केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report

on

AQUIFER MAPPING AND GROUND WATER MANAGEMENT

Nizamabad District, Telangana

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

भारत सरकार
जल संसाधन नदी विकास एवम् गंगा संरक्षण मंत्रालय
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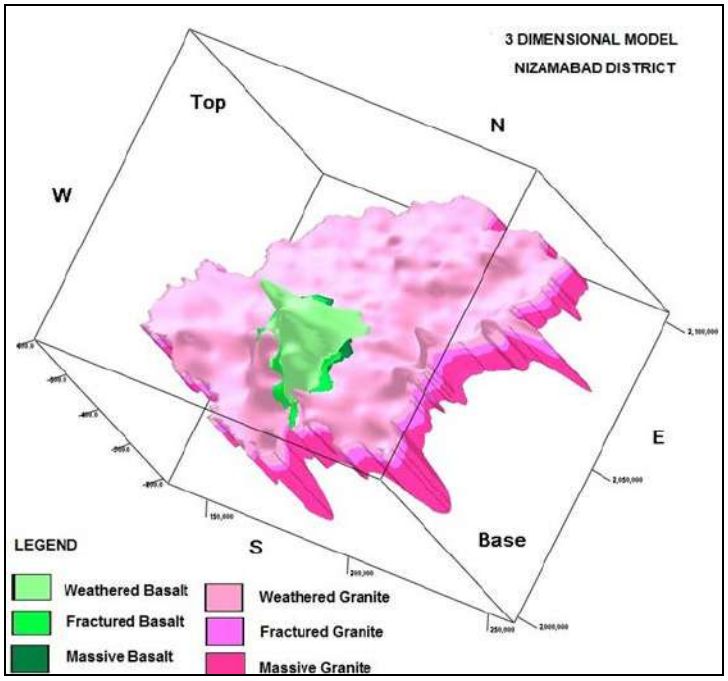
GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES RIVER DEVELOPMENT AND GANGA REJUVENATION

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



CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
JULY-2016

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

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

AT A GLANCE

S.No.	Item		Particulars
1	Districts	:	Nizamabad
2	Mandals	:	36
3	Revenue villages	:	923
4	Geographical area	:	7956 Km^2
5	Population (2011 Census)	:	~25.51 lakhs (77 % Rural and 23 % urban)
6	Locations	:	North Latitude 18°04´4.8"-19°00´54" East Longitude 77°31´41"-78°40´1.2"
7	Rainfall	:	878-1220 mm (avg: 1092) (SW-82% & NE 13%) During 2014 it received 640 mm (avg) (-42% than normal)
8	Geomorphology	:	Pedi plains (57 %), pediments (17%) , Denudation hills (11%) etc.
9	Major Rivers	:	Godavari River and Manjira River
9.1	Watersheds	:	48
10	Forests	:	~22% (1693Km^2)
11	Soils	:	Clayey soils and loamy soils
12	Land Utilization (Ha)	:	Net area sown: 290037 (~36% of geographical area). Total cropped area:449697; Area sown more than once:159660, Land put to non-agricultural use:97733, Current follows;59671 other follow land;98139
13	The Gross cropped area (Ha) 2014-15	:	Khariff: 290037 (paddy: 112400 (37%)), and Rabi: 159000 (paddy: 56800 (38%) Other crops :Cotton 15800 (Khariff) and 18500 (Maize (rabi)
14	Irrigation	:	Major: Sri Ram sagar and Nizamsagar Projects Medium: Pocharam (completed), Ramadagu, Nallavagu and Koulasnia (on going). Registered ayacut: 117306 ha and gross cropped area during 2014-15 is 10900 ha only (9%) MI Tanks:3022 with ayacut 18000 ha
15	Water conservation/Recharge practices	:	PT:1322, CD's:1019 and 2734 Farm Ponds

16	Geology	:	Banded Gneissic complex (67%) and granite (24%), Deccan Traps (9%)	
17	Exploratory Drilling (CGWB and SGWD)	:	122 wells (CGWB) mostly 100 m depth except 6 wells (4 in the range of 100-150 m and 2 150-200 m) and 89 (SGWD)	
18	Number of ground water structures	:	236142 (Irrigation;220511 and domestic:15631)	
19	Ground water yield (lps)	:	Weathered BGC and Granites :< 0.1 to 8.3 lps (avg:1.5lps) and Fractured BGC and Granites: 0.01 to 4.9 lps. Basalt 0.01 to 0.8 lps (avg:0.4 lps)	
20	Water Levels (2015)	:		
20.1	Depth to water Table Elevations (m amsl)	:	Pre-monsoon:277.1-583.7 and Post-monsoon: 279.6-584.3	
20.2	Depth to water levels (m bgl)	:	Pre-monsoon:2.1-43.5 (avg:13.7) (Majority 10-20 m: 63% of area followed by 5-10 m: 22%) Post-monsoon:1.3-36.1(avg:15.6)	
20.3	Water Level Fluctuations (m)	:	-15.1 to 22.5 m (avg fall of -1.2 m) 81 % of area shown fall and 19 % shown rise.	
20.4	Long term water level trends (2005-15)	:	Pre-monsoon: Falling: 0-1 :45, 1-2 :12, > 2:6, Rising: 0-1:11 Post-monsoon: Falling: 0-1 :46 wells, 1-2 :17, > 2:4, Rising: 0-1:9	
21	Geophysical data	:	53 nos (CGWB:28 and GWD:25)	
22	Hydrochemistry	:	272 samples (139:Premonsoon and 133:Post-monsoon)	
22.1	Electrical Conductivity (µ Siemens/cm)	:	Pre:197-3060 (avg: 993) and Post: 374-3550 (avg: 1025)	
22.2	Fluoride	:	Pre:0.1-2.6 and Post: 0.1-3.7 mg/L	
22.3	Nitrate	:	Pre:1-488 and Post: 1-243 mg/L	
22.4	Ground water suitability for drinking	:	60 and 62 samples (43% and 47%) are unfit for drinking purposes during pre and post-monsoon season respectively.	
23	Conceptualization		**Weathered zone**	**Fractured zone**
23.1	Aquifer Characterization	:	Up to 20 m In 75 % area 10-20 m thickness is prominent	20- 185 m. Majority of fractures (96 %) occur within 100 m depth
23.2	Ground water yield (lps)	:	Basalt:0.4 BGC and Gr:1.5	Basalt:0.3 BGC and Gr:1.25
21.3	Transmissivity (m^2/day)	:	5-181	1 to 117
21.4	Specific Yield	:	1.7 to 2 %	---

21.5	Storativity	:	---	0.00035 to 0.018	
22	**Ground water Resources (2013) MCM**	:	Command	Non-Command	Total
21.1	Net dynamic groundwater availability	:	581.1	730.2	1311.3
21.2	Gross GW Draft	:	333.71	484.05	817.76
21.3	Provision for Domestic &Industrial (2025)	:	33.1	49.7	82.8
21.4	Stage of Ground water development (%)		57.4%	66.3%	62.4%
21.5	Net GW Availability for future irrigation	:	222.1	208.7	430.9
21.6	Stage of GW development (%)		57.4	66.3	62.4 (avg)
21.7	In storage GW Resources	:	28.31	50.93	79.24
22	Major Ground Water Issues Identified	:	Few mandals are fluorosis endemic (geogenic), anthropogenic contamination due to nitrate is common. Over-exploitation in ~2140 km^2 area (324 villages). Deep water levels (>20 m) in 13 % and 25 % of area in pre and post-monsoon seasons respectively. Low yields in ~40 % of area, Water marketing		
23	Management Strategies	:	**Supply side measures** **Ongoing Projects (Mission Kaktiya)** • 834 tanks with storage capacity of ~283 MCM to remove 12.78 MCM silt. This will contribute ~6.4 MCM of GW and with this additional ~1066 ha of land can be brought under ID crops. **Mission Bhagiratha** • Total water requirement as per 2011 census 101.26 MCM with this imported SW there will be net saving of 55 MCM of GW which will create additional ~9300 ha irrigation potential. **To be taken up** • ~978 MI tanks and 1210 other small tanks **Artificial Recharge Structure (ARS)** **Priority-1 (Over-exploited villages:324)** • 2480 ARS (1251 CD's and 1229 PT) • Cost Rs ~185.45 Crores • Net recharge to GW will be 40 MCM **Priority-2 (Other villages:581)** • 6874ARS (3446 CD's and 3428 PT)		

			• Cost Rs ~515.1 Crores • Net recharge to GW will be 106.8MCM **Water Conservation measures (WCM) Farm Ponds** Recommended 7860 nos farm ponds with total cost 19.65 crores. **Demand side measure** **Ongoing work** • Total 4852 micro irrigation schemes are in operation irrigating ~4031 ha of land saving ~6 MCM of GW. **Proposed Work** • Total 49000 micro irrigation schemes are recommended (@100 ha in 490 villages) • Cost ~294crores (@0.6 lakh/ha) • Will save 98 MCM of GW to traditional Irrigation practices. **Regulatory measures** Change in cropping pattern from paddy/spices to other ID crops like pulses and oil seeds during khariff and rabi season in non-command areas. Compulsory rain water harvesting in proportionate to withdrawal. Intermittent pumping of adjoining bore wells. Restricted power supply in two spells. **Institutional measures** Participatory groundwater management (PGWM) approach are recommended. Other measures include providing calcium and phosphorous rich food to the children below the ages of 14 years in fluorosis endemic areas.
24	Expected Results and Out come	:	Stage of GW Development will come down from 62 % (present) to 50 % (12 % reduction) with one time investment of 1014.15 crores (excluding the cost of Mission Kakatiya and Mission Bhagiratha).

ABBREVATION:

2D	:	2 Dimentional
3D	:	3 Dimentional
ARS	:	Artificial Recharge Structures
Avg	:	Average
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 commite
GW	:	Ground Water
Ha	:	Hector
Ha.m	:	Hector meter
ID	:	Irrigated dry
Km2	:	square kilometer
LPS	:	Liters per second
M	:	meter
M^3	:	Cubic meter
max	:	Maximum
M bgl	:	Miters below ground leval
MCM	:	Millian cubic meter
Mg/L	:	Milligram per liter
MI	:	Micro irrigation
min	:	Minimun
MPT	:	Mini percolation tank
NL	:	North Lattitude
NO_3	:	Nitrate
OE	:	Over Exploited
PGWM	:	Participatory ground water management
PT	:	Percolation tank
SGWD	:	State Ground Water Department
S	:	Storativity
T	:	Transmissivity
WCM	:	Water conservation measures

EXECUTIVE SUMMARY

The Nizamabad district covering 7956 Km^2 area, receives an annual normal rainfall of 1092 mm of which 82 % is contributed by SW monsoon. During the year 2014 and 2015, the district received -42% and - 46 % deficient rainfall respectively. Administratively, the district is governed by 36 revenue mandals with 923 villages with 25.51 lakh population.

Pediplains are major geomorphic features (57% of area) followed by pediments and hills and is drained by river Godavari and its tributaries namely Manira, Maneru, Haileru, Phulang, Peddavagu and Yedalkattavagu and are divided into 48 watersheds. Paddy is the most irrigated crop in both seasons followed by cotton during kharif and maize during rabi season respectively. The soils are mainly clayey soils. ~92% of the area is underlain by granites and gneisses with basic intrusive rocks at places and 9 % by basalts. Irrigation is mostly by groundwater during the year 2014-15 due to less rainfall and 2,22,951 agricultural connections are provided with free power. There are 2 major, 4 medium (1 competed and 3 on-going) irrigation projects along with 3022 water bodies (command area:1079 and non-command area:1943).

Hydrogeological data from 260 wells (BW and DW) mostly down to 100 m depth are collected and compiled along with 53 VES data. Water levels are monitored through 140 wells during pre and post-monsoon season of 2015 and 272 ground water samples (Pre-monsoon:139 and Post-monsoon:133) were analyzed for knowing the suitability of ground water for drinking and irrigation purposes during the year 2015. The DTW varies from 2.1 to 43.5 meter below ground level (m bgl) (average: 13.7 m) and 1.3-36.1 m bgl (average: 15.6) during pre and post-monsoon season respectively. In majority of the area (63% and 55 % area), water levels are in the range of 10-20 m bgl during pre and post-monsoon season respectively. During the year there is fall in water levels in 81% of the area. Majority of hydrographs shows falling trend in both pre and post-monsoon season (15 wells out of 21) @-0.02 to -1.5 m/yr and -0.02 to -2.13 m/yr respectively.

High incidence of fluorosis (F up to 2.6 mg/L and 3.7 mg/L) during pre and post-monsoon season respectively is due to geogenic contamination and is major problem faced in 5 mandals. While high concentrations of nitrate are due to anthropogenic contamination (as high as 488 mg/L). About 63% and 47% of the samples are unfit for human consumption during pre and post-monsoon season of 2015. Overall the groundwater quality is suitable for irrigation purposes excluding 2 % area (mainly canal command).

Aquifers from the area can be conceptualized in to two nos namely, 1) weathered zone (~20 m) and 2) fractured zone (20-185 m). In 75 % of the area, thickness of weathered zone is in the range of 10-20 mbgl, followed by < 10 m. Yield ranges from 0.1-8.3 lps in BGC and 0.01-0.8 lps in basalt. The transmissivity ranges from 5-181 m^2/day, specific capacity 1-60 lp/mdd and specific yield of 1.7 to 2 %. Majority (97 %) of fractures occur within 100 m depth and deep fractures occur in Nizamabad, Lingampet and Sirikonda mandals. Ground water yield in fractures varies from 0.01 to 4.9 lps and T varies from 1 to 117 m^2/day and S is 0.00035 to 0.018.

Net annual ground water availability is 1311MCM, gross ground water draft is 817.76 MCM and net available balance for future irrigation use is 430.9 MCM. The stage of ground water development is 62.4 %. The in-storage ground water resources (~100 m depth) are 79.24 MCM.

Major issues identified are pollution (both geo-genic (F) and anthropogenic (NO_3), over-exploitation in 2140 km^2 area covering 324 villages, deep water levels (>20 m) in 13 % & 25% of the area during pre and post-monsoon season respectively, water logging in 2 % area (command area), declining water levels and low yields in 40 % of the area.

The management strategies include supply side, demand side, regulatory and institutional measures. The supply side measure includes ongoing work under Mission Kaktiya where 834 tanks having 283 MCM storage capacities are taken up during Phase-1 and Phase-2. Under Mission Bhagiratha, 101.26 MCM of surface water will be brought to supply to all households. Construction of 9354 ARS with ~700.55 crores and7860 farm ponds with Rs.19.65 crores are recommended. Demand side measure includes bringing 49000 ha of additional land from 490 villages under micro-irrigation with cost of 294 crores and saving ~98 MCM of ground water. Regulatory measures includes **c**hange in cropping pattern from paddy to ID crops, pulses and oil seeds in non-command areas, ccompulsory rain water harvesting in proportionate to withdrawal, iintermittent pumping of adjoining bore wells, restricted power supply in two spells, complete ban on paddy crop cultivation during rabi season. Institutional measures includes participatory groundwater management (PGWM) approach and other measures include providing calcium and phosphorous rich food to the children below the age of 14 years in fluoride affected 5 mandals. With above measures the stage of ground water development will come down by 10 % (from present 62 % to 52 %) with one time investment of 1014.15 crores.

NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGS-NIZAMABAD DISTRICT, TELANGANA STATE.

S. No.	Data	Aquifer	Total Data Points	Source	
				CGWB	SGWD
1	Panel Diagram (3-D)	Combine	260	EW 122: VES:28	Pz: 85, VES:25
2	Hydrogeological Sections	4 no	260	EW 122: VES:53	Pz: 85, VES:25
3	Fence/panel Diagrams	2 no	260	EW 122: VES:53	Pz: 85, VES:25
4	Depth of weathering	1 no	260	EW 122: VES:53	Pz: 85, VES:25
5	Depth of fracturing	1 no	260	EW 122: VES:53	Pz: 85, VES:25
6	Groundwater Yield	Weathered zone	260	EW 122: VES:53	Pz: 85, VES:25
		Fractured zone	260	EW 122: VES:53	Pz: 85, VES:25
7	Transmissivity (m^2/day)	Weathered zone	122	EW 122: VES:	Pz: 85, VES:25
		Fractured zone	122	EW 122: VES:53	Pz: 85, VES:25
8	Depth to Water Level Maps (2015)	Combine	140	42	98
9	Water Level Fluctuations	Combine	140	42	98
10	Water quality (2015) (EC, F and NO_3)	Combine	139 (Pre) 131 (Post)	29 Nil	110 131

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 "**groundwater development**" to "**groundwater 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 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. Thus the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of ground water management through community participation.

Hard rocks (Granites/Gneisses) lack primary porosity, and groundwater 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, 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 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 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. 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.

1.3 Area Details: The Nizamabad district having geographical area of 7956 km^2, lies between north latitude 18°04´4.8"-19°00´54" and east longitude 77°31´41"-78°40´1.2". It is part of the River Godavari basin (**Fig.1.1**). Out of total area, the non-command area is 67 % and command area (27 %) and hilly area is 6 %. Administratively the district is governed by 36 revenue mandals covering 923 villages with a population of ~25.51 lakhs (2011 census) (urban: 23 %, rural: 77 %).

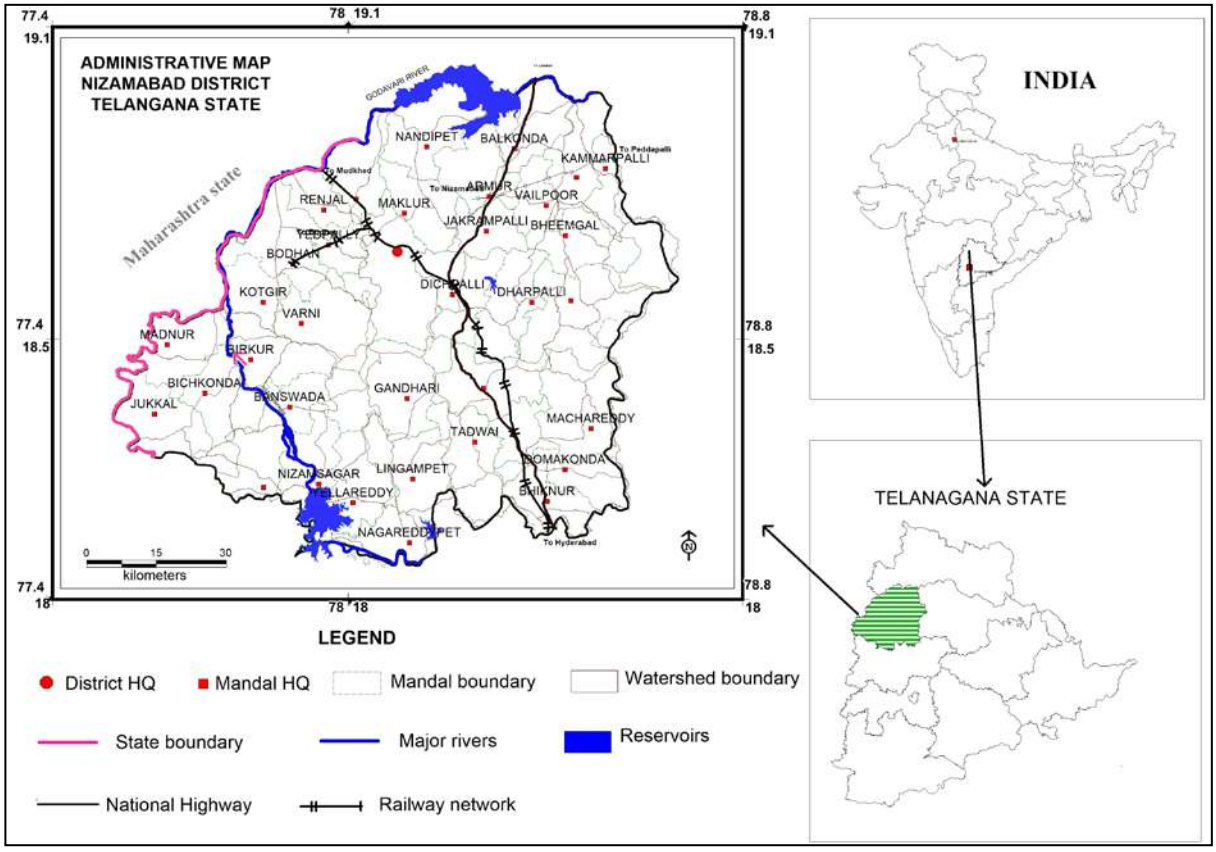

Fig.1.1: Location of Nizamabad district.

1.4 Climate and Rainfall: The climate of the district is characterised by hot summer and generally dry weather except during S-W monsoon season.The normal mean daily minimum and maximum temperature of 25.2 °C and 39.8 °C during May and 13.3 °C and 28.2 °C during December. Normal annual rainfall varies between 878 mm (Jakranapally) to 1220 mm (Gandhari) with average of 1092 mm (**Fig. 1.2**). ~ S-W monsoon contributes 82 % and 13 % is contributed by retreating monsoon (N-E) season and rest by winter and summer rainfall. Rainfall increses from west to central part and from north to central part and then decreases further east and south. As per district statistical abstract, during the year 2015, it received average rainfall of 558 mm (-46% less rainfall than normal rainfall) (-6 % at Jukkal to -60% at Renjal). During the year 2014 it received 640 mm of rainfall (-42 % less than normal rainfall).

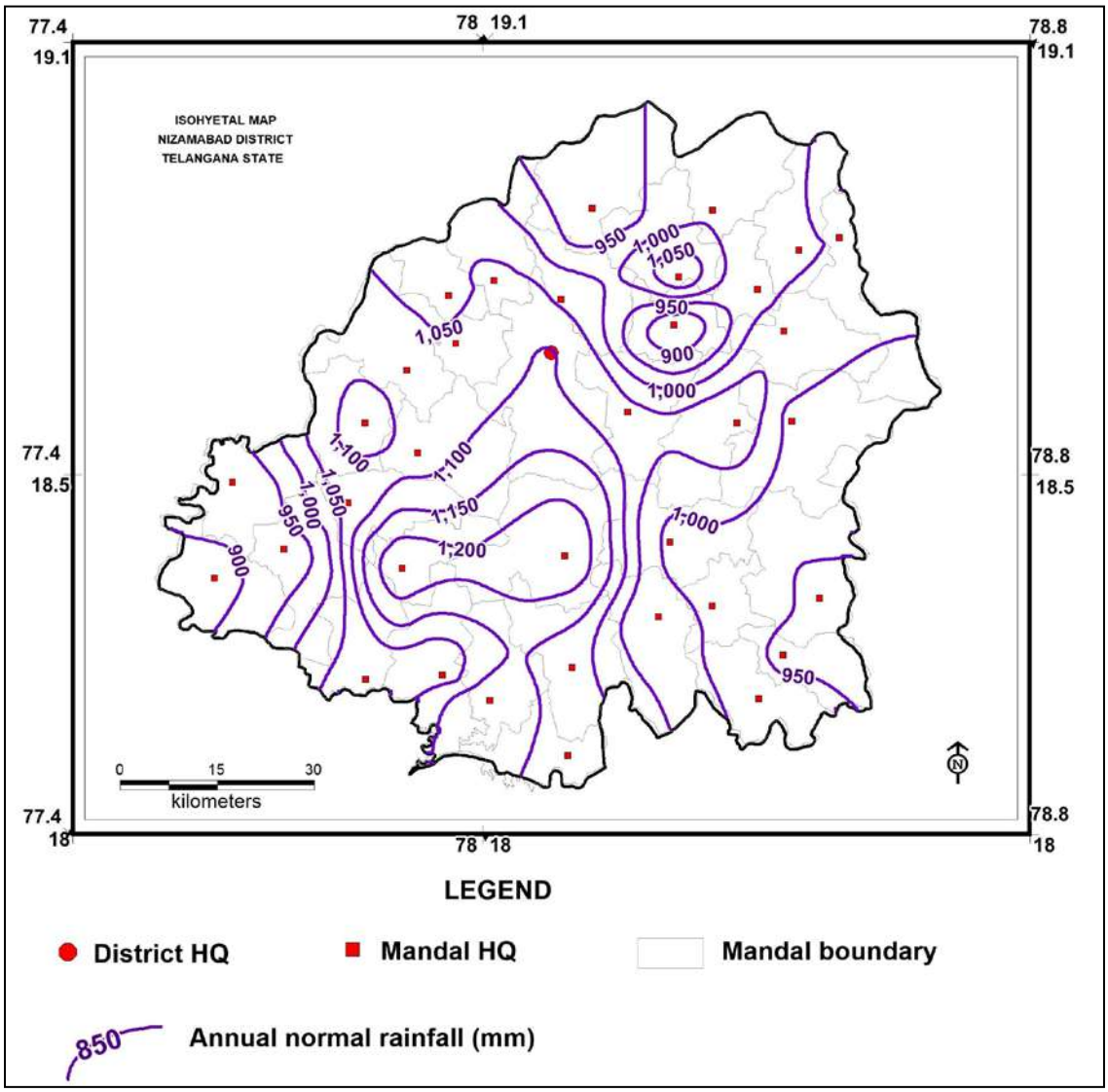

Fig.1.2: Isohyetal map of Nizamabad district.

1.5 Geomorphological Set up: Pediplain is the major landform covering about 4545 km^2 (57 %) area. The other landforms observed are pediment (17%), denudation hills (11%), plateau (7%), flood plain, residual hill, channel fill, etc. (**Fig.1.3**).

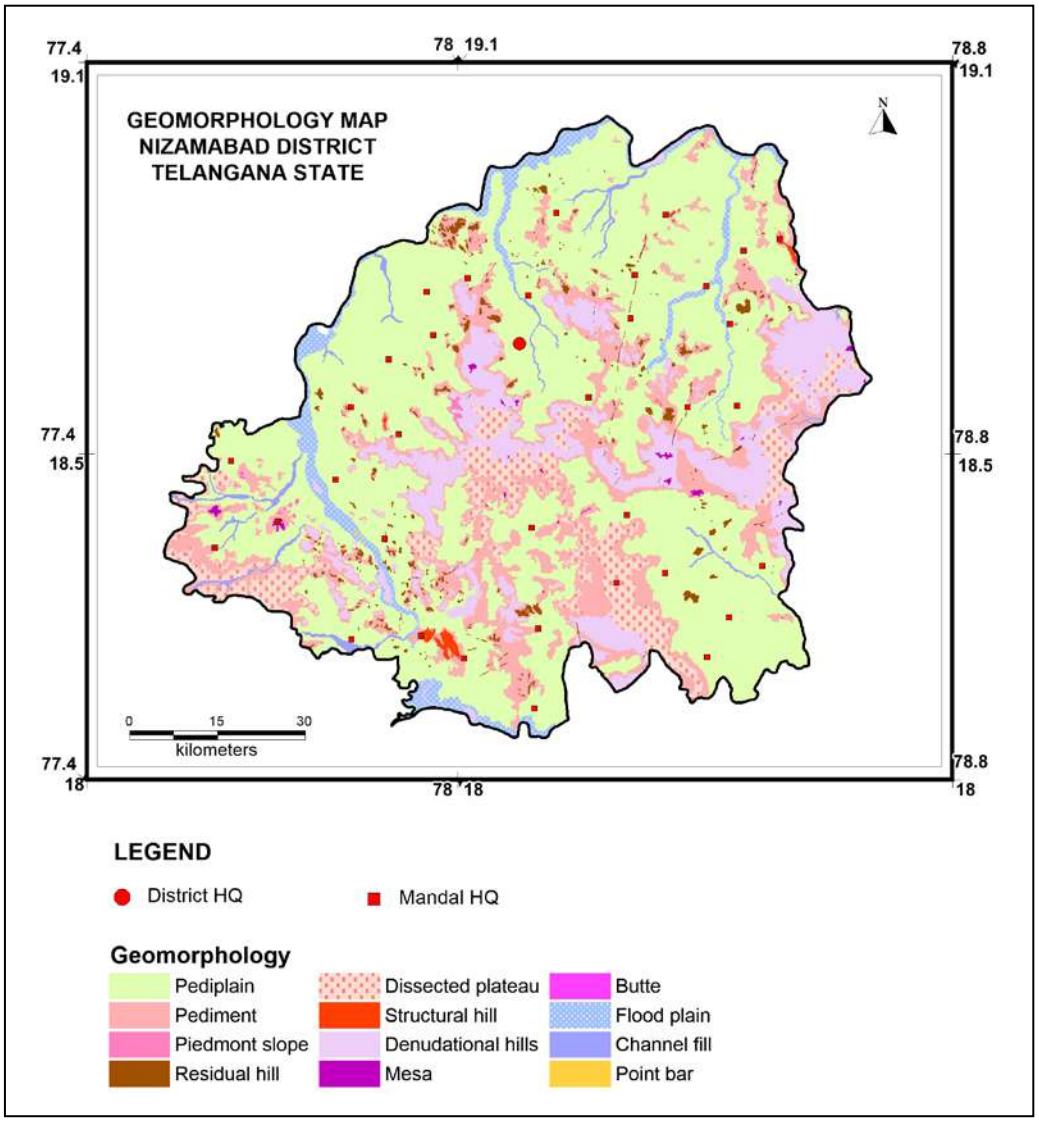

Fig.1.3: Geomorphology of Nizamabad district.

1.6 Drainage and Structures: The district is drained by the river Godavari and its tributary Manjira and other rivers are Maneru, Haileru, Phulang, Peddavagu and Yedalkattavagu and divided into 48 watersheds. Map depicting drainage, hills and water bodies is presented in **Fig.1.4**.

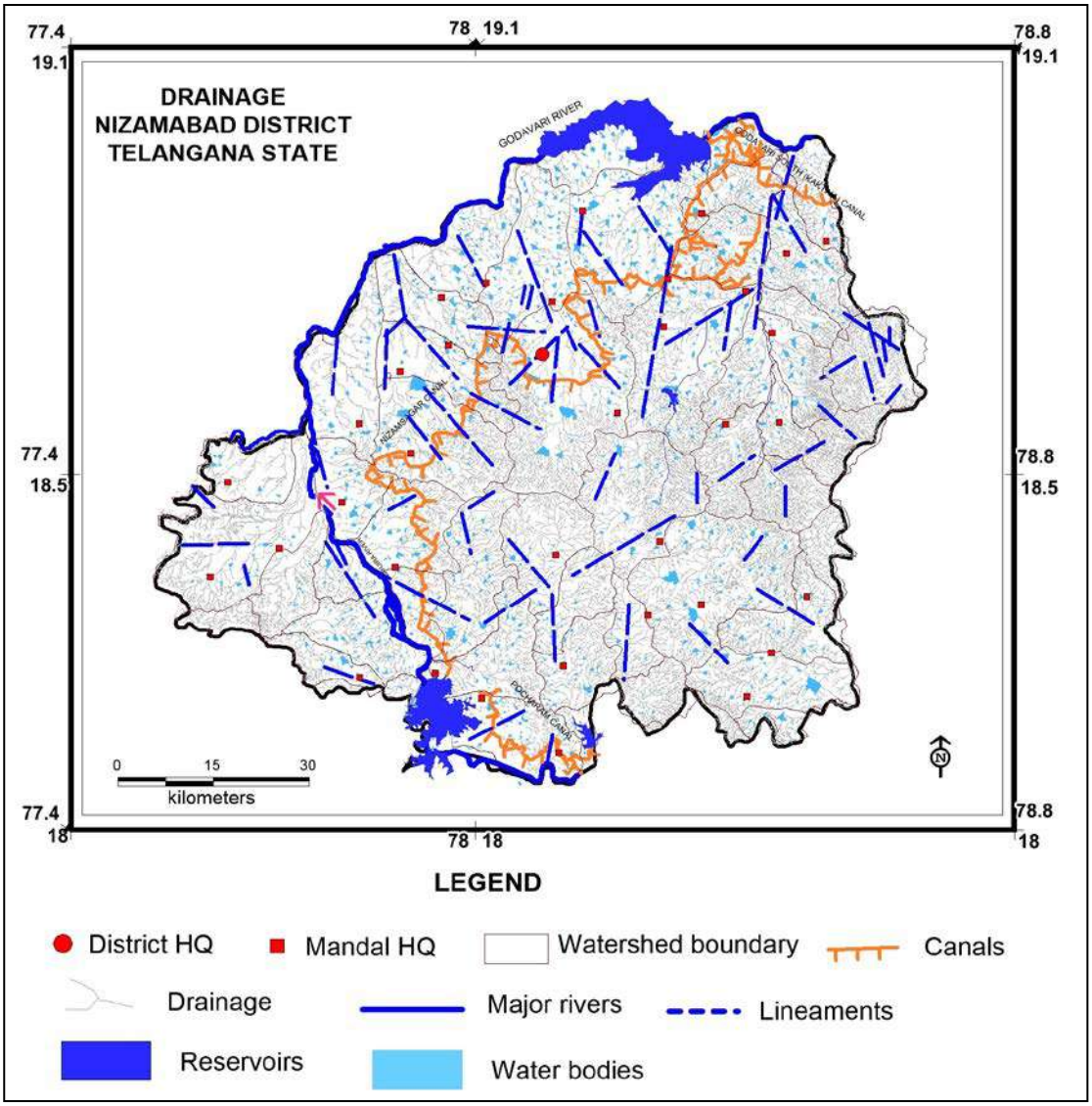

Fig.1.4: Drainage, lineaments, watershed boundaries and canal network.

1.7 Land use and cropping pattern (2014-15): In the area, the land use can be grouped into 16 classes (**Fig.1.5**). In the district, there are 473528 farmers of which 67 % are marginal farmers, 24 % are small farmers and rest by others. Forest occupies ~22% of the total geographical area, barren and cultivable land is 46833 ha, land put to non-agricultural use is 97733 ha, current follows 59671 ha and other follow lands is 98139 ha. The gross cropped area (2014-15) during khariff season is 290037 ha and during rabi season is 159000 ha (Total 449800 ha). Main crops grown are paddy112400 ha (37%) and 56800 ha (38 %) during khariff and rabi season respectively. Cotton is grown in 15800 ha during khariff season and maize in 18500 ha during rabi season. Oils seads are grown in both seasons in 32 % and 10% of the area during khariff and rabi season respectively. The other crops are pulses, spices and sugarcane.

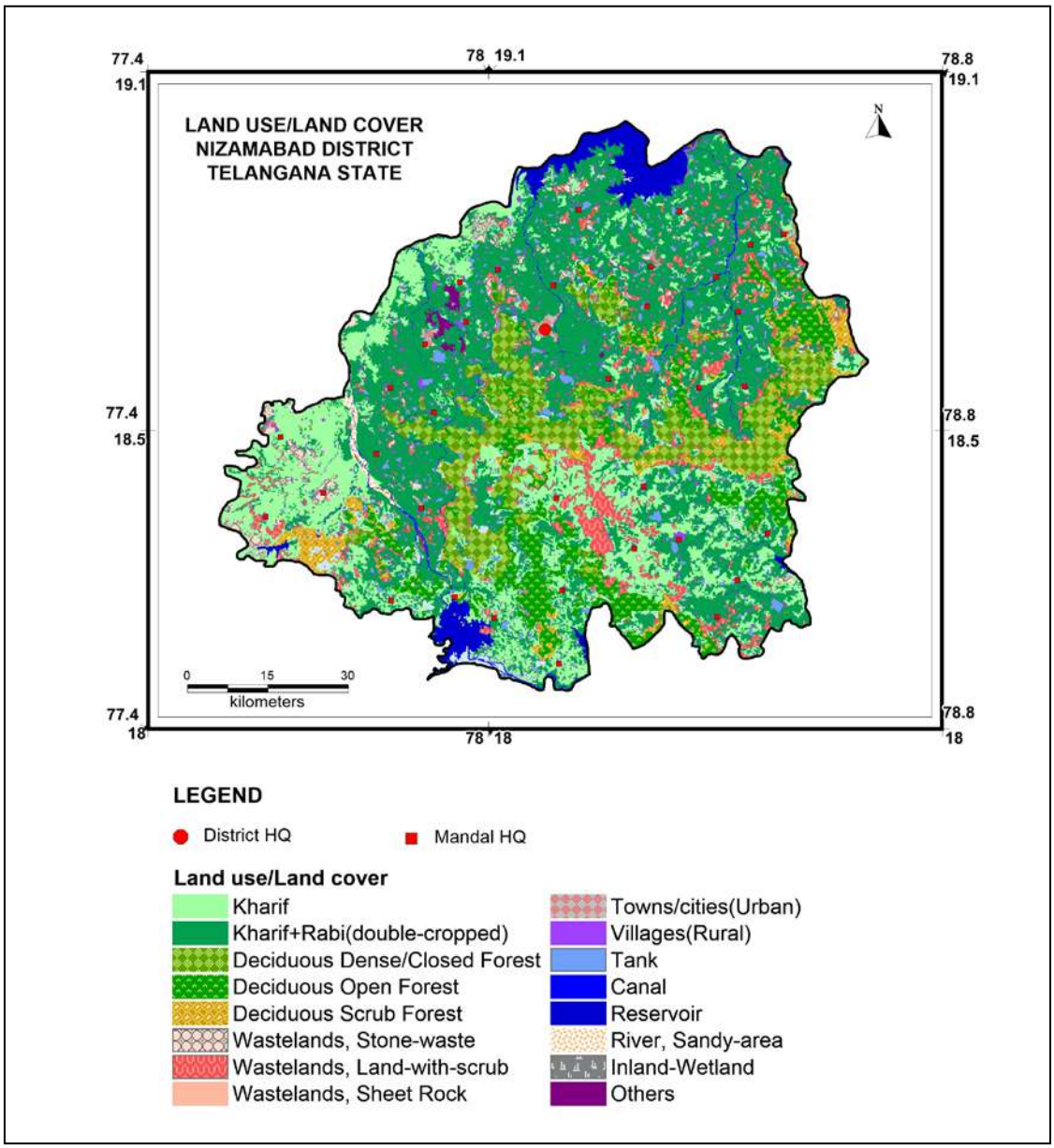

Fig.1.5: Land use and land cover of Nizamabad district.

1.8 Soils: The area is mainly occupied by clayey soils (moderately deep with medium avaialable water content (AWC) (26 %), shallow with low AWC (31 %), loamy soils (moderately shallow, excessively drained soils (24 %), well drained soils (9 %), rock out crops (5 %) and rest by water bodies (**Fig.1.6**).

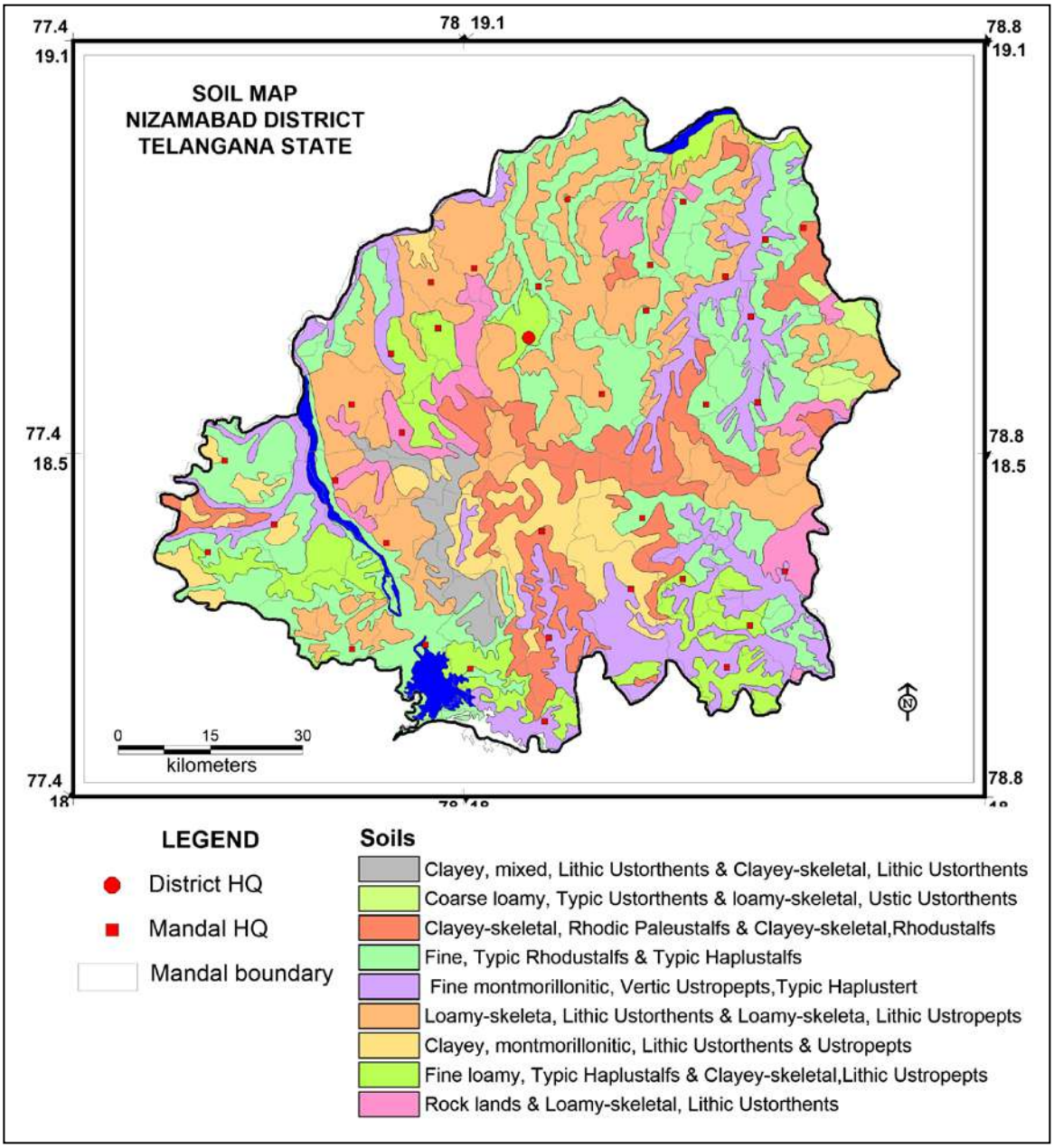

Fig.1.6: Soil map of Nizamabad district.

1.9 Irrigation:

The two major irrigation projects are Sri Ram Sagar Project on River Godavari at Pochampad village, Balkonda mandal and Nizamsagar Project on river Manjira at Achampet and Bijanapally village in Nizamsagar Mandal. The other medium irrigation project is Pocharam Project on river Haileru at Pocharam village in Nagareddipet mandal. The other projects are Ramadagu, Nallavagu and Koulasnia which are at various stages of completion. The registered ayacut under irrigation project is 117306 ha and out of this gross cropped area under surface water is under canals is 10900 ha only (9 %). Combined length of main canals

is 242 km (Nizamsagar: 178 km, Sriramsagar: 27 km and Pocharam: 37 kms). The Total water spread area of these major reservoirs is 24500 ha. During the year 2014-15, irrigation is mainly thorugh ground water (khariff: 91% and rabi: 94%) due to non filling of reseroirs (-46% less rainfall). In the district there are 222951 agicultural connections (191418 connections are provided free power) and 78 water user associations. There are 3022 minor irrigation tanks (Comand area:1079 and Non-command area:1943) with 45000 ha water spread area and 18000 ha registered ayacut. During the year 2014-15 only 700 ha of gross area was irrigated. The salient features of irrigation are given in **Table-1.1.**

Table-1: Salient features of Irrigation in Nizamabad district.

Irrigation	**Khariff**	**%**	**Rabi**	**%**
2014-15 (Ha)				
Ground water	151400	91	287700	95
• Bore wells	150700			
• Dug wells	700			
Surface water	14900	9	16400	5
• Canals	10700		140	
• Tanks	500		200	
• Lift	3700		4805	
Total	166300		137700	100

1.10 Prevailing Water Conservation/Recharge Practices: In the district there are ~1322 percolation tanks, 1019 Check dams and 2734 farm ponds. Under Mission Kakatiya (Phase 1 and 2) 834 tanks have been undertaken under RRR (Repairs, restoration and Rejuvenation) schemes.

1.11 Geology: ~ 91% of the area is underlain by crystalline rocks, namely Banded gneissic complex (67%), granites (24%) of Archaean to Proterozoic age and volcanic basalt rocks (Deccan Traps) (9 %) of late Cretaceous to early Eocene age (**Fig1.7**) occur in parts of Nizamabad, Banswada, Jukkal and Yellareddy mandals. Basalt consists of massive or vesicular and amygdaloidal flows. Maximum thickness of basalt is 64.1 m at Neral Tanda in Gandhari

mandal. Alluvial soils also noticed along the river Peddavagu in patches in Jakranpalle, Vailpur, Bheemgal and, Morthad mandals.

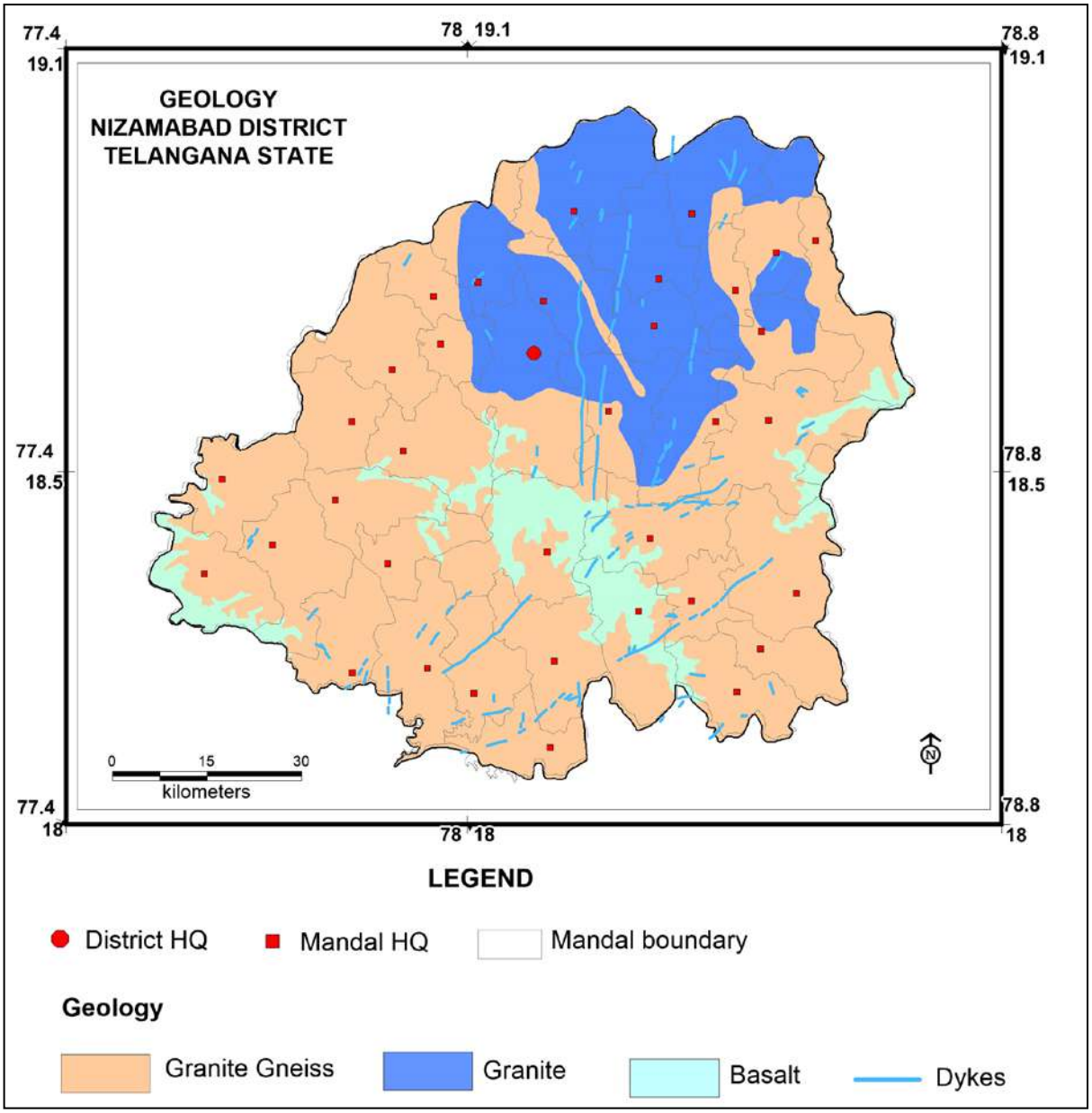

Fig.1.7: Geology of Nizamabad district.

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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 aquifer in the area is granites and gneisses and the occurrence and movement of ground water in these rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Based on 260 hydrogeological data points (**Fig.2.1)** hydrogeological map is prepared.

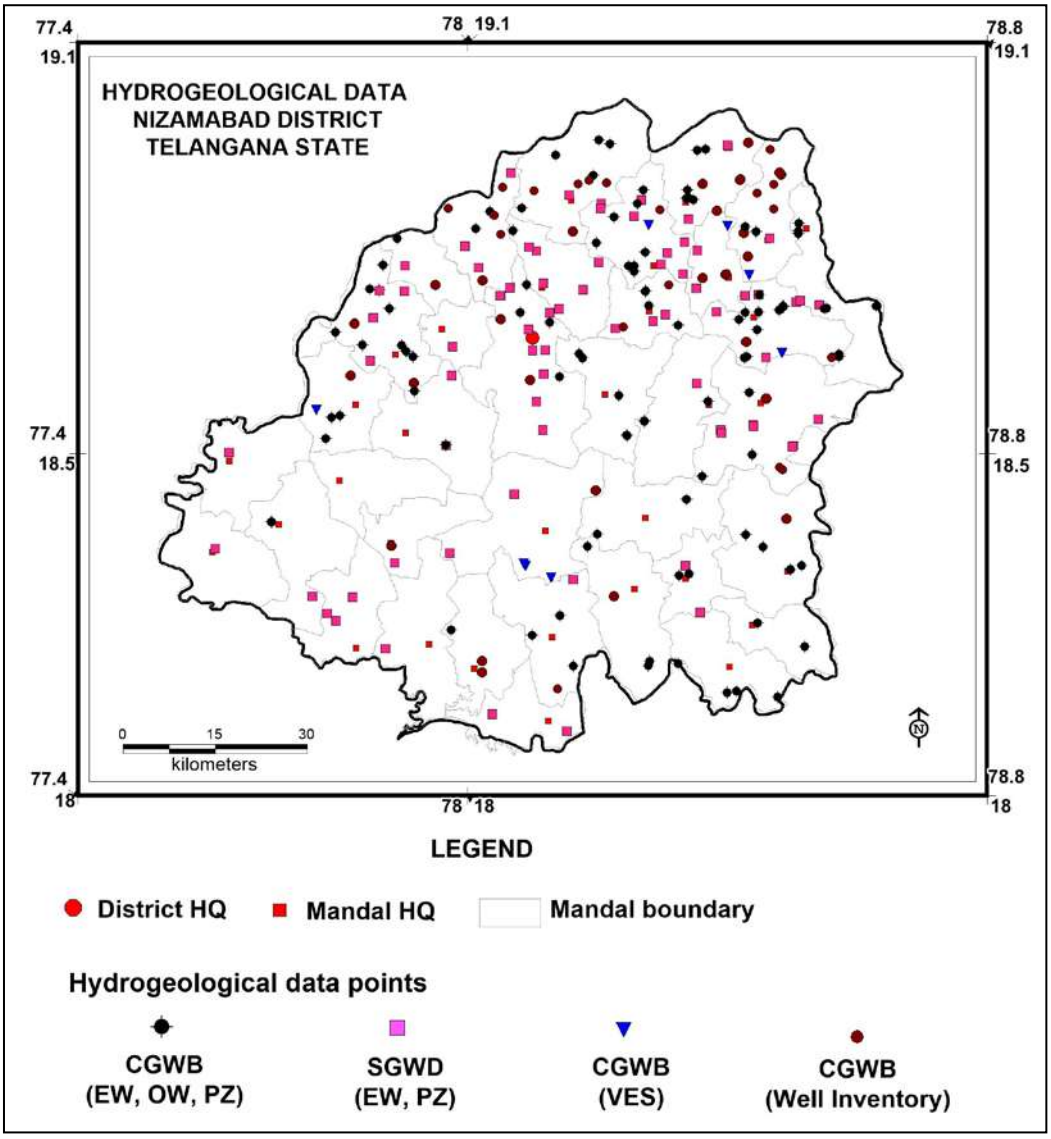

Fig. 2.1: Hydrogeological data availability.

2.1.1 Ground water occurrences and movement: Ground water occurs under unconfined and semi-confined conditions and flows downward from the weathered zone (saprolite and sap rock) into the fracture zone. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured/fissured zone at the bottom, generally extending down to 200 m depth. The storage in granite rocks is primarily confined to the weathered zone and its overexploitation, mainly for irrigation purpose, has resulted in desaturation of weathered zone at many places. At present, extraction is mainly through boreholes of 60-100 m depth, with yield between <0.2 and 7 litres/second (lps). ~ 96 % of fractures occur within 100 m depth and deepest fracture is encountered at the depth of 185 m depth (Nizamabad). The hydrogeological map of the area is presented in **Fig. 2.2**.

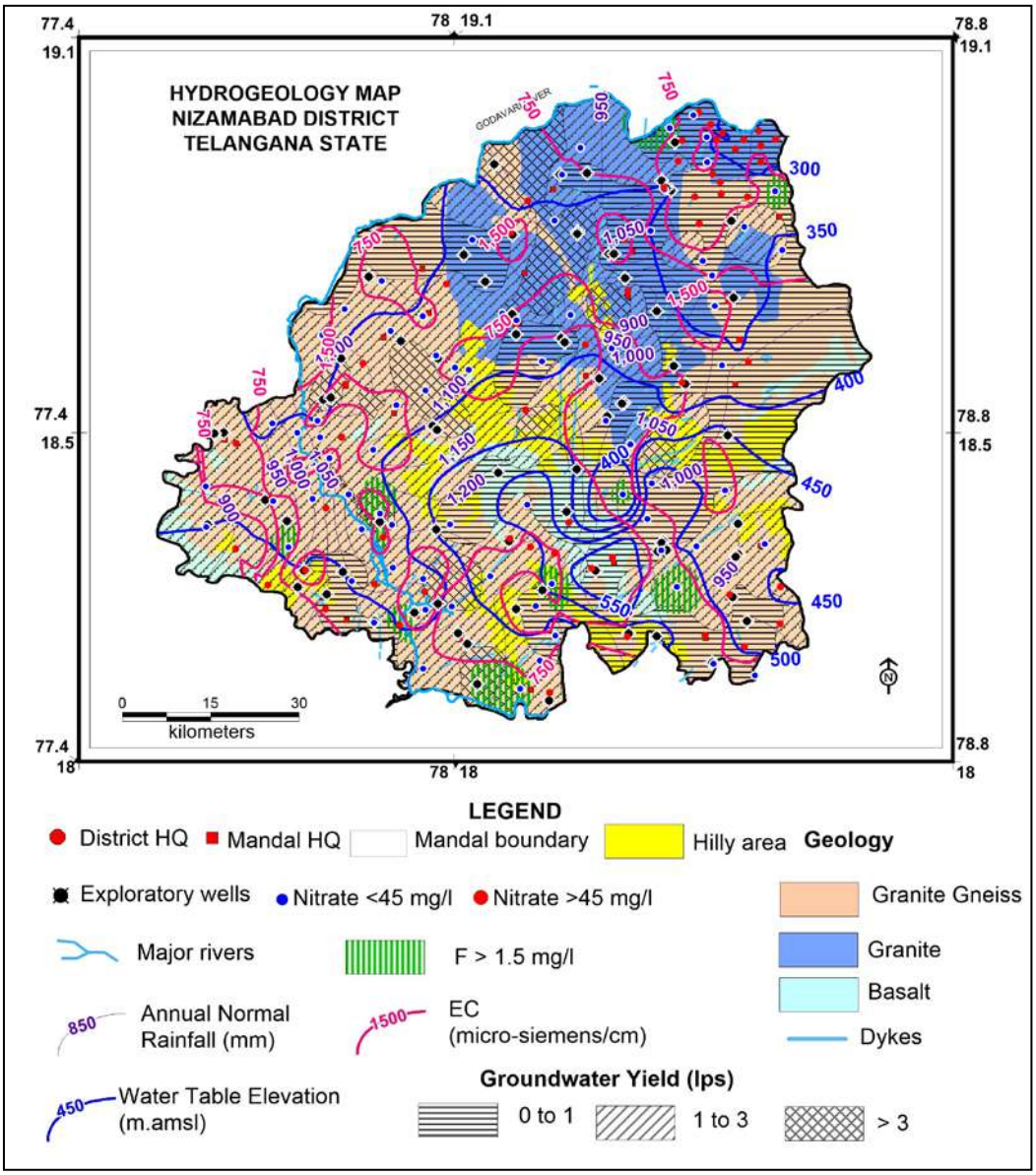

Fig.2.2: Hydrogeological map of Nizamabad district.

2.1.2 Exploratory Drilling: As on 31/03/2016, CGWB drilled 122 bore wells (exploratory, observation and piezometers) and SGWD drilled 89 wells in the district. Data analysed from CGWB wells indicates, 35 wells are of shallow depth (30 m), 26 nos (30-60 m), 34 nos (60-100 m) 5 nos (100-150 m) 22 nos (150-200 m) depth**.**

In the district, there are 2, 36,142 existing wells (Irrigation: 2, 20,511 (DW: 3210 and BW217301) and domestic: 15631 (HP: 13174 and BW with PP: 2457). As per electicity authority there are 2, 57,388 electric connections (Command area: 143950 and Non-command area:1, 13,438). Various hydraulic properties of the aquifers are discussed in C**hapter -3**.

2.1.3 Ground water Yield: Ground water yield from weathered granite/gneiss aquifer varies from <0.1 to 8.3 lps (avg: 1.5 lps) and from 0.01 to 0.8 lps (avg: 0.4 lps) in basalt aquifer. In fractured granite/gneiss yield varies from 0.01 to 4.9 lps (avg: 0.4 lps). Wells located in the command area have higher yield (1-3 lps) and sustain for more hours of pumping as compared to non-command area where yields are relatively low with sustainability for 2-3 hrs (**Fig.2.2).**

2.2 Water Levels (2015): Ground water levels from 140 wells (CGWB: 42 and SGWD: 98) consisting of dug wells and piezometers were monitored for pre-monsoon and 166 wells (DW: 33 and Pz: 133) during post-monsoon season.

2.2.1 Water Table Elevations: During pre and post-monsoon season (May and November) of 2015, the water-table elevation ranges from 277.1-583.7 and 279.6-584.3 meter above mean sea level (m amsl) respectively and general ground flow is towards river Manjra and towards river Godavari from south central part of district (**Fig.2.3**).

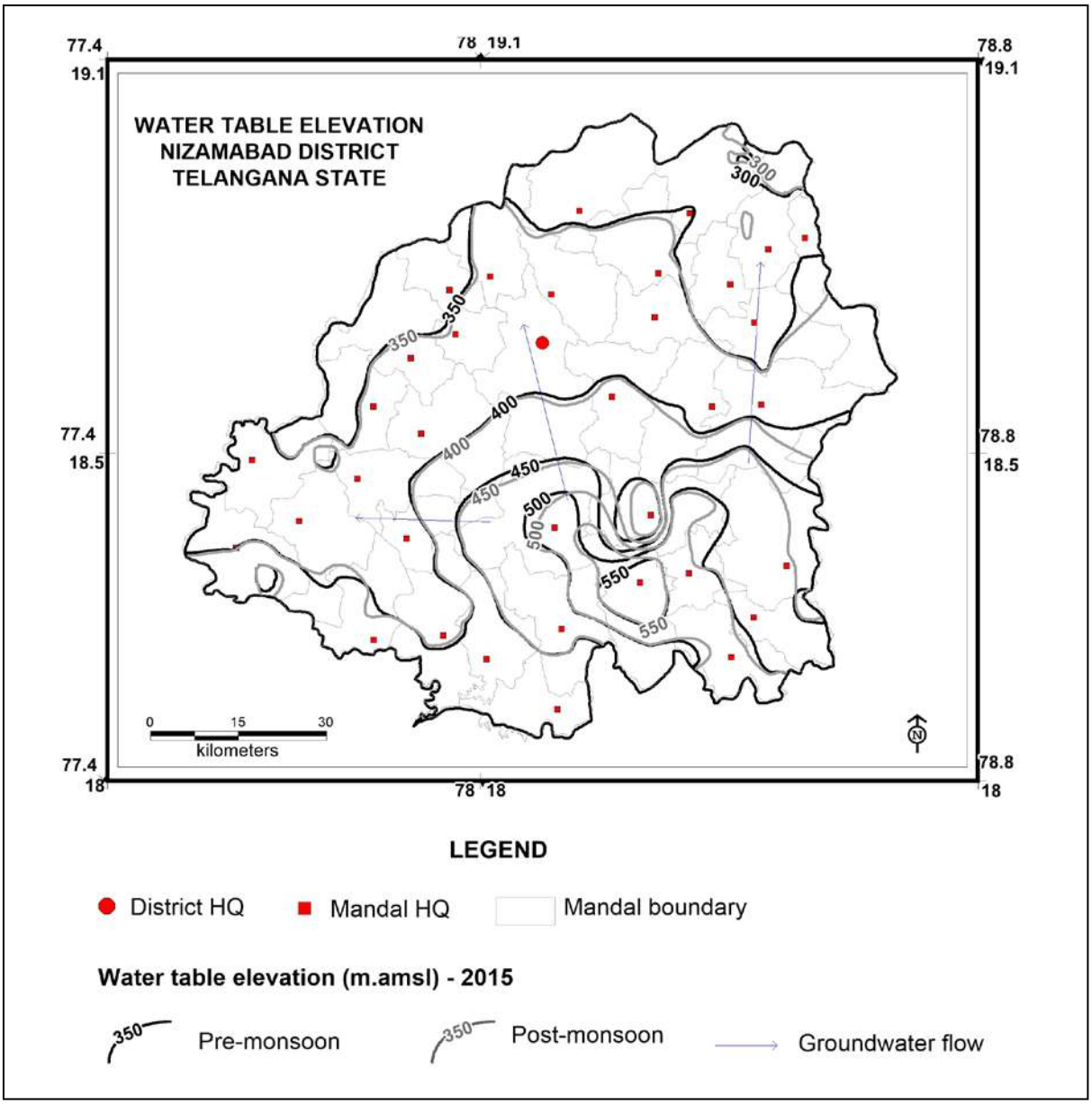

Fig.2.3: Water table elevations (m amsl) during pre and post-monsoon season-2015.

2.2.2 Depth to Water Levels (DTW): The DTW varies from 2.1 to 43.5 meter below ground level (m bgl) (average: 13.7 m bgl) and 1.3-36.1 m bgl (average: 15.6) during pre and post-monsoon season of 2015 respectively.

Pre-monsoon season: Majority of the water levels during this season are in the range of 10-20 m covering 63 % of the area, followed by 5-10 m bgl (22 %). Deep water levels in the range of 20-40 m bgl and > 40 m bgl occupy about 13 % of the area falling in Pitlam, Madnoor, Bodhan, Dichpally, Vailpur, Bheemgal, Domakonda, Bhiknoor, Tadwai and Gandhari mandals (**Fig.2.4**). Shallow water levels (2-5 mbgl) occupy about 2% of the area in Birkur mandal.

Post-monsoon season: Majority of the water levels during this season are in the range of 10-20 m bgl, covering 55 % of the area, followed by deep water levels (20-36.1 m bgl) covering 25 % of the area. Water level in the range of 5-10 mbgl and 2-5 mbgl occupy about 18 % and 2 % of the area respectively. Deep water levels (> 20 m) are observed in Pitlam, Madnoor, Bodhan, Dichpally, Vailpur, Bheemgal, Domakonda, Bhiknoor, Tadwai, Sadashivnagar and Gandhari mandals (**Fig.2.5**).

2.2.3 Water Level Fluctuations (November vs. May): The water level fluctuations vary from -15.1 to 22.5 m with average fall of -1.2 m (**Fig.2.6**). Out of 131 wells, 97 wells show a fall in water levels in the range of -0 to -15.1 (covering 81 % area). Falling water levels in the range of -0 to 2 m is observed in 37 %, 2-5 m in 36 %, 5-10 m in 7% and >10 m in less than 1% of the area. Rise in water levels is observed in 34 wells (19 % of the area). The rise is observed in command area of Sriram sagar and Bichkunda, Maklur, Tadwai and Domakonda mandals.

2.2.4 Long term water level trends: Trend analysis for the last 11 years (2005-2015) is studied from 75 hydrograph stations of CGWB and SGWD. It is observed that during pre-monsoon season 63 wells shows a falling trend (0-1:45, 1-2 m: 12 and >2 m:6 wells) (max fall: 4.77 m/yr) and 11 wells shows rising trend (0-0.9 m/yr). During post-monsoon season 67 shows falling trend (0-1:46, 1-2 m: 17 and >2 m: 4 wells) (maximum fall: 2.48 m/Yr) and 9 wells shows rising trends (0-0.5 m/yr). Average water levels for the last 10 years (2005-14) were compared with 2015 data and it is found that during pre-monsoon season 55 wells have shown fall and 17 shown rise and during post monsoon season 71 wells shown fall and 3 shown rise in water levels. The graphical representation of fall and rise is shown in **Fig 2.7** and area wise shown in **Fig 2.8**.

2.3 Geophysical Studies

A total of 53 VES data (CGWB:28 and SGWD:25) is interpreted, which reveals resistivity < 100 ohm (Ω) m for the weathered granite (1-23 m) (Pedda Sangam), 60-350 Ω m for underlying fractured granite with maximum thickness of 90 m (Utnur) and > 350 Ω m for massive granite.

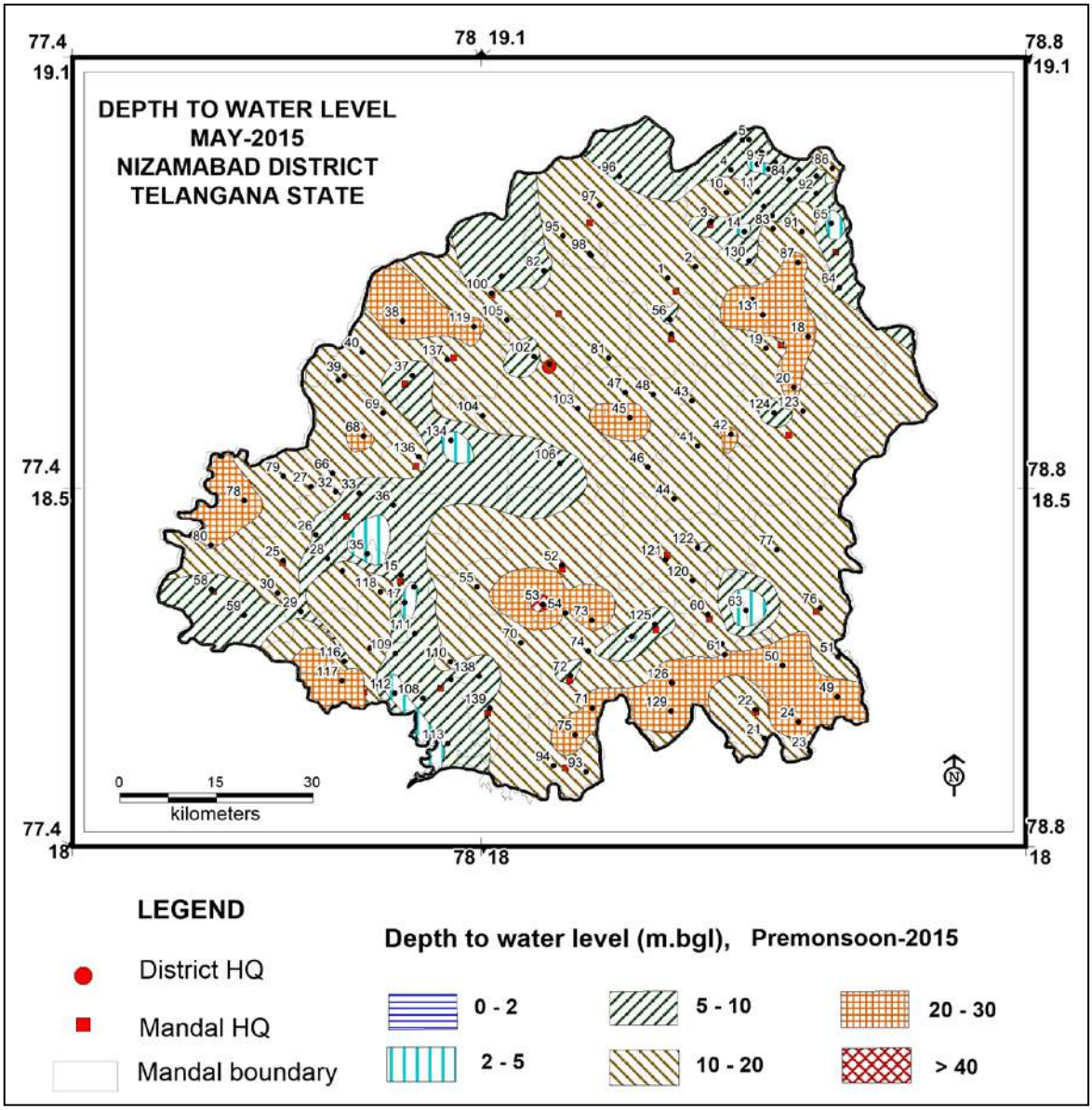

Fig.2.4: Depth to water levels Pre-monsoon (May-2015).

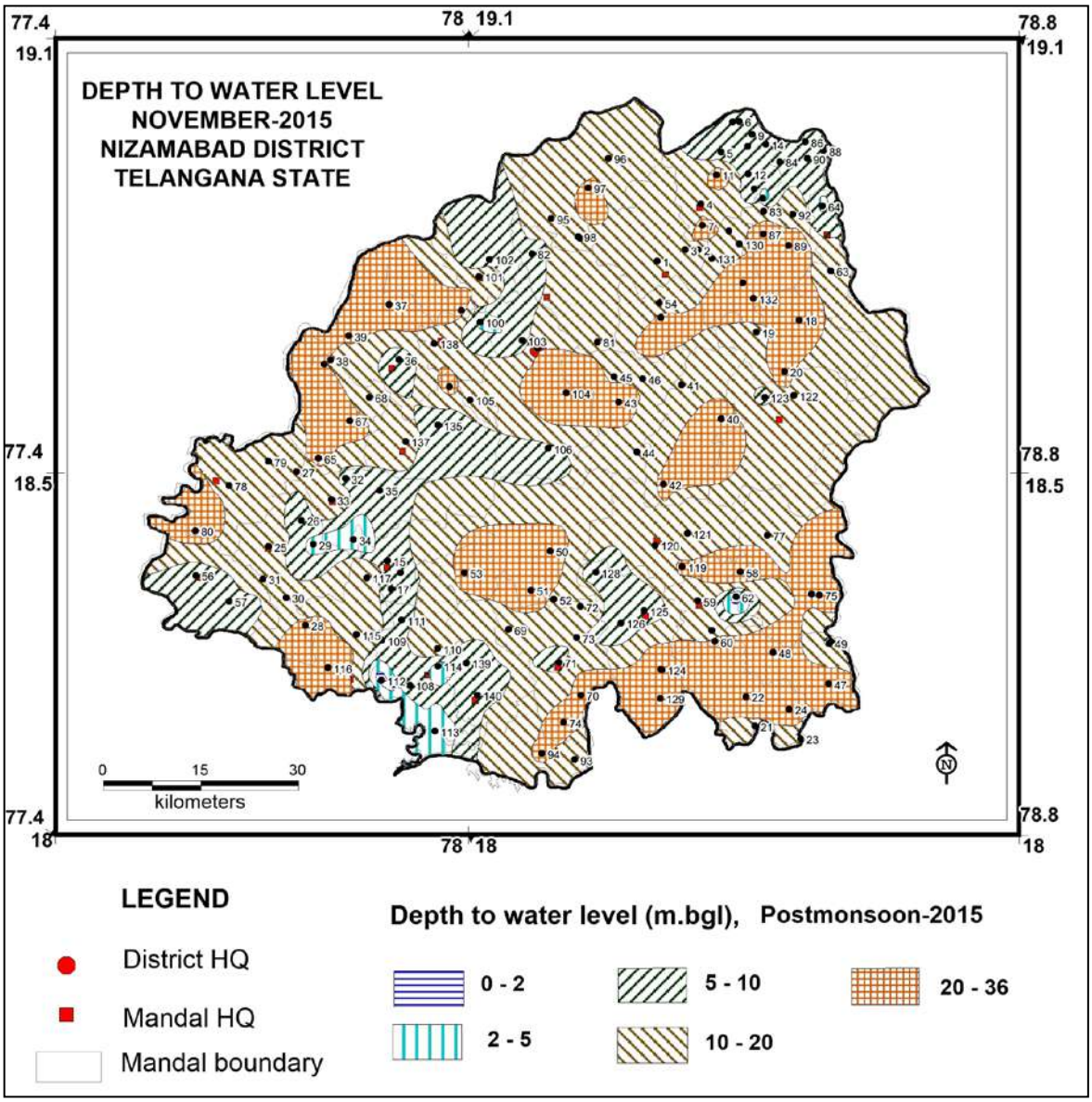

Fig.2.5: Depth to water levels Post-monsoon (Nov-2015).

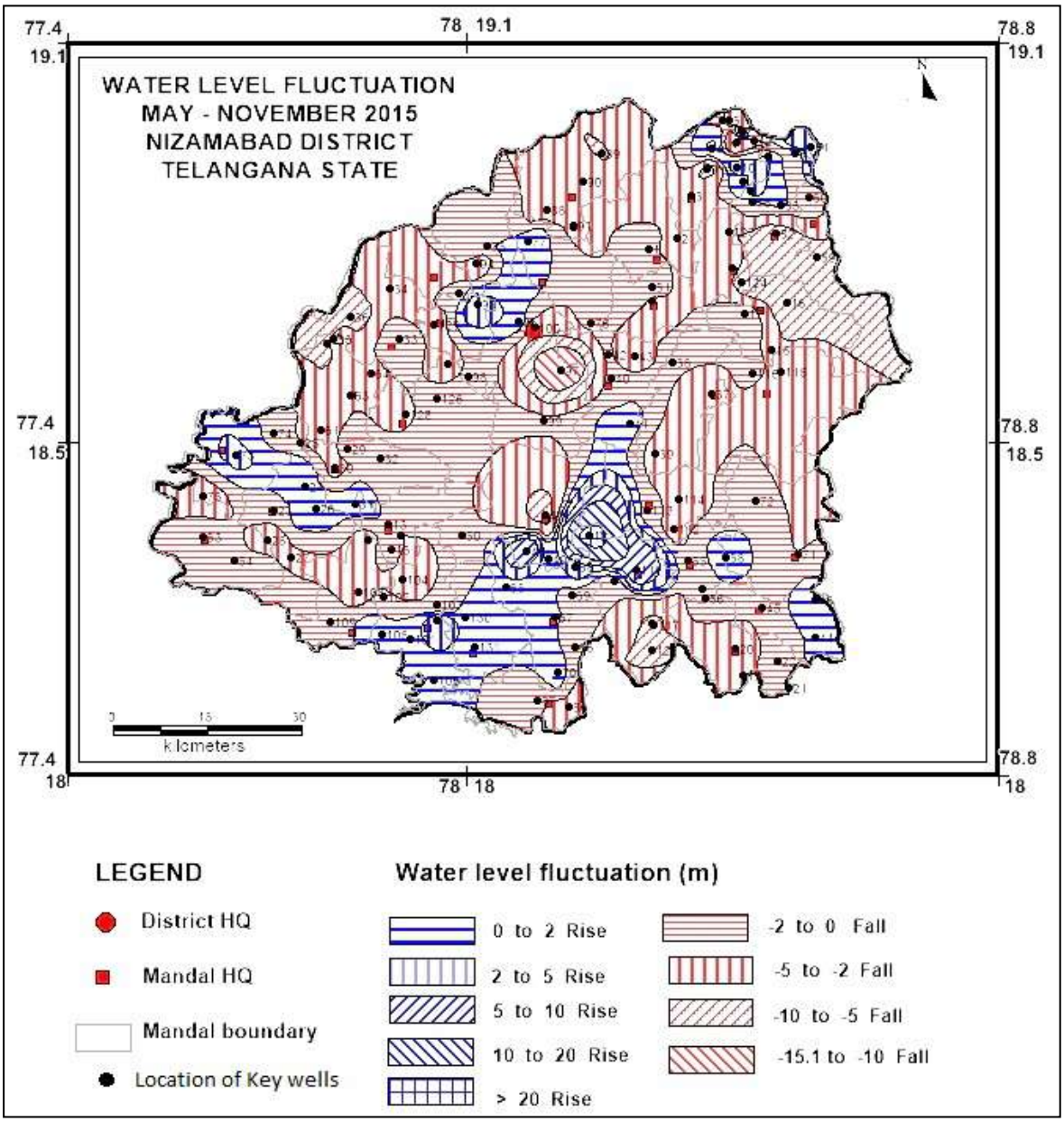

Fig.2.6: Water Level Fluctuations (m) (Nov with respect to May-2015).

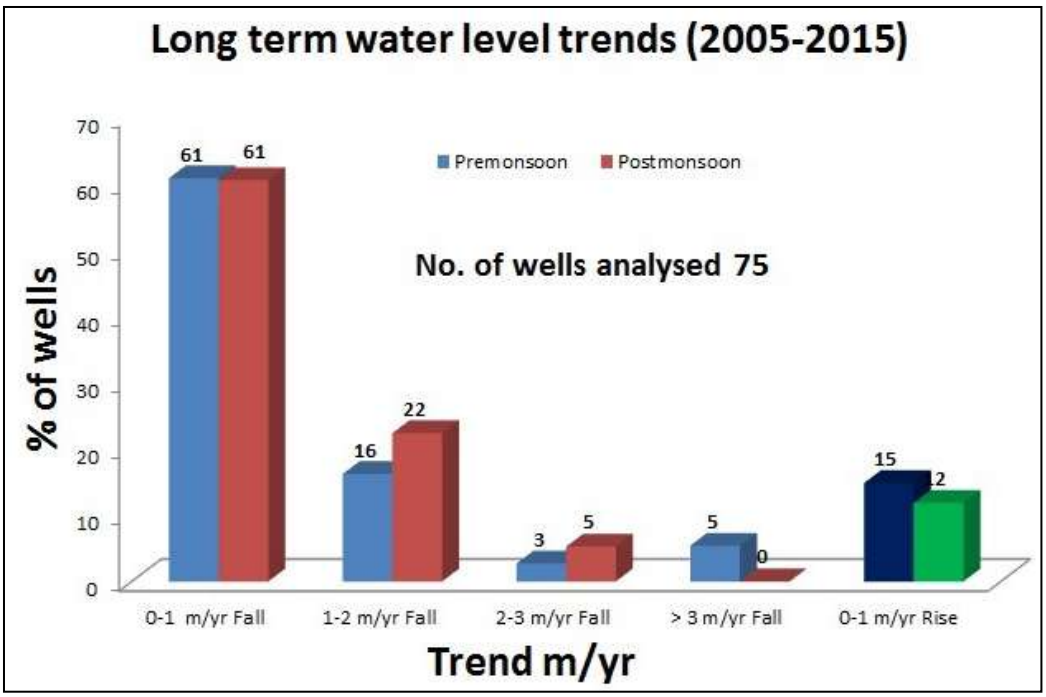

Fig. 2.7: Graphical representation of water level trends (2005-2015).

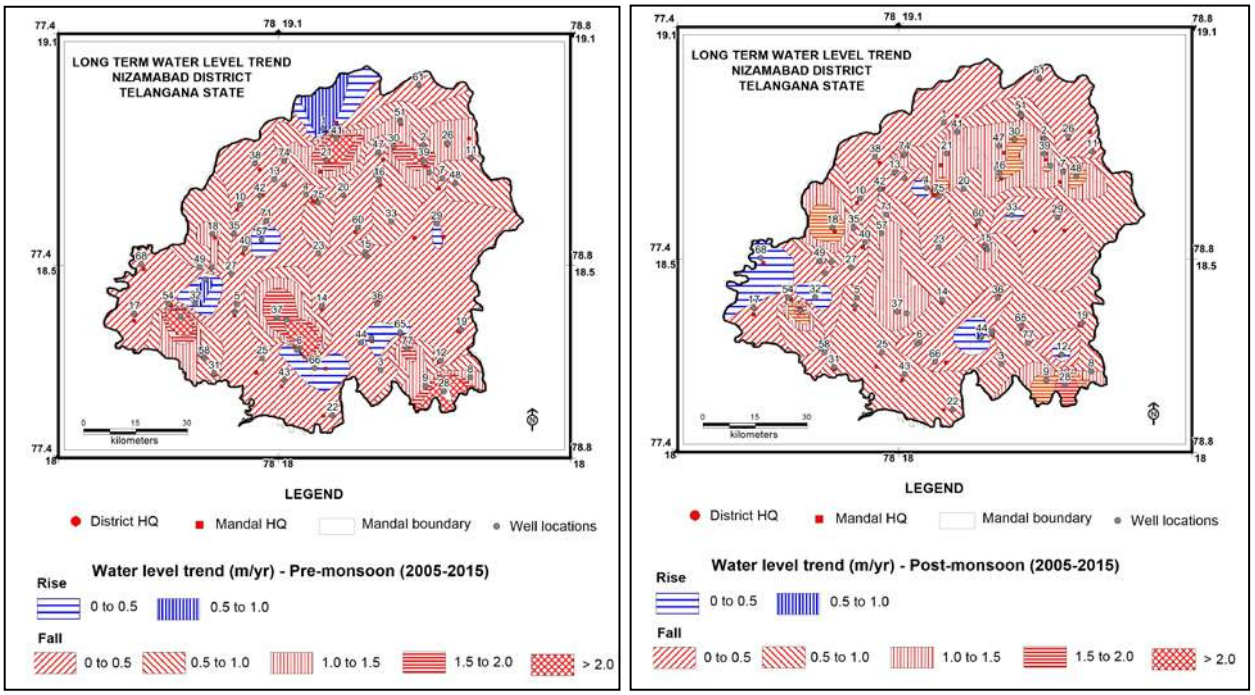

Fig. 2.8a-b: Long-term water level trends (2005-2015).

2.4 Hydro chemical Studies

To understand chemical nature of groundwater, total 272 data is utilized from ground water monitoring wells of CGWB and SGWD wells (Pre-monsoon:139 and post-monsoon:133) (mostly tapping combined aquifers Aq-1 and aq-2) during the pre and post-monsoon season of 2015. 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.

Pre-monsoon (May-2015) (Total 139 samples were analyzed (CGWB: 29 and SGWD:110):

Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 6.8-9.25 (Avg: 8.34). Electrical conductivity varies from 197-3000 (avg: 993) µ Siemens/cm**.** In 90 % of area EC is within 1500 µ Siemens/cm and in 10 % area, it is 1500-3000 µ Siemens/cm (**Fig.2.8).** Average concentration of TDS and TH is 624 & 106 mg/L respectively and NO_3 ranges from 1-488 mg/L. Nitate concentration in 58 samples (41%) is beyond permissible limits of 45 mg/L (**Fig.2.9**). Fluoride concentration varies from 0.1-2.6 (**Fig 2.10**) and 96 % of area (127 samples) is within permissible limits of BIS and rest is beyond permissible limit of 1.5 mg/L (12 samples). High fluoride concentration is observed in southern part (Jukkal, Pitlam, Bichkunda, Nagireddypet and Bhiknur mandals) and in northern part (Armur mandal). Over all 60 samples (43 %) are unfit for human consumption from the district.

Post-monsoon (May-2015) (Total 133 samples all SGWD):

Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 7.2-9.7 (Avg: 7.88). Electrical conductivity varies from 374-3550 (avg: 1025) µ Siemens/cm**.** In 93 % of area EC is within 1500 µ Siemens/cm and in 1 % area it is > 3000 µ Siemens/cm falling in command area (**Fig.2.11).** Average concentration of TDS and TH is 659 & 294 mg/L respectively and NO_3 ranges from 1-243 mg/L. Nitate concentration in 74 samples (56%) is beyond permissible limits of 45 mg/L (**Fig.2.12**). Fluoride concentration varies from 0.1-3.7 (**Fig 2.13**) and 94 % of area (116 samples) is within permissible limits of BIS and rest is beyond permissible limits of 1.5 mg/L (17 samples). High fluoride concentration is observed in southern (Jukkal, Pitlam, Bichkunda, Nagireddypet and Bhiknur), central (Dharpally), western (Bodhan) and in northern part (Armur Mandal). Over all 62 samples (47 %) are unfit for human consumption from the district.

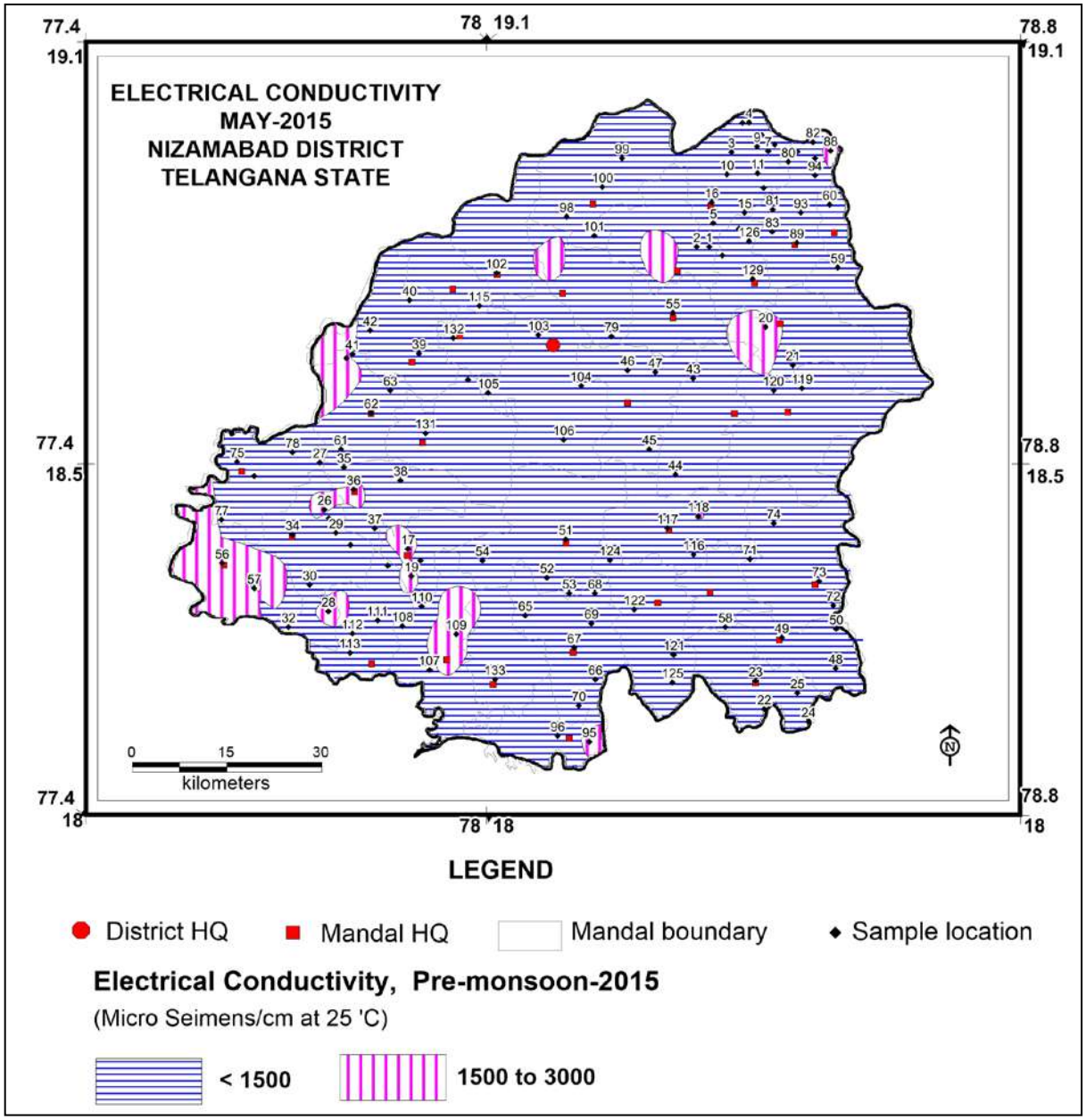

Fig.2.9: Distribution of Electrical conductivity (Pre-monsoon-2015).

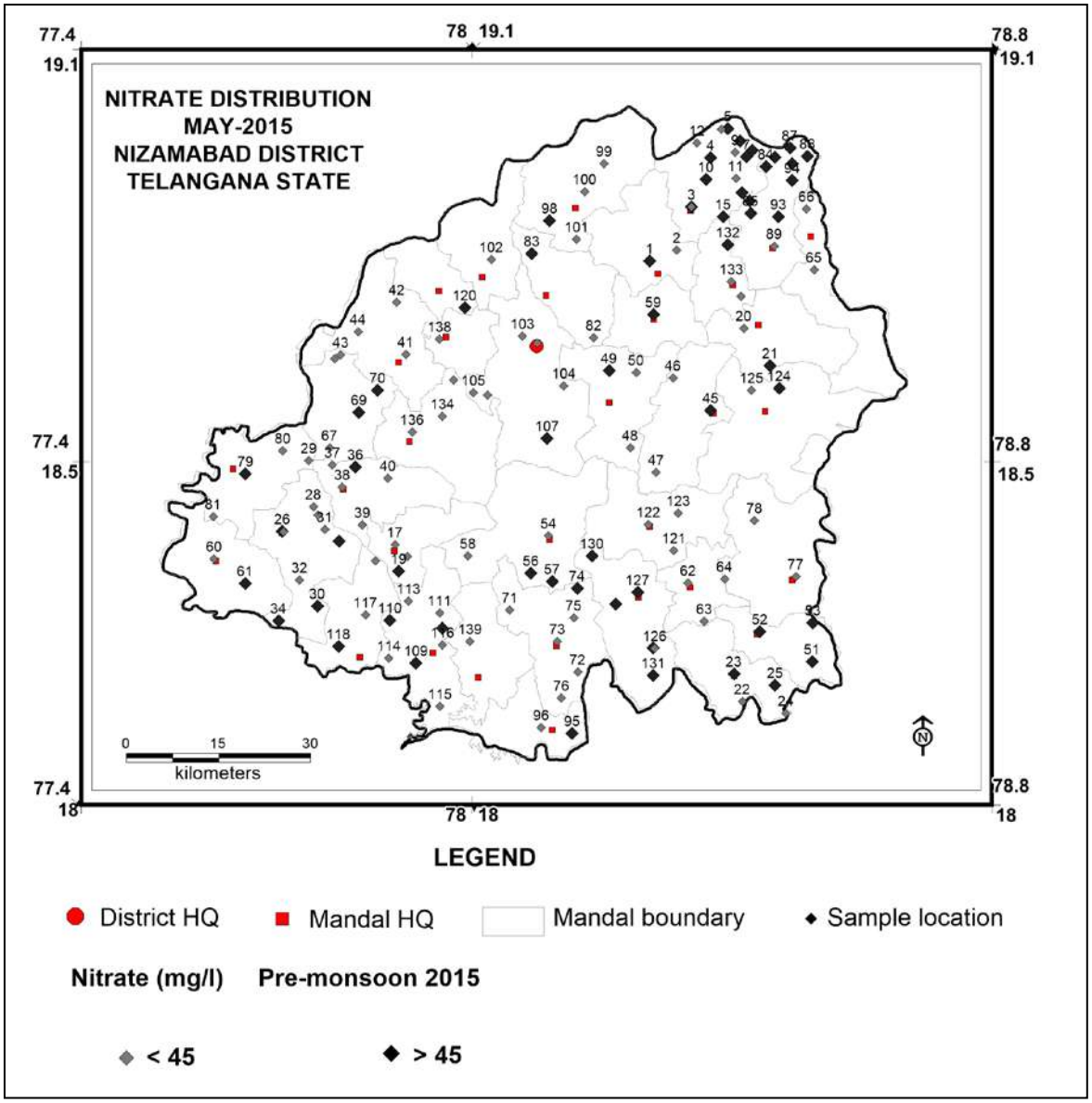

Fig.2.10: Distribution of Nitrate (Pre-monsoon-2015).

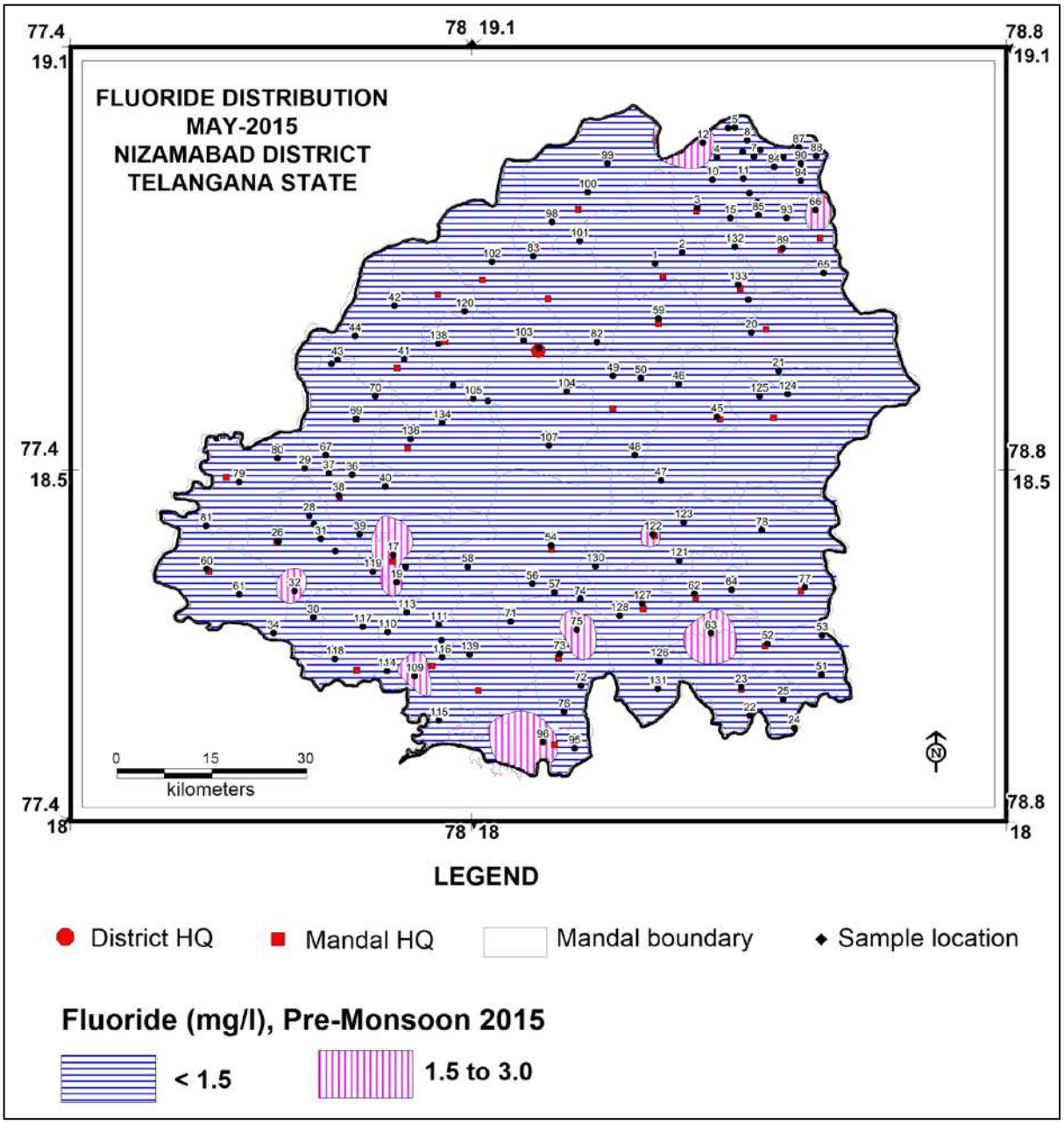

Fig.2.11: Distribution of Fluoride (Pre-monsoon-2015).

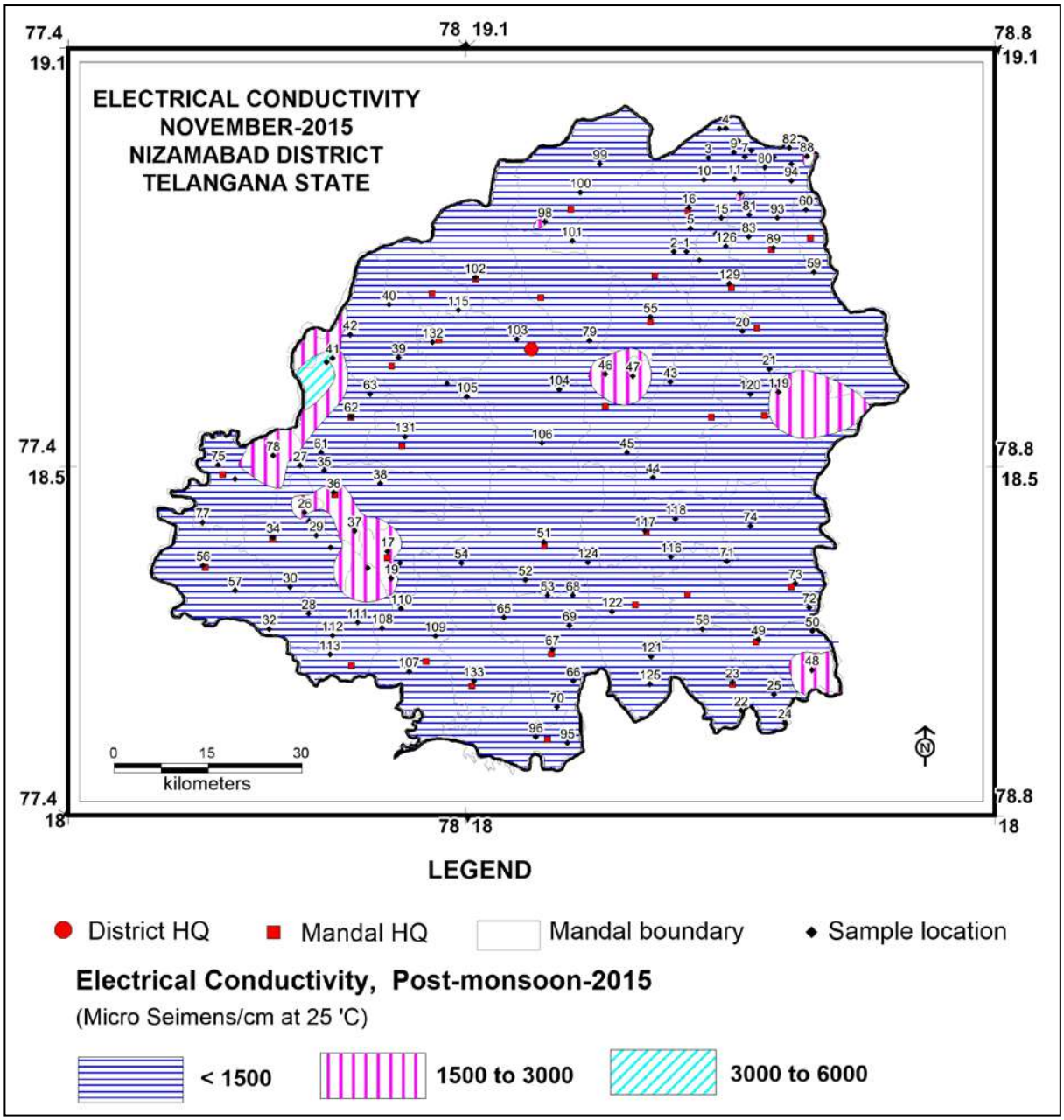

Fig.2.12: Distribution of Electrical conductivity (Post-monsoon-2015).

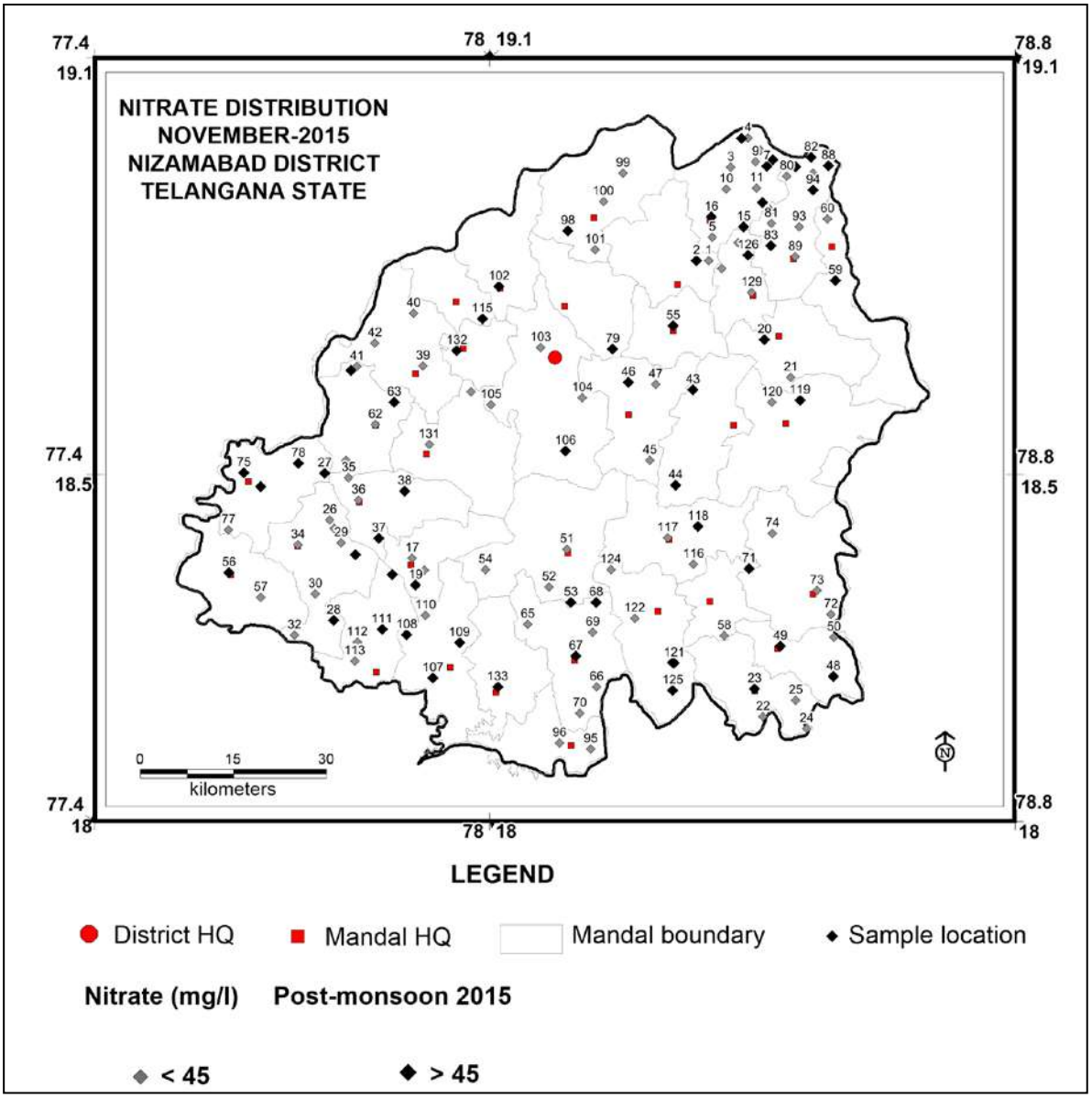

Fig.2.13: Distribution of Nitrate (Post-monsoon-2015).

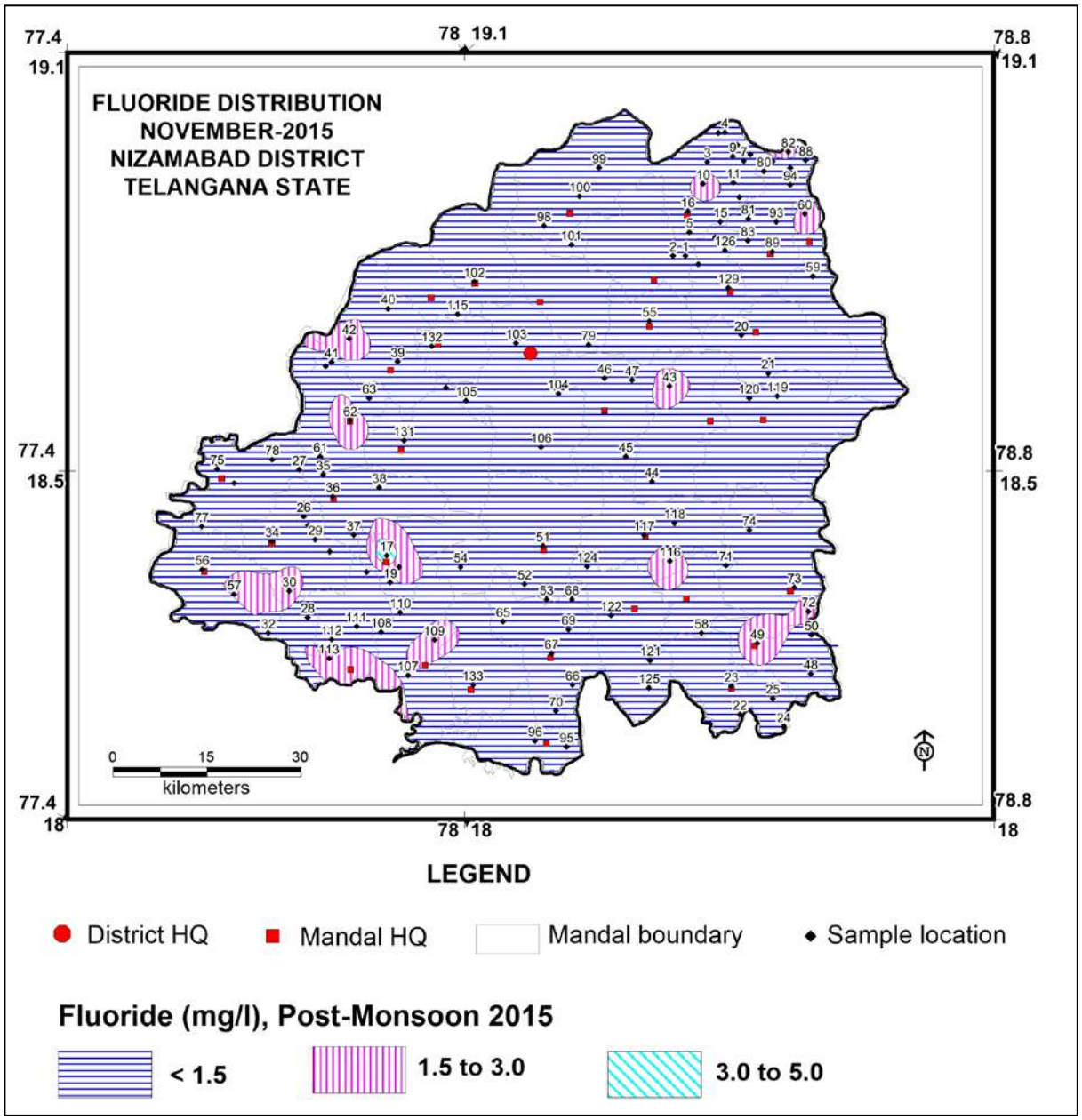

Fig.2.14: Distribution of Fluoride (Post-monsoon-2015).

3. DATA INTERPRETATION, INTEGRATION and AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 260 data points (both hydrogeological and geophysical down to 200 m) for preparation of 3-D map, panel diagram and hydrogeological sections. The data (**Fig.2.1**) 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 map for Nizamabad district (**Fig.3.1)** along with panel diagram (**Fig. 3.2a-b**) and hydrogeological sections.

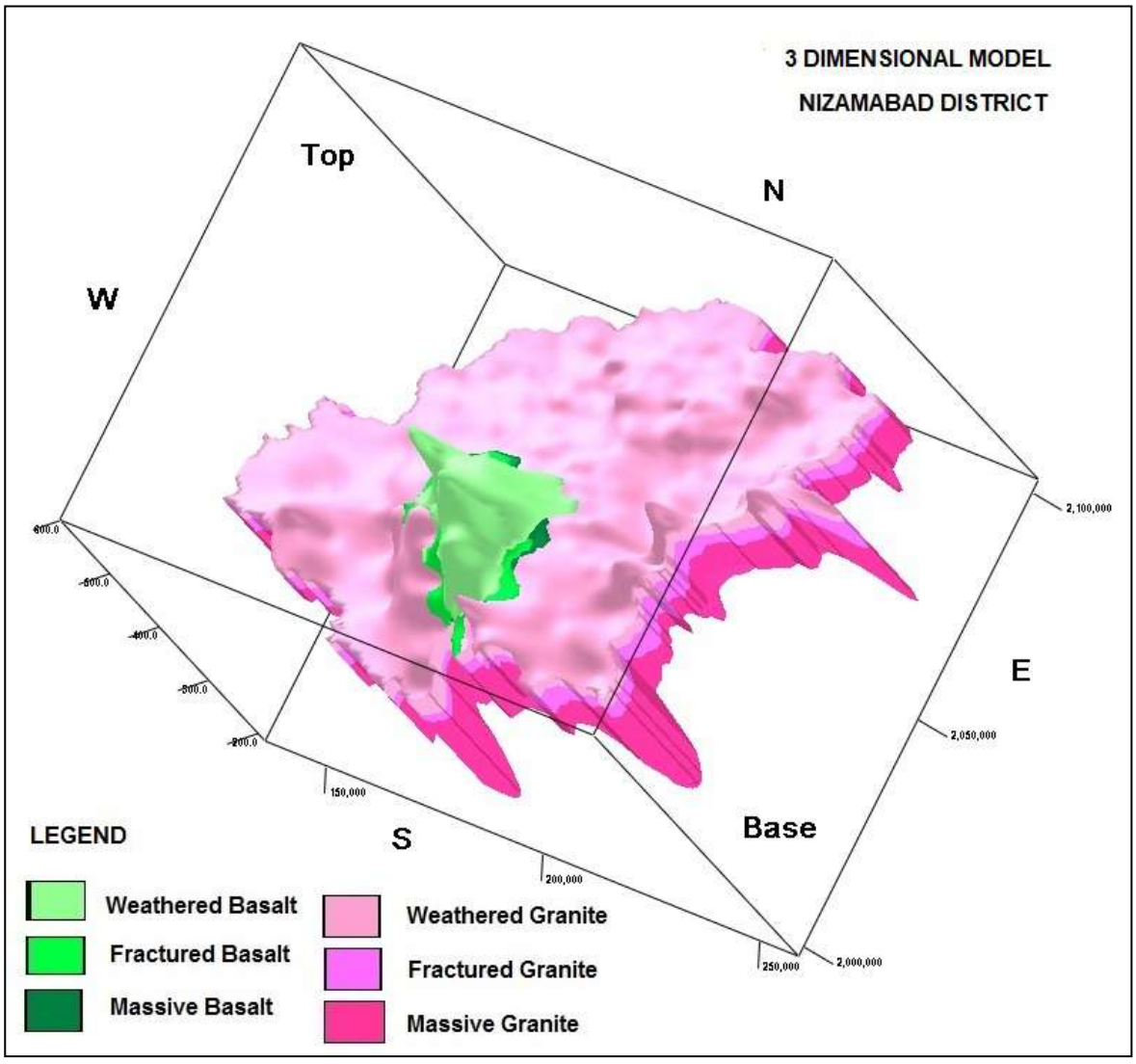

Fig.-3.1:3-D Model for study area.

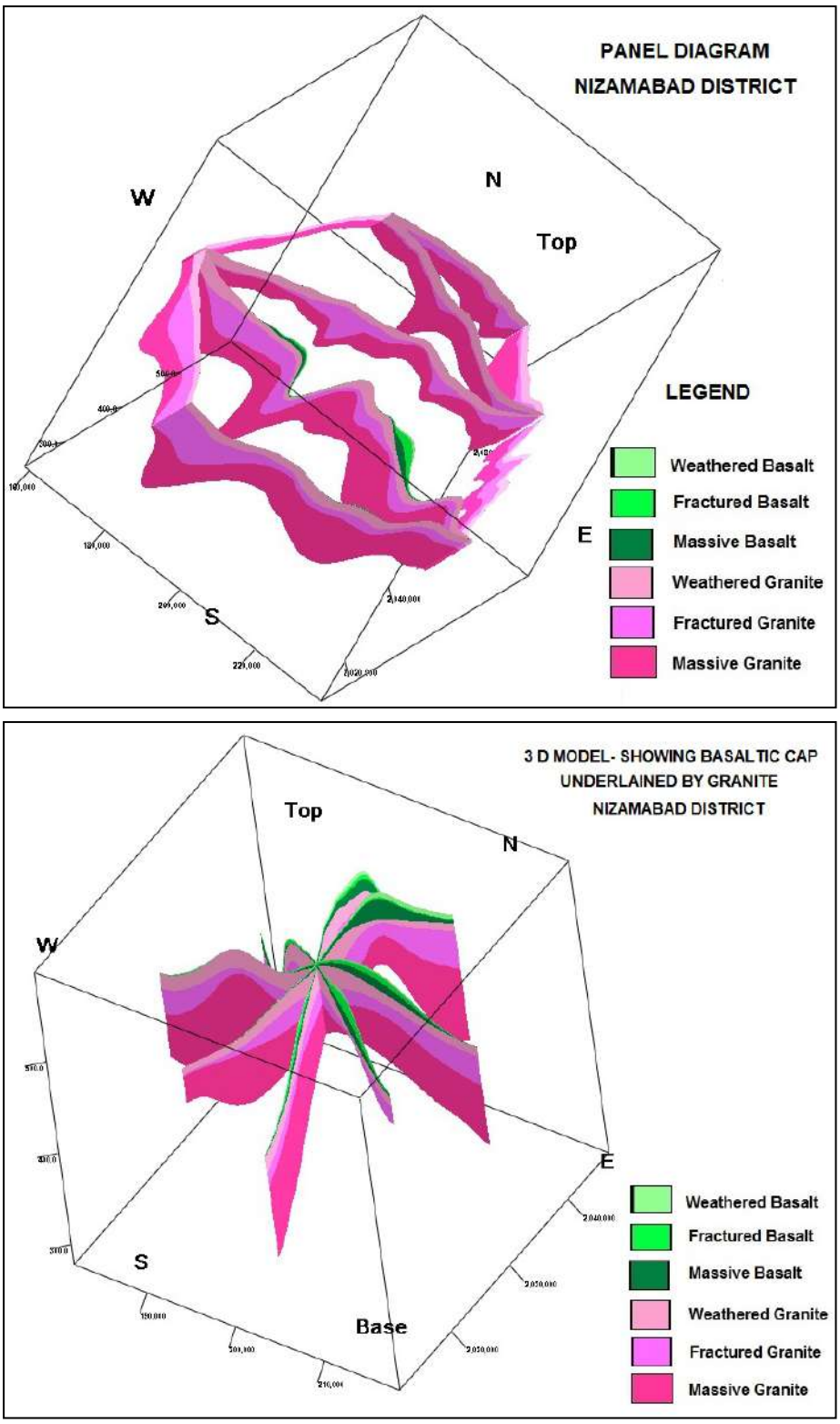

Fig.-3.2a-b: Panel Diagram-Nizamabad district.

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 ~20 m depth and the fractured zone (fractured granite) is considered up to the depth of deepest fracture below weathered zone (~20-185 m).

3.2 Hydrogeological Sections

4 Hydrogeological sections are prepared in N-S, NW-SE, W-E and SW-NE directions (**Fig. 3.3**).

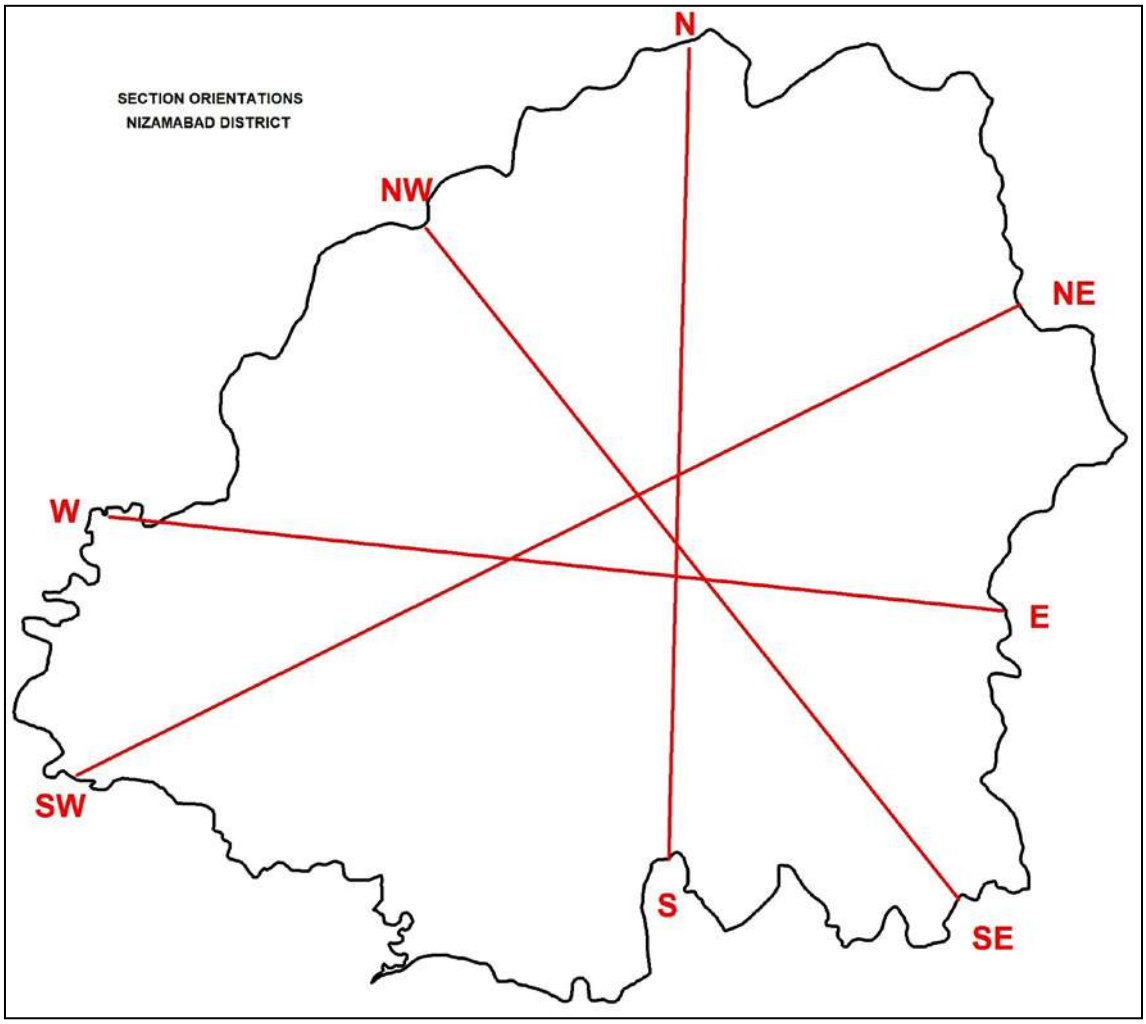

Fig.-3.3: Map showing orientation of various sections.

North-South Section: The section drawn vertically along the N-S direction covering distance of ~96 kms (**Fig.3.4a**). It depicts thick weathered zone in southern part and thick fractured zone in central part below basalt. Shallow depth of weathering and fracturing is observed in northern part. Basalt rocks occur in the central part of the section.

North-West and South-East Section: The section drawn along the NW-SE direction covering distance of ~97 kms (**Fig.3.4b**). It depicts thick weathered zone in southern-eastern part and thick fractured zone in central part below basalt. Shallow depth of weathering and fracturing is observed in northern western part. Basalt rocks occur in the central part of the section.

West-East Section: The section drawn horizontally along the West-East direction covering distance of ~96 kms (**Fig.3.4c**). It depicts uniform weathered zone in entire section and thick fractured zone in eastern part. Basalt rocks occur in the central part of the section.

South-West and North-East Section: The section drawn along the SW-NE parts covering distance of ~105 kms (**Fig.3.4d**). It depicts unifrom weathered zone in entire part and thick fractured zone in SW part. Thick basalt rocks occur in the central part of the section.

3.3 Aquifer Characterization

3.3.1 Weathered zone: The Weathered zone (~20 m) consisting of upper saprolite (~13 m) and lower sap rock (13-20) has gone dry in considerable part due to over-exploitation (excluding command area). Dug wells, which are in existence, have become defunct and only located in command area have water column. Thickness of weathered zone is in the range of 10-20 m in most part of area covering ~75 % of area, shallow weathering (< 10 m) occurs in 15 % of the area and deep weathering (> 20 m) occurs in rest of the area (**Fig.3.5**).

Ground water yield from weathered granite/gneiss aquifer varies from <0.1 to 8.3 lps (avg: 1.5 lps) and from 0.01 to 0.8 lps (avg: 0.4 lps) in basalt aquifer. In fractured granite/gneiss yield varies from 0.01 to 4.9 lps (avg: 0.4 lps). Wells located in the command area have higher yield (1-3 lps) and sustains for more hours of pumping as compared to non-command area where yields are relatively low and sustains for 2-3 hrs. The transmissivity varies from 5-181 m^2/day (avg: 10 m^2/day), specific capacity from 1-60 lpm/mdd and specific yield from 1.7 to 2 %.

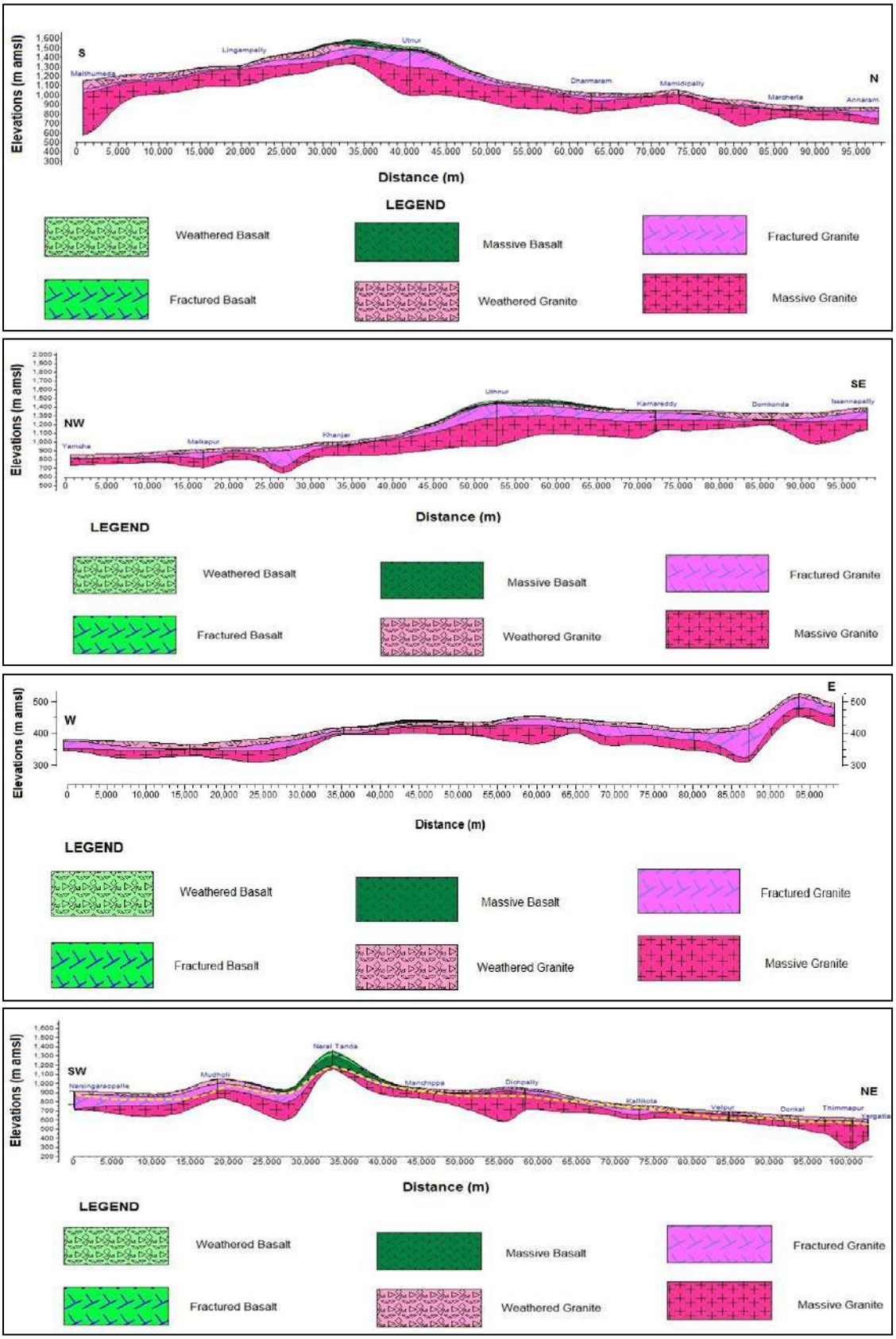

Fig.3.4 (a-d): Hydrogeological profile in different directions in Nizamabad district.

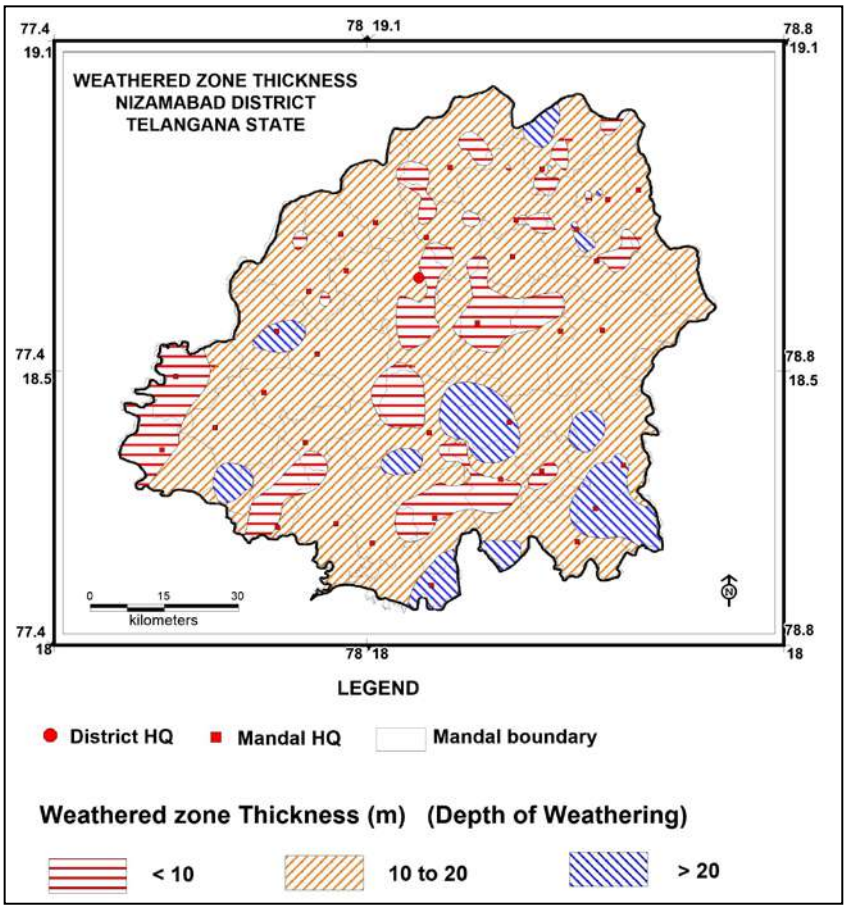

Fig.3.5: Thickness of Weathered zone-Nizamabad district.

Fractured zone: Ground water is extracted mainly through bore wells of 20 to 100 m depth from fractured zone (~20 to 185 m). Based on CGWB data, it is inferred that fractures in the range of < 30 m depth are more predominant (77 % of the area), 30-60 m and 60-100 fractures occur in 15 % and 4 % of area respectively and deep fractures in the range of 100-185 m occur in Nizamabad, Lingampet and Sirikonda mandals (**Fig.3.6**). Analysis of occurence of fractures (141 nos from 122 wells) reveal that majority of fractures (~96 %) occur within 100 m depth (**Fig. 3.7**). Ground water yield in this zone varies from 0.01 to 4.92 lps (avg: 1.24 lps). The transmissivity (T) varies from 1 to 117 m^2/day (avg: 16 m^2/day) and storativity varies from 0.00035 to 0.018.

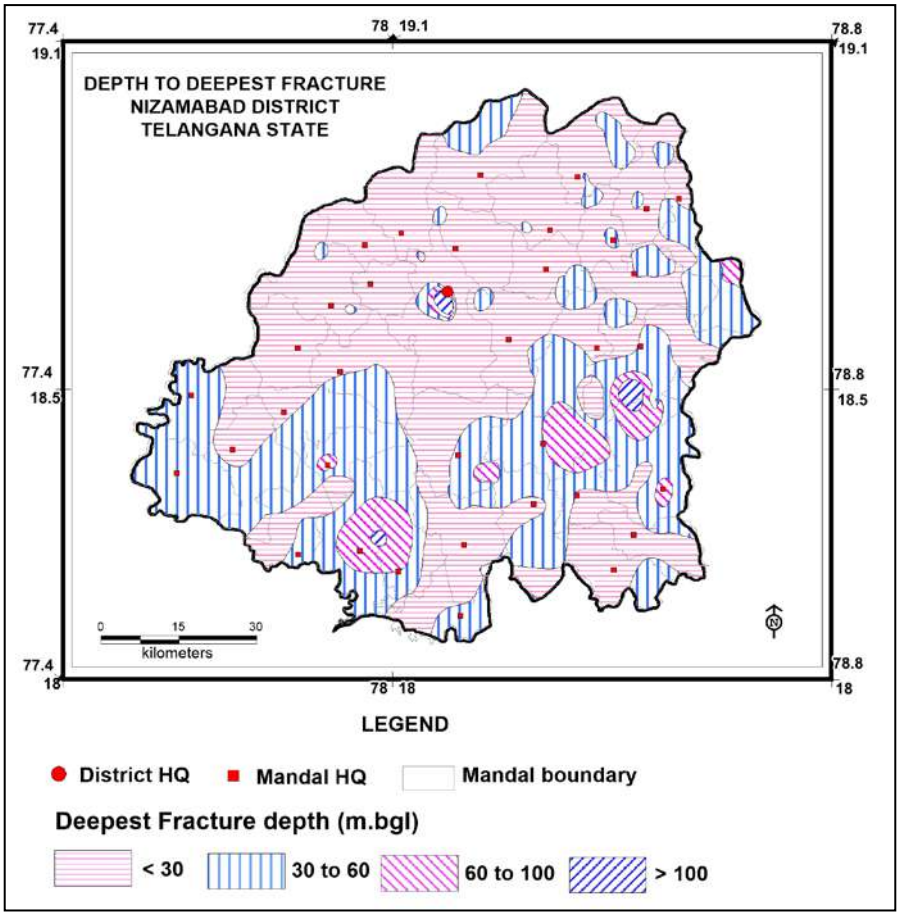

Fig.-3.6: Depth of Fractured zone (Maximum depth) (m bgl).

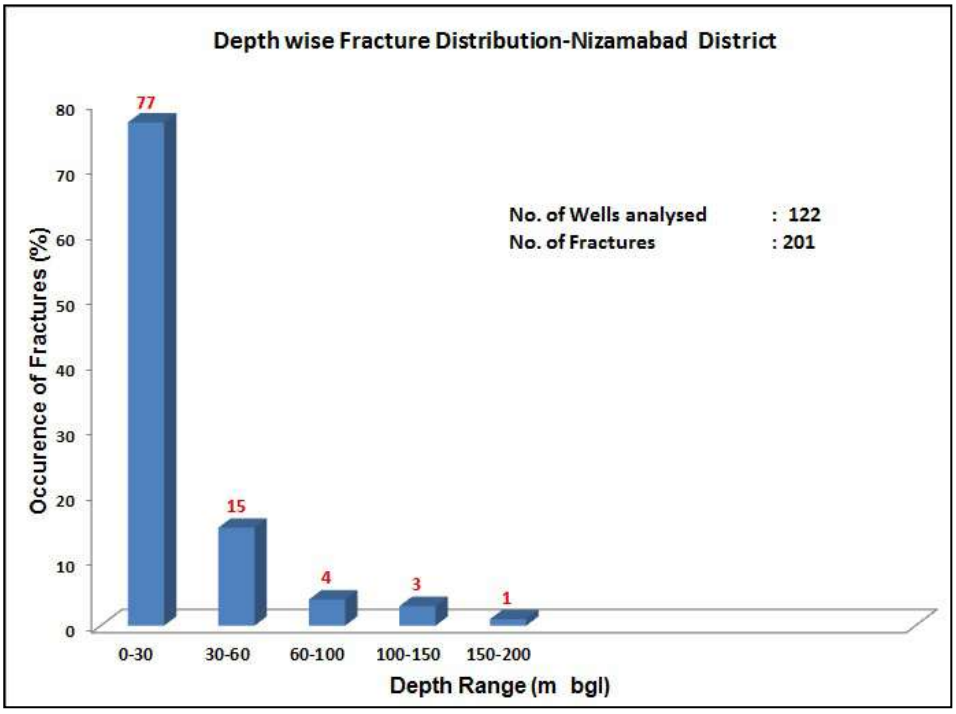

Fig.-3.7: Depth wise distribution of fractures.

4. GROUND WATER RESOURCES (2013)

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) is considered. Summarized command/ non-command area and mandal wise resources are given in **Table-4.1 and Annexure-1** respectively.

As per 2013 GEC report, the net dynamic replenishable groundwater availability is 1311.3 MCM, gross ground water draft for all uses 839.2 MCM, provision for drinking and industrial use for the year 2025 is 83 MCM and net annual ground water potential available for future irrigation needs is 431 MCM. Stage of ground water development varies from 57% in command area and 66 % in non-command area with average of 62 %. 2 mandals (Kamareddy and Vailpur) falls in over-exploited category, 1 (Sadashivnagar) in critical category, 4 in semi critical category (Biknoor, Domakonda, Machareddy and Morthad) and others in safe category. Mandal wise stage of ground water development varies from 35 % (Jukkal mandal) to 125 % (Kamareddy mandal). Based on 2013 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, Nizamabad district.

Parameters	Command	Non-command	**Total**
As per GEC 2013	MCM	MCM	MCM
Dynamic (Net GWR Availability)	**581.1**	**730.2**	**1311.3**
• Monsoon recharge from rainfall	184	473	657
• Monsoon recharge from other sources	185.3	94.4	279.7
• Non-Monsoon recharge from rainfall	56.1	104.2	160.3
• Non-monsoon recharge from other sources	218.6	129	347.6
Gross GW Draft	**333.71**	**484.05**	**817.76**
• Irrigation	325.83	471.8	797.63
• Domestic and Industrial use	15.9	25.7	41.6
Provision for Drinking and Industrial use for the year 2025	33.1	49.7	82.8
Net GW availability for future irrigation	222.1	208.7	430.9
Stage of GW development (%)	57.4 %	66.3 %	62.4 %
	Mandal wise it varies from 35 % (Gandhari) to 125 % (Kamareddy)		
In-storage GW Resources (down to the maximum depth of fractures)	28.31	50.93	79.24

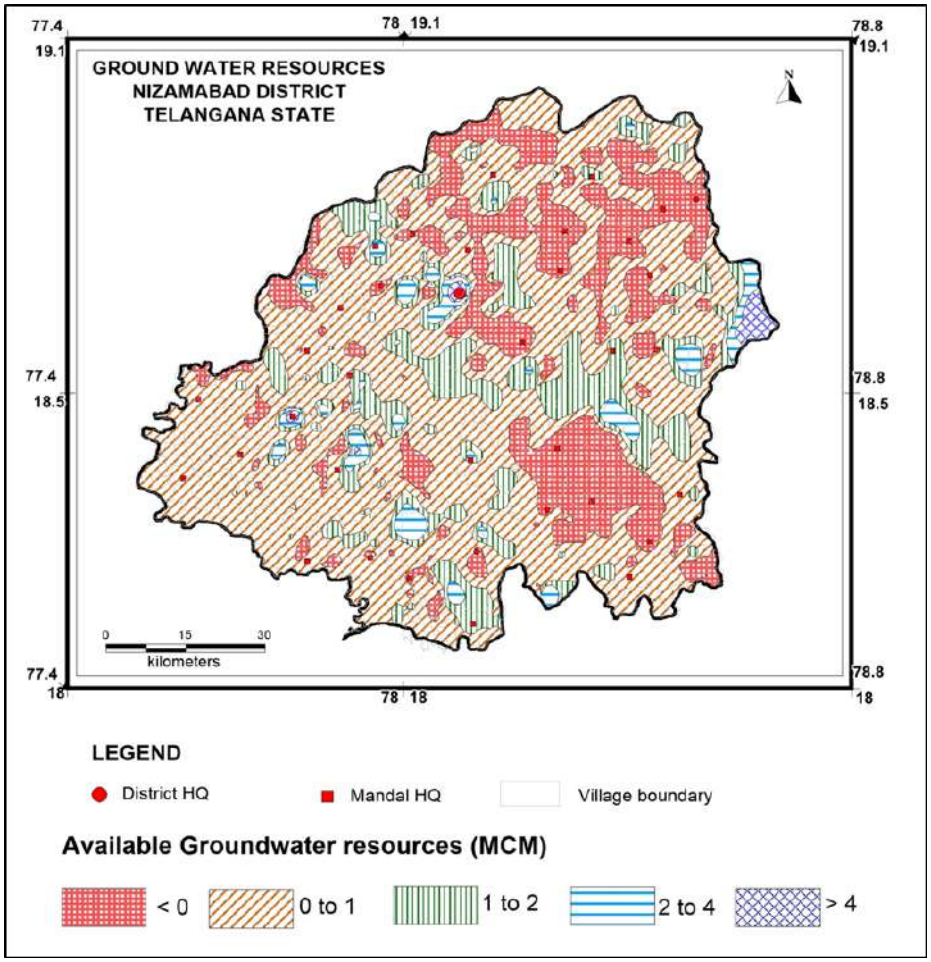

Fig.4.1: Utilizable ground water resources (2013).

5. GROUND WATER RELATED ISSUES and REASONS FOR ISSUES

5.1 Issues

Pollution (Geogenic and Anthropogenic)

1. Few mandals are fluorosis endemic where fluoride (geogenic) as high as 2.6 mg/L during pre-monsoon and 3.7 mg/L during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/L) occur in 4 % and 6 % of the area during pre and post-monsoon season of 2015.

2. High nitrate (> 45 mg/L) due to anthropogenic activities is observed in 58 samples (41%) and 59 samples (56%) during pre and post-monsoon season covering command and urban areas.

3. The high concentration of EC (> 3000 micro-seimens/cm) in 2 % and 1 % of the area is observed during pre and post-monsoon season respectively (mostly in canal command area).

Over-exploitation

4. ~ 2140 Km^2 area covering 324 villages are categorized as over-exploited where ground water balance for future irrigation is zero or negative.

Deep water levels

5. Deep water levels (> 20 m bgl) are observed during pre as well as post-monsoon season in 13 % and 25 % of the area respectively. The high percentage during post-monsoon season is due to deficient rainfall during 2014 (-42 %) and 2015 (-46%).

6. Out of 21 wells analysed, 15 wells shown falling trend in pre as wells as post-monsoon season in the last 10 years (@-0.02 to -1.5 and -0.03 to -1.7 m/yr) respectively.

Sustainability

7. Low yield (<1 lps) occurs in ~40 % of area and yields covering southern and eastern part. 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 in the last two years.

Water Marketing and other Issues

8. 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.

9. Change in land use from agricultural land to residential purposes and cropping pattern from traditional crops to cash crops (spices, cotton) is observed.

10. Based on ground water paddy is grown during rabi season in non-command area leading to heavy withdrawal of ground water during non-monsoon period.

5.2 Reasons for Issues

Geo-genic pollution (Fluoride)

1. 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.
2. Higher residence time of ground water in deeper aquifer.

Anthropogenic pollution (Nitrate)

3. 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.

Over-exploitation and Deep water levels

4. Over-extraction, paddy cultivation during rabi season (37 % to total crops) ground water mining, limited artificial measures etc.

Sustainability

5. Absence of primary porosity, negligible development of secondary porosity, low rainfall, desaturation of weathered zone and urbanization.

6. MANAGEMENT STRATEGIES

High dependence on groundwater coupled with absence of augmentation measures has led to a steady fall in water levels and desaturation of weathered zone in some parts, raising questions on sustainability of existing groundwater structures, food and drinking water security. The occurrence of fractures in fractured zone are 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 (96 %) (**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 98,418 MCM of unstaturated volume (below the depth of 3 m) is avaialable during post-monsoon season of 2015 having 1969 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.

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

6.1.1 Supply side measures:

Ongoing Projects

Repair Renovation and Restoration of existing tanks:

- De-silting of existing minor tanks (834 no) (storage capacity ~283 MCM) was taken under state Govt. sponsored Mission Kaktiya-Phase-1 and Phase-2 to remove 12.78

MCM of silt and this has created additional surface storage. This will contribute ~ 6.4 MCM to groundwater and with this additional ~1066 ha land can be brought under irrigated dry (ID) crops in tank ayacut.

- There is need to take remaining tanks (~978 MI and 1210 other small tanks) in next phases for de-silting, this will greatly help in stabilisation of tank ayacut and ground water augmentation.

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) Manjra river at Singur (Segment-13 & Date of completion 27/04/2018) covering 16 mandals and 1 Municipalaity (Bodhan) and 2) Godavari river at SRSP (Segment-12 & Date of completion 19/10/2017) covering 20 mandals, 2 municipalities (Armoor and Kamareddy) and 1 municipal corporation (Nizamabad) to provide protected water from surface reservoirs at the cost of Rs 2691 crores. 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 101.26 MCM and this imported water from surface sources will reduce the present utilized ~56 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~9300 ha of additional land under ID crops.

To be taken up

Artificial Recharge structures:

Construction of 9354 artificial recharge structures (ARS) (2480 priority-1 (over-exploited) and 6874: priority-2 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 3 m). Initially village wise dynamic groundwater resources of 2013 are considered (**Fig.4.1**). Potential surface run off is estimated by following standard procedures. On conservative side 20 % run off yield is considered as non-committed yield for recommending artificial recharge structures.

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 can be prioritized into **Priority-1(over-exploited)** which needs immediate intervention **and Priority-2**. Based on hydrogeological characteristics, the area is further sub-divided into following 8 categories (**Table-6.1**).

Table-6.1: Hydrogeological characteristics of area.

Category	**Hydrogeologic characterizations**
1	High EC with additional scope for artificial recharge.
2	High EC with no additional scope for artificial recharge.
3	High F with additional scope for artificial recharge.
4	High F with no additional scope for artificial recharge.
5	High EC and F with additional scope for artificial recharge.
6	High EC and F with no additional scope for artificial recharge.
7	Groundwater quality within permissible limits for drinking and irrigation with scope for artificial recharge.
8	Groundwater quality within permissible limits for drinking and irrigation with no scope for artificial recharge.

6.1.1.1 Priority-1 (Area where groundwater development > 100 %)

Area consisting of 324 villages covering ~2140 Km^2 (**Fig.6.1**) is considered as Priority-1 where 566 MCM recharge potential and 79.4 MCM utilizable yield is avaialable and immediate intervention is required because, here, the stage of groundwater development is > 100%. The area is again sub-divided into 8 categories based on hydrogeological conditions as mentioned above. For sustainable development and management of the groundwater resources the following recommendations are made and summarised in **Annexure-2**.

- 2480 artificial recharge structures (1251 CD's with 6 filling and 1229 mini PT's with 1.5 fillings) with a total cost of **185.45** crores can be taken up.
- After effective utilization of this yield, there will be 40 MCM of ground water recharge (50 % of total utilizable yield).
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

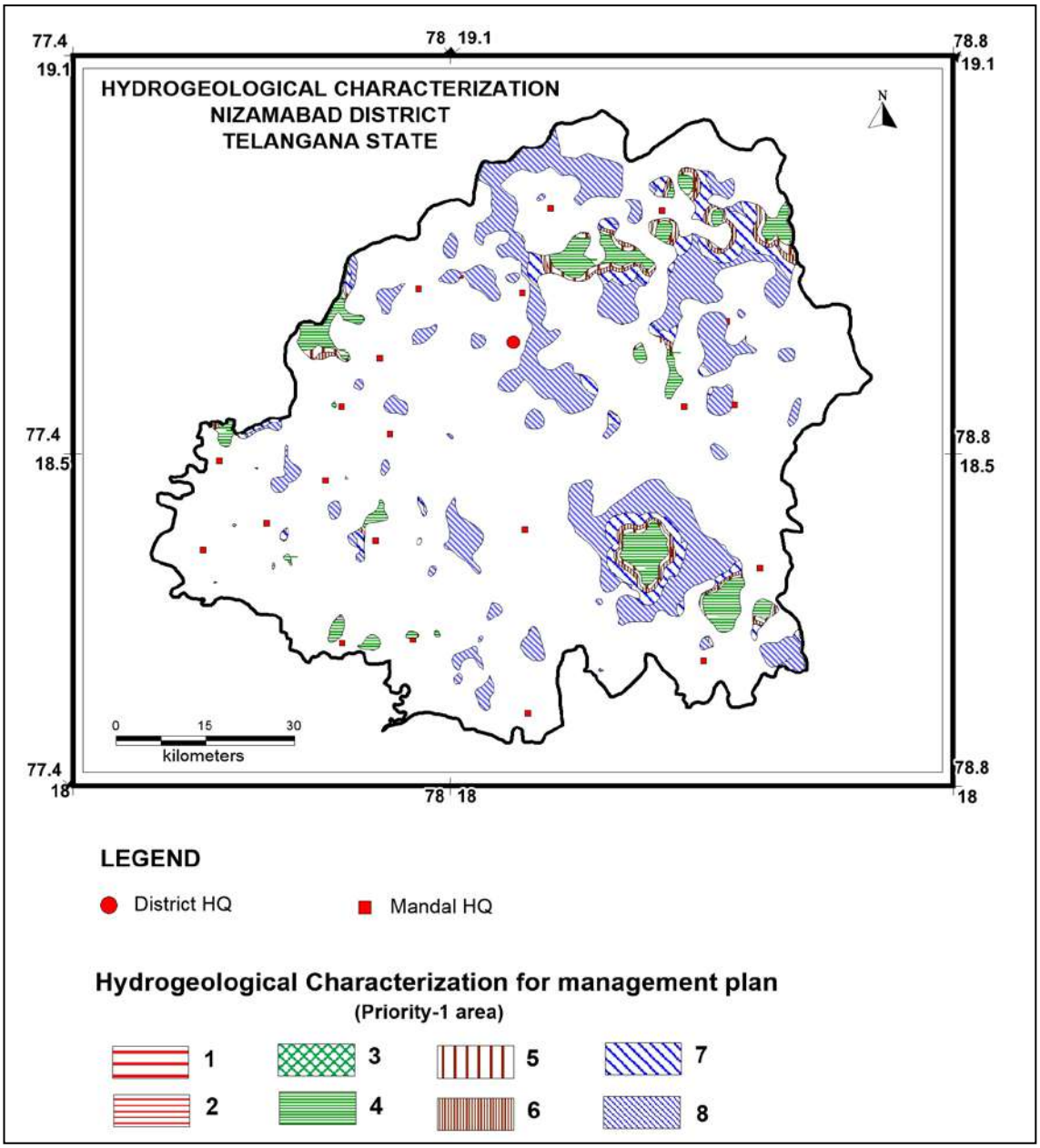

Fig.6.1: Priority-1 area (Over-exploited)

6.1.1.2 Priority-2 (Area where groundwater development <100 %)

Area consisting of 581villages with ~5132 Km^2 rechargable area (**Fig.6.2**) is considered as Priority-2, where 1403 MCM recharge potential and 213.6 MCM utilizable yield is avaialable. The area is again further divided into 8 categories based on hydrogeological characteristics as mentioned above. For sustainable development and management of groundwater resources, the recommendations are made (**Table-6.1)**.

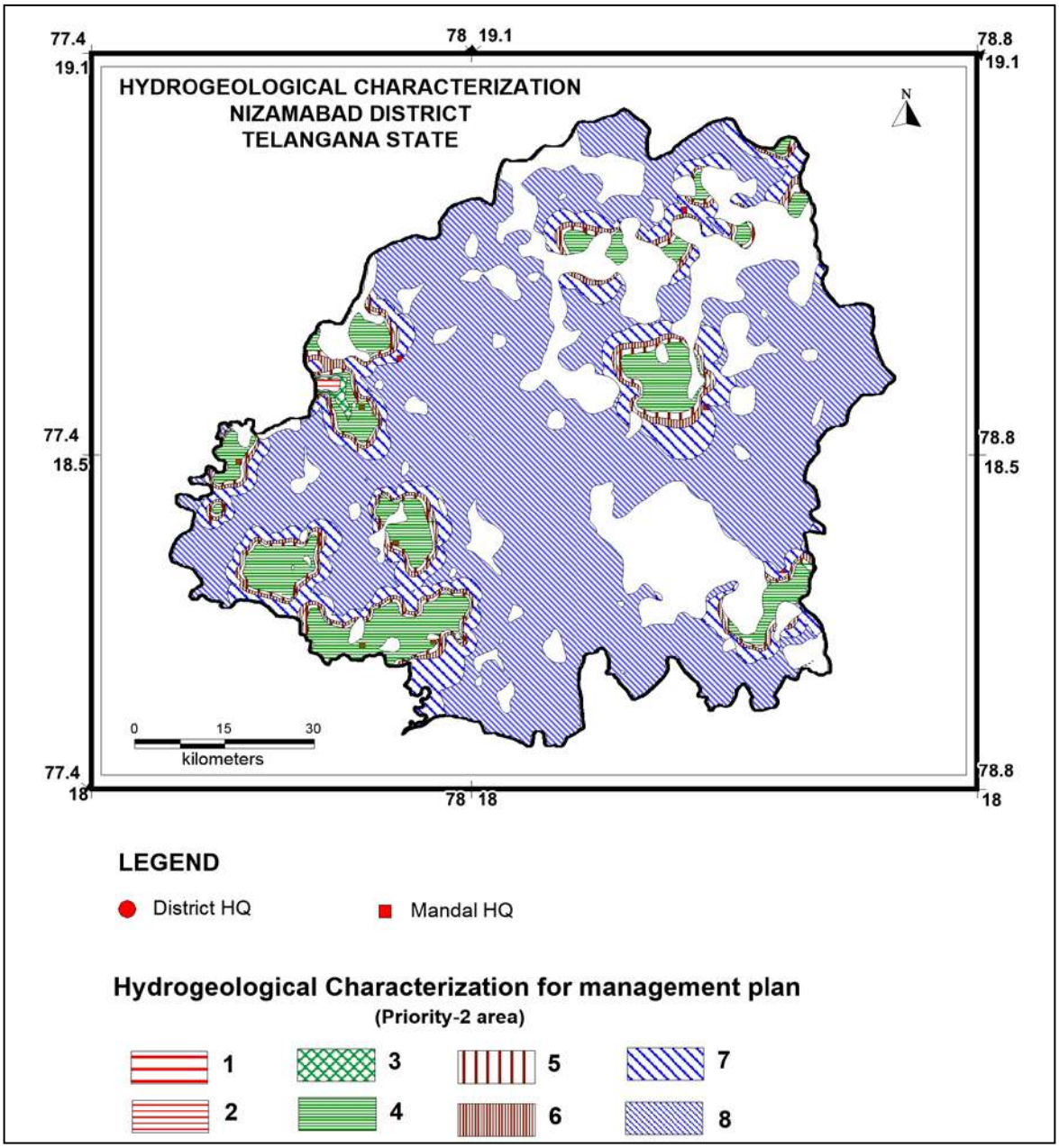

Fig.6.2: Priority-2 area.

- 6874 Artificial recharge structures (ARS) (3446 CD's with 6 fillings and 3428 mini PT's with 1.5 fillings) can be taken up with a cost estimate of **515.1** crores.

- After effective utilization of this yield, there will be 106.8 MCM of ground water recharge (50 % of total utilizable yield).

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

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.

- Some of de-silted tanks along river Manjira and river Godavari may be filled up with during lean monsoon period.

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 x 3 m. In the district total 27234 farm ponds exist in 523 villages and additional **7860** farm ponds are recommended (20 in each village in 393 villages) with total cost of **19.65** crores.

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

Ongoing Work

- In the area till date a total number of 4842 no's drip and sprinklers are sanctioned which has irrigated ~4031 ha under ID crops saving ~6 MCM of groundwater from the basin.

Proposed Work

- ~49,000 ha of additional land that can be brought under micro-irrigation (@100 ha/village in 490 villages) costing about 294 crores (considering 1 unit/ha @0.6

lakh/ha). With this 98 MCM of ground water can be conserved over the traditional irrigation practices (considering 0.006 MCM/ha for ID crops against 0.008 MCM/ha).

6.1.3 Regulatory measures

- Change in cropping pattern from water intensive paddy/spices (turmeric) to irrigated dry crops like pulses and oil seeds are recommended, particularly in water stress/Over-exploited/Critical areas. If necessary some regulatory rules may be framed and implemented.

- 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.

6.1.4 Institutional measures

- A participatory groundwater management (PGWM) approach in sharing of groundwater 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 groundwater 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 measure includes supplementary calcium and phosphorous rich food to the children in fluoride endemic 5 mandals. Creating awareness about safe drinking water habits, side effects of high fluoride and nitrate rich groundwater, improving oral hygiene conditions are recommended.

6.2 Expected Results and Out come

With the above interventions costing Rs 1014.15 crores (excluding the cost involved in Mission Kakatiya and Mission Bhagiratha), the likely benefit would be the net saving of 301.2 MCM of ground water. This will bring down the stage of ground water development by 12 % (from 62 % to 50 %).

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