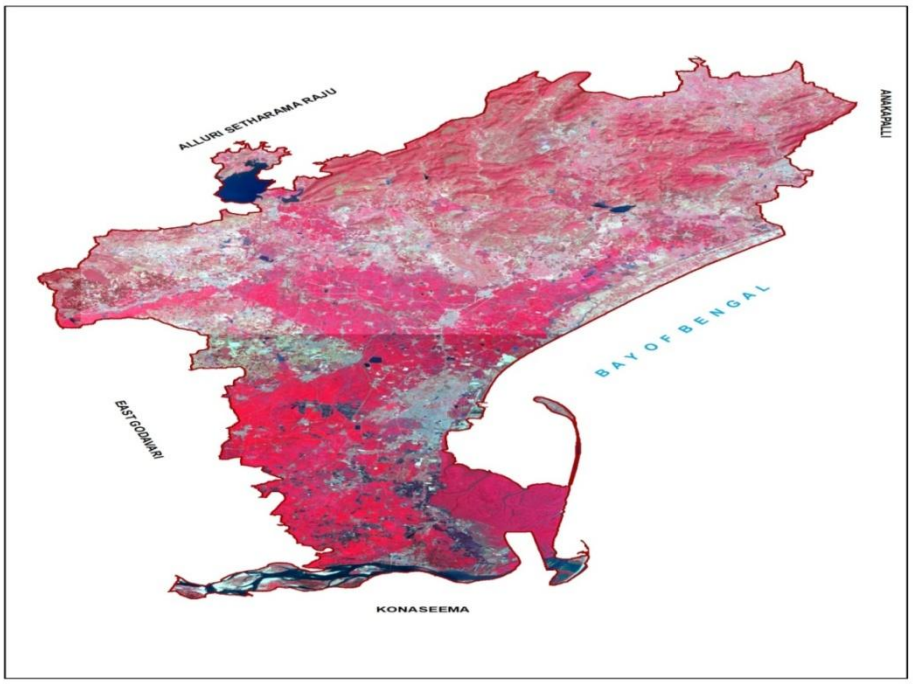
DISTRICT SURVEY REPORT
FOR SAND AND OTHER MINOR MINERALS
KAKINADA DISTRICT

(FOR THE DEPARTMENT OF MINES AND GEOLOGY, GOVT. OF AP)

As per Notification No. S.O. 141 (E), 15.01.2016, S.O. 3611(E), 25.07.2018, & Enforcement and Monitoring Guidelines for Sand Mining 2020 of MOEF&CC, GoI



Prepared by

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Submitted to

DEPARTMENT OF MINES AND GEOLOGY
Government of Andhra Pradesh

December 2023

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PREFACE

The Natural resource inventory is the assessment of the status of a given natural resource of an area at a given point in time. Population pressure results in over- exploitation of resources. The baseline information on the resources would help the administration for better planning and decision making. The main purpose of the report is to disseminate data on the natural resource up to the lowest administrative functionary to facilitate micro level planning and development. The efforts have been made to assess and document the information on land use land cover, crop, surface water resource, soils, slope, groundwater prospects, groundwater quality, geological information, and minerals resources in Kakinada District, Andhra Pradesh, based on the satellite remote sensing data and socioeconomic information.

The Department of Mines and Geology (DMG), Government of Andhra Pradesh (AP) requested the Andhra Pradesh Space Applications Center (APSAC) to update the district survey reports with availability of sand mineral information, major and minor mineral details, and river morphology for all the districts in the State. The District Survey report emphasizes and updated the major and minor minerals in the districts of AP. The District Survey reports are updated following the "Sustainable Sand Mining guidelines" issued in 2016 and 2020 and SO 741 of 2016 of the Ministry of Environment, Forests and Climate Change provided by the DMG. The comments received from the public, if found fit, shall be incorporated in the report. A list of leases in the district will be provided by the concerned Assistant Directors of Mines and Geology.

The report is an outcome of the efforts of the Scientists and Project Associates at APSAC. I heartily congratulate the team for compiling the report.

(Dr. Sundar Balakrishna, IFS)
Vice-Chairman
APSAC

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Our sincere gratitude to **Sri Gopal Krishna Dwivedi, IAS**, **Principal Secretary,** Department of Mines and Geology, Govt. of Andhra Pradesh for whole-hearted support.

Our sincere gratitude to **Sri Kona Sasidhar, IAS**, **Secretary to Government,** Information Technology, Electronics and Communications (ITE&C), Govt. of Andhra Pradesh and the **Chairman,** APSAC Governing Body, for his constant encouragement.

We would like to express our sincere gratitude to **Dr. Sundar Balakrishna, IFS**, **Special Secretary to Government,** Information Technology, Electronics and Communications (ITE&C), Govt. of Andhra Pradesh and the **Vice-Chairman, APSAC** Govt. of Andhra Pradesh, for his meticulous guidance and supervision.

We are grateful to the **Sri. V.G. Venkata Reddy**, **Director**, Department of Mines and Geology, Govt. of Andhra Pradesh for entrusting the work for the preparation of District Survey Reports of Andhra Pradesh.

We owe a great deal to **Sri. P Raja Babu, Joint Director,** Department of Mines and Geology for his overall support and guidance during the execution of this work.

We are very much thankful to **Dr.M.J.Ratnakanth Babu, Royalty Inspector (Head Office**), Mines and Geology for his support to complete the work successfully.

We are also thankful to the **District Mines and Geology Officer,** Kakinada District for their support in providing information

Our sincere thanks are due to the scientific staff of APSAC who has generated all the thematic maps for District Survey Reports.

APSAC

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List of Abbreviations

APSAC	: Andhra Pradesh Space Applications Centre
APMMC	: Andhra Pradesh Minor Mineral Concession
AMSL	: Above Mean Sea Level
AWiFS	: Advanced Wide Field Sensor
APWALTA	: Andhra Pradesh State Water, Land and Trees Authority
APMDC	: Andhra Pradesh Mineral Development Corporation
Bgl	: Below ground level
BT Road	: Bituminous Road
Cl	: Chlorine
CC Road	: Cement concrete
CRZ	: Coastal Regulatory Zone
CPSU	: Central Public Sector Undertaking
CGWB	: Central Ground Water Board
cu.m/day	: Cubic meter per day
DMF	: District Mineral Fund
DSR	: District Survey Report
DMG	: Directorate of Mines and Geology
DM&GO	: District Mines and Geology Officer
DES	: Directorate of Economics and Statistics
DEM	: Digital Elevation Model
DMF	: District Mineral Fund
dS/m	: Decisiemens per meter
EIA/EMP	: Environmental Impact Assessment
F	: Fluorine
FAC	: Full Additional Charge
FASAL	: Forecasting Agricultural output using Space, Agrometeorology and Land-based observations
Fe	: Iron
Ft	: feet
GD	: Geosciences Division
GIS	: Geographical Information System
GSI	: Geological Survey of India
Ha	: Hectare
Km	: Kilometre
IRS	: Indian Remote Sensing Satellite
ITE and C	: Information Technology Electronics and Communications
LISS	: Linear Imaging Self Scanning
LULC	: Land Use / Land Cover

Lps	: Litres per second
M	: meter
Mi	: mile
mm	: millimetre
MT	: Million Tonne
MERIT	: Mineral Exploration Research Innovation
MoEF	: Ministry of Environment and Forests
MSL	: Mean Sea Level
NIRD	: National Institute of Rural Development
NH	: National Highway
$NaNO_3$	: Sodium nitrate
NRSA	: National Remote Sensing Agency
NRSC	: National Remote Sensing Centre
PESA	: Panchayats Extension to Scheduled Areas
pH	: Power of hydrogen
PSD	: Performance Security Deposit
PSU	: Public sector Undertakings
R2	: ResourceSat-2
RGNDWM	: Rajiv Gandhi National Drinking Water Mission
RWS and S	: Rural Water Supply and Sanitation
SAR	: Synthetic Aperture Radar
SEB	: Special Enforcement Bureau
SO_4	: Sulfate
Sq.Km	: Square Kilometre
Sq.m	: Square metre
TA	: Tantalum
TIN	: Triangular Irregular Network
TGA	: Total Geographical Area
TIS	: Tank Information System
TTD	: Tirumala Tirupati Devasthanams
WBM	: Water Bound Macadam

Chapter I – Introduction and General Profile

1.1 Administrative Setup

Kakinada district is one of the coastal districts in the state of Andhra Pradesh established on 4th April 2022 with the administrative headquarter as Kakinada town. Geographically, Kakinada district is bounded to the north by the Anakapalli and Alluri Seetharama Raju districts, south by Dr.Br.Ambedkar Konaseema, west by the East Godavari district and east by the Bay of Bengal. The total geographical area of the district is 3154.53 Sq.km. It is covered with 2 Revenue divisions namely Kakinada and Peddapuram and comprising of 21 Revenue mandals and 437 Revenue villages. Roethulapudi mandal is having maximum number of villages (49) and Kakinada (U) mandals is having minimum number of villages (4). Out of 21 mandals of the district, the maximum area is occupied by Thallarevu mandal (338.36 Sq.km) and minimum area in Kakinada (Urban) mandal (34.93 Sq.km).

The mandals covered in each Revenue division are shown in Table-1 and its spatial distribution is shown in Figure-1. The satellite view of the district is also shown in Figure-2.

Table 1 List of mandals covered in each Revenue division

Kakinada Division	Peddapuram Division
Gollaprolu	Gandepalle
Kajuluru	Jaggampeta
Kakinada (Urban)	Kirlampudi
Kakinada (Rural)	Kotananduru
Karapa	Peddapuram
Kothapalle	Prathipadu
Pedapudi	Rowthulapudi
Pithapuram	Sankhavaram
Samalkota	Thondangi
Thallarevu	Tuni
-----	Yeleswaram

Data Source: APSAC, Vijayawada.

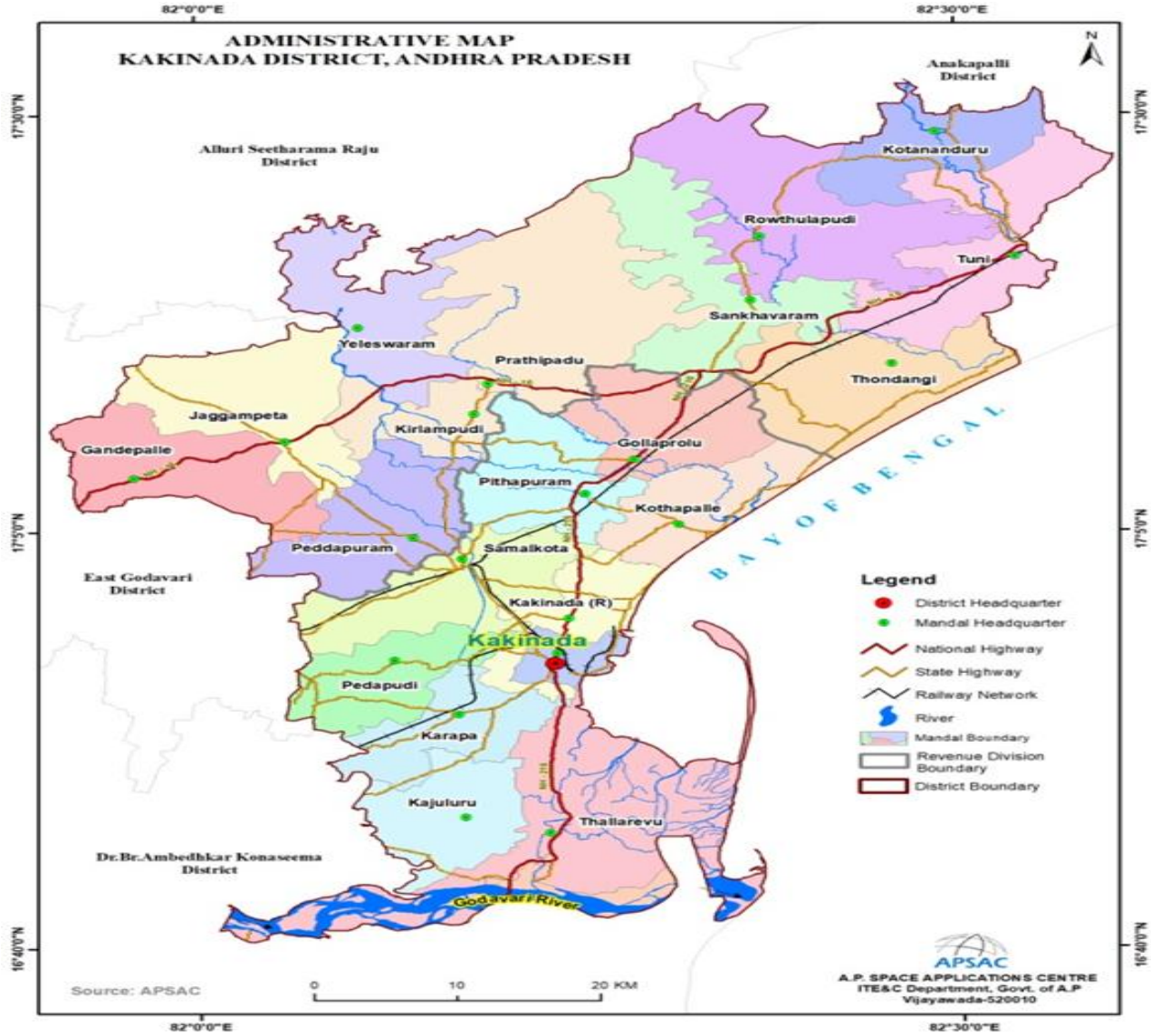

Figure-1: Administrative Map of Kakinada District, Andhra Pradesh

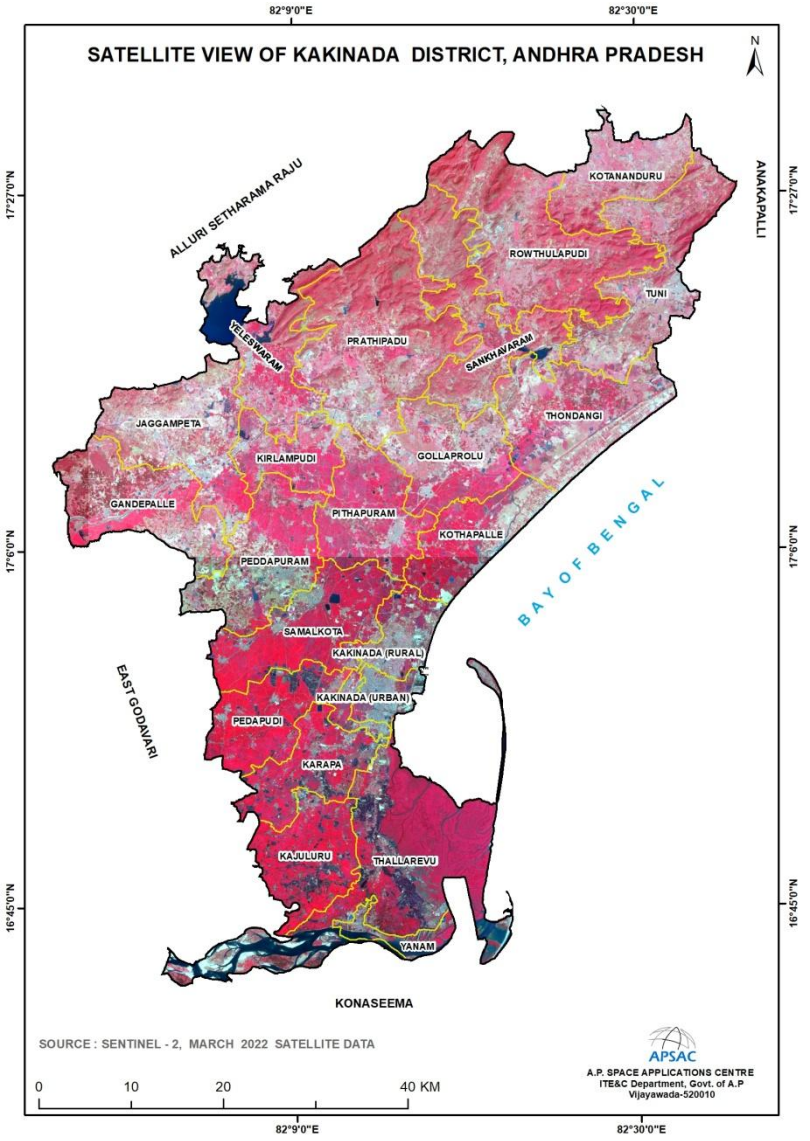

Figure-2: Satellite View of Kakinada District

1.2 Physiography

1.2.1 Physiography

Kakinada district is located on the northeast-east coast of Andhra Pradesh. It is bounded on the north by Anakapalli district and Alluri Sitaramraj district, on the east by the Bay of Bengal, on the west by East Godavari district and on the south by Konaseema.

1.2.2 Relief

The slope distribution clearly shows that the district terrain varies from hills to deltaic plains Figure-3. The slope map shows that the majority of the district land is nearly level, followed by very gently sloping areas. They account for 57.40% and 20.85% of the district's total area, respectively. These sloping areas are found along the coastal plains, southern and eastern parts of the district. The gently sloping areas (3-5%) are found along the streams and the northern parts of the district, which accounts 7.04% of the district geographical area. Moderately sloping (5-10%) accounted 2.76% of the district land. Most of the gently sloping and moderately sloping areas are distributed along the foothill zones and forest fringes. The remaining slope classes, which include those that are strongly, moderately steep to steep, and very steeply sloping are contribute 4.60%%, 4.03%%, and 3.32%, respectively. Strongly sloping areas are found in the forest areas ranging from 10-15%. Moderate and Very steep slopes are observed at the peak of the hills and are concentrated more in the forest areas ranging from 15-35% and more than 35%. These are found in the north, north-eastern, and parts northwest parts of the district.

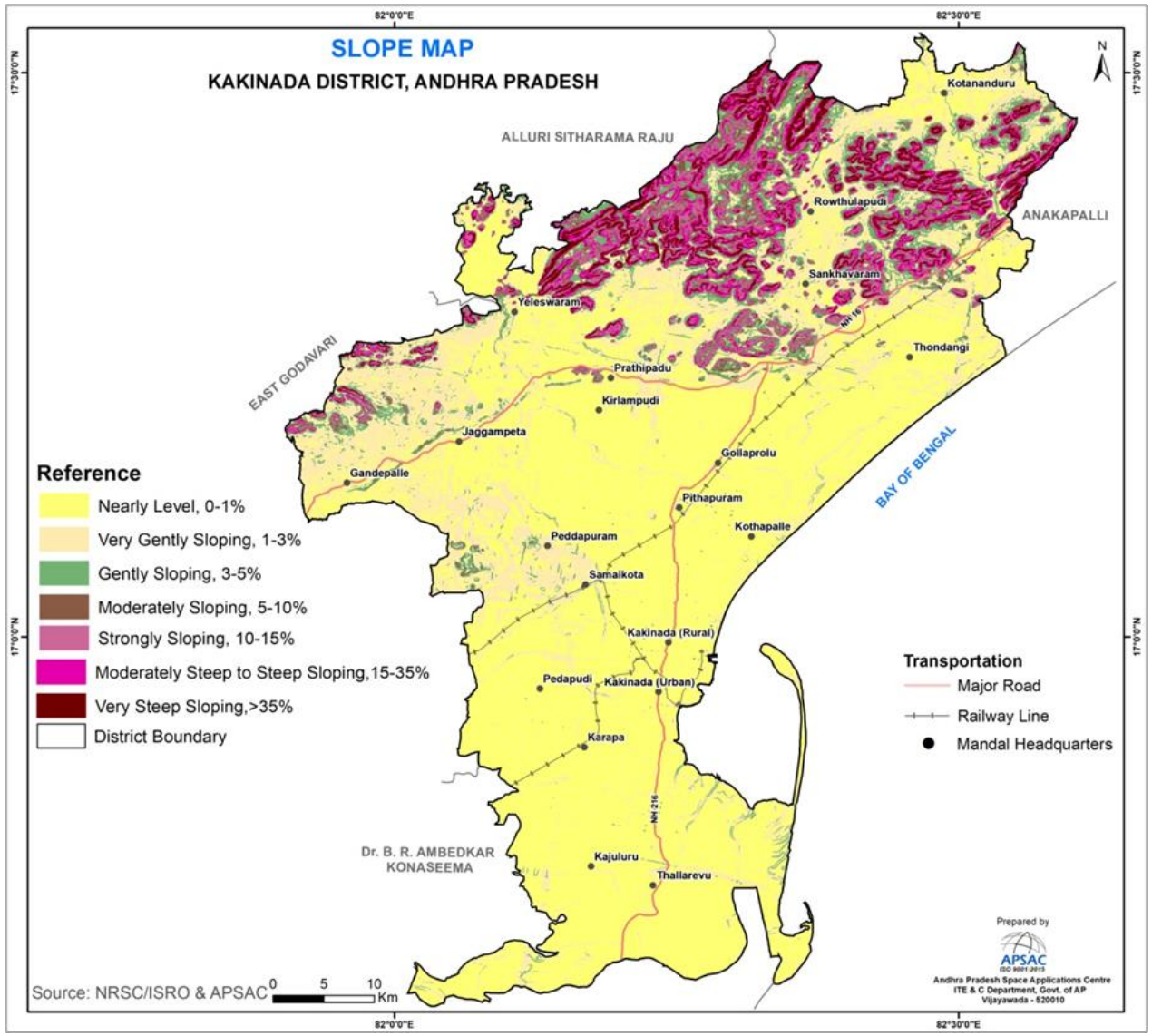

Figure-3: Slope Map of Kakinada District

1.2.3 Climate & Rainfall

1.2.3.1. Climate:

The Climate is comparatively moderate throughout the year except during the months of April to June when the temperature reaches a maximum of 48° C. The minimum and maximum temperatures recorded in the district are 20.3°C in the months of January and 35.6°C in May respectively. The average rainfall for the last 25 years data used for the analysis. The locations of Automatic Weather Stations (AWS) in Kakinada District are shown in Figure -4.

1.2.3.2. Rainfall:

The average annual rainfall of the district is 1047.78mm, of which 658.61 mm falls as South-West (June-September) and 268.89 mm as North-East (October-December) monsoon. The minimum and maximum temperatures recorded in the district are 20.3°C in January and 35.6°C in May, respectively. The average rainfall for the last 25 years is used for the analysis. The average annual rainfall is shown in Fig.5 and details are given in Table-2.

Table 2 Average Annual Rainfall (mm) in the district, during the year 1998-2021

S.No	Month	Average Annual Rainfall (mm)
1	January	4.37
2	February	10.11
3	March	9.95
4	April	24.31
5	May	71.53
6	June	130.70
7	July	175.68
8	August	166.23
9	September	186.01
10	October	175.02
11	November	80.18
12	December	13.69
	Total	**1047.78**

Data source: AWS & APSDPS, Vijayawada

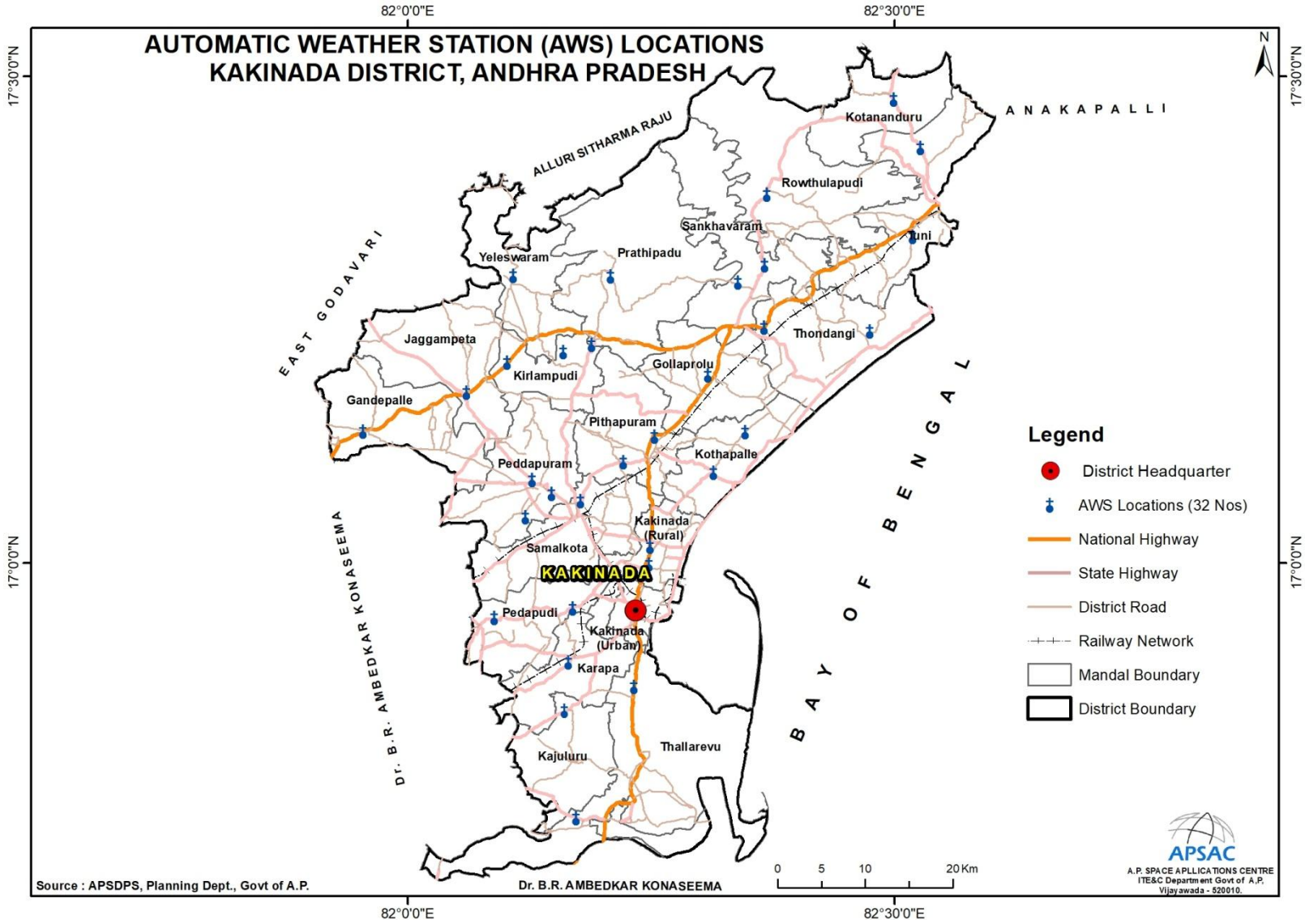

Figure-4: Locations of Automatic Weather Stations (AWS) in Kakinada District

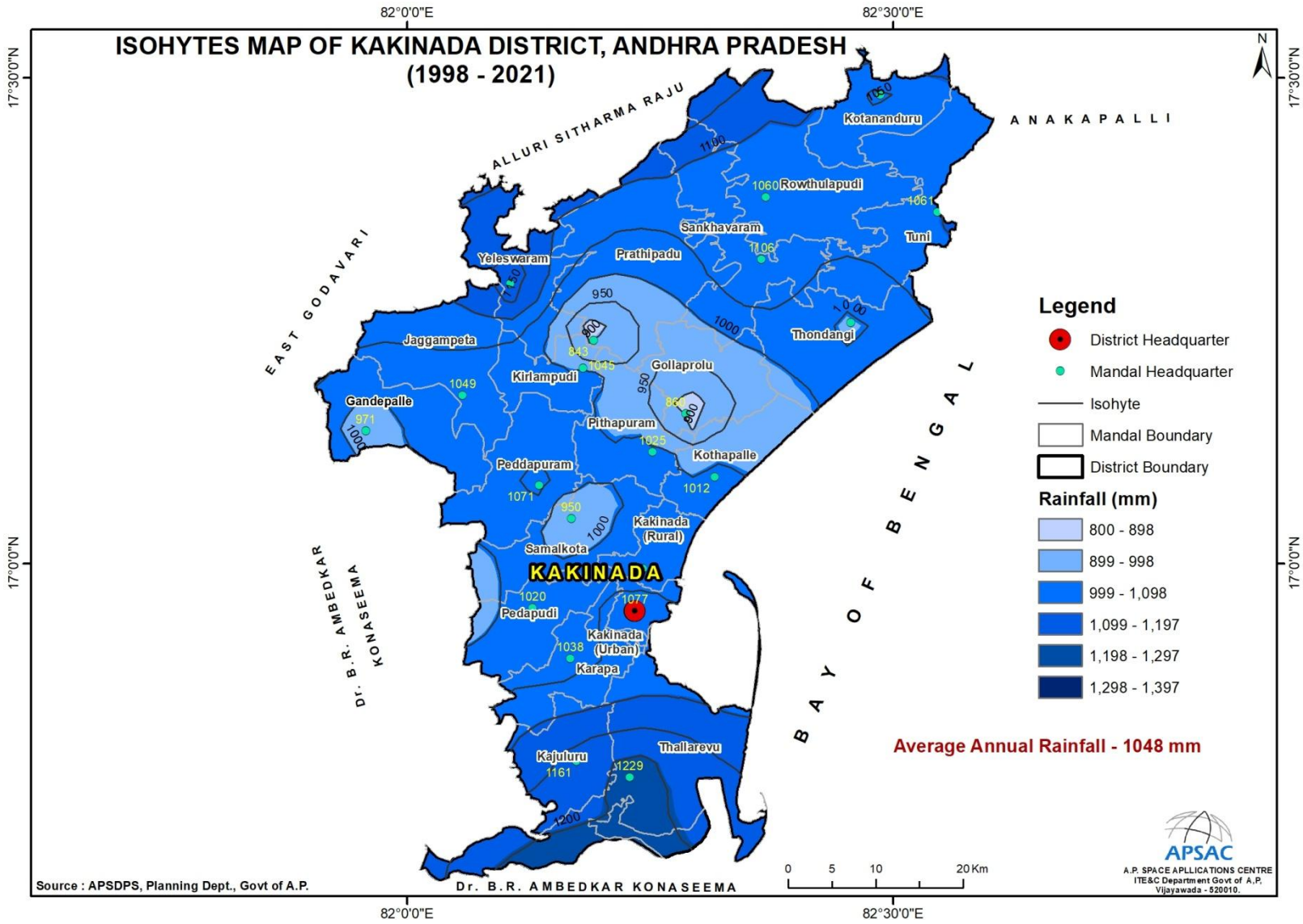

Figure-5: Rainfall distribution in Kakinada District

1.2.4 Drainage

The principal rivers flowing in the district are Godavari, Yeleru, Pampa, Thandava and Suddagedda. The Godavari river rises near Trimbakeshwar in the Nashik district of Maharashtra about 80 km from the Arabian Sea at an elevation of 1,067 m and The total length of Godavari from its origin to outfall into the Bay of Bengal is 1,465 km. It enters into the district near Pillanka village in Thallarevu mandal and flows towards south direction. The Godavari river bifurcates into Gautami Godavari and Vasishta Godavari rivers at Dawleswaram. The Gautami Godavari river flows towards south direction and joining into Bay of Bengal at Bhairavapalem, Tallarevu mandal in Kakinada district. The Yeleru River rises near Puttakota RF, Koyyeru mandal in Alluri Sitharama Raju disatrict and flows towards south direction and joining to the Bay of Bengal in Kakinada district. The Suddagedda River rises near Vatangi RF, Rajavommangi mandal in Alluri Sitharama Raju district and flows towards south east direction and joining to the Bay of Bengal near Kothapalle mandal, Kakinada district. The Pampa river rises near Lododdi RF, Rajavommangi mandal in Alluri Sitharama Raju district and flows towards south east direction and joining to the Bay of Bengal near Payakaraopeta mandal in Anakapalli district. The Thandava River rises near Bointi RF, G K Veedhi mandal in Alluri Sitharama Raju district and flows towards south direction and joining to the Bay of Bengal near Pentakota village, Payakaraopeta mandal in Anakapalli district. Four major drains are covered in the District; they are Tulyabhaga drain, Teki drain, Vajra Kaluva and Bikkavolu**.**

1.3 Population and Literacy

1.3.1. Population:

The total population of the district is 20,92,374 (2011 census); of which male and female are 10,42,307 and 10,50,067 respectively. Among all mandals, Kakinada (Urban) Mandal is having maximum population of 3,12,538; whereas Kotananduru Mandal is having minimum population of 48,512.

The total schedule caste (SC) population of the district is 3,31,103; of which male and female are 1,62,897 and 1,68,206 respectively. The schedule tribe (ST) population is 30,803; of which male and female are 15,174 and 15,629 respectively. The mandal wise population is shown in the Table – 3 and its spatial distribution is depicted in the Figure-6.

1.3.2. Literacy:

The total literates in the district are 12,61,867; of which male and female are 6,57,086 and 6,04,781 respectively. The total illiterates are 8,30,507; of which male and female are 3,85,221 and 4,45,286 respectively.

1.3.3. Details of the Occupational Health issues in the District (Last five-year data of number of patients of Silicosis): No cases were reported during last 5 years due to mining activity.

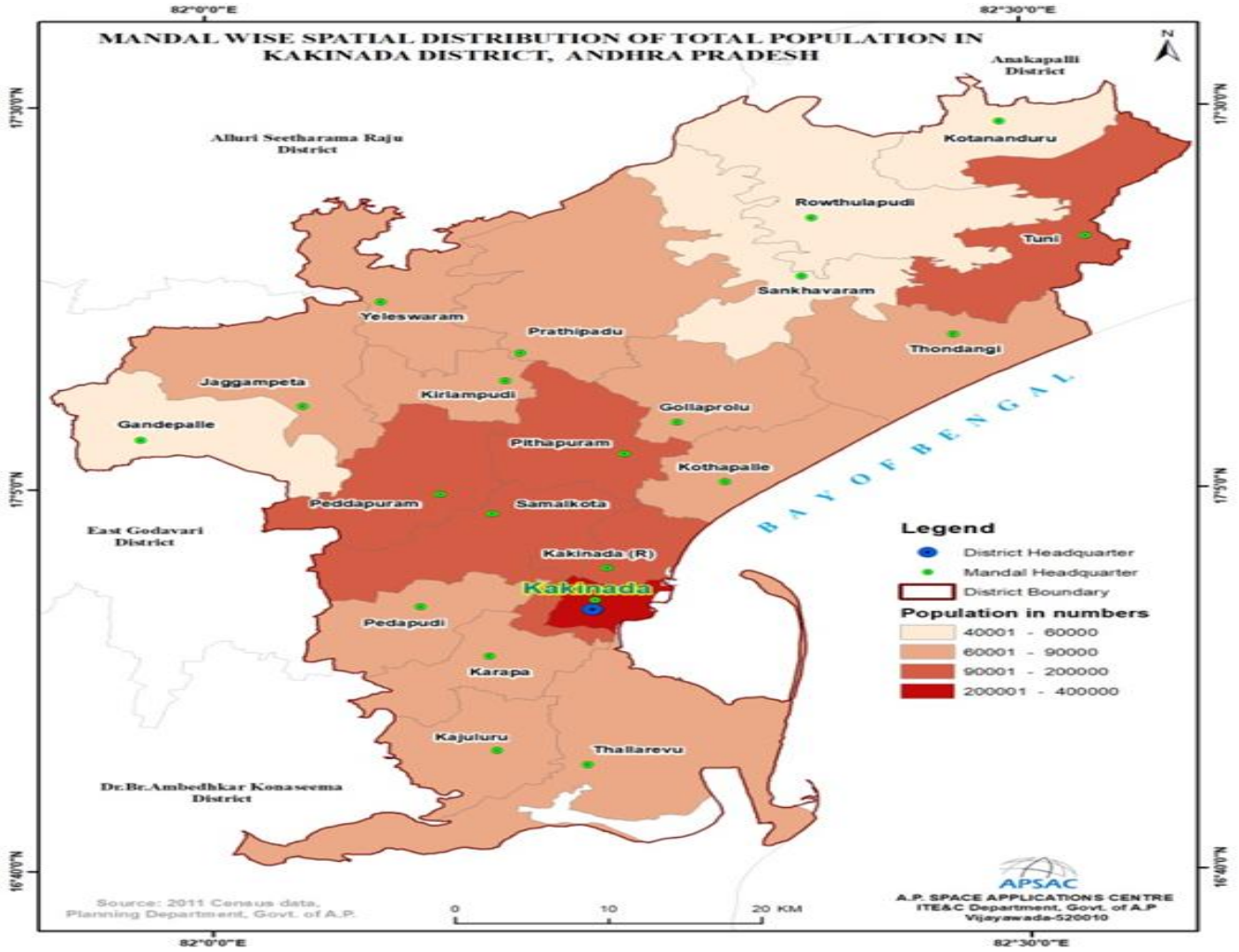

Figure-6: Mandal wise Spatial Distribution of Population in Kakinada district, AP

Table 3 Mandal wise Population Statistics

S.No	Mandal Name	No.of House Holds	Total Population	Male Population	Female Population	Total SC Population	Male SC Population	Female SC Population	Total ST Population	Male ST Population	Female ST Population
1	Gandepalle	15933	54278	27075	27203	10168	5040	5128	470	219	251
2	Gollaprolu	22008	78926	39773	39153	12752	6289	6463	179	98	81
3	Jaggampeta	22181	79640	39422	40218	11324	5392	5932	1383	687	696
4	Kajuluru	19985	70903	35825	35078	15812	7973	7839	590	294	296
5	Kakinada (Urban)	82333	312538	152571	159967	27197	12650	14547	1693	895	798
6	Kakinada (Rural)	46322	174129	87018	87111	19207	9335	9872	1170	576	594
7	Karapa	21905	76398	38460	37938	11755	5886	5869	374	189	185
8	Kirlampudi	20133	74379	37255	37124	10380	5121	5259	223	107	116
9	Kotananduru	13197	48512	24096	24416	10967	5489	5478	699	394	305
10	Kothapalle1	23575	82788	41466	41322	13544	6798	6746	189	91	98
11	Pedapudi	21176	71459	35883	35576	11459	5694	5765	351	167	184
12	Peddapuram	35101	123399	61713	61686	18022	8915	9107	788	394	394
13	Pithapuram	36276	129282	64906	64376	25408	12578	12830	683	340	343
14	Prathipadu1	21571	79076	39501	39575	15491	7660	7831	4406	2117	2289
15	Rowthulapudi	14728	55236	28050	27186	9255	4933	4322	4616	2341	2275
16	Samalkota	38889	137979	68663	69316	26657	13190	13467	1184	628	556
17	Sankhavaram	15593	57017	28575	28442	9418	4745	4673	5474	2744	2730
18	Thallarevu	22375	82799	41438	41361	17303	8553	8750	487	229	258
19	Thondangi	23667	87592	44412	43180	15743	7959	7784	147	72	75
20	Tuni	36769	138079	67734	70345	22177	10484	11693	1495	585	910
21	Yeleswaram	20242	77965	38471	39494	17064	8213	8851	4202	2007	2195
Grand Total		**573959**	**2092374**	**1042307**	**1050067**	**331103**	**162897**	**168206**	**30803**	**15174**	**15629**

Data Source: 2011 Census data, Planning Department & DES.

Table 4 Mandal wise Literacy statistics summary

S.No	Mandal Name	Total Literates	Male Literates	Female Literates	Total Illiterates	Male Illiterates	Female Illiterates
1	Gandepalle	29063	14859	14204	25215	12216	12999
2	Gollaprolu	43580	23209	20371	35346	16564	18782
3	Jaggampeta	40387	20405	19982	39253	19017	20236
4	Kajuluru	43890	23125	20765	27013	12700	14313
5	Kakinada (Urban)	228034	115949	112085	84504	36622	47882
6	Kakinada (Rural)	122399	63546	58853	51730	23472	28258
7	Karapa	46748	24456	22292	29650	14004	15646
8	Kirlampudi	40633	20781	19852	33746	16474	17272
9	Kotananduru	23626	13329	10297	24886	10767	14119
10	Kothapalle1	44371	23301	21070	38417	18165	20252
11	Pedapudi	45522	23619	21903	25937	12264	13673
12	Peddapuram	75019	38453	36566	48380	23260	25120
13	Pithapuram	78955	41076	37879	50327	23830	26497
14	Prathipadu1	39938	20606	19332	39138	18895	20243
15	Rowthulapudi	25063	14080	10983	30173	13970	16203
16	Samalkota	85916	44564	41352	52063	24099	27964
17	Sankhavaram	30365	16206	14159	26652	12369	14283
18	Thallarevu	52008	27401	24607	30791	14037	16754
19	Thondangi	43322	23840	19482	44270	20572	23698
20	Tuni	79525	41807	37718	58554	25927	32627
21	Yeleswaram	43503	22474	21029	34462	15997	18465
Grand Total		**1261867**	**657086**	**604781**	**830507**	**385221**	**445286**

Data Source: 2011 Census data, Planning Department & DES

1.4 Land Utilization Pattern

1.4.1 Land Use / Land Cover

The Land Use / Land Cover (LULC) pattern of any region is an outcome of various physical and cultural factors and their utilization by man in time and space. Land use refers to the type of utilization to which man has put the land. It also refers to the evaluation of the land with respect to various natural characteristics. But land cover describes the vegetal attributes of the land. Land use/land cover data is essential for planners, decision-makers, and those concerned with land resource management. For the proper understanding of the influence of the various human-induced land-use practices with regard to environmental change, it is essential to help simulate the land-use changes. Remote sensing technology is considered the most effective as it provides timely and authentic information about the spatial distribution of land use/land cover, while Geographical Information System (GIS) provides a flexible digital environment for collecting, storing, visualizing, and analyzing the spatial data. Remote sensing as a vital tool helps for rapid assessment and monitoring of a natural resource. When combined with GIS, it makes it possible to map land use/ land cover phenomena in detail for further planning, development, and decision-making, which is essential for meeting the increasing demands and welfare of the ever-growing population.

1.4.2 Spatial Distribution of Land Use / Land Cover

The major common LULC categories, including built-up (202.55 sq km), agriculture (2012.48 sq km), forest (448.12 sq km), wastelands (122.04 sq km), wetlands (16.34 sq km), and water bodies (217.46 sq km), were identified and delineated using on-screen interpretation techniques. The study area has been divided into 37 LULC classes at the level III classification (NRSA, 2006). Agriculture land is the most prevalent, followed by forest land. About 67% of the district's total land area is under agricultural land. The spatial distribution of land use / land cover map of the Kakinada district is presented in Figure-7 and the area statistics are shown in Table-5.

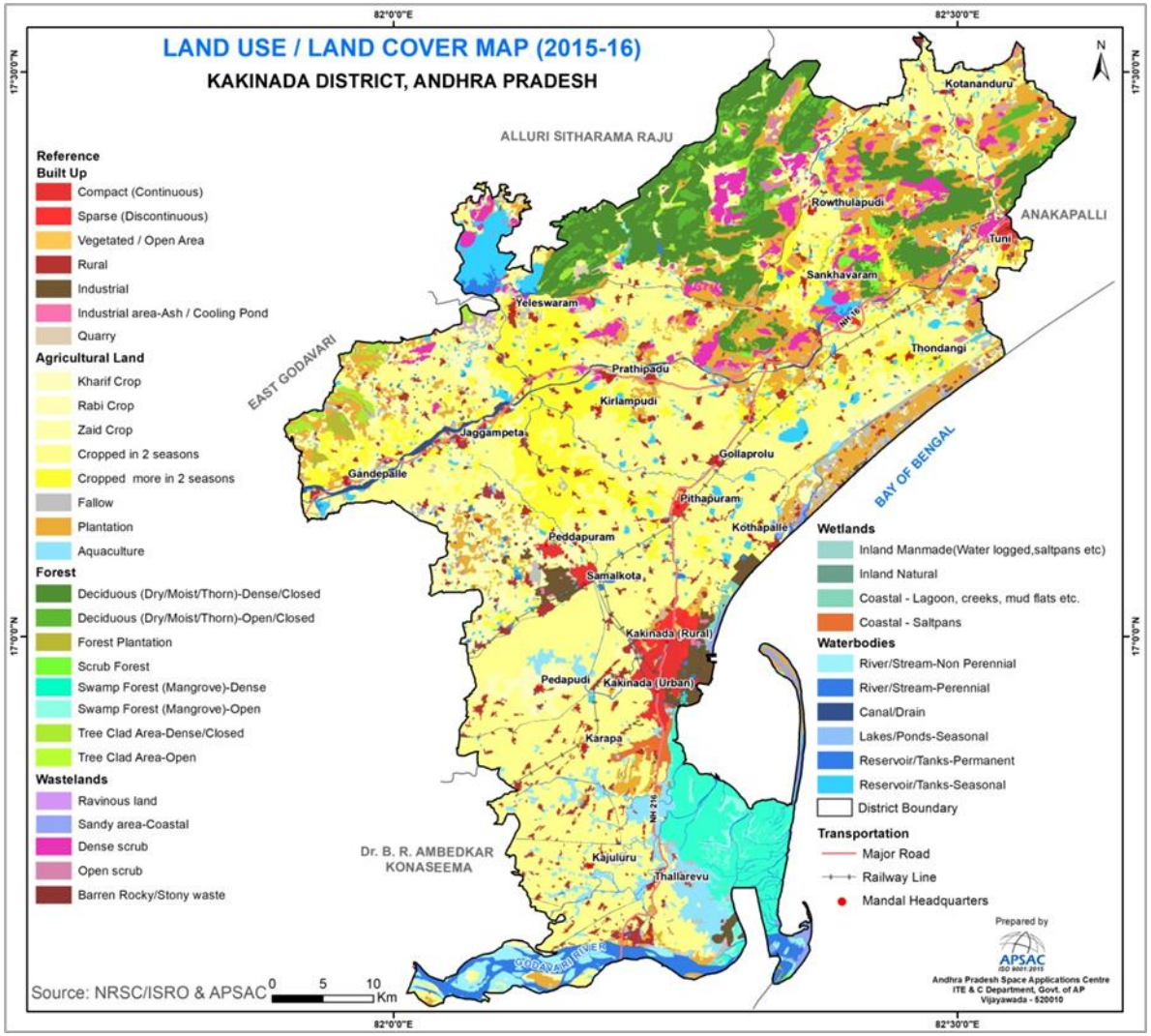

Figure-7: Land use / land cover map of Kakinada District 2015-16

Table 5 Category-wise distributions of Land Use/Land Cover during 2015-16

S. No	LULC categories	Area in sq. km	% to total
Built up		**202.55**	**6.71**
1	Compact (Continuous)	40.81	1.35
2	Sparse (Discontinuous)	7.53	0.25
3	Vegetated / Open Area	2.13	0.07
4	Rural	109.06	3.61
5	Industrial	35.99	1.19
6	Industrial area-Ash / Cooling Pond	1.17	0.04
7	Quarry	5.86	0.19
Agricultural Land		**2012.48**	**66.66**
8	Kharif Crop	195.62	6.48
9	Rabi Crop	21.97	0.73
10	Zaid Crop	1.74	0.06
11	Cropped in 2 seasons	1119.52	37.08
12	Cropped more in 2 seasons	240.71	7.97
13	Fallow	54.80	1.82
14	Plantation	312.23	10.34
15	Aquaculture	65.89	2.18
Forest		**448.12**	**14.84**
15	Deciduous (Dry/Moist/Thorn)-Dense	228.95	7.58
16	Deciduous (Dry/Moist/Thorn)-Open	49.91	1.65
17	Forest Plantation	19.67	0.65
18	Scrub Forest	9.81	0.32
19	Swamp Forest (Mangrove)-Dense	96.13	3.18
20	Swamp Forest (Mangrove)-Open	15.28	0.51
21	Tree Clad Area-Dense	25.35	0.84
22	Tree Clad Area-Open	3.03	0.10
Wastelands		**122.04**	**4.04**
23	Ravinous land	2.38	0.08
24	Dense scrub	87.55	2.90
25	Open scrub	15.51	0.51
26	Coastal Sand	16.04	0.53
27	Barren Rocky/Stony waste	0.55	0.02
Wetlands		**16.34**	**0.54**
28	Inland Natural	0.15	0.01
29	Inland Manmade (Water logged, saltpans etc.)	0.93	0.03
30	Coastal - Lagoon, creeks, mud flats etc.	6.05	0.20
31	Coastal - Saltpans	9.22	0.31
Water bodies		**217.46**	**7.20**
32	River/Stream-Perennial	71.90	2.38
33	River/Stream-Non Perennial	24.36	0.81
34	Canal/Drain	23.50	0.78

35	Lakes/Ponds-Seasonal	0.01	0.00
36	Reservoir/Tanks-Permanent	17.44	0.58
37	Reservoir/Tanks-Seasonal	80.25	2.66
Total		**3019.00**	**100.00**

Data source: NR Census 3rd cycle mapping, NRSC/ISRO & APSAC, GoAP

1.4.2.1. Built-up

These are the areas where people live, and they are supported by infrastructure such as buildings, roads, and other modes of transportation, as well as utilities linked to water, vegetation, and open spaces. It consists of built-up (Compact and Sparse), Vegetated / Open Area, Rural, Industrial, and Mining/Quarry. It occupies an area of 202.55 sq. km, which is about 6.71% of the total geographical area of the district. The built-up category includes district headquarters, some mandal headquarters, industrial areas, and rural settlement areas based on size and population. Many vacant lands with layouts and fencing are being developed for real estate development on the outskirts of the Kakinada, Samalkota, Pithapuram, Prathipadu, Jaggampeta, and Tuni towns.

1.4.2.2. Built-up - Compact (Continuous)

Most of the land is covered by buildings, roads, and artificially surfaced areas and covers almost all the ground. The built-up-compact class is assigned where the impermeable surfaces such as the transportation network and urban structures take up more than 80% of the surface area. This category occupied 40.81 sq. km, which is found in Kakinada, Samalkota, Pithapuram, Prathipadu, Jaggampeta, and Tuni towns.

1.4.2.3. Built-up - Sparse (Discontinuous)

The majority of the land is covered by structures such as buildings, roads, and artificially surfaced areas that are associated with vegetated areas and bare soil, occupying discontinuous but significant surfaces. Between 30 to 80 % of the total surface should be impermeable. This category delineates scattered blocks of residential flats, hamlets, and small villages. It covers an area of 7.53 sq. km and is located in fringe areas of Kakinada, Samalkota, Pithapuram, Prathipadu, Jaggampeta, and Tuni.

1.4.2.4. Vegetated / Open Area

These are vegetated areas within an urban agglomeration (areas located within or adjacent to urban areas). The vegetation cover of trees, shrubs, and herbs has been delineated and covers the surface area. Open areas used as parks, sports, and leisure facilities, camping grounds, sports grounds, leisure parks, golf courses, race courses, including formal parks,

etc are considered in this category. This category covers an area of 2.13 sq. km and is found in and around the towns of Kakinada, Samalkota, Pithapuram, Prathipadu, Jaggampeta, and Tuni.

1.4.2.5. Built-up – Rural

These are lands used for human settlement of a size comparable to urban settlements, in which more than 80% of the people are engaged in primary agricultural activity are associated with non-commercial and allied classes, and are classified as built-up (rural). The rural built-up area is the most prevalent of the built-up categories and is spread throughout the district. It contributed an area of 109.06 sq. km (3.61%) of the district's total geographical area.

1.4.2.6. Industrial

Non-linear impervious surfaces are included in this class, which is related to trade, manufacturing, distribution, and commerce. These are areas where human activity is observed in the form of manufacturing along with other supporting establishments for maintenance. The industrial area occupies an area of 35.99 sq. km, which is observed in and around the towns.

1.4.2.7. Industrial area-Ash / Cooling Pond

These are the portions of the industry which are used for temporary storage of ash, contaminated soil, rubble, cooling of hot water, or tailing pond associated with the industry. The areas where industrial waste is permanently kept are categorized as other waste which is delineated under this category. A stockpile of a storage dump of industrial raw material or slag/effluents or waste material or quarried/mixed debris from the earth's surface is considered under this category. It is observed that this category is found around the industrial areas with an area of 1.17 sq. km.

1.4.2.8. Quarry

These are manifestations of surface mining operations, which involve small-scale land surface excavation for quarries of Road metal, Granite, Laterite, Gravel, Fire clay, China clay, Sand, and other materials. They are primarily distinguished by their proximity to cities. It covers 5.86 sq. km and accounts for 0.19% of the district's total area.

1.4.2.9. Agricultural Land

Agriculture land is primarily used for the production of food, fiber, and other commercial and horticultural crops. It includes land under crops, namely cropland, fallow land, agricultural plantations, and aquaculture. The district's economy is primarily based on agriculture, which was found to account for 2012.48 sq. km (66.66%) of its total area during the period. It is also found

that the double-cropped area accounts for about 37% of the district total. Major food crops grown are Paddy, Maize, Black gram, Green gram, Banana, Coconut and Vegetables.

1.4.2.10. Kharif Crop

The agricultural area cultivated between June/July to September/October coinciding with the South-West monsoon season is considered as Kharif crop. It is associated with rain-fed crops under dry land farming with limited or no irrigation and areas of rain-fed paddy and other dry crops. Kharif cropland is the second-largest agricultural category, covering 195.62 sq. km. During the Kharif season, a variety of crops including paddy, maize, black gram, green gram, and others are widely grown in the district.

1.4.2.11. Rabi Crop

These areas are cultivated between November/December to February/March. It is associated with areas under assured irrigation irrespective of the source of irrigation. However, rain-fed areas with residual soil moisture, particularly in areas with black soil and high rainfall during the Kharif season, also have areas that are planted with Rabi crops. During the Rabi season, primarily irrigated crops like rice, sugarcane, and chillies are grown using canals, tanks, and groundwater resources. In the years 2015–16, Rabi cropland covered 21.97 sq. km of the total area.

1.4.2.12. Zaid Crop

These are the cropped areas that are mostly associated with irrigated areas with fertile soils and are confined to plains and delta areas during the summer (April-May). Summer crops grown from April to June were mapped under Zaid cropland and occupied an area of 1.74 sq. km.

1.4.2.13. Cropped in two seasons

These are the cropping areas that are commonly associated with irrigated areas during the two cropping seasons. Three combinations are possible in this category viz., - Kharif + Rabi, Kharif + Zaid, and Rabi + Zaid. Cropped areas in any two seasons are mapped under cropped in the two seasons category, occupying an area of 1119.52 sq. km (37.08%). These can be found throughout the district, with reliable irrigation provided by canals, tanks, and groundwater.

1.4.2.14. Cropped in more than two seasons

These are the areas that are cropped in more than two cropping seasons. It includes triple-cropped areas (Kharif, Rabi, and Zaid) under multiple cropping. Long-duration crops like sugarcane, cotton, and banana, are considered under this category. This category accounts for 240.71 sq. km

(7.97%) of the district's total geographical area. It can be found central part of the district with reliable irrigation provided by canals and groundwater.

1.4.2.15. Fallow land

Fallow land is agricultural land that is used for cultivation but is temporarily allowed to rest or un-cropped for one or more seasons, but not less than a year and not more than five years. The fallow land covers an area of 54.80 sq. km and is devoid of crops during both cropping seasons for various reasons.

1.4.2.16. Agricultural Plantation

These are the areas where agricultural tree crops have been planted using agricultural management techniques. These also include the areas of land use systems and practices wherein the cultivation of herbs, shrubs, and vegetable crops are deliberately integrated with crops mostly in irrigated conditions for ecological and economic reasons. These areas can be distinguished from cropland, especially using data collected during the Rabi/Zaid season. Plantations appear in varying sizes with regular and sharp edges, indicating the presence of a fence around them. Plantations such as banana, cashew, eucalyptus, teak, and others are grown throughout the district. The plantations category accounts for 312.23 sq. km (10.34%) of the district's total geographical area.

1.4.2.17. Aquaculture

These are the locations used for the commercial breeding and rearing of fish and shrimp. Aquaculture ponds are located mostly along the coast or in lakes, rivers and estuaries. This also includes breeding and rearing of freshwater or marine fish in captivity. A total of 65.89 sq. km is occupied by the category of aquaculture.

1.4.2.18. Forest

The term forest is used to refer to land with a tree canopy cover of more than 30 percent and an area of more than 0.5 ha. Forest is determined both by the presence of trees and the absence of other predominant land uses within the notified forest boundaries. The trees should be able to reach a minimum height of 5 m within the notified forest boundaries. The forest area occupies an area of 448.12 sq. km (14.84%) and is found along the northern and north-eastern parts of the district where several forest species grow. The important species are teak, nalla maddi, rosewood, devadari, etc.

1.4.2.19. Deciduous (Dry/Moist/Thorn)-Dense

This category is predominantly composed of species, which shed their leaves once in a year, especially during summer. These are mostly broad-leaved

tropical forests with a tendency to shed their leaves annually. This category includes all the areas where the canopy cover/density is more than 40 % and contributed 228.95 sq. km in the district.

1.4.2.20. Deciduous (Dry/Moist/Thorn)-Open

This category is predominantly composed of species, which shed their leaves once a year, especially during summer. These are mostly broad-leaved tropical forests with a tendency to shed their leaves annually. This category includes all the forest areas where the canopy cover/density ranges between 10% - 40%. In addition to timber, these forests also contain a large variety of fauna like tigers, leopards, wolves, bears, etc. An area of 49.91 sq. km is attributed to this category.

1.4.2.21. Forest Plantation

These are the locations where important tree species for forestry are grown and managed, particularly in notified forest areas. The majority of these are found in uplands and coastal regions. Many of these can be identified based on the sharp boundary exhibited by them. Forest plantations, mainly teak, bamboo, casuarinas, etc have been delineated with an area of 19.67 sq. km during the period.

1.4.2.22. Scrub Forest

These are the forest areas that are generally seen on the fringes of dense/open forest cover and settlements, where there is biotic and abiotic interference. Most times they are located closer to habitations. Forest blanks which are the openings amidst forest areas, devoid of tree cover, observed as openings of assorted sizes and shapes as manifested in the imagery are also included in this category. The scrub forests accounted for 9.81 sq. km (0.32%), which are generally prone to the conversion of forest plantations and other development activities within the notified forest.

1.4.2.23. Swamp Forest (Mangrove)-Dense

These are the areas with the plants evergreen in nature, halophytic, dense or woody in nature, occurring along tidal waters/creeks, estuaries and along the delta in coastal areas. They are densely colonized in coastal areas on tidal flats, estuaries salt marshes, etc. This category includes all the areas where the canopy cover/density is more than 40%. This category is found along the coastal areas with an account of 96.13 sq. km (3.18%) in the district.

1.4.2.24. Swamp Forest (Mangrove)-Open

These are the areas with the plants evergreen in nature, halophytic, dense or woody in nature, occurring along tidal waters/creeks, estuaries, and along

the delta in coastal areas. They are densely colonized in coastal areas on tidal flats, estuaries salt marshes, etc. This category includes all the forest areas where the canopy cover/density ranges between 10% - 40%. It is found that 15.28 sq. km (0.51%) area under this category in the district.

1.4.2.25. Tree Clad Area-Dense

Areas with tree cover lying outside the notified forest area with a woody perennial plant with a single, well-defined stem carrying a more-or-less-defined crown and being at least 3m tall. Plants essentially herbaceous but with a woody appearance (e.g. Bamboos and ferns) are also classified as trees if the height is more than 5m and as shrubs, if the height is less than 5 m. This category includes all the areas, where the canopy cover/density is more than 40%. The dense tree-clad area contributes an area of 25.35 sq. km, which is found along with forest areas in the district.

1.4.2.26. Tree Clad Area-Open

Areas with tree cover lying outside the notified forest area with a woody perennial plant with a single, well-defined stem carrying a more-or-less-defined crown and being at least 3m tall. Plants essentially herbaceous but with a woody appearance (e.g. Bamboos and ferns) are also classified as trees if the height is more than 5 m and as shrubs, if the height is less than 5m. This category includes all the forest areas where the canopy cover/density ranges between 10% – 40%. The tree-clad open category has been mapped with an area of 3.03 sq. km.

1.4.2.27. Wastelands

Wasteland is described as degraded land which can be brought under vegetative cover with reasonable effort and which is currently underutilized and land which is deteriorating due to lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent/imposed disabilities such as location, environment, chemical and physical properties of the soil, or financial or management constraints. During the study, the area under the wasteland category was mapped at 122.04 sq. km (4.04%), which includes the subcategories of ravenous land, dense scrub, open scrub, coastal sand, and barren rocky/stony waste.

1.4.2.28. Ravinous land

The word ravine is usually associated not with an isolated gully but an intricate network of gullies formed generally in deep alluvium and entering a nearby river, flowing much lower than the surroundings. Ravines are extensive systems of gullies developed along the river course. It covers an area of 2.38 sq. km.

1.4.2.29. Dense scrub

The scrub is usually confined to topographically elevated areas, on the hill slopes generally surrounded by agricultural lands. These areas possess shallow and skeletal soils, at times chemically degraded, extremes of slopes, severely eroded, and lands subjected to excessive aridity with scrubs dominating the landscape. It is found with varying sizes of small to large areas having a contiguous or dispersed pattern. The dense scrub areas can be found in the western parts of the district with moderate sloping areas. The area was mapped over 87.55 sq. km.

1.4.2.30. Open scrub

This category has a similar description as mentioned in the dense scrub except that they possess sparse vegetation or are devoid of scrub and have a thin soil cover. The open scrub areas are found at the foothills and moderate to gentle slopping areas, which are surrounded by agricultural lands. The area mapped under this category is about 15.51 sq. km in the district's east and north-eastern parts.

1.4.2.31. Coastal Sand

Coastal sands are the sands that are accumulated as a strip along the sea coast. Very high reflectance exhibited by this category, especially in the near-infrared region of the spectrum enables their separation with the salt-affected land. It is found in along the coast and occupies an area of 16.04 sq. km (0.53%).

1.4.2.32. Barren Rocky/Stony waste

The barren rock exposures are especially confined to hilly terrain with down slopes with rock outcrops, stony waste, and fragments. Barren rocky areas have been observed as rocky outcrops in the forest and scrubland. It is found that most of the barren rocky areas are being quarried for various construction activities in the district. The area under this category is 0.55 sq. km and it occupies 0.02 % of the district.

1.4.2.33. Wetlands

All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic which necessarily have a land-water interface, are defined as wetlands. Hence, the portions of the water body (partial or full) having emergent vegetation or observable submerged vegetation is placed in the wetlands category. The wetland category contributes 16.34 sq. km and is found along the coastal areas of the district.

1.4.2.34. Inland Natural

These are the areas that include ox-bow lakes, cut-off meanders, playas, swamp, marsh, peat bogs, etc (with vegetation). This category contributes to 0.15 sq. km of the district's total geographical area.

1.4.2.35. Inland Manmade (Water logged, saltpans, etc.)

The majority of the year, these are the areas flooded or prone to flooding by fresh, brackish, or standing water, with specific vegetation coverage consisting of low shrub, semi-ligneous, or herbaceous species. Waterlogged areas (seasonal and perennial) are formed as a result of the negative effects of human management practices and are vegetated. This is attributed to an area of 0.93 sq. km.

1.4.2.36. Coastal - Lagoon, creeks, mud flats, etc.

These are the areas which are submerged by high tides at some stage of the annual tidal cycle. Non-wooded areas tidally, seasonally or permanently waterlogged with brackish or saline water. These include estuaries, lagoons, creeks, backwaters, bay tidal flat/mud flat, mangroves, salt marsh/marsh with vegetation and other hydrophytic vegetation. These are contributed to an area of 6.05 sq. km.

1.4.2.37. Coastal - Saltpans

The saltpans are flat expanses of salt-covered land, usually white under the Sum. Saltpans are manmade saline ecosystems from which crude salt is extracted during summer. These are un-drained, usually small and shallow, natural depressions or hollows in which brackish water accumulates and evaporates leaving behind salt deposits. About 9.22 sq. km of area is occupied by this category in the district along the coast.

1.4.2.38. Water Bodies

This category comprises areas with surface water, either impounded in the form of ponds, lakes, and reservoirs or flowing as streams, rivers, canals, etc are delineated. These can be seen clearly in the satellite image in blue to dark blue or cyan depending on the depth of the water. This category includes rivers, streams, canals, lakes, ponds, reservoirs, and tanks. The total area of water bodies, including all sub-categories, is about 217.46 sq. km (7.20%).

1.4.2.39. River/Stream-Perennial

Rivers/streams are the natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or a lake or an inland basin in desert areas or a marsh or

another river. The rivers/streams that flow continuously throughout the year are considered as perennial. It contributes an area of 71.90 sq. km. The important river and rivulets in the District are the Krishna. The River Godavari flows through the district in the south.

1.4.2.40. River/Stream-Non Perennial

When the water covers the surface for less than nine months each year, it is considered non-perennial. This also includes the dry part of the river generally characterized by the presence of sand or exposed rocks. It contributes an area of 24.36 sq. km under this category.

1.4.2.41. Canal/Drain

Canals and drains are artificial watercourses constructed for irrigation, navigation or to drain out excess water from agricultural lands. It is found mostly in the coastal plains with an area of 23.50 sq. km.

1.4.2.42. Reservoir/Tanks-Permanent

The reservoir is an artificial lake created by the construction of a dam across the river specifically for hydel power generation, irrigation, and water supply for domestic/ industrial needs, and flood control, either singly or in combination. Tanks are small lakes of impounded waterways constructed on land surfaces for irrigation. They are associated with croplands, lowlands, and reservoirs surrounded by hills without vegetation. This includes all reservoirs/tanks with water spread seen at least during one season in a year is considered under the permanent category. The reservoir/tanks-permanent category was delineated with an area of 17.44 sq. km. These are the one of the sources of the irrigation and spread over the district.

1.4.2.43. Reservoir/Tanks-Seasonal

Dry reservoirs/tanks are those which do not have water spread throughout the year and are considered seasonal. During the mapping period, where the water spread is not found in the three seasons, those areas are mapped in this category. Many of the tanks are found to be seasonal, with a total area of 80.25 sq. km.

1.4.2.44. Lakes/Ponds-Seasonal

Lakes/ponds are those that retain water in them either for one season or throughout the year and are usually not subject to extreme fluctuation in water level. Ponds are a body of water limited in size, either natural or artificial, regular in shape, smaller in size than a lake, and generally located near settlements. These accounted for an area of 0.01 sq. km only.

1.4.3 Forest Cover Distribution

The forest cover maps were created by interpreting multiple sources of topographical maps and satellite data. Land with a tree canopy cover of more than 10% and a size of more than 0.5 ha is referred to as a forest. The forest is defined by the presence of trees and the absence of other dominant land uses within the notified forest boundaries. The trees should be able to reach a minimum height of 5 m within the notified forest boundaries. The spatial distribution of forest cover and its statistics are presented in Figure-8 and Table-6. As per the Forest Department, Government of Andhra Pradesh the Wildlife sanctuary map and the updated Forest boundary map in the district is presented in Figure-8A and Figure-9.

Table 6 Forest cover distribution in Kakinada District

S. No	Type of Forest	Area in sq. km	% to district total
1	Deciduous (Dry/Moist/Thorn)-Dense/Closed	228.95	7.58
2	Deciduous (Dry/Moist/Thorn)-Open/Closed	49.91	1.65
3	Forest Plantation	19.67	0.65
4	Scrub Forest	9.81	0.32
5	Swamp Forest (Mangrove)-Dense	96.13	3.18
6	Swamp Forest (Mangrove)-Open	15.28	0.51
7	Tree Clad Area-Dense/Closed	25.35	0.84
8	Tree Clad Area-Open	3.03	0.10
	Total Forest	**448.12**	**14.84**

Data source: NR Census 3rd cycle mapping, NRSC/ISRO & APSAC, GoAP

The district's forest cover is primarily found along the north, east, northeast and in a few isolated locations in the northwest. The predominant categories are dense deciduous and dense mangrove forests, which contribute 228.95 sq. km and 90.13 sq. km, respectively. The dense and open deciduous forests are mostly concentrated in the north and northeast, the mangrove forest is concentrated along the coast. The forest plantations category covers an area of 19.67 sq. km of the district. The tree-clad dense and open categories occupies 25.35 sq. km and 3.03 sq. km respectively.

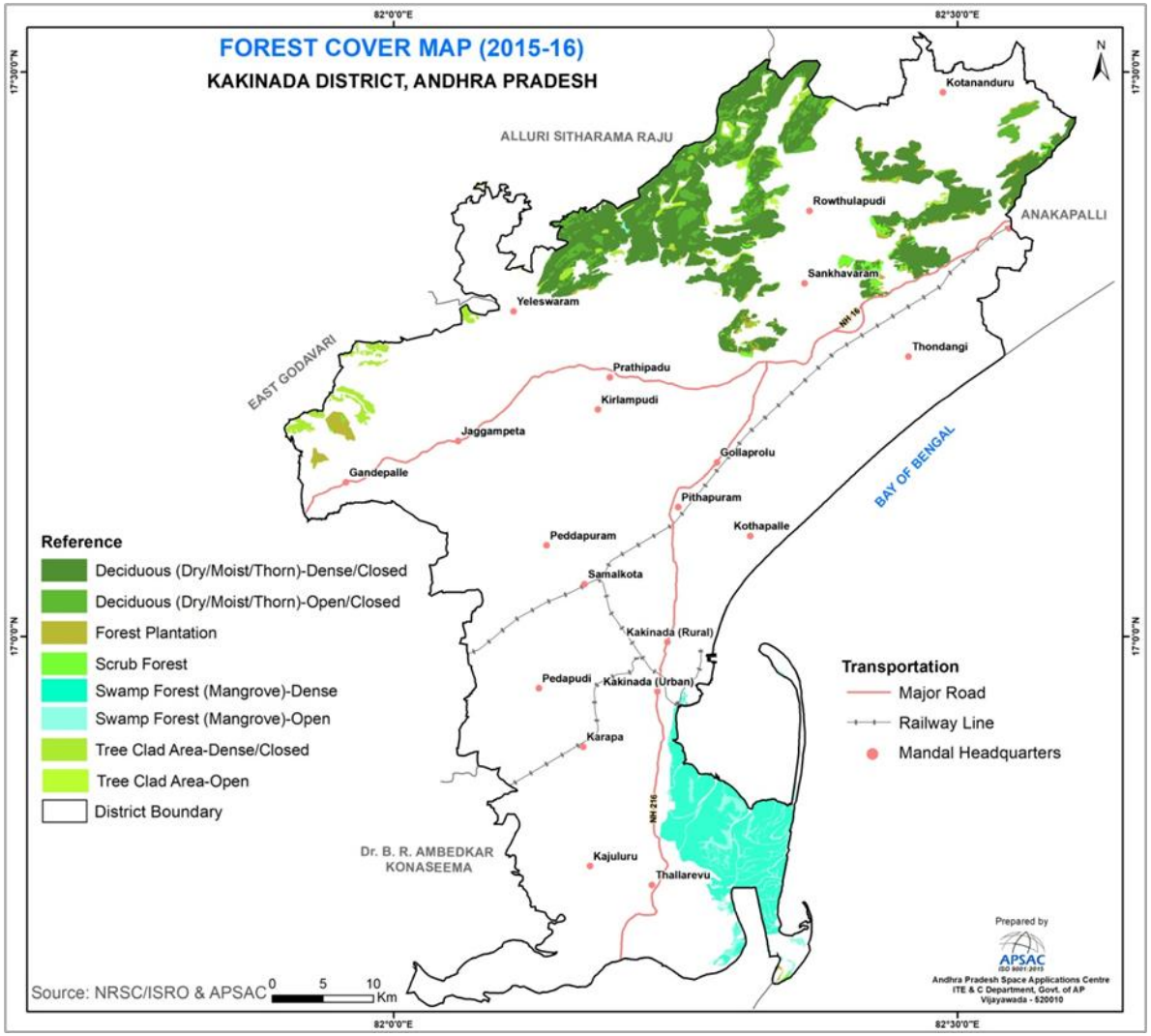

Figure-8: Forest cover map of Kakinada District

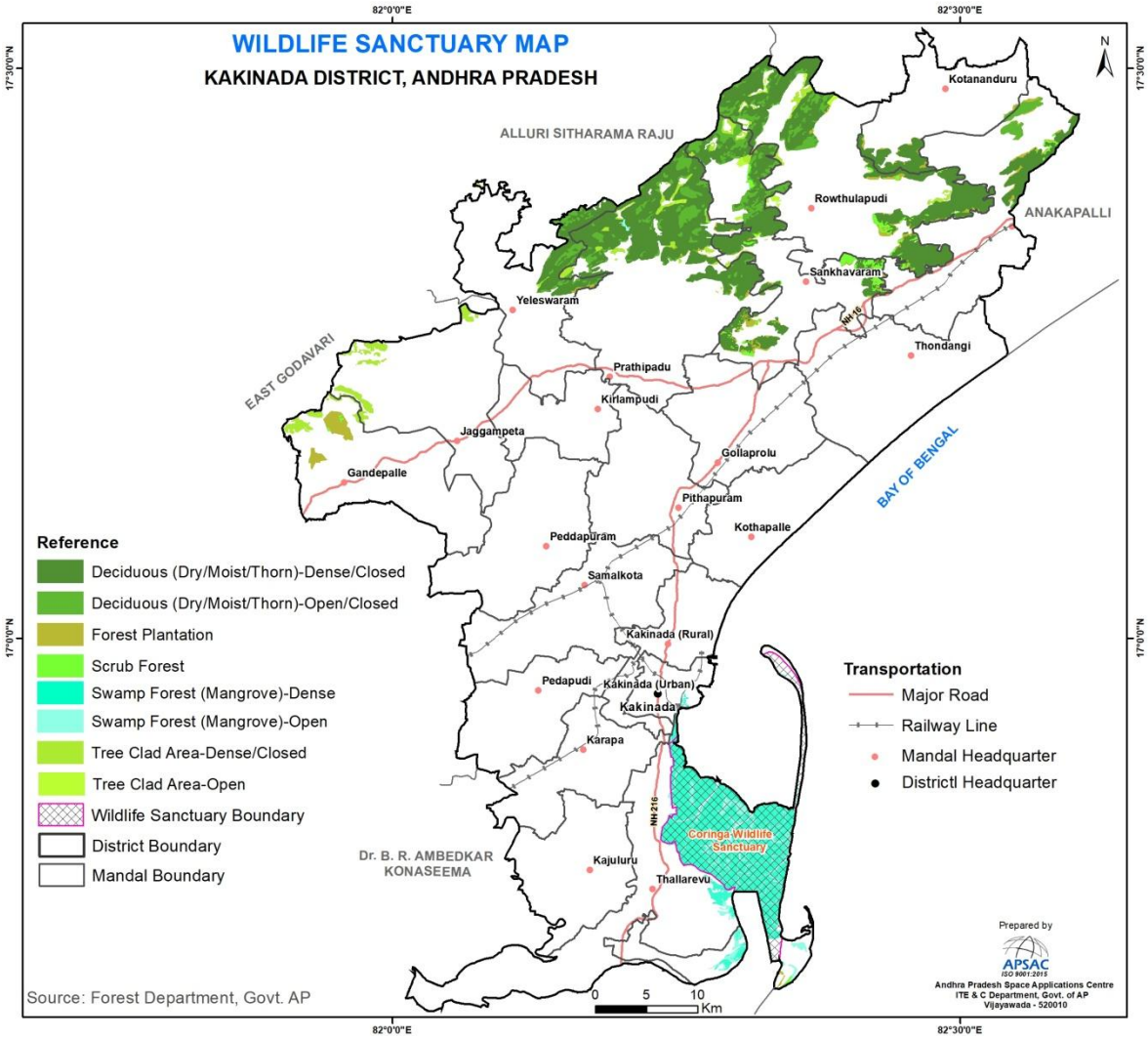

Figure-8A: Wildlife Sanctuary map of Kakinada District

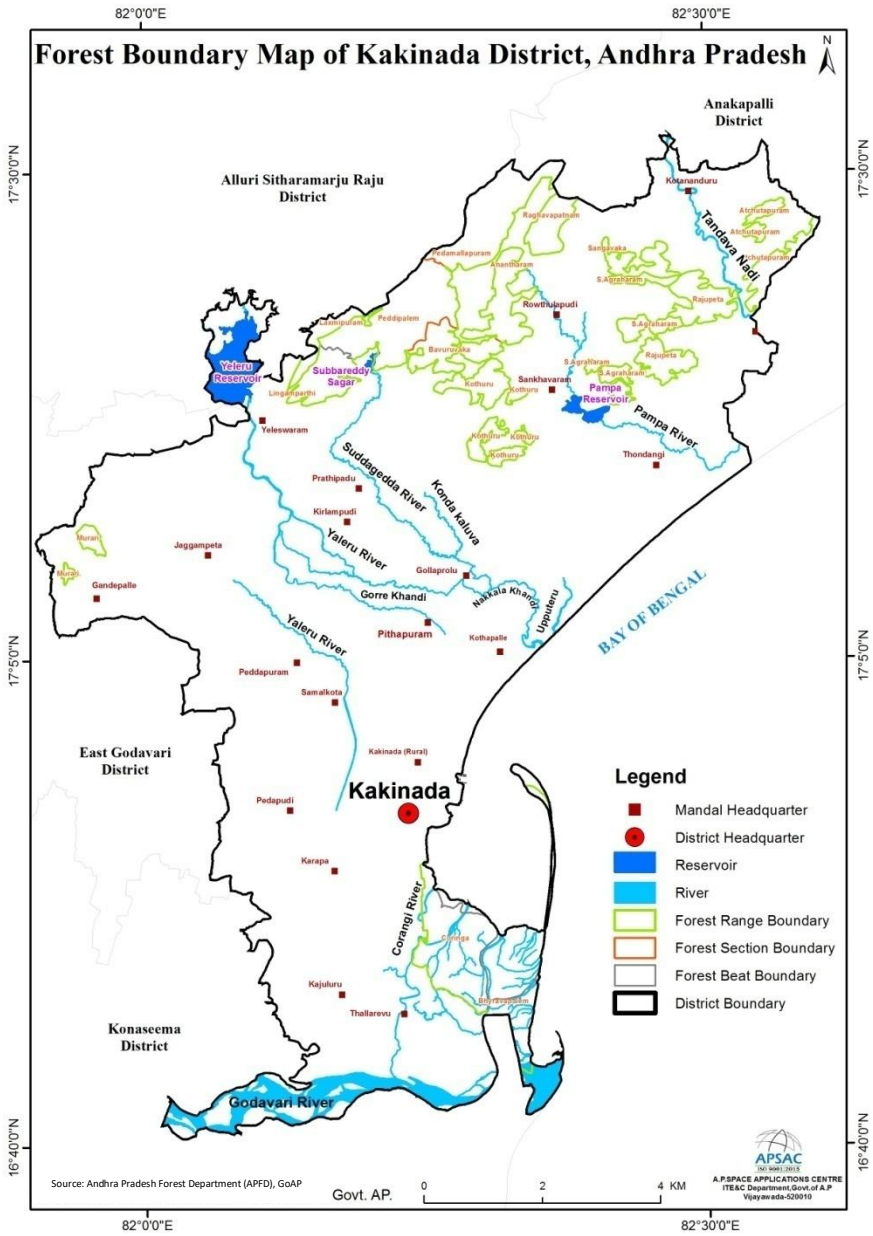

Figure-9: Forest boundary map of Kakinada District

1.4.4 Agricultural Resources in Kakinada District

Over the past two decades, APSAC has effectively employed remote sensing technology in agriculture, encompassing both spatial and temporal dimensions across various projects. The continuous evolution of satellite remote sensing technology has facilitated systematic monitoring of crop conditions and vigor across extensive regions. Within the realm of spectral vegetation indices derived from remote sensing data, the Normalized Difference Vegetation Index (NDVI) stands out as the most widely utilized for operational drought assessment. Its popularity stems from its straightforward calculation, ease of interpretation, and the capacity to mitigate the impacts of atmospheric conditions, illumination geometry, and other variables.

APSAC conducted in-season crop condition assessments at the Mandal level in Andhra Pradesh. This initiative aimed to provide administrators and planners with crucial insights for strategic decision-making regarding drought management, import-export policies, and trade negotiations. The NDVI is calculated using the formula (NIR–Red)/(NIR+Red), where NIR and Red represent the reflectance in the visible and near-infrared channels, respectively. Water, clouds, and snow exhibit higher reflectance in the visible region, causing NDVI to assume negative values for these features. Bare soil and rocks, with similar reflectance in both visible and near-infrared regions, yield index values close to zero. NDVI values for vegetation typically range from 0.2 to 0.6, with higher values associated with greater green leaf area and biomass. The Shortwave Infrared (SWIR) band is sensitive to soil and crop canopy moisture. Early in the cropping season, when soil background dominates, SWIR is sensitive to top 12 cm soil moisture. As crop growth progresses, SWIR becomes sensitive to leaf moisture content, providing surface wetness information.

The Normalized Difference Wetness Index (NDWI), computed using SWIR data, complements NDVI for drought assessment, especially in the early cropping season. NDWI is derived as follows: NDWI=(NIR-SWIR)/(NIR+SWIR), where NIR and SWIR represent reflected radiation in the Near-Infrared and Shortwave Infrared channels. Higher NDWI values indicate increased surface wetness.

For satellite-based crop condition anomalies indicating agricultural drought, the Vegetation Condition Index (VCI) of both NDVI and NDWI can be

computed. When combining VCI values of NDVI and NDWI, the minimum of the two can be considered. For instance, if at least one is categorized as severe, the overall category is considered severe. If at least one is moderate, the overall category is taken as moderate. The vegetation conditions and corresponding ranges are detailed in Table-7.

Table 7 Vegetation condition and range in percentage

VCI range (%)	Vegetation Condition	Description
60-100	Normal	Crop condition is Normal
40-60	Moderate	Crop condition is Moderate
0-40	Severe	Crop condition is Severe

1.4.4.1 Kharif Crop Condition Assessment

Andhra Pradesh Space Applications Centre (APSAC) conducted a crop condition assessment in Kakinada district during Kharif 2022-23 utilizing MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data. The assessment revealed that out of the total mandals in the district, 10 were categorized as having a normal crop condition, 05 were classified as moderate, and 06 were identified as severe. Notably, urban and forest cover mandals were excluded from the vegetation condition assessment. This comprehensive evaluation provides valuable insights into the agricultural landscape of Kakinada district, aiding in targeted interventions and resource allocation to mitigate the impacts of varying crop conditions.

1.4.4.2 Rabi Crop Condition Assessment

During Rabi 2022-23, the assessment identified 05 mandals with normal crop conditions, 11 mandals categorized as moderate, and 05 were identified as severe. Notably, mandals predominantly covered by urban or forest areas were excluded from the vegetation condition assessment. This evaluation provides valuable insights into the agricultural status of Kakinada district during the Rabi season, facilitating informed decision-making and resource allocation to support agricultural sustainability and productivity.

1.4.5 Soil Resources of the Kakinada District

In the Kakinada district of Andhra Pradesh, various soil types contribute to its diverse landscape. Among these, the predominant soil types cover a range of characteristics. Clayey to gravelly clayey moderately deep dark

brown soils occupy approximately 1006.58 sq. km (32.7%) of the area, followed by fine loamy gravelly clayey shallow reddish brown soils spanning 583.25 sq. km (19%). Deep black clayey soils encompass 474.1 sq. km (15.4%) of the district, while loamy to gravelly clay deep dark reddish brown soils cover 402.62 sq. km (13.1%). Moderately deep calcareous black soils extend across 271.11 sq. km (8.8%), and loamy to clayey skeletal deep reddish brown soils encompass 161.25 sq. km (5.2%). Additionally, dark greyish brown moderately deep moist stratified soils occupy 124.66 sq. km (4.1%), while very dark brown moderately deep wet silty soils and light gray deep sandy soils cover 40.02 sq. km (1.3%) and 10.5 sq. km (0.3%) respectively. This diversity in soil types contributes to the agricultural and ecological richness of the region. The soil resource map of the district is shown in Figure-10 and the soil category with area is shown in Table-8.

Table 8 Soil classes in Kakinada district

S.No	Classification	Area in Sq.km	Percentage (%)
1	Clayey to gravelly clayey moderately deep dark brown soils	1006.58	32.7
2	Dark greyish brown moderately deep moist stratified soils	124.66	4.1
3	Deep black clayey soils	474.1	15.4
4	Fine loamy gravelly clayey shallow reddish brown soils	583.25	19.0
5	Light gray deep sandy soils	10.5	0.3
6	Loamy to clayey skeletal deep reddish brown soils	161.25	5.2
7	Loamy to gravelly clay deep dark reddish brown soils	402.62	13.1
8	Moderately deep calcareous black soils	271.11	8.8
9	Very dark brown moderately deep wet silty soils	40.02	1.3
	Total[#]	3074.09	100

[#]*Excluding the Urban and Water bodies area*

Data Source: APSAC, Vijayawada

1.4.6 Horticulture

Horticulture encompasses both the science and art of cultivating, utilizing, and enhancing a variety of crops, including fruits and vegetables, spices, ornamental plants, plantation crops, medicinal herbs, and aromatic plants. It also involves activities such as plant conservation, landscape restoration, garden design and maintenance, arboriculture, and the cultivation of ornamental trees and lawns.

In the Kakinada district, Oil Palm stands out as the primary horticultural crop, cultivated across an area of 806.25 hectares. Following closely are Coconut plantations covering 38.67 hectares, Cashew nut cultivation occupying 17.57 hectares, and combined cultivation of Coconut and Cocoa spanning 15.82 hectares. Areca nut cultivation is also significant, covering 9.93 hectares. Overall, the total area dedicated to horticultural crops in the district amounts to 909.79 hectares. The horticulture crop-wise detail is shown in the Table-9.

Table 9 Soil classes in Kakinada district

S.No	Crop	Area in ha.
1	Papaya	2.56
2	Banana	7.89
3	Sweet Lime	4.00
4	Mangoes	0.86
5	Guava	1.83
6	Coconut	38.67
7	Coco	4.41
8	Coconut & Cocoa	15.82
9	Oil Palm	806.25
10	Areca nut	9.93
11	Cashew nut	17.57
	Total Area	**909.79**

Source: Rashtriya Krishi Vikas Yojana, 2022-23, GoAP.

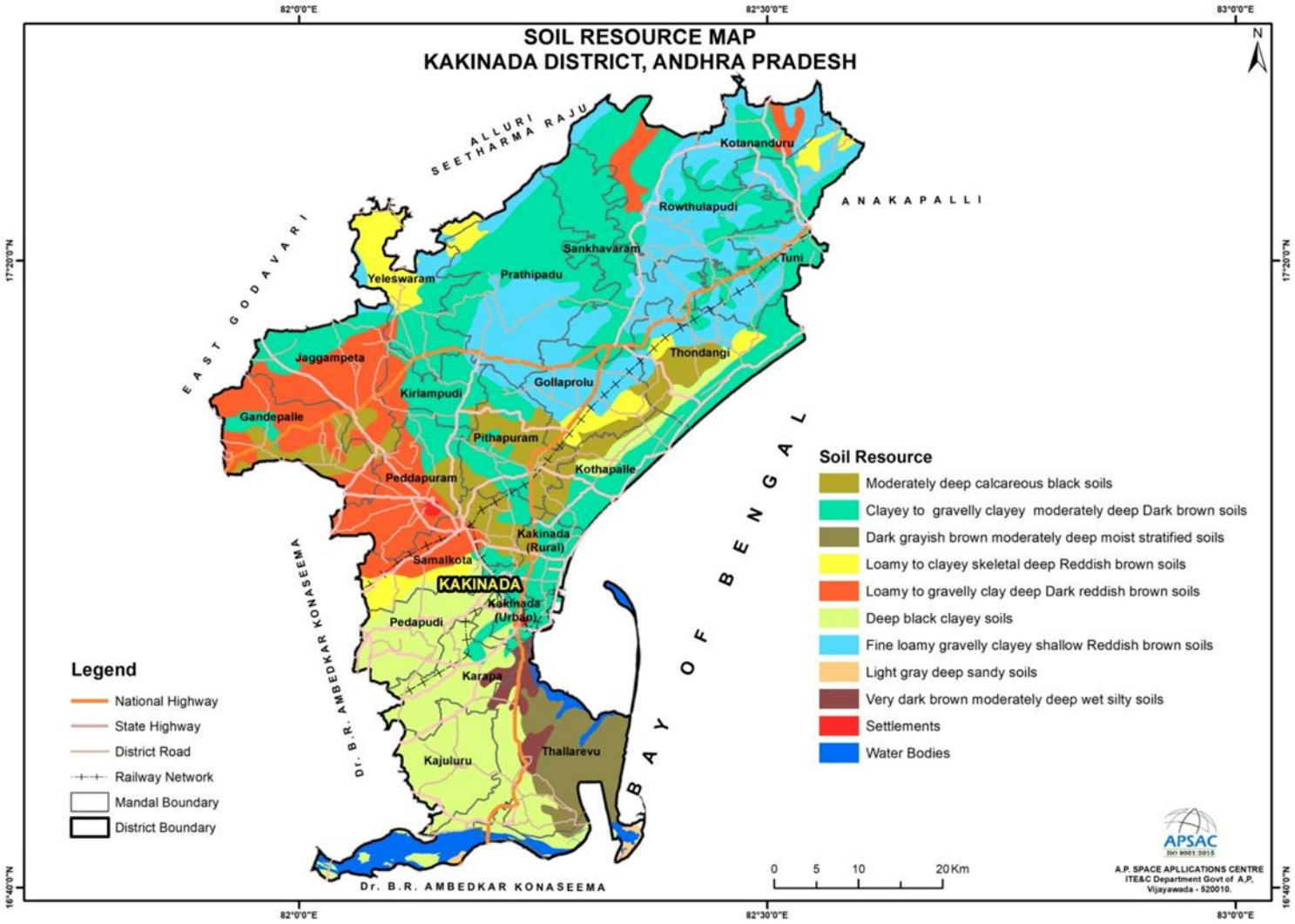

Figure-10: Soil resource map of Kakinada District

1.5 Ground Water Prospects in the District:

Ground water occurs in all most all geological formations and its potential depends upon the nature of geological formations, geographical setup, and incidence of rainfall, recharge, and other hydrogeological characters of the aquifer. In consolidated formations, ground water occurs under unconfined to semi-confined conditions. Ground water is developed in these formations by dug wells, dug cum bore wells, and bore wells tapping weathered and fractured zones. The yields are in the range from 20 to 70m^3/ day. The occurrence of fractures in the crystalline formations is limited down to 30 to 40m bgl and occasionally extends down to 70 - 100m bgl. The bore wells constructed in the crystalline formations generally tap the weathered and fractured zones. The yields of the bore wells generally range between 80 to 400 m^3/ day. The higher yields are limited to the available thickness of fractured and jointed zones. In the Meta sediments, the yields are very limited and are in the range from 10 to 80 m^3/ day. Higher yields occur in limestone formations. Ground water in semi-consolidated formations occurs under unconfined to confined conditions. Ground water is developed in these formations by dug-cum tube wells and tube wells. These formations are potential aquifers. The yields of the dug- cum tube wells are in the range from 30 to 45 m^3/ day. The granularity of the sandstone bed is the deciding factor of the yield potential as the higher yields are recorded in the Rajahmundry sandstones tapping coarse sandstone beds. The yields of the tube wells in Gollapalli sandstones and Rajahmundry sandstones are in the range from 60 to 200 m^3/ day and 600 to 1500 m^3/ day respectively. The deltaic area is underlain by alluvium of recent age consisting of varying proportions of clay, silt, sand, and gravel. The thickness of alluvium ranges from few meters to about 600 m followed by tertiary formations. In deltaic areas ground water, an occurrence is controlled by landforms. In deltaic area also a lot of heterogeneity in hydrogeological conditions exist both spatially and vertically. Fresh water is generally limited to shallow to moderate depths only, whereas in the southern part of the delta it occurs as pockets and lenses. The deep aquifers are generally saline. Palaeo-channels are favourable locations for fresh water aquifers. Ground water occurs under phreatic to confined conditions and is developed through shallow dug wells, filter point wells, and shallow tube wells. The depth of dug wells ranges from about 2 to 7 m, while the depth of filter point wells varies from 5 to 13 m, and the depth of tube wells varies from 40 to 80 m. The yields generally range in this aquifer between 250 to 400 m^3/ day. Occasionally high yields of up to 15 lps exist in the palaeo-channels. The

transmassivity value of the aquifer in the semi and unconsolidated formations varies from 2.5 to 5560 m^2/day. Water Level Scenario The depth to water levels during pre-monsoon season (May 2012) in the district ranges between 2 and 10 m bgl. Ground Water Scenarios in Kakinada District shown in Figure-11.

1.6 Infrastructure

1.6.1 Transport Network

Kakinada district has a well-connected by various modes of transportation such as Road, Rail and Seaports. The connectivity of each category is also depicted in Figure-12. The details of each transport network distribution in the district are given below.

1.6.1.1. Road Transport: The road network of the district has been delineated by using high resolution satellite data under Space Based Information Support for Decentralized Planning (SIS-DP) project and arrived the lengths of the each type of road network. It can be observed that Kakinada district has a well-developed road network that facilitates connectivity to all towns within the district, and to other major cities and towns of nearby districts. The major road network includes National Highways (NH), State Highways (SH), and District Roads (DR). The rural areas of the district is also have a good connectivity by Panchayat Raj roads / village roads.

The total length of the road network in the district is about 6461.74 km. Of which, the length of the National Highways is about 148.93 km, State Highways connecting all major towns and cities in the district is having a length of about 399.97 km. The district roads are having a length of 1117.74 km. The length of each road category covered in the district is shown in Table-10.

Kakinada district is traversed by two National Highways. The traverse and description of each highway is as given below:

1.6.1.1.1. National Highway 216 (NH216): The former highways of NH 214 and 214A were merged and renumbered as NH 216 in the state of Andhra Pradesh. This highway starts from NH 16 junction at Kathipudi in Kakinada district and passes through Gollaprolu, Pithapuram, Samalkota, Kakinada and Thallarevu mandals in Kakinada District, and enter into konaseema district.

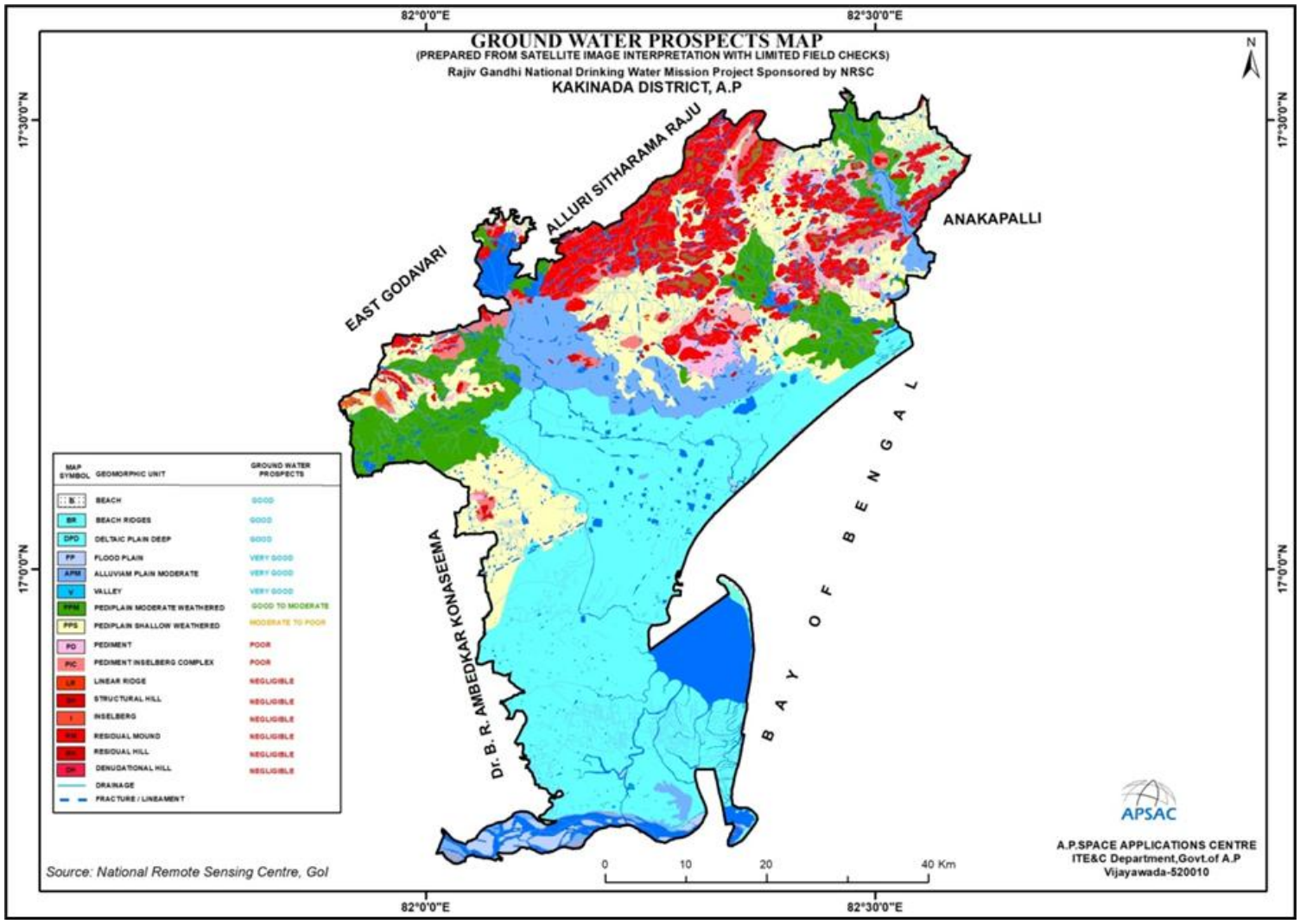

Figure-11: Ground Water prospects in Kakinada District, Andhra Pradesh

1.6.1.1.2. National Highway 16 (NH16): The NH16 is a major National Highway in India that runs along the east coast of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu states. It is a part of the Golden Quadrilateral project to connect India's major cities.

The NH starts at Odisha border which passes through the coastal districts in Andhra Pradesh and enters at Ichchapuram Mandal in Srikakulam district. It traverse through Kakinada District via Tuni, Thondangi, Sankhavaram, Gollaprolu, Prathipadu, Yeleswaram, Kirlampudi, Jaggampeta and Gandepalle mandals and connects East Godavari District.

Some important State Highway segments covered in the district are given below.

Sankhavaram - Rowthulapudi - Kotananduru - Tuni Road (SH013)
Kakinada - Karapa - Kalluru Road (SH014)
Kakinada- Samalkota - Peddapuram - Penumudi road (SH015)
Kakinada - Samalkota Road (SH017)
Tuni - Kotananduru (SH156)
Kakinada - Kothapalle - Thondangi (SH-162)
Kirlampudi - Pithapuram - Gollaprolu (SH-163)
Samalkota - Peddapuram - Jaggampeta Road (SH164)
Prathipadu - Kirlampudi - Peddapuram - Samalkota road (SH170)
Kothapalle - Pithapuram- Samalkota road (SH173)
Peddapuram - Gandepalle road (SH174)
Kakinada - Pedapudi road (SH191)
Karapa - Pedapudi road (SH195)
Thallarevulu – Kalluru Road (SH206)

Table 10 Road Category wise Lengths

S.No	Road Type	Length in km
1	National Highway	148.93
2	State Highway	399.97
3	District Road	126.26
4	Major District Road	615.24

5	City Road	376.24
6	Village Road	3003.16
7	Cart Track	1480.05
8	Foot Path	311.89
Total Length		**6461.74**

Data Source: R&B Department & APSAC, Vijayawada.

1.6.1.2. Railways : The Indian Railway line traversing from North to South in Kakinada district covering the various stations to cater the transportation needs of the people. The length of Rail network in the district is about 113.61 km covering 17 railway stations. Among these, the important railway stations in the district are Annavaram, Gollaprolu, Kakinada Port, Kakinada Town junction, Medapadu, Pithapuram, Samalkota Junction and Tuni; and the Train stations are Artalakatta, Durgada Gate, Hamsavanam, Karapa, Kovvada, Ravikampadu, Timmapuram, Vakada and Velangi.

Kakinada district is traversed by a significant railway line that connects various parts of the district and provides connectivity to neighbouring regions. The main railway line that passes through Kakinada district is Visakhapatnam junction - Vijayawada junction section railway line. It passes through Tuni, Hamsavaram, Annavaram, Ravikampadu, Durgada Gade, Gollaprolu, Pithapuram, Samalkota junction, Meadapadu in Kakinada district and connects East Godavari district, West Godavari district, Eluru, Krishna districts, and destination to Vijayawada junction in NTR district.

In addition to the main line, there is a branch line and spur line namely Kakinada - Kotipalli that extend from the main line to connect specific towns such as Kovvada, Artalakatta, Karapa, Vakada and Velangi with in Kakinada district. This line provides local connectivity and transportation services to different parts of the district

1.6.1.3. Sea Transport: Andhra Pradesh has the 2nd longest coastline of 974 km in the eastern peninsular India. Kakinada district has five Operational ports namely Kakinada(SEZ), Kakinada Port(Deep Water Port), Kakinada Port(Anchorage Port), Kakinada Port and S.Yanam Port. The description of each port is as given below:

1.6.1.3.1. Kakinada(SEZ): Kakinada(SEZ) is a operational port and fishing harbour located at Kothapalle mandal in Kakinada district.

Kakinada(SEZ) is a company established for the purpose of developing SEZ/Domestic tariff area including the industrial city and township in Kakinada special Economic Zone and is promoted by Auro Infra Realty & infrastructure private limited, which holds majority stake(99.8%) in Kakinada SEZ.

1.6.1.3.2. Kakinada Port (Deep Water Port): It is located at Kakinada off the east coast of India. It is 170 km south of Visakhapatnam Port. It is an all weather deep water port, and the channel has a depth of 12 metres (39ft). The port can handle vessels up to 50,000 DWT.

1.6.1.3.3. Kakinada Port (Anchorage Port): It is located at East coast of India, bay of Bengal. It is a medium sized Anchorage port. The types of vessels regularly calling at Kakinada Anch are Bulk Carrier(40%), oil/Chemical tanker(22%), General cargo (6%), container ship (5%), oil products tanker (5%).

1.6.1.3.4. Kakinada Port(Fishing harbour): This is the premier place for fresh sea fish. Experience the beautiful world of the blue that Kakinada fishing harbour. Every evening here is like a fair of ferries, with the entire harbour reverberating with boats. It's bliss full to see experience India's coastal rustic culture.

1.6.1.3.5. Yanam Port: It was the centre for the manufacture of salt and this salt constituted the major part of the quantity imported by the French into Bengal region. It was also an important centre of cotton goods and supplied a large part of the return cargo of the French ships visiting India.

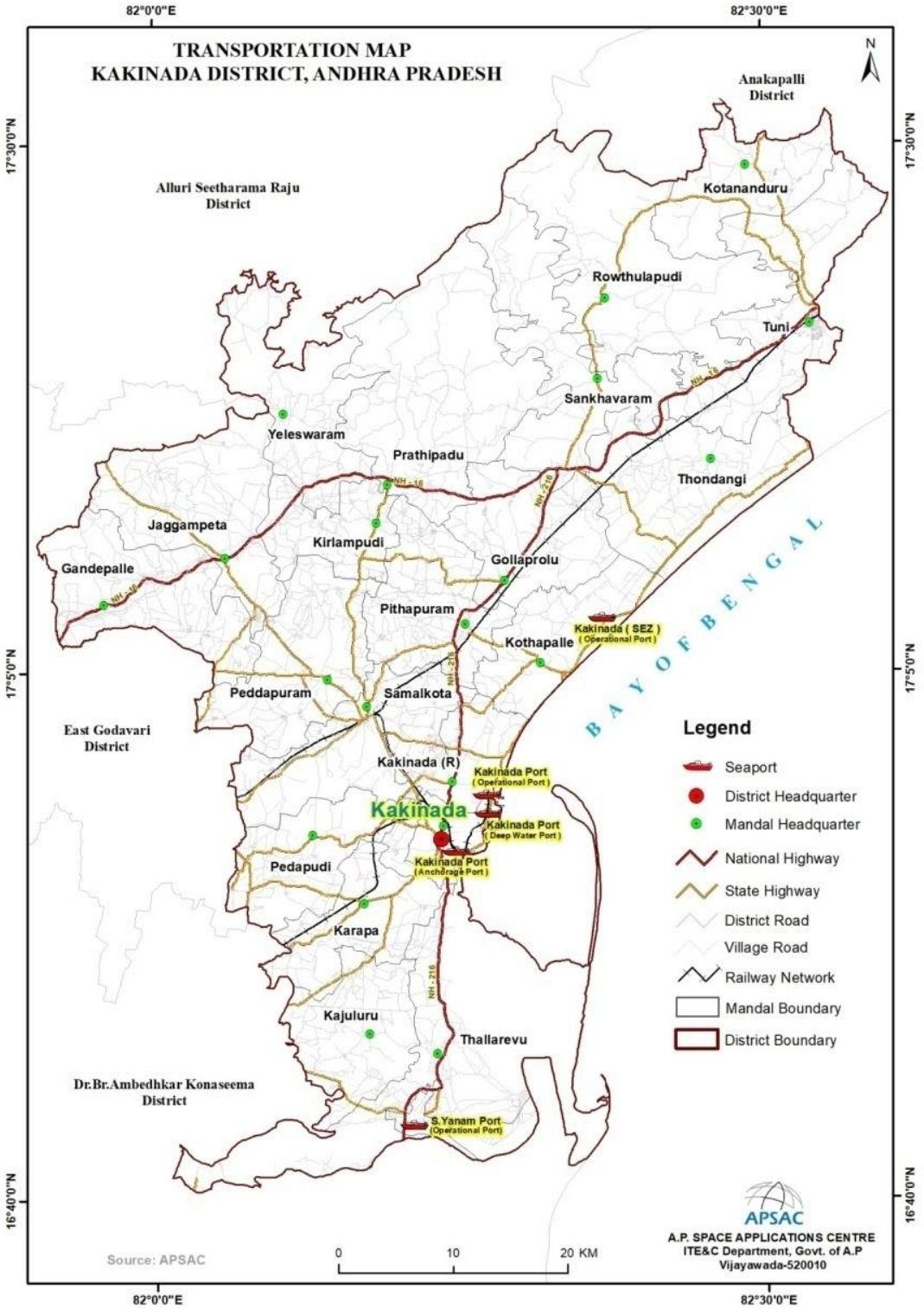

Figure-12: Transport Network of Kakinada District

1.6.2 Irrigation

1.6.2.1. Major and Medium Irrigation Projects in Kakinada district:

Irrigation has assumed an increasing significance in agriculture in the context of new technology, where high yielding varieties and multiple cropping are being practiced. The main reasons for low yields are inadequate rainfall, uneven and uncertain rains during the period of crop growth. It is generally found that the introduction of irrigation is associated with changes in the cropping pattern. The shift from a traditional cropping pattern to the most advantageous cropping pattern is possible only in the presence of irrigation facilities. The new agricultural technology is highly based on sufficient moisture conditions. Thus, the development of irrigation is crucial for increasing agricultural production. The irrigation projects are classified as major, medium and minor irrigation details are shown in Table.11 and Figure 13.

1.6.2.1.1. Major Irrigation Projects:

In Kakinada district there are five major irrigation projects i.e., Sir Author Cotton Barrage (Godavari Delta System-Eastern Delta), Polavaram Project, Yeleru Reservoir Project, Thota Venkatachalam Pushkara Lift Irrigation Scheme and Thandava Reservoir Project.

1.6.2.1.2. Medium Irrigation Projects:

In Kakinada district there are three medium irrigation projects i.e., Pampa Reservoir Project, Subbareddy Sagar Project and Sri KVRK Surampalem Project. The project wise ayacut details are Pampa Reservoir Project an extent of 12,005 Ac ayacut, Subbareddy Sagar Project an extent of 9,900 Ac ayacut and Sir KVRK Surampalem Project an extent of 881 Ac ayacut.

There are 11Nos of minor lift irrigation schemes in the district under Andhra Pradesh State Irrigation Development Corporation Limited (APSIDC), an ayacut of 10,590 Ac. . The Water Resources Department 112Nos of minor irrigation tanks covered in the district an extent of 31,442 Ac, 79Nos of Panchayat Raj tanks (P.R above 100 Ac ayacut) covered in the district an extent of 14,930 Ac ayacut and 96Nos of Panchayat Raj tanks (P.R bellow 100 Ac ayacut) covered in the district an extent of 7,208 Ac ayacut of Kakinada district.

Table 11 Major and Medium Irrigation Projects in Kakinada District

S.No	Project Type	Name of the Project	Status	Ayacut in Ac
1	Major	Sir Author Cotton Barrage *(Godavari Eastern Delta)*	Completed	1,44,362
2		Yeleru Reservoir Project		53,017
3		Thandava Reservoir Project		16,947
4		Polavaram Project	Ongoing	48,425
5		Thota Venkatachalam Pushkara LIS		1,85,906
6	Medium	Pampa Reservoir Project	Completed	12,005
7		Subbareddy Sagar Project		9,900
8		Sri KVRK Surampalem Project		881
9	Minor	Lift Irrigation Schemes under APSIDC (11Nos)	Ongoing	10,590
10		Minor Irrigation Tanks - 112Nos *(Ayacut above 100 Acres)*		31,442
11		Panchayat Raj Tanks (P.R) - 79Nos *(Ayacut Above 100 Acres)*		14,930
12		Panchayat Raj Tanks (P.R) - 96Nos *(Ayacut bellow 100 Acres)*		7,208
			Total	**5,35,613**

Data source: WRD, APWRIMS, Govt. of A.P.

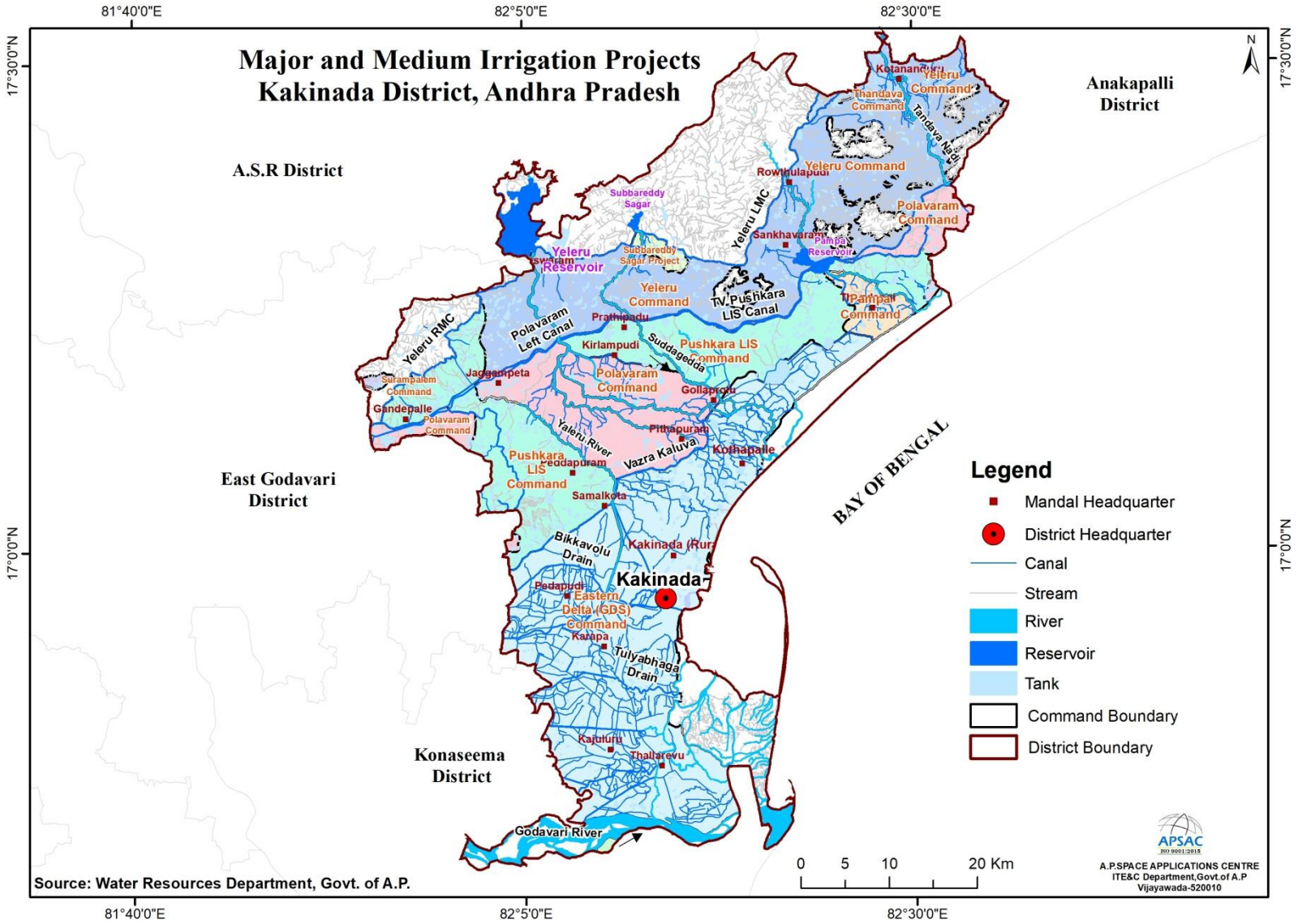

Figure-13: Major and Medium Irrigation Projects of Kakinada District

1.6.2.2. Tank Information System

As per the information of Water Resources Departmental portal, Andhra Pradesh Water Resources Information & Management System (APWRIMS) and the URL:https://apwrims.ap.gov.in/ in Kakinada district has 533 minor irrigation tanks. The Designed Storage Capacity of minor irrigation tanks in Kakinada district 1,220.19mcft and Current Storage Capacity is 867.6mcft. The coastal part the district is irrigated with the Godavari Delta System (GDS-Eastern Delta) Canals and Channels. The ponds and canal water used for drinking and irrigation purposes. The mandal wise minor irrigation tanks details of Kakinada district are shown in Table.12

Table 12 Mandal wise Minor Irrigation Tanks details of Kakinada district

S.No	Mandal	No.of MI Tanks	Designed Storage Capacity (mcft)	Current Storage Capacity (mcft)
1	GANDEPALLE	96	213.5	106.75
2	GOLLAPROLU	40	70.87	70.49
3	JAGGAMPETA	73	164.8	82.66
4	KIRLAMPUDI	6	11.6	11.6
5	KOTANANDURU	44	47.21	47.21
6	PEDDAPURAM	55	40.38	20.21
7	PITHAPURAM	6	7.13	7.13
8	PRATHIPADU	51	162.04	147.62
9	ROUTHULAPUDI	29	62.14	62.14
10	SAMALKOTA	29	233.77	116.88
11	SANKHAVARAM	18	74.24	67.73
12	THONDANGI	34	52.79	52.79
13	TUNI	36	39.78	39.78
14	YELESWARAM	16	39.94	34.61
	TOTAL	**533**	**1,220.19**	**867.6**

Data source: WRD, APWRIMS, Govt. of A.P.

1.6.3 Eco-sensitive Areas and Important places

Kakinada district is blessed with several tourist attractions that offer a mix of historical, cultural, and natural wonders. The important popular tourist, religious and cultural places to visit in the Kakinada district are shown in the Table –13.

Table 13 Important places of Tourism in Kakinada district.

S.No	Name	Village	Mandal
1	Beach & Beach Park Kakinada	Thammavaram	Kakinada (Rural)
2	Hope Island	Forest	Thallarevu
3	Lord Sringara Vallabha Swami Temple	Tirupati	Peddapuram
4	Maridamma Ammavari Temple	Peddapuram(U)	Peddapuram
5	Sri Bhavannarayana Swamy Temple	Sarpavaram	Kakinada (Rural)
6	Sri Chalukya Kumararama Bhimeswara Swamy Temple	Samalkota	Samalkota
7	Sri Kodanda Ramalya Swammy Temple	Kakinada	Kakinada (Fully Urban)
8	Sri Lakshmi Ganapathi Swammy Temple	Vakalapudi	Kakinada (Rural)
9	Sri Lakshmi Narasimha Swamy Vari Temple	Puttakonda	Pedapudi
10	Sri Puruhootika devi, sri Kukkuteshwara swamy, Sri Dattatreya Swamy, and Pada gaya	Pithapuram	Pithapuram
11	Sri Surya Narayana Murty Devasthanam Pandavulametta	Peddapuram	Peddapuram
12	Sri Veera Venkata Satya Narayana Swamy Vari Temple	Sankavaram	Annavaram
13	Uppada beach	Amaravalli	Kothapalle
14	Vinayaka Temple	Kakinada	Kakinada (Fully Urban)
15	Wild life Sanctuary forest department	Forest	Thallarevu
16	Zanddhani Sarees	Kothapalle	Kothapalle

Data Source: Tourism Department, Government of Andhra Pradesh.

A brief description of certain tourist places are given below:

1.6.3.1. Beach & Beach Park Kakinada: Beach is located approximately 8 km from the Kakinada town, the beach is a long stretch and can be accessed at various places. Kakinada beach is the most famous among the beaches here, and it has been recently developed with musical fountain, food courts, India's first glass bridge and a convention hall for official and private functions.

1.6.3.2. Hope Island: It is located in the Bay of Bengal, a short distance of 7 km out. It is a small tadpole shaped Island off the coast of Kakinada in Andhra Pradesh. It protects the city of Kakinada from the strong storm surges coming from the Bay of Bengal. Hope Island acts as a sort of natural break water and provides tranquillity to the ships anchored in Kakinada bay which makes Kakinada Port one of the safest natural ports in the Eastern coast of India. Visitors to hope Island will be presented with excellent views of the bay and the opportunity to explore the many protected species of plants and animals which grow and flourish there.

1.6.3.3. Lord Sringara Vallabha Swami Temple: It is located at Tirupati village in Peddapuram mandal, Kakinada district. It is situated about 28 km from Kakinada, 7 km from Peddapuram. Stone inscriptions can still be seen on the temples, indicating its uniqueness. It appears to the equal height of the viewer ie, for small children looks like of their height and elder people looks like of their height, Shankha and Chakra are altered positions in compared with Lord Balaji of Tirupati.

1.6.3.4. Maridamma Ammavari Temple: This temple located at Saravari street, Peddapuram mandal in Kakinada district. The Temple is dedicated to Goddess of Maridamma. It is located at a distance of 22 km from Kakinada, 45 km from Rajahmundry and 85 km from Amalapuram. Special jathara is celebrated for thirty one days from the Amavasya in the month of Jyeshtha to the Amavasya in the month of Ashadha, and also hosts dances like kolatam and displaying feats and skills with sticks.

1.6.3.5. Sri Bhavannarayana Swamy Temple: The temple is located at a distance of 5 km from Kakinada. The temple complex contains two lakes. The temple is surrounded by tall walls and is situated in the Sarpavaram village in Kakinada mandal. The story of sarpavaram is narrated in the Brahma Vyvarta Purana. The great saint Agastya narrated

this story to Saunaka and other saints of the Nymisha forest. The great saint Kashyapa married Kadru, to whom thousand serpents were born.

1.6.3.6. Sri Chalukya Kumararama Bhimeswara Swamy Temple: This temple is one of the five Pancharama Kshetras that are located in Samalkota of Kakinada district. It is located at a distance of 12 km from Kakinada and 52 km from Rajuhmundry. It is one of the centrally protected monument of national importance. The temple has a special Nandi idol and mounds Lord Shiva called Ekasila Nandi that is made up of a single stone. The temple main entrance of this temple called Surya Dwaram.

1.6.3.7. Sri Kodanda Ramalayam Swammy Temple: It is located at Gollala mamidada village in Kakinada district. The temple is dedicated to Rama, the seventh incarnation of Vishnu. It was built on the banks of Tulyabhaga (Antharvahini), a tributary of Godavari. This temple also known as Chinna Bhadradi or the Little Bhadrachalam.

Sri Lakshmi Ganapathi Swammy Temple: This temple is located at Vakalapudi village in Kakinada, and at a distance of 5 km from Kakinada.

1.6.3.8. Sri Lakshmi Narasimha Swamy Vari Temple: This temple is located at Puttakonda village, Pedapudi mandal in Kakinada district, and at a distance of 16 km from Kakinada. Zamindars of Peddapuram constructed a temple and gave land to Lord. It was once a small hillock by the side of which a small rivulet of the river Godavari flows. Lord Narasimha Swamy along with his consort Goddess Lakshmi adorns the place as their abode with the intention of blessings the people. It so happened that a great serpent chanced to see the lord and began to worship the lord with great devotion.

1.6.3.9. Sri Puruhootika Devi, Sri Kukkuteshwara Swamy, Sri Dattatreya Swamy, and Pada gaya: These temples are located in Pithapuram Mandal, Kakinada district. It is a temple complex of Sri Puruhootika devi, Sri Kukkuteswara swamy and sri dattatreya swamy. Pithapuram is the famous for the Ashta (Eighteen) Dasha Shakti Peethas. These temples are located at a distance of 16 km from Kakinda, 12 km from Samalkota and 2.5 km from Pithapuram railway station.

1.6.3.10. Sri Surya Narayana Murty Devasthanam Pandavulametta: The temple is located at Peddapuram, Kakinada

district, at distance of 22 km from Kakinada, 45 km from Rajahmundry and 85 km from Amalapuram. This temple is dedicated to God Son. The idol of Lord Sun faces the east and the rising sun from Bay of Bengal.

1.6.3.11. Sri Veera Venkata Satya Narayana Swamy Vari Temple: This temple is also known as Annavaram Temple. It is located at Annavaram town in Kakinada district. The temple is on a hillock named Ratnagiri and is dedicated to Veera Venkata Satyanarayana, an incarnation of Lord Vishnu.

1.6.3.12. Uppada beach: It is located at Amaravalli village, Kothapalli mandal of Kakinada district. It is located at a distance of 26 km from Kakinada. Uppada beach is a beautiful stretch of coastline located in the Kakinada district. The beach is known for its soft, golden sands and crystal-clear waters, making it a popular destination for sunbathing.

1.6.3.13. Vinayaka Temple: It is located at Kakinada mandal in Kakinada district. The main deity inside the temple is 7 feet tall. This temple is dedicated to Lord Vinayaka.

1.6.3.14. Wild life Sanctuary Forest Department: Coringa wildlife Sanctuary is an estuary situated near Thallarevu mandal in Kakinada district. It is located at a distance of 22 km from Kakinada and 10 km from Thallarevu. It is the third largest stretch of mangrove forests in India with 24 mangrove tree species and more than 120 bird species. It is home to the critically endangered White backed vulture and the long billed vulture.

1.6.3.15. Zanddhani Sarees: It is famous for beautiful designed silk sarees. Uppada well known for its traditional Jamdani/Uppada handlooms. Uppada handlooms are well known for its unique designs. Business listing of Uppada silk saree manufacturers, suppliers and exporters in Kakinada, along with their contact details & address.

1.7 Drainage Pattern

1.7.1 Drainage

The principal rivers flowing in the district are Godavari, Yeleru, Pampa, Thandava and Suddagedda. The Godavari river rises near Trimbakeshwar in the Nashik district of Maharashtra about 80 km from the Arabian Sea at an elevation of 1,067 m and The total length of Godavari from its origin to outfall into the Bay of Bengal is 1,465 km. It enters into the district near Pillanka village in Thallarevu mandal and flows towards south direction. The Godavari river bifurcates into Gautami Godavari and Vasishta Godavari rivers at Dawleswaram. The Gautami Godavari river flows towards south direction and joining into Bay of Bengal at Bhairavapalem, Tallarevu mandal in Kakinada district.

The Yeleru River rises near Puttakota RF, Koyyeru mandal in Alluri Sitharama Raju district and flows towards south direction and joining to the Bay of Bengal in Kakinada district. The Suddagedda River rises near Vatangi RF, Rajavommangi mandal in Alluri Sitharama Raju district and flows towards south east direction and joining to the Bay of Bengal near Kothapalle mandal, Kakinada district.

The Pampa River rises near Lododdi RF, Rajavommangi mandal in Alluri Sitharama Raju district and flows towards south east direction and joining to the Bay of Bengal near Payakaraopeta mandal in Anakapalli district. The Thandava river rises near Bointi RF, G K Veedhi mandal in Alluri Sitharama Raju district and flows towards south direction and joining to the Bay of Bengal near Pentakota village, Payakaraopeta mandal in Anakapalli district.

Four major drains are covered in the district, they are Tulyabhaga drain, Teki drain, Vajra Kaluva and Bikkavolu drain. Figure-14 illustrates the drainage system and the surface water bodies.

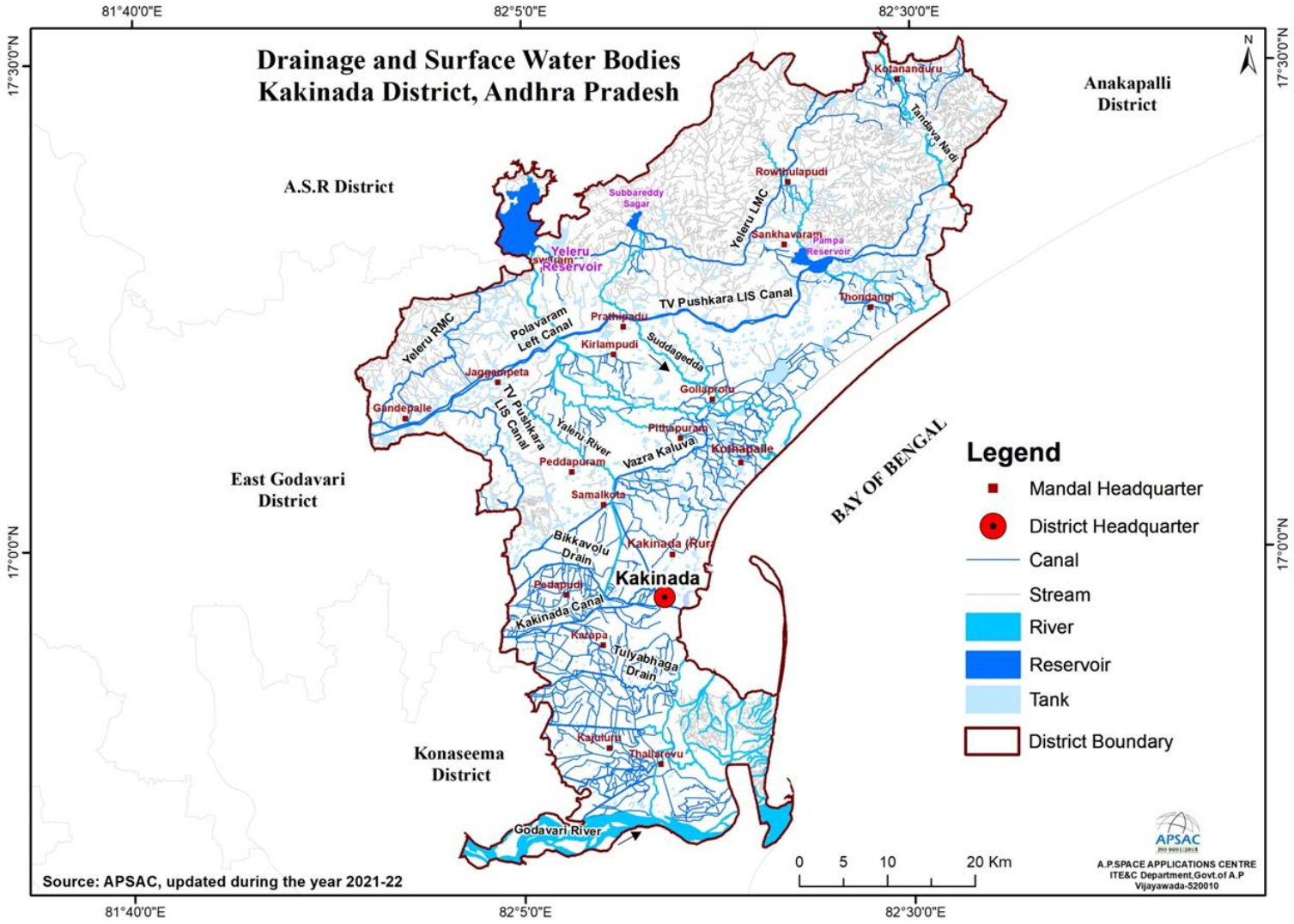

Figure - 14: Drainage Network and Surface Water Bodies of Kakinada District

1.7.2 Geomorphology of the District:

Geomorphologically, the district is divisible into (1) a low lying deltaic and coastal plain, having a gentle easterly slope in the south, (2) a sediplain region with mesas, structural hills, pediment, and piedmont complex, comprising valleyfins, taluscones, and fans in the middle and pediment *I* pediplain complex, with structural and denudational hills in the north. The deltaic plain shows a relief between 15m, at its apex to 2m, near the coast. The upland plain (plateau) of Rajahmundry Formation rises to a height of 45m to 70m, near Rajahmundy. The deltaic and coastal plains are characterised by landforms of both fluvial and marine regimes. Amongst the fluvial landforms, active channels (Gautami Godavari and Vasistha Godavari) with associated braided/ channel bars and levees form a part of the sub aerial top-set beds of the delta. Of all the levees, the one developed near Dowleswaram, 500m wide, and 2m high over the ambient flood plain is worth noting. Using IRS satellite data and GIS detailed geomorphological and structural map of Kakinada District was generated as per Rajiv Gandhi National Drinking Water Mission (RGNDWM) guidelines on a 1:50,000 scale. The objective of this mapping is to map lithology, geomorphology, and structural characteristics of an area on a 1:50,000 scale and to integrate the same to locate potential ground water prospect zones and to recommend suitable structures for groundwater recharge. Various hydrogeomorphic units are delineated and suitable recharge structures are proposed at drinking water affected villages under this project. Geomorphology map of Kakinada District is shown in Figure-15.

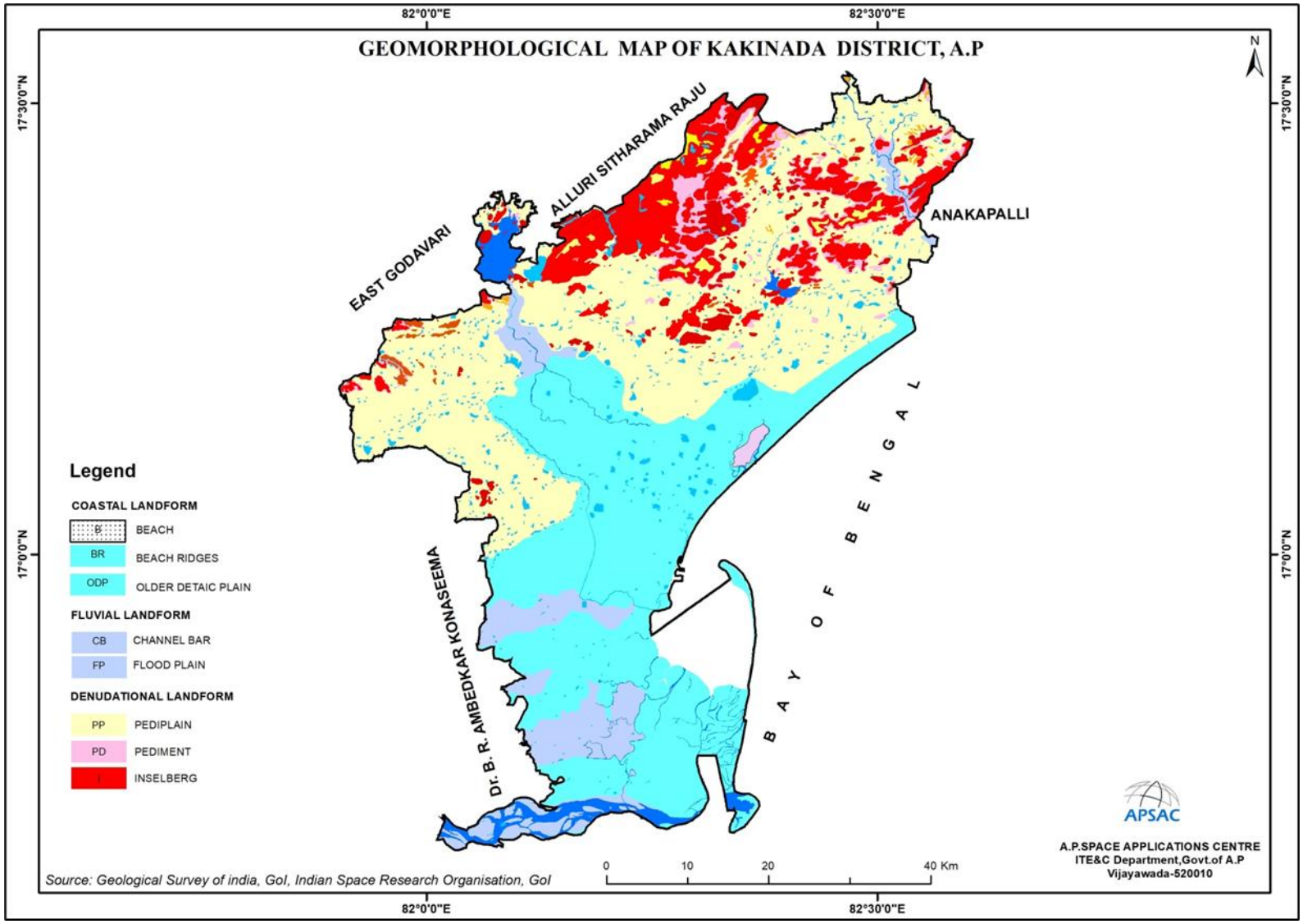

Figure-15: Geomorphology of Kakinada District, Andhra Pradesh

1.7.3 Landforms of Fluvial origin

The term "fluvial" is utilized in earth science to denote processes and landforms shaped by flowing water. Like other surface processes, flowing water can either erode material from the Earth's landscape or deposit layers of sediment. Consequently, resulting landforms can be categorized as either erosional or depositional. The remarkable power of flowing water in sculpting various landforms, both erosional and depositional, is widely recognized. Although the quantity of water in a stream may be small at certain times of the year, large volumes of water move through the channel, constituting a significant component of the hydrological cycle. Fluvial landscape dissection comprises valleys and their associated channel ways organized into a network known as a drainage system. Drainage systems exhibit numerous types of quantitative regularities that are valuable for analyzing both fluvial systems and the terrains they dissect (NRSA, 2007).

Floodplain: The surface or strip of relatively smooth land adjacent to a river channel, constructed (or in the process of being constructed) by the current river in its existing regimen. It becomes submerged when the river overflows its banks during periods of high water. Composed of alluvium carried by the river during floods, it is deposited in the slow-moving water beyond the influence of the swiftest currents.

Delta: A low, nearly flat, alluvial tract of land deposited near the mouth of a river. It commonly forms a triangular or fan-shaped plain of considerable area, intersected by many distributaries of the main river. Deltas often extend beyond the general trend of the coast, resulting from the accumulation of sediment supplied by a river in quantities that are not removed by tides, waves, and currents in the wider body of water, usually a sea.

1.7.4 Landforms of Coastal origins

Coasts are the focal points of a unique array of erosional and depositional processes. Various landforms found in coastal areas are primarily the result of ocean wave action. Wave activity creates some of the world’s most spectacular erosional landforms. Depositional landforms like beaches are formed where wave energy diminishes. Wave action serves as the primary source of energy for coastal erosion and sediment transport. A wave possesses potential energy due to its position above the wave trough and kinetic energy from water motion within the wave. This wave

energy is generated by the frictional effect of winds moving over the ocean surface. The higher the wind speed and the longer the fetch, or distance of open water across which the wind blows and waves travel, the larger the waves and the greater energy they possess. Long open ocean waves or swells travel faster than short, locally generated sea waves. They also have longer wave periods, distinguishing them from short sea waves upon reaching the coast. Long swells, which may travel hundreds of kilometers, can have wave periods of up to 20 seconds, while smaller sea waves typically have wave periods of 5 to 8 seconds. When ocean depths exceed the length of waves, wave motion does not extend to the ocean floor and remains unaffected. However, as the ocean depth falls below half the wavelength, the bottom increasingly affects wave motion. As water depth decreases, wave height increases rapidly and wavelength decreases, causing waves to become more peaked as they approach the shore and ultimately curl over as breakers, crashing onto the shore. As waves break, their potential energy is converted into kinetic energy, providing significant energy for shoreline work. Transportation by waves and currents is essential to move rock particles eroded from one part of a coastline to a deposition site elsewhere. One crucial transport mechanism is wave refraction. Since waves seldom break onto a shore at right angles, the upward movement of water onto the beach (swash) occurs at an oblique angle. Conversely, the return of water (backwash) is perpendicular to the beach, resulting in the lateral movement of beach material. This lateral movement, known as beach drift, is an endless cycle observed on all beaches. Frequently, backwash and rip currents fail to remove water from the shore zone as quickly as it is piled up by waves, resulting in a build-up of water and lateral movement of water and sediment just offshore in the direction of the waves. The currents produced by this lateral movement of water are known as longshore currents, while the movement of sediment is called longshore drift. This is distinct from beach drift, which operates on land at the beach. The combined movement of sediment via longshore drift and beach drift is known as littoral drift. Tidal currents along coasts can also effectively move eroded material. While incoming and outgoing tides produce currents in opposite directions daily, the current in one direction is usually stronger than the other, resulting in a net one-way transport of sediment. Longshore drift, longshore currents, and tidal currents collectively determine the net direction of sediment transport and deposition areas. The dynamics of the coast can be revealed using multi-temporal satellite data (NRSA, 2007).

1.7.4.1. Beach: A gently sloping zone, typically with a concave profile, of unconsolidated material that extends landward from the low-water line to the point where there is a definite change in material or physiographic form (such as a cliff) or to the line of permanent vegetation (usually marking the effective limit of the highest storm waves).

1.7.4.2. Beach ridge: A low, essentially continuous mound of beach or beach and dune material (sand, gravel, shingle) heaped up by the action of waves and currents on the backshore of a beach beyond the present limit of storm waves or the reach of ordinary tides. These ridges occur singly or as part of a series of approximately parallel deposits, roughly aligned with the shoreline, representing successive positions of an advancing shoreline.

1.7.4.3. Tidal flat: An extensive, nearly horizontal, marshy or barren tract of land that is alternately covered and uncovered by the rise and fall of the tide. It consists mainly of unconsolidated sediment (mostly mud and sand) and may form the upper surface of a deltaic deposit.

1.7.5 Landforms of Structural Origin

Landforms of structural origin are closely related to the structural aspects of the area. Most landforms within this category owe their genesis to the underlying geological structure. Structure plays a pivotal role in reducing the resistance of rock, leading to various geomorphic forms. These variations can range from minor to mega-scale. Mega-scale forms have a profound effect on landform genesis, and mapping such forms indirectly reveals the structural setup of the area. Mega-scale structural features like faults and folds, depending on their type, significantly influence the genesis of structural landforms. The influence of geologic structures on landscape development and appearance is significant. This influence spans from large features that exert a dominant impact on the entire landscape to small features that affect individual landforms and the geomorphic processes acting upon them. Structural control can be attributed to active structures, whose form directly influences the modern landscape, or ancient structural features, whose impact on a modern landscape is primarily due to differential erosion (NRSA, 2007).

1.7.5.1. Structural Hills: Hills and valleys originating from tectonic processes and extensively dissected by drainage lines. These can be further classified as highly, moderately, or lowly dissected based on the

density of joints and drainage. Interpretation of these features often relies on planimetric satellite data, and the classification is highly subjective.

1.7.6 Landforms of denudational origins

The landforms of denudational origin form where the denudation process predominates over other processes. Most landforms resulting from this process are the combined effect of mechanical and chemical weathering. Denudation, the process of material removal through erosion and weathering, has a direct influence on the relief of the area, particularly in reducing relief to the base level. The primary agents of denudation are water, ice, and wind. Major factors influencing denudation include geology, climate, tectonics, and anthropogenic effects. All rocks and minerals near the surface are subject to physical and chemical processes. However, the effect of these processes varies due to rocks' varying resistance to change. Consequently, weathering and erosion produce various landforms with distinct shapes and forms. Weathering is integral to the rock cycle. Parent material or weathered rock is disaggregated to form smaller fragments, and some minerals are dissolved and removed by agents such as water. This material removal, known as erosion, is accomplished by processes like running water, wind, and glaciers. Weathering provides the raw material for sedimentary rock and soil (NRSA, 2007).

1.7.6.1. Denudational Hill: A highly dissected hill where the structures have been obliterated.

1.7.6.2. Inselberg: A prominent, isolated, steep-sided, usually smoothed and rounded residual knob, hill, or small mountain of circumdenudation rising abruptly and surrounded by an extensive and nearly level, lowland erosion surface in a hot, dry region (such as in the deserts of southern Africa or Arabia). Generally bare and rocky, although partly buried by debris derived from and overlapping its slopes, it is characteristic of an arid or semiarid landscape in a late stage of the erosion cycle.

1.7.6.3. Pediment: A broad, flat or gently sloping, rock-floored erosion surface or plain of low relief, typically developed by subaerial agents (including running water) in an arid or semiarid region at the base of an abrupt and receding mountain front or plateau escarpment. Underlain by bedrock (occasionally by older alluvial deposits), it may be bare but more

often is partly mantled with a discontinuous veneer of alluvium derived from the upland masses and in transit across the surface.

1.7.6.4. Pediplain: An extensive, multi-concave, rock-cut erosion surface formed by the coalescence of two or more adjacent pediments and occasional desert domes, representing the result (the "peneplain") of the mature stage of the erosion cycle. Based on the thickness of weathering, they are further classified as shallow, moderate, and deep pediplains.

1.7.7 Structural Features of Kakinada District

Kakinada District comprises consolidated formations, including crystalline rocks such as Khondalites, Charnockites, and granitic gneisses, as well as meta-sediments like Leptinites, Migamatites, and Garnetiferous feldspathic gneisses from the Archaean and Pre-Cambrian periods, respectively. The Khondalite Group of rocks forms prominent hill ranges (strike ridges) south of Vijayawada, extending towards the north and northeast. These rocks exhibit foliation trending predominantly North-South, with occasional swerves to the Northeast-Southwest and Northwest-Southeast directions (GSI, 2000). The semi-consolidated formations in the region are represented by Tertiary formations, including Rajahmundry and Gollapalli sandstones, while unconsolidated formations consist of deltaic alluvial deposits from the Quaternary period (CGWB, 2013). The structural map of Kakinada District is illustrated in Figure-16.

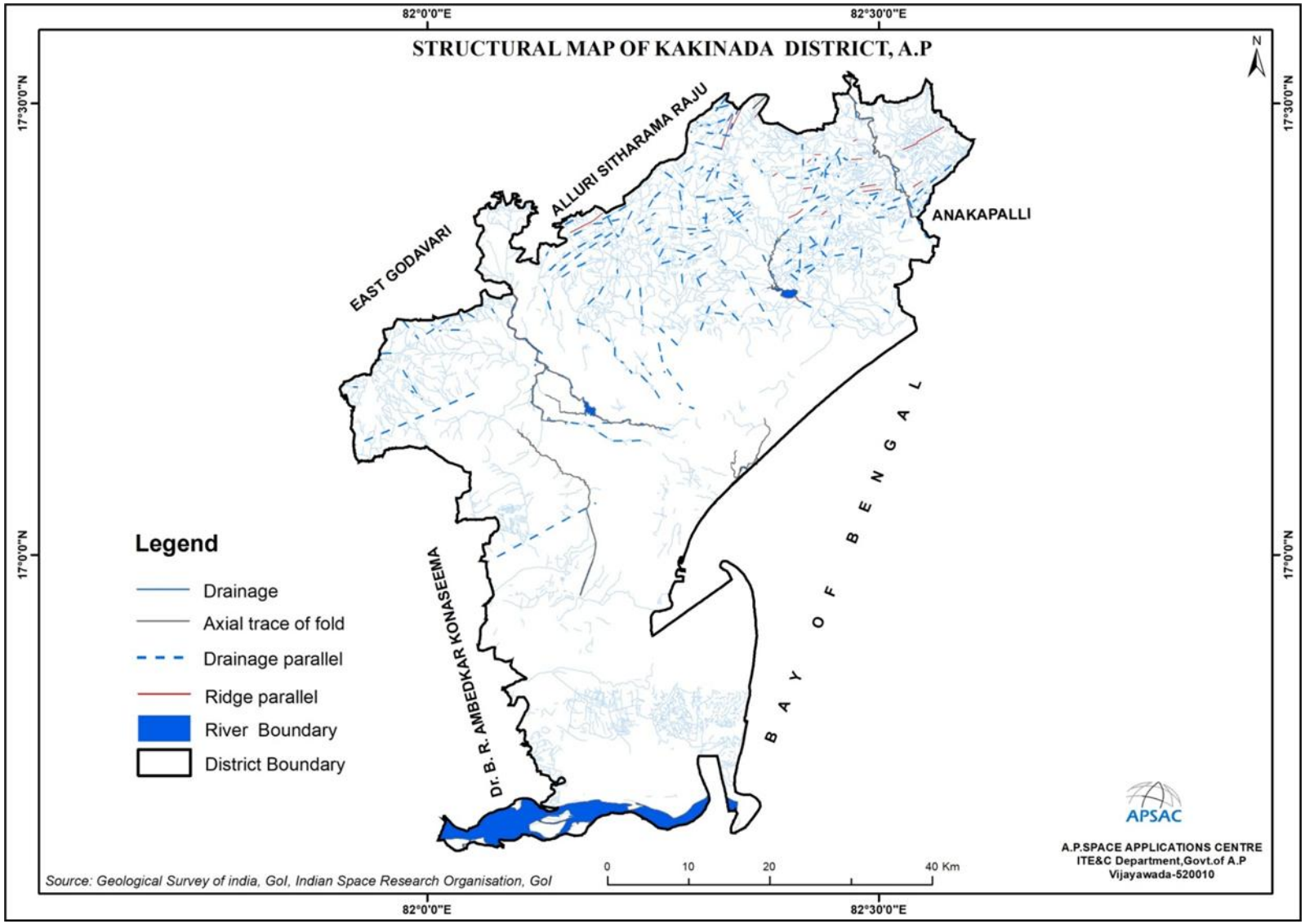

Figure-16 : Structural Map of Kakinada District, Andhra Pradesh

1.7.8 Ground Water Quality in Kakinada District

The Groundwater Quality Laboratory analyzed physicochemical parameters such as Total Dissolved Solids, Total Hardness, Chlorides, Nitrate, pH, Fluoride, Iron, Alkalinity, and Sulphate using standard techniques. Groundwater quality samples were collected for two seasons, i.e., post-monsoon and pre-monsoon, from the Rural Water Supply and Sanitation Department (RWS&S) between December 2017 and June 2019. These samples were then compared with the Bureau of Indian Standards (ISO, 2015) Groundwater Quality standards, classifying them into desirable, permissible, and non-potable classes. In the groundwater quality map of Kakinada district shown in Figure-17, blue, yellow, and red colors represent pre-monsoon quality, and +, -, symbols denote post-monsoon quality for desirable, permissible, and non-potable classes, respectively.

The analysis revealed that groundwater is polluted in both pre-monsoon and post-monsoon seasons, with approximately 40% of the area falling under the non-potable category due to high concentrations of Nitrate, Total Dissolved Solids, and Total Hardness. Additionally, around 30% of the area falls under the potable category, while the remaining 30% consists of hills and water bodies in the district. The occurrence and movement of groundwater in an area are influenced by various factors such as topography, lithology, geological structure, depth of weathering, drainage patterns, climate conditions, and the interrelationship between these factors.

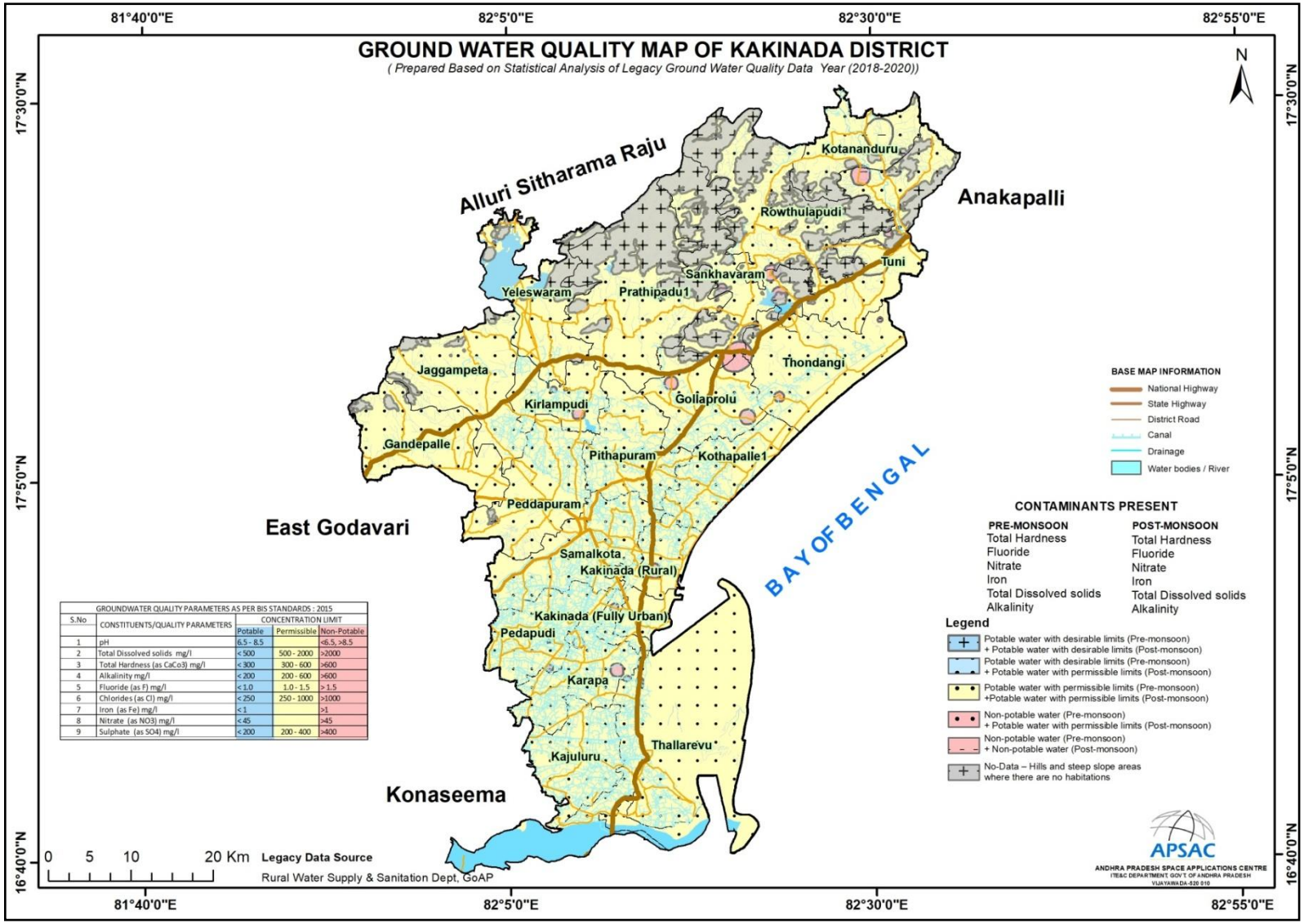

Figure-17: Ground Water Quality Map of Kakinada District

Chapter – II Minor Minerals

2.1 Overview of Mining Activity

The following leases exist in this Kakinada office jurisdiction. Mineral Regulatory, the important functioning of Mines and Geology department in these aspects are: -

2.1.1. Achievement of Targets of Mineral Revenue collections being fixed to this office annually

2.1.2. Receiving and processing of the Mineral Concession Applications duly conducting the technical inspection, Survey and demarcation of the Mineral bearing applied areas in Patta lands.

2.1.3. Identification of mineral bearing areas to prepare E-blocks and to send proposals to the DMG for conducting E-auctioon of block through e.procuremet portal of A.P. for allotment of block to the successful bidder.

2.1.4. Execution and Regulation of the operations of the Mining / Quarry leases in accordance with the Acts and Rules

Issuing of dispatch permits duly collecting the Advance Royalty / Seig.fee from the lease holders on the minerals produced and intend to dispatch from their leased areas through online permit system.

2.1.5. Collection of Monthly revenue from Seignorage fee, Consideration fee, collection (SCC) contractors and collection of monthly return from the SCC contractor.

Controlling the illegal Mining / Quarrying and transportation by conducting the periodical inspections of the Mines and Quarries and also conducting the surprise vehicular checking and imposing the penalties

2.1.6. Finalisation of Demand, Collection and Balance statements of the leases on annual basis

Kakinada District is one of the chief minor minerals producing districts in the state and endowed with rich & varied minor mineral resources such as china clay, fire clay, laterite, gravel, road metal and ordinary earth.

It is estimated that during the year 2022-23, 17,372 MT of China Clay, 92,920MT of Laterite are produced.

2.2 Geology of the District

Genaralized Litho-stratigraphic Succession of Andhra Pradesh

Geological Time (a)	Supergroup (b)	Group (c)	Formation (d)
Holocene	-	-	Alluvium, river terraces, beach sands and soils
Pleistocene	-	-	Laterite and Gravel
Mio-Pilocene	-	-	Rajahmundry Fm.
Late Cretaceous Eocene	-	-	Deccan Trap with infra-and inter-trappeans
Lower Cretaceous to Upper Carboniferous	Gondwana	Upper Gondwana	Godavari Valley (Fluviatile) Chikiala Fm. Gangapur Fm.
			Coastal Area (Fluvio-marine) Tirupati Fm. (Vejendla Fm) Raghavapuram Fm. (Vemavaram), Kandukuru, Sriperambadur Fms)
		Lower Gondwana	Kota Fm. Maleri Fm.
			Gollapalle Fm. (Satyavedu Fm.) Kamthi Fm. Barren Measures, Barakar Fm. Talchir Fm.
			Cuddapah Basin **Pakhal Basin** Sullavai Sandstone
Middle to Upper Proterzoic (980-500 m.y)	Kurnool		Nandyala Shale Koilakuntla Limestone Panyam Quarzite Owk Shale Narji Limestone Banaganapalli Quartzite
			Putnur Limestone Penganga Group Takalapalle Arkose

			Srisailam Quartzite	**Alabaka Sandstone**
		Nallamalai	Cumbum Fm.	Lankavaram Shale Pattipalle Quartzite
			Mulug Group	Polavaram Fm. Jakaram Arkose
Middle Proterozoic (1600-1300 m.y.)	Cuddapah	Chitravathi	Bairankonda Quartzite Gandikota Quartzite	Pandikunta Shale
			Tadipatri Fm.	Gunjeda Dolomite
			Pulivendula Quartzite Mallampalli Group	
		Papaghni	Vempalle Fm. Gulcheru Quartzite	Bayyaram Quartzite Bolapalle Fm.

EPARCHAEAN INTERVAL

Middle Proterozoic to Late Archean (2600-970 m.y)	Eastern Ghats		Charnockite	Charnockite with megacrystic k-feldspar charnockite
			Khondalites	Two pyrozene granulite / amphibolite
				Calc-silicate / granulite, Garnet-sillimanite-quartz-graphite gneiss (biotite-k-feldspar (Khondalite)
				Quartzite (gernet, sillimanite)
Late Archaean (2700 m.y)	Dharwar	Ramagiri-Penakacherla, Kolar, Kadiri, Gadwal-Narayanpet, Jonnagiri, Veligallu Peddavuru Schist Belts & W.Part of		Pyroclastic Rocks, local conglomerate / event conglomerate Metabasalt (Pillowed), Acid volcanics, minor andesite, dacite, rhyodacite, amphibolites, metaultramafics, minor quartzite, calcsilicates, phyllites, intrusives of basic

		Nellore Belt.	rocks and granites, rare lamprophyres.
Middle Archaean (3100-2900 y.m)	Older Supracrustals (Sargur)	Eastern and Southern parts of Nellore.	High Grade schists include include garnet, staurolite, kyanite, sillimanite, cordierite (rarely sapphirine-kornuropine as in Karimnagar) Mica schists, calcilicate rocks, crystalline limestone (minor). BIF, fuchsite quartzite, hornblende granulite, amphibolite, migmatite streaky biotite gneiss.
Gneissic Complex			Banded Tonalite-Trondhjemite Gneiss.

Geologically, the State of Andhra Pradesh form part of peninsular India and is one of the oldest land masses. The geological formations in Andhra Pradesh range from the oldest to the most recent.

The Sargur Supracrustals are the oldest rocks in Southern India, mainly present as enclaves within the migmatitic gneiss. These supracrustals are exposed in the eastern and southern parts of the Nellore schist belt. The lithology of Sargur mainly comprises garnet, staurolite, kyanite schists, BIFs, quartzites, granulites, and amphibolites. The gneissic complex consists of banded tonalite trondhjemite gneiss, which forms the basement rock of the study area along with migmatitic gneiss and biotite granite gneiss. TTGs are sodic, quartz-bearing granitic (plutonic) rocks with plagioclase as the most common feldspar and K-feldspar ranging from subordinate to nearly absent.

The Dharwarian rocks in Andhra Pradesh are exposed in the western part of the Nellore belt and in other areas like Anantapur, Ramagiri-Penakacherla, Kolar, Kadiri, Gadwal-Narayanpet, Jonnagiri, Veligallu Peddavuru Schist Belts, and the western part of the Nellore Belt. The lithology mainly comprises Metabasalt (Pillowed), Acid volcanics, minor andesite, dacite, rhyodacite, amphibolites, meta-ultramafics, minor quartzite, calcsilicates, phyllites, intrusives of basic rocks and granites, rare lamprophyres, as well as some Pyroclastic Rocks and local

conglomerates/event conglomerates defining hiatus in stratigraphy. Rocks from the middle Proterozoic to late Archaean are exposed in the Eastern Ghats mobile belt, characterized by extremely high grade metamorphism falling under granulite facies. They mostly include Khondalites and Charnockites.

The Cuddapah basin, part of the Dharwar craton, is the second-largest purana basin of Peninsular India. It marks the profound unconformity Eparchaen unconformity in early literature. The basin is divided into four groups: Nallamalai, Chitravathi, Papaghni, and Kurnool. Papaghni comprises dolomite and limestones, Chitravathi comprises shale, dolomite, and quartzites, Nallamalai comprises shale, quartzites, and arkosic sandstones, while Kurnool comprises shales, quartzites, and limestones. The Cuddapah basin is characterized by a rhythmic pattern of quartzite-shale-carbonate cycles, with reports of Uraniferous limestone. Major exposures of purana rock formations are found in Prakasam, Kurnool, Cuddapah, Chittoor, and Nellore. The Deccan traps are located in the East and West Godavari districts, with exposures near Rajahmundry. Outcrops of Tertiary formations are found in East and West Godavari and Visakhapatnam districts, while Quaternary sediments occur as thick blankets of alluvium in river valleys, deltas, and along the East coast.

2.3 Minor Mineral Resources of Kakinada District:

The following minerals are available in Kakinada District.

2.3.1. China Clay: Clay is a natural mineral substance consisting essentially of hydrated silicates and alumina which is plastic when sufficiently fine-grained and wet, rigid when dry and vitrifying when fired at a sufficiently high temperature. China clay is used in ceramics, textile and paper coating, rubber and in insecticide. It is found in Peddapuram, Pearai Ramchandrapuram.

2.3.2. Road Metal: The Road metal is used for the construction or repair of roads or railways. The mineral is available in Rowtulapudi, Prathipadu, Yeleswaram, Kotananduru and Sankavaram.

2.3.3. Gravel: The Gravel is used for formation of kacha roads and filling Low level areas and is found in Gandepalli, Peddapuram and Gollaprolu.

2.3.4. Fire Clay: It is a name given to a group of refractory clays which can stand temperatures above PCE 18. Refractories and plasticity are the two main properties needed in Fire Clay for its suitability in the manufacture of refractory bricks. It is mainly consumed in refractory industries. It is found in Gandepalli, Peddapuram and Jaggampeta

2.3.5. Laterite: Cement grade Laterite used in Cement industries and Metallugical grade Laterite used in Alumina Industries for blending purpose with Bauxite Mineral. Further Used to cover walls, as roofing tiles, as flooring, and stair steps is available in Prathipadu and Sankavaran.

2.3.6. Ordinary Earth: It is found in Gandepalli, Peddapuram and Gollaprolu.

The minerals are in the districts is shown in Figure-18.

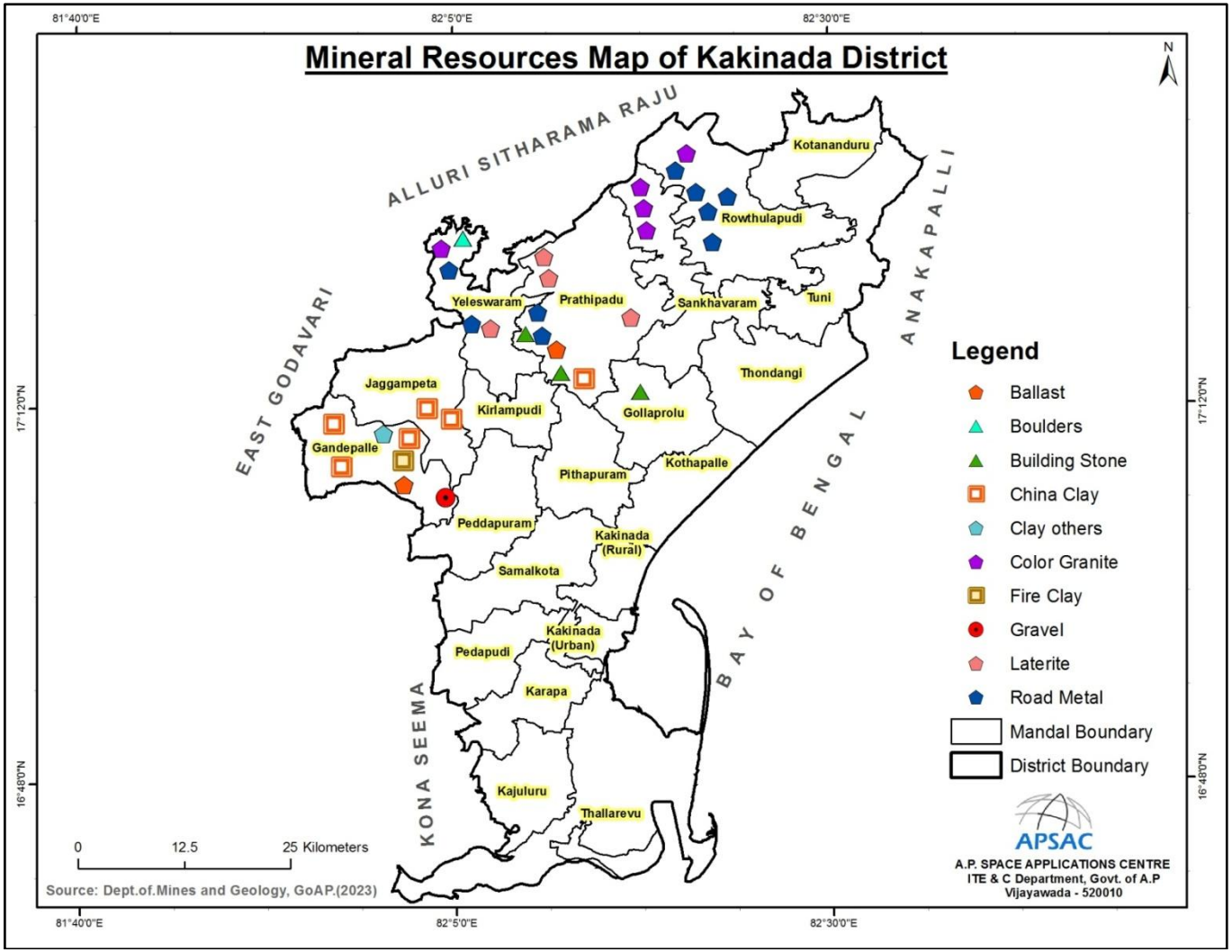

Figure- 18 Mineral resource map of Kakinada District, Andhra Pradesh

The Detailed List of statement showing the Leases wise for Minor Minerals during the period described in Table-14.

Table 14 The List of Minor Mineral Leases in Kakinada District

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
ROWTHULAPUDI MANDAL								
1	Road Metal	Rowthulapudi	Uppampalem	261	6	Working	$17^0 23^1 05.13921^{11}$N	$82^0 20^1 23.96320^{11}$E
2	Road Metal	Rowthulapudi	Mulagapudi	1	1.5	Working	$17^0 24^1 51.01344^{11}$N	$82^0 21^1 55.57598^{11}$E
3	Road Metal	Rowthulapudi	Mulagapudi	1	50	Working	$17^0 25^1 13.92034^{11}$N	$82^0 21^1 31.27045^{11}$E
4	Road Metal	Rowthulapudi	Tirupatammapeta	90	3	Working	$17^0 25^1 05.20^{11}$N	$82^0 21^1 32.98^{11}$E
5	Road Metal	Rowthulapudi	Jaldam	44	4.5	Working	$17^0 26^1 45.87358^{11}$N	$82^0 20^1 19.40772^{11}$E
6	Road Metal	Rowthulapudi	Mulagapudi	1	2	Working	$17^0 25^1 33.25^{11}$N	$82^0 21^1 26.17^{11}$E
7	Road Metal	Rowthulapudi	Tirupatammapeta	90	1.5	Working	$17^0 24^1 43.33^{11}$N	$82^0 21^1 55.69^{11}$E
8	Road Metal	Rowthulapudi	Tirupatammapeta	90	1.319	Working	$17^0 24^1 48.4286^{11}$N	$82^0 21^1 22.4766^{11}$E
9	Road Metal	Rowthulapudi	Mulagapudi	1	2.95	Working	$17^0 25^1 2.7079^{11}$N	$82^0 21^1 44.4536^{11}$E
10	Road Metal	Rowthulapudi	Tirupatammapeta	90	0.717	Working	$17^0 24^1 41.26184^{11}$N	$82^0 21^1 26.90925^{11}$E
11	Road Metal	Rowthulapudi	Tirupatammapeta	90	2.013	Working	$17^0 19^1 05.49067^{11}$N	$82^0 09^1 41.87580^{11}$E
12	Road Metal & Boulders	Rowthulapudi	S.Pydipala	15	4.032	Working	$17^0 24^1 45.04280^{11}$N	$82^0 21^1 15.25363^{11}$E
13	Road Metal & Boulders	Rowthulapudi	Mulagapudi	1	1.955	Working	$17^0 24^1 57.87911^{11}$N	$82^0 21^1 43.80047^{11}$E
14	Road Metal	Rowthulapudi	Mulagapudi	1	1	Non Working	No Cordinates	
15	Road Metal	Rowthulapudi	S. pydipala	15	2.12	Non Working	$17^0 25^1 20.27006^{11}$N	$82^0 21^1 12.07559^{11}$E
16	Road Metal	Rowthulapudi	S. pydipala	15	0.7	Non Working	$17^0 25^1 19.44831^{11}$N	$82^0 21^1 12.63019^{11}$E
17	Road Metal	Rowthulapudi	S. pydipala	15	1.2	Non Working	$17^0 25^1 18.09202^{11}$N	$82^0 21^1 13.54758^{11}$E
18	Road Metal	Rowthulapudi	S. pydipala	15	0.85	Non Working	$17^0 25^1 10.33^{11}$N	$82^0 20^1 59.16^{11}$E
19	Road Metal	Rowthulapudi	Tirupatammapeta	90	0.5	Non Working	$17^0 24^1 45.17092^{11}$N	$82^0 21^1 31.31097^{11}$E

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
20	Road Metal	Rowthulapudi	China mallapuram	1	18	Non Working	No Cordinates	
21	Road Metal	Rowthulapudi	S. pydipala	15	0.5	Non Working	No Cordinates	
22	Road Metal	Rowthulapudi	Tirupatammapeta	90	0.4	Non Working	No Cordinates	
23	Road Metal	Rowthulapudi	Tirupatammapeta	90	0.8	Non Working	$17^0 24^1 33.43576^{11}$N	$82^0 21^1 27.28555^{11}$E
24	Road Metal	Rowthulapudi	Tirupatammapeta	90	0.4	Non Working	No Cordinates	
25	Road Metal	Rowthulapudi	Uppampalem	261	4	Non Working	No Cordinates	
26	Road Metal	Rowthulapudi	S. pydipala	15	1.5	Non Working	$17^0 24^1 37.14197^{11}$N	$82^0 21^1 20.93413^{11}$E
27	Road Metal	Rowthulapudi	Tirupatammapeta	90	1.5	Non Working	$17^0 24^1 41.39217^{11}$N	$82^0 21^1 28.95913^{11}$E
28	Road Metal	Rowthulapudi	Tirupatammapeta	90	1	Non Working	$17^0 24^1 52.19349^{11}$N	$82^0 21^1 29.20053^{11}$E
29	Road Metal	Rowthulapudi	Tirupatammapeta	90	1	Non Working	$17^0 24^1 55.78159^{11}$N	$82^0 21^1 30.46964^{11}$E
30	Road Metal	Rowthulapudi	Mulagapudi	1	1	Non Working	$17^0 25^1 15.13330^{11}$N	$82^0 21^1 43.59857^{11}$E
31	Colour Granite (Others)	Rowthulapudi	Raghavapatnam	135	4.6	Non Working	$17^0 27^1 31.50^{11}$N	$82^0 20^1 41.30^{11}$E
32	Road Metal	Rowthulapudi	Uppampalem	261	4	Non Working	$17^0 23^1 21.44^{11}$N	$82^0 20^1 13.60^{11}$E
YELESWARAM MANDAL								
33	Boulders,Gravel,Ordinary Earth,Road Metal	Yeleswaram	J. annavaram	297	4.164	Working	$17^0 22^1 3.8833^{11}$N	$82^0 2^1 36.5905^{11}$E
34	Boulders,Gravel,Ordinary Earth,Road Metal	Yeleswaram	J. annavaram	297	1.277	Working	$17^0 22^1 4.3098^{11}$N	$82^0 6^1 29.4892^{11}$E

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
35	Laterite (Cement),Laterite (Metallugical Grade)	Yeleswaram	Lingamparthi	589	10	Working	$17^{0}19^{1}05.49067^{11}$N	$82^{0}09^{1}41.87580^{11}$E
36	Laterite (Cement),Laterite (Metallugical Grade)	Yeleswaram	Lingamparthi	589	10	Working	$17^{0}19^{1}06.60132^{11}$N	$82^{0}09^{1}50.98344^{11}$E
37	Road Metal	Yeleswaram	J. annavaram	297	1.629	Working	$17^{0}22^{1}18.7615^{11}$N	$82^{0}6^{1}28.0274^{11}$E
38	Road Metal	Yeleswaram	J. annavaram	297	3	Working		
39	Road Metal	Yeleswaram	J. annavaram	297	1.426	Working	$17^{0}21^{1}56.87210^{11}$N	$82^{0}6^{1}15.16458^{11}$E
40	Road Metal	Yeleswaram	J. annavaram	297	3.55	Working	$17^{0}22^{1}08.11262^{11}$N	$82^{0}6^{1}21.99169^{11}$E
41	Road Metal	Yeleswraram	J.Annavram	297	0.9	Working	$17^{0}22^{1}13.227^{11}$N	$82^{0}6^{1}27.3627^{11}$E
42	Color Granite-Leptinites,Colour Granite (Others)	Yeleswaram	Marriveedu	229	5	Non Working	$17^{0}21^{1}50.2992^{11}$N	$82^{0}4^{1}13.5440^{11}$E
43	Road Metal	Yeleswaram	J. annavaram	297	2	Non Working	No Geocordinates	
44	Road Metal	Yeleswaram	J. annavaram	297	1	Non Working	No Geocordinates	
45	Road Metal	Yeleswaram	J. annavaram	297	2	Non Working	$17^{0}22^{1}10.7463^{11}$N	$82^{0}6^{1}17.7032^{11}$E
46	Road Metal	Yeleswaram	J. annavaram	297	1.214	Non Working		
47	Road Metal	Yeleswaram	J. annavaram	297	4	Non Working	No Geocordinates	
48	Road Metal	Yeleswaram	Yeleswaram	297	3	Non Working	$17^{0}22^{1}14.2236^{11}$N	$82^{0}6^{1}27.8863^{11}$E
49	Road Metal	Yeleswaram	J. annavaram	297	0.81	Non Working	$17^{0}21^{1}50.5978^{11}$N	$82^{0}6^{1}14.6084^{11}$E
50	Road Metal	Yeleswaram	J. annavaram	297	0.64	Non Working	$17^{0}21^{1}59.7042^{11}$N	$82^{0}6^{1}16.9677^{11}$E
51	Road Metal	Yeleswaram	J. annavaram	297	0.6	Non Working	$17^{0}22^{1}06.4123^{11}$N	$82^{0}6^{1}16.9225^{11}$E
52	Road Metal	Yeleswaram	J. annavaram	297	3	Non Working		
53	Road Metal	Yeleswaram	Yeleswaram	54	1	Non	No Geocordinates	

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
						Working		
54	Road Metal	Yeleswaram	Yeleswaram	54	2.359	Non Working	No Geocordinates	
55	Road Metal	Yeleswaram	J. annavaram	54	0.5	Non Working	No Geocordinates	
56	Road Metal	Yeleswaram	Yeleswaram	54	0.7	Non Working	No Geocordinates	
57	Road Metal	Yeleswaram	Yeleswaram	54	0.5	Non Working	No Geocordinates	
58	Road Metal	Yeleswaram	Yeleswaram	54	0.849	Non Working	No Geocordinates	
59	Road Metal	Yeleswaram	Lingamparthi	1	4	Non Working	17°19'23.72214"N	82°07'11.94985"E
60	Road Metal	Yeleswaram	J. annavaram	297	0.461	Non Working	$17^{0}21^{1}48.6382^{11}$N	$82^{0}6^{1}27.3627^{11}$E
61	Road Metal	Yeleswaram	J. annavaram	313	5	Non Working	$17^{0}27^{1}7.37^{11}$N	$82^{0}5^{1}50.75^{11}$E
62	Road Metal	Yeleswaram	Yeleswaram		0.283	Non Working	No Geocordinates	

PRATHIPADU MANDAL

63	Ballast,Boulders,Building Stone,Ordinary Earth,Road Metal	Prathipadu	China sankarlapudi	53	4.97	Working	$17^{0}17^{1}.24.47^{11}$N	$82^{0}09^{1}39.25^{11}$E
64	China Clay (Crude)	Prathipadu	Dharmavaram	419	1.597	Working	$17^{0}13^{1}13.24629^{11}$N	$82^{0}13^{1}43.04963^{11}$E
65	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Chintaluru	1	36.669	Working	$17^{0}18^{1}41.93^{11}$N	$82^{0}17^{1}09.15^{11}$E
66	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Girijanapuram	703	10	Working	N 17.32728^{0}	E.82.17445^{0}
67	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Girijanapuram	703	10	Working	$17^{0}19^{1}25.52992^{11}$N	$82^{0}09^{1}55.81022^{11}$E
68	Laterite (Cement),Laterite	Prathipadu	Girijanapuram	703,589	10	Working	$17^{0}19^{1}18.42367^{11}$N	$82^{0}09^{1}46.07632^{11}$E

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
	(Metallugical Grade)							
69	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Girijanapuram	703	10	Working	$17^0 19^1 32.04889^{11}$N	$82^0 10^1 11.50771^{11}$E
70	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Girijanapuram	703,589	10	Working	$17^0 19^1 16.68921^{11}$N	$82^0 09^1 37.74208^{11}$E
71	Road Metal	Prathipadu	Peda sankarlapudi	160/1	4.754	Working	$17^0 17^1 44.06^{11}$N	$82^0 10^1 10.65^{11}$E
72	Building Stone,Gravel	Prathipadu	Prathipadu	80	3	Non Working	$17^0 17^1 36.02857^{11}$N	$82^0 09^1 57.45516^{11}$E
73	Building Stone,Gravel,Road Metal	Prathipadu	China sankarlapudi	53	0.809	Non Working	$17^0 17^1 36.02857^{11}$N	$82^0 09^1 57.45516^{11}$E
74	Laterite (Cement),Laterite (Metallugical Grade)	Prathipadu	Vanthada	7/1,7/2,10/P,11/P,12/P,16,17/P	10.417	Non Working	$17^0 20^1 09.73642^{11}$N	$82^0 09^1 56.29292^{11}$E
75	Laterite (Metallugical Grade)	Prathipadu	Vanthada	9/1,9/3,26/1,27/2	4.447	Non Working	$17^0 19^1 01.20^{11}$N	$82^0 09^1 05.90^{11}$E
76	Road Metal	Prathipadu	Peda sankarlapudi	160	1.25	Non Working	$17^0 17^1 40.96066^{11}$N	$82^0 10^1 06.97833^{11}$E
77	Road Metal	Prathipadu	China sankarlapudi	53	0.809	Non Working	$17^0 17^1 37.69922^{11}$N	$82^0 10^1 04.61970^{11}$E
78	Road Metal	Prathipadu	China sankarlapudi	53	1.902	Non Working	$17^0 17^1 18.24238^{11}$N	$82^0 09^1 44.43408^{11}$E
79	Road Metal	Prathipadu	China sankarlapudi	53	0.404	Non Working	$17^0 17^1 27.51316^{11}$N	$82^0 09^1 42.13029^{11}$E
80	Road Metal	Prathipadu	China sankarlapudi	53	0.09	Non Working	$17^0 17^1 25.60782^{11}$N	$82^0 09^1 46.00796^{11}$E
81	Road Metal	Prathipadu	China sankarlapudi	53	0.87	Non Working	$17^0 17^1 38.79013^{11}$N	$82^0 09^1 51.71975^{11}$E

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
82	Road Metal	Prathipadu	Peda sankarlapudi	160	0.809	Non Working	$17^{0}17^{1}40.52110^{11}$N	$82^{0}10^{1}09.31227^{11}$E
83	Road Metal	Prathipadu	China sankarlapudi	53	0.75	Non Working	$17^{0}17^{1}34.77^{11}$N	$82^{0}9^{1}54.57^{11}$E
SHANKAVARAM MANDAL								
84	Color Granite-Leptinites	Sankhavaram	Polavaram	61/4	1.983	Working	$17^{0}24^{1}35.30^{11}$N	$82^{0}17^{1}33.00^{11}$E
85	Colour Granite (Others)	Sankhavaram	Polavaram	66	4.421	Working		
86	Colour Granite (Others)	Sankhavaram	Pedamallapuram	73	0.875	Working	$17^{0}24^{1}19.35^{11}$N	$82^{0}17^{1}29.83^{11}$E
GANDEPALLI MANDAL								
87	China Clay (Crude)	Gandepalle	Zamindar ragampeta	20/1,2&25/2	2.063	Working	$17^{0}10^{1}47.25^{11}$N	$82^{0}01^{1}24.97^{11}$E
88	China Clay (Crude)	Gandepalle	Zamindar ragampeta	21/1	1.01	Working	$17^{0}11^{1}00.90^{11}$N	$82^{0}01^{1}17.10^{11}$E
89	China Clay (Crude)	Gandepalle	Neeladriraopeta	23/2P,24/2P	1.033	Working	$17^{0}10^{1}57.20^{11}$N	$82^{0}01^{1}14.20^{11}$E
90	China Clay (Crude),China Clay (Processed),China Clay (Washed)	Gandepalle	Zamindar ragampeta	21/2,22/1 22/2	2.412	Working	$17^{0}11^{1}02.40^{11}$N	$82^{0}01^{1}16.88^{11}$E
91	Clay others	Gandepalle	Zamindar ragampeta	17/1,17/1A,17/1B,17/1C,17/1D,1	2.55	Working	$17^{0}10^{1}53.90^{11}$N	$82^{0}01^{1}35.91^{11}$E
92	Fire Clay	Gandepalle	Zamindar ragampeta	20/2p,25/2p	1.926	Working	$17^{0}10^{1}52.93409^{11}$N	$82^{0}01^{1}28.36234^{11}$E
93	Fire Clay	Gandepalle	Zamindar ragampeta	63/3B	0.729	Working	$17^{0}10^{1}47.7322^{11}$N	$82^{0}01^{1}29.5227^{11}$E

S.No	Mineral	Mandal	Village	Sy.No	Extent	STATUS	LATITUDE	LONGITUDE
94	Ballast,Boulders,Ordinary Earth,Road Metal	Gandepalle	Yellamilli	79/P,2P,3 P 4P	5.75	Non Working	$17^{0}7^{1}45.3408^{11}$N	$82^{0}2^{1}03.8504^{11}$E
			GOLLAPROLU MANDAL					
95	Building Stone,Gravel	Gollaprolu	Chendurthi	4/1&4/2	2.092	Working	$17^{0}14^{1}19.48145^{11}$N	$82^{0}17^{1}03.22020^{11}$E
96	Gravel	Gollaprolu	Kodavali	133/1		Working	$17^{0}14^{1}46.20997^{11}$N	$82^{0}15^{1}.58.16239^{11}$E
97	Gravel	Gollaprolu	Kodavali	133/1	4.52	Working	$17^{0}14^{1}37.18000^{11}$N	$82^{0}15^{1}.56.76000^{11}$E
98	Gravel	Gollaprolu	Kodavali	133/1	3	Working	$17^{0}14^{1}49.43598^{11}$N	$82^{0}15^{1}.57.95357^{11}$E
			Jaggampeta Mandal					
99	China Clay (Crude)	Jaggampeta	Ramavaram	21	2.023	Non Working		
100	China Clay (Crude)	Jaggampeta	Jaggampeta	144/A	1.012	Working	$17^{0}11^{1}05.28589^{11}$N	$82^{0}3^{1}08.53444^{11}$E
101	China Clay (Crude)	Jaggampeta	Ramavaram	21/1, 22/1&2	2.298	Working	$17^{0}11^{1}45.9040^{11}$N	$82^{0}4^{1}00.3477^{11}$E
102	China Clay (Crude)	Jaggampeta	Jaggampeta	102/3	2.023	Working	$17^{0}11^{1}57.10^{11}$N	$82^{0}03^{1}20.10^{11}$E

Data Source: Assistant Director of Mines and Geology, Kakinada District, Andhra Pradesh

The Details of statement showing the letter of intent (LoI) in the district is showing in Table-15.

Table 15: The list of the letter of intent (LoI) in the District

S.NO	Name of the Mineral	Name of the Lessee	Address & Contact No. of Letter of Intent Holder	Letter of Intent Grant order No. & Date	Area of Mining lease to be allotted				Validity of LoI	Use (Captive/ Non-captive)	Location of the Mining lease (Latitude & Longitude)
					Sy.No.	Village	Mandal	Extent			
1	Laterite	Smt. Andru Anantha Padma Koti Satyavathi	W/o Krishna Rao, D.No.3-15, Gowripatnam Village,Devarapalli Mandal,west Godavari District	9890/R2-1/2017, dt.11/07/2017	289/1	Mandapam	Sankavaram	22.00	dt:10.07.2018	Non-captive	17^{0}19'50.0"N & 82^{0}25'05.6"E 17^{0}19'46.44"N & 82^{0}24'49.10"E
2	Laterite	Smt. Andru Usha Rani	D.No.3-15, Gowripatnam Village,Devarapalli Mandal,west Godavari District. Cell No.91 8790626599	9891/R2-1/2017, dt.11/07/2017	289/1	Mandapam	Sankavaram	18.00	dt:10.01.2018	Non-captive	17^{0}20'07.3"N & 82^{0}25'02.5"E 17^{0}20'06.93"N & 82^{0}25'01.77"E
3	Laterite	Sri Andru Srinivas	S/o Krishna Rao, D.No.3-15, Gowripatnam Village, Devarapalli Mandal, West Godavari District, Cell No.9440837599	9892/R2-1/2017, dt.11/07/2017	38/P	Billawaka	Rowthulapudi	24.00	dt:10.01.2018	Non-captive	17^{0}20'00.42"N & 82^{0}25'01.60"E 17^{0}20'00.92"N & 82^{0}25'26.40"E
4	Laterite	M/s. Swarna Bharathi Enterprises	Mg.Prat:Sri Gokada Sri Rama Chandra Murthy, D.No.2-34, Near Ramalayam, Tamarada, Kirlampudi Mandal, East Godavari District - 533281, Cell No.8466822333.	10808/D4/2021, dt.04/01/2022	1	Chintaluru	Prathipadu	13.550	dt:03.01.2023	Non-captive	17^{0}18'49.94149"N & 82^{0}16'15.16249"E 17^{0}18'24.24979"N & 82^{0}17'27.09258"E
5	Laterite	M/s. Marlin	Mobile:8466822333, Dir:Sri M.Satish,Plot	10805/D4/2021,	1	Chintaluru	Prathipadu	11.390	dt:03.01.2023	Non-captiv	17^{0}18'49.94149"N & 82^{0}16'15.16249"E

		Infrastructure Pvt. Ltd.,	No.1112 A, Road No.56, Jubli Hills, Hyderabad, Telangna State -500033.	dt.04/01/2022						e	17^{0}18'24.24979"N & 82^{0}17'27.09258"E
6	Laterite	M/s. Marlin Infrastructure Pvt. Ltd.,	Mobile:8466822333, Dir:Sri M.Satish,Plot No.1112 A, Road No.56, Jubli Hills, Hyderabad, Telangna State -500033.	10807/D4/2021, dt.04/01/2022	1	Chintaluru	Prathipadu	12.650	dt:03.01.2023	Non-captive	17^{0}18'46.66291"N & 82^{0}16'40.00047"E 17^{0}18'50.54797"N & 82^{0}16'39.37612"E
7	Laterite	M/s. Marlin Infrastructure Pvt. Ltd.,	Mobile:8466822333, Dir:Sri M.Satish,Plot No.1112 A, Road No.56, Jubli Hills, Hyderabad, Telangna State -500033.	10806/D4/2021, dt.04/01/2022	1	Chintaluru	Prathipadu	16.290	dt:03.01.2023	Non-captive	17^{0}18'4637.72062"N & 82^{0}17'13.13968"E 17^{0}18'37.58259"N & 82^{0}17'17.10375"E
8	Laterite	Sri I.Suresh Raju	Cell No.99898567885, D.No.68-11-4, Rajeswari Nagar, Beside Saptagiri Apartment, Engineeing College, Kakinada (Urban), East Godavari District.	11731/D4/2021, dt.25/01/2022	187	P.Jagannadhapuram	Prathipadu	7.447	24.01.2023	Non-captive	17^{0}16'19.00647"N & 82^{0}11'07.81701"E 17^{0}16'23.77695"N & 82^{0}11'16.29676"E
9	Laterite	Sri Ch.Venu Madhava	Cell No.8712344678, S/o Rama Rao, D.No.8-22, Yellapuvari Veedhi, Jagapathinagaram Village, Kirlampudi Mandal, East Godavari District	11730/D4/2021, dt.25/01/2022	187	P.Jagannadhapuram	Prathipadu	15.495	dt:24.01.2023	Non-captive	17^{0}16'37.85350"N & 82^{0}11'23.63913"E 17^{0}16'29.78261"N & 82^{0}11'20.97981"E
10	Laterite	Smt. I.Rama Venkata Lakshmi	Cell No.99898567885, W/o I. Suresh Raju, D.No.68-11-4, Rajeswari Nagar, Beside Saptagiri Apartment, Engineeing College, Kakinada (Urban), East Godavari District.	11729/D4/2021, dt.25/01/2022	187	P.Jagannadhapuram	Prathipadu	8.810	dt:24.01.2023	Non-captive	17^{0}16'19.00647"N & 82^{0}11'07.81701"E 17^{0}16'12.38901"N & 82^{0}11'06.49170"E

Data Source: Assistant Director of Mines and Geology, Kakinada District, Andhra Pradesh

2.4 Details of Royalty in last 3 years

The list of royalty in the last 3 years in the district is shown in Table-16.

Table 16 Details of Royalty in last 3 years

Royalty for 2022-23

S. No.	Mineral	Royalty (in Rs. Lakhs)	Consideration Amt. (in Rs. Lakhs)	DMF (In Rs. Lakhs)	MERIT (in Rs. Lakhs)
1	China Clay (Crude)	10.466	10.466	3.14	0.209
2	Clay others	18.54	18.54	5.562	0.371
3	Fire Clay	10.86	10.86	3.258	0.217
4	Gravel	31.637	31.637	9.491	0.633
5	Gravel	0.018	0.018	0.005	0
6	Laterite (Cement)	92.92	92.92	27.876	1.858
7	Ordinary Earth	68.139	68.139	20.442	1.363
8	Road Metal	417.371	417.371	125.211	8.347
9	Road Metal	321.388	321.388	96.416	6.428
TOTAL		**971**	**971**	**291**	**19**

Royalty for 2021-22

1	China Clay (Crude)	23.88	11.94	7.164	0.478

2	Clay others	18.42	9.21	5.526	0.368
3	Color Granite-Leptinites	1.59	0.3975	0.199	0.032
4	Colour Granite (Others)	30.86	7.715	3.857	0.617
5	Fire Clay	11.122	5.561	3.33	0.222
6	Gravel	39.595	19.7975	11.879	0.792
7	Ordinary Earth	5.301	2.6505	1.59	0.106
8	Road Metal	399.577	199.7885	119.873	7.992
TOTAL		**530**	**237**	**153**	**11**

Royalty for 2020-21

S. No.	Mineral	Royalty (in Rs. Lakhs)	DMF (In Rs. Lakhs)	MERIT (in Rs. Lakhs)
1	China Clay (Crude)	17.718	5.315	0.354
2	Clay others	11.37	3.411	0.227
3	Color Granite-Leptinites	3.281	0.41	0.066
4	Colour Granite (Others)	19.55	2.444	0.391
5	Fire Clay	3.9	1.17	0.078

S. No.	Mineral	Royalty (in Rs. Lakhs)	DMF (In Rs. Lakhs)	MERIT (in Rs. Lakhs)
6	Gravel	107.892	32.368	2.158
7	Laterite (Cement)	6.75	2.025	0.135
8	Ordinary Earth	62.419	18.726	1.248
9	Road Metal	420.065	126.02	8.401
TOTAL		**653**	**192**	**13**

Data Source: Assistant Director of Mines and Geology, Kakinada District, Andhra Pradesh

2.5 Details of Production in last 3 years

The details of the production in last 3 years in the district are shown in Table-17.

Table 17 Details of Production in last 3 years

Production for 2022-23

S. No.	Mineral	Unit	Production (in MT)
1	China Clay (Crude)	MT	17372.71
2	Clay others	MT	30890
3	Fire Clay	MT	17956.3
4	Gravel	Cubic Meter	70285
5	Gravel	MT	45
6	Laterite (Cement)	MT	92920
7	Ordinary Earth	Cubic Meter	150435
8	Road Metal	Cubic Meter	462229

S. No.	Mineral	Unit	Production (in MT)
9	Road Metal	MT	535579.07

Production for 2021-22

S. No.	Mineral	Unit	Production (in MT)
1	China Clay (Crude)	MT	39609
2	Clay others	MT	30231
3	Color Granite-Leptinites	Cubic Meter	46.076
4	Colour Granite (Others)	Cubic Meter	1201.173
5	Fire Clay	MT	17384.95
6	Gravel	Cubic Meter	86642
7	Ordinary Earth	Cubic Meter	8685
8	Road Metal	Cubic Meter	443494

Production for 2020-21

S. No.	Mineral	Unit	Production (in MT)
1	China Clay (Crude)	MT	29400
2	Clay others	MT	18950
3	Color Granite-Leptinites	Cubic Meter	106.154

S. No.	Mineral	Unit	Production (in MT)
4	Colour Granite (Others)	Cubic Meter	818.775
5	Fire Clay	MT	6500
6	Gravel	Cubic Meter	194719
7	Laterite (Cement)	MT	2112
8	Ordinary Earth	Cubic Meter	132149.536
9	Road Metal	Cubic Meter	466463.9

Data Source: Assistant Director of Mines and Geology, Kakinada District, Andhra Pradesh

2.6 Impact on environment

The extraction and utilization of minor minerals have become integral to our modern way of life, fuelling infrastructure development, construction, and various industries. However, the impact of these activities on the environment cannot be underestimated. Minor minerals, which include granite, road metal, gravel, clay, and more, play a significant role in shaping the natural landscape and ecosystems. The various environmental consequences associated with the extraction and use of minor minerals are:

2.6.1. Habitat Destruction: The mining of minor minerals often entails the removal of topsoil and vegetation, leading to habitat destruction. This can disrupt ecosystems, displace wildlife, and threaten the survival of numerous species. Loss of biodiversity is a significant concern in regions with extensive mining operations.

2.6.2. Land Degradation: Mining activities can lead to land degradation, including soil erosion and compaction. This not only reduces the land's fertility but also affects its ability to support agriculture and vegetation growth. Moreover, land degradation can contribute to increased vulnerability to natural disasters like floods.

2.6.3. Water Pollution: Mining operations can contaminate nearby water bodies through the discharge of sediments, chemicals, and heavy metals. This pollution can have detrimental effects on aquatic life, disrupt local hydrology, and compromise the quality of water available for human consumption.

2.6.4. Air Quality: Dust emissions from mining sites can deteriorate air quality in surrounding areas. The fine particles and pollutants released during excavation and transportation of minor minerals can pose health risks to both workers and nearby communities.

2.6.5. Regulatory Challenges: Enforcing regulations and monitoring mining activities in remote or unregulated areas can be challenging, allowing illegal and unsustainable practices to persist.

The extraction and utilization of minor minerals are essential for economic development, but they come at a cost to the environment. Recognizing the environmental impacts of these activities is crucial for sustainable resource management.

2.7 Remedial Measures

The provisions of Rule 12 (1) and Rule 12 (5) and of Andhra Pradesh Minor Mineral Concession Rules, 1966 allows the State Government to issue the Letters of Intent with the stipulated conditions to submit Approved Mining Plan (AMP), Environment Clearance (EC) and Consent for Establishment (CFE) for grant of lease.

Mine Plan stipulate the maximum permissible annual production of the mineral from the designated lease area and also includes estimated quantum of solid waste generation and its method of disposal, etc. Based on the Approved Mine Plan projections, Environment Management Plan shall be prepared and SEIAA makes the decision to grant the EC based on the EMP.

Leaseholders commit to all the remedial measures in the Mining Plan and the State Environment Impact Assessment Authority (SEIAA) ensures the remedial measures are being adhered to during the tenure of the Environmental Clearance.

Leaseholders in the district have adopted various remedial measures to mitigate the impact of mining on the environment. These measures aim to reduce the environmental footprint of mining operations and address the associated challenges. Some common practices include:

2.7.1. Environmental Impact Assessments (EIAs): Leaseholders conduct comprehensive EIAs to evaluate the potential environmental consequences of mining projects. They shall use this information to develop mitigation strategies.

2.7.2. Reclamation and Rehabilitation: Leaseholders work to restore mined areas by recontouring landscapes, replanting native vegetation, and stabilizing soils to promote ecosystem recovery.

2.7.3. Water Management: Proper management of water resources is crucial. Leaseholders use techniques like sedimentation ponds, water recycling, and water treatment facilities to minimize water pollution and ensure responsible water use.

The following preventive measures are being followed for minimizing adverse effects on water regime:

- Small Gully checks, gully check dams, silt settling tanks, silt traps, etc. shall be constructed.
- Along all discharge points leaving the mining lease, into the surrounding area, suitable number of filter walls of sufficient lengths shall be erected across the flow, at intervals, all along the length to prevent suspended solids entering the surrounding streams/ drains/ water courses, to confine the discharge water quality to the permissible limits.
- Regular monitoring may be carried out and further remedial steps as may be necessary may be taken.

2.7.4. Waste Management: Effective management of mining waste, such as tailings and slag, involves containment in secure

facilities to prevent soil and water contamination. Advances in waste disposal technologies are also being explored.

Steps being followed for effective waste management:

- Implementation of practices to minimize waste generation at the source. This involves optimizing extraction techniques, reducing overburden removal, and improving resource utilization.
- Encouraging recycling and reuse of waste materials wherever possible within the mining operation.
- Selection of an appropriate disposal methods based on waste characteristics and environmental considerations. Common methods include landfilling, controlled dumping, and backfilling.
- Treatment of contaminated water and effluents using appropriate technologies before discharge.

2.7.5. Afforestation: Leaseholders carry out a year-wise afforestation plan for the initial years with detailed costing of each plant, its maintenance per piece, etc.

While these measures represent positive steps toward mitigating environmental impact, it's important to note that the effectiveness of these practices can vary widely depending on factors such as the location, scale, and specific mineral being mined. Continuous improvement and adaptation are essential in the mining industry's ongoing efforts

2.8 Reclamation Measures

As per Rule 7A (ii) of Andhra Pradesh Minor Mineral Concession Rules, 1966, Mine Closure Plan shall be submitted by the leaseholder before 6 months of expiry of the lease in the proforma as prescribed by the Director. The District Mines and Geology officer concerned shall approve the mine closure plan and ensure compliance of conditions of the approved mine closure plan before expiry of the lease period.

Financial assurance of Rs.50,000/-(Rupees Fifty Thousand) for the quarry lease granted below five(5) hectares and Rs.10,000/- (Rupees Ten Thousand) per Hectare or part thereof for the quarry lease granted five (5) hectares and above, shall be submitted in the form of deposit. If the leaseholder does not reclamate the area as mentioned in the Mine Closure

Plan, the deposit shall be forfeited, and the Department of Mines & Geology ensure the proper implementation of the Mine Closure Plan.

2.9 Risk Assessment & Disaster Management Plan

Leaseholders conduct comprehensive risk assessment, prepare a model disaster management plan and submit in the Mining Plan.

The leaseholders maintain and arrange following resources at the mine site:

a) Fire fighting equipment

b) Ambulance services with location

c) List of volunteer organizations

d) List of Civil, Police and other authorities to be informed in case of an accident

e) Last of mobile crane operators (Government, Public Sector, and Private Sector).

f) List of mines, contacts, facility available nearby

g) List of first aiders and contacts.

h) List of Officers of DGMS to be informed in case of serious accidents Concerned DGMS officers concerned is displayed at the mine head.

The leaseholders shall monitor the total execution of the disaster management plan. The resources of all departments including men and material are being promptly made available. They are also conducting regular mock rehearsals with their staff to update the risk register and accordingly, disaster management plan

2.9.1. Mineral Regulatory:

The following leases exist in this Kakinada office jurisdiction. Mineral Regulatory, the important functioning of Mines and Geology department in these aspects are: -

i. Achievement of Targets of Mineral Revenue collections being fixed to this office annually

ii. Receiving and processing of the Mineral Concession Applications duly conducting the technical inspection, Survey and demarcation of the Mineral bearing applied areas in Patta lands.

iii. Identification of mineral bearing areas to prepare E-blocks and to send proposals to the DMG for conducting E-auctioon of block through e.procurement portal of A.P. for allotment of block to the successful bidder.
iv. Execution and Regulation of the operations of the Mining / Quarry leases in accordance with the Acts and Rules
v. Issuing of dispatch permits duly collecting the Advance Royalty / Seig.fee from the lease holders on the minerals produced and intend to dispatch from their leased areas through online permit system.
vi. Collection of Monthly revenue from Seignorage fee, Consideration fee, collection (SCC) contractors and collection of monthly return from the SCC contractor.
vii. Controlling the illegal Mining / Quarrying and transportation by conducting the periodical inspections of the Mines and Quarries and also conducting the surprise vehicular checking and imposing the penalties
viii. Finalisation of Demand, Collection and Balance statements of the leases on annual basis

2.10 Plantation & Green Belt Development

Leaseholders are complying with the plantation and green belt development programmes as committed in their Mining Plans.

CHAPTER III: SAND

3.1 Sand Mineral Resources of Kakinada District

3.1.1 General Sand Mineral Details Kakinada District

(Prepared as per Sustainable Sand Mining Management Guidelines 2016 & 2020) (Data Source: Assistant Director of Mines and Geology, Kakinada District, Andhra Pradesh. The details of the Production of Sand in the district are described in Table 18.

Table 18 Details of Production of Sand in Last three years in the District

Year	Production (In MTs)
2020-21	---
2021-22	0
2022-23	0

Data Source: District Mines and Geology Officer, Kakinada District

3.1.2 River Basins in Kakinada District

In Kakinada district there are five major river basins i.e, Godavari, Yeleru, Suddagedda, Pampa and Thandava river basins. The Godavari, Yeleru and Pampa river basins are covered with 75% of the total area in the district and remaining part covered with Suddagedda and Thandava River basins. The Yeleru river basin spread in Jaggampeta, Peddapuram, Prathipadu, Pithapuram and Kakinada Assembly constituencies in eastern part of the district.

The catchment area of each river basin is delineated by using master plan records and updated with survey of India toposheets (1:50K). The Godavari River basin and Yeleru river basin catchment areas are 781.36 Sq.km and 915.81Sq.km in the district. The district having total number of tanks including ponds and minor irrigation tanks 1,519. The Hydrological units of Kakinada district is shown in Table 19 and Figure 19, Drainage system with description of main rivers is shown in Table-20, Salient features and altitudes origin of rivers is shown in Table 21 and rivers lengths of Kakinada district is shown in Table 22.

Table 19 Hydrological units of Kakinada District

S.No	Major Basin	Minor Basin	Catchment Area (Sq.km)	No of. Tanks
1	Godavari	Burdakalva	78.07	44
2		Drinages in East Godavari Delta	305.51	116
3		Lower Godavari	397.78	71
4	Pampa	Pampa	687.3	278
5	Suddagedda	Suddagedda	486.7	216
6	Thandava	Thandava	313.34	141
7	Yeleru	Yeleru	915.81	653
		Total	**3,185**	**1,519**

Data Source: District Mines and Geology Officer, Kakinada District

Table 20 Drainage System with Description of main rivers

S.No	Name of the River	Area Drained (Sq.Km)	% of Area Drained in the District
1	Yeleru	912.84	28.72
2	Pampa	686.46	21.60
3	Suddagedda	487.53	15.34
4	Thandava	313.34	9.86
5	Lower Godavari	395.84	12.45
6	Drinages in East Godavari Delta	304.19	9.57
7	Burdakalva	78.07	2.46

Data Source: District Mines and Geology Officer, Kakinada District

Table 21 Salient Features of Important Rivers in Kakinada District

S.No	Name of the River	Place of Origin	Altitude at Origin (m)
1	Godavari	Nasikatrayambkam, Maharastra	1,067
2	Yeleru	Puttakota RF, Koyyeru mandal in Alluri Sitharama Raju disatrict	1,269

3	Suddagedda	Vatangi RF, Rajavommangi mandal in Alluri Sitharama Raju district	699
4	Pampa	Lododdi RF, Rajavommangi mandal in Alluri Sitharama Raju district	827
5	Thandava	Bointi RF, G K Veedhi mandal in Alluri Sitharama Raju district	1,412

Data source: APSAC, Vijayawada

Table 22 River Lengths in Kakinada District

S. No	Name of the Major Basin	Name of the Minor Basin	Name of the River	River Length in Km
1	Godavari	Drainages in East Godavari Delta	Corangi River	27.97
2			Matlapalem Kaluva	4.95
3		Lower Godavari	Bankollu Kaluva	4.82
4			Bottaleru Kaluva	9.02
5			Chinnavara Kaluva	1.73
6			Chittuvantram Kaluva	2.53
7			Dabadi Kaluva	4.51
8			Dindodivarava Kaluva	2.99
9			Duratanali Kaluva	1.41
10			Engilagoyya Kaluva	2.86
11			Gaderu River	14.64
12			Gavvalarava Kaluva	6.95
13			Godavari River	109.39
14			Gollavanigoyya Kaluva	3.88
15			Gudduvarava Kaluva	4.11
16			Gullanalu Kaluva	3.64
17			Isukanaligoyya Kaluva	4.43
18			Kuratanali Kaluva	2.96
19			Light House Kaluva	3.65
20			Mogalichettuvaruva Kaluva	4.14

21			Motu Kaluva	4.04
22			Mulakattuvasamu Kaluva	3.54
23			Nagadaruva Kaluva	6.34
24			Pillavarava Kaluva	3.77
25			Ponnanali Kaluva	2.01
26			Sarihaddu Kaluva	6.18
27			Savupillavarava Kaluva	3.26
28			Sukkalu Kaluva	4.97
29			Vadanalu Kaluva	13.07
30			Valakattu Kaluva	4.10
31			Varava Kaluva	9.02
32	Pampa	Pampa	Pampa River	24.28
33			Upputeru	6.92
34	Suddagedda	Suddagedda	Konda kaluva	10.73
35			Nakkala Khandi	15.27
36			Pedda Eru	7.05
37			Suddagedda	47.12
38			Gorre Khandi	10.87
39	Yeleru	Yeleru	Erra Kaluva	10.35
40			Gorre Khandi	11.39
41			Yaleru River	30.76
			Total	**455.65**

Data source: APSAC, Vijayawada

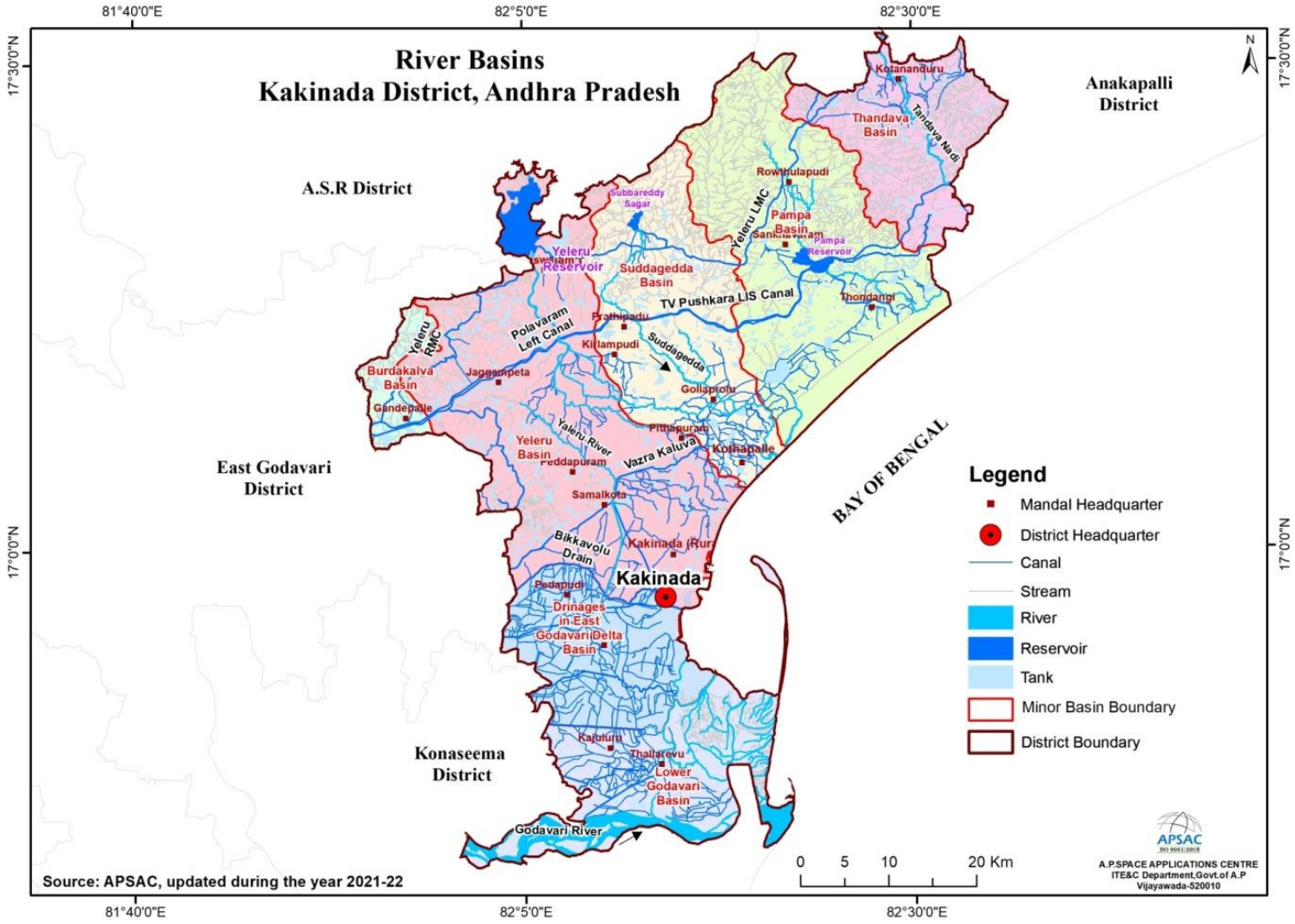

Figure-19: Major and Minor River basin boundaries

3.1.3 Process of Deposition of Sediments in the Rivers of the District

Sediment transport is a natural process, and many have argued that the point of rivers is to move sediment downstream. However, with land use changes, e.g., deforestation and construction; agricultural practices; and development activities, accelerated erosion rates are ubiquitous. Sediment in the water column reduces transparency and can be deposited downstream and exacerbate flooding. Three principal sources of sediment are the following:

Sediment transport is the movement of organic and inorganic particles by water. In general, the greater the flows, the more sediment that will be conveyed. Water flow can be strong enough to suspend particles in the water column as they move downstream, or simply push them along the bottom of a waterway. Transported sediment may include mineral matter, chemicals and pollutants, and organic material. Another name for sediment transport is sediment load. The total load includes all particles moving as bedload, suspended load, and wash load.

3.1.3.1. Bedload

As the name suggests, this element of sediment movement consists of loose, granular particles at the sediment-water interface (such as a stream bed or tidal flat). Air or water that moves across the bed will being to move grains if the flow velocity is great enough to overcome the force of gravity and any resistance at grain contacts. This is the **threshold velocity**.

The bedload contains two main components:

- the **traction load**, or traction carpet, and
- the **saltation loads**.

The various components of force involved in initiation of grain movement are shown above. Here, fluid flowing over a sediment bed produces shear stresses that can be resolved into a component of drag (parallel to the bed) and a lift component normal to the bed. At the threshold velocity when the resultant fluid force on grains is greater than gravity, grains begin to roll, slide and jostle along the bed like a moving carpet – the **traction carpet** (Figure-20).

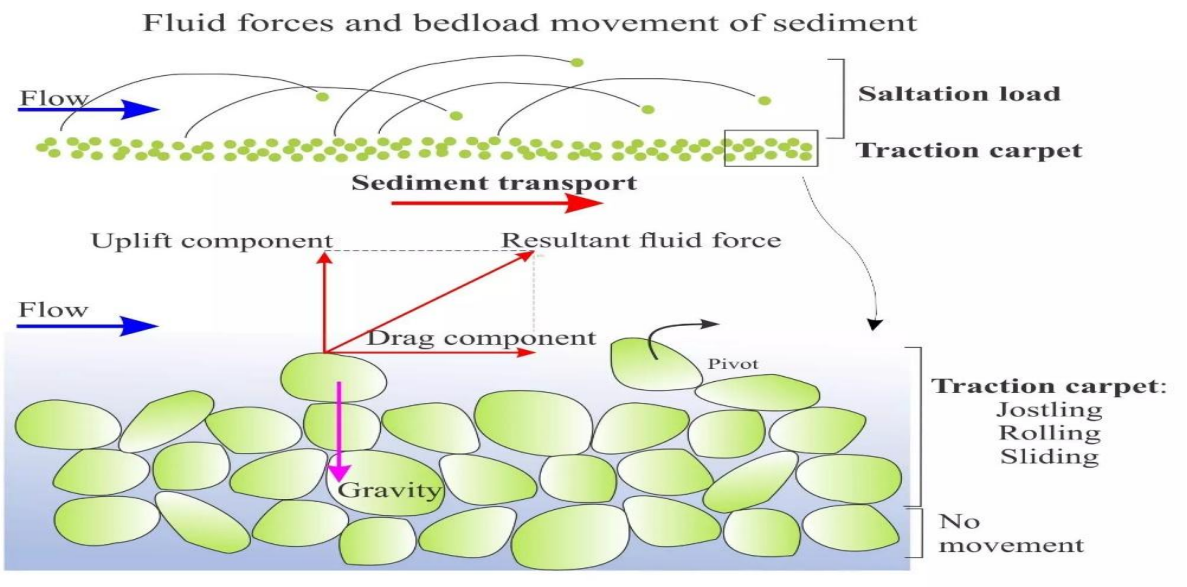

Figure-20: Bedload Movement of Sediment

3.1.3.2. Suspended Load Most natural flows in rivers, shallow marine settings and air are turbulent. Even at low-flow velocities, the speed and trajectories of flow can vary considerably – witness the eddies and boils in seemingly tranquil streams. Very fine particulate sediment (particularly clays) can be kept in suspension for long periods by turbulence; the stresses generated by turbulent flow balance or overcome the gravitational force acting on the particles.

If turbulence decreases significantly, for example when a river empties into a lake, then most particles will gradually settle to the sediment bed. The rate at which a particle settles out of suspension is called the **settling velocity**, where the force of gravity (downwards) exceeds the combined effects of upward-directed **buoyancy forces** acting on a grain and the drag on a particle caused by **fluid (viscous) resistance**. Thus, the rate of settling depends on the size, shape and density of particles, and the viscosity of the fluid. In general, settling through air is much more rapid than through water.

Both bedload and suspension load are important processes in the generation of sedimentary structures. In particular, bedload transport of loose sand is the critical process for growth of bedforms and their internal cross-stratification (crossbedding). The description of **bedforms** (crossbeds) and the flow conditions (**flow regime**) under which they form have been described in other posts (Figure-21).

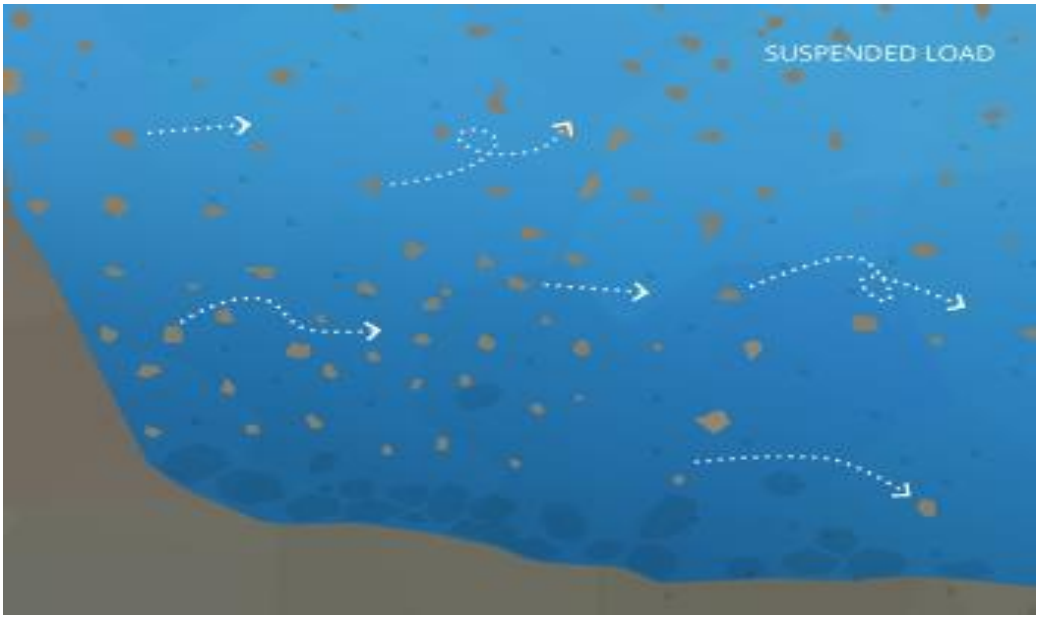

Figure-21: Sediment Load

3.1.3.3. Wash Load

The wash load is the portion of sediment that will remain suspended even when there is no water flow. The wash load is a subset of the suspended load. This load is comprised of the finest suspended sediment (typically less than 0.00195 mm in diameter). The wash load is differentiated from the suspended load because it will not settle to the bottom of a waterway during a low or no flow period. Instead, these particles remain in permanent suspension as they are small enough to bounce off water molecules and stay afloat. However, during flow periods, the wash load and suspended load are indistinguishable. Turbidity in lakes and slow-moving rivers is typically due the wash load 8. When the flow rate increases (increasing the suspended load and overall sediment transport), turbidity also increases. While turbidity cannot be used to estimate sediment transport, it can approximate suspended sediment concentrations at a specific location (Figure-22).

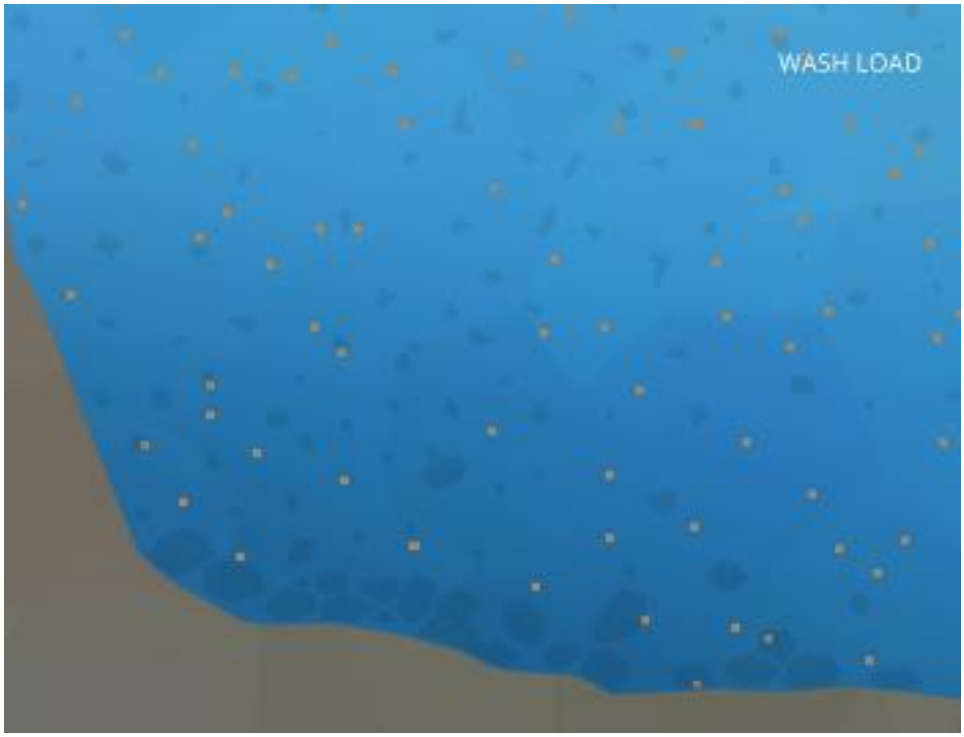

Figure-22: Wash Load

3.1.3.4. Settleable Solids

The suspended particles that fall to the bottom of a water body are called settleable solids. As they are found in riverbeds and streambeds, these settled solids are also known as bedded sediment. The size of settleable solids will vary by water system – in high flow areas, larger, gravel-sized sediment will settle out first. Finer particles, including silt and clay, can be carried all the way out to an estuary or delta (Figure-23).

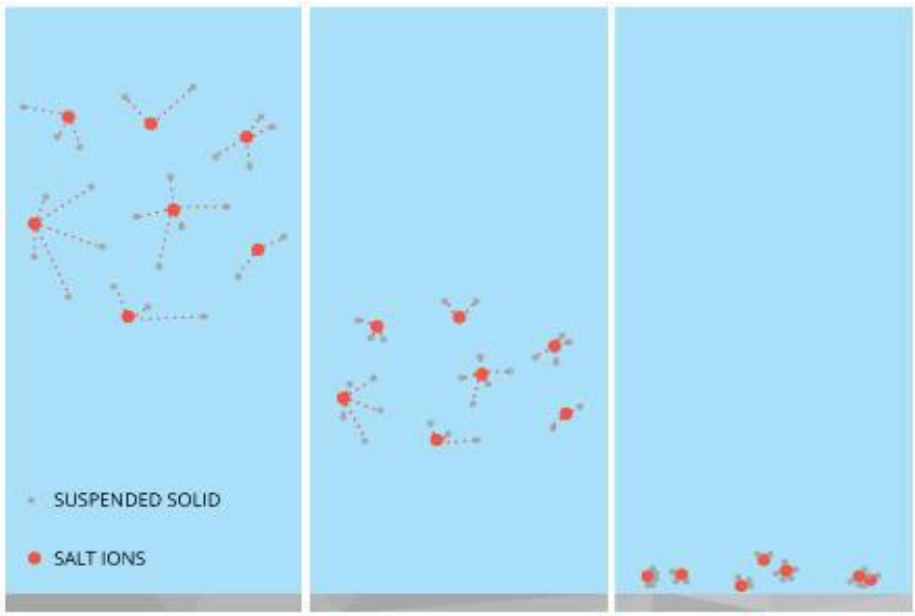

Figure-23: Settleable Solids

3.1.3.5. Sediment Deposition

Sediment is necessary to the development of aquatic ecosystems through nutrient replenishment and the creation of benthic habitat and spawning areas. These benefits occur due to sediment deposition – when suspended particles settle down to the bottom of a body of water. This settling often occurs when water flow slows down or stops and heavy particles can no longer be supported by the bed turbulence. Sediment deposition can be found anywhere in a water system, from high mountain streams, to rivers, lakes, deltas and floodplains. However, it should be noted that while sediment is important for aquatic habitat growth, it can cause environmental issues if the deposition rates are too high, or too low. Sediment transportation and Deposition depends upon various factors like Slope of the Area, Annual Rainfall, Lithology, flow intensity of River, Geomorphology, Soil, Geology and Land use (Figure-24)..

In sediment transport a distinction is generally made between fine and coarse sediment, because the transport mechanisms differ. Coarse sediment (grain size >63 μm) tends to be characterised by particles that remain separate and are chemically inert; fine sediments (<63 μm) on the other hand tend to come together as flocculated populations (flocs) and have the tendency to attract organic material and contaminants to their surface. A great deal has been researched and written about the break up and flocculation of these primary particles under turbulence and subsequent settling (e.g., Uncles et al., 2010). These differences imply important variations in the rate of transport and settling characteristics for the same flow conditions for different sediments. The nature of the physical environment also has an important bearing on this, in that fine sediment tend to be found in sheltered environments (shallow, enclosed estuarine systems), while beaches on open coasts are characterised by coarser materials. This reflects the energy of the water in which the particles become suspended and their subsequent fate.

Rates of transport of material are generally expressed in terms of a flux, as kg/s for example, where this figure is generally obtained by considering the product of the flow rate (in m^3/s) and the concentration of material in suspension (kg/m^3). This does not necessarily imply a requirement for the material to be suspended; it is equally possible to express a bed load using the same units, for example, but it does imply that to obtain an estimate of the sediment flux it is necessary to know both the concentration and the flow rate over a given cross section. Both these quantities can be measured and there are a variety of techniques

available to do this, using insitu collection or sampling, in situ optical or acoustic methods, or remote sensing from aircraft or satellites (Uncles and Mitchell, 2017)

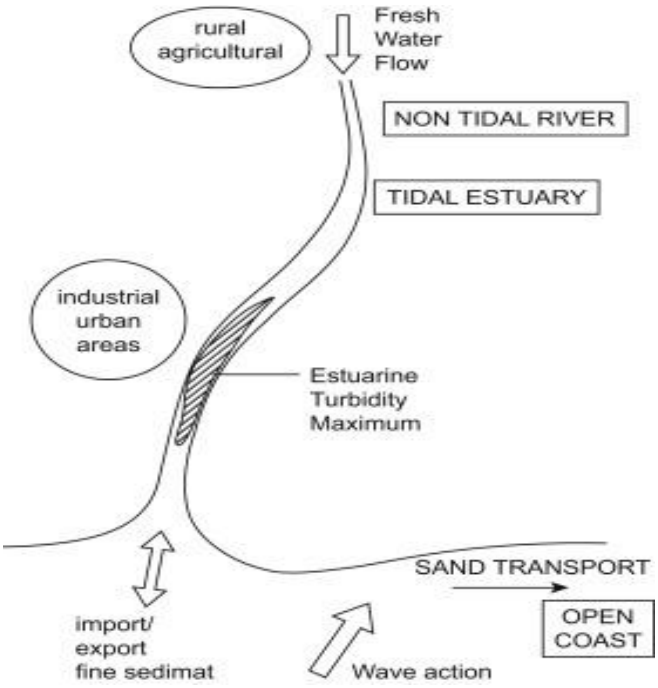

Figure-24: Sediment Deposition Process

Process of Deposition of Sediments in the Rivers of the District Sand is deposited because of the following reasons: (a) Floods: The surface or strip of relatively smooth land adjacent to a river channel constructed (or in the process of being constructed) by the present river in its existing regimen and covered with water when the river overflows its banks at times of high water. It is built of alluvium carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current (b) Valley fill: The unconsolidated sediment deposited by any agent so as to fill or partly fill a valley.

3.1.4 Replenishment Study

A replenishment study for riverbed sand is required in order to nullify the adverse impacts arising due to excessive sand extraction. Mining within or near the riverbed has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, flow velocity, discharge capacity, sediment transport capacity etc. For sustainable river sand mining, it is necessary that the mine pits formed as a result of sand excavation are refilled with sand by the natural process of replenishment in a reasonable period so that the area is again available for mining. The

rate of gross erosion is dependent upon many physical factors like climatic conditions, the nature of the soil, the slope of the area, topography and land use. The effect of any of these variables may vary greatly from one geographic location to another, and the relative importance of controlling factors often varies within a given land resource area (Dendy, 1976).

The estimation of sand replenishment is based on empirical and analytical approaches. There are many sediment transport equations as well as models which are suitable for use in the prediction of the replenishment rate of rivers/watersheds. The sedimentation models include SWAT, HEC-HMS etc. These models are developed based on the fundamental hydrological and sedimentological processes. They may provide detailed temporal and spatial simulation but usually require extensive data input. Hourly/daily input values of meteorological and radiation variables are required for continuous simulations. Some of the empirical equations for estimating sediment transport are as follows.

Annual Replenishment Rate for sand for Major Sand Resource Area is determined using empirical mathematical expression Dendy Bolton Equation and reproduced below:

- Einstein (1950)
- Laursen (1958)
- Bagnold (1966)
- Engelund-Hansen equation (1967)
- Yang equations (1973)
- Dendy- Bolton equation (1976)
- Modified Universal Soil Loss Equation (MUSLE) developed by Williams and Berndt (1977)
- Van Rijn (1984)
- Zanke (1987)

To estimate the transport capacity or the sediment load being conveyed by a water stream, one of the many transport equations that are available in the literature is frequently used. Einstein (1950) introduced statistical methods to represent the turbulent behaviour of the flow. Bagnold (1966) introduced an energy concept and related the sediment transport rate to work done by the fluid. Engelund and Hansen (1967) presented a simple and reliable formula for the total load transport in rivers. The Yang equation makes use of the total bed hydraulic radius, and studies show that it is good for estimating the sediment transport in the channel for the condition of dunes on the bed. MUSLE includes only one type of sediment

yield (sheet and rill Erosion). Van Rijn (1984) solved the equations of motions of an individual bed-load particle and computed the saltation characteristics and the particle velocity as a function of the flow conditions and the particle diameter for plane bedconditions. The equations of Zanke and Van Rijn seem to be only moderately satisfactory in estimating the sediment transport in the channel for the condition of dunes on the bed. However, it appears that no single equation could provide reliable estimates of a total load of sediment transport for all of the bed forms that could occur sequentially or randomly in alluvial channels or natural water courses. The comparison of the equations for estimating sediment rate is given below Table-23 –

Table 23: Types of Sediment Transport Equation

Sl.No.	**Sediment Transport Equation**	**Remarks**
1	Einstein (1950)	Bed load function was determined for many but not all types of stream channels
2	Laursen (1958)	Laursen equation outperforms other transport equations in the silt range
3	Bagnold (1966)	Bagnold related the sediment transport rate to work done by the fluid
4	Engelund-Hansen equation (1967)	The original Engelund-Hansen relation (OEH) is based on a single characteristic grain size, which limits its applicability in sand-bed rivers with a wide GSD
5	Yang equations (1973)	It makes use of a total bed hydraulic radius
6	Dendy- Bolton equation (1976)	It uses both drainage area and means annual runoff for estimation of sediment yield. It calculates all types of sediment yield like sheet and rill erosion, gully erosion, channel bed and bank erosion and mass movement

Sl.No.	Sediment Transport Equation	Remarks
7	Modified Universal Soil Loss Equation (MUSLE) developed by Williams and Berndt (1977)	MUSLE includes only one type of sediment yield (sheet and rill Erosion)
8	Van Rijn (1984)	Calculated equations of motions of an individual bed-load particle for plane bed conditions
9	Zanke (1987)	Zanke was found to be moderately satisfactory for the condition of the dunes on the bed.

Data Source: District Mines and Geology Officer, Kakinada District

In this study, the rate of gross silt production in the watershed and the ability of the stream system to transport the eroded material in a river have been carried out by the Dendy-Bolton equation. Dendy-Bolton formula is often used to calculate the sedimentation yield as it uses both drainage area and mean annual runoff as key parameters to give a yield value. Also, Dendy-Bolton equation calculates all types of sediment yield like sheet and rill-erosion, gully erosion, channel bed and bank erosion and mass movement.

The drainage area of Godavari River in Kakinada district is situated in upstream of the SAC Barrage. For calculation of sediment yield, the total realization of the SAC Barrage for water year 2022-23 (June 2022 to May 2023) of 6,250.56 TMC is taken as run-off.

Annual Replenishment Rate for sand for Major Sand Resource Area is determined using empirical mathematical expression Dendy Bolton Equation and reproduced below:

For Average Annual Run-off less than 2”

$$S = 1280 \times Q0.46 [1.43 - 0.26 \log (A)] \quad \text{Formula.....(A)}$$

For Average Annual Run-off move than 2”

$$S = 1965 \times (e^{-0.055 \times Q}) [1.43 - 0.26 \log (A)] \quad \text{Formula.....(B)}$$

Q = Mean Annual Run-off in mm

A = Net drainage Area in Sq. km

S = Sediment yield (tons/Sq. km/yr)

The sedimentation yield for Godavari River in Kakinada District is arrived based on the above Dendy Bolton Equation or Formula (B). The ssedimentation yield in Kakinada District is shown in Table -24

Table 24 Sedimentation yield for the rivers in Kakinada District

Name of the River	Area Drained (sq. km)	Mean Annual Run-off (in mm)	Rate of Annual Deposition in the River (tons / sq. km /year)	Annual Deposition (tonne)
Godavari	781.36	620.53	141.07	1,10,223*

Data Source: District Mines and Geology Officer, Kakinada District

In this report, the sediment yield was calculated using the standard records of Department of Water Resources. To ensure systematic and scientific studies, Department of Mines & Geology is in the process of selection of NABET Accredited agency for conducting detailed & regular replenishment studies for potential sand bearing areas.

3.1.5 Details of Sand Mining Leases:

The river Godavari and Thandavaare the main source of sand in the district through following mandals

Name of the river	List of Mandals
Akhanda Godavari	Tallarevu
Thandava (IIIrd Order Stream)	Tuni and Kotananduru
Yeleru Canal	Yeleswaram and Kirlampudi

Data Source: District Mines and Geology Officer, Kakinada District

***Note**: The sedimentation yield was calculated manually by APSAC and the value is **1,21,734 Tones/ year**. The details are provided as an Annexure at page number 112-113.

Proposed potential Sand Mining Leases in Kakinada district is shown in Table-25.

Table 25 The details of Potential Sand Mining Leases

Reach Name	Quantity (in MTs)	Geo-Coordinates	Remarks
Govallanka/2022-1	61500	16°43’24.45”N, 82°10’44.20”E 16°43’25.26”N,82°10’55.89”E 16°43’20.89”N, 82°11’ 4.05”E 16°43’19.75”N, 82°11’ 2.57”E 16°43’21.86”N, 82°10’57.11”E 16°43’22.76”N, 82°10’46.28”E	Proposed
Pillanka/2022-1	49500	16°42’43.60”N, 82°9’13.92”E 16°42’51.58”N,82°9’22.95”E 16°42’54.17”N, 82°9’ 22.20”E 16°42’49.75”N,82°9’ 11.28”E	Proposed
Pillanka/2022-2	73950	16°42’43.40”N 82° 8’46.48”E 16°42’45.58”N 82° 8’52.53”E 16°42’37.36”N82° 8’54.00”E 16°42’36.24”N82° 8’46.16”E	Proposed
Pillanka/2022-3	73500	16°42’41.52”N 82° 8’26.90”E 16°42’36.62”N 82° 8’26.01”E 16°42’40.74”N 82° 8’12.90”E 16°42’43.50”N 82° 8’14.20”E	Proposed

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

Probable Sand bearing areas in Kakinada district is shown in Table-26. Name of the sand bearing index are given from North to South direction. The Probable Sand bearing areas were identified through field survey with the help of hand held GPS (Global Positional System) and the help of existing literature. The map of the probable sand bearing areas are shown in Figure-26

Table 26: Probable Sand bearing areas in the Kakinada District

S.No	Name of the River	Sand Bearing Area	Central Coordinates		Area in Ha.
			Latitude	Longitude	
1	Godavari River	A	16° 55' 34.767" N	81° 45' 40.115" E	120.48
2	Godavari River	B	16° 55' 39.611" N	81° 46' 57.894" E	109.88
3	Godavari River	C	16° 55' 44.208" N	81° 44' 11.640" E	29.91
4	Godavari River	D	16° 55' 17.604" N	81° 43' 48.392" E	5.99
5	Godavari River	E	16° 54' 39.756" N	81° 45' 40.889" E	6.77
6	Godavari River	F	16° 52' 50.306" N	81° 44' 45.908" E	24.96
7	Godavari River	G	16° 53' 14.911" N	81° 46' 29.109" E	80.75

8	Godavari River	H	16° 52' 52.145" N	81° 47' 42.987" E	50.30
9	Godavari River	I	16° 52' 25.550" N	81° 46' 57.635" E	21.84
10	Godavari River	J	16° 50' 55.945" N	81° 47' 53.373" E	137.33
11	Godavari River	K	16° 49' 9.029" N	81° 45' 42.103" E	1.70
12	Godavari River	L	16° 49' 47.688" N	81° 49' 4.808" E	36.47
13	Godavari River	M	16° 49' 7.290" N	81° 49' 17.926" E	29.40
14	Godavari River	N	16° 49' 10.981" N	81° 49' 54.820" E	19.64
15	Godavari River	N	16° 47' 48.022" N	81° 49' 36.635" E	36.41
16	Godavari River	O	16° 46' 37.566" N	81° 45' 29.874" E	9.19
17	Godavari River	P	16° 45' 48.015" N	81° 47' 4.382" E	35.29
18	Godavari River	Q	16° 44' 33.338" N	81° 47' 40.916" E	5.13
19	Godavari River	R	16° 42' 26.910" N	81° 47' 32.649" E	9.07
20	Godavari River	S	16° 42' 14.167" N	81° 47' 39.700" E	8.59
21	Godavari River	T	16° 41' 8.216" N	81° 49' 11.411" E	23.67
22	Godavari River	U	16° 42' 38.888" N	81° 56' 39.073" E	47.11
23	Godavari River	V	16° 42' 47.091" N	81° 58' 42.677" E	40.81
24	Godavari River	W	16° 42' 51.193" N	81° 59' 35.971" E	52.14
25	Godavari River	X	16° 37' 9.723" N	81° 51' 36.720" E	21.22

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.6 Details of De-Siltation Location: (Lakes/Ponds/Dams etc.)

The detailed potential de-siltation location in Kakinada District is shown in Table-27.

Table 27 List of Potential De-Siltation Location: (Lakes/Ponds/Dams etc.) (Existing and proposed)

De-siltation Point	Quantity (in MTs)	Remarks
NIL		

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.7 Details of Patta Lands in the District:

The detailed list of Patta Lands in the Kakinada district is shown in Table-28.

Table 28 Details of Patta Lands.

Owner	Sy. No.	Area (Ha)	District	Tehsil	Village	Total Reserve (MT)	Total Mineral to be mined (MT)	Existing/ Proposed
Nil								

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.8 Details of M-Sand Plants in the District:

The details list of Manufacturing Sand in Kakinada district shown in Table-29.

Table 29 Shown Details of Details of M-Sand Plants

Plant Name	Owner	District	Tehsil	Village	Geo-location	Quantity Tonnes/ Annum
NISHAN	Sidhvi Infra Structures Projects Private Limited Authorized Person Sri P.Subba Reddy	Kakinada	Rowthulapudi	S.Pydilpala	$17^0$24’55.10”N $82^0$20’59.39”E	60000 tonnes
Priyanka Minerals and Projects LLP	Priyanka Minerals and Projects LLP	Kakinada	Rowthulapudi	Uppampalem	$17^0$39’28.5”N $82^0$20’15.8”E	120000 tonnes

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.9 Details of Cluster of Mining Leases

The area of Cluster of Mining Leases in Kakinada jurisdiction is shown in Table-30.

Table 30 Details Cluster of Mining Leases in Kakinada District

Sl.No	Name of the Cluster	Location (Latitude and Longitude)	Extent (in Ha)	Total No. of Mining Leases	No.of Leases working	Extent of the working leases

				in the Cluster		(in Ha)
1	Rowthulapudi	17^{0}25'13.92034"N 82^{0}21'31.27045"E	109.123 Hects	36	11	70.986 Hects
2	Yeleswaram	17^{0}19'23.72214"N 82^{0}07'07.14985"E	44.72 Hects	32	07	19.404 Hects
3	Prathipadu	17^{0}17'40.52110"N 82^{0}10'09.31227"E	23.217 Hects	13	04	15.274 Hects

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.10 Details of Contiguous Clusters

The area of Contiguous Cluster of Sand Reaches in Kakinada jurisdiction is shown in Table-31.

Table 31 Details of Contiguous Cluster of Sand Reaches in Kakinada District

Sl.No	Name of the Cluster	Location (Latitude and Longitude)	Extent (in Ha)	Total No. of Mining Leases in the Cluster	No.of Leases working	Extent of the working leases (in Ha)
NIL						

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh

3.1.11 Sand Reaches Details in Kakinada District

The Department of Mines and Geology has already identified sand reach points in the district. The locations details of the sand reach points are provided by the District Mines and Geology Officer, Kakinada, and are shown in Figure-25 and Figure-26.

The Probable Sand-bearing areas were identified through field surveys with the assistance of handheld GPS (Global Positioning System) devices and existing literature. The Probable Sand-bearing areas in the Kakinada District are depicted in Figure-27.

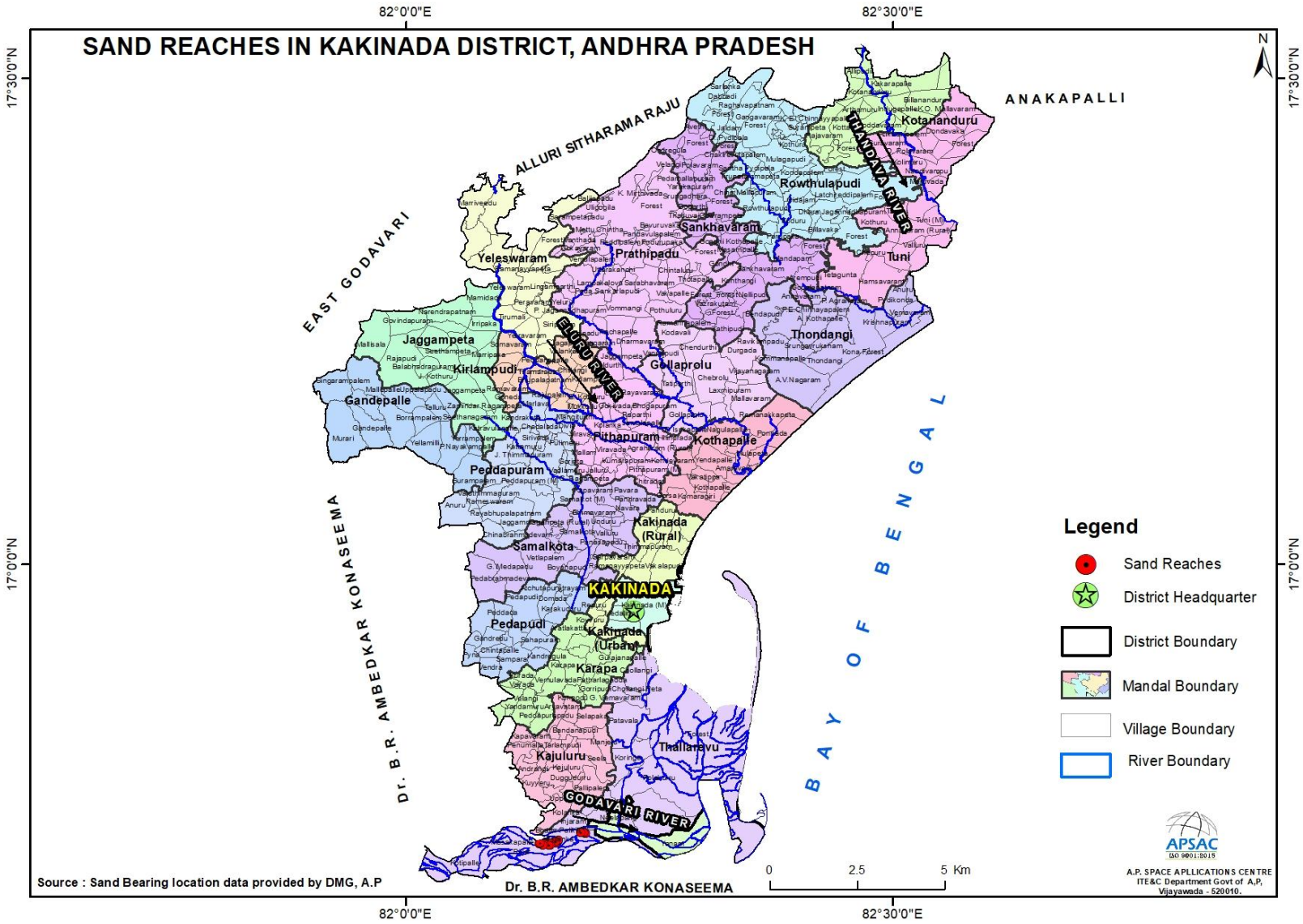

Figure-25: Administrave Map of Sand reaches in Kakinada *District*

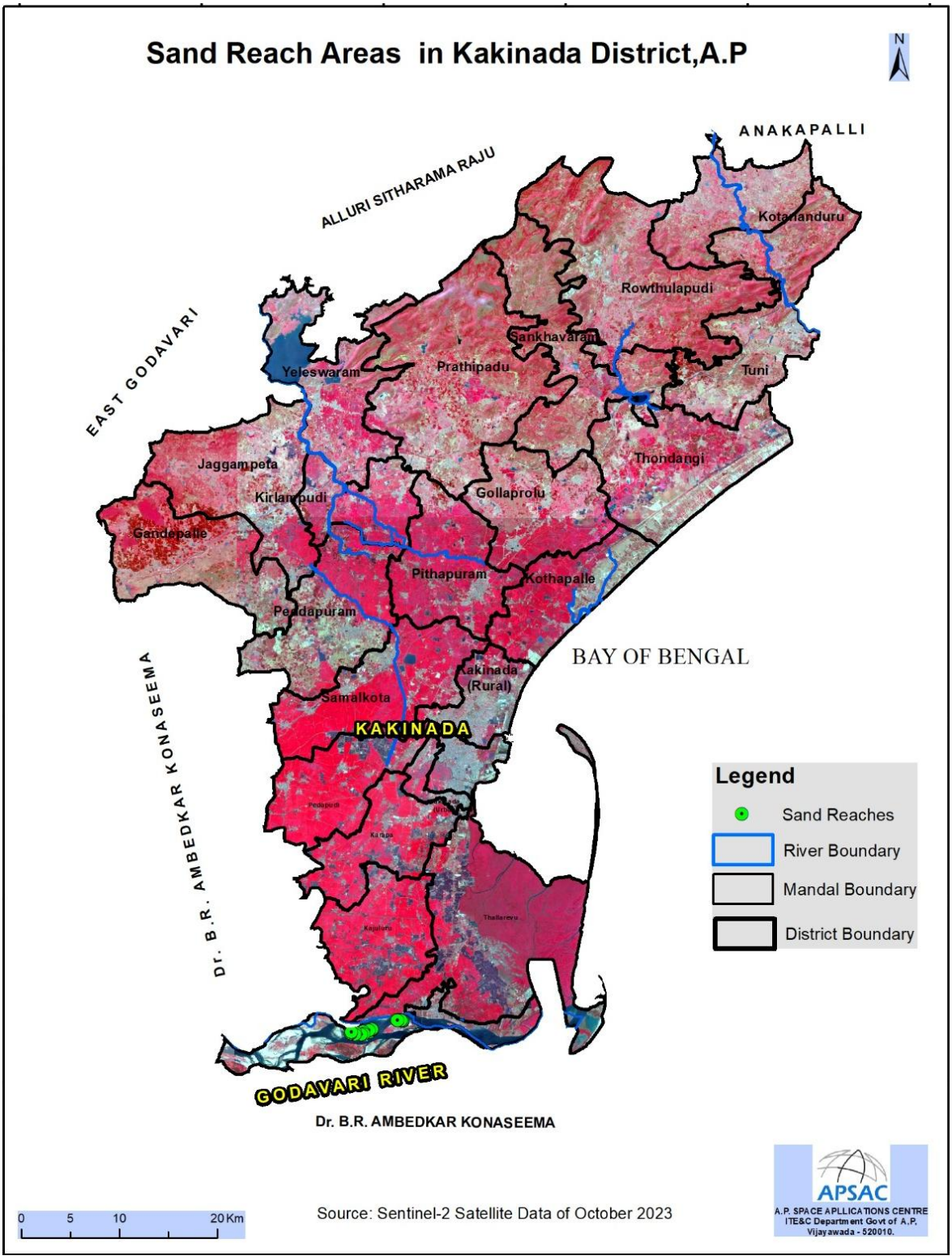

Figure-26: Satellite Map of Sand reaches in Kakinada *District*

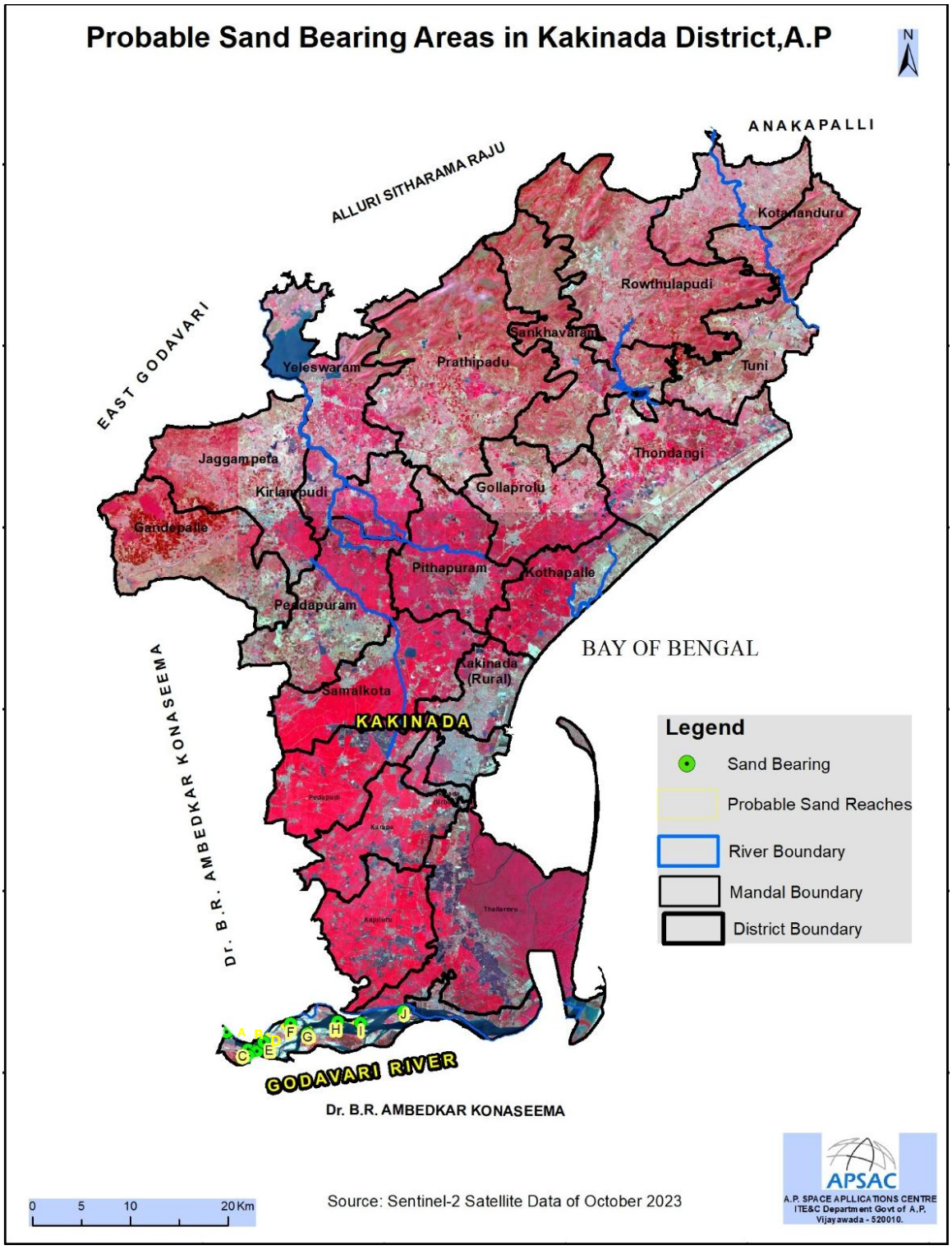

Figure-27: Probable Sand bearing areas in the Kakinada District

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ANNEXURE

As the average annual run-off more than 2" in the Kakinada District, the sedimentation yield for Godavari River in Kakinada District, APSAC has arrived the value manually based on the above Dendy Bolton Equation or Formula and is given below.

$$S = 1965 \times (e^{-0.055 \times Q}) [1.43 - 0.26 \log(A)]$$

Q = Mean Annual Run-off in mm

A = Net drainage Area in Sq. km

S = Sediment yield (tons/Sq. km/yr)

Name of the River	Area Drained (sq. km)	Mean Annual Run-off (in mm)
Godavari	781.36	620.53

Data Source: District Mines and Geology Officer, Kakinada District, Andhra Pradesh and APSAC, Vijayawada

The given drained area value converted from Sq.Km to Sq.miles and the mean annual run-off converted from mm to inches for the calculations.

$S = 1965 \times (e^{-0.055 \times Q}) [1.43 - 0.26 \log(A)]$ **Tones/sq.mile/year**

Drainage Area (A) = 781.36 sq. Km (1 Sq.km = 0.386 Sq.mile)

= 781.36 x 0.386

A = 301.605 Sq.mile ----------(1)

Mean Annual Run-off (Q) = 620.53mm (1 mm = 0.0393 inches)

= 620.53x 0.0393

Q = 24.3868 inches ----------(2)

e is Euler's number and the value is =2.718 ----------(3)

$S = 1965 \times (e^{-0.055 \times Q}) [1.43 - 0.26 \log(A)]$ **Tones/sq.mile/year**

$S = 1965 \times (2.718^{-0.055 \times 24.3868}) [1.43 - 0.26 \log(301.605)]$

Log 30 of 1 = 0.4786
0.6 = 8
As per base, the value = 2.0000
_____ ___(+)
Log 671.864=2.4794 ----------(4)

$= 1965 \times (2.718^{-0.055 \times 24.3868}) [1.43 - 0.26 \times 2.4794]$

$= 1965 \times (2.718^{-1.34128}) [1.43 - 0.6446]$

$= 1965 \times (2.718^{-1.34128}) [0.78535]$

The value of $2.718^{-1.34128}$

$1/2.718^{1.34128}$ = 0.78535 ----------(5)

$= 1965 \times 0.2615 \times 0.78535$

$= 403.62$

S = 403.62 **Tones/sq.mile/year** ----------(6)

For total district Sedimentation Yield =

Per Sq.mile Sedimentation Yield (6) x Total Drainage Area (1)

403.62 x 301.605 = 1,21,734

As the Sedimentation yield calculated manually,

The sedimentation in the total River in the kakinada District = **1,21,734 Tones/ year**

****END****