
1	Ca-Mg-Cl	2	19	Mg-Ca-Cl	10	37	Na-Ca-Cl-HCO3	3
2	Ca-Mg-Cl-HCO3	2	20	Mg-Ca-HCO3	16	38	Na-Ca-HCO3-Cl	1
3	Ca-Mg-HCO3	7	21	Mg-Ca-HCO3-Cl	1	39	Na-Ca-K-HCO3	1
4	Ca-Mg-HCO3-Cl	1	22	Mg-Ca-Na-	2	40	Na-Ca-Mg-Cl	5
5	Ca-Mg-Na-Cl	11	23	Mg-Ca-Na-Cl	28	41	Na-Ca-Mg-Cl-HCO3	2
6	Ca-Mg-Na-Cl-HCO3	3	24	Mg-Ca-Na-Cl-HCO3	9	42	Na-Ca-Mg-HCO3	1
7	Ca-Mg-Na-HCO3	17	25	Mg-Ca-Na-HCO3	20	43	Na-Ca-Mg-HCO3-Cl	3
8	Ca-Mg-Na-HCO3-Cl	5	26	Mg-Ca-Na-HCO3-Cl	4	44	Na-K-Mg-Cl	1
9	Ca-Mg-Na-K-Cl-HCO3	1	27	Mg-Cl	2	45	Na-Mg-Ca-Cl	18
10	Ca-Na-Cl	6	28	Mg-HCO3	1	46	Na-Mg-Ca-Cl-HCO3	8
11	Ca-Na-Cl-HCO3	7	29	Mg-Na-Ca-Cl	16	47	Na-Mg-Ca-HCO3	5
12	Ca-Na-HCO3	1	30	Mg-Na-Ca-Cl-HCO3	8	48	Na-Mg-Ca-HCO3-Cl	4
13	Ca-Na-HCO3-Cl	3	31	Mg-Na-Ca-HCO3	15	49	Na-Mg-Cl	12
14	Ca-Na-Mg-Cl	7	32	Mg-Na-Ca-HCO3-Cl	7	50	Na-Mg-Cl-HCO3	6
15	Ca-Na-Mg-Cl-HCO3	2	33	Mg-Na-Cl	8	51	Na-Mg-HCO3	2
16	Ca-Na-Mg-HCO3	3	34	Mg-Na-Cl-HCO3	2	52	Na-Mg-HCO3-Cl	1
17	Ca-Na-Mg-HCO3-Cl	4	35	Mg-Na-HCO3	4			
18	Ca-Na-Mg-K-Cl	1	36	Mg-Na-HCO3-Cl	2			

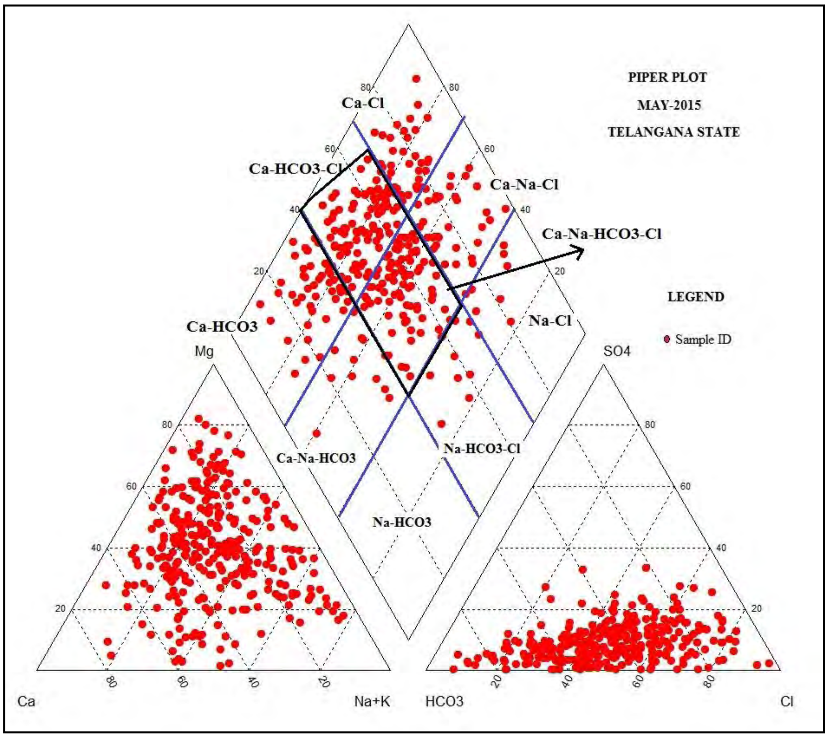


Fig.8.7: Ground water facies (Piper Plot)-May-2015.

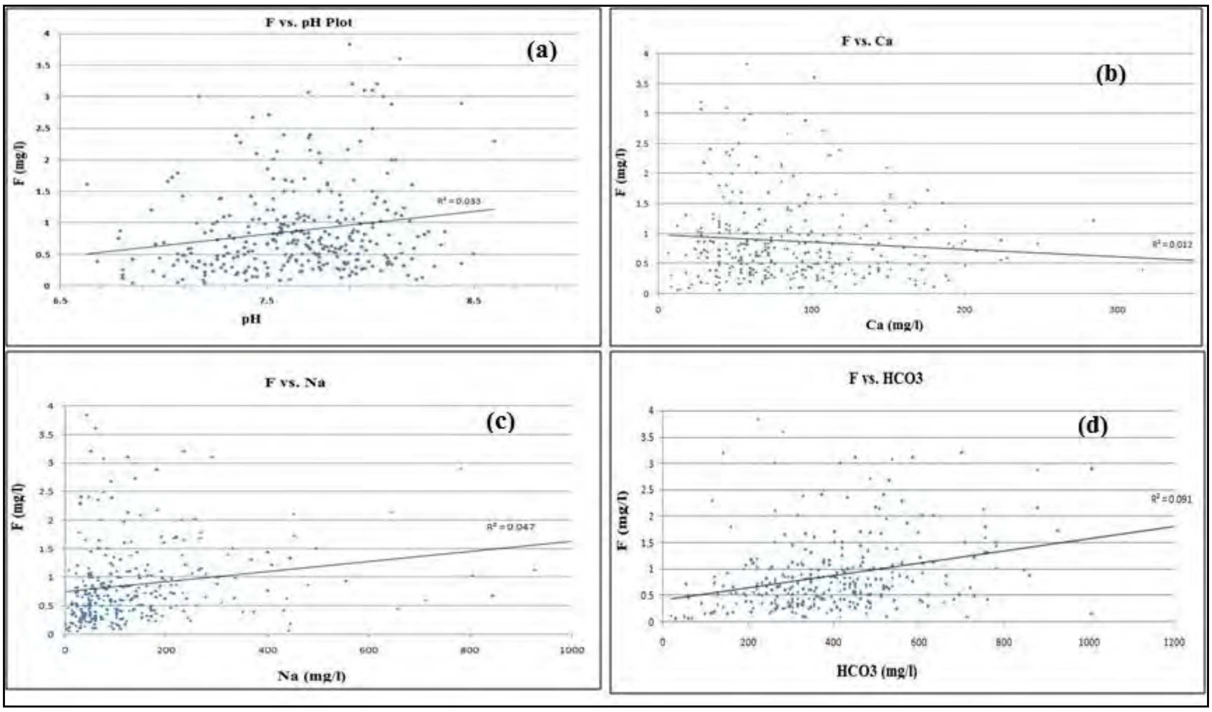


Fig.8.8 (a-d): Interrelationships between variables.

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Annexure-1

Summerised Results of Depth to water levels (m bgl)-May-2015.

S.No.	District	No. of wells analyzed	Depth to water Table (m bgl)		No of Wells/% of wells showing depth to water level (m bgl) in the range of											
			Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Adilabad	66	0.52	39.5	1	1.52	11	16.67	38	57.58	13	19.7	3	4.55	0	0
2	Hyderabad	10	3.12	18.91	0	0	4	40	3	30	3	30	0	0	0	0
3	Karimnagar	63	1.25	25.52	1	1.59	3	4.76	34	53.97	24	38.1	1	1.59	0	0
4	Khammam	59	0.74	16.65	5	8.47	13	22.03	29	46.15	12	20.34	0	0	0	0
5	Mahbubnagar	34	2.47	39.65	0	0	4	11.76	11	32.35	11	32.35	8	23.53	0	0
6	Medak	36	2.4	46.1	0	0	3	8.33	13	36.11	16	44.44	3	8.33	1	2.78
7	Nalgonda	91	2.57	37.37	0	0	24	26.37	37	40.66	28	30.77	2	2.2	0	0
8	Nizamabad	45	2.06	27.37	0	0	5	11.11	20	44.44	17	37.78	3	6.67	0	0
9	Ranga Reddy	78	0.33	44.78	2	2.5	4	5	24	30	40	50	6	7.5	2	2.5
10	Warangal	82	1.27	27.65	4	4.88	15	18.29	26	31.71	34	41.46	3	3.66	0	0
	Total	**564**	**0.33**	**46.1**	**13**	**2.3**	**86**	**15.2**	**235**	**41.7**	**198**	**35.1**	**29**	**5.1**	**3**	**0.5**

Annexure-2

Summerised Results of Depth to water levels (m bgl)-August-2015.

S.No.	District	No. of wells analyzed	Depth to water Table (m bgl)		No of Wells/% of wells showing depth to water level (m bgl) in the range of												
			Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%	
1	Adilabad	69	0.3	15.41	18	26.1	27	39.1	20	29	4	5.8	0	0	0	0	
2	Hyderabad	11	2.23	17.50	0	0	5	45.4	1	9.1	5	45.4	0	0	0	0	
3	Karimnagar	68	0.15	20.68	2	2.9	11	16.2	38	55.9	16	25.3	1	1.5	0	0	
4	Khammam	61	-0.08	15.05	16	26.2	30	49.2	13	21.3	2	3.4	0	0	0	0	
5	Mahbubnagar	55	1.44	50.98	2	3.6	7	12.7	13	23.6	16	29.1	14	25.4	3	5.5	
6	Medak	36	1.92	29.38	1	2.8	6	16.7	12	33.3	11	30.6	6	16.7	0	0	
7	Nalgonda	97	0.76	33.50	6	6.2	28	28.9	31	32	24	24.7	8	8.2	0	0	
8	Nizamabad	47	0.9	34.50	2	4.3	8	17.0	13	27.7	17	36.2	7	14.9	0	0	
9	Ranga Reddy	78	0.10	41.5	3	3.8	10	12.8	28	35.9	32	41	4	5.1	1	1.3	
10	Warangal	85	0.40	24.78	13	15.3	22	25.9	25	29.4	20	23.5	5	5.9	0	0	
	Total	**607**	**-0.08**	**50.98**	**63**	**10.4**	**154**	**25.4**	**194**	**32**	**147**	**24**	**45**	**7.4**	**4**	**0.65**	

Annexure-3

Summerised Results of Depth to water levels (m bgl)-Novemeber-2015.

S.No.	District	No. of wells analyzed	Depth to water Table (m bgl)		No of Wells/% of wells showing depth to water level (m bgl) in the range of											
			Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Adilabad	67	0.42	11.35	8	11.94	30	44.78	22	32.84	7	10.45	0	0	0	0
2	Hyderabad	10	2.44	12.80	0	0	4	40	2	20	4	40	0	0	0	0
3	Karimnagar	68	2.57	19.30	0	0	10	14.71	37	54.41	21	30.88	0	0	0	0
4	Khammam	60	-0.07	13.53	14	23.33	28	46.67	16	26.67	2	3.33	0	0	0	0
5	Mahbubnagar	56	2	59.38	1	1.79	4	7.14	16	28.57	21	37.5	11	19.64	3	5.36
6	Medak	37	2.97	52.88	0	0	2	5.41	17	45.95	12	32.43	5	13.51	1	2.70
7	Nalgonda	90	1.19	27.82	6	6.67	31	34.44	31	34.44	19	21.11	3	3.33	0	0
8	Nizamabad	46	1.25	34.50	3	6.52	5	10.87	16	34.78	16	34.78	6	13.04	0	0
9	Ranga Reddy	78	0.21	36.75	2	2.56	12	15.38	23	29.49	38	48.72	3	3.85	0	0
10	Warangal	87	0.45	27.10	10	11.49	26	29.89	32	36.78	16	18.39	3	3.45	0	0
	Total	**599**	**-0.07**	**59.38**	**44**	**7.3**	**152**	**25.4**	**212**	**35.4**	**156**	**26**	**31**	**5.2**	**4**	**0.66**

Annexure-4

Summerised Results of Depth to water levels (m bgl)-January-2016.

S.No.	District	No. of wells analyzed	Depth to water Table (m bgl)		No of Wells / % of wells showing depth to water level (m bgl) in the range of											
			Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Adilabad	66	0.97	18.66	3	4.55	19	28.79	32	48.48	12	18.18	0	0	0	0
2	Hyderabad	10	2.87	14.70	0	0	5	50.00	2	20.00	3	30.00	0	0	0	0
3	Karimnagar	68	2.40	21.68	0	0	5	7.35	32	47.06	29	42.65	2	2.94	0	0
4	Khammam	60	0.68	15.25	5	8.33	27	45.00	24	40.00	4	6.67	0	0	0	0
5	Mahbubnagar	67	1.14	52.62	1	1.49	6	8.96	17	25.37	25	37.31	15	22.39	3	4.48
6	Medak	36	4.17	69.50	0	0	2	5.56	12	33.33	15	41.67	6	16.67	1	2.78
7	Nalgonda	88	2.25	25.70	0	0	26	29.55	38	43.18	21	23.86	3	3.41	0	0
8	Nizamabad	43	1.60	30.45	2	4.65	5	11.63	12	27.91	17	39.53	7	16.28	0	0
9	Ranga Reddy	76	0.30	32.30	2	2.63	6	7.89	21	27.63	38	50.00	9	11.84	0	0
10	Warangal	88	0.96	25.91	7	7.95	20	22.73	33	37.50	26	29.55	2	2.27	0	0
	Total	**602**	**0.30**	**69.50**	**20**	**3.3**	**121**	**20.1**	**223**	**37**	**190**	**31.6**	**44**	**7.3**	**4**	**0.66**

Annexure-5

Summerised Results of Water level fluctuation- Rise and Fall in percentage of wells (May-2015 Vs May-2014).

S.No.	District	No. of wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	61	0.28	19.23	0.12	35.75	3	49.2	2	3.28	1	1.64	30	49.18	14	23	11	18.03	6	55
2	Hyderabad	10	0.16	6.9	0.11	2.28	1	9.09	1	9.09	1	9.09	6	54.55	1	9.09	1	9.09	3	8
3	Karimnagar	63	3.61	3.61	0.07	9.22	0	0	1	1.59	0	0	20	31.75	25	39.7	16	25.4	1	61
4	Khammam	56	0.03	2.89	0.02	3.89	13	23.1	1	1.79	0	0	28	50	13	23.2	0	0	14	41
5	Mahabubnagar	33	1	9.54	0.19	19.63	2	6.06	0	0	1	3.03	13	39.39	8	24.2	6	18.18	3	27
6	Medak	36	0.2	0.41	0.05	23.5	2	5.56	0	0	0	0	10	27.78	10	27.8	11	30.56	2	31
7	Nalgonda	63	0.3	6.86	0.05	13.22	4	6.35	0	0	2	3.17	21	33.33	16	25.4	20	31.75	6	57
8	Nizamabad	44	0.13	6.49	0.05	9.33	4	9.09	1	2.27	1	2.27	4	9.09	14	31.8	17	38.64	6	35
9	Ranga Reddy	68	0.17	7.21	0.15	36.82	8	11.43	2	2.86	3	4.29	23	32.86	14	20	20	28.57	13	57
10	Warangal	77	0.01	8.16	0.24	17.45	6	7.79	1	1.3	1	1.3	24	31.17	24	31.2	20	25.97	8	68
	Total	**511**	**0.01**	**19.23**	**0.02**	**36.82**	**43**	**69**	**9**	**15**	**10**	**16**	**179**	**40.7**	**139**	**31.6**	**122**	**27.7**	**62**	**440**

Annexure-6

Summerised Results of Water level fluctuation- Rise and fall in percentage of wells (Aug-15 Vs Aug-2014).

S. No.	District	No. of wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	65	0.02	14.0	0.01	6.0	30	43.1	2	3.1	2	3.1	23	35.4	3	4.6	4	6.2	34	30
2	Hyderabad	11	0.03	5.9	0.65	3.2	4	27.3	1	9.1	1	9.1	4	36.4	1	9.1	1	9.1	6	6
3	Karimnagar	64	0.02	2.1	0.03	5.5	11	18.8	1	1.6	0	0	31	48.4	18	28.1	3	4.7	12	52
4	Khammam	54	0.1	4.9	0.06	13.3	25	35.3	8	14.8	2	3.7	16	29.6	2	3.7	1	1.9	35	19
5	Mahbubnagar	36	0.06	12.7	0.3	23.6	3	5.6	3	8.3	4	11.1	6	16.7	12	33.3	7	19.4	10	25
6	Medak	35	0.19	3.2	0.07	14.9	5	14.3	1	2.9	0	0	11	31.4	6	17.1	11	31.5	6	28
7	Nalgonda	63	0.05	10.9	0.15	25.4	9	15.9	4	6.4	3	4.8	18	28.6	13	20.6	16	25.4	16	47
8	Nizamabad	47	0.16	24.3	0.43	20.0	3	6.4	2	4.3	1	2.1	13	27.7	8	17.0	19	40.3	6	40
9	Ranga Reddy	69	0.05	29.8	0.13	30.5	10	14.3	1	1.5	2	2.9	14	20.3	22	31.9	17	24.6	13	53
10	Warangal	78	0.05	8.7	0.01	12.4	27	34.6	5	6.4	4	5.1	19	24.4	15	19.2	8	10.2	36	42
	Total	**522**	**0.02**	**29.8**	**0.01**	**30.5**	**127**	**73**	**28**	**16**	**19**	**11**	**155**	**45**	**100**	**29**	**87**	**26**	**174**	**342**

Annexure-7

Summerised Results of Water level fluctuation- Rise and fall in percentage of wells (M bgl) (Nov-15 Vs Nov-14).

S. No.	District	No. of wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	67	0.09	1.55	0.05	6.40	17	25.37	0	0	0	0	33	49.25	11	16.42	6	8.96	17	50
2	Hyderabad	9	0.74	1.18	0.03	3.38	3	33.33	0	0	0	0	5	55.56	1	11.11	0	0	3	6
3	Karimnagar	62	0.26	3.69	0.09	5.63	7	11.29	3	4.84	0	0	29	46.77	15	24.19	7	11.29	10	51
4	Khammam	58	0.07	2.99	0.02	2.01	25	43.10	4	6.90	0	0	28	48.28	1	1.72	0	0	29	29
5	Mahbubnagar	36	1.62	9.69	0.41	30.81	1	2.78	1	2.78	2	5.56	10	27.78	12	33.33	8	22.22	4	30
6	Medak	36	0.08	2.98	0.77	26.06	7	19.44	2	5.56	0	0	5	13.89	7	19.44	13	36.11	9	25
7	Nalgonda	84	0.11	6.77	0.02	8.67	7	8.33	2	2.38	5	5.95	44	52.38	17	20.24	8	9.52	14	69
8	Nizamabad	45	0.23	2.70	0.25	20.10	8	17.78	3	6.67	0	0	6	13.33	11	24.44	15	33.35	11	32
9	Ranga Reddy	72	0.28	24.35	0.03	18.58	10	13.89	6	8.33	2	2.78	15	20.83	24	33.33	13	18.06	18	52
10	Warangal	80	0.06	4.99	0.01	16.93	29	36.25	3	3.75	3	3.75	23	28.75	16	20	5	6.25	35	44
	Total	**549**	**0.06**	**24.35**	**0.01**	**30.81**	**114**	**76**	**24**	**16**	**12**	**8**	**198**	**51**	**115**	**30**	**75**	**19**	**150**	**388**

Annexure-8

Summerised Results of Water level fluctuation- Rise and Fall in percentage of wells (Jan-2016 Vs Jan-2015).

Sl. No.	District	No. of wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0- 2	%	2-4	%	> 4	%	0-2	%	2-4	%	> 4	%		
1	Adilabad	65	0.45	2.95	0.08	9.47	3	4.62	1	1.54	0	0	36	55.38	14	21.54	11	16.92	4	61
2	Hyderabad	10	0.33	4.74	0.10	4.75	3	30.00	0	0	1	10.00	4	40.00	1	10.00	1	10.00	4	6
3	Karimnagar	62	0.78	1.58	0.18	10.90	4	6.45	0	0	0	0	26	41.94	18	29.03	11	17.74	4	55
4	Khammam	57	0.01	4.65	0.01	2.33	20	35.09	2	3.51	2	3.51	30	52.63	2	3.51	0	0	24	32
5	Mahabubnagar	36	0.03	5.38	0.09	27.22	2	5.56	0	0	1	2.78	13	36.11	4	11.11	13	36.11	3	30
6	Medak	36	1.14	1.14	0.26	47.00	1	2.78	0	0	0	0	7	19.44	11	30.56	14	38.89	1	32
7	Nalgonda	81	0.07	16.33	0.03	13.59	7	8.64	4	4.94	1	1.23	40	49.38	16	19.75	9	11.1	12	65
8	Nizamabad	43	0.05	3.61	0.34	13.54	6	13.95	2	4.65	0	0	12	27.91	7	16.28	16	37.21	8	35
9	Ranga Reddy	74	0.11	9.10	0.01	25.00	12	16.22	2	2.70	3	4.05	20	27.03	20	27.03	15	20.27	17	55
10	Warangal	82	0.14	9.56	0.07	9.92	22	26.83	5	6.10	5	6.10	29	35.37	16	19.51	5	6.10	32	50
	Total	**546**	**0.01**	**16.33**	**0.01**	**47.00**	**80**	**73.3**	**16**	**14.7**	**13**	**12**	**217**	**51.5**	**109**	**26**	**95**	**22.5**	**109**	**421**

Annexure-9

District Wise Water Level Fluctuation From Mean of 10 Years ((May 2005-May 2014) Vs May 2015.

Sl. No.	District	No of Wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	62	0.05	8.51	0.04	33.36	18	29.03	4	6.45	1	1.61	22	35.48	9	14.5	8	12.9	23	39
2	Hyderabad	10	0.56	6.88	0.94	3.08	4	36.36	0	0	1	9.09	2	18.18	3	27.3	0	0	5	5
3	Karimnagar	63	0.19	5.39	0.11	5.5	9	14.29	2	3.17	1	1.59	29	46.03	17	27	5	7.94	12	51
4	Khammam	56	0.06	2.89	0.05	3.63	15	26.79	1	1.79	0	0	29	51.79	11	19.6	0	0	16	40
5	Mahbubnagar	34	0.86	10.21	0.12	17.24	4	11.76	1	2.94	3	8.82	13	38.24	8	23.5	5	14.71	8	26
6	Medak	36	0.02	1.55	0.02	23.1	6	16.67	0	0	0	0	12	33.33	9	25	8	22.22	6	29
7	Nalgonda	70	0.08	8.83	0.02	13.22	9	12.86	2	2.86	2	2.86	25	35.71	16	22.9	16	22.86	13	57
8	Nizamabad	44	0.13	3.37	0.04	9.82	7	15.91	3	6.82	0	0	13	29.55	8	18.2	11	25	10	32
9	Ranga Reddy	68	0.08	5.12	0.03	36.39	17	24.29	8	11.4	2	2.86	18	25.71	14	20	8	14.29	27	40
10	Warangal	79	0.16	6.69	0.03	12.26	13	16.46	3	3.8	3	3.8	32	40.51	11	13.9	17	21.52	19	60
	Total	**522**	**0.02**	**10.21**	**0.02**	**36.39**	**102**	**19.4**	**24**	**4.6**	**13**	**2.5**	**195**	**37.1**	**106**	**20.2**	**78**	**14.94**	**139**	**379**

Annexure-10

District Wise Water Level Fluctuation From Mean of 10 Years (August- 2005-2014) Vs August-2015.

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						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	65	0.04	2.6	0.04	9.26	18	26.7	1	1.5	0	0	32	49.2	8	12.3	6	9.3	19	46
2	Hyderabad	11	0.59	1.5	0.13	6.36	5	45.4	0	0	0	0	1	9.1	2	18.2	4	27.3	5	6
3	Karimnagar	65	0.01	3.04	0.06	7.83	3	4.6	2	3.1	0	0	23	35.4	22	33.8	15	23.1	5	60
4	Khammam	58	0.06	2.9	0.01	4.9	29	50.0	1	1.7	0	0	23	40	4	6.9	1	1.8	30	28
5	Mahbubnagar	36	0.45	11.4	0.07	22.7	3	8.3	4	11.1	3	8.3	5	16.7	8	22.2	12	33.3	10	26
6	Medak	35	0.21	2.1	0.33	16.6	1	2.8	1	2.9	0	0	9	25.7	7	20	15	45	2	32
7	Nalgonda	68	0.04	4.1	0.05	30.0	14	20.6	2	2.9	1	1.5	16	23.5	17	25.0	18	26.5	17	51
8	Nizamabad	48	0.14	8.9	0.43	20.43	4	8.5	0	0	1	2.1	9	18.8	10	20.8	24	50	5	43
9	Ranga Reddy	70	0.03	31.3	0.05	30.6	7	10	6	8.5	3	4.2	19	26.7	17	23.9	19	25	16	54
10	Warangal	78	0.15	5.7	0.03	13.3	14	17.9	5	6.4	3	3.8	23	29.5	22	28.2	11	14.1	22	56
	Total	**534**	**0.01**	**31.3**	**0.01**	**30.6**	**98**	**74**	**22**	**18**	**11**	**8**	**160**	**40**	**117**	**29**	**125**	**31**	**131**	**402**

Annexure-11

District Wise Water Level Fluctuation from Mean of 10 Years (November-2005-2014) Vs November 2015.

District Name	No of Wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
		Rise		Fall		Rise						Fall						Rise	Fall
		Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
Adilabad	67	0.03	1.14	0.01	7.80	8	11.94	0	0	0	0	39	58.21	13	19.40	7	10.45	8	59
Hyderabad	10	1.98	1.98	0.21	6.74	1	10	0	0	0	0	5	50	1	10	3	30	1	9
Karimnagar	64	0.12	1.58	0.23	8.53	7	10.94	0	0	0	0	13	20.31	25	20.31	19	29.69	7	57
Khammam	58	0.10	1.24	0.03	4.49	20	34.48	0	0	0	0	31	53.45	5	8.62	2	3.45	20	38
Mahbubnagar	36	1.44	5.29	0.38	33.12	1	2.78	0	0	1	2.78	9	25	6	16.67	19	52.78	2	34
Medak	37	0.38	2.98	0.28	31.35	2	5.41	1	2.70	0	0	6	16.22	10	27.03	18	48.65	3	34
Nalgonda	84	0.11	6.77	0.01	13.32	5	5.95	1	1.19	3	3.57	41	48.81	19	22.62	14	16.67	9	74
Nizamabad	46	0.0	5.04	0.42	24.10	3	6.52	1	2.17	1	2.17	4	8.70	12	26.09	24	52.17	5	40
Ranga Reddy	78	0.19	21.45	0.25	26.25	9	11.54	2	2.56	2	2.56	7	8.97	25	32.05	32	41.03	13	64
Warangal	83	0.12	3.03	0.02	18.79	10	12.05	5	6.02	0	0	34	40.96	21	25.30	12	14.46	15	67
Total	**563**	**0.03**	**21.45**	**0.01**	**33.12**	**66**	**80**	**10**	**12**	**7**	**8**	**189**	**40**	**137**	**29**	**150**	**31**	**83**	**476**

Annexure-12

District Wise Water Level Fluctuation from Mean of 10 Years (January-2006-2015) Vs January-2016.

S.No.	District	No of Wells analyzed	Range of Fluctuation (m)				No. of wells/Percentage Showing Fluctuation												Total No. of Wells	
			Rise		Fall		Rise						Fall						Rise	Fall
			Min	Max	Min	Max	0 to 2	%	2 to 4	%	> 4	%	0 to 2	%	2 to 4	%	> 4	%		
1	Adilabad	66	0.06	1.16	0.12	10.83	5	7.58	0	0	0	0	35	53.03	18	27.27	8	12.12	5	61
2	Hyderabad	10	0.67	3.45	0.17	7.83	2	20	1	10	0	0	3	30	2	20	2	20	3	7
3	Karimnagar	66	0.68	0.68	0.18	12.42	1	1.52	0	0	0	0	14	21.21	24	36.36	27	40.91	1	65
4	Khammam	59	0.02	4.22	0.1	4.88	15	25.42	1	1.69	1	1.69	34	57.63	6	10.17	2	3.39	17	42
5	Mahbubnagar	36	0.06	6.79	0.02	24.1	2	5.56	0	0	1	2.78	9	25	6	16.67	18	50	3	33
6	Medak	36	0.04	1.4	0.6	47.86	2	5.56	0	0	0	0	4	11.11	8	22.22	22	61.11	2	34
7	Nalgonda	81	0.15	3.63	0.01	13.59	6	7.41	3	3.7	0	0	31	38.27	20	24.69	19	23.46	9	70
8	Nizamabad	43	0.27	0.5	0.29	15.4	2	4.65	0	0	0	0	7	16.28	8	18.6	26	60.47	2	41
9	Ranga Reddy	76	0.06	9.1	0.05	22.39	11	14.47	0	0	2	2.63	14	18.42	21	27.63	28	36.84	13	63
10	Warangal	84	0.16	4.95	0.01	14.16	8	9.52	1	1.19	2	2.38	40	47.62	17	20.24	16	19.05	11	73
	Total	**557**	**0.02**	**9.10**	**0.01**	**47.86**	**54**	**82**	**6**	**9**	**6**	**9**	**191**	**39**	**130**	**27**	**168**	**34**	**66**	**489**

Annexure-13

Summerised Results of Depth to Water Level, from deeper aquifers during pre and Post-monooon season-2015 (m bgl).

S.No.	District	No of wells	Season	Depth to water Table (mbgl)		No of Wells /% of wells showing depth to water level (m bgl) in the range of											
				Min	Max	0 - 2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Adilabad	7	Pre	5.04	29.20	0	0	0	0	5	71	0	0	2	29	0	0
			Post	0.45	27.10	1	17	2	33	0	0	1	17	2	33	0	0
2	Hyderabad	10	Pre	6.1	70.1	0	0	0	0	2	20	3	30	1	10	4	40
			Post	1.3	22.19	1	10	1	10	1	10	5	50	2	20	0	0
3	Karimnagar	16	Pre	3.33	18.62	0	0	3	19	6	38	7	44	0	0	0	0
			Post	3.1	15.5	0	0	2	13	8	50	6	38	0	0	0	0
4	Khammam	7	Pre	7.57	17.51	0	0	0	0	3	43	4	57	0	0	0	0
			Post	3.83	14.0	0	0	1	14	4	57	2	29	0	0	0	0
5	Mahbubnagar	10	Pre	4.74	37.08	0	0	1	10	0	0	4	40	5	50	0	0
			Post	5.82	47.4	0	0	0	0	1	10	5	50	3	30	1	10
6	Medak	11	Pre	9.7	34.8	0	0	1	8	2	18	5	45	4	36	0	0
			Post	8.93	33.46	0	1	9	7	63	3	28	0	0	0	0	0
7	Nalgonda	12	Pre	3.65	91.86	0	0	1	8	4	33	5	42	1	8	1	8
			Post	2.85	91.93	0	0	4	33	1	8	3	25	3	25	1	9
8	Nizamabad	5	Pre	9.10	23.95	0	0	0	0	1	20	3	60	1	20	0	0
			Post	11.3	25.40	0	0	0	0	0	0	4	80	1	20	0	0
9	Ranga Reddy	18	Pre	2.93	54.4	0	0	3	17	2	11	10	56	1	6	2	11
			Post	3.9	23.0	0	0	2	11	3	17	10	55	3	17	0	0
10	Warangal	11	Pre	Auto flow	39.5	1	9	1	9	4	36	2	18	3	27	0	0
			Post	Auto flow	33.21	3	30	2	20	2	20	0	0	3	30	0	0
	Total	107	Pre	Auto flow	91.86	1	1	9	8	29	27	43	40	18	17	7	7
			Post	Auto flow	91.93	5	5	14	13	21	20	42	38	23	22	2	2

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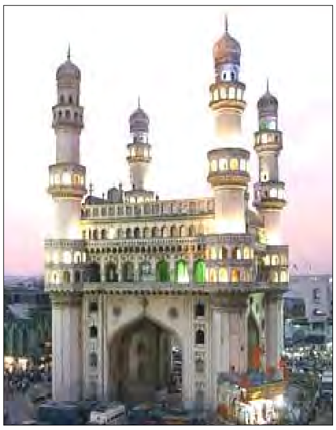

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