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Central Ground Water Board

Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ADILABAD DISTRICT, TELANGANA

दक्षिणी क्षेत्र हैदराबाद

Southern Region, Hyderabad

भारतसरकार

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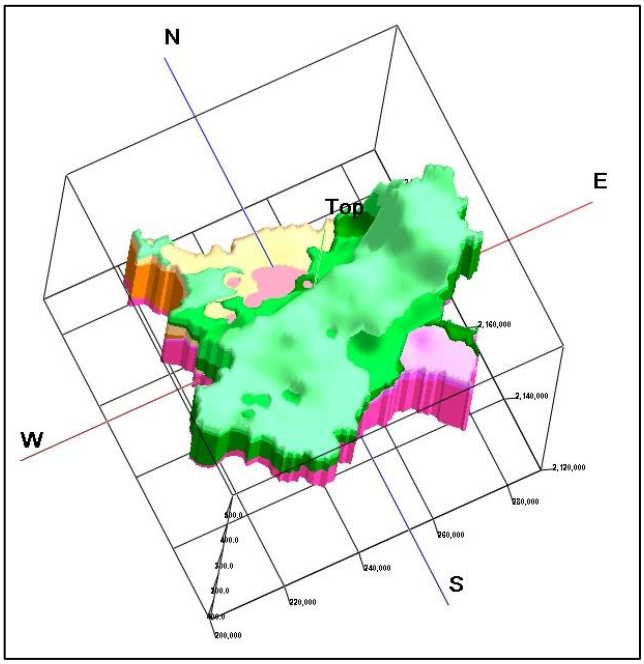
GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN ADILABAD DISTRICT, TELANGANA STATE



CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
FERBRAURY 2022

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HARD ROCK AREAS OF ADILABAD DISTRICT, TELANGANA STATE

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REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN ADILABAD DISTRICT, TELANGANA STATE

Executive summary

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(Area where groundwater development >70 %)

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(Area where groundwater development <70 %).

ABBREVATIONS

2D	:	2 Dimensional
3D	:	3 Dimensional
ARS	:	Artificial Recharge Structures
Avg	:	Average
BDL	:	Below Detection Level
BW	:	Bore Well
CD	:	Check dam
CGWB	:	Central Ground Water Board
Cr	:	Crore
DTW	:	Depth to water
DW	:	Dug well
EC	:	Electrical conductivity
EL	:	East Longitude
F	:	Fluoride
FP	:	Farm Pond
GEC	:	Ground Water Estimation committee
GW	:	Ground Water
ha.	:	Hector
ham	:	Hector meter
ID	:	Irrigated dry
IMD	:	Indian Meteorological Department
km^2	:	square kilometre
LPS	:	Litres per second
M	:	Meter
M^3	:	Cubic meter
m bgl	:	Metres below ground level
MCM	:	Million cubic meter
mg/l	:	Milligram per litre
MI	:	Micro irrigation
Min	:	Minimum
max	:	Maximum
MPT	:	Mini percolation tank
MSP	:	Minimum Support price
NL	:	North Latitude
NO_3	:	Nitrate
OE	:	Over Exploited
PGWM	:	Participatory ground water management
PT	:	Percolation tank
SGWD	:	State Ground Water Department
S	:	Storativity
Sy	:	Specific Yield
T	:	Transmissivity
WCM	:	Water conservation measures

EXECUTIVE SUMMARY

Adilabad district with geographical area of ~4153 km^2 and mappable area 3813 km^2 is taken up for NAQUIM . The area receives an average annual normal rainfall of 1194 mm of which 84 % is contributed by SW monsoon and 11 % by north-east monsoon. Analysis of long term rainfall data of 20 years shows rise in annual rainfall of 6.17 mm/yr. Administratively the district comprises of 18 Mandals and 503 villages with one Municipality. The population of the district is ~7.09 lakhs (2011 census) with average population density of 171 person/ km^2.

The district is underlain by Granites (22 %), Basalt (61%) and Limestone (17%). Pediplain is the major landform followed by pediment, dissected plateau and denudational hills.The district is drained by Godavari, Pengaganga and Pranhita Rivers with their tributaries and divided into 10 watersheds. Forest occupies ~41% of the total geographical area, Wastelands with scrub in 10% area, 28% area is utilized for kharrif corps cultivation and 16% area is utilized for double cropping. The gross cropped area during 2019-20 is 255769 ha .The soils from the district are mainly red loamy soils and black cotton soil.

The registered ayacut under the medium irrigation project Sathnala Reservoir projectis 9716 ha and Mathadivagu Reservoir project is 3440 ha. In the area there are ~363 Percolation Tanks and 82 Check dams and ~6.13 MCM of silt is removed under Mission Kakatiya.

Data analysed from 53 CGWB wells indicates, 06 well of shallow depth (30 m), 4 wells of 30-60 m depth, 01wells of 60-100 m. depth, and 42 wells of 150-200 m. Depth. Deepest fracture was encountered at 186 m.bgl at Tamsi kurd in Bheempur mandal.

Ground water levels from 33 piezometers and Dugwells (CGWB: 18 and SGWD: 15) were monitored during pre-monsoon and post-monsoon seasons in last 10 years. Water table elevations during pre-monsoon season vary from 205-473 m amsl and during post-monsoon season it varies from 214-477 m amsl. During pre-monsoon DTW varies from 3.37 to 36.58 m bgl (average: 9.9 m bgl). In most of the parts the water level are in the range of 5 to 10 m bgl (59% area) followed by 10-20 mbgl (31% area). Deep water levels (> 20 mbgl) occupy 10% of area. During post-monsoon DTW varies from 0.66 to 11.56 m bgl (average: 4.52). In most of the parts water level are in the range of 2-5 m bgl (69% area) followed by 5-10 mbgl (29 % area), <2 mbgl (0.2 % area) and >10 mbgl (1.5% area).

The seasonal water level fluctuations vary from 0.82 to 29.11 m rise with an average rise of 5.36 m. Rise in water level range of 2 to 10 m cover 75.51% of area followed by 10 to 20 m, covering 12.57% of area and >20m covering 4.46% of the area.

Long-term water levels trends from 29 wells shows that during pre-monsoon season, 22 wells show falling trend -1.49 to -0.02 m/yr and 7 wells show rising trend 0.03-0.71 m/yr. During post-monsoon season, 18 wells show falling trend -0.18 to -0.02m/yr and 11 wells show rising trend 0.01 to 0.37 m/yr.

Geophysical data from 85 VES (CGWB) reveals resistivity of weathered formations ranges from 20 to 100 ohm-m and thickness ranges from 3 to 20 m. For semi-weathered/ fractured formations the average resistivity ranges from 25 to 250 ohm-m and thickness ranges from 10 to 30 m. The average depth to basement varies from 9 to 35 m bgl.

The data analysed from the groundwater quality indicate that during pre-monsoon season, the EC in the range of 1500 to 3000 µ Siemens/cm is observed in 15% of samples. The NO_3 concentration ranges from 25 to 372 mg/l and noticed that in about 55% of the samples is beyond permissible limits for drinking purposes. The Fluoride concentration varies from 0.17-1.95 mg/l and high fluoride concentration(>1.5mg/l) is observed in 9% of the samples from Bazarhatnur, Utnoor, and Gudihatnoor mandals. During post-monsoon season, the EC varies from 555-2590 µ Siemens/cm. The NO_3 concentration ranges from 13.4 to 157 mg/l. In 64% of the samples, it is exceeding permissible limits. The Fluoride concentration varies from 0.12-2.21 mg/l. In 12% of the samples, fluoride concentration is beyond permissible limit.

Based on 138 hydrogeological data points, aquifers from the area can be conceptualized in to two Aquifer-1:weathered zone and Aquifer-2: fractured zone. The Weathered thickness varies from 1m bgl to 23m bgl in granitic formation, 1m bgl to 33 m bgl in basaltic formation and 1m bgl to 29m bgl in limestone formation. Shallow weathering (< 10 m) occurs in 40% of the area, 10-20 m in ~40 % of area and deep weathering (> 20 m) occurs in rest of 20% area.

Fracturing zone varies from 30 to 186 m (deepest fracture at Tamsi kurd in Bheempur mandal). The fractures in the range of < 60 m depth are identified in 30% of the area, 60-100, 100-150 fractures and >150 occur in 54%, 14% and 2% of area respectively. Fracture analysis (from 138 location) reveals that majority of fractures (~75%) occur within 100 m depth. The yield varies from >1lps to 16 lps, Transmissivity (T) varies from 0.2 to 305 m^2 /day and storativity varies 0.0001 to 0.02.

The dynamic replenishable ground water availability is 259 MCM, gross ground water draft is 132 MCM, provision for drinking and industrial use for the year 2025 is 38 MCM and net available balance for future irrigation use is 51.84 MCM. The stage of ground water development varies from 21 to >100 % (avg: 51%)..

Major issues identified are over-exploitation, ground water pollution (both anthropogenic (NO_3) and geo-genic (F), deep water levels are > 20 m bgl in 10% of the area during pre-monsoon season, declining water levels in majority of hydrograph stations, low sustainability and water marketing.

The management strategies mainly include both supply and demand side. The supply side measure includes ongoing work under Mission Kakatiya where ~6.13 MCM of silt has been removed from existing 134 tanks. This helped in strengthening of water bodies and created additional surface storage, thereby increased groundwater augmentation in the district Under Mission Bhagiratha, there is plan to import 27.71MCM of surface water for drinking purposes which will save the present ~15.53 MCM of utilization of ground water for drinking and domestic purposes and with this additional ~2588 ha of land can be brought under ID crops.

Construction of 39 Artificial Recharge Structures with 6.80 crores in **priority-1** area (over-exploited and Semi critical villages) and constructions of 736ARS with ~128 crores in **priority-2** area (other area) are recommended as supply side measures. Under Water conservation measures include, construction of 9730 nos of farm ponds with 24.32 crores in all villages.

Demand side measure includes ~25,150 ha of additional land that can be brought under micro-irrigation (@50 ha/village in 503 villages) costing about 150 crores (considering 1 unit/ha @0.6 lakh/ha). With this 37.734 MCM of ground water can be conserved over the traditional irrigation practices.

Other measure includes mandatory artificial recharge at every Govt and industrial units. providing proper sewerage system and participatory groundwater management (PGWM) are the other measures recommended.

With the above interventions costing Rs 310 crores (excluding the cost involved in Mission Bhagiratha and Kakatiya), the likely benefit would be the net saving of 61 MCM of ground water. This will bring down the stage of ground water development by 10 % (from 51 % to 41%). The other benefits will be more distribution of income among farmers. The one time

cost will be ~5.04 paisa/litre and the actual cost of invest will be 0.50 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGS-ADILABAD DISTRICT, ANDHRA PRADESH

S. No.	Data	Aquifer	Total Data Points	Source	
				CGWB	SGWD
1	Panel Diagram (3-D)	Combine	138	Expl:53 VES:80	VES:05
2	Hydrogeological Sections	4 no	138	Expl:53 VES:80	VES:05
3	Fence/panel Diagrams	1 no	138	Expl:53 VES:80	VES:05
4	Depth of weathering	1 no	138	Expl:53 VES:80	VES:05
5	Depth of fracturing	1 no	138	Expl:53 VES:80	VES:05
6	Groundwater Yield	Weathered zone Fractured zone	138	Expl:53 VES:80	VES:05
7	Transmissivity (m^2/day)	Weathered zone Fractured zone	138	Expl:53 VES:80	VES:05
8	Depth to Water Level Maps	Combine	33 Piezometers (10 Years data)	18	15
9	Water Level Fluctuation	Combine	33 Piezometers (10 Years data)	18	15
10	Long term water level trends	Combine	29 Hygrograph Station (10 Years data)	17	12
11	Water quality Pre-2019 Post-2019	Combine	47 Pre:33 Post:14	18 0	15 14

1. INTRODUCTION

Aquifer mapping is amultidisciplinaryscientific approach wherein a combination of geologic, geophysical, hydrologic and chemical analysis is applied to characterize the quantity, quality and sustainability of ground water in aquifers. In recent past, there has been a paradigm shift from "**groundwater development**" to "**groundwater management**". As large parts of India particularly hard rock aquifers have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing lifestyle. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also.

The Peninsular Shield consists mostly of consolidated sedimentary rocks, Deccan Trap basalts and crystalline rocks. Occurrence and movement of ground water in these formations are restricted to weathered residuum and interconnected fractures at deeper levels and have limited ground water potential. Weathered zone is the potential recharge zone for deeper fractures and excessive withdrawal from this zone leads to drying up in places and posing challenges on sustainability. Besides these quantitative aspects, groundwater quality also represents a major challenge, which is threatened by both geogenic and anthropogenic pollution. In some places, the aquifers have high level of geogenic contaminants, such as fluoride, rendering them unsuitable for drinking purposes. High utilization of fertilizers for agricultural productions and improper development of sewage system in rural/urban areas lead to point source pollutionviz.,nitrate and chloride.

1.1 **Objectives:**In view of the above challenges, an integrated hydrogeological study was taken up to develop a reliable and comprehensive aquifer map and to suggest suitable groundwater management plan on 1: 50,000 scale.

1.2 Scope of study: The main scope of study is summerised below.

1. Compilation of existing data (exploration, geophysical, groundwater level and groundwater quality with geo-referencing information and identification of principal aquifer units.
2. Periodic long term monitoring of ground water regime (for water levels and water quality) for creation of time series data base and ground water resource estimation.
3. Quantification of groundwater availability and assessing its quality.
4. To delineate aquifer in 3-D along with their characterization on 1:50,000 scale.
5. To formulate groundwater management plans.

1.3 Area: The Adilabad district having geographical area of 4153 km^2, lies between north latitude 19°10′ 19.2"-19°55′ 1.2" and east longitude 78°09′ 39.6”-78° 58′ 36.6" with a mappable area of 3813 km^2. It is the part of Godavari basin (**Fig.1.1**). Administratively the District Comprises of 18 Mandals and 503 villages. There is one Municipality in the District. The District is conveniently formed into two revenue divisions, 1) Adilabad 2) Utnoor with a population of ~7.09 lakhs (2011 census) with average population density of 171 person/km^2

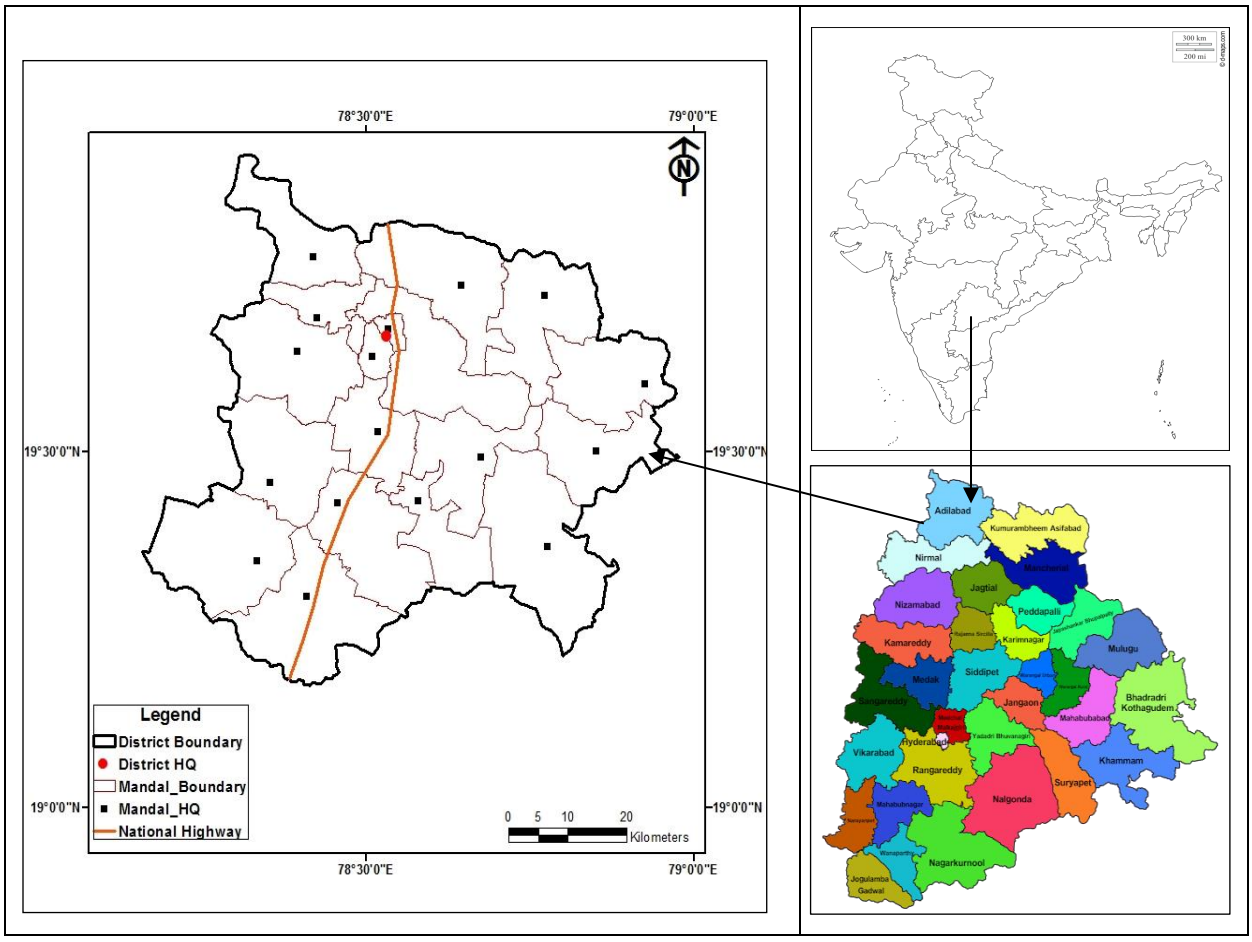


Fig.1.1: Location map of Adilabaddistrict.

1.4 Climate and Rainfall: The climate of the district is characterized by hot summer and in generally dry except during the south-west monsoon season. The year may be divided into four seasons. The cold season from December to February is followed by the summer season from March to May. The period from June to September constitute the south west monsoon season, while October and November from the post monsoon season. December is generally the coldest month, with the mean daily maximum temprature at about 29^{o} C and the mininum daily is 15^{o} C. Normal annual rainfall varies between 1079 mm (Bheempur and Tamsi) and 1347mm (Indravelly) with average of 1194 mm (**Fig. 1.2**).SW monsoon contributes 84%, NE monsoon contributes 11% while the rest by winter and summer rainfall.Rainfall increses from South west to central part and decreases from central part to north -west.Adilabad district received 1119 mm rainfall during the year 2019-20 as per the IMD rainfall data.

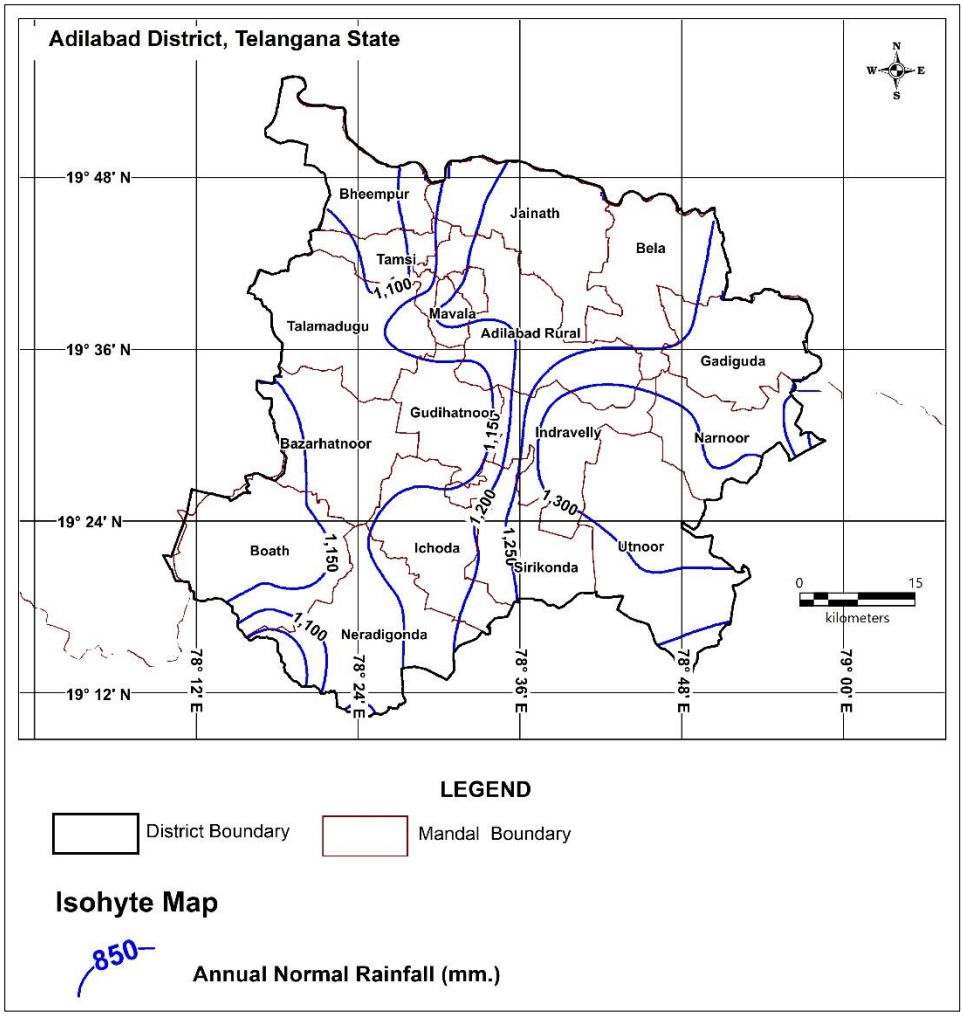


Fig.1.2: Isohyetal map of Adilabad district.

Analysis of long term rainfall data of 20 years shows rise in annual rainfall of 6.17 mm/yr. Increase in monthly rainfall trend for 20 years is observed mainly in monsoon months September (6 mm/yr) and July (1.9 mm/yr) and decline is observed in monsoon month August (3.7 mm/yr).

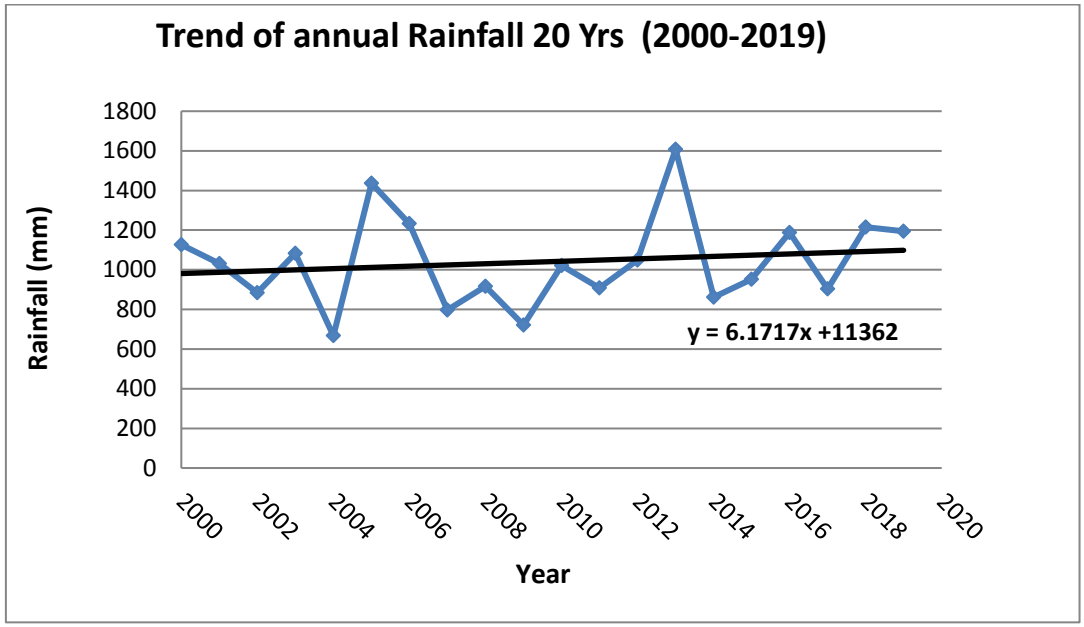


Fig-1.3a: Annual Rainfall trend

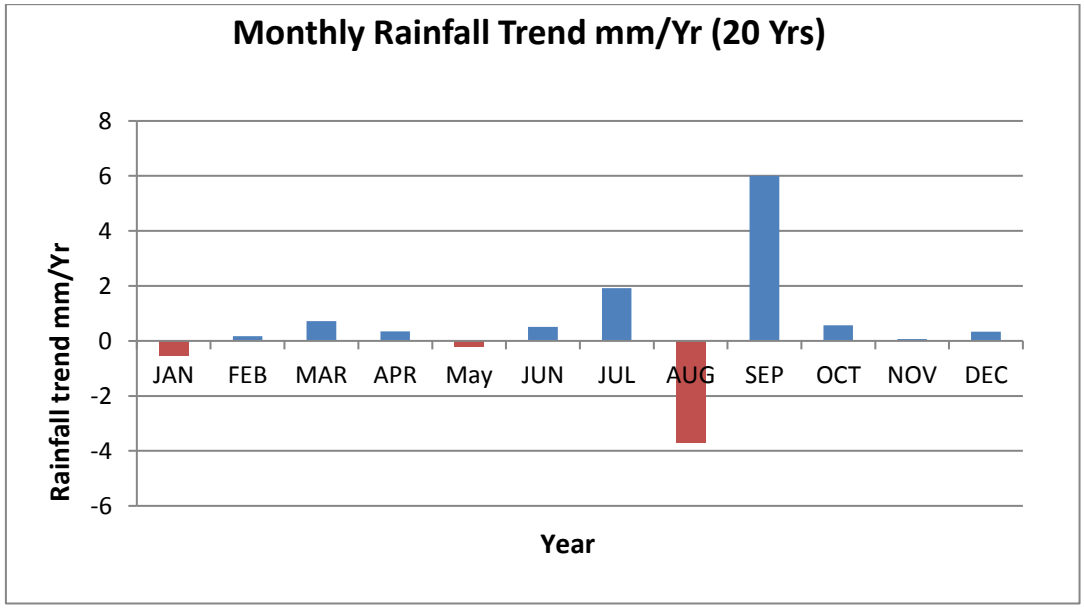


Fig-1.3b: Monthly Rainfall trend

1.5 Geomorphological Set up: The Adilabad district is characterised by undulating topography.Pediplain is the major landform covering about 1659km^2(41%) area. The other landforms observed are dissected plateau (32%),pediment (18%), denudation hills, flood plain, residual hill and channel fill, etc. (**Fig.1.4**).

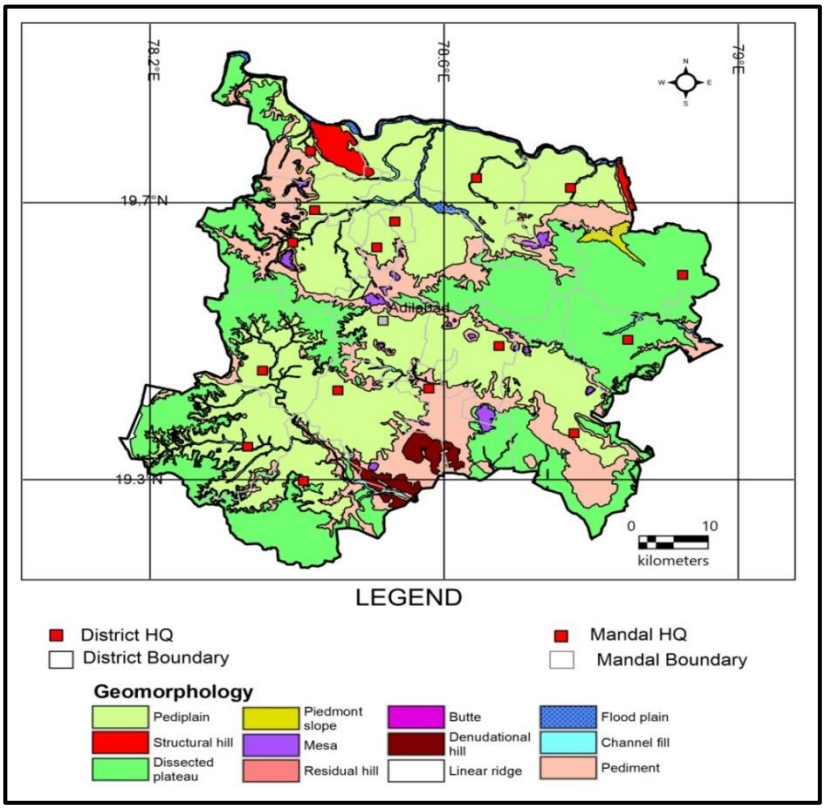


Fig.1.4: Geomorphology of Adilabad district.

1.6 Drainage and Structures: The district falls under Godavari basin.The District is divided into 3 sub basins and 10 watersheds of Godavari, Pengaganga and Pranhitawith their tributaries. Southern part of district drains into the major Godavari River. The river Pranhita in the east flows in a southerly direction.The Pengagga river flows along the north western and northern Boundary of the district. Lineaments are running mainly in NE-SW, N-S and NW-SE directions. Map depicting drainage, water bodies, lineaments and watershed boundaries is presented in **Fig.1.5**.

1.7 Land use and cropping pattern: Agriculture and forest are the two important units of land utilization. In the area, the land use can be grouped into 17 classes (**Fig.1.6**).Desiduous forest occupies ~41% of the total geographical area, Wastelands with scrub in 10% area, 28% area is utilized for kharrif corps cultivation and 16% area is utilized for double cropping. The gross

cropped area 2019-20 during khariff season is 207849 ha and during rabi season is 47920 ha (Total 255769 ha). Main crops grown in Khariff season includes Cotton 140332 ha (67%) followed by Oil seeds37272ha (18%) and Pulses 25389 ha (12%). During rabi season major crops grown includes Pulses in 34473 ha(60%), followed by Cerels& Millets in 12091 (21%) and Millets 9702ha (17%). Season wise cropping pattern is given in **Fig.1.7a** and **Fig.1.7b.**

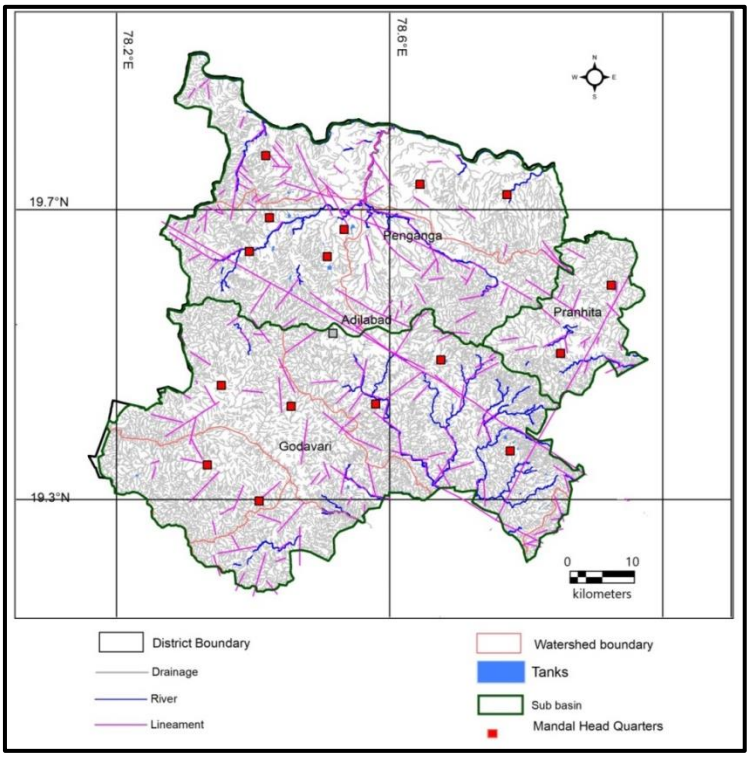


Fig.1.5: Drainage, lineaments and watershed boundaries.

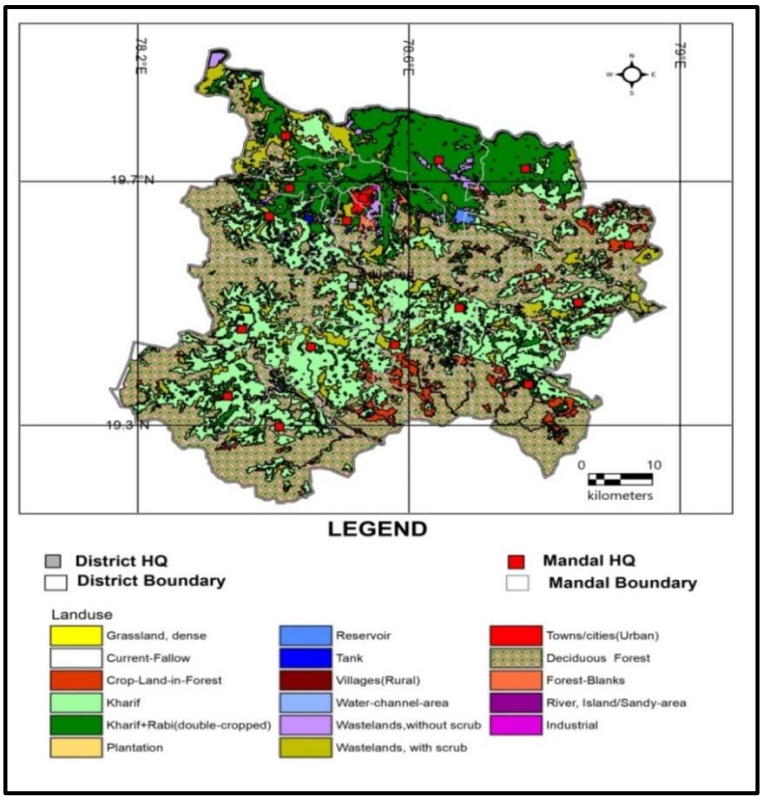
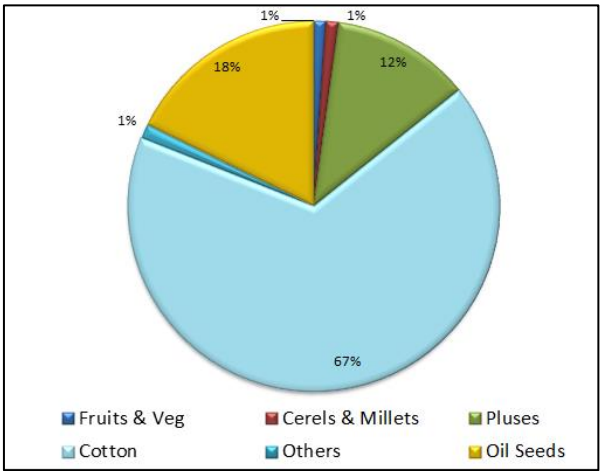


Fig.1.6: Land use and land cover of Adilabaddistrict.



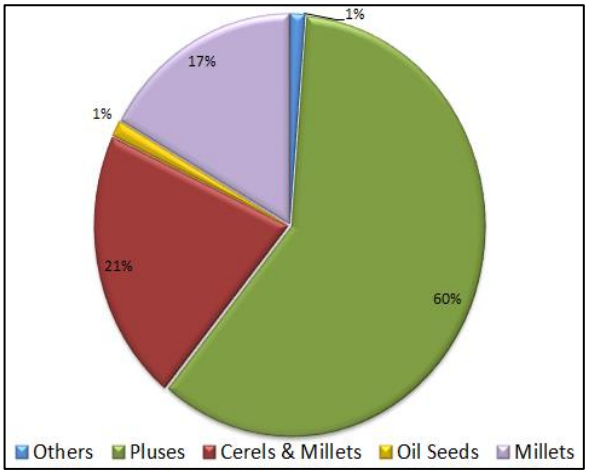


Fig.1.7a:Cropping pattern in Khariff

Fig.1.7b:Cropping pattern in Rabi

1.8 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. The soils are classified into nine categories in the district. Clayey montmorillonitic soil covers the 32% area of the district (Shallow, well drained, clayey soils with low avaialable water content (AWC), Loamy mixed in 15 % (Very shallow, well drained, loamy soils withvery low AWC), Fine Clayey

montmorillonitic in 15 %(Deep, moderately well drained, cracking clay, calcareous soils with very high AWC),Clayey skeletal in 14 %(Shallow, well drained, gravelly clay soils with very low AWC), Clayey mixed in 7 %(Very shallow, well drained, clayey soils with very low AWC), Rock land &Clayey skeletal, Very fine Montmorillonitic, Loamy Skeletal and Fine mixed in the remaining areas. (**Fig.1.8**).

1.9 Irrigation:

Sathnala Reservoir project: Sathnala project is a completed medium irrigation project across Satnala River a tributary to Pengagaa River in Godavari basin. The Scheme is situated near Kanpa village of Jainath mandal in Adilabad district. The design ayacut is 9716 Ha (24000Acres) benefiting 25 villages in the jainath, Bela, Adilabad mandals of the district.

Mathadivagu Reservoir project: The Mathadivagu Reservoir project is a medium irrigation project across Mathadivagu, a tributary of Godavari, near Waddadi village in Tamsi mandal. The project feeds the ayacut of 8500 acres in Tamsi, Adilabad and Jainath mandals.The project is designed to provide Ayacut in 12 villages with command area of 3440 ha inTamsi, Adilabad and Jainath mandals of Adilabad district.

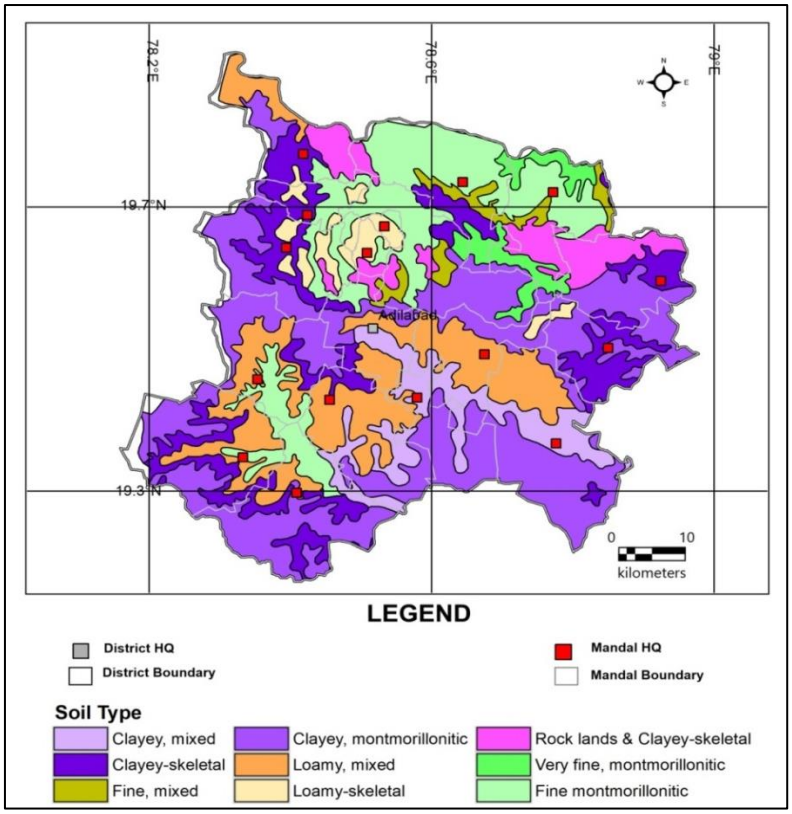


Fig.1.8: Soil map of Adilabaddistrict.

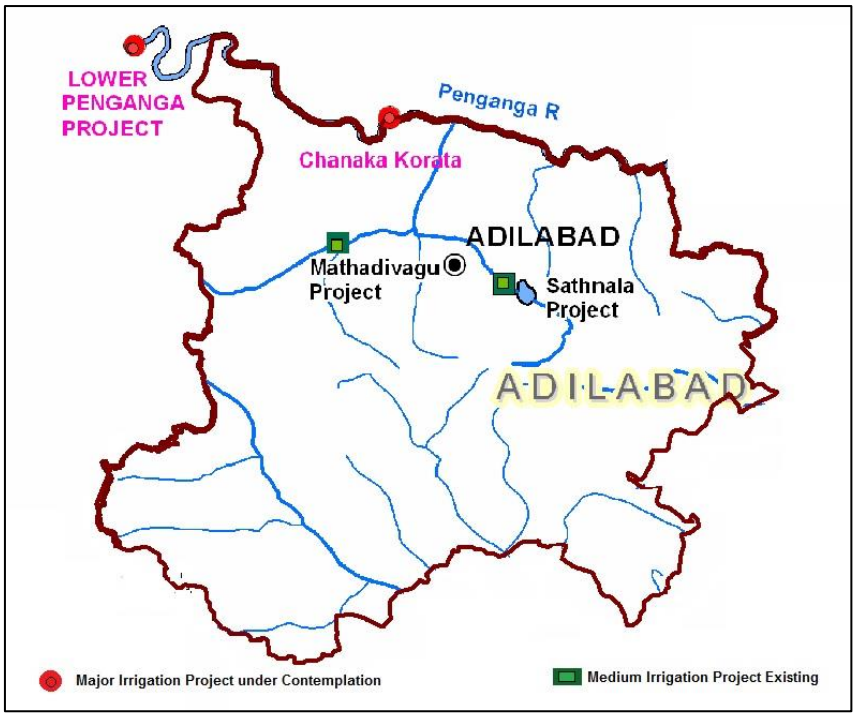


Fig.1.9 : Irrigation projects with command areas in Adilabad district

(Source: Major & Medium Irrigation projects, I&CAD)

1.10 Prevailing Water Conservation/Recharge Practices: In the district there are ~363 percolation tanks, 82 Check dams and 330 farm ponds.Under Mission Kakatiya (Phase 1 to 4) 196 tanks have been undertaken under RRR (Repairs, Restoration and Rejuvenation) schemes.

1.11 Geology: The district is underlain by various geological formations from oldest archeans to the Teritiary basaltic formations**.** The crystalline rocks of Archean age comprise granites and gneisses. Dolerite dyke intruding the granites rocks are common in the area. The crystalline rocks are exposed in southern part of the district forming basement for the younger formations.The crystalline rocks develop secondary porosity with weathering, jointing and fracturing. The degree and depth of weathering vary from palce to place. Penganga formations the equivalent of Cuddapah system of rocks are the consolidated metasedimentary rocks in the district. The limestones of pengaga formation overlie the Archean and are exposed in the north of Adilabad distict.The Deccantrap constitutes a number of lava flows of basaltic compostion and overlies the Archean in the west to east of Adilabad. Both vesicular and non vesicular traps occur in the district.61% of the district is covered by Deccan traps and Banded Gneissic Complex exposed (22%) in southern and north central part. The 17% of the northern part is covered the limetones (**Fig1.10**).

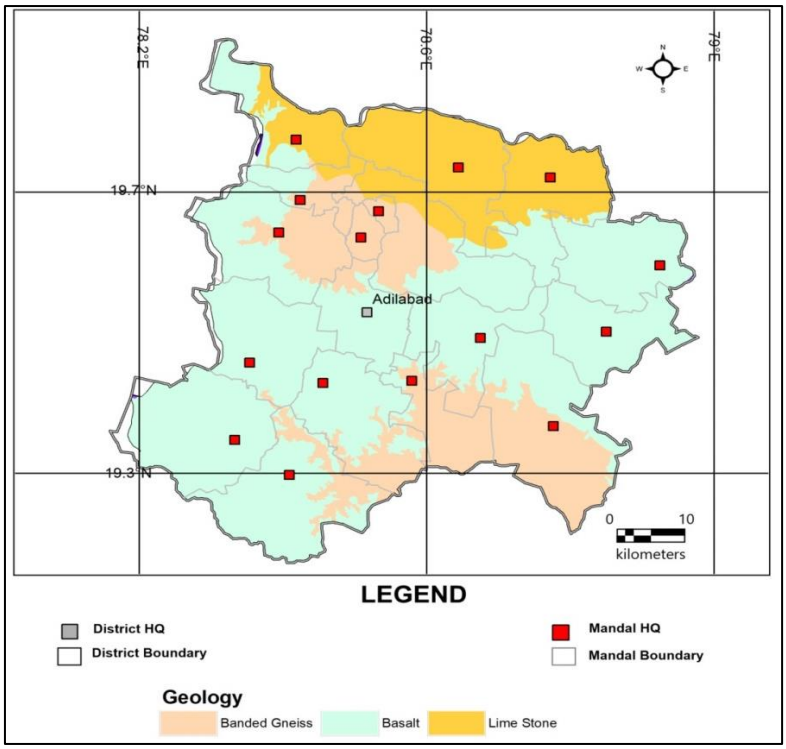


Fig.1.10: Geology of Adilabad district.

2. DATA COLLECTION AND GENERATION

Collection and compilation of data for aquifer mapping studies is carried out in conformity with Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities **(Table-2.1)**.

Table-2.1: Brief activities showing data compilation and generations.

S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical etc. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data etc.
		Identification of Data Gap	Data gap in thematic layers, sub-surface information and aquifer parameters, information on hydrology, geology, geophysics, hydrogeology, geochemical, in aquifer delineation (vertical and lateral) and gap in aquifer wise water level and draft data etc.
2.	Generation of Data	Generation of geological layers (1:50,000)	Preparation of sub-surface geology, geomorphologic analysis, analysis of land use pattern.
		Surface and sub-surface geo-electrical and gravity data generation	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging etc.
		Hydrological Parameters on groundwater recharge	Soil infiltration studies, rainfall data analysis, canal flow and recharge structures.
		Preparation of Hydrogeological map (1:50, 000 scale)	Water level monitoring, exploratory drilling, pumping tests, preparation of sub-surface hydrogeological sections.
		Generation of additional water quality parameters	Analysis of groundwater for general parameters including fluoride.
3.	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data.
4.	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

2.1 Hydrogeological Studies

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifers in the area aregranites, gneisses, limestone and basalts and the occurrence and movement of ground water in these rocks is controlled bythe degree of interconnection of secondary pores/voids developed by fracturing and weathering. Based on 135 hydrogeological data points (**Fig.2.1)** hydrogeological map is prepared.

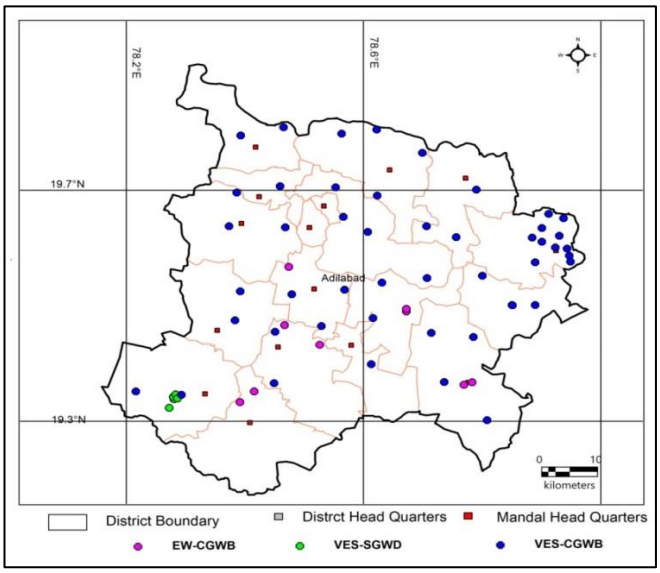


Fig. 2.1: Hydrogeological data availability.

2.1.1 Ground water occurrences and movement:

Granites and Gneiss: Ground water in granites and gneisses occurs in secondary porosities developed due to weathering process and tectonic activities. Thus the occurrence and prospects for development of ground water in these rocks is highly variable and limited. Ground water occurs under unconfined in the shallow weatherd mantle and semiconfined conditions in the deeper fractured and fissured zones.The storage in granite rocks is primarily confined to the weathered zone and its overextraction, mainly for irrigation purpose, has resulted in desaturation of weathered zone at many places. The depth of weathering ranges from 2 and

23.57 metres below ground level and depth of fracturing is extended down to depths varying in general from 06 to 172m.

Compact Limestone/Metasediments: The limestone of pengagas of sedimentary orgin is mostly hard and compact and behaves similar to consolidated crystalline rocks.The aquifers are formed due to weathering and fracturing. The limestones form good aquifers due to the development of solution channels except in the area where they are siliceous.The depth of weathering ranges from 2 and 29 metre below ground level and depth of fracturing is extended down to depths varying in general from 20 to 183m.

Deccan traps/Basalts: The basalt occuring in the district is the fringe of vast Deccan plateau of central India. The contact zones of successive flows and between basalt and inter-trappean beds form good aquifers in addition to the top weathered zones and fractured zones. The vesicles present in the top portion of each lava flows form potential zone for ground water. This unique setup in the baslt rocks presents a multi squifersystem.The depth of weathering ranges from 2 and 33 metre below ground level and depth of fracturing is extended down to depths varying in general from 6 to 175m.The hydrogeological map of the area is presented in **Fig. 2.2**.

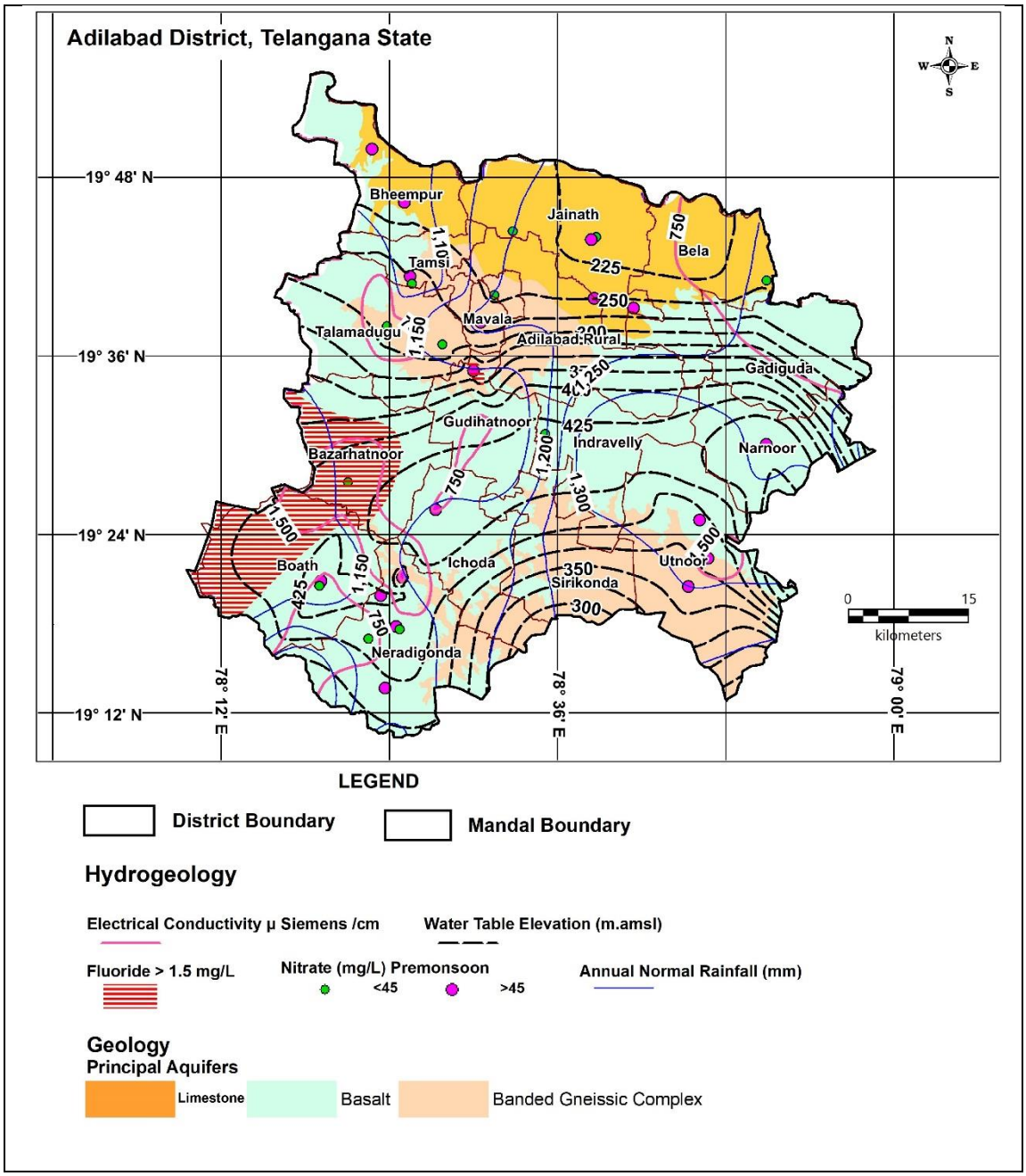


Fig.2.2: Hydrogeological map of Adilabaddistrict.

2.1.2 Exploratory Drilling: As on 31/03/2021, CGWB drilled 53 bore wells (exploratory, observation and piezometers), 25 wells in basaltic area and 20 well encountered granite, 8 well in Lime stone formation. Data analysed from CGWB wells indicates, 06 well of shallow depth (30 m), 4 wells of 30-60 m depth, 01wells of 60-100 m. depth and 42 wells of 100-200 m. Depth. Deepest fracture was encountered at 186m.bglat Tamsi Khurdin Bheempur mandal.

2.1.3 Ground water Yield: In fractured granite/gneiss yield varies from 0.01 to 8.0 lps (avg: 1.38 lps). The deepest fracture encountered is at 167m.bgl in granitic formation. The transmissivity varies from 1-32 m^2/day. In Basaltic terrain, yield varies from 0.01 to 16.04 lps. Transmissivity varies from 0.1 to 305 m^2/day. In Limestone area, yield varies from 0.01 to 6.71 lps. Transmissivity varies from 3 to 53 m^2/day.

2.2 Water Level (Average 10 years): Ground water levels from 33 piezometers and Dugwells (CGWB: 18 and SGWD: 15) were monitored during pre-monsoon and post-monsoon seasons in last 10 years.

2.2.1 Water Table Elevations: During pre-monsoon and post-monsoon season (May and November) the water-table elevation ranges from 205-473 m amsl and 214-477m amsl respectively. Ground water flow is towards north direction in central to northern part of Adilabad, and in the central to southern part theground water flow isin the southeast direction. The groundwater divides, marked by the divergence of flow lines, almost coincide with the topographic divides(**Fig.2.3**).

2.2.2 Depth to Water Level (DTW): The DTW varies from 3.37 to 36.58 meter below ground level (m bgl) (average: 9.9 m bgl) and 0.66- 11.56 m bgl (average: 4.52 m bgl) during pre-monsoon and post-monsoon season during last 10 years respectively.

Pre-monsoon season: Majority of the water levels during this season are in the range of 05-10 m covering 59% of the area, followed by 10-20 m bgl (31%). Deep water levels in the range of >20 m bgl occupy about 10% of the area falling in parts of Naredigonda and Bazarhatnoor mandal. (**Fig.2.4**). Shallow water levels (< 5 mbgl) occupy about 0.25% area.

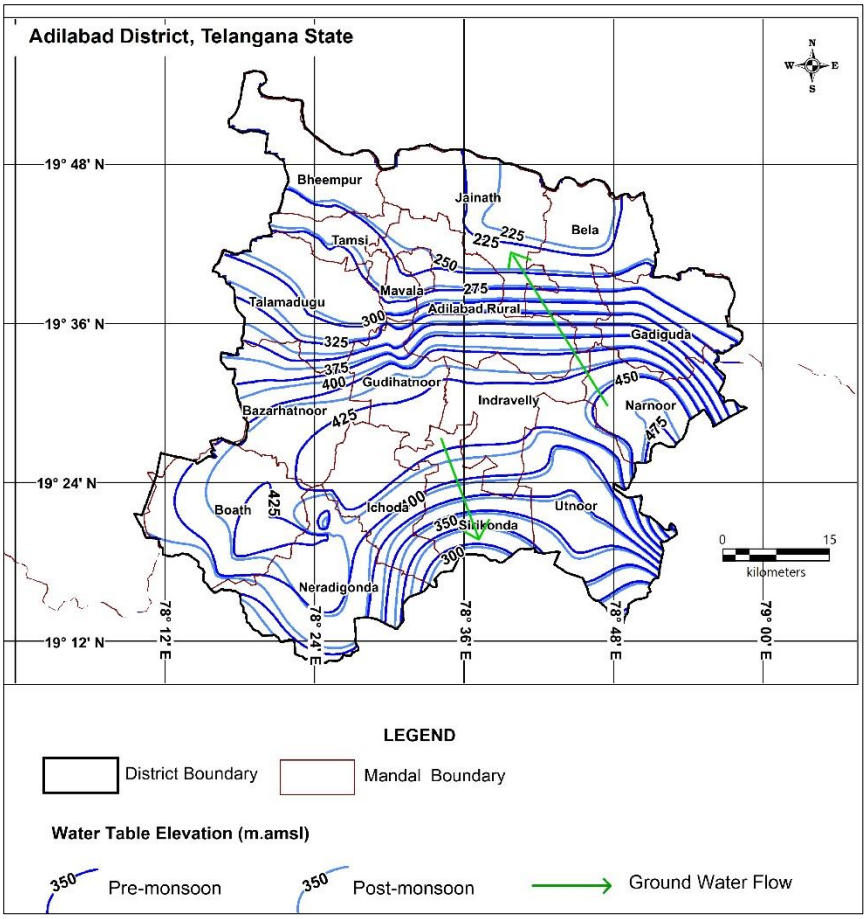


Fig.2.3: Water table elevations (m amsl) during pre and post-monsoon season

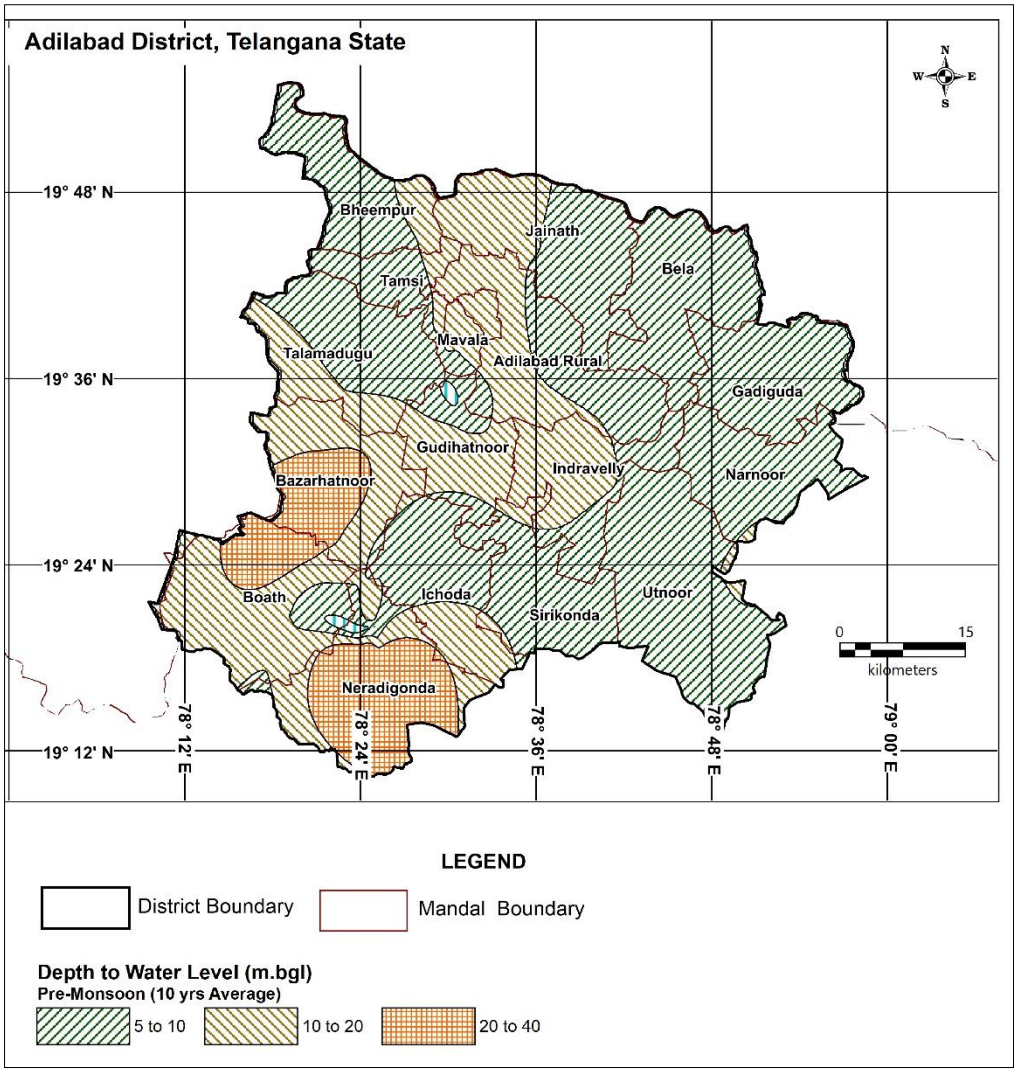


Fig.2.4: Depth to water levels Pre-monsoon (10 year Average).

Post-monsoon season: Majority of the water levels during this season are in the range of 2 to 5 m bgl, covering 69 % of the area, followed by 5 to 10 m.bgl water levels with 29 % of the area. Shallow water levels <2m.bgl cover 0.2% of the area mainly in parts of Boath and Naradigonda Mandals.Water levels (>10 m) cover 1.5% of the area spreading in parts of Jainad mandal (**Fig.2.5**).

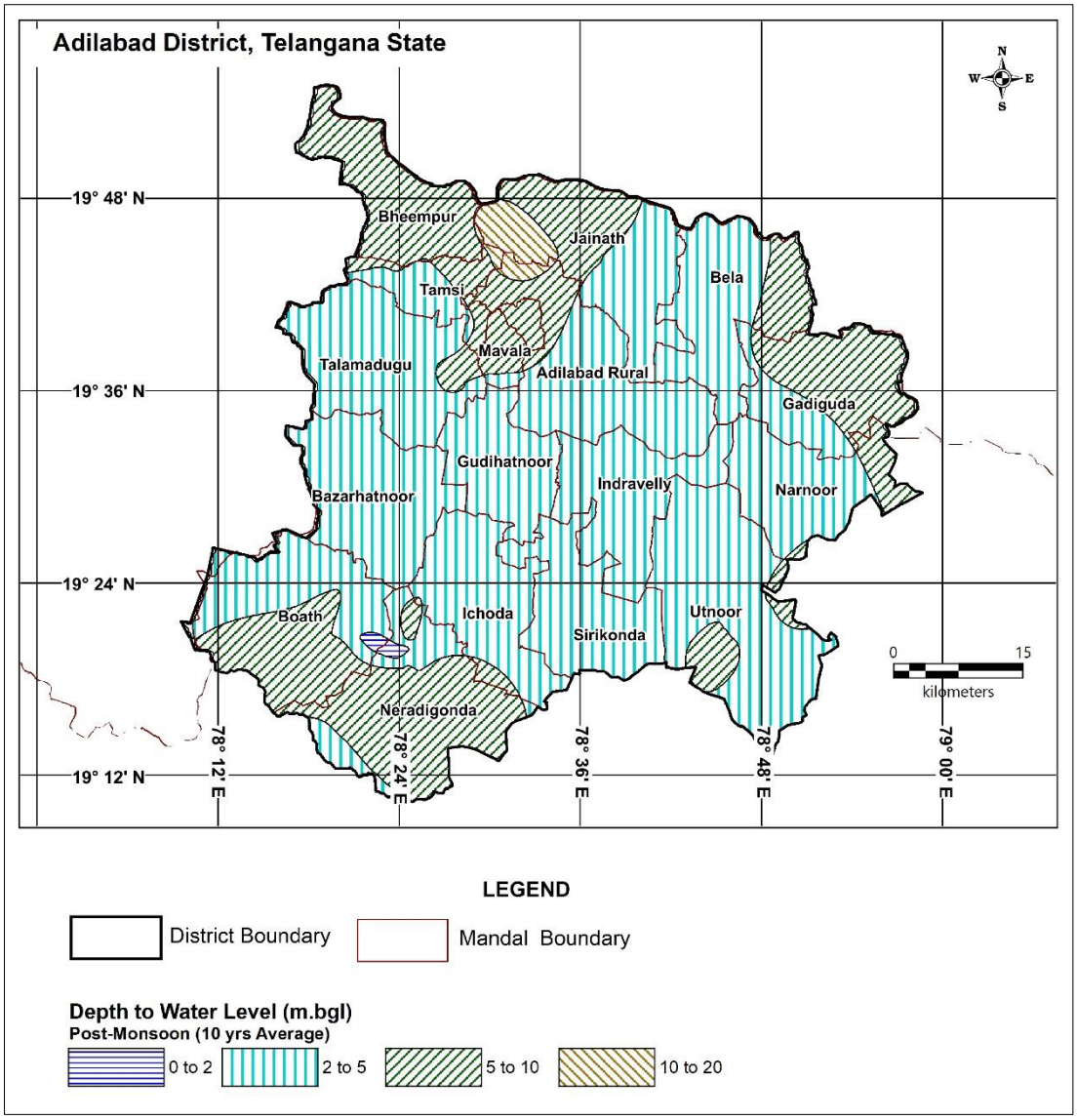


Fig.2.5: Depth to water levels Postmonsoon (Average 10 years).

2.2.3 Water Level Fluctuations (May vs. November): The water level fluctuations vary from 0.82 to 29.11 m rise with average rise of 5.36 m (**Fig.2.6**). Rise in water level range of 2 to 10 m cover 75.51% of area followed by 10 to 20 m, covering 12.57% of area. Water level rise of >20 m, covering 4.46% of the area is observed in parts of Neradigonda and Bazarhatnoor mandal and rise of < 2 m covering area 7.45% of the area in parts of Bheempur, Gudigudaand Bela mandals.

2.2.4 Long term water level trends: Trend analysis for the last 10 years (2011-2020) is studied from 29 hydrograph stations of CGWB (17 nos) and SGWD (12 nos). During pre-monsoon season, 22 wells show falling trends -1.49 to -0.02 m/yr (Naradigonda, , Indravelly, Bheempur, Jainath, , Talamadugu, Bela, Tamsi, Mavala, Boath, Narnoor mandals) and 7 wells shows rising trend in the range of 0.03 to 0.71 m/yr (Echoda, Jainath, Naradigonda, Gudihatnoor, Utnoor mandals. Whereas, in post-monsoon season, 18 well showing falling trend -0.18 to -0.02 m/yr noticed in Jainatha, Bela, Gudihatnur, Utnoor mandals and in remaining 11 wells, it is showing rising trend ranging from 0.01 to 0.37 m/yr in Utnoor, Boath, Gudihatnoor, Ehoda, Naradigonda, Mavla, Indravelly mandals(**Fig 2.8 and Fig 2.9)**.

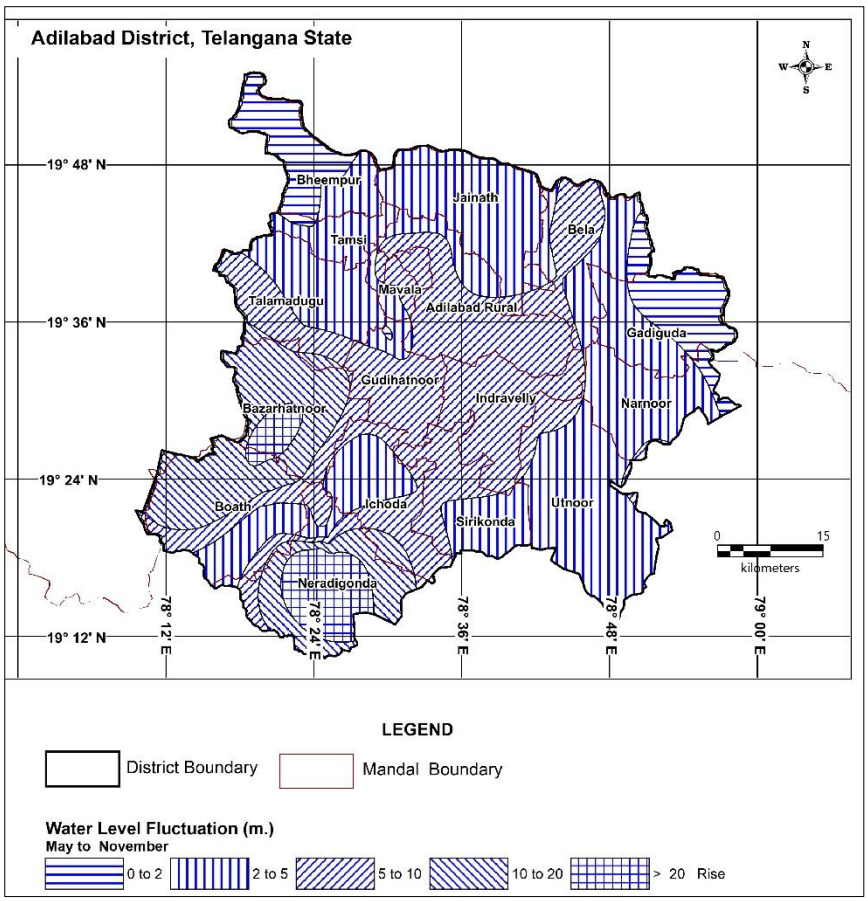


Fig.2.6: Water Level Fluctuations (m) (November with respect to May).

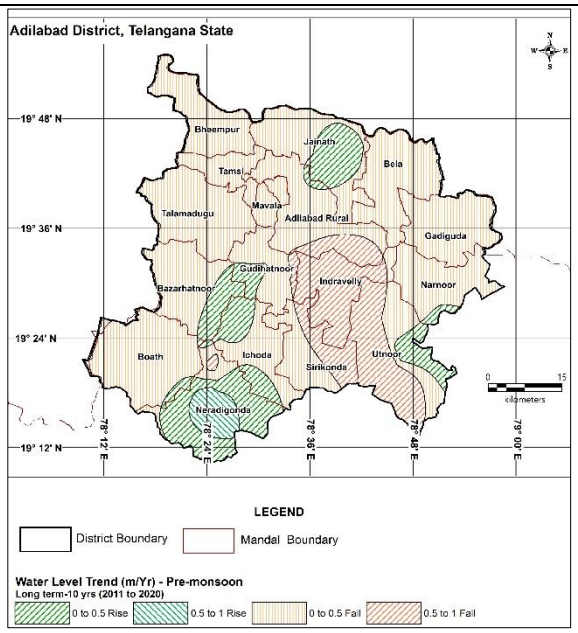


Fig. 2.7: Long-term water level trends pre monsoon (2011-2020)

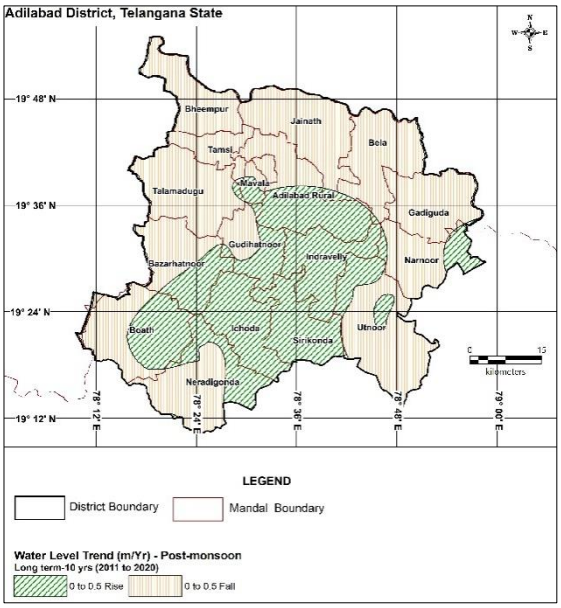


Fig. 2.8: Long-term water level trends Post monsoon (2011-2020)

2.3 Geophysical Studies

Resistivity surveys are carried out in some parts of Adilabad district to know the characteristic features of subsurface formations. A total of 40 Vertical Electrical Soundings (VES) are carried out in 40 villages/sites in study area falling in parts of 18 mandals viz. Adilabad, Bhimpur, Tamsi, Jainad, Bela, Talamadugu, Bazarhatnoor, Ichoda, Boath, Gudihatnoor, Sirikonda, Utnur, Jainoor, Sirpur, Narnoor, Gaduguda, Indervelli and Kerameri. Based on interpreted VES results, it is detected that there exists 3 to 4 layer substratum. They are in the sequence of top soil, weathered semi-weathered and massive rock formations in respect of granitic terrains. Few VES results in Basaltic areas, suggests the presence of water-bearing intertrappeans/vesicular and fractured zones within the trap sequence. The resistivity and thickness of these formations depend on the hydrogeological characteristics of the subsurface formations of the area. Average resistivity and thickness of the 1st layer are in the range of 15-80 ohm-m and 1-4 m respectively. For weathered formations the average resistivity ranges from 20 to 100 ohm-m and thickness ranges from 3 to 20 m. In case of semi-weathered/ fractured formations the average resistivity ranges from 25 to 250 ohm-m and thickness ranges from 10 to 30 m. The average depth to basement varies from 9 to 35 m bgl and the fractures obtained are in the depth range of 40-60, 60-80 and 100-120 m bgl.

2.4 Hydro chemical Studies

To understand chemical quality of groundwater, a total of 33 wells data is utilized from CGWB (Pre-monsoon: 18 nos.) and SGWD (Pre: 15 & Post: 25) wells during the year 2019. Various chemical parameters namely pH, EC (in µS/cm at 25 ° C), TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3 and F were analyzed. Out of which, five parameters namely pH, EC, TDS, NO_3 and F were interpreted for suitability for drinking purposes and is assessed as per BIS standards (2012) and irrigation suitability as per electrical conductivity.

2.4.1 **Pre-monsoon (Total samples 33: CGWB - 18, SGWD - 15)**

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.02-8.31 (avg. 8.05). Electrical conductivity varies from 510-2280 µ Siemens/cm (avg. 1108 µ Siemens/cm). In 28 number of samples (85%), the EC is within 1500 µ Siemens/cm and noticed in Neradigonda, Bela, Narnoor, Talamadugu, Boath, Gudihatnur, Ichoda, Adilabad Urban, Jainath, Bheempur, Indravelly, Mavala, Utnoor and Tamsimandals while 5 samples (15%), it is in the range of 1500-3000 µ Siemens/cm noticed in Bazarhatnoor, Narnoor and some villages

of Utnoor, Nerardigonda mandals. (Fig. 2.8). The concentration of TDS varies from 326 to 1391 mg/l (avg. 698 mg/l) and found that in all samples (100 %) it falls within maximum permissible limits of BIS (<2000 mg/l). The NO_3 concentration ranges from 25 to 372 mg/l. It is noticed that in about 55% of the samples (18 samples) from Neradigonda, Bela, Narnoor, Talamadugu, Boath, Gudihatnur,Adilabad Urban, Jainath, Indravelly, Bazarhatnoor, Tamsi,Mavala, Utnoor Ichoda, Bheempur mandals the quality is not suitable for drinking water purpose (>45 mg/l) (Fig. 2.9). The Fluoride concentration varies from 0.17-1.95 mg/l and in 30 samples (91 %) it is within permissible limit of <1.5 mg/l. The high fluoride concentration (>1.5 mg/l) is observed in 3 samples (9%) in Bazarhatnoor, Utnoor Gudihatnoor mandal (Fig. 2.10).

2.4.2 **Post-monsoon(Total samples 14: SGWD - 14)**

Groundwater from the area is mildly alkaline in nature with pH in the range of 7.09-8.32 (avg. 7.97). The Electrical conductivity varies from 555-2590 µ Siemens/cm (avg. 1130 µ Siemens/cm). In 19 samples (76%) from Neradigonda, Bela, Narnoor, Gudihatnur, Ichoda, Jainath, Bheempur, Indravelly, Mavala, Utnoor and Tamsi Bazarhatnoor, Narnoor ,the EC is within 1500 µ Siemens/cm while in 6 sample (24%) from in Talamadugu, Boath, Adilabad Urban mandals, it is in the range of 1500-3000 µ Siemens/cm. (Fig. 2.11). The concentration of TDS varies from 355 to 1657 mg/l (avg. 729 mg/l) and found that in all samples (100%) falls within maximum permissible limits of BIS (<2000 mg/l). The NO_3 concentration ranges from 13.4 to 157 mg/l (avg.75 mg/l). It is noticed that in about 16 samples (64%) from Naredigonda, Adilabad Urban, Bela, Tamsi, Utnoor, Bheempur, Talamadugu, Boath, Narnoor mandals exceeding permissible limit (>45 mg/l) not suitable for drinking water purpose while in 9 samples (36%) it under permissible limit (<45 mg/l). (Fig. 2.12). The Fluoride concentration varies from 0.12-2.21 mg/l and found that 22 samples (88 %), it is falling under permissible limit of <1.5 mg/l. While in 3 samples (12%) from Bheemput, Utnoor and Bazarhatnoor mandals are having high fluoride concentration (>1.5 mg/l)

2.4.3 Water Quality during January 2022 (Total samples 30)

Water samples about 30 were collected from different borewells and analysed during January 2022.Groundwater from the area is mildly alkaline in nature with pH in the range of 6.64-8.28 (avg. 7.01). The Electrical conductivity varies from 530-2290 µ Siemens/cm (avg. 1167 µ Siemens/cm). In 22 samples (73%) the EC is within 1500 µ Siemens/cm while in 8 sample (26%) it is in the range of 1500-2290 µ Siemens/cm. The concentration of TDS varies from 299 to 1497 mg/l (avg. 697 mg/l) and found that in all samples (100%) falls within maximum permissible limits of BIS (<2000 mg/l). The NO_3 concentration ranges from 1.8 to 297 mg/l (avg.95 mg/l). It is noticed that in about 22 samples (73%) exceeding permissible limit (>45 mg/l) not suitable for drinking water

purpose while in 8 samples (26%) it under permissible limit (<45 mg/l). The Fluoride concentration varies from 0.62-3.85 mg/l and found that 21 samples (70 %), it is falling under permissible limit of <1.5 mg/l. While in 9 samples (30%) from Bela, Bazarhatnoor, Jainath, Adilabad Rural, Utnoor, Narnoor and Ichoda mandals are having high fluoride concentration (>1.5 mg/l)

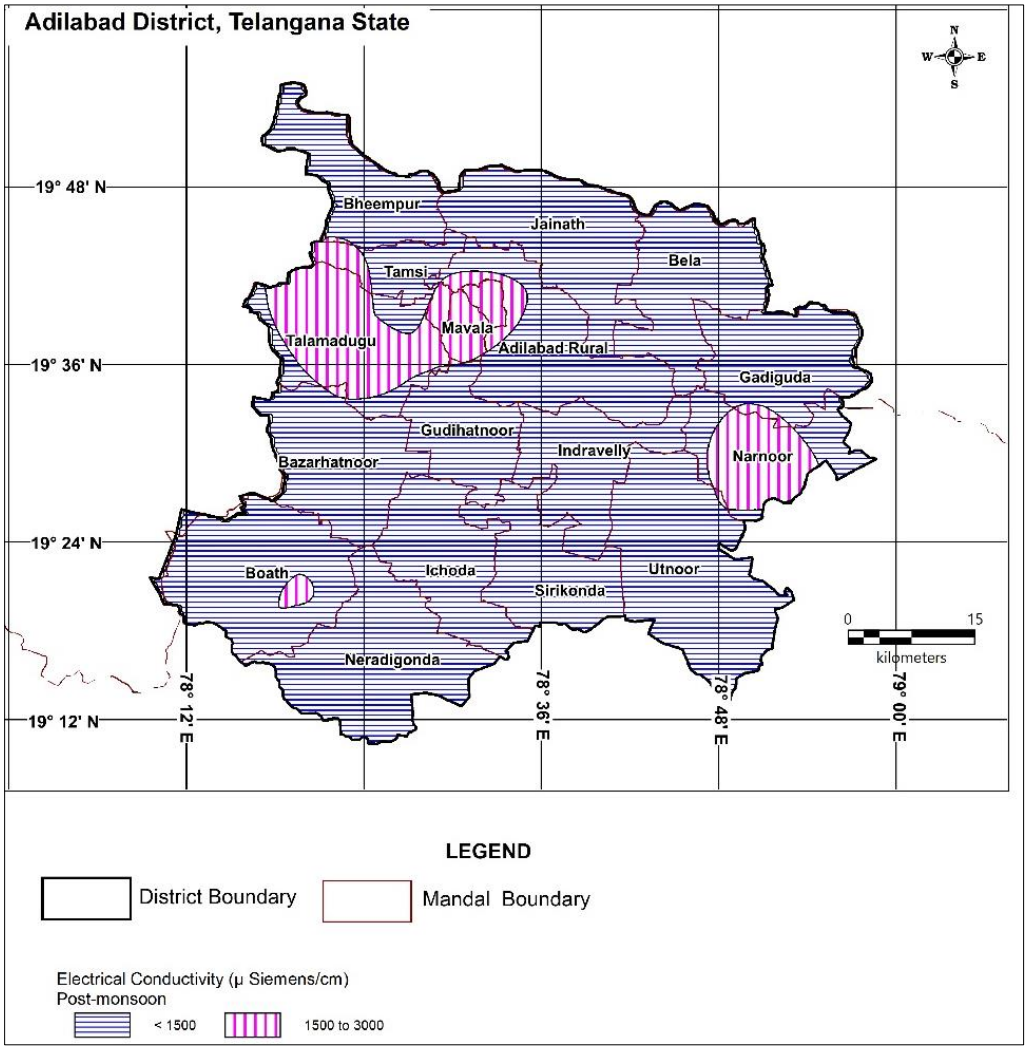


Fig.2.9: Distribution of Electrical conductivity (Pre-monsoon).

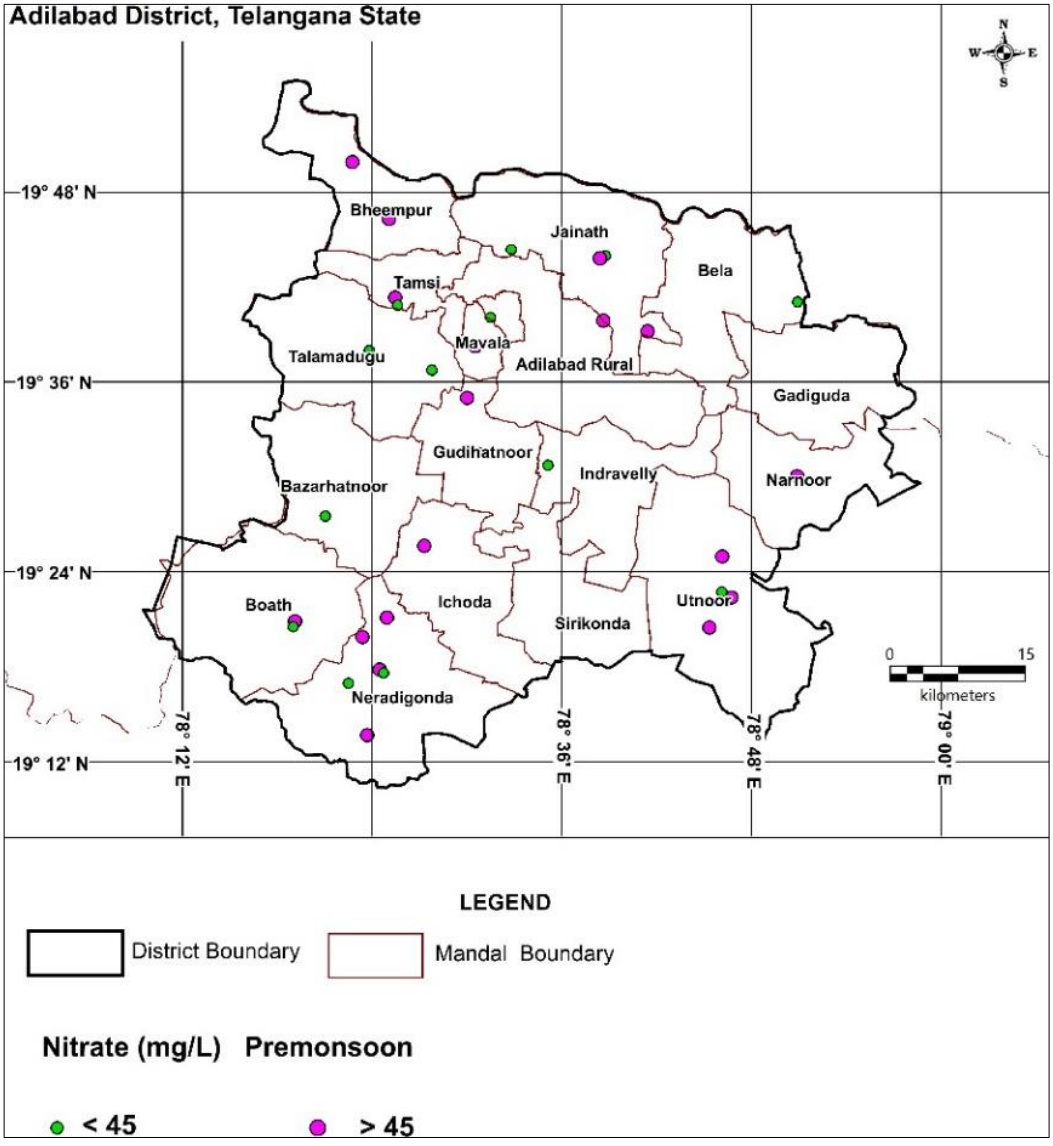


Fig.2.10: Distribution of Nitrate (Pre-monsoon).

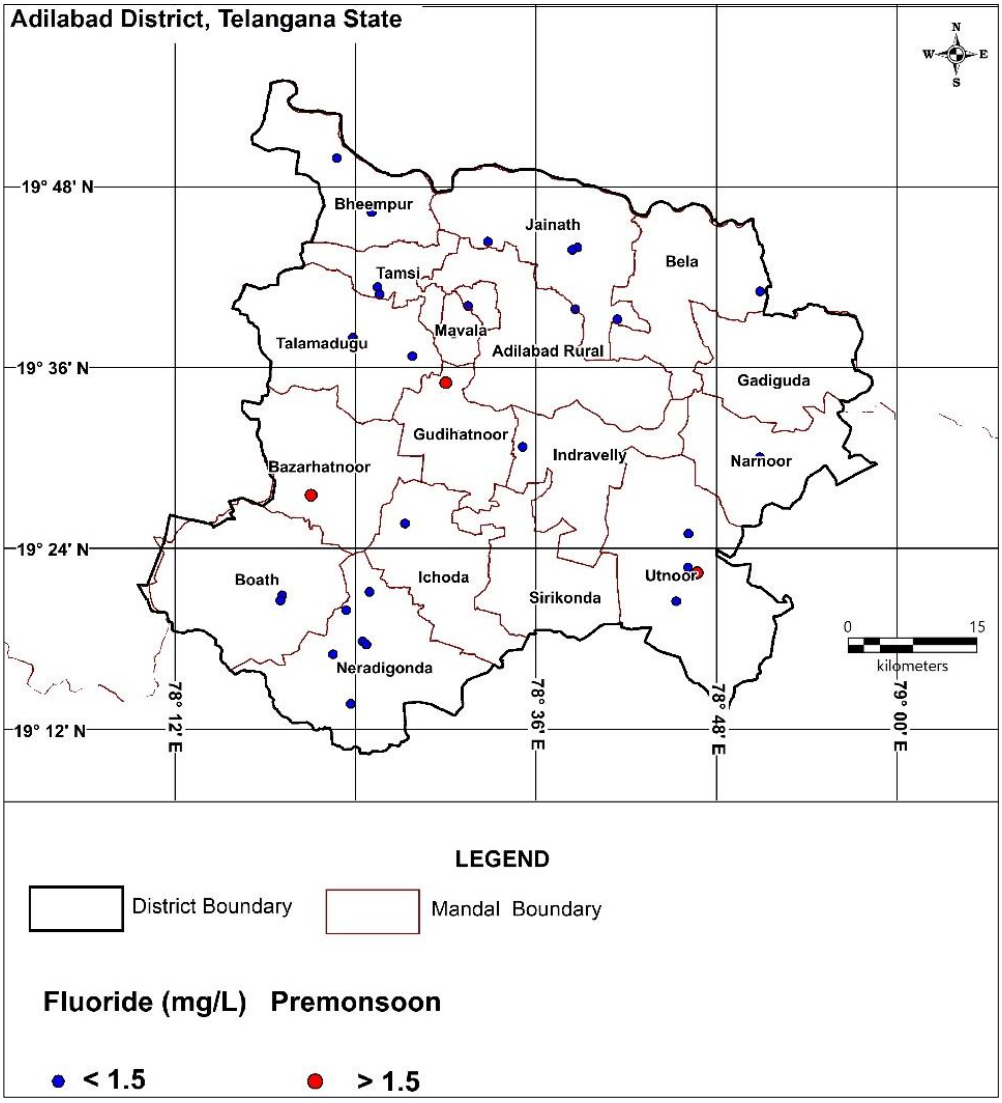


Fig.2.11: Distribution of Fluoride (Pre-monsoon).

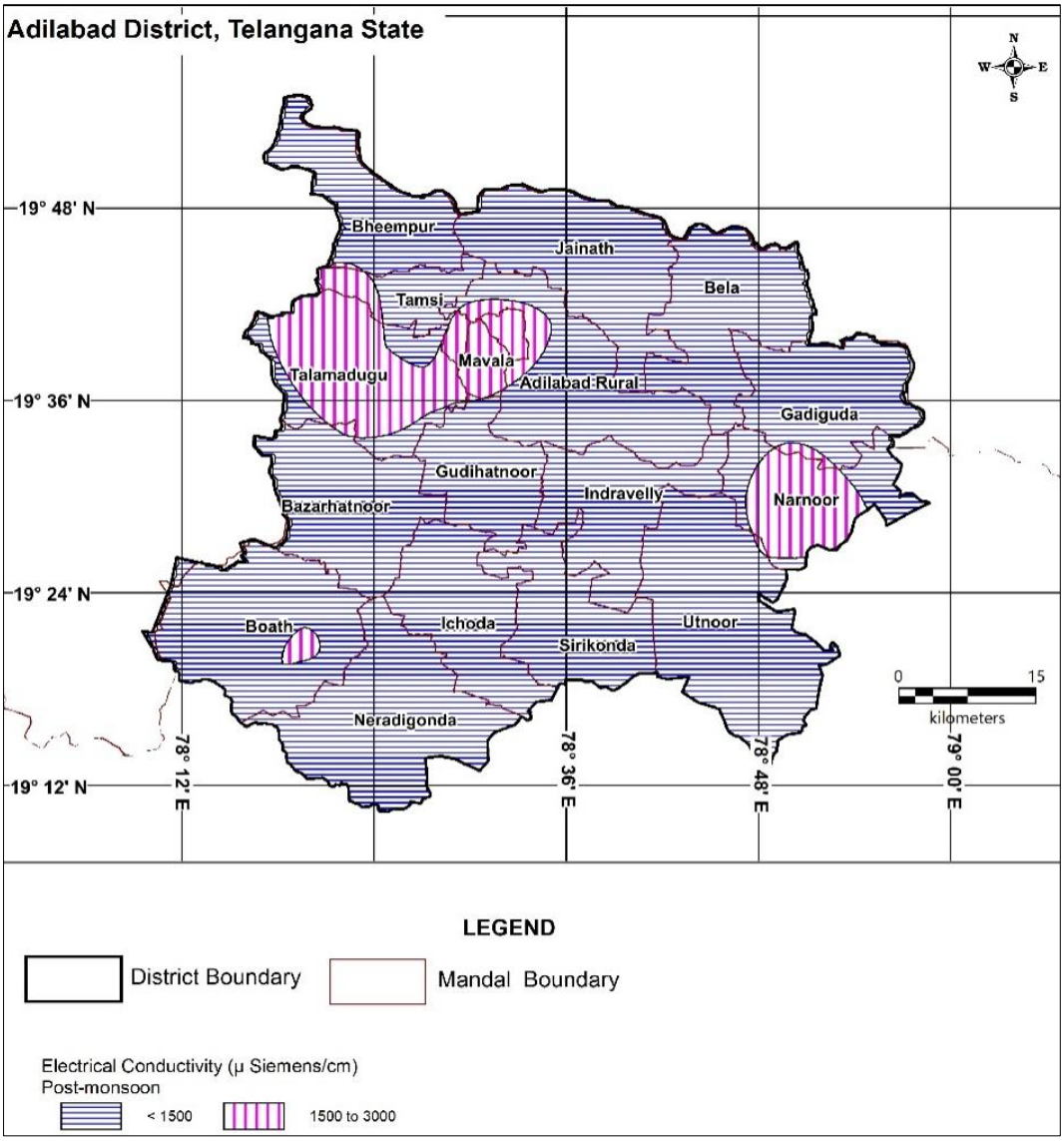


Fig.2.12: Distribution of Electrical conductivity (Post-monsoon).

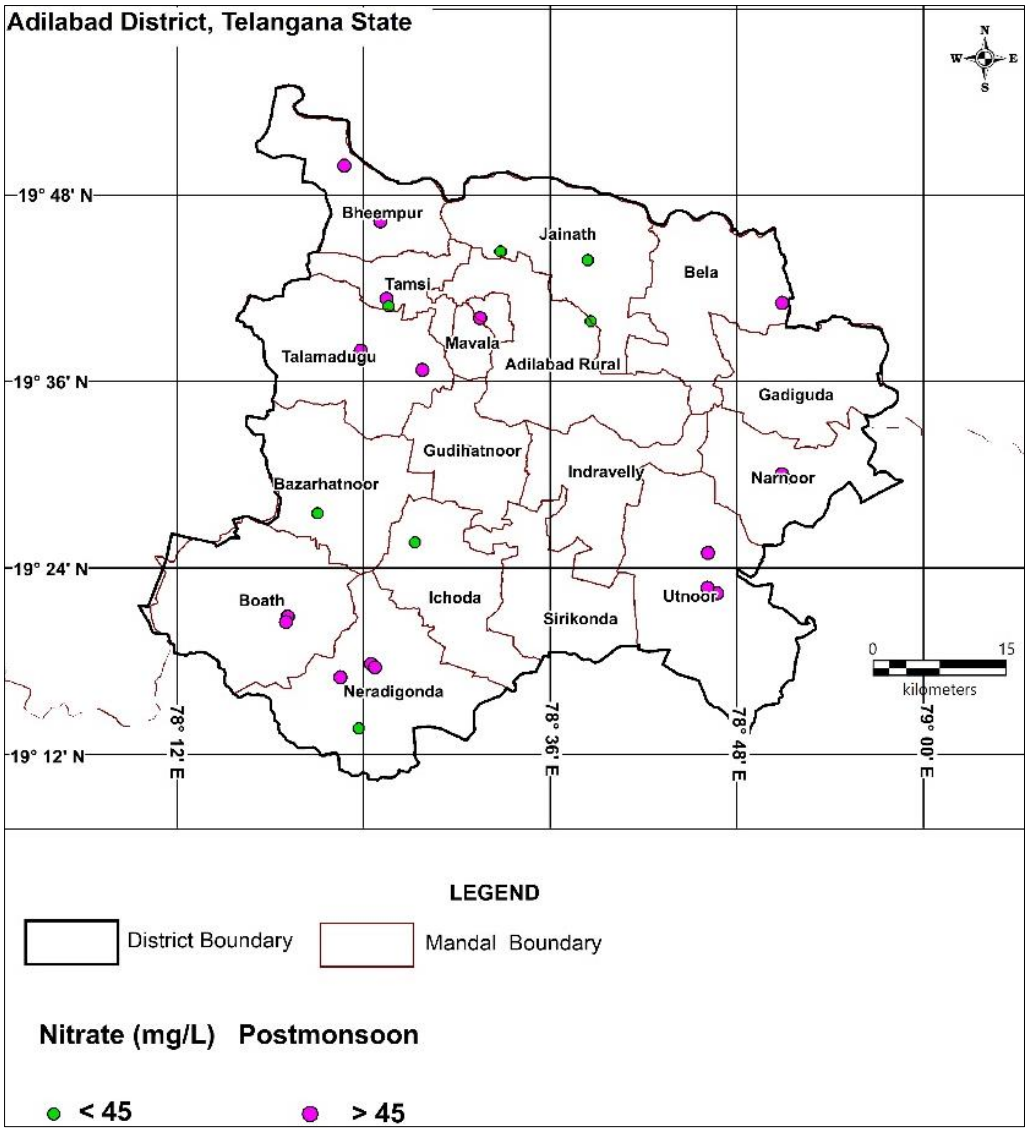


Fig.2.13: Distribution of Nitrate (Post-monsoon).

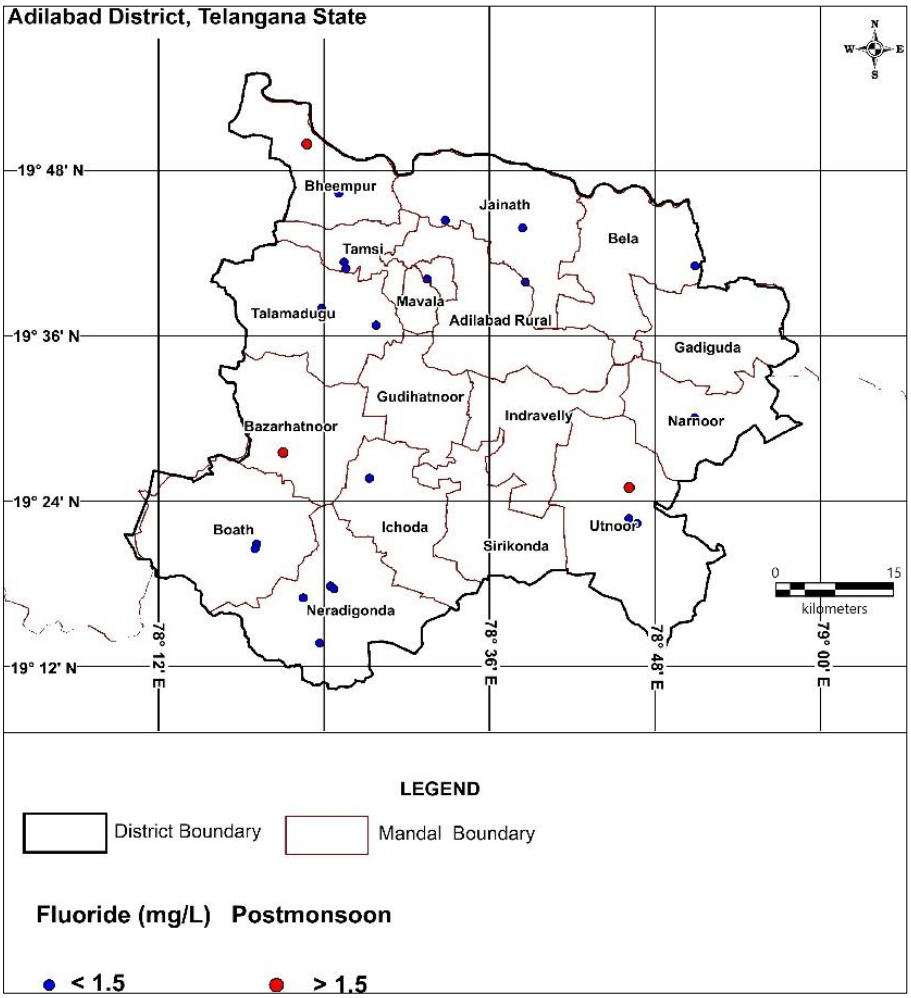


Fig.2.14: Distribution of Fluoride (Post-monsoon).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 138 data points (both hydrogeological and geophysical down to 200 m) for preparation of 3-D map, panel diagram and hydrogeological sections. The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The lithological information was generated by using the RockWorks-16 software and generated 3-D mapforMedak district (**Fig.3.1)** and hydrogeological sections.

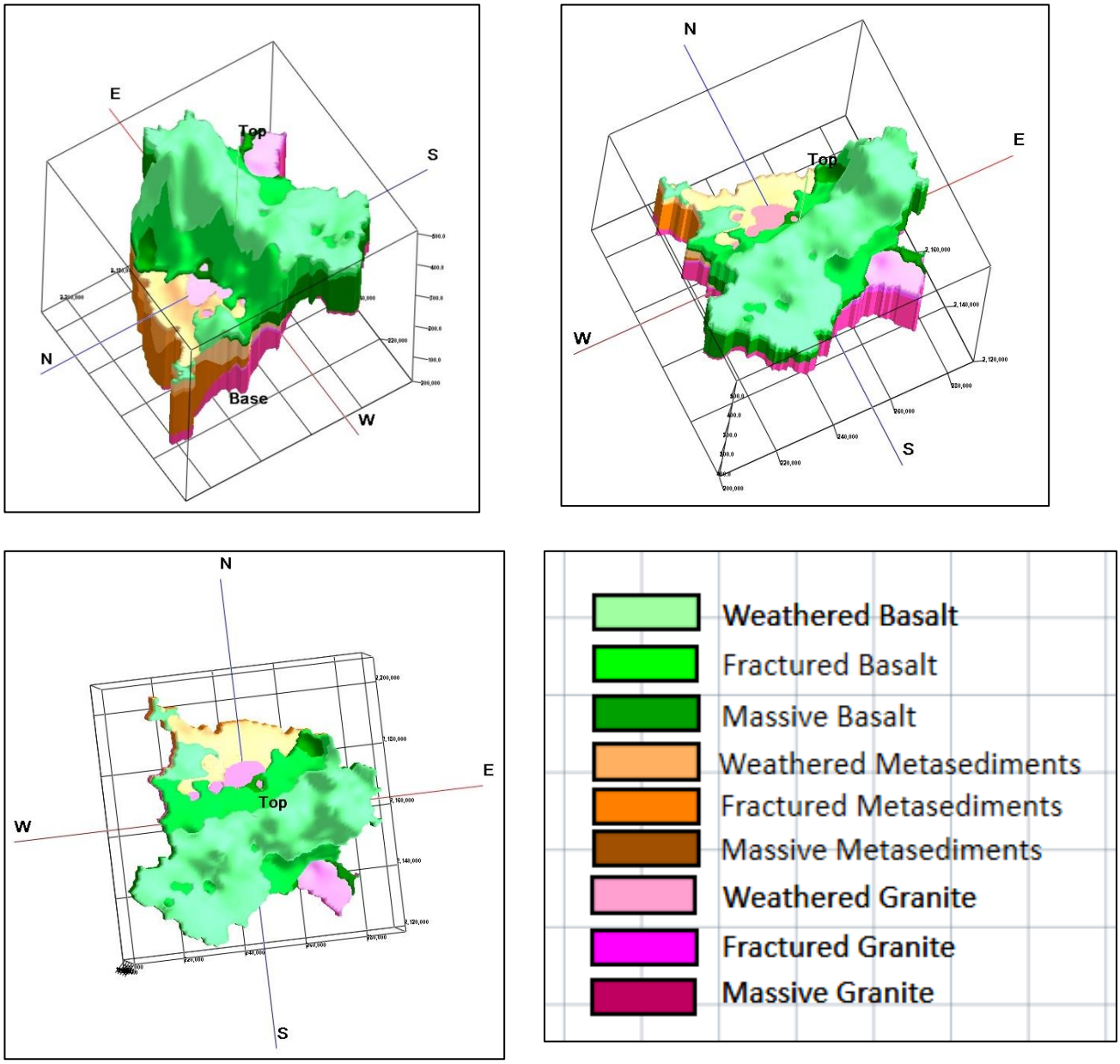


Fig.-3.1:3-D Model for study area.

3.1 Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. Weathered zone is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~20m depth and the fractured zone (fractured granite, basalt and meta sediment) is considered up to the depth of deepest fracture below weathered zone (~20-186 m).

3.2 Hydrogeological Sections

Hydrogeological sections are prepared in NW-SE,NE-SWandNNE-SSW directions (**Fig. 3.2**).

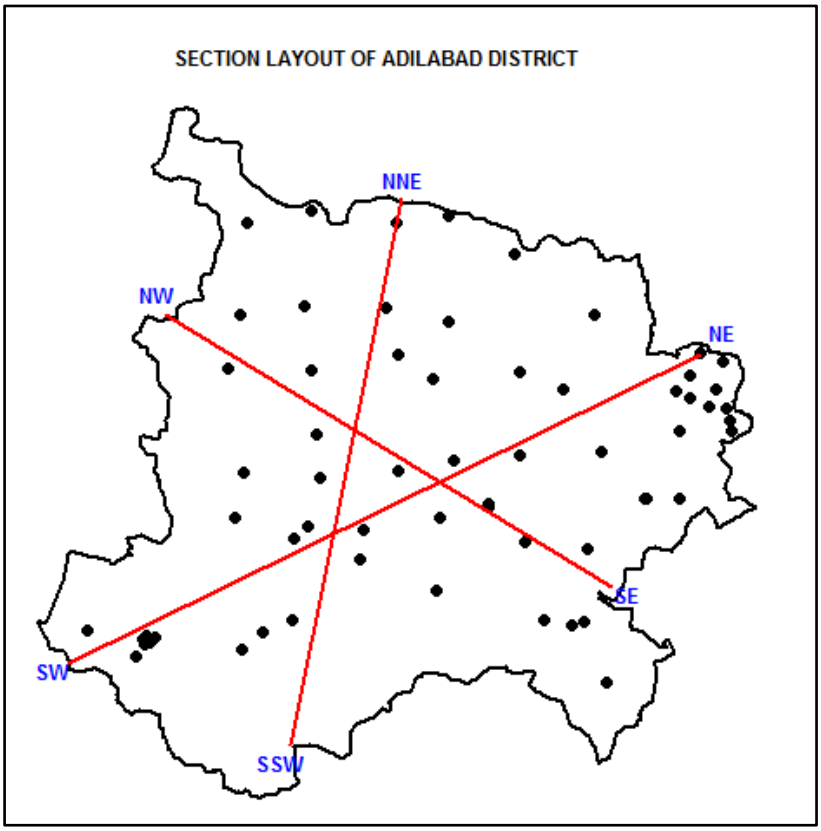


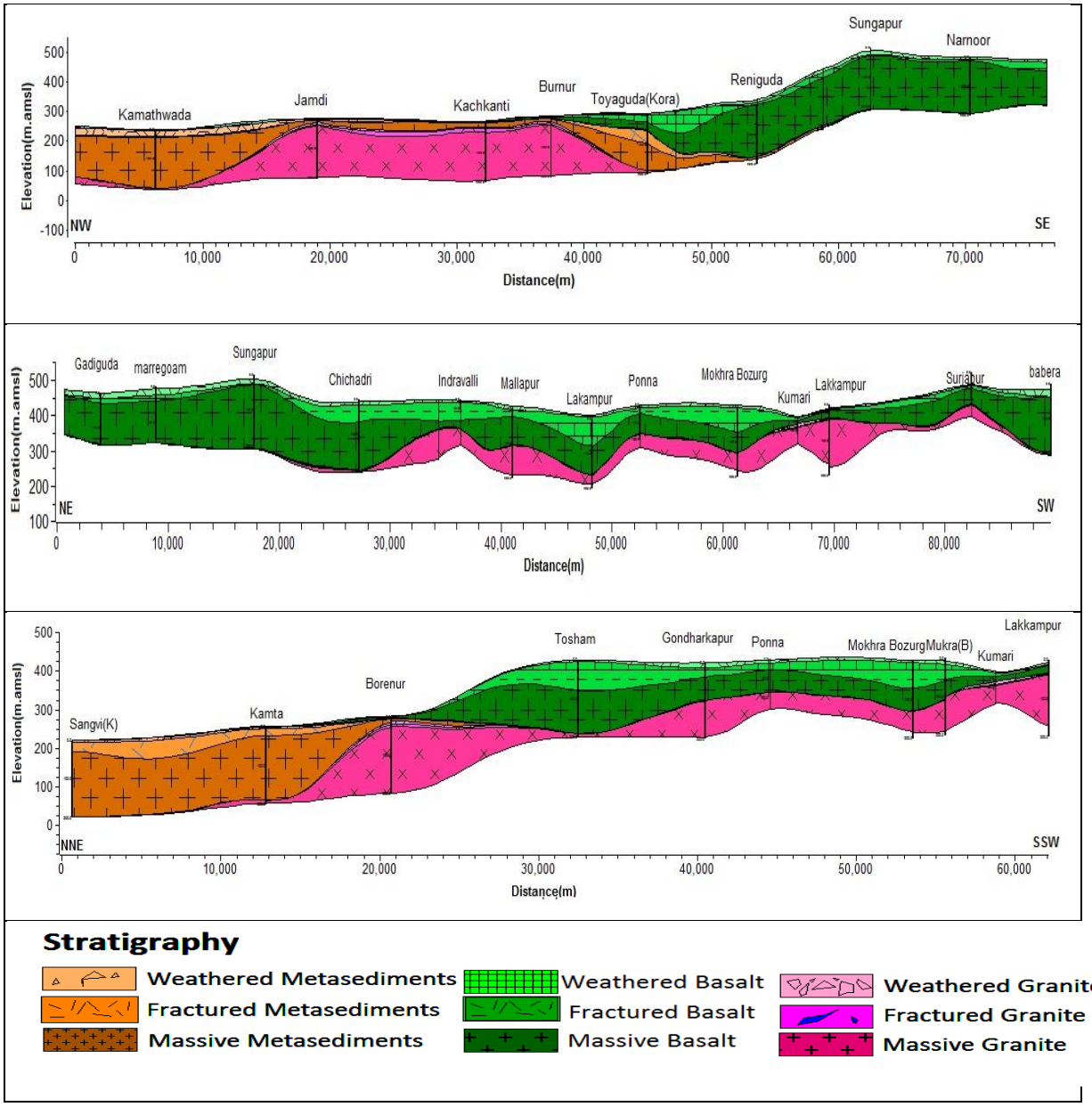
Fig.-3.2: Map showing orientation of hydro geological Sections

3.2.1 North-West and South-East Section: The section is drawn along the NW-SE directioncovering distance of ~70kms (**Fig.3.3a**). The section passes through the thick metasedimentary limestone formations in North West, granitic formations in the central part and the Deccan trap basaltic fromtaion in the south east.

3.2.2 North-East and South-WestSection: The section is drawn along the NE- SW covering distance of ~85kms (**Fig.3.3b**). It depicts thick weathered and fractured zone in the central part and thin fracture zones on both sides. Basalts extends the entire stretch from NE-SW. The granite formation encounter below basalts at 25 km from NE.

3.2.3 North North-East and South South-West Section: The section drawn horizontally along the NNE-SSW direction covering distance of ~66kms (**Fig.3.3c**), depicts thick weathered zone in central part and thick fracture zones in the central and North North eastern part. Meta sedimentary formation extendsupto ~22 km from NNE boundary, Basalt layers overlies the granite formation at ~22 km from NNE boundary.

Fig.3.3 (a-c): Hydrogeological profile in different directions in Adilabaddistrict.



3.3 Aquifer Characterization

3.3.1 Weathered zone: The Weathered thickness varies from 1m bgl to 23m bgl in granitic formartion, 1m bgl to 33 m bgl in basaltic formation and 1m bgl to 29m bgl in limestone formation. Spatial distribution of weathering depth zone map is given in **Fig.3.4**. Shallow weathering (< 10 m) occurs in ~40% of the area. Weathered zone in the range of 10-20 m in most part of area covering ~40 % of area and deep weathering (> 20 m) occurs in rest of the area (**Fig.3.5**).

3.3.2 Fractured zone: Ground water is extracted mainly through bore wells of 20 to 186 m depth from fractured zone (~20 to 186m). Based on the available CGWB, SGWD data, it is inferred that fractures in the range of < 60 m depth are identified in 30% of the area, 60-100, 100-150 fractures and >150 occur in 54%, 14% and 2% of area respectively (**Fig.3.6**). Fracture analysis (125nos from 138sites) reveals that majority of fractures (~75%) occur within 100 m depth (**Fig. 3.7**).In fractured granite/gneiss yield varies from 0.01 to 8.0 lps (avg: 1.38 lps). The deepest fracture encountered is at 167 m.bgl in granitic formation. The transmissivity varies from 1-32 m^2/day. In Basaltic terrain, yield varies from 0.01 to 16.04lps. Transmissivity varies from 0.1 to 305 m^2/day. In Limestone area, yield varies from 0.01 to 6.71lps. Transmissivity varies from 3 to 53 m^2/day.

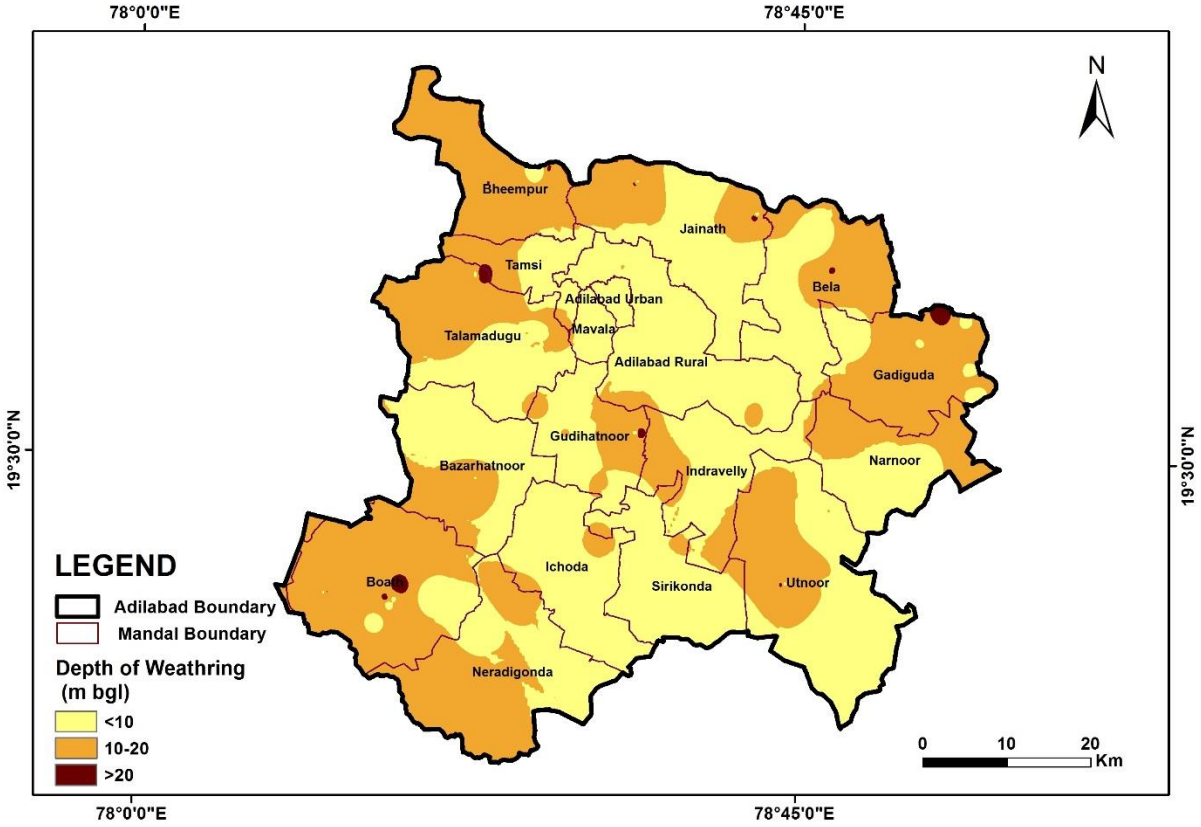


Fig.3.4: Thickness of Weathered zone-Adilabaddistrict.

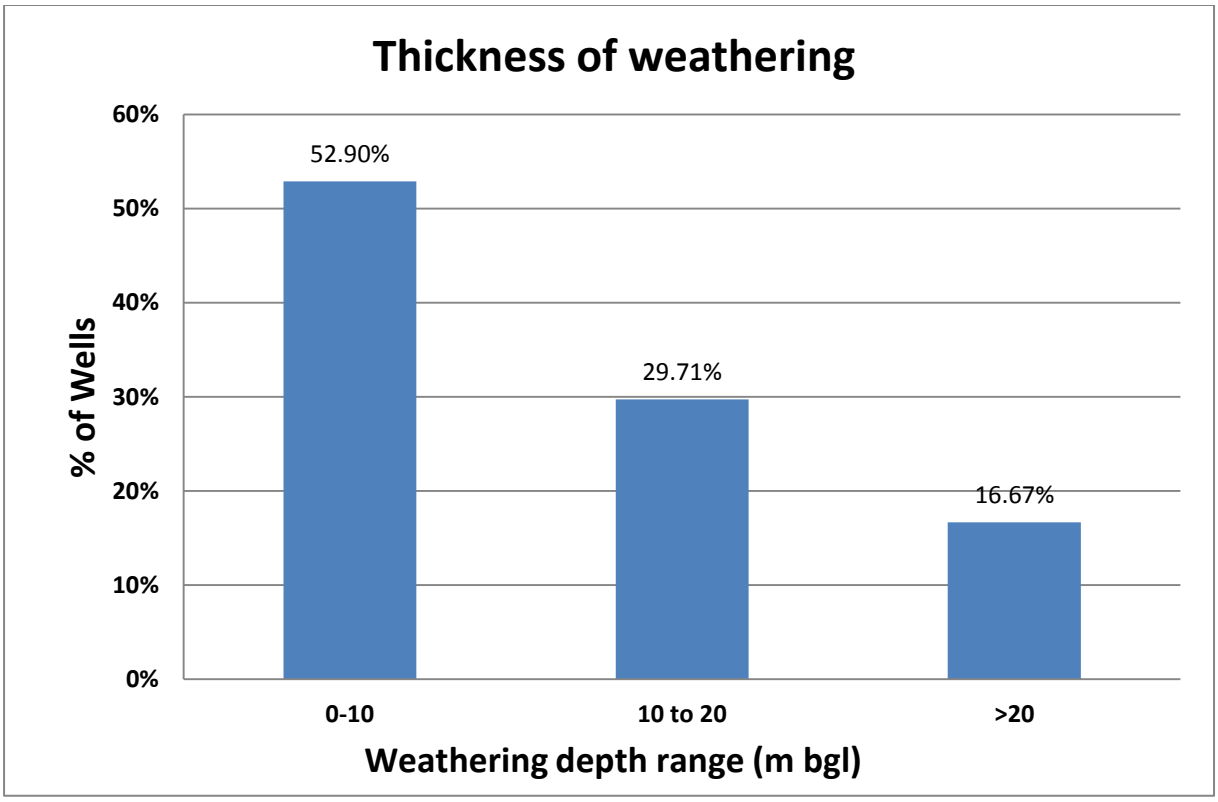


Fig.3.5: Depth wise distribustion of weathered zone zone

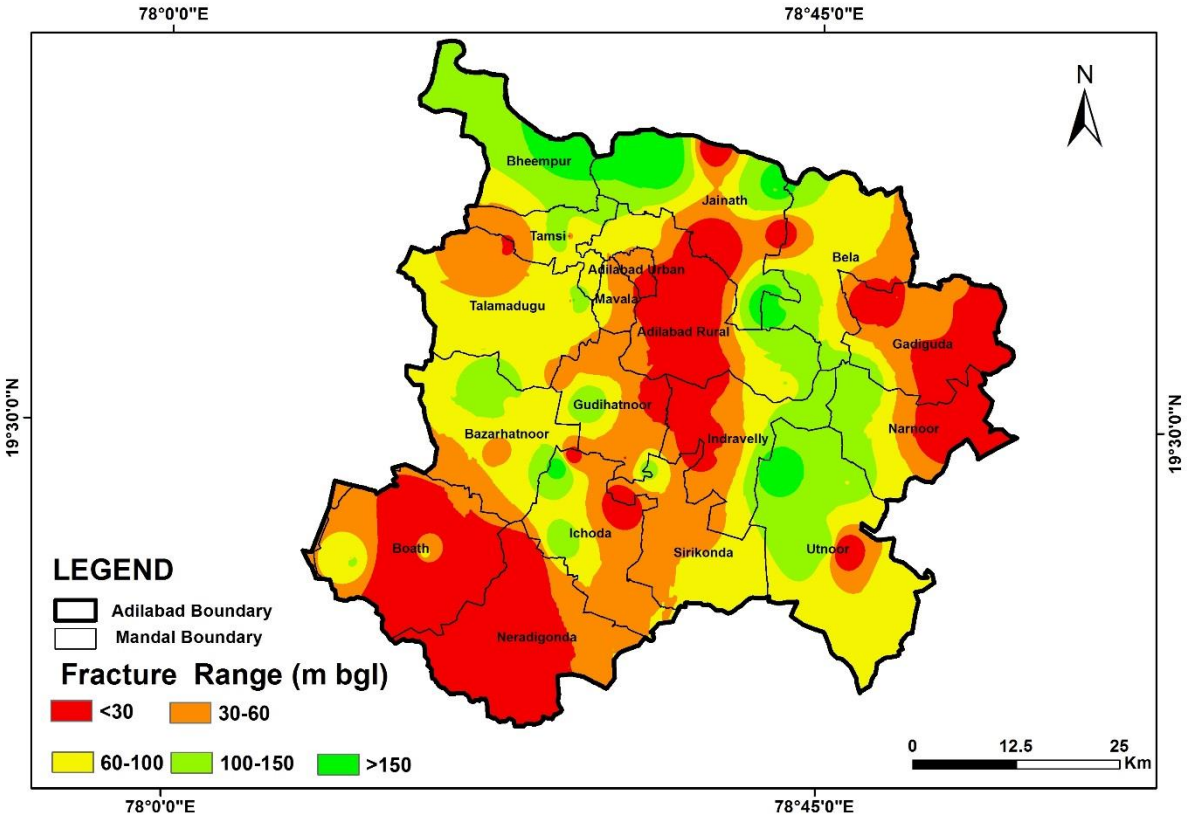
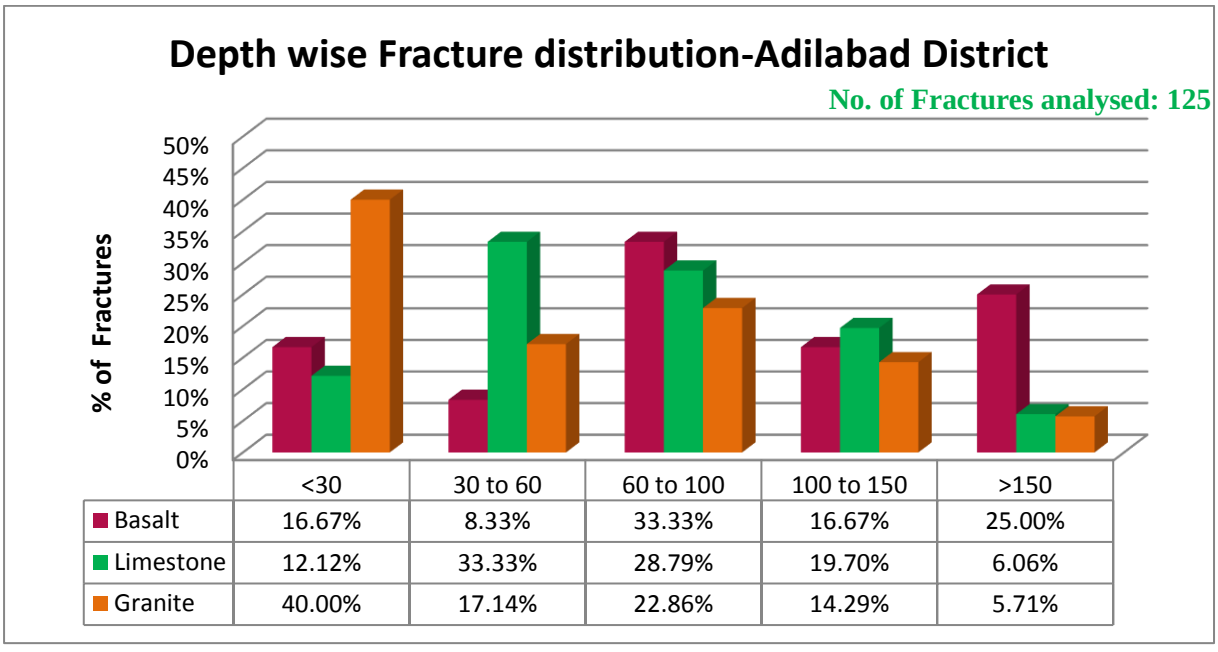


Fig.-3.6: Depth of Fractured zone (Maximum depth) (m bgl).



	<30	30 to 60	60 to 100	100 to 150	>150
Basalt	16.67%	8.33%	33.33%	16.67%	25.00%
Limestone	12.12%	33.33%	28.79%	19.70%	6.06%
Granite	40.00%	17.14%	22.86%	14.29%	5.71%

Fig.-3.7: Depth wise distribution of fractures

4. GROUNDWATER RESOURCES (2020)

In hard rocks, for practical purpose it is very difficult to compute zone wise (aquifer wise) groundwater resources, because the weathered zone (WZ) and fractured zone (FZ) are inter-connected with fractures/joints and fractured zone gets recharged through weathered zone. Therefore it is very difficult to demarcate the boundary between two aquifers; hence the resources are estimated considering entire area as a single aquifer system. Village wise dynamic and in-storage groundwater resources are computed as per the guidelines laid down in GEC methodology.

While computing the in-storage resources, the general depth of deepest fractures in the area, pre-monsoon water levels and 2 % of granular zone (depth below pre-monsoon water level and down to deepest fracture depth in the village) is considered. Summarizedcommand/ non-command area and mandal wise resources are given in ***Table-4.1***.

As per 2020 GEC report, the net dynamic replenishable groundwater availability is 260 MCM, gross ground water draft for all uses 132 MCM, provision for drinking and industrial use for the year 2025 is 52 MCM and net annual ground water potential available for future irrigation needs is 126.70MCM. 2 mandals (Adilabad Urban and Mavla) falls in over-exploited category, 2 mandals (Bazarhatnur and Narnoor) fall in semicritical category and remaining 14 mandals fall in safe category. Mandal wise stage of ground water development varies from 21 % (Adilabad Rural) to >100% (Adilabad Urban) with average of 51%.

Table-4.1: Computed Dynamic, In-storage ground water resources, Adilabaddistrict.

Parameters	**Resources (GEC 2020) in MCM**
As per GEC 2020	MCM
Dynamic (Net GWR Availability)	**259.60**
• Monsoon recharge from rainfall	234.04
• Monsoon recharge from other sources	15.30
• Non-Monsoon recharge from rainfall	0
• Non-monsoon recharge from othersources	28.90
Gross GW Draft	**132.32**
• Irrigation	81.08
• Domestic and Industrial use	51.24
Provision for Drinking and Industrial use for the year 2025	51.84
Net GW availability for future irrigation	126.70
Stage of GW development (%)	51%
Categarization of mandals	OE:2, SC:2, and Safe 14

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

Over-exploitation

- ~51 Km^2 area covering 4 villages are categorized as over-exploited where ground water balance for future irrigation is zero or negative and 449 Km^2 area covering 53 villages are categorized as Semicrical.

Low Sustainability

- Low yield (<1 lps) occurs in 44 % of exploratory wells area covering Echoda, Indravelly, Boath, Tamsi, Jainad, Bela, Neradigonda mandals of the district.
- Few villages are fluorosis endemic where fluoride (geogenic) is 1.9 mg/L during pre-monsoon and 2.21 mg/L during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/L) occur in 9% and 12 % of the samples during pre-monsoon and post-monsoon season respectively.
- High nitrate (> 45 mg/L) due to anthropogenic activities is observed in 55% of samples during pre-monsoon period and 64% during post-monsoon period.

Water Marketing and other Issues

- Water marketing is present in almost all over the area and people are buying bottled water from the market for drinking purposes as there is no sufficient supply of surface water.

5.2 Reasons for Issues

Over-exploitation and Deep water levels

- Over-extraction, Hydrogeological conditions and limited artificial measures etc.

Low Sustainability

- Absence of primary porosity, negligible development of secondary porosity and urbanization.

Geo-genic pollution (Fluoride)

- Higher concentration of fluoride in ground water is attributed due to source rock, rock water interaction where acid-soluble fluoride bearing minerals (fluorite, fluoro-apatite) gets dissolved under alkaline conditions.
- Higher residence time of ground water in deeper aquifer.

Anthropogenic pollution (Nitrate)

- Higher concentration is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas.Use of NPK fertilizers and nitrogen fixation by leguminous crops.

6. MANAGEMENT STRATEGIES

The occurrence of fractures is very limited in extent, as the compression in the rock reduces the opening of fractures at depth and the majority of fractures occur within 100 m depth (75%) (**Fig.3.7**). Higher NO_3^- concentrations (> 45 mg/L) in weathered zone is due to sewage contamination and higher concentration of F^- (>1.5 mg/L) in weathered zone and fractured zone is due to local geology (granite/gneiss rock), high weathering, longer residence time and alkaline nature of groundwater.

6.1 Management plan

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy.

In the district 2143 MCM of unstaturated, volume (below the depth of 5 m) is avaialable during post-monsoon season having 43 MCM of recharge potential (2%).This can be utilized for implementing management strategy.

The study suggests notable measures for sustainable groundwater management, which involves a combination of various measures given below. State Governments initiatives in groundwater recharge were also considered.

1. Supply side measures
2. Demand side measures
3. Regulatory measures
4. Institutional measures

6.1.1 Supply side measures:

Ongoing Projects

6.1.1.1 Repair Renovation and Restoration of existing tanks (Mission Kakatiya):

- Under State Govt. sponsored Mission Kakatiya, during Phase-1 to Phase-4, out of 784 minor irrigation tanks, 134 tanks were desilted. This helped in strengthening of water bodies and created additional surface storage, thereby increased groundwater augmentation in the district.

- There is a need to take remaining tanks in the next phases for de-siltation. This will greatly help in stabilisation of tank ayacut and groundwater augmentation.

6.1.1.2 Mission Bhagiratha:

- Under Telangana Drinking Water Supply Project (TDWSP) also known as Mission Bhagiratha, all the villages and towns are proposed to be covered from the water gridwith intake from Sri Ram Sagar Project (SRSP) coveringentire districtto provide protected water from surface reservoirs.The scheme is to enhance the existing drinking water scheme and to provide 100, 135 and 150 lpd/person of water in rural, municipal and Municipal Corporation respectively.

- The total water requirement as per 2011 census is 27.71 MCM and this imported water from surface sources will reduce the present utilized ~15.53 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~2588 ha of additional land under ID crops.

6.1.1.3 Artificial Recharge structures:

Construction of 775 artificial recharge structures (ARS) 39 in priority-1 (over-exploited and semi critical) and 736 in priority-2 (other areas) are suggested by following standard methodology.

While formulating the village wise groundwater management plan, the unsaturated volume of aquifer is estimated by multiplying the area with specific yield and unsaturated thickness (post-monsoon water levels below 5 m). Initially village wise dynamic groundwater resources of 2020 are considered (**Fig.4.1**). Potential surface run off is estimated by following standard procedures. On conservative side 25% runoff yield is considered as non-committed yield for recommending artificial recharge structures in intermittent areas 50 % of yield is considered and remaining 50% is recommended for implementing water conservation measures in recharge areas through MGNREGS.

The pre-monsoon groundwater quality is considered for categorising contaminated area (F >1.5 mg/l &EC >3000 µ S/cm). Nitrate is not considered here because it is point source pollution and localized. Based on above criteria, the area is prioritized into **Priority-1(over-exploitedand semi critical)** which needs immediate interventionand **Priority-2**.

Priority-1 (Area where groundwater development >70 %)

Area consisting of 57 villages covering ~490 Km^2 is considered as Priority-1 where 1.925 MCM recharge potential and 28.30 MCM utilizable yield (Uncommited runoff) is avaialable. This requires immediate intervention as the stage of groundwater development is >74%. For sustainable development and management of the groundwater resources the following recommendations are made and summarised in **Annexure-1**.

- 78 artificial recharge structures (12 CD's and 66 mini PT's) exist in the area.
- In addition to the existing structures, 39 artificial recharge structures (20CD's with shafts and19mini PT's with shafts) with a total cost of 6.80 crores (@ 15Lakh/CD and 20 Lakh/PT) can be taken up.
- After effective utilization of this yield, there will be 1.04 MCM of ground water recharge with new structures.
- All existing artificial recharge structures are to be desilted and maintained properly.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

Priority-2 (A**rea where groundwater development <70 %)**

Area consisting of 446 villages with ~3663 Km^2 rechargable area is considered as Priority-2, where 40.9 MCM recharge potential and 202MCM utilizable yield is avaialable. For sustainable development and management of groundwater resources, the recommendations are madeand summarised in **Annexure-II**.

- 367 artificial recharge structures (70 CD's and 297 mini PT's) exist in the area.
- In addition to the existing structures, 736 artificial recharge structures (ARS) (383CD's with shafts and 353 mini PT's with shafts) can be taken up with a cost estimate of 128 crores.
- After effective utilization of this yield, there will be 19.79 MCM of ground water recharge with new structures.

- All existing artificial recharge structures are to be desilted and maintained properly.

- Roof top rainwater harvesting structures should be made mandatory to all Government buildings.

6.1.1.4 Other supply side measures:

- Existing ARS like percolation tanks and check dams and dried dug wells can be de-silted involving people's participation through the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (NREGA 2005). This will also help in sustainable management of groundwater resources.

6.1.1.5 Water Conservation Measures (WCM) (Farm Ponds):

- The farm ponds are the ideal water conservation structures, which are constructed in the low lying areas of the farm. The size of form ponds can be 10 x 10 x3 m. In the district total 330 farm ponds exist in 24 villages and additional **9730** farm ponds are recommended (20 in each village in 479 villages) with total cost of **24.32**crores.

6.1.2 Demand side measures: In order to manage the available resources more effectively the following measures are recommended.

6.1.2.1 Ongoing Work

- In the area till date drip and sprinklers are sanctioned for ~12749 ha under ID crops saving ~19.1 MCM of groundwater from the basin.

6.1.2.2 Proposed Work

- ~25,150 ha of additional land that can be brought under micro-irrigation (@50 ha/village in 503 villages) costing about 150 crores (considering 1 unit/ha @0.6 lakh/ha). With this 37.73 MCM of ground water can be conserved over the traditional irrigation practices (considering 25% of net savings ID crops).

- To avoid the interference of cone of depression between the productive wells, intermittent pumping of bore wells is recommended through regulatory mechanism.

- Power supply should be regulated by giving power in 4 hour spells two times a day in the morning and evening by the concerned department so that pumping of the bore well

is carried out in phased manner to allow recuperations of the aquifer and increase sustainability of the bore wells.

- As a mandatory measure, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction.

6.1.3 Other measures

- Subsidy/incentives on cost involved in sharing of groundwater may be given to the concerned farmers.

- A participatory groundwater management (PGWM) approach in sharing of groundwater resources and monitoring on a constant basis along with effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002) are the other measures suggested. Subsidy/incentives on cost involved in sharing of groundwater may be given to the farmers involved.

- In urban and rural areas the sewerage line should be constructed to arrest leaching of nitrate.

6.2 Expected Results and Out come

With the above interventions costing Rs. 310 crores, the likely benefit would be increases in gross groundwater availability with net saving of 61 MCM of groundwater or net reduction of 10% in stage of groundwater extraction, i.e., from the existing 51 to 41%. The onetime cost will be 5.04 paisa/litre and the actual cost of invest will be 0.50 paisa/litre if considered the life of the artificial recharge structures and micro irrigation equipment as 10 year.

Acknowledgment

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Annexure – I

Proposed interventions in Priority-1 areas (Area where ground water development >70 %).

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Adilabad Urban	ADILABAD			2	2
Mavala	BATTISAWARGAON	4	5		
Mavala	DASNAPUR			1	1
Mavala	MAVALA			5	5
Bazarhatnoor	ANANTHAPUR	18			
Bazarhatnoor	BAZARHATHNUR	4			
Bazarhatnoor	BHUTAI KHURD	5	1		
Bazarhatnoor	DARAMPURI	4	2		
Bazarhatnoor	HARKAI	7	3		
Bazarhatnoor	KANDLI	18	1		
Bazarhatnoor	KINNERPALLE	1			
Bazarhatnoor	YESAPUR	5			
Narnoor	MALANGI			7	6
Narnoor	MALEPUR			3	3
Narnoor	UMRI			2	2

Annexure – II

Proposed interventions in Priority-2 areas (Area where ground water development <70 %).

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Adilabad Rural	ANUKUNTA		4		
Adilabad Rural	TARADA (SRIMATH)			1	
Adilabad Rural	ANKOLI	2	9		
Adilabad Rural	KACHKANTI	4	3		
Adilabad Rural	TONTOTOI	5	6		
Adilabad Rural	CHINCHUGHAT	43			
Adilabad Rural	ARLI (BUZURG)				1
Adilabad Rural	DIMMA			1	1
Adilabad Rural	GANESHPUR (D)			1	1
Adilabad Rural	NISHANGHAT			1	1
Adilabad Rural	RAMPOOR (ROYATI)			1	1
Adilabad Rural	JAMDAPUR	16	1	1	1
Adilabad Rural	BELLURI			2	2
Adilabad Rural	POCHARA			2	2
Adilabad Rural	LANDASANGVI			3	3
Adilabad Rural	MALLAPUR (D)			3	3

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Adilabad Rural	CHANDA			4	4
Adilabad Rural	BHEEMSERI			5	5
Bela	KHAGDUR		1		
Bela	POHAR				
Bela	SYEDPUR		3		
Bela	BHADI	1			
Bela	JUNONI	2			
Bela	CHAPRALA			1	1
Bela	KHADKI			1	1
Bela	KOBHAI			1	1
Bela	KOPARUZANA			1	1
Bela	MANGROOL			1	1
Bela	PATAN			1	1
Bela	SONKHOS			1	1
Bela	PONNALA			2	2
Bela	RAMKAM			2	2
Bela	CHANDPALLE			4	3
Bela	PITGAON			3	3
Bheempur	BABBAKANCHI			1	1
Bheempur	BHEEMPOOR			2	1
Bheempur	GONA			1	1

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Bheempur	WADGAON			1	1
Bheempur	ANTARGAON			2	2
Bheempur	BELSARI RAMPUR			2	2
Bheempur	DHANORA			2	2
Bheempur	GUNJALA			2	2
Bheempur	KAMATHWADA			2	2
Bheempur	WADOOR			3	2
Bheempur	NIPANI			3	3
Bheempur	ANDARBANDH			5	4
Bheempur	GUBDI			4	4
Bheempur	GOLLAGHAT			6	5
Bheempur	TAMSI (K)			5	5
Bheempur	PIPPALKHOTI			7	6
Bheempur	GOMUTRI			7	7
Bheempur	KARANJI (T)			9	8
Bheempur	ARLI (T)			16	14
Boath	BANDREW				
Boath	BABERA		4		
Boath	PARDI KHURD		2		
Boath	MARLAPALLY	1	3		
Boath	KOWTHA BUZURG	5			

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Boath	GHANPUR	15			
Boath	WAJAR	20			
Boath	BAHRAPUR			1	1
Boath	BIRLAGONDI			1	1
Boath	DHANNUR KHURD			1	1
Boath	KESLAPUR			1	1
Boath	MEDI			1	1
Boath	NAKKALAWADA			1	1
Boath	PATNAPUR		4	1	1
Boath	KARATHWADA	4		1	1
Boath	BOATH (K)			2	2
Boath	NIGINI			2	2
Boath	PIPPALADHARI			2	2
Boath	DHANNUR BUZURG			3	3
Boath	NARAYANPUR			4	3
Boath	SURADAPUR			4	3
Boath	ANDURU			4	4
Gadiguda	DHABA (BUZURG)			1	1
Gadiguda	KONDI			1	1
Gadiguda	PIPRI			1	1

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Gadiguda	POWNUR			2	1
Gadiguda	PUNAGUDA			2	1
Gadiguda	WARKWAI			1	1
Gadiguda	GOURI			2	2
Gadiguda	KADODI			2	2
Gadiguda	KHANDOW			2	2
Gadiguda	KOUTHALA			2	2
Gadiguda	KUNIKASA			2	2
Gadiguda	MAREGAON			3	2
Gadiguda	SAWARI			2	2
Gadiguda	DONGARGAON			3	3
Gadiguda	GADIGUDA			3	3
Gadiguda	KOTHAPALLE (G)			3	3
Gadiguda	RAMPUR			4	3
Gadiguda	RUPAPUR			3	3
Gadiguda	KOLAMA			5	4
Gadiguda	PARASWADA (B)			6	5
Gadiguda	SEDWAI			5	5
Gadiguda	ADEMEYON			6	6
Ichoda	TALAMADRI	6	1		
Ichoda	KOKASMANNAR	8			

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Indravelly	DEVAPUR	10			
Indravelly	GOURAPUR	22			
Jainath	ADA				
Jainath	BALLORI		8		
Jainath	BELGAON				
Jainath	HARIYALI				
Jainath	JAINAD		9		
Jainath	JAMINI				
Jainath	KAMTHA				
Jainath	KANPA (MEDIGUDA)				
Jainath	KARANJI				
Jainath	KHAPRI				
Jainath	KODEKOTHA				
Jainath	KURA		2		
Jainath	KUTHOMPUR				
Jainath	BAHADURPUR	2			
Jainath	DEEPAIGUDA	2	2		
Jainath	AWALPUR			1	1
Jainath	DOLLARA			2	1
Jainath	KARANWADI			1	1

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Jainath	KOWTHA			1	1
Jainath	MIRZAPUR			1	1
Jainath	NIZAMPUR			1	1
Jainath	SAVAPUR			1	1
Jainath	AKOLI			2	2
Jainath	AKURLA			2	2
Jainath	BHORAJ			2	2
Jainath	DADAPOOR			2	2
Jainath	FOUZPUR			2	2
Jainath	HASHAMPUR			2	2
Jainath	KAMAI			2	2
Jainath	KEDARPUR			2	2
Jainath	KORTA			2	2
Jainath	LEKARWADI			3	2
Jainath	MANDAGADA			2	2
Jainath	NIRALA			2	2
Jainath	SEKAPOOR			2	2
Jainath	SIRSONNA			2	2
Jainath	BALAPUR			3	3
Jainath	PIPPARWADA			3	3
Jainath	POOSAI			3	3

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Jainath	SANGVI (K)			3	3
Jainath	TARADA BUZURG			4	3
Jainath	GIMMA BUZURG			4	4
Jainath	GUDA			6	4
Jainath	HATHIGHAT			4	4
Jainath	RAMPUR TARAF			4	4
Jainath	GIMMA KHURD			6	5
Jainath	PENDALWADA			5	5
Neradigonda	JASNAPUR			1	
Neradigonda	KUMARI	4			
Neradigonda	NARAYANAPUR	8	2		
Neradigonda	NAGAPUR	20			
Neradigonda	DARBA			1	1
Neradigonda	KORATKAL BUZURG			1	1
Neradigonda	PURUSHOTHAMPUR			1	1
Neradigonda	SOWERGAON			1	1
Neradigonda	VENKATAPUR			1	1
Neradigonda	WADDUR			1	1
Neradigonda	AREPALLE			2	2

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Neradigonda	BONDIDI			2	2
Neradigonda	BUGGARAM			2	2
Neradigonda	ISPUR			3	2
Neradigonda	KISHTAPUR			2	2
Neradigonda	KORATKAL KHURD			2	2
Neradigonda	WANKIDI			2	2
Neradigonda	BONDEMREGOD			3	3
Neradigonda	NERADIGONDA			3	3
Neradigonda	SHANKARAPUR			3	3
Neradigonda	SURDAPUR			3	3
Neradigonda	LINGATLA			5	4
Neradigonda	ROLMAMDA			4	4
Neradigonda	BORAGAON			9	9
Neradigonda	RAJURA			11	10
Neradigonda	NAGAMALYAL			12	11
Sirikonda	KONDAPUR	10			
Sirikonda	SIRIKONDA	24	4		
Talamadugu	KAPPARDEVI	1			
Talamadugu	LINGI	1			
Talamadugu	RUYYADI	4	2		

New Mandal	Village	Existing No. of Percolation Tanks	Existing No of Check Dams	Proposed Check Dams	Proposed Percolation Tanks
Talamadugu	DEVAPUR			1	1
Talamadugu	KAJJARLA	2			1
Tamsi	BANDALNAGAPUR			1	1
Tamsi	GHOTKURI			2	1
Tamsi	KHAPPERLA			2	2
Tamsi	SANVERGAON			3	2
Utnoor	NAGAPUR	7			
Utnoor	TEJAPUR - J	7			
Utnoor	CHANDUR	14			
Utnoor	NARSAPUR (KHURD)	27			
Utnoor	LAKKARAM			4	3