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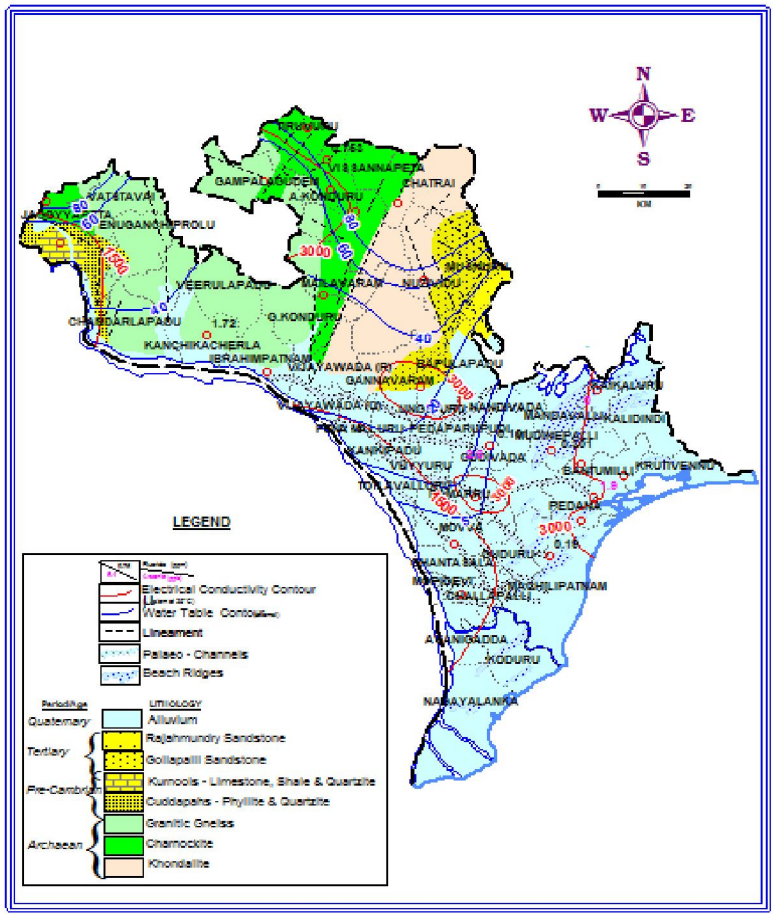
CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

GROUND WATER BROCHURE
KRISHNA DISTRICT, ANDHRA PRADESH



SOUTHERN REGION
HYDERABAD
September 2013

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MINISTRY OF WATER RESOURCES
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GROUND WATER BROCHURE
KRISHNA DISTRICT, ANDHRA PRADESH
(AAP-2012-13)

BY

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GROUND WATER BROCHURE
KRISHNA DISTRICT, ANDHRA PRADESH

CONTENTS

KRISHNA DISTRICT AT A GLANCE

1. GENERAL INFORMATION		
Geographical Area	:	8797 sq. km
Administrative Divisions		
District HQ	:	Machilipatnam
Mandals	:	50
Towns	:	6
Villages	:	1005
Population	:	4529009 (2011 census)
Average Annual Rainfall	:	1011 mm
Annual Rainfall (2012)	:	1510 mm
2. GEOMORPHOLOGY		
Major Physiographic Units	:	Pediplains,
Alluvial plains and		
Coastal plains		
Major Drainage	:	Krishna, Muniyeru,
Tammileru & Budameru		
3. LAND USE (ha) 2012		
Forest Area	:	76186
Net Area Sown	:	510655
Cultivable waste	:	25694
4. SOIL TYPE		
Red loamy soils, Sandy soils, Black soils		
5. IRRIGATION BY DIFFERENT SOURCES (ha)		
Dug Wells	:	7800
Tube wells/ Bore wells	:	86000
Tanks	:	9900
Canals	:	314200
Other Sources	:	3200
Net Irrigated Area	:	302400
6. GROUND WATER MONITORING WELLS		
Dug Wells	:	28
Piezometers	:	4
7. GEOLOGICAL FORMATIONS		
Recent	:	Alluvium
Tertiary	:	Sandstones
Pre-Cambrian	:	Limestone
Quartzite		

Phyllite		
Shale		
Archaean	:	Granitic Gneiss
Charnockite		
Khondalite		
8. Hydrogeology		
Water Bearing Formations	:	
Hard Rock : Gneiss, Charnockite, Khondalite & Metasediments		
Soft Rock : Sandstones & Alluvium		
Pre-monsoon	:	1.52 to 11.20 m bgl
Depth to Water Level (May, 2012)		
Post-monsoon	:	0.21 to 9.06 m bgl
Depth to Water Level (Nov., 2012)		
9. GROUND WATER EXPLORATION (CGWB)		
Wells Drilled	:	38
Depth Range	:	140 to 600 m
Discharge	:	<1 to 51 lps
Transmissivity	:	2.5 to 5560 m^2/day
10. GROUND WATER QUALITY		
In general, the quality is good and suitable for drinking and irrigation purposes, except in the southern part of the deltaic area.		
11. DYNAMIC GROUND WATER RESOURCES		
Total Recharge	:	1825.42 MCM
Total Draft	:	547.98 MCM
Projected Demand (2025) for Domestic & Industrial Uses	:	166.23 MCM
Stage of GW development	:	33 %
12. GROUND WATER CONTROL & REGULATION		
Over Exploited Mandals	:	2
Semi-Critical Mandals	:	Nil
Notified Mandals	:	Nil
13. GROUND WATER PROBLEMS AND ISSUES		
Salinity and water logging are the major problems in the deltaic aquifers.		

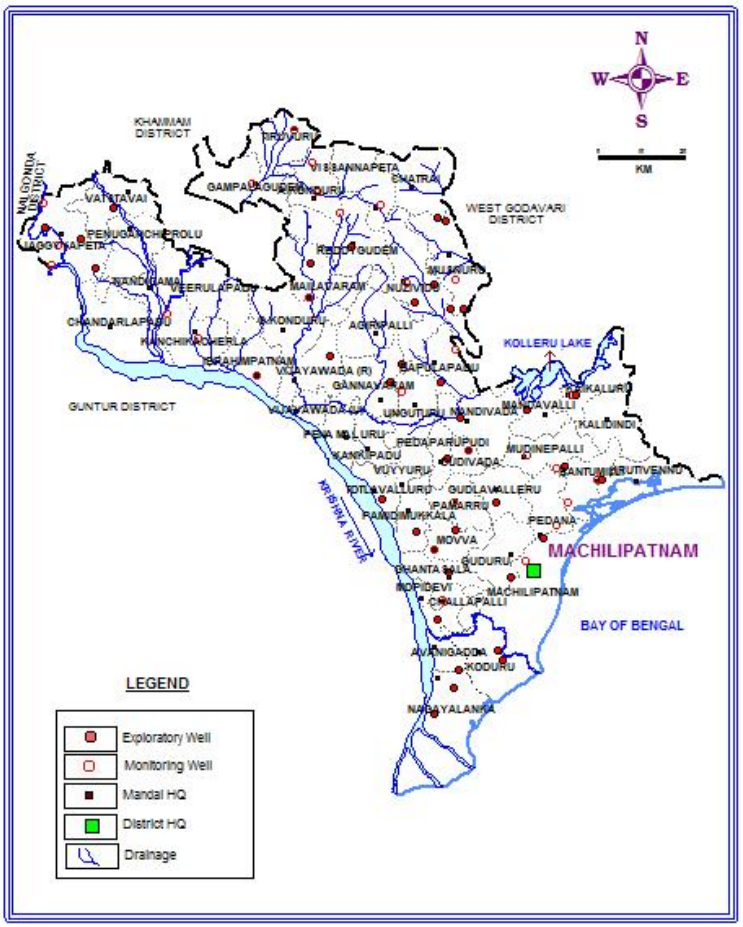
GROUND WATER BROCHURE
KRISHNA DISTRICT, ANDHRA PRADESH

1.0 Introduction

Krishna district is one of the 9 coastal districts of Andhra Pradesh and agriculturally it is an important district. The district has a coastline of 88 km. It is endowed by good rainfall and surface water. The district lies between North latitude of 15° 43' and 17° 10' and East longitudes of 80° 00' and 81° 33' with an aerial extent of 8797 km^2. It is bounded by the Bay of Bengal on the southeast, West Godavari district on the East, Khammam district on the North and Guntur & Nalgonda districts on the West. Howrah – Chennai broad gauge railway line and NH-5 are passing through the district. In addition to the surface transport the district has aerodrome at Gannavaram and sea port at Machilipatnam.

Machilipatnam town is the district's headquarters. The district is divided into four revenue divisions' viz., Machilipatnam (Bandar), Vijayawada, Gudivada and Nuzivid. Further these revenue divisions are divided into 50 revenue mandals (**Fig. 1**).

Fig. 1 ADMINISTRATIVE DIVISIONS - KRISHNA DISTRICT



There are 6 towns 1005 villages in the district. As per the 2001 census the population of the district is 41,87,841. The urban population of the district is 13,43,447 whereas rural population constitutes 28,44,394. The decennial growth rate from 1991 to 2001 is 13.19 percent. The density of population of the district is 480 persons per sq. km.

1.1 Drainage

The Krishna is the major river which drains the district, it is perennial in nature and flows along the western boundary of the district. South of Avanigadda the river bifurcates into four branches before it debouches into the Bay of Bengal. The other important rivers flowing in the district are Muniyeru, Tammileru and Budameru. The general drainage pattern is dendritic to sub-dendritic**.** The drainage density is high in consolidated formations, low in semi-consolidated formations, whereas in alluvial areas the density is meager. Kolleru lake is located between Krishna and Godavari delta and spans into two districts - Krishna and West Godavari. It is the largest freshwater lake in Asia.The lake serves as a natural flood-balancing reservoir for these two rivers. The lake is fed directly by water from the seasonal Budameru and Tammileru rivers, and is connected to the Krishna and Godavari systems by over 68 inflowing drains and channels. The lake is an important habitat for an estimated 20 million resident and migratory birds. It is known the world over for the famous Kolleru Bird Sanctuary.

1.2 Irrigation

The district is served with both surface and ground water irrigation sources. Major and medium irrigation projects exist in the district. The total net area irrigated is 323240 ha (2012) by means of all sources of irrigation available in the district. The gross area irrigated through the surface water irrigation projects is of 230336 ha in the district. Irrigation in the district is mainly from the network of canals in the delta area fed by the Krishna river. East main canal of Prakasam (Krishna) Barrage irrigates entire delta area through a network of its three canals viz., Eluru canal, Ryves canal and Bandar canal. The registerd ayacut under irrigation project of Krishna Barriage, Nagarjuna Sagar, Paleru, Muniyeru and Tammileru is around 274800 ha, 103600 ha, 6300 ha, 6600 ha and 500 ha respectively. The area irrigated through canals is 219428 ha and irrigation through other sources is 11826 ha. 59824 ha area is irrigated through tube wells and dug wells.

1.3 CGWB activities

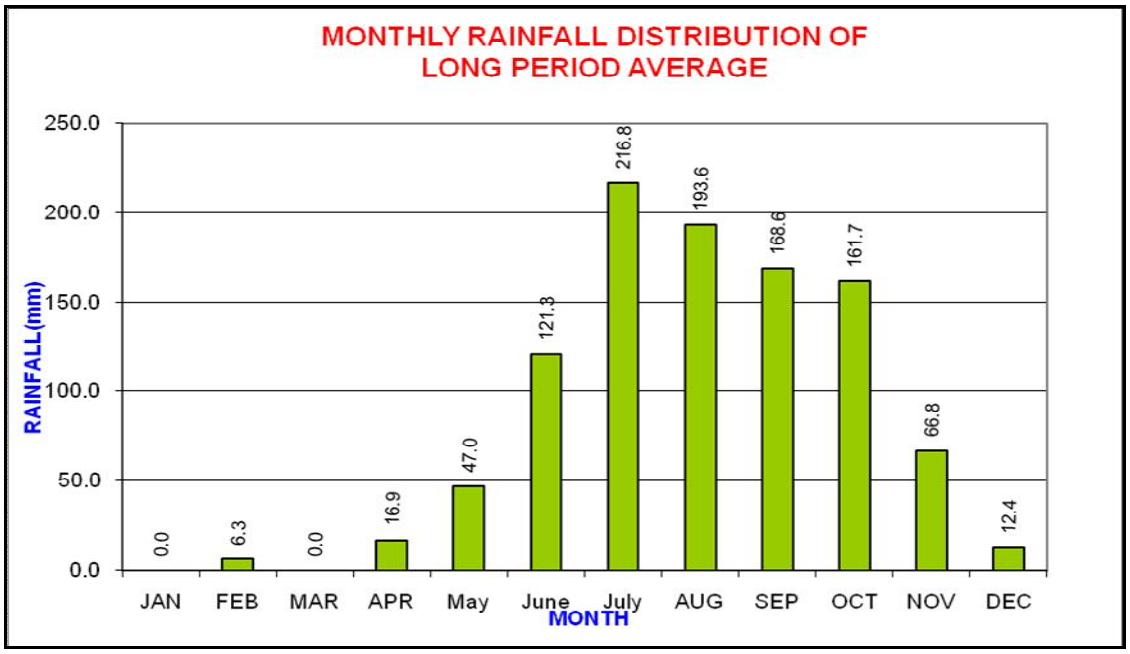
The Central Ground Water Board took up long term hydrogeological studies since 1969 with the establishment of Network Hydrograph Stations in various hydrogeological environments as a part of the all India programme and presently there are 32 (28 dug wells and 4 piezometers) such hydrograph stations in the district. The systematic hydrogeological surveys were carried out during 1960 – 1990. Ground water management surveys and Geophysical surveys were carried out in various parts of the district during 1997-2003. As a part of ground water exploration programme Geophysical surveys were carried out during 1977-1993. Ground water exploratory drilling programme was taken up during 1958 – 1981 in the district in both hard rock and soft rock areas, and has drilled 38 exploratory wells to evaluate the aquifer properties of deeper aquifers. Under Hydrology Project 11 piezometers were constructed. Conjunctive utilisation studies of the deltaic canal systems were carried out during 1978-85. Urban Hydrogeological investigations were carried out during 2000-01 in Vijayawada urban area.

2.0 Rainfall & Climate

The climate of the district is moderate and characterized by tropical rainy climate with aggressive summer. The period from December to middle of February is generally the season of fine weather. The summer season is from March to May. This is followed by monsoon period from June to September, the post monsoon from October to December and the winter season from January to February.

The average annual rainfall of the district is 1011.2 mm, which ranges from nil rainfall in January and March to 216.8 mm in July. The mean seasonal rainfall distribution is 700 mm in southwest monsoon (June-September), 241 mm in northeast monsoon (Oct-Dec), 6.3 mm rainfall in Winter (Jan-Feb) and 64 mm in summer (March – May). The percentage distribution of rainfall, season-wise, is 69.25% in southwest monsoon, 23.82 % in northeast monsoon, 0.62 percentage in winter and 6.31 % in summer **(Fig. 2)**. In general, the amount of rainfall increases from west to east. The mean daily maximum temperature in the district is about 38°C in May and the mean daily minimum temperature is about 20°C in December/ January. Temperature in the district begins to rise from the middle of February till May. With the onset of southwest monsoon in June, the temperature decreases to about 20°C and is more or less uniform during the monsoon period. The relative humidity in the district is of the order of 80% in the mornings throughout the year, whereas in the evenings the relative humidity varies from about 70 to more than 80%. The annual rainfall during 2012 is 1510mm.

Fig. 2 Mean Monthly Rainfall Distribution



3.0 Geomorphology & Soil Types

Geomorphologically the district can be broadly divided into 3 distinct units, viz., Pediplain, Alluvial plains, and Coastal & Deltaic plains. The pediplain area i.e., northern part of the district consists of an undulated plain with broken ridges. Major part of the district in the southern part is represented by the alluvial plains forming the Krishna delta. The river Krishna and its tributaries have contributed to the formation of this alluvial plain. There is no significant surface drainage in these alluvial plains. The delta is relatively a flat area. The alluvial plains along the major course of rivers form the flood plain deposits. The coastal and deltaic alluvial plain extends from Challapalli on the west to Kolletikota on the east and upto the coast line on the south. The main geomorphic units exist in these plains are palaeo-channels, beach ridges, lagoons, sand spits and sand barriers. Krishna river divides itself at Avanigadda and south of Nagayalanka into four branches forming an arcuate delta. The deltaic coast protrudes towards open sea at the mouths of these four branches forming a cuspate foreland.

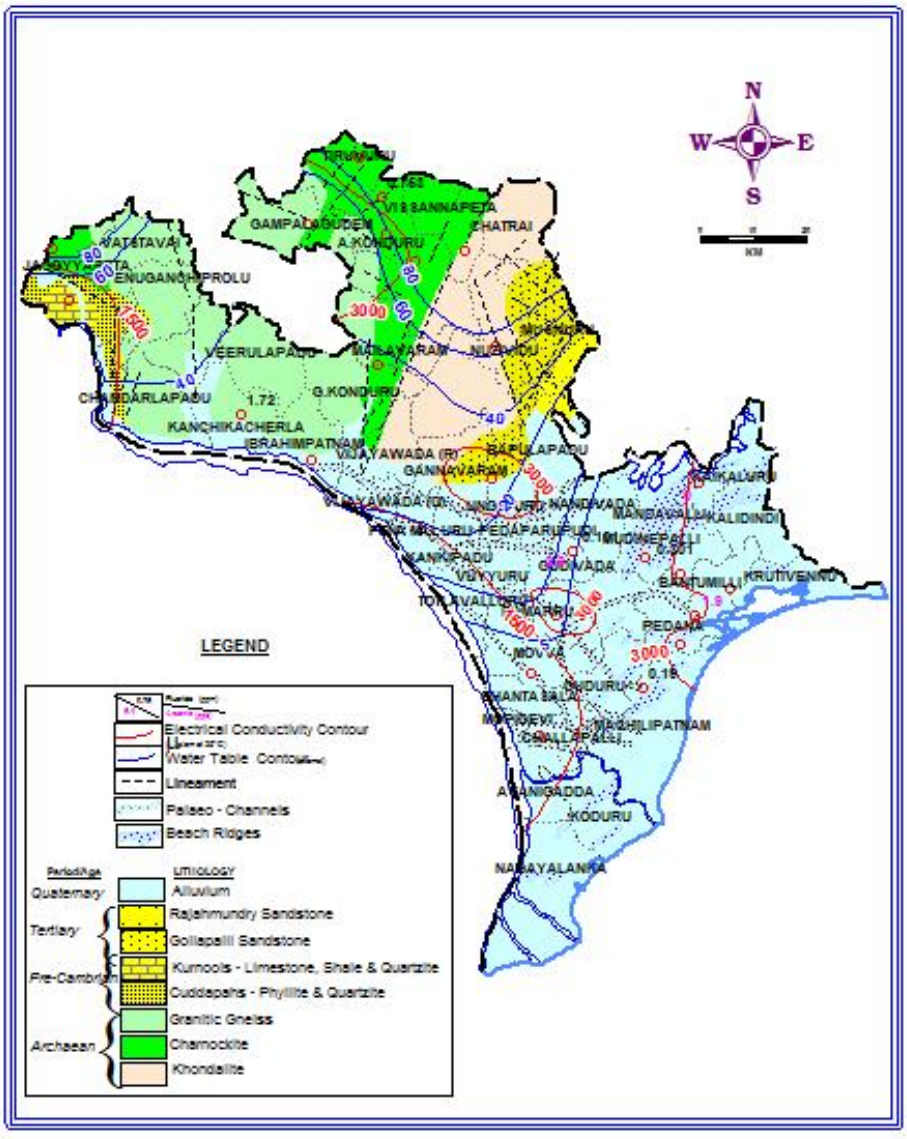
The predominant soils in the district are black cotton soils/deltaic soils, red loamy soils and sandy soils. Red clayey soils with sandy loam to clayey loam in texture and occur in the northern part of the district. The deltaic alluvium is grey brown to black in colour with fine to medium texture and poorly permeable. They are fertile soils. The coastal sandy soils occur all along the coast, highly porous and lack of binding material.

4.0 Ground Water Scenario

4.1 Hydrogeology

The district is underlain by variety of geological formations comprising from the oldest Archaeans to Recent Alluvium. Hydrogeologically these formations are classified as consolidated (Hard), semi-consolidated (Soft) and unconsolidated (Soft) formations. The consolidated formations include crystallines (khondalites, charnockites and granitic gneisses) and metasediments (Limestones, shales, phyllites and quartzites) of Archaean and Pre-cambrian periods respectively. The semi consolidated formations are represented by Tertiary formations (Rajahmundry & Gollapalli sandstones) and unconsolidated formations comprise deltaic alluvial deposits of Quaternary period. Prominent lineaments are trending in NE-SW, NW-SE and NNE-SSW direction **(Fig. 3)**.

Fig. 3 HYDROGEOLOGY - KRISHNA DISTRICT



Consolidated formations occur in the northern part of the district. Among consolidated formations occurrence of metasediments is restricted to NW part of the district i.e., in parts of Jaggayyapeta, Penuganchiprolu, Nandigama and Chandralapadu mandals. Semiconsolidated formations occur in the northeastern part of the district and its extension is limited to small area i.e., in parts of Musunuru, Nuzividu, Bapulapadu and Gannavaram mandals. Unconsolidated formations occur in the southern part of the district i.e., in the delta area. Ground water occurs in all most all geological formations and its potential depends upon the nature of geological formations, geographical setup, incidence of rainfall, recharge and other hydrogeological characters of the aquifer.

In consolidated formations ground water occurs under unconfined to semiconfined conditions. Ground water is developed in these formations by dug wells, dug cum bore wells and bore wells tapping weathered and fractured zones. The yields are in the range of 20 to 70 m^3/day. The occurrence of fractures in the crystalline formations is limited down to 30 to 40 m bgl and occasionally extends down to 70 - 100 m bgl. The bore wells constructed in the crystalline formations generally tap the weathered and fractured zones. The yields of the bore wells generally range between 80 to 400 m^3/day. The higher yields are limited to the available thickness of fractured and jointed zones. In the metasediments the yields are very limited and are in the range of 10 to 80 m^3/day. Higher yields occur in limestone formations.

Ground water in semi-consolidated formations occurs under unconfined to confined conditions. Ground water is developed in these formations by dug cum tube wells and tube wells. These formations are potential aquifers. The yields of the dug cum tube wells are in the range of 30 to 45 m^3/day. Granularity of the sandstone bed is the deciding factor of the yield potential as the higher yields are recorded in the Rajahmundry sandstones tapping coarse sandstone beds. The yields of the tube wells in Gollapalli sandstones and Rajahmundry sandstones are in the range of 60 to 200 m^3/day and 600 1500 m^3/day respectively. The deltaic area is underlain by alluvium of recent age consisting of varying proportions of clay, silt, sand and gravel. The thickness of alluvium ranges from few meters to about 600 m followed by tertiary formations. In deltaic area ground water occurrence is controlled by landforms. In deltaic area also a lot of heterogenity in hydrogeological conditions exist both spatially and vertically. Fresh water is generally limited to shallow to moderate depths only, whereas in the southern part of the delta it occurs as pockets and lenses. Deep aquifers are generally saline. Palaeochannels are favourable locations for fresh water aquifers. Ground water occurs under phreatic to confined conditions and is developed through shallow dug wells, filter point wells and shallow tube wells. The depth of dug wells ranges from about 2 to 7 m, while the depth of filter point wells varies from 5 to 13 m and the depth of tube wells varies from 40 to 80 m. The yields generally range in this aquifer between 250 to 400 m^3/day. Occasionally high yields upto 15 lps exist in the palaeochannels. The transmissivity value of the aquifer in the semi & unconsolidated formations varies from 2.5 to 5560 m^2/day.

Water Level Scenario

The depth to water levels during pre-monsoon season (May, 2012) in the district ranges between 2 and 10 m bgl (**Fig. 4**). Water levels more than 5 m bgl occur in the parts of Gannavaram, Jagayyapet, Reddygudem, Visannapeta and Tiruvuru mandals, whereas, water levels less than 2 m bgl occur in parts of the Kalidindi and Ibrahimpatnam mandals. The depth to water level during post monsoon season (Nov, 2012) in general is less than 2m bgl (**Fig. 5**), whereas in parts of Jaggayyapeta, Vijayawada, Musunuru water levels are more 2m bgl.

FIG 4 DEPTH TO WATER LEVEL – PREMONSOON (MAY 2012)
KRISHNA DISTRICT

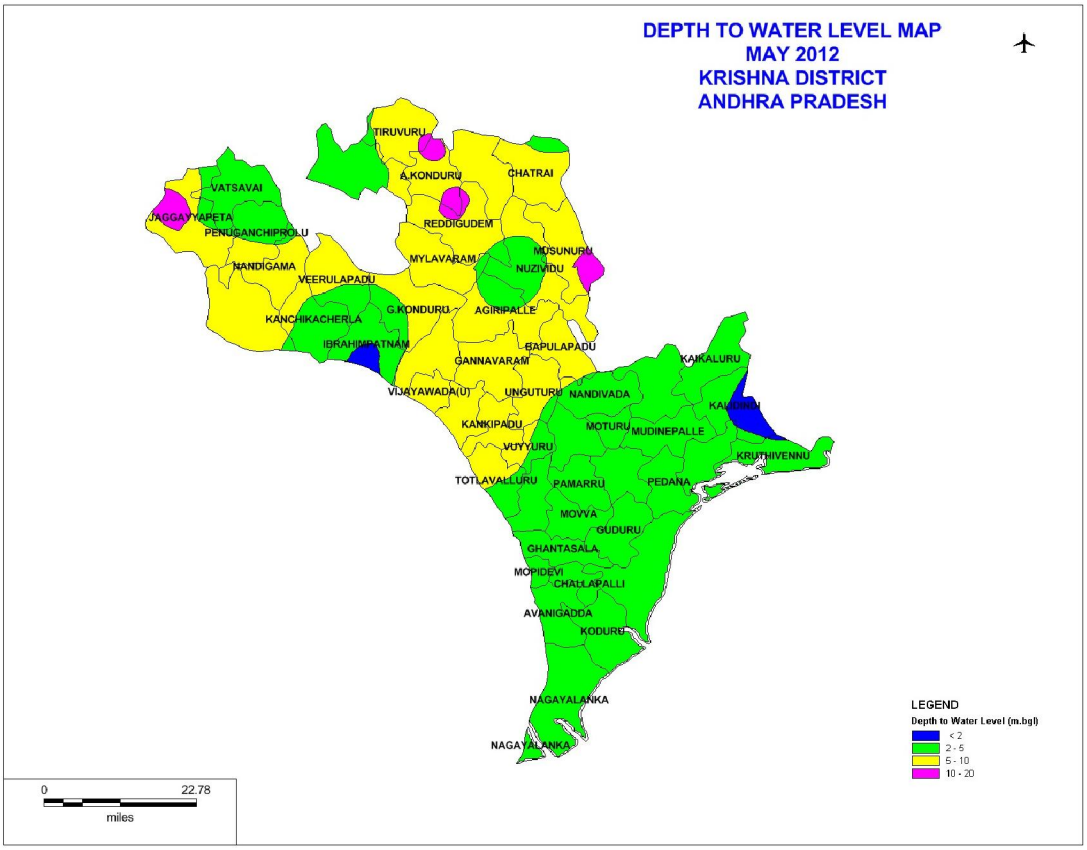
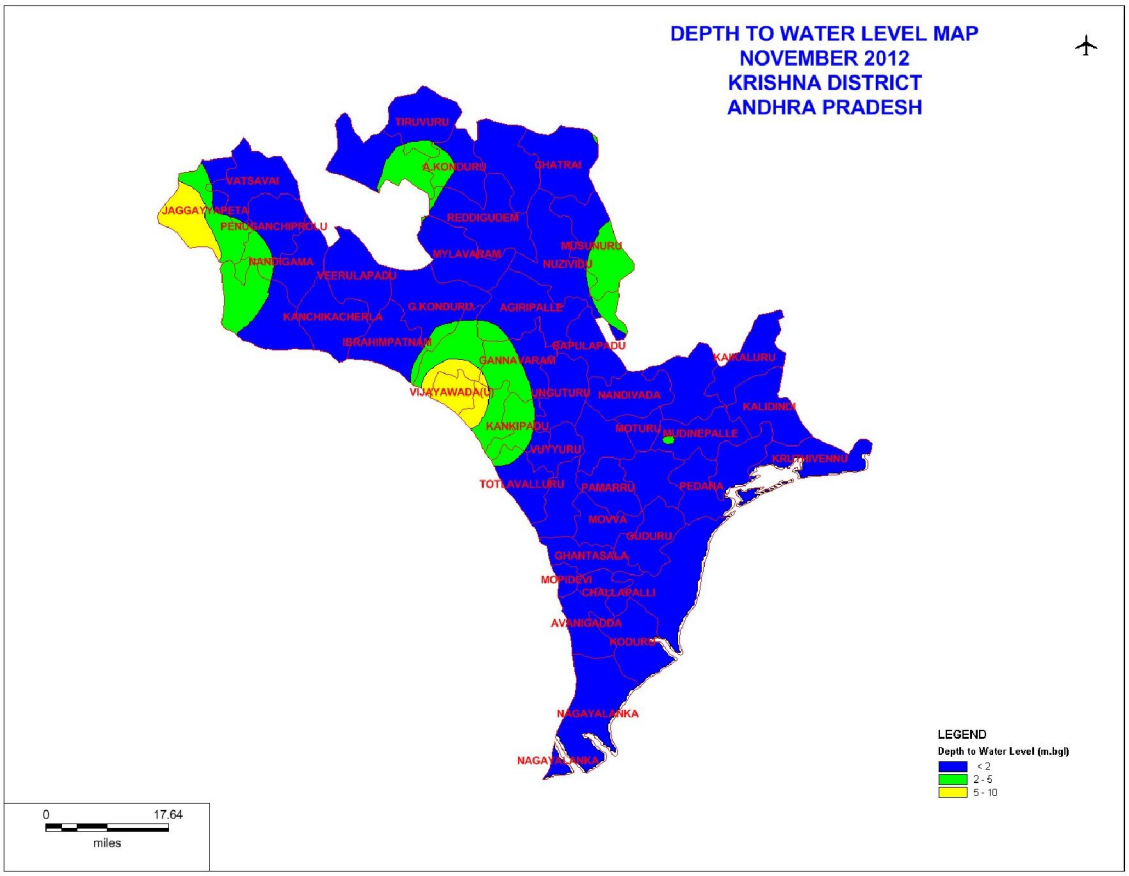


FIG 5 DEPTH TO WATER LEVEL – POST MONSOON (NOV 2012)
KRISHNA DISTRICT



Ground water levels fluctuate considerably in response to the recharge and draft conditions of ground water reservoir. Overall rise in water levels from pre-monsoon to post-monsoon in the range of 0.83 to 9.37 m exist in the district. Magnitude of the fluctuation is less in the deltaic area when compared to northern part of the district. Long-term trend of water level (2001 to 2011) indicates that during pre-monsoon a raise in the range of 0.0102 to 0.3456 m/yr in Gampalagudem, Vissannapeta, Ibrahimpatnam and Challapalli areas, whereas in the majority of the district a fall in the range of 0.0003 to 0.2379 m/yr is recorded. During post monsoon period a raise in the range of 0.0091 to 0.2217 m/yr and a fall in the range of 0.0016 to 0.2070 m/yr exists in the district. The water table elevation ranges between <1 m amsl in coastal areas and 133 m amsl in the northeastern part of the district (Vissannapeta mandal). The water table contours are almost parallel to the topographic contours and the general ground water flow direction is towards southeast and south i.e., towards the sea.

4.2 Ground Water Resources

The ground water recharge worthy area in the district is 860501 ha. which is subdivided in to 320520 ha of command, 860501 ha of non-command area and the remaining 271139 ha is Poor Ground Water Quality area. The ground water recharge due to rainfall in the command area is 396.56 MCM whereas the recharge due to other sources is 1095.17 MCM with total annual ground water resources of 1491.73 MCM. In the non-command area the recharge due to rainfall is 263.31 MCM and recharge due to other sources is 70.38 MCM with total annual resources of 333.69 MCM. Net annual ground water availability is 1345.76 MCM in the command and 304.59 MCM in non-command area with a total of 1650.35 MCM in the entire district.

The gross ground water draft for all uses in the command area is in the order of 327.14 MCM whereas it is 220.84 MCM in non-command area and the total gross ground water draft for all uses in the district is 547.98 MCM. Out of this resource 104.39 MCM in command area and 61.84 MCM in non-command area with the total of 166.23 MCM in the entire district is allocated to cater the domestic and industrial needs of the population in the district as on 2025. Net ground water availability for future irrigation use is 978.43 MCM in the command, 93.59 MCM in non-command area and 1072.02 MCM in the entire district. The details are as below:

Total Ground Water Recharge Worthy Area : *860501 ha*
Command Area : *320520 ha*
Non Command Area : *268842 ha*
Poor Ground Water Quality Area : *271139 ha*

(in MCM)

	Command area	**Non command area**	**Total**
Recharge from Rainfall	396.56	263.31	659.87
Recharge from other sources	1095.17	70.38	1165.55
Total Recharge	1491.73	333.69	1825.42
Gross draft for all uses	327.14	220.84	547.98
Stage of Ground Water development	24%	73%	33%
Category	Safe	Safe	Safe
Allocation for future domestic & Industrial uses	104.39	61.84	166.23
Net ground water available for future irrigation uses	978.43	93.59	1072.02

Ground water resources for each mandal are presented in **Table – 1.**

Table : 1 DYNAMIC GROUND WATER RESOURCES - KRISHNA DISTRICT

(ham)

Sl. No.	Mandal	Sub-Unit	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing gross ground water draft for all uses	Provision for domestic and trial requirement supply to 2025	Net ground water availability ure irrigation development	Stage of ground water develop-ment	Category
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	A.Kondur	Command	1528	153	1375	600	319	775	44	Safe
		N.C	1143	114	1029	681	278	348	66	Safe
		Poor	0	0	0	0	0	0	0	
		Total	2671	267	2404	1281	597	1123	53	Safe
2	Agiripalli	Command	0	0	0	0	0	0	0	
		N.C	2504	250	2254	1503	600	751	67	Safe
		Poor	0	0	0	0	0	0	0	
		Total	2504	250	2254	1503	600	751	67	Safe
3	Avanigad	Command	3902	390	3512	521	148	2907	15	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	3902	390	3512	521	148	2907	15	Safe
4	Bantumilli	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	7520	752	6768	6	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
5	Bapulapa	Command	7369	737	6632	589	190	5943	9	Safe
		N.C	1551	155	1396	1436	79	0	103	Over Exploited
		Poor	0	0	0	0	0	0	0	
		Total	8920	892	8028	2025	269	5943	25	Safe
6	Challapall	Command	5716	572	5144	1721	500	3423	33	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	5716	572	5144	1721	500	3423	33	Safe
7	Chandarl	Command	3176	317	2859	552	249	2307	19	Safe
		N.C	1104	54	1050	481	272	569	46	Safe
		Poor	0	0	0	0	0	0	0	
		Total	4280	371	3909	1033	521	2876	26	Safe

1	2	3	4	5	6	7	8	9	10	11
8	Chatrai	Command	2313	148	2165	563	202	1602	26	Safe
		N.C	1618	162	1456	1470	229	0	101	Over Exploited
		Poor	0	0	0	0	0	0	0	
		Total	3931	310	3621	2033	431	1602	56	Safe
9	G.Kondur	Command	0	0	0	0	0	0	0	
		N.C	2160	170	1990	1594	253	344	80	Safe
		Poor	0	0	0	0	0	0	0	
		Total	2160	170	1990	1594	253	344	80	Safe
10	Gampala	Command	5224	522	4702	1035	583	3667	22	Safe
		N.C	704	40	664	405	125	259	61	Safe
		Poor	0	0	0	0	0	0	0	
		Total	5928	562	5366	1440	708	3926	27	Safe
11	Gannavar	Command	3846	384	3462	176	131	3223	5	Safe
		N.C	1192	119	1073	304	355	458	28	Safe
		Poor	0	0	0	0	0	0	0	
		Total	5038	503	4535	480	486	3681	11	Safe
12	Ghantasa	Command	6265	626	5639	959	190	4680	17	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	6265	626	5639	959	190	4680	17	Safe
13	Gudiwad	Command	7603	760	6843	856	523	5646	13	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	7603	760	6843	856	523	5646	13	Safe
14	Gudlavall	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	6019	602	5417	61	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
15	Guduru	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	10521	1052	9469	79	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
16	Ibrahimp	Command	813	81	732	316	107	351	43	Safe
		N.C	848	65	783	277	216	351	35	Safe
		Poor	0	0	0	0	0	0	0	
		Total	1661	146	1515	593	323	702	39	Safe
17	Jaggaiah	Command	4256	426	3830	440	227	3390	11	Safe
		N.C	1190	113	1077	386	287	645	36	Safe
		Poor	0	0	0	0	0	0	0	
		Total	5446	539	4907	826	514	4035	17	Safe

1	2	3	4	5	6	7	8	9	10	11
18	Kaikaluru	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	3295	329	2966	17	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
19	Kalidindi	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	5580	558	5022	14	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
20	Kanchika	Command	2544	254	2290	411	148	1841	18	Safe
		N.C	890	44	846	296	161	526	35	Safe
		Poor	0	0	0	0	0	0	0	
		Total	3434	298	3136	707	309	2367	23	Safe
21	Kankipad	Command	6503	650	5853	3541	222	2137	60	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	6503	650	5853	3541	222	2137	60	Safe
22	Koduru	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	10236	1024	9212	59	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
23	Kruthiven	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	5392	539	4853	5	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
24	Machilipa	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	10867	1087	9780	24	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
25	Mandaval	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	4228	423	3805	46	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
26	Mopidevi	Command	6210	621	5589	1480	128	4045	26	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	6210	621	5589	1480	128	4045	26	Safe
27	Movva	Command	7791	779	7012	1153	270	5734	16	Safe
27	Movva	N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	7791	779	7012	1153	270	5734	16	Safe

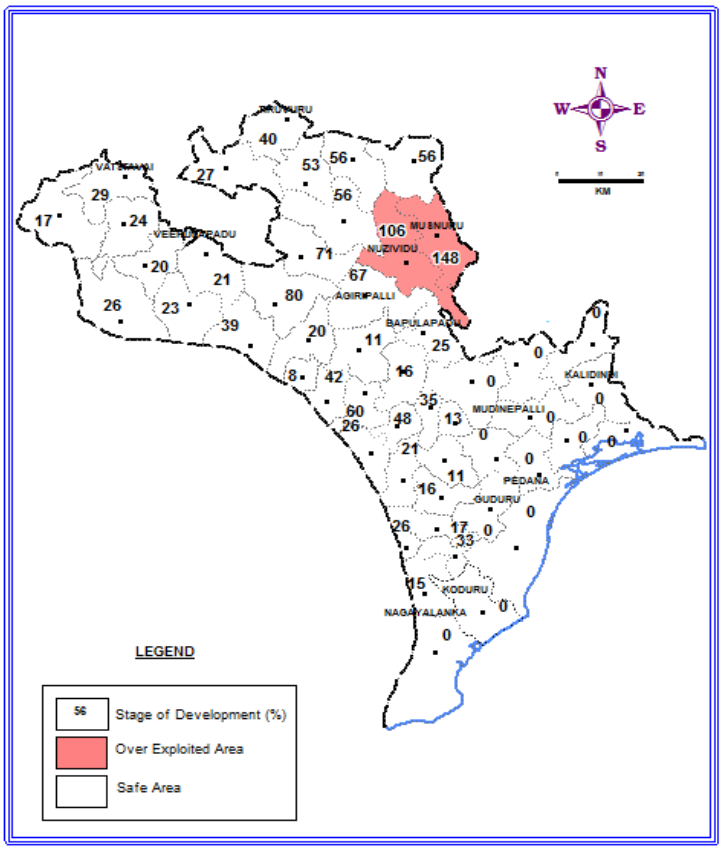
1	2	3	4	5	6	7	8	9	10	11
28	Mudinepa	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	10632	1063	9569	26	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
29	Musunur	Command	0	0	0	0	0	0	0	
		N.C	3680	368	3312	4901	209	0	148	Over ploited
		Poor	0	0	0	0	0	0	0	
		Total	3680	368	3312	4901	209	0	148	Over ploited
30	Mylavara	Command	0	0	0	0	0	0	0	
		N.C	2171	217	1954	1387	459	567	71	Safe
		Poor	0	0	0	0	0	0	0	
		Total	2171	217	1954	1387	459	567	71	Safe
31	Nagayala	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	11454	1145	10309	3	0	0	0	
		Total	0	0	0	0	0	0	0	Poor
32	Nandiga	Command	2563	257	2306	329	274	1883	14	Safe
		N.C	1284	85	1199	384	210	810	32	Safe
		Poor	0	0	0	0	0	0	0	
		Total	3847	342	3505	713	484	2693	20	Safe
33	Nandiwa	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	8050	805	7245	77	0	0	1	
		Total	0	0	0	0	0	0	0	Poor
34	Nuzvid	Command	0	0	0	0	0	0	0	
		N.C	3645	364	3281	3466	1302	0	106	Over Exploited
		Poor	0	0	0	0	0	0	0	
		Total	3645	364	3281	3466	1302	0	106	Over Exploited
35	Pamarru	Command	6973	697	6276	679	208	5420	11	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	6973	697	6276	679	208	5420	11	Safe
36	Pamidimk	Command	4822	482	4340	896	197	3393	21	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	4822	482	4340	896	197	3393	21	Safe
37	Pedana	Command	0	0	0	0	0	0	0	Poor
		N.C	0	0	0	0	0	0	0	
		Poor	10330	1033	9297	64	0	0	1	
		Total	0	0	0	0	0	0	0	Poor

1	2	3	4	5	6	7	8	9	10	11
38	Pedaparu	Command	5926	593	5333	1861	123	3417	35	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	5926	593	5333	1861	123	3417	35	Safe
39	Penamal	Command	4732	237	4495	1908	440	2265	42	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	4732	237	4495	1908	440	2265	42	Safe
40	Penugan chiprolu	Command	4023	403	3620	857	214	2763	24	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	4023	403	3620	857	214	2763	24	Safe
41	Reddigud	Command	327	33	294	96	32	192	33	Safe
		N.C	1428	143	1285	783	357	417	61	Safe
		Poor	0	0	0	0	0	0	0	
		Total	1755	176	1579	879	389	609	56	Safe
42	Thotlavall	Command	12180	1218	10962	2592	140	8306	24	Safe
		N.C	775	39	736	419	0	317	57	Safe
		Poor	0	0	0	0	0	0	0	
		Total	12955	1257	11698	3011	140	8623	26	Safe
43	Tiruvuru	Command	6172	617	5555	2132	1328	3423	38	Safe
		N.C	387	34	353	246	91	107	70	Safe
		Poor	0	0	0	0	0	0	0	
		Total	6559	651	5908	2378	1419	3530	40	Safe
44	Unguturu	Command	7538	754	6784	1078	182	5581	16	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	7538	754	6784	1078	182	5581	16	Safe
45	Vatsavai	Command	1411	141	1270	47	26	1214	4	Safe
		N.C	1751	159	1592	771	273	802	48	Safe
		Poor	0	0	0	0	0	0	0	
		Total	3162	300	2862	818	299	2016	29	Safe
46	Veerulap	Command	1008	101	907	98	29	809	11	Safe
		N.C	2389	119	2270	575	296	1650	25	Safe
		Poor	0	0	0	0	0	0	0	
		Total	3397	220	3177	673	325	2459	21	Safe
47	Viayawada (Rural)	Command	5044	504	4540	872	234	3472	19	Safe
		N.C	656	66	590	149	106	343	25	Safe
		Poor	0	0	0	0	0	0	0	
		Total	5700	570	5130	1021	340	3815	20	Safe
48	Viayawada (Urban)	Command	2176	218	1958	166	1926	0	8	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	2176	218	1958	166	1926	0	8	Safe

1	2	3	4	5	6	7	8	9	10	11
49	Vissanna	Command	3310	331	2979	1641	471	1265	55	Safe
		N.C	299	30	269	170	26	95	63	Safe
		Poor	0	0	0	0	0	0	0	
		Total	3609	361	3248	1811	497	1360	56	Safe
50	Vuyyuru	Command	5909	591	5318	2549	478	2769	48	Safe
		N.C	0	0	0	0	0	0	0	
		Poor	0	0	0	0	0	0	0	
		Total	5909	591	5318	2549	478	2769	48	Safe
	District -	**Command**	**149173**	**14597**	**134576**	**32714**	**10439**	**97843**	**24**	
		N.C	**33369**	**2910**	**30459**	**22084**	**6184**	**9359**	**73**	
		Poor	**104124**	**10412**	**93712**	**481**	**0**	**0**	**1**	
		Total (Excluding PQ)	**182542**	**17507**	**165035**	**54798**	**16623**	**107202**	**33**	

The net availability of ground water in the district varies from 15.15 MCM in Ibrahimpatnam mandal to 116.98 MCM in Thotlavalluru mandal. Gross ground water draft for all uses varies from 1.66 MCM in Vijayawada(U) Mandal to 49.01 MCM in Musunuru mandal. The stage of ground water development is as low as 8% in Vijayawada(U) mandal and as high as 148% in Musunuru Mandal. All the mandals in the district are categorised as safe except Musunuru and Nuzividu mandals, which are categorized as over exploited mandals. (**Fig. 6**).

Fig. 6 GROUND WATER RESOURCES - STAGE OF GW DEVELOPMENT



4.3 Ground Water Quality

The quality of ground water is as important as quantity. Ground water from shallow as well as deeper aquifers occurring in the northern parts of the district underlained by consolidated and semi-consolidated formations is generally good. The type of water is mainly Ca-Mg-Na--SO_4-HCO_3 type. In general ground water is suitable for domestic, industrial and irrigation purposes, except at Kanchikacherla, Vissannapeta and Gampalagudem areas, where EC values are more than permissible limit exist.

In the deltaic area i.e., southern part of the district, the quality of ground water deteriorates from north to south. All along the coast both shallow and deeper aquifers are saline. Away from the coast fresh water in the aquifers is limited to very shallow to moderate depths. Deeper aquifers are invariably saline. Shallow aquifers exhibit wide range of quality variations due to deltaic nature of the deposits and drainage conditions. Quality of water from the palaeochannels is comparatively good. In general the type of water varies from Ca-Mg-Na-HCO_3-SO_4 in the north to Na-K-Cl-SO_4 in the south. Overall the ground water from shallow aquifers is suitable for domestic and irrigation purposes, except at Unguturu, Pamarru, Mudinepalli and Kaikaluru areas and the areas immediately adjoining the coast falling in Krutivennu, Bantumilli, Pedana, Machilipatnam, Krutivennu, Koduru, Nagayalanka, Avanigadda, Challapalli and Guduru mandals, where values of EC and some of the chemical constituents are more than permissible limits. This salinity in these areas may be due to the palaeo coast line which was passing through Nandivada, Gudivada, Pamarru, Movva, Ghantasala, Challapalli and Avanigadda mandals in the geologic past. However, in these mandals limited potable ground water zones do exist, but they may not sustain for heavy withdrawals.

Arsenic and Fluoride contents in the ground water are within the permissible limits. Nitrate enrichment (more than permissible limit) is high at isolated places in A.Konduru, Tiruvuru, Gampalagudem, Kanchikacherla, Nuzividu, Gudivada, Gannavaram, Machlipatnam, Bantumilli areas due to localised pollution. Ground water from these areas can be used for other than drinking purposes.

4.4 Status of Ground Water Development

The assessment of ground water resources in the district has brought to light the wide scope for utilising the ground water resources to boost the irrigation. Ground water is one of the most important and essential commodities for agricultural development and thus the judicious and scientific management of the resource is essential. It is therefore, imperative that wells have to be designed and spaced properly for meeting the irrigation water requirements of the district. In the consolidated formations at present dug wells of 4 to 6m diameter with depths of 5 to 15 m exists. In the unconsolidated formations with 2 to 3m diameter in the depth range of 2 to 7 m are prevalent in the district. In unconsolidated formations, wells are either

stone or brick lined (masonry lined) and RCC rings are lowered upto sufficient depths. Ground water in the district is also developed through bore wells of 250 to 380 mm diameter with casing upto 10 to 15 m deep and are drilled down to 40 to 60m depth in consolidated formations. Similarly tube wells in semi-consolidated formations are with 380mm diameter is drilled down to depths of about 150 m, tapping 30 to 40m saturated aquifer material. And also filter point wells of 254 mm diameter are driven down to a depth ranging between 7 to 15 m in the deltaic alluvium areas wherever the potential zones available beyond 5m. In the consolidated and semi-consolidated formations ground water is also developed through dug cum bore/tube wells as the dug wells are being dried up or not getting sufficient yields. The depth of inwells of these structures ranges from 40 to 60 m and 30 to 100 m in consolidated and semi-consolidated formations respectively.

Ground water irrigation in the district is not extensive and accounts only 29% of the gross irrigation of the district. A total number of 16976 dug wells and 16340 bore/tube wells are functioning in the district. A total area of 93800 ha is irrigated through ground water, of which 7800 ha with dug well sources and 860 sq.kms by bore/tube wells.

Urban water supply to Vijayawada, Gudivada, Machilipatnam and Pedana is from Krishna river and its canal system, for Jaggayyapeta from Paleru river. The requirement for Nuzividu town is being met mostly by ground water. The rural water supply in the district is through both surface and ground water. A total number of 217 open wells, 10000 bore/tube wells, 1040 protected water schemes and 236 other sources are meeting the drinking water requirements of the rural population.

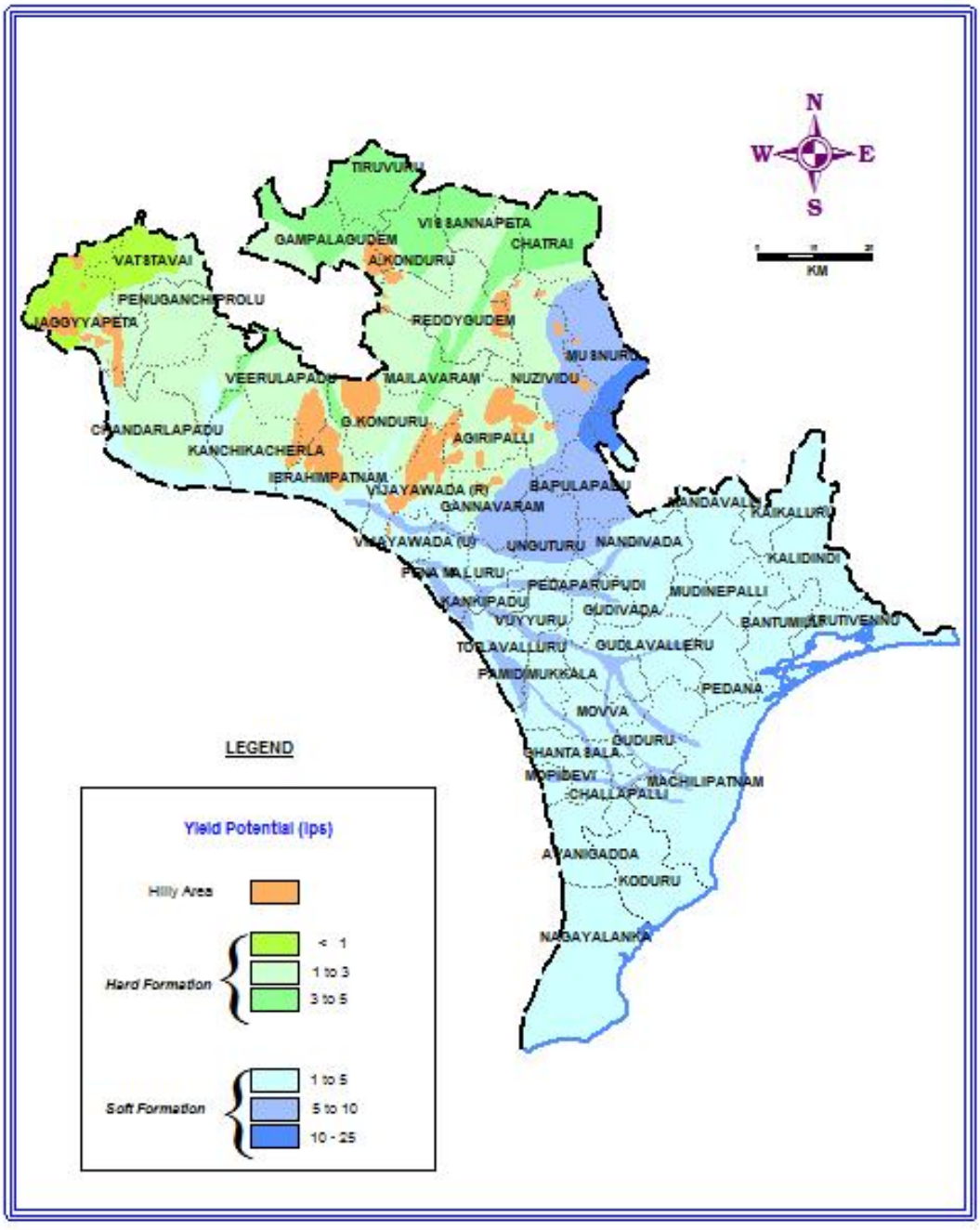
5.0 Ground Water Management Strategy

5.1 Ground Water Development

The scope for further development of ground water in the district varies widely from place to place and from mandal to mandal. Hence scientific and judicious development and management of available water resource will contribute to the overall planned development and improving the economy of the district. There is a huge scope for further development of ground water resources in order to bring more areas under irrigation in the district. Present irrigation is confined to 65% of the net sown area. Hence a balance of 35% area is devoid of irrigation facilities. Though surface water is abundant, during summer season its availability is very less due to swift nature of streams and rivers. The district is underlained by hard (Consolidated formations) and soft (semi-consolidated & unconsolidated formations) formations, therefore DTH rigs and DR rigs respectively suggested for deployment. In the deltaic area the ground water is supplementary source for irrigation requirements in few mandals. The ground water development in the deltaic area is to be carried out judiciously by installing low capacity pumps as the fresh water zones are limited and also to minimise salinity problems. In order to monitor the advancement of fresh water/saline water interface towards inland in due

course of time with rapid ground water development, it is necessary for construction of piezometers perpendicular to the coast line for monitoring the water level and chemical quality of the water. Based on the yield potential the aquifers of the hard (consolidated) formations of the district are classified as low (<1 lps), Low to Moderate (1 to 3 lps) and High (3 to 5 lps), and the soft (semi & Un consolidated) formations as Low (1 to 5 lps), Moderate (5 to 10 lps) & High (10 to 25 lps) yield potential areas (**Fig. 7**).

Fig. 7 GROUND WATER YIELD POTENTIAL - KRISHNA DISTRICT



5.2 Water Conservation and Artificial Recharge

Construction of artificial recharge structures like check-dams, contour trenches, percolation tanks and water conservation structures like sub-surface dykes are feasible in the areas where water levels are declining and considerable exploitation of ground water resources is taking place viz. Bapulapadu, Chatrai, Musunuru, and Nuzividu mandals. In the deltaic area artificial recharge schemes have to be implemented to avoid further deterioration of quality of ground water. Roof top Rainwater Harvesting is to be implemented in the urban areas wherever deepening of water levels is taking place.

6.0 Ground Water Related Issues and Problems

Coastal salinity and water logging are the major problems in the deltaic area of the district. In the deltaic area the fresh to brackish/ saline ground water occur in hydraulic contact with fresh ground water. The quality of ground water varies widely from place to place even within short distances and the deeper aquifers are invariably saline. The salinity of ground water is caused mainly due to depositional environment and other factors like geomorphic landform, water logging conditions, sluggish nature in ground water movement, excess use of fertilizers and unregulated growth of aquaculture in the coastal area which also play an important role. The most of the command area in the delta is either water logged or seasonally water logged. The intensive irrigation, near flat topography, low ground water development, poor drainage and clayey soils are the factors responsible for the water logging conditions. Localized Nitrate pollution is another problem in the district, which is due to excess use of fertilizers, urban sewerage and improper drainage system.

7.0 Recommendations

- Ground water should be judiciously exploited in the shallow fresh water aquifers of deltaic area without disturbing the fresh/saline water interface.

- In the limited fresh ground water potential areas, modern irrigation methods like drip and sprinkler irrigation should be adopted to increase the command area of the well.

- The aqua culture development should be restricted to areas close to the coast only. The practice of converting agricultural lands in the inland areas should be stopped to avoid the pollution of fresh water aquifers.

- Conjunctive use of surface and ground water needs to be planned in the command area, particularly in the deltaic area, to prevent the adverse effects of the water logging conditions and to improve or to avoid further deterioration of quality of ground water.

- Artificial recharge measures should be adopted in the urban areas, in the deltaic area and areas with considerable exploitation of ground water for improving the ground water situation.

- A multi-sectorial approach is needed to study the ground water development, augmentation and management perspective. Therefore, all the aspects related to ground water, involvement of NGOs and mass awareness campaigns will play an important role in conserving and developing the precious fresh ground water resources.

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