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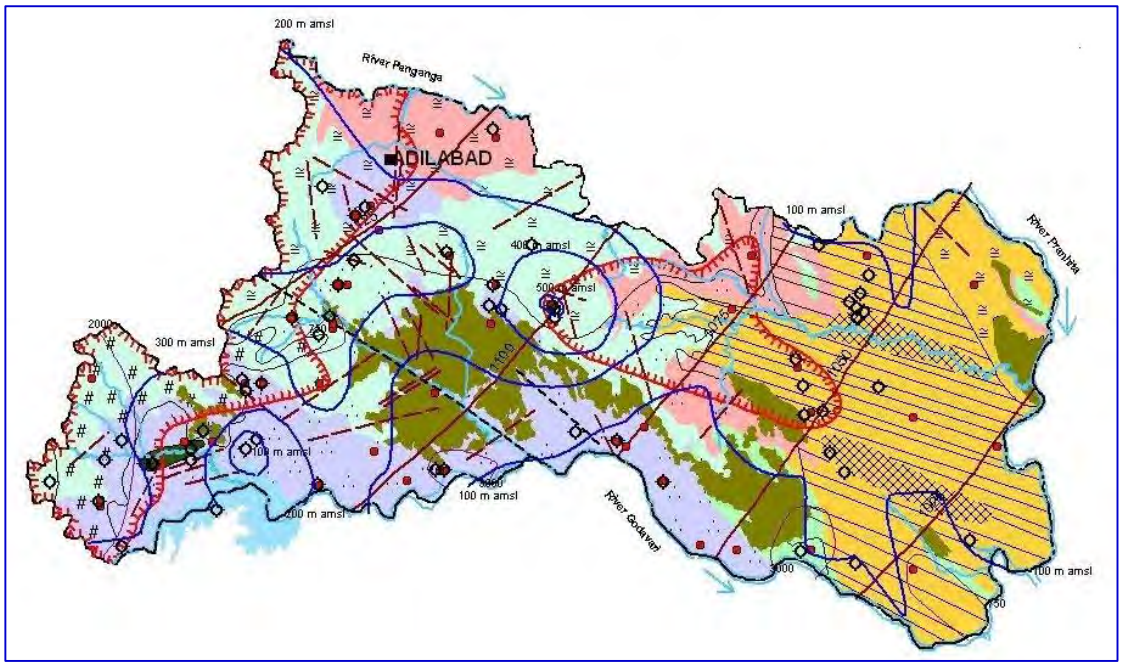
CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

GROUND WATER BROCHURE
ADILABAD DISTRICT, ANDHRA PRADESH



SOUTHERN REGION
HYDERABAD
September 2013

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

BY

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GROUND WATER BROCHURE
ADILABAD DISTRICT, ANDHRA PRADESH

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ADILABAD DISTRICT AT A GLANCE

S.No.	ITEM	Statistics
1	**GENERAL INFORMATION**	
	Geographical area	**16,105 km^2**
	Administrative Divisions Number of Mandals Number of Gram Panchayats Revenue Villages Municipalities Member of Legislative Assemblies (MP) Member of Legislative Assemblies (MLA)	 52 866 1725 7 2 10
	Provisional Population (As on 2011 Census)	27.38 lakhs
	Rural	19.80 lakhs
	Urban	7.58 lakhs
	Growth rate over the previous census	10.04 %
	Density	170 persons/ km^2
	Sex Ratio	1003(1003 females/1000 males)
	Literacy rate	61.55 %
	LAND USE (ha)	
	Major Forest area	689517 (42.81%)
	Gross Cropped Area	634263
	Net Cropped Area	575626
	Major Crops	Cotton, Rice, Jowar, Redgram, Maize, Bengalgram,
	Major Hills	Sahyadri Parvat (or Satmala range)
	Major drainages	The river **Godavari** with river Kadam and river Peddavagu and rivulets like the Satnala, Swarna, and the Sudda. The river **Penganga**, the river Wardha, the river Pranhita,
	Major Soil Types	Black cotton soils, red loamy soils
2	**CLIMATE**	
	Temperature	Min and Max 15°C & 29 °C in December and 28°C & 46°C (May)
	Normal Rainfall	1157 (mm)
	Actual Rainfall (2012)	1049(mm)
3	**HYDROLGOY**	
	Basin	The Godavari
	Major/Medium Irrigation Projects	2 and 9 (11 nos) Major: Kaddam, Sri Ramsagar Medium: Vattivagu (Stage I and II), Satnala, Chalamala (NTR stage), Suddavagu, Ralivagu, Peddavgu, Gollavagu and Yerravagu
	Registered Ayacut	175797 Ha
	Actual area irrigated	1634 Ha
	Minor Irrigation Sources	246 nos

	Registered Ayacut	30856 Ha		
	Actual area irrigated	26892 Ha		
	Area Irrigated Under Different Sources (2009-10)			
	Through Tubewells/Borewells	44509 Ha		
	Dug wells	25421 Ha		
	Tanks/ponds	4574 Ha		
	Canals	5405 Ha		
	Lift Irrigation	870 Ha		
	Other sources	10 Ha		
	Gross Irrigated Area	80789 Ha		
	Net Irrigated Area	63655 Ha		
	Number of Ground Water Monitoring Wells CGWB (As on 1/1/2012) - Un-confined Aquifer - Semi-Confined Aquifer SGWD (Govt of AP)	 54 nos. 48 6 32 nos.		
4	**HYDROGEOLOGICAL SET UP**			
	Predominant Geological Formations	Archaean, Pre-Cambrian Sedimentary, Deccan Traps & Alluvium		
	Principal Aquifers Pre-monsoon Depth to water level , 2012 Post-monsoon Depth to water level, 2012 Water Level Fluctuation in Nov with respect to May	Granite & gneisses, Basalt, Sandstone, Limestone, Shale and 2.86 to 17.20mbgl 0.48 to 12.08mbgl -2.7 to 12.58m		
	Ground Water Exploration by CGWB (as on 31.03.2012)	**Hard rock**	**Soft rock**	
	No. of wells drilled	106 (48 EW, 14 OW and 44 PZ)	23 (19 EW, 2 OW and 2 PZ)	
	Depth Range (m)	30-200	60-280	
	Major fractures	Up to 100 m	Up to 150 m	
	Discharge (litres per second)	1-19	10-50	
	Specific yield (Unconfined Aquifers from Granite Rock)	0.25-5.73 %		
	Specific Capacity (lpm/mdd)	5-72	12-50	
	Transmissivity (m^2/day)	3-400	1-115	
	Storativity (S)	-	6×10^{-4} to 1.7×10^{-3}	
5	**DYNAMIC GROUND WATER RESOURCES (As on March 2009) (Ham)**	**Command**	**Non-Command**	**Total**
	Net Annual Ground Water availability	17612	130757	148369
	Existing gross Groundwater draft for all uses	7630	32847	40477
	Ground Water Balance	9982	97910	107892
	Stage of Ground water development	43	25	27
	Categorization of Mandals			
	Over-exploited	Nil		
	Critical	Nil		

	Semi-critical	2 (Nirmal and Dandepally)
	Safe	50
7	**GROUND WATER CHEMISTRY**	32 NHS Ground water samples (May-2012)
	pH	6.6-8.0
	Electrical Conductivity (**µS/cm)**	660-3680
	Minimum and Maximum concentration of Chemical constituents in Groundwater (in mg/L)	Calcium (**20-360);** Magnesium (**1.24-194**) Sodium (**25-322**); Potassium (<**1-313**) Bicarbonate (**122-671**); Chloride (**18-610**) Sulphate (**2-168**); Nitrate (25-500); Fluoride (**0.2-4.3**)
	Sodium Adsorption Ration (SAR)	0.6-8.5

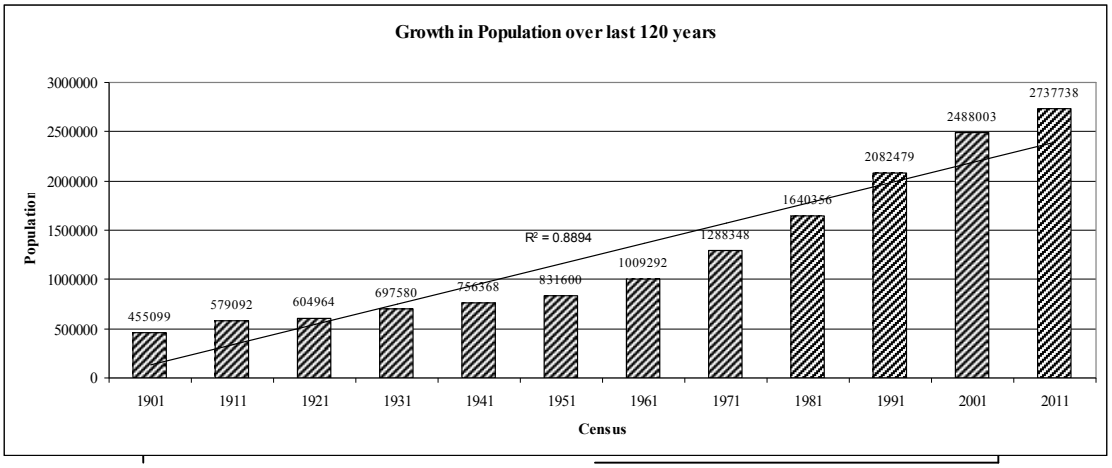
1. INTRODUCTION

1.1 **General:** The district derives its name “Adilabad” from its headquarter town which was named after the ruler of Bijapur Ali Adil Shah. The geographical area of the district is 16105 Km^2, it was upgraded from sub-district in the year 1905. It lies between 77° 46´ to 80° 00´east longitudes and 18° 40´ to 19° 56´ north latitudes and situated in the northern most part of Telangana Region of Andhra Pradesh state. The district consists of 52 mandals (**Fig.1**). It is bounded on north by Yeotmal and Chandrapur district, on south by Nizamabad and Karimnagar district and on west by Nanded district of Maharashtra state.

Fig.1: Administrative map of Adilabad District, A.P.

1.2 Demography: As per 2011 census (provisional data), the district has a population of 27.38 lakhs of which 72.32 % is rural and 27.68% is urban. The decadal growth rate is 10.04% with a population density of 170 persons/km^2. The literacy rate is 61.55% and the male-female sex ratio is 1003 females per 1000 males. Variation in population from 1901 to 2011 is given in **Fig.2.**

Fig.2: Growth in Population (1901 to 2011), Adilabad District, A.P.



1.3 Physiography: By and large the district is characterized by undulating topography, whereas, the central part exhibits rugged topography formed by hills and hill ranges.

The sahyadri parvat or satmala range traverses the district in N-W and S-E direction for about 281 km with highest peak known as “Mahabubghat”. Other hills on the eastern side are of minor importance.

1.4 Geomorphology: The major geomorphic regions identified in the district are Deccan Trap Plateau region, Hilly region, Pediplain and fluvial regions. The mega lineament trending NW-SE and NNW-SSE correlate with joint pattern occurring in the district. The other sets of lineaments trend in NE-SW, ENE-WSW directions. The higher fracture density is observed in Boath, Utnoor, Marlawai, Pushpur and Asifabad area of the district.

1.5 Drainage: River Godavari, which enters Andhra Pradesh state at Basar, is the most important river that drains the district with its tributaries such as river Kadam, river Peddavagu and rivulets like the Satnala, Swarna and Sudda. The other rivers are Penganga, Wardha and Pranhita.

1.6 Soils: Red loamy soils are the main soils, which are derived from country rocks. The other soils are black cotton soils mainly derived from basalt rock. In sedimentary formations the soils are deep up to 5 m and in other formations up to 1.5 m.

1.7 Flora and Fauna: The forests cover about 42.8% of the geographical area of the district. Teak, ebony, sandalwood, rosewood, bilgu, jittigi, dhanra, tamarind, mango are major trees. The fauna includes tiger, leopard, hyena, wolf, jackal, fox, sloth beer, black-buck, Indian bison, antelopes, gazelles, deer, nilgai. The common birds are peafowl, peacock, parrots, myna and game sanctuary called “Kawal Sanctuary” exists in the district. The forests from the district earned revenue of 2130.85 lakhs during the year 2009-10. Forest produce has generated revenue of 2131 lakhs in the district during the year 2009-10.

1.8 Land Use and Land Cover: Agriculture and forests are the two important units of land utilization and the forests occupy about 689517 hectares (42.8 % of total geographical area of the district). The gross cropped area during the year 2009-10 in the district is 634263 ha (39.4%) which declined by 3.5 % from previous year. The net area sown is 575626 ha, which is 35.74 % of total geographical area of the district. Land put to non-agricultural use is only 3.77% and area sown more than once is very low i.e., 3.64 %. Barren & un-cultivable land and cultivable wasteland is about 2.73 % and 0.90 % respectively. While permanent pastures and other grazing land is 0.88 % and land under miscellaneous, tree, crops and grooves are not included in net area sown is 0.53% of the total geographical area of the district. The land utilization data is given in **Table-1.**

Table 1: Land Use-Land Cover, Adilabad District (2011-12).

S. No.	Category	Area (in Ha)	% With respect to total geographical area
1	Total Geographical area	1610500	100
2	Forest	689517	42.80
3	Barren & un-utilizable lands	43920	2.73
4	Land put to non-agriculture use	60684	3.77
5	Cultivable waste	14737	0.90
6	Permanent pastures and other Grazing lands	14234	0.88
7	Land under miscellaneous, tree, crops and grooves not included in net sown area	8504	0.53
8	Other fallow lands	74757	4.60
9	Current fallow lands	128521	8.0
10	Net area sown	575626	35.74
11	Gross cropped area	634263	39.40
12	Area sown more than once	58637	3.64

1.9 Cropping pattern (2011-2012): Two cropping seasons namely, Khariff (June to September) and Rabi (October to March) with a little variation in these periods. Cotton is the main commercial crop of the district and nearly 48.73 % of the net area sown is covered. Only Cotton yielded 5841 kg/ha during the year 2009-10. Other principal crops are soyabean, jowar, redgram, rice and maize in decreasing order. The other crops are green gram, black gram, Bengal gram, wheat, bajra horse gram etc. The commercial crops like cotton are grown mostly under rain-fed and chilies, turmeric and groundnut are grown under irrigation. The total area under food grains is 211025 ha, out of which 146457 ha is under khariff crop and 64568 ha is under rabi crops. Rotation of crops is a well-established practice in the district and usually no crop other than paddy is sown in the same land in two or more successive seasons and mixed cropping is limited to dry crops. Summarized result comprising net area sown, production per tones and yield of principal crops is given in **Table-2**.

Table-2: Area under Principal Crops, Adilabad District (2011-2012).

S. No.	Crops	2009-10		
		Net area (in Ha)	Production in tones	Yield in Kgs/ha
1	Cotton	280536	1638660	5841
2	Soyabean	92093	52677	572
3	Jowar	58316	70743	1213
4	Redgram	48728	27434	563
5	Rice	48118	98499	2047
6	Maize	17899	68468	3825
7	Greengram	12376	2311	187
8	Blackgram	10482	3700	353
9	Bengalgram	9536	14342	1504
10	Turmeric	5701	20809	3650
11	Chillies	4662	4263	914
12	Wheat	3392	4566	1346
13	Groundnut	2225	4131	1857
14	Mangoes	22731	109455	5109
15	Tomatoes	3928	33411	8506

1.10 Size of agricultural holdings: There are 215788 marginal farmers (land <2.47 acres) and the total area is 246334 acres. Small farmers (land between 2.47-4.93 acres) are about 118305, semi-medium farmers (4.94-9.87 acres) are 88445, medium (9.88-24.7 acres) and large farmers 9>24.71 acres) are 29012 and 2661 respectively. The total number of holding of various sizes along with percentage is given in **Table-3.**

Table-3: Distribution of Agricultural Holdings, Adilabad District.

S. No.	Category of farmer	Size of holdings (acres)	Holdings (2011-12)		
			Nos	Area (acres)	%
1	Marginal	Below 2.47	215788	246334.28	47.50
2	Small	2.47-4.93	118305	419310	26.04
3	Semi-medium	4.94-9.87	88445	565872	19.47
4	Medium	9.87-24.7	29012	399841	6.38
5	Large (Big)	>24.7	2661	99605	0.58
	Total		**454211**	**1730962**	100%

1.11 Economic Minerals: Major minerals are coal, which is extensively found in Asifabad, Tandur, Chennur and north Godavari valley and actively mined by Singareni Collaries Company Ltd (SCCL), Limestone of cement grade belonging to Penganga series occur in NW of Mancherial and Asifabad town. Low-grade iron ore occur in Kadam Lakshettipet and Utnur mandals. Extensive deposits of clay from Gondwana formation occur in Asifabad area.

1.12 Previous Studies by CGWB: The Central Ground Water Board (CGWB) has carried out systematic hydrogeological surveys in 1961-62 and completed entire district in 1987.

1. Exploratory drilling for ground water for the first time carried out in the year 1974-75 with the construction of 10 deposit wells down to 200 m under Rehabilitation Project areas of Sirpur-Kagaznagar in soft rock formations. Exploration in sedimentary rock was carried out during 1975-76 with construction of 9 exploratory wells and 2 observation wells of 280.5 m depth. Exploratory drilling was taken up in the hard rock areas and 24 exploratory wells, 14 observation wells and 1 slim hole were drilled down to a maximum depth of 200 m. In order to help the drinking water needs of tribal people, exploration was taken up again during the year 1987 and total 24 wells were drilled. Under Hydrology Project 18 piezometer wells were constructed for continuous water level monitoring. In order to determine specific yield of un-confined aquifer total 26 shallow pz down to 40 m were drilled during the AAP 2010-11. Thus so for in the district thus 129 bore wells were drilled till 31-03-2010.
2. The Board also carried out geophysical surveys and profiling to locate the favorable sites for ground water exploration.
3. The water levels from 54 observation wells are monitored 4 times a year and ground water quality is also observed during pre-monsoon season (May).
4. To educate people on availability of ground water resources, its occurrence, development and conservation, etc. training on ground water management and mass awareness programmes were also conducted at Adilabad, Nirmal and Utnoor town.

1.13 Places of tourist importance: Temple dedicated to the Goddess Saraswati at Basar, Prakrit Stone inscriptions at Jainad, highest water fall in A.P. at Kuntala on

Kadam river, Famous Nagoba temple at Keslapur (Bk) village (Indervelly mandal), Nirmal Painting at Nirmal are famous.

2. CLIMATE

The climate of the district is characterized by hot summer and is generally dry except during the S-W monsoon season. The year may be divided into 4 seasons namely cold season (Dec-Feb), summer season (March-May), Southwest monsoon season (June-September) and followed by post-monsoon season (Oct-Nov). In the year December is the coldest month and May is the hottest month of the year. The mean daily minimum and maximum temperature is 15°C & 29 °C, during December and 28°C & 46°C during May month are observed. The normal annual rainfall in the district is 1157 mm and during the year 2012, it received 1049 mm of rainfall. The rainfall increases from S-W towards N-E direction. Monthly rainfall distribution of long period average is given in **Table-4** and seasonal rainfall along with percentage and departure from long period average in **Table-5** and in **Fig.-3.**

Table-4: Monthly Normal Rainfall Distribution of Long Period Average.

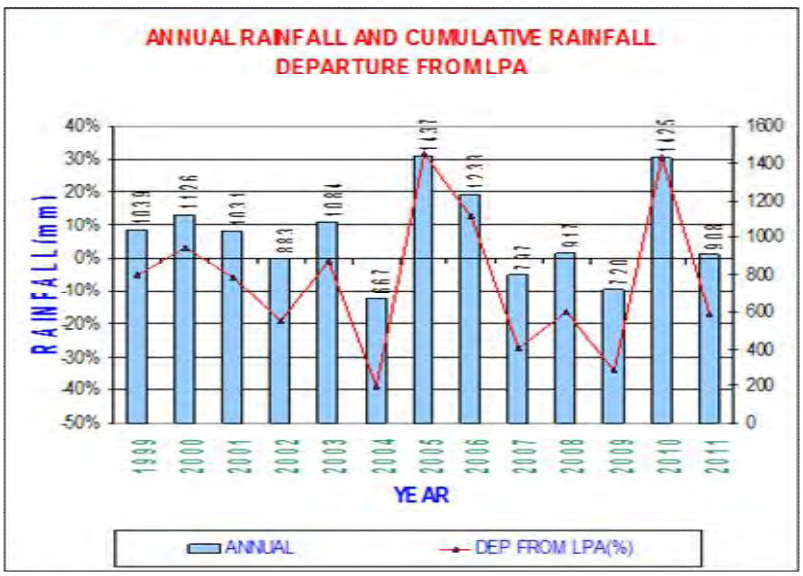
S. No.	Month	Normal Rainfall (mm)		S. No.	Month	Normal Rainfall (mm)
1	January	0.00		7	July	318.8
2	February	6.9		8	August	291.4
3	March	11.4		9	September	170.9
4	April	11.9		10	October	88.3
5	May	18.2		11	November	0.00
6	June	178.4		12	December	0.00

Table-5: Seasonal Rainfall along with Percentage and Departure from Long Period Average at Adilabad Rain Gauge Station (1999-2011).

YEAR	ANNUAL	SWM	NEM	WINTER	SUMMER	SWM (%)	NEM (%)	WINTER (%)	SUMMER (%)	DEP FROM LPA (%)
1999	1039.0	893.0	80.0	18.0	48.0	85.95	7.70	1.73	4.62	-5
2000	1126.0	1043.0	8.0	11.0	64.0	92.63	0.71	0.98	5.68	3
2001	1030.7	836.0	130.7	9.0	55.0	81.11	12.68	0.87	5.34	-6
2002	883.5	803.5	33.0	22.0	25.0	90.94	3.74	2.49	2.83	-19
2003	1083.5	972.4	72.0	10.0	29.1	89.75	6.65	0.92	2.69	-1
2004	667.1	583.6	44.2	6.8	32.5	87.48	6.63	1.02	4.87	-39
2005	1436.5	1162.5	150.8	92.4	30.8	80.93	10.50	6.43	2.14	31
2006	1232.7	1054.9	69.6	0.0	108.2	85.58	5.65	0.00	8.78	13
2007	796.5	729.9	39.4	0.0	27.2	91.64	4.95	0.00	3.41	-27
2008	916.8	837.9	11.0	1.9	66.0	91.39	1.20	0.21	7.20	-16
2009	720.3	594.4	82.7	15.5	27.7	82.52	11.48	2.15	3.85	-34
2010	1425.3	1226.6	170.4	15.2	13.1	86.06	11.96	1.07	0.92	30
2011	908.3	854.6	5.3	2.0	46.4	94.09	0.58	0.22	5.11	-17
	1096.3	**959.6**	**88.3**	**6.9**	**41.5**	**87.53**	**8.06**	**0.63**	**3.79**	

Note : SWM = South Western Monsoon, NEM= North East Monsoon, LPA = Long Period Annual

Fig.3: Long-term Rainfall and Cumulative Rainfall Departure from LPA, Adilabad District, A.P.



3. HYDROLOGY

Hydrological point of view the entire district falls under Godavari basin and is divided into 38 major watersheds.

3.1 Major Irrigation Projects (Capacity > 10000 Ha): In the district has two major irrigation projects namely Kaddam Narayanreddy Project and S.R.S Saraswati Canal (Sri Ramsagar Project-Left canal) with registered ayacut of 68500 and 35735 ha and Ayacut utilized is 50000 and 32735 ha respectively. The project wise details of irrigation ayacut and actual area irrigated are given in **Table-6**.

Table-6: Major and Medium Irrigation Sources and Area Irrigated, Adilabad District (2011-12).

Project Number	Name of the Project	Registered Ayacut (Ha)	Actual Area Irrigated (Ha)	
			Gross	Net
1101	Kaddam	68500	1322	1322
1201	Srrrama Sagar Project-1	35735	0	0
2104	Vattivagu (stage I &II)	24500	312	312
2105	Satnala	24000	0	0
2102	Swarna	8945	0	0
2201	Sudda Vagu	6840	0	0
2103	Chalamala Vagu	6000	0	0
2311	Ralivagu	865	0	0
2301	Pedda Vagu	246	0	0
2303	Golla Vagu	162	0	0
2202	Yerra Vagu (Palvai Purushottama Rao)	4	0	0
	Total	**175797**	**1634**	**1634**

3.2 Medium Irrigation Projects (Capacity > 2000-10000 Ha): The medium irrigation projects are Vattivagu (Stage I and II), Satnala, Chalamala (NTR stage), Suddavagu, Ralivagu, Peddavgu, Gollavagu and Yerravagu with 71562 Ha registered ayacut and 48600 utilized ayacut. The work on some of these projects is undertaken in

"Jalayagnam Programme". The details of major and medium irrigation sources along with area irrigated are given in **Table-6**.

3.3 Minor Irrigation Projects (Capacity > 40-2000 and <40 ha): In the district there are 675 minor irrigation tanks (>40-2000 ha irrigation capacity) and 1378 tanks below <40 Ha capacity with 140746 ha and 42197 ha utilized ayacut. Mandal wise minor irrigation sources under Nirmal division are given in **Table-7**.

Table-7: Mandal Wise Minor Irrigation Tanks and Their Settled Ayacut (> 40 ha Irrigation Capacity) Under Nirmal Division (in Ha).

S. No.	Mandal Name	No of minor irrigation tanks	Actual Area Irrigated		S. No.	Mandal Name	No of minor irrigation tanks	Actual Area Irrigated
1	Tallamadugu	15	1955		15	Bhainsa	11	1534
2	Tamsi	5	295		16	Tanoor	8	1164
3	Adilabad	5	292		17	Mudhol	15	3023
4	Jainad	5	149		18	Lokeshwaram	8	464
5	Bela	4	117		19	Dilawarpur	11	818
6	Narnoor	5	66		20	Sarangpur	12	1406
7	Indervelly	7	435		21	Nirmal	26	1650
8	Gudihatnoor	3	130		22	Laxmanchanda	11	1331
9	Icchoda	2	98		23	Mamda	10	824
10	Bazarhatnoor	3	1791		24	Khanapur	8	617
11	Boath	3	2061		25	Kaddam/Peddur	10	628
12	Neridgonda	8	579		26	Utnoor	15	880
13	Kuntala	16	1212		27	Jainoor	1	44
14	Kubeer	19	3329			**Total**	**246**	**26892**

3.4 Ground Water Irrigation: The major sources of irrigation in the district are through ground water (86.55%) followed by tanks and canals. During the year 2009-10 out of 80789 ha (hectares), gross area irrigated, the area through ground water irrigated (both dug wells and tube wells) was 69630 ha. The details of net area irrigated, source wise is given **Table-8.**

Table-8: Net Area Irrigated, Adilabad District (Source-Wise, 2011-12).

S. No.	Source	Area Irrigated (Ha)
1	Canals	5405
2	Tanks	4574
3	Tube wells (Groundwater)	44509
4	Dug wells (Groundwater)	25421
5	Lift irrigation	870
6	Other sources	10
7	Total net area irrigated	63655
8	Area irrigated more than once	17134
9	Total gross area irrigated	80789

4 HYDROGEOLOGICAL SET-UP

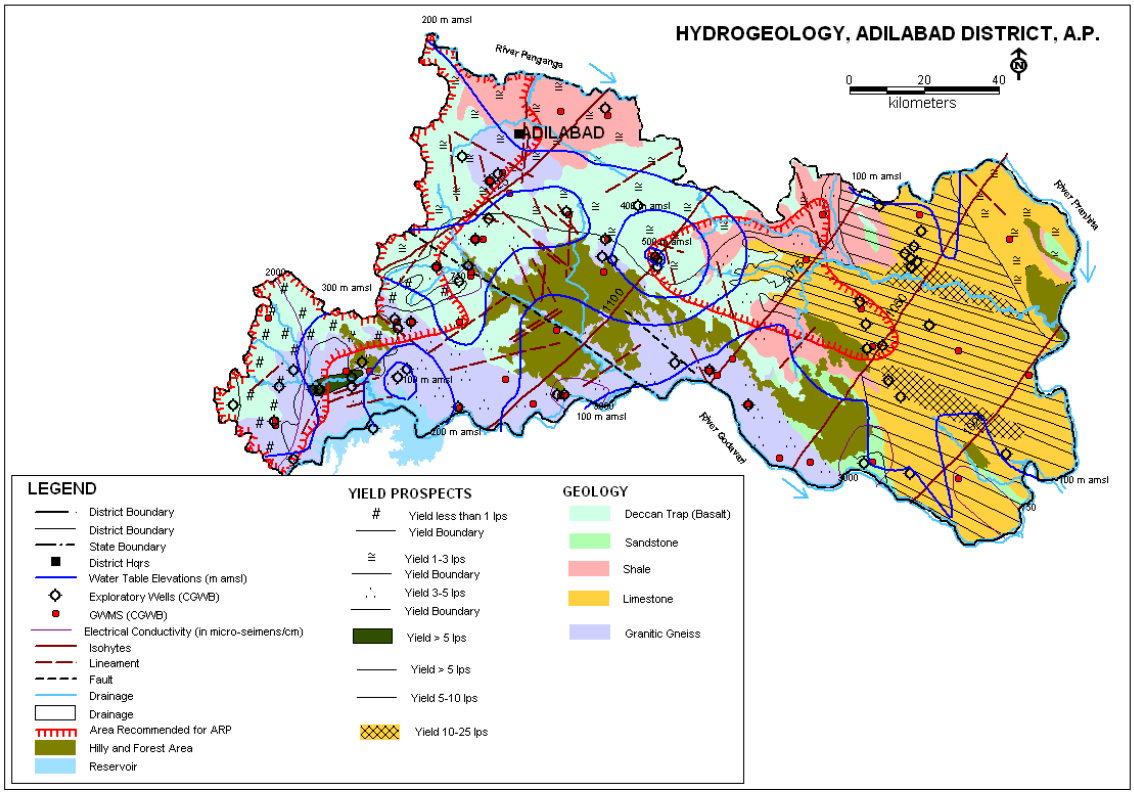
4.1 Geology: The southern part of district is mainly underlain by pink and grey granites and gneisses with dolerite dykes as intrusions. The shale, limestone and sandstone of Penganga formations overlie granites/gneisses and occur in north of Adilabad and Asifabad area and between Mancherial and Asifabad town. The Sullavai formation comprising grits, conglomerates and sandstone rest over Penganga formations in Mancherial, Sipur-Kagaznagar area. The Gondwana formations consisting of sandstone, which occupy the eastern part of the district in Sirpur, Asifabad, Mancherial, Chennur and Yemanpalle area. The Deccan traps are represented by both vesicular and massive basalt and occupy the central and western part of the district. Sub recent alluvium consisting of laterite occurs as capping over Deccan traps in Utnoor Taluk. Recent alluvium consisting of sand, silt and clay occur along the river courses.

The Granite, gneiss, schist, limestone, dolerite and basalt rocks are grouped under consolidated formation. The Gondwana formations comprising sandstones, shales, limestones, etc. form a thick sequence of sediments and are grouped under Semi-consolidated formations. The Unconsolidated formations consist of laterites and recent alluvium.

4.2 Occurrence and Movement of Ground Water: Climate, distribution & intensity of rainfall, topography, geological formations, aquifer matrix like weathering, joints, fractures, fissures, bedding planes, recharge conditions, transmissivity & storage conditions of the aquifers, etc play an important role in occurrence and movement of

groundwater. Hydrogeological map along with area recommended for artificial recharge of the district is presented in **Fig-4.**

Fig.4: Hydrogeology- Adilabad District, A.P.



4.2.1 Consolidated Rocks:

Granites and Gneisses: In these rocks, ground water occurs in the pores formed due to secondary porosity (except Basalts and Inter-Trappeans), which have developed due to weathering and tectonic activities over the period. Consequently, the occurrence and prospect for development of ground water is highly variable and limited in nature. Ground water occur under unconfined conditions in the shallow weathered mantle and semi-confined to confined conditions in the fractured and fissured zones. The depth of weathering ranges between 6 to 15 m below ground level (mbgl) and the depth of fracturing extends down to 30 to 60 m depth and occasionally up to 150 m. Deep fractures were encountered at Khanapur (168-169 m) and Utnoor (125-126 m). Ground water is generally tapped from shallow weathered zone through large diameter dug wells and from deep fractures through dug-cum bore wells and bore wells. The

depth of open wells are in the range of 4 to 16 m bgl, with depth to water level between 2 to 5 mbgl. The yield of open wells in the consolidated rocks varies from 40 to 277 m^3/day.

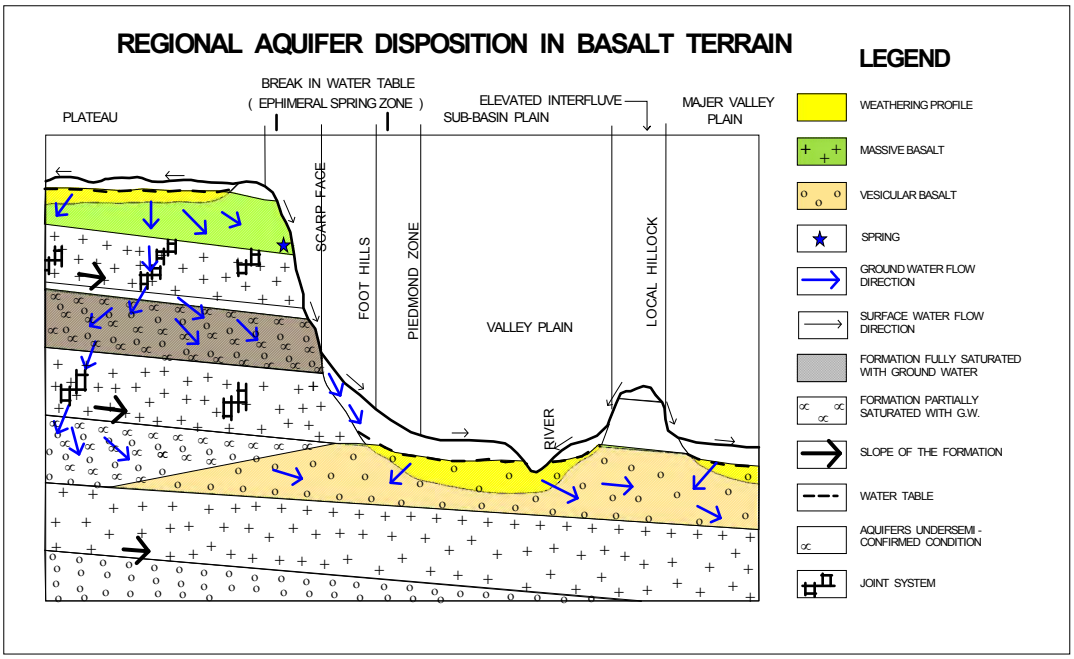
Schists: Presence of foliation planes, fractures and fissures, forms potential aquifers in these rocks and fractures are observed down to a depth of 60 to 70 m bgl. The occurrence of fractures at deeper levels below weathered zone enhances the chances of development of ground water by dug-cum-bore wells. The depth of open wells varies between 3 to 27 m bgl with a yield range of 10 to 30 m^3/day.

Compact Sandstone, Limestone and Shale: The sandstone, limestone and shale of Penganga and Sulliavai formations are of sedimentary origin, but are mostly hard and compact due to which the rocks behave similar to consolidated crystalline rocks and the aquifers are formed due to weathering and fracturing. The limestones form good aquifers due to development of solution channels except in areas, where they are siliceous. Though the shales are splintery in nature, having fractures and well developed joints favoring the movement of ground water. Wells penetrating these formations usually get dried up in summer. The average yield of dug wells from these formations varies between 30 to 60 m^3/day. Bore wells drilled by Ground Water Department, Government of Andhra Pradesh, down to 80 m depth yielded 70 to 180 liters per minute (lpm). The specific capacity varied from 6.4 to 12 lpm/m of drawdown and transmissivity from 1.2 to 34 m^3/day.

Deccan Traps (Basalts): Basalt rock occurring in the western and central part of the district, forms the fringe areas of the vast Deccan Plateau of Central India. Successive lava flows both “aa” and “pahoehoe” resulted in a layered crystalline rock with intervening beds of clay (red bole/black bole, ash beds, etc. The contact zones between successive flows and inter-trappean beds form good aquifers in addition to the top weathered and fractured zones. The vesicles present in top portion of the each lava flows also form potential aquifer. This unique set-up in basalt presents a multi- aquifer system (Fig.-5). Sometimes, this multi-aquifer system with wide variation in its compaction poses problems in construction of production wells. Under ground water exploration programme of CGWB, these multi aquifers were explored in backward and tribal areas during 1987-1997. The depth of open wells ranges between 9 to 26 m bgl. In general, depth of open wells in massive basalts, varies

between 4 to 6 m bgl, whereas in vesicular basalt the depth of wells range between 9 to11 m bgl with an yield range of 10 to 277 m^3/day.

Fig.5: Regional Aquifer Disposition in Basalt Terrain.



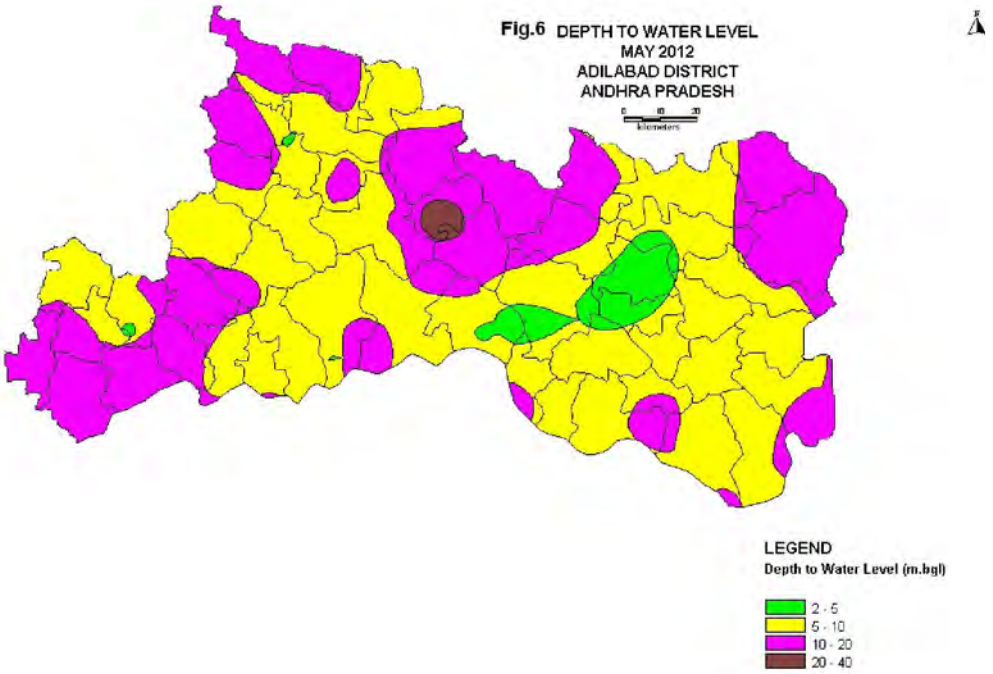
4.2.2 Semi-consolidated formations: Rocks grouped under this formations are generally bedded deposits with well defined lithology affected by structural disturbances and may show vertical and lateral variations within short distances and due to which the hydrogeological properties vary widely. The sandstones become friable and loose due to weathering. The ferruginous kankary material of 1 to 3 m thickness formed on the surface due to weathering augments, infiltrates and saturates the underlying sandstones. They are generally medium to coarse grained and form good aquifers except where they occur as the intercalations and argillaceous in nature. The depth of dug wells in sandstones varies between 6-12.5 m and in limestone and shales it varies between 9.0-17.0 m. Fracturing and jointing in shale offer good scope for percolation, but due to rapid variations in structure, they fail to form good aquifers. Limestones when occur alternately with shale, forms the contact

between the formations acts as a good conduit for ground water movement. Dug wells tapping these formations are reported yield between 30 to100 m^3/day.

4.2.3 Unconsolidated formations: In this group of formations, ground water occurs in primary pores. Because of primary porosity and pore-connectivity, these formations form very good aquifers. Laterite is formed, as a product of weathering and leaching process, over the basaltic rocks. Though the thickness of the formation is limited, it forms potential aquifer system, wherever favourable conditions exists. The average yield of dug wells in laterite is in the range of 18-180 m^3/day. The loose and unconsolidated formation of alluvium comprises mainly gravel, sand and silt, occurring along the river courses. Ground water occurs under phreatic and confined conditions in these formations and generally developed through small diameter dug wells, filter point wells and tube wells. Wells tapping these aquifers on an average yield about 40 m^3/hr. Dug wells constructed in these formation yield between 36 to 60 m^3/hr and can sustain 8 to 10 hours of pumping in a day.

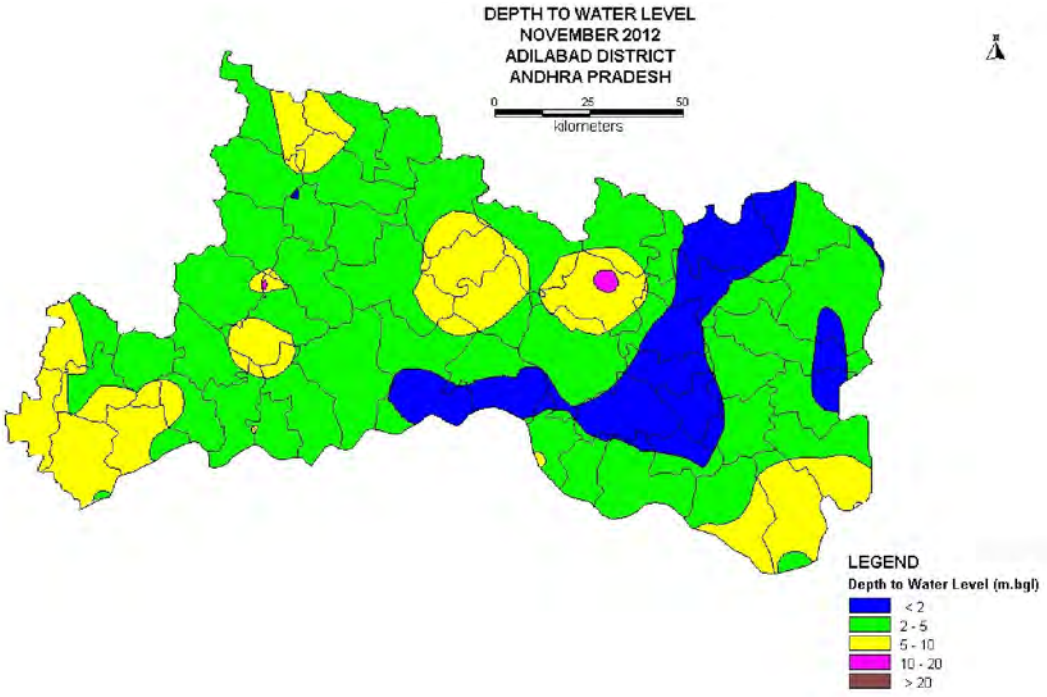
4.3 Depth to Water Level (DTW): Ground water levels are being monitored by CGWB in the district since 1969 and presently 54 observation and piezometers wells are monitored 4 times a year (both water levels and one time water quality). Apart from CGWB, State Ground Water Department also monitors 32 Piezometers monthly.

4.3.1 Pre-monsoon (May-2012): Depth to water level (DTW) varies from 2.86-17.20m bgl. The pre-monsoon DTW level map is presented in Fig.-6. In the district 5 to 10 m water levels are more predominant and cover most of the area. Less than 5m water level zone is observed as isolated pocket in eastern part. The water level ranging 10-20 m has been noticed in central, northwestern, southwestern and north eastern parts of the district. Whereas, the deeper water levels of more than 20mbgl exist in a small area in the central part of the district.



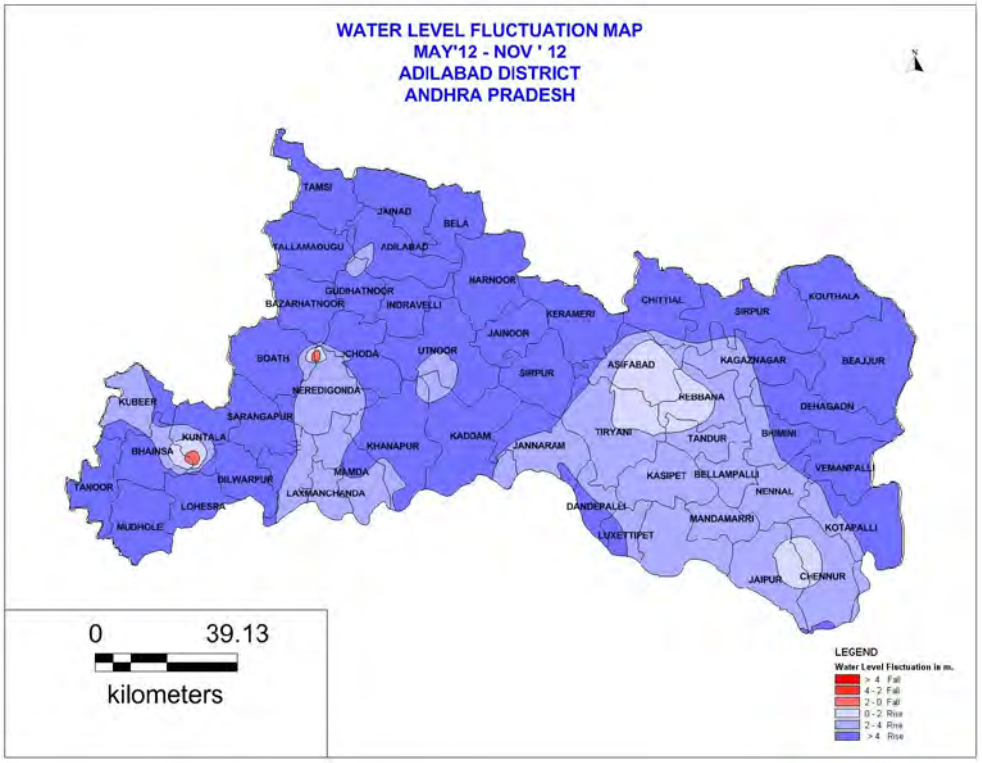
4.3.2 Post-monsoon (November-2012) The post-monsoon DTW varies from 0.48 to 12.08mbgl. The post monsoon DTW level map is presented in Fig.7. In the district 2 to 5 m water levels are more predominant and cover most of the area. Less than 2 m water levels occur in two patches in eastern part and 5-10m water levels occupy central, southeastern and south-western part of the district.

Fig.7



4.4 Water level fluctuation (WLF) (Pre and Post-monsoon season-2012): Fluctuations in water level occur in the ground water regime in response to recharge and discharge. The water level fluctuation (May-Nov 2012) varies between -2.72 to 12.58m. The WLF map is presented in Fig.8. Rise in water levels of more than 4m has been observed in 60% of the area in central, southern, western and eastern parts of the district followed by 2-4m rise in southern part of the area. 0-2m rise in water levels has been observed as isolated pockets in eastern part. Fall of water levels of 2-4m and 0-2m have been observed at Kumari and Lolam Observation wells respectively.

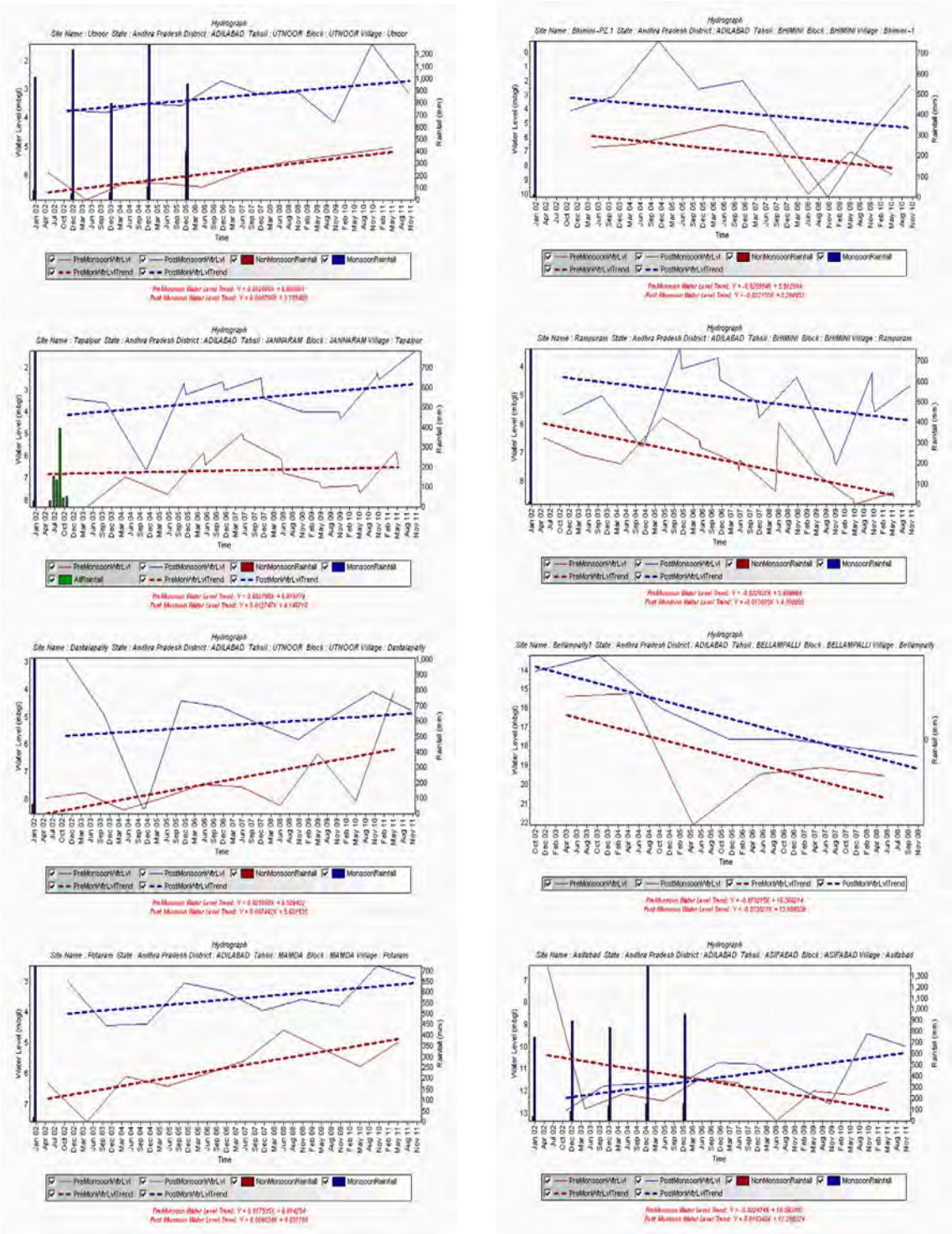
Fig.8



4.5 Decadal Water Level Trends (2002-2012): Ground water being dynamic in nature needs to be studied in detail over a long period of time (minimum 10 years). Therefore, long-term water level trends of depth to water levels using the data from 8 representative Ground Water Monitoring Wells of CGWB for the last decade (2002-2011) were carried out for pre and post-monsoon season (Fig.9). Out of 8 representative hydrographs 4 hydrographs namely Utnoor, Tapalpur, Dantalpally and Potaram show a rising trend 0.0334 to 0.253 m/yr and 0.089 to 0.1524 m/yr during pre and post-monsoon season respectively. The Bhimni, Ramapuram, Bellampally and

Asifabad hydrographs show a falling trend in both season @ -0.27—0.843 m/yr and -0.166-0.876 m/yr in pre and post-monsoon season respectively.

Fig.9: Long-term Water Level trends from Selective GWMS (2002-2012), Adilabad District, A.P.



5. GROUND WATER RESOURCES (As on March 2009)

The dynamic ground water resource potential of the district has been estimated as per the methodology given by the Ground Water Estimation Committee 1997 (GEC 1997). As per the revised methodology the resource assessment is done on watershed basis and is apportioned from the watersheds (sub-basins) to mandal. Based on the percentage of ground water utilization, the watersheds/mandals are categorized into four categories.

As per the latest estimates (March, 2009), the net annual ground water availability in the district is 148369 ham (17612 in command and 130757 in non-command mandals), the existing gross ground water draft is 40462 ham (7614 in command and 32848 in non-command mandals), and the provision for domestic and industrial use for the year 2025 is 12390 ham (1474 in command and 10966 in non-command mandals). The net balance available for future irrigation development is 106507 ham (9964 in command and 96543 in non-command mandals) and the stage of ground water development varies between 7 to 81 % with overall stage of development of 27%. The district as a whole falls under safe category (**Table-9**). Out of 52 mandals, 50 falls under safe category and 2 under semi-critical category.

Table-8: Mandal Wise Ground Water Resources, Adilabad District, Andhra Pradesh (as on 2008-09) (in Ham).

S. No	Mandal	Category of Mandal	Net annual ground water availability	Existing gross ground water draft for all uses	Provision for domestic and industrial requirement supply to 2025	Net groundwater availability for future irrigation development	Stage of ground water development (%)
1	2	3	4	5	6	7	8
1	Adilabad	Command	530	62	38	469	12
		Non-command	3062	583	653	2029	19
		Total	3592	645	691	2498	18
2	Asifabad	Command	0				
		Non-command	2191	344	411	1746	16
		Total	2191	344	411	1746	16
3	Bazarhathnur	Command	0				
		Non-command	4579	469	120	4109	10
		Total	4579	469	120	4109	10
4	Bejjur	Command	0				
		Non-command	4326	412	302	3893	10
		Total	4326	412	302	3893	10
5	Bela	Command	117	19	4	101	16
		Non-command	2482	376	187	2127	15
		Total	2599	395	191	2228	15
6	Bellampally	Command	0				
		Non-command	607	384	157	180	63
		Total	607	384	157	180	63

1	2	3	4	5	6	7	8
7	Bhainsa	Command	0				
		Non-command	2943	1546	252	1183	53
		Total	2943	1546	252	1183	53
8	Bhimini	Command	0				
		Non-command	1900	461	185	1381	24
		Total	1900	461	185	1381	24
9	Boath	Command	0				
		Non-command	3533	773	168	2748	22
		Total	3533	773	168	2748	22
10	Chennur	Command	0				
		Non-command	3079	1129	252	1807	37
		Total	3079	1129	252	1807	37
11	Dahegaon	Command	0				
		Non-command	2892	409	254	2470	14
		Total	2892	409	254	2470	14
12	Dandepally	Command	1704	1392	223	366	82
		Non-command	899	629	97	222	70
		Total	2603	2021	320	588	78
13	Dilwarpur	Command	0	0	0		
		Non-command	2481	1497	150	986	60
		Total	2481	1497	150	986	60
14	Ghathnur	Command	0				
		Non-command	2109	408	163	1667	19
		Total	2109	408	163	1667	19
15	Ichoda	Command	0				
		Non-command	5437	717	234	4695	13
		Total	5437	717	234	4695	13
16	Indervelly	Command	0				
		Non-command	4250	526	165	3729	12
		Total	4250	526	165	3729	12
17	Jainad	Command	1730	256	105	1470	15
		Non-command	1677	251	118	1405	15
		Total	3407	507	223	2875	15
18	Jainoor	Command	0				
		Non-command	1395	243	173	1130	17
		Total	1395	243	173	1130	17
19	Jaipoor	Command	0				
		Non-command	3383	833	172	2634	25
		Total	3383	833	172	2634	25
20	Jannaram	Command	1996	364	198	1611	18
		Non-command	1218	73	44	1128	6
		Total	3214	437	242	2739	14
21	Kadem	Command	2274	686	116	1679	30
		Non-command	2240	743	106	1507	33
		Total	4514	1429	222	3186	32
22	Kagaznagar	Command	0				
		Non-command	3369	711	278	2738	21
		Total	3369	711	278	2738	21
23	Kasipet	Command	0	0	0		
		Non-command	3234	215	113	3012	7
		Total	3234	215	113	3012	7
24	Kerameri	Command					
		Non-command	1984	328	203	1689	17
		Total	1984	328	203	1689	17
25	Khanapur	Command	1899	552	130	1334	29
		Non-command	3383	888	134	2474	26
		Total	5282	1440	264	3808	27

1	2	3	4	5	6	7	8
26	Kotapally	Command	0				
		Non-command	3028	855	159	2133	28
		Total	3028	855	159	2133	28
27	Kouthala	Command	0				
		Non-command	2835	417	214	2425	15
		Total	2835	417	214	2425	15
28	Kubeer	Command	0				
		Non-command	3174	891	273	2356	28
		Total	3174	891	273	2356	28
29	Kuntala	Command	0	0	0		
		Non-command	2913	1227	148	1591	42
		Total	2913	1227	148	1591	42
30	Laxmanchanda	Command	1479	1011	143	521	68
		Non-command	620	322	20	348	52
		Total	2099	1333	163	869	64
31	Lokeshwaram	Command	0				
		Non-command	2562	1781	150	973	70
		Total	2562	1781	150	973	70
32	Luxettipet	Command	1431	1067	221	277	75
		Non-command	510	23	7	491	5
		Total	1941	1090	228	768	56
33	Mamda	Command	1163	590	71	560	51
		Non-command	1767	643	90	1246	36
		Total	2930	1233	161	1806	42
34	Mancherial	Command	967	513	62	453	53
		Non-command	3087	1211	807	1529	39
		Total	4054	1724	869	1982	43
35	Mandamarri	Command	0				
		Non-command	2246	668	431	1240	30
		Total	2246	668	431	1240	30
36	Mudhole	Command	0				
		Non-command	3142	1317	256	1877	42
		Total	3142	1317	256	1877	42
37	Narnoor	Command	0				
		Non-command	2248	513	300	1667	23
		Total	2248	513	300	1667	23
38	Nennal	Command	0				
		Non-command	2026	321	115	1697	16
		Total	2026	321	115	1697	16
39	Neradigonda	Command	0				
		Non-command	2691	385	136	2317	14
		Total	2691	385	136	2317	14
40	Nirmal	Command	871	393	59	455	45
		Non-command	1563	1570	169	69	100
		Total	2434	1963	228	524	81
41	Rebbana	Command	0				
		Non-command	2837	476	293	2391	17
		Total	2837	476	293	2391	17
42	Sarangapur	Command	1076	702	104	294	65
		Non-command	1257	741	76	598	59
		Total	2333	1443	180	892	62
43	Sirpur(U)	Command	0				
		Non-command	2456	484	163	2139	20
		Total	2456	484	163	2139	20
44	Sirpur(T)	Command	0				
		Non-command	2209	390	186	1833	18
		Total	2209	390	186	1833	18

1	2	3	4	5	6	7	8
45	Talamadugu	Command	0				
		Non-command	3635	580	109	2967	16
		Total	3635	580	109	2967	16
46	Tamsi	Command	0				
		Non-command	2631	505	183	2145	19
		Total	2631	505	183	2145	19
47	Tandur	Command	0				
		Non-command	1785	296	275	1378	17
		Total	1785	296	275	1378	17
48	Tanoor	Command	0				
		Non-command	1928	757	210	1249	39
		Total	1928	757	210	1249	39
49	Tiryani	Command	375	7	0	374	
		Non-command	1592	274	291	1215	17
		Total	1967	281	291	1589	14
50	Utnur	Command	0				
		Non-command	3675	677	363	2912	18
		Total	3675	677	363	2912	18
51	Vemanpally	Command	0				
		Non-command	1871	292	148	1576	16
		Total	1871	292	148	1576	16
52	Wankidi	Command	0				
		Non-command	1816	284	253	1492	16
		Total	1816	284	253	1492	16
	Command Total		**17612**	**7614**	**1474**	**9964**	**43**
	Non-command Total		**130757**	**32848**	**10916**	**96543**	**25**
	District Total		**148369**	**40462**	**12390**	**106507**	**27**

6. GROUND WATER QUALITY

In order to assess the quality of ground water for drinking as well as for irrigation purposes from unconfined/semi-confined aquifers, Central Ground Water Board monitors about 54 network stations during the pre-monsoon season (May). However, during the year 2011 only 32 samples were collected and analyzed for 12 parameters (Table-10). The ground water from the district is alkaline in nature, where the pH varies from 6.6 (at Utnoor) to 8.0 (Jainoor). The electrical conductivity ranges from 660 (Bhimavaram) to 3680 (Khanapur) micro siemenes/cm at 25 $^{\circ}$C. The minimum and maximum concentration of major cations like calcium, magnesium, sodium and potassium (in mg/L) varies between 20 (Jainoor), 1.24 (Jainoor), 25 (Swarana) and 1 (Mudhol) and between 360 (Hazipur), 194 (Mancherial), 290 (Jannaram) and 235 (Tandur) respectively. The minimum and maximum concentration of major anions like bicarbonate, chloride, sulphate nitrate and fluoride (in mg/L), varies between 122

(Jainoor), 18 (Wankidi), 2 (Wankidi), 25 (Boath) and 0.19 (Mancherial) and between 671 (Tandur), 610 (Khanapur), 168 (Khanapur), 500 (Mancherial) and 4.3 (Jainoor) respectively. The carbonate is below detectable limit in all samples. The Sodium Adsorption ration (SAR) varies between 0.6 to 8.5 and the ground water from the area falls under low salinity hazard. From the results it is found that nearly 78% of the samples are not suitable for drinking purposes where Ca, NO_3 or F is beyond the maximum permissible limits of BIS.

Table-9: Ground Water Quality from Un-confined Aquifers, Adilabad District (May-2012).

Location	pH	EC µS/cm	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	F^{-}	SAR
			Mg/L									
Sitagondi	7.0	1500	132	54.9	115	3	439	138	110	170	1.44	2.1
Gudihathnur	7.0	1170	162	23.3	46	4	427	138	5	64	0.30	0.9
Wankidi	7.1	900	66	48.7	67	1	555	18	2	36	0.99	0.5
Echoda	7.6	1185	36	64.5	110	1	281	223	29	25	0.21	2.5
Utnoor	6.6	1940	232	43.1	92	23	384	273	144	160	0.24	1.5
Jainoor	8.0	760	20	1.24	145	2	122	131	48	30	4.30	8.5
Asifabad	7.3	1035	74	42.6	94	1	592	25	10	40	1.8	2.2
Boath	7.3	800	68	11	92	4	427	32	5	25	0.93	2.7
Neredikonda1	7.1	844	34	74.2	28	0	439	25	24	45	0.53	0.6
Rebna-1	6.9	1510	162	53.9	83	1	537	152	48	120	0.89	1.4
Wakri	7.8	810	52	28	53	45	293	60	31	69	0.31	1.5
Narsapur	6.6	1800	206	61.3	69	4	348	262	38	280	0.44	1.1
Khanapur	7.1	3680	280	95.4	322	1	610	610	168	320	1.05	4.2
Lakshetipetta-2	7.1	2200	240	22.4	166	16	525	308	77	149	0.40	2.8
Mancherial	6.7	3540	206	194	184	4	445	581	115	500	0.19	2.2
Bhimavaram-1	7.3	660	72	24.4	28	2	256	46	14	60	0.92	0.7
Mamda	7.6	1190	82	43.9	92	2	403	121	14	85	0.56	2.0
Lolam	7.0	2100	154	70.9	161	2	384	266	86	299	0.45	2.7
Tandur	7.3	1750	82	39	101	235	671	131	36	140	0.55	2.3
Swarna	6.7	780	70	45.1	25	2	232	103	24	69	0.60	0.6
Hazipur	6.7	2490	360	25	92	2	390	312	96	420	0.69	1.3
Pembi	7.2	1040	114	31.8	58	5	397	74	43	85	0.67	1.2
Bela	7.2	770	86	34.1	25	1	360	18	14	90	0.62	0.6
Palsi	7.2	2470	144	56.1	92	313	525	241	58	440	0.43	1.7
Potaram	7.1	1060	114	24.5	67	7	421	64	24	80	1.30	1.5
Tapalpur	7.1	1640	100	90.1	115	5	561	206	38	105	1.8	2.0
Jannaram	7.3	2300	68	90.0	290	4	628	337	77	120	3.0	5.4
Jainath	7.5	940	110	12.3	30	70	397	60	24	50	0.31	0.7
Rampuram	7.1	1840	168	51.5	69	117	451	184	72	279	0.73	1.2
Kalamadagu	7.1	1720	176	56.4	69	26	403	191	62	229	0.66	1.2
Nirmal	7.3	1150	104	28.1	94	5	427	106	29	60	2.0	2.1
Mudhol	7.2	1380	144	33	92	1	482	177	10	45	0.53	1.8

7. GROUND WATER DEVELOPMENT & MANAGEMENT

7.1 Ground Water Development: Irrigation and drinking water needs in the district are mainly met through ground water. Out of 80,789 ha area irrigated during 2009-10, nearly 86.55% (69,630 ha) is met through ground water. The main ground water abstraction structures used for domestic purposes are dug wells and borewells / tube wells. Small diameter dug wells of 1 to 4 m with a depth of 5 to 33 m (average 15 m) are in vogue. The water from these wells is lifted by means of bucket and rope and by electric motors of 1 to 2 HP for domestic purposes. For irrigation purposes, large diameter dug wells/dug-cum-bore wells, especially in non-command areas are in operation. In hard rock areas, depth of dug well varies between 4 to 22 m with a yield of 10 to 277 m^3/day with a general yield range of 50 to 80 m^3/day. The bore wells/tube wells are operated by electric motors fitted with submersible pumps of 5 to 10 HP. In soft rocks, depth of open wells varies between 6 to 16.75 m with yield in the range of 30 to 100 m^3/day (average of 50 m^3/day). In alluvium (un-consolidated formation), depth of open wells varies between 5 to 10 m with a yield a 100 to 300 m^3/day. The dug/dug-cum-bore wells are operated mostly by 3-7.5 HP pumps and also by diesel engines fitted with centrifugal pumps. The weathered and fractured zones are tapped by bore wells of 30-100 m depth with discharge varying between 3.6 to 18 m^3/hr. The maximum depth of potential aquifers identified by CGWB in hard rock areas is down to a depth of 125 m. The depth of tube wells constructed in semi-consolidated rocks vary between 70 to 200 m with a yield of 10-50 m^3/hr. The filter point wells constructed in alluvium formations are of 5 to 10 m depth, with an yield rate of 25 to 50 m^3/hr.

7.2 Ground Water Management: The entire district excluding two mandals falls under safe category with overall stage of ground water development being 27%. But, these resources are not distributed uniformly; therefore these resources are to be managed carefully and judiciously on scientific basis in a phased manner to avoid over-exploitation.

Ground Water Recharge Plan: There is a scope for harnessing rainwater in Nirmal mandal covering an area of 206.3 km^2. The monsoon rainfall in this mandal is 1.04 m and the percentage of runoff to rainfall is 28.8 with 61.81 MCM volume of water. After

leaving 70% of the volume of water to the existing structures 18.54 MCM is available for further development (30% of 61.81 MCM) of which 9.27 MCM each is allotted for percolation tanks (PT) and check dams (CD). Total 31 percolation tanks and 206 check dams are proposed (allotting 0.5 MCM for each PT and 0.045 for each CD). The total cost of these structures is worked out to be **1304.1 lakhs** including maintenance & impact assessment studies cost (15% of the total cost).

Spacing between Wells: Spacing between two wells is made mandatory by Government of India while sanctioning the loan. The spacing between 2 dug wells is 100 m in ayacut and 160 m in non-ayacut area. Between two filter points/shallow tube wells it is 160 m and 120 m in ayacut and non-ayacut area respectively. Between two bore/tube wells,300 to 500 m spacing is recommended in ayacut and non-ayacut area respectively.

Water Conservation Practices: In the district sprinklers and drip irrigation projects are in use and during the year 2009-10 the total number of sprinklers and drip irrigation are 2499 and 4360 in operations, irrigating about 2499 and 2493 ha respectively.

Government of Andhra Pradesh (under S.C. action plan) has also assisted 651 beneficiaries with a subsidy of 44.58 lakhs. These funds were utilized under construction of bore wells/ enerigization of pump sets as per APWALTA-Act. Various banks also given the subsidy to about 106619 farmers for construction of bore wells on patta lands. District Water Management Agency also taken up various activities under their programme.

7.3 Ground Water Issues

Farmers Distress Condition: In recent past suicide cases are reported due to failure of bore wells, mostly in semi-critical area of the district. In these areas, the success rate of bore wells is reported to be 40-60% and about 80% of the failures of bore wells are accounted to selection of sites on non-scientific lines like water divining methods.

Drinking Water Facilities: In the district almost all villages are having the adequate drinking water facilities except 19 villages (Including 4 fluoride endemic villages and 5 with no drinking water facility is available). The fluoride endemic villages lie in Bazarhatnur (2 nos), Neredigonda (1), Jannaram (3), Kaddam (Peddur) (2), Dandepalli (1) and Chennur (5).

8. RECOMMENDATIONS

1. In non-command area, where further development of groundwater is possible the sites should be selected on scientific basis.
2. In non-command area, ground water resources are scarce, therefore, less water intensive crops be raised and alternative irrigation methods like drip and sprinkler irrigation may be encouraged and farmers may be given loans with enhanced subsidy. Technical guidance has to be provided to the illiterate farmers in maintaining these irrigation equipment.
3. To stop surface run off and to enhance ground water storage, ground water conservation and artificial recharge structures must be taken up, on suitable locations.
4. Watershed management plans with people's participation must be adopted and impact assessment studies should be carried out on scientific basis.
5. Peoples Participatory Programme along mass awareness programmes must be conducted widely on regular basis in the rural areas to educate the farmers regarding the water management and to update their knowledge.
6. Training for local government functionaries, NGOs, voluntary organizations engaged in watershed development activity to be given in scientific selection of sites, design of structures, for construction of rainwater harvesting and artificial recharge structures.
7. There should be a complete institutional credit cover to the small and marginal farmers for drilling deep bore wells in ground water potential areas, for procuring water saving equipment like drip and sprinkler systems, etc. Insurance facility should be provided to cover the health of farmers and their families, damaged crops due to severe drought conditions, unforeseen loss, market rates for the agriculture produce, etc.
8. To minimize the dependence solely on agriculture, the government should provide loan facility with enhanced subsidy to the farmers to initiate dairy and poultry farm for supplementary income.
9. In order to impart education to the farmers, regarding cropping pattern, hybrid varieties, pesticides, irrigation techniques etc., 'Agri-clinics' may be established in rural areas for every five villages in non-command areas.

10. Construction of additional 31 percolation tanks and 206 check dams proposed in Semi-critical, Nirmal mandal may be taken with a cost of 1304.1 lakhs.
11. The spacing norms between two adjacent bore wells, as per the norms of APWALTA act, should be strictly implemented.

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