भारत सरकार

जलशक्ति मंत्रालय

जलसंसाधन नदी विकास एवम् गंगा संरक्षण विभाग

केंद्रीय भूमि जल बोर्ड

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

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

CENTRAL GROUND WATER BOARD
AP SUO, VISAKHAPATNAM
NOVEMBER, 2023

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AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES PARVATHIPURAM MANYAM DISTRICT, ANDHRA PRADESH
(AAP-2023-2024)

Contributors' page

Name	Designation
Ravi Kumar Gumma	Scientist-D & OIC, CGWB, APSUO, Visakhapatnam, AP.
Supervision & Guidance	
G. Krishnamurthy	Regional Director, CGWB, Southern Region, Hyderabad.

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AT A GLANCE

S. No.	Item		Particulars
1	District	:	Parvatipuram Manyam
2	Mandals	:	15
3	Revenue villages	:	956
4	Geographical area	:	3559 km^2
5	Geographic Extent	:	North Latitude 17^0 15′ and 19^0 15′ East Longitude 83^0 0′ to 83^0 45′
6	Population (2011 Census)	:	~9.25 lakhs (Rural: 86.51 %, urban: 13.41%). The density of population is 253 persons/ km^2
7	Rainfall (Normal)	:	981 mm (Kurupam) to 1283 mm (Garugubilli) (avg: 1097.4 mm) (The South west monsoon contributes 65% of the rainfall and northwest monsoon contributes 16% of the rainfall in the district.
8	Geomorphology	:	Pediplain (33%), Structural hill (24%), Pediments (13%) , Vally Fills (6%)etc.
9	Major Rivers	:	Nagavali, Suvarnamukhi, Vegavathi, Gomukhi and its tributaries.
9.1	Watersheds	:	100
10	Forests	:	32% (1155 Km^2)
11	Soils	:	Red soils, sandy loams and sandy clay constitute 96% of the total area. The soils in the district are predominantly loamy with medium fertility
12	Land Utilization (Ha)	:	Net area sown: 126496 (35%), Barren & uncultivable land: 41083 (11%); Land put to non-agricultural use: 38635 (11%)
13	Total cropped area (Ha)	:	160737
14	Irrigation	:	Net area irrigated is 79135 ha (62%), out of total Net area sown of 126452 ha. The Irrigation through surface water sources is 35813 ha (45%), Tanks is 22238 ha (28%), LIS is 230 ha (<1%) and

<table>
<tr><td></td><td></td><td></td><td>other sources is 2860 ha (4%) accounts for 77% of total irrigation in the district. The major/Medium irrigation projects in the district are Thotapalli, Janjavathi, Vottigedda and Vengalarayasagaram projects.

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22	Long term water level trends (2012-22)	:	Pre-monsoon: Falling: 31 wells (0.39-0.035 m/yrs and avg.0.18 m/yrs) Rising: 3 wells (0.033-0.040 m/yrs and avg.0.038 m/yrs) Post-monsoon: Falling: 14 wells (0.280-0.121m/yrs and avg. 0.119 m/yrs), Rising: 22 wells (0.052-0.68 m/yrs and avg. 0.260 m/yrs)
23	Electrical Conductivity (µ Siemens/cm)	:	93-4400 (avg: 1352)
24	Fluoride	:	0.07-1.91 mg/L
25	Nitrate	:	0.31-278 mg/L;
26	Ground Water suitability for drinking	:	In majority of area 2734 sq.km (75 %) EC is within 750 to 2250 µ Siemens/cm; in 316 sq. kms (9 %) area, it is 1500 to 2250 µ Siemens/cm; in 559 sq. kms (15 %) area, it is <750 µ Siemens/cm. Fluoride:97 nos. sample (97%)<1.5 mg/L & 03 nos. sample (31%) >1.5mg/L. Nitrate: 68 nos. (62%) <45 mg/L & 42 nos. sample (38%) >45mg/L.
27	Hydrogeological Attributes	:	Formation wise Hydrogeological Attributes

Attributes	**KH/GN**	**GN**	**CH**	**AL**	**QTZ**	**LT**	**Total**
Area (Sq kms)	1229	1185	744	232	22	9	3421
Mandals (No.s)	242	401	363	83	14	3	1106
Villages (No.s)	242	401	363	83	14	3	1106
Average of Normal Rainfall (mm)	1267	1240	1270	1187	1202	1167	1251
Average of Pre-Monsoon Decadal DTWL	6.89	6.77	6.61	6.22	6.27	5.66	6.70
Average of Post Monsoon Decadal DTWL	4.67	4.77	4.49	4.09	4.16	3.38	4.59
Average Thickness of Weathering (m)	24	22	21	19	18	17	22
Average Depth of Fracture Occurrence (m)	67	72	65	75	69	55	69
Yield (LPS)	1.8	1.4	1.6	1.5	1.4	1.1	1.6

28	Ground Water Resources (MCM) 2022	:	Annual Extractable GW Resources	:	917
			Gross GW Draft	:	191
			Stage of Ground water development (%)	:	22
			Net GW Availability for future use	:	730
			Provision for Domestic Use (2025)	:	31
			Safe mandal (nos.)	:	15
			Semi-critical (nos.)	:	0
			Critical (nos.)	:	0

			Over-exploited (nos.) : 0
29	Major Ground Water Issues Identified	:	Low yield (<3 lps) ~90% of the district. High nitrate (> 45 mg/L) is observed in 43 samples (55%).
30	Management Strategies	:	○ Scope for GW extraction: Identified feasibility of construction of 7437 bore wells in 729 villages in all 15 mandals, for bringing an additional area of 7928 ha in under GW irrigation. ○ Recommended for construction of 336 additional artificial recharge structures. ○ Existing ARS like percolation tanks and check dams can be de-silted through convergence of schemes ○ Micro Irrigation is recommended 17325 ha @25 ha per village in 693 villages. ○ Desiltation and cascading of existing MI tanks. This can result in increased ayacut, sustainability of bore wells. ○ Roof top rain water harvesting in Government buildings (new and existing) as per the existing post monsoon depth to water levels, provisions of AP WALTA. ○ Participatory groundwater management (PGWM) approach. ○ In urban and rural area, the sewerage line should be constructed to arrest leaching of nitrate.

ABBREVATION:

2D	:	2 Dimensional
3D	:	3 Dimensional
ARS	:	Artificial Recharge Structures
Avg	:	Average
BW	:	Bore Well
CD	:	Check dam
CGWB	:	Central ground water board
Cr	:	Crore
DTW	:	Depth to water
DW	:	Dug well
EC	:	Electrical conductivity
EL	:	East Longitude
F	:	Fluoride
FP	:	Farm Pond
GEC	:	Ground Water Estimation committee
GW	:	Ground Water
Ha	:	Hector
Ha.m	:	Hector meter
ID	:	Irrigated dry
IMD	:	Indian Meteorological Department
Km2	:	square kilometre
LPS	:	Litres per second
M	:	meter
M^3	:	Cubic meter
max	:	Maximum
mbgl	:	Mitres below ground level
MCM	:	Million cubic meter
Mg/L	:	Milligram per litre
MI	:	Micro irrigation
min	:	Minimum
MPT	:	Mini percolation tank
NL	:	North Latitude
NO_3	:	Nitrate
OE	:	Over Exploited
PGWM	:	Participatory ground water management
PT	:	Percolation tank
SGWD	:	State Ground Water Department
S	:	Storativity
T	:	Transmissivity

EXECUTIVE SUMMARY

The Parvathipuram Manyam district, Andhra Pradesh is the Northern district of Andhra Pradesh having geographical area of 3559 km^2, lies between 17^0 15′ and 19^0 15′ of the Northern Latitude and 83^0 0′ to 83^0 45′ of the Eastern Longitude. The district was formed as 26^{th} district in the State on 4^{th} April, 2022 with Headquarters at Parvathipuram with portions carved from erstwhile Srikakulam and Vizianagaram Districts. There are 956 villages (habitated: 910 and unhabitated: 46) with a population of ~9.25 lakhs (2011 census) (Rural: 86.51 %, urban: 13.41%). The total forest area in the district accounts for 1155 km^2 occupying 32% of the total Geographical area. The average normal annual rainfall is1158 mm.

The district can be divided into two distinct natural physiographic divisions i.e., plain and hilly regions. The hilly region is mostly covered with densely wooded forests and comes under agency part of the district. The plain portion of the district is a well cultivated tract. The main hill ranges are Dumakonda, Antikonda, Palakonda, Kodagandi and Gamatikonda. All these individual ranges form part of the Eastern Ghats. These ranges with their detached hills show a distinct North-West-South-East trend. Pediplains, Structural hills, Denudational hills, Pedi plains and pediments are the major geomorphological units in the district. The district is drained by the rivers of Nagavali, Suvarnamukhi, Vegavathi and Gomukhi. The Nagavali is the main river in the district.

The total cropped area is 160737 ha, out of which net area sown is 126452 ha and area irrigated more than once is 34285 ha. The district is mainly irrigated by both surface and ground water. Out of total Net area sown of 126452 ha, the net area irrigated is 79135 ha (62%), out of which the Irrigation through surface water sources like Canals is 35813 ha (45%), Tanks is 22238 ha (28%), LIS is 230 ha (<1%) and other sources is 2860 ha (4%) accounts for 77% of total irrigation in the district. The major/Medium irrigation projects in the district are Thotapalli, Janjavathi, Vottigedda and Vengalarayasagaram projects. The irrigation through Ground Water is 17994 ha (22%). There are 4896 Minor Irrigation Tanks having a registered ayacut of 29010 ha and actual irrigated area is 27754 ha. A total of 2165 artificial recharge structures (269 Percolation Tanks, 163 Mini Percolation Tanks, 1137 Check Dams and 209 Check Walls and Others) are constructed under IWMP and MGNREGS.

The district is underlain by Eastern Ghat Mobile Belt of Archaean age. It includes rocks of Khondalite Group, Charnockite Group and Migmatite complex. Sediments of Cenozoic laterite and Quaternary deposits overlie the Archaeans. The principal aquifers in the district is Archean eastern ghat mobile belt mainly comprising of Khondalites, Charnockites, Migmatites and Granite Gneisses etc overlain by Recent Alluvium.

The Central Ground Water Board had drilled 58 no's bore wells (50 EW, 8 OW), carried out 23 Vertical Electrical Soundings (VES) so far. The ground water regime is being monitored form 33 GWM stations and ground water quality data from 78 GW quality monitoring stations. The density of the data calculated as 1 data point for 40 sq kms for deciphering the lateral and vertical disposition of aquifers, 1 data points per 99 sq kms for understanding the spatial and temporal variation in ground water regime and 1 data point per 42 sq.kms for understanding the spatial and temporal variation in ground water quality.

The Depth to Water Levels (DTWL) of 10 years (2012 to 2022) for both pre and post-monsoon seasons were analysed for understanding the spatio-temporal variation of ground water regime. The DTWL varies from 2.4 to 16.8 meter below ground level (m bgl) (average: 6.9 m bgl) and 1.4 to 13.9 m bgl (average: 4.8 m bgl) during pre-monsoon and post-monsoon seasons respectively. Trend analysis for the last 10 years (2012-2022) is studied from 34 hydrograph stations of CGWB and SGWD for pre-monsoon and post-monsoon season respectively. It is observed that during pre-monsoon season 31 wells shows falling trend ranging from 0.035 m to 0.4 m/year (Avg: 0.18 m/yr) and 3 wells shows rising trends ranging 0.03 m to 0.04 m/yr (Avg: 0.038 m/yrs). During post-monsoon season 14 wells shows falling trend ranging 0.28 to to 0.12 m/yr (Avg: 0.119 m/yr) and 22 wells shows rising trend ranging 0.052 to 0.68 m/yrs (Avg: 0.260 m/yrs). During pre and post-monsoon season (May and November), the water-table elevation ranges from 38.5 to 467.5 m amsl and 40.4 to 469 m amsl respectively.

Ground Water is mildly alkaline to alkaline in nature with pH in the range of 6.7 to 8.15 (Avg: 7.54). Electrical conductivity varies from 93 to 4400 (Avg: 1352) µ Siemens/cm**.** In majority of area 2734 sq.km (75 %) EC is within 750 to 2250 µ Siemens/cm; in 316 sq. kms (9 %) area, it is in between 1500 to 2250 µ Siemens/cm; in 559 sq. kms (15 %) area, it is <750 µ Siemens/cm and in 14 sq.kms (0.4 %) area is >2250 µ Siemens/cm. The Concentration of NO3 ranges from 0.31-278 mg/l with an average 47.74 mg/l. Nitrate

concentration <45 mg/l is observed in 68 (62 %) sample out of 110 sample and above permissible limit of >45 mg/l is observed 42 (38%) samples**.** The concentration of Fluoride ranges from 0.07-1.91 mg/l with an average of 0.53 mg/l. In 97 samples (97%), F concentration is observed less than the permissible limits (<1.5 mg/l) and in 03 (03%) samples F is more than the permissible range (>1.5 mg/l).

Based on 192 hydrogeological data points, the aquifers are conceptualized in to Aquifer-1 comprising of weathered and contiguous semi weathered and fractures with an average thickness of 30-35 m and Aquifer -2 comprising of discrete fractured zone between the depths of 30/35 to 200 m). The Thickness of weathered zone varies from <5 m to 48 m with an average thickness of ~22 m. The average thickness of weathering is 24 m in Khondalites, 22 m in Granites and Granite gneisses, 10 m in Charnockites, 17 m in Quartzites and 22 m in Laterites. Thickness of weathering < 10 m occurs in ~1 % of the area, 10 to 20 m occurs in ~36 % of area, 20-30 m occurs in 54 % of area. High thickness of weathering (>30 m) occurs in in 9% of the district in isolated parts of Makkuva, Kurupam, Salur and Parvathipuram Manyam mandals. The depth of fracturing varies from 13 - 191 m and deepest fracture encountered in exploratory drilling is 191 m at Appayya Peta, Seethanagaram mandal. From the data, it is inferred that fractures in the range of 120 to 150 m depth are more predominant (45 % of the area), > 150 m occur in 33 % area; < 30 m occurs in 16% of the district. The yield ranges from <1.0 to 5.5 lps and highest discharge (5.5 lps) found in L. Kota mandal. In majority of the area, the ground water yield in the range of 1 to 3 lps followed by < 1 lps and 3 to 5 lps.

As per Ground Water Resource Assessment – 2022, the annual extractable ground water resource in the district is 917 MCM, gross ground water draft for all uses is 191 MCM, provision for drinking and industrial use for the year 2025 is 31 MCM and Net GW Availability for future use is 730 MCM. The Stage of ground water extraction varies from 2.7 % in Gumma Lakshmi Puram to 49% in Salur (avg: 22%). Based on the stage of ground water development, all mandals in the district are categorized as Safe.

The major ground water issues are Low yield (<3 lps), which occurs in ~90% of the district. The hard rock aquifers lack primary porosity and ground water yield depends on secondary porosity developed due to weathering or fracturing. Poor interconnection and discrete nature of fractures and less recharge aquifers of hard rocks are the reasons for low

in yield. High nitrate (> 45 mg/L) due to anthropogenic activities is observed in about 43 samples (55%). This is due to unscientific sewage disposal of sewage and use of NPK fertilizers.

Ground Water contributes around 21% of irrigation needs despite of having good ground water potential of 730 MCM for future utilization in the district indicating a scope for further ground water development in the district. The management approach recommended a judicious enhancement of ground water extraction by constructing and energizing 7437 bore wells in 729 villages in all 15 mandals, which can bring an additional area of 7928 ha in the district. In addition to the existing structures, it is recommended to construct 336 additional artificial recharge structures in the district. Existing ARS like percolation tanks and check dams can be de-silted involving people's participation. As demand side measurement, Micro Irrigation is recommended 17325 ha @25 ha per village in 693 villages. Desiltation and cascading of existing MI tanks and filling up MI tanks with surface water schemes. This can result in increased ayacut, sustainability of bore wells and decrease the ground water irrigation. Roof top rain water harvesting in Government buildings (new and existing) as per the existing post monsoon depth to water levels, provisions of AP WALTA. The other recommendations include Participatory groundwater management (PGWM) and the sewerage lining to arrest leaching of nitrate in urban and rural areas of the district.

REPORT ON

AQUIFER MAPPING FOR SUSTAINABLE MANAGEMENT OF GROUND WATER RESOURCES IN PARVATHIPURAM MANYAM DISTRICT, ANDHRA PRADESH

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 for sustainable development and management of ground water resources of the country. As a part of NAQUIM in Andhra Pradesh, the Parvathipuram Manyam district has been selected and completed during AAP 2022-2023.

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) or creation of time series data base and ground water resource estimation.
3. Quantification of groundwater availability and assessing its quality.
4. To delineate aquifer in 3-D along with their characterization on 1:50, 000 scale.
5. Capacity building in all aspects of ground water development and management through information, education and communication (IEC) activities, information dissemination, education, awareness and training.
6. Enhancement of coordination with concerned central/state govt. organizations and academic/research institutions for sustainable ground water management.

1.3 Area details: The Parvathipuram Manyam district is the Northern district of Andhra Pradesh having a geographical area of 3559 km^2, lies between 17^0 15′ and 19^0 15′ of the Northern Latitude and 83^0 0′ to 83^0 45′ of the Eastern Longitude. The district was formed as 26^{th} district of the State on 4^{th} April, 2022 with headquarters at Parvathipuram with portions carved from erstwhile Srikakulam and Vizianagaram Districts. The district is bounded on the East by Odissa state, on the West by Srikakulam district, on the South by Vizianagaram district and on the North by Odissa state (**Fig.1.1**). For administrative convenience, the district is divided into 2 Revenue Divisions, Palakonda and Parvathipuram with 15 Revenue Mandals. Parvathipuram division consisting Parvathipuram, Seethanagaram, Balijipta, Salur, Pachipenta, Makkuva, Komarada, Kurupam and GL Puram mandals from old Vizianagaram district and Palakonda division consisting Palakonda, Seethampeta, Bhamini and Veeraghattam from old Srikakulam district and Jiyyammavalasa, Garugubilli mandal from old Vizianagaram district. There are 956 villages (habitated: 910 and unhabitated: 46) with a population of ~9.25 lakhs (2011 census) (Rural: 86.51 %, Urban: 13.41%). The density of population is 253 persons/ km^2 whereas it

is 304 per Sq.km. in the State. The total forest area in the district accounts for 1155 km^2 occupying 32% of the total geographical area. The basic details of the district are provided in Table-1.

Table-1.1: Details of the Parvathi Puram Manyam District, Andhra Pradesh

S.No.	Mandal	Area (km^2)	Gram Panchayats	Villages	Habitated Villages	Un habitated Villages	No. of hamlets	Total No. of Households
1	Balijipeta	161	24	34	31	3	41	15692
2	Bhamini	139	26	22	22	0	84	10429
3	Garugubilli	143	25	34	32	2	48	12056
4	GLakshmipuram	401	27	124	118	6	208	10809
5	Jiyyammavalasa	166	31	58	55	3	113	13245
6	Komarada	294	31	99	92	7	154	13042
7	Kurupam	442	23	95	92	3	342	11332
8	Makkuva	184	21	54	49	5	101	12573
9	Pachipenta	385	28	54	51	3	234	11369
10	Palakonda	120	31	44	44	0	63	19252
11	Parvathipuram	304	26	49	46	3	113	28449
12	Salur	328	29	86	83	3	245	26203
13	Seethampeta	303	53	118	113	5	467	12984
14	Seethanagaram	153	34	44	43	1	53	15126
15	Veeraghattam	137	34	41	39	2	67	16823
	Total	**3660**	**443**	**956**	**910**	**46**	**2333**	**229384**

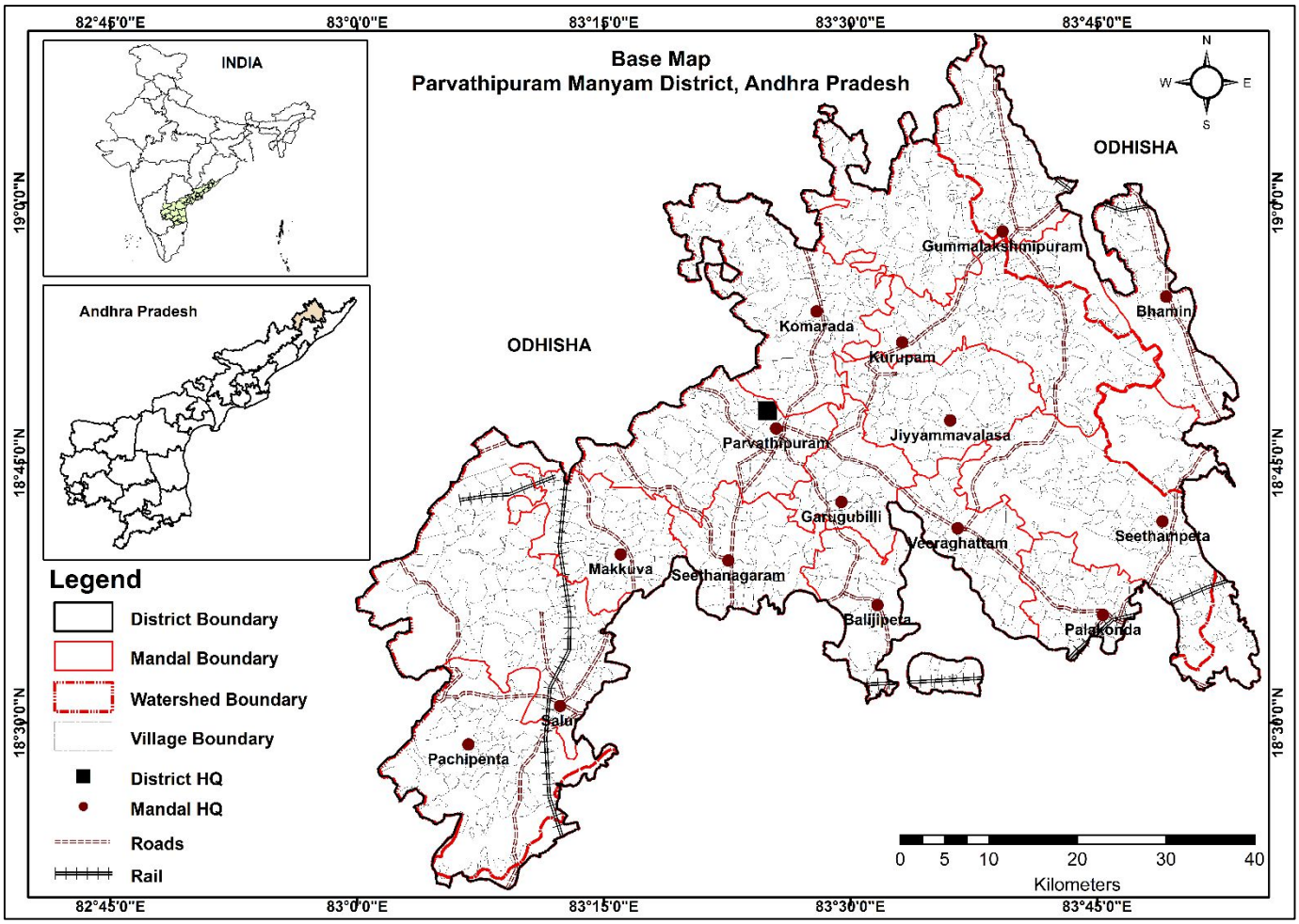


Fig.1.1: Location map of Parvathipuram Manyam district.

1.4 Climate and Rainfall: The climate of the district is characterised by hot summer and generally dry weather except during S-W monsoon season. The normal maximum and minimum temperatures recorded in the district are 36.2° C and 27.3° C respectively. The Maximum temperature is usually recorded in the months April, May and June. The average normal annual rainfall of the district is1158 mm. This varies between 981 mm (Kurupam) to 1283 mm (Garugugubilli) (Fig. 1.2). The South west monsoon contributes 65% of the rainfall and northwest monsoon contributes 16% of the rainfall in the district. The season wise normal and actual rainfall is provided in Table-1.2.

Table: 1.2 Season wise Rainfall in the Parvathi Puram Manyam District, AP

S.No.	Mandal	SW Monson		NE Monsoon		Winter		Summer		Total	
		Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal
1	Balijipeta	627	694	340	220	31	23	199	204	1197	1140
2	Bhamini	558	754	334	210	112	25	189	201	1192	1190
3	Garugubilli	709	818	383	205	28	31	150	185	1269	1239
4	GL Puram	811	824	400	158	100	18	151	201	1461	1201
5	Jiyyammavalasa	916	807	281	183	29	34	93	166	1319	1190
6	Komarada	1029	875	311	176	56	27	134	205	1530	1283
7	Kurupam	932	683	318	135	50	20	153	143	1453	981
8	Makkuva	635	724	315	199	79	19	182	168	1211	1110
9	Pachipenta	625	628	326	236	7	19	101	180	1058	1063
10	Palakonda	627	694	340	220	31	23	199	204	1197	1140
11	Parvathipuram	775	817	249	183	35	35	209	194	1268	1228
12	Salur	756	686	296	208	31	20	217	158	1300	1073
13	Seethampeta	635	724	315	199	79	19	182	168	1211	1110
14	Seethanagaram	558	754	334	210	112	25	189	201	1192	1190
15	Veeraghattam	775	817	249	183	35	35	209	194	1268	1228

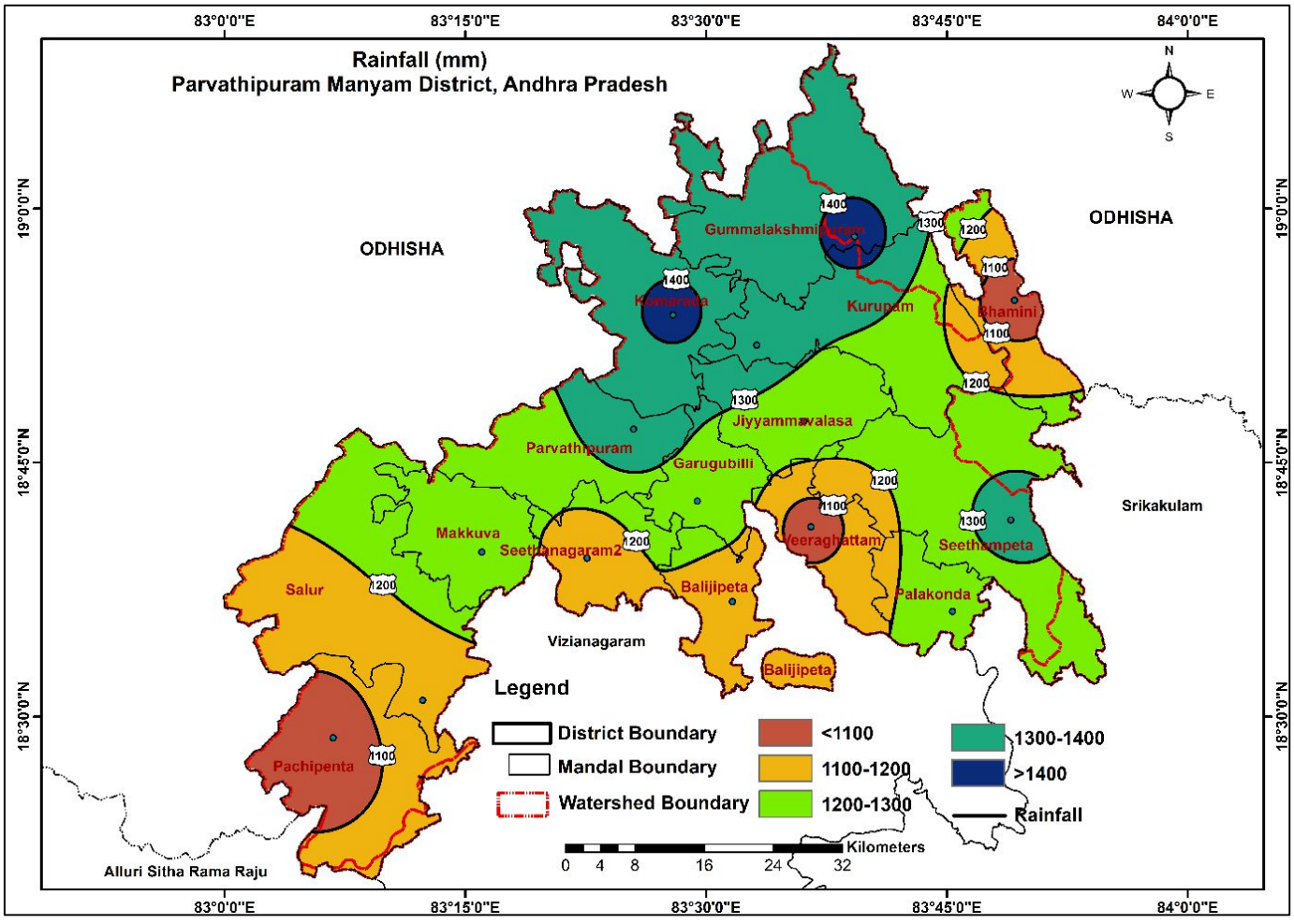


Fig.1.2: Isohyetal map of Parvathipuram Manyamdistrict.

1.5 Geomorphology: Pediplains, Structural hills, Denudational hills, Pedi plains and pediments are the major geographic units in the district. The details and percentage of geomorphological features of the district is given in the table 1.3 and depicted in **Fig.1.3.**

Table-1.3: Geomorphology of Paravatipuram Manyam

S. No.	Code	Geomorphology	Area (Sq kms)	Percentage (%)
1	Pp	Pediplain	1195.59	33.25
2	Sh	Structural Hills	893.779	24.86
3	Dh	Denudational Hills	612.583	17.03
4	Pd	Pediment	494.177	13.74
5	Iv	Valley Fills	228.603	6.358
6	Fp	Flood Plain	134.893	3.752
7	Rh	Residual Hills	34.3861	0.956
8	Oth	Others	1.17582	0.032
Total			**3995.19**	**100**

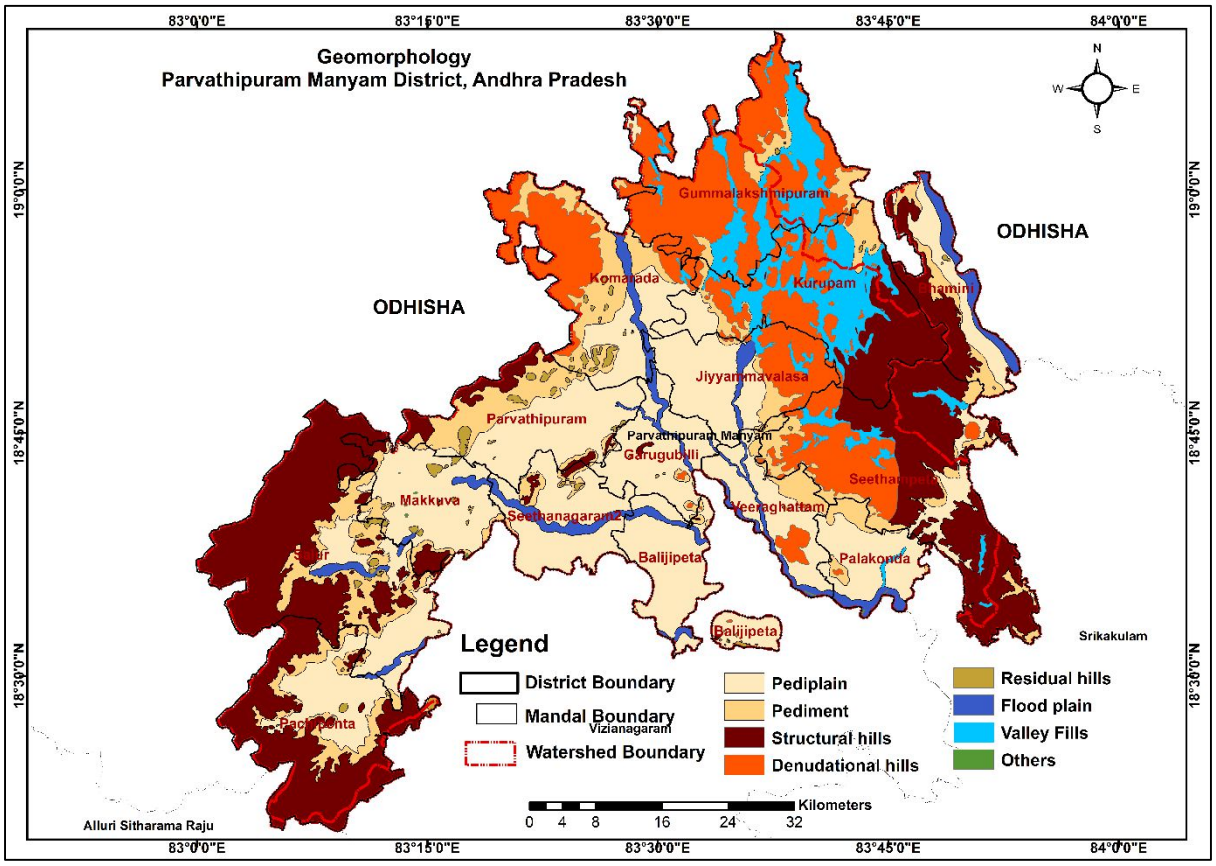


Fig.1.3: Geomorphology of Parvathipuram Manyamdistrict.

1.6 Physiography:

The district can be divided into two distinct natural physical divisions i.e., plain and hilly regions. The hilly region is mostly covered with densely wooded forests and comes under agency part of the district. The plain portion of the district is a well cultivated tract. The main hill ranges are Dumakonda, Antikonda, Palakonda, Kodagandi and Gamatikonda. All these individual ranges form part of the Eastern Ghats. These ranges with their detached hills show a distinct North-West-South-East trend. The elevation map of the district is provided in **Fig-1.4**

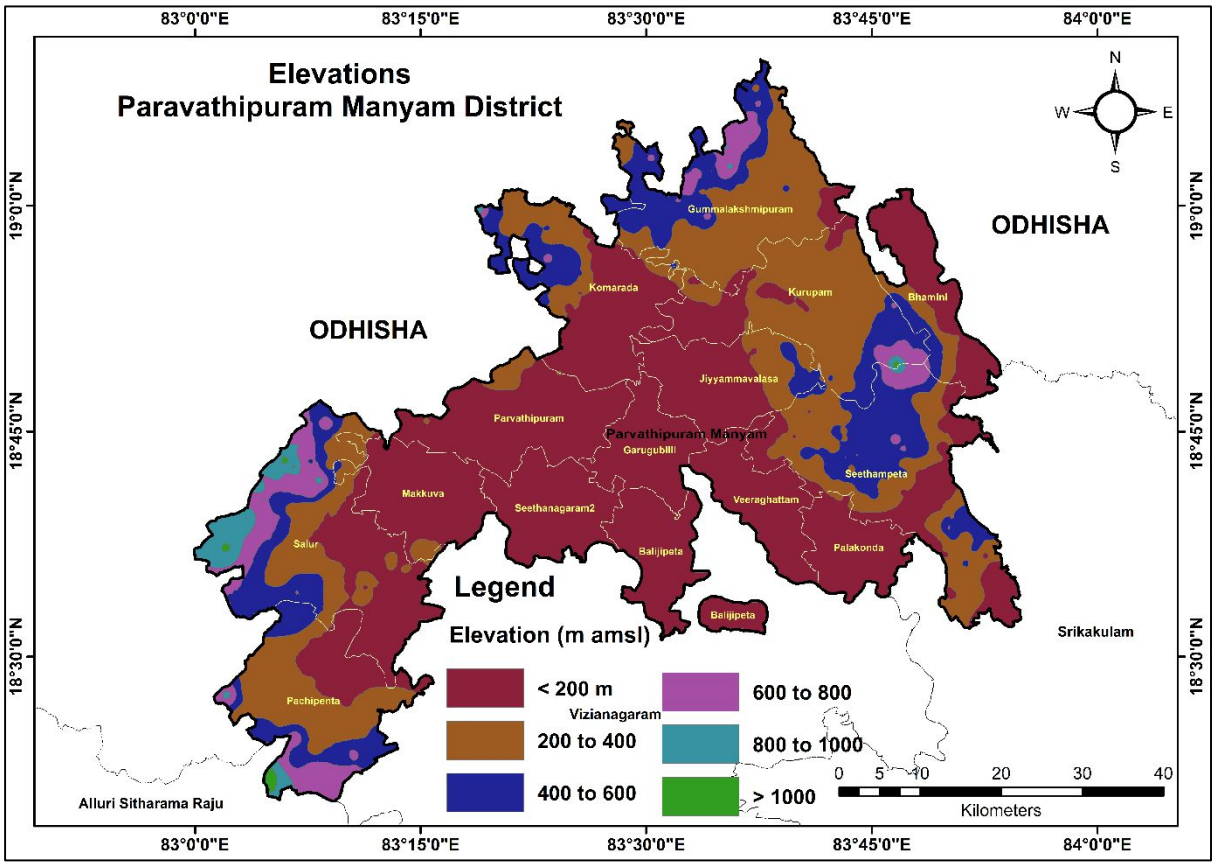


Fig-1.4: Physiography of the Parvathipuram Manyam District, Andhra Pradesh

1.7 Drainage: The district is drained by the rivers of Nagavali, Suvarnamukhi, Vegavathi and Gomukhi. The Nagavali is the main river in the district. It originates from Rayagada taluk in Odhisha State and enters the district in Komarada mandal. It passes about 142 km in Manyam district through Komarada, Jiyyammavalasa and Garugubilli, Veeraghattam mandals. The total catchment area of this river is 8,964 sq.kms. The main tributaries of this river are Vegavathi, Suvarnamukhi, Janjhavathi and Vottigedda. The Suvarnamukhi River originates in Saluru and takes eastern direction and finally joins the Nagavali river in Palakonda mandal. The River

Vegavathi originates in Pachipenta hills of Pachipenta mandal and flows parallel to the Suvarnamukhi and finally joins Nagavali River. The river Gomukhi originates from the Eastern Ghats and flows North-West of Saluru and joins the Suvarnamukhi River. The general drainage pattern is dendritic to sub-dendritic. The map depicting river, drainage and water bodies is presented in **Fig.1.5.**

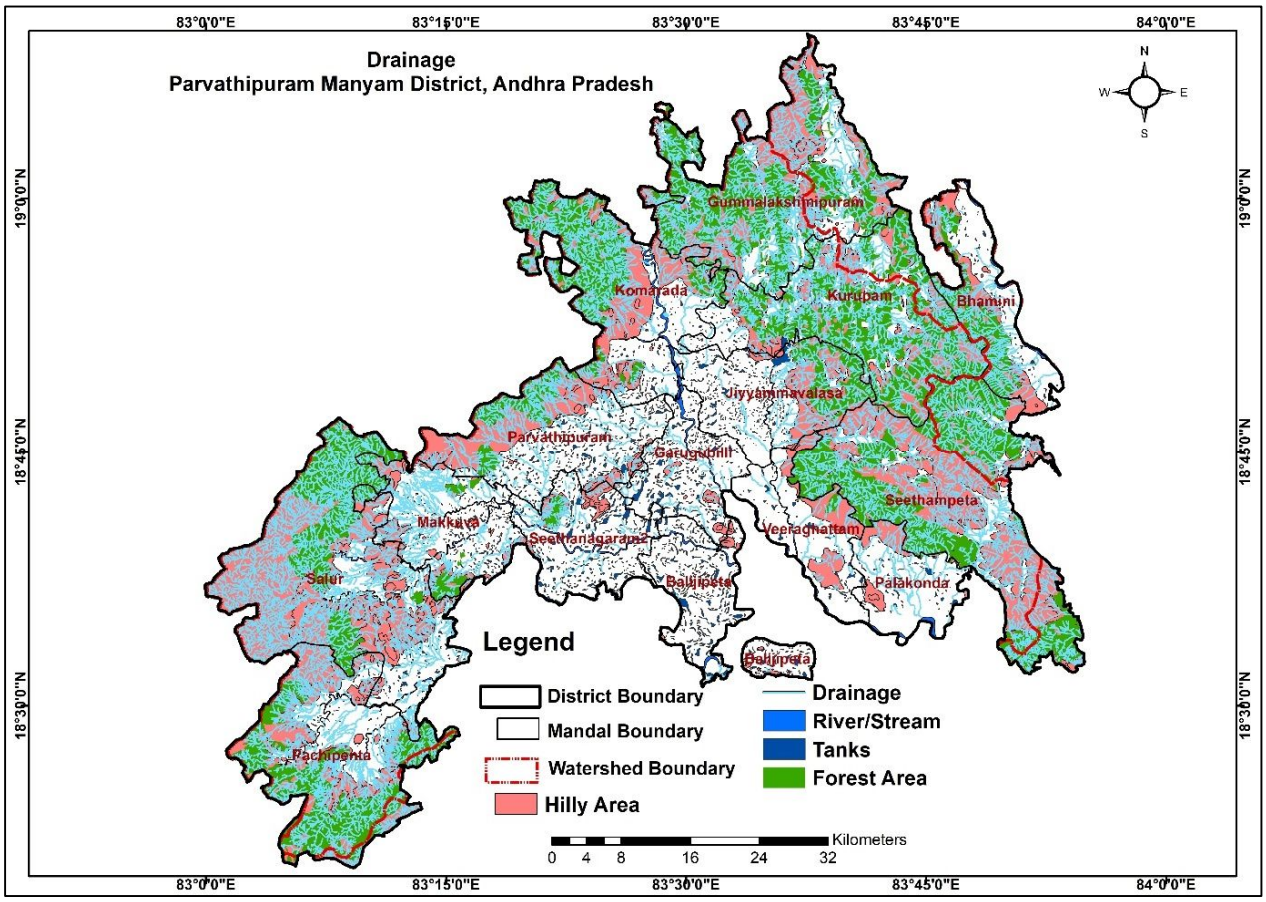


Fig.1.5: Drainage map of Parvathipuram Manyam District, Andhra Pradesh.

1.8 Land Use: Out of total geographical area of 3659 km^2, forest occupies 1155 sq. kms (~32%), The net area sown is 1265 sq kms (35%), barren and uncultivable land is 410 sq kms (11.5%), land put to non-agricultural uses is 386 sq. kms (11%), the fallow is 442 sq kms (12%) etc. The details of land use pattern in the district are provided in Table-1.4. The maps depicting Land use and land cover of the district is provided in Fig. 1.5 and 1.6.

S. No	CATEGORY	AREA (ha)	Area (Sq. kms)	Percentage
1	Total Geographical area	365914	3659	100
2	Forests	115496	1155	32
3	Net Area Sown	126496	1265	35
4	Barren & Uncultivable Land	41083	411	11
5	Land put to Non Agri & Others	38635	386	11
6	Fallows	44204	442	12
7	Total Cropped Area	160737	1607	44
8	Area Sown More than Once	34285	343	9

Table-1.4: Land use and land cover of Parvathipuram Manyam district

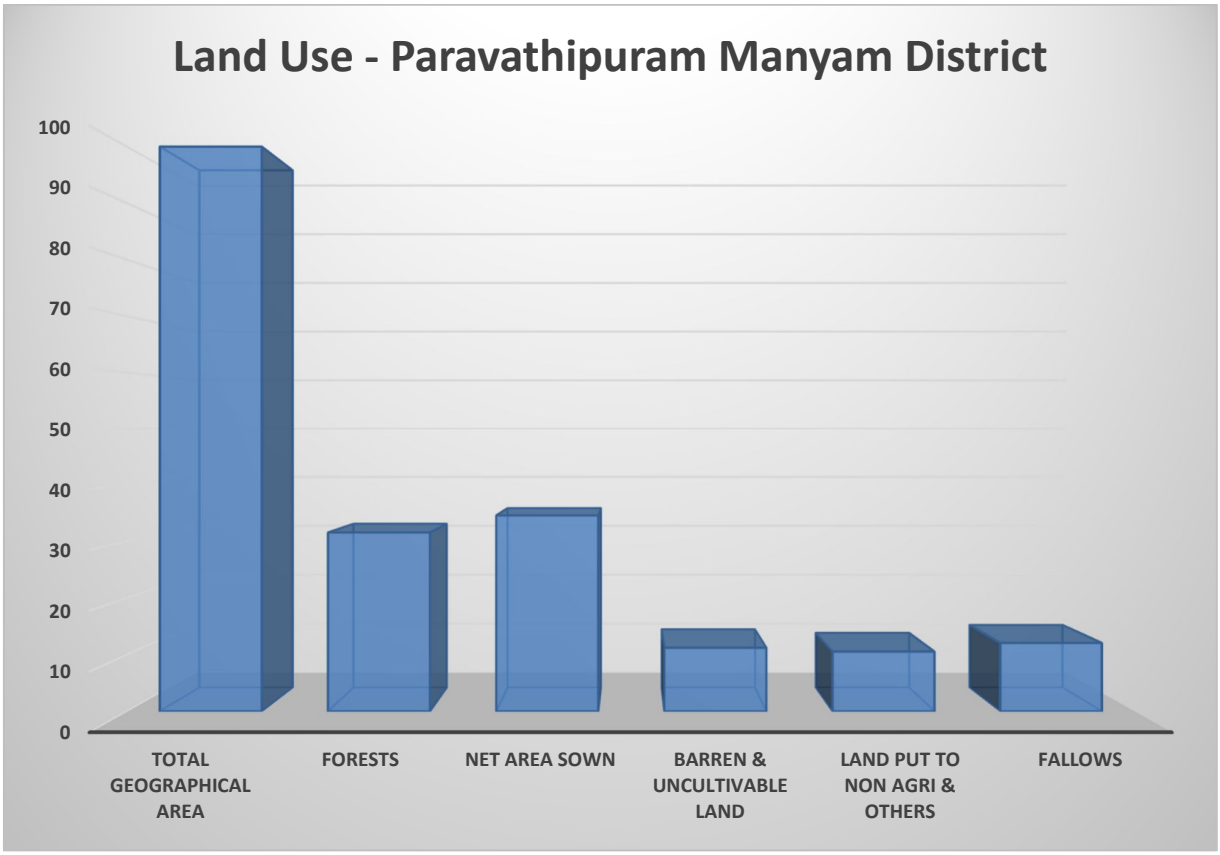


Fig- 1.6 Graphical presentation of Land Use in Parvathi Puram Manyam District, AP

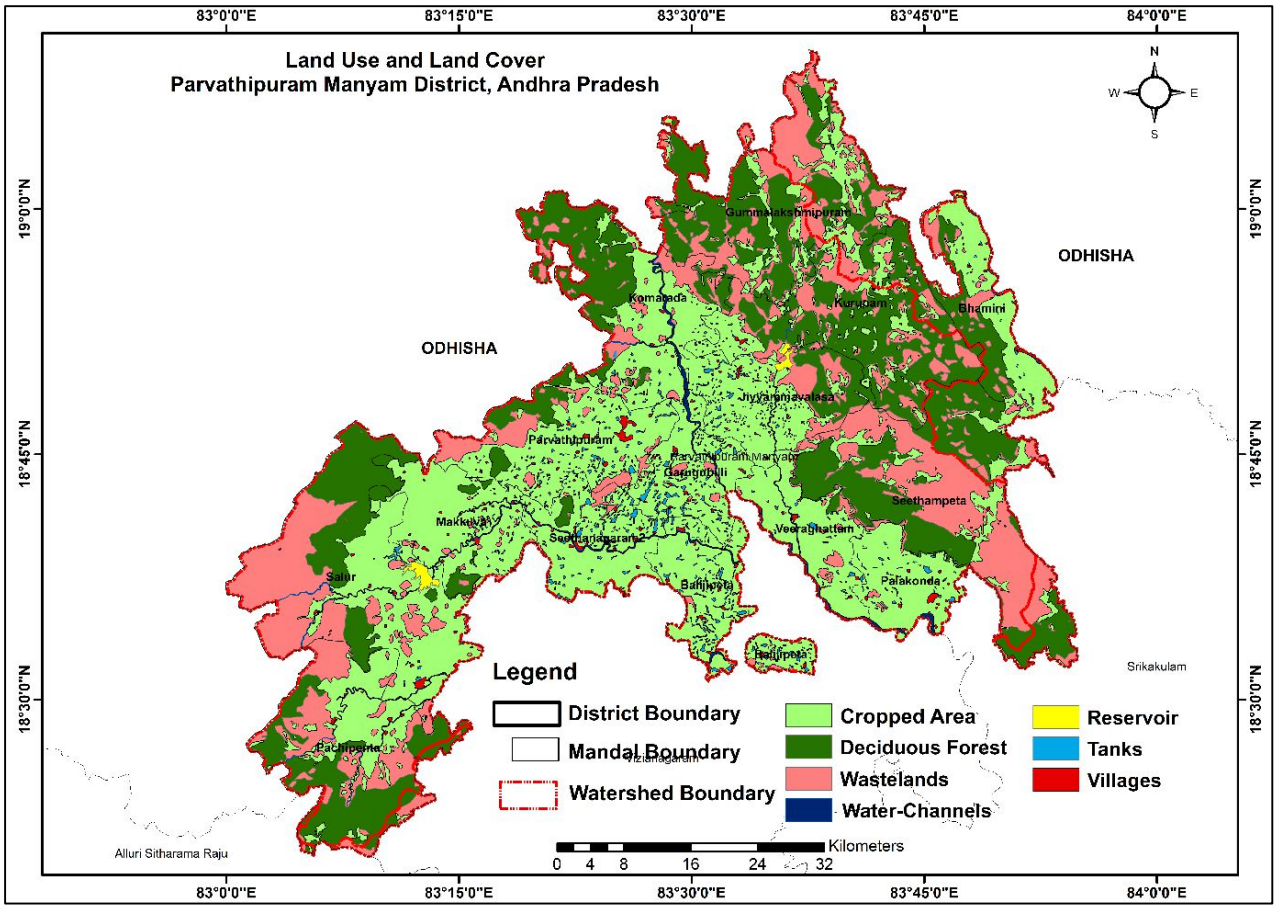


Fig-1.7: Land Use in Parvathipuram Manyam District, AP

1.9 Soils: The main soils in the district are red soils, sandy loams and sandy clay and they constitute 96% of the total area. The soils in the district are predominantly loamy with medium fertility. The soils at some places are as thick as 4 Metres in alluvial tracts and valleys. The map depicting the soils are provided in fig-1.7

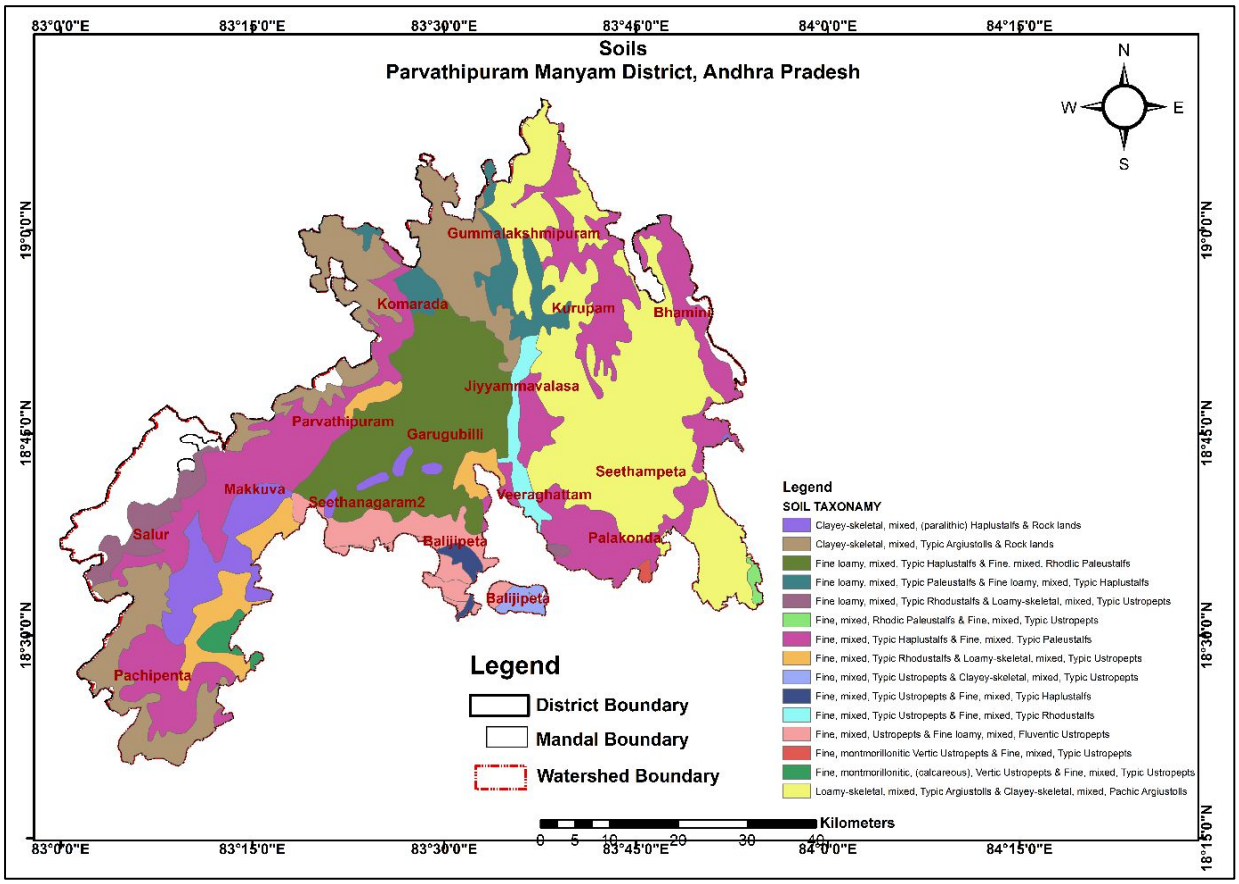


Fig-1.8: Soils of Parvathi Puram Manyam District, AP

1.10 Agriculture and Irrigation:

The total cropped area in the district is 160737 ha, out of which net area sown is 126452 ha and area irrigated more than once is 34285 ha. The details of cropped area are provided in Table-1.5

Table-1.5: Details of cropped area in Parvathipuram Manyam District, AP

S.No.	Mandal	Net Area Sown (Ha)	Total Cropped Area (ha)	Area Sown (Kharif)	Area Sown (Rabi)
1	Balijipeta	7742	10495	7742	2753
2	Bhamini	6422	7491	6422	1069
3	Garugubilli	7820	10188	7820	2368
4	Gummalakshmipuram	6195	6358	6195	163
5	Jiyyammavalasa	9207	12864	9207	3657
6	Komarada	9446	10837	9446	1391
7	Kurupam	6851	7280	6851	429
8	Makkuva	9214	12856	9214	3640
9	Pachipenta	7735	9833	7735	2098
10	Palakonda	7192	11723	7192	4531
11	Parvathipuram	10203	11891	10203	1688
12	Salur	12632	15264	12632	2632

13	Seethampeta	7846	8464	7846	618
14	Seethanagaram	9003	11281	9003	2278
15	Veeraghattam	8944	13912	8944	4968
		126452	**160737**	**126452**	**34283**

The district is mainly irrigated by both surface and ground water. Out of total Net area sown of 126452 ha, the net area irrigated is 79135 ha (62%), out of which the Irrigation through surface water sources like Canals is 35813 ha (45%), Tanks is 22238 ha (28%), LIS is 230 ha (<1%) and other sources is 2860 ha (4%) accounts for 77% of total irrigation in the district. The irrigation through Ground Water is 17994 ha (22%). The major/Medium irrigation projects in the district are Thotapalli, Janjavathi, Vottigedda and Vengalarayasagaram projects (Fig-1.8)

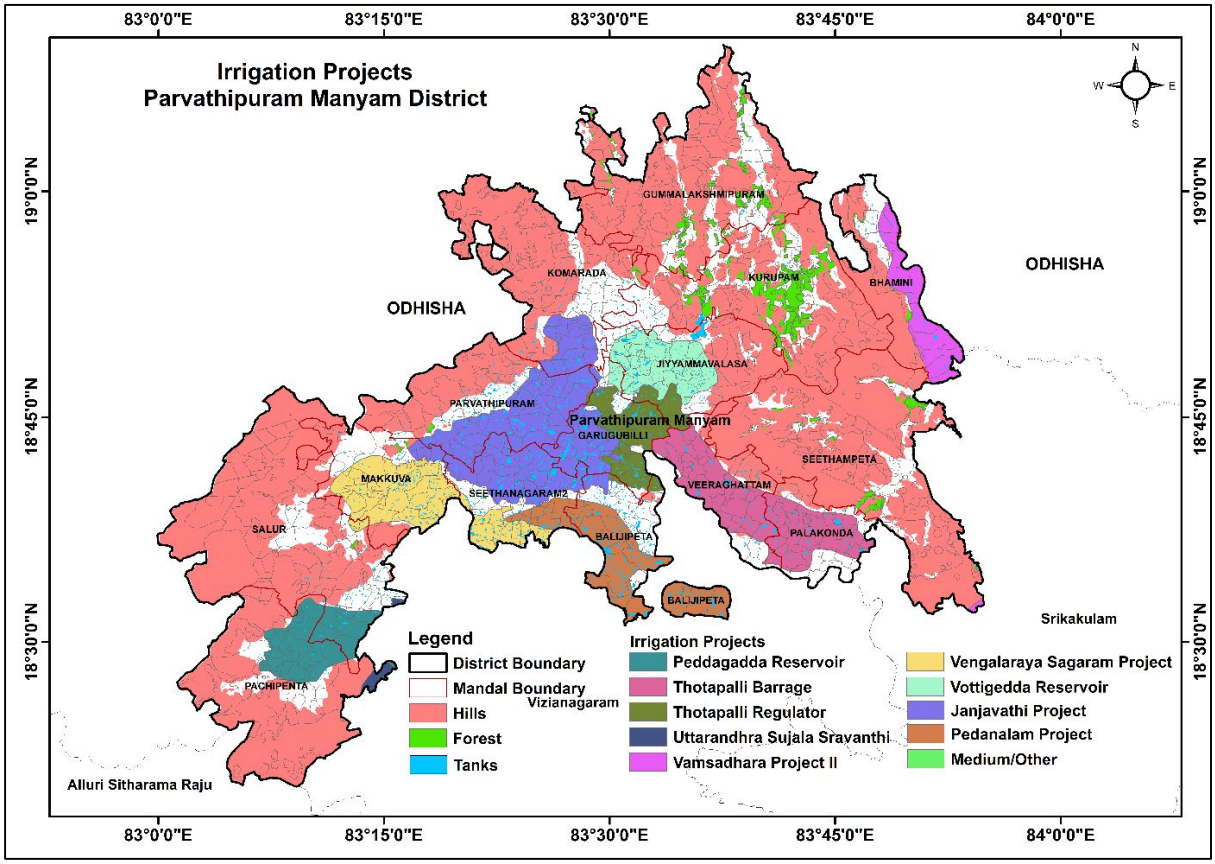


Fig-1.9: Major/ Medium Irrigation Projects, Parvathipuram Manyam District (Source: WRD)

The net area sown vs net area irrigated in the district is shown in Table-1.6 and fig 1.9.1 and the percent of Irrigation in the district by different sources is provided in Table-1.7 and Fig-1.9.2.

Table - 1.6: Net Area Sown versus Net Area Irrigated

S.No.	Mandal	Net Area Sown (Ha)	Total Cropped Area (Ha)	Total Net Area Irrigated (Ha)	Area Irrigated More than Once (Ha)	Gross Area Irrigated (Ha)
1	Balijipeta	7742	10495	6364	493	6857
2	Bhamini	6422	7491	2187	647	2834
3	Garugubilli	7820	10188	5959	823	6782
4	Gummalakshmipuram	6195	6358	1487	88	1575
5	Jiyyammavalasa	9207	12864	10507	1343	11850
6	Komarada	9446	10837	6361	475	6836
7	Kurupam	6851	7280	3871	263	4134
8	Makkuva	9214	12856	4749	3228	7977
9	Pachipenta	7735	9833	3426	569	3995
10	Palakonda	7192	11723	6864	720	7584
11	Parvathipuram	10203	11891	5821	160	5981
12	Salur	12632	15264	5729	1740	7469
13	Seethampeta	7846	8464	1310	343	1653
14	Seethanagaram	9003	11281	6728	725	7453
15	Veeraghattam	8944	13912	7772	1394	9166
	Total	**126452**	**160737**	**79135**	**13011**	**92146**

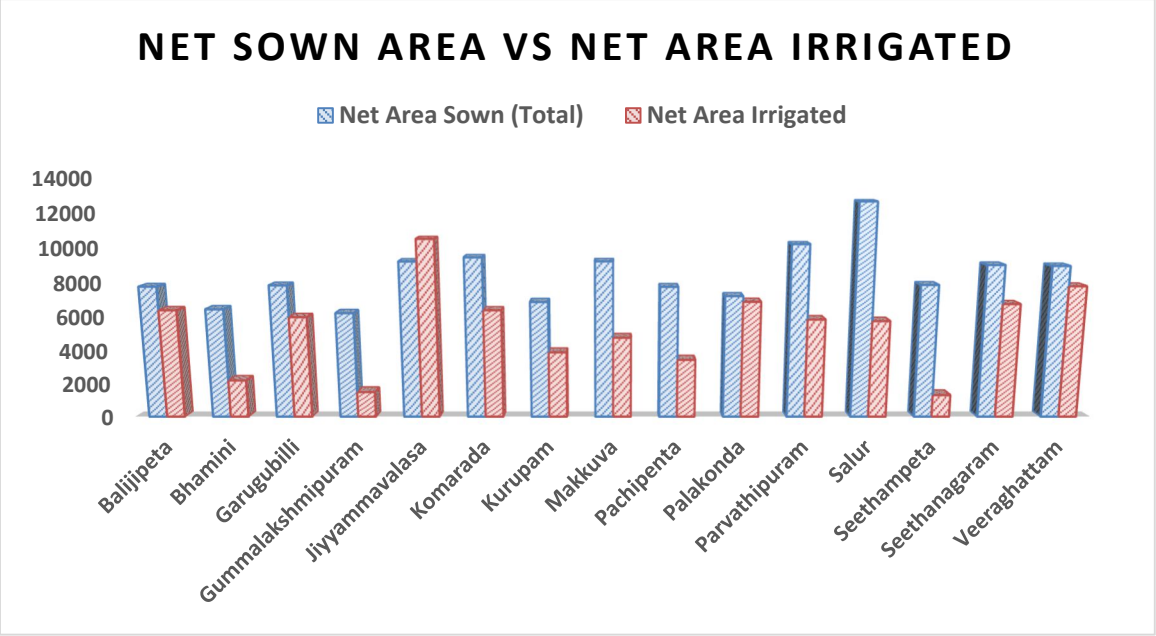


Fig – 1.9.1: Net Area Sown Vs Net Area Irrigated

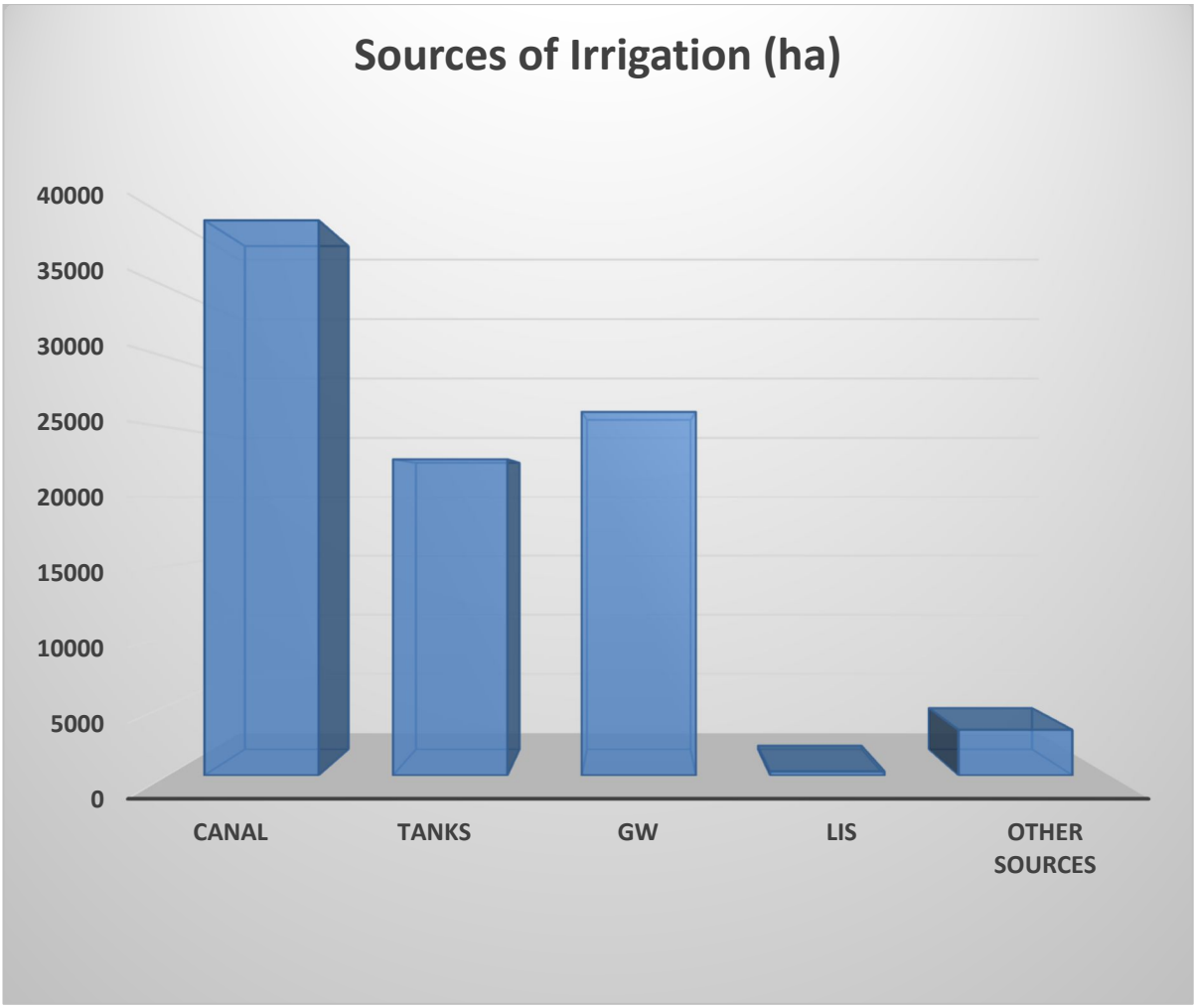


Fig. 1.9.2: Area irrigated under different sources.

Table-1.7: Percentage of Irrigation by different sources in the district

Sources	**% of Irrigation**
Canals	50
Tanks	29
Ground Water	33
LIS	0.4
Other Sources	4
Area Irrigated More than Once	14%
Net Area Irrigated	79135

In the district, there are 4896 Minor Irrigation Tanks having a registered ayacut of 29010 ha and actual irrigated area is27754 ha. **(Table-1.8 and Fig.1.9.3)**.

Table-1.8: Details of Minor Irrigation tanks and its Ayacut

S.No.	Mandal	No. of Sources	Registered Ayacut (ha)	Actual Area Irrigated (Ha)
1	Balijipeta	428	3223	2656
2	Bhamini	509	332	1059
3	Garugubilli	269	2559	2397
4	Gummalakshmipuram	96	1120	1383
5	Jiyyammavalasa	194	321	1086
6	Komarada	313	3594	2245
7	Kurupam	234	2452	2399
8	Makkuva	346	1234	740
9	Pachipenta	79	508	436
10	Palakonda	429	1290	534
11	Parvathipuram	516	6297	5438
12	Salur	236	2112	1336
13	Seethampeta	280	79	1214
14	Seethanagaram	355	3402	3761
15	Veeraghattam	612	487	1070
	Total	4896	29010	27754

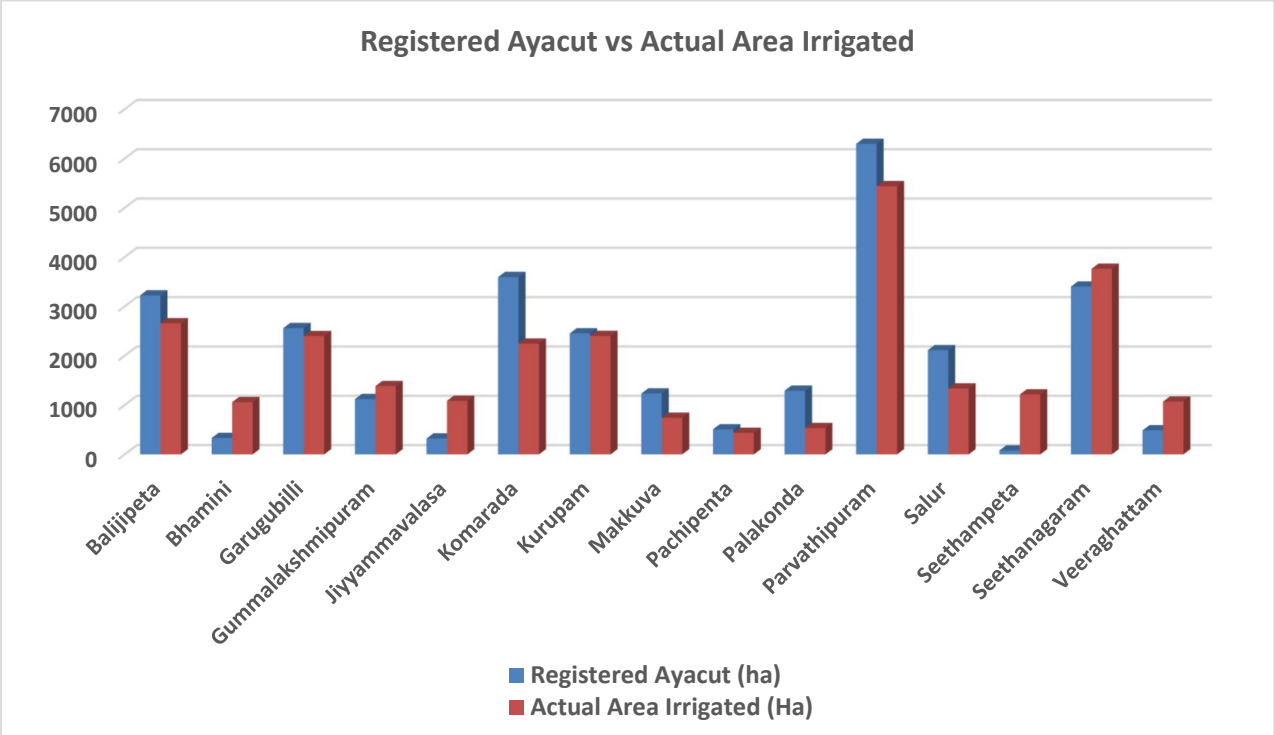


Fig: - 1.9.3 Area Irrigated under Minor Irrigation.

1.11 Prevailing water conservation/Recharge practices: In the district, a total of 2165 artificial recharge structures (269 Percolation Tanks, 163 Mini Percolation Tanks, 1137 Check Dams and 209 Check Walls and others) are constructed under IWMP and MGNREGS. The mandal wise distribution of the ARS is provided in Table-1.9 and f**ig.1.9.4.**

Table-1.9: Mandal wise details of Existing ARS in P Manyam District, AP

S.No.	Mandal	No. of Existing ARS
1	BALAJIPETA	25
2	BHAMINI	151
3	GARUGUBILLI	14
4	GUMMALAKSHMIPURAM	127
5	JIYYAMMA VALASA	74
6	KOMARADA	76
7	KURUPAM	96
8	MAKKUVA	41
9	PACHIPENTA	222
10	PALAKONDA	116
11	PARVATHIPURAM	146
12	SALUR	140
13	SEETHAMPETA	676
14	SEETHANAGARAM	63
15	VEERAGHATTAM	198
	Grand Total	2165

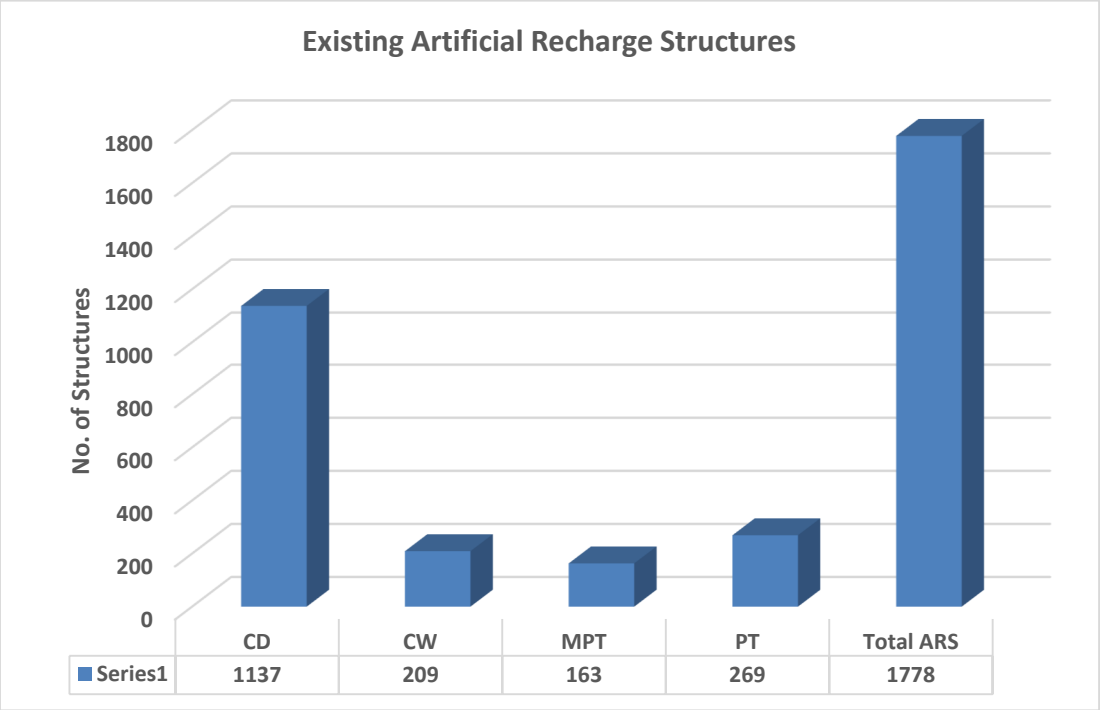


Fig. 1.9.4: Existing AR Structures in P Manyam District

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	Analysis of groundwater for general

		additional water quality parameters	parameters including fluoride.
3.	Aquifer Map Preparation (1:50,000 scale)	Analysis of data and preparation of GIS layers and preparation of aquifer maps	Integration of Hydrogeological, Geophysical, Geological and Hydro-chemical data.
4.	Aquifer Management Plan	Preparation of aquifer management plan	Information on aquifer through training to administrators, NGO's, progressive farmers and stakeholders etc. and putting in public domain.

The aquifer mapping and management plan of Parvathipuram Manyam district is broadly carried out in following steps:

2.1 Data gap analysis, generation and Data Compilation: The identification of data gap was done after the detailed analysis, examination, synthesis and interpretation from available sources. The conversion of analog data in the form of digital data that could be processed readily on GIS platform. The data from erstwhile Viziangaram district and Srikakulam district, basic data reports of exploratory wells/observation wells/ piezometers drilled by CGWB, details of wells drilled by State Departments, geophysical data of CGWB are compiled and integrated for aquifer mapping.

The Central Ground Water Board had drilled 58 no's bore wells (50 EW, 8 OW), carried out 23 Vertical Electrical Soundings (VES) in the district so far. The ground water regime is being monitored form 33 GWM stations and ground water quality data from 78 GW quality monitoring stations. The spatial distribution of data points are provided in Fig-2.1 and the no. of data points utilized for NAQUIM is provided in Table-2.1. The density of the data calculated as 1data point for 40 sq kms for deciphering the lateral and vertical disposition of aquifers, 1 data points per 99 sq kms for understanding the spatial and temporal variation in ground water regime and 1 data point per 42 sq.kms for understanding the spatial and temporal variation in ground water quality. The data is utilized for NAQUIM in the district.

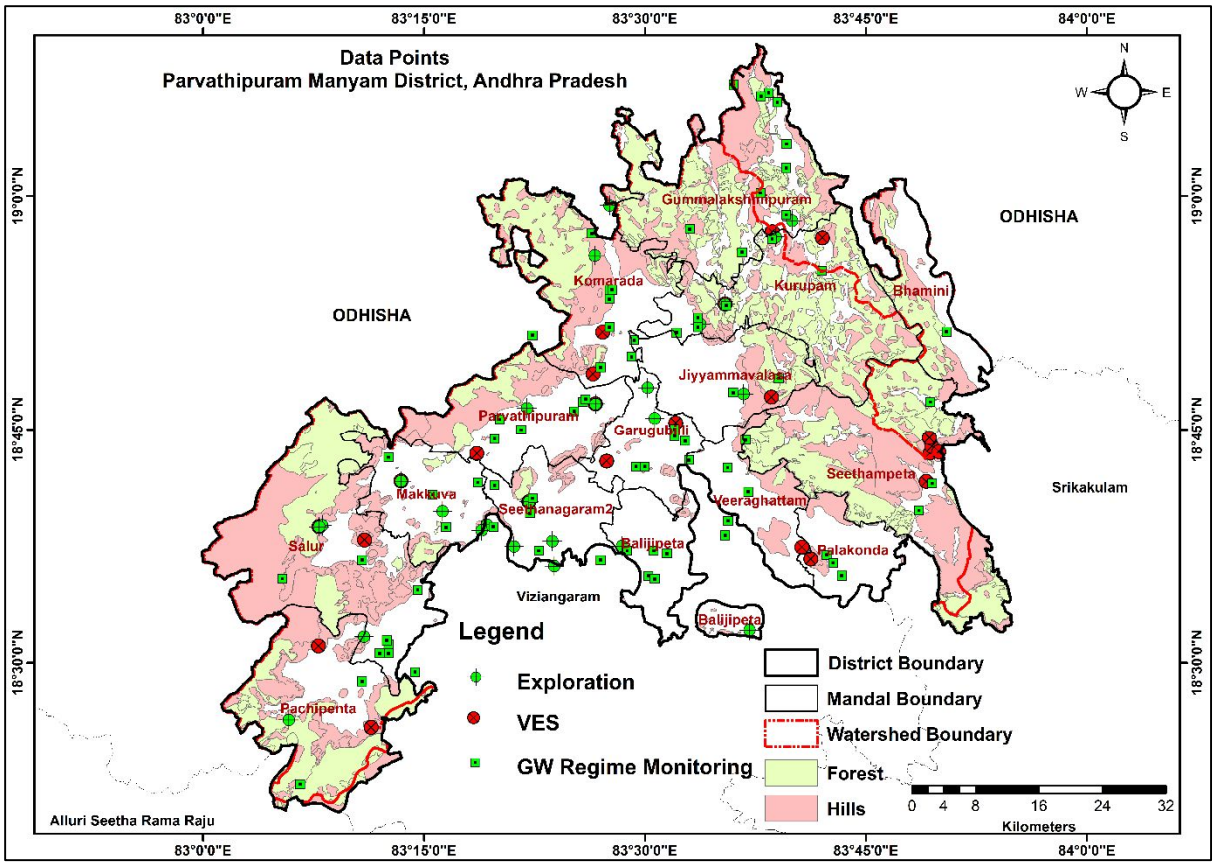


Fig. 2.1: Hydro geological data availability.

Table 2.2: Status of Data Integration		
S. No.	Activity	No. of data Points
1	Exploration	58
2	Geophysical	23
3	GW Quality Monitoring Stations	78
4	Ground water level Monitoring Stations	33
		192

3. Geology, Hydrogeology and Aquifer Characterization

The district is underlain by Eastern Ghat Mobile Belt of Archaean age. It includes rocks of Khondalite Group, Charnockite Group and Migmatite complex. Sediments of Cenozoic laterite and Quaternary deposits overlie the Archaeans. The lithological units of Khondalite Group include quartzite, talc- granulite and talc-silicate rock. The Charnockite Group include pyroxene granulite (basic Charnockite) and charnockite (acid/intermediate). The Migmatite complex includes hypersthene-biotite gneiss, hypersthene-quartz-feldspar augen gneiss, granitoid gneiss. Gneissosity in the granite gneiss is more pronounced in the vicinity of Khondalite. Quaternary sediments, including brown, residual soil of fluvial origin occur along the river courses. Thick mantle of flood plain deposits comprising clay and silt occurs in the Gostani, Champavati, Kandivalasa, Vegavati, Suvarnamukhi, and Nagavali river valleys. Nagavali River is marked by a major NNW-SSE trending lineament. The geological map and percentage distribution of geological formations in the district is shown in Fig-3.1 and 3.2 respectively. The distribution of lithological units is shown in Table- 3.1.

Table- 3.1: Distribution of Lithological units, P Manyam, AP

LITHOLOGY	**Code**	**Area (Sq. kms)**	**Percentage (%)**
Granite Gneiss	GN	1397.96	38.20
Charnockite	CH	1106.29	30.23
Khondalite/Gneiss/Schist	KH	898.693	24.55
Alluvium	AL	208.997	5.71
Quartzites	Qtz	38.9644	1.06
Laterite	Lt	9.08469	0.25
Total		**3659.989**	**100**

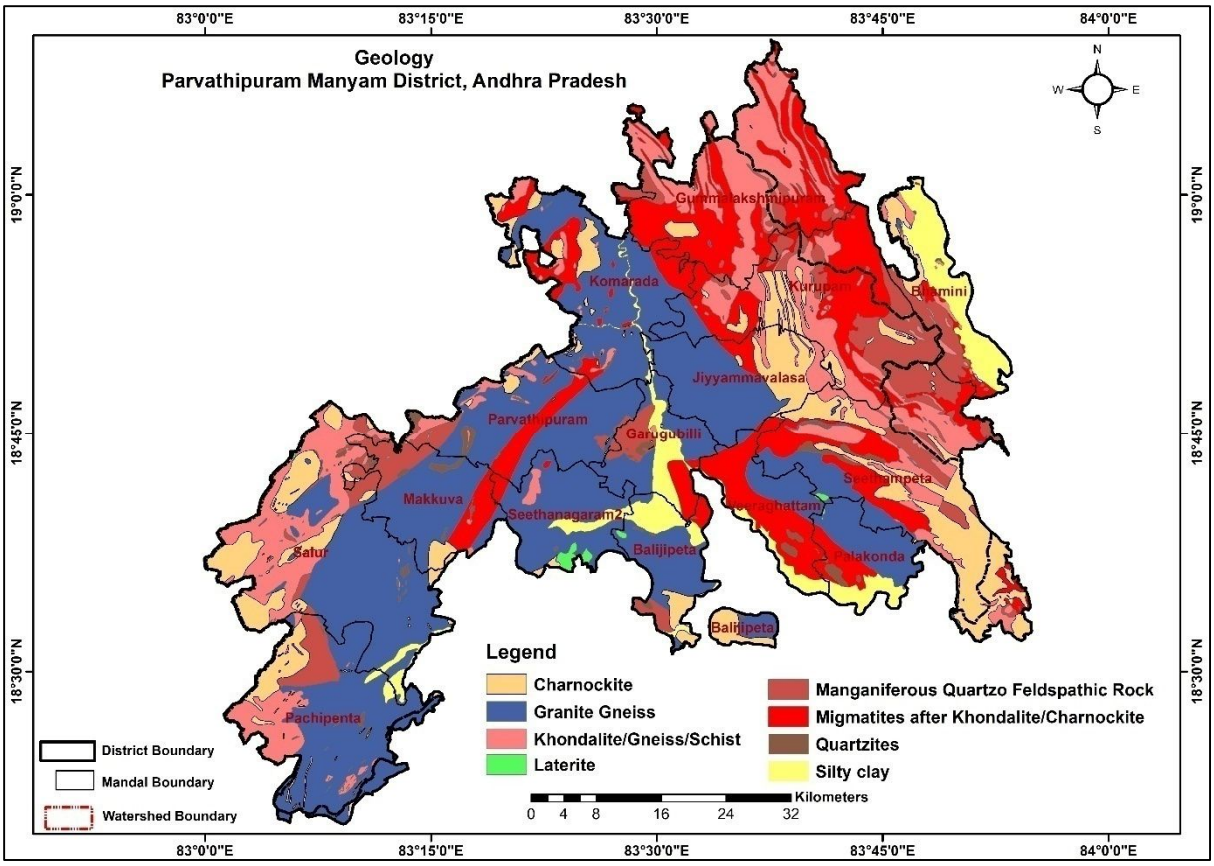
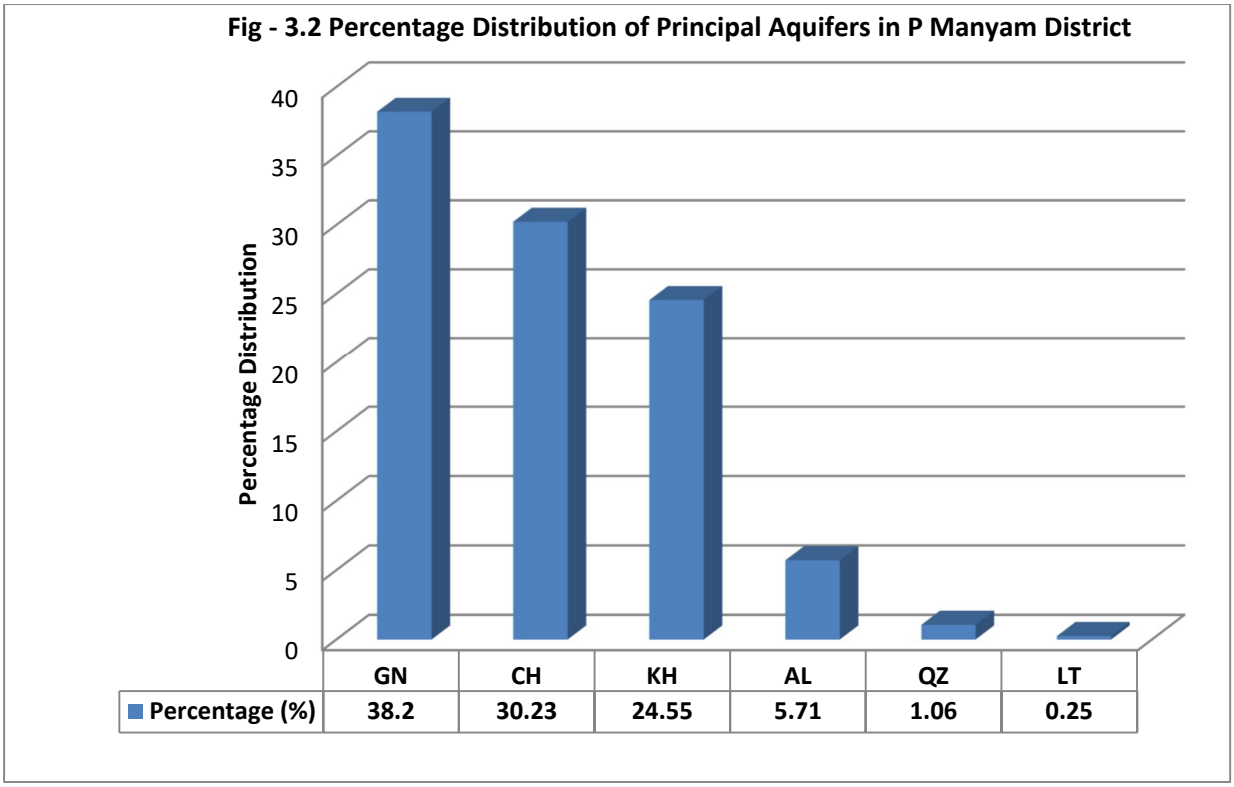


Fig.3.1: Geology of Parvathipuram Manyam district.



Hydrogeology is concerned primarily with mode of occurrence, distribution, movement and chemistry of ground water occurring in the subsurface in relation to the geological environment. The 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 Archean eastern ghat mobile belt mainly comprising of Khondalites, Charnockites, Migmatites and Granite Gneisses etc overlain by Recent Alluvium. The occurrence and movement of ground water in these rocks is controlled by the degree of interconnection of secondary pores/voids developed by fracturing and weathering of hard and crystalline formation and presence of sand and clay layers in alluvium formation.

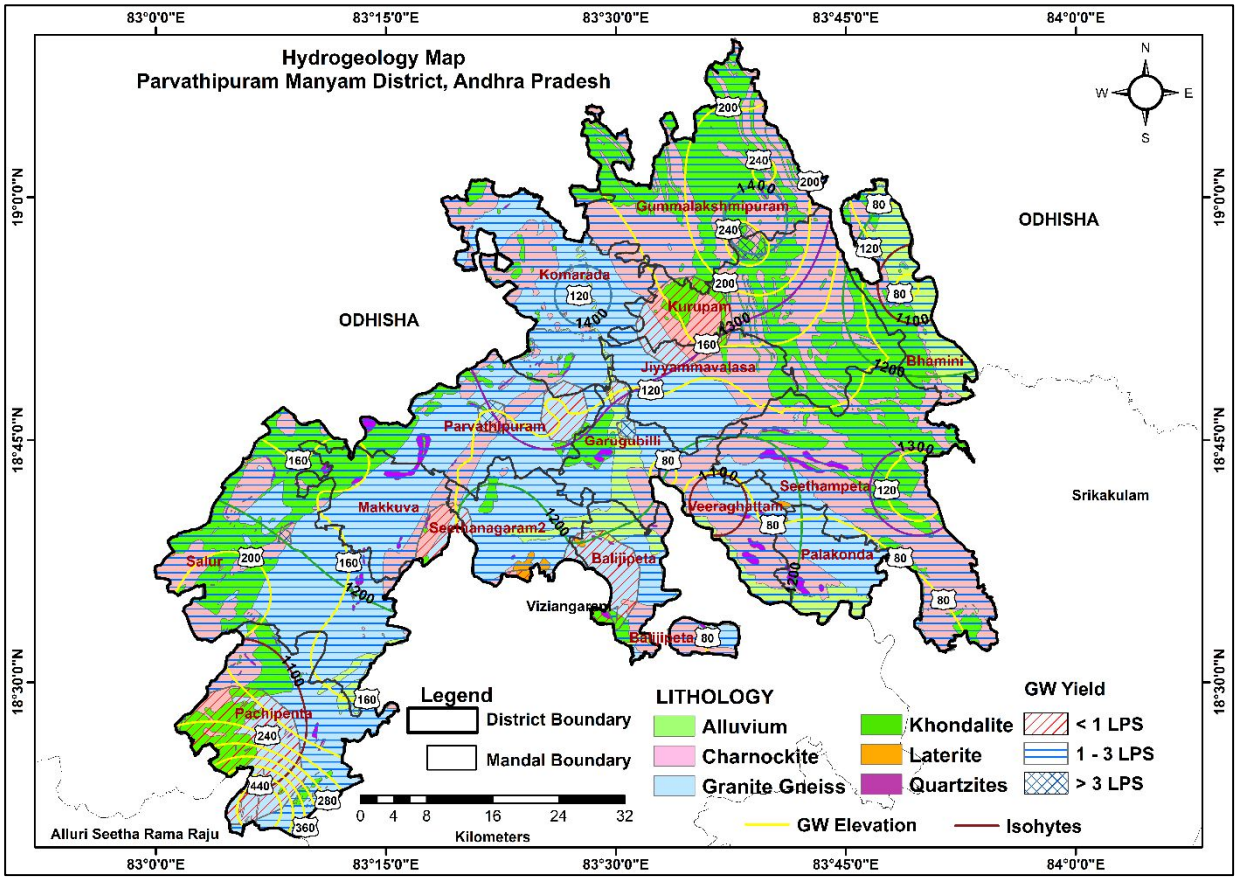


Fig-3.3 Hydrogeology Map of Parvathipuram Manyam District

3.1 Aquifer Characterization:

Data analysed from CGWB exploration and VES studies indicates that the weathering ranges from 5 m to 57 m with an average weathering thickness of 22 m. The fracture occurs in range

of 13 to 191 m bgl depth The yield ranges from <1.0 to 5.5 lps and highest discharge (5.5 lps) found in L. Kota mandal.

3.1.1 Weathered zone: The Thickness of weathered zone varies from <5 m to 48 m with an average thickness of ~22 m. The average thickness of weathering is 24 m in Khondalites, 22 m in Granites and Granite gneisses, 10 m in Charnockites, 17 m in Quartzites and 22 m in Laterites. The spatial distribution of weathering thickness is shown in Fig.3.4 & Fig.3.5 respectively. Thickness of weathering < 10 m occurs in ~1 % of the area, 10 to 20 m occurs in ~36 % of area, 20-30 m occurs in 54 % of area. High thickness of weathering (>30 m) occurs in in 9% of the district in isolated parts of Makkuva, Kurupam, Salur and Parvathipuram Manyam mandals.

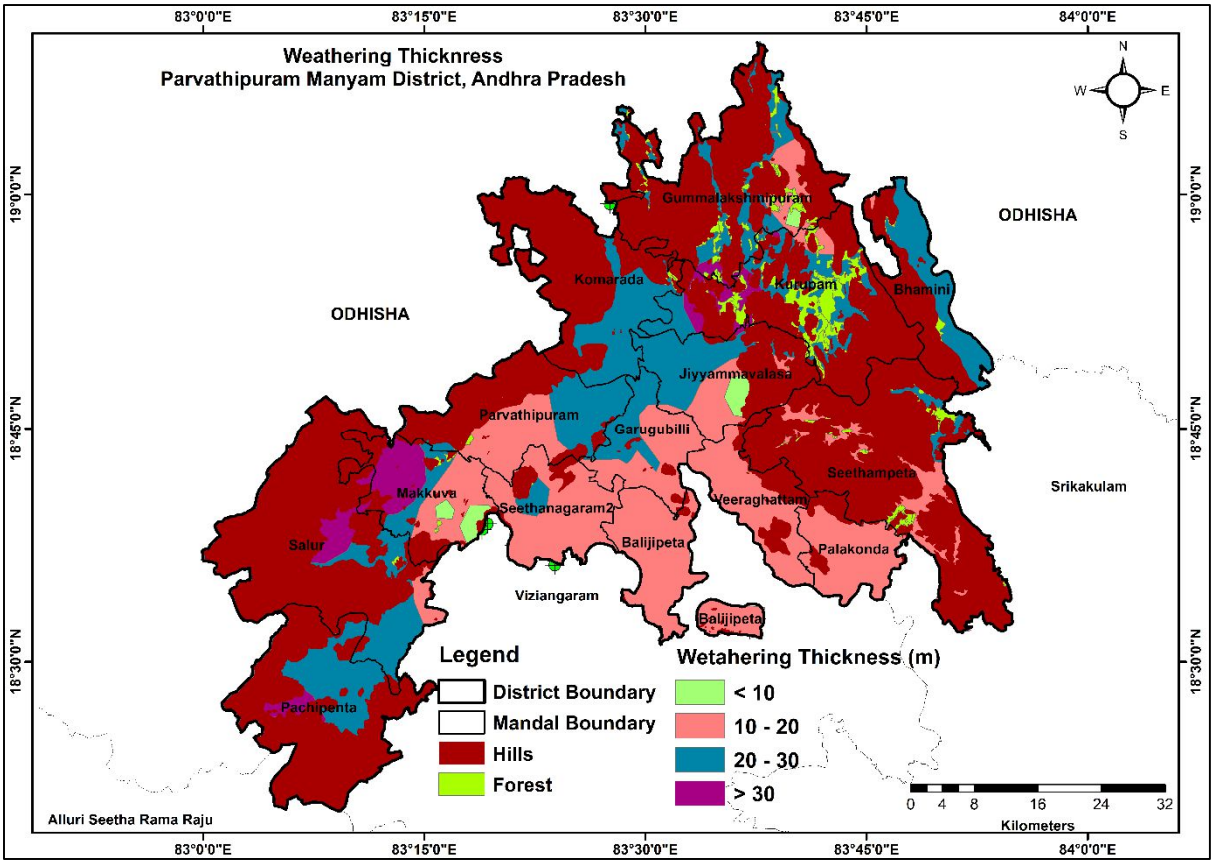


Fig.3.4: Depth to weathered zone, Parvathipuram Manyam district.

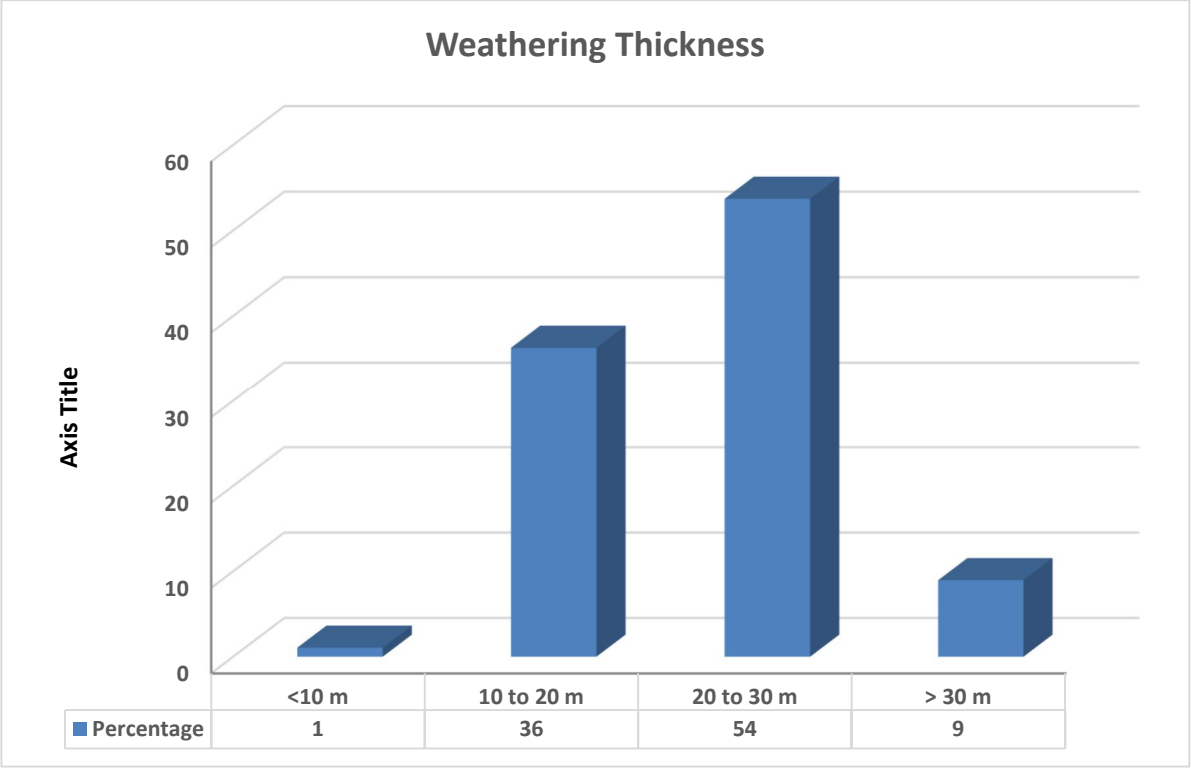


Fig: 3.5 Depth wise distribution of weathering, Parvathipuram Manyam District.

3.1.2. Fractured zone: The depth of fracturing varies from 13-191 m and deepest fracture encountered in exploratory drilling is 191 m at Appayyapeta, Seethanagaram mandals. The yield of the deepest fracture encountered is 1.2 lps. From the data, it is inferred that fractures in the range of 120 to 150 m depth are more predominant (45 % of the area), > 150 m occur in 33 % area; < 30 m occurs in 16% of the district. The Depth wise distribution of fractures is shown in Fig.3.6 and 3.7

Table-3.2: The Occurrence of Weathering and Fractures in Parvathipuram Manyam District, AP

Weathering Thickness (m)	Area (Sq. kms)	% of Occurrence	Fracture Occurrence (m)	Area (Sq kms)	% of Occurrence
<10 m	38.28	1	<30 m	564.37	15.58
10 to 20 m	1314.08	36	30 to 60 m	99.20	2.74
20 to 30 m	1945.39	54	60 to 90 m	36.57	1.01
> 30 m	324.51	9	90 to 120 m	81.10	2.24

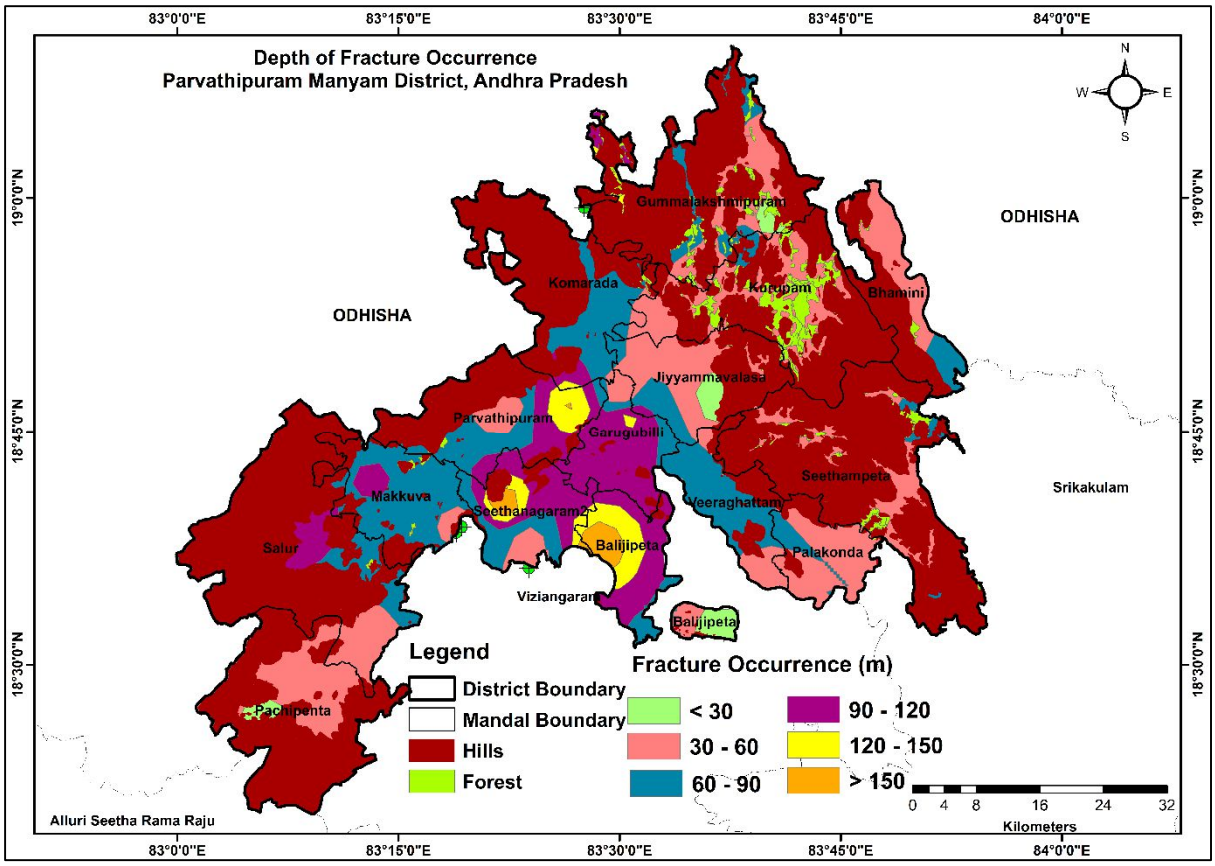


Fig.3.6: Depth of Fractured zone, Parvathipuram Manyam District.

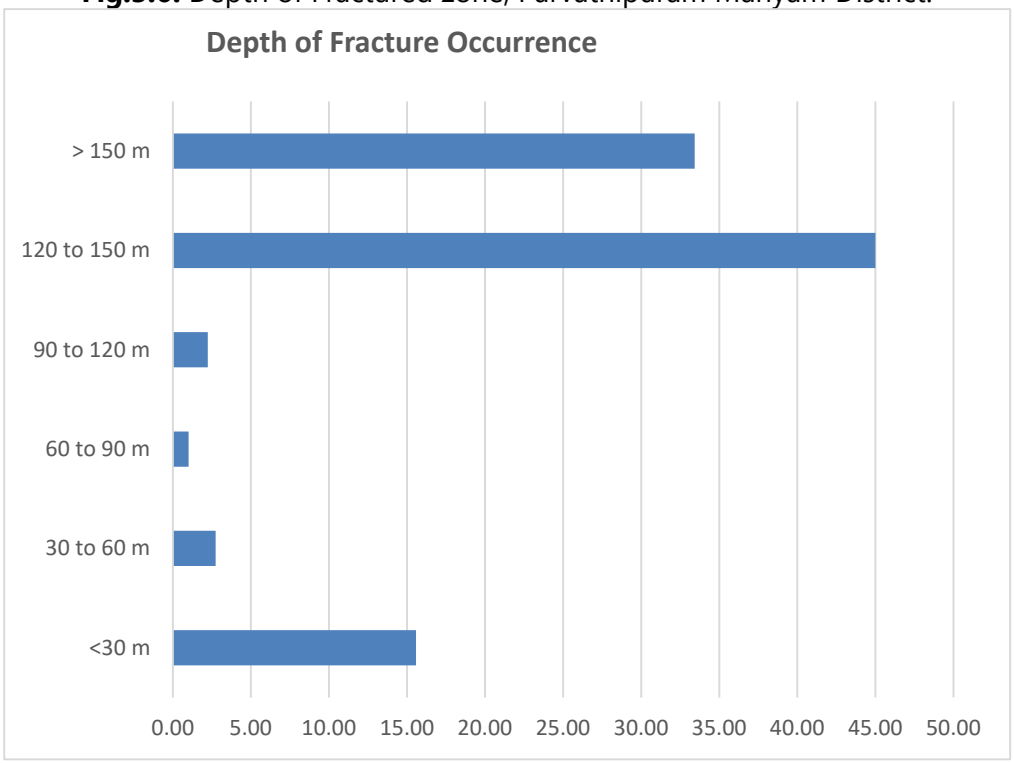


Fig: 3.7 Depth wise distribution of fractures, Parvathipuram Manyam District

3.1.3. Ground Water Yield: The yield ranges from <1.0 to 5.5 lps and highest discharge (5.5 lps) found in L. Kota mandal. In majority of the area, the ground water yield in the range of 1 to 3 lps followed by < 1 lps and 3 to 5 lps. The map showing ground water yield of the district is shown in Fig.3.8 and 3.8.1.

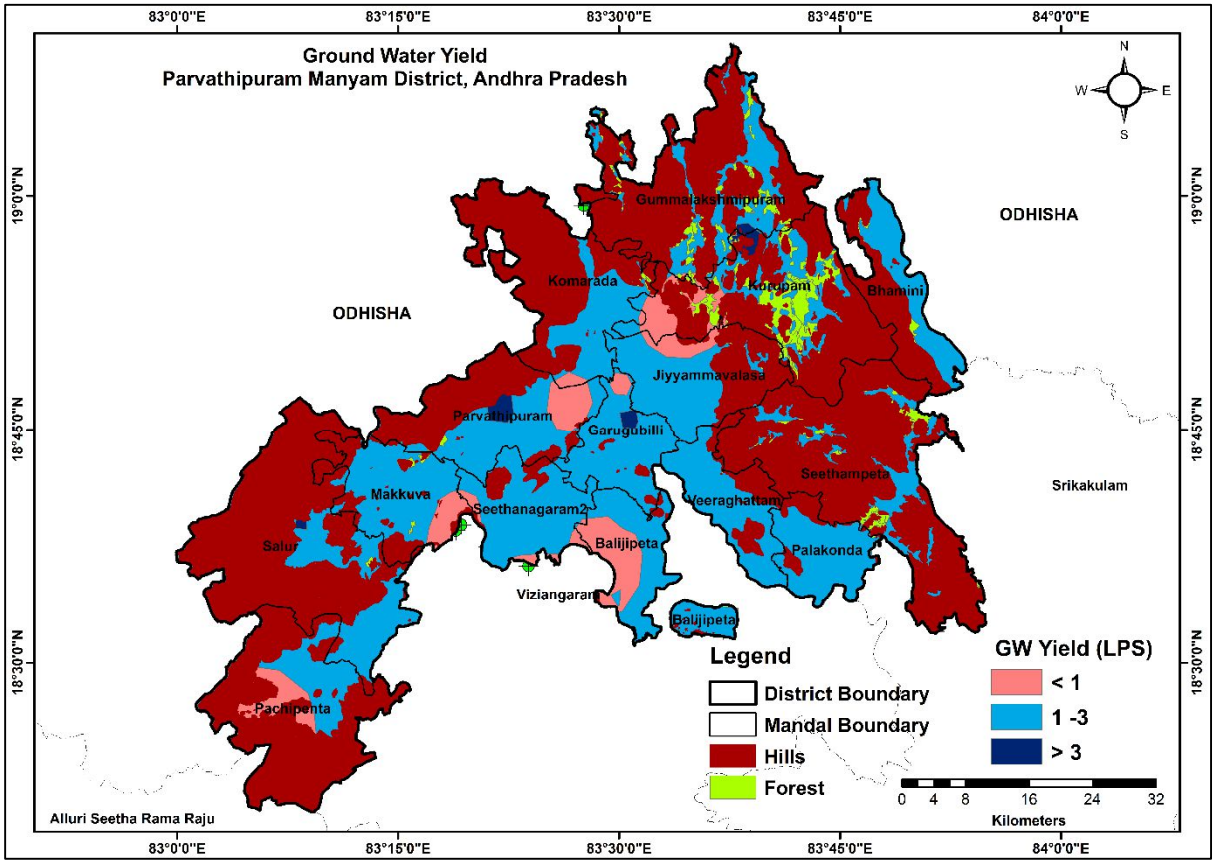


Fig-3.8: Ground water yield potential map of Parvathipuram Manyam district.

Yield (LPS)	Area (Sq kms)	Percentage
< 1	332.11	9
1 to 3	3264.74	90
3 to 5	26.80	1

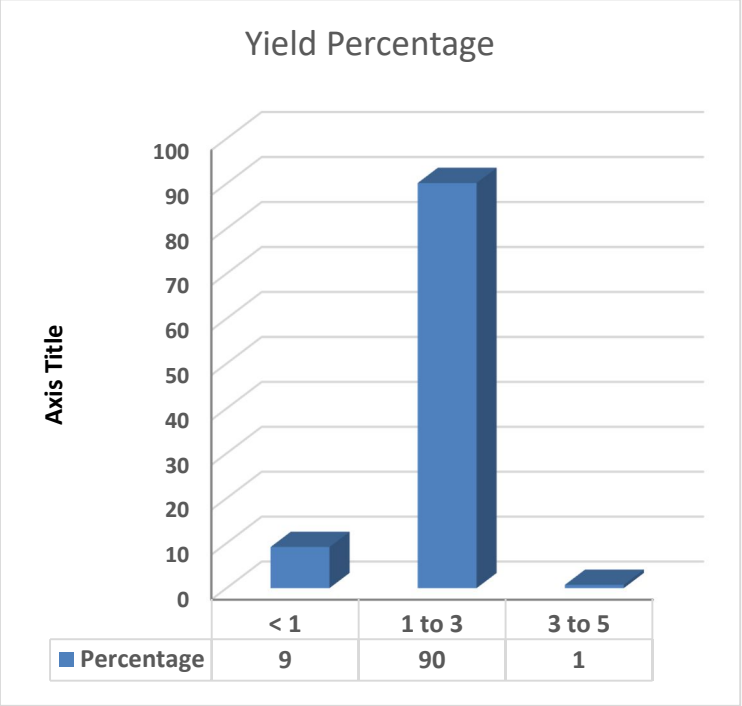


Fig-3.9 Yield Percentage

3.2 Depth to Water Levels: Ground Water Levels are continuously being monitored by Central Ground water Board and Ground Water & Water Department in the district. The data of Ground water level monitoring from 34 monitoring stations (CGWB: 14 and SGWD: 20) of both pre and post-monsoon seasons (2012 to 2022) was utilized for understanding the ground water regime of the district.

3.2.1 Water Table Elevations: During pre and post-monsoon season (May and November), the water-table elevation ranges from 38.5 to 467.5 m amsl and 40.4 to 469 m amsl respectively. **(Fig.3.10)**

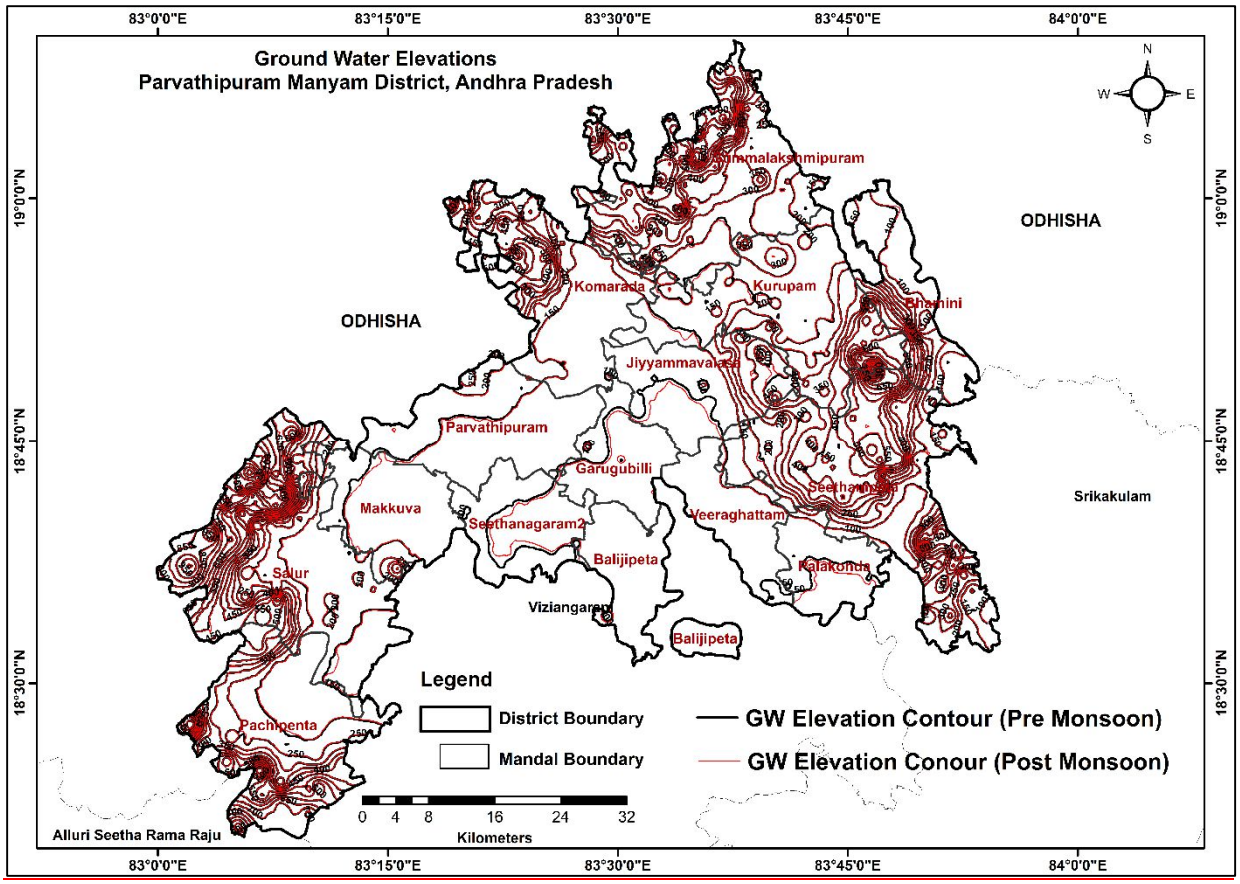


Fig 3.10 Ground Water Elevation

3.2.2 Depth to Water Levels (DTWL): The average DTWL of 10 years (2012 to 2022) for pre-monsoon and post-monsoon were analysed, the avg. DTWL varies from 2.4 to 16.8 meter below ground level (m bgl) (average: 6.9 m bgl) and 1.4 to 13.9 m bgl (average: 4.8 m bgl) during pre-monsoon and post-monsoon seasons respectively.

3.2.2 (a) Pre-monsoon season: Majority of the water levels during this season are in the range of 5 to 10 m covering 80 % of the area, followed by < 5 m bgl (10 %) and 10 to 15 m (9%). DTWL more than 15 m is observed very sporadically, which is insignificant (**Fig.3.11**)

3.2.2 (b) Post-monsoon season: Majority of the water levels during this season are in the range of <5 m (73%) of the area, followed by 5 to 10 m bgl (24 %) and > 10 m (3%) of area. (**Fig.3.12**)

3.2.3 Long term water level trends: Trend analysis for the last 10 years (2012-2022) is studied from 34 hydrograph stations of CGWB and SGWD for pre-monsoon and post-monsoon season respectively. It is observed that during pre-monsoon season 31 wells shows

falling trend ranging from 0.393214 m to 0.03575 m/year (Avg: 0.18 m/yr) and 3 wells shows rising trends ranging -0.03321 to -0.04046 m/yr (Avg: 0.038 m/yrs).

During post-monsoon season 14 wells shows falling trend ranging 0.280238 to to 0.122806 m/yr (Avg: 0.119 m/yr) and 22 wells shows rising trend ranging -0.052 to 0.68 m/yrs (Avg: 0.260 m/yrs).

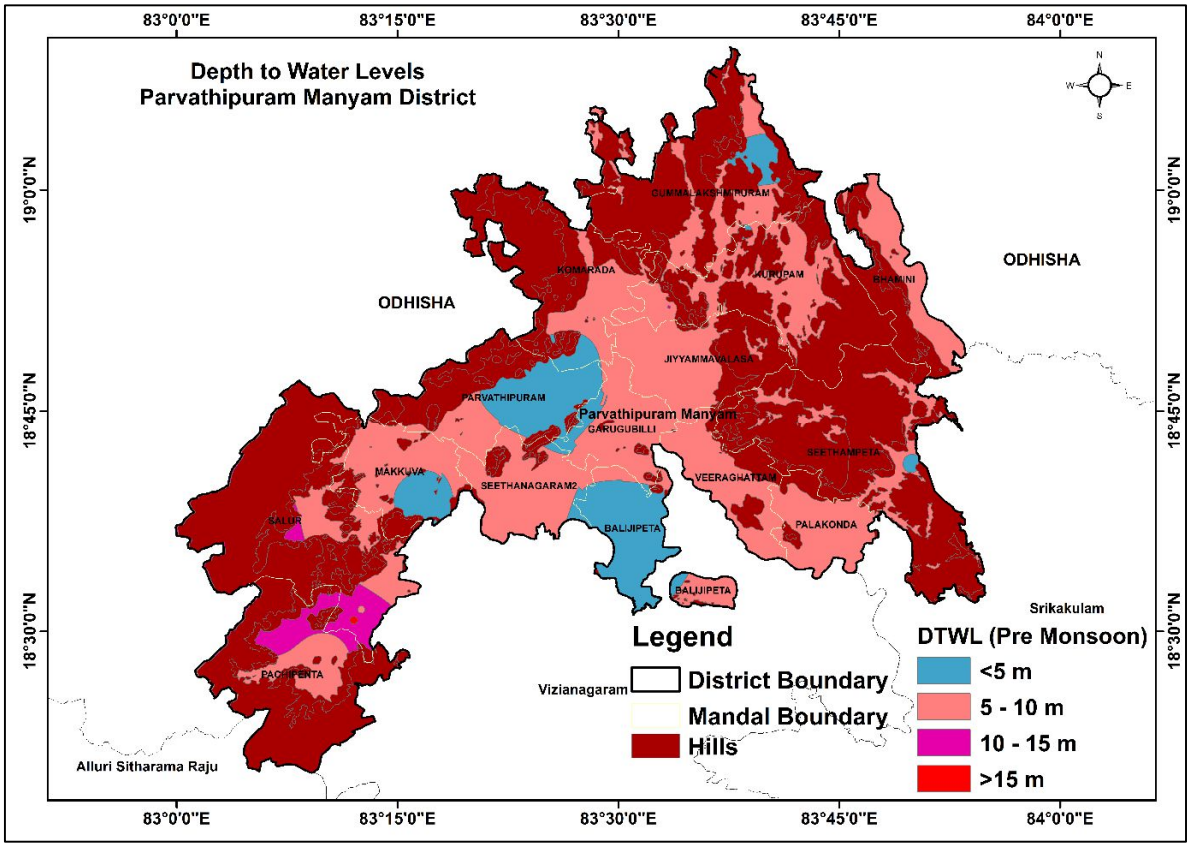


Fig.3.11: Depth to water levels Pre-monsoon (Decadal Average).

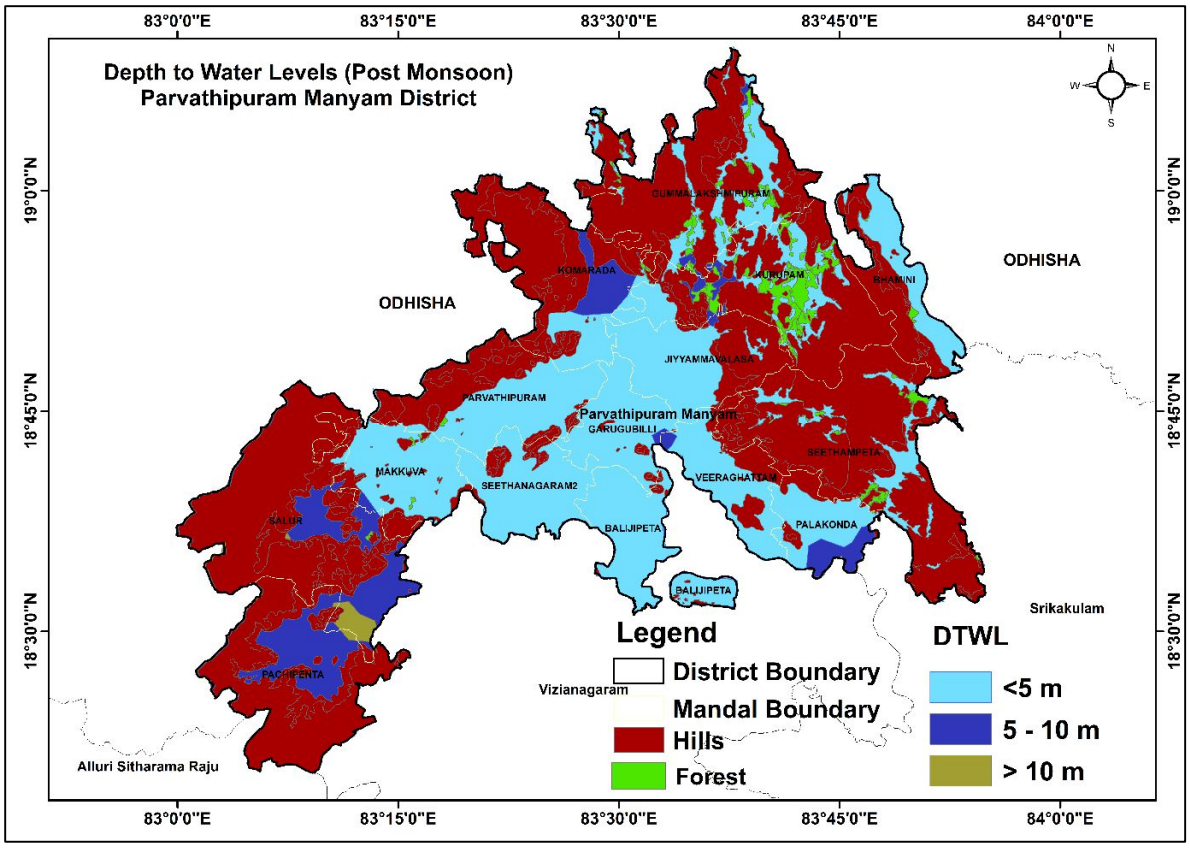


Fig.3.12: Depth to water levels Post-monsoon (Decadal Average).

3.2. Hydro chemical Studies: For groundwater quality analysis 75 NHS monitoring well and 35 key wells data are being used for spatial and temporal variation of ground water quality.

Ground Water from the area is mildly alkaline to alkaline in nature with pH in the range of 6.7 to 8.15 (avg: 7.54). Electrical conductivity varies from 93 to 4400 (avg: 1352) µ Siemens/cm**.** In majority of area 2734 sq.km (75 %) EC is within 750 to 2250 µ Siemens/cm; in 316 sq. kms (9 %) area, it is 1500 to 2250 µ Siemens/cm; in 559 sq. kms (15 %) area, it is <750 µ Siemens/cm and in 14 sq kms (0.4 %) area is >2250 µ Siemens/cm. **(Fig.3.13 & Fig.3.14 & Fig 3.14 a).** The Concentration of NO3 ranges from 0.31-278 mg/l with an average 47.74 mg/l. Nitrate concentration <45 mg/l is observed in 68(62 %) sample out of 110 sample and above permissible limit of >45 mg/l is observed 42(38%) samples **(Fig.3.15).** The concentration of Fluoride ranges from 0.07-1.91 mg/l with an average of 0.53 mg/l. In 97samples (97%), F concentration is observed less than the permissible limits (<1.5 mg/l) and in 03 (03%) samples F is more than the permissible range (>1.5 mg/l) **(Fig.3.16& Fig.3.16 aa)**

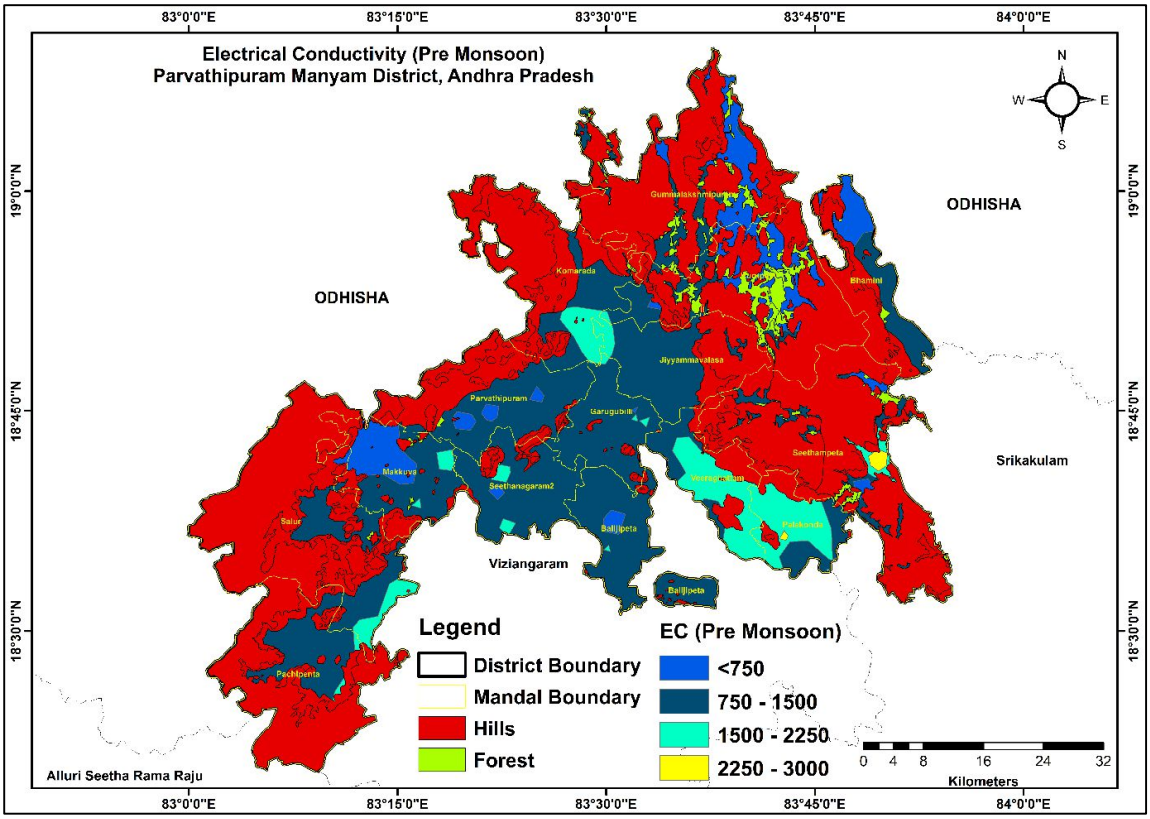


Fig.3.13. Distribution of Electrical Conductivity in Pre monsoon.

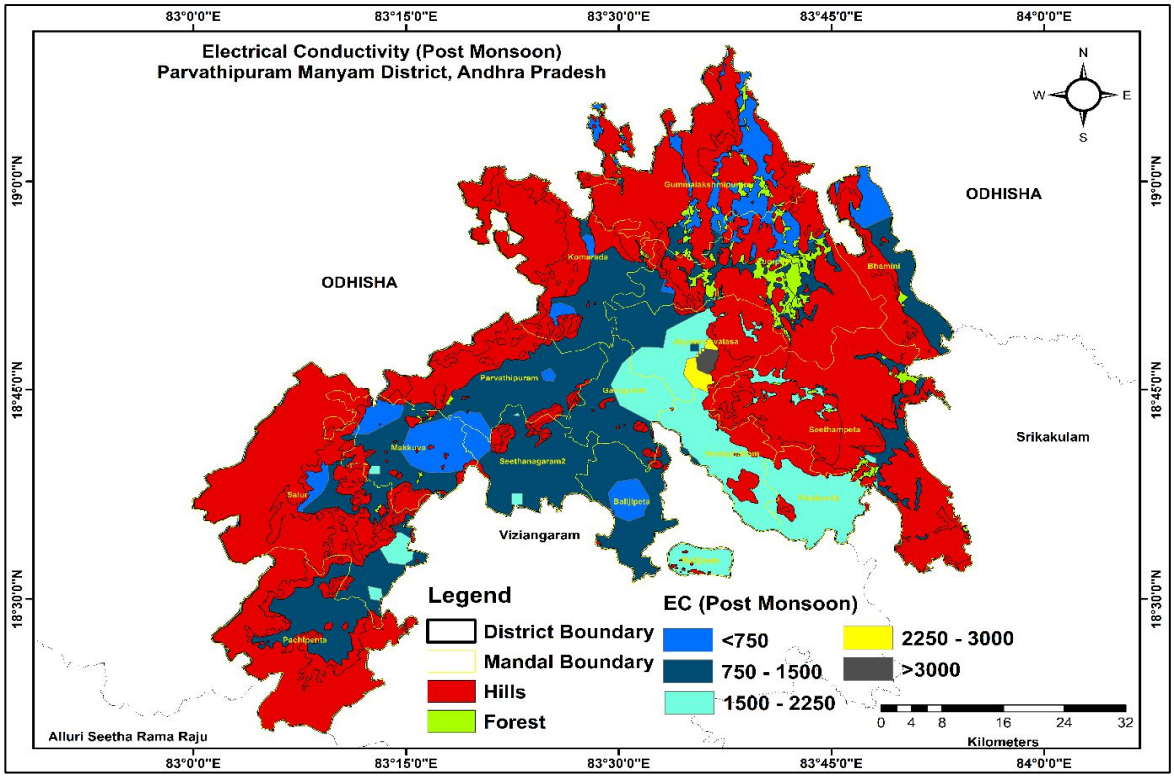


Fig.3.14. Distribution of Electrical Conductivity in Post monsoon

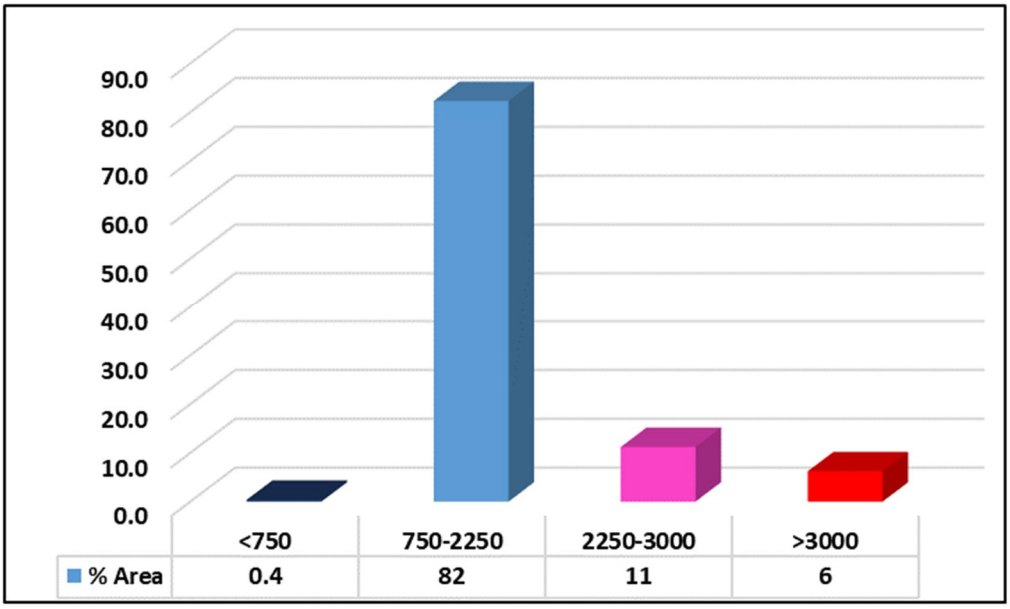


Fig.3.14a: Percentage of area (EC).

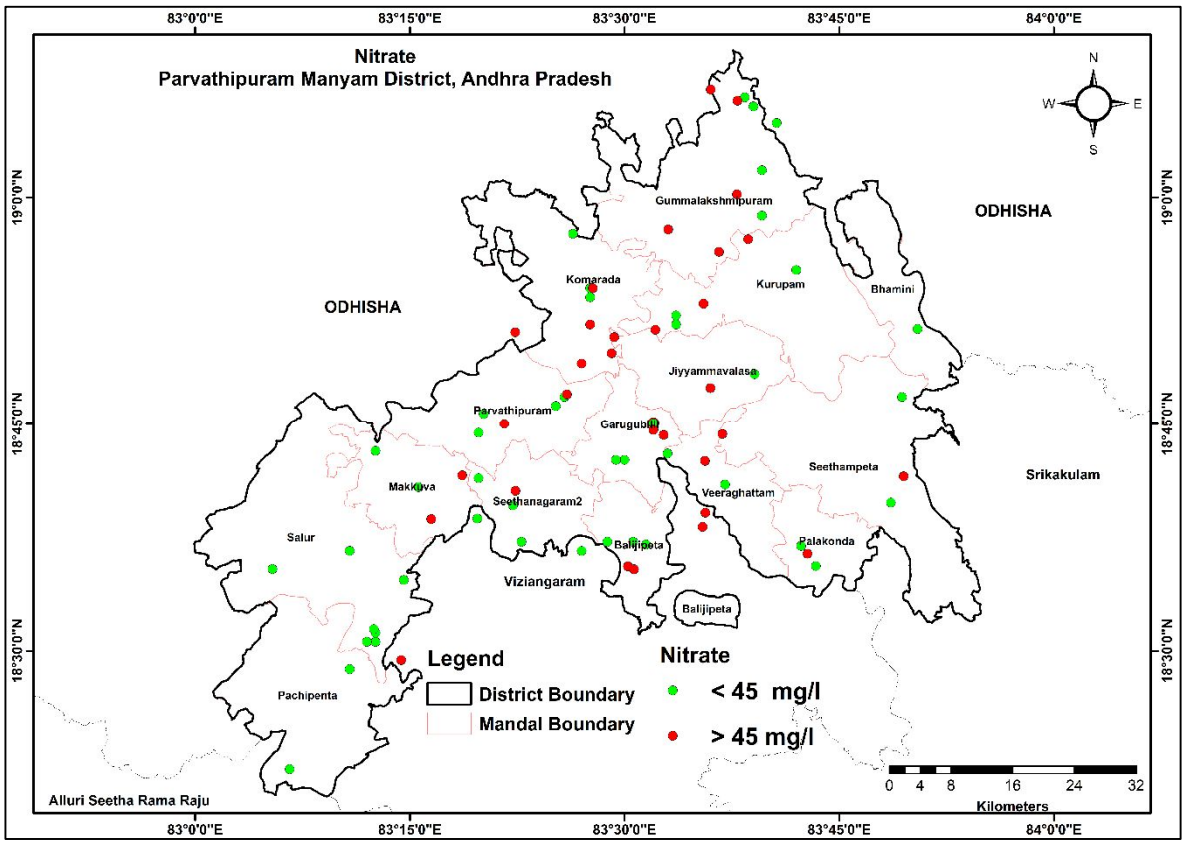


Fig.3.15: Distribution of Nitrate.

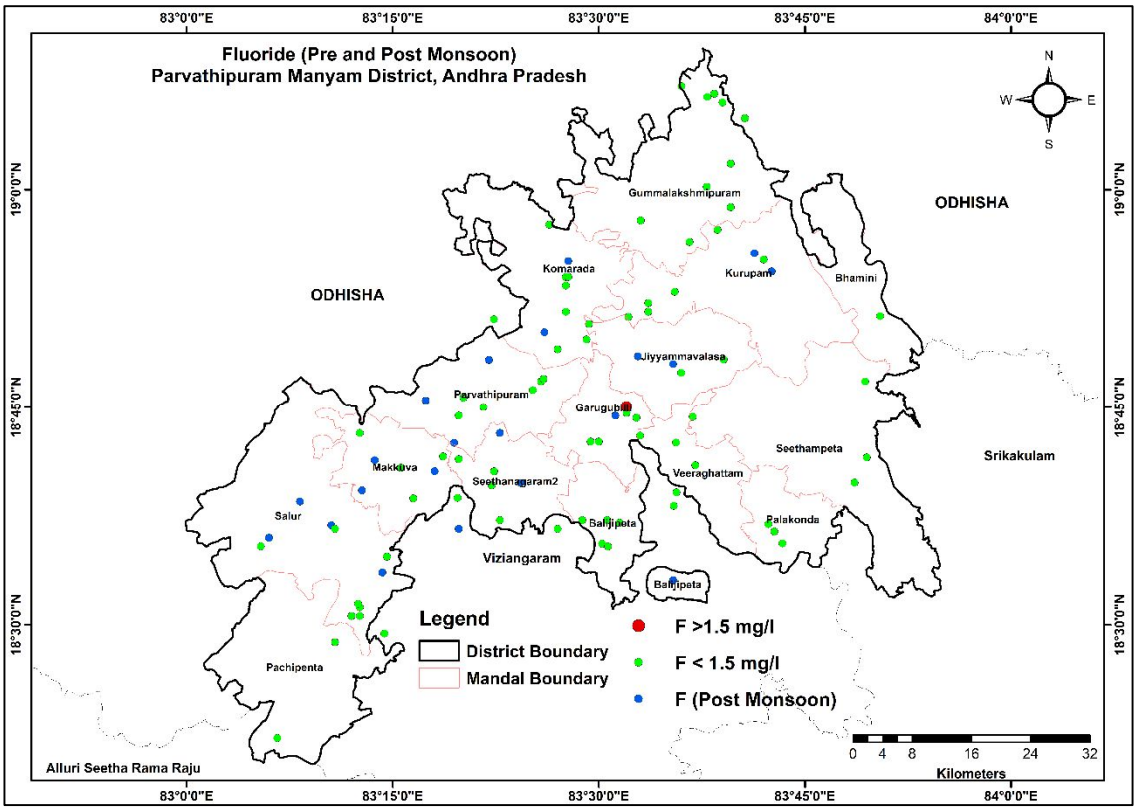


Fig.3.16: Distribution of Fluoride.

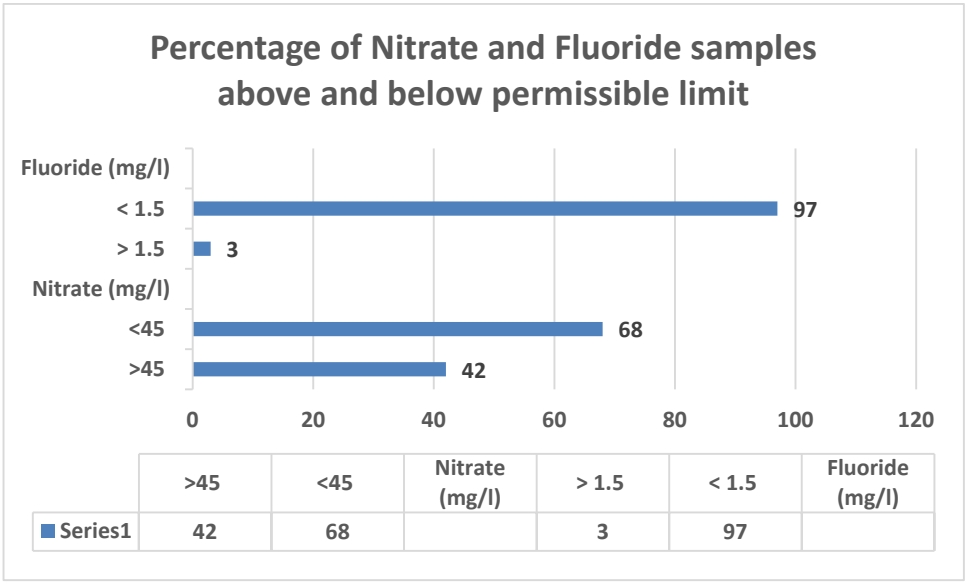


Fig.3.16 a.: Percentage of Nitrate and Fluoride samples above and below permissible limit.

Table-3.3: Hydrogeological Attributes

Attributes	**KH/GN**	**GN**	**CH**	**AL**	**QTZ**	**LT**	**Total**
Area (Sq kms)	1229	1185	744	232	22	9	3421
Mandals (No.s)	242	401	363	83	14	3	1106
Villages (No.s)	242	401	363	83	14	3	1106
Average of Normal Rainfall (mm)	1267	1240	1270	1187	1202	1167	1251
Average of Decadal DTWL (Pre)	6.89	6.77	6.61	6.22	6.27	5.66	6.70
Average of Decadal DTWL (Post)	4.67	4.77	4.49	4.09	4.16	3.38	4.59
Average Thickness of Weathering (m)	24	22	21	19	18	17	22
Average depth of Fracture occurrence (m)	67	72	65	75	69	55	69
Yield (LPS)	1.8	1.4	1.6	1.5	1.4	1.1	1.6

4. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

Conceptualization of 3-D hydrogeological model was done by interpreting and integrating representative 81 data points (58 exploration and 23 VES). The data is calibrated for elevations with Shuttle Radar Topography Mission (SRTM) data. The lithological information was generated by using the Rock Works-16 software and generated 3-D, panel diagram of aquifers and hydro geological sections for Parvathipuram Manyam district **(Fig.3.17 & Fig.3.18).** The 2 D hydro geological sections are shown **in Fig.3.19, Fig.3.20 & Fig.3.21.).**

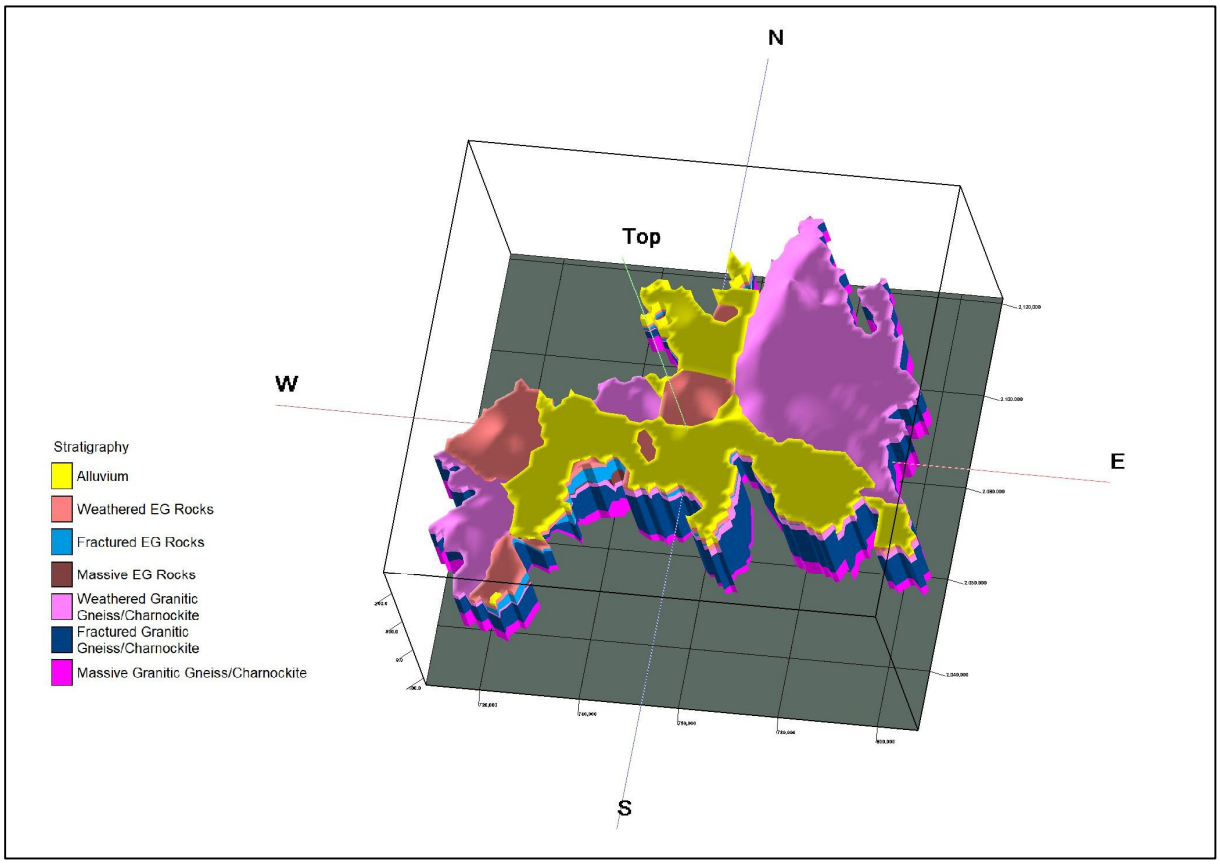


Fig.3.17: Aquifer disposition in 3D, ParvathipuramManyamdistrict, Andhra Pradesh.

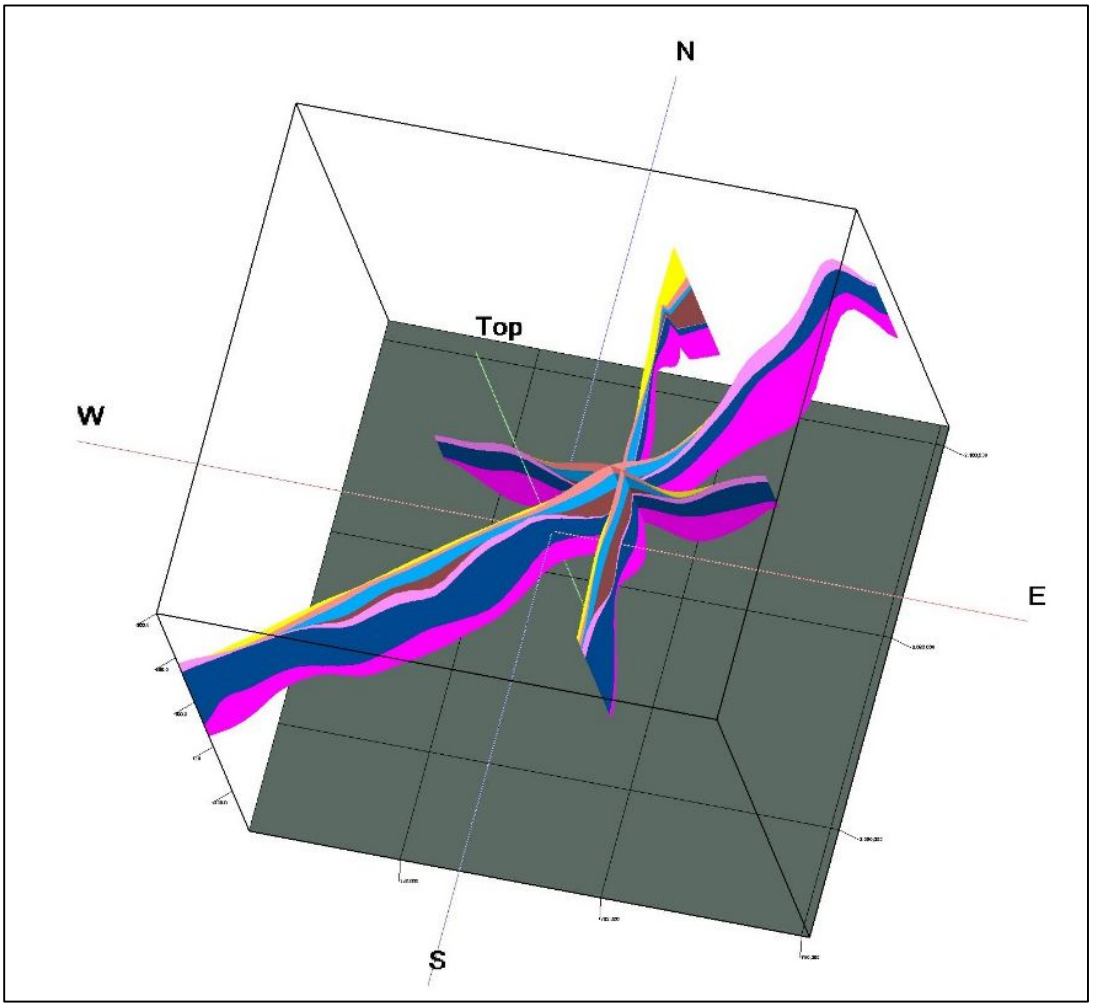


Fig.3.18: Fence Diagram

4.1 Conceptualization of aquifer system in 3D:

Aquifers were characterized in terms of potential and quality based on integrated hydrogeological data and various thematic maps. Weathered zone is considered up to the maximum depth of weathering and first fracture encountered (below weathered depth) generally down to ~21 m depth and the fractured zone (fractured granite) is considered up to the depth of deepest fracture below weathered zone (~21 to 200 m).

4.2 Hydrogeological Sections:

Hydro geological sections are prepared in N-S, NW-SE and SW-NE direction. (**Fig.3.19 & Fig3.20 & Fig 3.21**).

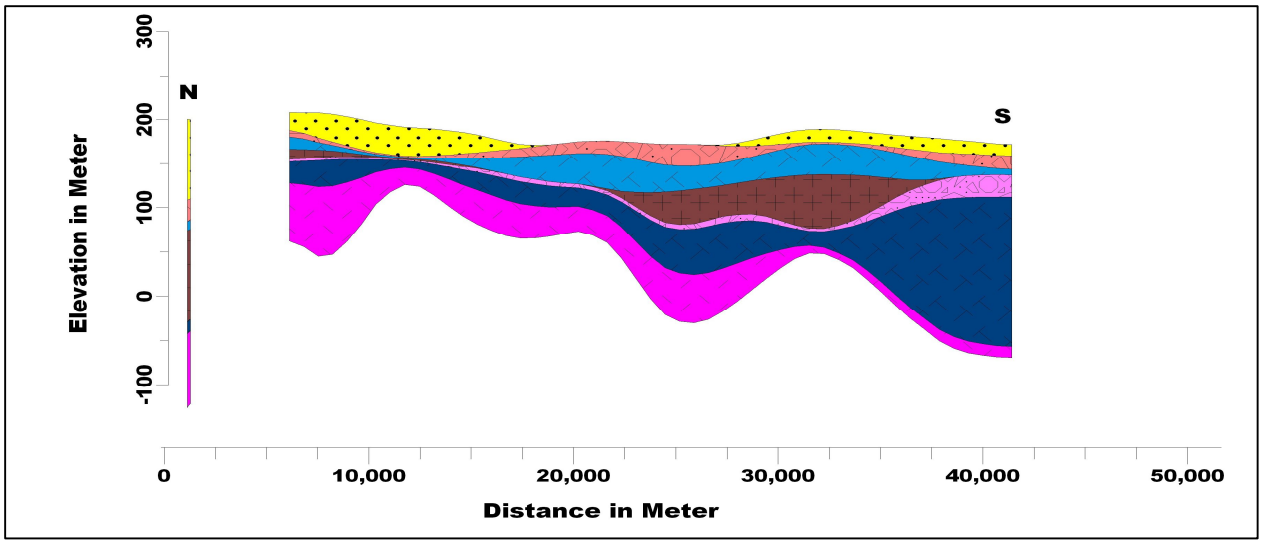


Fig.3.19: Hydrogeological Cross Section (N-S Direction).

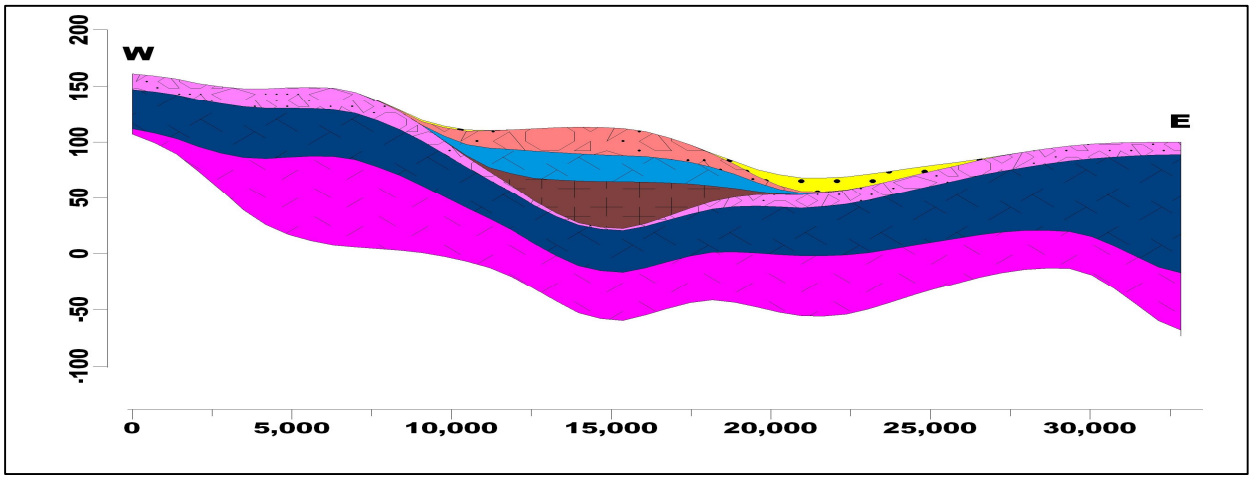


Fig 3.20 Hydro geological Cross Section E to W direction

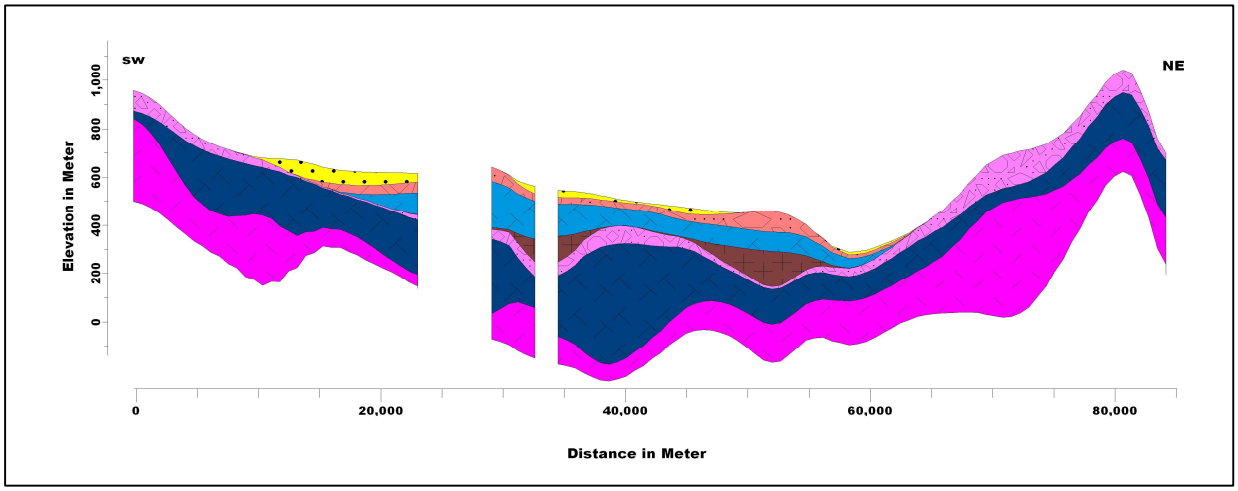


Fig 3.21 Hydro geological Cross section in SW-NE direction

5.0 GROUND WATER RESOURCES (2022)

In hard rocks, the weathered zone and fractured zone are inter-connected with fractures/joints and fractured zone gets recharged through weathered zone. Therefore, it is very difficult to demarcate the boundary between two aquifers; hence the resources are estimated considering entire area as a single aquifer system. Village wise dynamic ground water resources are computed as per the guidelines laid down in GEC methodology. The mandal wise dynamic ground water resources of the Parvathipuram Manyam District, Andhra Pradesh (2022) are given in **Table-4.1and Annexure**

Ground Water Resources - 2022		
Total area of the district	Sq kms	3659
Recharge worthy area	Sq kms	3298
Recharge from Rainfall - Monsoon	MCM	314
Recharge from Other Sources - Monsoon	MCM	375
Recharge from Rainfall - Non-Monsoon	MCM	37
Recharge from Other Sources-Non-Monsoon	MCM	240
Total Annual Ground Water Recharge	MCM	966
Total Natural Discharges	MCM	48
Annual Extractable Ground Water Resource	MCM	917
Irrigation Use	MCM	174
Industrial Use	MCM	0
Domestic Use	MCM	17
Total Extraction	MCM	191
Annual GW Allocation for Domestic Use as on 2025	MCM	31
Net Ground Water Availability for future use	MCM	730
Stage of Ground Water Extraction	(%)	22
Categorization	(OE/C/SC/Safe)	Safe

As per 2022 Ground Water Resource Assessment report, the net annual extractable groundwater resources in the district are 917 MCM, gross ground water draft for all uses 191 MCM, provision for domestic utilisation for the year 2025 is 31 MCM and Net Ground Water Availability for future use is 730 MCM. The stage of ground water extraction varies from 2.7 % in Gumma Lakshmipuram to 49% in Salur with an overall SoE of 22%. Based on the stage of ground water development, all mandals in the district are categorized as Safe.

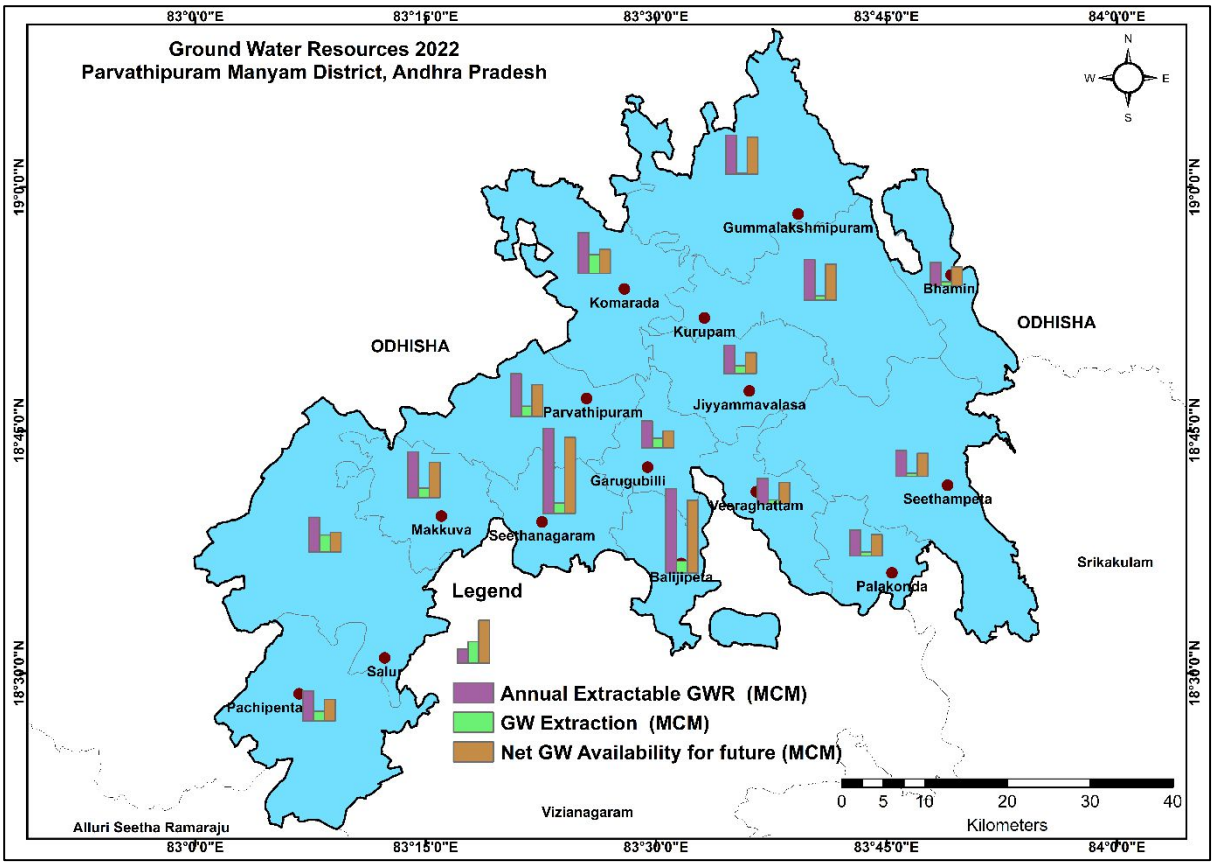


Fig.3.22: Categorization of Mandals (GWRA-2022), Parvathipuram Manyam district.

6.0 Ground Water Issues, Development and Management

6.1 Low Groundwater Yield

Low yield (<3 lps) occurs in ~more than 90% of the district. This is due to hard rock aquifer system in the district. The hard rock aquifers lack primary porosity and ground water yield depends on secondary porosity developed due to weathering or fracturing. The Poor interconnection and discrete nature of fractures and less recharge aquifers of hard rocks are resulting in low yield.

6.2 Ground Water Contamination: High nitrate (> 45 mg/L) due to anthropogenic activities is observed in about 43 samples (55%). This is due to unscientific sewage disposal of sewage and use of NPK fertilizers.

6.3 Ground Water Development:

The Ground Water Assessment – 2022 shows the annual extractable ground water resources is 917 MCM, whereas ground water extraction for all purposes is 191 MCM with stage of ground water extraction of 22%, indicating the scope for further ground water development in the district. Based on criterion of Depth to Water levels (<15 m), Rainfall (>750 mm) and stage of ground water extraction (<60%) and net annual availability of ground water for future use, a judicious enhancement of ground water extraction is recommended in the district by constructing 7437 bore wells in 729 villages in all 15 mandals (that can be taken up under YSR Jala Kala/convergence of schemes) which can bring an additional area of 7928 ha under ground water irrigation in the district. The details of the proposed structures and area that can be irrigated is provided in Table-6.1 and the villages identified is provided in the map fig-3.23.

S.No	Mandal	No. of Villages	No. of Feasible Structures	Area Proposed to be irrigated (Ha)	Total Cost (Lakhs)
1	BALAJIPETA	32	470	597	2154.43
2	BHAMINI	15	436	762	2020.82
3	GARUGUBILLI	26	168	167	764.87
4	GL PURAM	84	758	753	3450.44
5	J VALASA	47	377	376	1714.90
6	KOMARADA	94	955	955	4348.11
7	KURUPAM	79	364	363	1650.92
8	MAKKUVA	45	306	301	1393.14
9	PACHIPENTA	43	1095	1099	4995.39
10	PALAKONDA	31	234	234	1066.36
11	PARVATHIPURAM	37	171	168	776.91
12	SALUR	68	416	458	1894.15
13	SEETHAMPETA	58	258	257	1171.69
14	SEETHANAGARAM	36	311	319	1417.48
15	VEERAGHATTAM	34	1118	1119	5100.51
	Grand Total	**729**	**7437**	**7928**	**33920.12**

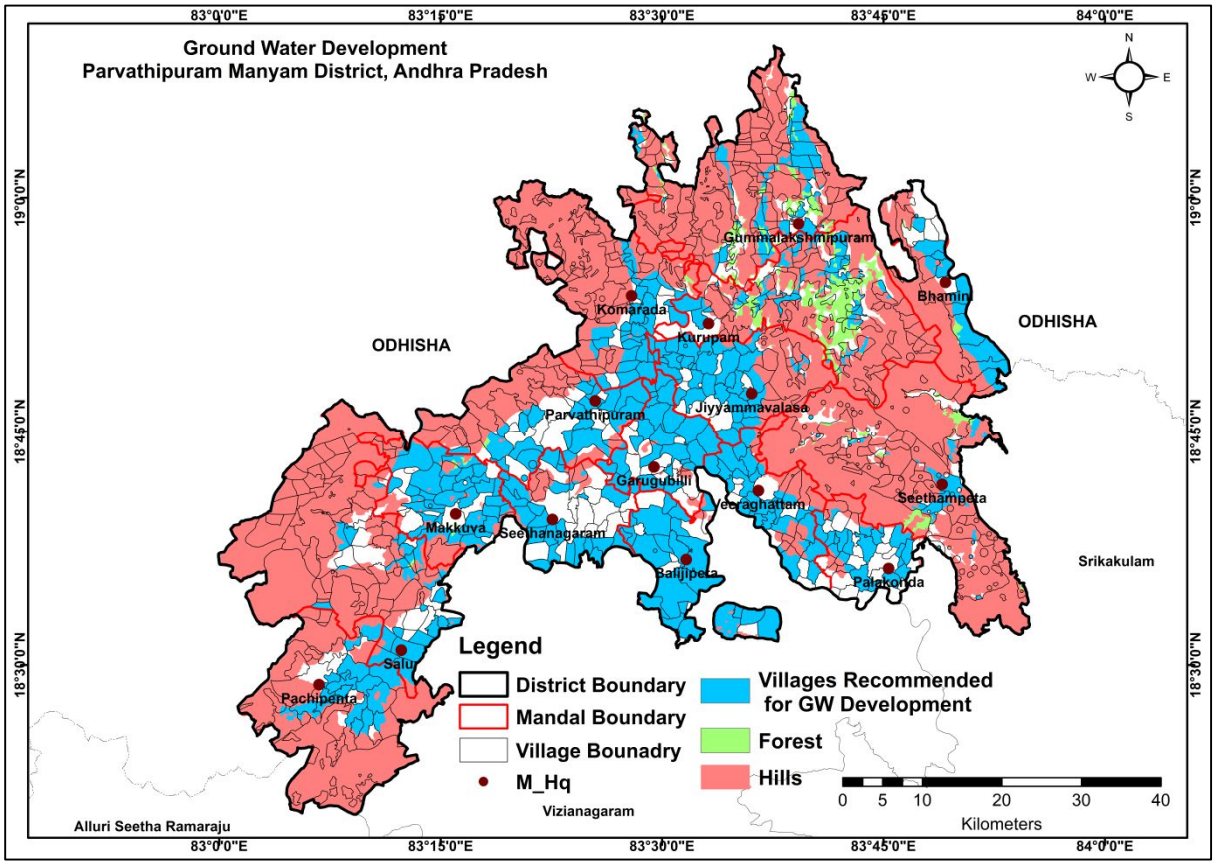


Fig:3.23- Map showing Villages/Mandals identified for Ground Water Development

6.4 Ground Water Management:

The supply side management include artificial recharge of available surplus runoff through construction of check dams and percolation tanks in rural areas and roof top rainwater harvesting in urban areas. More over repair renovation & restoration of existing tanks in rural and urban areas will also help in ground water recharge.

The recharge potential of the aquifers in the district is 2095 MCM and the availability of surplus run off (20% of the monsoon run off) is 98 MCM. The District Water Management Agency (DWMA), Rural Development Department, Govt. of Andhra Pradesh had constructed 2165 artificial recharge structures (269 Percolation Tanks, 163 Mini Percolation Tanks, 1137 Check Dams and 209 Check Walls and others) are constructed under IWMP and MGNREGS (Table 6.2- and Fig - 3.24).

Table- 6.2 Existing Artificial Recharge Structures in the P Manyam District

S. No.	Mandal	Check Dam	Check Wall	Mini PT	PT	Others	Total
1	Bhamini	111	17	3	4		135
2	Garugubilli	3	10				13
3	GL Puram	118	4		8		130
4	J. Valasa	64	11	3	1		79
5	Komarada	52	14	5	1		72
6	Kurupam	33	1	23	18		75
7	Makkuva	23			7		30
8	Pachipenta	52	10	30	82		174
9	Palakonda	68	6	16	1		91
10	Parvathipuram	123	18		3		144
11	Salur	74	11	9	38		132
12	Seethampeta	304	39	65	91		499
13	Seethanagaram	34	10	1	4		49
14	Veeraghattam	78	58	8	11		155
	Total	**1137**	**209**	**163**	**269**	**387**	**2165**

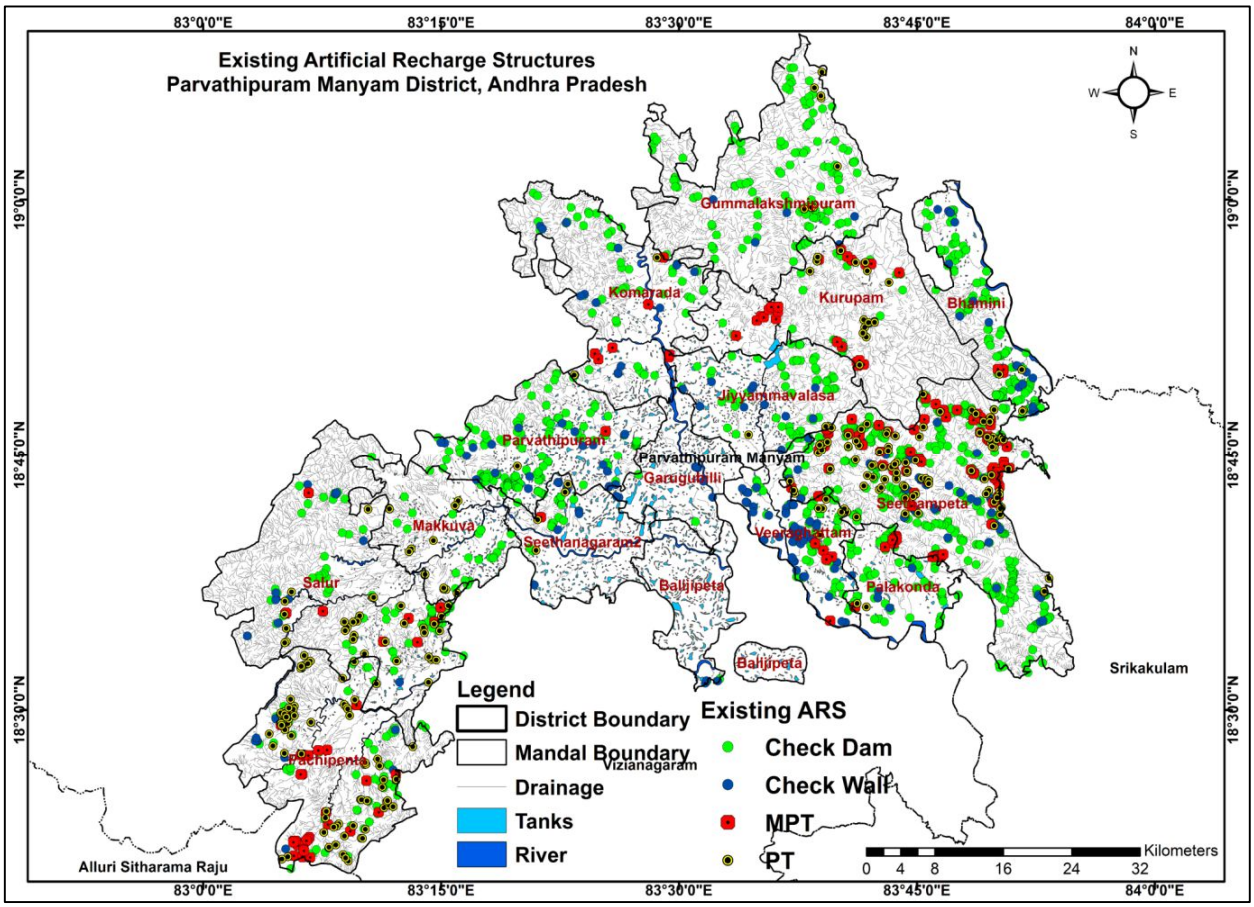


Fig-3.24 Existing Artificial Recharge Structures in P Manyam District

The existing storage created through existing ARS is 62.23 MCM. In addition to the existing structures, it is recommended to construct 336 additional artificial recharge structures in the district (Table- 6.3). Further, it is recommended that the existing check dams and percolation

tanks may be de-silted involving people's participation through the Mahatma Gandhi National Rural Employment Guarantee Scheme. This will also help in sustainable management of ground water resources. In addition, it is recommended for desiltaion of existing MI tanks and cascading of tanks. This can result in increase in Ayacut/Irrigation area, sustain the bore well yields and decrease the ground water irrigation.

Table-6.3 Proposed ARS in P Manyam District

S.No.	Village Type	No. of Villages	Surplus Monsoon Run Off (MCM)	No. of ARS Feasible	No. of Existing ARS	No. of Proposed ARS
1	Hamlets	395	3.75	21	798	12
2	Hilly and Forest	18	23.71	54	33	43
3	Villages other than hilly and Hamlets	693	71.37	472	1334	280
	Grand Total	**1106**	**98.84**	**547**	**2165**	**336**

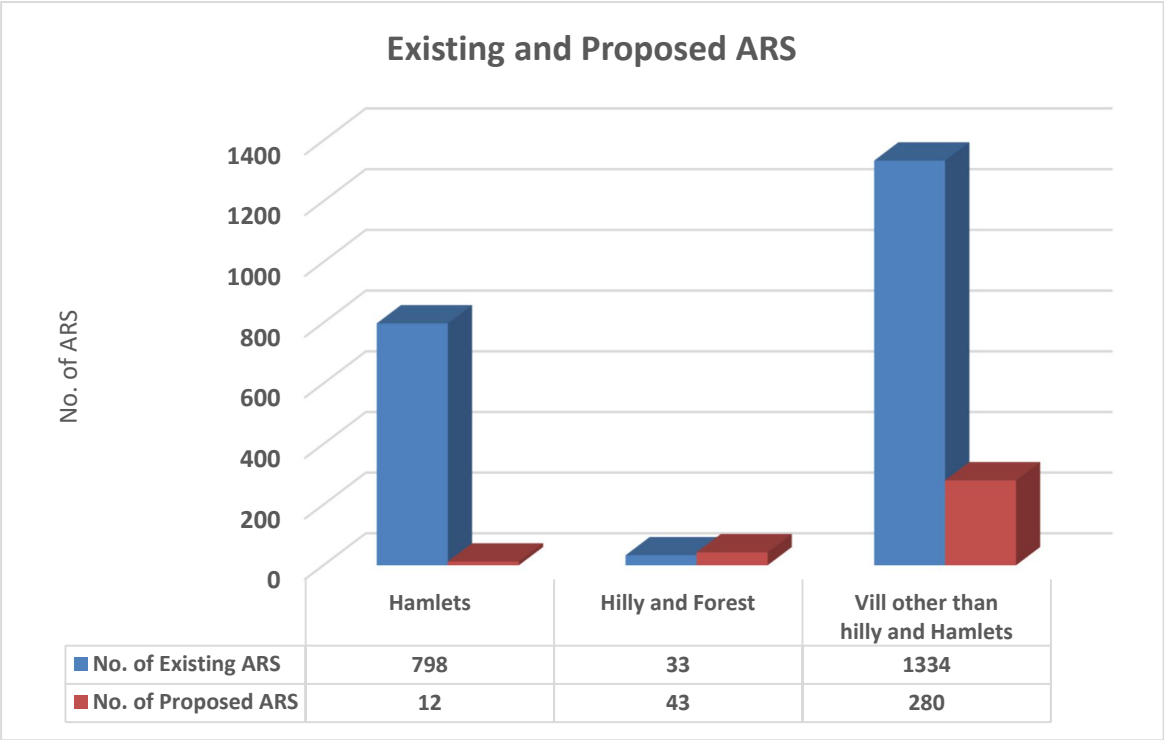


Fig-3.25: Graphical representation of existing and Proposed ARS

As demand side measurement, Micro Irrigation is recommended 17325 ha @25 ha per village in 693 villages. Roof top rainwater harvesting in Government buildings, proper waste water management, participatory groundwater management (PGWM), lining of sewerage to arrest leaching of nitrate and effective implementation of the existing 'Water, Land and Trees Act' of 2002 (WALTA-2002) are other recommended measures in the district.

Acknowledgment

The author expresses sincere gratitude to Sri. Md. Sarif Khan, Sc-C, Sri. L. N. Damodara, Scientist- 'C', Dr. D. Anantha Rao, AHG and Mrs. Nilima Patra, AHG, Executive Engineer and his drilling crew of CGWB for their support. The author acknowledges State Ground Water Department, Govt. of Andhra Pradesh and Department of Rural Development, Govt. of Andhra Pradesh for making field data available in the portals for bringing this report in the present form and shape.

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