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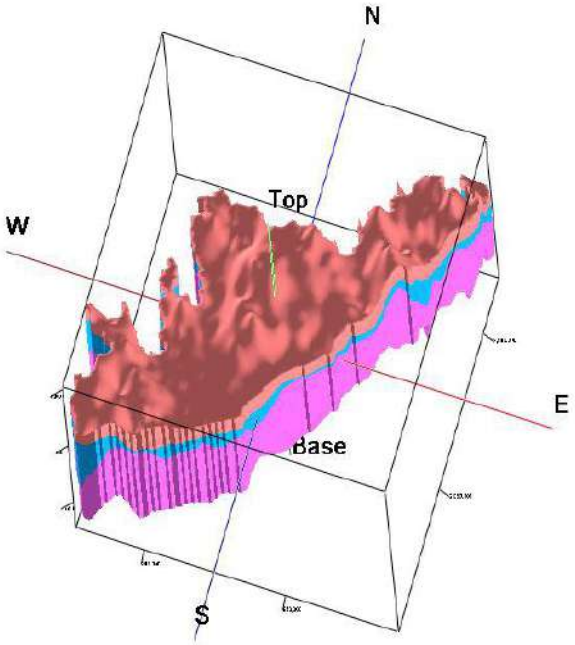
GOVERNMENT OF INDIA
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RD & GR

REPORT ON
AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN SRIKAKULAM DISTRICT, ANDHRA PRADESH STATE



CENTRAL GROUND WATER BOARD
APSUO, VISAKHAPATNAM
FEBRUARY 2023

REPORT ON
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AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN SRIKAKULAM DISTRICT, ANDHRA PRADESH STATE

Figures

Table

REPORT ON
AQUIFER MAPPING AND MANAGEMENT OF SRIKAKULAM DISTRICT,
ANDHRA PRADESH STATE (AAP-2022-23)

At a Glance

S.No.	Item		Particulars
1	District	:	Srikakulam
2	Mandals	:	30
3	Villages	:	1446 villages
4	Mappable area	:	4139 s q . k m s
5	Population (2011Census)	:	21.91 lakhs
6	Density	:	466 persons/km^2
7	Locations	:	North latitude 18°04′-19°09′and east longitude 83°35′-84°45’
8	Rainfall (Normal)	:	The annual normal rainfall of the area varies from 1009 mm (Laveru mandal) to 1321 mm (Kaviti mandal) with normal average of 1166 mm.
9	Geomorphology	:	Pediplain (65% of the area), Denudational hills (8 % of t the area),Flood plain (7% of the area), Pediment (6 % of the area), Structural hill (5% of the area), Coastal plain (3% of thearea) and Others (6% of the area).
10	Major River	:	Vamsadhara and Nagavali
11	Land Utilization	:	Agricultural land occupies nearly 76% of the area, forest occupies nearly 9% of the area, 15% of the area is waste lands
12	Soils	:	Based on the soil texture, the area is mainly occupied by Fine, mixed soils (87%), fine montmorillonitic (7%) and loamy skeletal (3%)
13	Cropping Pattern(2018-19) (Ha)	:	The total gross cropped area is 3,47,519 ha. The principal crops are paddy, food crops, food grains and maize. The other crops are pulses, black gram, green gram, dry fruits, and oil seeds. Paddy and food grains are main crop in Kharif season.
14	Irrigation	:	The Gross area irrigated is 1,74,140 ha and the area irrigated more than once is 27,182 ha. 65% (95502 ha) of the irrigation is through Canal & LIS and 31% (45918 ha) of the area is irrigated through Tanks and 3% (4056 ha) of the area is irrigated through Ground Water.
15	Geology		Pre-Cambrian rocks include Banded Gneiss (43%), Gneiss (9%), Khondalite (13%) and Charnockites (15%). The Sub-Recent to Recent formations comprise laterites (1%) to Alluvium (19%).
16	Hydrogeological data points		
	Exploratory drilling	:	CGWB Exploration: 34
	Water Level	:	50 wells (CGWB:21, SGWD:29)
	Hydrochemical	:	Total 72 Pre-monsoon:72(CGWB: 31, SGWD: 41)
	Geophysical	:	VES: 87 (CGWB)
17	Data Interpretation, Integration and Aquifer Mapping		
18	Ground water Level Scenario		

	Water Levels Depth to water level (m bgl)		During Pre-Monsoon, water-table elevation ranges from 3.56 to 94.1 meter above mean sea level. Depth to water level varies from 2.35 to 27.25 m bgl with an average of 6.59 mbgl during pre- monsoon.In Majority of the areas in pre monsoon water level is 5-10 m (68% of the area), followed by 2-5 m bgl in 26% of the area, and > 10 m bgl occupy about 6% of the area. During post-monsoon season water level, <1 m - 25.95 m bgl with an average of 5.08 m bgl. and majority of the water level are in range of 2-5 m bgl covering 76% of the area followed by 5 to 10 m bgl in 16% of the area, < 2 mbgl occupy about 2% of the area and > 10 m bgl occupy about 6% of the area.	
	Water Level Fluctuations (May vs.November)	:	Most of the wells in the state records water level rise. The seasonal water level fluctuations varyfrom -5.97 to 8.58 m bgl.	
19	Ground Water Quality			
	Electrical Conductivity(µ Siemens/cm)	:	Pre: 190-4500 (avg: 1656) micro-Siemens/cm. 97 % of area EC is within 3000 µ Siemens/cm.	
	Nitrate (mg/l)	:	Nitrate concentration in 71% of samples is beyond permissible limits of 45 mg/L, varies between 0.53 – 278.3 mg/L.	
	Fluoride (mg/l)	:	Fluoride concentration varies from 0.06-1.45 mg/L and all samples falling under permissible limits of 1.5 mg/L	
20	Conceptualization		Weathered zone: 3 to 85 m.bgl	Fractured zone: 10 to 160 m.bgl
21	Aquifer Characterization	:	Thickness of weathered zone is in the range of 20 - 30 m in most part of area covering ~57 % of area, 10 – 20 m weathering thickness occurs in ~40 % of the area and shallow (<10 m) and deeper (>30 m) weathering occurs in rest of the area.	More predominant occurrence is in between the range of 20 to 40 m (44 %), followed by 40 to 60 m (39 %),60 to 80 m (10 %) and deep fractures >80 m occurs in 2 % area.
22	Ground water Resources (2020)		MCM	
	Net Dynamic Ground Water availability	:	933.66 MCM	
	Gross GW Draft	:	196.4 MCM	
	Provision for Domestic(2025)	:	99.82 MCM	
	Average Stage of Ground Water development (%)		20.8 %	
	Net GW Availability for future irrigation	:	751.29 MCM	
	Categorization of Mandal		All Mandals in the district are categorized are safe	

23	Management Strategies	:	Ground Water Development: PMKSY/YSR Jala Kala: As the Stage of Ground Water development of the district is 21% and considering the present contribution of Ground Water in Irrigation sector, and the availability of 751.29 MCM of ground water for future, it is recommended to develop ground water in 29 mandals by constructing 16544 no. of structures to bring an additional area of 19116 ha into the admit of ground water irrigation. Supply Side Measures: Artificial Recharge: Existing AR Structures: 4728 (4025 Check dams and 703 percolations tank) with a density of 1 artificial recharge structure per square km area in the district. Desilting, Repair and renovation of existing ARS recommended and new AR structures in specific areas as per requirement. Demand Side Measures: Micro-irrigation: As sustainability of bore well is low, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management.

EXECUTIVE SUMMARY

Srikakulam district covering an area of 4575 km^2 is the Northern most district of Andhra Pradesh State sharing interstate borders. The district is mainly agrarian, tribal and backward in the State. Administratively, the district is governed by 30 mandals with 1446 inhabitated villages. The density of population in Srikakulam is 466 people/ km2 (2011 census). The district receives an average annual normal rainfall of 1166 mm of which SW monsoon 59% and north-east monsoon contributes 30%.

The total gross cropped area is 3,47,519 ha. The principal crops are paddy, food crops, food grains and maize. The other crops are pulses, black gram, green gram, dry fruits and oil seeds. Paddy and food grains are main crops in Kharif season. Geomorphologically, the district can be broadly divided into 4 distinct units viz pediplains, structural hills, flood plain and coastal plain. Northern and western parts of district is represented by structural hills, the extensions of Eastern Ghats consist of Charnockites and Khondalites and exhibits NW-SE trend.

The District is part of Eastern Ghat mobile belt, mainly underlain by Banded Gneiss (43%), Khondalite (13%), Gneiss (9 %) and Charnockite (15%) and form the principal aquifer systems in the district. The weathering varies form 3 m to 85 m with an average of 21 m. Majority of fractures occur in 20 to 40 m depth and deepest fracture is encountered at 160 m. bgl. Ground Water yield of Principal aquifers varies from <0.1 to 8.19 lps (avg: 1.30 lps). Low yield (<1 lps) occurs in ~59 % of area, 1 to 3 lps yield occurs in ~41 % of area of the district.

The depth to water levels during Pre-monsoon season represent that majority of the water levels are in the range of 5.0 to 10 m (68% of the district), followed by 2.0 to 5.0 m bgl (26%) and >10 m bgl (6%). The water levels > 10 m. bgl occupy in parts of Palasa, Ranasthalam, Kanchili and Etcherla mandals. During Post-monsoon season, majority of the water levels are in the range of 2.0 to 5.0 m bgl (76% of the area), followed by 5.0 to 10 m bgl (16%), < 2.0 m bgl (2%). The water levels > 10 m bgl occupy about 6 % of the area falling in parts of Kanchili and Ranasthalam mandals during post monsoon periods. Shallow water level < 2.0 m bgl occupy in parts of G. Sigadam, Nandigam, LN Peta, Gara, Ranasthalam, Mandasa, Srikakulam, Hiramandalam and Polaki mandals. Most of the wells in the state records water level rise. The seasonal water level fluctuations vary from -

5.97 to 8.58 m bgl. The water table elevation varies from 4 to 94 m amsl and in general ground water flow is towards NW to SE directions.

Groundwater is mildly alkaline to alkaline in nature with pH in the range of 6.74-8.15 (Avg: 7.49). Electrical conductivity varies from 190-4500 (avg: 1656) µ Siemens/cm**.** In 53 % of area, EC is within 1500 - 3000 µ Siemens/cm, in 43 % area, it is 750-1500 µ Siemens/cm; in 3 % area it is > 3000 µ Siemens/cm and in 1 % area and EC is <750 µ Siemens/cm**.** Nitrate concentration varies between 0.53 – 278.3 mg/L and in 71% of samples it is beyond permissible limits of 45 mg/L. Fluoride concentration varies from 0.06-1.45 mg/L and all samples falling under permissible limits of 1.5 mg/L.

Aquifers from the area can be conceptualized into 2 no. s namely Aquifer-1, weathered and its contiguous semi-weathered/fracture up to 30 m & Aquifer-2, discrete fracture system from 30 to 200 m. The Weathered zone varies from 3 to 38 m. bgl in Srikakulam with an average of ~21 m. Thickness of weathered zone is in the range of 20 - 30 m in most part of area covering ~57 % of area, 10 – 20 m weathering thickness occurs in ~40 % of the area and shallow (<10 m) and deeper (>30 m) weathering occurs in rest of the area. The Occurrence of fractures are discrete and more predominant fractures occurrence is in between the range of 20 to 40 m (44 %), followed by 40 to 60 m (39 %),60 to 80 m (10 %) and deep fractures >80 m occurs in 2 % area.

The net dynamic replenishable groundwater availability is 933.66 MCM, gross ground water draft for all uses is 196.4 MCM, provision for drinking and industrial use for the year 2025 is 99.82 MCM and net annual ground water potential available for future use is 751.29 MCM. Stage of ground water development is 21%. All Mandals in the district are categorized are safe.

At present the ground water abstraction in the district is quiet low as the overall level of ground water development is only 21% and there is a vast scope for further ground water development by construction of additional wells for irrigation. Under YSR Jalakala/PMKSY, Government of Andhra Pradesh is proposed to construct 16544 no. of bore wells for to bring an additional area 19116 ha under irrigation.

Govt of AP had constructed 4025 no. of CDs & 703 no. of PTs in the district. As the density of structures are almost 1 artificial recharge structure per sq.kms, it is recommended to renovate and desilt the existing artificial recharge structures and new structures can be taken up as per site specific requirement. 306 no. of check dams and 196 percolation tanks

are pinpointed as per the gap and requirement in the district. Micro irrigation is recommended for increase the water use efficiency and more crop per drop. Area with < 1 lps is prioritized that can be taken up as per requirement.

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 rock 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 rock (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 purpose. 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 summarised 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: Srikakulam District is the North-eastern District of Andhra Pradesh State with a geographical area of 4576 km^2. The district lies between north latitude 18°04´46" to 19°09´55" and east longitude 83°35´22" to 84°45´52" falling in parts of Survey of India Toposheets 65 N/11, 12, 13, 14, 15 & 16 ,76 B/01 ,02 ,03 ,05 ,06, 08 & 09.

Administratively, the district is governed by 30 mandals and 1446 villages with a population of ~21.91 lakhs (2011 census). The district is bounded by Vizianagaram district in the south, Bay of Bengal in the east, Parvathipuram Manyam district in the west and Odisha State in the North (**Fig.1.1**). The district has a coast line of about 193 km. The density of population in Srikakulam is 499 people/ km^2 (2011 census).

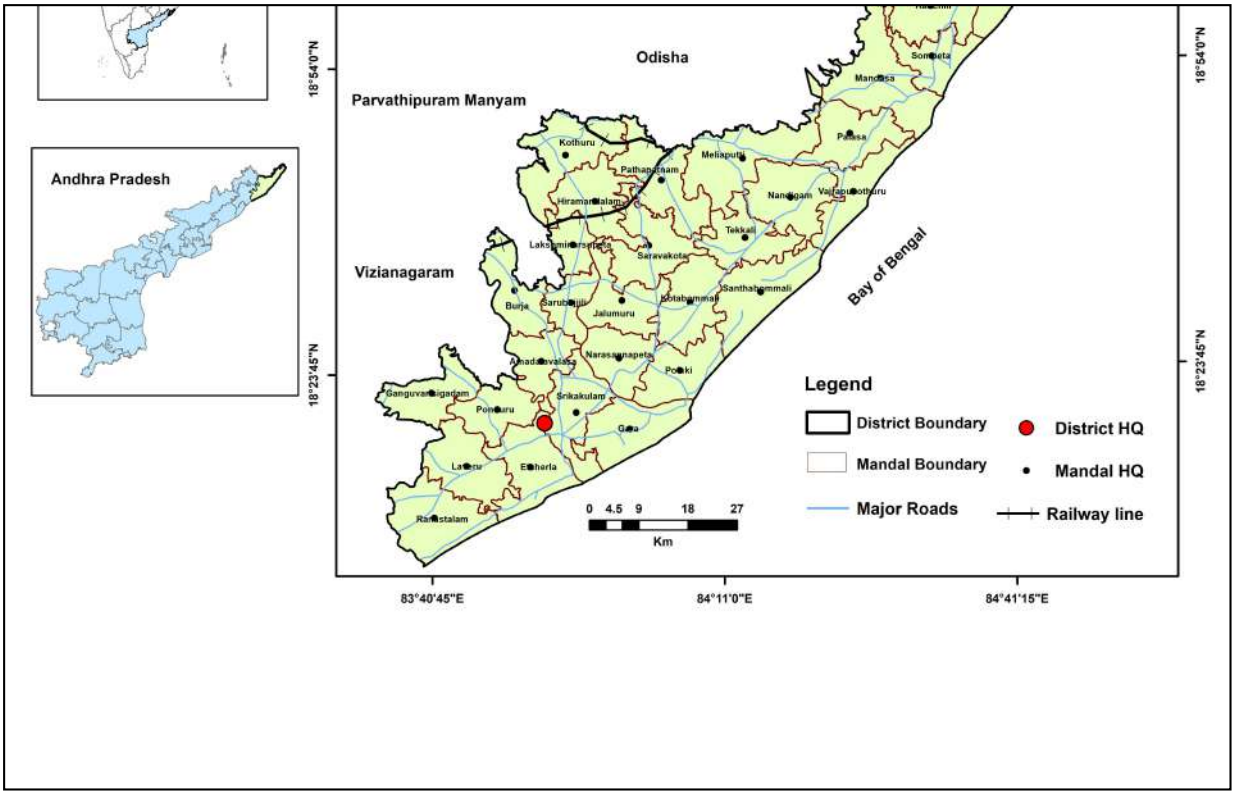


Fig.1.1: Location map of Srikakulam District

1.4 Climate and Rainfall: The climate of the district is moderate and characterized by high humidity all through the year along with oppressive summer and good seasonal rainfall. The mean daily maximum temperature in the district is about 34°C in May and the mean daily minimum temperature is about 17.5°C in December/January. The mean daily maximum temperature increases from east to west of the district where as mean daily minimum temperature decreases from east to west of the district. The mean relative humidity is 75%. The relative humidity increases after the onset of monsoon.

The annual normal rainfall of the area varies from 1009 mm (Laveru mandal) to 1321 mm (Kaviti mandal) with an average of 1166 mm. The South west monsoon (June to October) contributes ~59 %, North east monsoon (November and December) contributes ~30 %, and remaining by pre-monsoon season. Isohyetal map prepared using annual normal rainfall of mandals in the district is shown in Fig.1.2

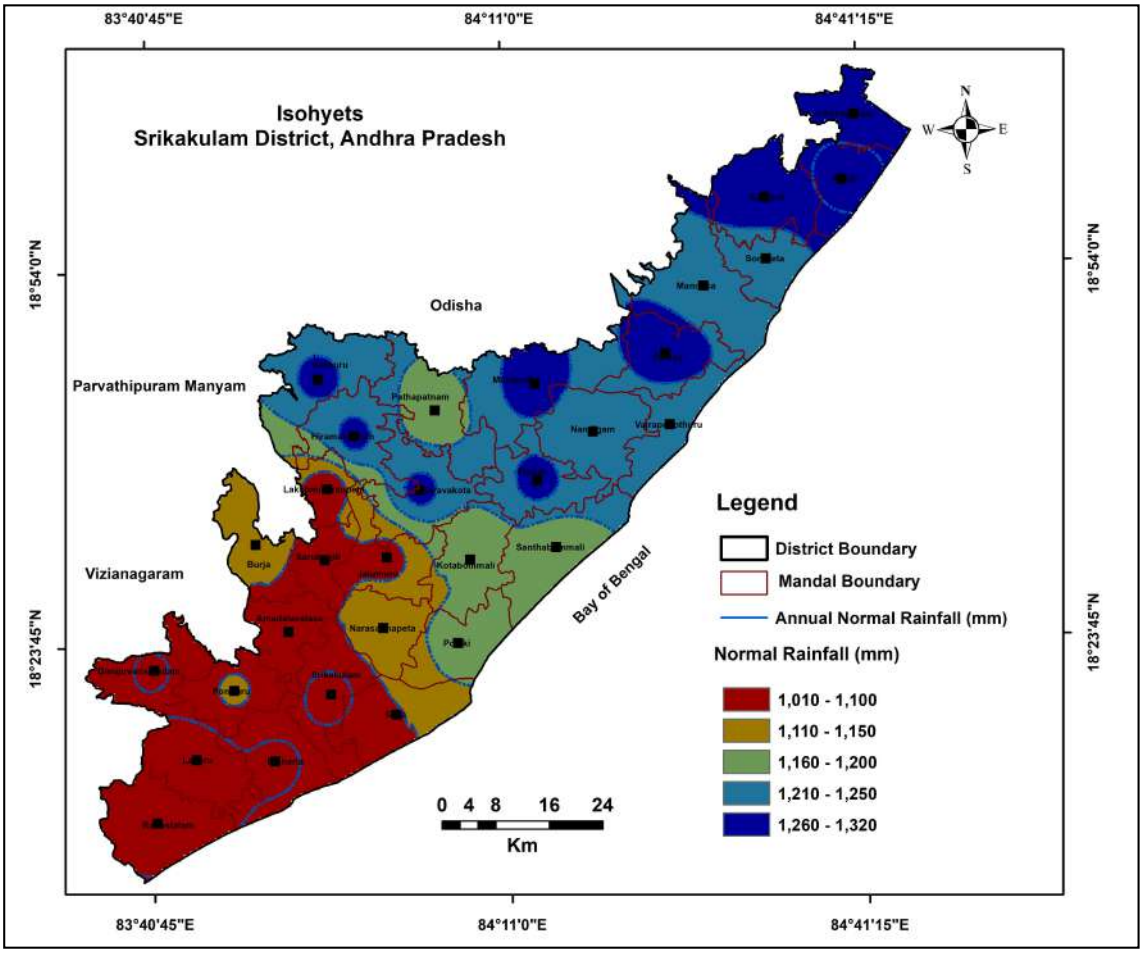


Fig.1.2: Isohyetal map of Srikakulam District

1.4 Geomorphological Set up: Geomorphologically, the district can be broadly divided into 4 distinct units viz pediplains, structural hills, flood plain and coastal plain. Northern and western parts of district is represented by structural hills, the extensions of Eastern Ghats consist of Charnockites and Khondalites and exhibits NW-SE trend. The occurrence of ground water in this unit are generally poor except along fractures where moderate yields can be expected. The Pediplains occupy a larger part of the district and constitute shallow buried pediplain, deeply buried pediplain, pediments and residual hills. The Residual hills are generally occupied by granites and gneisses and generally they are poor aquifers except along fracture zones. The alluvial plains are developed along major river courses, along valleys and at the foothill zones of structural hills. The alluvial plains along the major course of rivers form the flood plain deposits. The alluvial plains form shallow to deep fresh water aquifers with good to very good yields. The coastal plains occur parallel and nearer to the sea and are of marine origin. The other landforms observed are tidal flat, denudation hills etc. The details and percentage of geomorphological features of the area is given in the table and depicted in **Fig.1.3.**

Geomorphology	Area (Sq.kms)	%
Pedi plain	2936	64
Denudational hill	377	8
Flood plain	313	7
Pediment	302	7
Structural hill	224	5
Coastal plain	126	3
Others	298	7
Total	**4576**	**100**

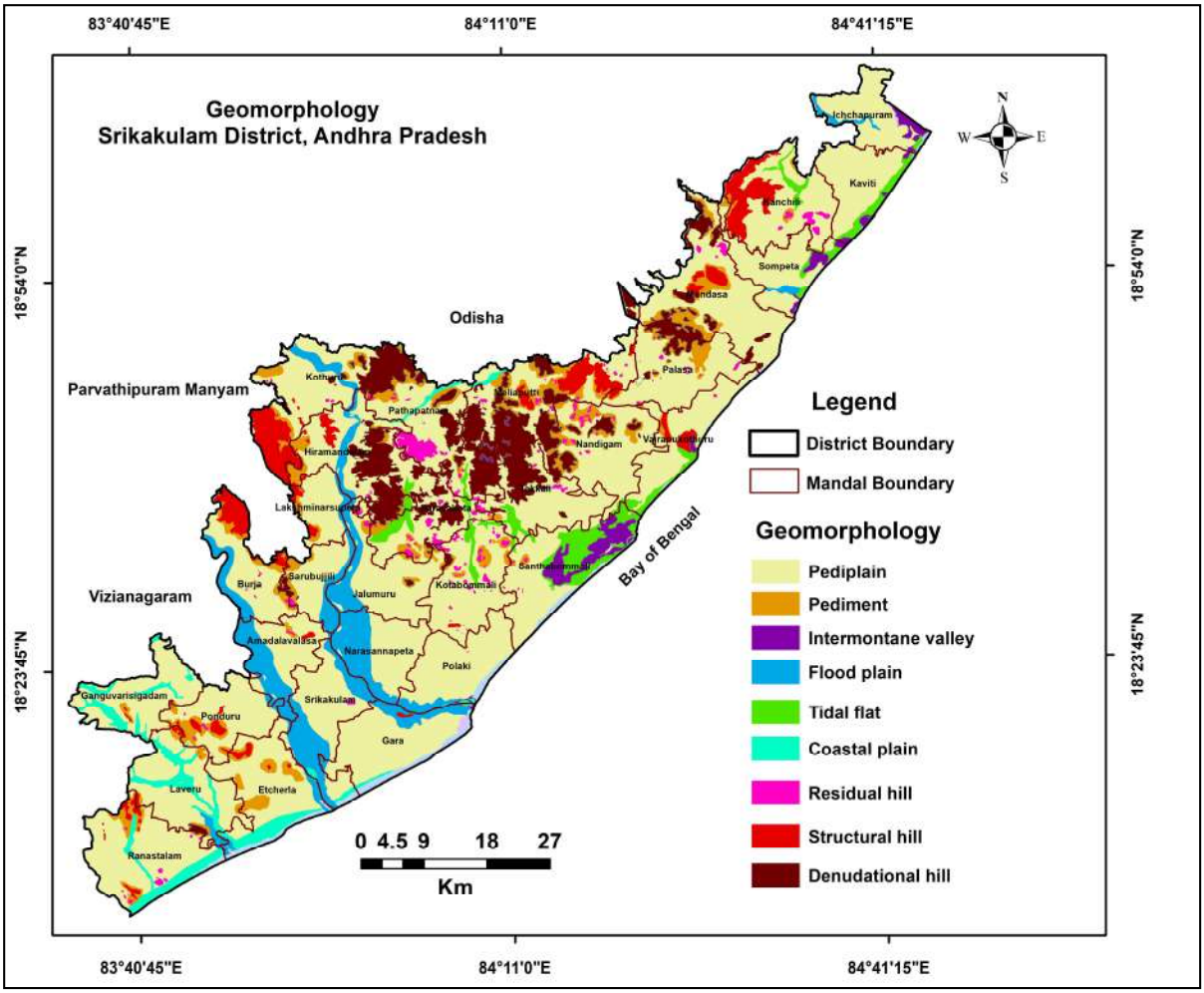


Fig.1.3: Geomorphology of Srikakulam District

1.6 Drainage and Structures: The main rivers in the district are Vamsadhara and Nagavali which are perennial in nature. The other important rivers flowing are Mahendra Tanya and Bahuda. The general drainage pattern is dendritic to sub-dendritic and occasionally parallel at places. The overall drainage is of medium to coarse textured. Map depicting drainage, River, tanks and watershed boundaries is presented in Fig.1.4.

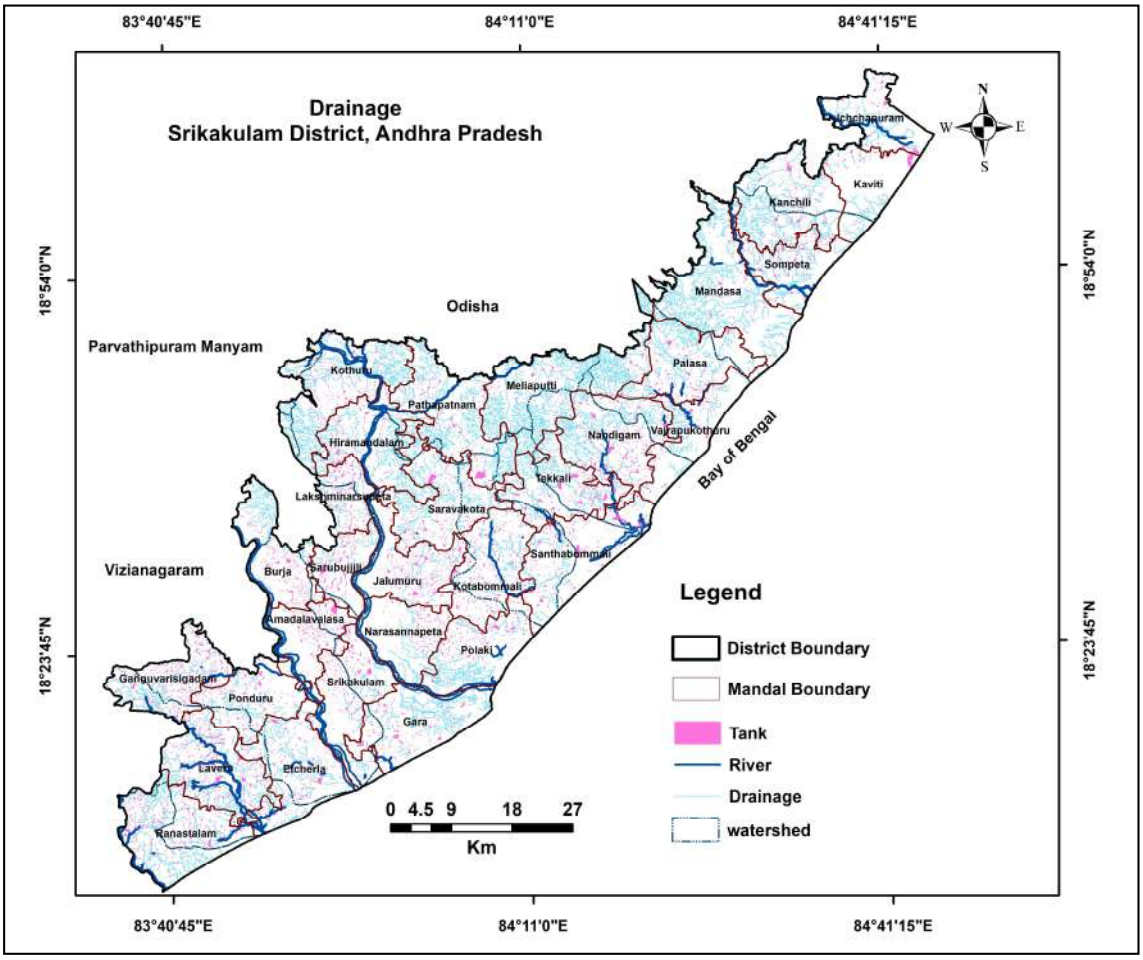


Fig.1.4: Drainage and watershed boundaries of Srikakulam District

1.7 Land Use and Land Cover: Out of total geographical area of 4576 sq. kms, forest occupies 437 sq. kms (9%), gross cropped area is 3476 sq. kms (76%) and waste lands occupy 663 sq. kms (15%). The Land use and land cover map of the district is depicted in Fig. 1.5. The graphical representation of Land use pattern of the district is presented as Fig. 1.5a.

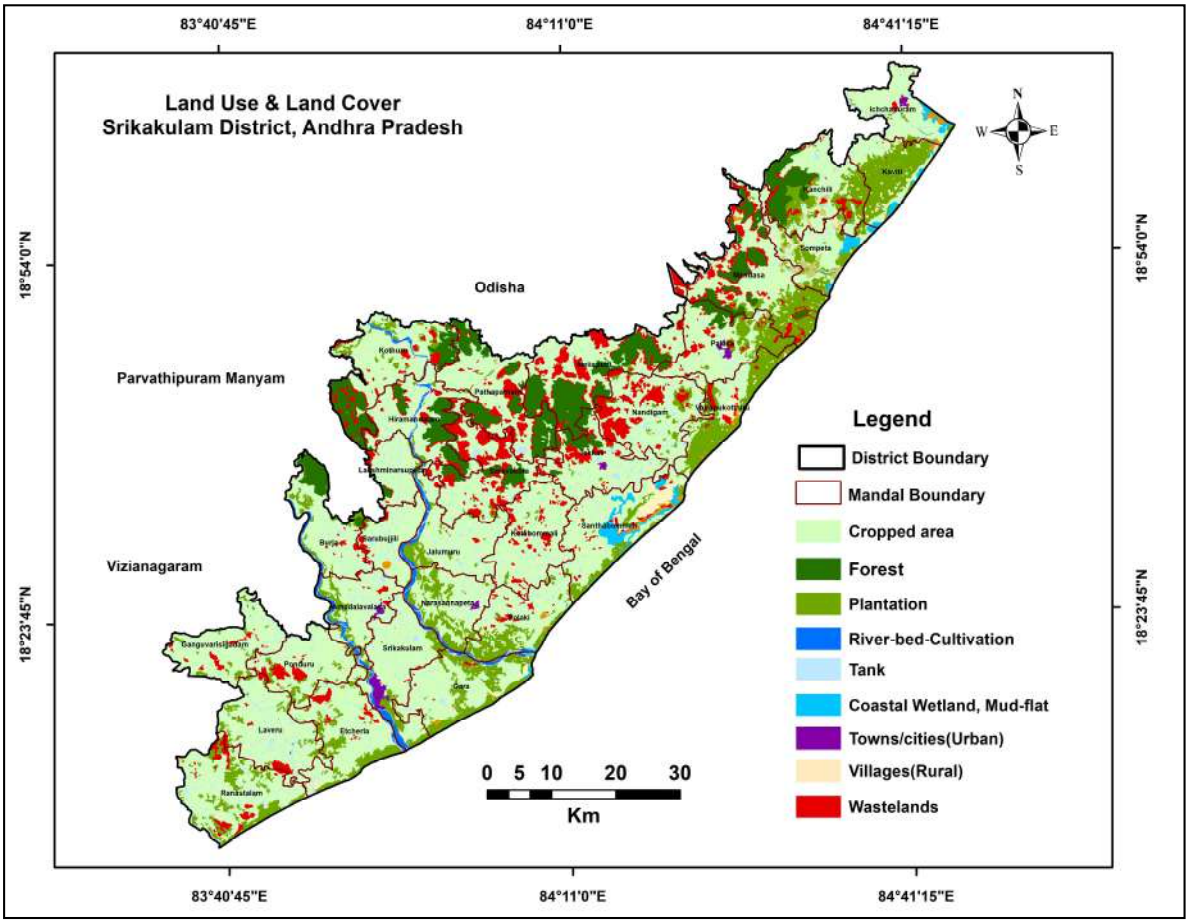


Fig.1.5: Land use and land cover of Srikakulam District.

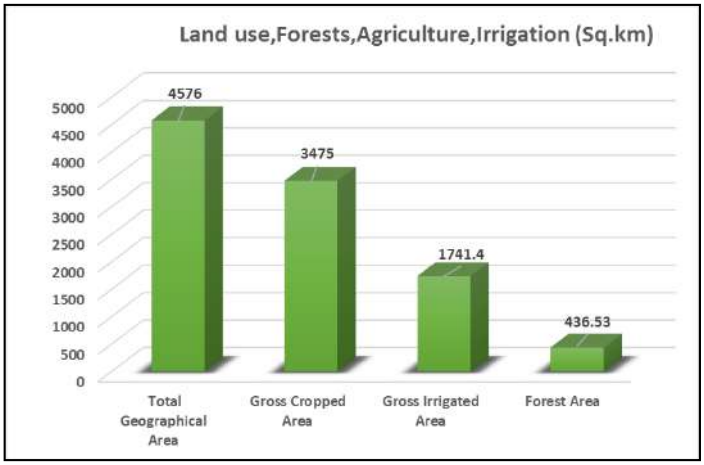


Fig.1.5a: Land use pattern

1.8 Cropping & Irrigation: The district is mostly agrarian. The principal crops are paddy, food crops, food grains and maize. The other crops are pulses, black gram, green gram, dry fruits and oil seeds. Paddy and food grains are main crop in Kharif season. The district is irrigated by both Surface and ground water sources. Surface water is the main source of irrigation (~65%) and sources of irrigation are canals and lift irrigations. The graphical representation of area irrigated by different sources in the district is presented as Fig. 1.5b.

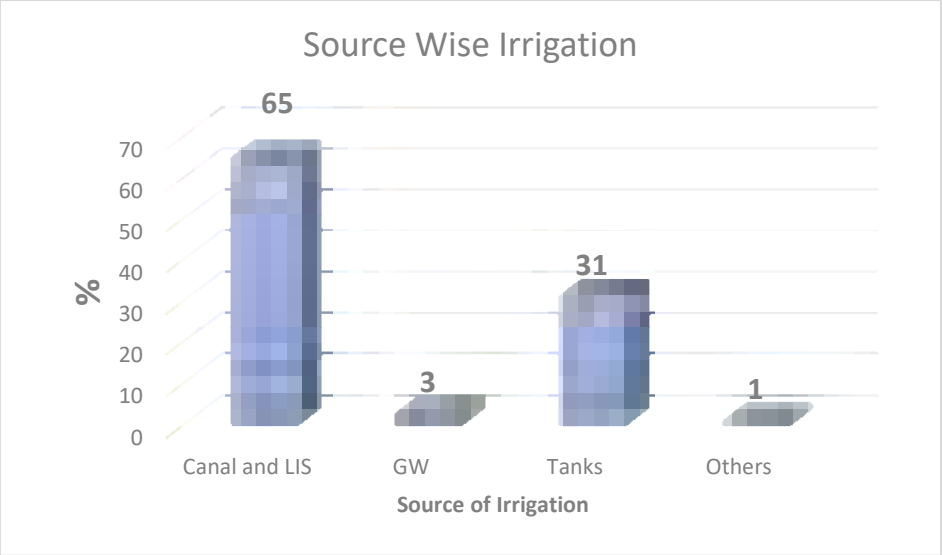


Fig.1.5 b: Area Irrigated by Different Sources

Different sources of Irrigation	Area Irrigated (Ha)	%
Canal and LIS	95502	**65**
Ground Water	4056	**3**
Tanks	45918	**31**
Others	1482	**1**
Total	146958	**100**

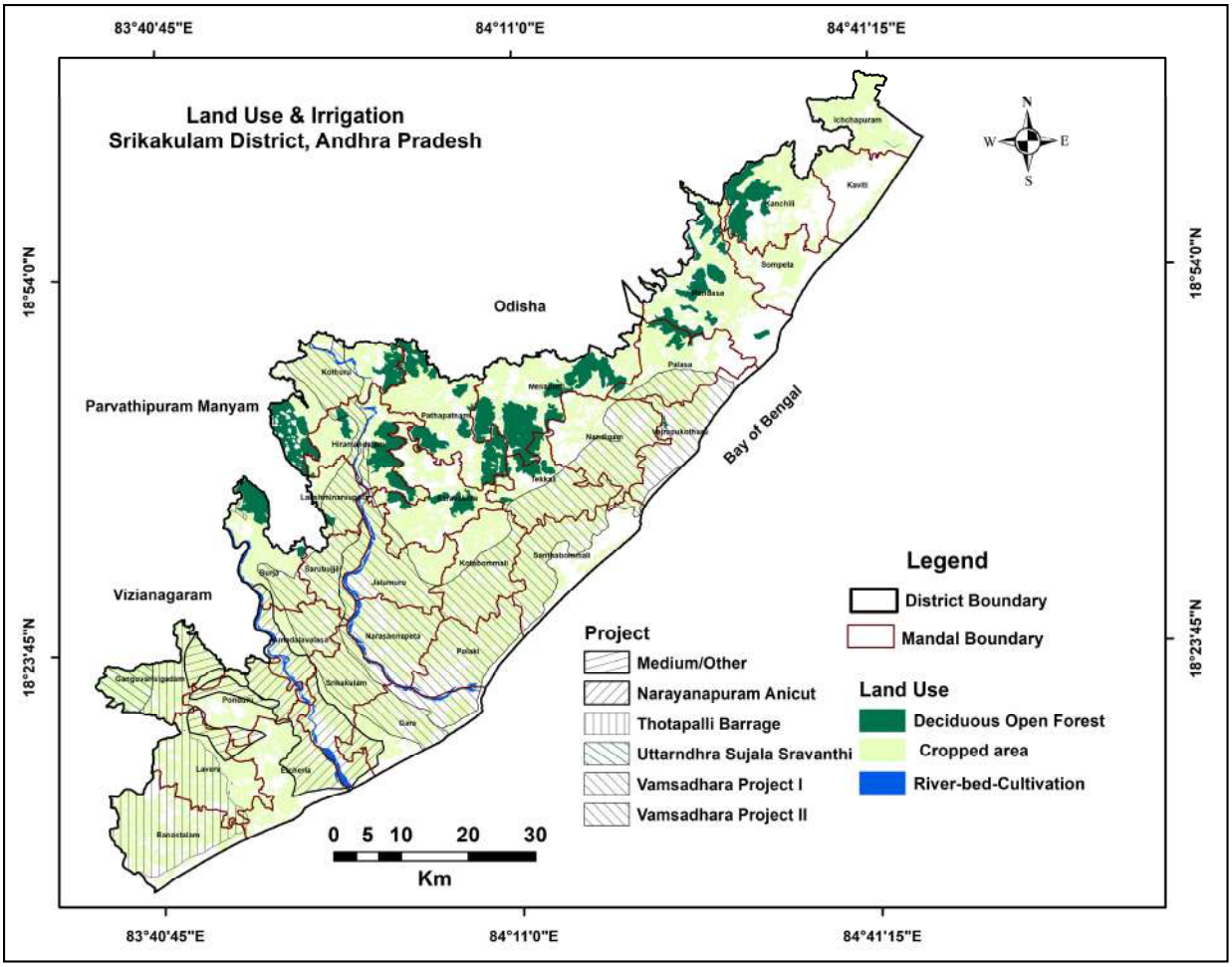


Fig.1.6: Cropped Area and Project wise envisaged Irrigated Area of Srikakulam District

1.9 Soils: The area is mainly occupied by fine, mixed soils (87%) (Moderately deep, somewhat excessively drained, clayey soils), Fine, montmorillonite (7 %) (Deep, imperfectly drained, cracking clay soils), Loamy-skeletal (3%) (Moderately deep, somewhat excessively drained, gravelly loam soils). (**Fig.1.6**)

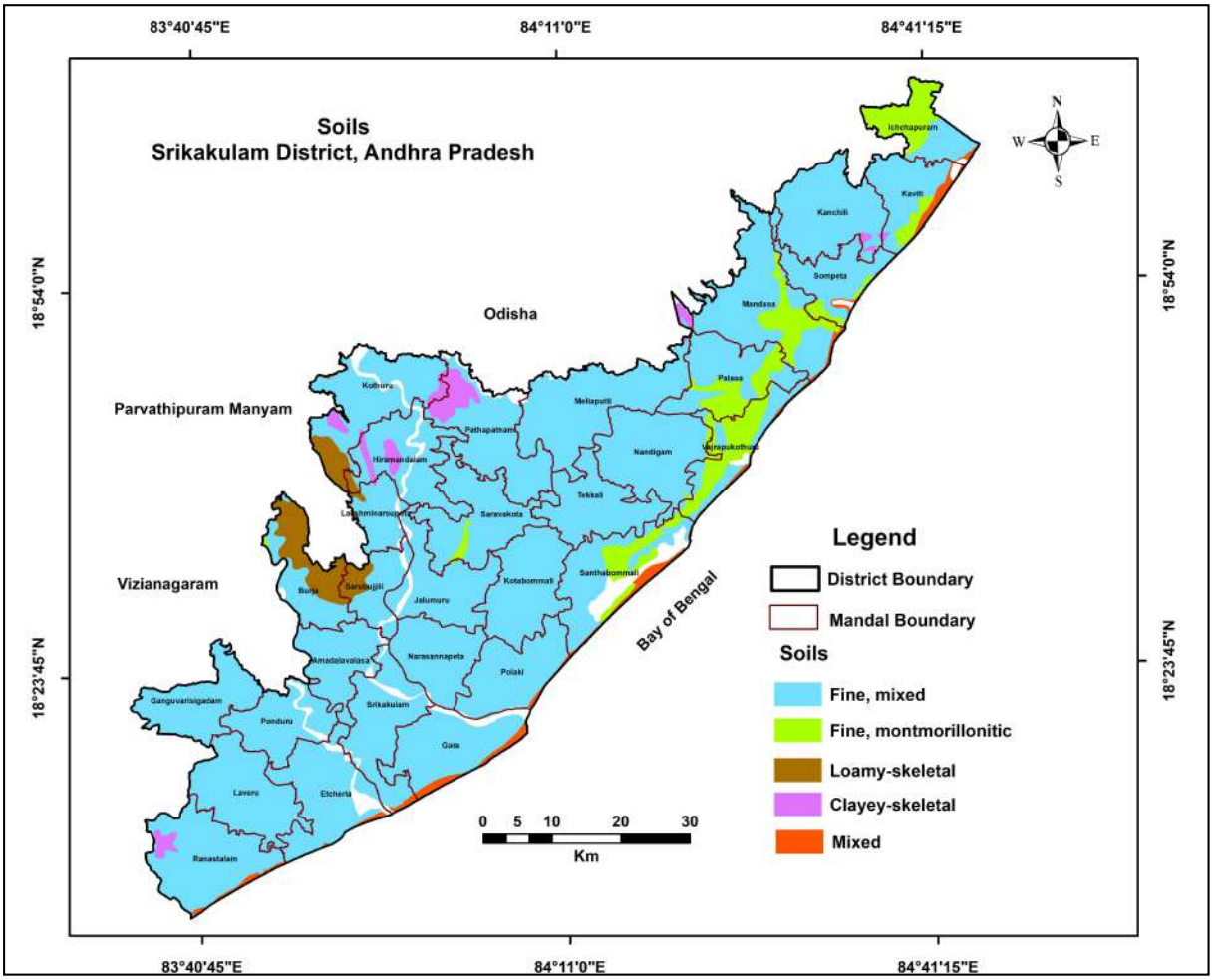


Fig.1.6: Soil map of Srikakulam District

1.10 Geology: Srikakulam district is underlain by geological formation ranging from older Archaean to Recent alluvium. The Pre-Cambrian rock include Banded Gneiss (43 %), Gneiss (9%), Khondalite (13%) and Charnockites (15%). The Gondwanas are represented by sandstones. The Sub-Recent to Recent formations comprise laterites (1%) to Alluvium (19%). **(Fig.1.7)**

Table- 1: Geological Succession in Srikakulam District

Age	Formation	Lithology
Recent	Alluvium	Sands, gravels, silt and occasional clays
Sub-Recent	Laterite	Laterite derived from crystalline formation
Gondwanas	Sandstones	Sandstones and clays
Pre-Cambrian	Charnockites, Khondalites and BG	Granite Gneisses, Charnockites, Garnet Sillimanite Gneiss, Cordierite Sillimanite Gneiss

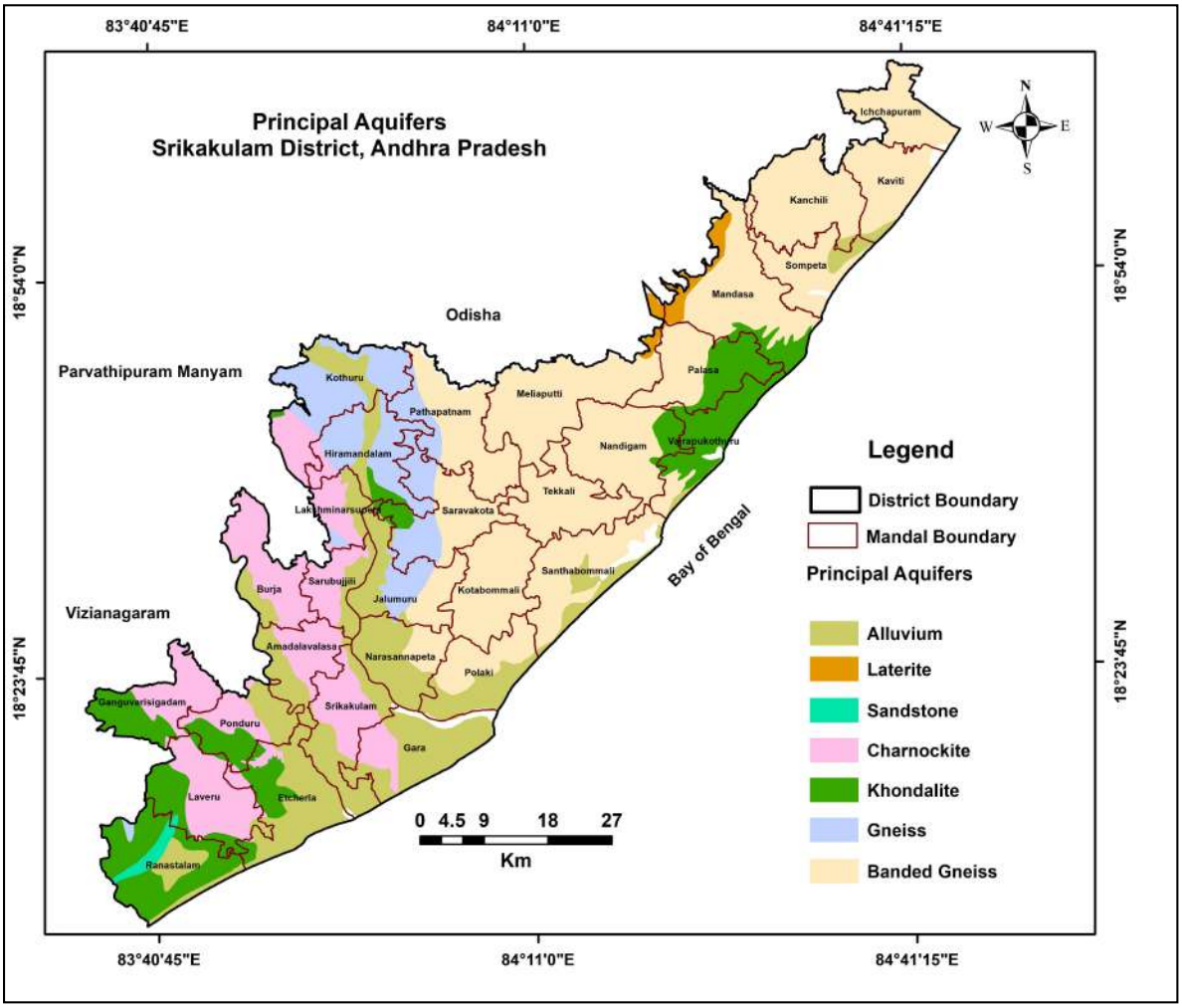


Fig.1.7: Geology of Srikakulam District

2. DATA COLLECTION AND GENERATION

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

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

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

2.1 Hydrogeological Studies:

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement, and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifer in the area is Banded gneisses, Gneiss Charnockite and Khondalite and alluvium, The occurrence and movement of ground water in these hard rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering and in alluvium it is controlled by primary pores. Based on 334 hydrogeological data points **(Fig.2.1)** hydrogeological map is prepared. The details of data availability is given bellow-

Organisation	Water Level	Water Quality		Aquifer Geometry		
		NHS	Key Wells	EW	Well Inventory	VES
CGWB	21	31	41	34	91	87
State GW Dept.	29	-		-	-	-
Total	50	72		34	91	87

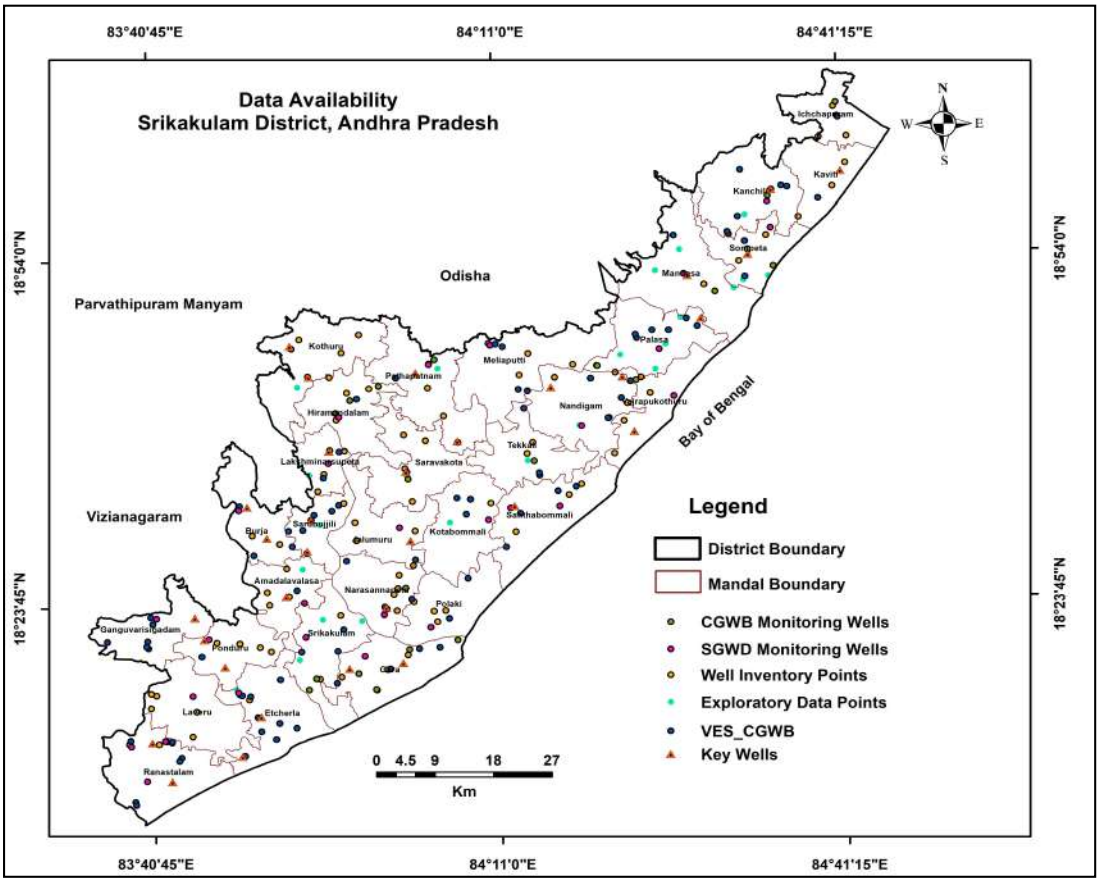


Fig. 2.1: Hydrogeological data availability.

2.1.1 Ground Water occurrences and movement: Ground water occurs under unconfined and semi-confined/confined conditions and flows downward from the weathered zone 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 60 m depth. The potential fracture zones were encountered within the depth range of 20 to 60 m only. At some location like Jalantrakota, Mamidipelli, Besi Ramachandrapuram, Nadimivalasa, the potential fractures were encountered between 110 to 167 m bgl. The discharge in the exploratory wells vary from meagre to as high as 8.19 lps with general occurrence of 2-3 lps. . The hydrogeological map of the area is presented in **Fig. 2.2.**

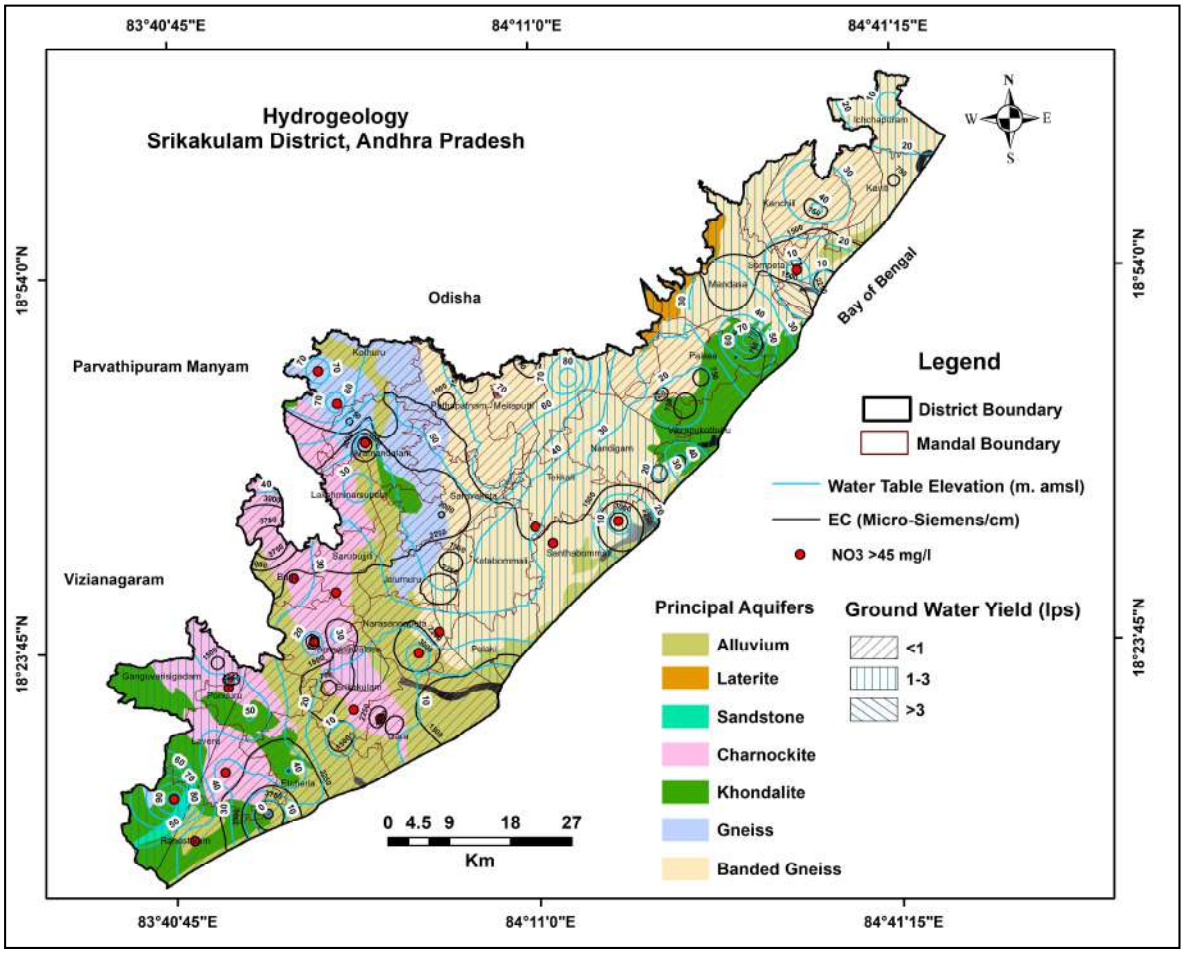


Fig.2.2: Hydrogeological map of Srikakulam District.

2.1.2 Exploratory Drilling: CGWB drilled 34 no's bore wells (28 no's exploratory and 06 no's observation) in the district. 18 wells were drilled in Banded Gneisses and Gneisses, 08 wells in Khondalites, 05 wells in Charnockites and 03 wells in alluvium. Data analysed from CGWB wells indicates, depth ranges of wells are 19.2-200 m. The deepest fracture was encountered at 167 m. bgl at Nadimivalasa, G.Sigadam mandal.

2.1.3 Ground water Yield: Ground Water yield of Principal aquifers varies varies from <0.1 to 8.19 lps (avg: 1.30 lps). The low yield (<1 lps) occurs in ~59 % of area, 1 to 3 lps yield occurs in ~41 % of area covering district. (**Fig.2.3)**

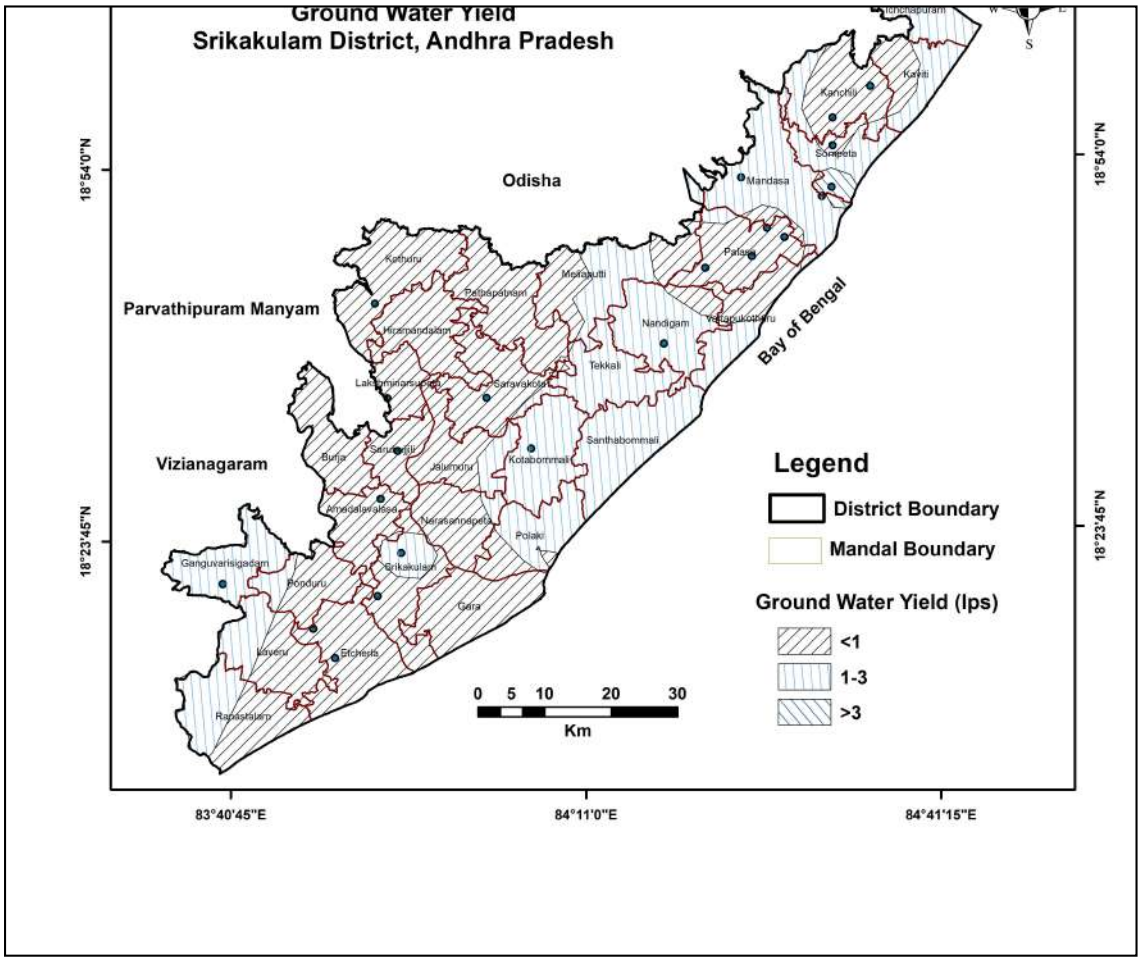


Fig.2.3: Ground Water Yield Potential Map of Srikakulam District.

2.2 Water Levels: Ground water levels from 50 Wells (CGWB: 21 and SGWD: 29) were monitored for pre-monsoon and post-monsoon season.

2.2.1 Water Table Elevations: During pre-monsoon season, the water-table elevation ranges from 3.56 – 94.1 meter above mean sea level (m amsl) and general ground flow is towards NW to SE directions of the district. (**Fig.2.4**)

2.2.2 Depth to Water Levels (DTWL): The average DTWL of 10 years (2013 to 2022) for pre-monsoon and post-monsoon were analysed, the avg. DTWL varies from 2.35 to 27.25 meter below ground level (m bgl) (average: 6.59 m bgl) and 0.70 to 25.95 m bgl (average: 5.08 m bgl) during pre-monsoon and post-monsoon seasons respectively.

Pre-monsoon season: Majority of the water levels during this season are in the range of 5.0 to 10 m covering 68% of the area, followed by 2.0 to 5.0 m bgl (26%) and >10 m bgl (6%). The water levels > 10 m.bgl occupy in parts of Palasa, Ranasthalam, Kanchili and Etcherla mandals. (**Fig.2.5**)

Post-monsoon season: Majority of the water levels during this season are in the range of 2.0 to 5.0 m bgl covering 76% of the area, followed by 5.0 to 10 m bgl (16%), < 2.0 m bgl (2%). The water levels > 10 m bgl occupy about 6 % of the area falling in parts of Kanchili and Ranasthalam mandal. Shallow water level < 2.0 m bgl occupy in parts of G. Sigadam, Nandigam, LN Peta, Gara, Ranasthalam, Mandasa, Srikakulam, Hiramandalam and Polaki mandals. (**Fig.2.6**)

2.2.3 Water Level Fluctuations (May vs. November): The water level fluctuations vary from -5.97 to 8.58 m with average rise of 2.17 m (**Fig.2.7**). The water levels rise is observed in district except in parts of Kanchili & Gara Mandals. Rise in water level range of <2 m covers majority of the area with 54 % followed by >4 m rise in 42% of the area followed by 2-4 m rise in 3% of the area.

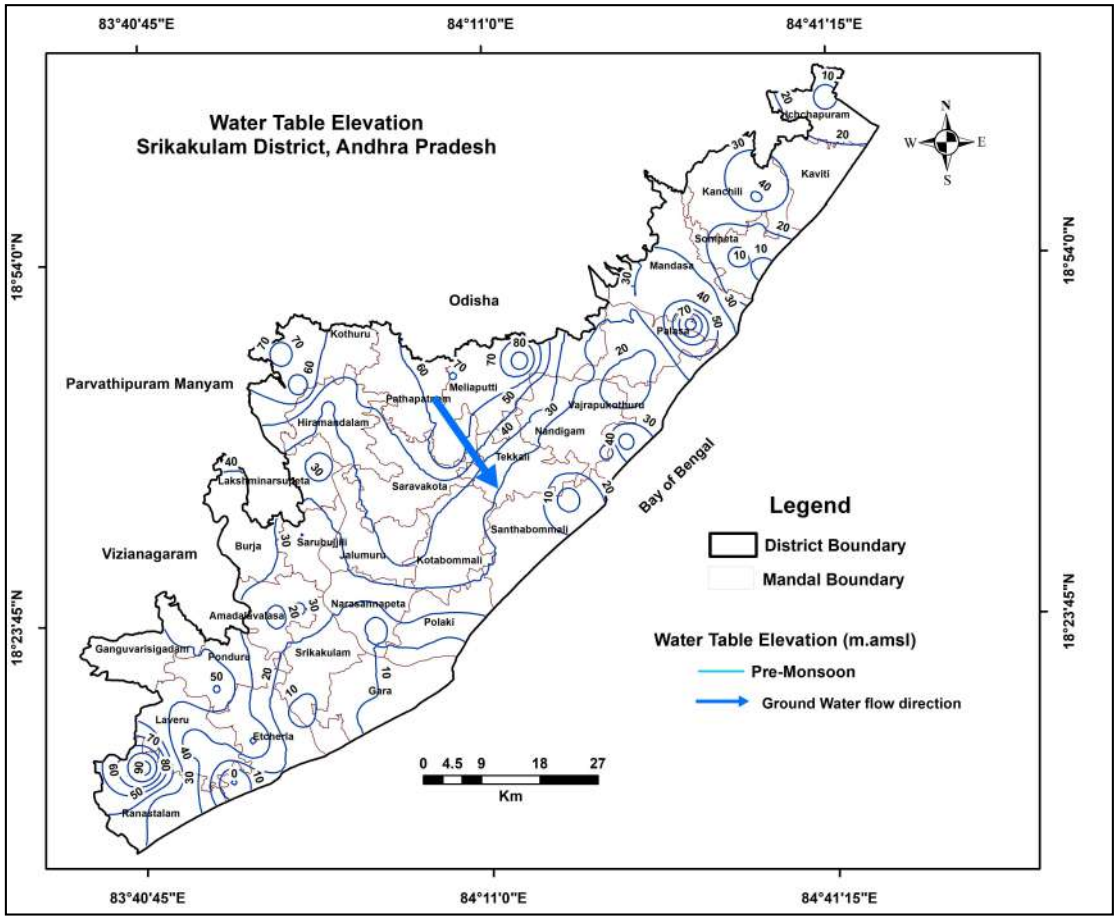


Fig.2.4: Water table elevations (m amsl) during pre-monsoon season

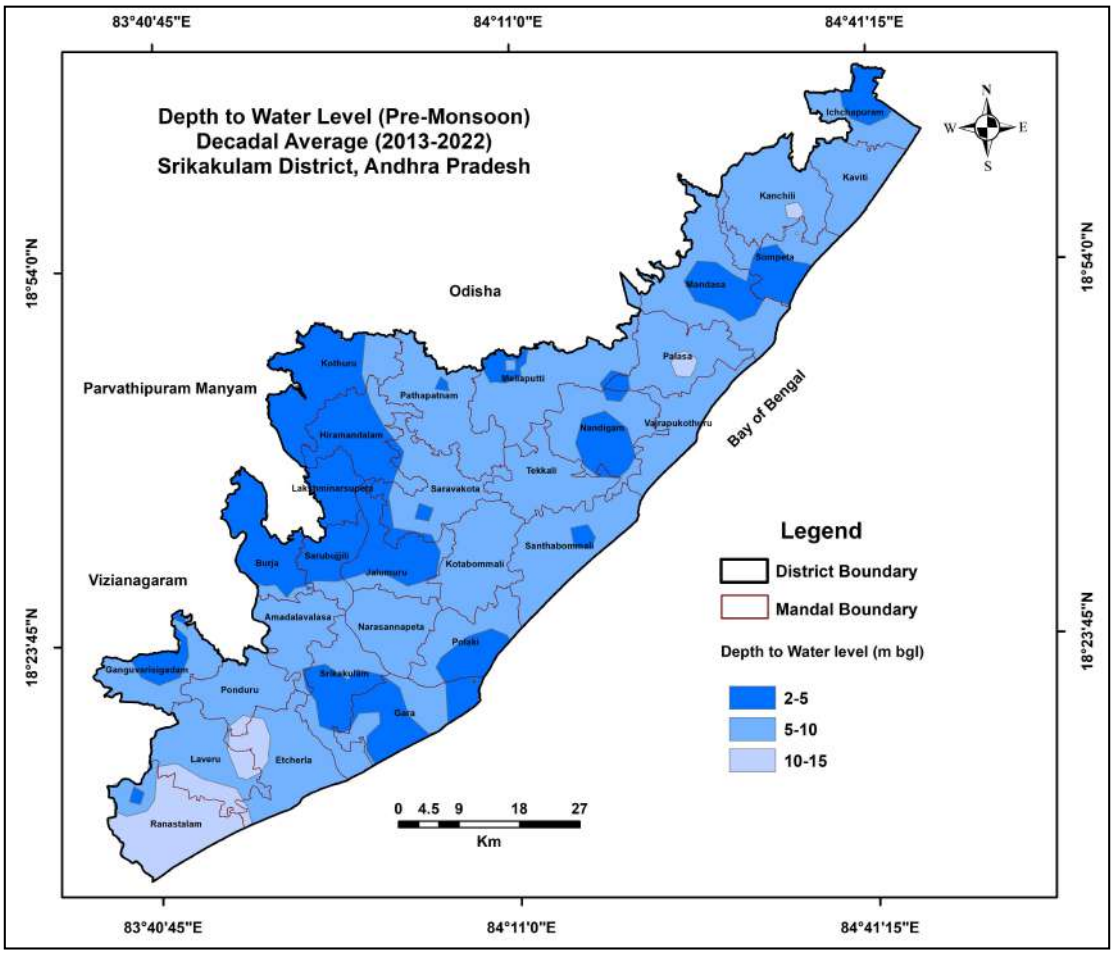


Fig.2.5: Depth to water levels Pre-monsoon (Decadal Average).

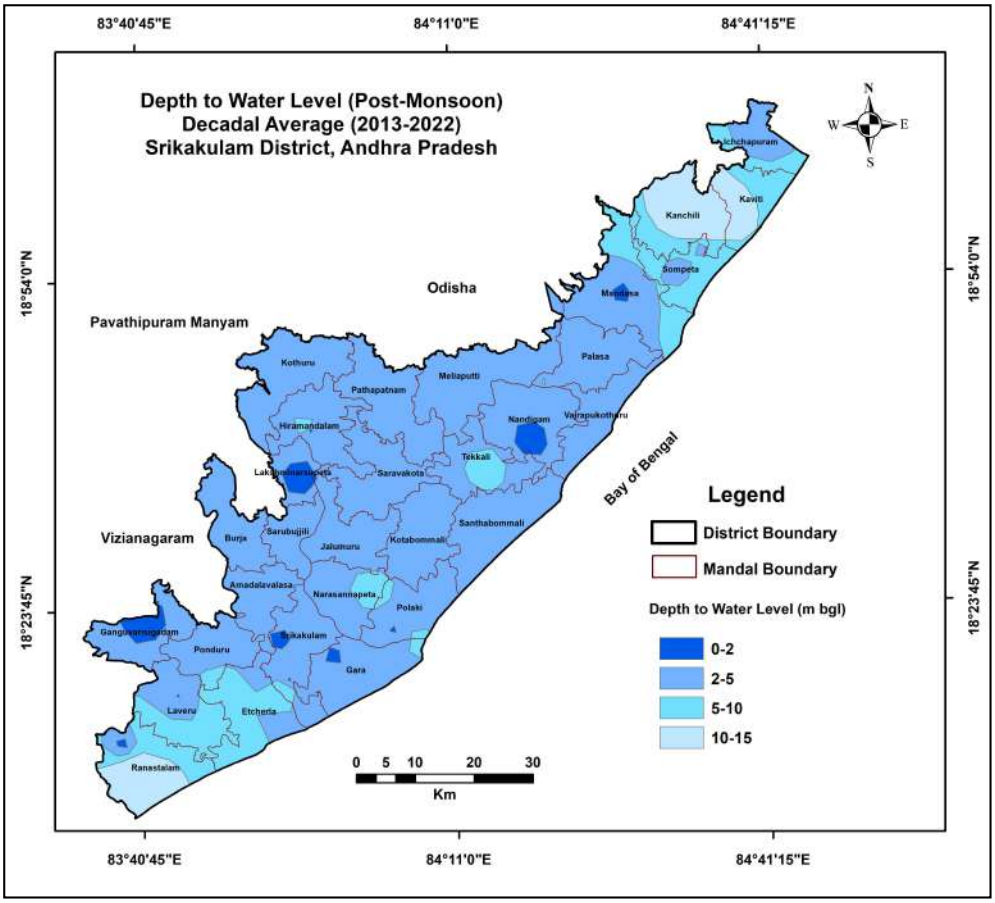


Fig.2.6: Depth to water levels Post-monsoon (Decadal Average).

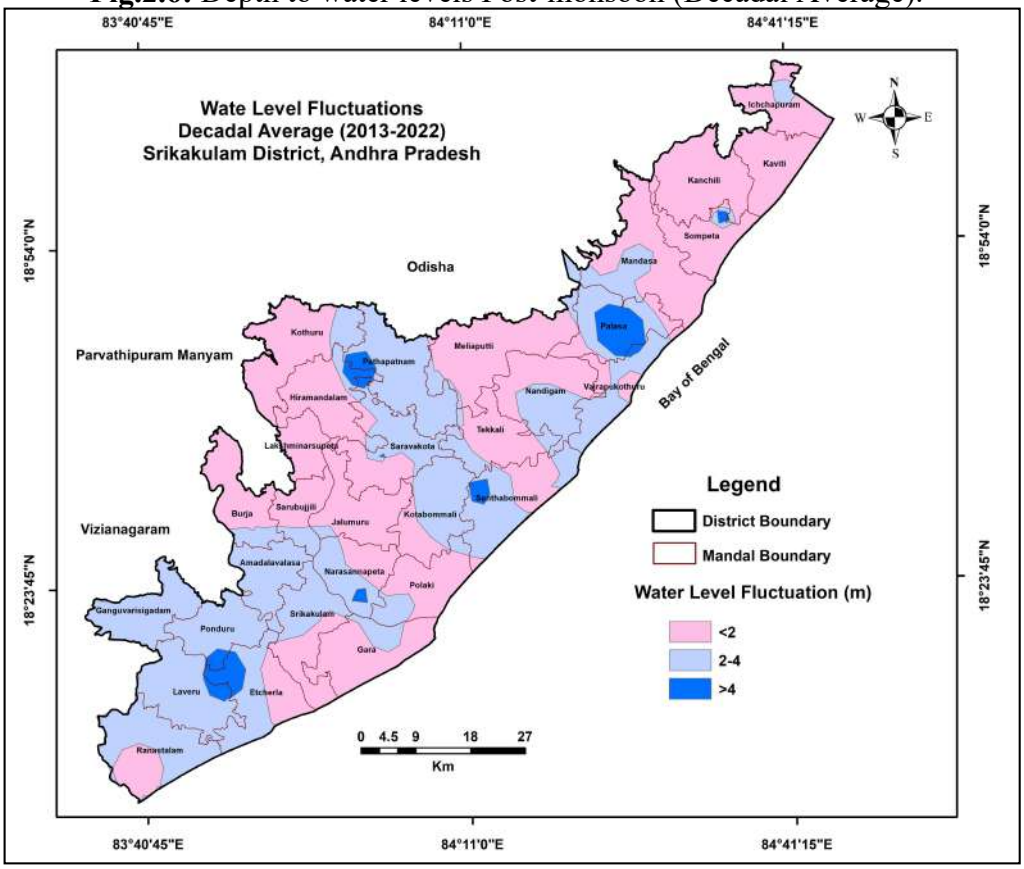


Fig.2.7: Water Level Fluctuations (m) (Nov with respect to May).

2.3 Hydro chemical Studies

To understand chemical nature of groundwater, 72 water sample data (CGWB monitoring well-41, Key Well-31) during the pre-monsoon season of 2022 are collected and analysed for 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.

2.3.1 Pre-monsoon:

Groundwater from the area is mildly alkaline to alkaline in nature with pH in the range of 6.74-8.15 (Avg: 7.49). Electrical conductivity varies from 190-4500 (avg: 1656) µ Siemens/cm**.** In 53 % of area EC is within 1500 - 3000 µ Siemens/cm; in 43 % area, it is 750-1500 µ Siemens/cm; in 3 % area it is > 3000 µ Siemens/cm; in 1 % area and EC is <750 µ Siemens/cm, (**Fig.2.8).** Nitrate concentration in 71% of samples is beyond permissible limits of 45 mg/L, varies between 0.53 – 278.3 mg/L (**Fig.2.9**). Fluoride concentration varies from 0.06-1.45 mg/L and all samples falling under permissible limits of 1.5 mg/L (**Fig 2.10**).

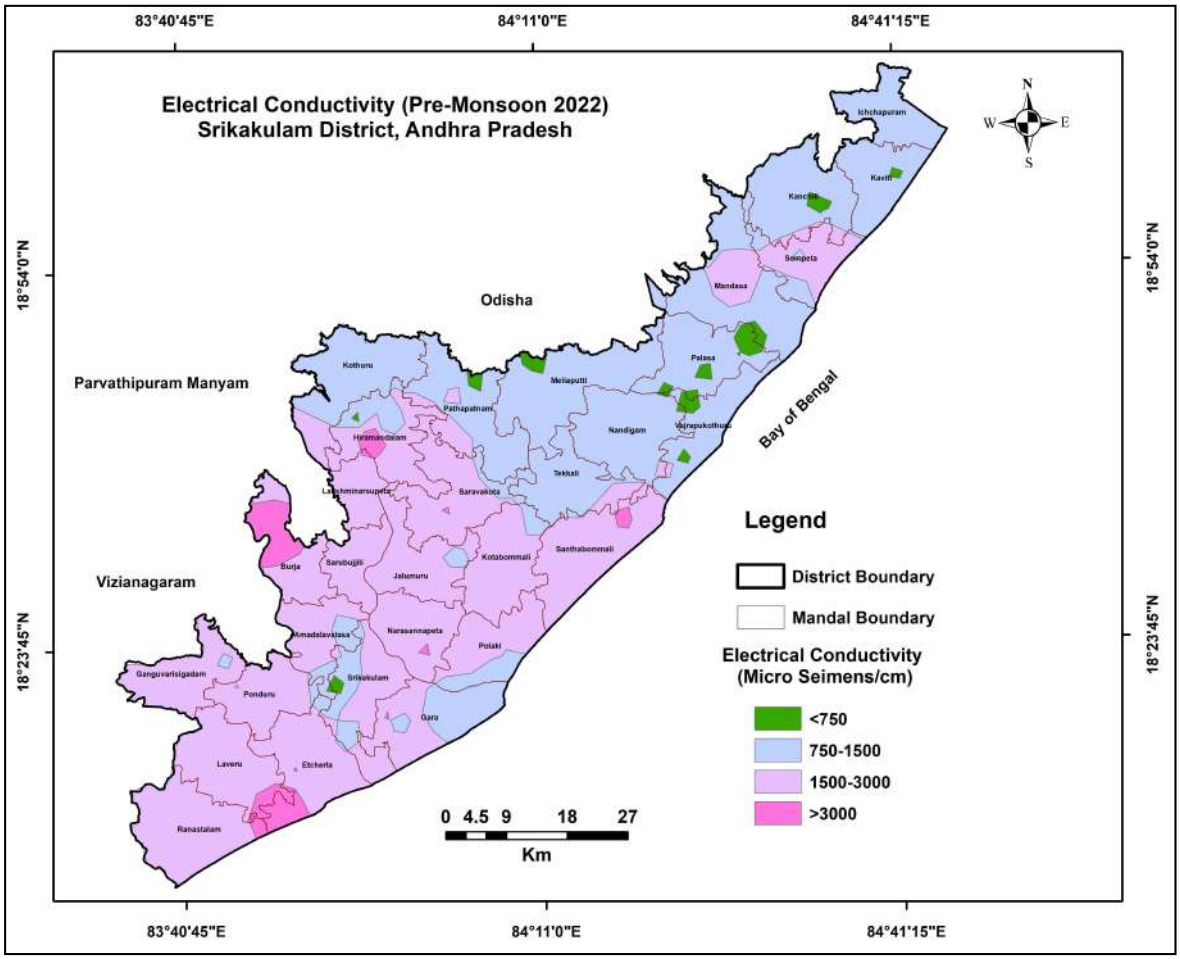


Fig.2.8: Distribution of Electrical conductivity (Pre-monsoon)

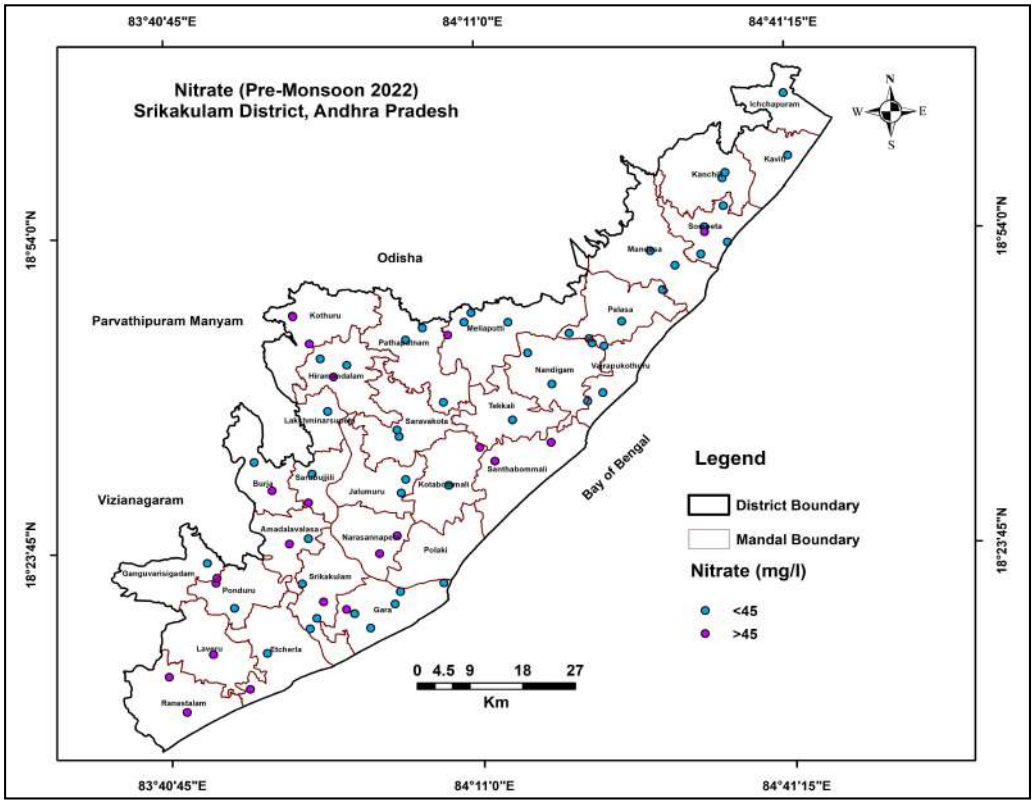


Fig.2.9: Distribution of Nitrate (Pre-monsoon).

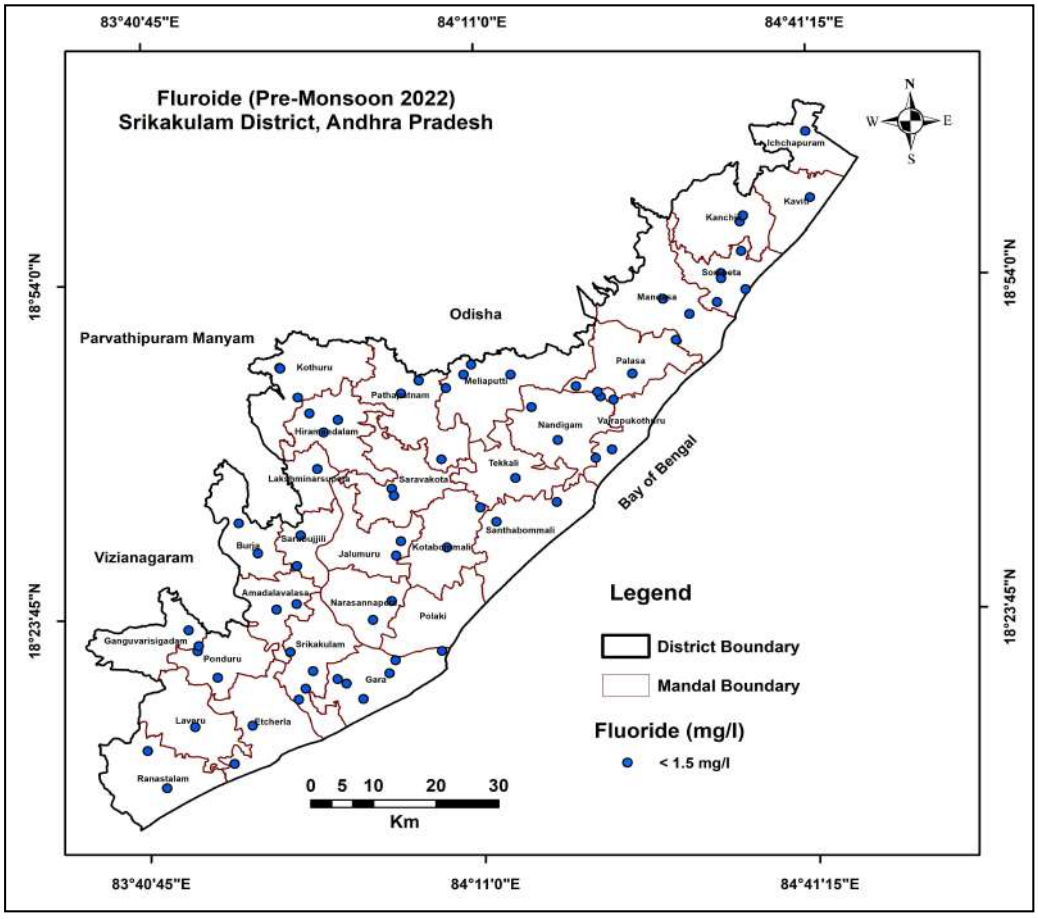


Fig.2.10: Distribution of Fluoride (Pre-monsoon).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 212 data points (both hydrogeological and geophysical down to 200 m) for preparation of 3-D map 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-17 software and generated 3-D map for Srikakualm district (**Fig.3.1)** and hydrogeological sections.

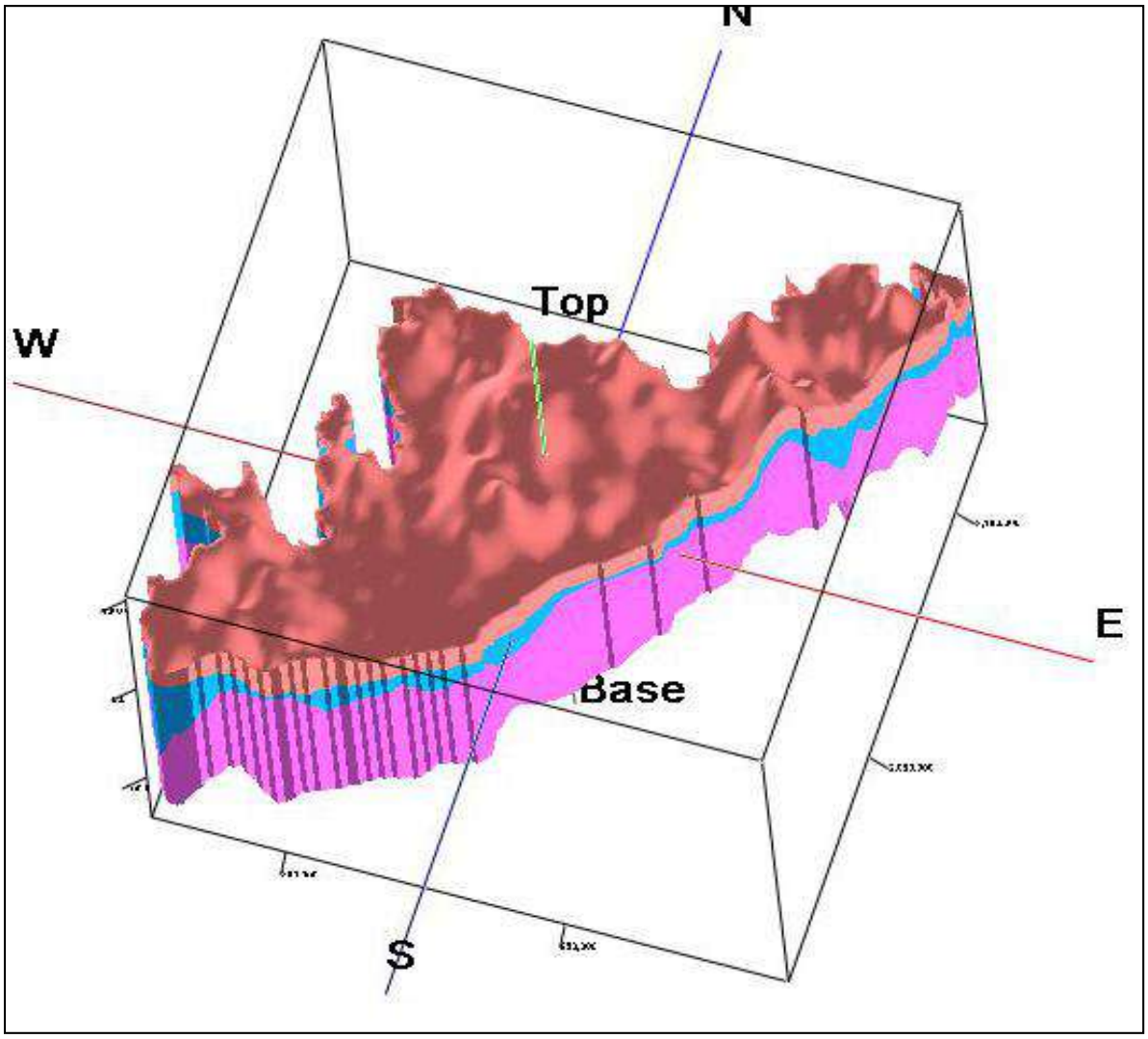


Fig.-3.1:3D Aquifer Disposition of Srikakulam District.

3.1 Hydrogeological Sections

Hydrogeological sections are prepared in A-A' and B-B' directions (**Fig.3.2**).

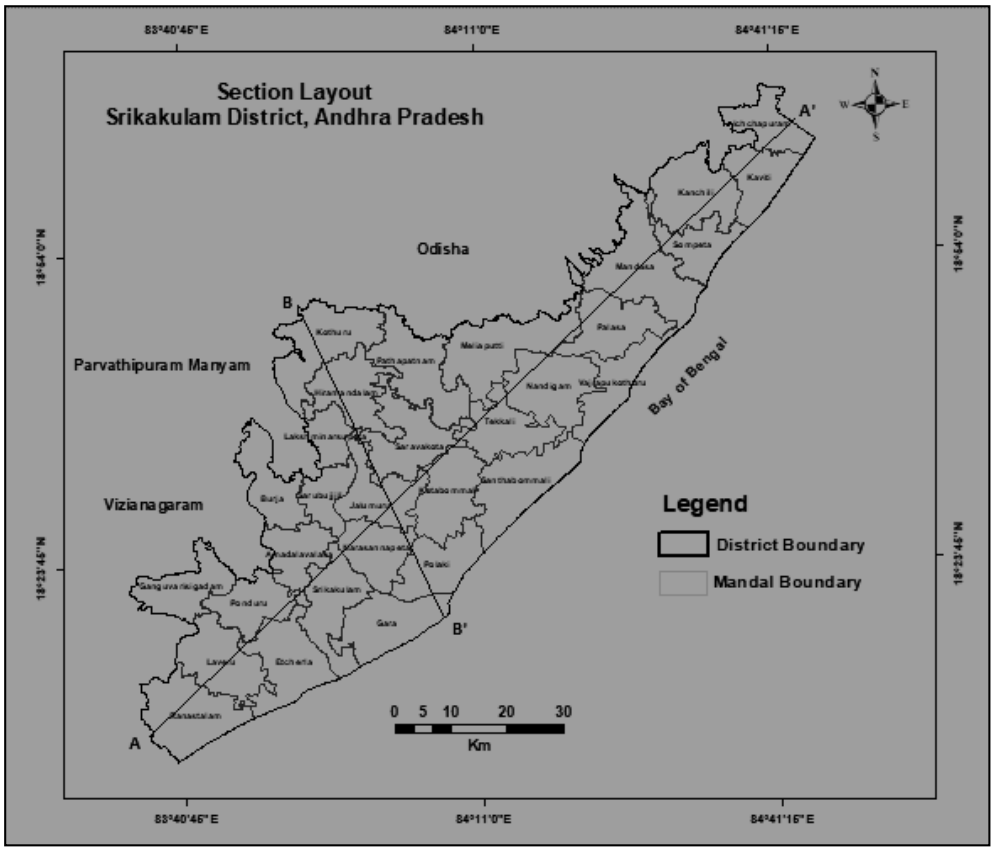


Fig.-3.2: Map showing orientation of hydro geological Sections

150

Fig.-3.2a: Hydrogeological Cross Section SW to NE

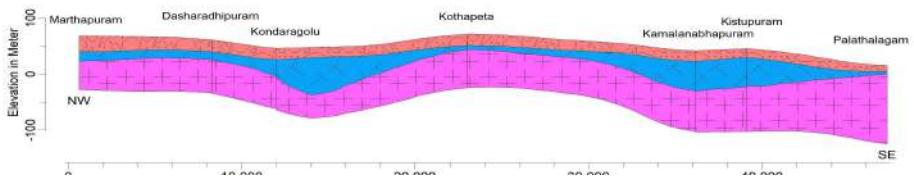


Fig.-3.2b: Hydrogeological Cross Section NW to SE

3.2 Aquifer Characterization

3.2.1 Weathered zone: The Weathered zone varies from 3 to 38 m. bgl in Srikakulam with an average of ~21 m. Spatial distribution of weathering depth zone map is given in **Fig.3.3**. Thickness of weathered zone is in the range of 20 - 30 m in most part of area covering ~57 % of area, 10 – 20 m weathering thickness occurs in ~40 % of the area and shallow (<10 m) and deeper (>30 m) weathering occurs in rest of the area.

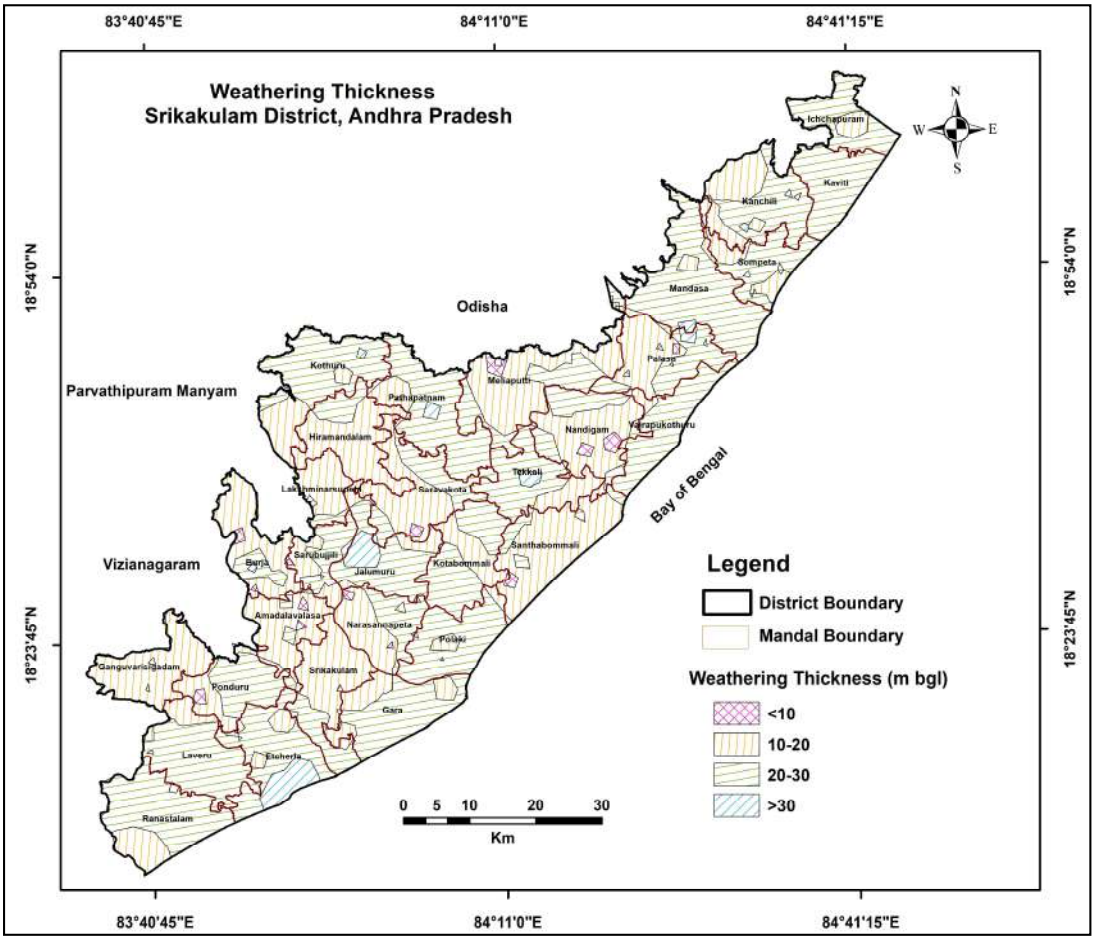


Fig.3.3: Depth to weathered zone

3.2.2 Fractured zone:

The Occurrence of fractures are discrete and more predominant fractures occurrence is in between the range of 20 to 40 m (44 %), followed by 40 to 60 m (39 %),60 to 80 m (10 %) and deep fractures >80 m occurs in 2 % area.

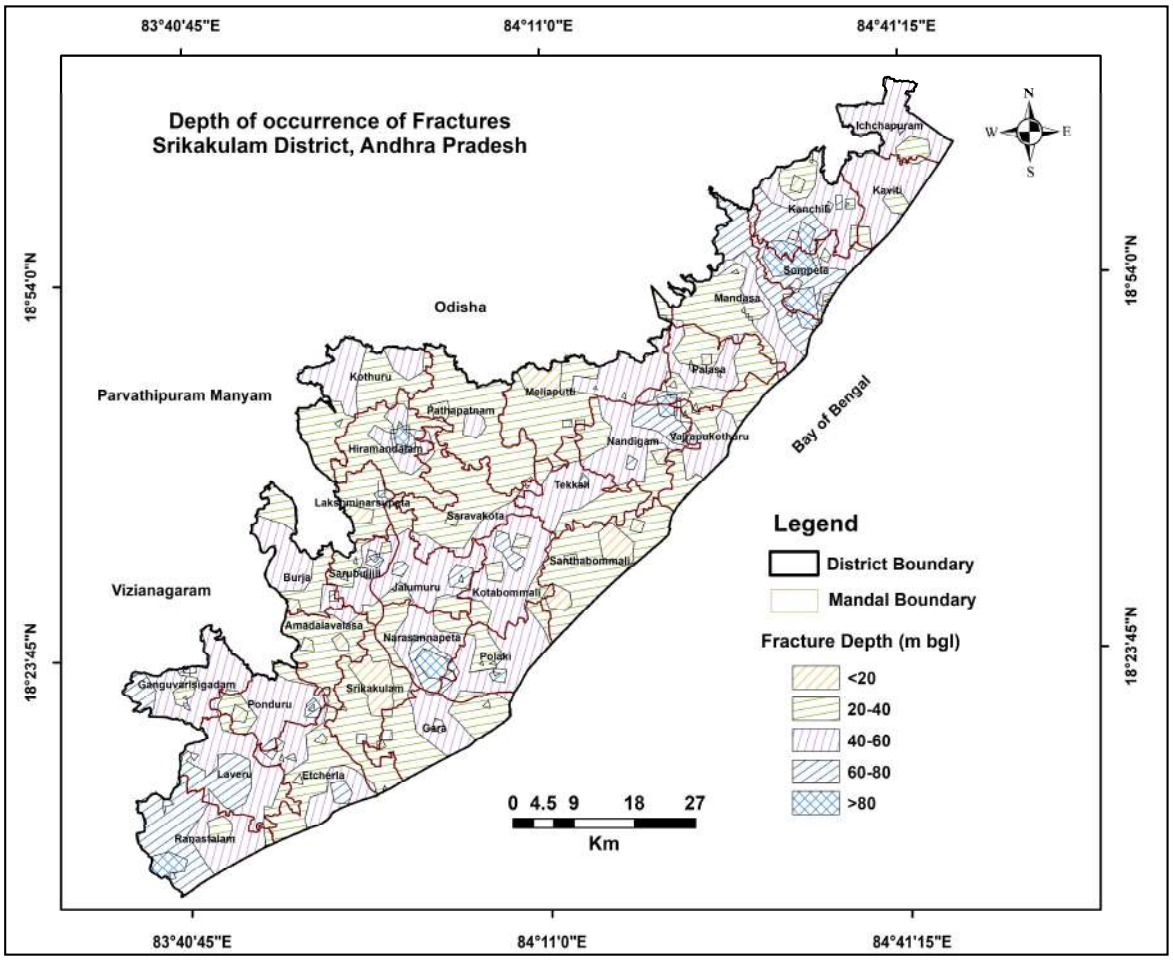


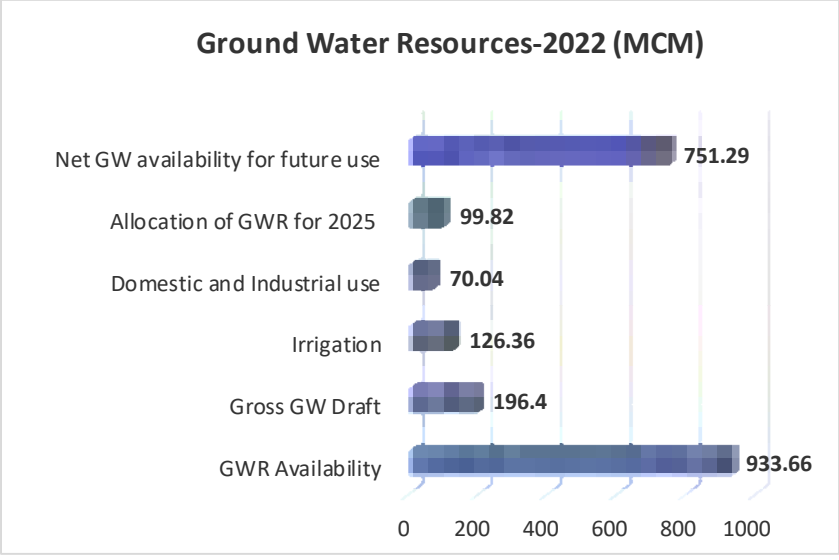
Fig.-3.4: Depth of Fractured zone

4.0 GROUND WATER RESOURCES (2022)

The net dynamic replenishable groundwater availability is 933.66 MCM, gross ground water draft for all uses is 196.4 MCM, provision for drinking and industrial use for the year 2025 is 99.82 MCM and net annual ground water potential available for future use is 751.29 MCM. Stage of ground water development is 21%. The summarized mandal wise resources are given in Table-4.1. All Mandals in the district are categorized are safe. The details of Ground Water resources are provided in Annexure-3 and 4.

Table-4.1: Computed Dynamic Ground Water resources, Srikakulam District.

Parameters	**Total (MCM)**
Dynamic (Net GWR Availability)	933.66
• Monsoon recharge from rainfall	414.28
• Monsoon recharge from other sources	382.29
• Non-monsoon recharge from rainfall	31.24
• Non-monsoon recharge from other sources	154.99
• Total Natural Discharge	49.14
Gross GW Draft	196.4
✓ Irrigation	126.36
✓ Domestic and Industrial use	70.04
Allocation of Ground Water Resource for Domestic Utilisation for projected year 2025	99.82
Net GW availability for future use	751.29
Stage of GW development (%)	20.8



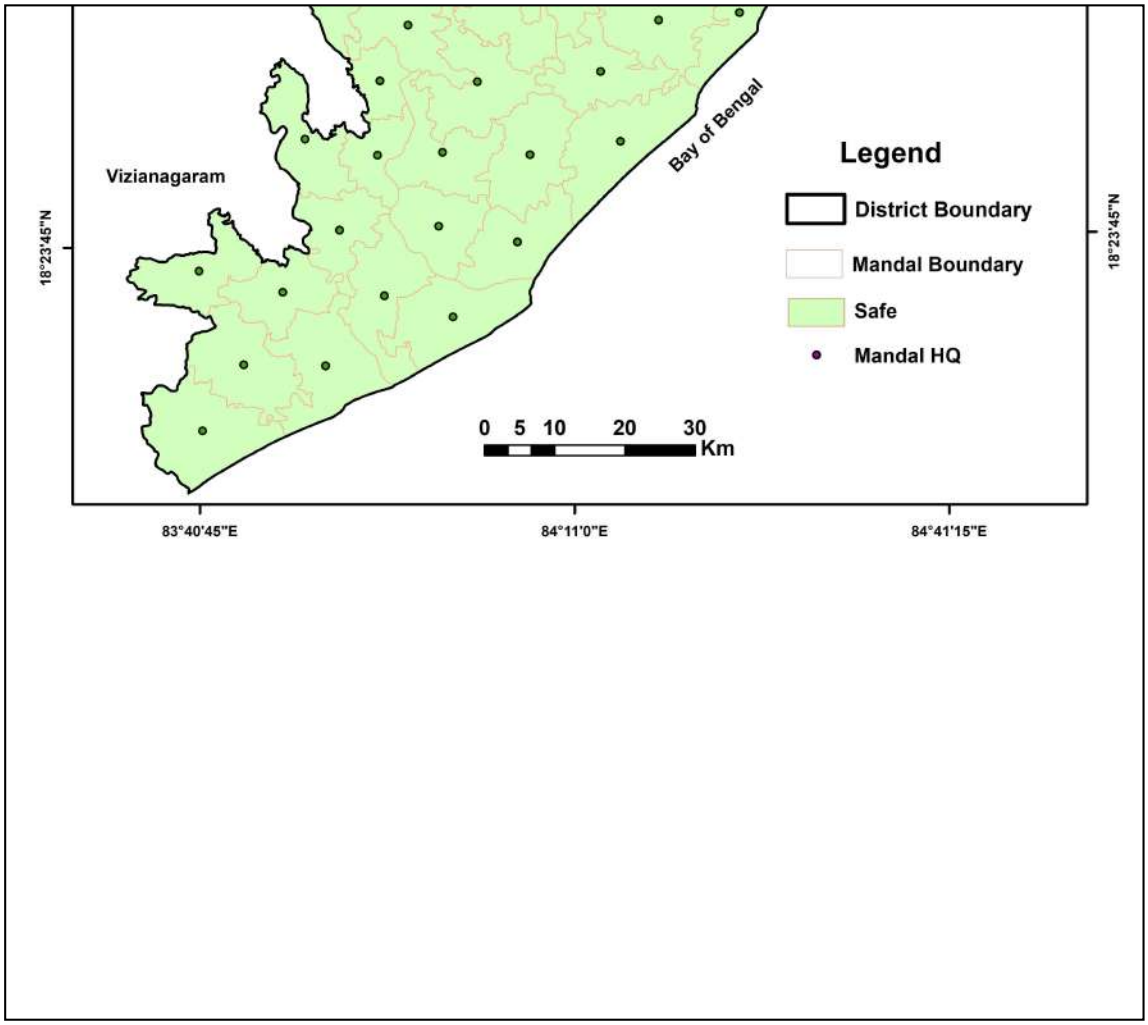


Fig 4.1-Categorisation of Mandals (GWRA-2022)

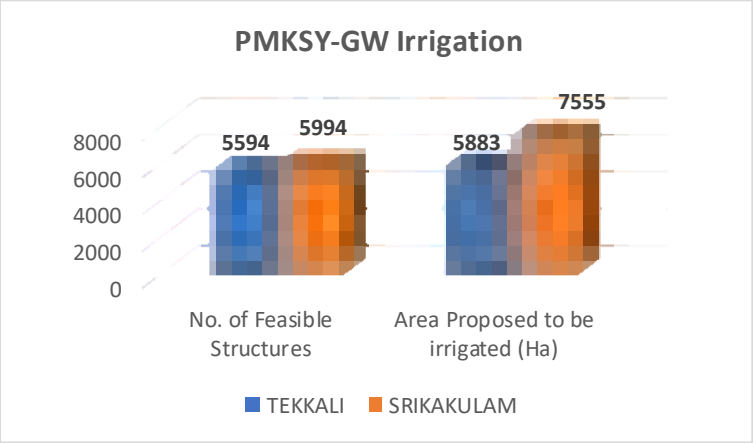
5. GROUND WATER DEVELOPMENT AND MANAGEMENT STRATEGIES

5.1. Groundwater Development:

At present the ground water abstraction in the district is quite low (21%) and there is a scope for further ground water development for irrigation. The total utilization of ground water is 196 MCM against the total ground water potential of 751 MCM available for future use. Ground water irrigation in the district is accounts only for 4 % of the net irrigation of the district.

Table 6.1: PMKSY- Proposal in Srikakulam district, AP

S.No	Mandal Name	No. of Villages	No. of Feasible Structures	Area Proposed to be irrigated (Ha)
1	Amadalavalasa	35	777	1078.52
2	Bhamini	15	436	761.67
3	Burja	34	368	438.16
4	Gara	13	547	965.57
5	Hiramandalam	29	387	504.59
6	Ichchapuram	16	390	389.68
7	Jalumuru	38	507	738.56
8	Kanchili	51	689	695.99
9	Kothuru	28	691	822.62
10	Laxminarasampet	43	516	670.55
11	Mandasa	65	1398	1398.55
12	Meliaputti	37	523	521.32
13	Nandigam	60	408	407.80
14	Palakonda	31	234	233.93
15	Palasa	34	354	353.98
16	Pathapatnam	28	101	99.40
17	Polaki	29	532	666.70
18	Regidiamadalavalasa	38	1438	1584.84
19	Santhabommali	28	652	701.81
20	Santhakaviti	39	749	996.59
21	Saravakota	30	763	763.30
22	Sarubujjili	30	345	509.41
23	Seethampeta	58	258	257.30
24	Sompeta	22	287	285.95
25	Srikakulam	13	444	514.88
26	Tekkali	38	486	486.53
27	Vajrapukothuru	43	423	424.58
28	Vangara	27	723	724.34
29	Veeraghattam	34	1118	1119.08



5.2. Groundwater Management Strategies:

5.2.1. Supply Side Measures:

Artificial Recharge:

Government of Andhra Pradesh had already created a total of 4728 recharge structure (4025 Check dams and 703 percolations tank) though MGNREGS and IWMP scheme. At present, 1 artificial recharge structure exist per square km area in the district. Considering this, it is recommended that the existing CD's and PTs shall be desilted and maintained. An additional 306 no. of check dams and 196 no. of percolations tanks are recommended to construct in the gaps and as per feasibility. The sites are pinpointed on the map and provided in Fig 5.3

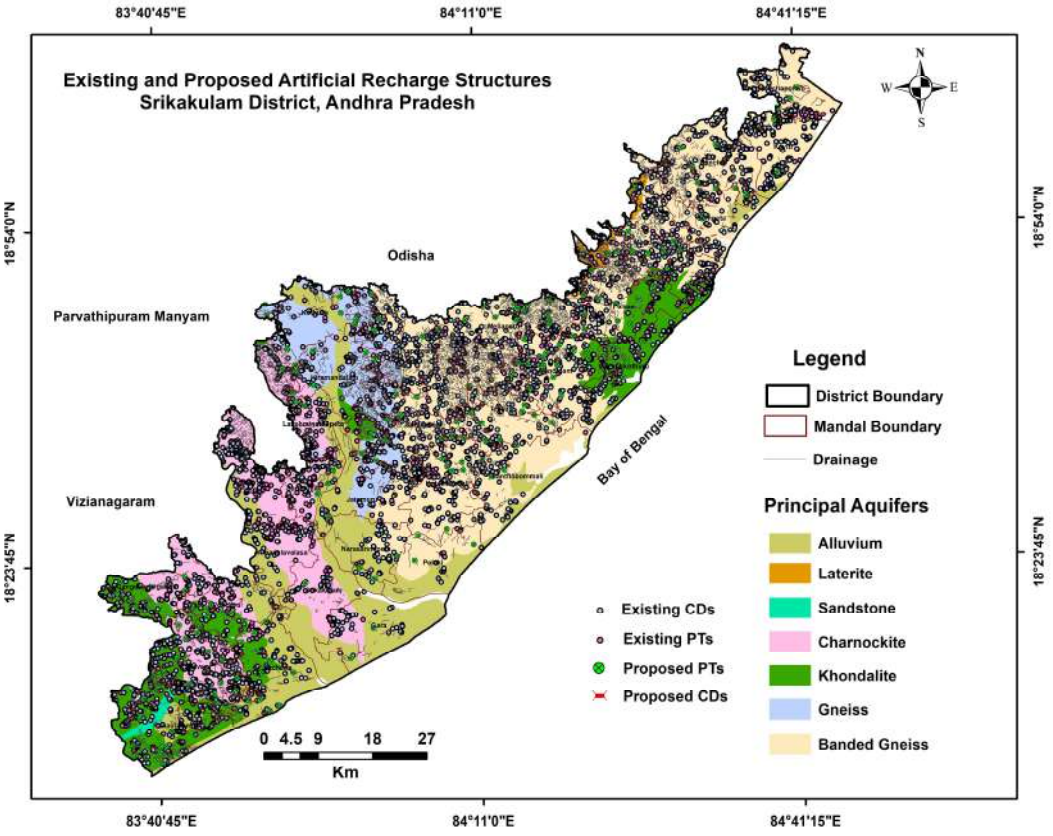


Fig 5.2-Existing and Proposed Artificial Recharge Structures of Srikakulam District

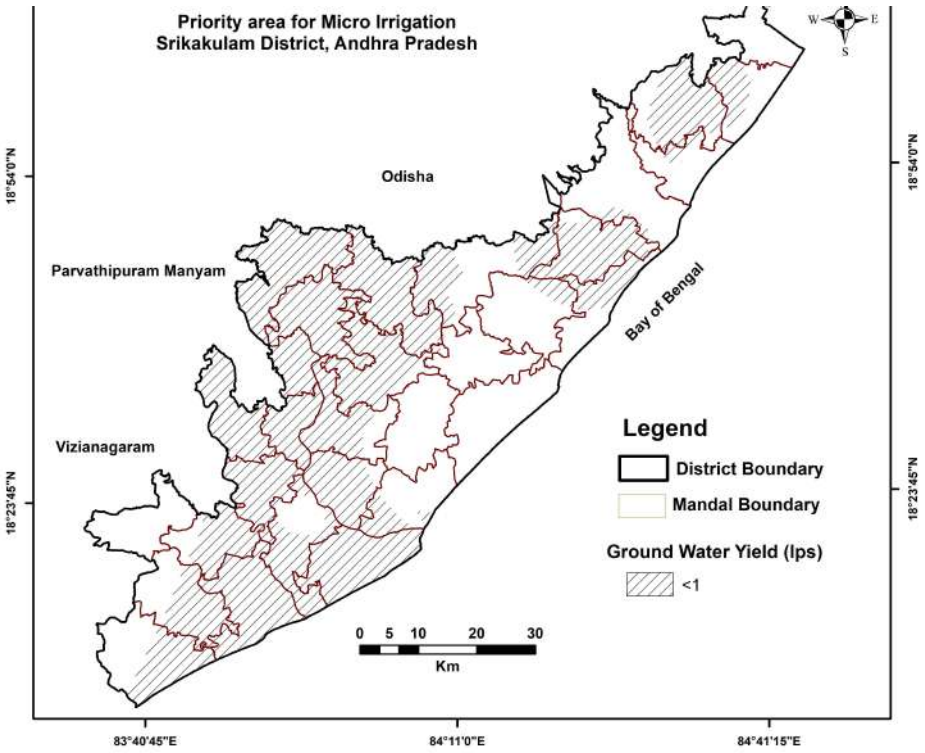


Fig 5.4-Priority Area for Micro-Irrigation of Srikakulam District.

5.2.2. Demand Side Measures:

Micro-irrigation: The yield of bore well is <1.0 lps in 59 % of the district is due to hard/ crystalline rocks and kaolinization of weathering, low interconnection among fractures and fracture becomes closed by clay due to chemical dissolution action of weathered portion in khondalite formation. As sustainability of bore well is low, the sprinkler and drip irrigation system with suitable cropping pattern wherever feasible may be practiced as a measure for groundwater conservation, protection and management.

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Acknowledgment

The author thanks to Sri J Siddhardha Kumar, Regional Director (I/C), CGWB, Hyderabad, Sri Ravi Kumar Gumma, Scientist- 'D' & OIC for their encouragement and guidance. The author sincere gratitude towards Sri LN Damodar (Scientist-'C'), Sri Md Sarif Khan (Scientist-'C'),) and Dr. D Anantha Rao, (AHG) for their valuable help in preparation of various maps and model generation. The author acknowledges State Ground Water Department, Govt of Andhra Pradesh for making available of field data.

ANNEXURE-1

Key Wells location and Depth to Water levels in Srikakulam District

Sl no	Latitude	Longitude	Village	DTW (mbgl)	Type
1	19.0184	84.6916	Kaviti	21.2	BW
2	18.9926	84.5896	Kanchili	2.82	DW
3	18.8984	84.5545	Brahmini Korlam	6.6	DW
4	18.8689	84.4658	Mandasa	4.04	DW
5	18.8066	84.4846	Gurudas Puram	13.3	BW
6	18.723	84.3688	Undrukudia	6.8	DW
7	18.6432	84.3849	Amlapadu	12.8	BW
8	18.5367	84.2082	Santhabomali	3.95	DW
9	18.7087	84.264	Kallada	7.02	DW
10	18.632	84.1263	Temburu	6.97	DW
11	18.7323	84.0667	Buragam	3.22	DW
12	18.5888	84.0504	Saravakota	8.1	DW
13	18.4878	84.0557	Rana	4.48	DW
14	18.3912	84.0192	Komarthi	10	BW
15	18.1413	83.7042	Patharlapalli	10.2	BW
16	18.1769	83.8067	Kuppili	8.55	BW
17	18.2342	83.835	SSR Puram	7.5	BW
18	18.3026	83.9643	Lingavalasa	10.5	BW
19	18.3102	84.0427	Koyyanipeta	3.65	DW
20	18.4744	83.9051	Rotta valasa	8.04	DW
21	18.5203	83.9116	Savala Puram	14	BW
22	18.4088	83.8735	Korlakota	11.2	BW
23	18.4942	83.8466	Latchayyapeta	7.7	BW
24	18.5399	83.8183	AP Peta	3.8	BW
25	18.6199	83.9386	LN Peta	8.4	BW
26	18.7283	83.9106	Yenniramanna Peta	6.15	BW
27	18.7736	83.8836	Parapuram	6.45	DW
28	18.3795	83.7401	Santha Urity	3.02	DW
29	18.3475	83.7536	Ponduru	7.55	BW
30	18.3072	83.7832	Lolugu	10.9	BW
31	18.1981	83.6759	Kondamulagam	3.5	BW

ANNEXURE-2

Exploratory well details in Srikakulam district

Sl No	Location	Mandal	Longitude	Latitude	Lithology	Total Depth (m)	Casing	Deepest Fracture Depth (m)	Discharge (lps)	Drilling Year
1	Ambogam	Sompeta	84.533	18.850	Khondalite	52.0		27	2.20	1970
2	Balaga	Srikakulam	83.892	18.317	Chornokite	23.4			0.47	1973
3	Baruva	Sompeta	84.584	18.867	Chornokite	22.0				1974
4	Budambo colony	Mandasa	84.419	18.877	Khondalite	81.4	26	25	2.10	1999
5	Chinnabadam	Palasa	84.417	18.733	Khondalite	33.3		27		1973
6	Chipi	Mandasa	84.454	18.907	Gneiss	166.7	17	18		1998
7	Irapadu	Kothuru	83.894	18.714	Gneiss	200.0	13	18	0.59	2000
8	Karajada	Narasannapeta	83.983	18.372	Charnokite	43.0		21	0.00	1970
9	Kothapeta	Kothabommali	84.113	18.514	Khondalite	37.5	18	18	1.79	1998
10	Kothapeta	Kothabommali	84.113	18.514	Khondalite	172.8	22	20	1.79	1998
11	Nandigama	Nandigaon	84.305	18.653	Gneiss	188.9	8	64	1.49	1998
12	Ondrajola	Sarabujijili	83.910	18.585	Gneiss	172.8	6	9	0.22	1999
13	Ondrajola	Sarabujijili	83.910	18.585	Gneiss	131.0	9	10	0.21	1999
14	Patapatnam	Patapatnam	84.099	18.738	Gneiss	123.0		19		2000
15	Savarakota	Savarakota	84.051	18.583	Gneiss	200.0	13	15	0.22	1999
16	Savarakota	Savarakota	84.051	18.583	Gneiss	100.0	13	13	0.22	1999
17	Tekkali	Tekkali	84.228	18.603	Gneiss	63.0	24	45		1999

ANNEXURE-3

Mandal wise Recharge from various sources

Sl.No	Mandal	Recharge from Rainfall-Monsoon	Recharge from Other Sources-Monsoon	Recharge from Rainfall-NM	Recharge from Other Sources-NM	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
1	AMADALAVALASA	1149.02	916.27	60.64	204.58	2330.51	116.58	2213.94
2	BURJA	888.75	1277.78	56.27	467.46	2690.26	134.5	2555.76
3	ETCHERLA	1958.17	542.37	118.4	167.57	2786.51	139.31	2647.2
4	GANGUVARI SINGADAM	1037.41	873.27	89.68	200.69	2201.05	110.08	2090.97
5	GARA	2187.01	1473.17	169.03	261.69	4090.9	204.54	3886.36
6	HIRAMANDALAM	1258.66	503.39	132.59	222.07	2116.71	105.87	2010.84
7	ICHCHAPURAM	862.9	542.93	39.26	298.2	1743.29	87.19	1656.1
8	JALUMURU	1102.98	1392.9	132.62	611.68	3240.18	162.01	3078.15
9	KANCHILI	1766.46	1059.43	125.47	109.56	3060.92	153.1	2907.82
10	KAVITI	1392.73	218.29	29.29	30.74	1671.05	83.57	1587.48
11	KOTABOMMAL	1243.4	1676.06	88.36	559.48	3567.3	178.4	3388.9
12	KOTHURU	1832.03	998.02	212.32	166.34	3208.71	160.4	3048.31
13	LAVERU	816.76	611.59	67.33	529.2	2024.88	101.24	1923.64
14	LAXMINARASAMPET	1084.23	708.67	94.96	136.61	2024.47	101.24	1923.24
15	MANDASA	2223.22	706.26	156.64	172.09	3258.21	162.92	3095.29
16	MELIAPUTTI	1703.3	815.91	163.58	133.6	2816.39	140.85	2675.54
17	NANDIGAM	1388.7	1389.81	105.19	314.53	3198.23	159.93	3038.29
18	NARASANNAPETA	1278.2	1549.83	106.55	378.8	3313.38	165.74	3147.64
19	PALASA	1830.2	935.11	77.98	105.52	2948.81	147.45	2801.36
20	PATHAPATNAM	1199.72	1115.3	110.56	215	2640.58	131.99	2508.59
21	POLAKI	1392.13	1922.6	121.67	651.84	4088.24	204.45	3883.79

22	PONDURU	1164.64	751.64	158.96	55.31	2130.55	106.6	2023.95
23	RANASTALAM	1669.88	460.02	131.84	636.69	2898.43	144.97	2753.45
24	SANTHABOMMALI	1328.65	3513.08	75.45	1583.11	6500.29	324.98	6175.3
25	SARAVAKOTA	1926.2	1738.51	122.98	799.16	4586.85	229.36	4357.49
26	SARUBUJJILI	682.27	1498.51	56.88	419.28	2656.94	132.88	2524.06
27	SOMPETA	1372.2	586.24	90.91	126.36	2175.71	108.8	2066.91
28	SRIKAKULAM MANDAL	1413.51	1311.35	75.48	2374.51	5174.85	258.72	4916.13
29	TEKKALI	1184.11	6556.32	67.94	3412.33	11220.7	561.03	10659.67
30	VAJRAPUKOTHURU	1091.28	584.51	85.47	155.73	1916.99	95.85	1821.14

Mandal wise GW Extraction and ground water categorization ANNEXURE-4

Sl. No	Mandal	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Irrigation Use (Ham)	Industrial Use (Ham)	Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (OE/Critical/ Semi critical/Safe)
1	AMADALAVALASA	2330.51	116.58	2213.94	360.9219	0	117.504	478.42	280.55	1726.41	21.6	safe
2	BURJA	2690.26	134.5	2555.76	141.07	0	107.677	248.75	124.06	2290.64	9.7	safe
3	ETCHERLA	2786.51	139.31	2647.2	288.95	20.16	157.896	467.01	164.87	2174.14	17.6	safe
4	GANGUVARI SINGADAM	2201.05	110.08	2090.97	642.31	2.88	179.424	824.62	183.58	1262.18	39.4	safe
5	GARA	4090.9	204.54	3886.36	1274.926	0	202.104	1477.01	202.12	2409.35	38.0	safe
6	HIRAMANDALAM	2116.71	105.87	2010.84	292.2288	0	87.29816	379.52	358.88	1610.83	18.9	safe
7	ICHCHAPURAM	1743.29	87.19	1656.1	322.3816	5.76	217.5282	545.7	416.76	1081.29	33.0	safe
8	JALUMURU	3240.18	162.01	3078.15	152.606	0	90	242.63	137.01	2788.5	7.9	safe
9	KANCHILI	3060.92	153.1	2907.82	170.6097	0	266.436	437	266.47	2470.82	15.0	safe
10	KAVITI	1671.05	83.57	1587.48	9.268	0	208.72	218.06	208.72	1369.42	13.7	safe
11	KOTABOMMAL	3567.3	178.4	3388.9	1311.65	0	219.096	1530.73	219.11	1858.17	45.2	safe
12	KOTHURU	3208.71	160.4	3048.31	442.8884	0	210.1975	653.08	271.35	2334.09	21.4	safe
13	LAVERU	2024.88	101.24	1923.64	393.5055	5.76	135.216	534.53	135.2	1389.11	27.8	safe
14	LAXMINARASAMPET	2024.47	101.24	1923.24	80.6585	0	38.592	119.25	38.59	1803.99	6.2	safe
15	MANDASA	3258.21	162.92	3095.29	361.201	0	151.936	513.07	151.98	2582.22	16.6	safe
16	MELIAPUTTI	2816.39	140.85	2675.54	407.75	0	232.172	639.9	232.19	2035.64	23.9	safe
17	NANDIGAM	3198.23	159.93	3038.29	47.4115	0	283.464	330.82	300.84	2698.15	10.9	safe
18	NARASANNAPETA	3313.38	165.74	3147.64	202.22	5.76	96.552	304.53	103.16	2836.5	9.7	safe
19	PALASA	2948.81	147.45	2801.36	419.667	2.88	123.66	546.15	138.62	2240.25	19.5	safe
20	PATHAPATNAM	2640.58	131.99	2508.59	813.5663	2.88	171.468	987.9	365.98	1500.01	39.4	safe
21	POLAKI	4088.24	204.45	3883.79	988.064	0	199.224	1187.33	211.31	2684.37	30.6	safe
22	PONDURU	2130.55	106.6	2023.95	234.3745	0	82.152	316.56	104.16	1686.88	15.6	safe
23	RANASTALAM	2898.43	144.97	2753.45	826.802	169.92	276.7458	1273.48	303.96	1479.6	46.3	safe
24	SANTHABOMMALI	6500.29	324.98	6175.3	342.06	0	96.048	438.11	161.93	5672.74	7.1	safe
25	SARAVAKOTA	4586.85	229.36	4357.49	551.93	0	110.952	662.9	1538.32	3663.09	15.2	safe
26	SARUBUJJILI	2656.94	132.88	2524.06	245.334	0	61.1742	306.51	67.54	2211.18	12.1	safe
27	SOMPETA	2175.71	108.8	2066.91	495.732	2.88	86.616	585.18	270.3	1354.47	28.3	safe
28	SRIKAKULAM MANDAL	5174.85	258.72	4916.13	259.32	0	165.24	424.56	2480.79	4406.45	8.6	safe
29	TEKKALI	11220.7	561.03	10659.67	456.553	5.76	168.408	630.72	174.49	10024.65	5.9	safe
30	VAJRAPUKOTHURU	1916.99	95.85	1821.14	100.481	0	221.344	321.89	370.02	1483.94	17.7	safe

Existing Artificial Recharge Structures of Srikakulam District **ANNEXURE-5**

Sl No.	District	Mandal	Check Dam	Check Wall	MPT	PT	Grand Total
1	Srikakulam	Amadalavalasa	75	16	20	12	123
2	Srikakulam	Burja	199	17	18	17	251
3	Srikakulam	Etcherla	90	28	9	32	159
4	Srikakulam	Ganguvari Singadam	141	2	1	8	152
5	Srikakulam	Gara	31	4	1	2	38
6	Srikakulam	Hiramandalam	124	17	11	4	156
7	Srikakulam	Ichchapuram	59	22	18	10	109
8	Srikakulam	Jalumuru	70	42	8	9	129
9	Srikakulam	Kanchili	180	31	1	3	215
10	Srikakulam	Kaviti	186	35		8	229
11	Srikakulam	Kotabommili	114	38	2	12	166
12	Srikakulam	Kothuru	83	20	20	11	134
13	Srikakulam	Laveru	375	40	5	10	430
14	Srikakulam	LaxmiNarsuPeta	65	13	1	35	114
15	Srikakulam	Mandasa	237	115	3	77	432
16	Srikakulam	Meilaputti	295	24	17	50	386
17	Srikakulam	Nandigam	170	28	16	45	259
18	Srikakulam	Narasannapeta	32	38	2		72
19	Srikakulam	Palasa	114	37	4	21	176
20	Srikakulam	Pathapatnam	264	21	1	9	295
21	Srikakulam	Polaki	7	1	4		12
22	Srikakulam	Ponduru	109	7	1	16	133
23	Srikakulam	Ranastalam	232	18	5	31	286

24	Srikakulam	Santhabommali	48	35			83
25	Srikakulam	Saravakota	225	71	13	8	317
26	Srikakulam	Sarubujjili	86	6	14	32	138
27	Srikakulam	Sompeta	93	18		1	112
28	Srikakulam	Srikakulam	20	7	15	7	49
29	Srikakulam	Tekkali	116	30	1	4	151
30	Srikakulam	Vajrapukothuru	153	35	3	8	199
		Grand Total	**4025**	**817**	**218**	**485**	**5545**