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Original Paper

Recommended Optimal Land Utilization and Farming Techniques (ROLUFS) in Pendurthi Mandal, A Geospatial Approach, Vishakhapatnam District, Andhra Pradesh, INDIA

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Abstract

Integrating land and water resources is a major key in sustainable development. Managing agricultural land is a concerning task keeping the ever increasing population in mind as agriculture utilizes largest amount of water in the world. A case study of Pendurthi mandal, Vishakhapatnam district, Andhra Pradesh, India has been taken up for resource appraisal. Basic integration of land and water resources (BILWRUS), generation of thematic maps using remote sensing in conjunction with Geographical Information System, and ground laboratory techniques has been the major task. The proposed landuse has been assigned to all the 23 villages of the study area, using recommended optimal land utilization and farming techniques (ROLUFS) as per the norms set by National water Development Program for Rainfed areas (NWDPRA).

Keywords

bilwrus, rolufs, mandal

1. Introduction

Indian civilization was rich and prosperous in the ancient past. However with the ever increasing population and the changing philosophy of the governments, the traditional methods of rural lifestyle and practices have become anachronistic. This has necessitated a change in the outlook and practices in so far as rural living, agriculture, arts, crafts and administrations are concerned. In the light of this application, modern and scientific methods has become necessary and mandatory too. Inappropriate and uncontrolled use of natural resources can downgrade their quality and destroy them. Sustainable development and optimized use of natural resources involves effective utilization of the existing resources without damaging the assets and preserves these valuable resources for the future generations. At Present, scientific and optimized management of agriculture and natural resources are considered to be important items in sustainable development. In order to achieve sustainability and optimized land allocation we can use linear programming, multi objective linear programming and Geographical Information System (GIS) approaches. Watershed Planning and management (2018).

Land use is a crucial link between human activities and the natural environment. Large parts of the terrestrial land surface are used for agriculture, forestry, settlements and infrastructure. This has vast effects on the natural environment. Land use is the most important factor influencing biodiversity at the global scale. TijanaVulević et al. (2018), freshwater availability Rosegrant et al. (2002), Sala et al. (2000). Global biogeochemical cycles, McGuire et al. (2001), and climate Brovkin et al. (1999).

Keeping the above objective in mind, the study area Pendurthi Mandal of Vishakhapatnam district with a total area of 120sqkms consisting of 23 villages, has been taken up for resource appraisal and utilization of its natural resources using modern techniques of remote sensing and GIS. With critical study, and analysis of a wealth of information related to the people of the mandal coupled with survey of India toposheets, geological maps, satellite imageries, thematic maps, Basic Integration of land and water resources (BILWRUS) has been generated, and integrated with landuse/landcover. Finally proposed landuse for all the 23mandals have been derived from Recommended optimal land utilization and farming system (ROLUFS) as per the norms set by National Water development Program for Rainfed areas (NWDPRA).

2. Review of Literature

Few studies have been carried out in and around Pendurthi mandal and Meghadrigedda, the major river that flows through the mandal. Among them are Identification of soil erosion zones with special reference to silt deposition in Meghadrigedda reservoir,Usha Chirala, Ph.D Thesis (2013),Correlation of geometric parameters for the hydrological characterization of the Meghadrigedda watershed, Vishakhapatnam, A GIS approach, Usha Chirala et.al. (2012), Nageswara Rao and Narendra, (2009 & 2006), Mapping and evaluating the urban sprawl, Nageswara Rao et al. (2008), on the ground water quality of the Meghadrigedda Watershed, Narendra and Nageswara Rao (2006), Mapping of Hydrogeomorphic features in the Pendurthi mandal using IRS data Usha Chirala (2003).

3. Study Area

The study area, Pendurthi mandal falls in Vishakhapatnam mandal in between 17^{0}49’30” north latitudes and 82^{0}12’13” east longitudes under SOI toposheet 650/1 and 0/2&3 on 1:50000 scale (Table 1). The total area is 120sqkm, 40m above MSL. The mandal headquarters is located 25km north-west of Vishakhapatnam and extends for a maximum distance of 20km in the north-south direction and 12km in east-west direction. The vegetation type is deciduous comprising mostly of deciduous dry and deciduous scrub. Red soils predominates the area. Agriculture is the main economic activity of the people. Paddy is the main crop and other crops include sugarcane, groundnut, macrotyloma uniflorum (horsegram), finger millet (ragi) and sesame. There is no irrigation system; the entire activity is under dug wells, bore well and tanks. The number of tanks found after delineation are 108 covering an area of 5.22 sqkm. as per 2020 Sentinel-2 satellite data.

The location map of the study area is shown in Figure 1(a) and the sentinel data of the study area in 1(b).

Table 1. Division of Mandals (Blocks)

Narsipatnam division	13
Paderu agency division	11
Vishakhapatnam division	19
Total	43

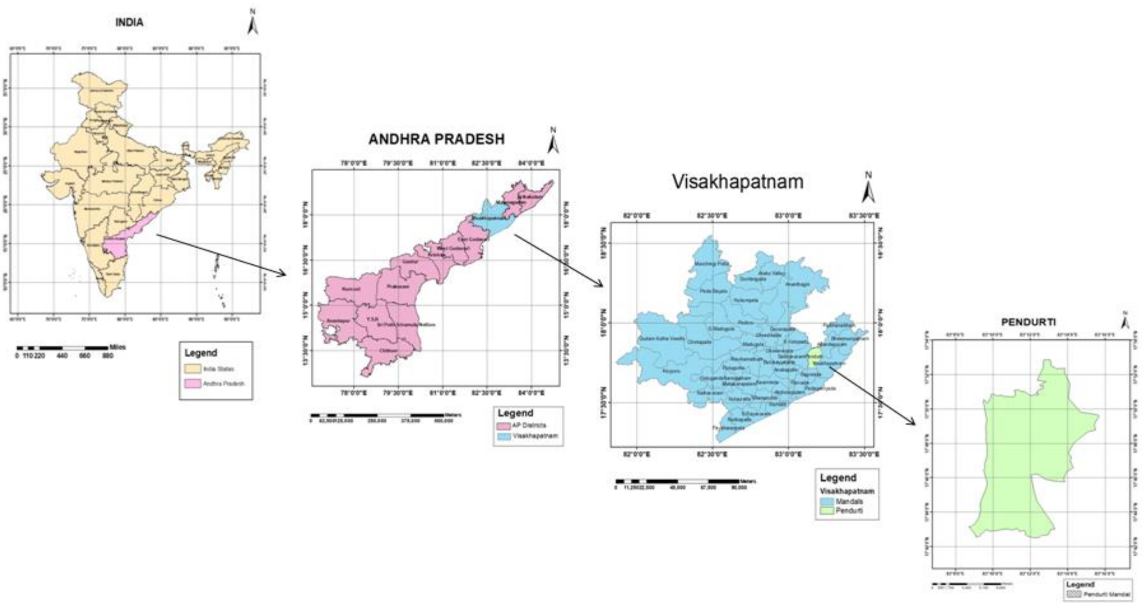

Figure 1(a). Location Map of the Study Area

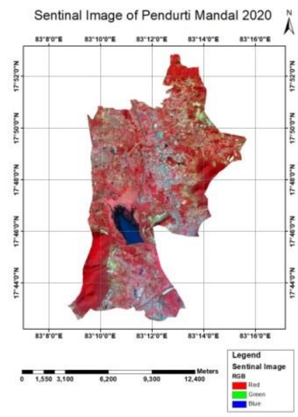

Figure 1(b). Satellite Image of the Study Area

4. Physiography

The study area forms part of Vishakhapatnam fold belt, and the foliation generally strikes NE-SW. In the central part of the EGGB there are four main tectono thermal events dated at 2600, 2200-1900, 1180-950 625-500Ma Fonarev et al. (1998). Majority of the area is plain and under agriculture, with hills in the eastern, northern and southern parts of the mandal. The predominant rock type is khondalite, followed by charnockites, kalonized clay and quartzite. The charnockites occur as outcrops in small patches. Some of the big rock (khondalite quarries) are at Juttada and Chinnamushiwada. Laterite with iron oxide concretions is exposed near Pendurthi. All the hills inside the study area are khondalites. Workable deposits of graphite are reported near Narava (Figure 2a).

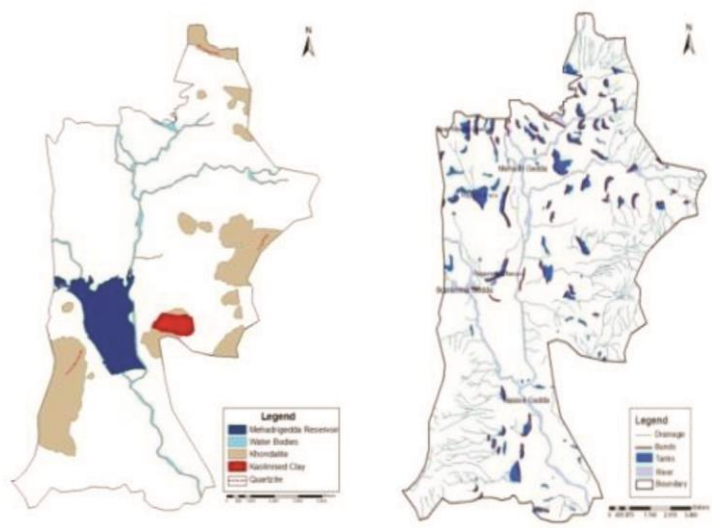

Figure 2(a). Geology Map and (b) Drainage Map

The study area enjoys sub-tropical climatic conditions and the temperature ranges between min 14^0-20^0C during the month of December and maximum 33^0-42^0C during May. The area receives rainfall during June to December from both south-west and north-east monsoon and the average rainfall is 1110mm per annum (Source: Zilla Praja Parishad, Vishakhapatnam, Andhra Pradesh).

5. Hydrology of Meghadrigedda Reservoir

The study area has numerous ephemeral streams, and depicts dendritic type of drainage which is found in regions where rocks offer uniform resistance in a horizontal direction. The highest order obtained is 6^{th}, most part of this particular subbasin comes under the jurisdiction of the study area. Meghadrigedda is an east flowing river taking its rise from the Eastern Ghats from the Nandikonda hill. It flows south upto karupavani village and thereafter in south eastern direction until it joins the sea near Dolphin's nose, Vishakhapatnam town (Figure 2b). Meghadrigedda reservoir drains an area of 220.77sqkm .

The Meghadrigedda reservoir occupies 6.6 sqkm in the study area, hence deserves a mention separately. The geographical dam site is East Longitude $83^0$11'27'' and North Latitude $17^0$45'54''. Meghadrigedda reservoir was formed near the confluence of Meghadrigedda and Narava rivers to supply 8MGD drinking water to the people of the Vishakhapatnam city. The flood bank was formed on the left side of the reservoir to protect the Howarh-Vizianagaram railway line. The FRL of the reservoir is fixed at 61.00m. The gross capacity of the reservoir at FRL is estimated to be 1169mcft. The dead storage is 1043mcft. The catchment area is under the influence of S.Kota, Vishakhapatnam, Chodavaram and Anakapalli rain gauge stations. The catchment is studded with numerous tanks above the full reservoir level. Below the reservoir there exists wetland of 510 acres on the right sided which is stabilized under the reservoir scheme. Lower riparian rights have been considered while working out the proposals for the reservoir scheme. The catchment area is influenced by both south west and north east monsoons form June to September, and flash floods occur mostly in October and November due to the influence of cyclones in the Bay of Bengal (Source: Zilla Praja Parishad, Vishakhapatnam, Andhra Pradesh). The drinking water facilities are met by 385 bore wells, 15 open wells and 1 piped water supply. The minor irrigation sources are 115, along with 15 sprinklers and 4 drips covering an ayacut of 1835 hectares (18.35sqkm) where tanks cover 1.24sqkm, tube wells 6.55sqkm dug wells 4.55sqkm, sprinklers 0.12sqkm and drip irrigation covering 0.03sqkm as per the year 2018-2019 (source: Chief Planning Officer, Vishakhapatnam, Andhra Pradesh).

6. Methodology

Sentinel data 2 has been georeferenced using Survey of India (SOI) topographical maps 65O/1 and 65O/2&3 on 1:50000 which cover the study area. The drainage network has been demarcated as a vector layer in *.shp format. Individual maps as well as thematic maps have been studied in combination. Generation of basic resources and thematic maps using remote sensing in conjunction with ground laboratory technique has been the major task for integration. Geology, geomorphology and structural maps have been combined to achieve at ground water potential zones. Basic Integration of land and water resources (BILWRUS) was generated using slope, soil, hydrogeomorphology and landuse/landcover (Table 6). Schematic chart showing methodology adopted for integrated resource analysis for the study area is shown in (Figure 8). Various intersecting polygons have been classified according to combinations, and the two composite maps have been integrated to arrive at Recommended optimal land utilization and farming techniques (ROLUFS). Finally present landuse and proposed landuse of the study area has been displayed in Table 7.

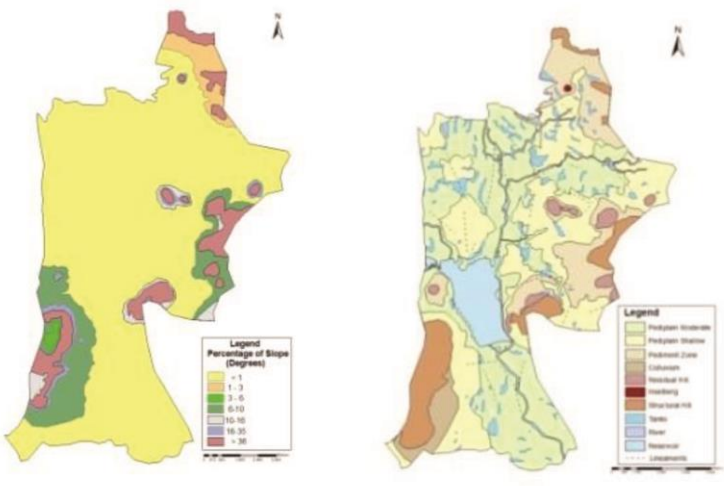

Figure 3(a). Slope and 3(b) Hydrogeomorphology

7. Thematic Maps

7.1 Slope

Slope, aspect and altitude are the important terrain parameters which influence micro climatic temperature regime and runoff which play a significant role in soil development, vegetation and crop productivity. Slope plays a very important role in the utilization of the prevailing land surface. A higher slope contributes very high erosion as compared to lower slope to less erosion. The first paper in which observed slope form is applied to the elucidation of the origin of landforms was studied by Sorby (1850) of the origin of the striking steep sided valleys. Significant contributions have been made in calculation of slope by Wentworth (1930), Raisz and Henry (1937), Robinson (1948), Miller (1953), and Strahler (1957).

Highest slopes of more than 15 degrees to 35 degrees are confined to south-western, eastern and norther parts. Major part of the area is under less than 1 degree (Figure 3(a) and Table 2).

Table 2. Contour Spacing Related to Percentage Slope

1	Slope	Lower and upper limits of contour spacing
2	0-1	>4cm
3	1-3	1.33-4
4	3-5	0.8-1.33
5	5-10	0.4-0.8
6	10-15	0.26-0.4
7	15-35	0.11-0.26
8	>35	0.11 and less

7.2 Hydrogeomorphic Units

According to Jean Bhunes, “there is no house or human habitation in the building of which man has not had to take into account the proximity of water” in the archaeological excavations of the Saraswati and Indus Valley civilizations well developed water works came to light. Vishnu Kautilya (4th century B.C) in his book “Artha Shastra” mentioned about the importance of water resources in the economy of the state. Varahamira (3rd Century B.C) in his book “Brihat Samhita” discussed about the ground water exploration and quality.

Extraction of hydrological parameters from remotely sensed data were done as early as by Jackson and Mcuen (1979) Kelly et al. (1977), Peck et al. (1981), Johnson et al. (1982), Peck et al. (1983).

Hydrogeomorphology deals with the ground water occurrence, its distribution and has the interrelationships with rock types, geological structures, landforms and surface recharge conditions. Groundwater potential of any area is mainly dependent on geology (various rock types), geomorphology (different landforms) and structures (Lineaments, fractures etc.). The related hydrogeological characters have been considered, evaluated and presented together as hydrogeomorphological units. The occurrence of ground water plays an important role in sustainable agricultural operations.

Twelve hydrogeomorphic units have been categorized in the study area viz, Pediplain moderate, Pediplain shallow, structural hills, Inselbergs, residual hills, pediment zone and pediment. The three geomorphic units made up of pediplain moderate, pediplain shallow, pediplain and pediment zones dominate the study area, followed by small patches of residual hills and inselbergs (Figure 3b and Table 3). Ground water prospects map of the study area shows a plenty of scope to increase ground water sources. There is no irrigation system; the entire activity is under dug wells, bore well and tanks. The total number of tanks are 108 tanks and tank area is 5.22sqkm, the smallest tank is in Juttada covering 0.01sqkm and the largest tank is in Pinagadi covering an area of 0.87sqkm (Sentinel data 2020, Figure 3(b) and Table 3).

7.2.1 Pediplainmoderate (PPM)

There are plain table lands with very gentle to nil slopes (flat table lands) with ground water potential being moderate to good. It has moderately thick 5-20m over burden of weathered material of varying lithology. This unit covers the western and northern parts of the mandal lying in the contour interval of 10-30m. The pediment is overlaid with moderate layer of overburden (cobble to clay). Ground water prospects are moderate to good because the unit is adjacent to rivers Meghadrigedda and Naravagedda.

7.2.2 Pediplainshallow (PPM)

These are flat and smooth surface of buried pediment with shallow 0-5m of overburden of weathered material of varying lithology. Ground water prospects are poor to moderate. This unit mostly covers the eastern part of the mandal, and lies to some extent in western and southern parts, and is between the contours 20-30m. In this layer the pediment is laid with a thin layer of overburden and is exposed to shallow depths.

7.2.3 Pediment Zone (PZ)

It is a transitory zone between the debris slope and the next important hill slope element the Pediment. Nookaraju and Vaidhyanadhan (1971). This zone lies in the contour interval of 50-100m. It's noticeable on the foot hills near the villages Porlupalem, Cheemalapalli, Vepagunta, Sowbhagyapuram and Mudapaka.

Being at the foot of the hills they are composed of loose and rocky outcrops with a thin a veneer of detritus. The pediments in this unit have developed on charnockites and khondalites. Ground water potential depends on the thickness of the debris. Wide pediments have been observed on the eastern and southern sides of the mandal. Moderate ground water aquifers are identified in this zone.

7.2.4 Pediment (P)

Pediment as stated by Twidale (1976) is a complex phenomenon and single explanation applies to all pediments; several different processes could apparently produce similar landforms.

Pediment is noticeable in Chintagatla, Mudapaka and Vepagunta villages. It lies in the contour interval of 30-50m. It has a gentle slope and rocky surface. The joints in the khondalites will be the channels of recharge to groundwater.

7.2.5 Inselbergs (I)

Expansion of the pediment or series of pediments may continue until all the remains of the original mountain mass are scattered knolls which rise above its surface. Such hills are analogue to Mouad rocks on a peneplain surface and were originally and to some extent are still, called Insebergs. Thornbury (1999). These inselbergs are noticed at four places lying in the contour interval of 100 to 200m near Sowbhagyapuram (281 and 211m), Mudapaka (169m) and in Chintagatla (211m) made of charnockites. The slope of these inselbergs is between 6 to 18 degrees.

7.2.6 Residual Hills (RH)

These residual forms are relic features lift out during scrap retrieval and pediplanation. These boulder maps owe their origin to mineralogical resistance (Twidale, 1976) and to primary parting/pacing Schumm and Chorley (1966) Garner (1974). These isolated hills are noticed at two places lying in the contour interval of (80-100m) Jerripotulpalem village (96m) and Pulagalipalem (98m) and are also made of charnockites. The slope of the hills varies from 12 to 18 degrees. The slope and sparse vegetation accounts to high runoff, hence ground water prospects are very poor. Mass wasting is prevalent in the form of soil creep.

7.2.7 Structural Hills (SH)

There are five structural hills, Yerrakonda (370m), Narava (375m), Vepgunta (263m), Porlupalem (324m), and near Mudapaka (321m). These are made up of well jointed Khondalites. The slope of the hills is in between 12 to 13 degrees. The Yerrakona hill range in the reserve forest is named after the forest. The Narava hill and the reserved forest are named after the Narava village.

Table 3. Hydrogeomorphic Units of the Study Area

S.No	Hydrogeomorphic unit	Area in sqkm	Percentage of the study area
1	Structural hills	17.70	14.75
2	Residual hills	0.50	0.41
3	Inselberg	0.52	0.43
4	Pediment zone	12.03	10.02
5	Pediment	3.10	2.58
6	Pediment shallow	39.22	32.68
7	Pediment moderate	46.02	38.35
8	Total	120	100.00

7.3 Ground Water Prospects and Water Quality

Ground water hydrology may be defined as the science of the occurrence of the distribution and movement of water below the surface of the Earth Todd (1980). Ground water prospects map is prepared for the study area (Figure 4).

92 samples were collected from the 23 villages of the study area (Table 4). The hydrochemcial data includes the samples from both bore and open wells for certain parameters like pH, TDS, chlorides, flourides, hardness, alakalinity etc. These are determined by using the standard procedures (US salnity Laboratory, 1954; USGS, 1996; Hem, 1970; APHA, 1971) in the laboratory.

pH is determined elcetronically with a direct reading called public health meter. Chloride is estimated by tritating the water sample against shear nitrate solution (0.005N) using potassium chromate indicator. Total alakalinity of water sample is estimated by tritating against standard sulphuric acid using methyl orange as indicator and represented as cacosin mg/l. Hardness of the water sample is determined by tritating against EDTA solution (0.02N) and expressed as mg/l. Flouride is determined by the Zirinium alizarine method and is expressed as mg/l (Figure 5(a), (b) and (c)).

Figure 4. Ground Water Prospects Map

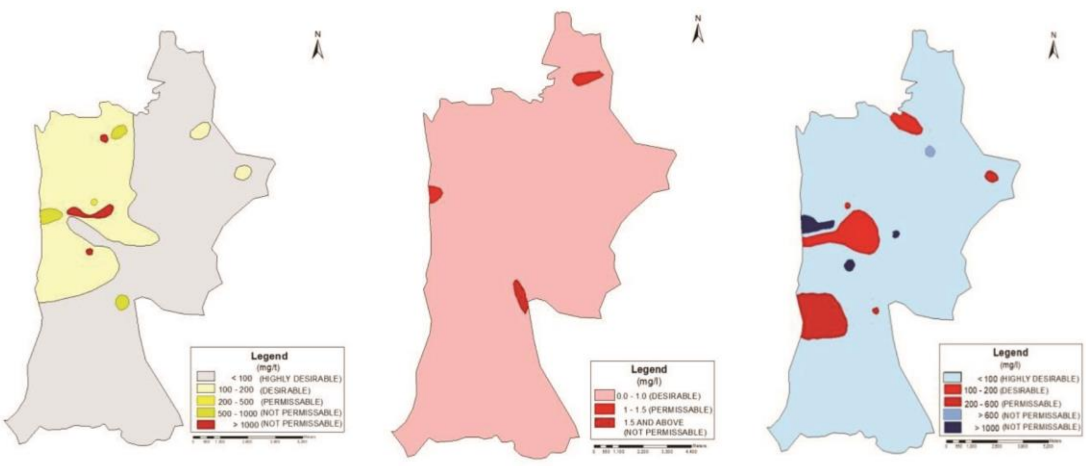

Figure 5. Water Quality Maps (a) Chorides (b) Fluroide (c) Total hardness

7.4 Soils and Soil Erodability

Barring the hills and the water bodies the rest of the area is covered with alluvial soils and red loams and clays The gravelly loams are confined to the peripheral areas of the hills in the eastern and northern part of the study On the basis of the soil map prepared, the soils of the Pendurthi mandal have been categorized into alluvial, redloams and clays, gravelly loams and shallow skeletal sandy soils which are confined to the mountains. Figure 6(a). The soils of Pendurthi are free from salinity hazard, but the study area is subject to varying degrees of erosion hazard depending upon the topographic location. The soil fertility is low to medium, necessitating the application of both organic and chemical fertilizers for obtaining good yields. Soil samples were collected for estimation of physical and chemical characteristics in the Laboratory (Anakapalli soil Laboratory, Ankapalli, Vishakhapatnam district). Based on the soil analysis, it can be stated that the soil reaction (pH) is tending to be alkaline. The soluble salt content is normal (less than 0.1mhos/cm). The fertility status in respect of organic carbon is low, available Po5 is low to medium attaining good crop yields. The spatial distribution of the soils is shown in (Table 5).

Table 4. Chemical Analysis of the Water Samples of the Study Area

No	Name of the Village	Type of Source	pH	T.D.S	Total Alkalinity as $CaCo_3$	Total Hardness as $CaCo_3$	Fluoride as Fd mg/lit	Chloride as Cl mg/lit	Nitrate	Magne-sium as Mg	Iron as Fe mg/lit	Calcium as Ca mg/lit	Carbonate Hardness as $CaCo_3$	Remarks
1	Pendurthi (W.A)	B. W	7.4	570	135	524	0.2	72	Nil	33	Nil	116	389	Potable
2	Pendurthi Near Vet Hos	B. W	6.8	1500	220	324	0.2	256	Nil	28	Nil	208	104	Potable
3	Jerripotulapalem	B. W	8.2	480	200	180	0.6	60	Nil	22	Nil	90	Nil	Potable
4	MPWS Mudapaka colony	B. W	8.2	570	240	180	0.4	60	Nil	20	Nil	100	Nil	Potable
5	MPWS at Gurrampalem	O. W	8.2	1680	310	320	0.4	300	Nil	50	Nil	110	10	Excess in TDS
6	MPWS SR Puram	B. W	8.2	1630	340	460	0.4	340	Nil	36	Nil	310	120	Excess in TDS& Calcium
7	Juttada	O. W	8.2	1390	340	420	0.2	230	Nil	44	Nil	240	80	Potable
8	Purushotam puram	B. W	7.3	1200	450	380	0.1	160	Nil	60	Nil	120	Nil	Potable
9	Pulagalipalem	O. W	7.5	660	260	220	0.4	60	Nil	24	Nil	120	Nil	Potable
10	Chinnamushidwada (MPWS)	B. W	8	1010	350	400	0.4	160	Nil	65	Nil	130	150	Potable

11	MPWS Chimalapalalli	O. W	8.5	960	370	240	0.2	100	Nil	65	Nil	130	150	Potable
12	Porlupalem	O. W	8.5	2580	430	610	0.4	520	Nil	112	Nil	150	180	Excess in TDS
13	Vepagunta	O. W	7.5	920	280	270	0.2	100	Nil	30	Nil	160	Nil	Potable
14	MPWS at Peddagadi	B. W	7.5	1480	230	280	0.4	270	Nil	60	Nil	30	50	Potable
15	MPWS at Pinagadi	B. W	7.5	730	180	220	0.4	60	Nil	43	Nil	50	60	Potable
16	Rampuram	B. W	7.5	1090	160	190	0.1	180	Nil	34	Nil	50	30	Potable
17	Gorapalli	B. W	7	1500	160	320	0.4	340	Nil	60	Nil	70	160	Potable
18	MPWS at Saripalli	B. W	8	1630	230	300	0.6	320	Nil	46	Nil	110	70	Excess in TDS
19	Rayyayapeta	B. W	8	900	240	260	1	70	Nil	46	Nil	70	20	Potable
20	Peddagadi Elementary School	B. W	7.5	5240	Nil	1860	0.2	1880	Nil	136	Nil	1300	Nil	Excess in TDS, TH, CL, Mg, Ca
21	Saripalli SC colony	B. W	8.5	2900	380	480	0.6	660	Nil	48	Nil	280	100	Excess in TDS &Ca
22	Pinagadi NH roadside	B. W	8	1010	340	280	0.4	260	Nil	49	Nil	72	Nil	Potable
23	Pinagadi	B.W	8.2	1040	220	480	0.2	860	Nil	82	Nil	143	260	Excess in Ca hardness
24	Pinagadi	O.W	8.2	3060	348	1240	0.2	240	Nil	288	Nil	80	890	Excess in TDS, TH, Mg&CH
25	Laxmipuram	B.W	8.4	1500	296	610	0.2	280	Nil	130	Nil	64	310	Excess in TDS, TH, CH
26	Laxmipuram	O.W	8.2	1720	292	630	2	1360	Nil	110	Nil	170	340	Excess in TDH, TH&CH
27	Laxmipuram	O.W	8.4	3120	468	1080	0.3	430	Nil	243	Nil	56	610	Excess in TDH, TH&CH

28	Laxmipuram	B.W	8.2	1770	260	690	0.2	1540	Nil	150	Nil	68	430	Excess in TDH, TH&CH
29	Laxmipuram	B.W	8.2	1060	380	680	0.3	560	Nil	132	Nil	142	300	Excess in TH&CH
30	Laxmipuram	B.W	8.4	1011	820	664	3	456	Nil	153	Nil	36	Nil	Excess in TH, Fluoride And Mg
31	Laxmipuram	B.W	8.6	1040	600	749	1.8	400	Nil	151	Nil	130	140	Excess in TH, Fluoride And Mg
32	Laxmipuram	B.W	8.5	840	580	372	0.3	200	Nil	74	Nil	66	Nil	Potable
33	Laxmipuram	O.W	8.9	890	540	428	1	190	Nil	94	Nil	40	Nil	Potable
34	Pinagadi	O.W	8	5610	272	3040	0.2	1300	Nil	527	Nil	870	2760	Excess in TDH, TH, CL, Mg, Ca &CH
35	Pinagadi	O.W	7.8	1900	332	1300	0.3	2280	Nil	277	Nil	160	970	Excess in TDH, TH, CL, Mg&CH
36	Pinagadi	B.W	8.2	1880	590	524	0.3	260	Nil	110	Nil	42	Nil	Excess in TDS
37	Pinagadi	B.W	8.2	1040	480	240	0.3	140	Nil	50	Nil	26	Nil	Potable
38	Porlupalem	B.W	8.8	700	440	340	0.8	200	Nil	76	Nil	26	Nil	Potable
39	Porlupalem	O.W	8.7	1120	450	344	2.8	190	Nil	68	Nil	64	Nil	Excess in Fluoride
40	Porlupalem	B.W	8.8	1700	454	280	2	100	Nil	41	Nil	110	Nil	Excess in TDS& Fluoride
41	Porlupalem	O.W	8.6	3560	510	436	2	260	Nil	147	Nil	32	126	Excess in TDS& Fluoride
42	Pinagadi	B.W	8.4	1210	488	932	0.4	336	Nil	82	Nil	48	Nil	Potable

43	Pinagadi	O.W	8.4	1840	362	656	0.2	488	Nil	135	Nil	96	304	Excess in TDS, TH, CH
44	Pinagadi	B.W	9	1030	490	472	2.2	280	Nil	79	Nil	148	Nil	Excess in Fluoride
45	Pinagadi	O.W	8.8	790	548	380	2	190	Nil	60	Nil	110	Nil	Excess in Fluoride
46	Pinagadi	B.W	8.4	1050	410	368	2	360	Nil	77	Nil	52	Nil	Excess in Fluoride
47	Pinagadi	B.W	8.5	710	510	280	1.8	140	Nil	60	Nil	32	Nil	Excess in Fluoride
48	Cheemalapalli	B.W	8.4	700	350	320	2	144	Nil	34	Nil	180	Nil	Excess in Fluoride
49	Cheemalapalli	B.W	8.5	630	430	268	1.8	80	Nil	56	Nil	37	Nil	Excess in Fluoride
50	Cheemalapalli	B.W	8.4	650	490	290	1.8	20	Nil	63	Nil	32	Nil	Excess in Fluoride
51	Cheemalapalli	B.W	8.4	740	580	360	1.8	100	Nil	66	Nil	92	Nil	Excess in Fluoride
52	Saripalli	B.W	8.4	1830	480	660	0.8	752	Nil	138	Nil	92	180	Excess in TDS, TH
53	Saripalli	B.W	8.6	1510	420	652	0.4	508	Nil	148	Nil	92	280	Excess in TDS, TH
54	Saripalli	B.W	8.6	1680	440	790	0.8	404	Nil	178	Nil	40	350	Excess in TDS, TH &Mg
55	Saripalli	B.W	8.5	1190	440	408	0.4	1180	Nil	75	Nil	90	Nil	Excess in P.H
56	Saripalli	O.W	9	1320	400	500	0.4	220	Nil	114	Nil	26	100	Excess in Fluoride
57	Saripalli	B.W	9	960	320	220	2.2	160	Nil	39	Nil	58	100	Excess in Fluoride
58	Saripalli	B.W	8.8	780	490	200	2.1	260	Nil	34	Nil	56	100	Potable
59	Rajayyapeta	B.W	8.6	640	460	52	0.8	68	Nil	1	Nil	28	100	Potable
60	Rajayyapeta	B.W	8.7	400	280	44	0.4	64	Nil	1	Nil	28	100	Potable
61	Rajayyapeta	O.W	8.7	400	280	260	0.8	52	Nil	56	Nil	32	100	Potable

62	Rajayyapeta	B.W	8.6	620	320	306	0.2	116	Nil	58	Nil	66	100	Potable
63	Gurrampalem	O.W	9	960	460	370	0.3	462	Nil	80	Nil	42	100	Potable
64	Gurrampalem	B.W	8.8	1000	400	440	0.6	240	Nil	92	Nil	60	40	Potable
65	Gurrampalem	O.W	8.8	600	320	330	0.2	88	Nil	58	Nil	90	10	Potable
66	Gurrampalem	B.W	8.4	840	370	640	1	160	Nil	140	Nil	52	270	Excess in TH&CH
67	Gurrampalem	B.W	8.6	1400	600	210	2.6	360	Nil	44	Nil	26	Nil	Excess in Fluoride
68	Gurrampalem	B.W	8.2	1300	670	456	1	352	Nil	100	Nil	40	Nil	Potable
69	Mudapaka	O.W	8.2	1090	320	260	0.2	310	Nil	44	Nil	34	Nil	Potable
70	Mudapaka	B.W	8.6	440	260	220	0.2	100	Nil	32	Nil	86	Nil	Potable
71	Mudapaka	O.W	8.7	410	320	200	2.4	40	Nil	36	Nil	48	Nil	Excess in Fluoride
72	Mudapaka	B.W	8.3	1840	320	836	0.4	740	Nil	143	Nil	50	560	Excess in TDS, CH,C
73	Mudapaka	B.W	8.8	520	380	272	0.6	410	Nil	41	Nil	100	Nil	Potable
74	S.R. Puram	B.W	8.4	1000	590	644	0.2	316	Nil	151	Nil	20	54	Excess in TH & MG
75	S.R. Puram	B.W	8.5	820	260	600	0.2	128	Nil	126	Nil	78	384	Excess in TH & CH
76	S.R. Puram	O.W	8.1	960	440	310	0.4	252	Nil	60	Nil	52	384	Potable
77	Saripalli MPWS	B. W	8.4	1400	330	460	0.6	490	Nil	92	Nil	22	130	Potable
78	Chinamushivada PWGS	B. W	8.6	880	260	460	0.6	138	Nil	94	Nil	74	200	Excess in TH, MG, CH ETC
79	Purushotam Puram PWS	B. W	8.6	540	270	280	0.6	50	Nil	50	Nil	62	10	Potable
80	Purushotam Puram PWS	B. W	8.5	940	560	440	0.4	150	Nil	80	Nil	84	Nil	Potable
81	Pendurti OW	B. W	8.4	730	280	220	0.3	90	Nil	40	Nil	53	Nil	Potable
82	Mudapaka	B. W	8.5	660	210	200	0.4	110	Nil	40	Nil	32	Nil	Potable
83	Gurrampalem	O. W	8.4	1900	240	420	0.4	84	Nil	94	Nil	28	180	Potable
84	Rampuram	B.W	7.8	1600	200	624	0.6	420	Nil	115	Nil	48	420	Excess in TH, MG,

														CH ETC
85	Rampuram	O.W	8.7	1720	270	490	0.4	500	Nil	92	Nil	110	270	Excess in TH, MG, CH etc
86	Rampuram	O.W	8	1010	260	490	0.4	80	Nil	80	Nil	84	160	Potable
87	Rampuram	B.W	8	2400	300	1200	0.3	1020	Nil	243	Nil	200	460	Excess in TDS, TH, CL, MG
88	Rampuram	O.W	8	2400	300	1140	0.2	1060	Nil	219	Nil	84	160	Excess in TDS, TH, CL, MG
89	Rampuram	B.W	8.2	200	260	1080	0.3	910	Nil	210	Nil	220	420	Excess in TDS, MG
90	S.R. Puram	B.W	8.7	1240	300	380	0.8	246	Nil	78	Nil	55	80	Potable
91	Rampuram	B.W	8.8	980	220	180	0.3	142	Nil	37	Nil	28	Nil	Potable
92	Juttada	O.W	8.4	1120	385		0.5	200	Nil	77	Nil	77	-	Excess in TDS

Note. * B.W(Bore well), O.W(Open Well).

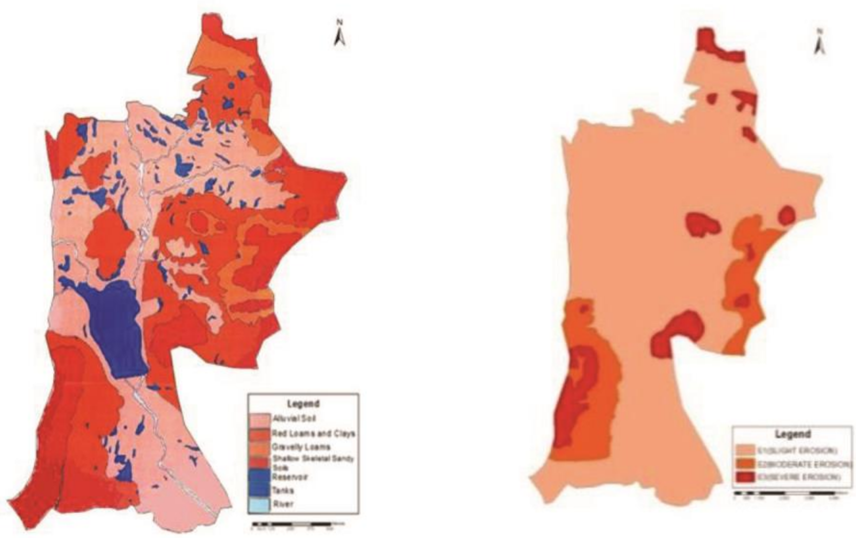

Figure 6(a). Soil and Figure 6(b). Soil Erodibility

Soil erodibility map has also been prepared and has been categorized into three categories. Figure 6(b). Slight erosion(e1) these areas are flat having none to slight degradation in the form of sheet wash resulting in the loss of 0.5cm top soil.

Moderate erosion(e2). In moderate erosion soil profile loses about 50-75 percent of the soil erosion.

Severe erosion(e3) when the soil profile has lost the entire surface horizon, and also a part of subsurface erosion, it is said to be severely eroded.

Table 5. Soils of the Study Area

S.No	Category	Area in sqkm	Percentage of the study area
1	Alluvial soil	39.22	32.68
2	Red loams and clays	41.56	34.63
3	Gravelly loams	15.20	12.66
4	Shallow skeletal sandy soils	16.45	13.70
5	Reservoir	6.60	5.50
	Total	120	100

7.5 Landuse Landcover

Landuse refers to “mans” activities and the various uses which are carried out on the land. Landcover refers to natural vegetation, water bodies, rock/soil besides any artificial cover that may result due to land transformation. The terms landuse and landcover are apparently very closely related and are mutually dependent. According to Vink (1975), the use to which land in a certain region at a certain time is put to use is known as landuse. Based on the 1920 census data (USA) Weaver 1954 published a land use map of that country. Based on Stamps (1950) land utilization system numerous studies were carried out in the Eastern European countries. Landuse maps were prepared by Avery (1965) for the USA and Bruyin (1974) for Netherlands. The world Atlas of Agriculture (1973) was based on the landuse survey map of Vink (1975).

It is estimated that the human footprint has affected 83 percent of the global terrestrial land surface and has degraded about percent of the ecosystems services in the past 50 years alone. Land Use and land cover (LUCC) change has been the most visible indicator of the human footprint and the most important driver of loss of biodiversity and other forms of land degradation (SD21, 2012).

The landuse/landcover information mapped have been arranged and grouped into a framework of landuse/landcover classification system primarily developed for interpretation with remotely sensed data. The landuse/landcover has been classified into level I and level II classes, National Remote

Sensing Center (NRSA) Here, the "level" indicates the degree of information content. Higher the level, greater will be the information. Variations in multispectral responses of the different landcover categories enable detection, identification and categorization of different landuse classes commensurate with the scale of mapping. Temporal variability of landuse/landcover evidenced by seasonal changes in water bodies and agricultural crops as well as confusion arising from similar spectral response from the different landuse/landcover classes categories are resolved by resource to multi season remote sensing data and group verification. Systematic image interpretation involving detection, identification, classification and codification of the landuse/landcover with reference to image interpretation keys in conjunction with corresponding SOI topographical sheets and other ancillary maps were utilized (Figure 7 and Table 6).

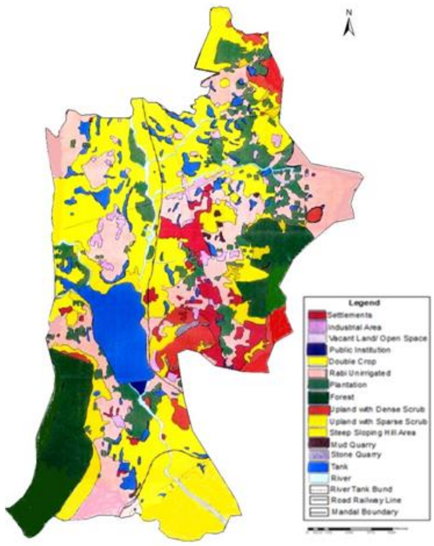

Figure 7. Landuse/Landcover

7.5.1 Built Up Land

It is defined as an area of human habitation developed due to no agricultural use where the land is covered with residential, transportation, institutional industrial recreational in association. The built up land in this mandal accounts for 15.01sqkm, 8.45 percent of the land area.

7.5.2 Agricultural Land

It is defined as the land primarily used for the cultivation of agricultural crops. The agriculture in the study area is irrigated by tanks and is rainfed. The major crops that are grown in the study area include

7.5.2.1 Double Crop

Double Crop refers to the standing crop during both kharif and rabi season. It constitutes to 29.86sqkm, i.e., 24.88 percent of the of the study area.

7.5.2.2 Kharif Unirrigated

It is associated with rainfed crops under dryland farming covering 32.85sqkm of the mandal and accounting for 27.37 percent of the landuse.

7.5.3 Plantations

Plantations are clearly identified in the crop lands during rabi season by their relatively low response particularly red and infrared regions related to their internal structure of their foliage and sizable open area of the soil exposed between the trees. Major plantations in the region are Cashew, Casuraina and Mango, covering 4.50sqkm and constitute 3.75 percent of the study area.

7.5.4 Forests

It's an area within the notified forest boundary having an association of trees and other vegetation types. The total forest area is 10.15sqkm covering 8.45 percent of the study area which is associated with trees and other vegetation cover. The scrub forest is an area of degraded forest mainly due to excessive biotic interference and natural causes which contain mainly bushes and scrubs. The degradation is mainly seen on steep slopes of the hills of the Pedurthi and Vepagunta area subject to severe erosion.

Table 6. Landuse/Landcover

Landuse Category	Area in Hectares	Area in percentage
Forest	10.15	8.45
Settlements	15.01	12.50
Industrial	2.10	1.75
Tanks	5.22	4.35
Reservoir	6.60	5.50
Upland with dense scrub	4.51	3.75
Upland with sparse scrub	4.00	3.33
Public Institution	1.30	1.08
Plantations	4.50	3.75
Stone quarry	0.07	0.05
Mud quarry	1.09	0.90
Steep sloping hilly area	2.50	2.08
Double crop	29.86	24.88
Kharif unirrigated	32.85	27.37
Total	120	100

7.5.5 Water Bodies

This class encompasses surface water bodies either impounded in the form of lakes ponds rivers, etc.

7.5.6 River/Stream

It is a natural course of water flowing on the land surface along a defined channel. It may be seasonal or perennial.

7.5.7 Reservoir/Tanks

A lake is a large body of surface impounded water natural or artificial within the landmass. Tanks are small lakes of impounded water. The reservoir constitutes 6.60sqkm, 5.50 percent of the study area and tanks 5.22sqkm comprising 4.35 percent of the study area.

7.5.8 Others

Industrial and mining are has been combined in the landuse/landcover map. It covers 2.10sqkm comprising 1.75 percent of the study area.

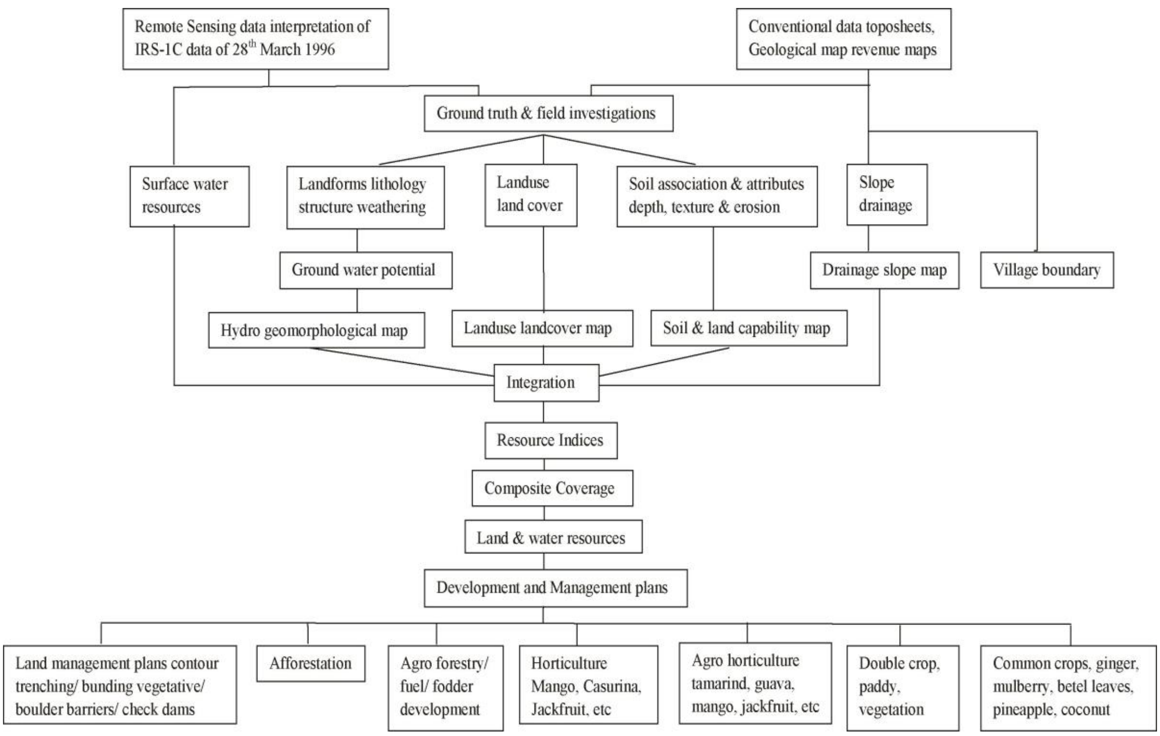

Figure 8. Schematic Chart Showing Methodology Adopted for Integrated Resource Analysis in the Study Area

Table 7. Basic Integration of Land and Water Resources (BILWRUS)

S.No	Category	Lithology	Geomorphology	Slope %	Soil	Land capability	Landuse	Groundwater prospects
1	Dryland agriculture	Khondalite	Pediplain shallow	0-3	Redloams and clays	II	Kharif unirrigated	Moderate
2	Intensive agriculture 1	Khondalite	Pediplain moderate	0-3	Alluvial	II	Double crop	Good
3	Intensive agriclutre-2	Khondalite	Pediplain moderate	0-3	Redloams and clays	III	Kharif unirrigated	Good
4	Intensive agriculture-2	Khondalite	Pediplain moderate	0-3	Alluvial	II	Kharif unirrigated	Good
5	Intensive agriculture-4	Khondalite	Pediplain shallow	0-3	Redloams and clays	III	Double crop	Moderate
6	Intensive agriculture-5	Khondalite	Pediment	3-15	Alluvial	II	Double crop	Poor
7	Agro horticulture-1	Khondalite	Pediplain shallow	0-3	Red loams and clays	III	Plantation	Moderate
8	Agro horticulture-1	Khondalite	Pediplain shallow	0-3	Alluvial	II	Kharif unirrigated	poor
9	Agro horticulture-1	Khondalite	Pediment	0-3	Gravelly loams	IV	Kharif unirrigated	poor
10	Agro horticulture-2	Khondalite	Pediplain shallow	0-3	Alluvial	II	Plantation	Moderate
11	Agro horticulture-2	Khondalite	Pediplain shallow	>15	Redloams and clays	III	Plantation	Moderate
12	Agro horticulture-3	Khondalite	Pediplain moderate	0-3	Alluvial	III	Upland with sparse scrub	Good
13	Agro horticulture-4	Khondalite	Pediment zone	0-3	Gravelly loams	IV	Plantation	Poor
14	Agro horticulture-5	Khondalite	Pediment	0-3	Gravelly loams	IV	Plantation	Poor
	Agrohorticulture-6	Khondalite	Pediment zone	5-15	Gravelly loams	IV	Kharif unirrigated	Poor
15	Horticulture-2	Khondalite	Pediplain moderate	0-3	Alluvial	II	Plantation	Moderate

16	Horticulture-2	Khondalite	Pediplain moderate	3-5	Alluvial soil	II	Plantation	Good
17	Horticulture-3	Khondalite	Pediplain shallow	3-5	Red loams and clays	III	Plantation	Poor
18	Afforestation	Khondalite	Inselberg	>15	Alluvial	VII	Upland with dense scrub	Poor
19	Afforestation	Khondalite	Pediment zone	0-3	Gravelly loams	IV	Dense scrub	Poor
20	Afforestation	Khondalite	Structural hill	>15	Alluvial	VII	Upland with dense scrub	poor
21	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	DO/DS	Poor
22	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Dense scrub	Poor
23	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Dense deciduous	Poor
24	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Deciduous open/Decid uous scrub	Poor
25	Afforestation	Khondalite	Structural hill	3-5	Shallow skeletal sandy soils	VII	Deciduous open/Decid uous scrub	Poor
26	Afforestation	Khondalite	Structural hill	5-15	Shallow skeletal sandy soils	VII	Dense scrub	Poor
27	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Dense deciduous	Poor
28	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Upland with sparse scrub	Poor

29	Afforestation	Khondalite	Structural hill	>15				Poor
30	Afforestation	Khondalite	Structural hill	5-15	Red loams and clays	VII	Deciduous scrub	Poor
31	Afforestation	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Dense deciduous	Poor
32	Afforestation	Khondalite	Colluvium	5-15	Red loams and clays	III	Dense scrub	Poor
33	Afforestation	Khondalite	Structural hill	5-15	Shallow skeletal sandy soils	VII	Upland with dense scrub	Poor
34	Afforestation	Khondalite	Colluvium	5-15	Red loams and clays	VII	Upland with sparse scrub	Poor
35	Afforestation-1	Khondalite	Colluvium	5-15	Red loams and clays	III	Deciduous open/deciduous scrub	Poor
36	Afforestation-1	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Deciduous open/ Deciduous scrub	Poor
37	Social forestry-2	Khondalite	Residual hill	>15	Alluvial	VII	Sparse scrub	Poor
38	Social forestry-5	Khondalite	Pediment zone	0-3	Gravelly loams	IV	Steep sloping hill area	Poor
39	Social forestry-5	Khondalite	Pediment zone	5-15	Gravelly loams	IV	Steep sloping hill area	Poor
40	Social forestry-6	Khondalite	Structural hill	5-15	Gravelly loams	IV	Pediment	Poor
41	Social forestry-6	Khondalite	Pediment zone	5-15	Gravelly loams	IV	Kharif unirrigated	Poor
42	Social forestry-7	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Upland with sparse scrub	Poor

43	Social forestry-7	Khondalite	Inselberg	0-3	Shallow skeletal sandy soils	IV	Upland with dense scrub	Poor
44	Social forestry-7	Khondalite	Structural hill	>15	Shallow skeletal sandy soils	VII	Upland with dense scrub	Poor
45	Silvi pasture-2	Khondalite	Pediment zone	0-3	Gravelly loams	IV	Upland with sparse scrub	Poor
46	Silvi pasture-3	Khondalite	Pediplain shallow	5-15	Red loams and clays	III	Upland with sparse scrub	moderate
47	Silvi pasture-3	Khondalite	Pediplain shallow	0-3	Red loams and clays	III	Upland with sparse scrub	Poor
48	Silvi pasture-4	Khondalite	Residual hill	>15	Red loams and clays	III	Upland with sparse scrub	Poor
49	Barren stone area	Khondalite	Pediplain shallow	0-3	Gravelly loams	IV	Mud quarry	Poor
50	Barren stone area	Khondalite	Pediment zone	3-5	Gravelly loams	IV	Mud quarry	Poor
51	Barren stone area	Khondalite	Pediment zone	3-5	Gravelly loams	IV	Mud quarry	Poor
52	Barren stone area	Khondalite	Structural hill	>15	Gravelly loams	VII	Mud quarry	Poor
53	Barren stone area	Khondalite	Pediment zone	3-15	Red loams and clays	VII	Stone quarry	Poor

Table 8. Recommended Optimal Land Utilization and Farming Techniques (ROLUFS)

S.No	Categories		Conservation measures
I	Dryland Agriculture	KU-PPS- II	Vegetation barriers and contour bunding
II	Intensive Agriculture		
1)	DC-PPS, PPM-II		
2)	F, KU-PPM, VF-II, III		Irrigation and water Management
3)	DC-PPS, PPM-II(Sodic)		Field bund maintenance
4)	DC-PPS, III		
5)	P, DC II		
III	Horticulture		
1)	P,PPS, PPM		Contour trenches
2)	PPM,P, II		
3)	PPS-II		
IV	Agrohorticulture		
1)	F, KU, PPS,P, IV, V II, III		
2)	LS, PPS,P, II, III, IV		
3)	LS, PPM, II		
4)	P-PZ-IV		
5)	P-P-IV		
6)	KU-PZ, IV		
V	Silvipasture		
1)	LS-P-V,VI		Soil and moisture conservation
2)	LS-PZ,IV		
	Sodic		
3)	PPS-LS, III		
4)	RH-LS,III		
VI	Social Forestry		
1)	LS-P,V,VI,VII		
2)	RH, LS,VIII		
3)	PPS		Gully plugging, contour trenches with vegetation hedges
4)	KU, hills-VI		
5)	PZ,IV		
6)	Hills, P,VII		
7)	Hills-LS, VII		
VII	Afforestation		

	SF-Hills	Vegetation barriers across waterways.
	Quarrying	
1)	BSA-Hill	Contour trenches with vegetation hedges.
2)	BSA-P	

The expanded form of the abbreviated words listed in the above table can be seen in Table 7.

8. Development and Management Plans

Inappropriate and uncontrolled use of natural resources can downgrade their quality and destroy them. Sustainable development and optimized use of natural resources involves effective utilization of the existing resources without damaging the assets and preserve these valuable resources for the future generations. At Present, scientific and optimized management of agriculture and natural resources are considered to be important items in sustainable development. In order to achieve sustainability and optimized land allocation we can use linear programming, multi objective linear programming and Geographical Information Systems (GIS) approaches (Watershed Planning and management 2018).

The development of the landuse optimization tool called for a detailed understanding of the variation in productivity and physical characteristics on the field parcel scale, as these conditions are important drivers for land allocation and landuse changes. PirjoPeltonen-Sainio[a]et al. (2019). One of the most basic requirements for planning is the availability of timely accurate landuse data at the shortest possible time which was achieved here with the satellite data in the area of land use and more so in the agriculture land use. Following activities have been suggested pertaining to the hydrogeomorphology, slope, soil, and ground water prospects on the existing landuse/land cover for all the 23 villages to augment the income of the farmers as agrarian economy prevails in the study area.

8.1 Intensive Agriculture

Intensified agriculture which aims at higher yields per unit area. This particular type of cropping involves high amount of labor and money. If it's practiced in the allocated villages, it will increase the incomes of the families.

8.2 Agrohorticulture

Alongside agricultural crops, horticulture sector has been suggested in the villages with a holistic growth of spices, fruits, vegetables, aromatic plants, coconut, cashew, etc. as nearness to Vishakhapatnam city makes a good business for supply of fresh flowers as well.

8.3 Horticulture

By switching on to species like local berries (ber), cluster beans, gooseberry (aonla) wood apple (custard apple) and pomegranate, the green cover can be increased to eight times. By adopting to drip irrigation the coverage increases to 32 times. The other moisture stress species are guava, cashew, pineapple and manilkarazapota, commonly known as sapodilla (Sapota). Flowers and aromatic plants can also be encouraged.

8.4 Silvipasture

Nourishment of cattle improves their working capacity, milk and meat production. Jowar, maize, bajra and horsegram are good fodder crops followed by cowpea, glycine, digitaria, pospalum, and tubers like casava, sweet potato, and arrowroot are some of the crops which can improve the health of the cattle.

8.5 Afforestation

It grows maximum foliage next to forestry; an activity chiefly looked after the government. Wood industries are the chief consumers of plantations and forests, next only to fuel needs. Of them housing and paper industry takes the lions share. Wood dust boards must be used instead of main trunkbranches, and for paper, mesta based factories must be increased.NAP (National Afforestation Programme) NAP Scheme aims to support and accelerate the ongoing process of devolving forest protection, management and development functions to decentralized institutions of Joint Forest Management Committee (JFMC) at the village level, and Forest Development Agency (FDA) at the forest division level. (http://naeb.nic.in/NAP_glance.htm). NAP scheme could be taken as an aid by the mandal revenue office, and forward the proposed afforestation for the covered villages.

Hibiscus Sabdarifa species yields 12-15 tonnes per hectare, while Cannabinus 10 to 17 tonnes/hectare. There are several species which spur out long branches in no time and they must be encouraged. EryhtinaIndica (local name, Dadap), ficusInfectoria (bunyan) and Firligosia (Pipa) are all very good to support afforestation, by implanting such ideas biomass growth can be increased.

8.6 Social Forestry

Social forestry is an activity of utmost importance to the common man, hence must be practiced anywhere from high moisture zones like tank bunds, water harvesting structures, etc. Even broad casting of seeds in rock beds also will yield excellent results. The stress should be laid on local needs, growing a variety of plants and social fencing. Neglect of the organic matter of the trees by training at growing stage not only wastes biomasss, but also stunts growth and economy. Close density hastens vertical growth, trimming girth, growth, and biomass. Social fencing is a must for survival of greenery.

8.7 Barren Stone Area

The quarrying is mostly done in the villages on the sides of the barren mountainous area. In the first place heavy quarrying must be stopped by the local government, however if the activity is being carried on with the support of the local or state government, then it must be encouraged in making large plunge holes in the center, in such a way that they become reservoirs of water in the monsoon season, especially near Vepagunta village.

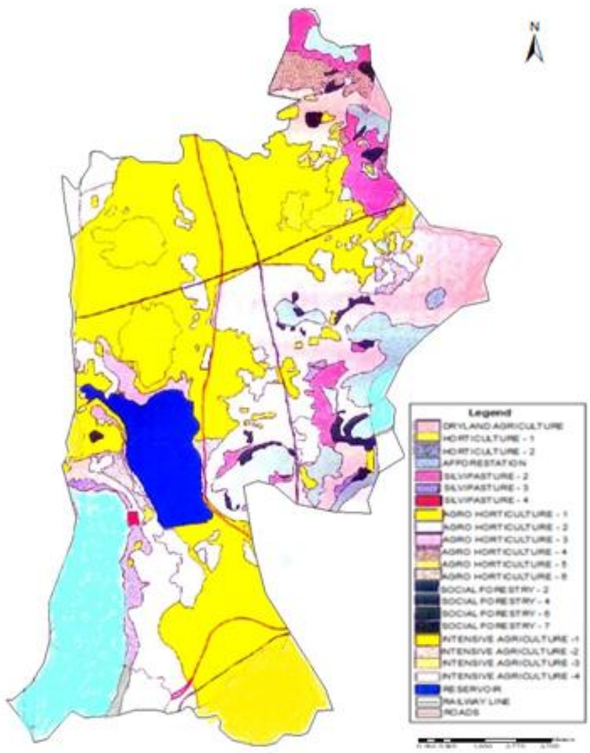

Figure 9. Proposed Landuse for the Study Area

Table 9. Current Landuse and Proposed Land Use of the Study Area

S.No.	Name of the Village	Present Landuse	Proposed Landuse
1	Gorrapalle	Rabi unirrigated, plantation, Double crop	Dryland Agriculture, Agrohorticulture-2, 4, Intensive agriculture-1, 4
2	Saripalle	Double crop, Rabi unirrigated, Plantation	Intensive agriculture-1, Social forestry
3	Mudapaka	Upland with dense scrub, Upland with sparse scrub, plantation, Rabi unirrigated	Afforestation, Silvipasture, Agro horticulture-4,6, Dryland agriculture
4	Gurrampalem	Upland with dense scrub, Upland with sparse scrub, plantation	Afforestation, Horticulture-2, Silvi-pasture, Agro horticulture
5	Rajayyapeta	Double crop, Rabi unirrigated, Plantation	Social Forestry, Dryland agriculture, Silvipasture
6	S.R. Puram	Rabi unirrigated	Dryland agriculture, Horticulture-2
7	Valimeraka	Plantation, forest, Rabi unirrigated, Upland with sparse scrub	Agro horticulture-2, Horticulture-2, Intensive Agriculture-1, 2, Dryland Agriculture, Afforestation
8	Pulagalipalem	Rabi unirrigated, Plantation	Dryland Agriculture, Social Forestry-2

9	Juttada	Plantation, Double crop	Agro horticulture-2, Horticulture-2, Silvipasture
10	Chinnamushiwada	Rabi unirrigated, Plantation, Settlements	Dryland Agriculture, Agro horticulture-1, 2, 4, Intensive agriculture-1, Social forestry-2, 5, Silvipasture-2, Afforestation
11	Ramapuram	Plantation, Double crop, Rabi unirrigated	Agro horticulture-1,2, Horticulture-3
12	Pinagadi	Plantation, Double crop, Rabi unirrigated, Industrial and mining area	Intensive Agriculture-1, Agro horticulture-2, Dryland Agriculture
13	Pedagadi	Double crop, Rabi unirrigated, mining area	Agro horticulture-2, Dryland Agriculture, Horticulture, Intensive Agriculture-2
14	Chintagatla	Double crop, Rabi unirrigated, Upland with sparse scrub, Plantation	Agro horticulture-1, Silvipasture, Social Forestry
15	J.R. Palem	Forest, Upland with dense scrub, Upland with sparse scrub, plantation	Agro horticulture-4, Silvipasture-3, 4
16	Narava	Forest, Upland with dense scrub, Double crop, Rabi unirrigated	Silvipasture, Dryland Agriculture, Agro horticulture-1, 2, Horticulture-3
17	Porlupalem	Upland with dense scrub, Upland with sparse scrub, Stone quarrying	Afforestation, Silvipasture, Intensive agriculture-2
18	Chemalapalli	Upland with dense scrub, Upland with sparse scrub, Rabi unirrigated, Stone quarrying	Silvipasture-2, Dryland agriculture, Social Forestry, Afforestation
19	Lakshmipuram	Double crop, Plantation	Agro horticulture-1, 2
20	Krishnarayapuram	Plantation, Rabi unirrigated, Industrial area, Settlements	Social Forestry-2, Intensive agriculture-1, Agro horticulture-2
21	Purushotampuram	Rabi unirrigated, Settlements, Plantation	Dryland agriculture, Intensive agriculture-1, Agro horticulture-2
22	Vepagunta	Double crop, Upland with sparse scrub, Rabi unirrigated, Plantation, Industrial area, Settlements	Social forestry-2, 5, 7, Afforestation, Dryland agriculture, Agro horticulture-1, 2, 3, 4, Silvipasture-2, 3, Intensive agriculture-1
23	Pendurti	Double crop, Plantation Rabi unirrigated, Mining and Industrial area	Social forestry, Silvipasture-2, Dryland agriculture, Horticulture

9. Discussions

National Water Development Program for rainfed areas (NWDPRA) norms have been followed in acheiveng at (BILWRUS) Basic Inegration of land and water resources by integrating Drainage, Slope, Soil, and Hydrgeomorphology, which has inturn been overlayed with Landuselandcover to arrive at Recommended Optimal Landutilization and Farming Techniques (ROLUFS). The Prepared BILWRUS (Table 7) has been set as a guidleine to match with the ROLUFS (Table 8) to arrive at conclusion for a propsed landuse for each and every village (Table 9). In Table 7, 55 categories of land utlization have been covered as against geology, geomorphology, slope, soil,landcapability, ground water prospects, and as per the pertaining landuse, the propsed land use has been suggested for all the 23 villages with sutiable conservation methods as well (Figure 9, Table 9).

It is essential to develop rural technologies system with a proper setup of delivery modes in growing greens. The covered aspects are silivpasture, horticulture, social forestry afforestation and organic fertilization. Rain water strategy could be developed so that water is stored in underground channels during the rainy season when in plenty,and consumed duing the dry season, when water is scarce. This strategy will also complement the bore well technique which is much more expensive and sometimes non-functional. The constructiocn of rural roads must be backed with adequate transportation system so that the rural dweller should be able to transport their agriculture produce to the district headquarters. The farmers could organize marketing of their products to obtain better returns. Facilities must be extended to lease out machinary as most of the villagers lack the machinery, and have to expend most of their energy for physical work, their productivity is also very low, and their cycle of poverty becomes a viscous one. In order to allow and maintain continuity in the rural development programs, the Government must enshrine rural development programs into Law, so that subsequent administration will continue to follow and maintain the program, as it is common practice when one administration leaves power, the subsequent administrations tend to jettison or underplay the previous government programs. Proposed land use pattern helps in improving the environmental conditions and rural economic growth, equally helping in sustainable development.

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