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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

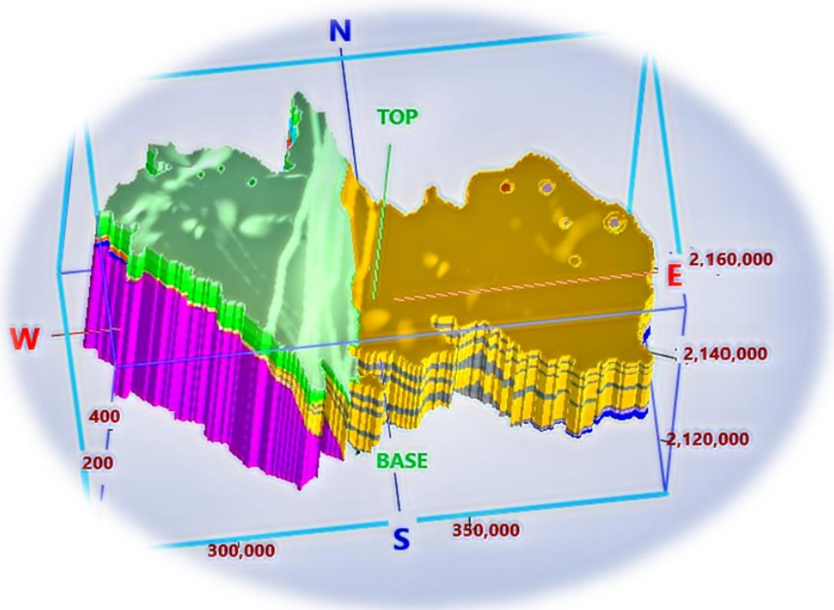
KUMURAM BHEEM ASIFABAD DISTRICT, TELANGANA

दक्षिणी क्षेत्र, हैदराबाद

Southern Region, Hyderabad

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

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



CENTRAL GROUND WATER BOARD
SOUTHERN REGION
HYDERABAD
NOVEMBER 2021

REPORT ON

AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN KUMURAM BHEEM ASIFABAD DISTRICT, TELANGANA STATE

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

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Annexure-1: Proposed Supply side interventions

Mandal	Village	Latitude	Longitude	Proposed CD's	Proposed PT's
Kaghaznagar	Marepalle	19.45829964	79.39959717	0	0
Kaghaznagar	Gannaram	19.36580086	79.57839966	0	0
Kaghaznagar	Malini	19.49740028	79.43070221	0	0
Kaghaznagar	Vallakonda	19.35720062	79.55249786	0	0
Kaghaznagar	Metindhani	19.47200012	79.38639832	0	0
Kaghaznagar	Dubbaguda	19.35350037	79.38710022	1	1
Kaghaznagar	Metpalle	19.37409973	79.39559937	1	1
Kaghaznagar	Badapalli	19.30789948	79.54489899	1	1
Kaghaznagar	Boregaon	19.2784996	79.55460358	1	1
Kaghaznagar	Seetanagar	19.32629967	79.5522995	1	1
Kaghaznagar	Raspalli	19.32489967	79.61060333	2	2
Kaghaznagar	Jambuga	19.32259941	79.57620239	3	3
Kaghaznagar	Nagampet	19.34049988	79.58149719	3	3

ABBREVATIONS

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

EXECUTIVE SUMMARY

The Kumuram Bheem Asifabad district has a geographical area of 4491 km2, with 15 revenue mandals lies between north latitude 19° 3' 3"-19° 37' 35" ´and east longitude 78° 48' 1"- 79° 58' 38" with a mappable area of 3717 km^2. Administratively the district is governed by two revenue divisions, 433 villages having a population of ~5.15 lakhs (2011 census, population density of 115 person/ km).

The area is underlain by various geological formation from the oldest Archaean rocks comprising granite/gneisses to Purana, Gondwana to the recent alluvium. About 60% of the area is underlain by Sandstones, Basalt (20%), Banded Gneissic Complex (14%) and Limestone (6 %) The Penganga and Sullavai group unconformably overlies the Archean and the Gondwana formation lies unconformably over the Archean and Proterozoic Metasedimentary rocks. Basaltic rocks occurring in the western part of the district, forms the fringe areas of the vast Deccan Plateau of Central India. Pediment are the major landforms followed by structural hills and dissected plateau. The district is drained by river Pranahita and other tributaries of Godavari River. The total gross cropped area during the year 2019-20 is 131481 ha. The gross cropped area (2019-20) during khariff season is 123260 ha and during rabi season is 8220 ha (Total 131481 ha). Forest occupies nearly 55 % of the area; agricultural land occupies nearly 27% of the area. Remaining area is occupied by water bodies, waste land, built up etc. The area is mainly occupied by Fine loamy, mixed and montmorillonic soil (55%) and clayey soil (26%).

Water level is monitored through 30 wells during pre and post-monsoon season . Water table elevations during pre-monsoon season vary from 135 to 519.5 m.amsl during premonsoon period and and 136.3 to 520.12 m.amsl during postmonoson period. During pre-monsoon DTW varies from 0.13 to 21.85 m bgl. In Majority of the area water level during this season is in the range of 5-10 m (69% of the area) and 2 to 5 mbgl (8% of the area). The deeper water levels of >10 m bgl are observed in parts of Tiryani, Dahegaon, Penchikalpet, Asifabad, Keramari and Jainoor mandals. During post-monsoon DTW varies from 0.76 to 17.77m bgl. In most of the parts water level are in the range of 5-10 m covering 50% of the area whereas 2-5m bgl covers 44%.

In overall the district shows rise in ground water levels. The seasonal water level fluctuations vary from 0.11 to 11.7 m rise). In majority of the district , the rise in water level range from 2 to 4 m covering 56% of the area, followed by 0 to 2 m covering 40% of area. Water level rise >4 m is observed in Tiryani, Kagaznagar and Asifabad mandals.

Trend analysis for the last 10 years (2010-2019) is studied from 20 hydrograph stations of CGWB and SGWD. The decadal premonsoon water level trend analysis indicates that during pre-monsoon period, 16 wells shows falling trend (>0.5m: 2, 0-0.5m: 14 wells) (max fall: 0.71 m/yr) and 14 wells shows rising trend (0-0.5m: 14 wells) (max rise: 0.322 m/yr). During post-monsoon season 13 wells show falling trend 0-0.5m.:12) (maximum fall: 0.58 m/Yr) and 17 wells shows rising trends (0-0.5m: 16 wells) (max rise: 2 m/yr).

Total 417 ground water samples (Pre-monsoon:200 and Post-monsoon:217) were analysed for knowing the suitability of ground water for drinking purposes. In 54 % and 45 % of area EC is in the range of 1500 to 3000 µ Siemens/cm pre and post-monsoon season respectively. During pre-monsoon season, concentration of NO_3 ranges from 0.02-5.58 mg/L and found that in 2 % samples nitrate is beyond maximum permissible limit of BIS (45 mg/l) and F concentration varies from 0.02-5.58 mg/l and found that in 2% samples it is beyond maximum permissible limits of BIS (1.5 mg/l). During post-monsoon season, concentration of NO_3 ranges from <1-149 mg/L and found that in 2% of samples it is beyond maximum permissible limit of BIS (45 mg/l). The F concentration varies from 0.02-2.3 mg/l and found that in 1% it is beyond maximum permissible limit of BIS.

On the basis of occurrence and movement of ground water, mainly rock units of the Asifabad is classified into two categories; hard rocks (consolidated formation/semiconsolidated) formation which occupies 40% of the area and soft rock formation (semi consolidated sedimentary rocks/unconsolidated) which occupies 60 % of the area. In hard rock areas, aquifers are conceptualized in to two namely; 1) weathered zone (25 - 30 m) and 2) fractured zone (30- 195 m). The Weathered zone (~30 m) consisting of upper saprolite (~13 m) and lower sap rock (13-35m.). Ground water yield of this zone varies from <1-2 lps. Ground water yield from fractured zone varies from <1 to 6 lps. The transmissivity (T) varies from 1 to 55 m^2/day and storativity varies from 0.00001 to 0.0001.

Four aquifers were demarcated in semi-consolidated Gondwana formation areas upto a depth of 300 m. Aquifer I is the shallowest aquifer, mostly upto a depth of 35 m, consists of weathered residuum where ground water occurs under water table condition. The aquifer II, aquifer-III and Aquifer-IV are deeper aquifers occurring in various depth upto 300m. The transmissivity (T) of these aquifers varies from 7 to 316 m^2/day. The Specific Capacity of the wells ranges between 9 and 112 lpm/mdd and Storage coefficient ranges between 1.4 x 10-4 and 3.57 x 10-4.

Net dynamic replenishable ground water availability is 300 MCM, gross ground water draft is 76 MCM, provision for drinking and industrial use for the year 2025 is 23 MCM and net available balance for future irrigation use is 221 MCM. The stage of ground water development varies from 25 to 20 % (avg: 5 %).

The management strategies mainly include both supply side and demand side. The supply side measure includes ongoing work under Mission Kakatiya where ~2.23 MCM of silt has been removed from existing 361 tanks. This will contribute ~0.56 MCM of ground water by recharge, with this additional ~93 ha land can be brought under irrigated dry (ID) crops in tank ayacut. Under Mission Bhagiratha, there is plan to import ~19.8 MCM of water for drinking purposes which will save the present ~11 MCM of water for drinking and domestic purposes and with this additional ~1900 ha of land can be brought under ID crops.

As the stage of ground water development in the area is 24% and all the mandals falling in safe category except Kagaznagar Mandal (Semi Critical) as per the GEC 2020 estimation. AR structures are suggested in Kagaznagar mandal only as the the stage of ground water development is 75%, therefore to control futher increase in stage of ground water development, artificial recharge structures are recommended in this mandal only. Kagaznagar Mandal covering 63.5Km^2 is considered for recommending artificial recharge structures (ARS) where, 1.42 MCM recharge potential with surplus runoff of 4.18 avaialable. 26 artificial recharge structures (13 CD's with 6 filling and 13 mini PT's with 2 fillings). After effective utilization of this yield, there will be 0.73 MCM of ground water recharge. Water conservation measures include taking up work through IWMP, MGNREGS and the projected recharge volume through CD's and PT's in the villages. Demand side measure includes, sanctioned 611 no's drip and sprinklers which has irrigated ~622 ha under ID crops saving ~1.1 MCM (considering 30% saving of 0.006 MCM/ha) of groundwater from the basin. Other measure includes mandatory artificial recharge at every Govt and industrial units. Capacity building, strict implementation of WALTA and participatory groundwater management (PGWM) are the other measures recommended.

NUMBER OF DATA POINTS USED FOR PREPARATION OF VARIOUS MAPS/FIGS-KUMURAM BHEEM ASIFABAD DISTRICT, TELANGANA STATE

S.No.	Data	Aquifer	Total Data Points	Source	
				CGWB	SGWD/SCCL/RWS
1	Panel Diagram (3-D)	Combine	83	Expl:26 VES:33	24
2	Hydrogeological Sections	3 no	83	Expl:26 VES:33	24
3	Fence/ panel Diagrams	1 no	83	Expl:26 VES:33	24
4	Depth of weathering	1 no	83	Expl:26 VES:33	24
5	Depth of fracturing	1 no	83	Expl:26 VES:33	24
6	Groundwater Yield	combined	83	26	24
8	Depth to Water Level Maps (2019)	Combined	30	10	20
9	Water Level Fluctuation	Combined	30	10	20
10	Long term water level trends	Combined	30	10	20
11	Water quality Pre-2019 Post-2019	Combined	Pre:200 Post:217	7 0	SGWD:20 RWS : 173) SGWD:20 RWS :197)

1. Introduction

National Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. It has been prioritised to study Over-exploited, Critical and Semi-Critical talukas as well as the other stress areas recommended by the State Govt. Aquifer mapping is a multidisciplinary and a holistic scientific approach wherein a combination of geologic, geophysical, hydrologic and chemical analysis is applied to characterize the quantity, quality and sustainability of ground water in aquifers. It had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulation mechanism has a detrimental effect on ground water scenario of the country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

The Peninsular Shield consists mostly of consolidated sedimentary rocks, Deccan Trap basalts, and crystalline rocks. The occurrence and movement of groundwater in these formations are restricted to weathered residuum and interconnected fractures at deeper levels and have limited groundwater potential. The 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. These diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the Administration of Asifabad district, Telangana for its effective implementation.

1.1 Objective and Scope

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. In view of this, an integrated hydrogeological study was taken up to develop a reliable and comprehensive aquifer map and to suggest a suitable groundwater management plan on a 1: 50,000 scale.

1.2 Approach and Methodology

The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects. Considering the objectives of the 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 given in (**Fig 1.1**)

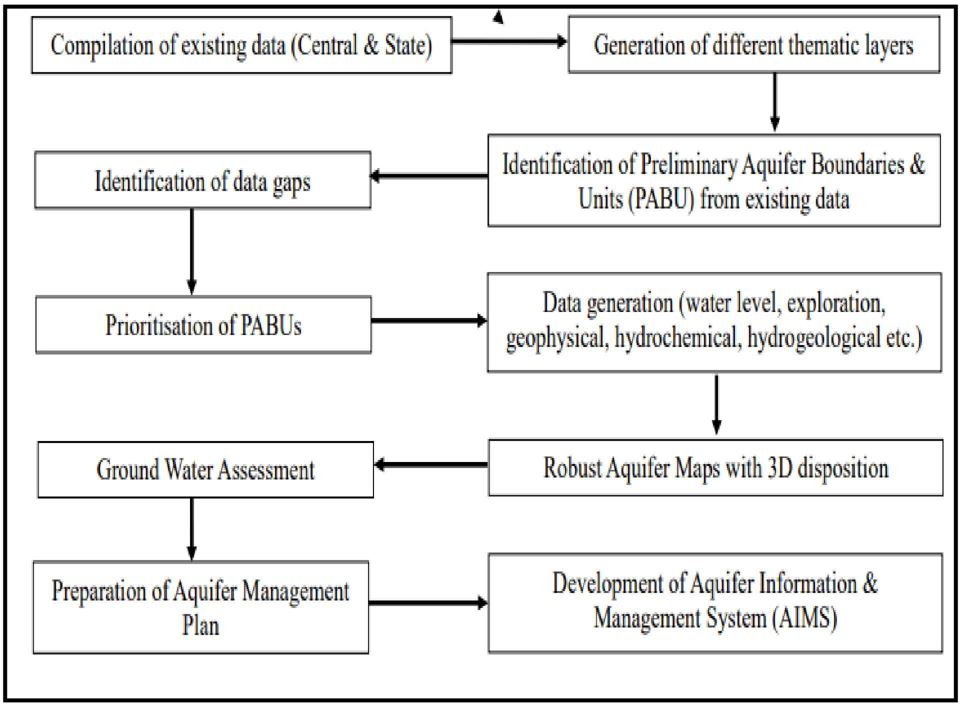

Fig .1.1 : Action Plan of Aquifer Mapping

1.3 Area Details:

The Kumuram Bheem Asifabad district having geographical area of 4491 km^2, lies between north latitude 19° 3' 3" 19° 37' 35" and east longitude 78° 48' 1"- 79° 58' 38" with a mappable area of 3717 km^2. The District is bounded on east by Adilabad district, on the south by Mancherial District, on the North by Maharashtra State. It is the part of Godavari basin (**Fig.1.2**). Administratively the District Comprises of 15 Mandals and 433 villages. There is one Municipality in the District. The District is conveniently formed into two revenue divisions 1) Asifabad and 2) Kagaznagar with a population of ~5.15 lakhs (2011 census) with average population density of 115 person/ km^2.

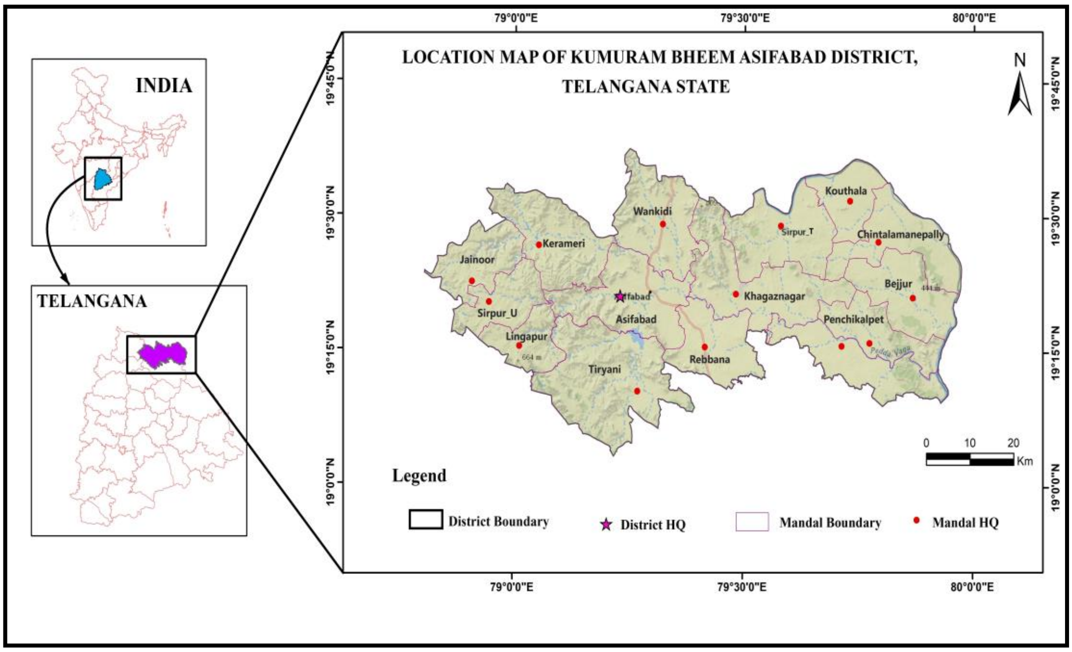

Fig.1.2 : Location map of Kumuram Bheem District.

1.4 Climate and Rainfall:

The district experiences tropical climate and is geographically located in a semi-arid area. The district falls under Northern Telangana agro-climatic zone. The Southwest monsoon enters into the district in June and lasts until September and Northeast monsoon from October to December. Summer starts in March, and reaches peak in May with average maximum temperatures of 41.9°C. Winter season starts in late November and lasts until early February with lowest average minimum temperature of 13.2°C in January. The annual normal rainfall of the district varies from 1073 mm (Rebbana mandal) to 1342 mm (Jainoor mandal) with district normal of 1164 mm. Average number of rainy days for a year is around 72 days. Southwest monsoon contributes 86% (1007 mm), Northeast monsoon by 8 % (89 mm) and rest 6 % by January to May months of normal annual rainfall. Mean monthly rainfall varies from 334.1 mm in July to 5.4 mm in December. Isohyetal map prepared using annual normal rainfall of mandals shows increase in rainfall from central region to both west and east direction in the district **(Fig.1.3).** The district received annual rainfall of 1338 mm (15% above normal) during the year 2020 (Jan to Dec) and 1356 mm in 2019 (16% above normal).

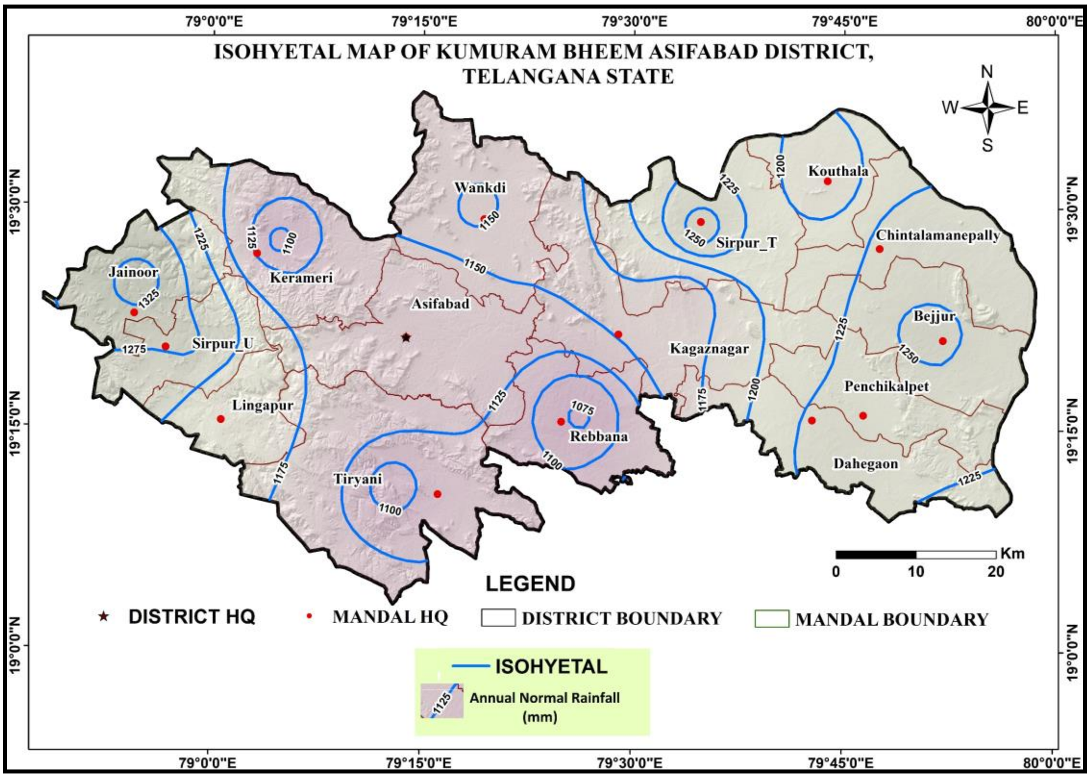

Fig.1.3: Isohyetal map of Kumuram Bheem district.

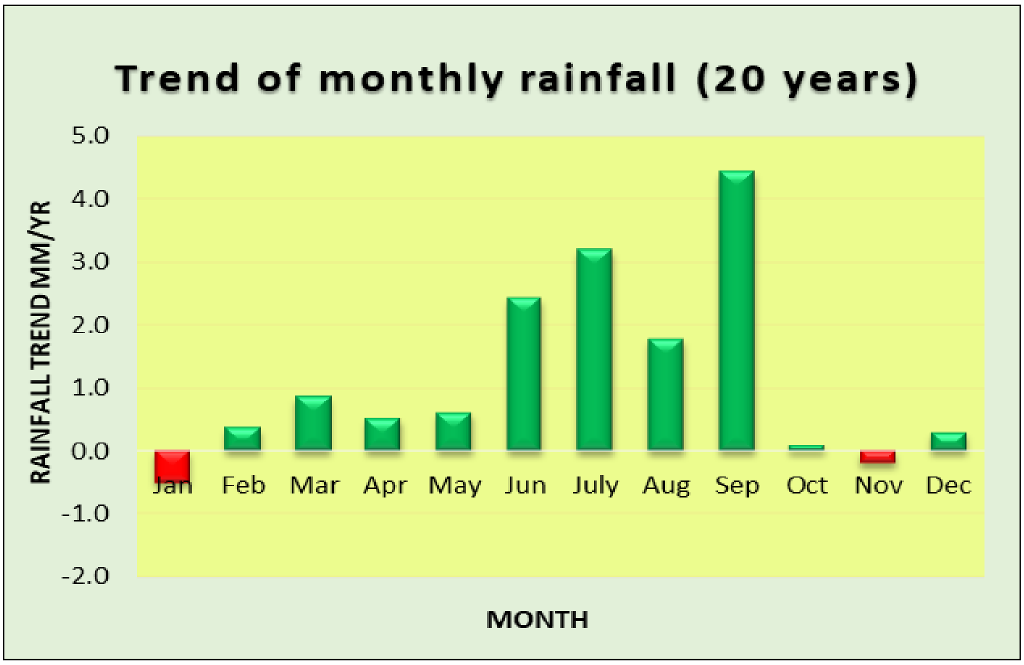

Fig-1.4 a: Monthly Rainfall trend

Analysis of long-term rainfall data of 20 years (2001-2020) shows rise in annual rainfall of 13.9 mm/yr. The monthly rainfall trend graph for 20 years shows rise in rainfall trend in southwest monsoon months from June to September especially for September (4.4 mm/yr). (**Fig.1.4a & 1.4b**).

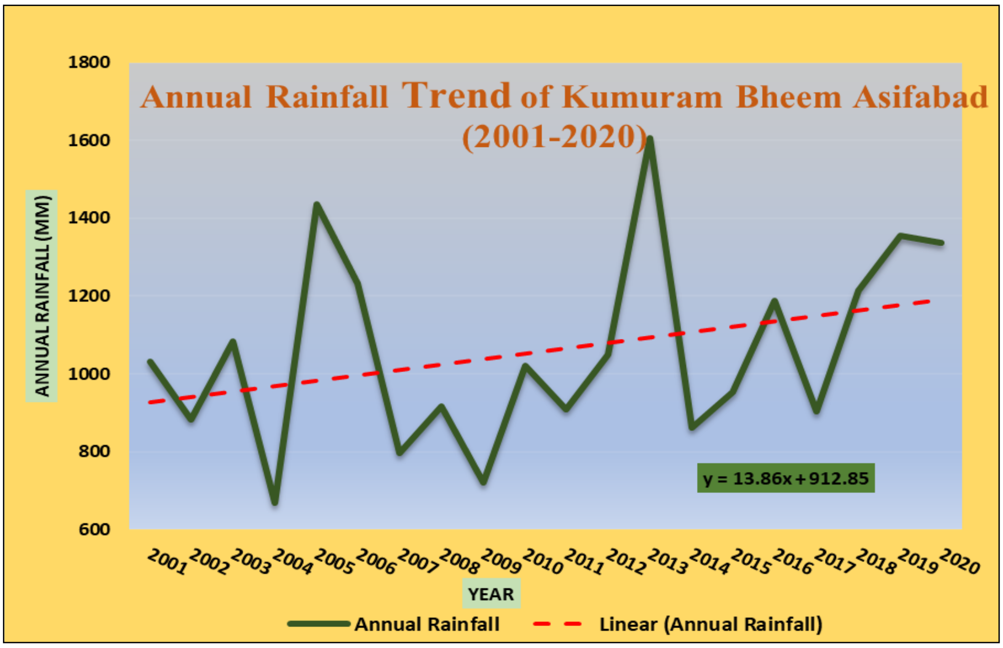

Fig.1.4 b: Annual Rainfall Trend

1.5 Geomorphological Set up:

The Kumuram Bheem Asifabad district is characterised by undulating topography. Pediment is the major landform covering about 1539 km^2 (34%) area. The other landforms observed are structural hill (29%), dissected plateau (19.28%), flood plain, Piedmont slope, denudation hills, channel fill, Mesa and Intermontane valley etc are presented in **Fig.1.5**.

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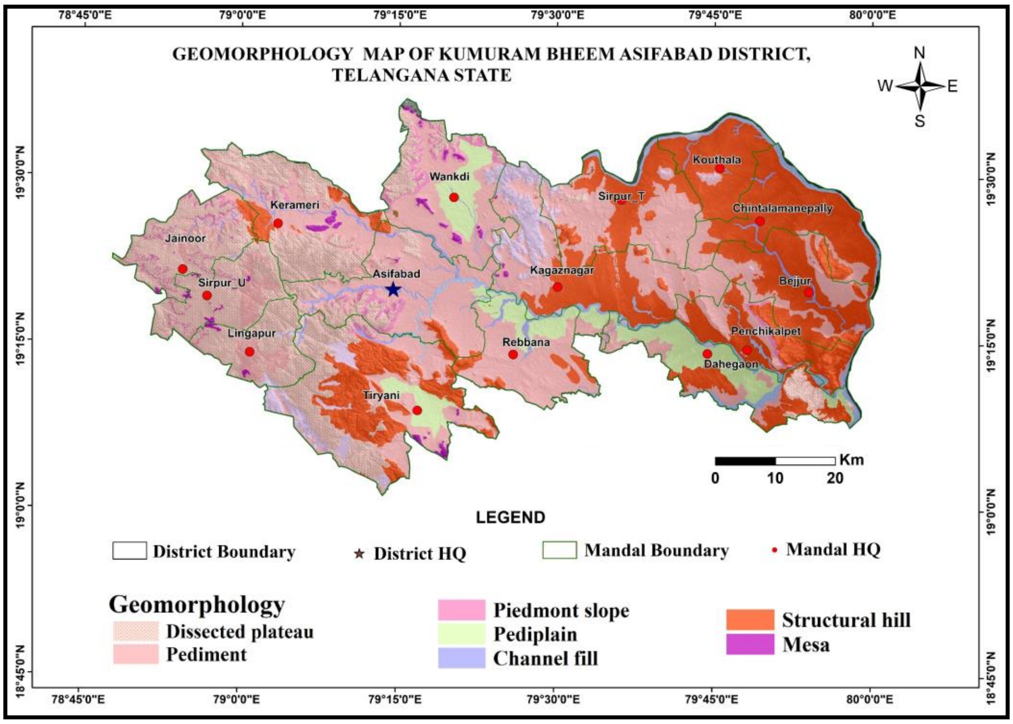


Fig.1.5: Geomorphology of Kumuram Bheem district.

1.6 Drainage and Structures:

The district falls under Godavari basin and divided into 2 sub basins namely Vardha and Pranhita. These sub basins are further sub divided into 10 watersheds. The river Pranahita begins at the confluence of the Wardha and the Wainganga rivers, which lies on the border between Maharashtra and Kouthala mandal in Asifabad district. It flows along the eastern boundary of the district and drains into Godavari River in the south. The drainage basin conveys the combined waters of the Penganga, Wardha and Wainganga rivers. Several tributaries such as pedda vaggu, Chelmelavagu rivers etc. also flow through the centre of the district. Lineaments are running mainly in NW-SE, NNW-SSE and NE-SW directions. Map depicting drainage, water bodies, lineaments and watershed boundaries is presented in **Fig.1.6**.

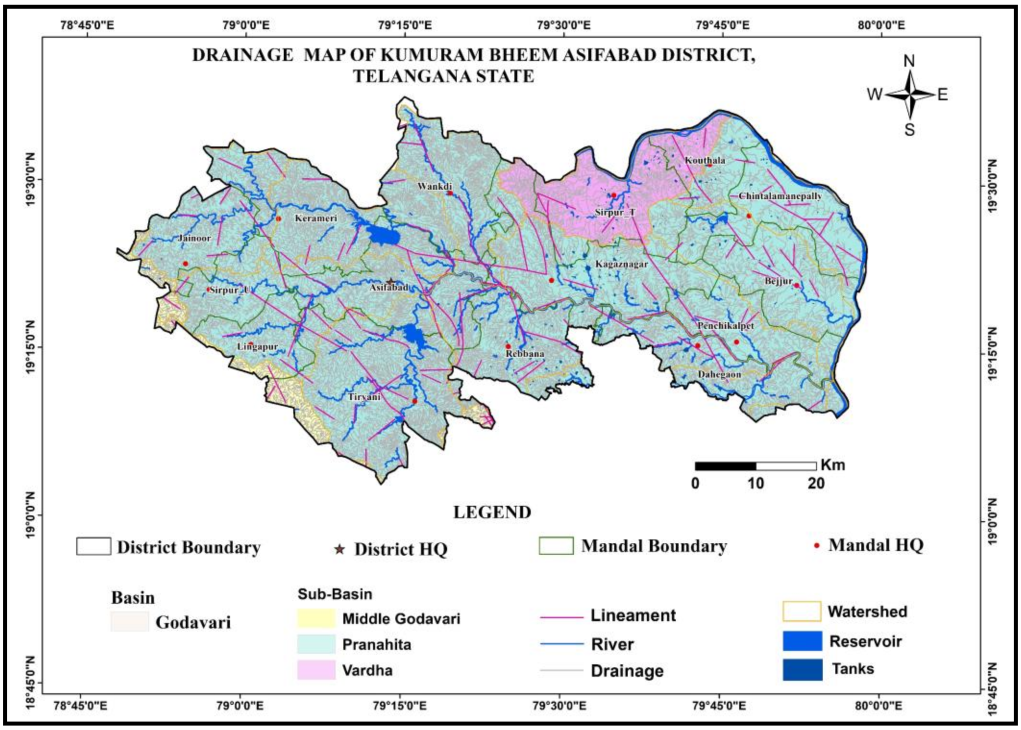


Fig.1.6: Drainage, lineaments and watershed boundaries.

1.7 Land use and cropping pattern (2019-20):

Out of the total geographical area, forest and agriculture land comprises the major land use in the Asifabad district covering 54.5 % and 27.4 % of total area respectively. About 3.77 % constitute the barren and uncultivable land. The land put to non-agricultural use is 1.68%, 1 % of the area is formed by permanent pasture and 5.0 % is other fallow land. The current fallows are about 5.2%. Nearly 1.67 lakh hectares are under cultivation, out of which 7 % of the area is under double cropping. The spatial distribution of land use is presented in **Fig. 1.7.**

The total gross cropped area during the year 2019-20 is 131481 ha. The gross cropped area (2019-20) during khariff season is 123260 ha and during rabi season is 8220 ha (Total 131481 ha). Main crops grown are Cotton 74% followed by Paddy 14% and Pulses 8% during khariff season and 41%, Pulses 24 %, Millets 21%, Fruits and Vegetables 12%, Others 2% during Rabi season. Season wise cropping pattern is given in **Fig.1.8a & b**.

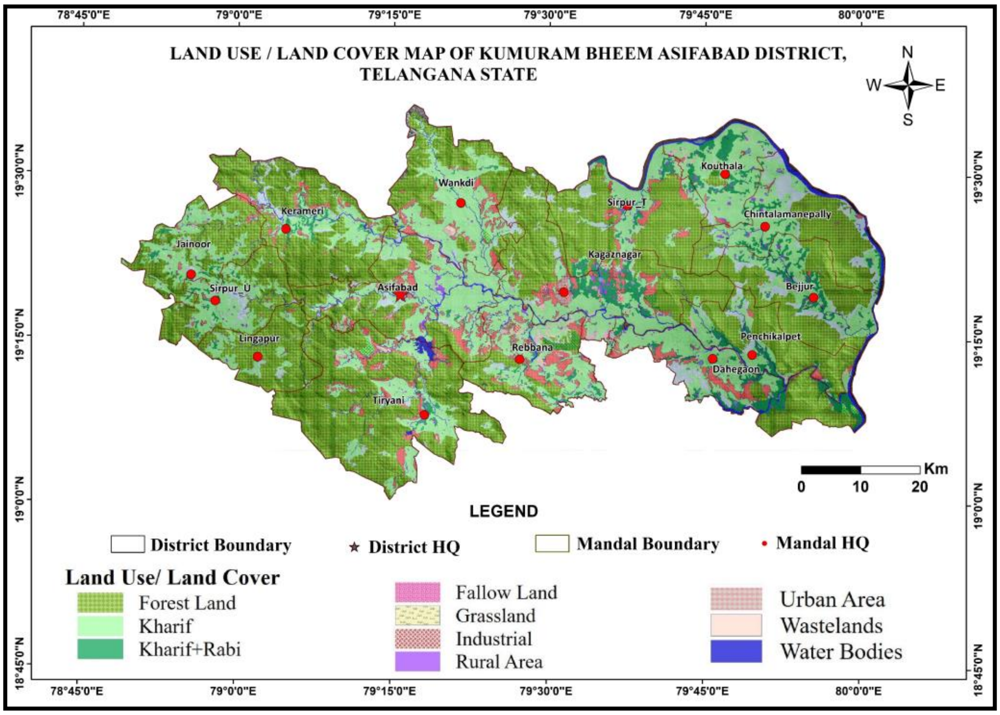
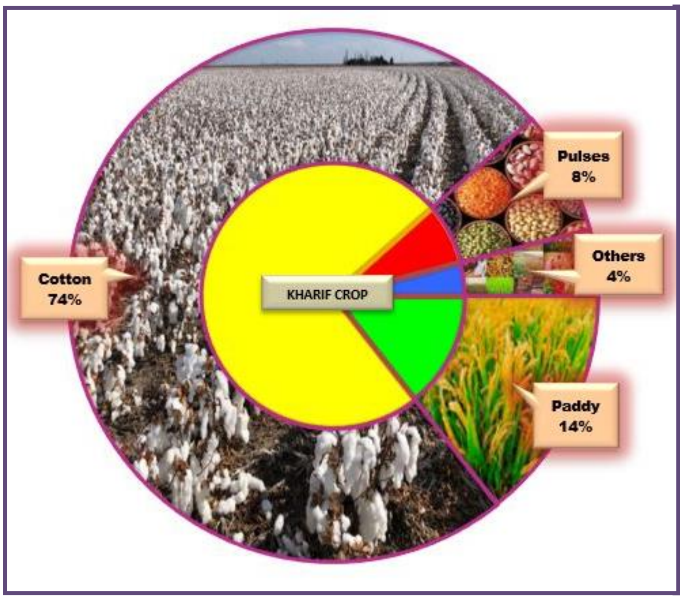


Fig.1.7: Land use and land cover of Kumuram Bheem district



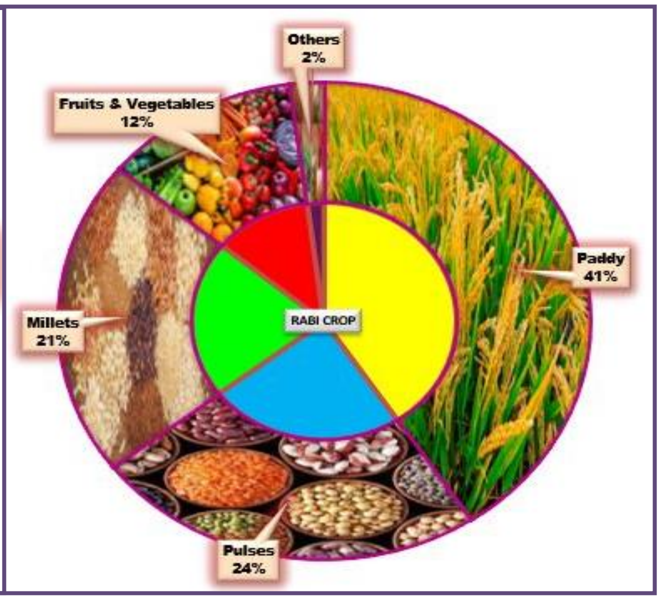


Fig.1.8a: Cropping pattern in Khariff

Fig.1.8b: Cropping pattern in Rabi

1.8 Soils

The area is mainly occupied by Fine loamy, mixed and montmorillonic soil (55%) followed by clayey soil (26%). Clayey, montmorillonitic soils are predominant in western part of the district. Loamy-skeletal and fine, mixed soils are abundant in eastern parts of the district and in some central part of the district and clayey skeletal-mixed soils are mostly seen in southern and northern part of the district (**Fig.1.9**).

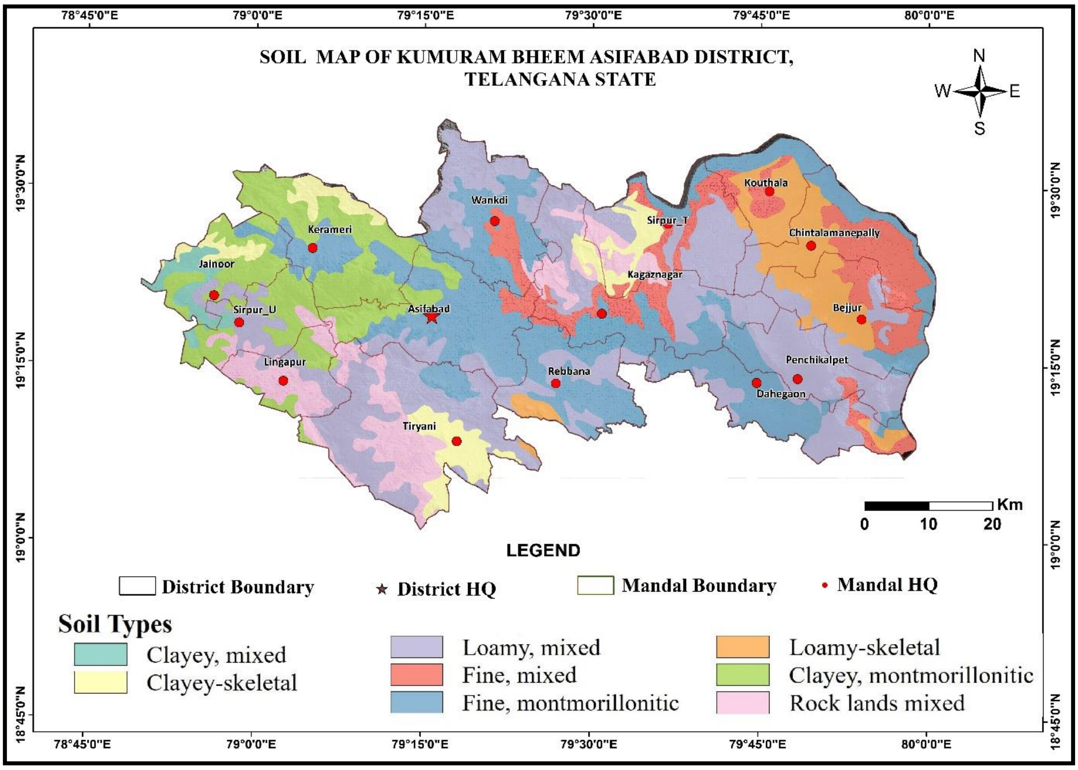


Fig.1.9: Soil map of Kumuram Bheem Asifabad district.

1.9 Irrigation:

1.9.1 Major Irrigation Project:

The ongoing **Peddavagu (Sri Komaram Bheem)** Project is a Major Irrigation Project constructed across Peddavagu River, a tributary of Godavari River in Ada village in Asifabad mandal in Kumuram Bheem district. This Project is having a catchment area of 1132 sq.km with an ayacut of 9712 ha.

Dr.B R Ambedkar Pranahita Project (ongoing) is a Major irrigation project across the Pranahita River, a major tributary of the river Godavari in Thummidihatti Village, Koutala Mandal in Kumuram Bheem district. This Project is having a catchment area of 98000 sq.km with a contemplated irrigational potential of 22864 ha.

1.9.2 Medium Irrigation Project:

The **Vativagu Project** is a medium irrigation project proposed across Vattivagu River located in Pahadibanda Village of Asifabad mandal of Kumuram Bheem district. This Project is having a catchment area of 530 sq.km with an ayacut of 9914 ha.

The **Chelmelavagu Project** (NTR Sagar) is a medium irrigation project proposed across Chelamala Vagu River located in Irkapally Village of Tiryani mandal of Kumuram Bheem district. This Project is having a catchment area of 103 sq.km with an ayacut of 2428 ha.

The **PP Rao Project (Yerravagu)** is a medium irrigation project proposed across Yerravagu River located in Kalwada Village of Dahegaon mandal of Kumuram Bheem district. This Project is having a catchment area of 451 sq.km with an ayacut of 4512 ha.

The **Peddavagu (Jagannathpur) Project** is a medium irrigation project proposed across Peddavagu River located in Jagannathpur Village of Kagaznagar mandal of Kumuram Bheem district. This Project is with an existing ayacut of 6070 ha.

Irrigation projects in Asifabad district and Irrigation particulars such as Commisioned lift irrigation scheme,Minor Irrigation tanks and groun water schemes are given in **Fig1.10**, **Table 1.1, Table 1.2** and **Table 1.3** respectively.

Table 1.1: Commisoned Lift Irrigation scheme

Ditrict	**No. of Schemes**	**Irrigation Potential created in ha**
Kumuram Bheem Asifabad	11	7893

Table 1.2 : Minor irrigation tanks

State	**No. of Tanks**	**Ayacut in acres**
Kumuram Bheem Asifabad	637	56,544

Table 1.3: Ground Water Schemes (Source: 6th Minor Irrigation Census, 2017-18)

District Wise Ground Water Scheme	**Number**
Villages Covered	433
Dugwell	2513
Shallow Tubewell	627
Medium Tubewell	2625
Deep Tubewell	486
Total	**6251**

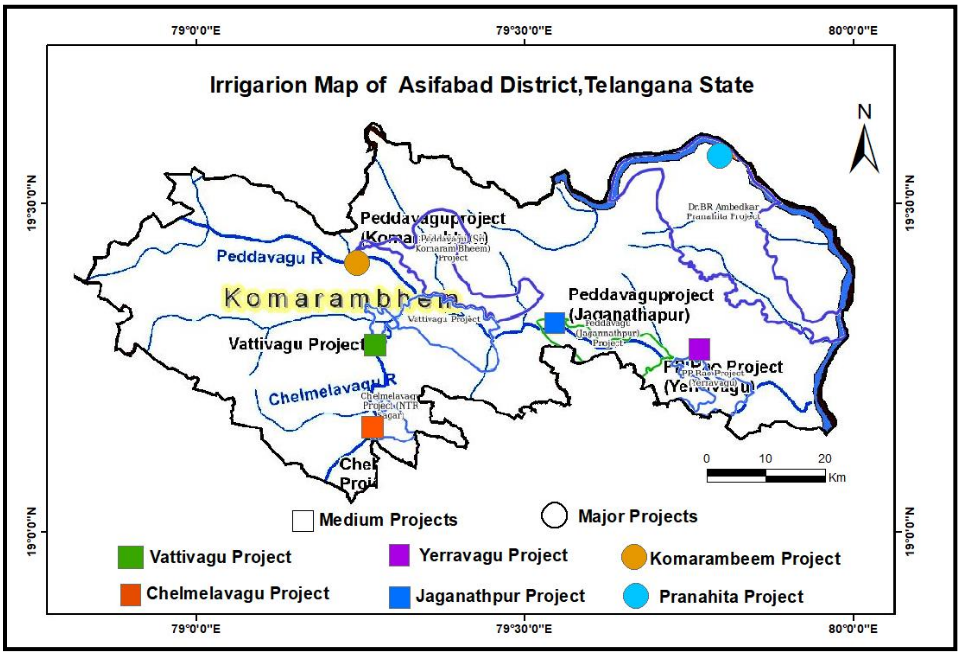


Fig.1.10 : Irrigation projects in Asifabad district

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

1.10 Prevailing Water Conservation/Recharge Practices: In the district there are **existing** ~681 percolation tanks and 9 check dams. Under Mission Kakatiya (Phase 1 to 4) 361 tanks have been undertaken under RRR (Repairs, restoration and Rejuvenation) schemes.

1.11 Geology: The area is underlain by various geological formation from the oldest Archaean rocks comprising granite/gneisses to Purana, Gondwana to the recent alluvium. The general geological succession of the area is presented in the **Table-1.1** About 60% of the area is underlain by Sandstones, Basalt(20%), Banded Gneissic Complex (14%) and Limestone (6 %) (**Fig1.11**).

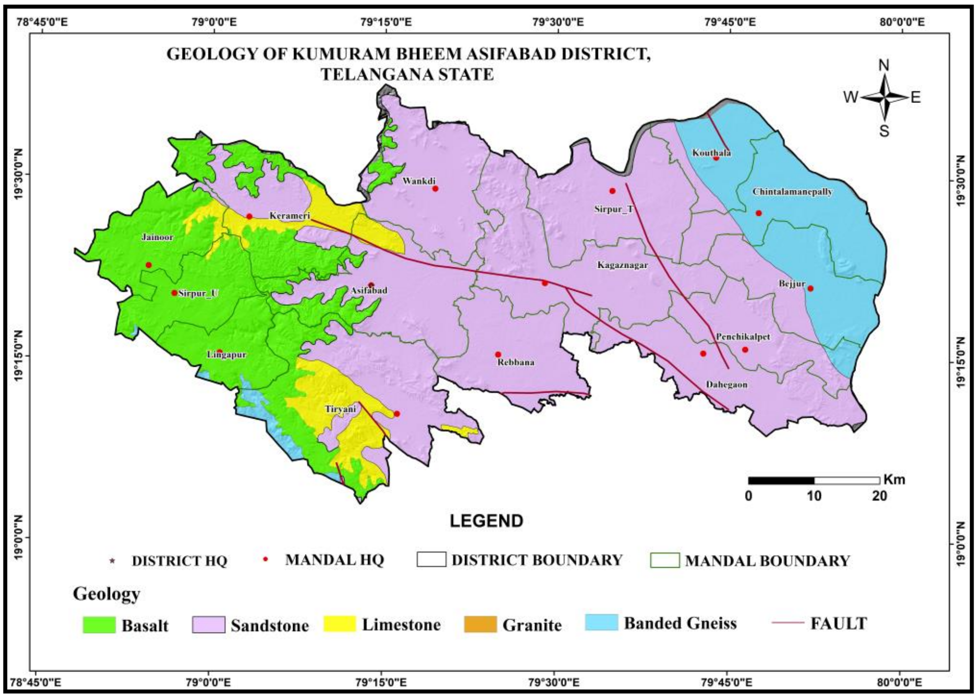


Fig.1.11: Geology of Asifabad district

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 aquifer geometry for shallow and deeper aquifer has been established through hydro geological studies, exploration, the surface and subsurface geophysical studies in the district covering all geological formations. 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 hard rocks, while in sedimentary rocks it depends on porosity, granularity, cementing matrix, ermeability, bedding plains and faults etc. On the basis of occurrence and movement of ground water, mainly rock units of the Asifabad district can be broadly classified into two categories. (i) consolidated formation of crystalline archean granites, gneisses, basalts of deccan traps and metamorphic schist, chlorite schist, hornblende and Proterozoic metasedimentary Pakhal, and Sullavai group of rocks. (ii) Semi-consolidated and Unconsolidated formation belonging to Gondwana Supergroup and younger alluvium. The stratigraphy of Asifabad district is given in **Table.1.4** and shown in **Fig.1.12**

Table 1.4: Stratigraphy of Kumuram Bheem Asifabad district

Era	Period	Group	Formation	Lithology
Quaternary	Recent to Sub-Recent	Alluvium		River Alluvium and Soils
Tertiary	Lower Eocene to Upper Cretaceous	Deccan Traps	Basalts	Intertrappeans
Mesozoic	Jurassic to Upper Carboniferous	Upper Gondwanas	Chikkialas Kota Maleris	Sandstone, Clay, Grit and Limestone
Paleozoic		Lower Gondwanas	Kamthis Barren Measures Barakars Talchirs	Sandstones, Shales and Clays, Coal seams and boulder beds
……………………………………**Unconformity**………………………………....…………………				
Protozoic	Lower Palaeozoic to Upper Precambrian	Sullavais		Grits, conglomerates & sandstones, shales, limestones, sandstones
		Pengangas		
		Dharwars		Talc-schist, chlorites, schists, hornblende, schists,quartz, magnetic, heamatites
Azoic	Archaeans	Archaean		Granites and Gneisses and Quartz viens

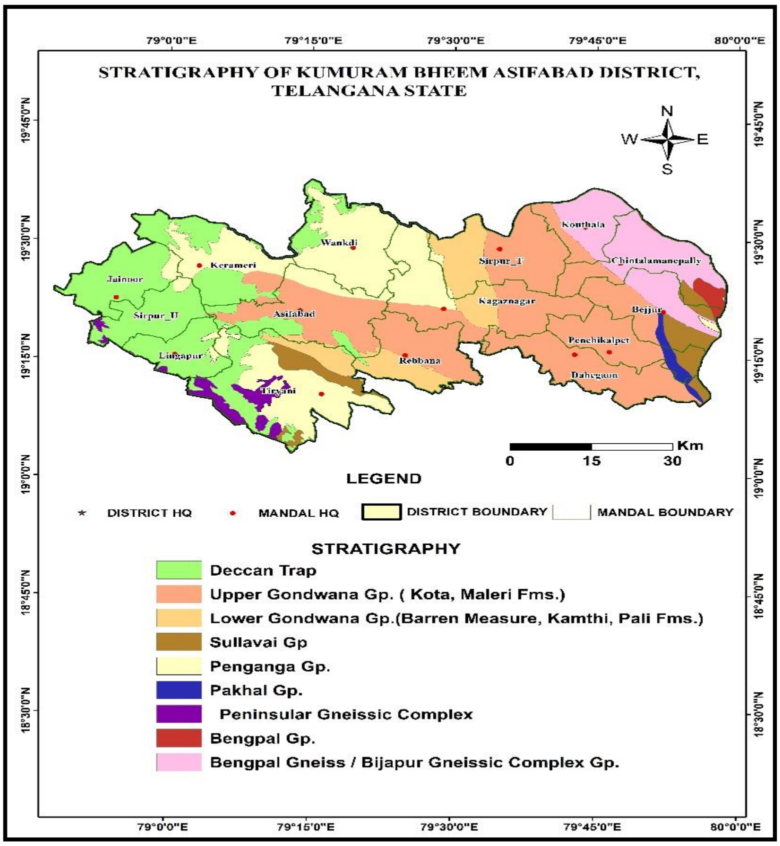


Fig.1.12: Stratigraphy of Asifabad district

1.11.1 Consolidated Formation: Consolidated rocks are commonly referred to as hard rocks, which include igneous and metamorphic rocks e.g. granites and gneisses of Archaean group, basalts of Deccan traps and schists, phyllites, shales, and limestones of Sullavais and Pakhal Series. The occurrence and movement of groundwater primarily depend on the degree of interconnection of secondary pores/voids developed by fracturing and weathering. Groundwater occurs in the under confined to semi-confined conditions in the fractured formation and unconfined conditions in the weathered formation. 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 thickness of weathered zone generally extends upto 30 m and the depth of fractured zones encountered between 30 to 170 mbgl. In the fracture zone ground water occurs under confined conditions.

i) Archaeans: The northeastern part of the study area in underlain by granites and gneisses of Archaean age. The crystalline rocks develop secondary porosity with weathering jointing and fracturing giving rise to water storing capacity to the formations.

ii) Penganga Beds: The Penganga beds equivalents of Palhals (Cuddapah Super Group) are the consolidated meta-sedimentary rocks exposed over Wankdi mandal. The Penganga beds are horizontally bedded with gentle dips towards southwestern or northeast. The limestones are grey, pink, or purplish colour and are thin bedded. The Penganga limestones are well jointed at places giving rise to moderate to secondary porosity.The shales are soft, reddish brown in colour and interbedded with thin layers of limestones.

iii) Sullavai Formations: The Sullavai Formations comprising grits conglomerates and sand stones rest over the Penganga and are equivalent of Kurnool. The sandstones are current bedded and are reddish brown in colour. The regional strike of these rocks vary from North 60°-80° West to South 60°-80° East and the beds dip at 20° due northeast. The Sullavai formations are exposed west and Northeast of Tandur town and a small patch in Bejjur area.

iv) Deccan Traps (Basalts): Basaltic rocks occurring in the western part of the district, forms the fringe areas of the vast Deccan Plateau of Central India. Successive lava flows both "aa" and "pahoehoe" resulted in a layered crystalline rock with intervening beds of clay (red bole/black bole, ash beds, etc. The contact zones between successive flows and inter-trappean beds form good aquifers in addition to the top weathered and fractured zones. The vesicles present in top portion of the each lava flows also form potential aquifer. The regional aquifer disposition in Basalt Terrain (**Fig.1.13**).

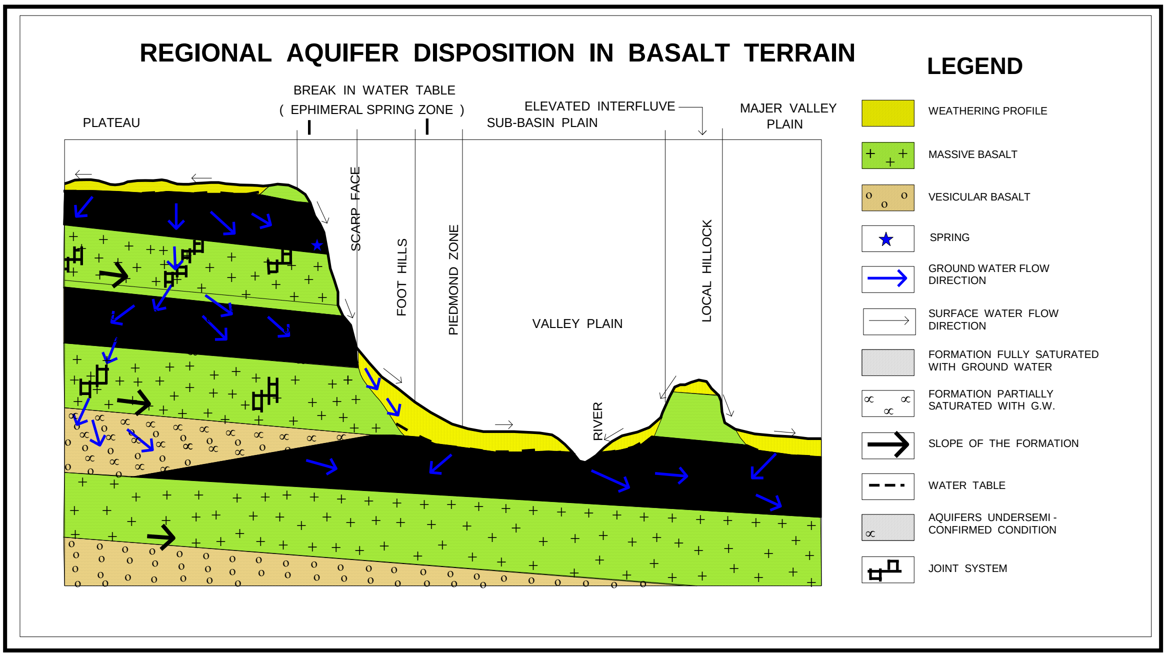


Fig.1.13: Basalt Aquifer disposition in Asifabad Region

1.11.2 Semi-consolidated/Unconsolidated formations: It comprises of conglomerates, grits, shales, and sandstones of Lower and Upper Gondwana Supergroup. The occurrence and movement of groundwater in these rocks are controlled by the primary porosity which is in turn affected by the grain size and clay content in sandstone.The sandstones are generally medium to coarse, friable and loose due to weathering. The sandstones form the principal aquifers except where they occurs as thin intercalations of clays. The ferruginous kankary material formed on the surface due to weathering augments the infiltration and saturates the underlying sandstones. The groundwater in the Gondwana formations occurs under both water table and confined conditions.

Gondwana Formations: The Gondwana formations consist of sandstones, shales and limestone and covers 70 percent of the area. The Gondwana formations are classified into two major divisions viz., the lower Gondwana and Upper Gondwana.

1. **Lower Gondwana:**

The lower Gondwanas comprises the Talchirs, the Barakar, the Kamthi stages.

i) Talchirs, Barakars and Kamthis: The Talchirs are the oldest and composed of boulder beds, shales and sand stones. The Barakas are fine to medium grained sandstones and shales and source for coal seams. The general strike of Barakars varies from North 20° and West to North 60° West and Generally exhibits gentle dips varying from 5° to 20° towards northeast.The Kamthis occur as isolated patch in North of Sirpur Kagaznagar. They overlie Barakars, consisting of medium to coarse-grained sand stones (friable grey and red colour). The Barakars are intercalated by shales and conglomerates.

2. Upper Gondwanas:

ii) Maleris, Kotas, Chikiala : The maleris are characterized by thin beds of friable sandstone with thick beds of shales as intercalations and red clay pockets. The Maleris occur in Rebna, Kagaznagar, Sirpur areas in the central part. The Maleris trend NNE-SSW and dip 40-45°. The thickness of shales varies from 3-42 m. The Kotas include sandstones, clays grits and limestones. These sand stones are greyish, reddish in colour. The Kotas exhibits limited thickness of sand stones Northeast of Sirpur town and west of Kouthala.These are the youngest of Gondwana formations consist of conglomerates, shales and sand stone. The conglomerates are made up of rounded to sub-rounded pebbles of quartz, quartzite, chert and jasper concentrated with arenaceous matrix. The chikiala group of rocks are exposed in Nala cuttings of Pedda vagu in southwest of Bejjur mandal and eastern part of Dehagaon mandal.

The occurrence and movement of water in the subsurface are broadly governed by geological frameworks. It depends on rock type, depth of weathering, and extension of weak zones like fractures, joints, etc., in hard rocks, while in sedimentary rocks it depends on porosity, granularity, cementing matrix, permeability, bedding plains, and faults, etc.

2. DATA COLLECTION AND GENERATION

Collection and compilation of data for aquifer mapping studies are carried out in conformity with the Expenditure Finance Committee (EFC) document of XII plan of CGWB encompassing various data generation activities **(Table-2.1)**. The historically available data of Geology, Geophysics, Hydrogeology, and Hydrochemistry generated under various studies by the CGWB through Systematic Hydrogeological studies, Reappraisal Hydrogeological studies, Groundwater Management studies, Exploratory drilling, and special studies have been utilized for data gap analysis, along with the data collected from various State and Central government departments **(Fig.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.

The aquifer geometry for shallow and deeper aquifer has been established through hydro geological studies, exploration, surface and subsurface geophysical studies in the district. The data used for the integration and interpretation includes:

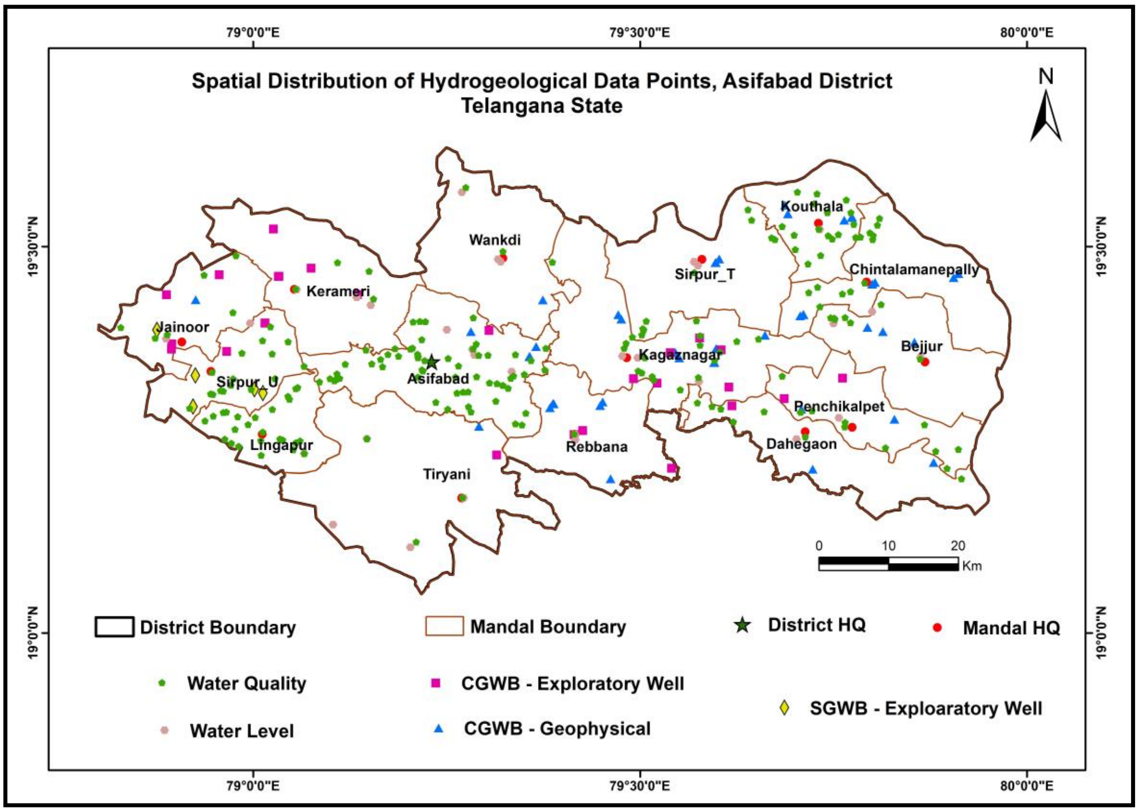


Fig. 2.1: Hydrogeological data availability.

2.1 Exploratory drilling

Information on aquifer geometry, Groundwater potential of various formations, fracture systems, their characterization is primarily inferred from the exploratory drilling data. A total of 50 exploratory borewell data of CGWB (26), SGWD (4) and 20 tubewells drilled by Agro Industries Corporation were used for the hydrogeological studies. Out of these CGWB has a total of 26 wells in the district, which were drilled in 2020-21 based on the data gap analysis carried out in the study area as part of NAQUIM. 33 wells are located in Gondwana formation and 17 wells in consolidated Basaltic, Granitic, and Metasedimentary areas.

2.2 Water Level

Water level monitoring wells of CGWB and SGWD is utilized for the Aquifer Mapping studies. 10 dug wells monitored by CGWB and 20 piezometers by SGWD. 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 groundwater regime.

2.3 Hydro chemical Studies

Water quality data of CGWB, SGWD and RWS is utilized for understanding the spatial variation of quality in the district. During Pre-monsoon 200 (CGWB: 7, SGWD: 20, RWS:

173) and in post-monsoon 217 (SGWD: 20, RWS:197) ground water monitoring wells data of Central Ground Water Board, Telangana State Ground Water Department and Telangana Rural Water Supply (mostly tapping combined aquifers Aq-1 and aq-2) is utilized to understand the chemical characteristics of groundwater. Parameters namely pH, EC (in µS/cm at 25 ° C), NO_3 and F were analyzed.

2.4 Geophysical Studies

Geophysical data on VES and profiling are used to extract information on the weathered thickness, fracture depth, thickness of fracture etc of 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 33 Vertical Electrical Soundings (VES) employing the Schlumberger electrode configuration with the maximum electrode separation (AB) of 400 meters is used for the aquifer mapping studies. The data was processed and interpreted by IPI2Win software eveloped by MoscowState University, after marginally modifying the manually interpreted results in corroboration with geology and hydrogeology.

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1. Ground water Level Scenario

3.1.1 Depth to ground water level

Analysis of the pre- and postmonsoon water level data from 30 (CGWB: 10 DW) and SGWD: 20 PZ) groundwater monitoring wells shows that depth to water level varies from 0.13 to 21.85 m bgl during pre monsoon and from 0.76 to 17.77 m bgl during post-monsoon season.

Pre-monsoon season: In Majority of the area water level during this season is in the range of 5-10 m (69% of the area) and 2 to 5 mbgl (8% of the area). The deeper water levels of >10 m bgl are observed in parts of Tiryani, Dahegaon, Penchikalpet, Asifabad, Keramari and Jainoor mandals. Shallow water levels (< 2 mbgl) are observed in parts of Asifabad, Sirpur and Lingapur mandals. (**Fig.3.1**).

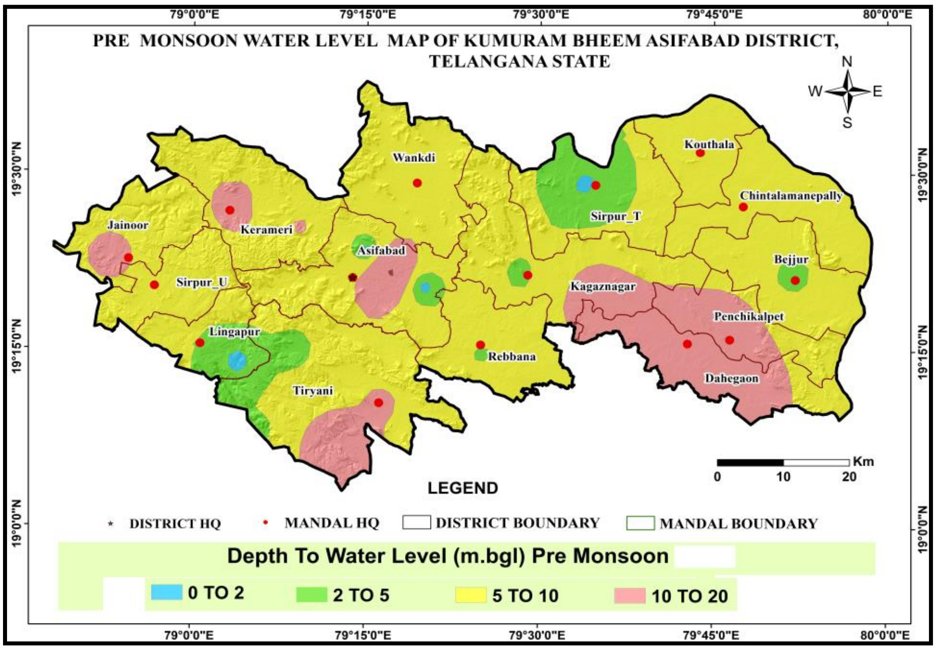


Fig.3.1: Depth to water levels Pre-monsoon

Post-monsoon season: In Majority of the area water level during this season are in the range of 5-10 m covering 50% of the area whereas 2-5m bgl covers 44%. Water Level between 10 to 20 m bgl is observed in parts of Dahegaon, Penchikalpet and Asifabad mandals covering 3 % of the area (**Fig.3.2**). Shallow water level <2 mbgl occupy about 2% of the area in parts of Sirpur, Tiryani, Lingapur and Kagaznagar mandals.

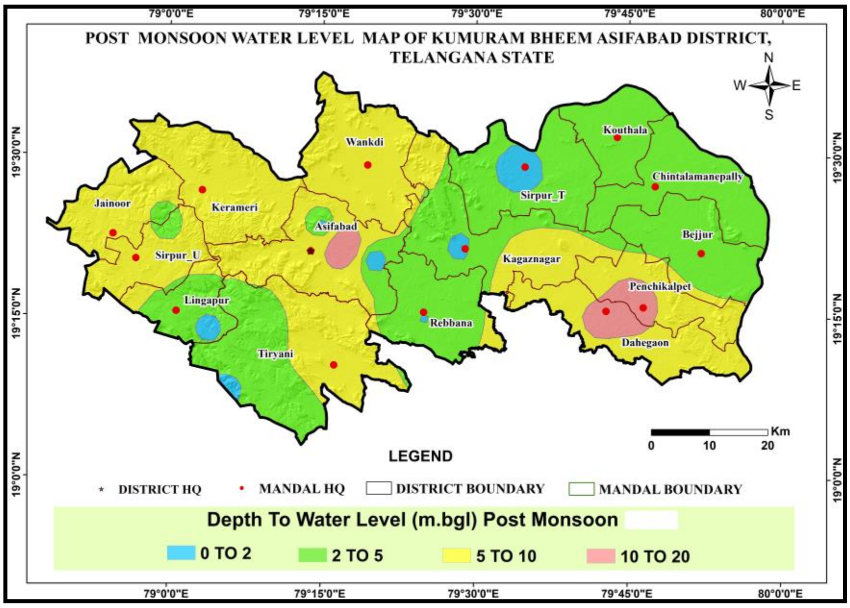


Fig.3.2: Depth to water levels Post-monsoon

3.1.2 Seasonal Water Level Fluctuations (May vs. November): The water level measured during pre and post monsoon period were used to compute the seasonal fluctuation. All the wells in the state records water level rise. The water level rise varies from 0.11 to 11.7 m. (Fig.2.6). Rise in water level range of 2 to 4 m cover majority of area with 56%, followed by 0 to 2 m covering 40% of area (**Fig.3.3**). Water level rise >4 m is observed in Tiryani, Kagaznagar and Asifabad mandals.

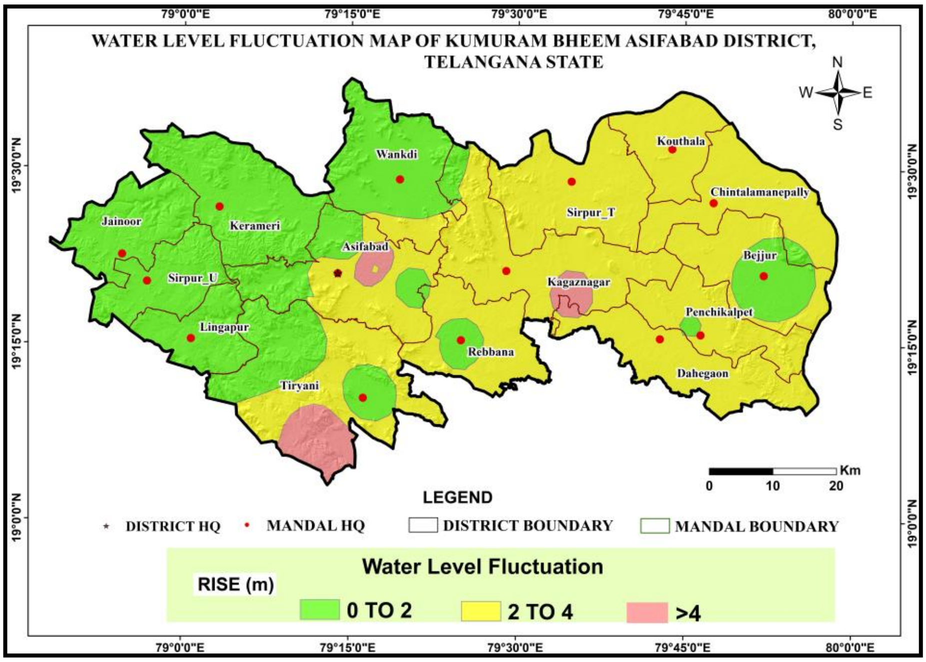


Fig.3.3: Water Level Fluctuation (m) (Nov with respect to May)

3.1.3 Water Table Elevation

The water table elevation map for premonsoon and postmonsoon period (2019) was also prepared (**Fig.3.5**) to understand the ground water flow directions. The water table elevation ranges from 135 to 519.5 m.amsl during premonsoon period and and 136.3 to 520.12 m.amsl during postmonoson period. The regional ground water flows mainly towards eastern direction. In the western part of the district the contours are comparatively closer indicating the steepness of the terrain thereby the gradient of ground water flow is high in comparison to the other part of the district. General ground flow is towards river Peddavagu and towards river Pranahita, the major drainage suggesting that the base flow is towards the drainage system. (**Fig.3.4**).

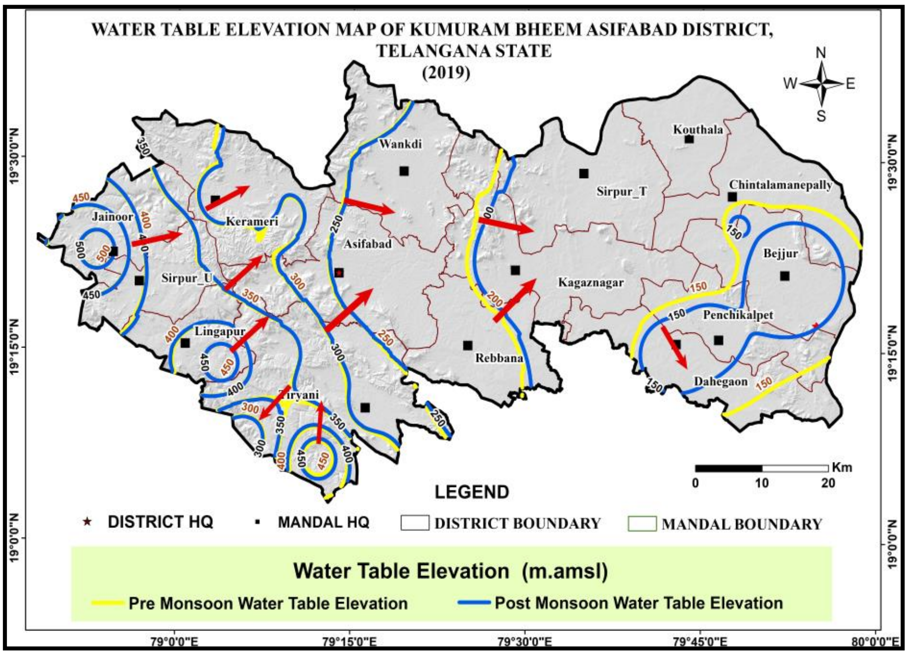


Fig.3.4: Water table elevations (m.amsl) during pre and post-monsoon seasons

3.1.4 Long Water Level Trend (2010-19)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data from 20 hydrograph station of CGWB and SGWD for the period 2010-19 have been computed and analyzed. The decadal premonsoon water level trend analysis indicates that during pre-monsoon period, 16 wells shows falling trend (>0.5m: 2, 0-0.5m: 14 wells) (max fall: 0.71 m/yr) and 14 wells shows rising trend (0-0.5: 14 wells) (max rise: 0.322 m/yr). During post-monsoon season 13 wells show falling trend 0-0.5m.:12) (maximum fall: 0.58 m/Yr) and 17 wells shows rising trends (0-0.5m.: 16 wells) (max rise: 2 m/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.**

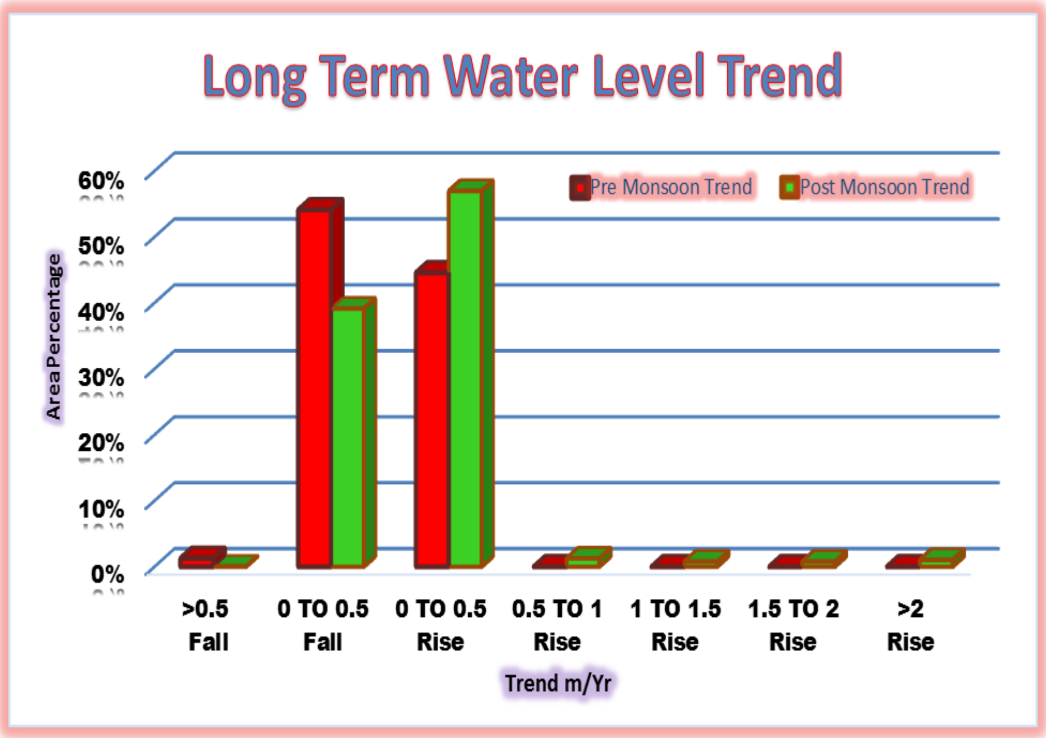


Fig. 3.5: Graphical representation of water level trends (2010-2019)

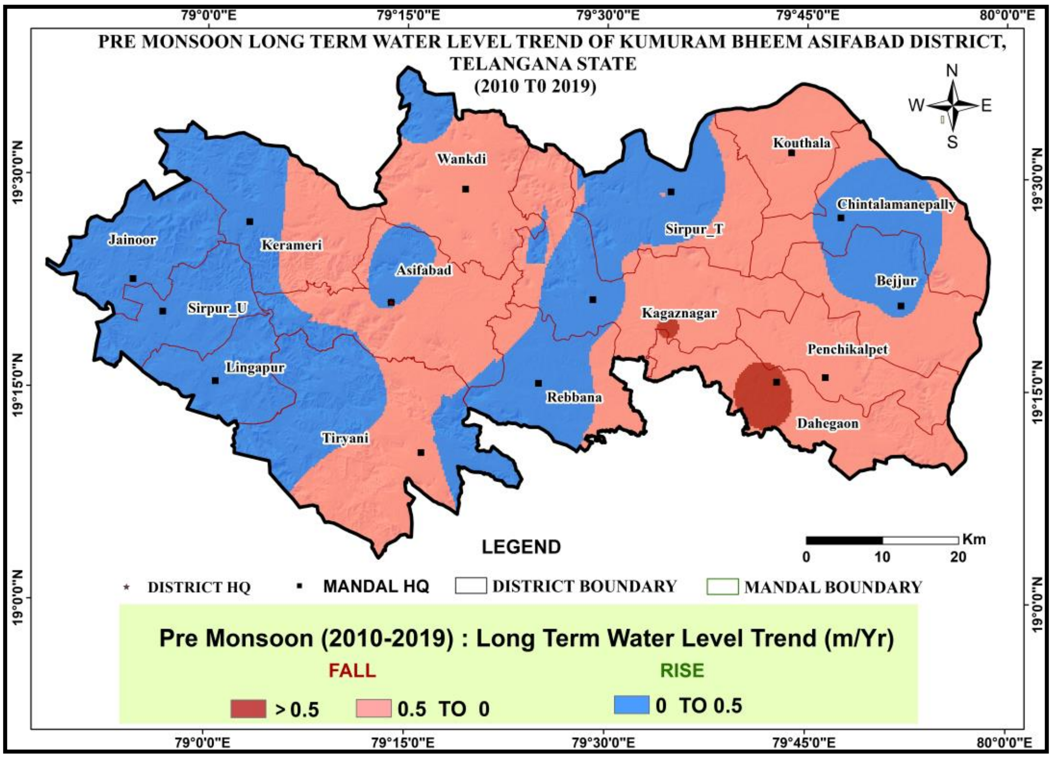


Fig. 3.6: Long-term water level trend-Premonsoon (2010-2019)

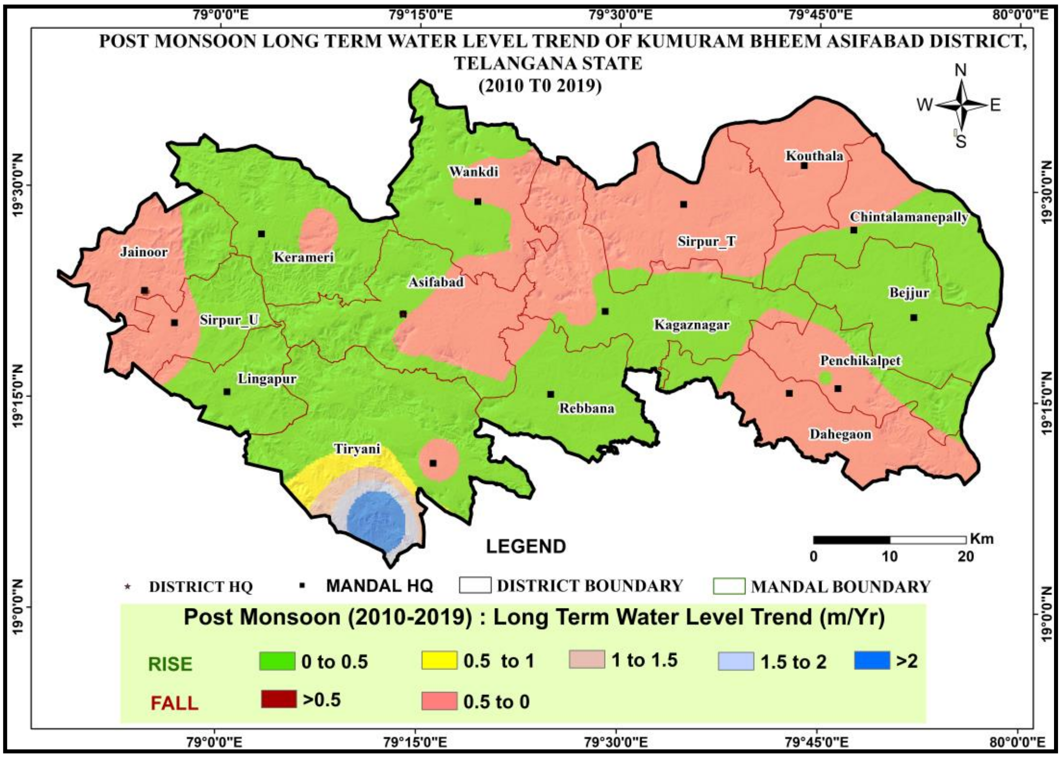


Fig. 3.7: Long-term water level trend-Postmonsoon (2010-2019)

3.2 Ground Water Quality

To understand chemical nature of groundwater, total 417 data is utilized from ground water monitoring wells of CGWB, SGWD and RWS wells (Pre-monsoon:200and post-monsoon:217). 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.The groundwater quality in the area is generally good for all purposes. In all the locations PH is within the acceptable limit with mild alkalinity.

Pre-monsoon:

A total of 200 samples were analyzed (CGWB:7, SGWD:20 and RWS:173). Groundwater from the area is mildly alkaline nature with pH in the range of 6.8-8.39 (Avg:7.59). Electrical conductivity varies from 310-2596 (avg: 1542) µ Siemens/cm. n 46% of area EC is within 1500 µ Siemens/cm, in 54% of area EC is 1500 to 3000 µ Siemens/cm (**Fig.3.8).** Average concentration of TDS is 929 mg/L and NO_3 ranges from 2-134 mg/L. Nitrate concentration in 2 % of samples is beyond permissible limits of 45 mg/L (**Fig.3.9**). Fluoride concentration varies from 0.02-5.58 mg/L (Fig:2.). Fluoride concentration in 2% of samples is beyond permissible limits of 1.5 mg/L (**Fig.3.10**). High fluoride concentration is observed in Asifabad and Bejjur mandals.

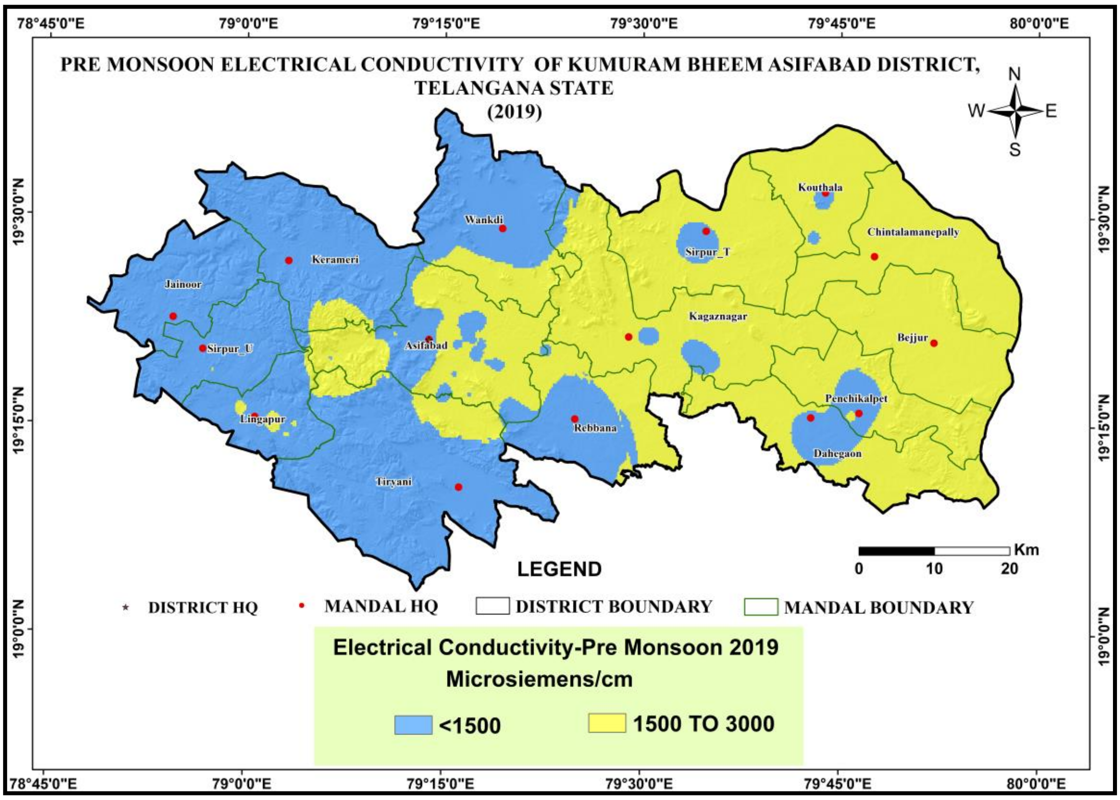


Fig.3.8: Pre monsoon EC distribution

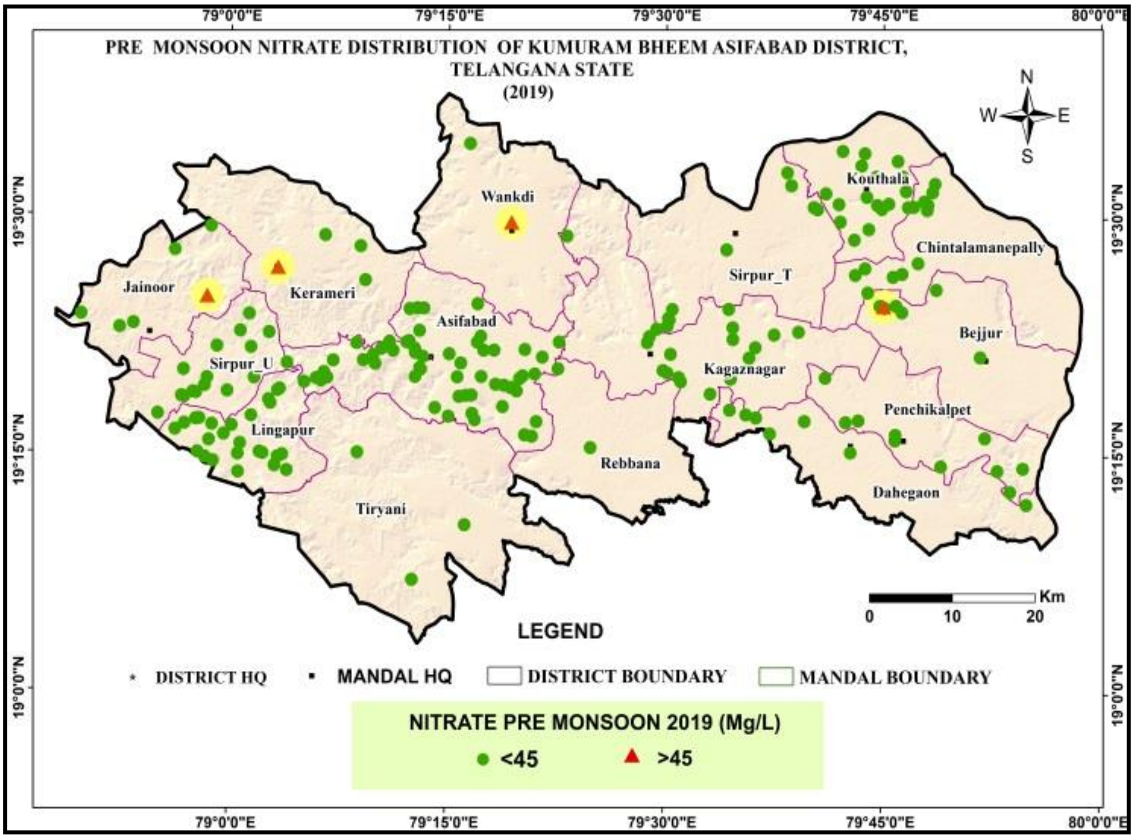


Fig.3.9 : Pre monsoon Nitrate distribution

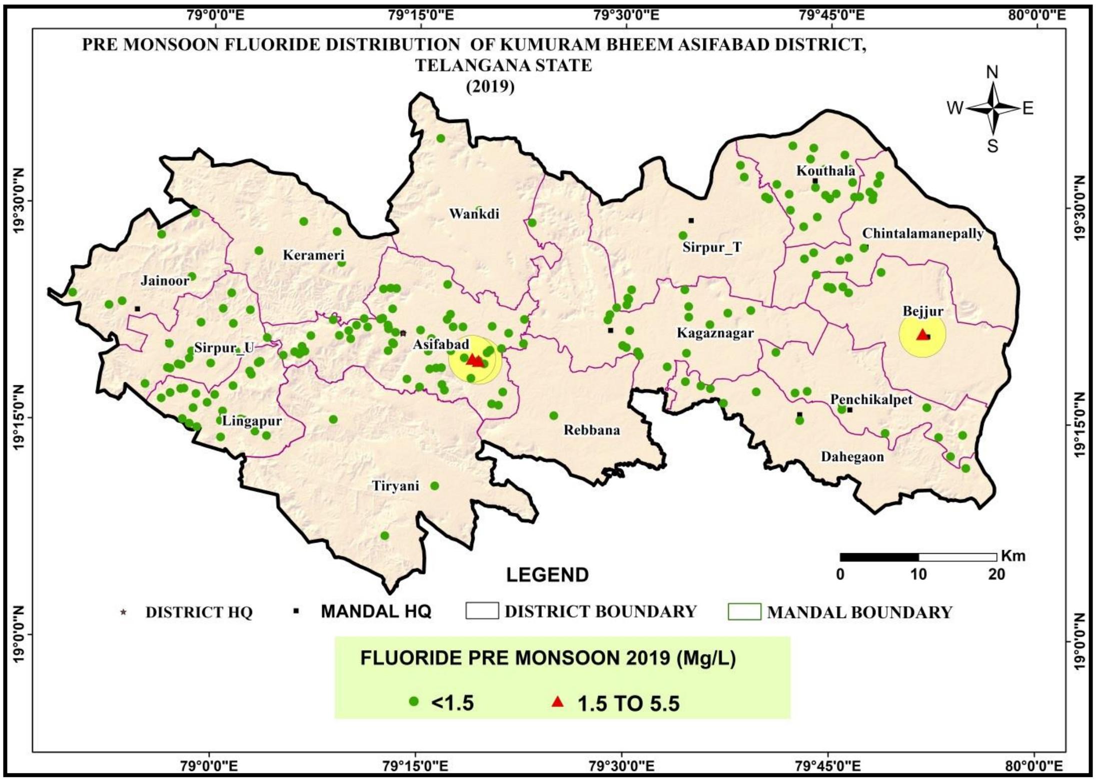


Fig.3.10: Premonsoon Fluoride distribution

Post-monsoon :

A total of 217 samples were analyzed (SGWD:20 and RWS:197). Groundwater from the area is mildly alkaline in nature with pH in the range of 6.8-8.1 (Avg:7.54). Electrical conductivity varies from 184-2085 (avg: 1510) µ Siemens/cm. In 55% of area EC is within 1500 µ Siemens/cm, in 45% of area EC is 1500 to 3000 µ Siemens/cm **(Fig.3.11)**. Average concentration of TDS is 909 mg/L and NO_3 ranges from <1-150 mg/L. Nitrate concentration in 2% of samples are beyond permissible limits of 45 mg/L **(Fig.3.12)**. Fluoride concentration varies from 0.02-2.3 **(Fig 3.13)** and 99 % of area is within permissible limits of BIS and rest is beyond permissible limits of 1.5 mg/L.

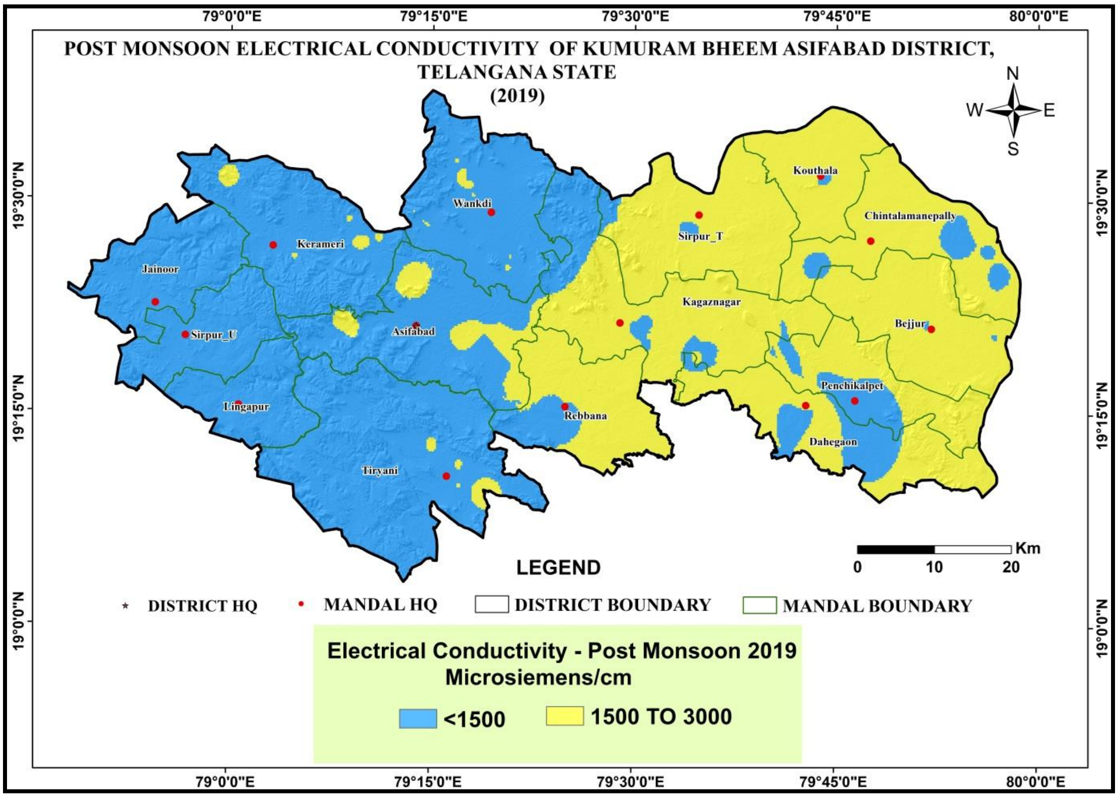


Fig.3.11: Post monsoon EC distribution

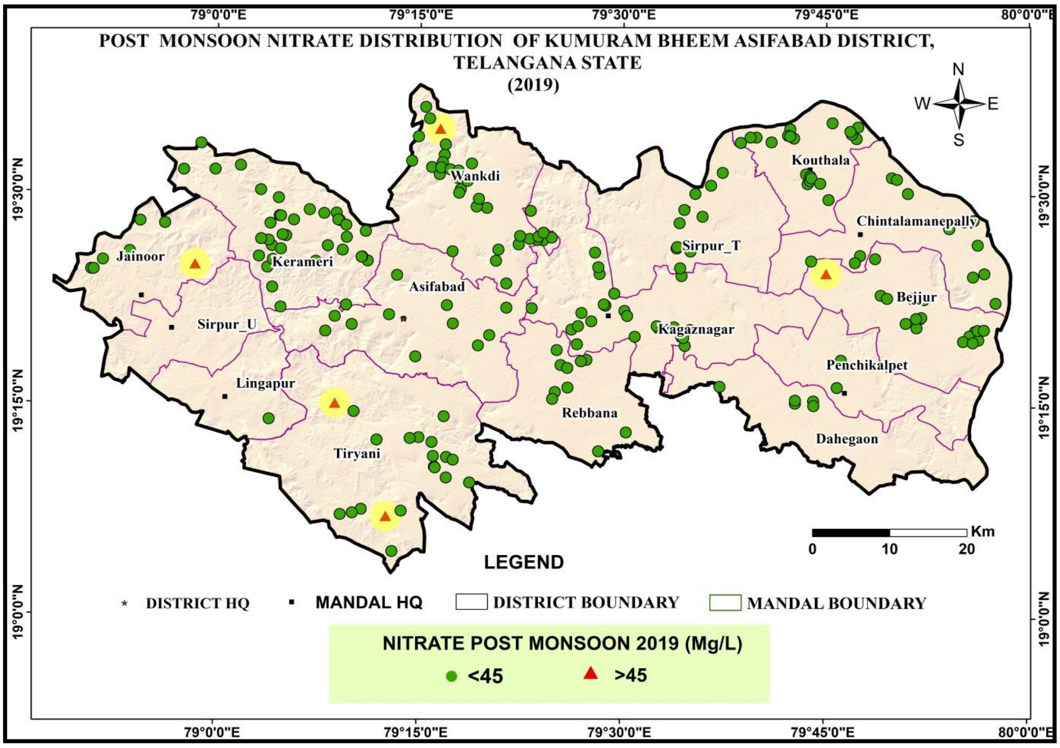


Fig.3.12: Post monsoon Nitrate distribution

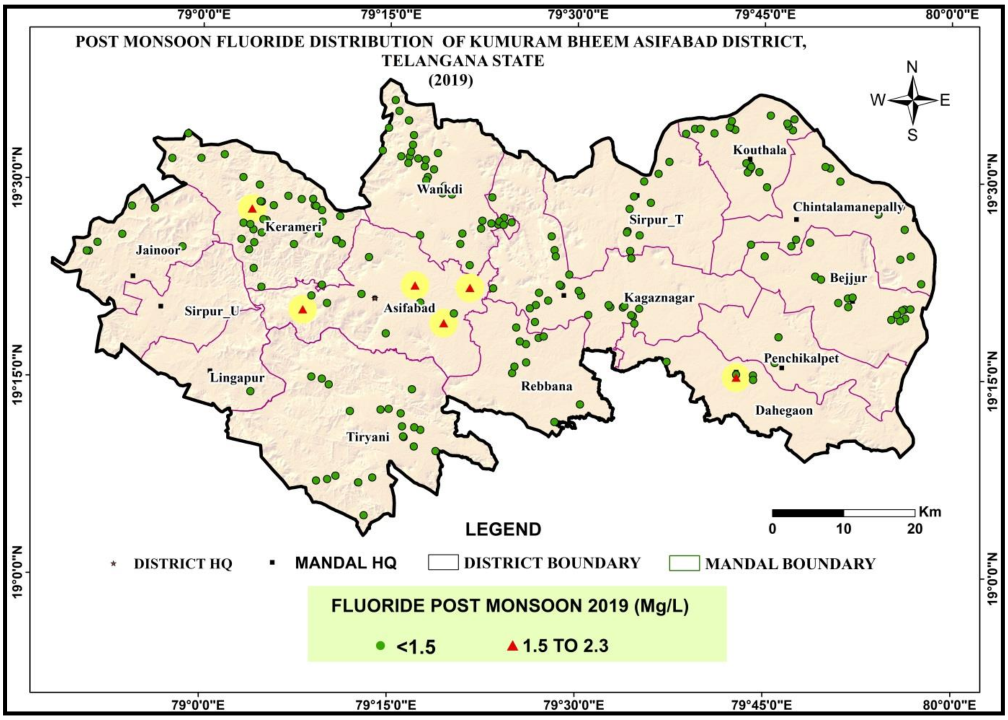


Fig.3.13: Postmonsoon Fluoride distribution

3.3 AQUIFER MAPPING

The aquifer geometry for shallow and deeper aquifer has been established through hydro geological studies, exploration, surface and subsurface geophysical studies in the district. Aquifers were characterized in terms of potential and quality. The aquifer wise characteristics have been delineated and are shown in **Table 3.1**. Hydrogeology map in the **Fig. 3.14** and Spatial Distribution of Aquifer –I thickness is depicted in **Fig. 3.15.**

On the basis of occurrence and movement of ground water, mainly rock units of the Asifabad is classified into two categories; hard rocks (Archean crystalline, Basalts and metasedimentary formation) formation which occupies 40% of the area and soft rock formation (semi consolidated sedimentary rocks) which occupies 60 % of the area.

3.3.1 a. Aquifer system in hard rock areas

Hard rock areas consist of consolidated Archean crystalline formation and Consolidated Metasedimentary formations.

a) Aquifer systems of Consolidated formation:

Weathered and fractured basalts, granites and gneisses and form the hard rock aquifer system. The main aquifers constitute the weathered zone at the top, followed by a discrete anisotropic fractured zone at the bottom, generally extending down to 170 m depth in basalt. Ground water occurs in weathered formation under unconfined condition is generally tapped through large diameter open wells. And its overexploitation mainly for irrigation purpose resulted in desaturation of weathered zone at many places. The aquifer units identified includes**:**

Shallow Aquifer (Aquifer-I): consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells. The shallow aquifer is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~30 m depth. They are unconfined aquifers. The depth of open wells ranges between 9-26 m bgl. In general in massive basalts , depth of open wells varies between 4-6 m bgl whereas in vesicular basalt the depth of wells ranges between 9-11 m bgl with yield of 10 to 200 m^3/day. In granite and Gneiss area the depth of open wells range from 4 to 16 m bgland yield vary from 40 to 250 m^3/day.

Deeper Aquifer in (Aquifer II): The second aquifer is the deeper aquifer which tapped the fractured zone (**Fig.3.16)**. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum depth of 170 m bgl (Deepest fracture encountered in basalt). The depth of fracturing varies from 30 m to 170 m with. In basaltic terrain, yield varies from 0.1 to 0.4 lps (avg: 0.2 lps). Transmissivity varies from 3 to 55 m^2/day. Ground water yield from fractured granite/gneiss varies from <0.01 to 1.5 lps. (avg: 0.4 lps). The transmissivity upto 29.4 m2/day and storativity varies from 0.0001 to 0.00001.

b) Aquifer systems of Consolidated Metasedimentary formations

The sandstone, limestone and Shale of Penganga and Sulliavai formations belong to sedimentary origin but are mostly hard and compact due to which the rocks behave similar to consolidated crystalline rocks and the aquifers are formed due to weathering and fracturing. The limestones form good aquifers due to development of solution channels except in areas where they are siliceous. Though the shales are splintery in nature, having fractures and well developed joints favoring the movement of ground water. Wells penetrating these formations usually get dried up in summer. These rocks comprising shales and silicious limestones occur in parts of Keramari and Tiryani mandals. The sullavais sandstone occur as isolated patches in Bejjur.

Shallow Aquifer (Aquifer-I): consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells as hand pump. The shallow aquifer is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~25 m depth. They are unconfined aquifers. The depth of weathered zone varies between 3 and 25 m bgl and the depth to water levels range between 4 to 16 m bgl. An average yield of dug wells from these formations varies between 30-60 m^3/day.

Deeper Aquifer in (Aquifer II): The second aquifer is the deeper aquifer which tapped the fractured zone. Ground water in the second aquifer occurs under semi-confined to confined condition in the fractures upto the maximum depth of 169 m bgl in Sangvi (Deepest fracture encountered). The depth of fracturing varies from 25 m to 168 m with yield of <1- 6 lps. The transmissivity (T) of the consolidated formation range between 3 and 55 s q.m/day and the specific capacity varies from 7- 33 lpm/mdd

3.3.1b Aquifer system in soft rock areas

The water bearing formations in the soft rock area are sandstones, shales and clays of Gondwana Super Group, forming a thick sequence of sediments and unconsolidated formation of river alluvium. They are generally bedded deposits with well-defined lithologic units and are affected by structural disturbances, the area shows lateral and vertical variation with in short distances, due to which the hydrogeological properties of the formation vary widely. The sandstones are generally medium to coarse, friable and loose due to weathering. The sandstones form the principal aquifers except where they occur as thin intercalations of clays. The ferruginous kankary material formed on the surface due to weathering augments the infiltration and saturates the underlying sandstones. The groundwater in the Gondwana formations occurs under both water table and confined conditions.

Soft rock area is underlain by Gondwana formations which consist of mainly conglomerates, sandstones, shales and clay of Lower and Upper Gondwana. Groundwater occurs in unconfined and confined conditions in these formations. The sandstones of Gondwana group (Barakar/Kamthi/Maleri) are very good aquifers and tube wells constructed in this formation at Chadwai, Andavalli and Areguda sites have yield in the range of 22 – 28 lps. The shallow aquifers occur down to 35 m bgl whereas the confined aquifers occur at different depths ranging from 35 to 300m. A total of 4 aquifers were identified by the exploratory drilling upto 300m in Asifabad district.

a. Shallow Aquifer: (Aquifer-I):

Aquifer I is the shallowest aquifer, mostly upto a depth of 35 m, consists of weathered residuum where ground water occurs under water table condition and is mainly developed by construction of dug wells or shallow bore wells as hand pump. The ground water occurs under phreatic/unconfined condition. The sandstones become friable and loose due to weathering. The depth of dug wells in sandstone formation varies from 6-12.5 mbgl and in limestone and shales from 9.0-17.0 mbgl. The dug well yields 300 – 100 m3/day. The Maleri formations are poor yielding wells for dugwells due to clay intercalation. Fracturing and jointing in shale offer good scope for percolation, but due to rapid variations in structure, they fail to form good aquifers.

b.Deeper aquifers (Auifer II to 1V): Unlike shallow aquifer, ground water occurs under confined to semi-confined condition in deeper aquifers (Aquifer II, Aquifer-III and Aquifer-IV). The occurrence of ground water depends on porosity, granularity, cementing matrix, permeability, bedding plains and faults etc. The deeper aquifer identified upto a depth of 300m. The aquifers are mainly composed of fine to coarse grained sandstone. The bedded sandstone deposits with well defined lithology and are affected by structural disturbances and may show vertical and lateral variations within short distances and due to which the hydrogeological properties vary widely. They are generally medium to coarse grained and form good aquifers except where they occur as the intercalations and argillaceous in nature. The deeper aquifes are more productive than shallower zones. The tube wells constructed beyond 200m depth have good discharge. Mutiple aquifers are more common in central and northern part of Asifabad. 4 aquifers were identified in Rebbana, Penchikalpet and Kagaznagar mandals. Ground water yield of sandstone aquifers varies from 3 to 28 lps (avg: 15.0 lps). The transmissivity varies from 7-316 m^2/day and storaivity varies from 1.4 x 10-4 and 3.57 x 10-4. The specific capacity ranges between 9 to 112 lpm/mdd.

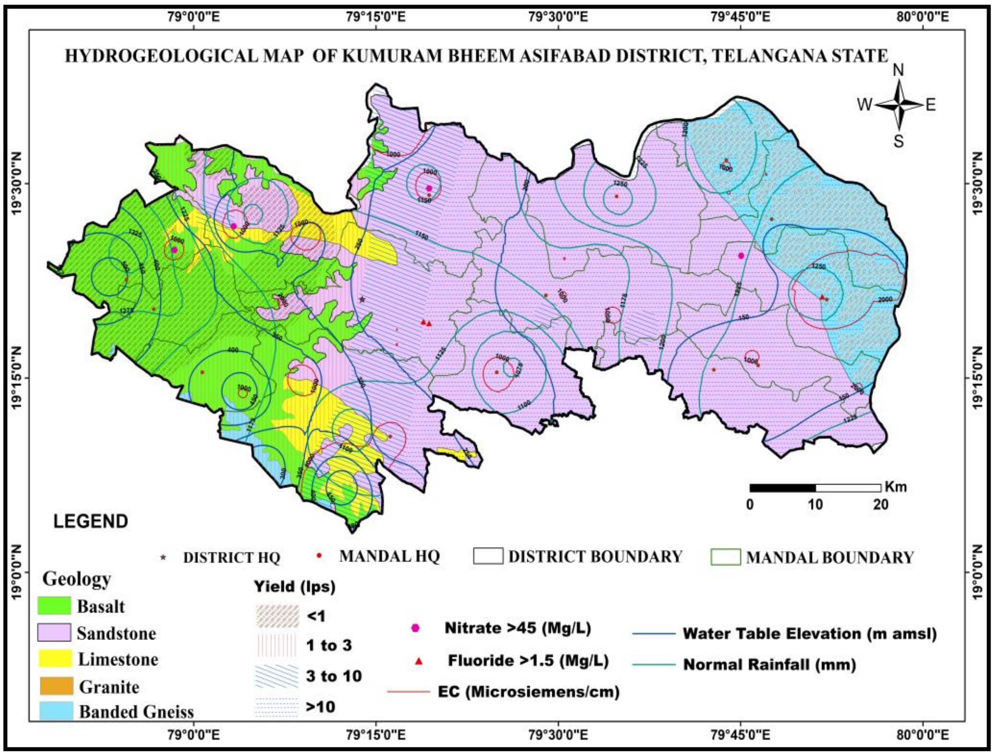


Fig. 3.14 :Hydrogeology map

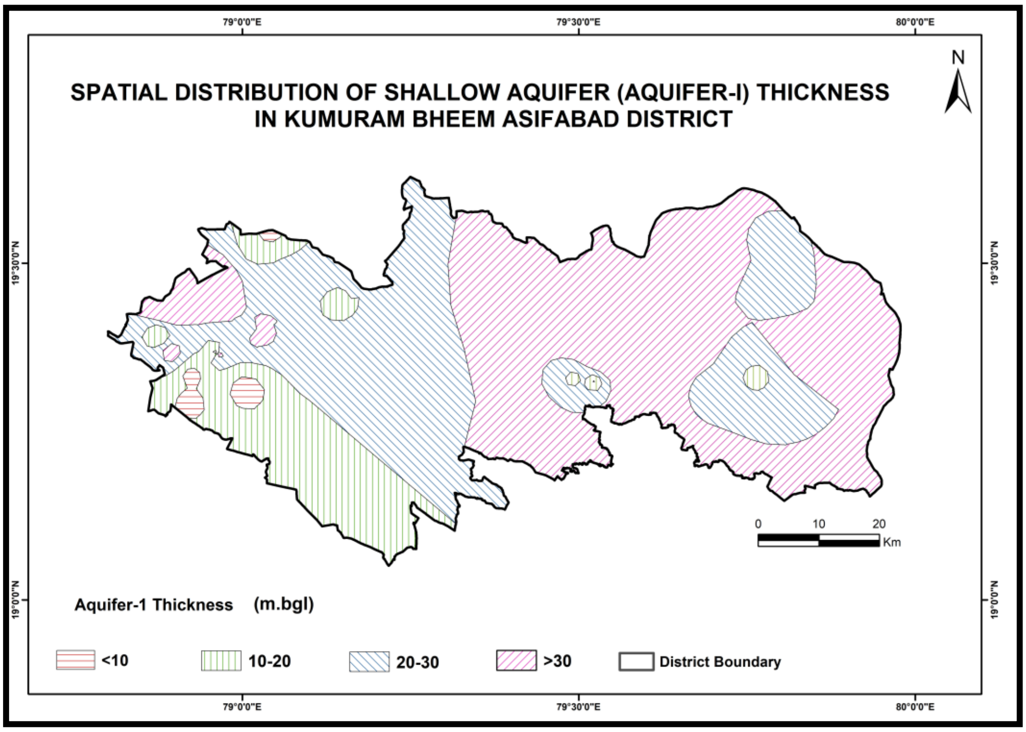


Fig. 3.15 : Spatial Distribution of Shallow Aquifer Thickness (Aquifer-1)

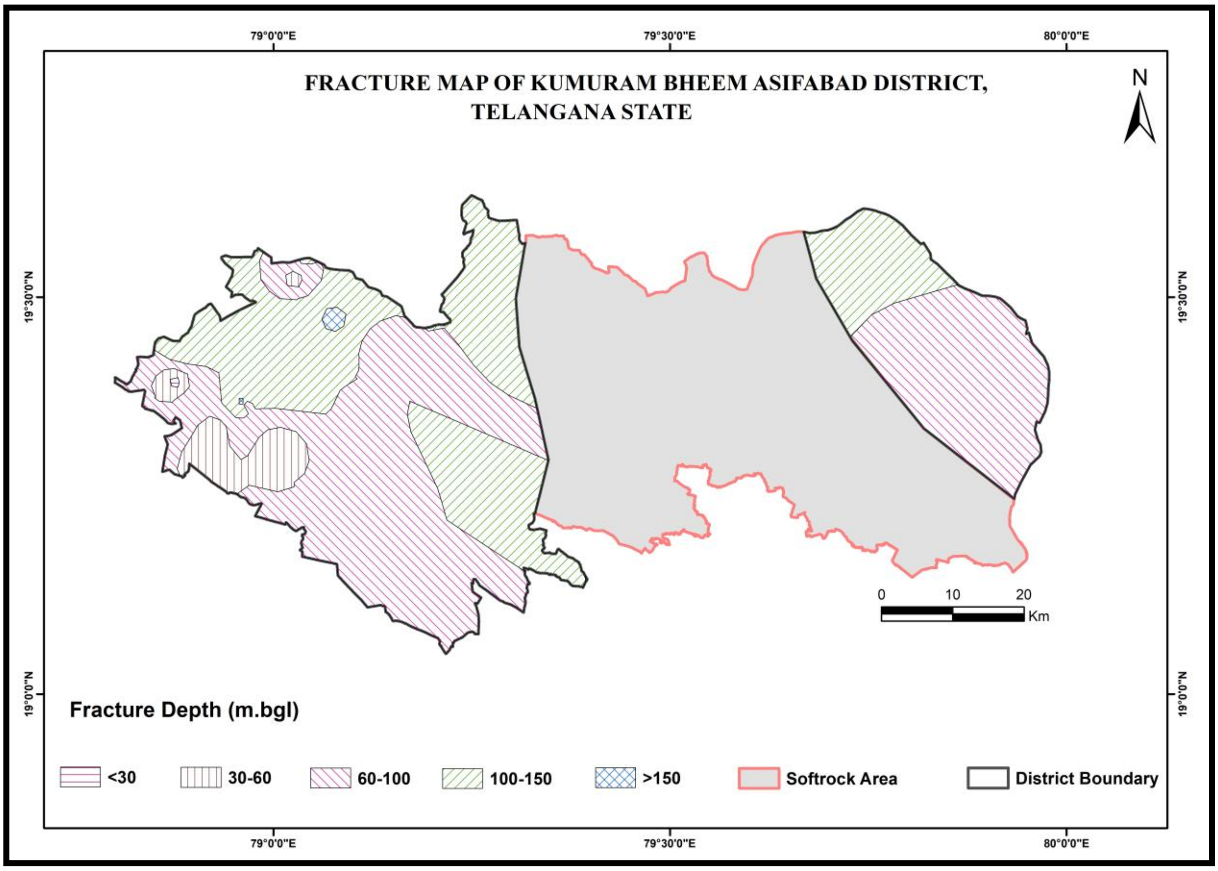


Fig.3.16 : Spatial Distribution depth of fracture encountered in Hard Rock Area

Table 3.1: Salient Features of Aquifer System in Asifabad District

	Archean Crystalline/Deccan Traps		Penganga/SullavaisFormation		Gondwana Formation	
Prominent Lithology	**Basalt Granite, gneiss**		**Metasediments**		**Sandstone**	
Aquifers	**Aquifer-1 (Weathered Zone)**	**Aquifer-2 (Fracture Zone)**	**Aquifer-1 (Weathered Zone)**	**Aquifer-2 (Fracture Zone)**	**Aquifer-1**	**Aquifer-II to IV**
Thickness range	<10-30m	upto 170m	<10 to 25	upto 168m	35m mostly	Upto 300 m at different depth ranges
Depth of range of occurrence of fractures	-	85% fracture encountered between 30 to 100m	-	97% fracture encountered between 30 to 150m	-	-
Range of yield potential	<1 to 2	<1 to 1.5	<1	<1 to 6	1 to 3	3 to >20
Transmissivity (m2/day)	Upto 55				7 to 316	
Specific Capacity (lpm/mdd)	Upto 33				9 to 112	
Quality(Suitabil ty of Irrigation)	Yes	Yes	Yes	Yes	Yes	Yes
Suitabilty of domestic purposes	Yes	Yes	Yes	Yes	Yes	Yes

3.3.2 Aquifer Disposition 3D and 2D

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 83 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**) The lithological information was generated by using the RockWorks-16 software and generated 3-D map for Asifabad district (**Fig.3.17)** along with panel diagram (**Fig. 3.18**) and hydrogeological sections.

i. Conceptualization of aquifer system in 3D

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. The principal aquifer system constitutes sandstones, Basalts, Limestone and granites. Four aquifers (Aquifer-I, II, II &IV) are found in the sandstone formations with intervening clay beds. The top most aquifer (Aquifer-i) is unconfined whereas the deeper aquifers are in semi-confined/ confined condition. In consolidated and semi-consolidated formations weathered zone is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~25 m depth and the fractured zone (fractured granite/basalt) is considered up to the depth of deepest fracture below weathered zone (~25-171 m). The details are given in **Table 3.2.**

TYPE OF AQUIFER	HARD ROCK	SOFT ROCK
Unconfined	Weathered Granite	Aquifer-1
Semiconfined/Confined	Fractured Granite	Aquifer-II to Aquifer-IV

The fence diagram indicating the disposition of various aquifers is presented in **Fig.3.18.** In western part of the area the presence of basalt can be seen. The disposition of weathered and fractured zone of basalt followed by metasedimentary formations can be observed in the Fence. In the central and eastern parts multi-aquifers system of sandstone can be seen separated by intervening clay layers with Granitic gneiss as the base.

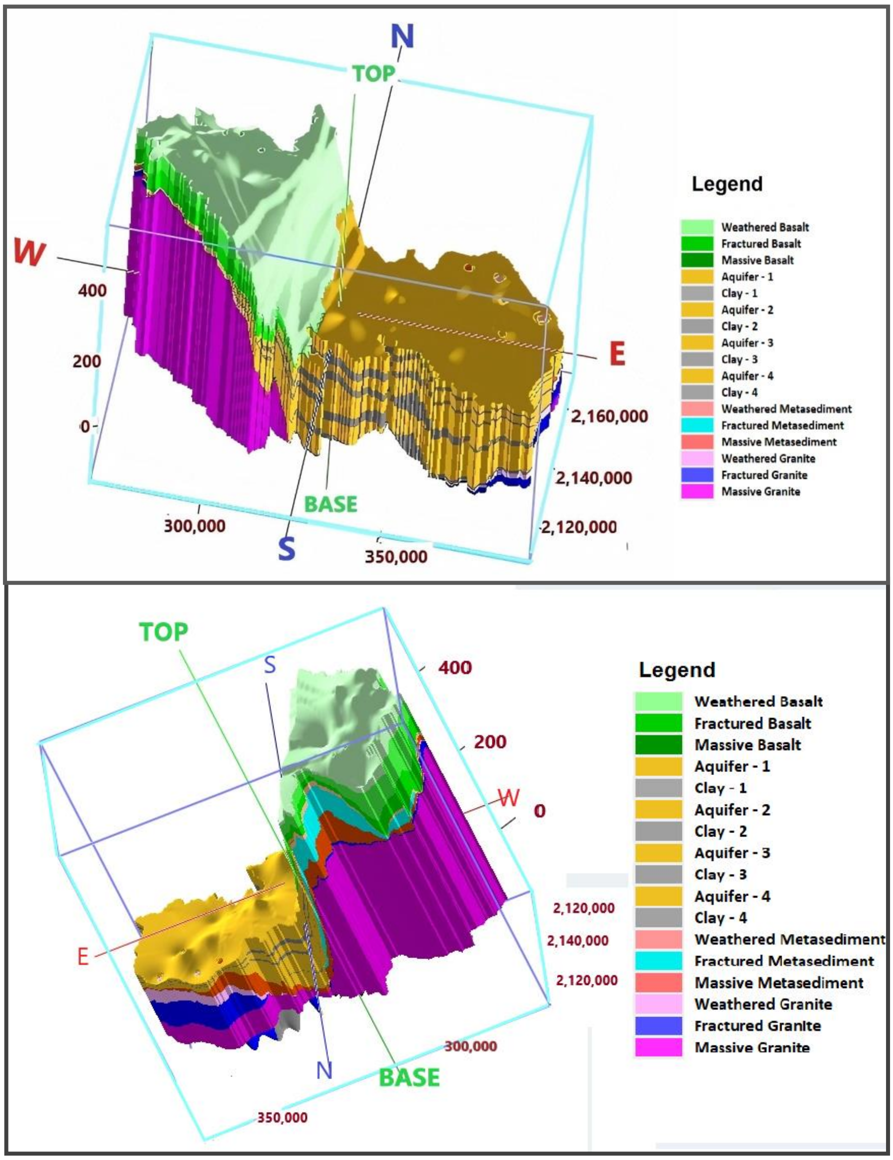


Fig.-3.17: 3-D Disposition of Aquifers

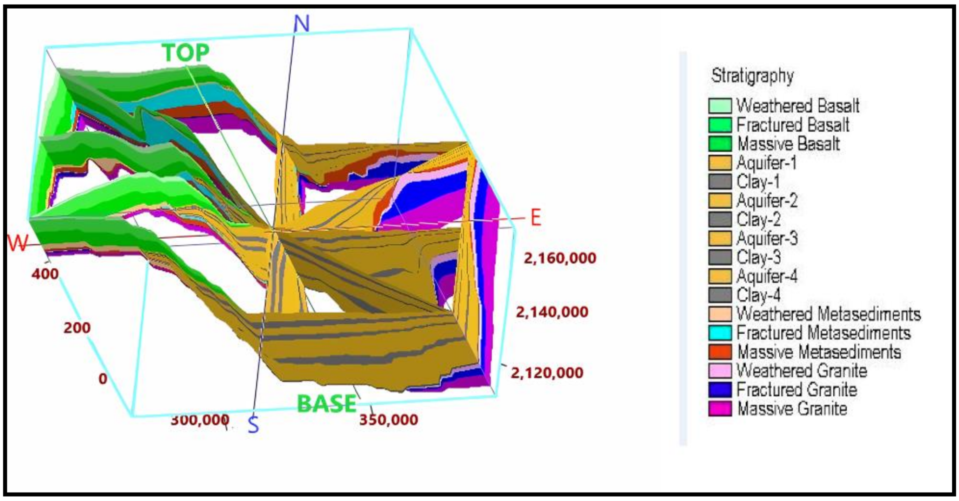


Fig.-3.18: Fence diagram

ii. Aquifer Disposition 2D

Three hydrogeological sections are prepared in NW-SE, W-E and SW-NE directions (**Fig. 3.19**).

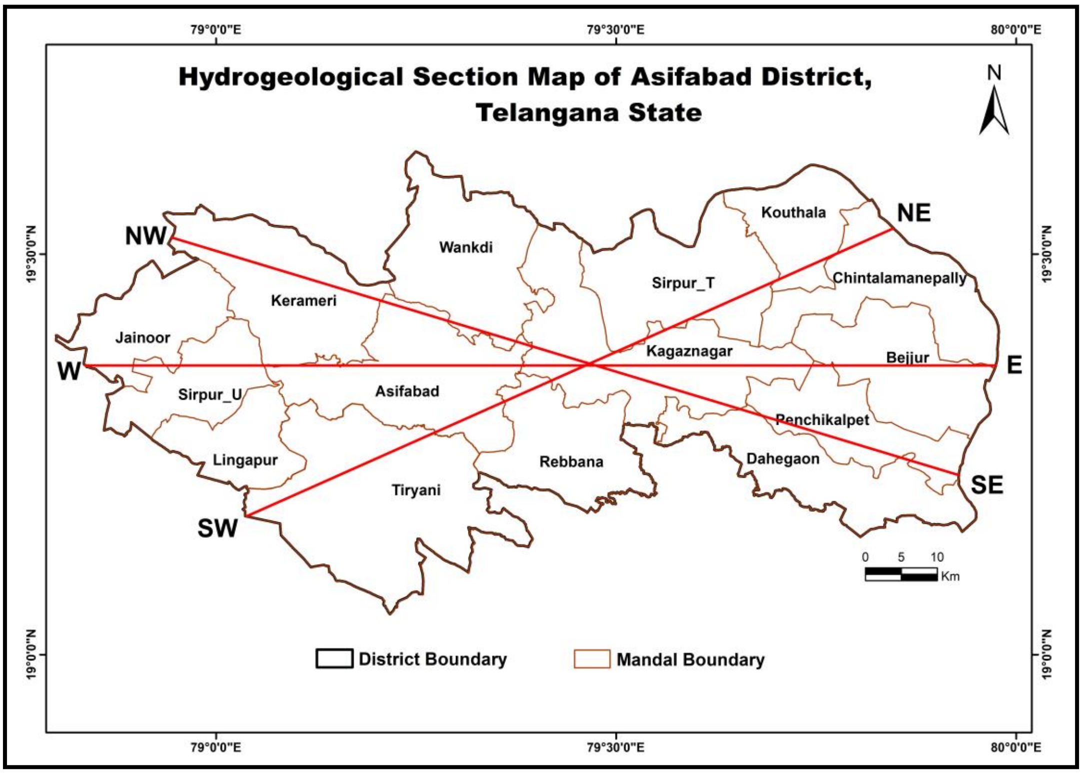


Fig.-3.19: Map showing orientation of various sections.

a) North-West and South-East Section: The section drawn along the NW-SE direction covering distance of ~108 kms (**Fig.3.20a**). It depicts the layered thick sandstone formations in the South East direction, thin weathered zone and thick fractured basalt in the North Western part and Metasedimentary are observed in the central part where basalt layer gradually tapers out. Basalts extend upto ~45 km into the district from NW boundary and the depth of Basalt occurence gradually decreases from NW –SE direction. Four aquifers are demarcated in the in the sandstone formation, separated by 3-intervening clay layers. These four aquifers are distinctly observed in Rebbana area .

b) West and East Section: The section drawn along the West -East covering distance of ~118 kms (**Fig.3.20b**). It depicts Basaltic layer in the west extending upto overlying Meta sedimentary formation. In the central region sandstone of Gondwana formation are found and thin metasedemintary layers overlies massive granitic gneiss. In the eastern most part granitic and gneissic formations are exposed. Thick basaltic fracture zones are observed in Babjipet and Babejeri areas. All the stratigraphic layers are visible at 40 kms from the west where the sedimentary formation overlies the Meta sedimentary formation.

c) South-West and North-East Section: The section drawn horizontally along the SW-NE direction covering distance of ~90 kms (**Fig.3.20c**), depicts thin weathered zone and thick fracture zones in the western part. Sandstone extends upto ~100 km into the central part of the district. Thick Aquifer layers of sandstone with intervening thin layrs of clay are observed in the central part. In the north eastern part, the granitic gneiss is exposed as outcrop.

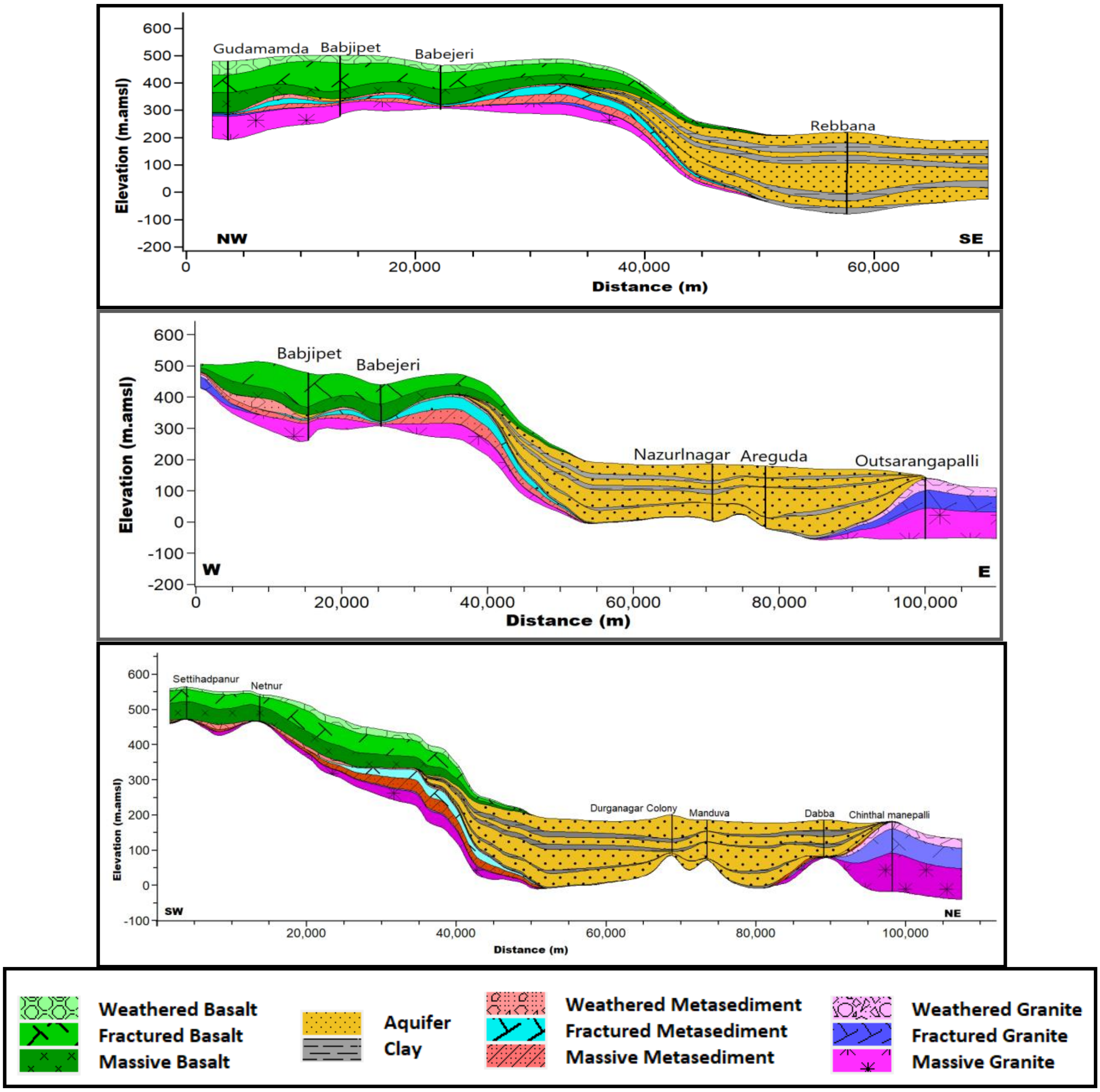


Fig.3.20 (a-c): Hydrogeological profile in different directions in Asifabad district.

3.4 Coal Minning in Asifabad District and Its Impacts On Ground Water

The coal mine area is the part of Bellampalli Coal belt of GodavariValley Coalfield situated in the Komaram Bheem district. The area has four Opencast Coal Mines (OCMs) namely Dorli-I & II, Khairagura Opencast Expansion Project and Bellampalli Open Cast-II Expansion Project. In these mines, Dorli-I & II open cast mines were closed in 31.03.2019 and 01.042017. All these mine belongto M/s. Singareni Collieries Company Limited (SCCL) a Government Company under the Companies Act. The Tiryani forest is at the north western side of the study area and Golletihills in the south eastern part.

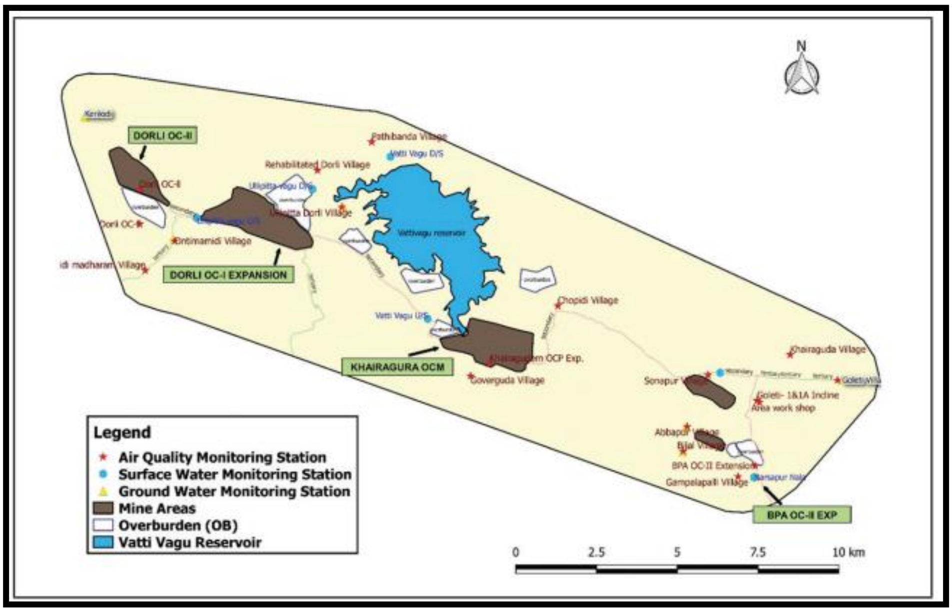


Fig.3.21 : Open Cast Coal Mine location in Asifabad

Dorli-Bellampalli Coalbelt forms an important coal-bearing Lower Gondwana sequence along the western margin of the Godavari Valley Coalfield in its north-western strike extremity. In the mine area, Penganga and Sullavai formations occupy about 30% area, while the remaining is covered by soft rocks of Gondwana formation The Barakars formation of the Lower Gondawana is the main coal bearing formation. It is mainly arenaceous with fine to medium grained sandstones, The shales and clays and coal seams. This is overlain by Barren Measures formation, which comprises medium to coarse grained and sandstones with red clay and siltstones.

3.4.1 Extent of Mine Dewatering:

The seepage of water into the mine workings depend on several factors like the permeability of overlying sandstone formations, its structure, number of seams/sections being mined, depth and aerial extent of the mine etc. The quantity of water generally pumped out per day is 14268 m^3/day. The quantum of inflow of water into proposed Goleti OCP will be vary from about 460 m^3/day to 20462 m^3/day during non-monsoon season. Most of this water is used for mine requirement, domestic use and plantation etc. Remaining excess water will be discharged into local down streams after conventional treatment.

The daily Inflow of water into the two SCCL coal mine in Asifabad District is shown in **Table 3.3**

Name of the mine	**Total Quantity of water (m^3/ day)**				
	Pumped per day	**Mine requirement**	**Domestic Use**	**For plantation**	**let out into the streams**
Khairagura OCP	8618	2300	60	0	6258
BPA OC-II Exp.	5650	310	28	160	5152
Total	**14268**	**2610**	**88**	**160**	**11410**

3.4.2 Hydrogeology Aspects & Impact of coal minning in Ground water:

The impact of mining on local ground water regime depends on the mine parameters like depth, excavated area and rate of expansion, ground water recharge and hydraulic parameters of the aquifers intercepted in the quarry area. SCCL is monitoring the piezometric water levels around the existing projects in the buffer area aimed at evaluating the impact of coal mining on ground water regime. The piezometric heads around BPA OC-II project vary from 5.44m to 20.31m in pre-monsoon season and 5.01m to 20.11m in post-monsoon season. Similarly, around Khairagura OCP it vary from 7.86m to 23.97m in pre-monsoon and 7.28m to 23.00m in post-monsoon season. An Aquifer Performance Test (APT) was also conducted in the mine area by SCCL and the hydraulic parameters are given below in **Table 3.4**:

Parameters	**Value**
Transmissivity	24.96 m^2/ day
Hydraulic Conductivity	5.08×10^{-1} m/day.
Storativity	6.42×10^{-4}

The impact of ground water drawdown cone is limited to a small distance from the edge of the mine as the permeable beds act as individual units and develop multi-aquifer system. Due to prominent boundaries/faults, the propagation of this cone of influence is further restricted. The mine water discharged into the local drainage net work/tanks act as constant source of recharge and improves the water levels. After cessation of mining, due to increased permeability in the backfilled area, the infiltration of rain water increases and the water levels recoup in a short time. At the final stage, the void left in the dip-side area will be gradually filled with rain water and surface run off and become a good reservoir and acts as constant source of recharge to the groundwater regime and improves the water levels around the mine area. As most of the mines are located near to forest areas which are good recharge zones for ground water. The ground water quality analyses by the Singareni Collieries Company Limited has shown that the samples falls within the permissible limit and are stipulated for water to be fit for drinking purpose with ground water as source.

All the mining mandals falls in safe category based on the GEC 2017.Based on the studies carried out, there were no major impacts reported by the mining in the district.

4. GROUND WATER RESOURCES

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. Mandal wise resources of GEC -17 and GEC-20 are given in ***Table-4.1***.

As per 2020 GEC report, the net dynamic replenishable groundwater availability is 300 MCM, gross ground water draft for all uses 76 MCM, provision for drinking and industrial use for the year 2025 is 23 MCM and net annual ground water potential available for future irrigation needs is 221 MCM. Out of 15 mandals, 1 mandal (Kagaznagar mandal) fall in semi critical category and remaining 14 mandals fall in safe category. Mandal wise stage of ground water development varies from 6 % (Tiryani mandal) to 77 % (Kagaznagar mandal) with average of 25%. Based on 2020 resources, mandal categorization map is given in Fig. 4.3 and village wise utilizable ground water resource map is prepared and presented in **Fig. 4.1.**

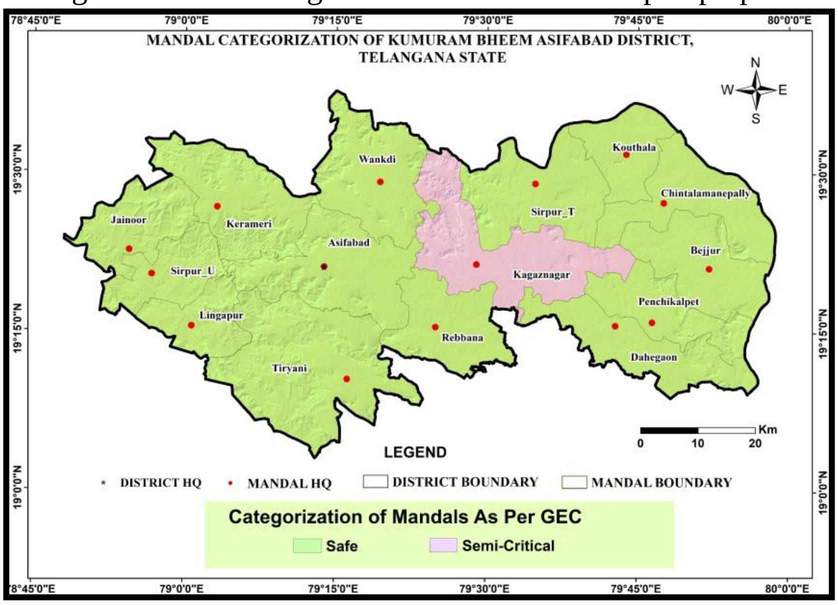


Fig.4.1: Mandal Categorization of Asifabad District (As per GEC)

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

Parameters	GEC 2017	GEC2020
As per GEC 2017 &2020	MCM	MCM
Dynamic (Net GWR Availability)	**323**	**300**
➢ Monsoon recharge from rainfall	318	313
➢ Monsoon recharge from other sources	7	7
➢ Non-Monsoon recharge from rainfall	15	0
➢ Non-monsoon recharge from other sources	12	12
➢ Total Natural Discharges (Ham)	30	33
Gross GW Draft	**73**	**76**
➢ Irrigation	53	55
➢ Domestic and Industrial use	20	20
Provision for Drinking and Industrial use for the year 2025	23	23
Net GW availability for future irrigation	246	221
Stage of GW development (%)	24	25

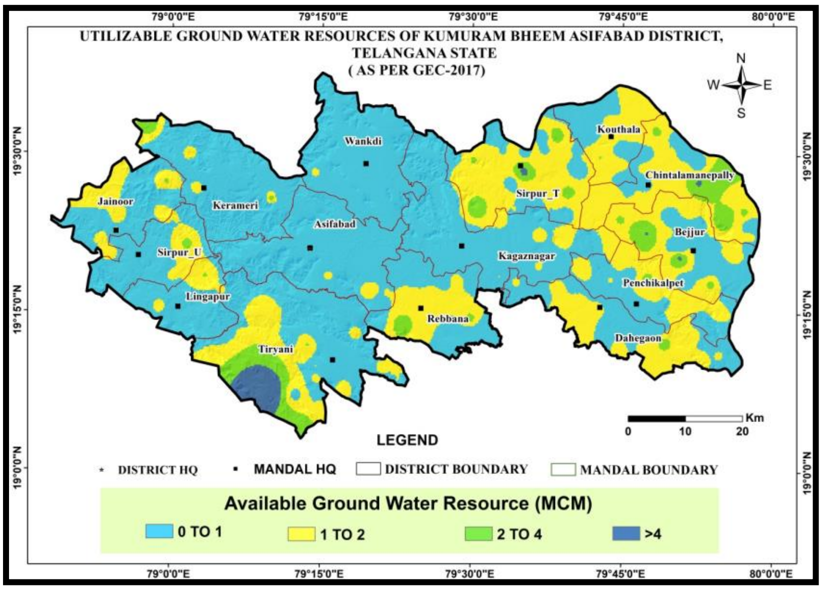


Fig.4.2: Utilizable ground water resources (2017).

5 GROUND WATER RELATED ISSUES

5.1 Low groundwater potential

In KumuramBheem Asifabad district, low ground water potential (< 1 lps) areas have been identified in 15% of the area in western and eastern part, mostly area underline by basalt and granitic terrain (absence of primary porosity, negligible development of secondary porosity) and restricted depth of weathering (< 20 m) as seen in Fig. 5.1. The occurrence of less rainfall and urbanization also affects the potential. 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) as high as 5.58 mg/L during pre-monsoon and 2.3 mg/L during post-monsoon season is found in groundwater. The high fluoride concentration (>1.5 mg/L) occur in 2 % and 1% of the samples during pre and post-monsoon season.
- 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 and higher residence time of ground water in deeper aquifer.
- High nitrate (> 45 mg/L) due to anthropogenic activities is observed in 2% samples during pre and post-monsoon.
- Higher concentration is due to unscientific sewage disposal of treated and untreated effluents in urban and rural areas. Use of NPK fertilizers and nitrogen fixation by leguminous crops.

6. MANAGEMENT STRATEGIES

In the management strategies there are mainly 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. 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 1871 MCM of unstaturated volume (below the depth of 5 m) is avaialable during post-monsoon season having 49.5 MCM of recharge potential (2%). This can be utilized for implementing management strategy.

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

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

6.1.1 Supply side measures:

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

De-silting of existing minor tanks (361 no) was taken under state Govt. sponsored Mission Kaktiya-Phase-1, Phase-2, Phase-3 and Phase-4 to remove 2.23 MCM of silt and this has created additional surface storage. This will contribute ~ 0.56 MCM to groundwater and with this additional ~93 ha land can be brought under irrigated dry (ID) crops in tank ayacut.

There is need to take remaining tanks (~276 MI tanks) in next phases for de-silting, this will greatly help in stabilisation of tank ayacut and ground water augmentation.

6.1.1.2 Mission Bhagiratha:

Under Telangana Drinking Water Supply Project (TDWSP) also known as Mission Bhagiratha, all the villages and towns are proposed to be covered from the water grid with intake from 1) Godavari River (Segment- Kumuram Bheem Asifabad) covering 7 mandals to provide protected water from surface reservoirs. People living in 1,151 habitations across Kumram Bheem-Asifabad district are now receiving potable drinking water under the Mission Bhagiratha. 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 19.8 MCM and this imported water from surface sources will reduce the present utilized ~11 MCM of ground water (considering 60 lpcd). This can be effectively utilized to irrigate ~1900 ha of additional land under ID crops.

To be taken up

6.1.1.3 Artificial Recharge structures:

A total of 477 artificial recharge stuctures exist in the area. After considering the existing water conservation structures and other recharge measures, the feasibility of artificial recharge structures are studied based on the surplus runoff and recharge potential. 689 artificial recharge structures (ARS) are feasible (CDs: 354 and PTs: 335) in the study area. As the stage of ground water development in the area is 24% and all the mandals falling in safe category except Kagaznagar Mandal (Semi Critical) as per the GEC 2020 estimation, the artificial recharge structures are not proposed for entire area. Kagaznagar mandal shows the stage of ground water development of 75%, therefore to control futher increase in stage of ground water development, artificial recharge structures are recommended in this mandal only.

While formulating the village wise groundwater management plan, the unsaturated volume of aquifer is estimated by multiplying the area with specific yield and unsaturated thickness (post-monsoon water levels below 5 m). 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. In intermittent areas 50% of yield is considered and remaining 50% is recommended for implementing water conservation measures in recharge areas through MGNREGS. The pre-monsoon groundwater quality is considered for categorising contaminated area (F >1.5 mg/l & EC >3000 µ S/cm). Nitrate is not considered here because it is point source pollution and localized.

Kagaznagar Mandal covering 63.5Km^2 is considered for recommending artificial recharge structures (ARS) where, 1.42 MCM recharge potential with surplus runoff of 4.18 avaialable. For sustainable development and management of the groundwater resources the following recommendations are made and summarised in **Annexure-1**.

- 26 artificial recharge structures (13 CD's with 6 filling and 13 mini PT's with 2 fillings).
- After effective utilization of this yield, there will be 0.73 MCM of ground water recharge.
- Roof top rainwater harvesting structures should be made mandatory to all Government buildings (new and existing).

Table 6.1 Area Identified for artificial recharge structures

Area Identified for AR (Sq.Km.)	Available Subsurface Space for AR (MCM)	Recharge Potential (MCM)	Available Surplus runoff (MCM)	Proposed Numbers of structures		Total volume of water expected to be recharged	
				CD	PT	CD	PT
63.5	47.17	1.42	4.18	13	13	0.55	0.18

Other supply side measures:

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

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

6.1.2.1 Ongoing Work

In the area till date a total number of 611 no's drip and sprinklers are sanctioned which has irrigated ~622 ha under ID crops saving ~1.1 MCM (considering 30% saving of 0.006 MCM/ha) of groundwater from the basin. Considering the current scenario of groundwater 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.

Proposed Work

- ~1000 ha of additional land that can be brought under micro-irrigation (@50 ha/village in 20 villages from 1 mandal) . With this 1.8 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 Kagaznagar. 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

6.1.3 Other 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.

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

- The other measure includes 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 are recommended.

6.2 Expected Results and Out come

With the above interventions, the likely benefit would be the net saving of 2.53 MCM of ground water. This will bring down the stage of ground water development (SoGWD) by 1% (from 25 % to 24%) in the entire study area and in Kagaznagar mandal (semi critical), where water conservation measures are proposed, and the stage of ground water development will be improved by 11% (from 77% to 66 %).

Acknowledgments

The author express her thank s to Shri Sri.Nandakumar Chairman CGWB, Govt. of India and Shri J. Siddartha Kumar, Regional Director(I/C), CGWB, Shri.Praveen Kumar, Scientist C, Shri Ravi Kumar Gumma, Scientist C and Miss. Caroline Louis for encouragement and support. The author acknowledges State Ground Water Department and Rural Water Supply department, Department of Horticulture, Minor Irrigation, Govt of Telangana for providing the available field data.