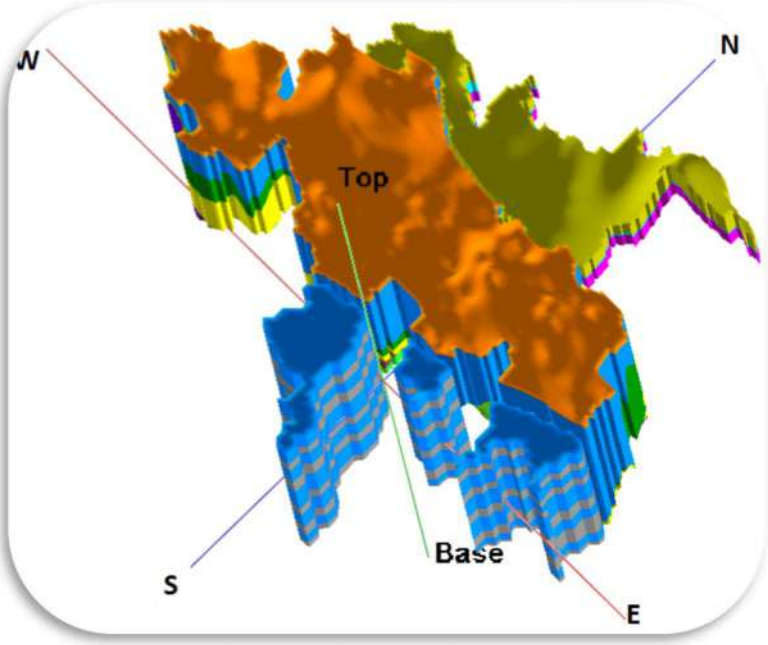
भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन नदी विकास एवम् गंगा संरक्षण विभाग
केंद्रीय भूमिजल बोर्ड

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

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



CENTRAL GROUND WATER BOARD
APSUO, VISAKHAPATNAM
DECEMBER 2023

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

CONTRIBUTORS' PAGE

Name		**Designation**
Principal Author		
Smt Nilima Patra	:	Assistant Hydrogeologist
Supervision & Guidance		
Shri Ravi Kumar Gumma	:	Scientist-'D' & Officer-in-Charge, A.P. State Unit Office, Visakhapatnam

AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN EAST GODAVARI DISTRICT, ANDHRA PRADESH STATE

Figures

Table

REPORT ON
AQUIFER MAPPING AND MANAGEMENT OF EAST GODAVARI DISTRICT,
ANDHRA PRADESH STATE (AAP-2023-24)

East Godavari District at a Glance

S. No.	Item		Particulars
1	District	:	East Godavari
2	Area	:	2560 km^2
3	Mandals	:	19
4	Villages	:	303 villages
5	Mappable area	:	2480 sq. kms
6	Population (2011Census)	:	18.32 lakhs
7	Density	:	477 persons/km^2
8	Location	:	North latitude 16°40′ to 17°20′ and east longitude 81°18′ to 82°6′
9	Rainfall (Normal)	:	Normal annual rainfall varies between 1007 mm (Devarapallle) and 1230 mm (Undrajavaram) with average of 1142 mm.
10	Geomorphology	:	The alluvial plain covers 18 % of the area in southern part of the district, while pediplain covers 58% in central part and 24 % covers Hill ranges of Eastern Ghats in north eastern part of the district.
11	Major River	:	Godavari
12	Land Utilization	:	Agricultural land occupies nearly 93% of the area, forest occupies nearly 4% of the area, Others is 3%
13	Soils	:	Based on the soil texture, the area is mainly occupied by Fine, mixed soils (43%), fine montmorillonitic (30%), clayey skeletal (15%), Pine mixed (8 %) and Fine loamy (3 %) soils.
14	Cropping Pattern (Ha)	:	The total cropped area in the district is 2,39,705 ha. Main crops grown during Kharif are Paddy 78,399 ha (57%), total Oil seed 22,973 ha (17%), Total fresh & dry fruits 21,748 ha (16%), Coconut 6,092 ha (4%) and total vegetables 3,693 (3%) and during Rabi season are Paddy 52,452 ha (52%), Other food crops 26,051 ha (26%), Maize 10,225 ha (10%), Total fresh & dry fruits 4,954 ha (5%) and black gram 1,990 ha (2%).
15	Irrigation		Out of total Net area sown of 1, 54,084 ha, the net area irrigated is 1,24,635 ha (81%). The area has the distributary network of the river Godavari. The district is irrigated by both Surface and ground water sources. Ground water is the main source of irrigation (~59%) and other sources of irrigation are canals and lift irrigations (35%) and tanks (5%).
16	Geology	:	Geologically the area is mainly underlain by sandstone of Gondwana, Rajahmundry sandstone, Alluvium and Pre-cambrian crystalline formations. The Archaean crystallines form the basement for the younger formations i.e., sandstone and alluvium formation in the area.
17	Hydrogeological data points		
	Exploratory drilling	:	CGWB Exploration: 51
	Water Level	:	34 wells

	Hydro chemical	:	Total: 25, Pre-monsoon:25(CGWB: 25)
	Geophysical	:	VES: 9 (CGWB)

18	**Data Interpretation, Integration and Aquifer Mapping**		
19	**Ground water Level Scenario**		
	Depth to water level (m bgl)	:	During pre-monsoon(May, 2011-2020), the water-table elevation ranges from 1.35 - 58 meter above mean sea level (m amsl) and general ground flow is towards river Godavari from southwest to north-east part of district. The average DTWL of 10 years (2011 to 2020) for pre-monsoon varies from 1.9 to 28.4 meter below ground level (mbgl) (average: 9.4 m bgl). Majority of the water levels during this season are in the range of 5.0 to 10 m covering 48% of the area, followed by 0.0 to 5.0 m bgl (30%), 10-20 mbgl (19 %) and >20 m bgl (3%). The water levels >20 m.bgl occupy in parts of Rangampeta, Rajanagaram, and Rajahmundry (U) mandals. The average DTWL of 10 years (2011 to 2020) for post-monsoon varies from 1.4 to 27.5 m bgl (average: 8.5 m bgl). Majority of the water levels during this season are in the range of 5.0 to 10 m bgl covering 46% of the area, followed by 0 to 5 m bgl (34%), 10-20 m bgl (18 %) and 20-30 m bgl (2%).
	Water Level Fluctuations (May vs. November)	:	The water level fluctuations vary from -6.36 to 10.60 m with average rise of 1.56 m. The water levels rise is observed in district except in parts of Tallapudi, Nidadavole, Rajahmundry and Rajanagaram Mandals. Rise in water level range of <1 m covers majority of the area with 63 % followed by 1-2 m rise in 21% of the area followed by >2 m rise in 16% of the area.
20	**Ground Water Quality**		
	Electrical Conductivity (µSiemens/cm)	:	Electrical conductivity varies from 254-3330 (avg: 1294) µ Siemens/cm**.** In 78 % of area EC varies betweem 750-1500 µ Siemens/cm, in 19 % area, it is >1500 µ Siemens/cm and in 03 % area, it is <750 µ Siemens/cm.
	Nitrate (mg/l)	:	NO_3 ranges from 1-124 mg/L. Nitrate concentration in 71% of samples is beyond permissible limits of 45 mg/L.
	Fluoride (mg/l)	:	Fluoride concentration varies from 0.032-1.79 mg/L and 96 % of samples it is within permissible limits of BIS and rest is beyond permissible limit of 1.5 mg/L.
22	**Ground water Resources (2022) MCM**		
	Net Dynamic Ground Water availability	:	1029 MCM
	Gross GW Draft	:	295 MCM
	Provision for Domestic (2025)	:	21 MCM
	Average Stage of Ground Water development (%)	:	33 %

	Net GW Availability for future irrigation	:	697 MCM
	Categorization of Mandal	:	18 Mandals in the district are categorized as safe except Nallajerla.
23	**Major Ground Water Issues Identified**	:	**Sandstone part of study area** **Deep water levels** 1. Deep water levels (> 20 m bgl) are observed during pre and post-monsoon season in 3 % and 2 % of the area respectively. 2. The reason for depletion of piezometric head is may be due to increase in cultivation of water consuming crops by ground water mainly by tube well irrigation even during Rabi season. **Alluvium part of study area** The major considerable ground water issues in the Alluvium are • Water Logging • Ground Water Salinity • **Water Logging:** Irrigation by surface water, minimal withdrawal of ground water, flat topography, high rainfall, poor drainage and nature of soils are responsible for the water logging conditions in the area. • **Ground Water Salinity:** Deeper aquifers ground water is invariably saline. The origin of the salinity in any area can be due to the following three reasons viz., palaeo salinity, due to leakage from the bottom aquifer, due to sea water intrusion caused by human activity. **Hard Rock part of study area** ➢ **Low Sustainability** • Low yield (<1 lps) occurs in ~26 % of area covering entire district. • The reason of low sustainability is due to absence of primary porosity, negligible development of secondary porosity, low rainfall and desaturation of weathered zone.

24	**Ground Water Development and Management Strategies**		
		:	**1. Ground Water Development:** • **PMKSY/YSR Jala Kala**: At present the ground water abstraction in the district is low (34%) and there is a scope for further ground water development for irrigation. The total utilization of ground water is 295 MCM against the total ground water potential of 1029 MCM available for future use. Ground water irrigation in the district is accounts only for 59 % of the net irrigation of the district.It is recommended to develop ground water in 19 mandals by constructing 5150 no. of structures to bring an additional area of 9231 ha. **2.Area Identified for Artificial Recharge in the Study Area** • There is a scope for construction of artificial recharge structures considering the available run-off and recharge potential which can be taken up as per requirement in the district. An area of about 1666 sq. km has been identified in District. **3.Aquifer Management Strategy of Sandstone part of study Area** • **Supply side Measures** The areas where intense ground water development, reduction in yields, DTW and piezometric heads are considered in identifying the area for artificial recharge. In the area scope exists for augmenting the ground water resources through artificial recharge. An area of 1225 km^2 is considered for ground water management of recharging deeper aquifers. The available sub-surface space volume is 349 MCM. • **Regulatory measures** Change in cropping pattern from water intensive paddy to irrigated dry other crops like pulses and oil seeds are recommended.

			As a mandatory measure, every groundwater user should recharge rainwater through artificial recharge structures in proportionate to the extraction. **4.Aquifer Management Strategy of Hard Rock part of study Area** • **Supply Side Measures:** **Artificial Recharge:** In the study area, there is a scope for future GW development. Considering the upland part of East Godavari district, the area forms recharge zone and suitable for adoption of water conservation structures and micro irrigation practices. Under PMKSY-MGNREGS, the Govt. of AP had constructed 25 no. of CDs & PTs in upland the parts of East Godavari. The desilting and maintenance of existing PTs and CDs are recommended. In future, artificial recharge structure shall be recommended in specific areas, where vulnerabilities for groundwater resources increase. • **Demand Side Measures:** **Micro-irrigation**: The sustainability of bore well is low because of hard/ crystalline rock. 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. Micro irrigation is recommended in all villages i.e 100 ha per village. **5.Aquifer Management Strategy of Godavari Delta part of study Area** Promoting Groundwater Utilization in Alluvium part of study Area: Encouraging the judicious use of fresh groundwater resources is essential, especially when surface water is available. Awareness campaigns and education on aquifer disposition are crucial to ensure that farmers and communities can access and utilize this valuable resource efficiently. Addressing Waterlogging in Alluvium part of study Area: Water logged areas can benefit from groundwater extraction through a network of filter points and the distribution of water to canals for irrigation.

			Implementing a ban on surface water supply in such areas can help mitigate waterlogging issues.

EXECUTIVE SUMMARY

The East Godavari district having geographical area of 2560 km^2, lies between north latitude 16°40′ to 17°20′ and east longitude 81°18′ to 82°6′. The total forest area in the district accounts for 90 km^2 forming 4 % of the total Geographical area. The district is bounded by West Godavari district in the south, Kakinada in the east, Eluru district in the west and Alluri Sitharama Raju district in the North .Administratively the district is governed by 19 revenue mandals. There are 303 villages with a population of ~18.32 lakhs (2011 census). The density of population is 477 persons/ km^2.

The climate of the district is characterised by sub-humid climate with oppressive summers and good seasonal rainfall. The district receives an average annual normal rainfall of 1142 mm of which SW monsoon contributes 66%, NE monsoon contributes 23% while the rest by winter and summer rainfall.

Pediplain, Alluvial Plain, Pediments and Flood plains are the major geographic units in the study area. The alluvial plain covers 18 % of the area in southern part of the district, while pediplain covers 58% in central part and 24 % covers Hill ranges of Eastern Ghats in north eastern part of the district. Major part of the district falls under Godavari basin. Godavari river flows N to S direction in the area. The District is divided into 3 major drainage basins namely Godavari, Yerrakalva and Yeleru. The general drainage pattern is dendritic to sub-dendritic.

Out of total geographical area of 2,56,069 ha, Net area Sown is 1,54,084 (~60%), land put to non-agricultural uses is 49,882 ha (19%), current fallow is 12,322 ha (~5%), Barren and uncultivable land is 10,867 ha (4%). Forest occupies 8,990 ha (~4%), Cultivable waste is 4,663 ha (2%) etc.

The total cropped area in the district is 2,39,705 ha. Main crops grown during Kharif are Paddy 78,399 ha (57%), total Oil seed 22,973 ha (17%), Total fresh & dry fruits 21,748 ha (16%),Coconut 6092 ha (4%) and total vegetables 3693 (3%) and during Rabi season are Paddy 52452 ha (52%), Other food crops 26,051 ha (26%), Maize 10,225 ha (10%), Total fresh & dry fruits 4954 ha (5%) and blackgram 1990 ha (2%). Out of total Net area sown of 1,54,084 ha, the net area irrigated is 1,24,635 ha (81%). The area has the distributary network of the river Godavari. The district is irrigated by both Surface and Ground Water sources. Ground water is the main source of irrigation (~59%) and other sources of irrigation are canals and lift irrigations (35%) and tanks (5%).

The area is mainly occupied by fine, mixed soils (43 %) (Very deep, well drained, clayey soils), Fine, montmorillonite (30 %) (Very Deep, imperfectly drained, clay soils), Clayey-skeletal (15 %) (Shallow, somewhat excessively drained, gravelly clay soils), Pine mixed (8 %) and Fine loamy (3 %) soils.

Geologically the area is mainly underlain by sandstone of Gondwana, Rajahmundry sandstone, Alluvium and Pre-Cambrian crystalline formations. The Archaean crystallines form the basement for the younger formations i.e., sandstone and alluvium formation in the area.

CGWB drilled 101 no's bore wells, 06 wells were drilled in alluvium area, 92 wells were drilled in sandstone area and 3 wells are drilled in Hard rock area. Data analysed from CGWB wells indicates, 04 well of shallow depth (<30 m), 06 wells of 30-60 m depth, 10 wells of 60-100 m depth, 38 wells of 100-150 m. Depth, 18 wells of 150-200m depth, 10 wells of 200-250m depth, 15 wells of >250m depth.

During pre-monsoon (May, 2011-2020), the water-table elevation ranges from 1.35 - 58 meter above mean sea level (m amsl) and general ground flow is towards river Godavari from southwest to north-east part of district. The average DTWL of 10 years (2011 to 2020) for pre-monsoon and post-monsoon were analysed, the avg. DTWL varies from 1.9 to 28.4 meter below ground level (m bgl) (average: 9.4 m bgl) and 1.4 to 27.5 m bgl (average: 8.5 m bgl) during pre-monsoon and post-monsoon seasons respectively. Majority of the water levels during pre-monsoon season are in the range of 5.0 to 10 m covering 48% of the area, followed by 0.0 to 5.0 m bgl (30%), 10-20 m bgl (19 %) and >20 m bgl (3%). The water levels >20 m.bgl occupy in parts of Rangampeta, Rajanagaram, and Rajahmundry (U) mandals. Majority of the water levels during post-monsoon season are in the range of 5.0 to 10 m bgl covering 46% of the area, followed by 0 to 5 m bgl (34%), 10-20 m bgl (18 %) and 20-30 m bgl (2%).

Groundwater is mildly alkaline to alkaline in nature with pH in the range

of 7.21-8.1(Avg: 7.76). Electrical conductivity varies from 254-3330 (avg: 1294) µ Siemens/cm. In 78 % of area EC varies betweem 750-1500 µ Siemens/cm, in 19 % area, it is >1500 µ Siemens/cm and in 03 % area, it is <750 µ Siemens/cm. NO_3 ranges from 1-124 mg/L. Nitate concentration in 71% of samples is beyond permissible limits of 45 mg/L. Fluoride concentration varies from 0.032-1.79 mg/L and 96 % of samples it is within permissible limits of BIS and rest is beyond permissible limit of 1.5 mg/L.

The stratigraphic sections depicting in Sandstone area constitutes sandstones of multi layered Gondwana and Rajahmundry sandstones. The Gondwana formations represented by Chintalapudi, Gollapalli, and Thirupathis are occupy in the western part of the study area where as in eastern part of the area Thirupathi and Rajahmundry are major formations. The stratigraphic sections depicting in Alluvium area comprising silt, sand, clay and gravel formed multi layered aquifer system with intervening thick clay beds. Sand beds act as aquifers in the area and there are five distinct beds which behave as regional aquifer. In Hard rock area mainly Eastern Ghat rocks comprising khondalite, Charnockite and Gneiss present in the district in which weathered Aquifer depth of occurrence is from 0 to 35 m and fractured aquifer depth of occurrence is from 35 to 70 m.

As per 2022 GEC report, the net dynamic replenishable groundwater availability is 1029 MCM, gross ground water draft for all uses 295 MCM, provision for drinking and industrial use for the year 2025 is 21 MCM. 18 mandals fall in safe category except Nallajerla. Mandal wise stage of ground water development varies from 7% (Rajahmundry Urban mandal) to 80 % (Nallajerla mandal) with average of 34%.

The study reveals that common issue in the region are Deep water level in sandstone part of study area, Water logging & Ground Water salinity level in alluvium part of study area and Low Sustainability hard rock part of study area.

At present the ground water abstraction in the district is low (34%) and there is a scope for further ground water development for irrigation. The total utilization of ground water is 295 MCM against the total ground water potential of 1029 MCM available for future use. Ground water irrigation in the district is accounts only for 59 % of the net irrigation of the district.

There is a scope for construction of artificial recharge structures considering the available run-off and recharge potential which can be taken up as per requirement in the district. An area of about **1666 sq. km** has been identified in District for artificial recharge. The run off required to recharge the unsaturated volume **797.21 MCM**. The Surplus runoff available for recharge is 129 MCM.

The study suggests notable measures for sustainable groundwater management which involves a combination of various measures. The sandstone part of study areas where intense ground water development, reduction in yields, DTW and piezometric heads are considered in identifying the area for artificial recharge. In the area scope exists for augmenting the ground water resources through artificial recharge. An area of 1225 km^2 is considered for ground water management of recharging deeper aquifers. The available sub-surface space volume is 349 MCM. To overcome the shallow aquifers problem, It is proposed to take the activity of desilting of existing tanks for effective recharging the shallow aquifers. It is proposed to construct 'Recharge Shafts' for recharging the deeper aquifers where piezometric heads are more than 20 to 30 m bgl. Change in cropping pattern from water intensive paddy to irrigated dry other crops like pulses and oil seeds are recommended.

Considering the upland part of East Godavari district, the area forms recharge zone and suitable for adoption of water conservation structures and micro irrigation practices. Under PMKSY-MGNREGS, the Govt. of AP had constructed 25 no. of CDs & PTs in the parts of East Godavari. The desilting and maintenance of existing PTs and CDs are recommended. In future, artificial recharge structure shall be recommended in specific areas, where vulnerabilities for groundwater resources increase. The sustainability of bore well is low because of hard/ crystalline rock. 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. Micro irrigation is recommended in all villages i.e 100 ha per village.

Promoting Groundwater Utilization in Alluvium part of study Area: Encouraging the judicious use of fresh groundwater resources is essential, especially when surface water is available. Awareness campaigns and education on aquifer disposition are crucial to ensure that farmers and communities can access and utilize this valuable resource efficiently.

Addressing Waterlogging in Alluvium part of study Area: Water logged areas can benefit from groundwater extraction through a network of filter points and the distribution of water to canals for irrigation. Implementing a ban on surface water supply in such areas can help mitigate waterlogging issues.

1. INTRODUCTION

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. In recent past, there has been a paradigm shift from "**groundwater development**" to "**groundwater management**". As large parts of India particularly hard rocks have become water stressed due to rapid growth in demand for water due to population growth, irrigation, urbanization and changing life style. Therefore, in order to have an accurate and comprehensive micro-level picture of groundwater in India, aquifer mapping in different hydrogeological settings at the appropriate scale is devised and implemented, to enable robust groundwater management plans. This will help in achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural and many parts of urban India. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of National Aquifer Mapping (NAQUIM) is not merely mapping, but reaching the goal-that of ground water management through community participation.

Hard rocks (Granites/Gneisses) lack primary porosity, and groundwater occurrence is limited to secondary porosity developed by weathering and fracturing. Weathered zone is the potential recharge zone for deeper fractures and excessive withdrawal from this zone leads to drying up in places and reducing the sustainability of structures. Besides these quantitative aspects, groundwater quality also represents a major challenge which is threatened by both geogenic and anthropogenic pollution. In some places, the aquifers have high level of geogenic contaminants, such as fluoride, rendering them unsuitable for drinking purposes. High utilization of fertilizers for agricultural productions and improper development of sewage system in rural/urban areas lead to point source pollution viz., nitrate and chloride.

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

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

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

1.3 Area Details: The East Godavari district, Andhra Pradesh having geographical area of 2560 km^2, lies between north latitude 16°40′ to 17°20′ and east longitude 81°18′ to 82°6′(**Fig.1.1**). The total forest area in the district accounts for 90 km^2 forming 4 % of the total Geographical area. The district is bounded by West Godavari district in the south, Kakinada in the east, Eluru district in the west and Alluri Sitharama Raju district in the North .Administratively the district is governed by 19 revenue mandals. There are 303 villages with a population of ~18.32 lakhs (2011 census). The density of population is 477 persons/ km^2 whereas it is 304 per Sq.km. for the State.

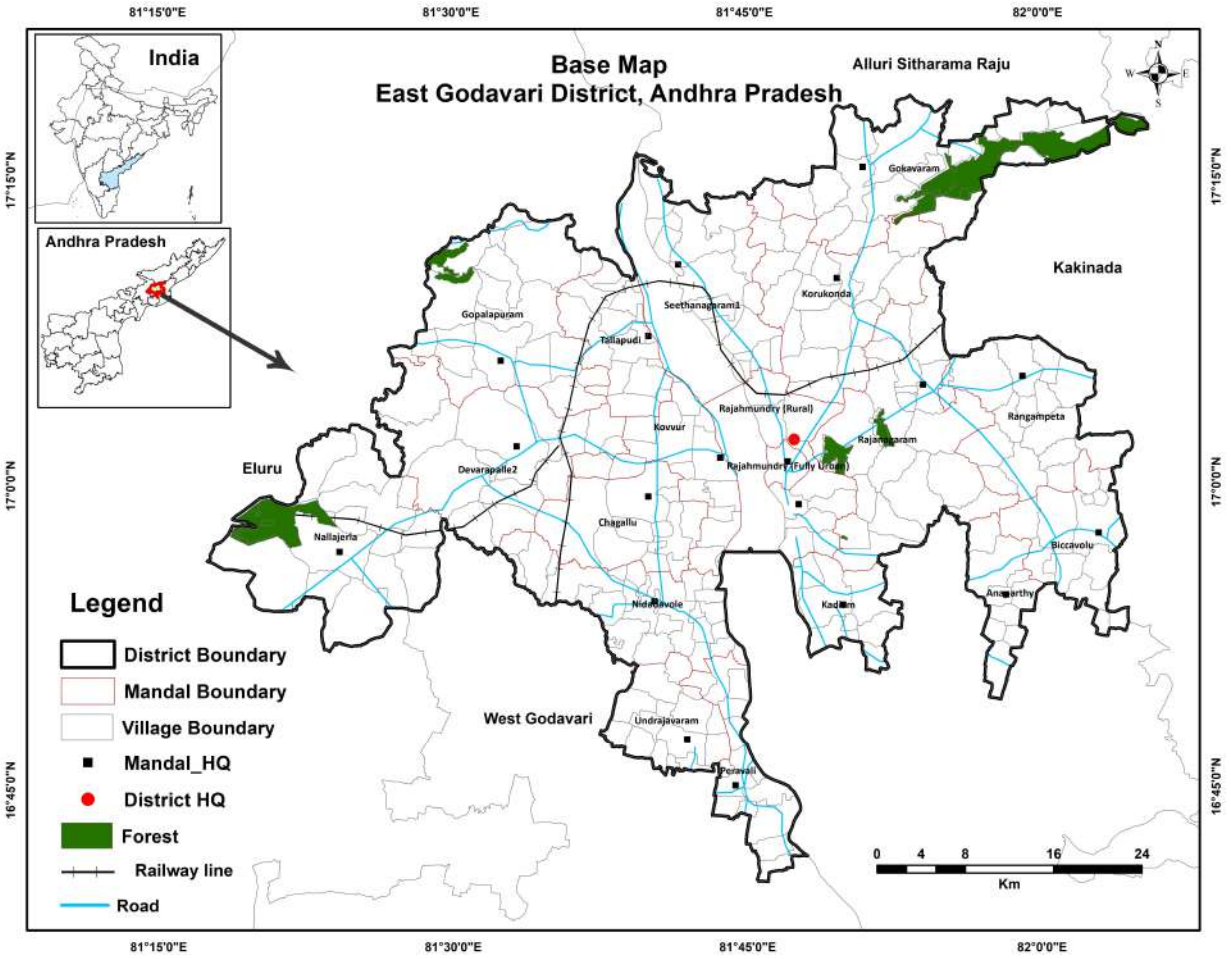


Fig.1.1: Location map of East Godavari district.

1.4 Climate and Rainfall: The climate of the district is characterised by sub-humid climate with oppressive summers and good seasonal rainfall.The normal mean daily minimum and maximum temperatures are 27 °C and 37 °C during May and 20°C and 29 °C during December. Normal annual rainfall varies between 1007 mm (Devarapallle) and 1230 mm (Undrajavaram) with average of 1142 mm (**Fig. 1.2**). ~ SW monsoon contributes 66%, NE monsoon contributes 23% while the rest by winter and summer rainfall. Mandal wise normal rainfall is provided in table.

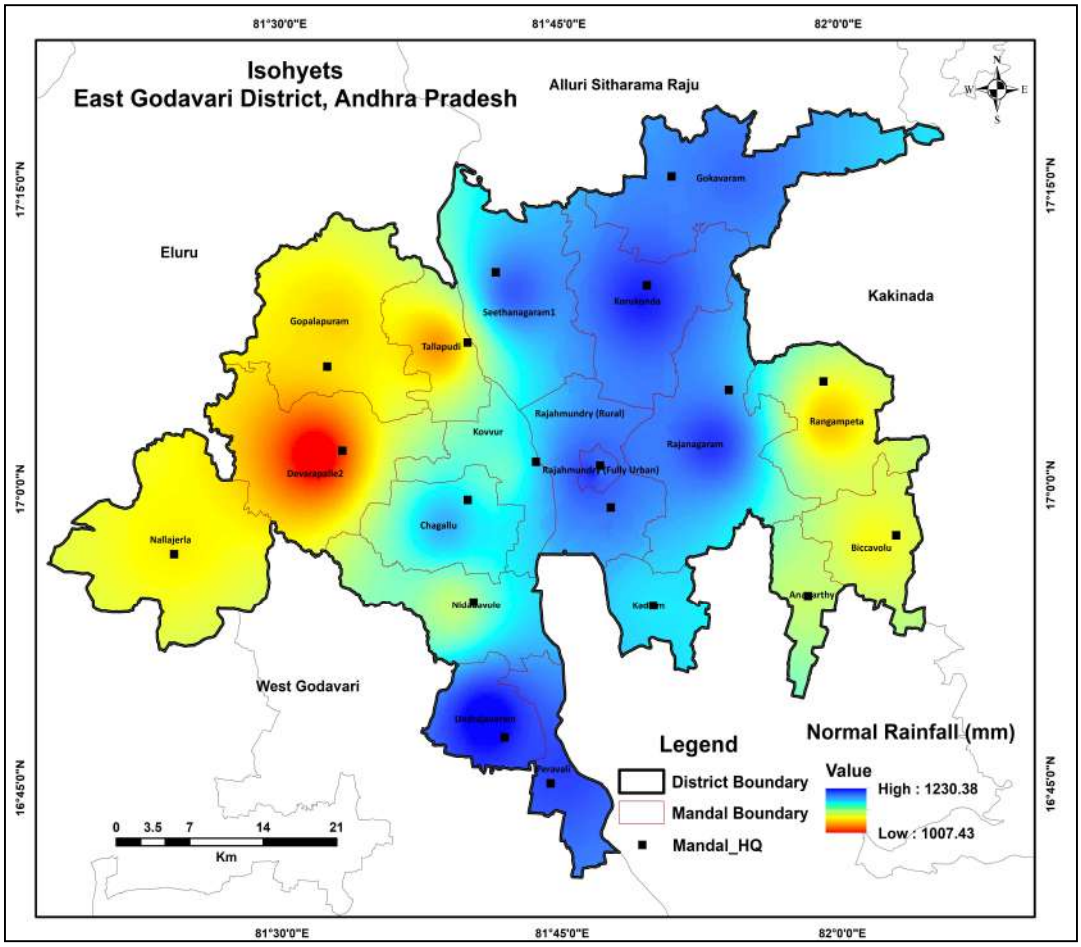


Fig.1.2: Isohyetal map of East Godavari district.

Table: 1.1 Mandal wise Normal Rainfall in East Godavari District, AP

SL.No	Mandal	Normal Rainfall
1	Anaparthy	1112.5
2	Biccavolu	1089.4
3	Chagallu	1175.4
4	Devarapalle	1007.4
5	Gokavaram	1194.4
6	Gopalapuram	1074.7
7	Kadiam	1160.2
8	Korukonda	1217.4
9	Kovvur	1141.1
10	Nallajerla	1084.8
11	Nidadavole	1115.4
12	Peravali	1207.4
13	Rajahmundry (Fully Urban)	1184.9
14	Rajahmundry (Rural)	1217.1
15	Rajanagaram	1211.2
16	Rangampeta	1070.3
17	Seethanagaram	1199.7
18	Tallapudi	1057.1
19	Undrajavaram	1230.4

1.5 Geomorphological Set up: Pediplain, Alluvial Plain, Pediments and Flood plains are the major geographic units in the study area. The alluvial plain covers 18 % of the area in southern part of the district, while pediplain covers 58% in central part and 24 % covers Hill ranges of Eastern Ghats in north eastern part of the district.The details and percentage of geomorphological features of the area is given in the **Table 1.2** and depicted in **Fig.1.3.**

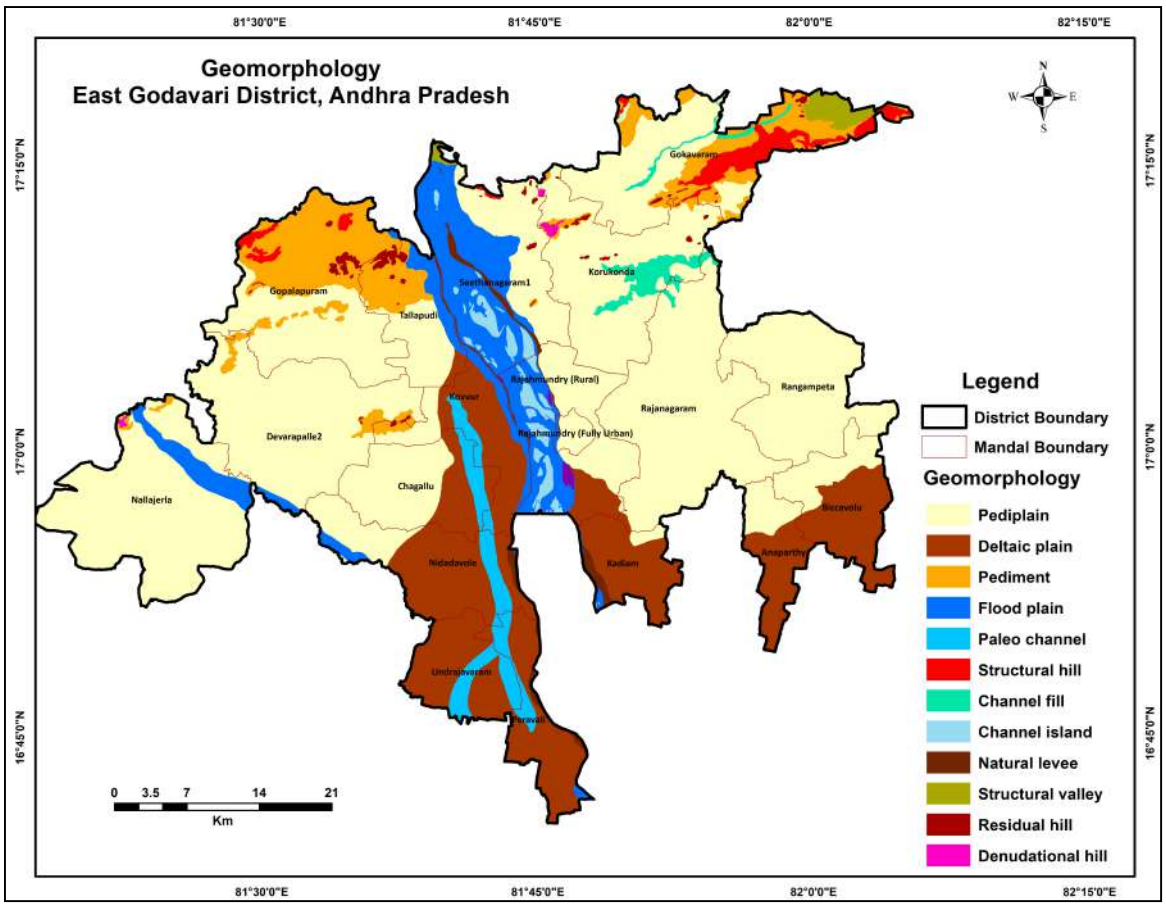


Fig.1.3: Geomorphology of East Godavari district.

Table: 1.2 Geomorphology of East Godavari District, AP

Geomorphology	Area (Sq.kms)	%
Pediplain	1524	58
Deltaic plain	469	18
Pediment	202	8
Flood plain	198	8
Paleo channel	62	2
Structural hill	43	2
Others	119	5

1.6. Physiography: Physiographically the area is mainly occupied by plain regions. The plain portion of the district is a well cultivated tract. The elevation map of the district is provided in **Fig-1.4.**

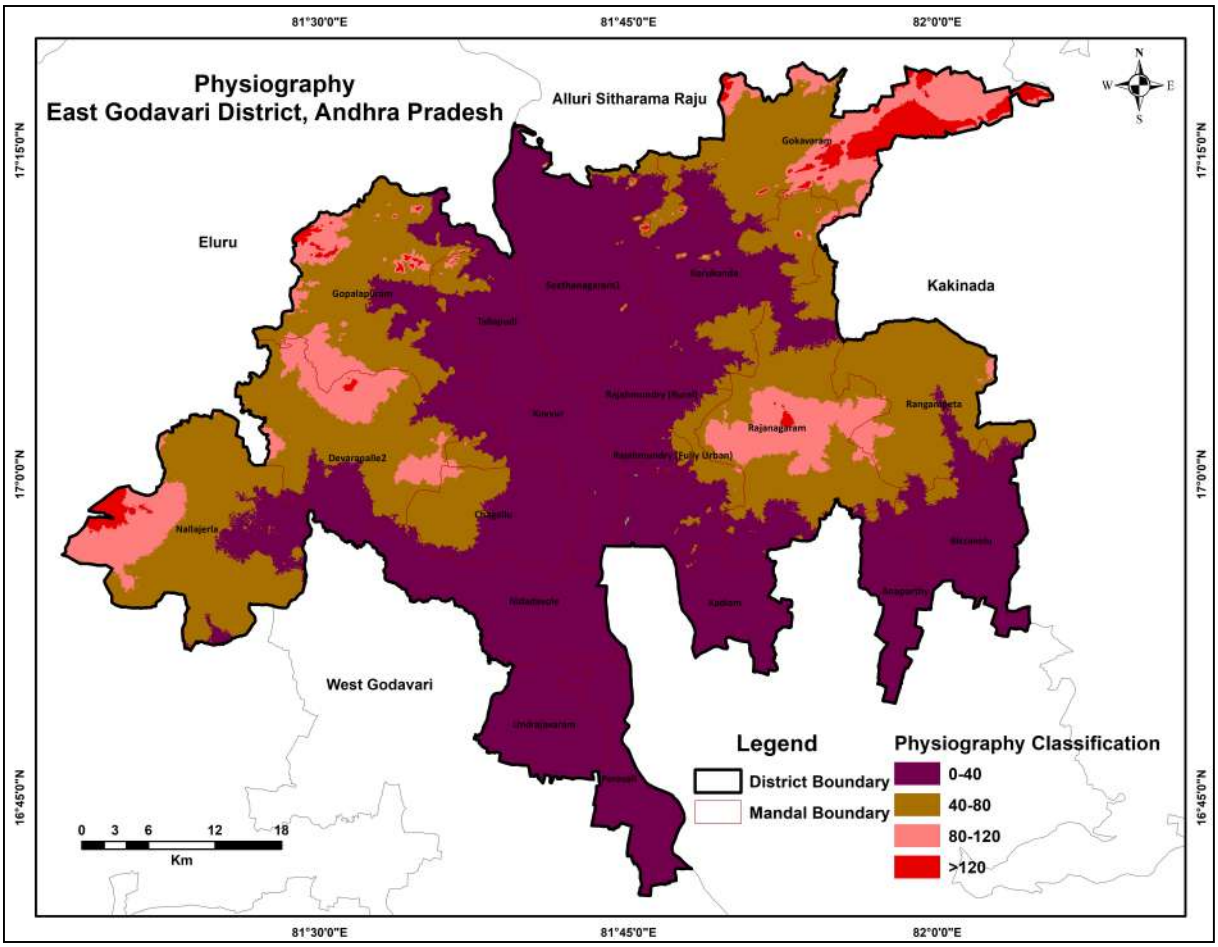


Fig.1.4: Physiography of East Godavari district

1.7 Drainage and Structures: Major part of the district falls under Godavari basin. River Godavari starts as a trickle at Nasik in Maharashtra. If flows through the States of Marashtra and Andhra Pradesh and becomes mighty and majestic at Rajahmundry. Godavari river flows N to S direction in the area.The District is divided into 3 major drainage basins namely Godavari, Yerrakalva and Yeleru. The general drainage pattern is dendritic to sub-dendritic. In general the drainage density decreases from north to south. Map depicting drainage, River, tanks and river basin is presented in **Fig.1.5.**

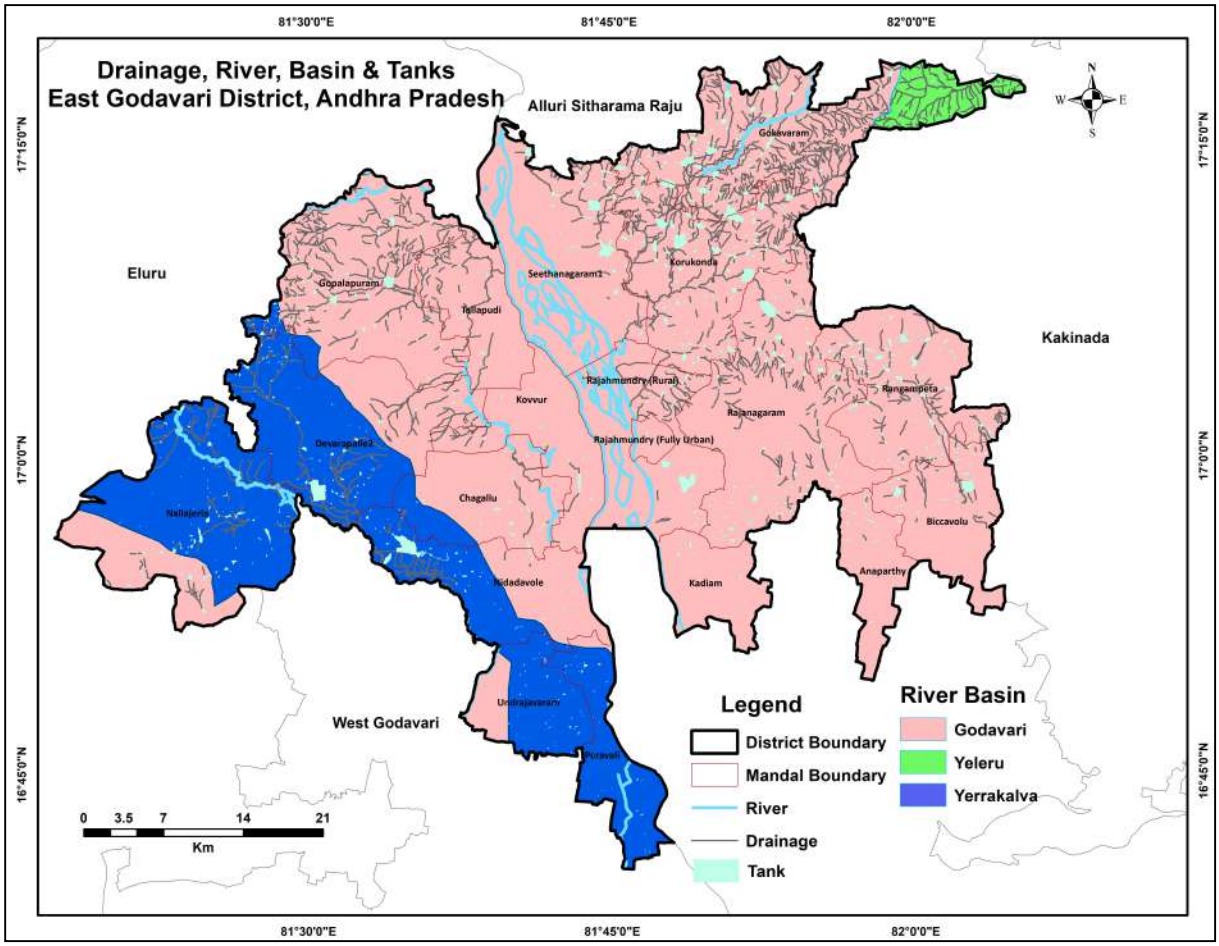


Fig.1.5: Drainage, River, Basin and Tanks.

1.8. Land Use and Land Cover: Out of total geographical area of 2,56,069 ha, Net area Sown is 1,54,084 (~60%), land put to non-agricultural uses is 49,882 ha (19%), current fallow is 12,322 ha (~5%), Barren and uncultivable land is 10,867 ha (4%), Forest occupies 8,990 ha (~4%), Cultivable waste is 4,663 ha (2%) etc. Land use and land cover map of the district is depicted in **Fig. 1.6** and graphical presentation is depicted in **Fig-1.6a.**

Table: 1.3. 13 classification of Land Use in East Godavari District, AP

Sl.No	LULC	Area (ha)
1	Total Geographical Area	256069
2	Total Cropped Area	239705
3	Net Area Sown	154084
4	Area Sown More than Once	85621
5	Land put to Non. Agricultural Uses	49882
6	Current Fallows	12322
7	Barren & Uncultivable Land	10867
8	Other Fallows	10823
9	Forest Area	8990
10	Cultivable waste	4663
11	Permanent Pastures & other grazing lands	2702
12	Misc. Tree crops & groves not included in net	1261
13	Fish & Prawn Culture	475

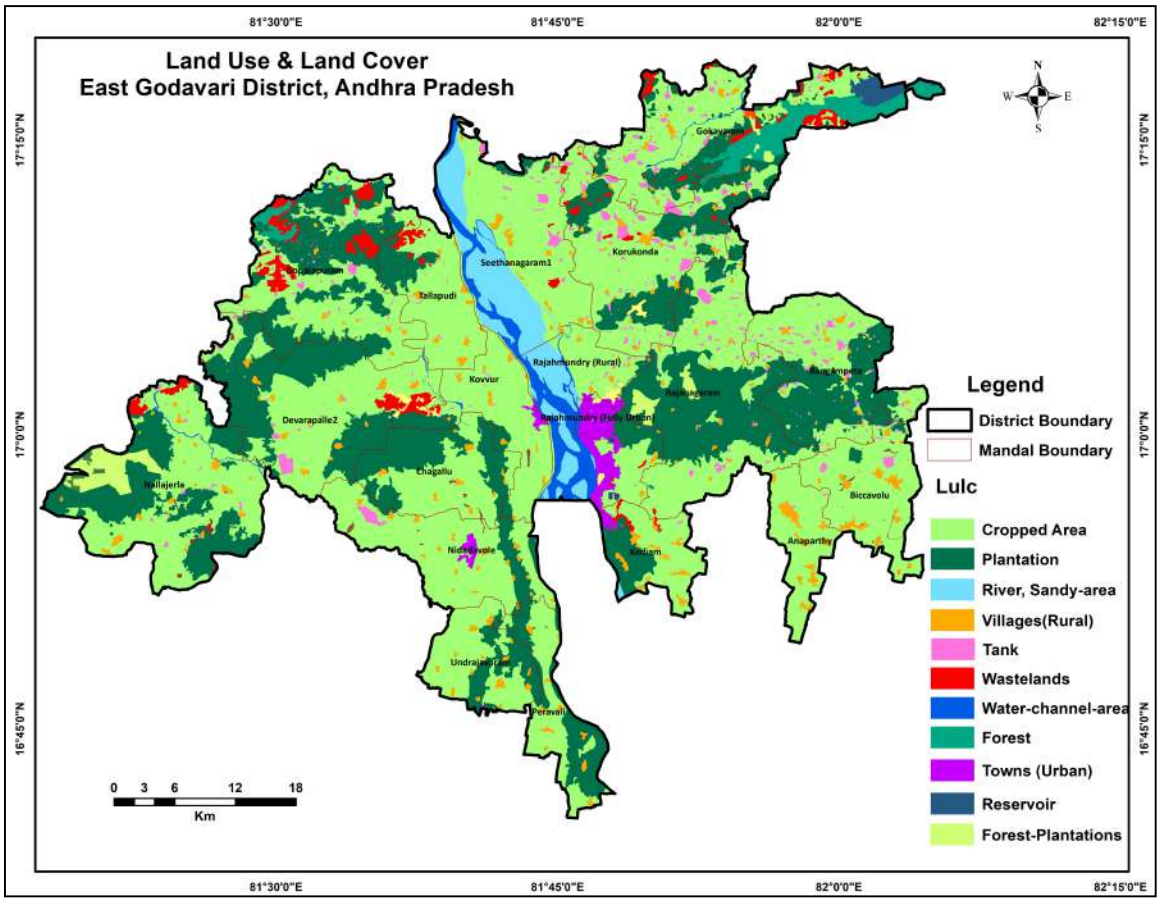


Fig.1.6: Land use and land cover of East Godavari district.

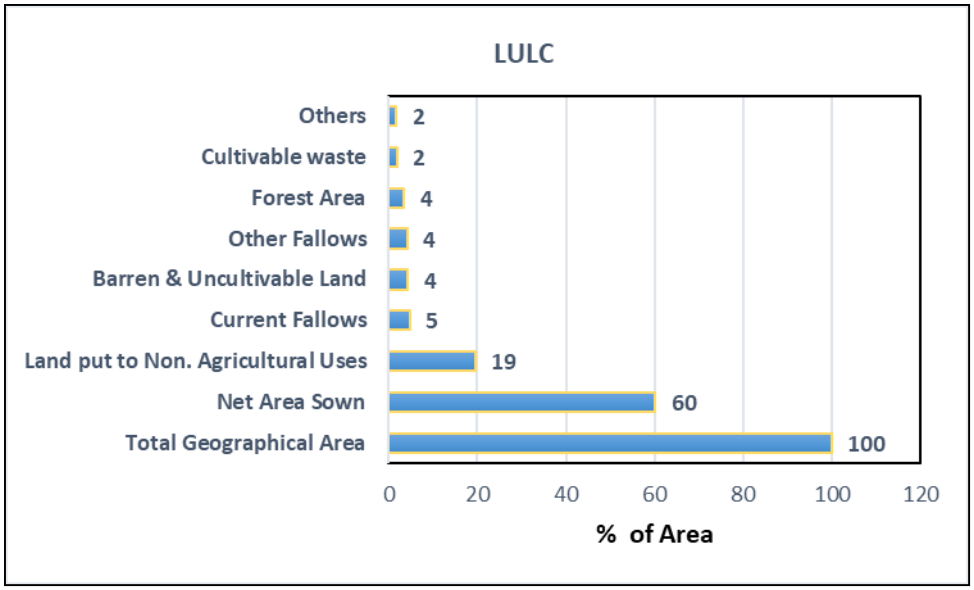


Fig.1.6a: Graphical presentation of Land Use of East Godavari District

1.9 Agriculture and Irrigation: The total cropped area in the district is 2,39,705 ha, out of which net area sown is 1,54,084 ha and area irrigated more than once is 80,014 ha. The details of cropped area are provided in **Table-1.4** and presented in **Fig-1.7**. Main crops grown during Kharif are Paddy 78,399 ha (57%), total Oil seed 22,973 ha (17%), Total fresh & dry fruits 21,748 ha (16%),Coconut 6,092 ha (4%) and total vegetables 3,693 (3%) and during Rabi season are Paddy 52,452 ha (52%), Other food crops 26,051 ha (26%), Maize 10,225 ha (10%), Total fresh & dry fruits 4,954 ha (5%) and blackgram 1,990 ha (2%).**(Fig-1.8)**

Out of total Net area sown of 154084 ha, the net area irrigated is 124635 ha (81%). The area has the distributary network of the river Godavari. The district is irrigated by both Surface and ground water sources. Ground water is the main source of irrigation (~59%) and other sources of irrigation are canals and lift irrigations (35%) and tanks (5%). The graphical representation of area irrigated by different sources in the district is presented as **Fig. 1.9b**.The major/Medium irrigation projects in the district are Eastern Godavari Delta, Godavari Western Delta, Thatipudi LIS, ISRMC Polavaram and Chagalnad LIS projects **(Fig-1.9 a).**

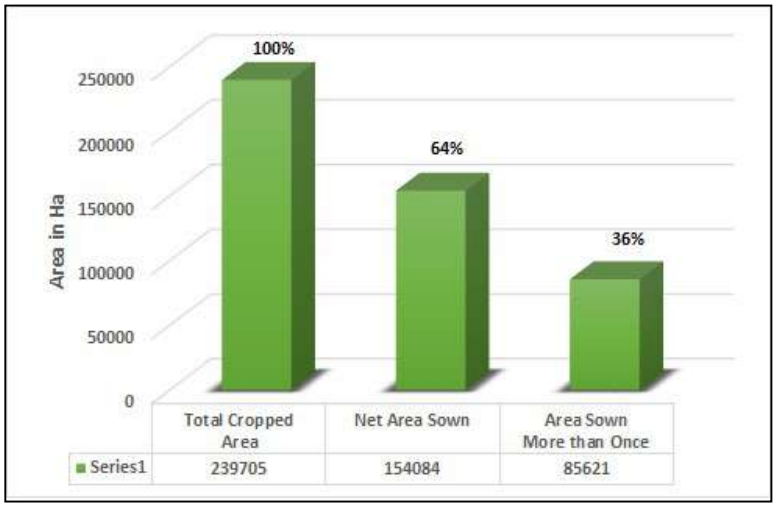


Fig.1.7: Graphical presentation of Cropped Area of East Godavari District

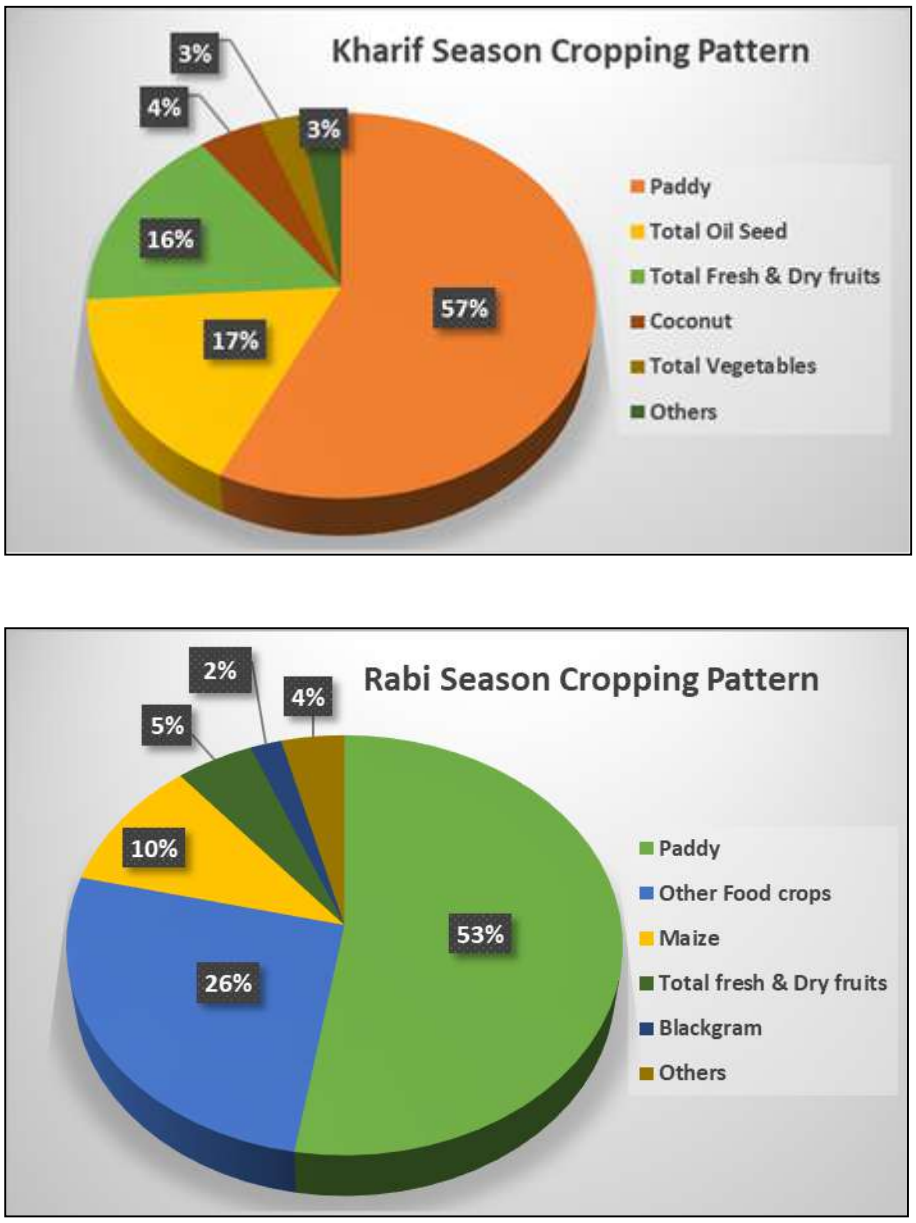


Fig.1.8: Cropping pattern in Kharif & Rabi

Table-1.4: Details of cropped area in East Godavari District, AP

S.No.	Mandal	Total Cropped Area	Net Area sown (Kharif)	Net Area sown (Rabi)	Net Area Sown (Total)
1	ANAPARTHY	8629	4428	0	4428
2	BICCAVOLU	14309	7575	0	7575
3	CHAGALLU	13683	8713	0	8713
4	DEVARAPALLE	18942	13480	0	13480
5	GOKAVARAM	11196	8485	0	8485
6	GOPALAPURAM	15360	11488	0	11488
7	KADIAM	6039	2950	0	2950
8	KORUKONDA	14412	10016	0	10016
9	KOVVUR	14610	7679	0	7679
10	NALLAJERLA	19342	13676	0	13676
11	NIDADAVOLE	18541	9424	0	9424
12	PERAVALI	12129	6352	0	6352
13	RAJAHMUNDRY (RURAL)	3843	2780	0	2780
14	RAJAHMUNDRY (URBAN)	50	47	0	47
15	RAJANAGARAM	17376	14201	0	14201
16	RANGAMPETA	12868	11277	0	11277
17	SEETHANAGARAM	14563	7280	1237	8518
18	TALLAPUDI	10797	6542	0	6542
19	UNDRAJAVARAM	13016	6453	0	6453
	Total	**239705**	**152846**	**1237**	**154084**

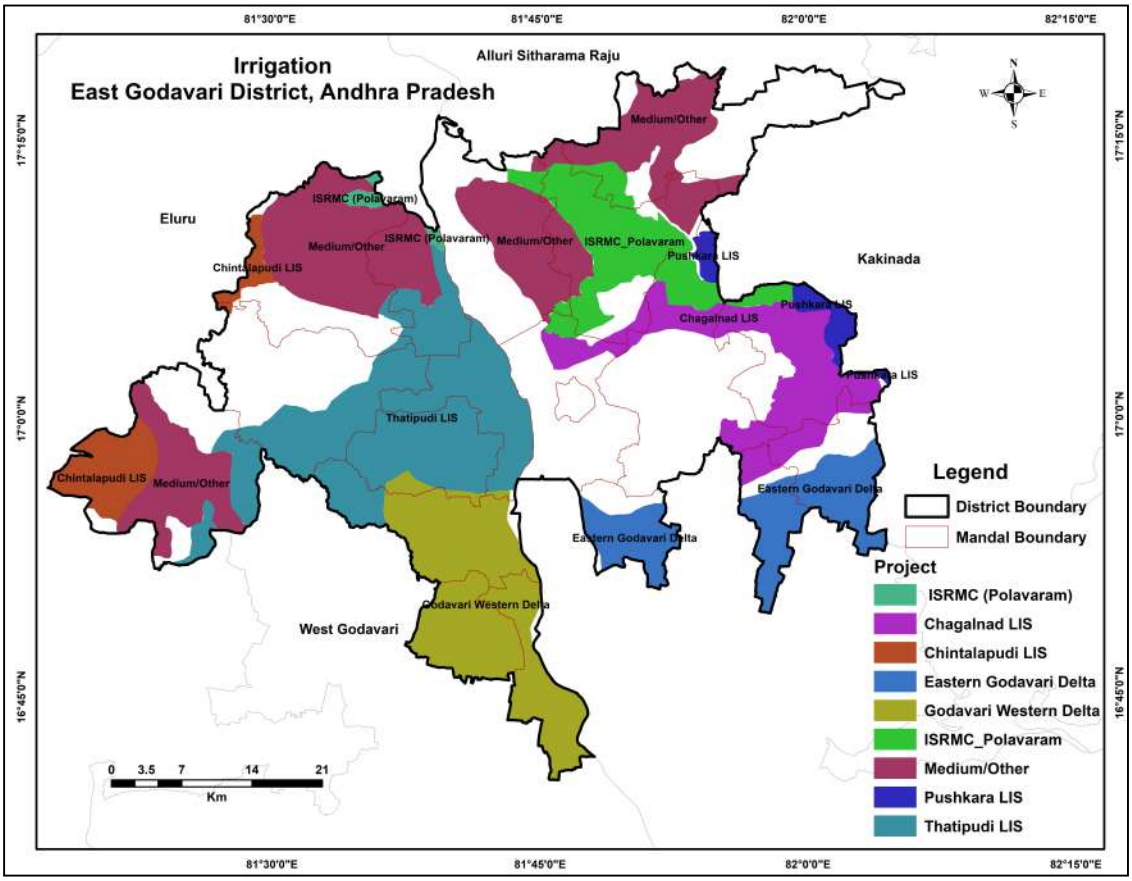


Fig.1.9a: Irrigation projects in East Godavari district

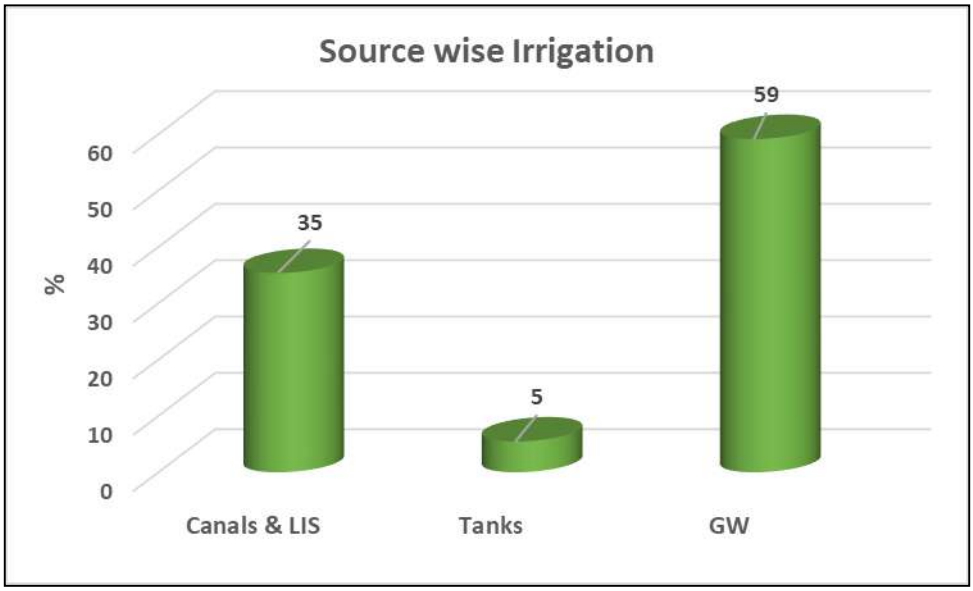


Fig.1.9 b: Area Irrigated by Different Sources

Different sources of Irrigation	Area Irrigated (Ha)	%
Canals & LIS	44088	35
Tanks	6818	5
GW	73729	59

1.10 Soils: The area is mainly occupied by fine, mixed soils (43 %) (Very deep, well drained, clayey soils), Fine, montmorillonite (30 %) (Very Deep, imperfectly drained, clay soils), Clayey-skeletal (15 %) (Shallow, somewhat excessively drained, gravelly clay soils), Pine mixed (8 %) and Fine loamy (3 %) soils. (**Fig.1.10**)

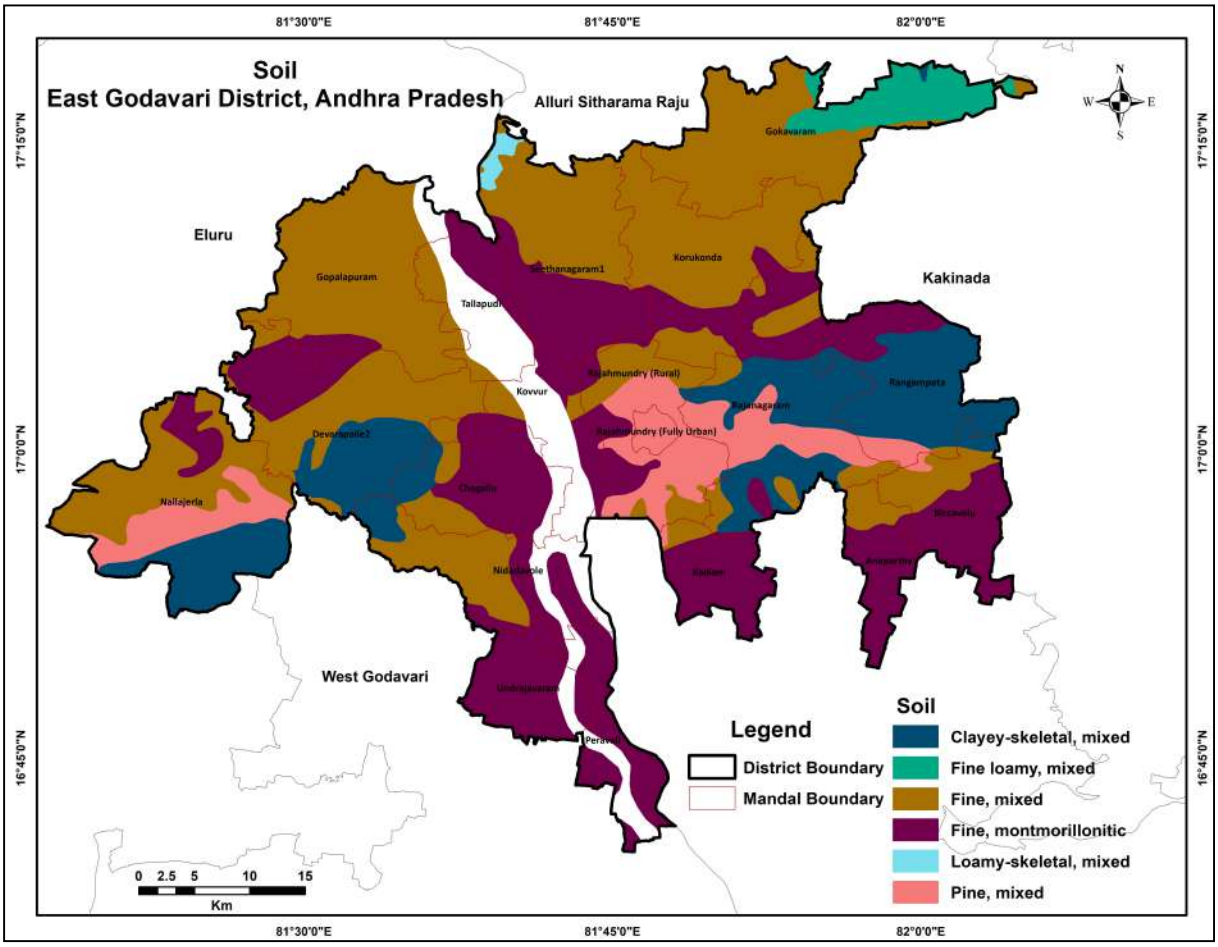


Fig.1.10: Soil map of East Godavari district.

1.11 Prevailing Water Conservation/Recharge Practices: In the district there are ~13 percolation tanks, 27 Check dams.

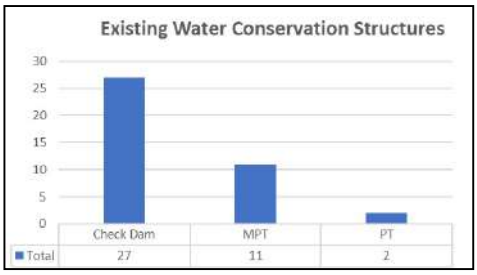


Fig.1.11: Existing ARS of East Godavari district

1.12 Geology: Geologically the area is mainly underlain by sandstone of Gondwana, Rajahmundry sandstone, Alluvium and Pre-cambrian crystalline formations. The Archaean crystallines form the basement for the younger formations i.e., sandstone and alluvium formation in the area. The general geological succession of the area is shown in **Table 1.5**. The geological map of the area is given as **Fig. 1.12.**

Table-1.5: Geological Succession in East Godavari District

Age	System	Formation	Lithology
Recent		**Alluvium**	Gravel, Sand and silt
Unconformity			
Mio-Pliocene		**Rajahmundry**	Conglomerate sandstone and clays
Upper Cretaceous to Lower Eocene		**Deccan Traps**	Basalt
Lower cretaceous to Lower Triassic	Upper Gondwana system	**Tirupathi** **Gollapalii**	Sandstone, shale/clays
	Lower Gondwana	**Chintalapudi**	Sandstone, shale/clays
Unconformity			
Pre-cambrian			Khondalites, Charnockites Gneiss and Banded Gneisses

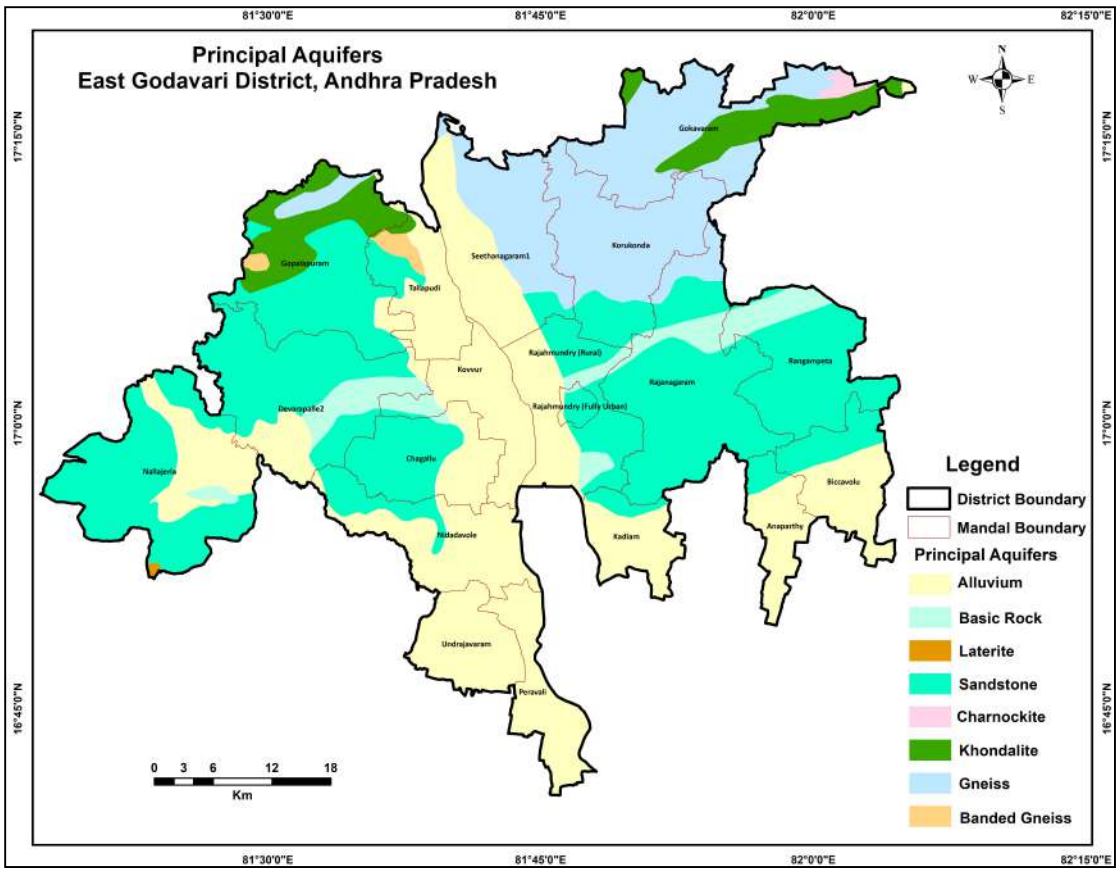


Fig.1.12: Geology of East Godavari district.

Principal Aquifer	Area (Sq.km)	%
Sandstone	1028	39
Alluvium	877	34
Gneiss	429	16
Khondalite	142	5
Basalt	114	4
Banded Gneiss	13	1
Charnockite	8	0
	2613	100

2. DATA COLLECTION AND GENERATION

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

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

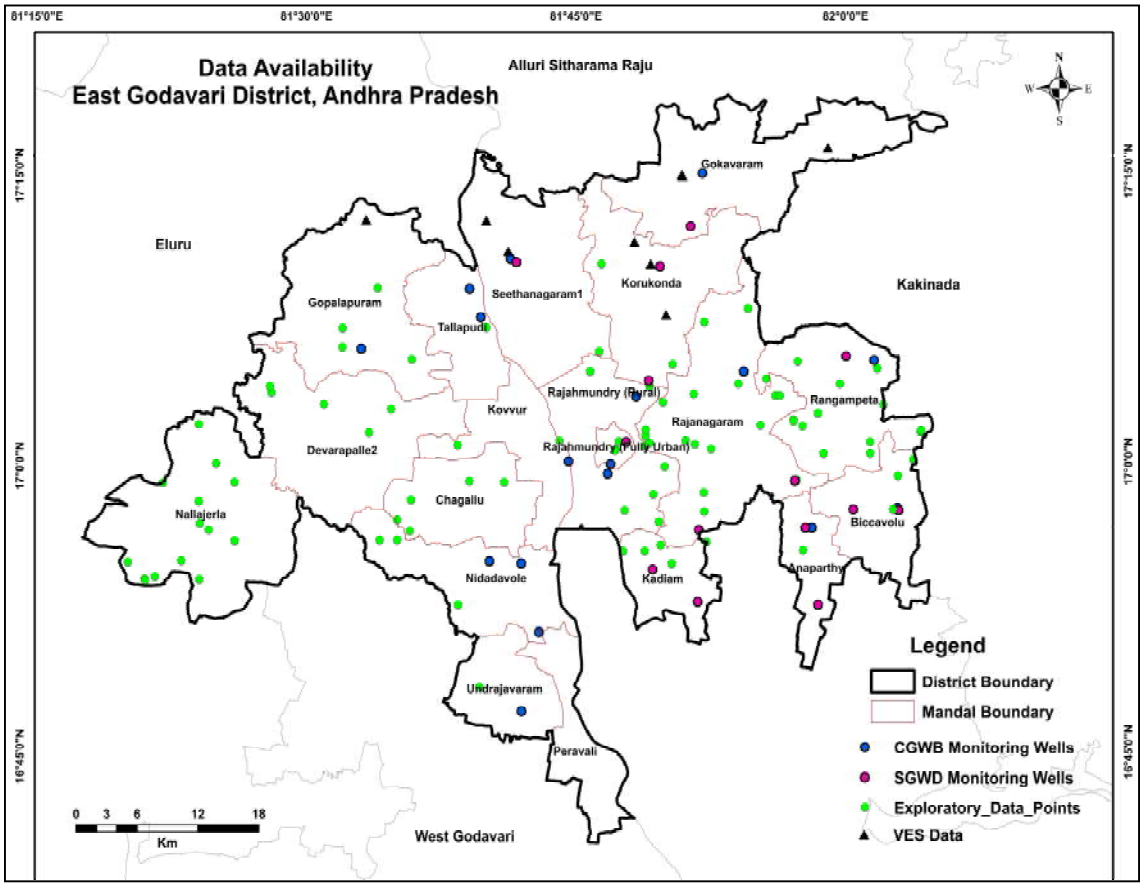
S. No.	Activity	Sub-activity	Task
1	Compilation of existing data/ Identification of Principal Aquifer Units and Data Gap	Compilation of Existing data on groundwater	Preparation of base map and various thematic layers, compilation of information on Hydrology, Geology, Geophysics, Hydrogeology, Geochemical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

2.1 Hydrogeological Studies

Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifers in the area are Sandstone, Alluvium, Gneiss and Khondalite, the occurrence and movement of ground water in hard rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering and in alluvium & sandstone, it is controlled by primary pores. Based on 169 hydrogeological data points (**Fig.2.1)** Data Availability map is prepared.

Organisation	Water Level	Water Quality	Aquifer Geometry		Geophysical
			EW	VES	VES
CGWB/SGWD	34	25	51	9	9

Fig. 2.1: Hydrogeological data availability.



2.1.1 Hydrogeology. The area is underlain by Precambrian crystalline, multilayered and productive Gondwana sandstones, Rajahmundry Sandstone, Deltaic alluvium consisting of fine to medium sand, silt and gravel with intercalations of clay of recent age followed by sandstones of Mio Pliocene age. Hydrogeological map of the area is presented as **Fig. 2.2**. Gondawana comprising Chintalpudi, Gollapalli and Tirupati sandstones form important aquifer systems. Ground water occur in sandstone formation under water table, semi-confined and confined conditions.

Ground water in alluvium occurs under unconfined conditions in shallow aquifers, whereas semiconfined to confined conditions in the deeper aquifers. Shallow aquifer is being tapped by dug wells and by filter points/ shallow tube wells in alluvial area. The depth of the wells generally ranges from 3 to 12 m bgl. Rainfall, canal system and the river Godavari are the main source of recharge. The fresh ground water is limited to shallow aquifer. The depth of these fresh water shallow aquifers vary considerably from place to place. In the Godavari delta the deeper alluviual aquifers explored down to 300 m depth contains saline water, whereas sandstone aquifers encountered below alluvium yielded fresh water.

Ground water in hard rock area 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 70 m depth.

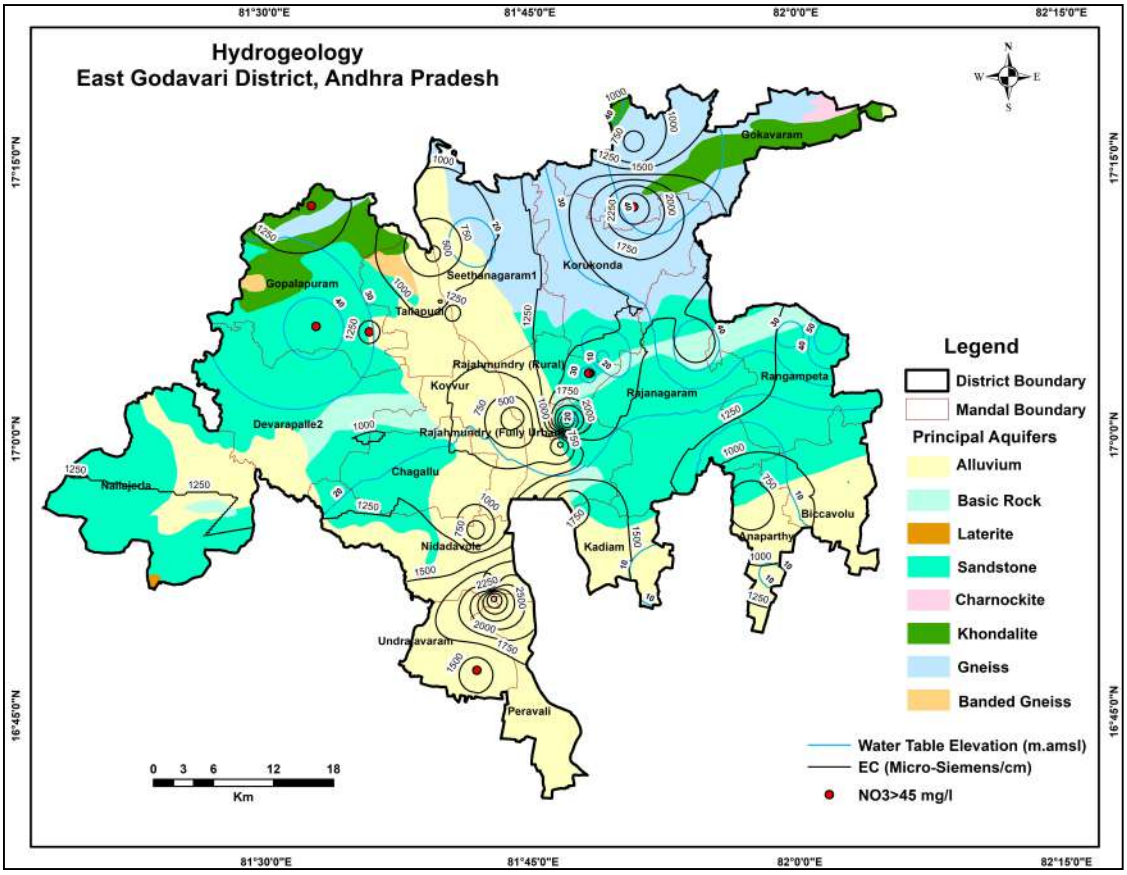


Fig.2.2: Hydrogeological map of East Godavari district.

. **2.1.2 Exploratory Drilling:** As on date, CGWB drilled 101 no's bore wells ,06 wells were drilled in alluvium area, 92 wells were drilled in sandstone area and 3 wells are drilled in Hard rock area. Data analysed from CGWB wells indicates, 04 well of shallow depth (<30 m), 06 wells of 30-60 m depth, 10 wells of 60-100 m depth, 38 wells of 100-150 m. Depth, 18 wells of 150-200m depth, 10 wells of 200-250m depth, 15 wells of >250m depth,

2.2 Water Levels: Ground water levels from 35 wells (CGWB: 17 and SGWD: 18) were monitored during pre-monsoon and post-monsoon seasons respectively.

2.2.1 Water Table Elevations: During pre-monsoon (May, 2011-2020), the water-table elevation ranges from 1.35 - 58 meter above mean sea level (m amsl) and general ground flow is towards river Godavari from southwest to north-east part of district. (**Fig.2.3**)

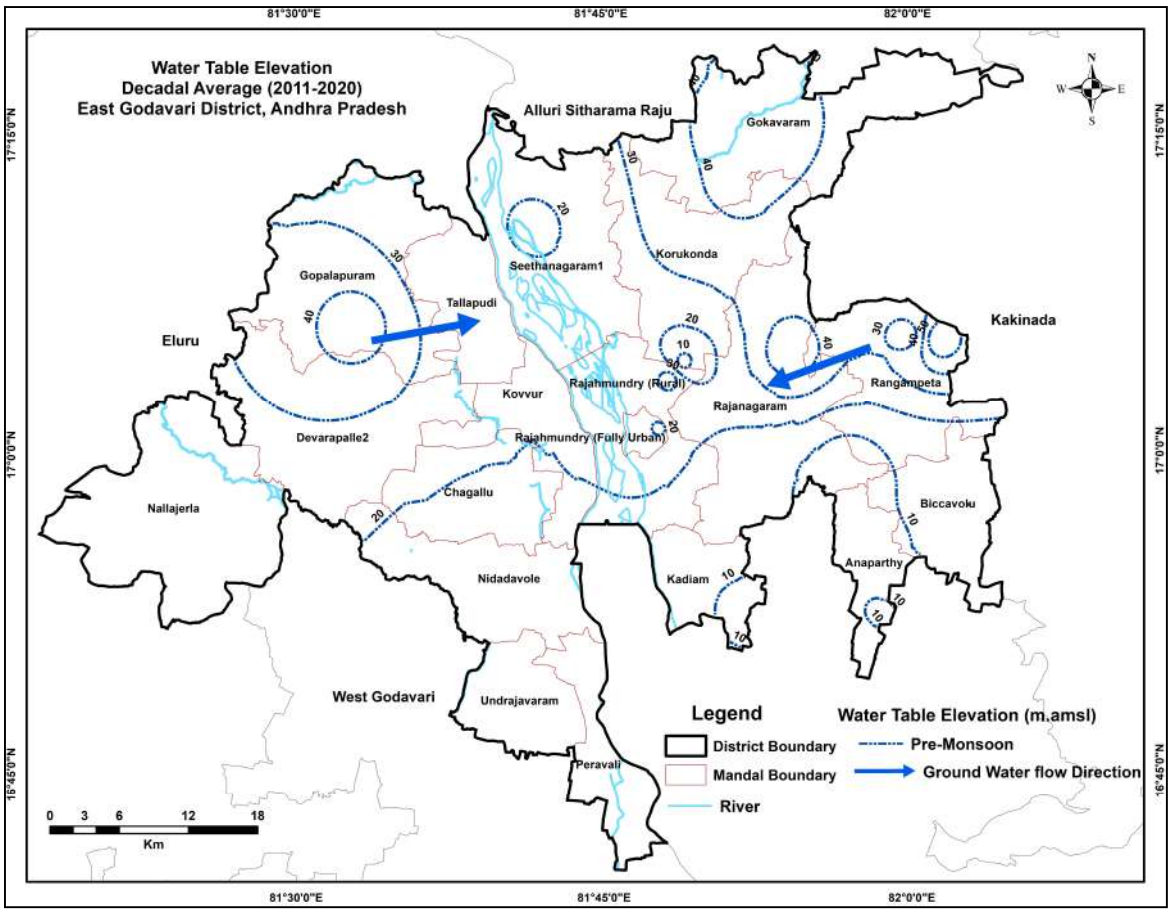


Fig.2.3: Water table elevations (m amsl) during pre-monsoon season

2.2.2 Depth to Water Levels (DTWL): The average DTWL of 10 years (2011 to 2020) for pre-monsoon and post-monsoon were analysed, the avg. DTWL varies from 1.9 to 28.4 meter below ground level (m bgl) (average: 9.4 m bgl) and 1.4 to 27.5 m bgl (average: 8.5 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 48% of the area, followed by 0.0 to 5.0 m bgl (30%), 10-20 m bgl (19 %) and >20 m bgl (3%). The water levels >20 m.bgl occupy in parts of Rangampeta, Rajanagaram, and Rajahmundry (U) mandals. (**Fig.2.4**)

Post-monsoon season: Majority of the water levels during this season are in the range of 5.0 to 10 m bgl covering 46% of the area, followed by 0 to 5 m bgl (34%), 10-20 m bgl (18 %) and 20-30 m bgl (2%). (**Fig.2.5**)

2.2.3. Water Level Fluctuations (May vs. November): The water level fluctuations vary from -6.36 to 10.60 m with average rise of 1.56 m (**Fig.2.6**). The water levels rise is observed in district except in parts of Tallapudi, Nidadavole, Rajahmundry and Rjanagaram Mandals. Rise in water level range of <1 m covers majority of the area with 63 % followed by 1-2 m rise in 21% of the area followed by >2 m rise in 16% of the area.

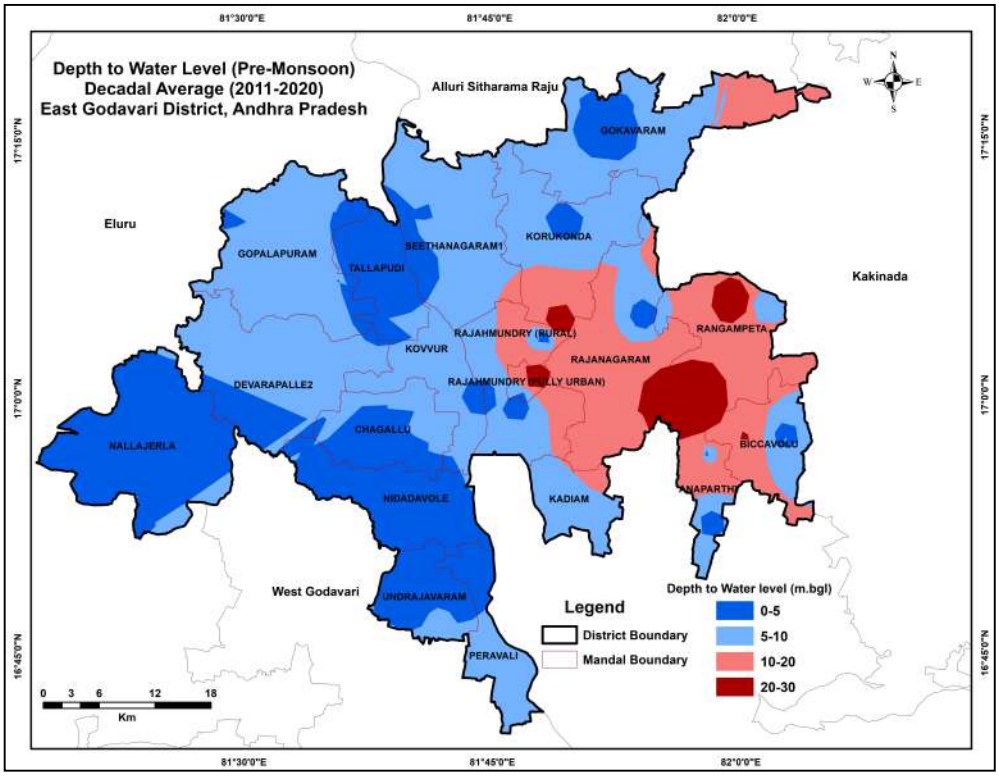


Fig.2.4: Depth to water levels Pre-monsoon

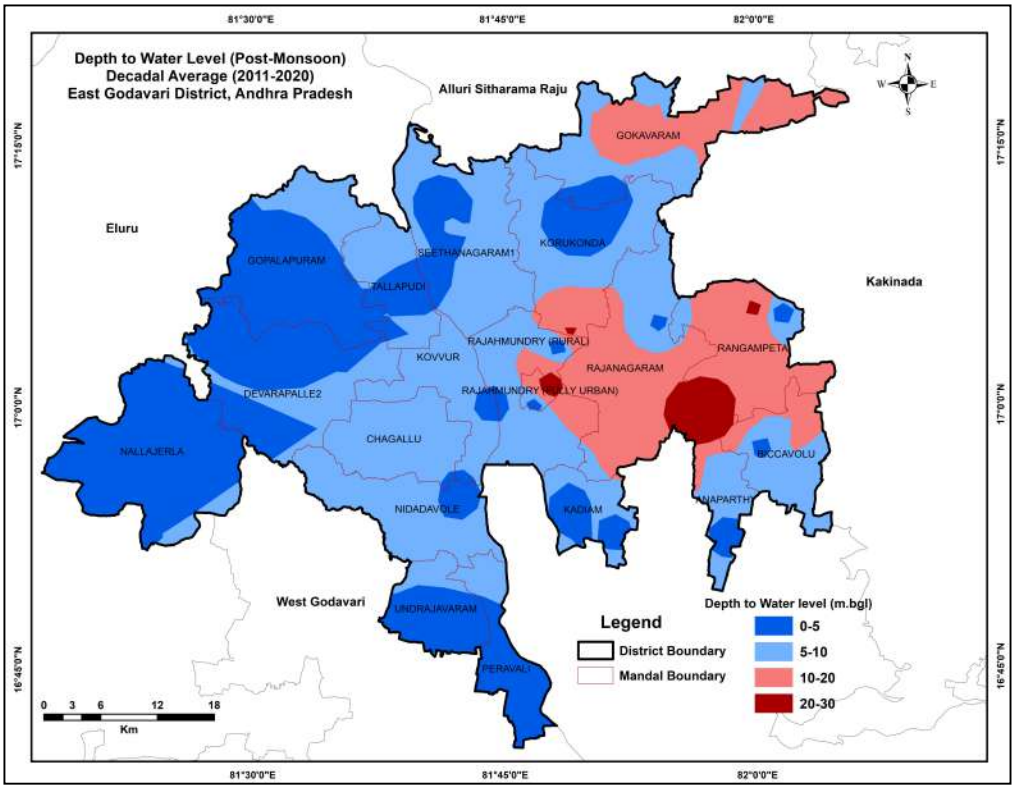


Fig.2.5: Depth to water levels Post-monsoon.

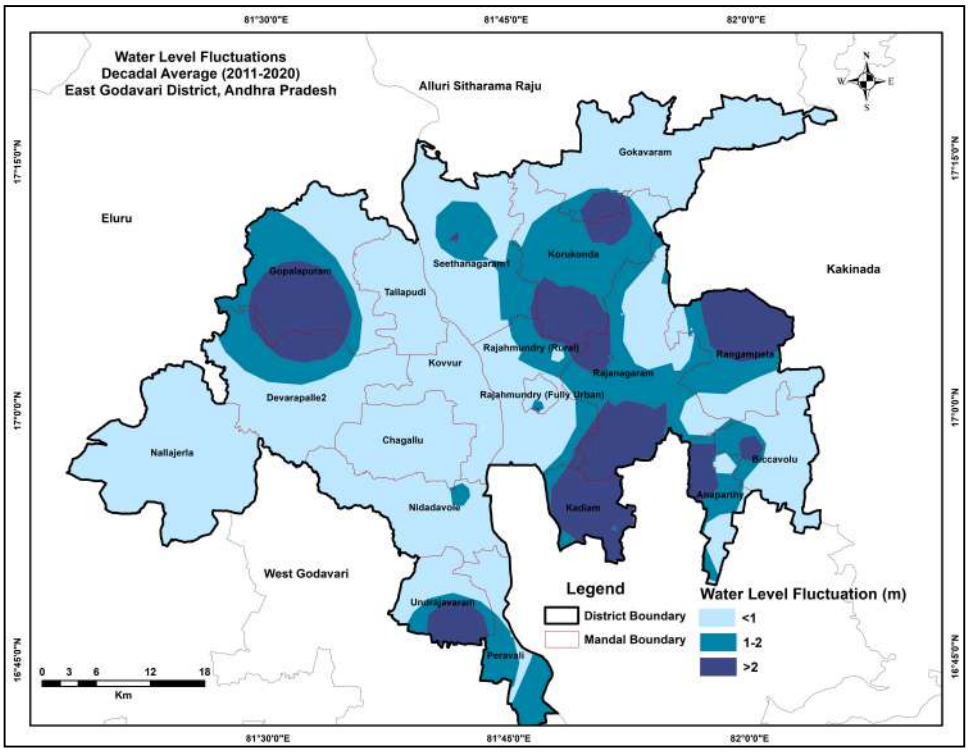


Fig.2.6: Water Level Fluctuations (m) (Nov with respect to May).

2.3 Hydro chemical Studies

To understand chemical nature of groundwater, total 25 data is utilized from ground water monitoring wells of CGWB during the pre-monsoon season of 2022. 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.

2.3.1 Pre-monsoon (May)

Groundwater is mildly alkaline to alkaline in nature with pH in the range of 7.21-8.1(Avg: 7.76). Electrical conductivity varies from 254-3330 (avg: 1294) µ Siemens/cm**.** In 78 % of area EC varies betweem 750-1500 µ Siemens/cm, in 19 % area, it is >1500 µ Siemens/cm and in 03 % area, it is <750 µ Siemens/cm (**Fig.2.7).** NO_3 ranges from 1-124 mg/L. Nitate concentration in 71% of samples is beyond permissible limits of 45 mg/L (**Fig.2.8**). Fluoride concentration varies from 0.032-1.79 mg/L (**Fig 2.9**) and 96 % of samples it is within permissible limits of BIS and rest is beyond permissible limit of 1.5 mg/L.

).

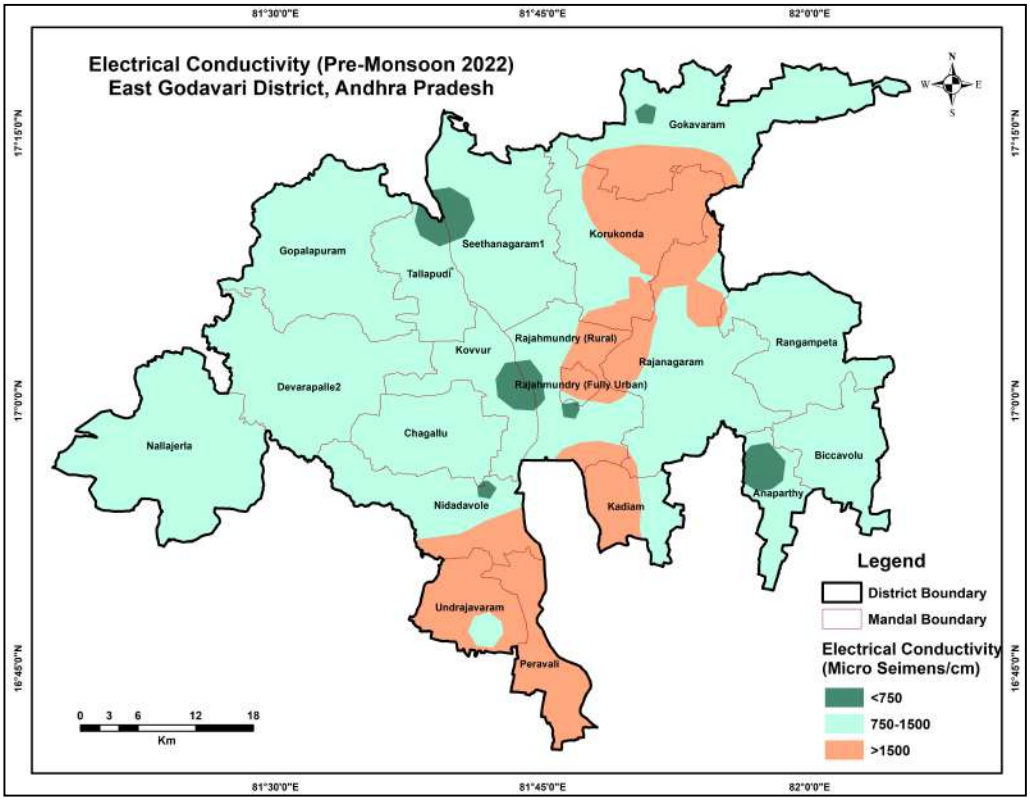


Fig.2.7: Distribution of Electrical conductivity (Pre-monsoon)

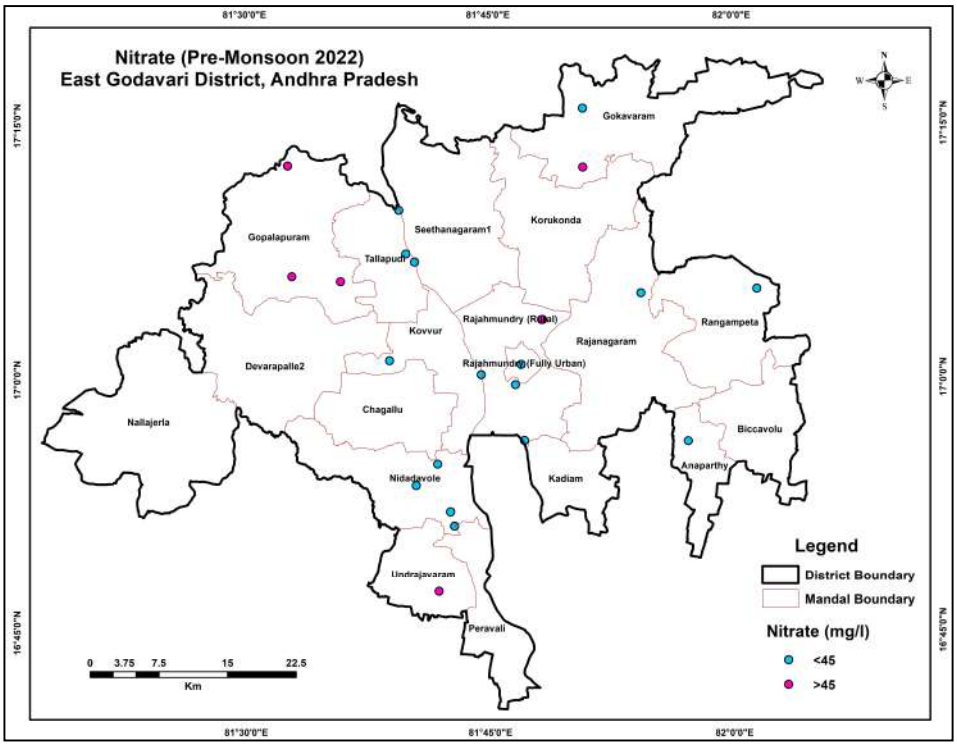


Fig.2.8: Distribution of Nitrate (Pre-monsoon).

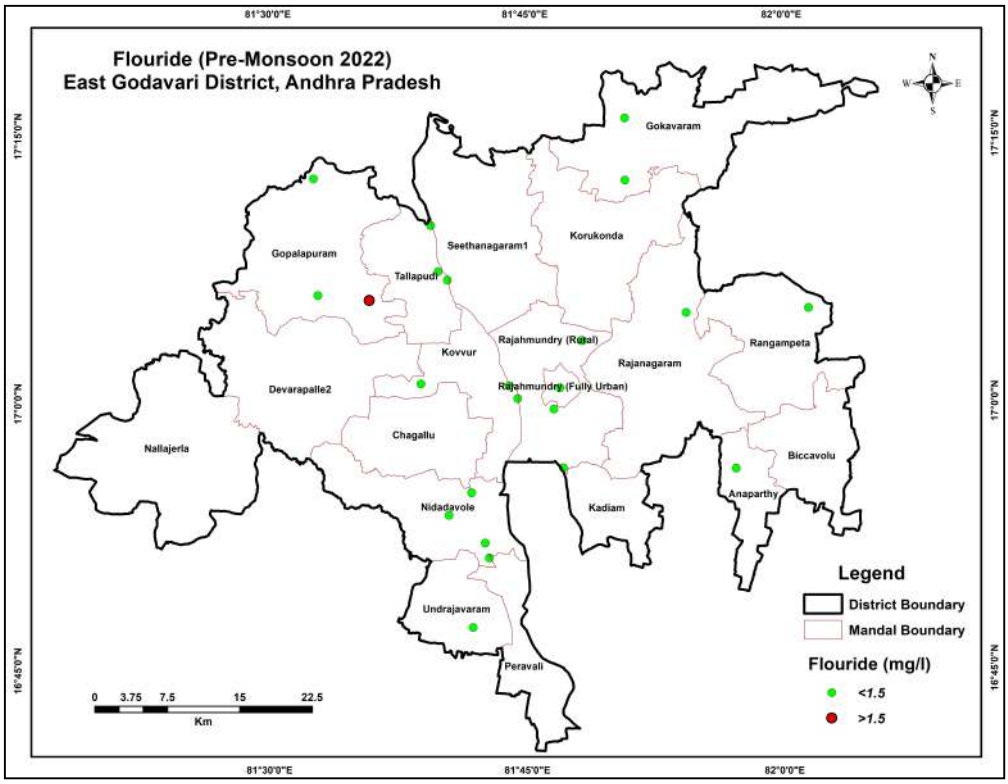


Fig.2.9: Distribution of Fluoride (Pre-monsoon).

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was carried out by interpreting and integrating representative 60 data points (both hydrogeological and geophysical down to 350 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 East Godavari district (**Fig.3.1 Fig.3.2, Fig.3.3 & Fig. 3.4)**

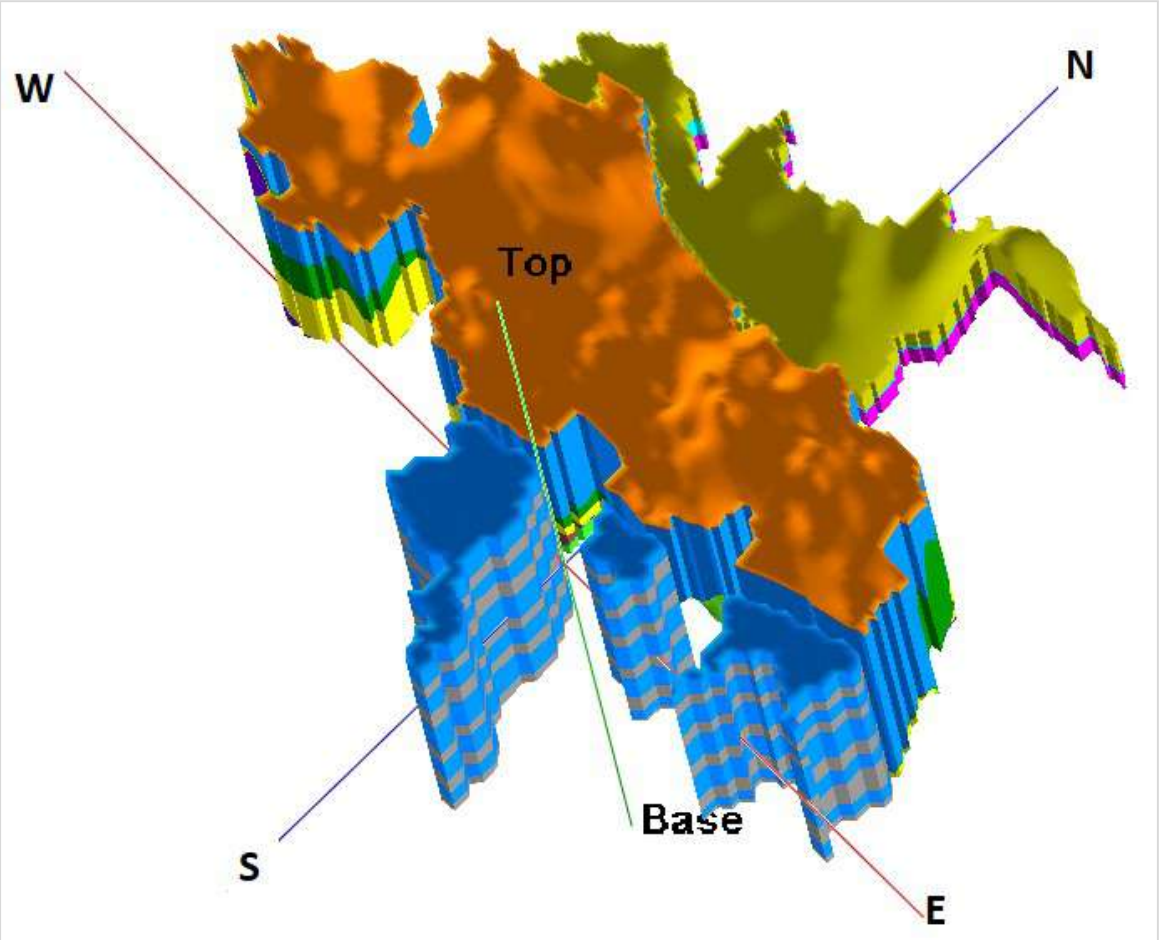


Fig.-3.1: 3-D Model for study area.

Stratigraphy index of Hard Rock	Stratigraphy index of Sandstone	Stratigraphy index of Alluvium
Weathered Granite Fractured Granite Massive Granite	Alluvium Rajahmundry_SST Basalt Thirupati_SST Gollapalli_SST Chintalapudi_SST Khondalite Gneiss	S1 C1 S2 C2 S3 C3 S4 C4 S5 C5

3.1 Conceptualization of aquifer system in 3D:

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. The detailed analysis of the data reveals that the Sandstone, alluvium and Eastern Ghat rocks are the principal aquifer system. 3-Dimensional model of the area is presented as **Fig. 3.1.** Ground water occurs in unconfined, semi-confined and confined conditions in the study area.

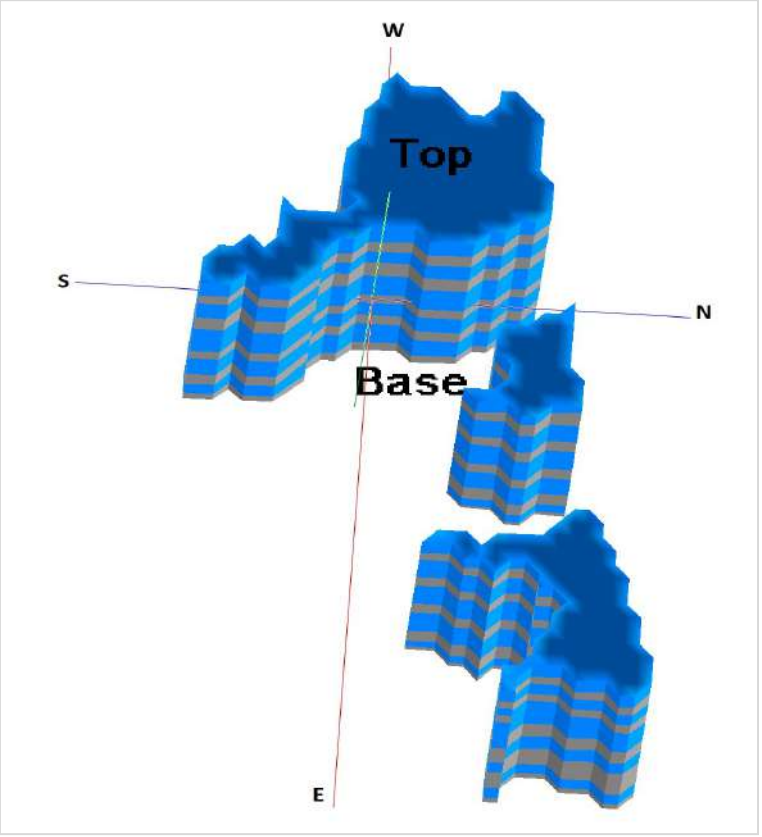


Fig.3.2: 3D Aquifer disposition in Alluvium

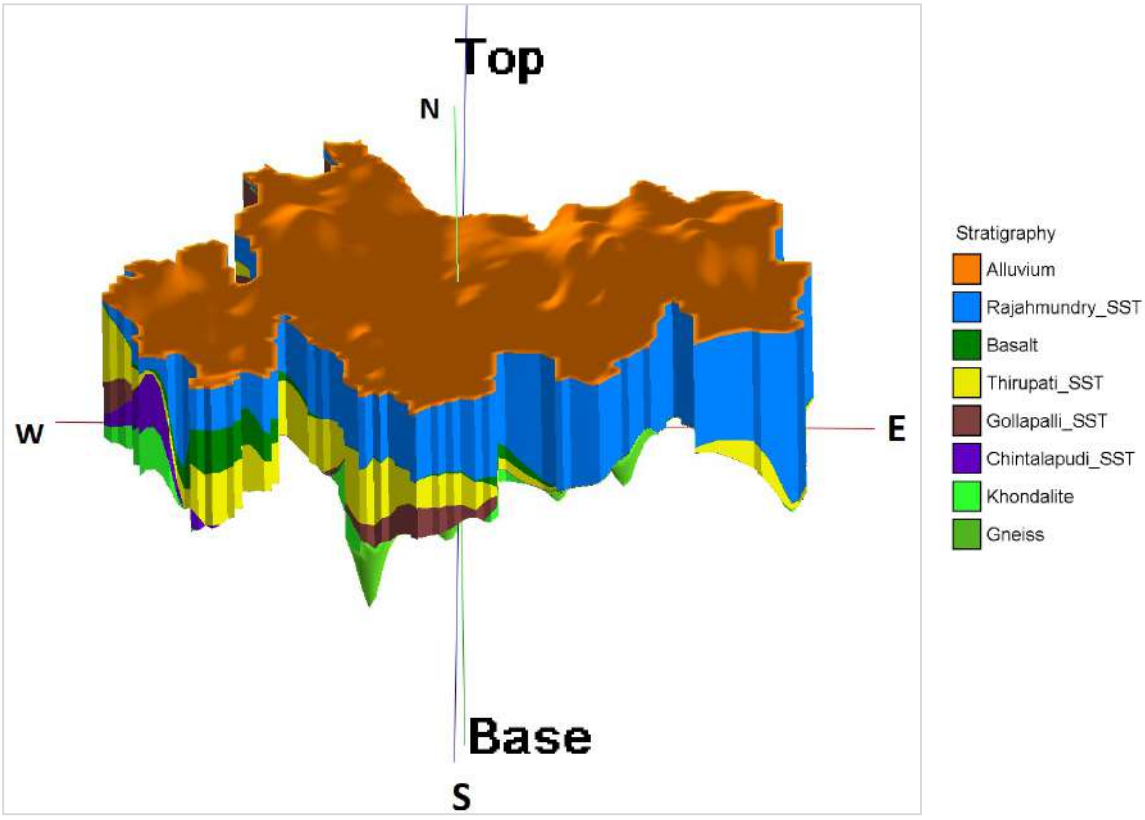


Fig.3.3: 3D Aquifer disposition in Sandstone

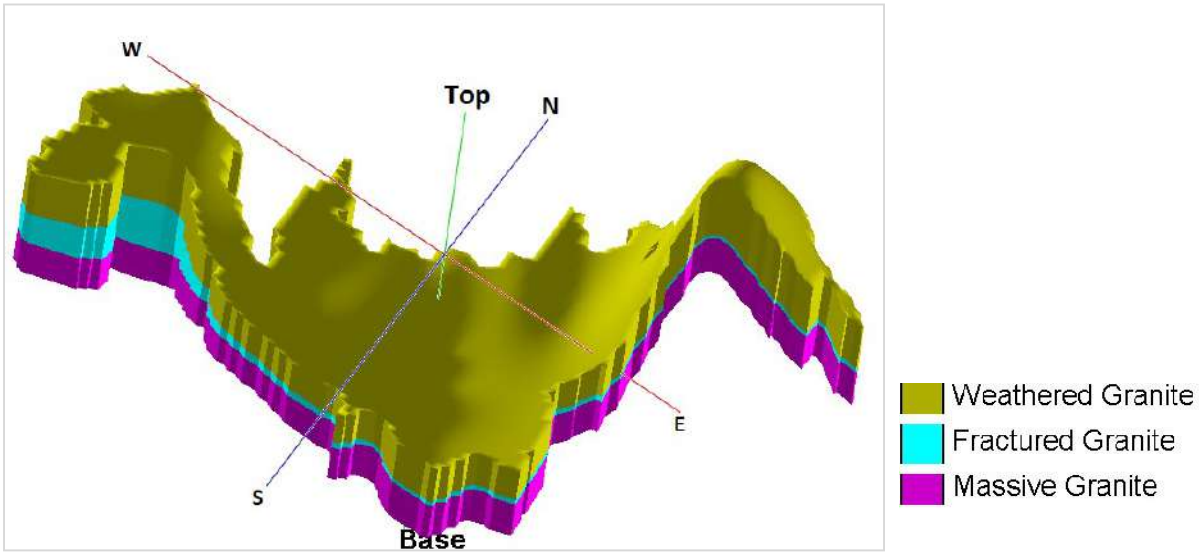


Fig.3.4: 3D Aquifer disposition in Hard Rock

3.2 Hydrogeological Sections:

East Godavari district is underlain by variety of geological formations comprising from the oldest Archaean to Recent Alluvium. The Archaean crystallines form the basement for the younger formations i.e., sandstone and alluvium formation in the area. These are represented by khondalites, charnockites and gneisses. Hydrogeological sections are prepared in different directions. (**Fig.3.5a-d**)

The stratigraphic sections depicting in Sandstone area constitutes sandstones of multi layered Gondwana and Rajahmundry sandstones. The Gondwana formations represented by Chintalapudi, Gollapalli, and Thirupathis are occupy in the western part of the study area where as in eastern part of the area Thirupathi and Rajahmundry are major formations.The Chintalpudi formation overlies unconformbly over the Archaeans It is represented by fine to medium grade sandstone interbedded with shale clays and pebbly sandstone. The Golapalli formation of the upper Gondwana directly overlis the archeans in the western part of the area and directly underlies the Tirupati sandstone and overlies Chintalapudi sandstone. These formations are represented by sandstone, shale and conglomerate of yellowish brown to buff colour and are sometimes purple in nature. The Tirupati formation is the youngest formation of the Gondwana super group in the district directly rests on Archaean basement at other places. These are overlain by Deccan Traps of Eocene age in central part. All the above formations are trending in NE-SW with 5 to 10^{o} dip toward southeast. Deccan traps are well exposed in central part of the area. The basaltic flows are overlain mostly by Rajahmundry sandstones. The Rajahmundry formation of Tertiary age overlies the traps in the eastern part and Gondwanas in the western part.

Disposition of all geological formations, viz., Chintlapudi sandstone,Gollapalli sandstone, Tirupati sandstone, Basalt and Rajahmundry sandstone are clearly noticed in the section prepared across the entire along the direction of NW – SE between Peddagudem- Kotapadu. Tirupati sandstone and Rajahmundry sandstone forms the main formations in the area. Cross sections drawn along different directions of the area are presented as Fig. **3.5 a to b**. The sections reveal that Chintalapudi, Gollapalli and Thirupathi formations occupy in the western part of the study area where as in eastern part of the area Thirupathi and Rajahmundry are major formations.

The stratigraphic sections depicting in Alluvium area comprising silt, sand, clay and gravel formed multy layered aquifer system with intervening thick clay beds. Sand beds act as aquifers in the area and there are five distinct beds which behave as regional aquifer. Hydrogeological cross section is depicted in **Figs 3.5 c**.

In Hard rock area mainly Eastern Ghat rocks comprising khondalite, Charnockite and Gneiss present in the district in which weathered Aquifer depth of occurrence is from 0 to 35 m and fractured aquifer depth of occurrence is from 35 to 70 m. Hydrogeological cross section is depicted in **Figs 3.5 d**.

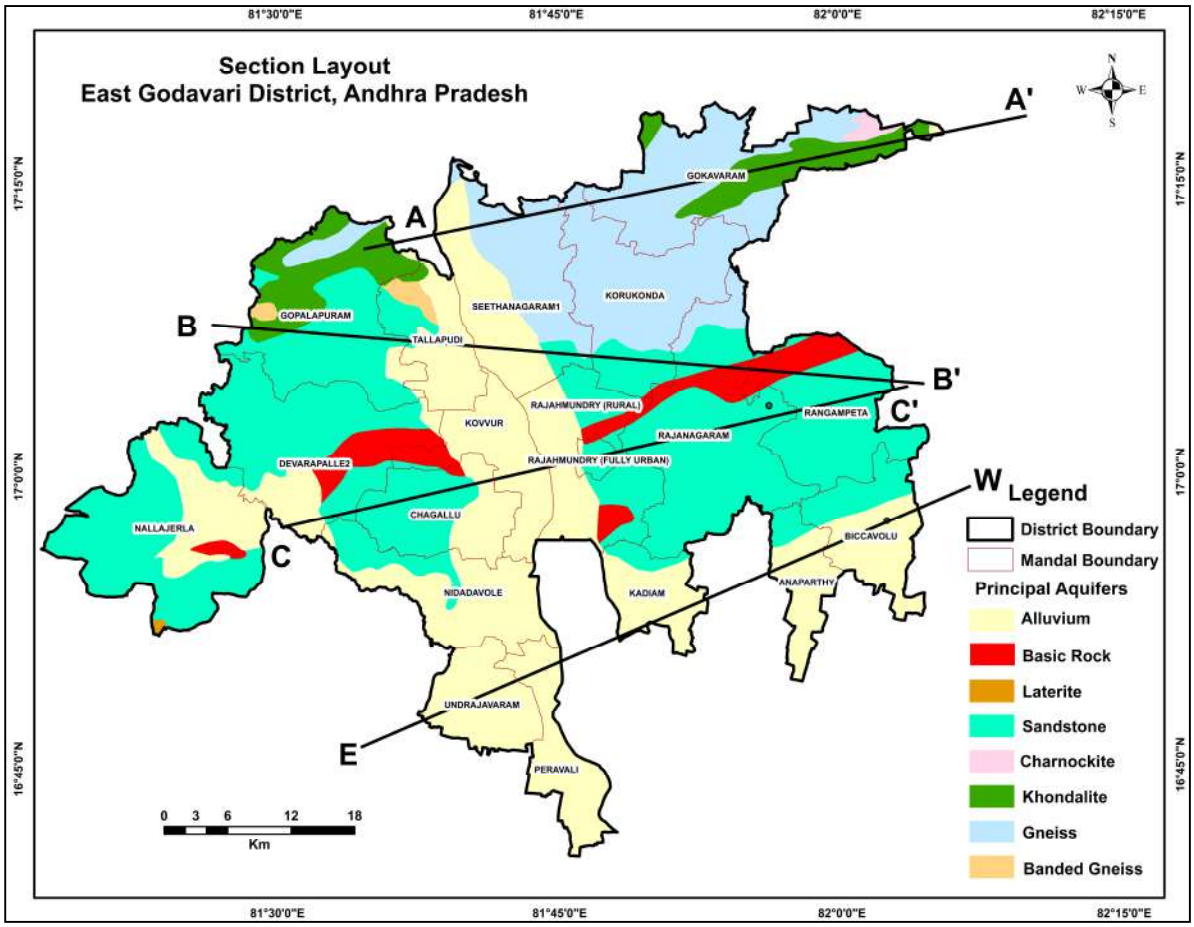


Fig.-3.5: Map showing orientation of hydro geological Sections

Fig.3.5a.

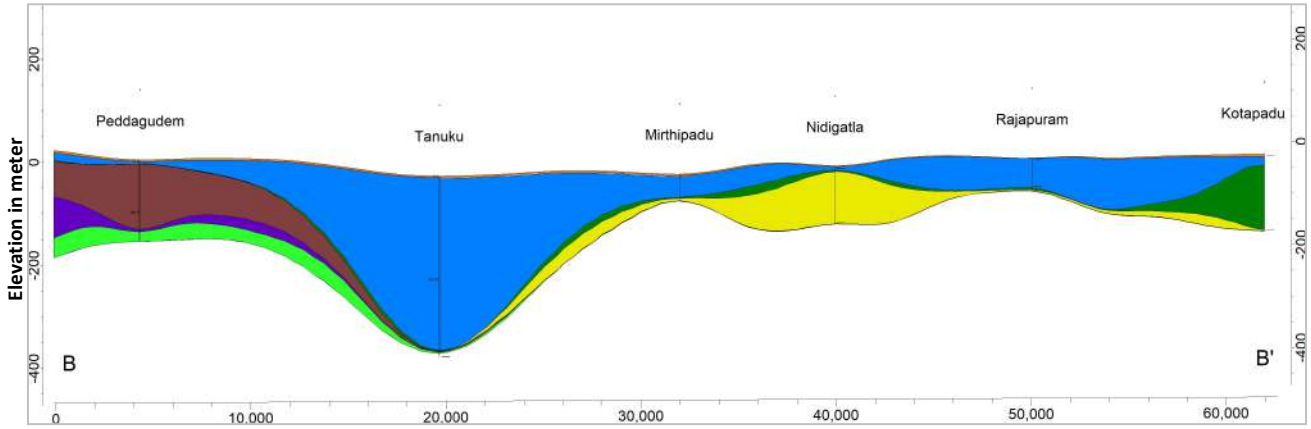


Fig.3.5b.

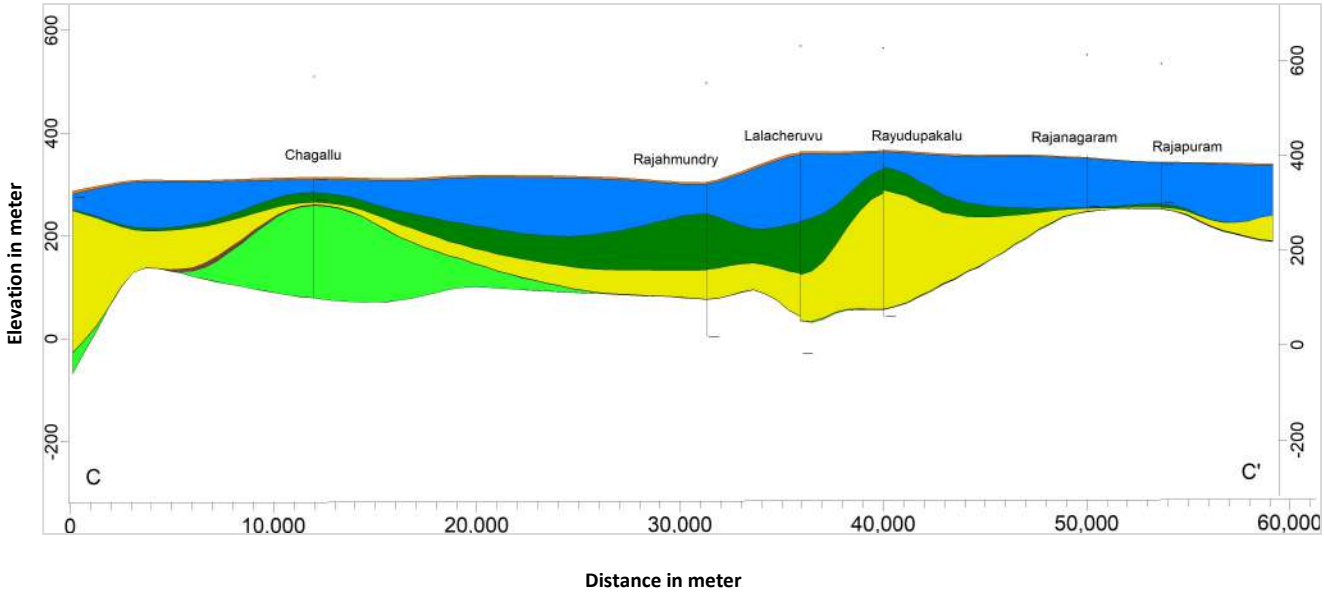


Fig.3.5c

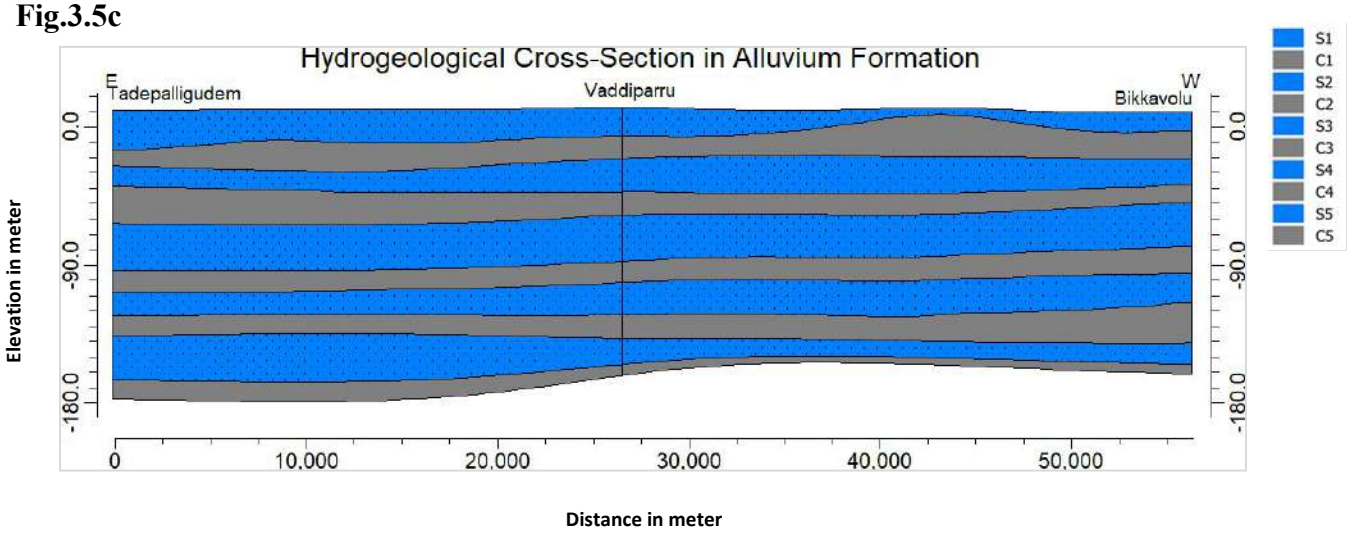
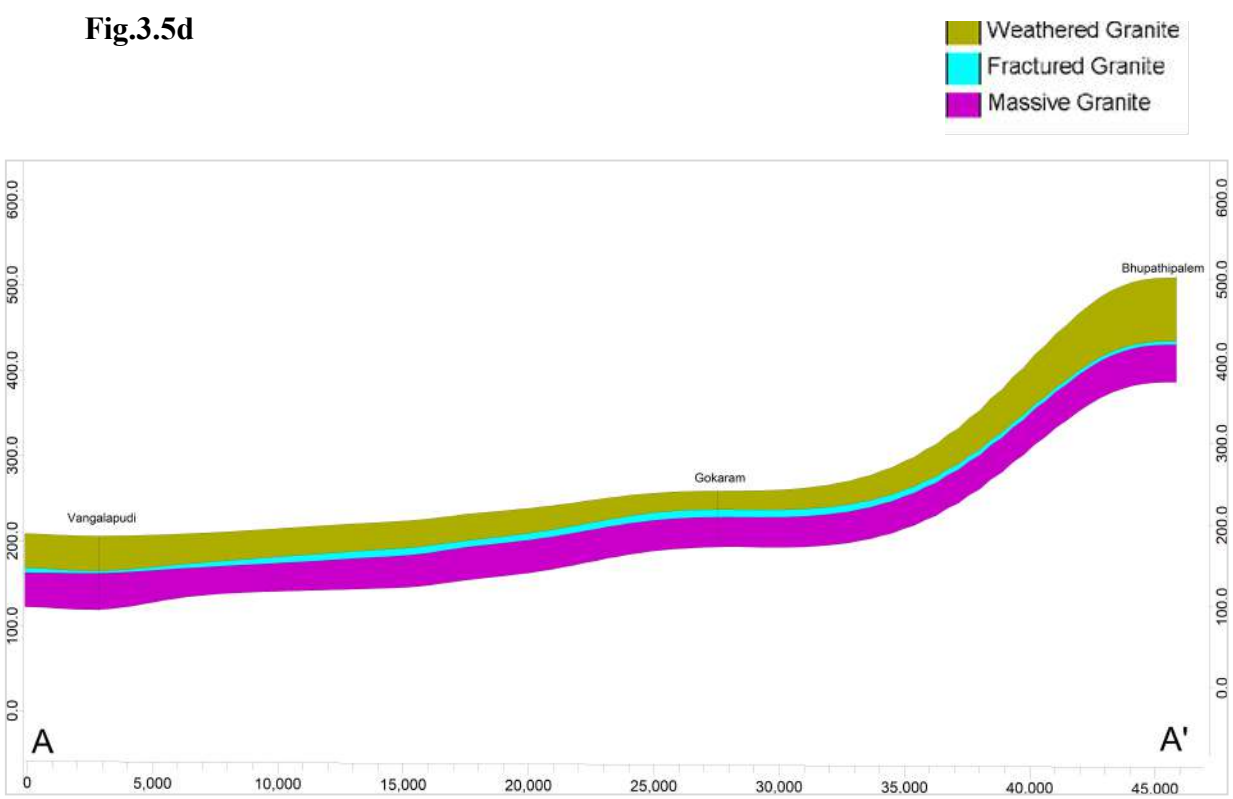


Fig.3.5d



3.3 Aquifer Characterization

3.3.1 Sandstone part of study Area

The Chintalapudi formations are the oldest sedimentary rocks in the area. Ground water occurs in this formation under water table, semi confined to confined conditions. The depth of the wells constructed in this formation range between 60 and 120 m bgl. The yields of the wells vary from 604 to 419 m3/day for drawdown of < 1 to 23 m. The specific capacity of the wells varies from 20.95 to 530.6 lpm/mdd and the transmissivity of wells varies from 50 to 1465 m2/day.

In Gollapalli formations ground water occurs under unconfined, semi-confined to confined conditions. The depth of the wells ranges between 84 and 169 bgl with a maximum discharge of 2419 m3/day. The yields vary between 691 and 1382 m3/day. The specific capacity of the wells is of the order of 20 to 389 lpm/m/dd and the transmissivity of this formation ranges between 247 and 1055 m2/day.

In Thirupati formations ground water occurs under water table to confined conditions. However in southern part, these formations occur beneath Deccan trap formation where the ground water occurs under confined conditions. The depth of the wells constructed in this formation range between 99 and 300 m bgl. The yields of the wells vary from 155 to 345 m^3/day with a maximum yield of 3888 m^3/day. The specific capacity of the wells varies from 35 to 328 lpm/m/dd and transmissivity of formation varies between 76 and 846 m^2/day.Deccan traps are restricted to small area in the central part of the study area. They are generally massive and the yield from this formation is low.

Rajahmundry formations occupy major portion in the eastern part of the study area. The thickness of this formation in the area recorded upto 390 m below which Deccan traps occur. Ground water occurs under unconfined to confined conditions. The discharge of the wells constructed in these formations generally varies from 1200 to 3000 m3/day transmissivity varies between 395 and

3168 m^2/day. The summarized details of parameters formationwise are given in **Table 3.**

The interpretation of the available hydrogeological data indicates that there are multi aquifers (2 to 3 aquifers) in the sandstone formations of the area with intervening clay/shale beds. The first aquifer is unconfined where as the other aquifers are semi- confined/confined.

Table 3 –Formation wise Aquifer Parameters

Formation	Max. Thickness	Q (lps)	T (m2/day)
Rajahmundry Sandstone	692	15 - 35	395 - 3168
Thirupati Sandstone	224	4 - 18	76 - 846
Gollapalli Sandstone	71	8 - 16	247 - 1055
Chintalapudi Sandstone	107	7 - 28	50 - 1465

3.3.2 Hard Rock part of study Area

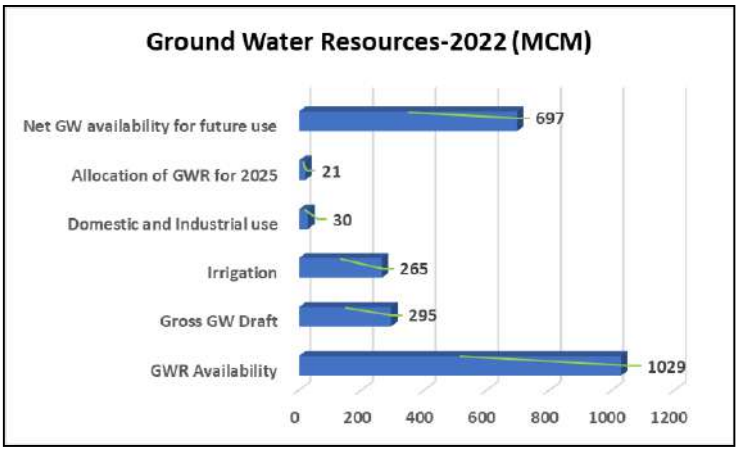
In Hard rock area mainly Eastern Ghat rocks comprising khondalite, Charnockite and Gneiss present in the district in which weathered Aquifer depth of occurrence is from 0 to 35 m and fractured aquifer depth of occurrence is from 35 to 70 m.

4. GROUND WATER RESOURCES (2022)

The dynamic ground water resources are computed as per the guidelines laid down in GEC methodology. As per 2022 GEC report, the net dynamic replenishable groundwater availability is 1029 MCM, gross ground water draft for all uses 295 MCM, provision for drinking and industrial use for the year 2025 is 21 MCM and net annual ground water potential available for future irrigation needs is 697 MCM. 18 mandals fall in safe category except Nallajerla. Mandal wise stage of ground water development varies from 7 % (Rajahmundry Urban mandal) to 80 % (Nallajerla mandal) with average of 34%**.** The summarized mandal wise resources are given in Table-4.1. The details of Ground Water resources are provided in Annexure-3 and 4.

Table-4.: Computed Dynamic Ground Water resources, East Godavari District.

Parameters	**Total**
As per GEC 2022	**MCM**
Dynamic (Net GWR Availability)	**1029**
• Monsoon recharge from rainfall	242
• Monsoon recharge from other sources	424
• Non-Monsoon recharge from rainfall	25
• Non-monsoon recharge from other sources	339
Gross GW Draft	**295**
• Irrigation	265
• Domestic and Industrial use	30
Provision for Drinking and Industrial use for the year 2025	21
Net GW availability for future irrigation	697
Stage of GW development (%)	**33%**



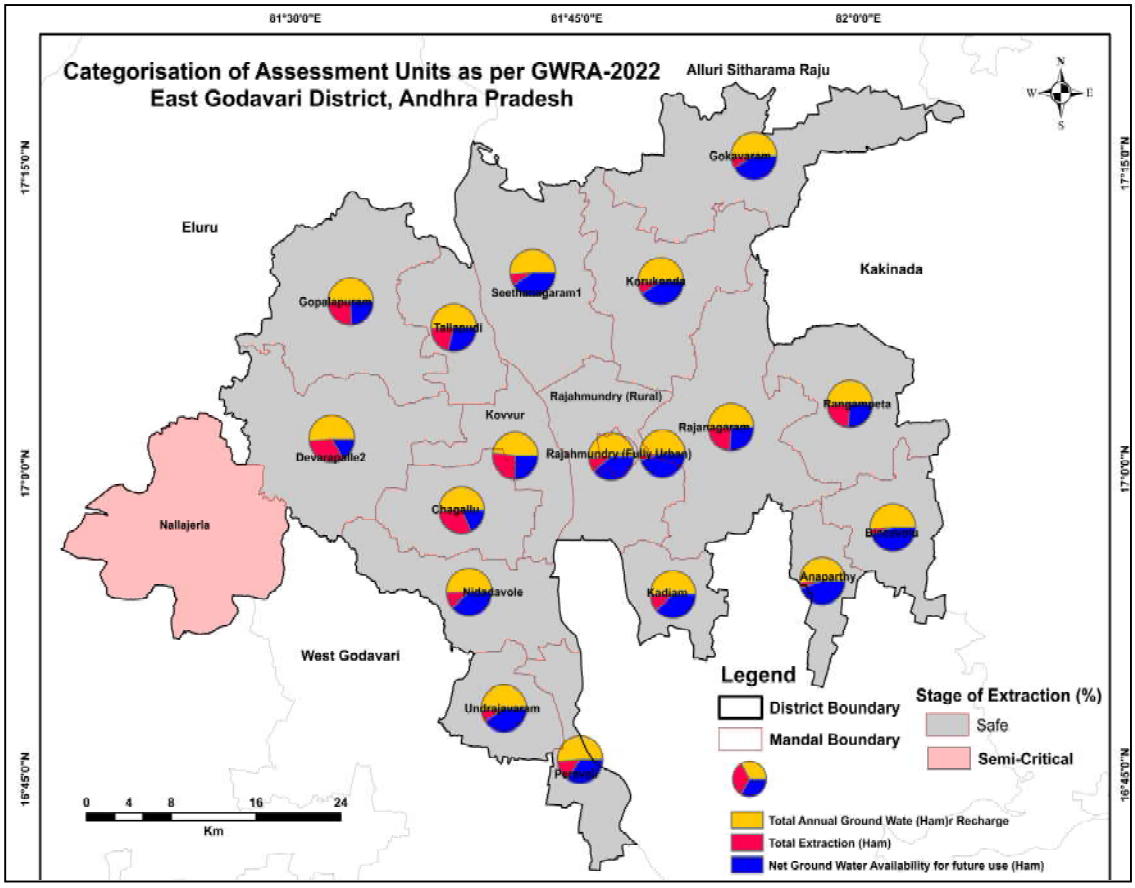


Fig.4.1: Categorisation of Mandals (GWRA-2022)

5. GROUND WATER RELATED ISSUES AND REASONS FOR ISSUES

5.1 Issues

5.1.1 Sandstone part of study area

Deep water levels

- Deep water levels (> 20 m bgl) are observed during pre and post-monsoon season in 3 % and 2 % of the area respectively.
- The major considerable ground water issue in the area is water level depletion. Due to increased ground water development in the area, there is depletion of piezometric heads and to some extent water table.
- The reason for depletion of piezometric head is may be due to increase in cultivation water consuming crops by ground water mainly by tube well irrigation even during Rabi season.

5.1.2 Alluvium part of study area

The major considerable ground water issues in the Alluvium are

- Water Logging
- Ground Water Salinity

Water Logging:

- Irrigation by surface water, minimal withdrawal of ground water, flat topography, high rainfall, poor drainage and nature of soils are responsible for the water logging conditions in the area.

Ground Water Salinity:

- Deeper aquifers ground water is invariably saline. The origin of the salinity in any area can be due to the following three reasons viz., palaeo salinity, due to leakage from the bottom aquifer, due to sea water intrusion caused by human activity.

5.1.3 Hard Rock part of study area

Low Sustainability

- Low yield (<1 lps) occurs in ~26 % of area covering entire district.
- The reason of low sustainability is due to absence of primary porosity, negligible development of secondary porosity, low rainfall and desaturation of weathered zone.

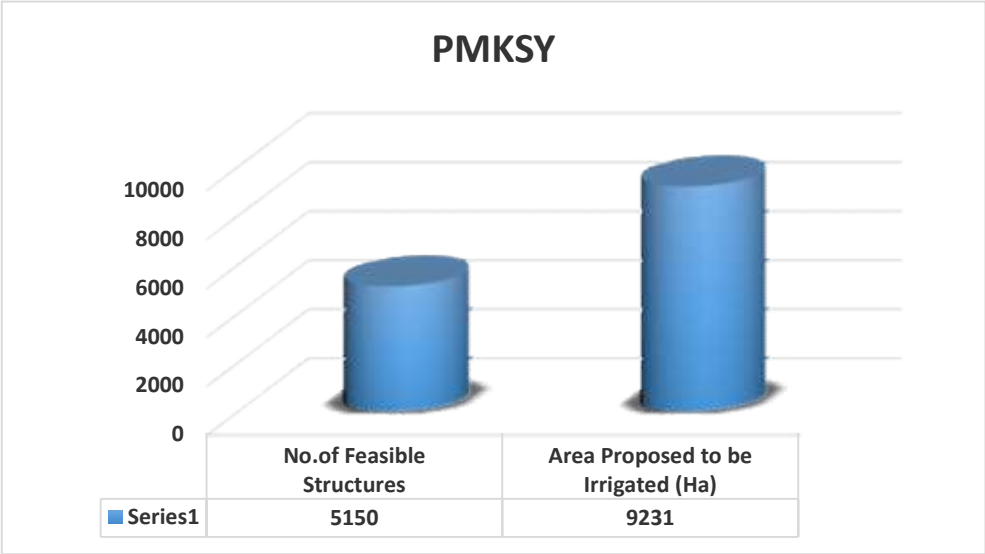
6. GROUND WATER DEVELOPMENT AND MANAGEMENT STRATEGIES

6.1. Groundwater Development:

At present the ground water abstraction in the district is low (34%) and there is a scope for further ground water development for irrigation. The total utilization of ground water is 295 MCM against the total ground water potential of 1029 MCM available for future use. Ground water irrigation in the district is accounts only for 59 % of the net irrigation of the district.

Table 6.1: PMKSY- Proposal in East Godavari district, AP

Sl.No	District	Mandal	No.of Villages	No.of Feasible Structures	Area Proposed to be Irrigated	Total Cost
1	East Godavari	ANAPARTHI	8	490	981.3065	2355.306
2	East Godavari	BICCAVOLU	8	446	889.5713	2143.176
3	East Godavari	GOKAVARAM	13	253	251.5844	1190.031
4	East Godavari	KADIAM	4	210	421.528	1009.244
5	East Godavari	KORUKONDA	14	266	289.9014	1297.514
6	East Godavari	SEETHANAGARAM	10	389	434.1927	1910.631
7	East Godavari	GOPALAPURAM	15	357	540.3506	2058.158
8	East Godavari	KOVVUR	12	287	538.969	1375.635
9	East Godavari	NIDADAVOLE	23	464	924.6213	2620.836
10	East Godavari	PERAVALI	10	404	804.7706	1942.176
11	East Godavari	THALLAPUDI	18	798	1581.518	4655.647
12	East Godavari	UNDRAJAVARAM	15	786	1572.82	3777.68



6.2 Area Identified for Artificial Recharge in the Study Area

There is a scope for construction of artificial recharge structures considering the available run-off and recharge potential which can be taken up as per requirement in the district. An area of about 1666 sq. km has been identified in District for artificial recharge. The thickness of available unsaturated zone (below 5 m bgl) is computed on basis of Post monsoon (2013-2022) decadal average water level depth. The run off required to recharge the unsaturated volume 797.21 MCM. The Surplus runoff available for recharge 129 MCM calculated as 20% of the total run off available in the district.

Table 6.2

Formation	Total Area (Sq.km)	Area Identified for Artificial Recharge (Sq.km)	Subsurface Volume Available (MCM)	Volume of Surplus Run-off (MCM)	Proposed CDs	Proposed PTs
Sandstone	1522	1225	349			
Hard Rock	670	320	19			
Alluvium	368	121	7			
Total	**2560**	**1666**	**375**	**53**	**239**	**272**

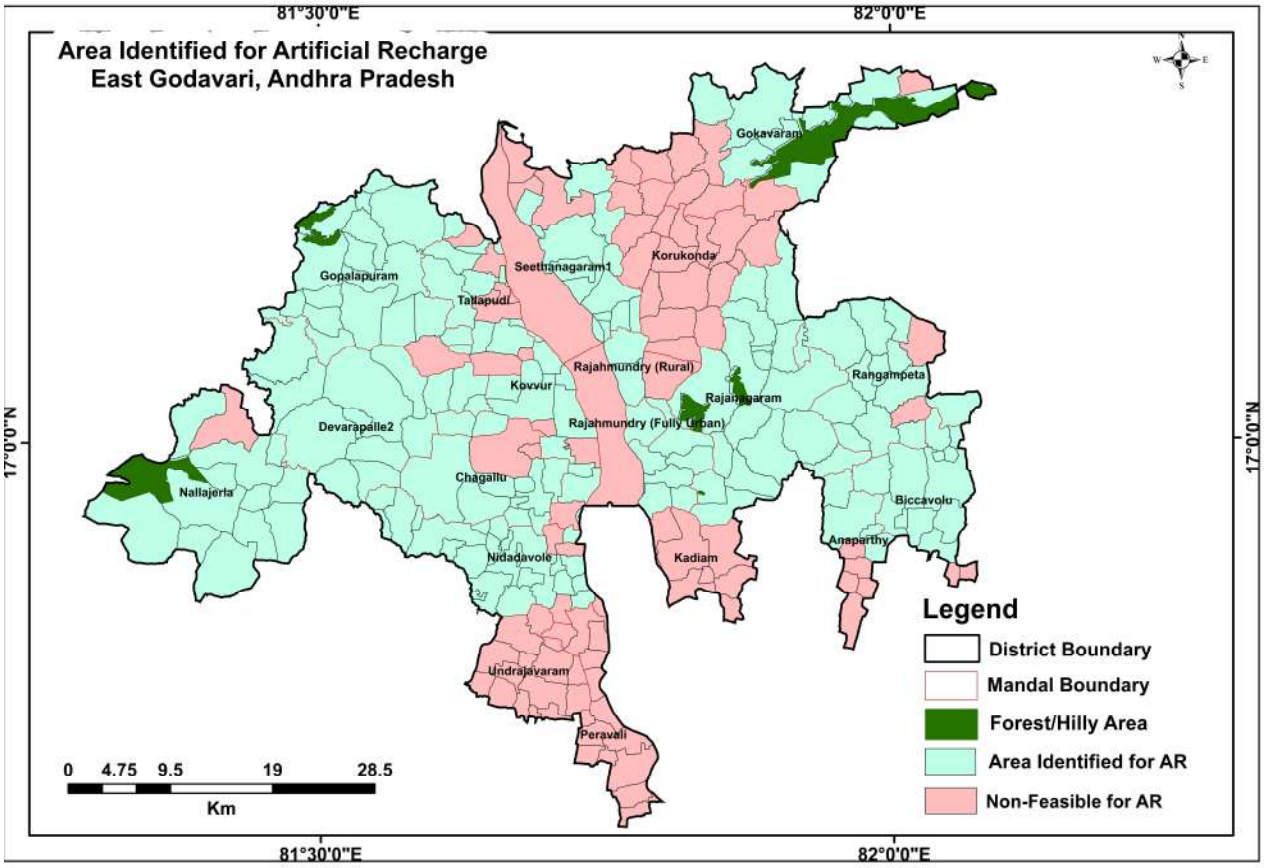


Fig 6.2 Area identified for Artificial Recharge in East Godavari

6.3 Aquifer Management Strategy of Sandstone part of study Area

The uneven distribution of groundwater availability and its utilization indicate that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy.The study suggests notable measures for sustainable groundwater management which involves a combination of various measures given below.

Supply side Measures

Ground water is the main source of both for drinking and irrigation requirements.The main source of recharge in the area is precipitation. Therefore, it is essential that every drop of water fallen on the ground is to be properly utilized for better management.With this view a

number of recharge structures proposed in the study area where water levels are deep and depleting.

The areas where intense ground water development, reduction in yields, DTW and piezometric heads are considered in identifying the area for artificial recharge.In the area scope exists for augmenting the ground water resources through artificial recharge. An area of 1225 km^2 is considered for ground water management of recharging deeper aquifers. The available sub-surface space volume is 349 MCM.

Table -6.3 Volume of Sub-surface Storage Space Available for Artificial Recharge

District	Mandal	Sub-surface Space (MCM)
East Godavari	ANAPARTHY	2
East Godavari	BICCAVOLU	5
East Godavari	CHAGALLU	32
East Godavari	DEVARAPALLE2	74
East Godavari	GOPALAPURAM	14
East Godavari	KADIAM	0
East Godavari	KORUKONDA	0
East Godavari	KOVVUR	7
East Godavari	NALLAJERLA	129
East Godavari	NIDADAVOLE	6
East Godavari	RAJAHMUNDRY (FULLY URBAN)	3
East Godavari	RAJAHMUNDRY (RURAL)	6
East Godavari	RAJANAGARAM	35
East Godavari	RANGAMPETA	36
East Godavari	TALLAPUDI	0
	Total	**349**

To overcome the shallow aquifers problem the following management strategy may be adopted.Almost all the villages in the study area have one or two village tanks.With time,these tanks get silted and hardly any water percolates downward.Also, any excess water coming into the pond goes away as a run off due to limited storage capacity. It is proposed to take the activity of desilting of existing tanks for effective recharging the shallow aquifers.

After completion of the ongoing Polavaram project the shallow aquifers naturally likely to be recharged due to canal network and irrigation activities, hence the present concentration may be given to recharging of deeper aquifers.The most effective ground water structure considered to recharge the deeper aquifers by isolating shallow aquifer is Recharge Shaft/ Recharge well constructed within or in the vicinity of the existing tank.

It is proposed to construct 'Recharge Shafts' for recharging the deeper aquifers where piezometric heads are more than 20 to 30 m bgl. The recharge well has to be designed in a manner that maximum surplus water would likely to be utilized for recharge as well as sufficient water is retained in the pond for local use. The major features of the recharge shaft are:

- The well should have sufficient diameter for recharge 10 to 12 inch diameter well with top and bottom screen, top opening.
- The well should have screen/ opening at the top, which should be at least 1.5m above the bed level of the pond.
- The upper opening should be surrounded with filter pack comprising graded filter media of medium, coarse sand & gravel, so that the Recharge well does not get silted.

The opening for inflow to the well has been proposed at 1.5m above Bed level of tank. This is necessary to ensure that the tank retains sufficient water for use by local consumers. A Single well as discussed above would be suitable for a pond upto an area of about 1.5 ha. Therefore, more number of such Recharge wells are

envisaged for larger tanks. It is proposed one recharge shaft for tank area between 1.5 and 5 ha, 2 shafts for 3 to7 ha and 4 for > 8 ha. Location and design of recharge shaft may be finalised scientifically based on the geological and geophysical investigations. Periodically these structures should be maintained for effective recharge. If recharge shaft is not feasible to construct within the tank bed, it may be constructed in the vicinity of the tank so that the source water can be supplied through trench or siphon system from the optimal level.

The source water requirement for the recharge plan can be met from the right andleft canals of ongoing Polavaram project.

Regulatory measures

Change in cropping pattern from water intensive paddy to irrigated dry other cropslike pulses and oil seeds are recommended. If necessary, some regulatory rules may be framed andimplemented.

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

6.4 Aquifer Management Strategy of Hard Rock part of study Area

6.4.1. Supply Side Measures:

Artificial Recharge:

In the study area, there is a scope for future GW development. Considering the upland part of East Godavari district, the area forms recharge zone and suitable for adoption of water conservation structures and micro irrigation practices.

Under PMKSY-MGNREGS, the Govt of AP had constructed 25 no. of CDs & PTs in the parts of East Godavari. The desilting and maintenance of existing PTs and CDs are recommended. In future, artificial recharge structure shall be recommended in specific areas, where vulnerabilities for groundwater resources increase.

6.4.2. Demand Side Measures:

6.4.2a. Micro-irrigation: The sustainability of bore well is low because of hard/ crystalline rock. 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. Micro irrigation is recommended in all villages i.e 100 ha per village.

6.5 Aquifer Management Strategy of Godavari Delta part of study Area

The Problems in the Godavari Delta can be summarised as below:

- Limited utilization of fresh ground water resources
- Water Logging

6.5.1. Management Plan for the areas where limited utilization of fresh ground water resources:

When surface water is available plenty, normally people will not extract ground water for any purpose. But it should be encouraged so that the available surface water can be utilised in the tail end areas. Unless and until people understand the aquifer disposition and availability of fresh ground water in the aquifers, people may fail in tapping the available fresh ground water. Hence for encouraging farmers for utilising the fresh ground water resources, Awareness campaigns are to be organized to educate the farmers about the aquifer disposition and the bottom of first aquifer in the area which is containing fresh water so that the depth of the filter points should be limited to the bottom of fresh unconfined aquifer in the area.

The available fresh ground water may be encouraged to extract through conjunctive use. One option can be limiting surface water for the tail end areas and encouraging GW usage in upper and middle reaches. It can also be attempted that the Government can extract ground water through a network of filter points preferably in

the shallow water table areas and supply the water through the canal system for irrigating the lower command. The surplus surface water will lead to enhanced command / gross irrigated area.

6.5.2 Management Plan for the areas which are water logged or prone to water logging:

For the water logged areas, Ground water extraction should be encouraged through conjunctive use. Pumping the ground water through a net work of filter points and pump the water in the canals for catering the irrigation needs of the lower reaches of the command. There should be strict Implementation of Ban on Surface Water Supply for Irrigation and Industrial purpose.

Acknowledgment

The authors express sincere thanks to Sri. G. Krishnamurthy, Regional Director, CGWB, Hyderabad, Sri Ravi Kumar Gumma, Scientist- 'D' & OIC for their encouragement and guidance. The author sincere gratitude towards Sri L N 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 genera