केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

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

HANAMKONDA DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

भारत सरकार

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MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION

CENTRAL GROUND WATER BOARD

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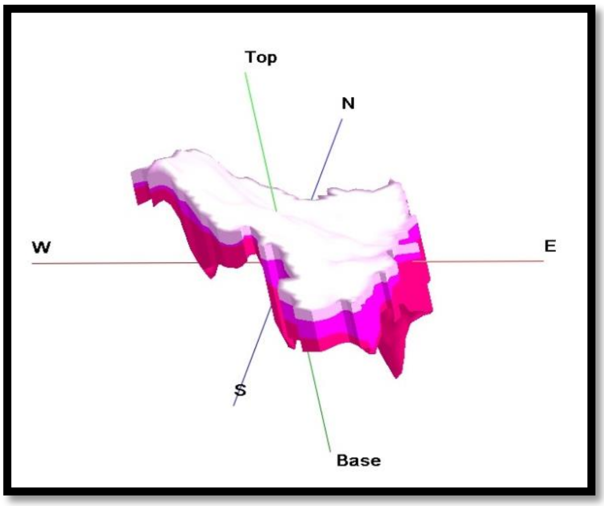

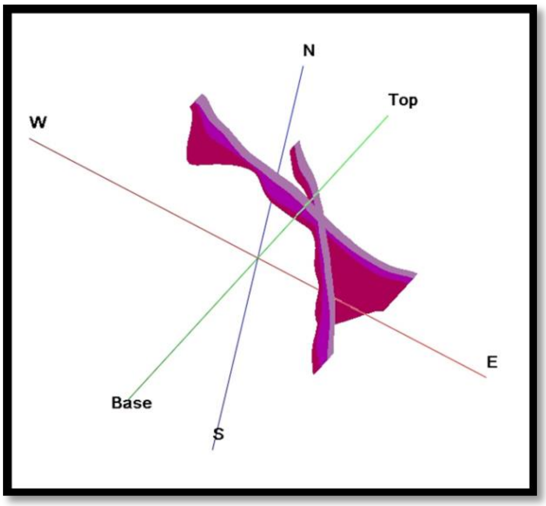

CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
JANUARY, 2023

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

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AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN HANAMKONDA DISTRICT, TELANGANA STATE

Executive summary

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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	:	Hectare
Ha.m	:	Hectare 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

The Hanamkonda district having geographical area of 1312.02 km2 lies between north latitudes from 16°15´0" N to 17°45´0" N and east longitudes from 79°15´0" E to 79°45´0" E located in the east of Telangana State. The location map of the study area is presented in Fig.1.1. The District shares boundaries with (02) Districts i.e., Jayashankar Bhupalpally and Karimnagar on the North and North-Eastern side, Mulugu on the eastern side, Siddipet in North West side, Jangaon Districts in South-West direction and Warangal Districts in Southeastern side of Telangana State. The District headquarters is located at Hanamkonda City. It is part of the River Godavari and River Krishna basin. Administratively the area is governed by 2 revenue mandals covering 163 villages with a population of ~10.6 lakhs (2011 census) (urban: ~53.1%, rural: ~46.9 %) with average density of 642 persons/km2.

The district is characterised by undulating topography with hill ranges, valleys and plains. Pedeplain is the major landform covering about 93% of the area. The other landforms observed are pediment (5%), structural hills (1%), channel Fill (<1 %), intermontane valleys, channel bar and valley fills .

Hanamkonda district soil can be broadly grouped into 2 classes and 6 sub classes. Broadly area is occupied by loamy soils (63 %) followed by clayey soils (36%), Clayey-skeletal soils which cover 12 % , Fine mixed soils which cover 55 % , Montmorillonitic soils, which cover 23 % , Loamy-skeletal which cover 8 % and Rock lands cover 2% area of the district.

Out of the total geographical area of 1312.02 km2, agriculture and non-agricultural are the prominent land use aspects in Warangal (Rural) district and forms 45.72 % and 13.36 % of total area respectively. The net sown area is 599.84 km2 while the gross cropped area is 868.54 km2. There are wide varieties of crops grown in the district. Paddy and Cotton are the major crop grown in the district (70% and 25 %).

Sri Rama Sagar Project (SRSP) Reservoir is located across the Godavari River near Pochampad (v) in Nizamabad District is a Multipurpose Irrigation Project. The Stage–I of the Project contemplates to provide Irrigation facilities to an extent of 9.69 lakh acres. It also provides drinking water to urban & rural areas along the canal system, particularly Karimnagar and Warangal towns. It also meets the water demands of National Thermal Power Corporation at Ramagundam. In addition to the above, 4 Units of 9 MW each to generate 36 MW have also been set up on the right side in the non-overflow portion of the Masonry Dam at Sriramsagar Reservoir.

The Flood Flow Canal (FFC) project envisages Irrigation facility to an area of 2.2 lakh acres in the drought prone areas of Telangana region duly diverting about 20 TMC of surplus waters from Sriramasagar Project during floods and storing in Balancing reservoirs. Under Re-Engineering of the FFC project, the ayacut has been increased to 2.52 lakh acres. This project envisages irrigating an ayacut of 220000 Acres in erstwhile Karimnagar & Warangal Districts. In re-engineering the ayacut has increased to 2,52,882 acres.

In the district there exists 137 percolation tanks and 45 check dams. Under Mission Kakatiya (Phase 1 to 4), 320 tanks have been undertaken under RRR (Repairs, restoration and Rejuvenation) schemes. A total of 680 minor irrigation tanks exist in the district with an ayacut of 44,881.47 acres. In the district there are 31,143 irrigation wells (24,145 dugwells and 6998 tubewells). There is 1 lift irrigation schemes existing in the district creating an irrigation potential of 315 Acres

Water level is monitored through 26 groundwater monitoring stations of both CGWB and SGWD (CGWB: 11, SGWD: 15)) during pre and post-monsoon season. The pre-monsoon depth to water levels ranged between 3.00 m bgl (Warangal) and 28.44 bgl (Inavolu 2010Pz). The post-monsoon depth to water levels ranges between1.33 m bgl (Warangal) and 18.92 m bgl (Inavolu 2010Pz).. The water table elevation ranges from 219.82 to 360.13 m amsl during pre-monsoon period and 223.94 to 366.30 m amsl during post-monosoon period. The groundwater flow is mainly towards southern direction.

100% (26 no's) of the wells show rise in water level and no wells show fall in water level. The analysis of water level fluctuation data indicates that maximum water level fluctuation was observed at Velair-DW13 (11.82 m) while minimum water level fluctuation was observed at Elkathurthy (1.21 m). The analysis indicates that majority of the area (57.5%) are falling in less fluctuation range indicating good aquifer storage, whereas moderate water level fluctuations are observed in 42.21 % area and high water level fluctuation of more than 10m are observed in 0.17 % area in the district.

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data from 08 hydrograph station (CGWB:08, SGWD:0) for pre-monsoon and 09 hydrograph station (CGWB:09, SGWD:0) for post-monsoon for the period 2011-20 have been computed and analyzed. The decadal pre-monsoon water level trend analysis indicates that 05 wells show falling trend (>1.0 m: 0, 0-0.5 m: 4 wells, > 0.5 m: 1 well) (max fall: 0.59 m/yr) and 03 well shows rising trend (0-0.5: 03 well) (maximum rise: 0.31 m/yr). For the post monsoon data from 09 hydrograph station (CGWB: 09, SGWD:0) for the period 2011-20 have been computed and analyzed During post-monsoon season 03 wells show falling trend (0-0.5m: 2, >0.5: 1) (maximum fall: 0.96m/Yr) and 06 wells shows rising trends (0-0.5 m: 6) (max rise: 0.48m/yr).

On the basis of occurrence and movement of ground water, rock units of the district can be broadly classified as consolidated formation (Archean crystalline and metasedimentary formation) which occupies approximately 100 % of the area.

In consolidated formations, weathered zone forms the unconfined aquifer. The weathered zone (~22.1 m) consisting of upper saprolite and lower sap rock . Thickness of weathered zone is in the range of 10-20 m in about ~76% % of area, shallow weathering (< 10 m) occurs in 23 % % while deep weathering (> 20 m) is seen only in 1% of the area. The depth of fracturing varies from 4.5 m to 70 m (deepest fracture encountered at Dharmapuram). Based on CGWB data, it is inferred that fractures in the range of 10 to 30 m depth are more predominant (90 % of the area); 0 to 10 m and 30 to 50 fractures occur in 1 % and 8 % of area respectively and deep fractures (50 to 70) are observed in only 1 % of the area. Ground water yield in this zone varies from 0.01 to 5 lps. The transmissivity (T) varies from 1 to 36.1 m2/day (avg: 1.63 m2/day) and storativity varies from 0.0001 to 0.001.

Total 55 ground water samples (Pre-monsoon: 21 and Post-monsoon:3 4) were analysed for understanding groundwater quality of the district. In 98 % and 100 % of area EC is in the range of < 3000 µ Siemens/cm during pre and post-monsoon season respectively. During pre-monsoon season, concentration of NO_3 ranges from 2.41-379 mg/L and found that in 47.6 %of samples nitrate is beyond maximum permissible limit of BIS (45 mg/l) and F concentration varies from 0.41 to 8.51 mg/L and found that in 19% samples it is beyond maximum permissible limits of BIS (1.5 mg/l). During post-monsoon season, concentration of NO_3 ranges from 3.22-211.38 mg/L and found that in 42 % of samples it is beyond maximum permissible limit of BIS (45 mg/l). The F concentration varies from0.07-8.02 mg/L mg/l and found that in 23.5 % it is beyond maximum permissible limit of BIS.

Net dynamic replenishable ground water availability is 189.62 MCM, gross ground water draft is 118.12 MCM, provision for drinking and industrial use for the year 2025 is 52.79 MCM and net available balance for future irrigation use is 71.25 MCM. The stage of ground water development is 62 % .

Major issues identified are low ground water potential (< 1 lps) in some 52% of area particularly in consolidated granitic formation, high fluoride concentration (>1.5 mg/L) occur in 19 % and 23.5 % % of the samples during pre and post-monsoon season, high EC concentration (> 3000 micro-seimens/cm) in 2 % of the area during pre-monsoon and post-monsoon seasons respectively, High nitrate (> 45 mg/L) occur in47.6 % and 42 % of the samples during pre-monsoon and post-monsoon season respectively.

The overall groundwater scenario and regime of the district is good except a minor quality issues and few areas of low groundwater potentiality. However, considering the dependency on groundwater and further to maintain the sustainability, few supply side and demand side measures have been recommended. In the granitic area, the artificial recharge structures recommended to improve the overall sustainability and recharge the Aquifer-I which is mainly of weathering part.

The management strategies mainly include supply side management. The supply side measure includes ongoing work under Mission Kakatiya where de-silting of existing minor tanks (680no.) was taken under state Govt. sponsored Mission Kaktiya (Phase-1 to 4) to remove silt and this has created additional surface storage and enhance groundwater recharge.

Under Mission Bhagiratha, all the villages and towns are proposed to be covered from the two water grids with intake from 1) Lower Manair Dam (Segment- LMD MHH), 2) Lower Manair Dam (Segment- LMD WGL) to provide protected water from surface reservoirs. The scheme is to enhance the existing drinking water scheme and to provide safe drinking water to 75914 no. of households.

As the stage of ground water development in the district is 62 % and 06 out of 11 mandals are falling in safe category as per the GEC 2020 estimation, the artificial recharge structures are not proposed for entire district. To control further increase in stage of ground water development, artificial recharge structures are recommended in 3 semi-critical mandals (i.e. Elakathurthy, Inavolu and Warangal) and 2 Over Exploited mandals (i.e. Velair and Bheemdevarapally) only which includes construction of 96 artificial recharge structures (57 CD’s and 39 PT’s) with a total cost of 16.3 cores are recommended as supply side measures. ~3500 ha of additional land that can be brought under micro-irrigation (@1000 ha /mandal including existing area in 3 semi-critical mandals and 2 over-exploited mandals costing about 21 crores (considering 1 unit/ha @0.6 lakh/ha). With this 5.25 MCM of ground water can be conserved over the traditional irrigation practices.

In addition to this roof top rainwater harvesting structures should be made mandatory to all Government buildings.

Other measure includes strict implementation of WALTA and participatory groundwater management (PGWM). With the above interventions, the likely benefit would be the net saving of 8.05 MCM of ground water, which can bring down the stage of ground water development by 2.3 % (from 62 % to 59.7%).

1. INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. In recent past, there has been a paradigm shift from "**ground water development**" to "**ground water management**". As large parts of India particularly hard rocks have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of ground water in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust ground water 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. Thus the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of ground water management through community participation.

Crystalline rock's (Granites/Gneisses) lack primary porosity, and ground water occurrence is limited to secondary porosity developed by weathering and fracturing. Weathered zone is the potential recharge zone for deeper fractures and excessive withdrawal from this zone leads to drying up in places and reducing the sustainability of structures. Besides these quantitative aspects, ground water 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 pollution viz., 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 ground water management plan on 1: 50,000 scale.

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

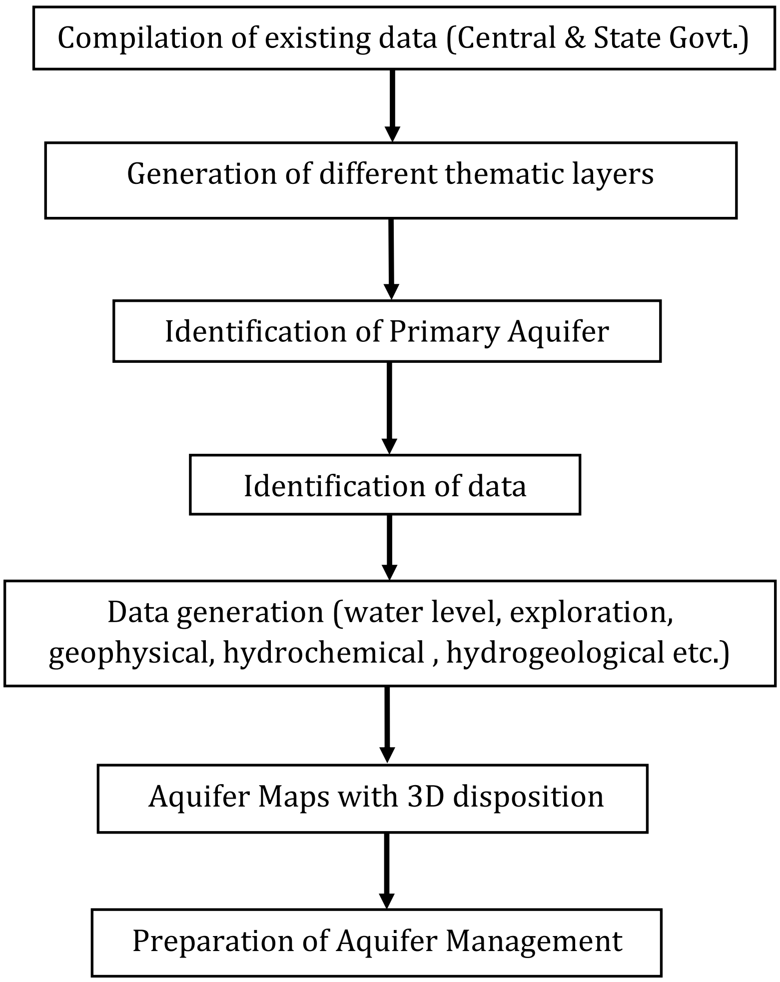
1. Compilation of existing data (exploration, geophysical, ground water level and ground water quality with geo-referencing information and identification of principal aquifer units.
2. Periodic long term monitoring of ground water regime (for water levels and water quality) for creation of time series 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. Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.
6. Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.1 Approach and Methodology

The ongoing activities of NAQUIM include toposheet wise micro-level hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200- 300 meters.

Considering the objectives of NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.2 Study area

The Hanamkonda district having geographical area of 1312.02 km^2 lies between north latitudes from 16°15´0" N to 17°45´0" N and east longitudes from 79°15´0" E to 79°45´0" E located in the east of Telangana State. The location map of the district is presented in Fig.1.1. The district shares boundaries with Jayashankar Bhupalpally and Karimnagar on the north and north-eastern side, Mulugu on the eastern side, Siddipet in north west side, Jangaon Districts in south-west direction and Warangal Districts in southeastern side of Telangana State. The district headquarters is located at Hanamkonda City. (**Fig.1.1**). Administratively the area is governed by 2 revenue mandals covering 163 villages with a population of ~10.6 lakhs (2011 census) (urban: ~53.1%, rural: ~46.9 %) with average density of 642 persons/km^2.

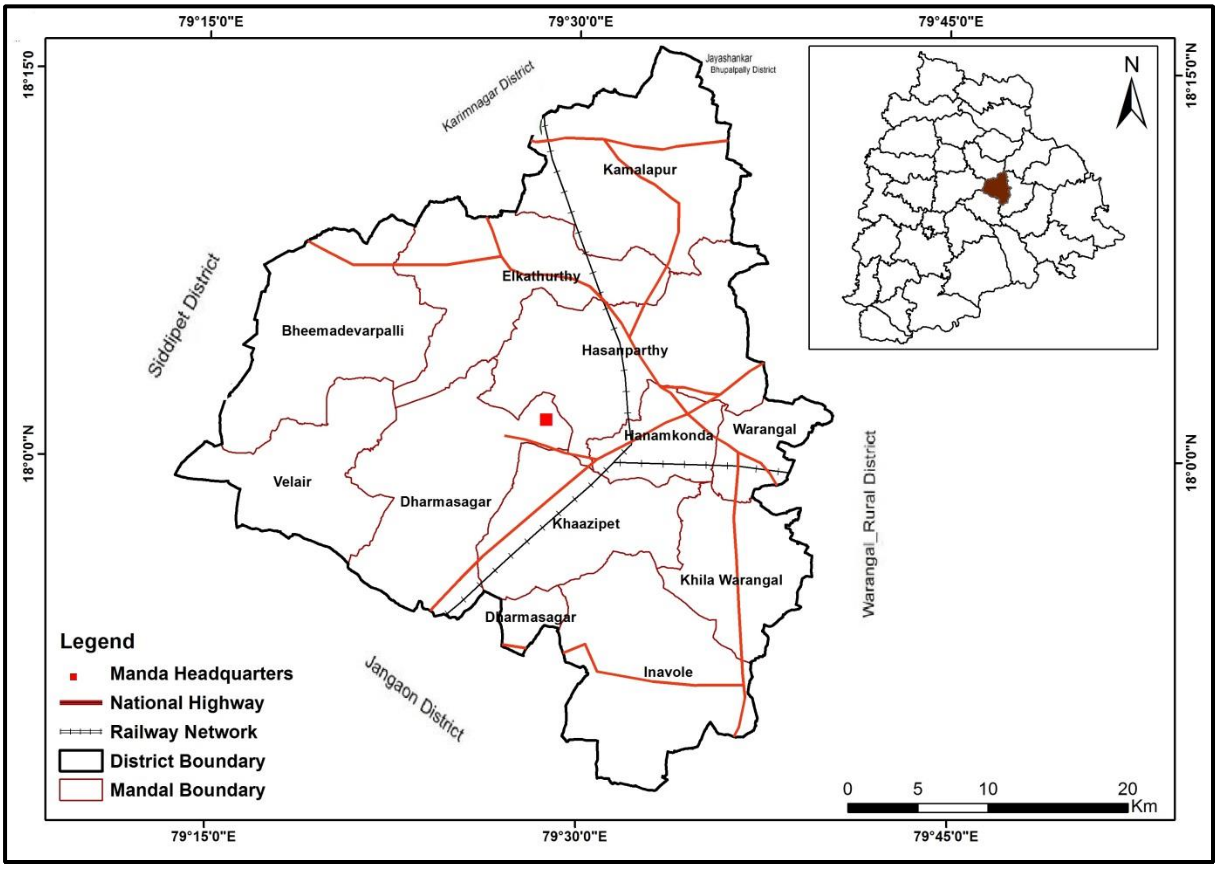


Fig.1.1: Location map of Hanamkonda district.

1.3 Climate and Rainfall

The climate of the district is characterised by hot summer and cool winters with a fairly good amount of seasonal rainfall. The normal mean daily minimum and maximum temperature is 5.6 °C and 47.6 °C. The annual normal rainfall of Warangal district is 889.50 mm which ranges from 991.2 mm at Khilla Warangal Mandal to 754 mm at Dharmasagar Mandal. The area receives more than 80 % of the annual rainfall by southwest monsoon between June and September and the rest during the northeast monsoon from October to November. As per Indian Meteorological Department for the year 2021, it received average annual rainfall of

1,755.7 mm (97 % more rainfall than normal rainfall). The isohyetal map of the district is presented in **Fig.1.2a.**

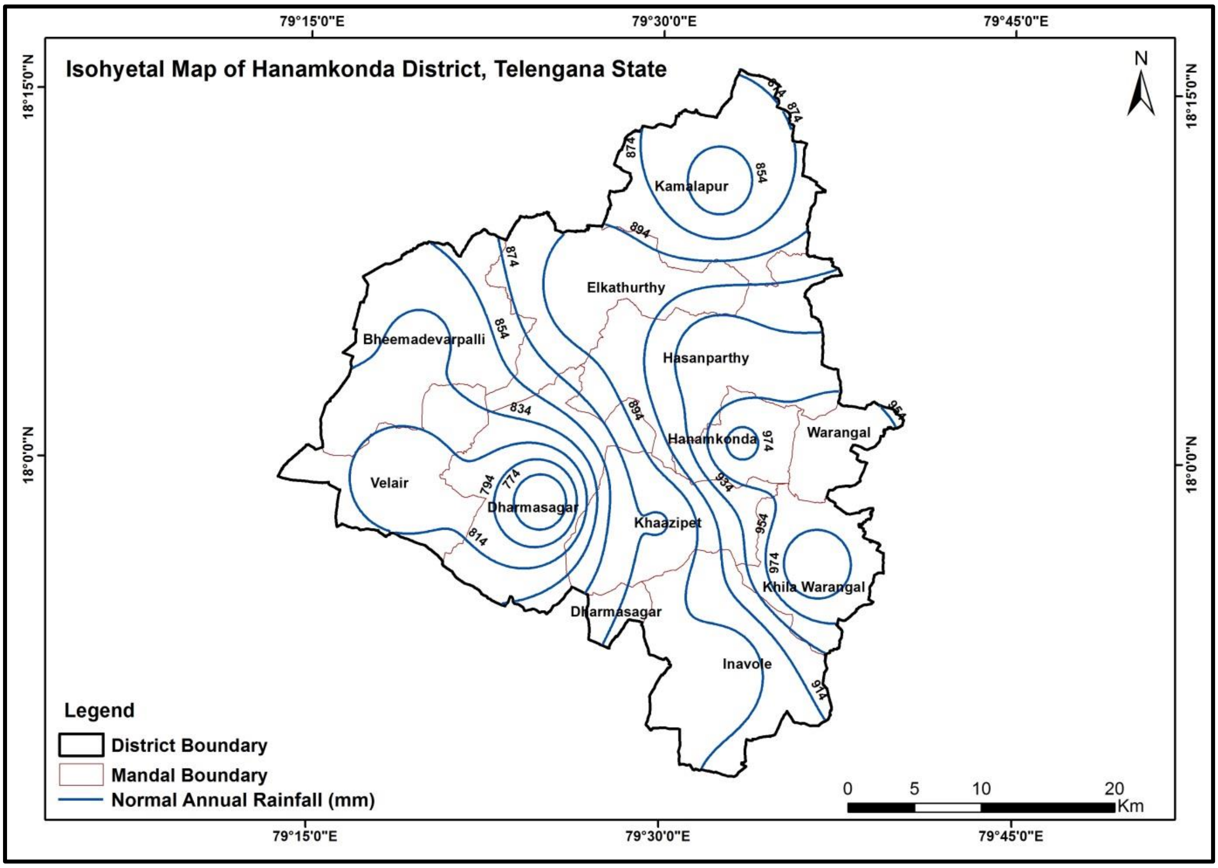


Fig.1.2a: Isohyetal map of Hanamkonda district.

Analysis of long term rainfall data of 17 years from 2004-05 to 2021-22 shows decreasing trend in annual rainfall by 31.2 mm/year. District received excess rainfall (+20% and above normal) in 2010-11, 2012-13, 2013-14, 2016-17, 2019-20 2020-21, and 2021-22, deficient rainfall (-20% and below normal) in 2004-05, 2009-2010, 2011-12 and 2014-15 and normal rainfall (-19% to +19%) in remaining years (**Fig.1.2b)**. The monthly rainfall time series analysis for 17 years from 2004-05 to 2021-22 shows increasing trend in monthly rainfall for January, February, April, May, June, July, August, September and October months (0.92, 0.10, 0.44, 0.84, 8.5, 5.77, 13.19,0.76 & 3.36 mm/year respectively) and decreasing trend for March , November and December (-1.59, -0.96, -0.18 mm/year) (**Fig. 1.2c**).

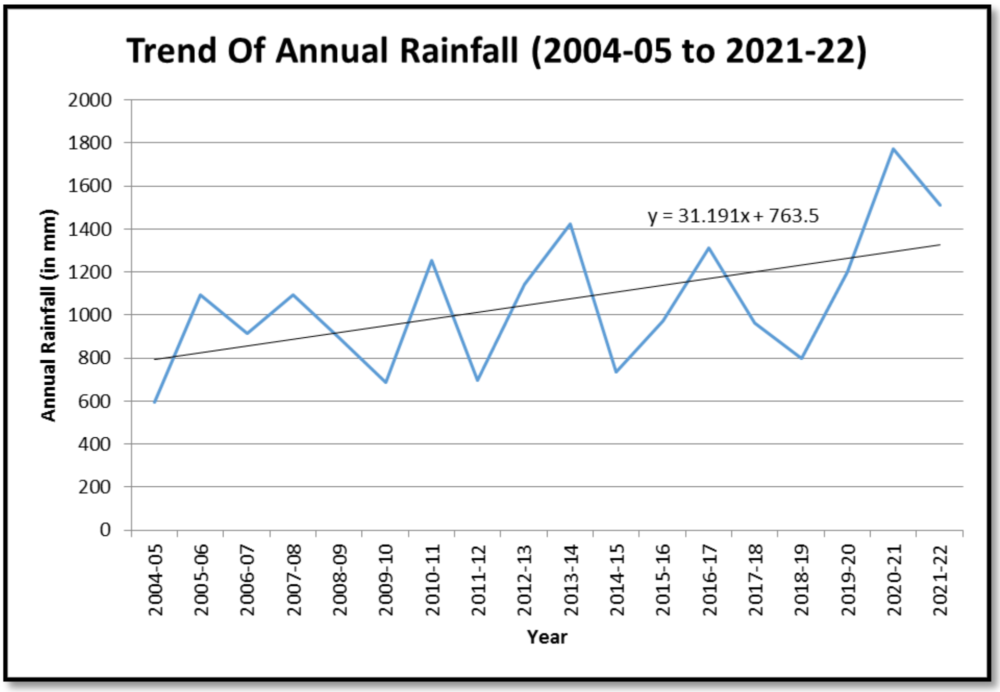


Fig.1.2b: Annual rainfall trend (2005-2021)

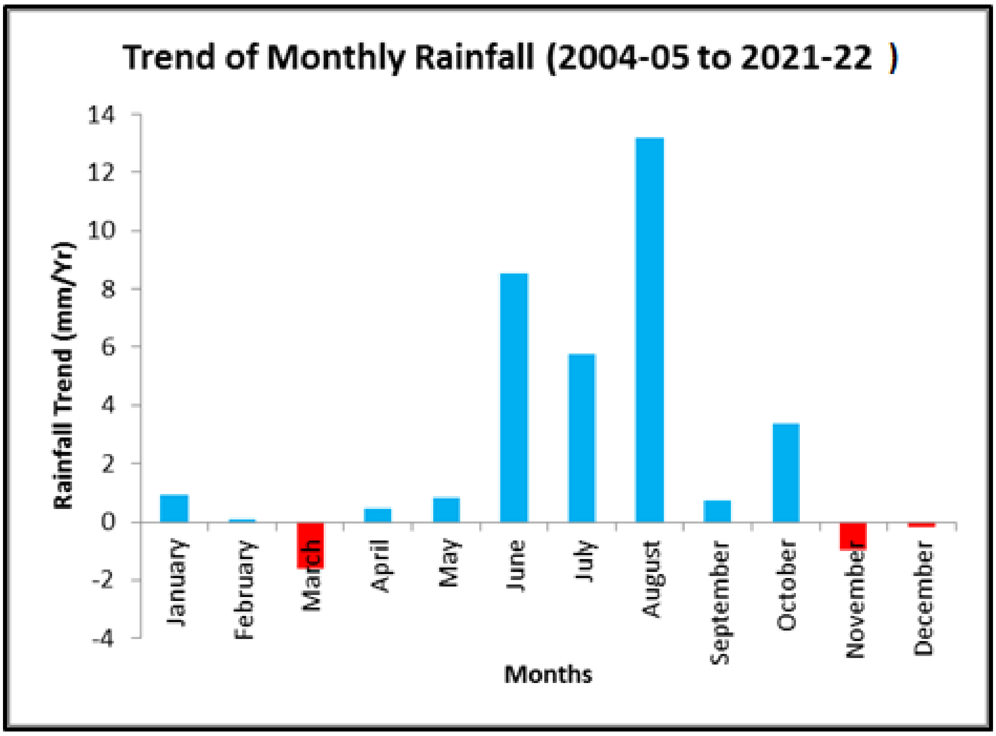


Fig.1.2c: Monthly rainfall trend (2005-2021)

1.4 Geomorphological Set up

The district is characterised by undulating topography with hill ranges, valleys and plains. Pediplain is the major landform covering about 93% of the area. The other landforms observed are pediment (5%), structural hills (1%), channel fill (<1 %), intermontane valleys, channel bar and valley fills .

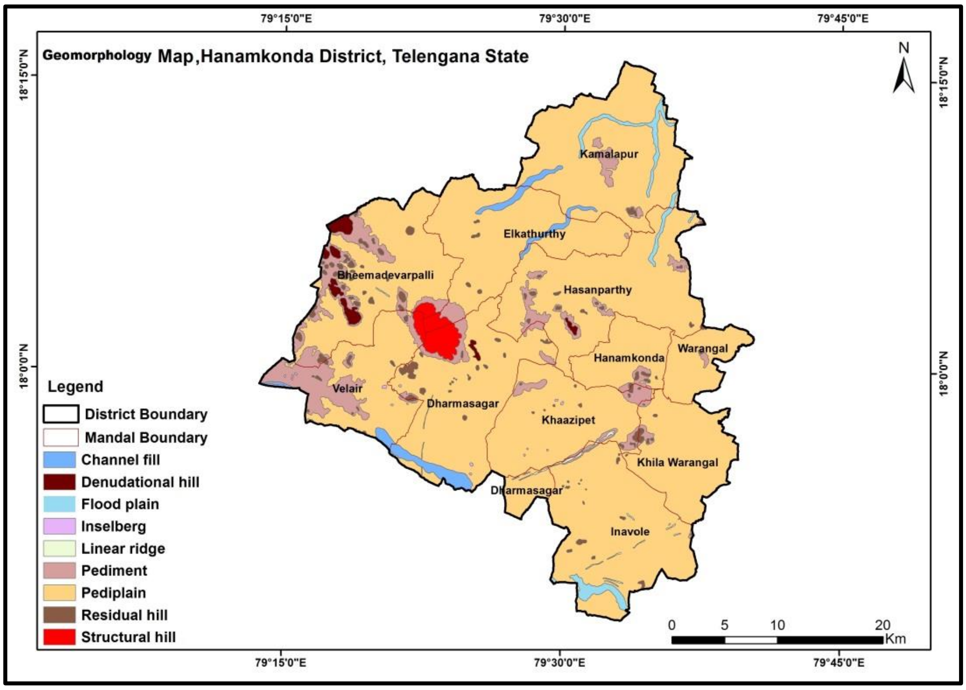


Fig.1.3: Geomorphology map of Hanamkonda district.

1.5 Drainage and Structures

The district forms part of Krishna river basin and Muneru, Paler sub basins. The district is drained by tributaries of Krishna River. No major river flows through the district. The drainage pattern in the area is dendritic to sub-dendritic in nature. Map depicting drainage, water bodies, and river is presented in **Fig.1.4.**

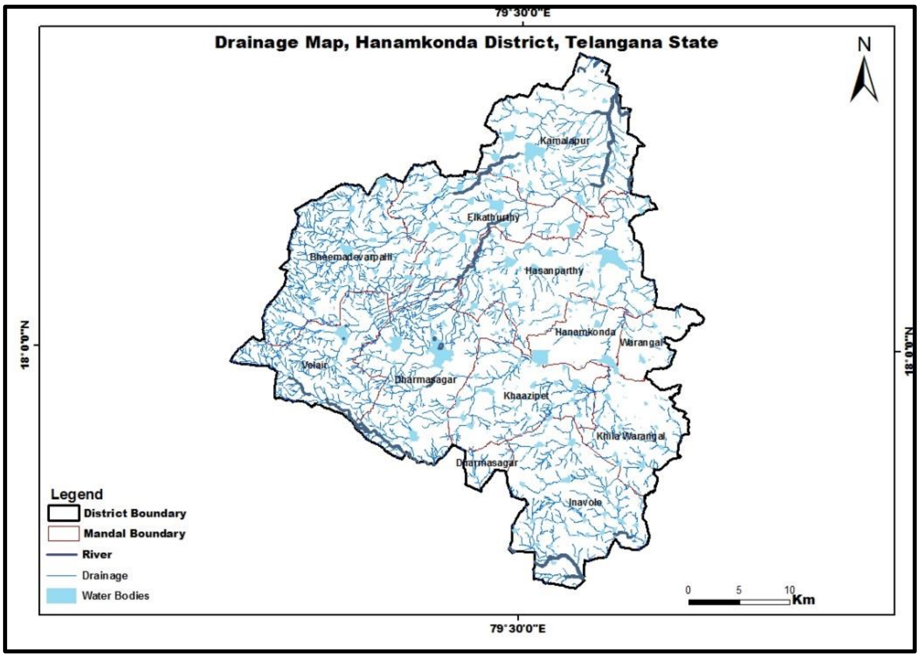


Fig.1.4: Drainage map of Hanamkonda district

1.6 Land use and cropping pattern

Out of the total geographical area of 1312.02 km^2, agriculture and non-agricultural are the prominent land use aspects in Hanamkonda district and forms 45.72 % and 13.36 % of total area respectively. The spatial distribution of land use is presented in **Fig. 1.5.**

The land utilization of Hanamkonda district is given in Table 1.1 and crop distribution is given in table 1.2.

Table: 1.1 Land utilisation in Hanamkonda District

Land Utilisation	%age to Geographical Area
Forest	2.35 %
Barren and Uncultivable	9.20 %
Land put to Non-Agricultural uses	13.36 %
Culturable Waste	4.31 %
Permanent pasture and Other Grazing lands	5.18 %
Land under Miscellaneous Tree, Crops, Grovers (Not included in Net Sown Area)	1.66 %
Current Fallow Land	10.03 %
Other Fallow Land	8.20 %
Net Area sown	45.72 %
Total Geographical Area	**100 %**

Source: Telangana Statistical Abstract, 2021-22

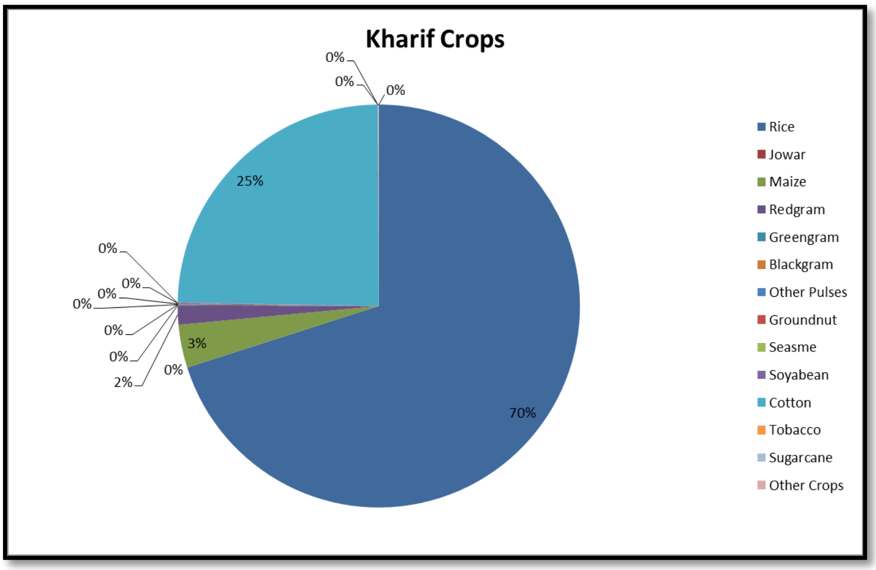
The net sown area is 599.84 km^2 while the gross cropped area is 868.54 km^2. There are wide varieties of crops grown in the district. Paddy and Cotton are the major crop grown in the district. Among various crops grown, the climate is most favourable for maize, pulses and chillies. Other crops grown here include jowar, bajra, cowpea, ground nut, sesam, cantor, sunflower, sugarcane and tobacco. Wide range of horticulture crops like mango, banana, cashew, coconut, palm oil, cocoa, pepper, arecanut are also grown.

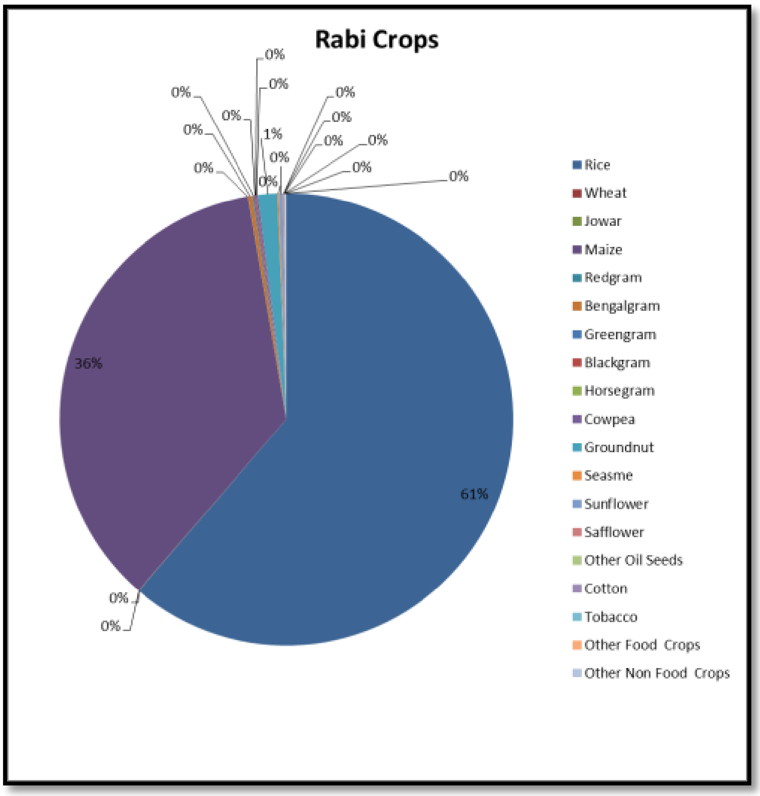
Table: 1.2 Crop distribution in Hanamkonda district

Kharif		Rabi	
Crops	**Area (Acre)**	**Crops**	**Area (Acre)**
Rice	124527	Rice	93621
Jowar	15	Wheat	12
Maize	6123	Jowar	25
Redgram	2719	Maize	54908
Greengram	134	Redgram	25
Blackgram	1	Bengalgram	488
Other Pulses	16	Greengram	211
Groundnut	171	Blackgram	165
Seasme	10	Horsegram	8
Soyabean	74	Cowpea	197
Cotton	43850	Groundnut	2104

Tobacco	8	Seasme	178
Sugarcane	1	Sunflower	408
Other Crops	106	Safflower	119
Wheat	0	Other Oil Seeds	27
Cowpea	0	Cotton	21
Sunflower	0	Tobacco	58
Safflower	0	Other Food Crops	4
Other Non Food Crops	0	Other Non Food Crops	148
Total	**1,77,755**	**Total**	**1,52,727**

Source: Telangana Statistical Abstract, 2021-22





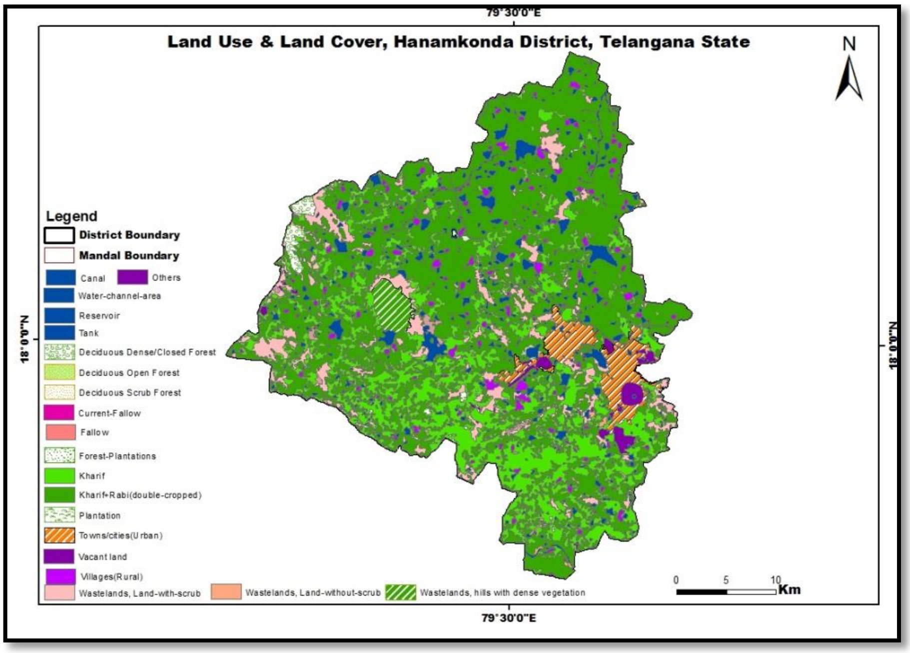


Fig.1.5: Land use and land cover of Hanamkonda district.

1.7 Soils

Hanamkonda district soil can be broadly grouped into 2 classes and 6 sub classes. Broadly area is occupied by loamy soils (63 %) followed by clayey soils (36%). Clayey-skeletal soils which cover 12 % of the district have 35 percent by volume fragments coarser than 2 mm, Fine mixed soils which cover 55 % of the district have a clayey particle size that has 35 to 60 percent clay in the fine earth fraction. Montmorillonitic soils, which cover 23 % of the district more than half montmorillonite and *nontronite* by weight, or have a mixture of clays with more montmorillonite than any other single clay mineral. Loamy-skeletal which cover 8 % of the district soils have 35 percent by volume fragments coarser than 2 mm, with enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is defined as loamy. Rock lands cover 2% area of the district.

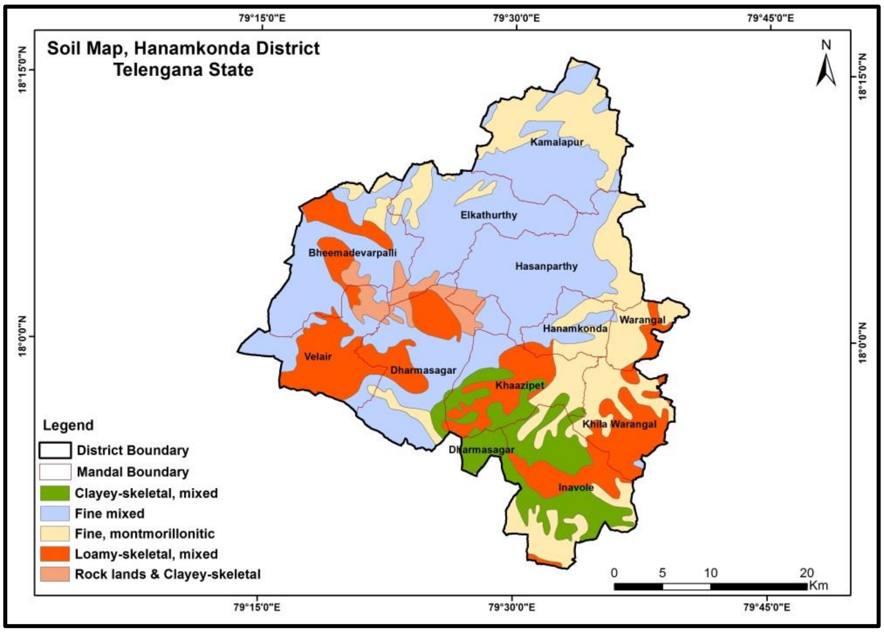


Fig.1.6: Soil map of Hanamkonda district

1.8 Irrigation

Major Irrigation Projects:

Table: 1.3 Medium Irrigation Project

Name of the Project	IP Irrigation Project) (in Acres)
Indiramama Flood Flow Canal	37056
Sri Rama Sagar Project (SRSP) Stage I	3,64,078

Sri Rama Sagar Project (SRSP) Reservoir is located across the Godavari River near Pochampad (v) in Nizamabad District is a Multipurpose Irrigation Project. The Stage–I of the Project contemplates to provide Irrigation facilities to an extent of 9.69 lakh acres. It also provides drinking water to urban & rural areas along the canal system, particularly Karimnagar and Warangal towns. It also meets the water demands of National Thermal Power Corporation at Ramagundam. In addition to the above, 4 Units of 9 MW each to generate 36 MW have also been set up on the right side in the non-overflow portion of the Masonry Dam at Sriramsagar Reservoir.

The Flood Flow Canal (FFC) project envisages Irrigation facility to an area of 2.2 lakh acres in the drought prone areas of Telangana region duly diverting about 20 TMC of surplus waters from Sriramasagar Project during floods and storing in balancing reservoirs. Under Re-Engineering of the FFC project, the ayacut has been increased to 2.52 lakh acres. This project envisages irrigating an ayacut of 220000 Acres in erstwhile Karimnagar & Warangal Districts. In re-engineering the ayacut has increased to 2,52,882 acres. **(Fig 1.8, Table: 1.3).**

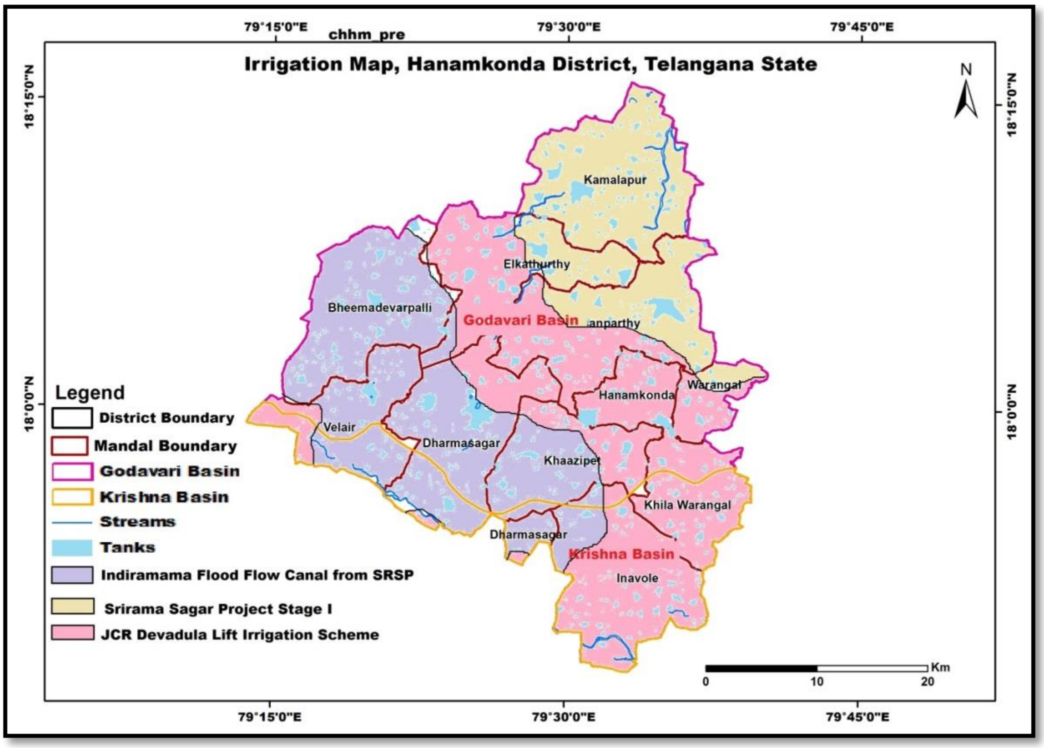


Fig. 1.7 Irrigation project in Hanamkonda district

Lift Irrigation Schemes:

JCR Devadula Lift Irrigation Scheme: J.Chokka Rao Devadula Lift Irrigation Scheme envisaged with lifting of 38.16 TMC water from Godavari River near Gangaram (V), Eturunagaram (M), Warangal District of Telangana to irrigate 6.21 Lakh Acres in upland drought prone areas of Karimnagar, Jayashankar Bhupalpally, Warangal (U), Warangal (Rural), Siddipet, Yadadri, Jangaon and Suryapet Districts creating an irrigation potential of 315 Acres in Hanamkonda (Source: Telangana state statistical abstract-2020).

Minor Irrigation Tanks:

A total of 680 minor irrigation tanks exist in the district with an ayacut of 44,881.47 acres. In the district there are 31,143 irrigation wells (24,145 dugwells and 6998 tubewells). (Source: Telangana state statistical abstract-2020).

1.9 Prevailing Water Conservation/Recharge Practices

In the district, there exists 137 percolation tanks and 45 check dams. Under Mission Kakatiya (Phase 1 to 4), 320 tanks have been undertaken under RRR (Repairs, restoration and Rejuvenation) schemes.

1.10 Geology

About ~ 98% of the area is underlain by crystalline rocks, namely granites, and 2% by Gneiss of Archaean to Proterozoic age. (**Fig1.8).**

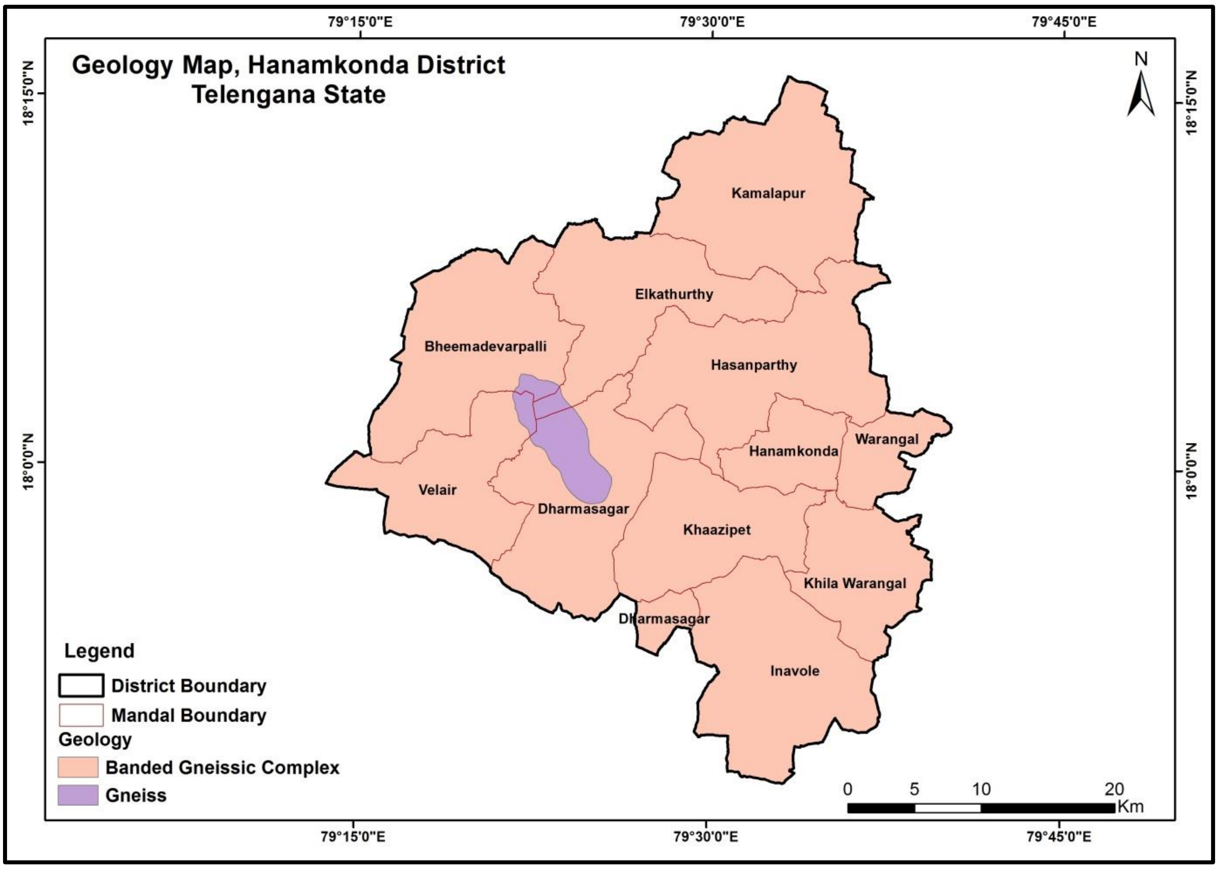


Fig.1.8: Geology map of Hanamkonda district.

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 ground water	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology and Geo-chemical. Creation of data base of Exploration Wells, delineation of Principal aquifers (vertical and lateral) and compilation of Aquifer wise water level and draft data.
		Identification of Data Gap	Data gap in 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.
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 data generation	Vertical Electrical Sounding (VES), bore-hole logging, 2-D imaging.
		Hydrological Parameters on ground water 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 ground water 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 and dissemination through training to administrators, NGO's, progressive farmers and stakeholders and putting in public domain.

The aquifer geometry for shallow and deeper aquifer has been established by utilising the data generated through various hydrogeological exploration, surface and subsurface geophysical studies in the district. The data used for the integration and interpretation is explained in the following sections:

2.1 Ground Water Exploration

CGWB had constructed 12 bore wells at different depths in the Hanamkonda District (Table 2.2). Data analysed from CGWB wells indicates that 11 nos in the range of 30 to 100 m, and 01 nos in the range of 150-200 m depth. Deepest fracture was encountered at 70 m.bgl at Dharmapuram in consolidated granitic formation. The locations of exploratory wells are shown in **Fig. 2.1**.

Table-2.2: Ground Water Exploration wells

Source	Exploratory wells/ Observation wells
CGWB	12

2.2 Ground Water Monitoring Wells

Ground water level monitoring wells of **26** Wells **(**CGWB: **11,** SGWD: **15)** were utilized for the aquifer mapping studies. In order to understand the ground water level trend, current and historical water levels along with water level trend data for pre-monsoon 8 wells and post-monsoon season of 9 wells has been used**.** CGWB wells are being monitored four times (January, April, August and November) in a year whereas; the monitoring wells of State Ground Water Department (SGWD) are being monitored every month. These groundwater monitoring wells were used in order to understand the spatio-temporal behaviour of the ground water regime.The data is given in **Table-2.3** and locations of monitoring wells are shown in **Fig. 2.1.**

Table-2.3: Ground Monitoring wells

Source	No. of wells
CGWB	11
SGWD	15
Total	**26**

2.3 Ground Water Quality

To understand chemical nature of ground water, 21 (CGWB: 04, SGWD:17) and SGWD: 34 (SGWD: 34) water quality data for pre-monsoon season and post-monsoon season respectively were utilized in the analysis (Table 2.4.). 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 and locations of monitoring wells are shown in Fig. 2.1.

Table-2.4: Ground Water Sampling wells

Source	Pre-monsoon	Post-monsoon
CGWB	04	-
SGWD	17	34

2.4 Geophysical Studies

Geophysical data on VES and profiling are used to extract information on the weathered thickness, fracture depth and thickness of fractures in hard rock area. For the interpretation of the aquifer geometry, geophysical data in conjunction with the available groundwater exploration data is utilised. The data from 10 Vertical Electrical Soundings (VES) employing the Schlumberger electrode configuration with maximum electrode separation (AB) of 400 meters is used for the aquifer mapping studies **(Fig. 2.1)**. The data was processed and interpreted by IPI2Win software enveloped by Moscow State University, after marginally modifying the manually interpreted results in corroboration with geology and hydrogeology. The details of resistivity with change for various formations encountered in the district is given in **Table-2.5.**

Table-2.5: Resistivity values for various formations

Formation	Resistivity range (ohm-m)	Thickness (m)
Weathered granite/Gneiss	5-76	2-25
Fractured/Jointed/Semi-weathered Granite/Gneiss	100-400	30-90
Hard/compact granite/Gneiss	More than 500	

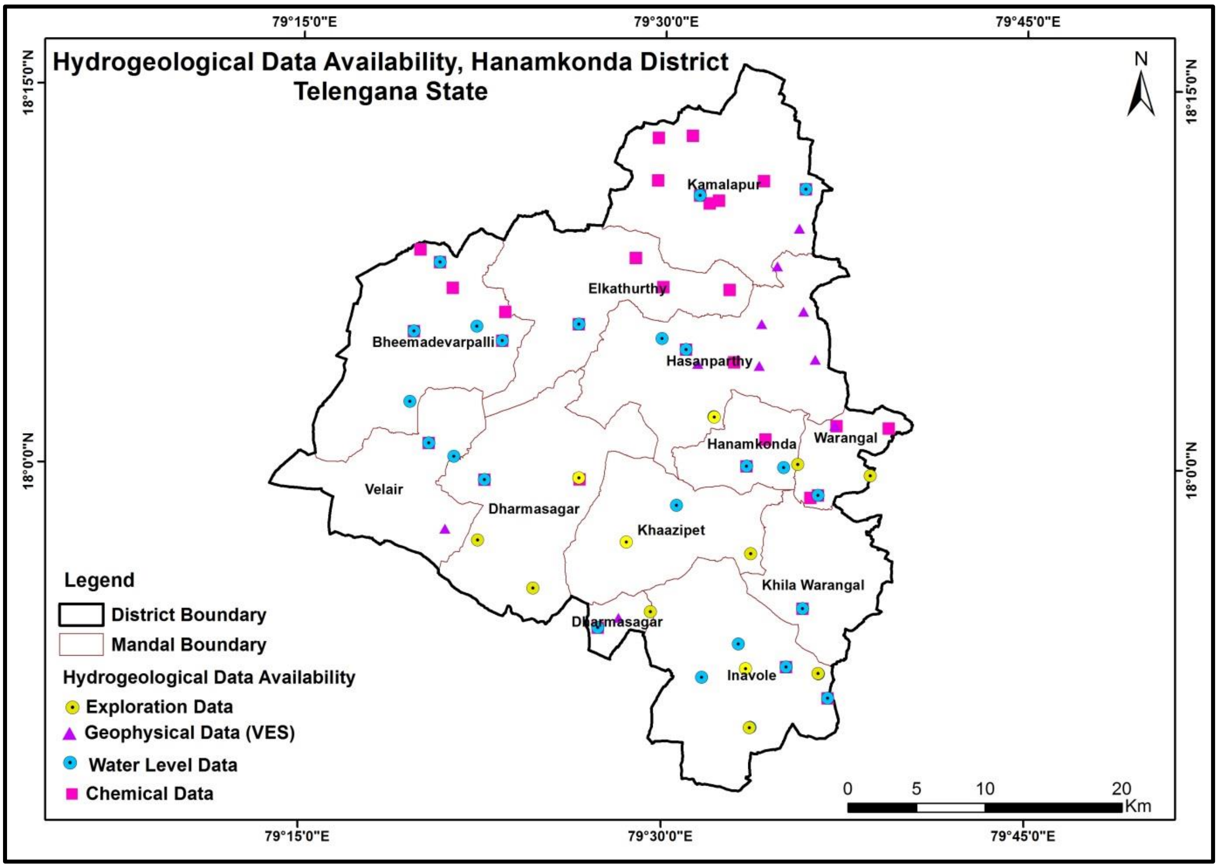


Fig.2.1: Hydrogeological Data availability

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation was interpreted and integrated. Based on this, various thematic layers such as hydrogeology, water level scenario of both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, yield potential, groundwater resources were generated and are discussed in detail in following sections.

3.1 Water Level Scenario The depth to water level scenario for 2020-2021 for pre-monsoon and post-monsoon season was generated by utilizing water level data of 26 (CGWB: 11, SGWD: 15) monitoring wells. The pre-monsoon depth to water levels ranged between 3.00 m bgl (Warangal) and 28.44 bgl (Inavolu 2010Pz). The shallow water levels of less than 3 mbgl are not observed in the district, whereas water levels between 3to5 mbgl are mainly observed in patches in the district of Khazipet and Hanamkonda (0.5 % of area). The water level in the range of 5to10 mbgl is observed in 43.2% of the district . The water level in the range of 10 to 20 mbgl is observed in major parts of the district (55.6 %). The deeper water levels of more than 20 m bgl is observed in parts of Inavole mandal (0.7 % of area). The pre-monsoon depth to water level map is given in Fig.3.1.

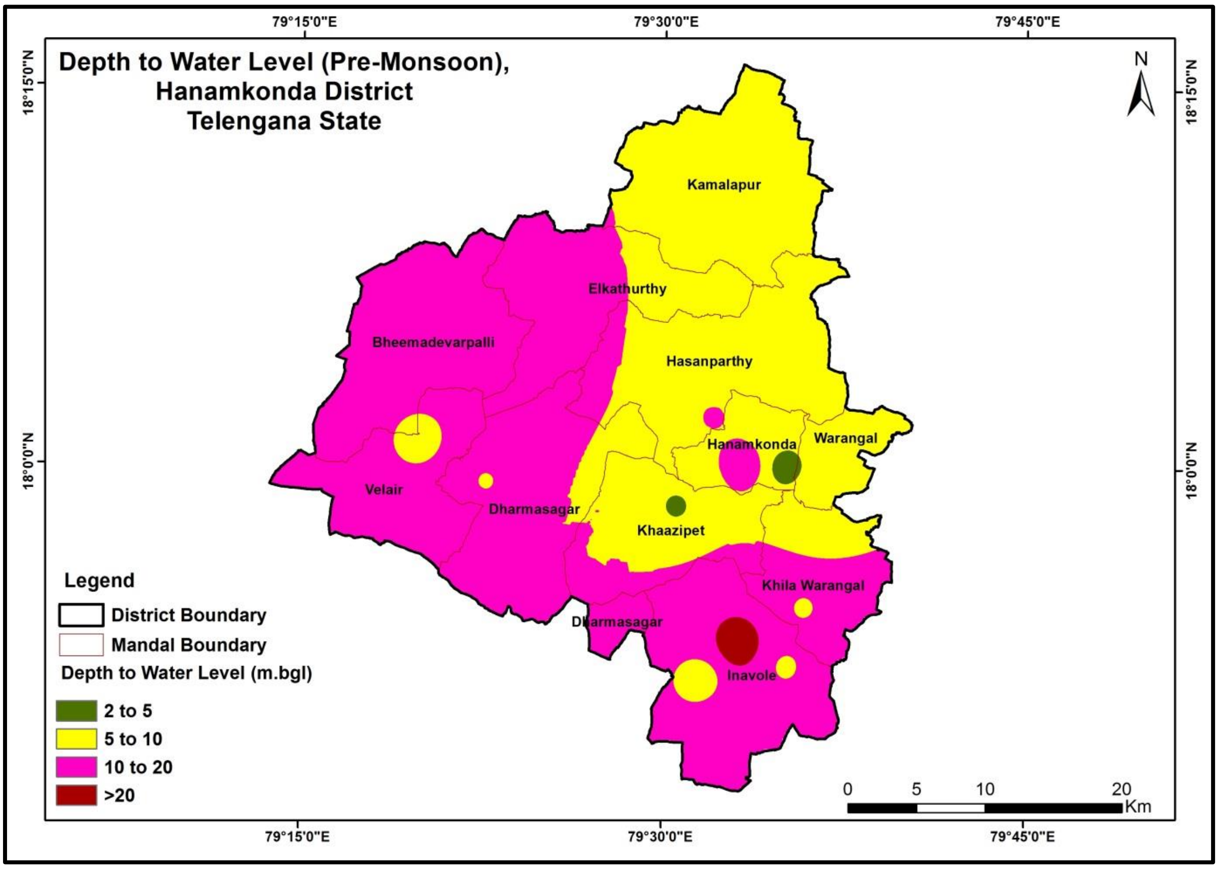


Fig.3.1: Depth to water level map of pre-monsoon season

The post-monsoon depth to water levels ranges between 1.33 m bgl (Warangal) and 18.92 m bgl (Inavolu 2010Pz). The water levels between 3 to 5 mbgl are observed in 39% of area of the district. Moderate water levels between 5 to 10 mbgl are observed in major parts of the district (59% of area). The deeper water levels of more than 10 mbgl are observed as isolated patch in Inavole and Elkathurthy mandal (2% of area). The post-monsoon depth to water level map is given in **Fig.3.2.**

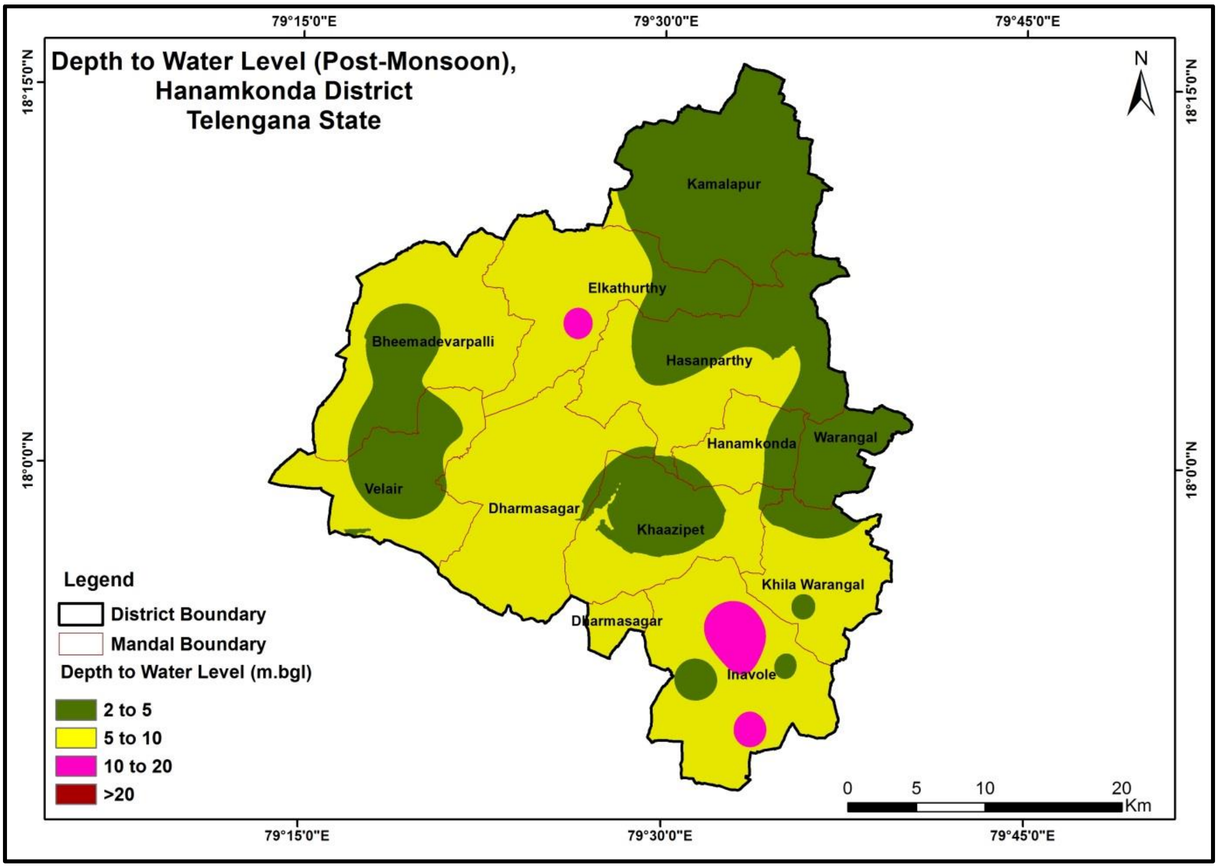


Fig.3.2: Depth to water level map of post-monsoon season

3.1.1 Water Level Fluctuation

The water level measured during pre and post monsoon period was used to compute the seasonal fluctuation. 100% (26 no's) of the wells show rise in water level and no wells show fall in water level. The analysis of water level fluctuation data indicates that maximum water level fluctuation was observed at Velair-DW13 (11.82 m) while minimum water level fluctuation was observed at Elkathurthy (1.21 m). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analysed (**Table-3.1**).

Table-3.1: Analysis of Water Level Fluctuation

S. No.	Category	Fluctuation Range	% of area
1.	Less water level fluctuation	0 to 5 m	57.5%
2.	Moderate water level fluctuation	5 to 10 m	42.21%
3.	High water level fluctuation	>10m	0.17%

The analysis indicates that majority of the area (57.5%) are falling in less fluctuation range indicating good aquifer storage, whereas moderate water level fluctuations are observed in 42.21 % area and high water level fluctuation of more than 10m are observed in 0.17 % area in the district. The seasonal fluctuation map is presented as **Fig.3.3**, the perusal of map indicates that fluctuation of upto 5 m is observed in major part of the district, whereas moderate fluctuation of more than 5 m is observed in parts of Bheemadevarpalli, Velair, Dharamsagar, Inavole and patches of Hasanparthy and Kamalapur mandals.

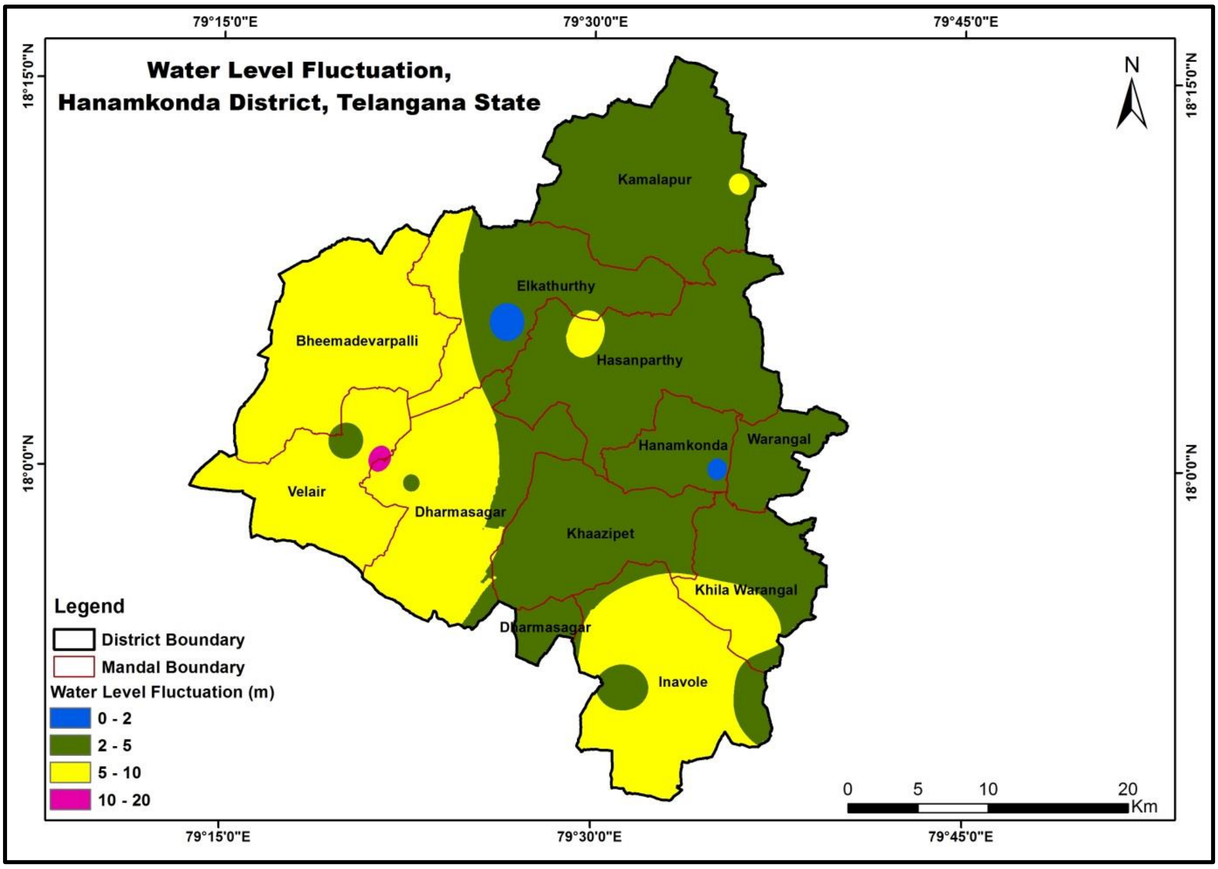


Fig.3.3: Seasonal Water Level Fluctuations (m) (post-monsoon with respect to pre-monsoon

3.1.2 Water Table Elevation

The water table elevation map for pre-monsoon and post-monsoon period was also prepared (**Fig. 3.4(a), 3.4(b)**) to understand the ground water flow directions. The water table elevation ranges from 219.82 to 360.13 m amsl during pre-monsoon period and 223.94 to 366.30 m amsl during post-monosoon period. The ground water flow is mainly towards southern direction.

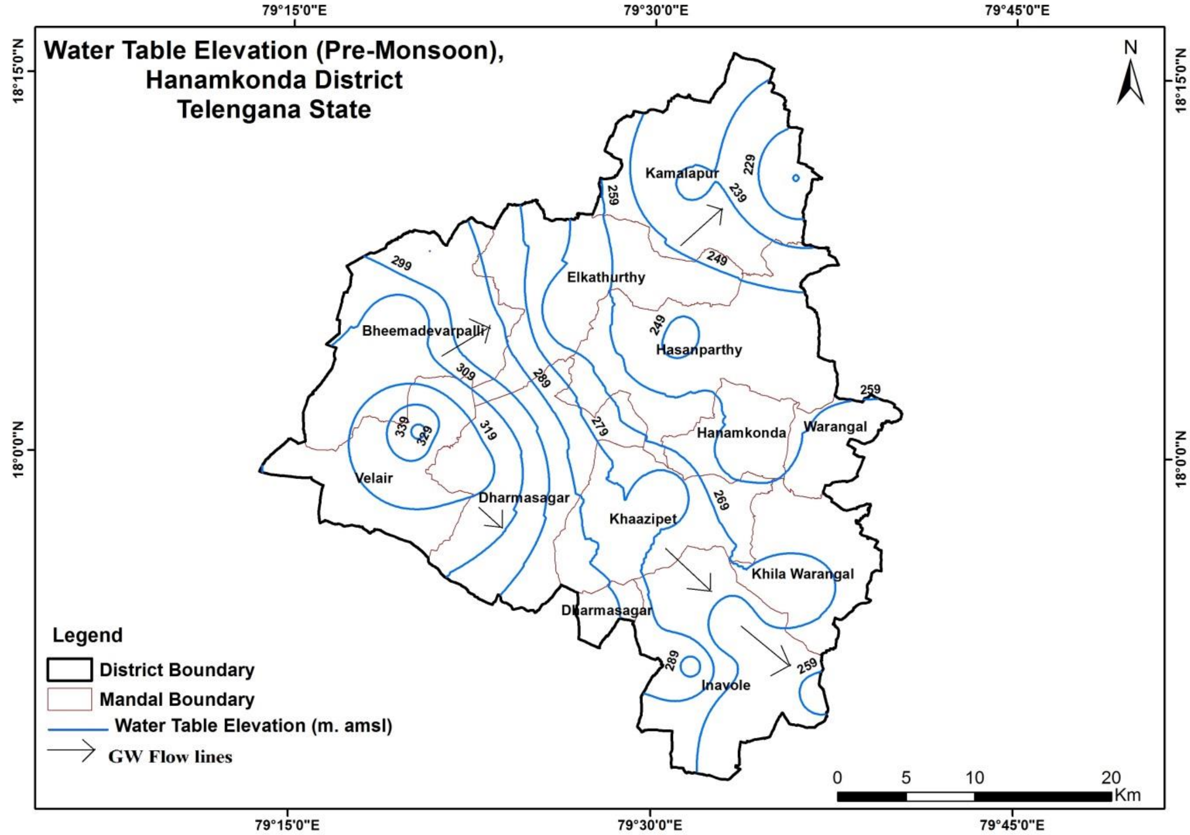


Fig.3.4 (a): Water table elevations (m amsl) during pre-monsoon season (Average: 2011-2020)

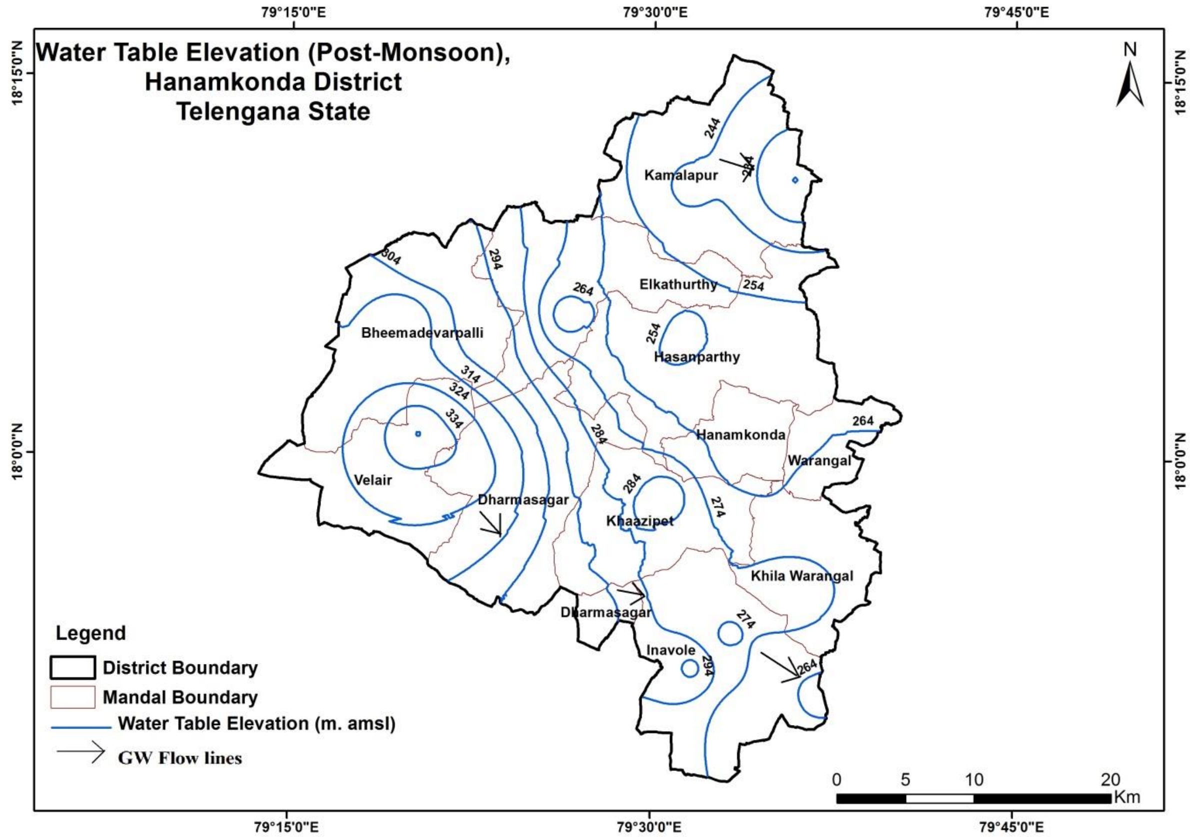


Fig.3.4 (b): Water table elevations (m amsl) during post-monsoon season (Average: 2011-2020)

3.1.3 Long Water Level Trend (2011-20)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data from 08 hydrograph station (CGWB:08, SGWD:0) for pre-monsoon and 09 hydrograph station (CGWB:09, SGWD:0) for post-monsoon for the period 2011-20 have been computed and analyzed. The decadal pre-monsoon water level trend analysis indicates that 05 wells show falling trend (>1.0 m: 0, 0-0.5 m: 4 wells, > 0.5 m: 1 well) (max fall: 0.59 m/yr) and 03 well shows rising trend (0-0.5: 03 well) (maximum rise: 0.31 m/yr). For the post monsoon, data from 09 hydrograph station (CGWB: 09, SGWD:0) for the period 2011-20 have been computed and analyzed During post-monsoon season 03 wells show falling trend (0-0.5m: 2, >0.5: 1) (maximum fall: 0.96m/Yr) and 06 wells shows rising trends (0-0.5 m: 6) (max rise: 0.48m/yr). The graphical representation of fall and rise is shown in **Fig.3.5** and spatial distribution map is shown in **Fig.3.6** and **3.7.**

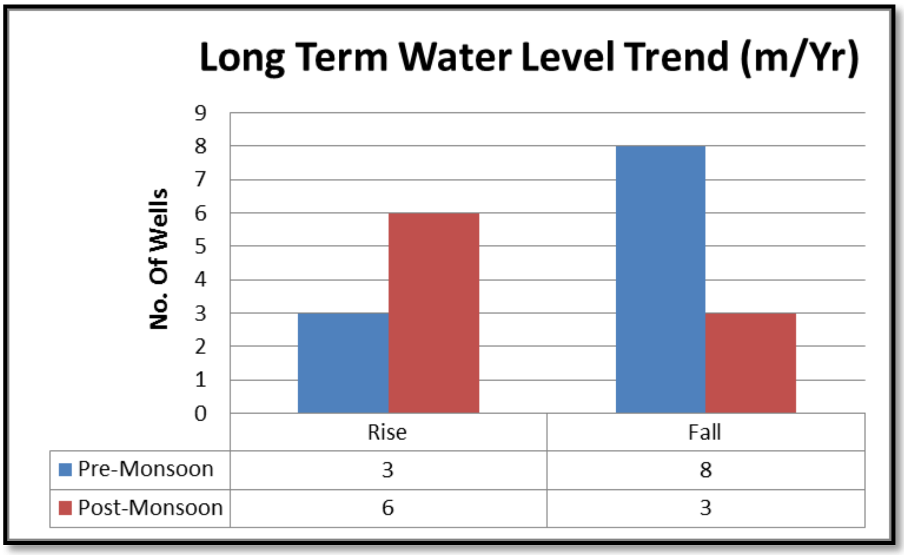


Fig. 3.5: Graphical representation of water level trends (2011-2020)

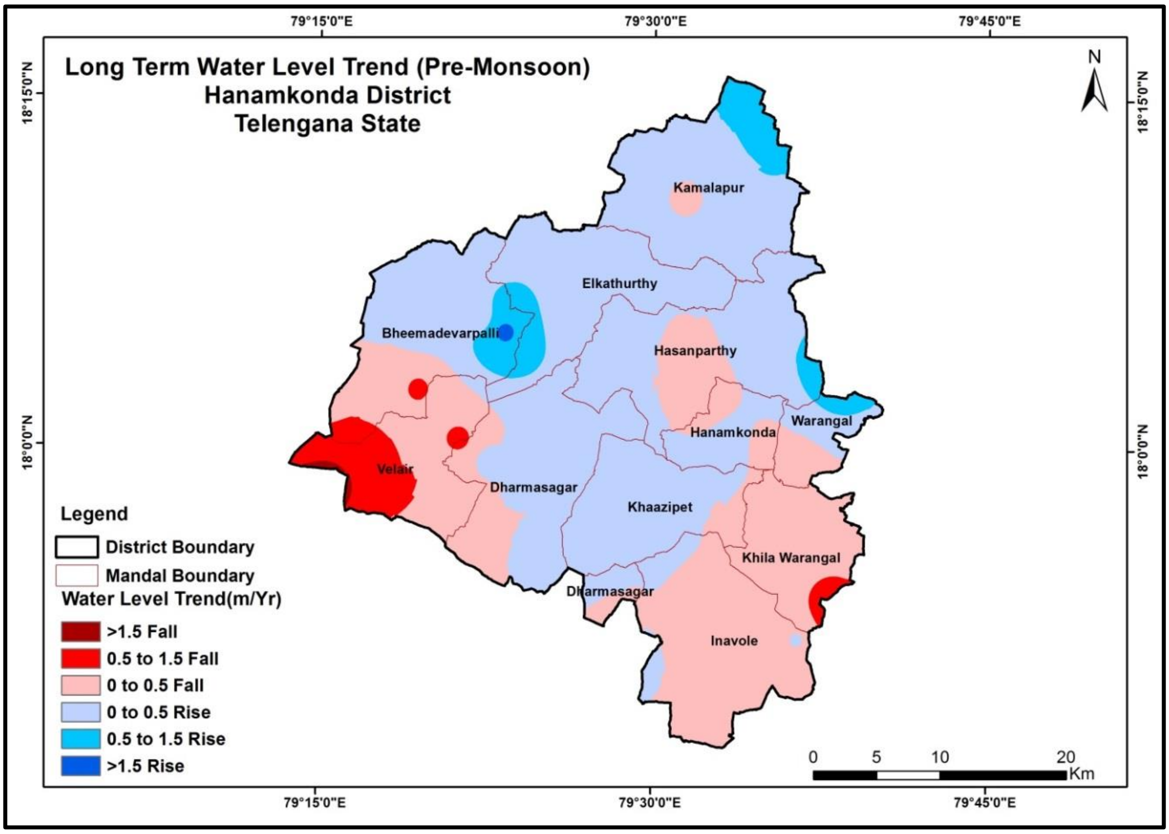


Fig. 3.6: Long-term water level trend, Pre-monsoon (2011-2020)

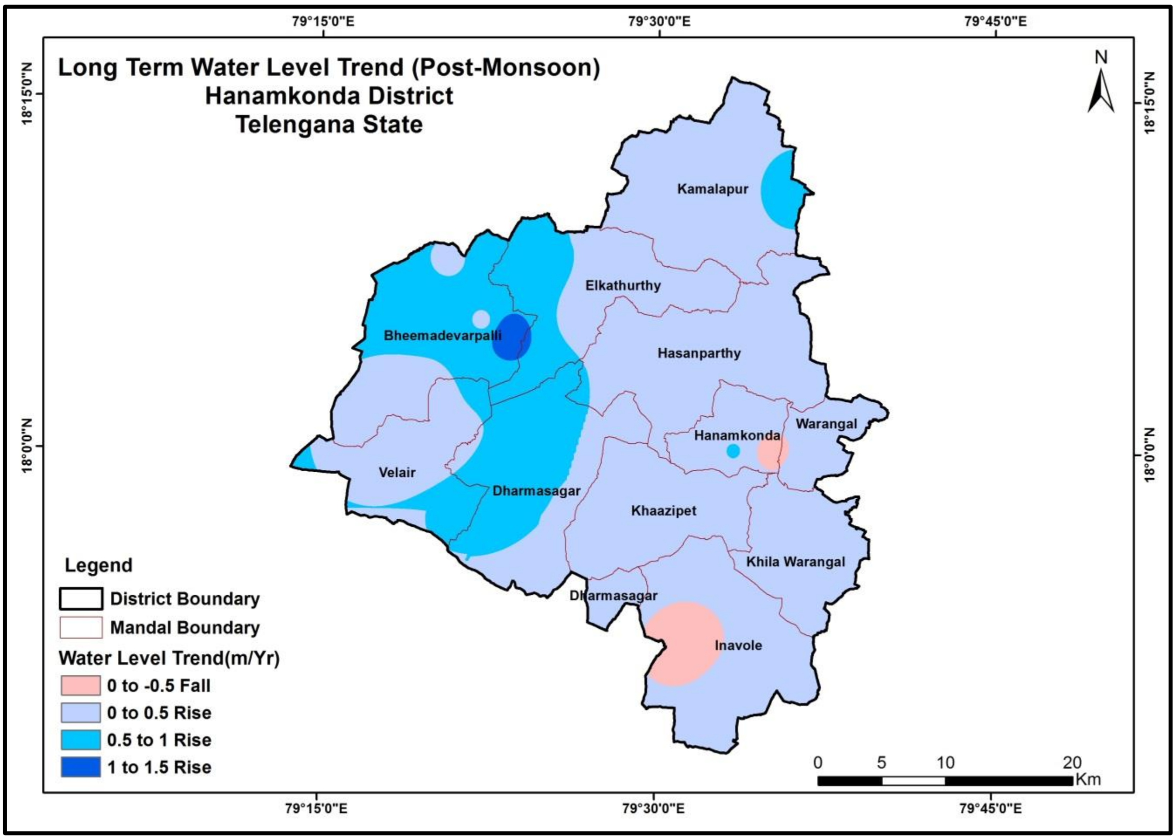


Fig. 3.7: Long-term water level trend, Post-monsoon (2011-2020)

3.2 Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. For assessment of ground water quality, 55 samples (Pre-monsoon: 21 and post-monsoon: 34) were utilised from monitoring wells of CGWB and SGWD. The ground water samples were analysed for major chemical constituents. 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 analysed.

3.2.1 Pre-Monsoon

A total of 21 samples were analyzed (CGWB: 04, SGWD:17). Ground water is mildly alkaline to alkaline in nature with pH in the range of 8.02-8.36 (Avg: 8.2). Electrical conductivity varies from 795-4014 (avg:1599) µSiemens/cm. In 98 % of area EC is within 3000 µSiemens/cm, in 2% of area it is beyond 3000 µSiemens/cm (**Fig.3.8**). Nitrate concentration varies from 2.41-379 mg/l and 47.6 %of the samples it is beyond permissible limits of BIS Standard (>45 mg/l) (**Fig.3.9**). High Nitrate concentration is observed in major parts of the district covering Kamalapur, Hasanparthy, Warangal, Khila Warangal, Inavole, Dharamsagar, Velair and Bheemadevarpalli mandals. Fluoride concentration varies from 0.41 to 8.51 mg/l (**Fig 3.10**) and in 19 % of samples it is beyond permissible limits of BIS standard (>1.5 mg/l). High fluoride concentration is observed mainly in Kamalapur, Inavole , Dharamsagar, and Elkathurthy mandals.

3.2.2 Post-Monsoon

A total of 34 samples were analyzed (SGWD: 34). Ground water from the area is mildly alkaline to alkaline in nature with pH in the range of 7.09-8.33 (Avg:7.96). Electrical conductivity varies from 284-2350 (avg:1382) µSiemens/cm. In 100 % of area EC is within 3000 µSiemens/cm (**Fig.3.11**). Nitrate concentration varies from 3.22-211.38 mg/l and in 42 % of the samples it is beyond permissible limits of BIS Standard (>45 mg/l) (**Fig.3.12**). High Nitrate concentration is observed in majority parts of the district. Fluoride concentration varies from 0.07-8.02 mg/l (Fig 3.13) and in 23.5 % of samples it is beyond permissible limits of BIS standard (>1.5 mg/l). High fluoride concentration is observed mainly in Warangal, Hanamkonda , Dharamsagar, Inavole, Elkathurthy and Bheemadevarpalli mandals .

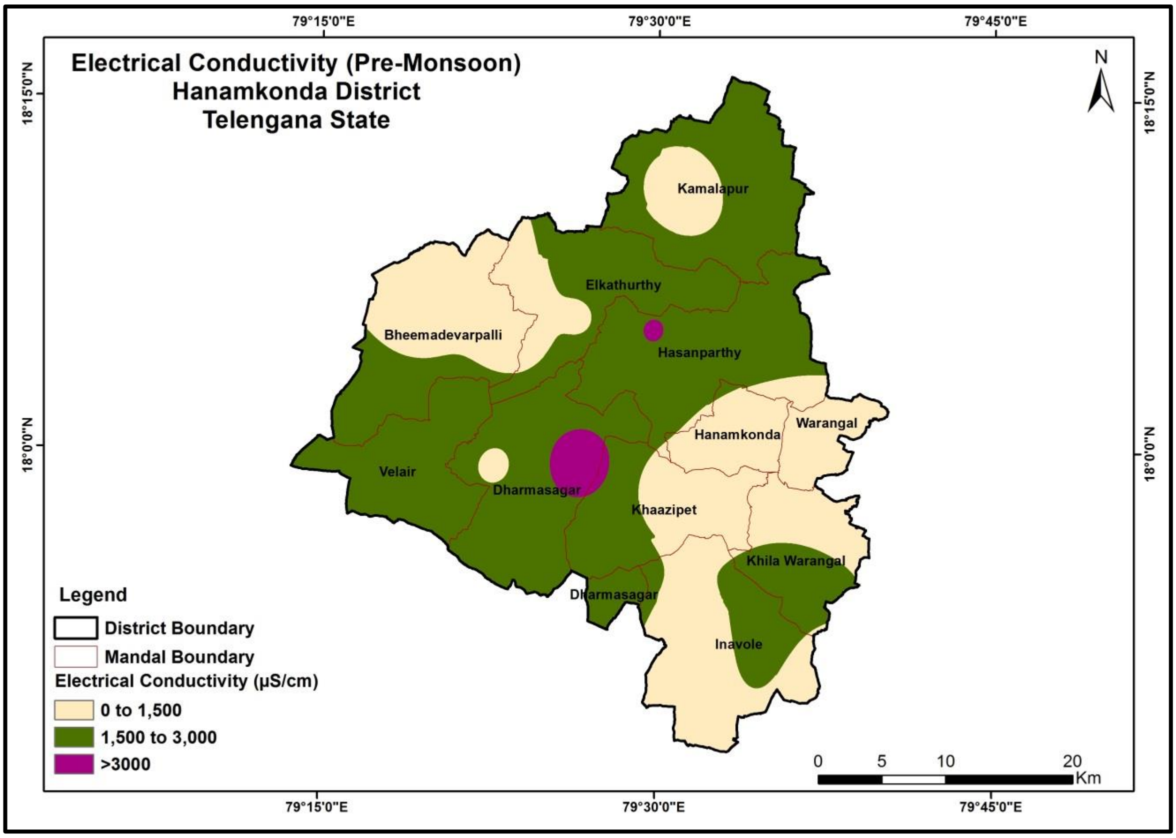


Fig.3.8: Distribution of Electrical conductivity (Pre-monsoon).

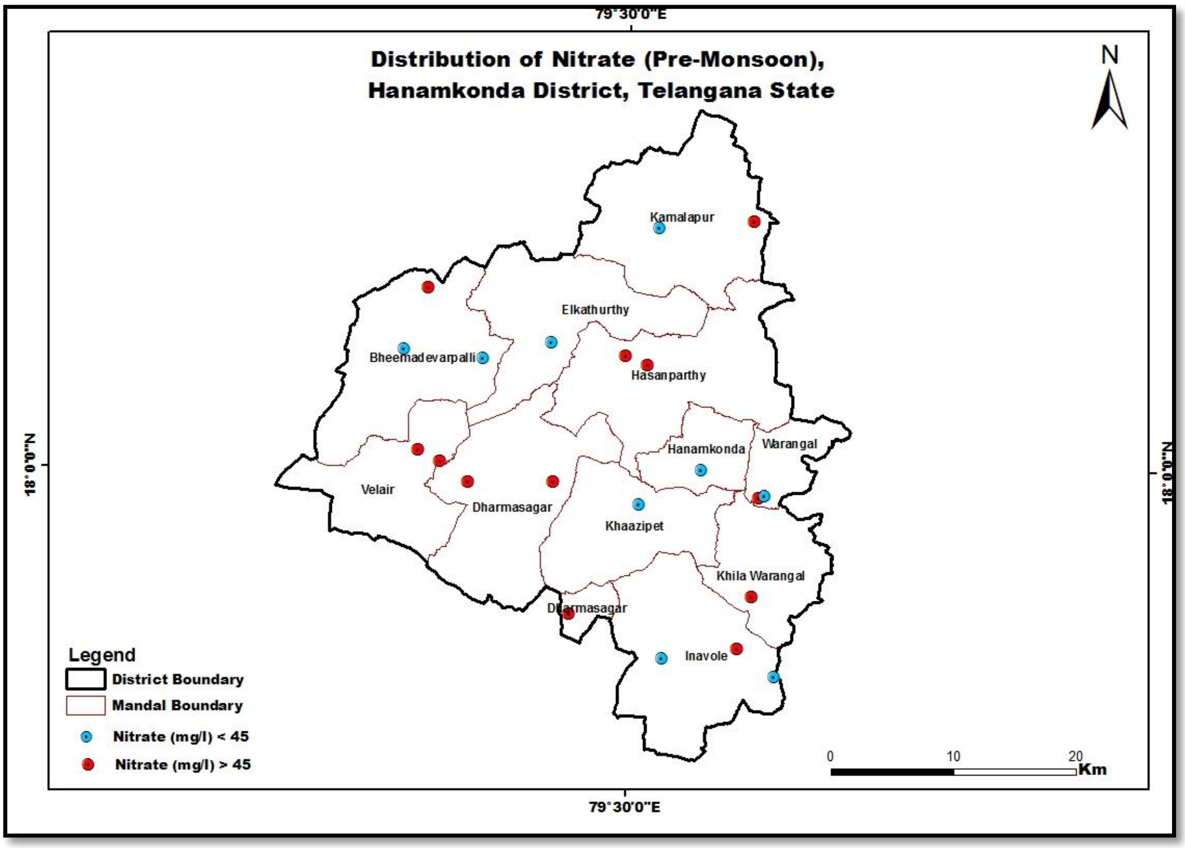


Fig.3.9: Distribution of Nitrate (Pre-monsoon)

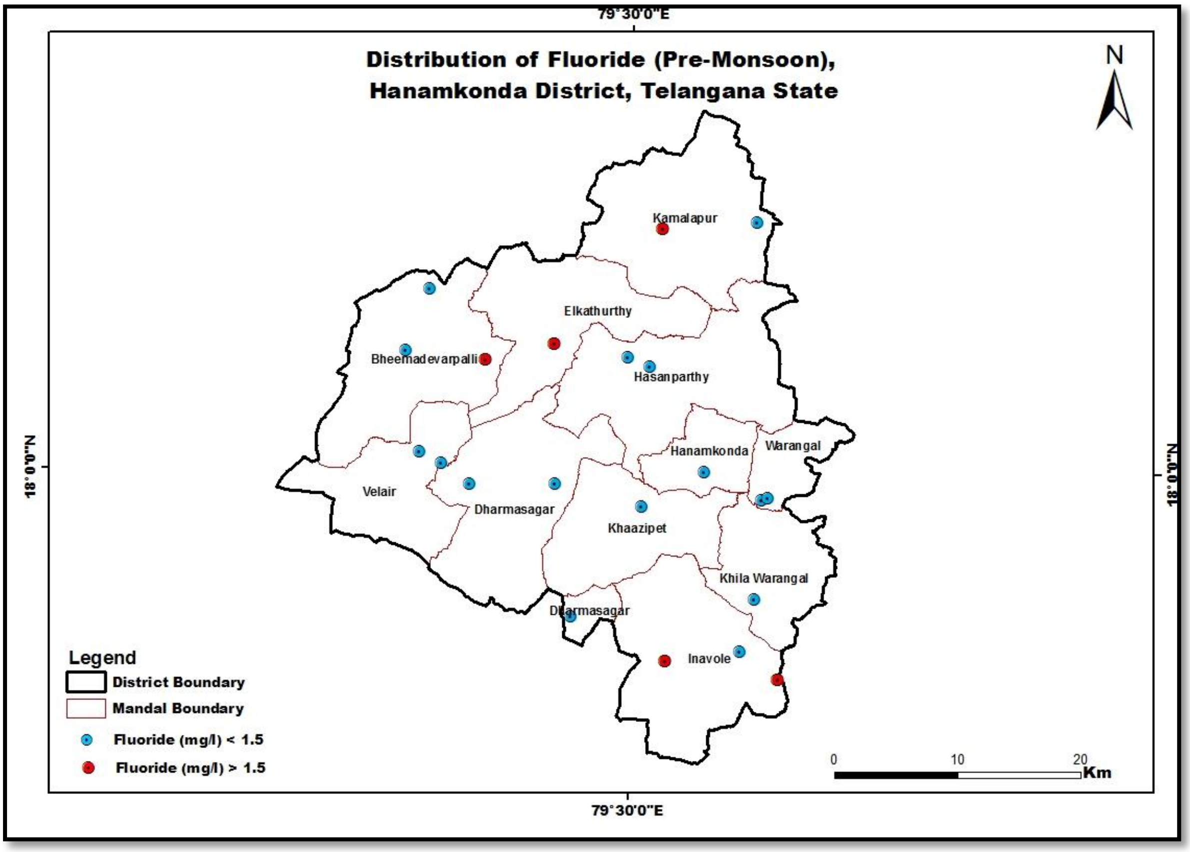


Fig.3.10: Distribution of Fluoride (Pre-monsoon)

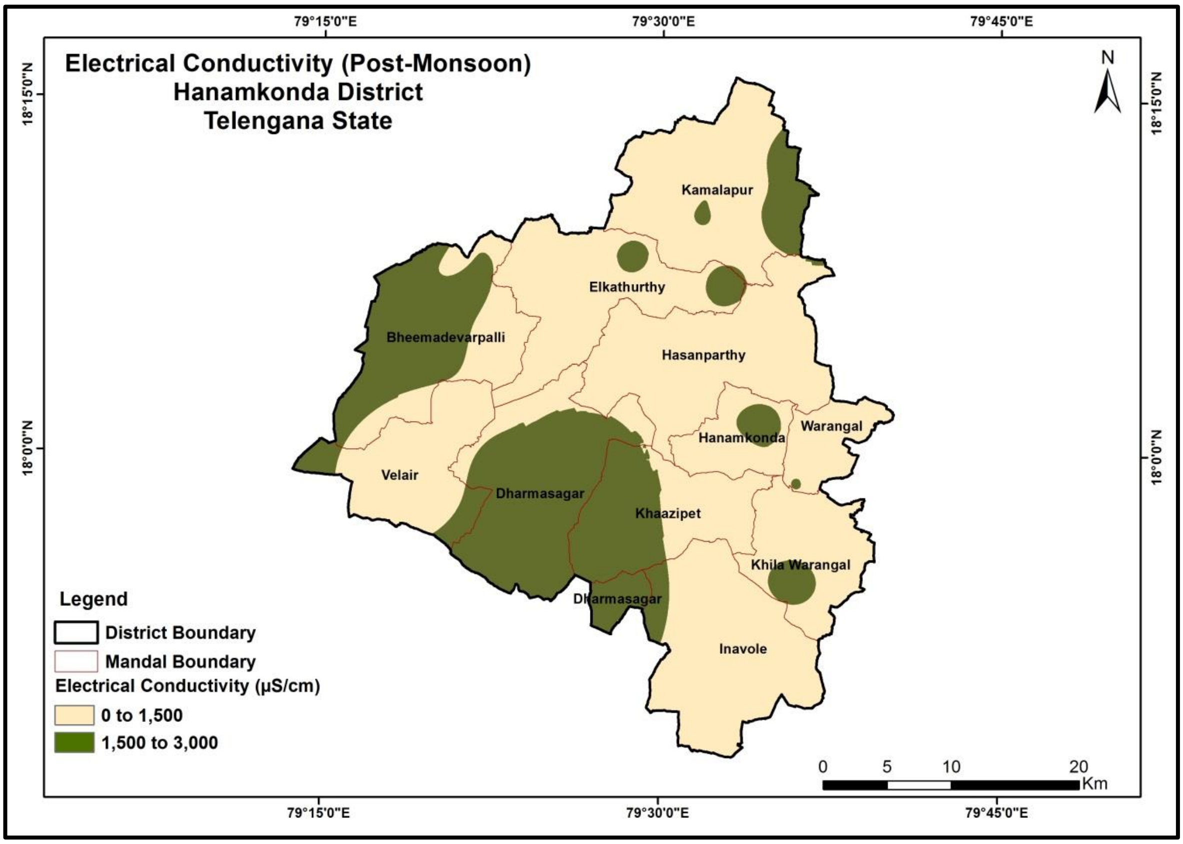


Fig.3.11: Distribution of Electrical conductivity (Post-monsoon)

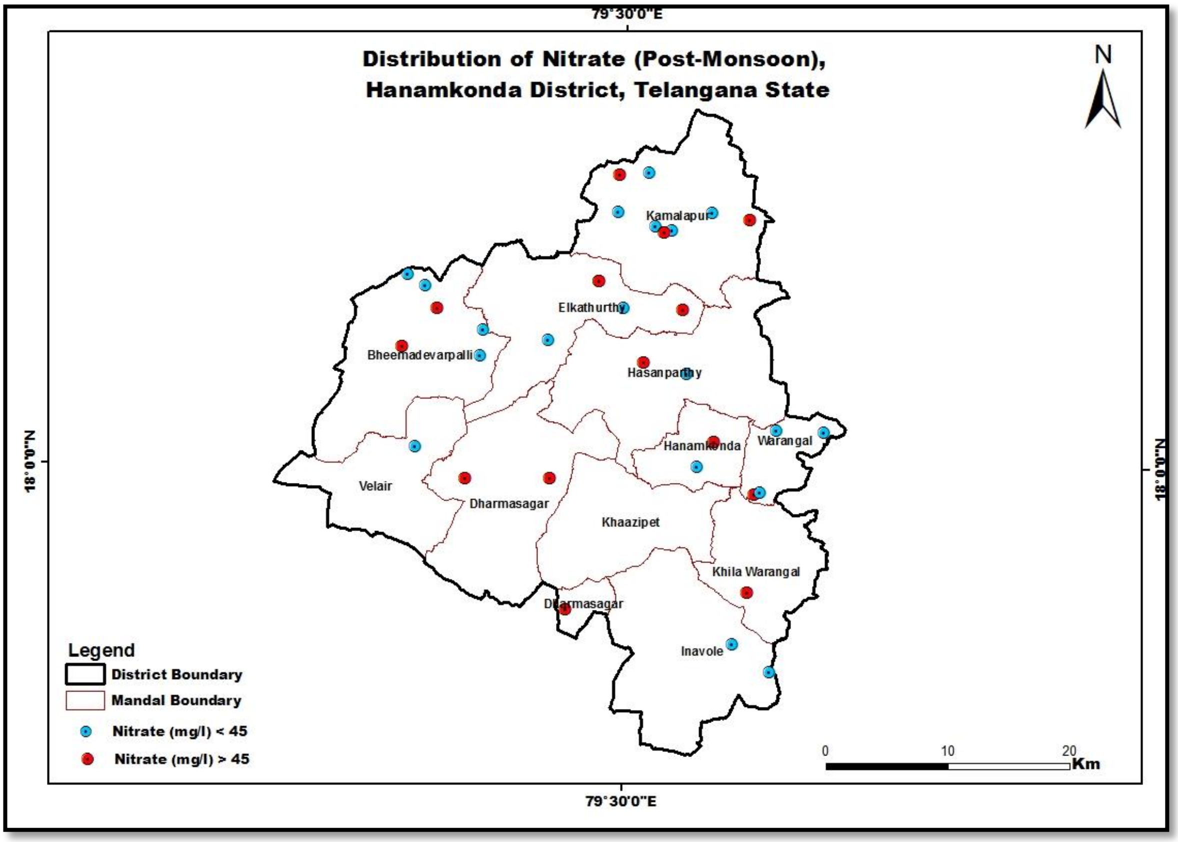


Fig.3.12: Distribution of Nitrate (Post-monsoon)

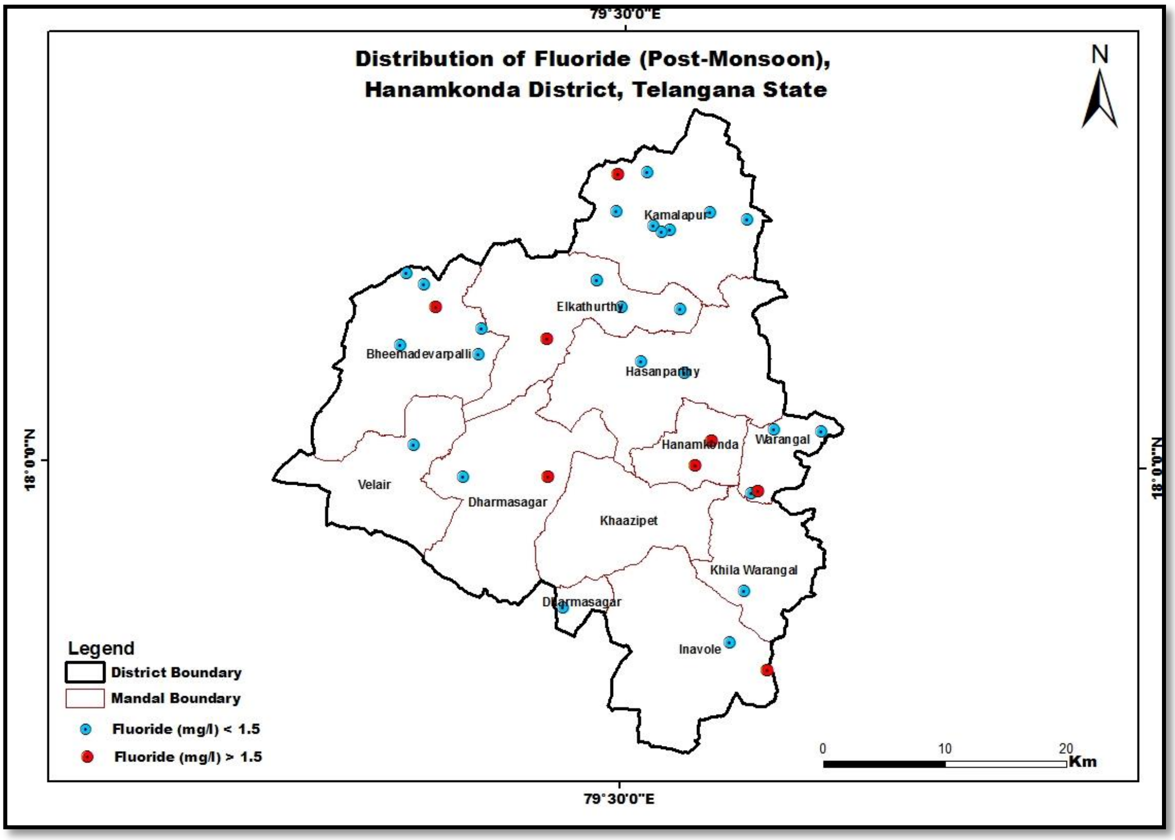


Fig.3.13: Distribution of Fluoride (Post-monsoon)

3.3 Aquifer Mapping

The aquifer geometry for shallow and deeper aquifer has been established through analysing data generated through various hydrogeological, exploration, surface and subsurface geophysical studies in the district. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks. It depends on rock type, depth of weathering and extension of weak zones like fractures, joints etc., in crystalline rocks, while in sedimentary rocks it depends on porosity, granularity, cementing matrix, permeability, bedding plains and faults. Based on 103 hydrogeological data points, hydrogeological map is prepared and is presented in **Fig 3.14**.

On the basis of occurrence and movement of ground water, rock units of the Hanamkonda district can be broadly classified as consolidated formation (Archean crystalline and metasedimentary formation) which occupies complete area.

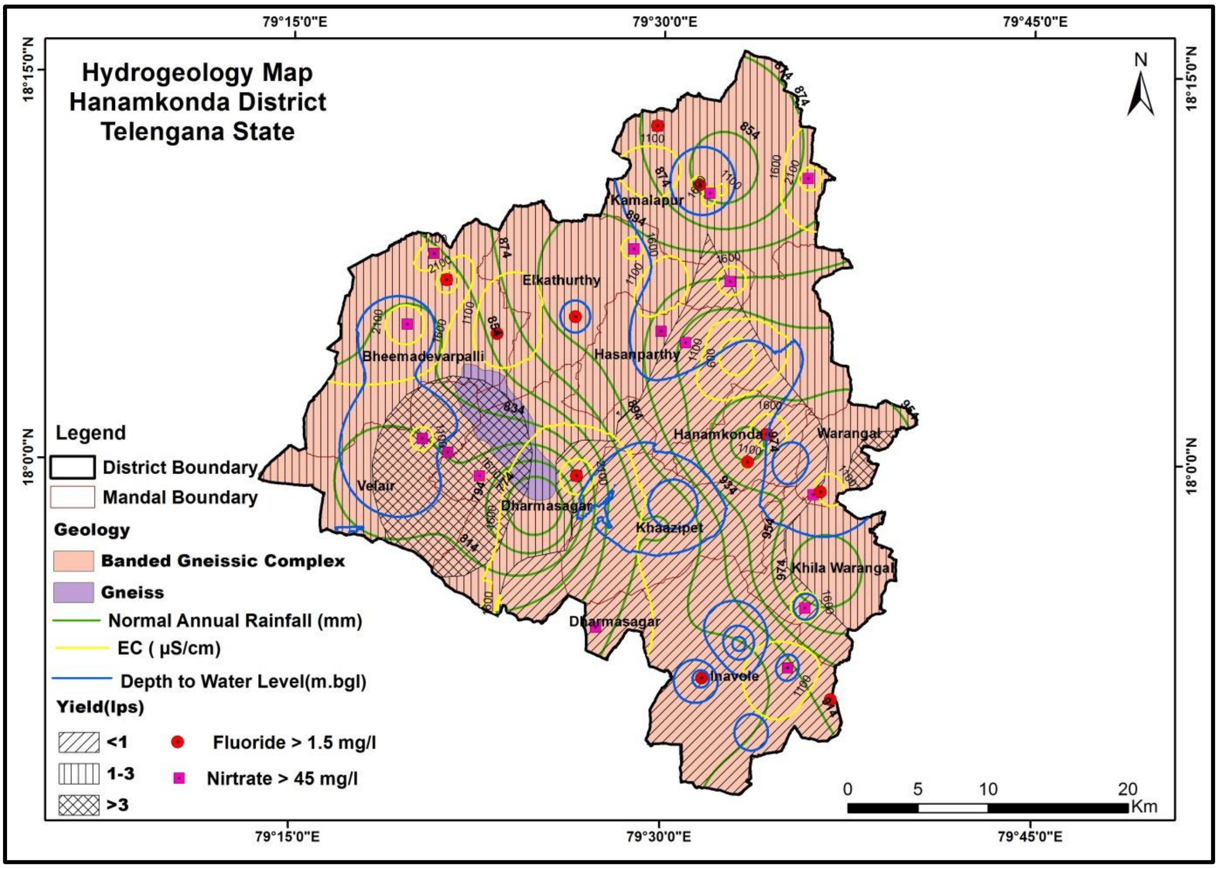


Fig.3.14: Hydrogeological map of Hanamkonda district

3.3.1 Aquifer system in consolidated formation

Consolidated formation consists of Archean crystalline formation comprising crystalline granites and gneisses that are devoid of primary porosity. However, subsequent weathering, fracturing and fissuring developed secondary porosity and possess a weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to 70 m depth.

3.3.1.1 Weathered Zone (Aquifer -I)

It consists of weathered residum where ground water occurs under unconfined conditions in the intergranular pore spaces of weathered mantle and is mainly developed through dug wells or shallow bore wells with hand pumps. The storage in granite rocks is primarily confined to the weathered zone and it has been used mainly for irrigation purpose, which extends upto depth of 22.1 m in Hanamkonda district. Thickness of weathered zone is in the range of 10-20 m in about ~76% of area, shallow weathering (< 10 m) occurs in 23 % while deep weathering (> 20 m) is seen only in 1% of the area (**Fig 3.15**).

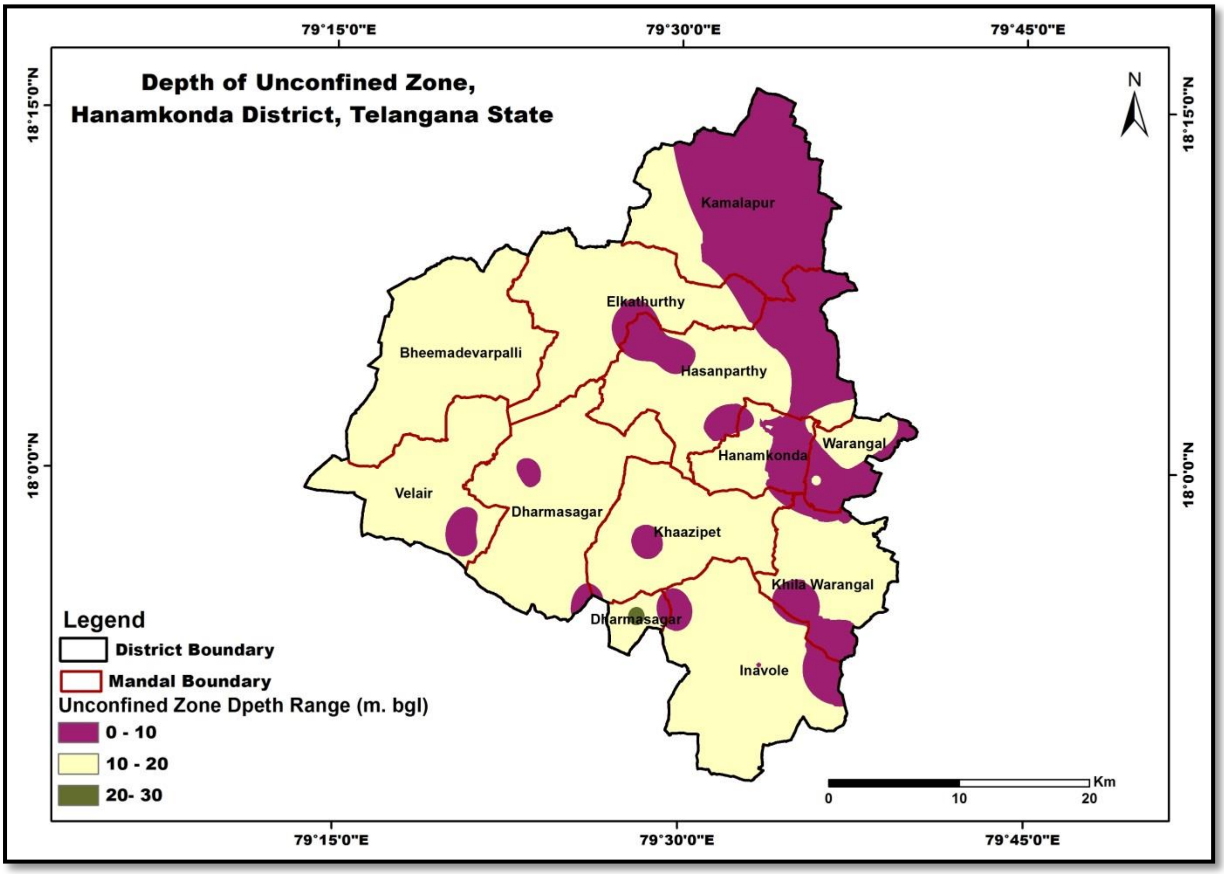


Fig.3.15: Unconfined zone map of Hanamkonda district

3.3.1.2 Fractured Zone (Aquifer -II)

In the fractured zone, groundwater occurs under semi-confined to confined conditions. The fractured zone is considered from bottom of weathered zone to the top of deepest fracture. Ground water in fractured zone is developed through construction of shallow/deep bore wells and dug-cum borewells. The depth of fracturing varies from 4.5 m to 70 m (deepest fracture encountered at Dharmapuram). Based on CGWB data, it is inferred that fractures in the range of 10 to 30 m depth are more predominant (90 % of the area); 0 to 10 m and 30 to 50 fractures occur in 1 % and 8 % of area respectively and deep fractures (50 to 70) are observed in only 1 % of the area. Ground water yield in this zone varies from 0.01 to 5 lps. The transmissivity (T) varies from 1 to 36.1 m^2/day (avg: 1.63 m^2/day) and storativity varies from 0.0001 to 0.001.(**Fig 3.16**).

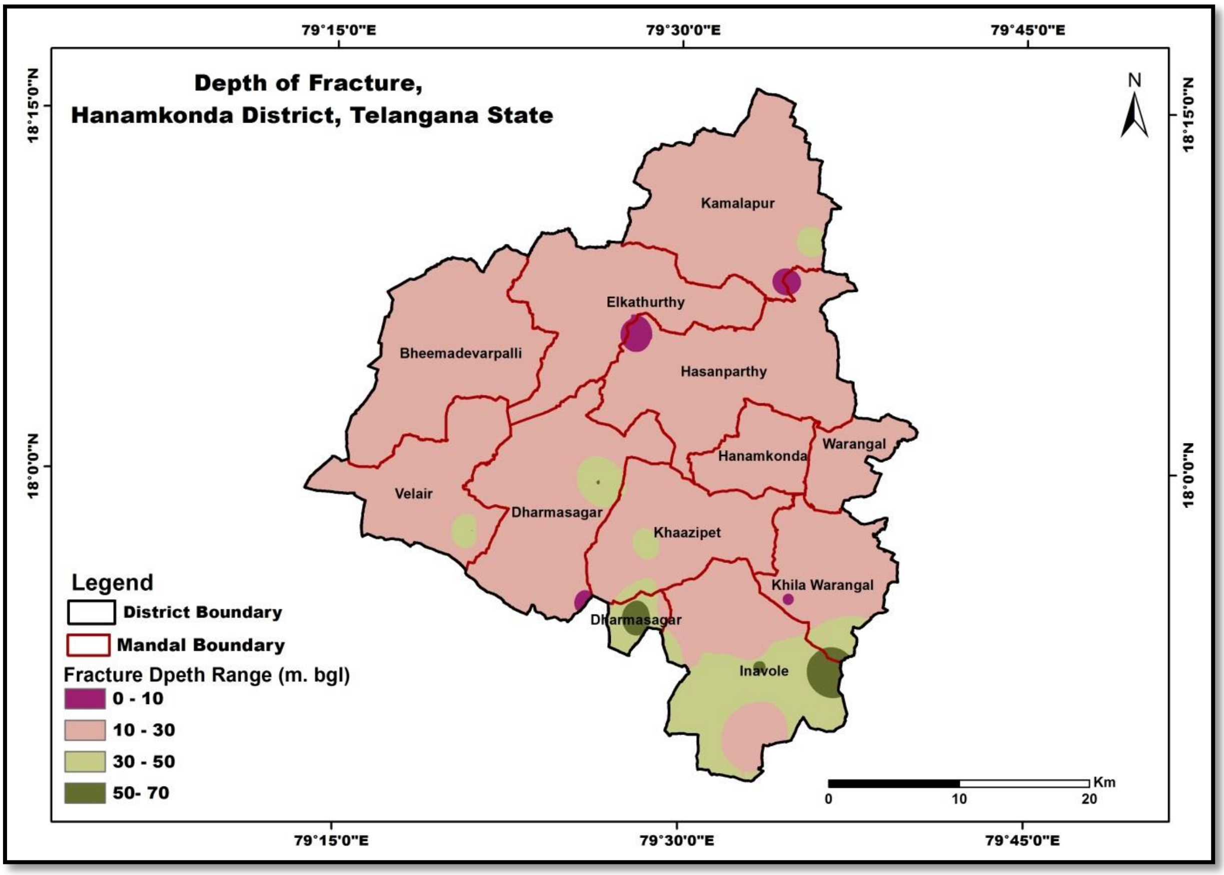


Fig.3.16: Fracture zone map of Hanamkonda district

3.4 3D and 2D Aquifer Disposition

The data generated from ground water monitoring wells, hydrogeological inventories, exploratory wells and geophysical studies as well as various thematic layers were utilized to decipher the aquifer disposition of the area. This particularly includes the information on 3D geometry of aquifers, panel diagram and hydrogeological information of these aquifers. RockWorks-16 software was used for this purpose. The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The 3-D representation of Aquifer disposition is presented in **Fig. 3.17**

The fence diagram indicating the disposition of various aquifers is presented in **Fig.3.18**. In major part of district, granites/gneiss can be seen. The disposition of weathered and fractured zone followed by massive granite/gneiss can be observed in the fence.

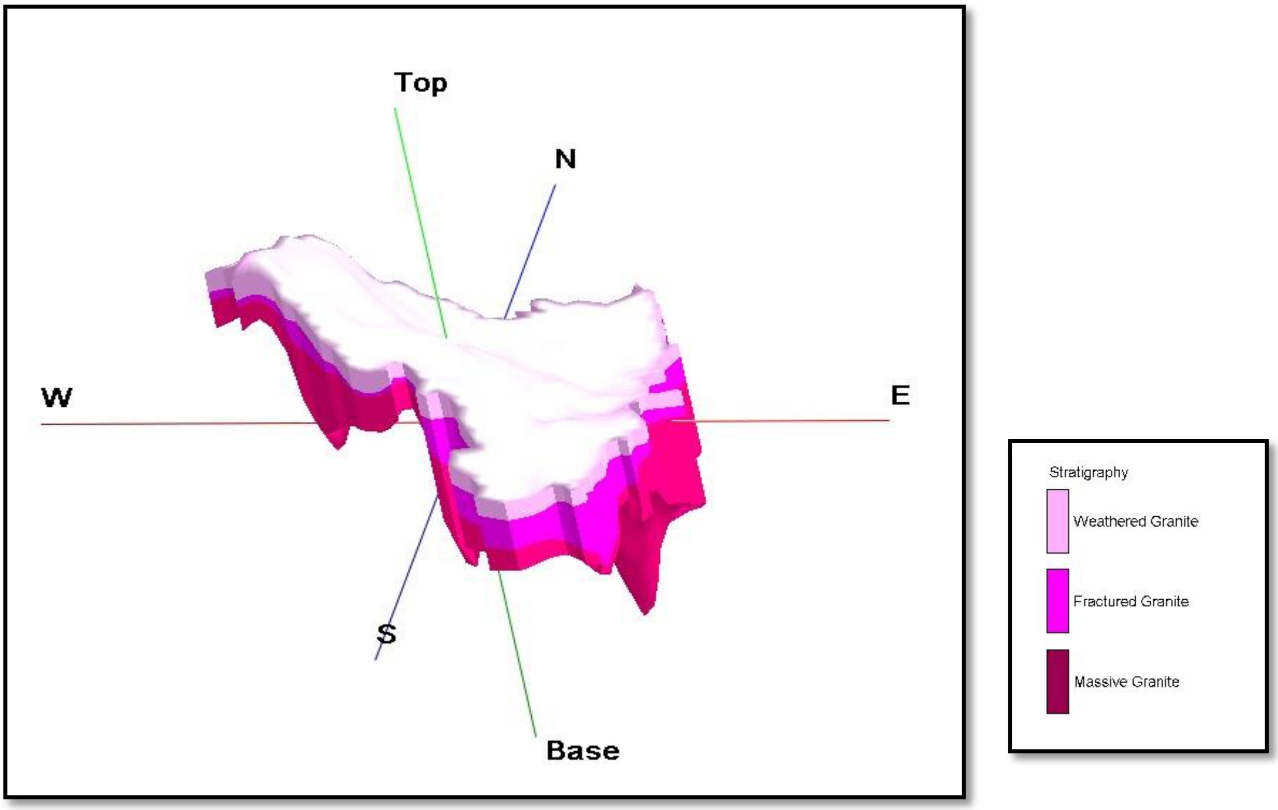


Fig.-3.17: 3-D disposition of Aquifers

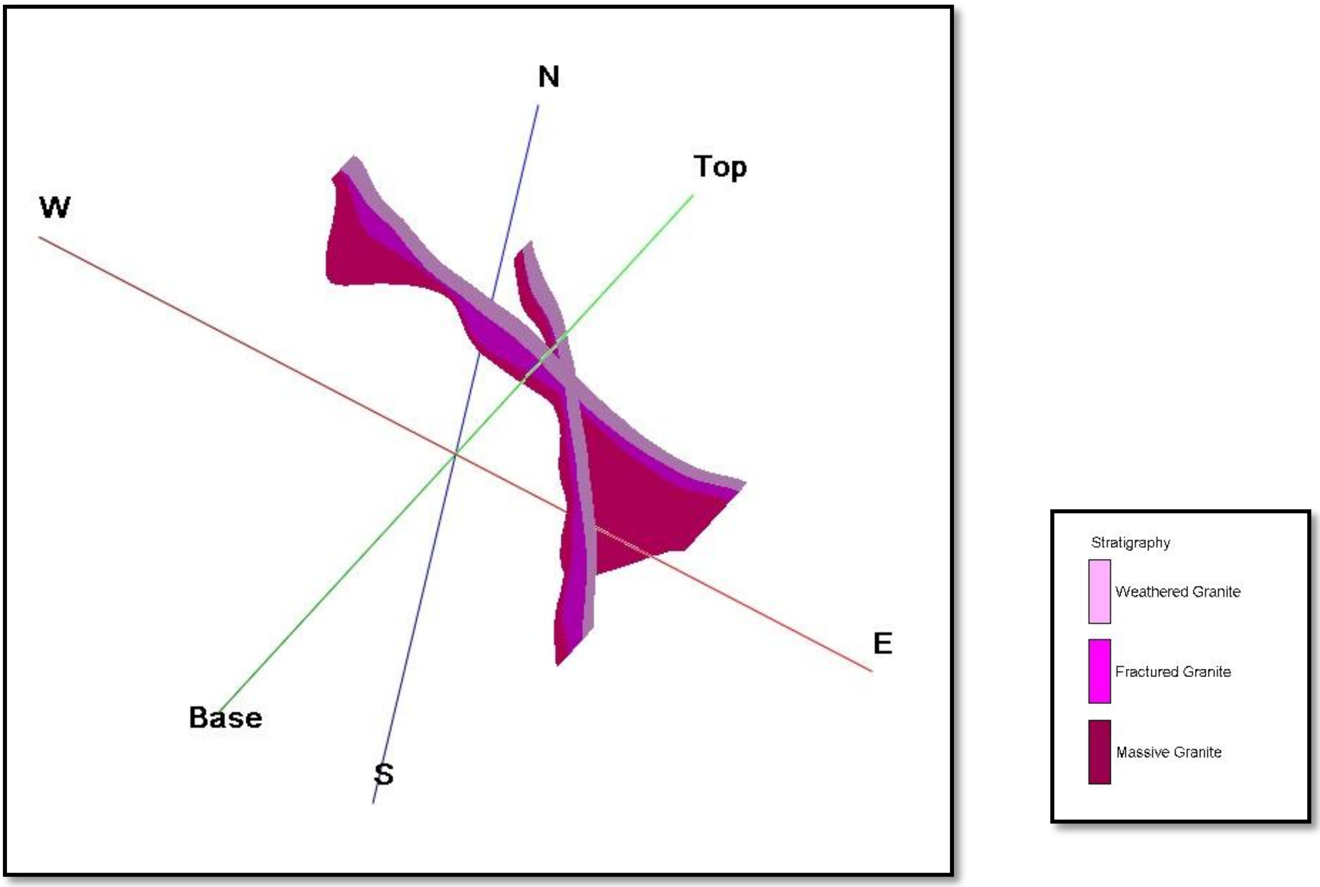


Fig.-3.17: 3-D disposition of Aquifers

3.4.1 Hydrogeological Cross Sections

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. NE-SW, NW-SE and N-S direction in Granitic area (**Fig. 3.18**).

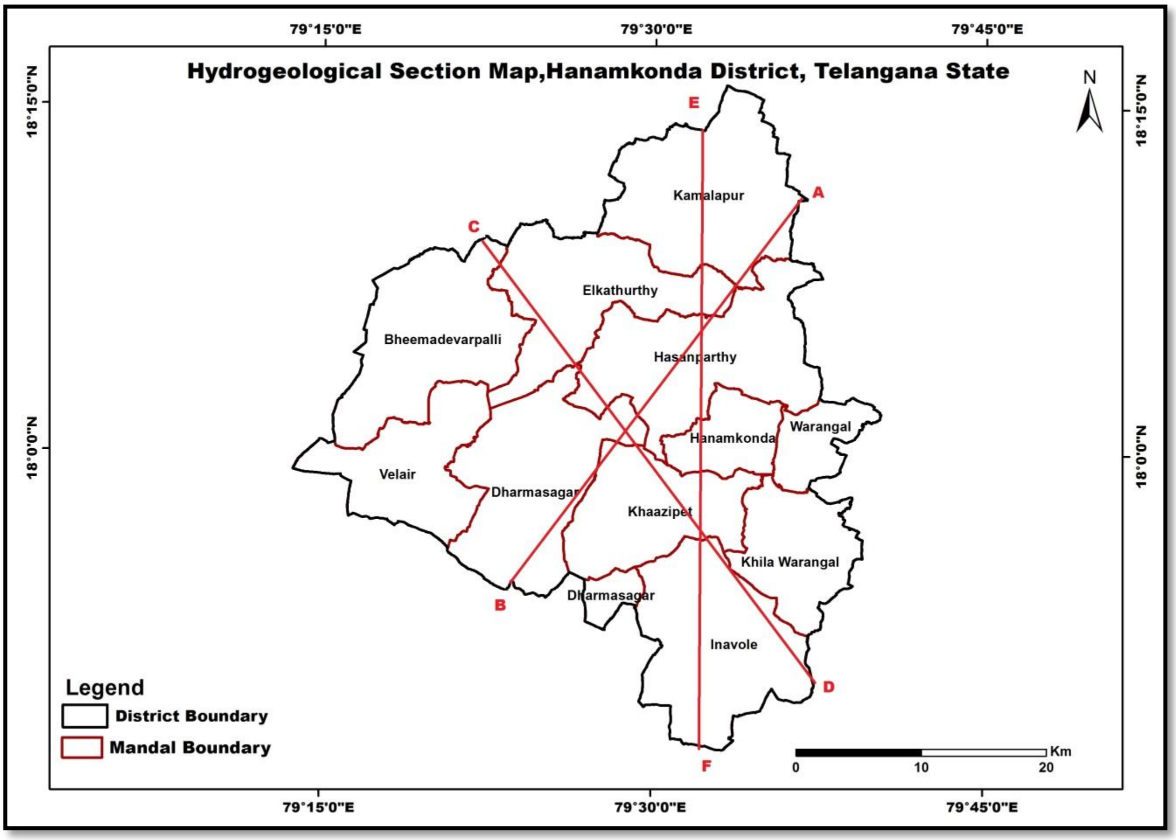


Fig.-3.19: Map showing orientation of hydrogeological sections

3.4.1.1 Hydrogeological Cross Section A-B

Hydrogeological cross section A-B (**Fig.3.19**) represents northeast- southwest direction covering a distance of ~40kms. It depicts thin fractured zone overlaid by thick weathered zone in granites. As we move from northeast to southwest direction, depth of weathered zone varies from 9.5 mbgl at Gunaparthi to 4.5 mbgl at Karunapuram. The maximum depth of weathering is at Rampur at 14.5 mbgl. The maximum depth of fracture ranges from 4.5 mbgl at Karunapuram to 35 mbgl at Gunaparthi.

3.4.1.2 Hydrogeological Cross Section C-D

Hydrogeological cross section C-D (**Fig.3.20**) represents northwest–southeast direction covering a distance of ~44kms. Thin fractured zone overlaid by thick weathered zone in granites. As we move from northwest to southeast direction, depth of fracture zone varies from 20 mbgl at Somadevarapalle to 12 mbgl at Kakiralapalli-1. The maximum depth of weathering ranging from 20 mbgl at Somadevarapalle to 9.85 mbgl at Inavolu.

3.4.1.3 Hydrogeological Cross Section E-F

Hydrogeological cross section E-F (**Fig.3.21**) represents north–south direction in granitic terrain area covering a distance of ~38kms. Thick fractured zone overlaid by thin weathered zone in granites. As we move from north to south direction, depth of fracture zone varies from 7 mbgl at Ananthasagar to 70 mbgl at Dharmapuram. The maximum depth of weathering ranging from 22.1 mbgl at Dharmapuram to 6.1 mbgl at Mallakpalli-1.

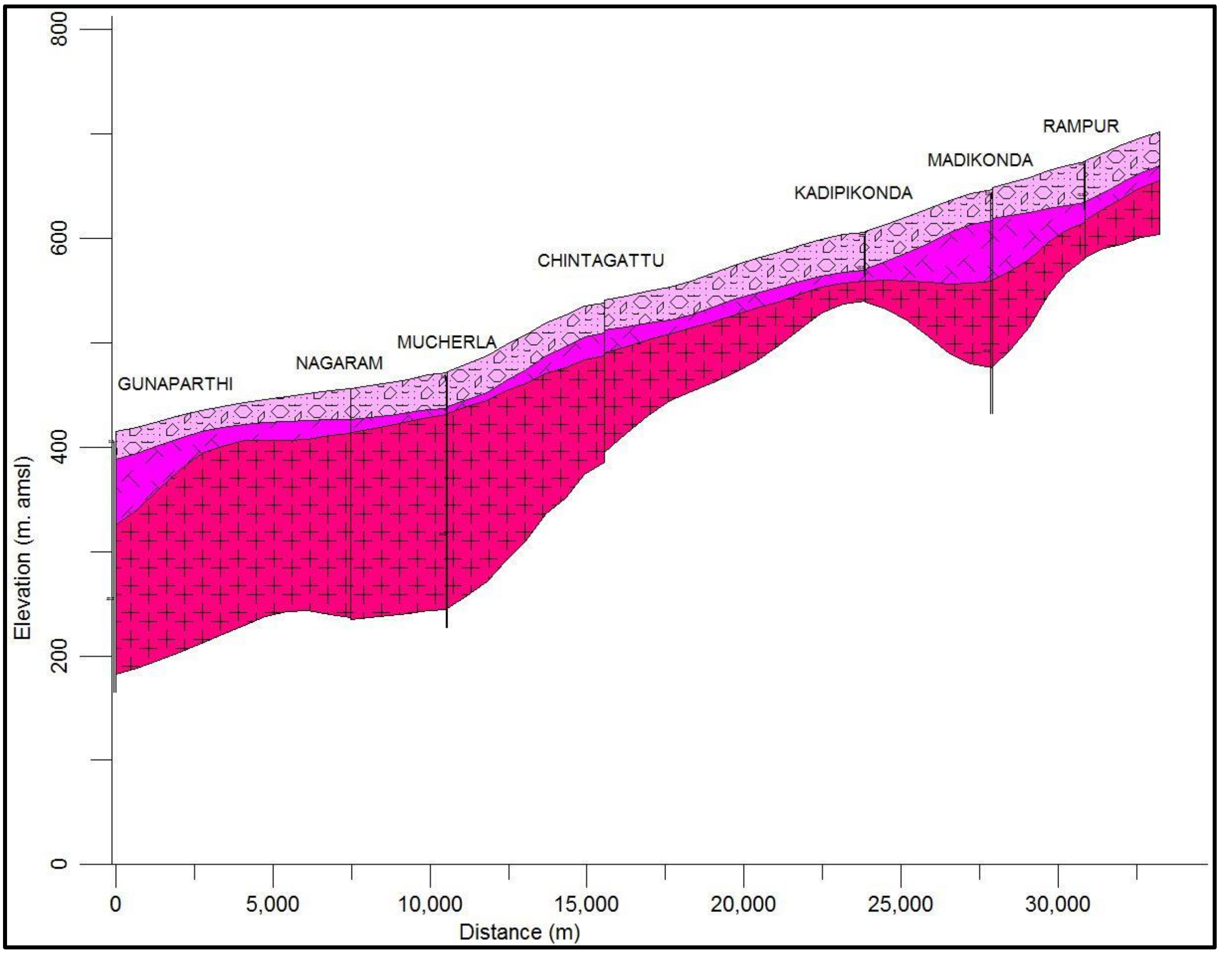


Fig.3.20: Hydrogeological cross section A-B

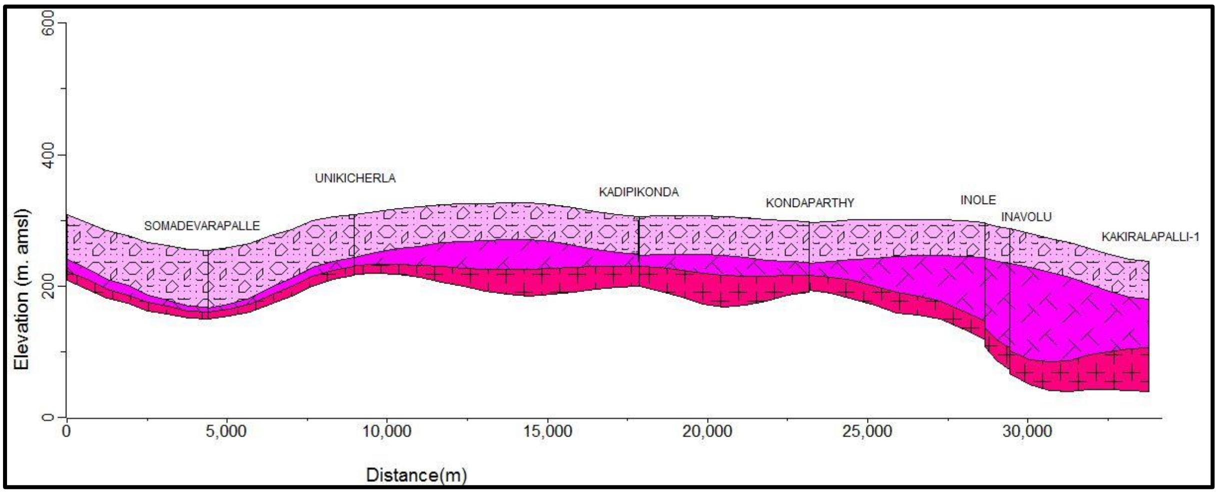


Fig.3.21: Hydrogeological cross section C-D

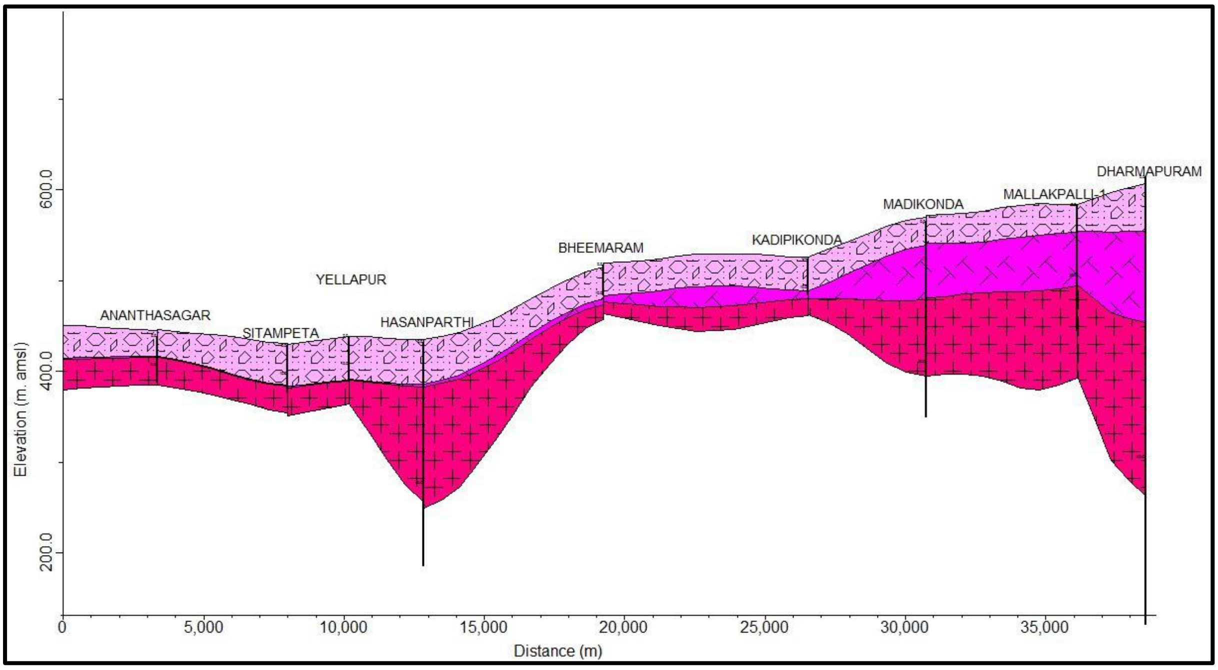
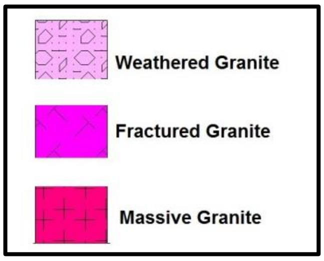


Fig.3.22: Hydrogeological cross section E-F

Legend



4. GROUND WATER RESOURCES

In hard rocks, for practical purpose it is very difficult to compute zone wise (aquifer wise) ground water 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 ground water 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) and 3% as specific yield is considered. Summarized command/non-command area wise and mandal wise resources for **16** mandals are given in **Table-4.1** .

As per GEC 2020 report, the net dynamic replenishable groundwater availability is 189.62 MCM, gross ground water draft for all uses 118.12 MCM, provision for drinking and industrial use for the year 2025 is 52.79 MCM and net annual ground water potential available for future irrigation needs is 71.25 MCM. The stage of ground water development varies from 43 % in command area and 77 % in non-command area with average of 62 %. 02 mandals falls in overexploited category, 03 mandals falls in semi critical category and 06 mandals in safe category. Mandal wise stage of ground water development varies from 11 % (Hanamkonda mandal) to 117 % (Bheemdevarapally mandal). Based on 2020 resources, village wise utilizable ground water resource map is prepared and presented in **Fig. 4.1.**

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

Parameters	**Total**
As per GEC 2020	MCM
Dynamic (Net GWR Availability)	189.62
• Monsoon recharge from rainfall	106.61
• Monsoon recharge from other sources	42.39
• Non-Monsoon recharge from rainfall	0.8
• Non-monsoon recharge from other sources	49.81
Gross GW Draft	**118.12**

• Irrigation	106.05
• Domestic and Industrial use	12.07
Provision for Drinking and Industrial use for the year 2025	52.79
Net GW availability for future irrigation	71.25
Average Stage of GW development (%)	62

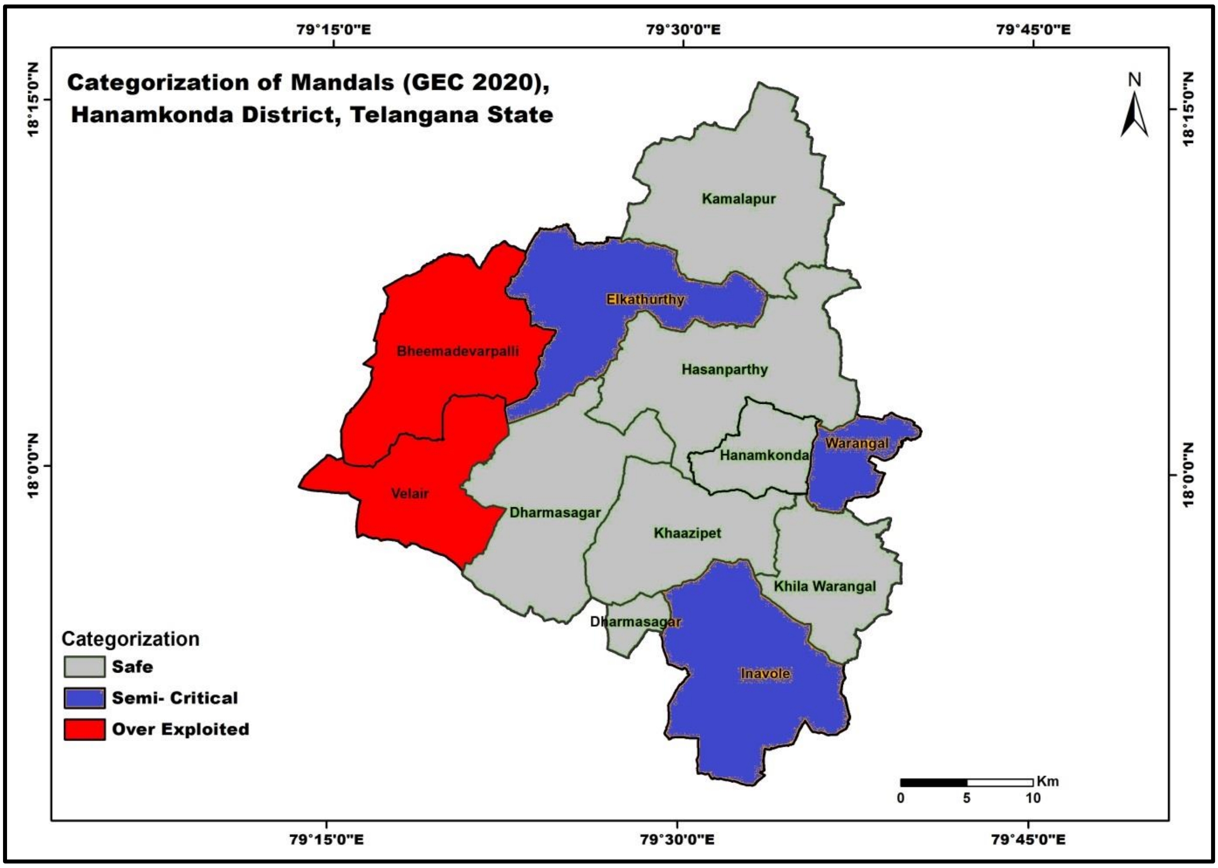


Fig.4.1 : Categorization of mandals (GEC-2020)

5. GROUND WATER RELATED ISSUES

5.1 Low groundwater potential

In the district, low ground water potential (< 1lps) has been identified in 52% of area mostly due to granitic terrain (absence of primary porosity, negligible development of secondary porosity) and restricted depth of weathering. The occurrence of less rainfall and urbanization also affects the potential. The yield from bore wells have reduced over a period of time and some bore wells which used to yield sufficient quantity of water have gone dry due to low rainfall. Sustainability of the aquifer is limited and the wells normally sustain pumping for 0.5 to 2 hours only.

5.2 Inferior groundwater quality

- Few mandals are fluorosis endemic where fluoride (geogenic) is as high as 8.51 mg/l during pre-monsoon and 8.02 mg/l during post-monsoon season. The high fluoride concentration (>1.5mg/l) occur in 19% and 23.5% of the samples during pre-monsoon and post-monsoon season.
  Higher concentration of fluoride in ground water is attributed due to source rock water interaction where acid-soluble fluoride bearing minerals (fluorite, fluoro-apatite) gets dissolved under alkaline conditions and higher residence time of ground water in deeper aquifer.
- High nitrate (> 45mg/l) due to anthropogenic activities are observed in few mandals as high as 379mg/l during pre-monsoon and 211.38mg/l during post-monsoon season. The high nitrate concentration (>45 mg/l) occur in 47.6% and 42% of the samples during pre-monsoon and post-monsoon season respectively.
  Higher concentration is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas and use of NPK fertilizers and nitrogen fixation by leguminous crops.
- The high concentration of EC (>3000 micro-seimens/cm) is observed in 2% of the area during pre-monsoon while during post-monsoon all stations show <3000 micro-seimens/cm seasons respectively.

5.3 Declining Water Level

- Out of 8 wells analyzed, 5 wells shown falling trend in pre-monsoon and during post-monsoon out of 9 wells analyzed 6 wells shows falling trend (@-0.96 to -0.16 and-0.59 to -0.05 m/yr) respectively.

6. MANAGEMENT STRATEGY

The uneven distribution of ground water 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. The management plan comprises two components namely supply-side management and demand-side management. The supply-side management is proposed based on surplus surface water availability and the unsaturated thickness of aquifer whereas the demand side management is proposed by use of micro irrigation techniques.

6.1 Supply side management

The supply-side management of ground water resources can be done through the artificial recharge by computing surplus runoff available within river sub-basins and also by repairing, renovation & restoration of existing tanks.

6.1.1 Artificial Recharge Structures (To be taken up)

The areas feasible for construction of recharge structures has been demarcated based on the analysis of post-monsoon depth to water level data and existing data on artificial recharge structures constructed under various schemes of MGNREGA and IWMP by Rural Development department, Govt. of Telangana. The availability of unsaturated volume of aquifer was computed by multiplying the area feasible for recharge and unsaturated depth below 5 mbgl. The recharge potential of aquifer is calculated by multiplying the unsaturated volume with specific yield of the aquifers (0.02 for hard rock).

The source water availability is estimated from the rainfall and run-off correlations. The runoff was calculated by taking into account of normal monsoon rainfall of the mandal and corresponding runoff yield from Strangers table for average catchment type. Out of the total run-off available in the mandal, only 20% is considered for recommending artificial recharge structures in intermittent areas.

The storage required for existing artificial recharge structures by State Govt. departments under different IWMP and MNREGS schemes is deducted to find the available surplus run-off for recommending the additional feasible artificial recharge structures.

50% of the available surplus run-off is considered for the recommendation of artificial recharge structures, as the remaining 50 % is recommended for implementing water conservation measures in recharge areas through MGNREGS. **Table 6.1** gives the area feasible and volume available for the recharge.

As the stage of ground water development in the district is 62 % and 06 out of 11 mandals are falling in safe category as per the GEC 2020 estimation, the artificial recharge structures are not proposed for entire district. To control further increase in stage of ground water development, artificial recharge structures are recommended in 3 semi-critical mandals (i.e. Elakathurthy, Inavolu and Warangal) and 2 Over Exploited mandals (i.e. Velair and Bheemdevarapally) only.

Table 6.1: Area feasible and volume available for artificial recharge

Total geographical area of district (Sq.km)	1312.02
Area feasible for recharge (Sq.km) (in 5 mandals)	609.79
Unsaturated Volume (MCM)	864.02
Recharge Potential (MCM)	17.28
Surplus run-off available for recharge (MCM)	15.12
PROPOSED ARTIFICIAL RECHARGE STRUCTURES	
Percolation Tanks (@ Rs.20 lakh, Av. Gross Capacity=0.007 MCM*2 fillings = 0.0140 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure (in Crores)	39 0.54 7.8
Check Dams (@ Rs.15 lakh, Av. Gross Capacity=0.007 MCM* 5 fillings = 0.035 MCM) Volume of Water expected to be conserved / recharged (in MCM) Estimated Expenditure (in Crores)	57 1.9 8.5
Total volume of water expected to be recharged (in MCM)	2.4
Total Estimated Expenditure for Artificial Recharge (Rs. in Cr.)	**16.3**

The total unsaturated volume (below the depth of 5m) available for artificial recharge is 609.79 MCM, having 17.28 MCM of recharge potential (2%). The available surplus run-off can be utilized for artificial recharge through construction of percolation tanks, check dams at suitable sites. The number of percolation tanks, and check dams are decided based on the number of suitable streams available in the district.

Thus, after taking into consideration all the factors, only 15.12 MCM of surplus water can be utilised for recharge, which is given in **Table 6.1**. This surplus water can be utilized for constructing 57 check dams with estimated expenditure of Rs. 8.5 crores and 39 percolation tanks with estimated expenditure of Rs. 7.8 crores at suitable sites. The amount of recharge from these artificial recharge structures was calculated by considering 0.0140 MCM per percolation tanks and 0.035 MCM per check dam. This intervention would lead to recharge of about 2.4 MCM/year. The details are given in **Annexure-1.** The feasible locations for artificial recharge structures in the 5 mandals are given in the **Fig 6. 1, 6.2 and 6.3**

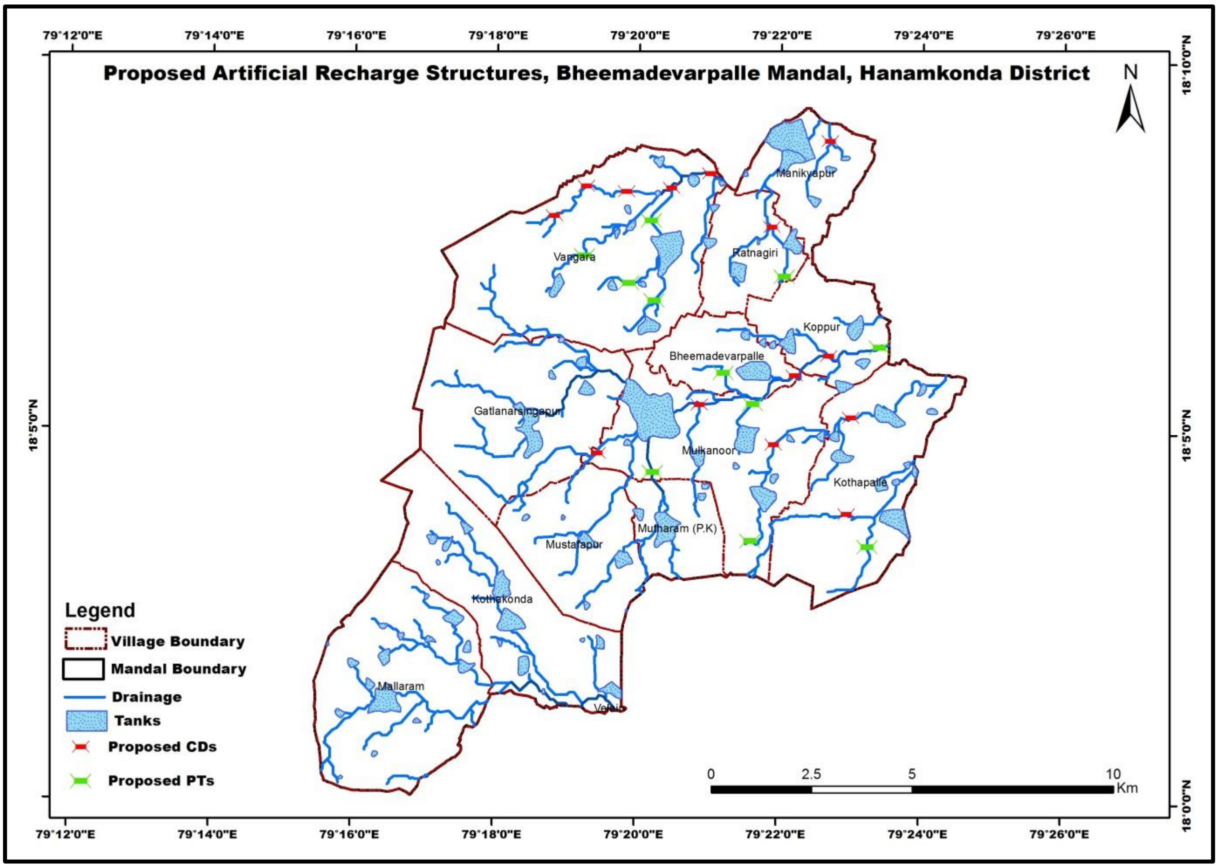


Fig.6.1 : Proposed Artificial Recharge Structures Locations for Bheemadevarpalle Mandal

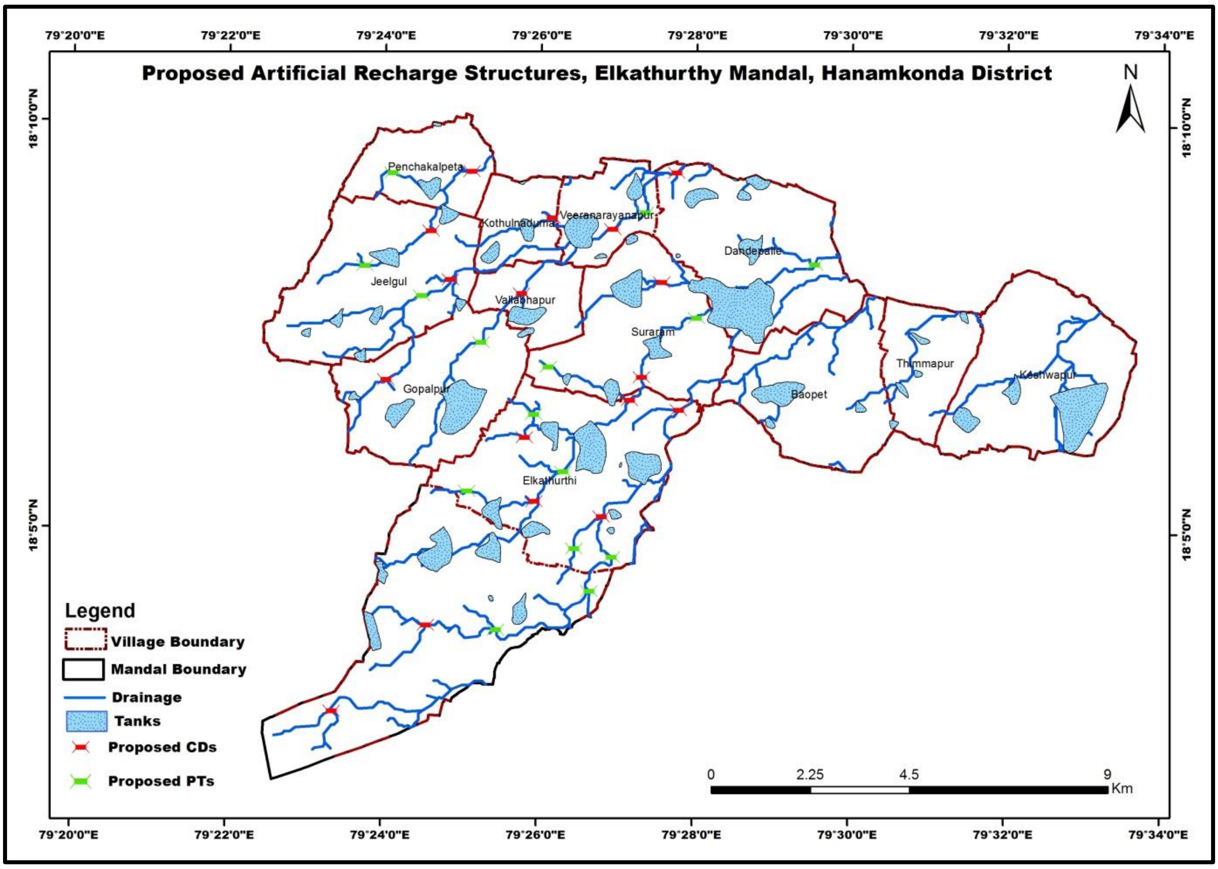


Fig.6.2 : Proposed Artificial Recharge Structures Locations for Elkathurthi Mandals

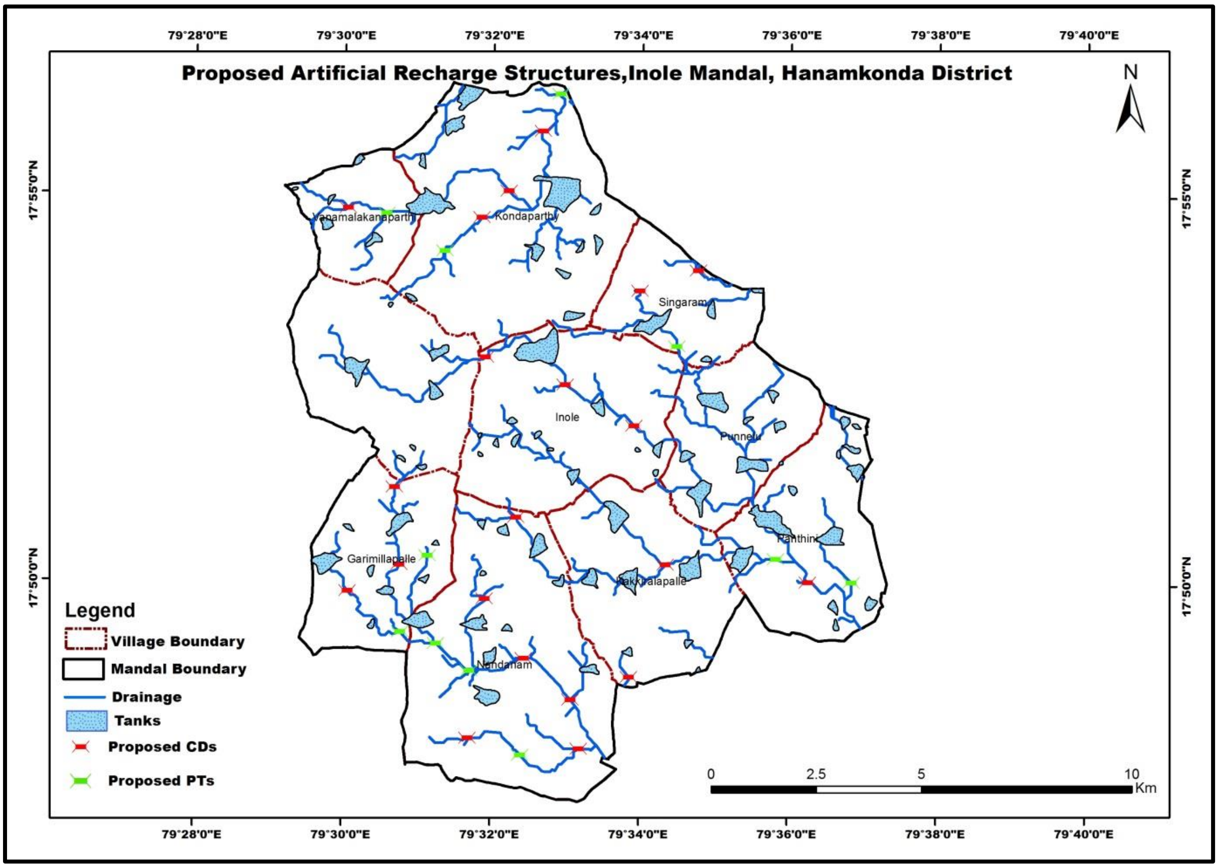


Fig.6.3 : Proposed Artificial Recharge Structures Locations for Inole Mandal

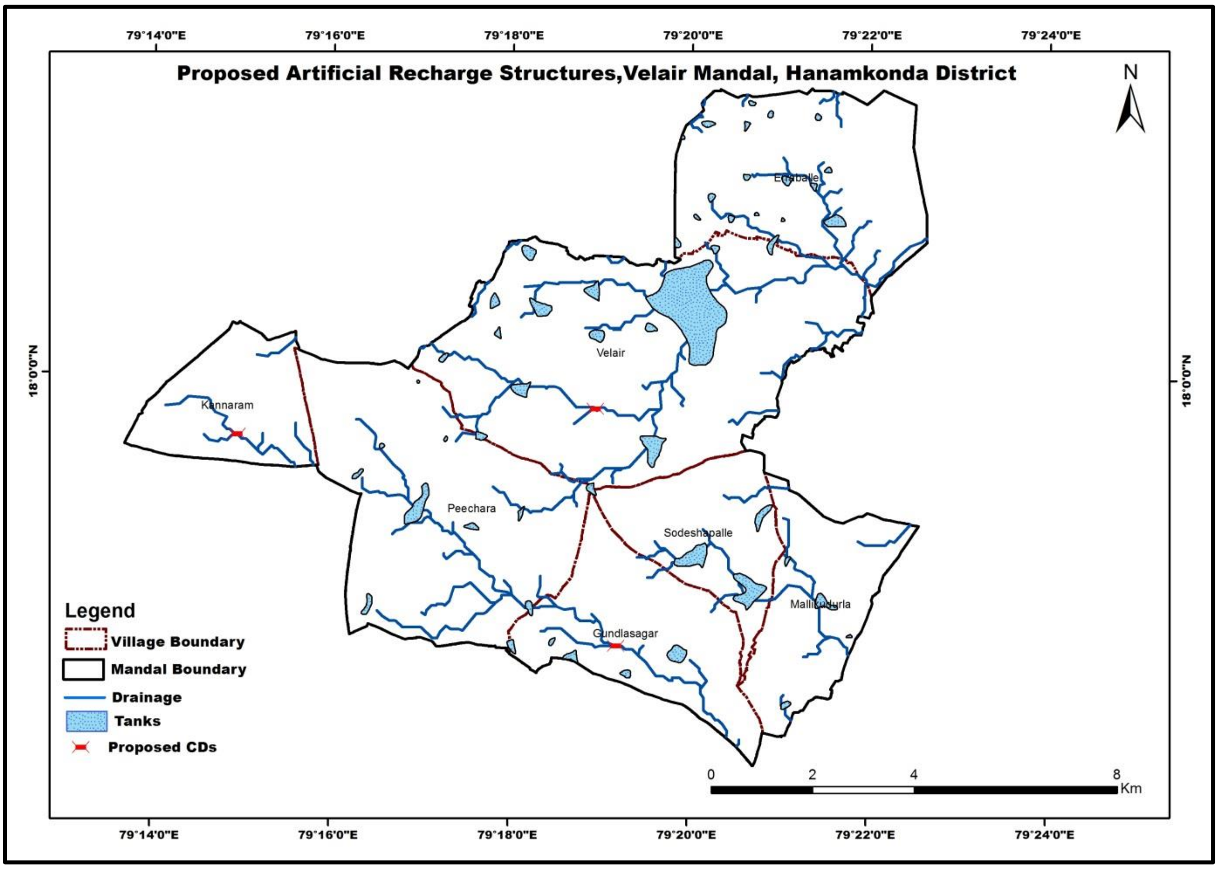


Fig.6.4 : Proposed Artificial Recharge Structures Locations for Velair Mandal

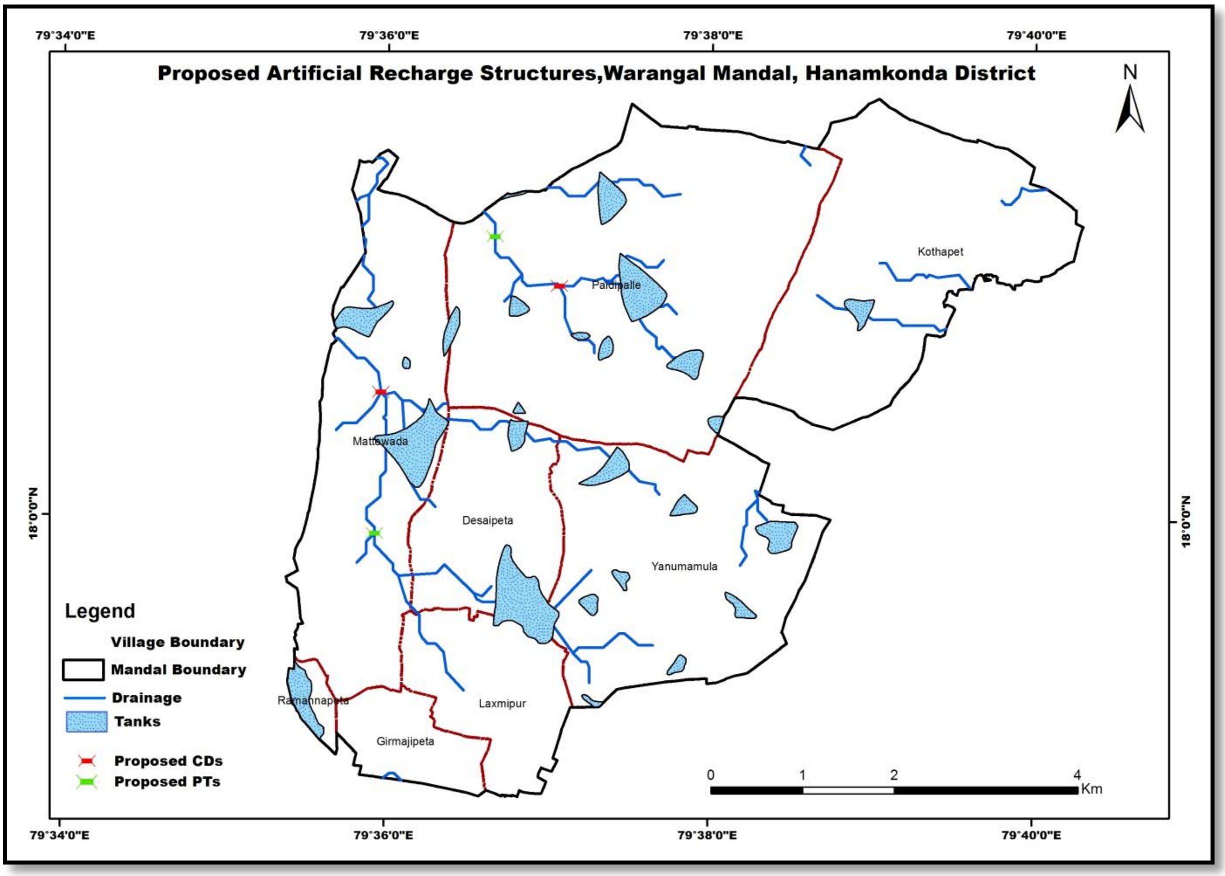


Fig.6.5 : Proposed Artificial Recharge Structures Locations for Warangal Mandal

In addition to this roof top rainwater harvesting structures should be made mandatory to all Government buildings.

6.1.2 State Government Projects

- **Mission Kakatiya (Repair, Renovation and Restoration of existing tanks):**
  De-silting of existing minor tanks (680 no.) was taken under state Govt. sponsored Mission Kaktiya (Phase-1 to 4) to remove silt and this has created additional surface storage and enhance groundwater recharge.
- **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 two water grids with intake from 1) Lower Manair Dam (Segment- LMD MHH), 2) Lower Manair Dam (Segment- LMD WGL) to provide protected water from surface reservoirs. The scheme is to enhance the existing drinking water scheme and to provide safe drinking water to 75914 no. of households.

The total water requirement as per 2020 census is 13.03 MCM and this imported water from surface sources will reduce the present utilized ~7.8 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~1300 ha of additional land under ID crops.

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.

6.2 Demand side management

In order to manage the available resources more effectively the following measures are recommended.

- ❖ In the district, till date 2498 no's drip and sprinklers are sanctioned which has irrigated ~2540 ha under ID crops saving ~3.81 MCM (considering 25% saving of 0.006 MCM/ha) of groundwater from the basin. Considering the current scenario of ground water development, existing number of structures and shallow water levels, demand side intervention such as change in cropping pattern and micro irrigation has not been proposed.
- ❖ ~3500 ha of additional land that can be brought under micro-irrigation (@1000 ha /mandal including existing area in 3 semi-critical mandals (i.e. Elakathurthy, Inavolu and Warangal) and 2 Over Exploited mandals (i.e. Velair and Bheemdevarapally) costing about 21 crores (considering 1 unit/ha @0.6 lakh/ha). With this 5.25 MCM of ground water can be conserved over the traditional irrigation practices.
- ❖ Change in cropping pattern from water intensive paddy to irrigated dry crops like pulses and millets are recommended particularly in 5 mandals viz. Elakathurthy, Inavolu, Warangal, Velair and Bheemdevarapally.
- ❖ 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

6.3 Other Recommendations

- ❖ A participatory groundwater management (PGWM) approach in sharing of ground water and monitoring resources 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 ground water may be given to the farmers involved.
- ❖ In urban and rural areas, the sewerage line should be constructed to arrest leaching of nitrate.
- ❖ The other measures that are recommended include supplementary calcium and phosphorous rich food to the children in fluoride endemic mandals. Creating awareness about safe drinking water habits, side effects of high fluoride and nitrate rich groundwater, improving oral hygiene conditions.

6.4 Expected results and outcomes

With the above interventions costing Rs 16.3 crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be net saving of 8.05 MCM of ground. This will bring down the stage of groundwater development by 2.3 % (from 62 % to 59.7%)

Acknowledgment

The author expresses her sincere thanks to Shri. Sunil Kumar, Chairman of CGWB, Govt. of India and Shri. J. Siddhardha Kumar, Regional Director and Smt. Rani V.R, Scientist-D for encouragement and support and other officers for their support and guidance The author also acknowledge State Ground Water Department and Rural Water Supply department, Govt. of Telangana for providing field data. Authors also thank the Executive Engineer and his drilling crew of CGWB, for carrying out the exploration activity.

Annexure-1

Proposed supply side interventions for ARS

Mandal	Village	Round Proposed CDs	Round Proposed PTs	Cost of Cds @ 15 lakhs	Cost of PTs @ 20 lakhs
Inole	Kondaparthy	3	2	45	40
Inole	Wanamalakanparthy	1	1	15	20
Inole	Raghunathpally	0	0	0	0
Inole	Inavolu	3	0	45	0
Inole	Kakkiralapalli	2	0	30	0
Inole	Nandanam	6	3	90	60
Inole	Panthini	1	2	15	40
Inole	Punnelu	0	0	0	0
Inole	Singaram	2	1	30	20
Inole	Garmillapalli	3	2	45	40
Bheemadevarpalle	Bheemadevarpalle	1	1	15	20
Bheemadevarpalle	Gatlanarsingapur	0	0	0	0
Bheemadevarpalle	Koppur	1	1	15	20
Bheemadevarpalle	Kothakonda	0	0	0	0
Bheemadevarpalle	Kothapalle	2	1	30	20
Bheemadevarpalle	Mallaram	0	0	0	0
Bheemadevarpalle	Manikyapur	1	0	15	0
Bheemadevarpalle	Mulkanoor	3	3	45	60
Bheemadevarpalle	Mustafapur	0	0	0	0
Bheemadevarpalle	Mutharam (P.K)	0	0	0	0
Bheemadevarpalle	Ratnagiri	1	1	15	20
Bheemadevarpalle	Wangara	5	4	75	80
Elkathurthi	Baopet	0	0	0	0
Elkathurthi	Damera	2	2	30	40
Elkathurthi	Dandepalle	1	1	15	20
Elkathurthi	Elkathurthi	5	4	75	80
Elkathurthi	Gopalpur	1	1	15	20
Elkathurthi	Jeelgul	2	2	30	40
Elkathurthi	Keshwapur	0	0	0	0
Elkathurthi	Kothulnaduma	1	0	15	0
Elkathurthi	Penchakalpeta	1	1	15	20
Elkathurthi	Suraram	2	2	30	40
Elkathurthi	Thimmapur	0	0	0	0
Elkathurthi	Vallabhapur	1	0	15	0
Elkathurthi	Veeranarayanapur	1	1	15	20

Velair	Gundlasgar	0	0	0	0
Velair	Mallikudurla	0	0	0	0
Velair	Peesara	0	0	0	0
Velair	Sodashapally	0	0	0	0
Velair	Velair	0	0	0	0
Velair	Errabelligudem	0	0	0	0
Velair	Kannaram	3	0	45	0
Warangal	Laxmipur	0	0	0	0
Warangal	Girmarajipeta	0	0	0	0
Warangal	Desaipeta	0	0	0	0
Warangal	Kothapet	0	0	0	0
Warangal	Paidipally	2	1	30	20
Warangal	Rangasaipeta	0	0	0	0
Warangal	Yenumamula	0	0	0	0
Warangal	Laxmipur	0	0	0	0
Warangal	Mattewada	1	1	15	20

Annexure-2

Proposed locations for ARS on supply side interventions

S. No.	Village	Mandal	Longitude	Latitude	Structure
1	Bheemadevarpalle	Bheemadevarapalle	79.35361111	18.09667	PT
2	Koppur	Bheemadevarapalle	79.39026399	18.1026	PT
3	Kothapalle	Bheemadevarapalle	79.38777778	18.05773	PT
4	Mulkanoor	Bheemadevarapalle	79.36057869	18.08965	PT
5	Mulkanoor	Bheemadevarapalle	79.33722222	18.07417	PT
6	Mulkanoor	Bheemadevarapalle	79.36027778	18.05889	PT
7	Ratnagiri	Bheemadevarapalle	79.36777778	18.11833	PT
8	Vangara	Bheemadevarapalle	79.33722222	18.11278	PT
9	Vangara	Bheemadevarapalle	79.33123376	18.11667	PT
10	Vangara	Bheemadevarapalle	79.33638889	18.13075	PT
11	Vangara	Bheemadevarapalle	79.32083333	18.12278	PT
12	Bheemadevarpalle	Bheemadevarapalle	79.37027778	18.09611	CD
13	Koppur	Bheemadevarapalle	79.37833333	18.10056	CD
14	Kothapalle	Bheemadevarapalle	79.38361111	18.08667	CD
15	Kothapalle	Bheemadevarapalle	79.38277778	18.065	CD
16	Manikyapur	Bheemadevarapalle	79.37833333	18.14889	CD
17	Mulkanoor	Bheemadevarapalle	79.34805556	18.08944	CD
18	Mulkanoor	Bheemadevarapalle	79.36555556	18.08056	CD
19	Mulkanoor	Bheemadevarapalle	79.32416667	18.07833	CD
20	Ratnagiri	Bheemadevarapalle	79.36472222	18.12944	CD
21	Vangara	Bheemadevarapalle	79.31361111	18.13167	CD
22	Vangara	Bheemadevarapalle	79.32111111	18.13833	CD
23	Vangara	Bheemadevarapalle	79.33055556	18.13722	CD
24	Vangara	Bheemadevarapalle	79.35027778	18.14139	CD
25	Vangara	Bheemadevarapalle	79.34111111	18.13806	CD
26	Dandepalle	Elkathurthi	79.49222222	18.13806	PT
27	Elkathurthi	Elkathurthi	79.43861111	18.09528	PT
28	Elkathurthi	Elkathurthi	79.43222222	18.10694	PT
29	Elkathurthi	Elkathurthi	79.41805556	18.09111	PT
30	Elkathurthi	Elkathurthi	79.44916667	18.07778	PT
31	Elkathurthi	Elkathurthi	79.44111111	18.0795	PT
32	Gopalpur	Elkathurthi	79.42083333	18.12167	PT
33	Jeelgul	Elkathurthi	79.40805812	18.13111	PT
34	Jeelgul	Elkathurthi	79.39583333	18.13722	PT
35	Penchakalpeta	Elkathurthi	79.40169469	18.15623	PT
36	Suraram	Elkathurthi	79.46694444	18.12694	PT
37	Suraram	Elkathurthi	79.43527778	18.11667	PT
38	Veeranarayanapur	Elkathurthi	79.45577003	18.14845	PT
39	Danera	Elkathurthi	79.42444444	18.06278	PT
40	Danera	Elkathurthi	79.44444444	18.07083	PT
41	Dandepalle	Elkathurthi	79.4625	18.15667	CD
42	Elkathurthi	Elkathurthi	79.4325	18.08917	CD

43	Elkathurthi	Elkathurthi	79.43027778	18.10222	CD
44	Elkathurthi	Elkathurthi	79.46333333	18.10806	CD
45	Elkathurthi	Elkathurthi	79.45277778	18.11	CD
46	Elkathurthi	Elkathurthi	79.44694444	18.08611	CD
47	Gopalpur	Elkathurthi	79.40055556	18.11389	CD
48	Jeelgul	Elkathurthi	79.41416667	18.13444	CD
49	Jeelgul	Elkathurthi	79.41	18.14444	CD
50	Kothulnaduma	Elkathurthi	79.43583333	18.14722	CD
51	Penchakalpeta	Elkathurthi	79.41861111	18.15667	CD
52	Suraram	Elkathurthi	79.45944444	18.13417	CD
53	Suraram	Elkathurthi	79.45527778	18.11474	CD
54	Vallabhapur	Elkathurthi	79.42944444	18.13167	CD
55	Veeranarayanapur	Elkathurthi	79.44888889	18.145	CD
56	Danera	Elkathurthi	79.40944444	18.06361	CD
57	Danera	Elkathurthi	79.38944444	18.04583	CD
58	Garimillapalle	Inole	79.51305556	17.8225	PT
59	Garimillapalle	Inole	79.51906	17.83889	PT
60	Kondaparthy	Inole	79.5225	17.90444	PT
61	Kondaparthy	Inole	79.54833333	17.93833	PT
62	Nandanam	Inole	79.52111111	17.82	PT
63	Nandanam	Inole	79.52861111	17.81417	PT
64	Nandanam	Inole	79.5401787	17.79612	PT
65	Panthini	Inole	79.59722222	17.83861	PT
66	Panthini	Inole	79.61416667	17.83361	PT
67	Singaram	Inole	79.57472222	17.88417	PT
68	Vanamalakanaparthi	Inole	79.50944444	17.9125	PT
69	Garimillapalle	Inole	79.51166667	17.85361	CD
70	Garimillapalle	Inole	79.50115995	17.83119	CD
71	Garimillapalle	Inole	79.51277778	17.83694	CD
72	Inole	Inole	79.54972222	17.87583	CD
73	Inole	Inole	79.56523483	17.86708	CD
74	Inole	Inole	79.53179447	17.88166	CD
75	Kakkiralapalle	Inole	79.5725	17.83722	CD
76	Kakkiralapalle	Inole	79.56444444	17.81306	CD
77	Kondaparthy	Inole	79.53083333	17.91167	CD
78	Kondaparthy	Inole	79.53680803	17.91744	CD
79	Kondaparthy	Inole	79.54444444	17.93028	CD
80	Nandanam	Inole	79.55333333	17.7975	CD
81	Nandanam	Inole	79.52833333	17.79972	CD
82	Nandanam	Inole	79.53194444	17.82972	CD
83	Nandanam	Inole	79.53888889	17.84722	CD
84	Nandanam	Inole	79.54083333	17.81694	CD
85	Nandanam	Inole	79.55138889	17.80806	CD
86	Panthini	Inole	79.60444444	17.83361	CD
87	Singaram	Inole	79.57944444	17.90056	CD
88	Singaram	Inole	79.56638889	17.89611	CD

89	Vanamalakanaparthi	Inole	79.50083333	17.91361	CD
90	Gundlasagar	Velair	79.32	17.95194	CD
91	Velair	Velair	79.31583333	17.99417	CD
92	Kannaram	Velair	79.24916667	17.98917	CD
93	Paidipalle	Warangal	79.61111111	18.02761	PT
94	Mattewada	Warangal	79.59888889	17.99833	PT
95	Paidipalle	Warangal	79.61778	18.02278	CD
96	Mattewada	Warangal	79.59944	18.01222	CD