

***Land Resources of Madahalli micro-watershed of
Chamrajnagar district, Karnataka for Integrated
Watershed Planning.***



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INTRODUCTION

Land and water are the most vital natural resources of the country and these are under tremendous stress due to ever increasing biotic pressure (Gawande, 2002). The optimal management of these resources with minimum adverse environmental impact is essential not only for sustainable development but also for human survival. Watershed is an ideal unit calling for multidisciplinary approach to the resources management for ensuring continuous benefit on sustainable basis. Integrated watershed management is a prerequisite not only for land, water and management of degraded areas for conservation and protection of areas so that bio-diversity and genetic resources are protected for future generations. Land Resource Inventory mapping plays a vital role in resource management in Karnataka. It assists in the planning for future land use, particularly agriculture, because it assesses the land resource and its potential for sustainable agricultural production.

Karnataka state is one of the pioneering states in watershed development activities in India. The Project is designed to demonstrate more effective watershed management through greater integration of various programmes related to rain-fed agriculture in the area. It is to strengthen the science base of watershed management by enhancing the understanding of soil related constraints and potentials, and climatic variability, and developing tools for measuring them within the planning process.

The detailed soil survey and related activities were planned in April. 2014. Detailed characterization and mapping of all the existing land resources like soils, climate, water, minerals and rocks, vegetation, crops, land use pattern, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government. From the data collected at farm level, the specific problems and potentials of the area identified and highlighted, Conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed to the farmer and other land users of the area.

The present study aims to provide site specific database for the Madahalli watershed (698 ha), Gundlupet taluk, Chamrajnagar district. The land resource database was generated by using cadastral map of the watershed as base along with cartosat-1 imagery. The major objectives of the study are

1. Detailed Land Resources Inventorization for Madahalli microwatershed for scientific integrated watershed planning.
2. Collection and interpretation of climatic and agronomical data for crop planning.

3. Assessment of the suitability of land resources for various crops and other uses.
4. Watershed Assessment on scientific lines to identify best management practices and researchable issues.
5. To enable the watershed and other line departments to prepare the action plan for the micro watershed.

GEOGRAPHICAL SETTING

2.1 Location And Extent

Madahalli microwatershed is located in Terakambi Hobli, Kudasoge grama panchayath, Gundlupet taluk of Chamaraj nagar district (Fig.2.1). The microwatershed with total area of 698 hectares lies between $76^{\circ}46' 15.16''$ and $76^{\circ}48' 15''$ East longitudes and $11^{\circ}43' 05.91''$ and $11^{\circ}44'43.13''$ North latitudes. It is located at about 30 kms from Gundlupet. The villages coming under madahalli watershed is Karkla madahalli(298 ha), Thodipura(172 ha), Vaddagere(49 ha) Alwadi (178 ha) and Kudasoge (4ha).

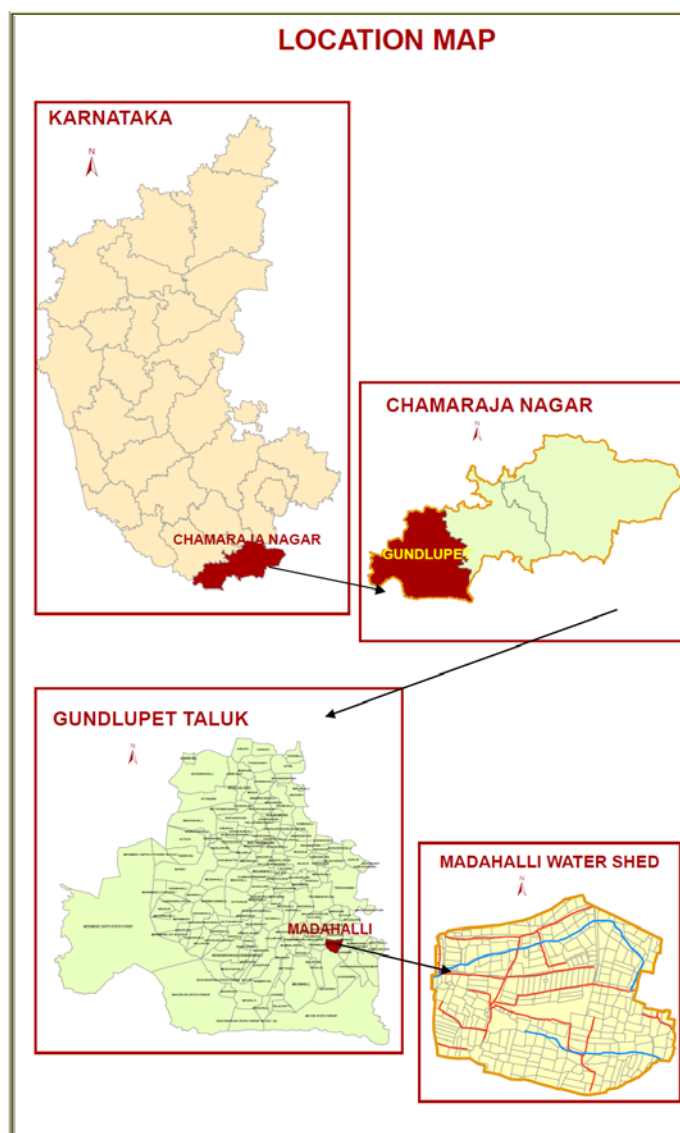


Fig.2.1.Location of Madahalli micro watershed Gundlupet taluk, Chamaraj nagar district

2.2 Geology

Granite and gneiss is the major rock type observed in the watershed. Quartz, feldspar and mica are the major mineral composition of granite and gneissic rock types occurring in the watershed. These variations are reflected in the soil types identified in the area



Fig.2.2 The granite and gneiss show significant variations in their texture, colour, mineral assemblage and degree of weathering

2.3 Slope

The elevation of the area ranges from 868 to 919 m above MSL. The area is in very gently sloping to gently sloping uplands with slope percentage ranging from 1 to 5. The direction of the slope is from east to west.

2.4 Drainage

The watershed is drained by two streams and one tank. The tank is located in western part of watershed. This tank is seasonal and dependent only on rain. The tank receives its supply from limited catchment area which is not sufficient to fill the tank completely every year. Due to uncontrolled erosion from the marginal lands and uplands the tanks are heavily silted and have very limited water storage capacity.



Fig.2.3 Gently sloping summits in Madahalli village



Fig.2.4 Nearly level foot slopes in Madahalli village

2.5 Physiography /land form

The area can be broadly divided into uplands and footslopes. Very gently sloping to gently sloping covers around 67% of the area in the micro watershed. These areas are under cultivation for long time and terracing is commonly observed in the watershed. In about 30 percent of the area level to nearly levellands exist.

2.6 Climate

The climate of the area is semi-arid transition. The climate of the region is characterized by hot and dry summer with mild winter. The annual precipitation is 734.5 mm. Most precipitation falls in October, with an average of 161 mm and the driest month is January with 3 mm. The average annual temperature in Gundlupet is 23.7 °C. April is the hottest month in the year with mean temperature of 34.6°C and January and December are the coldest months. The LGP ranges from 90 to 120 days. The soil moisture regime is ustic and soil temperature regime is isohyperthermic.

The growing period, which indicates the availability of water for plant growth, is 90-120 days. It starts from the April and continues up to the end of November. Due to this, short to medium duration crops (like Ragi, groundnut, pigeon pea, horse gram, fodder sorghum, etc.) are grown successfully in the area. Cultivation of any long duration crops need supplemental or assured irrigation facilities. The deep rooted cotton and pigeon pea are important inter crops to exploit the residual moisture present in the lower horizons of the soil.

Table 2.1. Mean monthly rainfall and PET for the period from 1960 to 2011

S.No	Months	Rainfall in mm	PET in mm
1	January	0.8	129.1
2	February	6.8	133.8
3	March	26.9	164.9
4	April	73.6	153.8
5	May	103.9	147.2
6	June	56.0	124.6
7	July	50.4	116.4
8	August	55.8	117.1
9	September	92.0	116.8
10	October	164.1	111.1
11	November	80.5	106.2
12	December	23.5	109.9
Total		734.5	1530.9

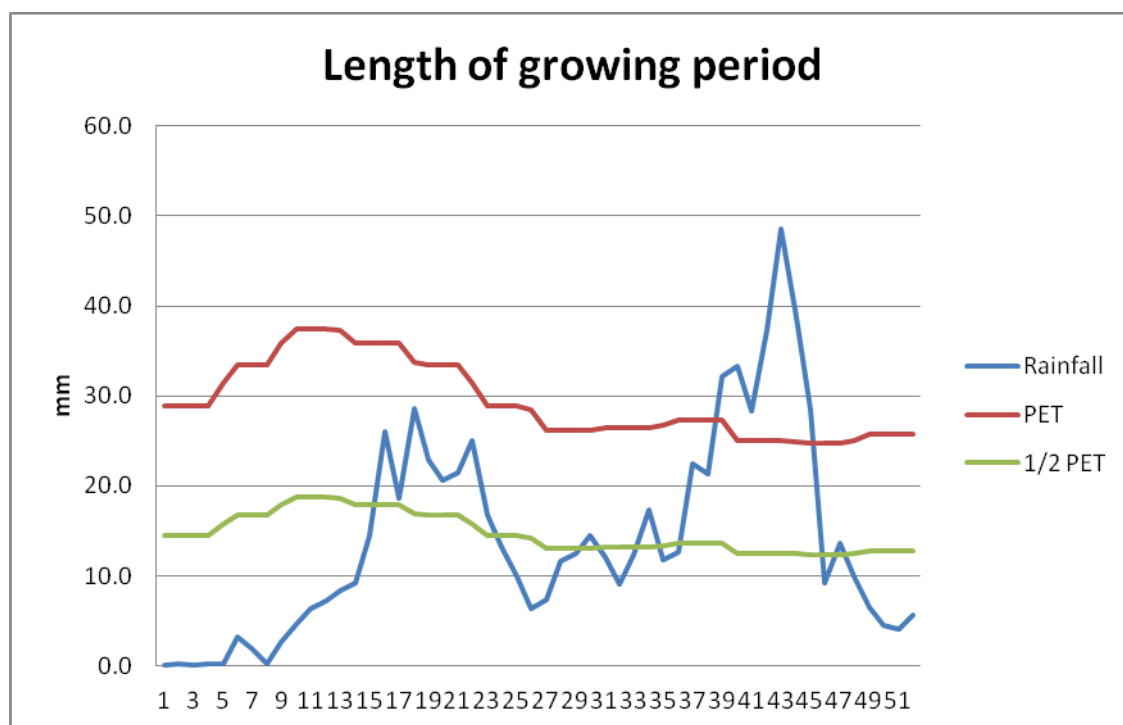


Fig.2.5 rainfall distribution and PET of Madahalli micro watershed

2.7. Natural Vegetation

The natural vegetation is sparse, comprising few tree species, shrubs and herbs viz Pongamia, Neem, Lontana, Tamarind, Soapnut tree, ficas religiosa. They were under moderate to thick forest vegetation earlier. But due to the encroachment and deforestation, which is very well evident in the area, almost the entire vegetated or forest areas have become barren without any tree cover at present. Still there are some remnants of the past forest cover, which can be seen in patches in some ridges in the watershed. Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the village is causing vegetative degradation of whatever little vegetation is left in the area. The uncontrolled grazing has left no time for the regeneration of the vegetative cover.

2.8. Land Use

The major crops grown are ragi, groundnut, pigeonpea, castor, mango, tamarind etc. About one fourth of the total area in the watershed is cultivated to ragi, which is also a staple crop of the villages. Next to ragi, groundnut is cultivated in about 39 ha in the village. Pulses like Red gram, horse gram and dolichos are cultivated as mixed crops in the rainfed uplands, mostly along with groundnut. Apart from the annual crops, horticultural crops like mango and tamarind in the rainfed uplands and banana and coconut, vegetables viz. tomato, chillies and onion are the major crops cultivated in the irrigated lowlands of the watershed area.



Fig 2.7. Turmeric and Field bean cultivation in irrigated uplands

Survey Methodology

The purpose of the land resource inventory is to delineate similar areas, which respond or expected to behave similarly to a given level of management. This was achieved in Madahalli by the detailed study of watershed area (like slope of the land, erosion, drainage, occurrence of rock fragments etc.) and soil characteristics (like depth, texture, colour, structure, consistency, coarse fragments, porosity, soil reaction etc.), followed by grouping of similar areas based on soil-site characteristics into homogenous (management) units and showing their extent and distribution on the village cadastral map. The high intensity survey (at 1:10000 scale) was carried out in 698 ha area. The techniques and tools used are given below

3.1 Base map used

Detail survey of the watershed was carried out by using cadastral map as a base. The cadastral map shows field boundaries with their survey numbers, location of tanks, streams and other permanent features of the area. Remote sensing data products from Cartosat-1(ortho corrected) at the same scale was used in conjunction with the cadastral maps to identify the landforms and other surface features. Imageries helped in the identification and delineation of boundaries between hills, uplands and lowlands, water bodies, forest and vegetated areas, roads, habitations and other cultural features of the area.

3.2 Field investigations

Preliminary traverse of the micro watershed was carried out by using cadastral map which shows field boundaries with their survey numbers, location of tank and streams, and other permanent features of the area. During the traverse geological formations, drainage patterns, surface features, slope characteristics, landforms and land use patterns of the area were identified based on the initial traversing. Three transect were selected to study the profile at closely spaced intervals to take care of any change in the land features like break in slope, erosion gravels, stones etc. At selected sites profiles were opened upto 2 meter or shallow depth limited by rock or hard substratum. Profiles were studied in detail for all their morphological and physical characteristics.

The soil and site characteristics were recorded for all profile sites in a standard Performance as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff 1993). Apart from the transect study profiles were studied at random, almost like in a grid pattern, between the transects.. Based on depth, texture, gravel and depth of their occurrence six soil series were identified in the area.

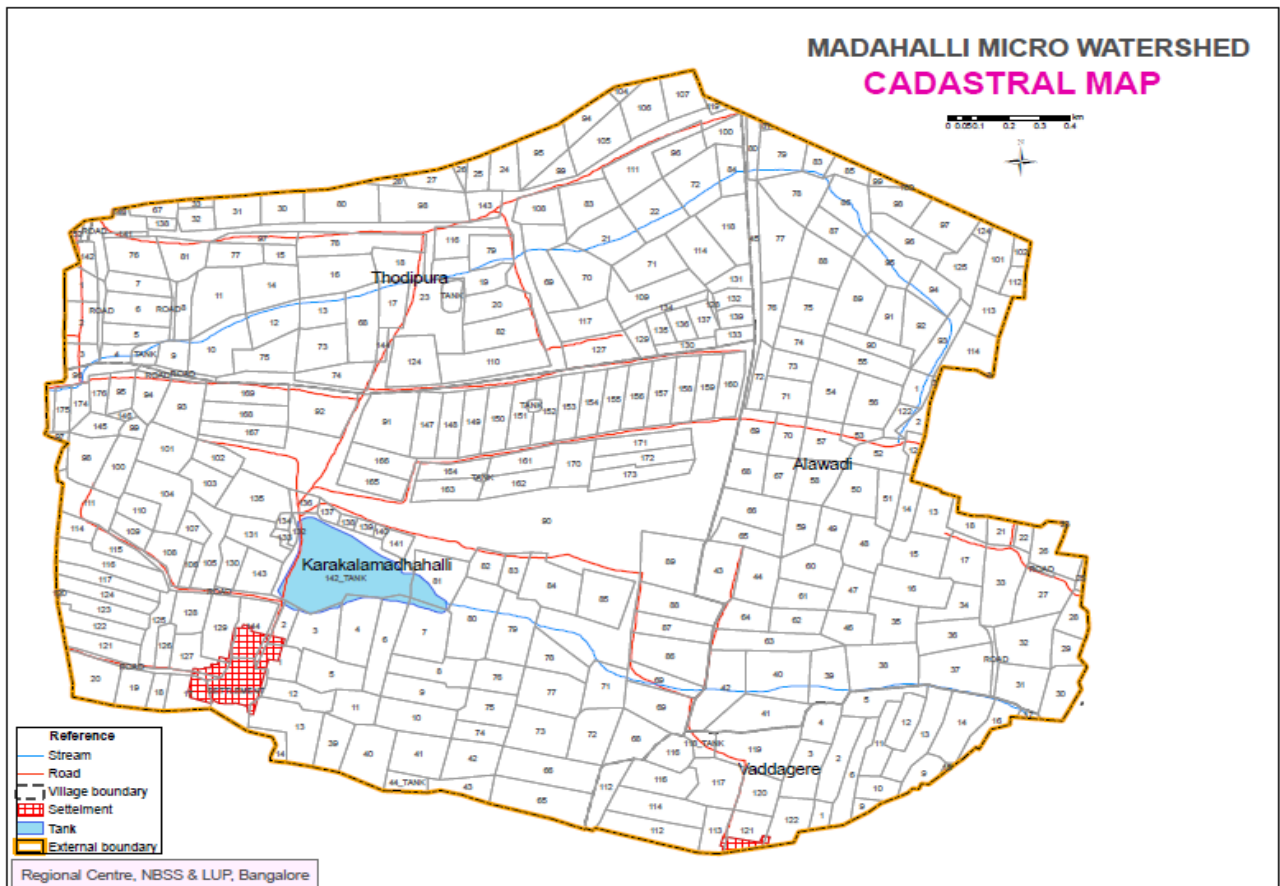


Fig. 3.1 Scanned and Digitised Cadastral map of Madahalli micro-watershed

3.3. Laboratory characterisation

Soil samples were collected from representative master profiles for laboratory characterization. Surface samples were collected from farmer's fields (41 samples) for fertility status (major and µ nutrients).

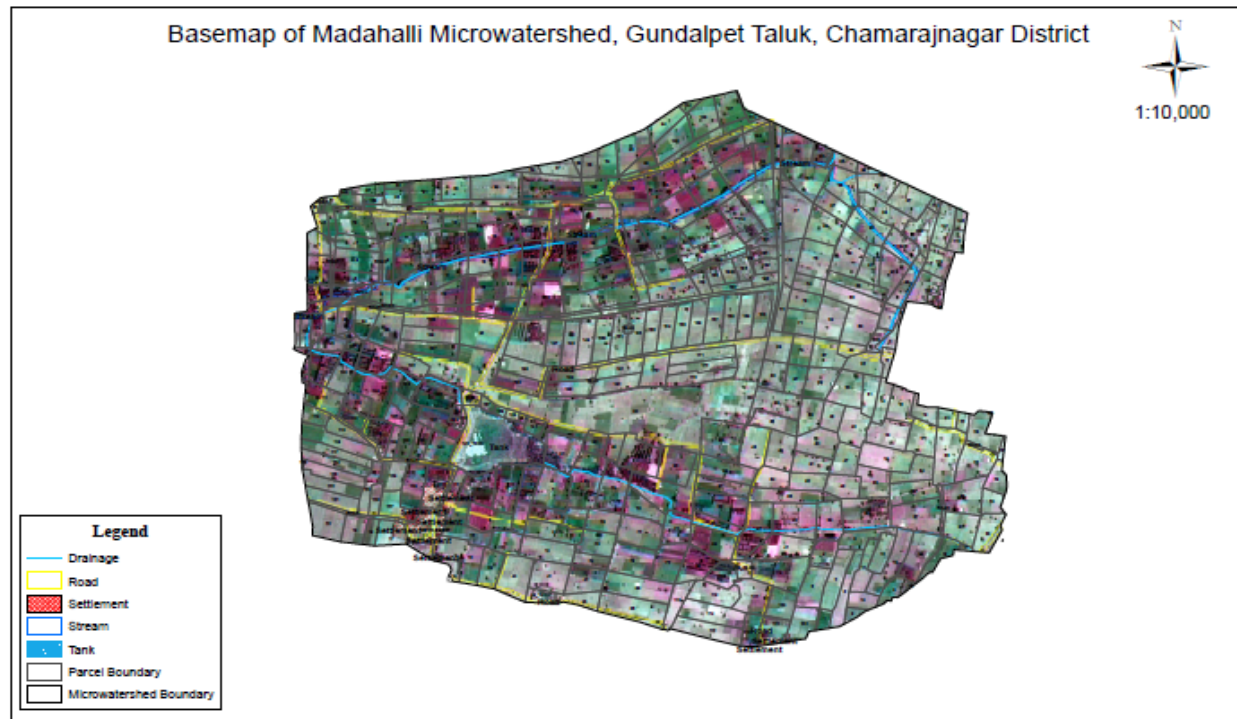


Fig. 3.2 Cadastral layer overlaid Cartosat-1merged imagery, Madahalli micro watershed.



Fig. 3.3 Boundary of Madahalli watershed overlaid on Google imagery

3.4.Finalisation of Soil Maps

The area under each series was further divided into phases and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, slope, erosion, presence of gravels, stoniness, etc. A phase is a subdivision of a soil series based mostly on surface features that affect its use and management.

The soil map of the watershed shows the distribution of 30 mapping units occurring in the watershed (Fig.3.4). The map unit description is provided in the accompanying table (Table 3.1). The series map shows the occurrence of six soil series identified and mapped in the watershed. Moderately deep, well drained red gravelly sandy loam soils, belonging to M1 and M4 Series, is the dominant soil in watershed. This soil occupies about 47 per cent of the area (330 ha). Series N5, which includes very deep dark red sandy clay loam soils occur in about 46 per cent (326 ha) area. The other soils occur in less than 5 per cent of the area each in the watershed.

3.5. GENERATION OF THEMATIC MAPS

The soil-site characteristics were interpreted for identifying the constraints and potentials like soil depth, erosion, gravelliness, salinity, and land suitability maps for various crops by using GIS software were generated.

Table 3.1 Mapping unit description of Madahalli microwatershed

Sl no	Map symbol	Description	Area (ha)
1.	M1cAg1	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 0-1 %, slight erosion and slightly gravelly (15-35%). This unit covers 5 to < 10 % rock out crops. Also includes 20% moderately deep soils (series-M2). Also 20-25 area is having 1-3 % slope.	14.31
2.	M1cB	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion This unit covers about 5 % rock out crops. Also includes 20% area having (15-35%) gravels on the surface. Also 20-25 area under 3-5 % slope.	31.1
3.	M1cB2	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently	8.03

		sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, moderate erosion Also includes 20% area having sandy clay loam surface.	
4.	M1cB2g1	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, moderate erosion, slightly gravelly (15-35%). Also includes 20% area having 3-5 % slope.	10.18
5.	M1cBg1	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion, slightly gravelly (15-35%). Also includes 20% area having 0-1 % slope.	8.24
6.	M1cC2g2	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 3-5 %, moderate erosion, moderately gravelly (35-60%). Also includes 20% area having 15-35 % gravels on the surface.	23.76
7.	M1hA	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 0-1 %, slight erosion Also includes 20% area moderately deep soil and 20-25 area under 1-3 % slope and sandy loam surface.	9.97
8.	M1hB	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 1-3 %, slight erosion Also includes 20% area under 1-3 % slope and sandy loam surface texture.	9.18
9.	M1hC2	Moderately shallow, well drained gravelly loam soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 3-5 %, moderate erosion Also includes 20-25 % area under 1-3 % slope and sandy loam surface texture.	15.93
10.	M2cB2	Moderately deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %,	12.67

		moderate erosion Also includes 20-25 % area having moderately shallow depth. 20 % areas have 10-15 % surface gravels.	
11.	M2cC2g2	Moderately deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 3-5 %, moderate erosion. Slightly gravelly (35-60 %).	36.60
12.	M2hB	Moderately deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 1-3 %, slight erosion Also includes 20-25 % area under M3 series. About 20 % area has 3-5% slope and sandy loam surface texture.	48.97
13.	M2hB2g1	Moderately deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 1-3 %, moderate erosion, slightly gravelly. Also includes 20-25 % area under M3 series. About 20 % area has sandy loam surface texture.	19.32
14.	M3cA	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 0-1 %, slight erosion Also includes 20% area with 1-3% slope and 20-25 % area has sandy clay loam surface texture.	27.20
15.	M3cBg1	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion. Slightly gravelly (15-35 %). Also includes 20% area with sandy clay loam surface and about 20 % area has deep soil.	23.75
16.	M3cC2	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 3-5 %, moderate erosion. Also includes 20% area with sandy clay loam surface and about 20 % area has 1-3 % slope with slight erosion.	16.00
17.	M3hA	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 0-1 %, slight erosion Also includes 20% area with 1-3% slope and 20-25 % area	42.23

		has sandy loam surface texture.	
18.	M3hB	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 1-3 %, slight erosion Also includes 20-30% area with moderately shallow and deep soils.	70.83
19.	M3hB2	Moderately deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy clay loam surface, slope 1-3 %, moderate erosion. Also includes 20-25 % area with 15-35 % gravels on the surface and slight erosion.	18.89
20.	M4bAg1	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Loamy sand surface, slope 0-1 %, slight erosion. Slightly gravelly (15-35 %). Also includes 20% area with 1-3% slope and 20-25 % area has sandy loam surface texture.	11.23
21.	M4bB	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Loamy sand surface, slope 1-3 %, slight erosion. Also includes 20% area with moderately deep soils and 20-25 % area has sandy loam surface texture.	15.59
22.	M4cA	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 0-1 %, slight erosion. Also includes 20% area with moderately deep soils and 20-25 % area has sandy clay loam surface texture.	21.32
23.	M4cB	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion. Also includes 20% area with moderately deep soils and 20-25 % area has sandy clay loam surface texture.	47.96
24.	M4cBg1	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion. Slightly gravelly (15-35 %) gravel.	9.04

25.	M4cC2g1	Deep, well drained gravelly clay soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 3-5 %, moderate erosion. Slightly gravelly (15-35 %). Also includes 20-30 % area with moderately shallow and moderately deep soil.	13.85
26.	M5cA	Deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 0-1 %, slight erosion.	20.81
27.	M5cB	Deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion. Also includes 20% area with moderately deep soils and 20-25 % area has sandy clay loam surface texture.	4.85
28.	M5hA	Deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 0-1 %, slight erosion. Also includes 20% area having very deep soils.	31.46
29.	M5hB	Deep, well drained clayey soil, developed from granite gneiss, occurring on very gently sloping to gently sloping uplands under cultivation. Sandy loam surface, slope 1-3 %, slight erosion. Also includes 20% area having moderately deep soil and sandy loam surface.	29.96
30.	M6hA	Very deep, moderately well drained clayey soil, developed from alluvial deposits, occurring on nearly leveled valleys under cultivation. Sandy loam surface, slope 0-1 %, slight erosion. Also includes 20% area having deep clayey soils.	29.68

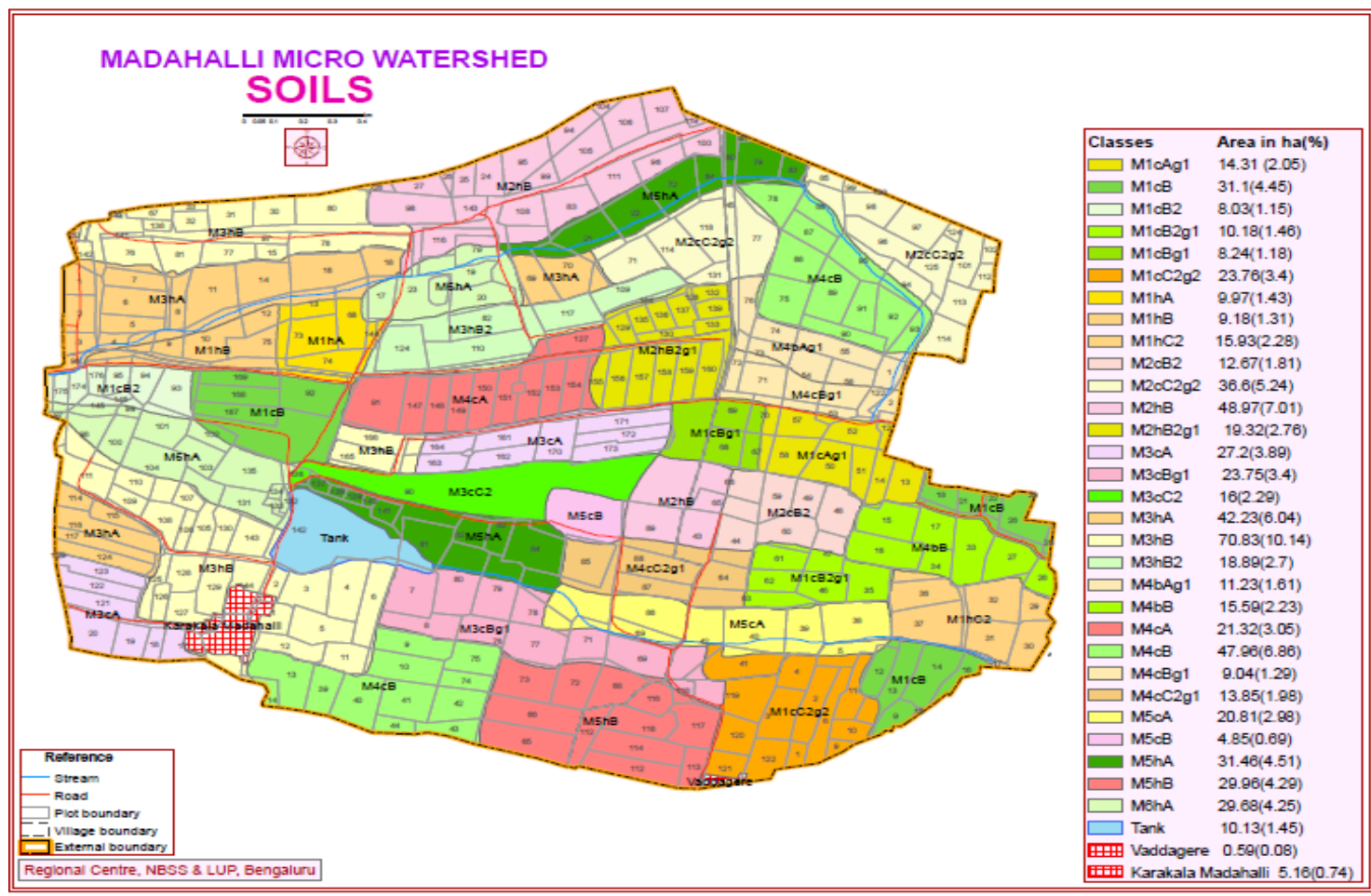


Fig.3.4 soil map of Madahalli micro-watershed

THE SOILS

The detailed information pertaining to the nature, extent, and distribution of different soils occurring in Madahalli watershed is provided in this chapter. Broadly the area is divided into two distinct landforms, uplands and lowlands/valleys and soils occurring in each landform were described below. During the course of survey, 6 soil series with 30 phases were identified. Out of this, five soil series occur in the upland areas and one soil series occur in the lowland area.

Out of the five soil series identified, M3 occur extensively, occupying about 28 per cent area of the upland followed by M1 and M2 . The series M4 and M5 occupies about 206 ha of the watershed. The one lowland series occupy about 30 ha (4%) in the watershed. The extent of the soil series and their phases mapped in the watershed is given in the

Table 4.1 identifying characteristics of Soils identified in Madahalli watershed

Seri es	Land form	Depth (cm)	Colour (moist)	Texture	Gravel %	Horizon sequence	Profile Nos.
M-1	Uplands	50-75	2.5 YR3/4,3/6, 4/4	scl-sc fine loamy	35-60	Ap-Bt-cr	T1/P1,T1/P3,R5 , R12,R11
M-2	Uplands	75-100	2.5 YR3/4,3/6, 4/4	sc	35-60 % start just after Ap layer or within 25 cm	Ap-Bt-cr	T2/P2,T2/P3,R8
M-3	Uplands	75-100	2.5 YR3/4,3/6, 4/4	sc-c	35-60 % start after 25 cm mostly within 50 cm depth	Ap-Bt-cr	T3/P2,R3,T2/P4 R6
M-4	Uplads	100- 150	2.5 YR3/4,3/6, 4/4,4/6	sc-c	35-60	Ap-Bt-cr	T2/P1,R1, R10, T1/P4,T3/P1,R9
M-5	Uplands	100- 150	2.5 YR3/4,3/6, 4/4	sc	35-60% gravels start after 50 cm	Ap-Bt-cr	R2,T1/P5,R2
M-6	Lowlan ds	>150	10YR4/6,4/2, 3/3	scl-c	-	Ap-Bw	T2/P5,R4

The identifying characteristics of all the 6 soil series mapped in the watershed are given in Table 3.1. A brief description of each series followed by description of the phases identified

and their area are furnished below. The soil-site characteristics of each mapping unit identified in the village are given in the Appendix I.

The classification of soil series, as per Soil Taxonomy, is given in Table 4.1 (USDA Soil Taxonomy, 2003). As per Taxonomy, all the upland soils are grouped under Alfisols and the lowland soils under Inceptisols. Profile development is very well expressed in the uplands compared to the foot slopes

4.1 Series M1 (madahalli-1)

These soils are formed from granite-gneiss and occur on gently sloping uplands with 1-3 per cent slopes with an elevation of 870 m above MSL (Fig. 4.1a and 4.1b). The soils are moderately shallow, well drained non-calcareous with gravelly sandy loam texture. The gravel content varies from 10 to 60 per cent.

The thickness of A horizon varies from 10 to 18 cm. Its colour is in 7.5YR, and 2.5YR hues with value 3 to 4 and chroma 4 to 6. The surface soils are light textured and varies from sandy loam to sandy clay loam with 5 to 30 per cent gravel. The thickness of B horizon ranges from 45 to 65 cm. Its colour is 2.5YR hues with value 3 to 4 and chroma 3 to 6. Its texture is gravelly sandy clay loam to gravelly sandy clay with 35 to 50 per cent gravel with moderate, medium sub angular block structure. Soil erosion is slight to moderate, which is the major constraint. The indiscriminate cutting of trees accelerates the detachment and removal of the soil cover from uplands. This problem needs to be addressed with proper conservation measures to protect this soil from erosion.

Based on location, and site characteristics, the area occupied by M1 series are divided into nine phases, which are briefly described below.

Phase	Description
M1cAg1	Sandy loam surface, slope 0-1 %, slight erosion and 15-35 % gravels
M1cB	Sandy loam surface, slope 1-3 %, slight erosion and 0-15% gravels
M1cB2	Sandy loam surface, slope 1-3 %, moderate erosion and 0-15% gravels
M1cB2g1	Sandy loam surface, slope 1-3 %, moderate erosion and 15-35 % gravels
M1cBg1	Sandy loam surface, slope 1-3 %, slight erosion and 15-35 % gravels
M1cC2g2	Sandy loam surface, slope 3-5 %, moderate erosion and 35 -60% gravels
M1hA	Sandy clay loam surface, slope 0-1 %, slight erosion and 0-15 % gravels
M1hB	Sandy clay loam, surface, slope 1-3 %, slight erosion and 0-15 % gravels
M1hC2	Sandy clay loam, surface, slope 3-5 %, moderate erosion and 0-15% gravels



Fig.4.1 and 4.2 landscape around madahalli series 1 and profile features. Survey no 169.
 Madahalli village gundlupet taluk chamrajnagar district.

4.2 Series M2 (Madahalli-2)

Soils of M-2 series have sandy loam to sandy clay loam A horizon followed by gravelly sandy clay loam to gravelly sandy clay B horizon. They have developed from granite gneiss and occur on very gently sloping to gently sloping uplands 1-5 per cent slopes with an elevation of 885 m above MSL

The thickness of solum is from 87-96 cm The thickness of A horizon varies from 10 to 22cm. Its colour is in 7.5YR, 5YR and 2.5YR hues with value 3 to 4 and chroma 4 to 6. Its texture varies from sandy loam to sandy clay loam with 5 to 10 per cent gravel. The thickness of B horizon ranges from 53 to 82 cm. Its colour is 2.5YR hues with value 3 and chroma 4 to 6. Its texture is gravelly sandy clay loam to gravelly sandy clay with 35 to 60 per cent gravel. The Bt3 horizon, Dark red colour sandy clay loam texture having moderate, medium sub angular block structure with 20 to 25 per cent fine gravels (Fig.4.3a and 4.3b).

The four phases identified under this series are briefly described below.

M2cB2	Sandy loam surface, slope 1-3 %, moderate erosion and 0-15% gravels
M2cC2g2	Sandy loam surface, slope 3-5 %, moderate erosion and 35-60 % gravels
M2hB	Sandy clay loam surface, slope 1-3 %, slight erosion and 0-15% gravels
M2hB2g1	Sandy clay loam surface, slope 1-3 %, moderate erosion and 15-35 % gravels

4.3 Series M3 (Madahalli-3)

The soils of M-3 series have sandy loam to sandy clay loam A horizon followed by gravelly sand clay to gravelly clay B horizon. They have developed from granite gneiss and occur on very sloping uplands with 5-10 per cent slopes with an elevation of 895 m above MSL.

The depth of the soil ranges from 87 to 100 cm. The thickness of A horizon varies from 13 to 19 cm. Its colour is 7.5YR hue with value 3 to 4 and chroma 4 to 6. Texture varies from sandy loam to sandy clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 69 to 81 cm. Its colour is 2.5YR hues with value 3 to 4 and chroma 4 to 6. Its texture is gravelly sandy clay loam to gravelly sandy clay with 35 to 60 per cent gravel.

6 phases identified under this series are discussed below,

M3cA	Sandy loam surface, slope 0-1 %, slight erosion and 0-15% gravels
M3cBg1	Sandy loam surface, slope 1-3 %, moderate erosion and 15-35 % gravels
M3cC2	Sandy loam surface, slope 3-5 %, moderate erosion and 0-15% gravels
M3hA	Sandy clay loam surface, slope 0-1 %, slight erosion and 0-15% gravels
M3hB	Sandy clay loam surface, slope 1-3 %, slight erosion and 0-15% gravels
M3hB2	Sandy clay loam surface, slope 1-3 %, moderate erosion and 0-15% gravels

4.4 Series M4 (madahalli-4)

The M-4 series consists of deep, well drained clayey soils on nearly level uplands. These soils are loamy sand to sandy loam A horizon followed by gravelly sandy clay to gravelly clay B horizon. They have developed from granite-gneiss and occur on nearly level uplands with 1-5 per cent slope with an elevation of 925 m above MSL (Fig.4.5a and 4.5b).

The thickness of solum ranges from 101 to 108 cm. The thickness of A horizon varies from 13 to 20 cm. Its colour is in 7.5YR, 5YR and 2.5YR hues with value 4 and chroma 3 to 6. Its texture varies from loamy sand to sandy loam with 5 to 20 per cent gravel. The thickness of B horizon ranges from 86 to 93 cm. Its colour is 2.5YR and 5YR hues with value 3 to 5 and chroma 4 to 6. Its texture is gravelly sandy clay to gravelly clay with 35 to 60 per cent gravel.

Only six phases identified under this series are described below.

M4bAg1	Loamy Sand surface, slope 0-1 %, slight erosion and 15-35 % gravels
M4bB	Loamy Sand surface, slope 1 -3%, slight erosion and 0-15% gravels
M4cA	Sandy loam surface, slope 0-1 %, slight erosion and 0-15% gravels
M4cB	Sandy loam surface, slope 1-3 %, slight erosion and 0-15% gravels
M4cBg1	Sandy loam surface, slope -31 %, slight erosion and 15-35% gravels
M4cC2g1	Sandy loam surface, slope 3-5 %, moderate erosion and 15-35% gravels

4.5 Series M5 (Madahalli-5)

These soils have sandy loam to sandy clay loam texture. A horizon followed by sandy clay loam to clay B horizon. They have developed from granite gneiss and occur on very gently to gently sloping uplands with 1-5 per cent slopes with an elevation of 890 m above MSL.

The thickness of solum is ranges from 126 to 150 cm. The thickness of A horizon varies from 15 to 20 cm. Its colour is 5YR hues with value 3 and 4 and chroma 3 to 6. Its texture varies from sandy loam to sandy clay loam. The thickness of B horizon ranges from 111 to 134 cm. Its colour is 2.5YR and 5YR hues with value 3 to 4 and chroma 3 to 6. Its texture is sandy clay loam to gravelly clay with 35 to 60 per cent gravel which mostly start after 50 cm depth.

Only four phases identified under this series is described below.

M5cA	Sandy loam surface, slope 0-1%, slight erosion and 0-15% gravels
M5cB	Sandy loam surface, slope 1 -3%, slight erosion and 0-15% gravels
M5hA	Sandy clay loam surface, slope 0-1%, slight erosion and 0-15% gravels
M5hB	Sandy clay loam surface, slope 1 -3%, slight erosion and 0-15% gravels



Fig4.7 and 4.8 Soil and landscape around madahalli series 4 and profile features. Survey no. 54
Madahalli village gundlupet taluk chamrajnagar district.



Fig.9. Moderately deep, gravelly clay with 35 to 60 per cent gravel after 50 cm depth. (Series M5 in Survey No.75)

4.6 Series M6 (Madahalli-6)

M-6 series have sandy clay loam A horizon followed by sandy loam to clay B horizon. They have developed from both colluvium and alluvium deposits and occur on nearly levelled lower slopes of uplands with 0-1 per cent slopes with an elevation of 880 m above MSL.

The thickness of solum is more than 150 cm. The thickness of A horizon varies from 11 to 26 cm. Its colour is 10YR hues with value 4 and chroma 3 to 4. Its texture varies from sandy loam sand to sandy clay loam. The thickness of B horizon is more than 150cm. Its colour is 10YR hues with value 3 to 4 and chroma 3 to 6. Its texture is sandy clay loam to clay.

Only one phase identified under this series is described below

M6hA	Sandy clay loam surface, slope 0-1%, slight erosion and 0-15% gravels
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PROBLEMS AND POTENTIALS OF LAND RESOURCES IN MADAHALLI WATERSHED

The land resource database generated from detailed soil survey of Madahalli watershed provides comprehensive information on the all land resources of the area, more specifically on soils, landforms, climate, land use pattern and socio-economic conditions. This chapter provides information pertaining to the constraints and potential areas occurring in the watershed for different uses.

5.1. Soil Depth

Soil depth generally refers to the depth of the soil occurring above the parent material or hard rock. It determines the effective rooting depth and water holding capacity. It is one of the important characteristics used to identify the productivity of the soils for various uses.

The soils occurring in the watershed are grouped into four depth classes. Out of the six soils series mapped, one soil series is very deep (>150 cm), two are deep (100-150 cm), two series are moderately deep (75-100 cm) and another one is moderately shallow (50-75 cm). Lowlands series is very deep and is not having limit for any type of use. On the other hand two soils occurring in the uplands (M1 M2 and M3 Series) have depth less than 100 cm and may affect the growth of deep rooted crops, particularly horticultural and tree crops. The depth of remaining two upland soils (M4 and M5 Series) range from 100 to 150 cm are suitable for most of the cultivated crops in the watershed.

The area under each depth class is given in Table 5.1 and Fig. 5.1. About 18.71 per cent area has moderately shallow (50-75 cm) soils. The moderately deep (75-100 cm) soils occur in about 316.46 ha (45.28%) area. Deep soils (100-150 cm) accounted for 206 ha (29.5%) area and very deep soils (>150 cm) occur in about 29 ha (4.25%) area.

Table 5.1. Soil depth classes

Depth class	Area in ha	Percent
Moderately shallow (50-75cm)	130.70	18.71
Moderately deep (75-100cm)	316.46	45.28
Deep (100-150cm)	206.07	29.49
Very deep (>150cm)	29.68	4.25

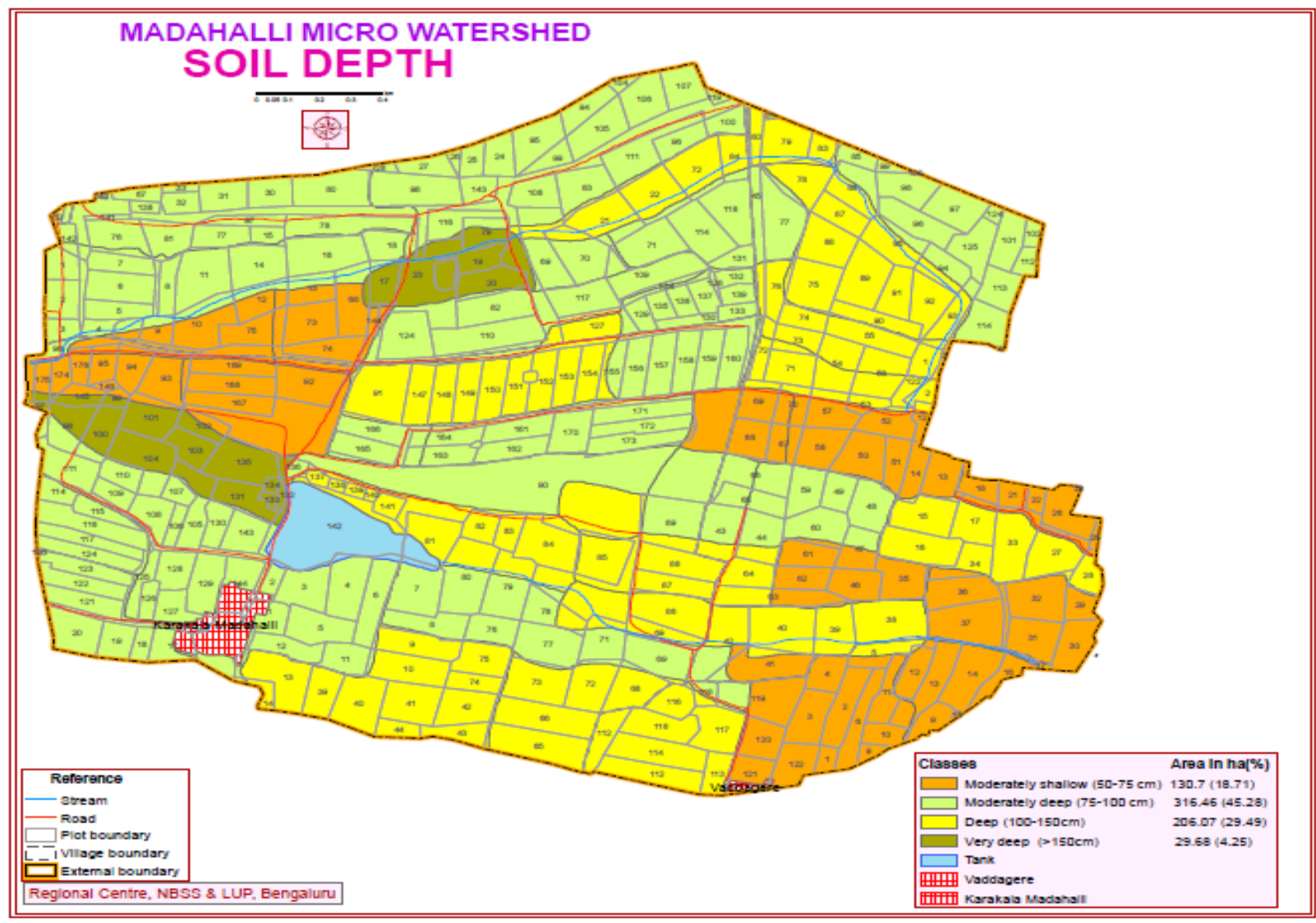


Fig.5.1 Depth classes in Madahalli micro-watershed.

5.2. Surface Soil Texture

Texture indicates the coarseness or fineness of the soil, which is determined by the relative proportion of primary particles like sand, silt and clay present in the soil. Based on the relative proportion of sand, silt and clay the soils are grouped into various textural classes like sand, loamy sand, sandy loam, sandy clay loam, clay loam, sandy clay and clay. The texture of the surface layer or plough layer plays an important role in influencing the growth and yield of crops, particularly the shallow rooted crops. Texture is an important soil characteristic that influence water intake rate, water storage in the soil, tillage operations, aeration status etc. and combined influence soil fertility.

Soils of Madahalli watershed are grouped into 5 surface soil textural classes (Table 5.2 and Fig. 5.2). The dominant soil texture is sandy loam, loamy sand and sandy clay loam. The surface soil texture in uplands is lighter (sandy loam, loamy sand) and heavier (sandy clay loam) in lowlands. This is due to the removal of finer particles in the uplands by erosion and their deposition in lowlands. About 27 ha (4%) area is having loamy sand texture at the surface and sandy loam texture observed in about 329.67 ha (47%) area. Nearly 326.42 ha (46.72%) area has sandy clay loam in texture.

5.2. Distribution of surface soil textural classes

Texture	Area in ha	Percent
Loamy sand	26.82	3.84
Sandy loam	329.67	47.17
Sandy clay loam	326.42	46.72

5.3 Soil Gravelliness

Gravel refers rock fragments present in the soil having > 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff, and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization. The amount of gravel and depth of occurrence were used as an important characteristic in grouping the soils into various soil series.

Gravels present in the surface layer are one of the important characteristic used to separate the soil series into different phases. Gravel is commonly seen in uplands areas (Fig. 5.3). Out of the 5 soil series mapped in the uplands, 2 series (M1 to M2) mostly have more than 35 per cent gravels and the soil (M4 and M5) has gravels less than 15 per cent. Nearly 73 per cent of cultivated lands have Non gravelliness (<15%).

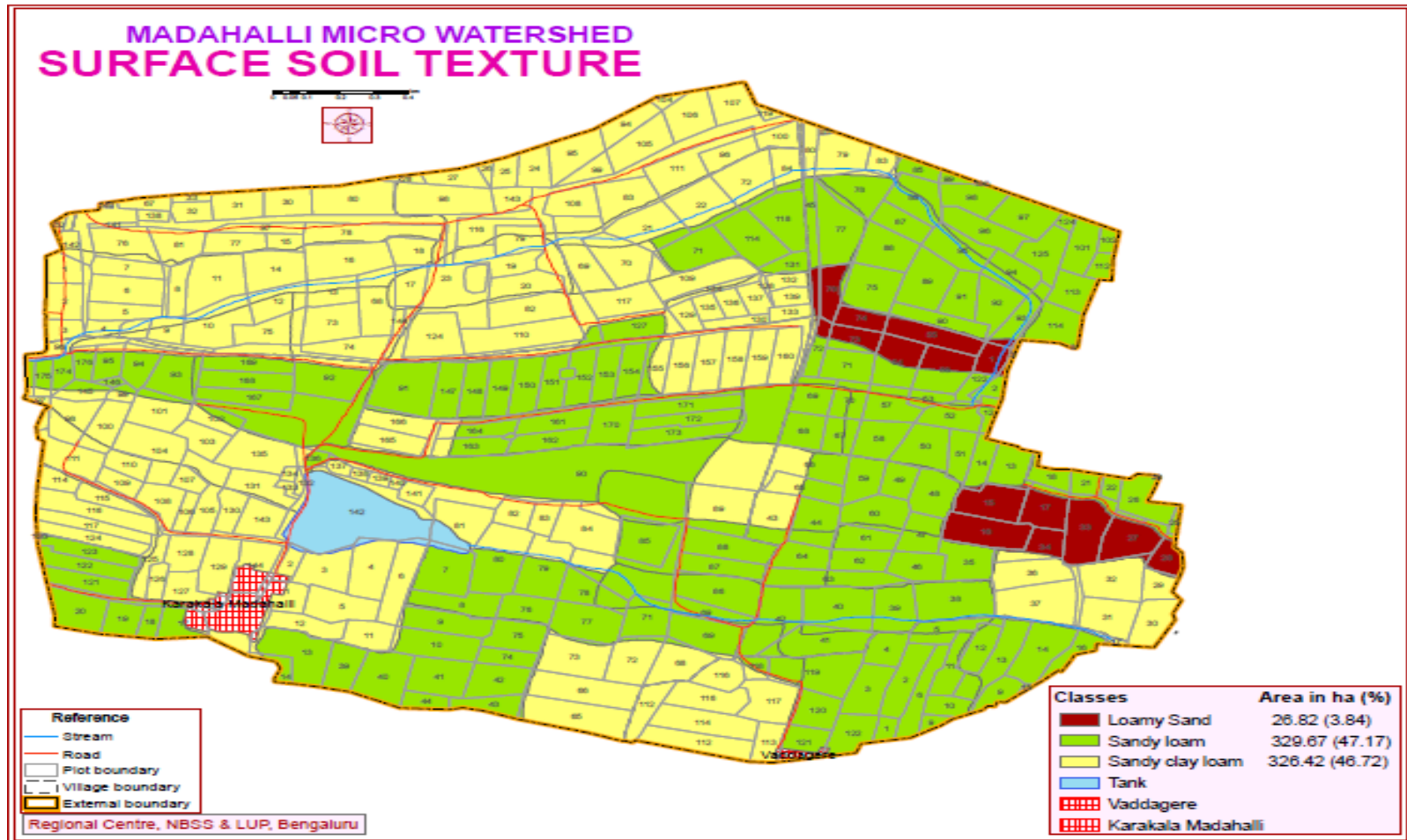


Fig.5.2 Texture classes in Madahalli micro-watershed.

Table 5.3. Distribution of Gravelliness

Gravelliness	Area in ha	Percent
Non gravelly (<15%)	512.63	73.36
Slightly gravelly (15-35%)	109.92	15.73
Moderately gravelly (35-60%)	60.36	8.64



Fig 5.3.2 Occurrence of stones and gravels on the surface in upland fields

5.4. Slope

Slope is defined by its gradient, shape and length. The length and gradient of slope influence the soil formation and soil depth, which intern affects land development and land use in any area. The slope classes range from nearly level in the lowland areas to moderately sloping in the uplands of the watershed. The slope classes identified in the watershed are given in the Table 5.4 and Fig.5.4

Table 5.4. Distribution of Slope classes

Slope class	Area in ha	Percent
Nearly level (0-1%)	208.21	29.81
Very gently sloping (1-3%)	368.56	52.73
Gently sloping (3-5%)	106.14	15.19

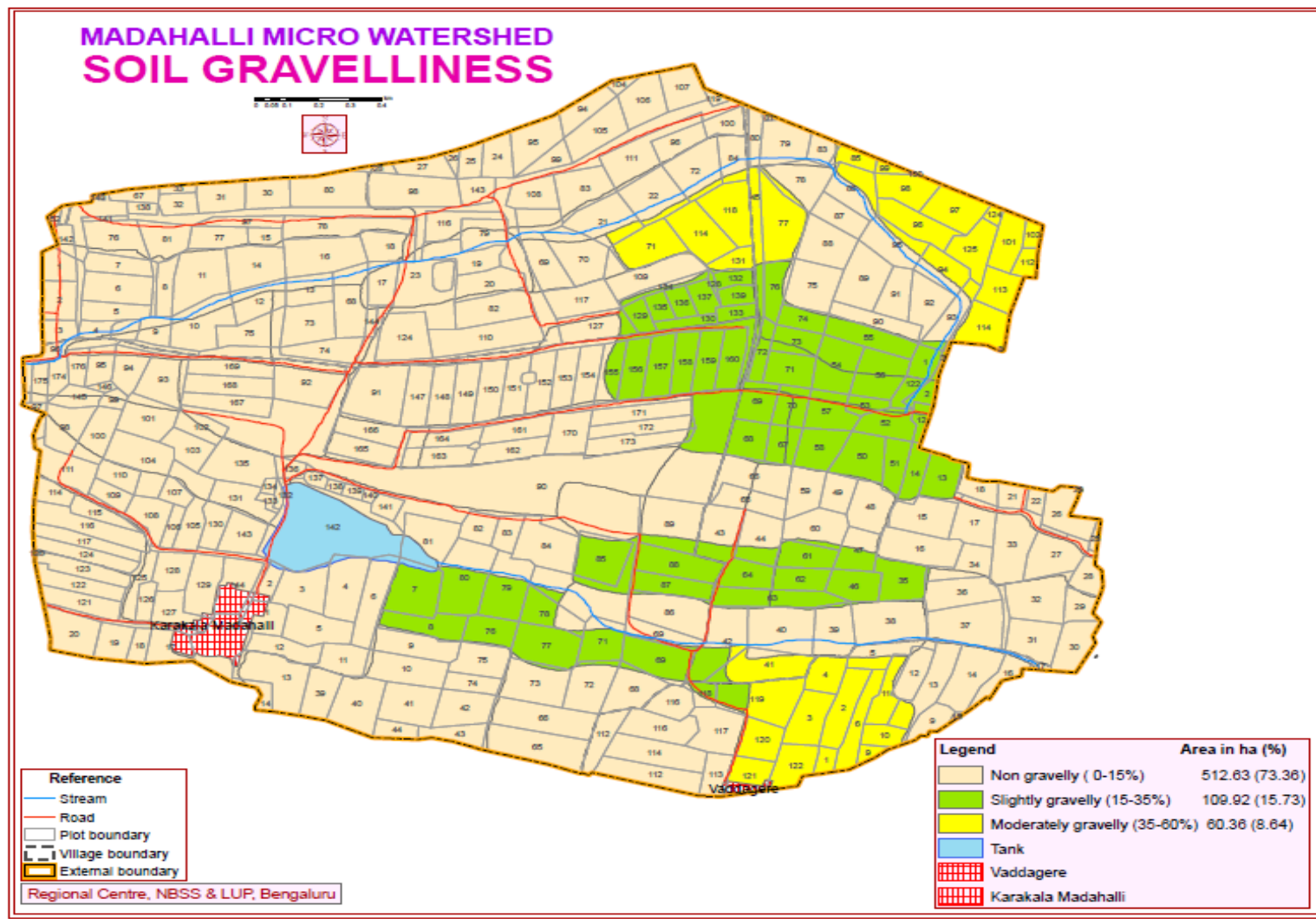


Fig.5.3.1 soil Gravelliness classes in Madahalli micro-watershed.

The low land soils with slope class range from 0-3% (Nearly level to Very gently sloping lands) account for 82 per cent of the area and all the remaining upland soils varying from gently sloping lands indicting the area prone to moderate soil erosion problems.

5.5 Soil Erosion

Soil erosion is the process involving detachment and transport of soil particles by raindrop impact. The removal of soil by water is common in the upland and hilly areas of the village. The prevalence of moderate to steep slopes in the hills/rocklands and gentle slopes in the uplands favors easy detachment and removal of soil particles from the surface. This is aggravated by the absence of vegetative cover on the hill slopes and cultivated areas of the village. Sheet, rill and gully erosion are commonly observed in the uplands and hill slopes/rockland areas.

Sheet erosion removes all finer particles and nutrients from the upper layer of soil and the soils become less fertile in course of time. Due to the continuous loss of finer particles from the surface, the soil becomes coarser in texture and in extreme situations only gravels or stones are left at the surface. The occurrence of sandy surface texture in many upland soils and presence of stones and gravel at the surface indicates the erosion problem. Sheet/rill erosion features are prevalent in the entire upland areas of the village (Fig 5.4). Based on the intensity of erosion and also the amount of soil removed (loss of A & B horizons) three erosion classes (slight and moderate) were identified in the area. Soils that are slightly eroded cover an area of about 349 ha (50.50%) and Moderately eroded area covers about 333.49 ha (47.7%).

Table 5.5.Distribution of soil erosion classes

Erosion class	Area in ha	Percent
Slight erosion	349.42	50.50
Moderate erosion	333.49	47.73

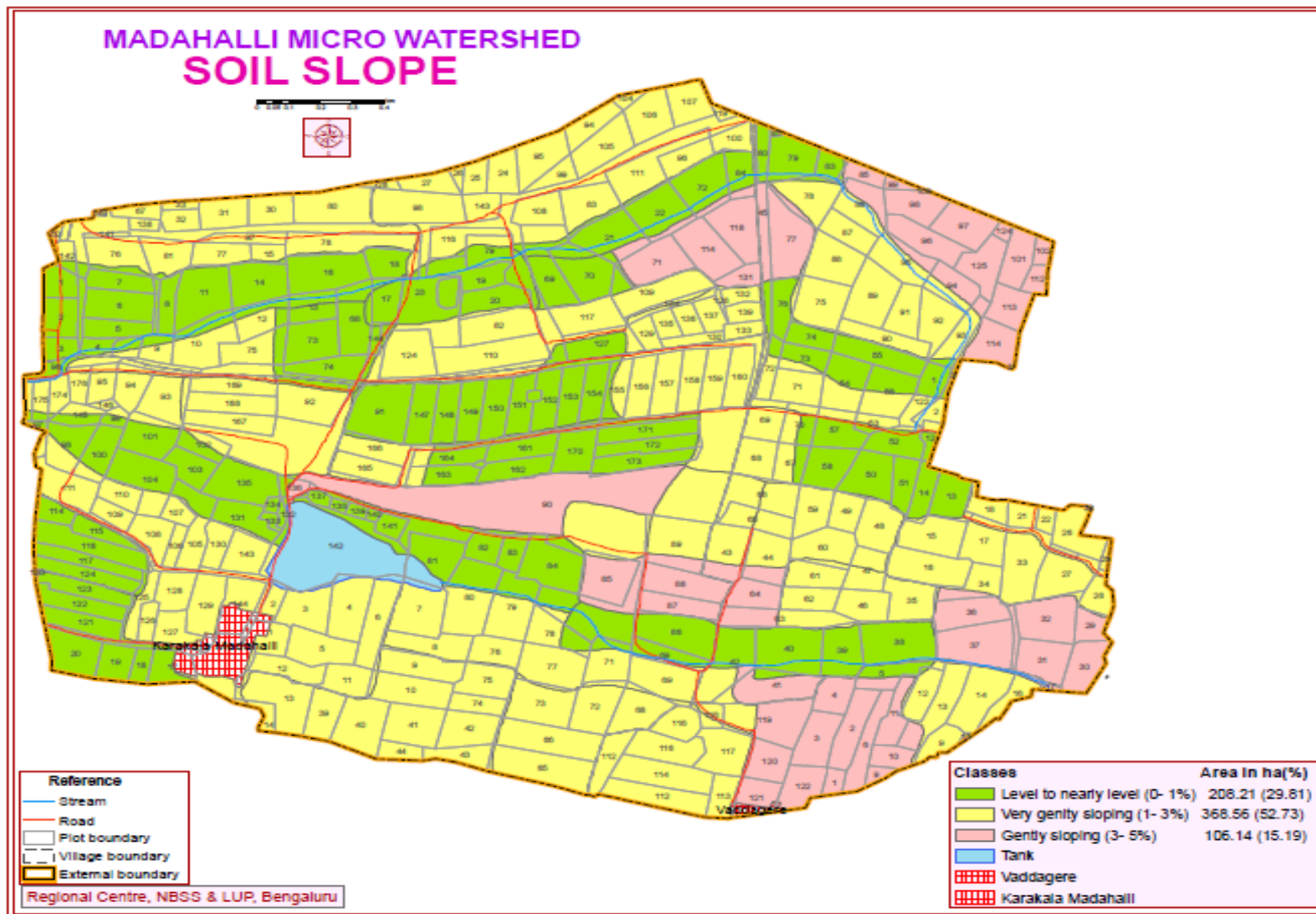


Fig.5.4. Slope c lasses in Madahalli micro-watershed.

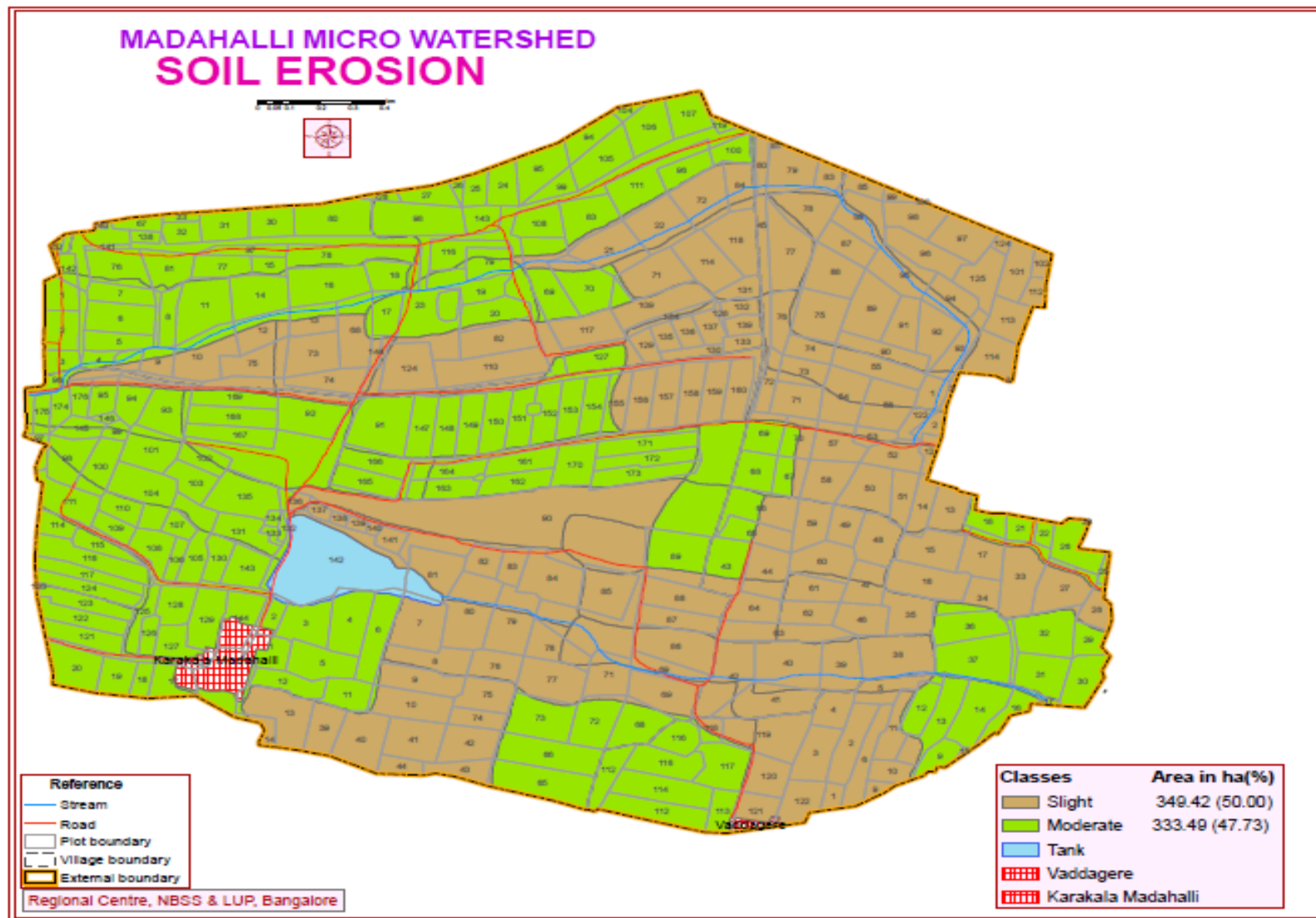


Fig.5.5. Erosion classes in Madahalli micro-watershed.

5.6 Land Capability grouping

Land capability classification is carried out by using I.A.R.I., 1971 to find out the general capability of the resources for various uses. This system is not aimed to find out the suitability of the land resources for specific uses or crops. The classification is based on the inherent soil characteristics, external land features and environmental factors that limit the use of the land for various uses.

The characteristics used to group the land resources of the area into different capability classes and sub classes are:

Soil characteristics	Depth, texture, gravelliness, pH and calcareousness
Land features	Slope, erosion and drainage.
Climate	Rainfall distribution and length of growing period

Class II	Mapping units have moderate limitations that reduce the choice of the crops or that require moderate conservation practices.
Class III	Mapping units have severe limitations that reduce the choice of the crops or that require special conservation practice, or both.
Class IV	Mapping units have very severe limitations that reduce the choice of the crops or that require very careful management, or both.
Class VII	The land area has very severe limitations that make them unsuitable for cultivation.
Class VIII	Soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are formed based on the limitations observed within the capability class. They are designated by adding a lower case letter like e, w, s, or c, to the class numeral. For example in subclass IVe, the letter 'e' shows that the main hazard in class IV land is the risk of erosion. Similarly, the symbol 'w' indicates drainage or wetness as a limitation for plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); the symbol 's' indicates shallow depth, calcareousness, salinity and sodicity or gravelly nature of soil as limitations and 'c' indicates climate or rainfall with short growing period as a limitation for plant growth in study area.

Soils of Madahalli watershed have been grouped under two land capability classes, 6 subclasses (Fig.5.6). About 526 ha (75%) area in the village has good cultivable lands (Class II) which have moderate limitations like shallow depth and that reduce the choice of the crops. Nearly 97 ha (14%) area in the village has moderately good cultivable lands (class III lands) distributed throughout the watershed. These Class III lands have gravelliness, shallow rooting depth and moderate to severe erosion. About 60.36 ha (8.6%) area has marginally cultivable lands and these lands have limitations of erosion, gravelliness and shallow rooting depth.

Fig.5.6. Land Capability Classes (LCC) in Madahalli watershed

LCC	Mapping unit	Area	Per cent
IIs	1,2,3,4,5,6,7,11,12,14,15,16,18,19,20,21,23,,25,26,28,29,30	525.89	75.27
IIse	9,27,24,13,22,17	96.6	13.82
IIIse	8 and 10	60.36	8.64

5.7. Land irrigability classification

Land irrigability classification is the grouping of mapping units into land irrigability classes and subclasses based on the degree of limitation observed in the land resources of the area for sustained use under irrigation (I.A.R.I., 1971). The criteria used for irrigability classification are effective soil depth, surface soil texture, permeability, coarse fragments, slope, erosion, drainage and so on. In this system, there are 6 classes, of which, first four classes are considered to be irrigable lands with slight, moderate, severe and very severe limitations respectively. Class 5 land is treated as presently not suitable and class 6 land is considered permanently not suitable for irrigation. Land irrigability classes identified were divided into subclasses depending on the nature of the limitations for irrigation namely soil (s), topography (t) and drainage (d).

Soils of Madahalli watershed have been grouped under two land irrigability classes, **two** subclasses (Fig.5.6). About 610 ha (87%) area in the watershed has lands that have limitations of soils and topography for sustained use under irrigation. About 74 ha (11%) lands in the watershed are marginal for sustained use under irrigation.

5.7 Land irrigability classification

LIC	Mapping unit	Area	Per cent
2s	11,14,18,20,25,28,30,1,2,3,4,15,19,21,23,26,29,7,12,16,5,6,9,27,24	576.77	82.54
2st	13 and 22	31.93	4.57
3st	8,10,17	74.21	10.62

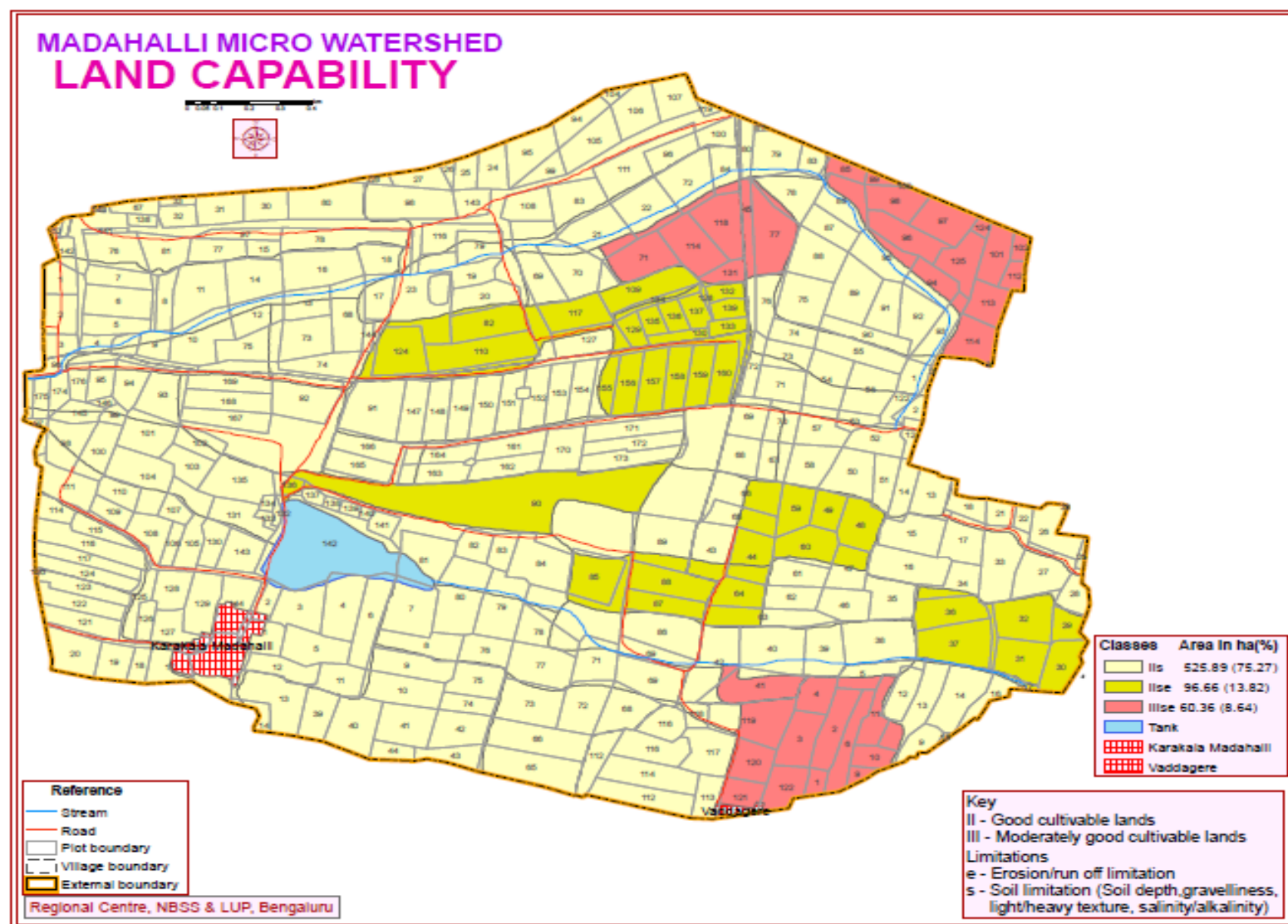


Fig.5.6. Land Capability classes in Madahalli micro-watershed

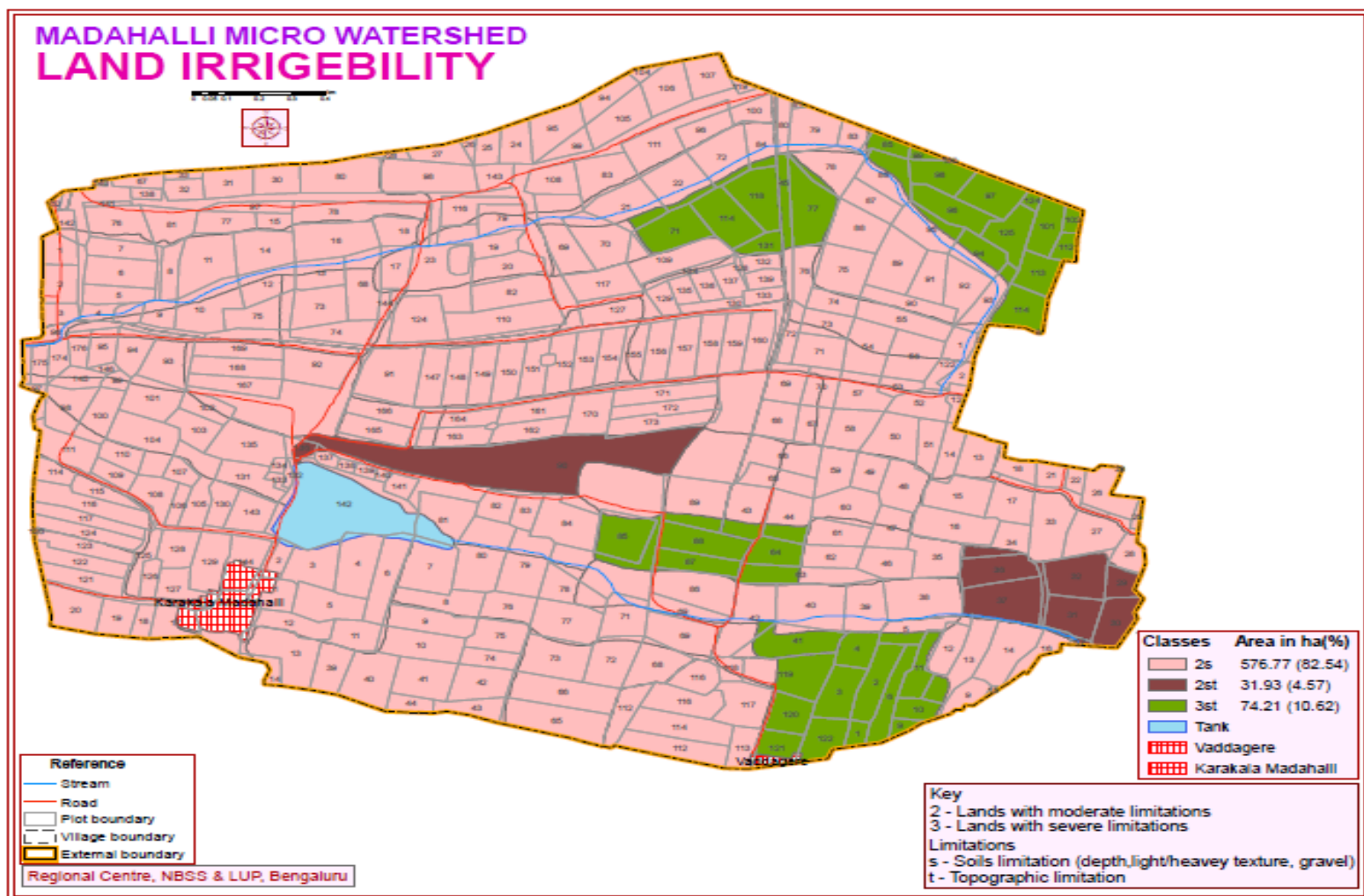


Fig.5.7. Land Capability classes in Madahalli micro-watershed

LAND SUITABILITY AESSMENT FOR MAJOR CROPS

Assessing the extent and degree of suitability of the land resources in watershed for various crops is necessary to choose the right crop and variety suitable for the area. In carrying out this assessment, the specific requirements of a crop (compiled from the existing literature) are compared with the characteristics of land and based on the extent of matching; the suitability watershed of the area for the crop is arrived (Naidu et al. 2006). Then by comparing the relative suitability village of different crops , an ideal combination of crops suitable for a particular farm within the watershed area can be selected.

6.1. Structure of the classification

There are four tiers in this system, namely orders, classes, subclasses and units. At the order level, the mapping units are grouped into suitable (S) or not suitable (N) based on suitability for the intended land use. The suitability order is divided into classes (S1 to S3) based on degrees of suitability and the classes are further divided into subclasses based on the kinds of limitations. The limitations that affect crop production in the village are identified based on the resource inventory are

Erratic rainfall, its distribution and length of crop growing period	c
Slope and erosion	e
Soil texture	t
Coarse fragments or gravels	g
Rooting depth	r
Topography	l

The limitations, wherever they occur, are indicated in lower case letters after the suitability class symbol. For example, marginally suitable land with low rainfall or shorter growing period as a limitation is designated as S3c. Using the above criteria, the land resources of the village were assessed to find out the suitability of the major crops cultivated at present.

6.2. Land suitability for Groundnut (*Arachis hypogaea*)

It is the traditional and major oilseed crop of India. It is predominantly a crop of tropical and sub-tropical climates. The major crop grown in Madahalli watershed is ground nut.

Loose/friable soils facilitate good pod development. Therefore loamy sand and sandy loam soils with fairly rich in organic matter are very well suited for this crop.

The suitability assessment for groundnut in the Madahalli showed that nearly 58 per cent of area is highly suitable and nearly 36 per cent area is moderately suitable. The main constraints are and gravelliness in moderately suitable areas. In three percent of the areas groundnut is marginally suitable due to the severe limitations of slope (Fig.6.1).

Land suitability for groundnut

Suitability Subclass	Mapping units	Area	
		Ha	Per cent
S1	11,14,18,25,28,2,15,19,23,26,29,1,12,16,	405.20	57.99
S2e	9,27,24	50.88	7.27
S2s	4,3, 7, 20,21	72.80	10.42
S2se	5 and 6	18.21	2.61
S2te	13,22,17	45.78	6.55
S2tg	10	36.60	5.24
S2w	30	29.68	4.25
S3tg	8	23.76	3.40

6.3. Land suitability for Redgram (*Cajanus cajan*)

Red gram is a highly drought resistant crop and can be grown successfully in areas receiving only 65 cm annual rainfall. The crop may be grown on any type of soil but loamy soils are preferred. Very deep, well drained, noncalcareous, and non saline soils are best suited for the crop. The suitability assessment for red gram in Madahalli watershed showed that nearly 22 per cent of area is highly suitable and about 49 percent of the area is moderately suitable due to limitations of gravelliness,. Remaining area is 26 percent marginally suitable. The main constraints are texture, rooting depth and gravelliness (Fig.6.2).

6.4. Land suitability for Ragi (*Elausine coracana*)

Ragi is a promising and well adapted crop for the area. It is highly drought tolerant crop and can be grown throughout the year in India where the temperature is above 15°C with rainfall ranging from 400 to1000 mm or even more. It can be cultivated in all types of soils ranging from poor to highly fertile soils, though it performs well in fertile and well drained loamy red and lateritic soils. Even alluvial and black soils are suitable if drainage is not a problem. It is highly salt tolerant and can be grown even in strongly alkaline soils.

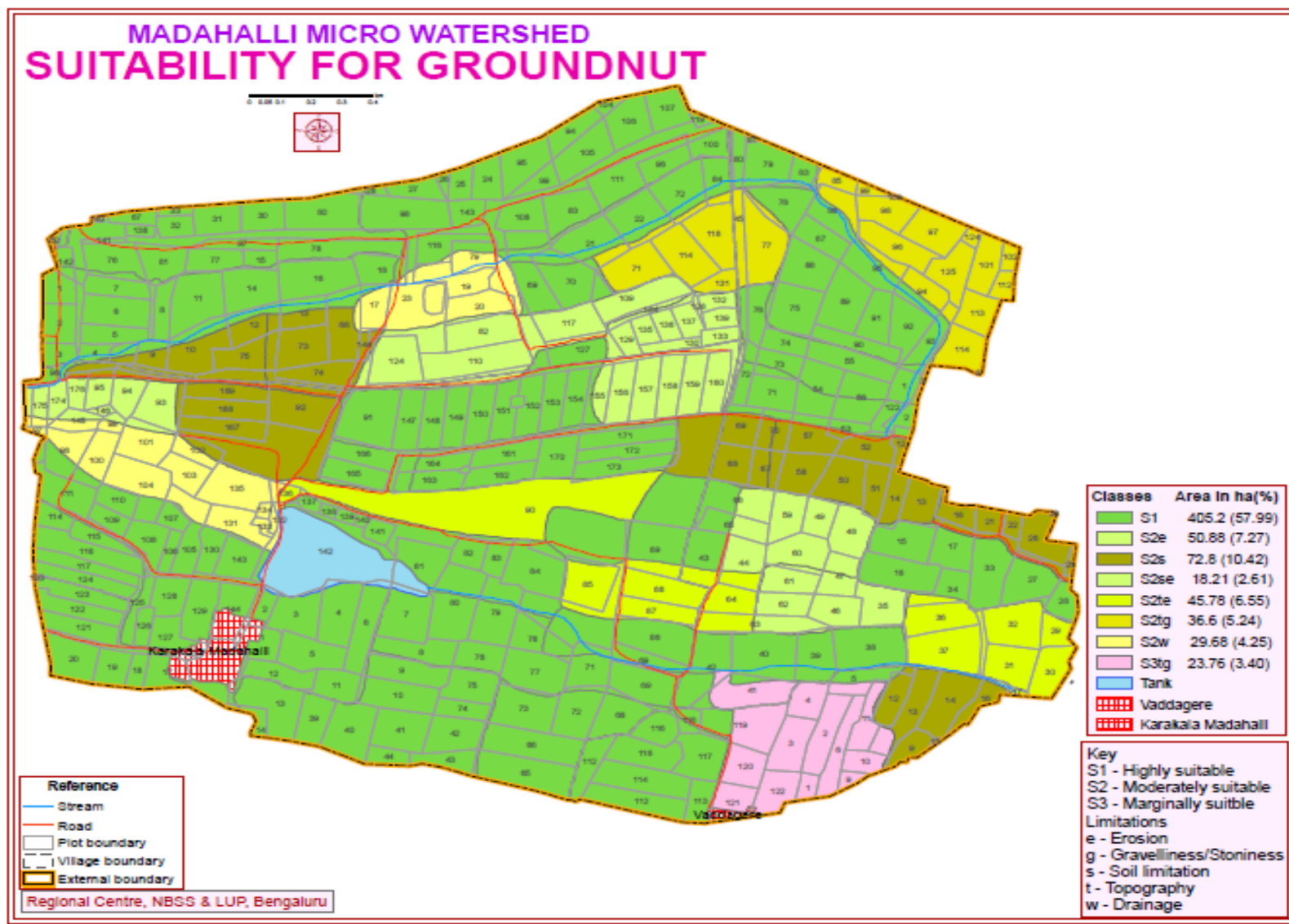


Fig. 6.1 Land suitability map for Ground nut in Madahalli micro-watershed

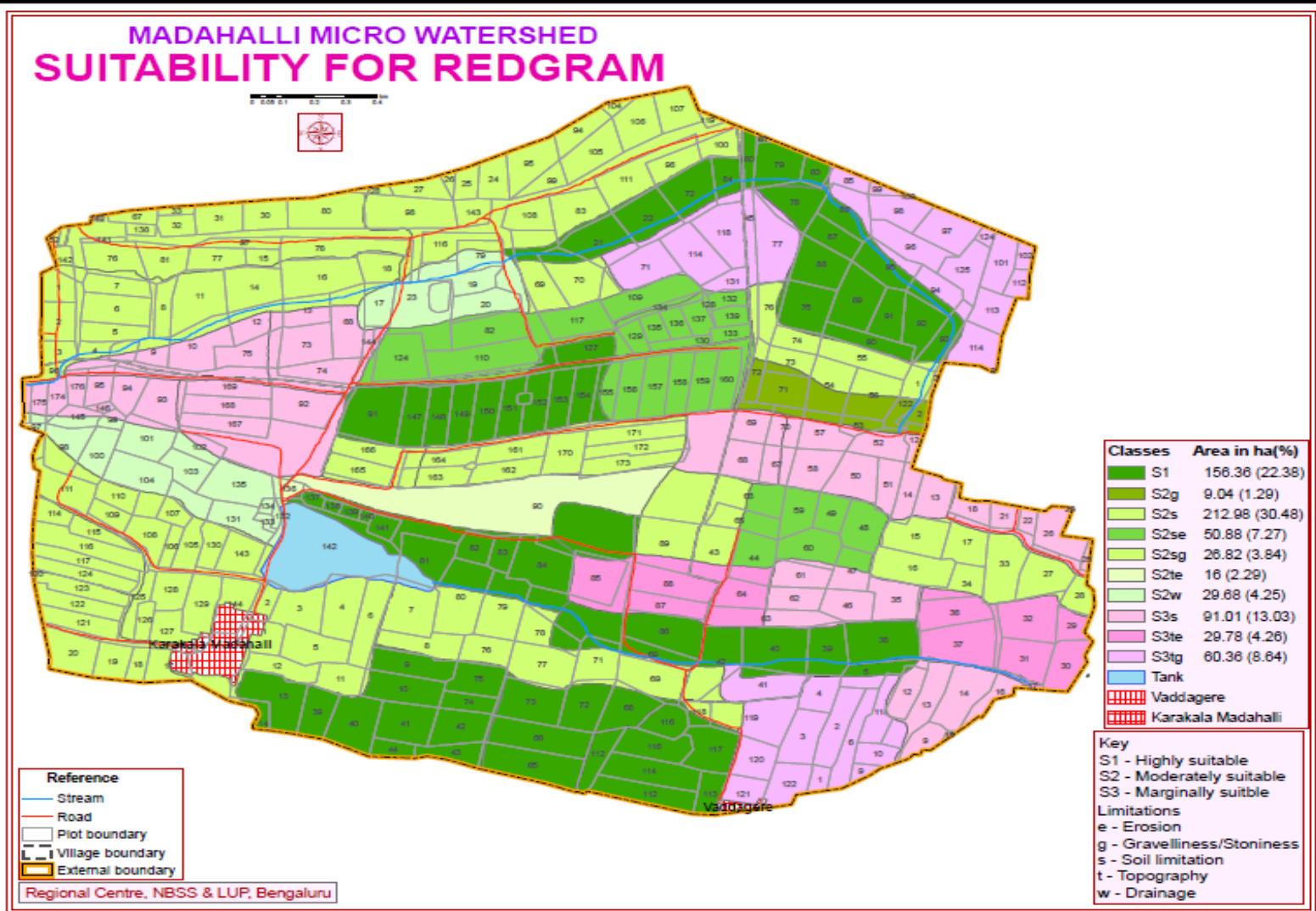


Fig. 6.2 Land suitability map for Red gram in Madahalli micro-watershed

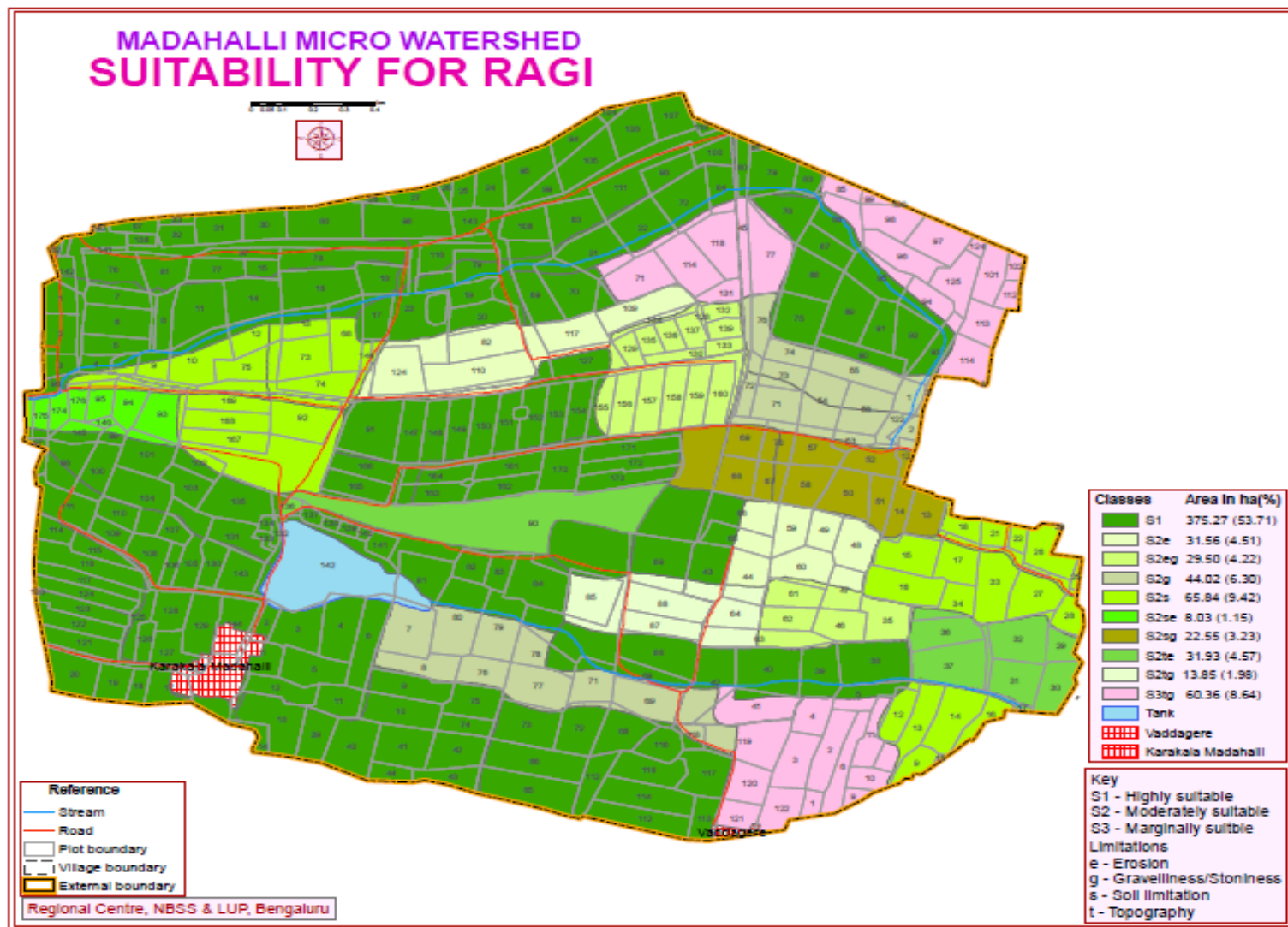


Fig. 6.3 Land suitability map for Ragi in Madahalli micro-watershed

The suitability assessment for Ragi in the Madahalli showed that nearly 54 percent of area is highly suitable and nearly 36 percent area is moderately suitable (Fig.6.3). The main constraint gravelliness in moderately suitable areas.

6.5 Land suitability for Cotton (*Gossypium hirsutum* L)

Cotton is basically a semi xerophytes, warm season woody shrubs with indeterminate growth habit grown over a wide range of climates. Cotton is grown under heavy vertisols to sandy loams soils. The deep, friable, well drained soils with good organic matter content are ideal. As per the assessment, soils in nearly 4.25 percent area of the watershed highly suitable for the cotton (Fig.6.4). In about 80 percent area soils are moderately suitable with limitations of depth & texture and gravelliness. About 13 percent is marginally suitable due to limitation.

6.6 Land suitability for Sunflower (*helianthus annus*, L)

It is an important recent addition to the list of edible oil seed crops in India. It is a short duration annual, photo –insensitive crop with wide adaptability and drought tolerance. Evenly distributed rain fall of 500-700mm during growing period is ideal, irrespective of soil type; soils with free drainage are best suited. In the whole study area, about is 84 percent area moderately suitable for sunflower due to limitation depth. About 14 percent is marginally suitable to sunflower (Fig6.5).

6.7 Land suitability for maize (*zea may* L)

Maize is one of the most important cereals of the world. In India, about 35% of the maize produced is used for consumption; 25 percent in poultry and cattle feed. Maize is best adapted to well drained sandy loam to silt loam soils. Maize will not thrive on the heavy clays, especially in low lands, Well distributed rainfall of 500-700mm is optimum.

In the whole study area, about 346 ha (50%) is highly suitable for maize. about 40 percent areas is moderately suitable for maize due to limitation of, gravelliness (fig6.6).

6.8. Land suitability for Mango (*Mangifera indica* L)

There is very good scope for cultivating mango due to occurrence of suitable soil in the watershed (Fig.7.7). Deep to very deep, well drained, medium textured soils having a pH range of 5.5 to 7.5 are ideal for mango. It is sensitive to poor drainage, presence of free CaCO₃, high pH, extreme gravel and stoniness, sodicity and salinity. It can tolerate drought to a great extend and also short period of flooding.

The suitability assessment for mango in the watershed showed that nearly 156 ha (22%) per cent of area is highly suitable and nearly 66 per cent area is moderately suitable (Fig.6.7). The main

constraints present of gravel in root zone and of areas marginally suitable due to shallow depth, and graveliness.

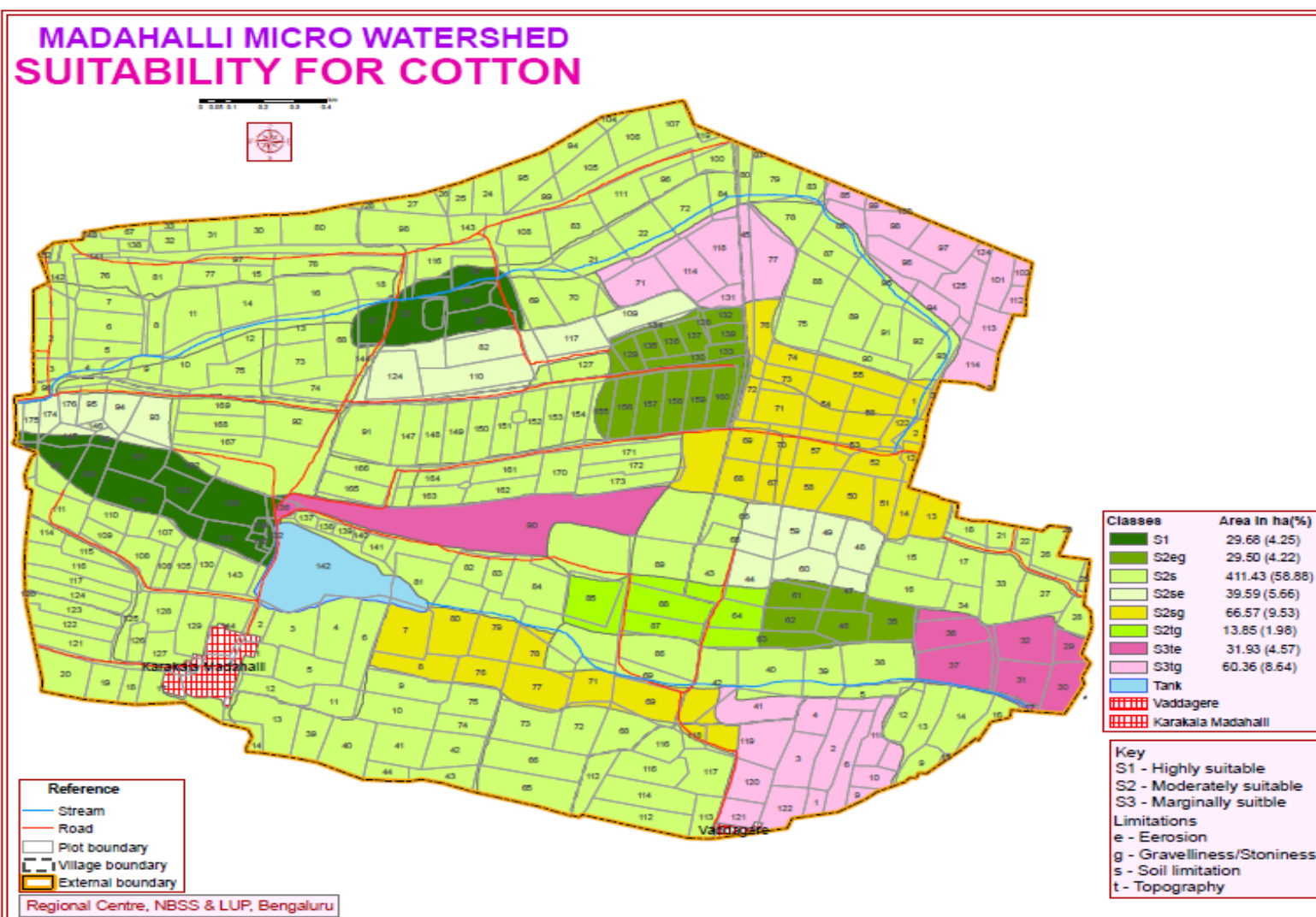


Fig. 6.4 Land suitability map for cotton in Madahalli micro-watershed

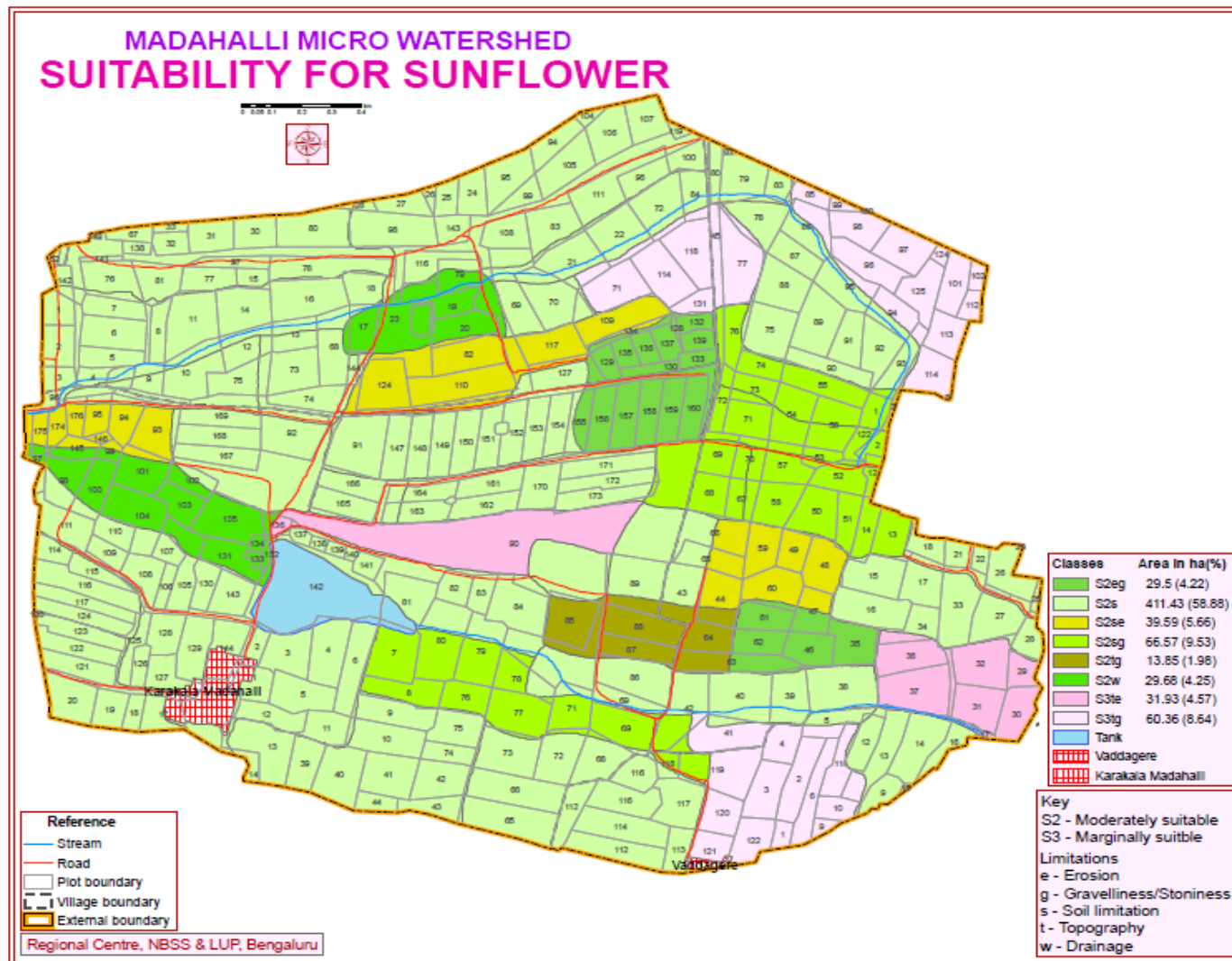


Fig. 6.5 Land suitability map for sunflower in Madahalli micro-watershed

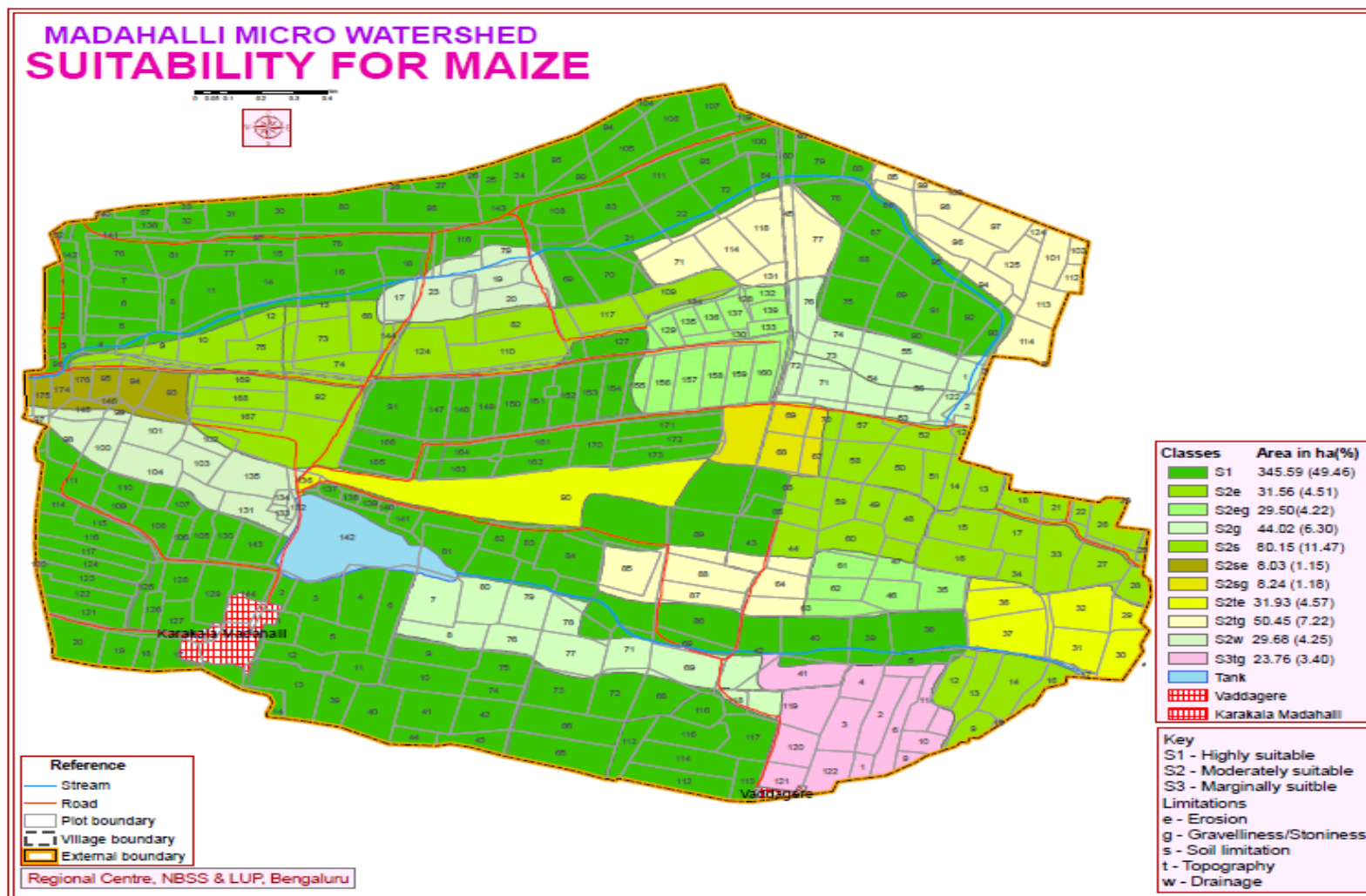


Fig. 6.6 Land suitability map for Maize in Madahalli micro-watershed

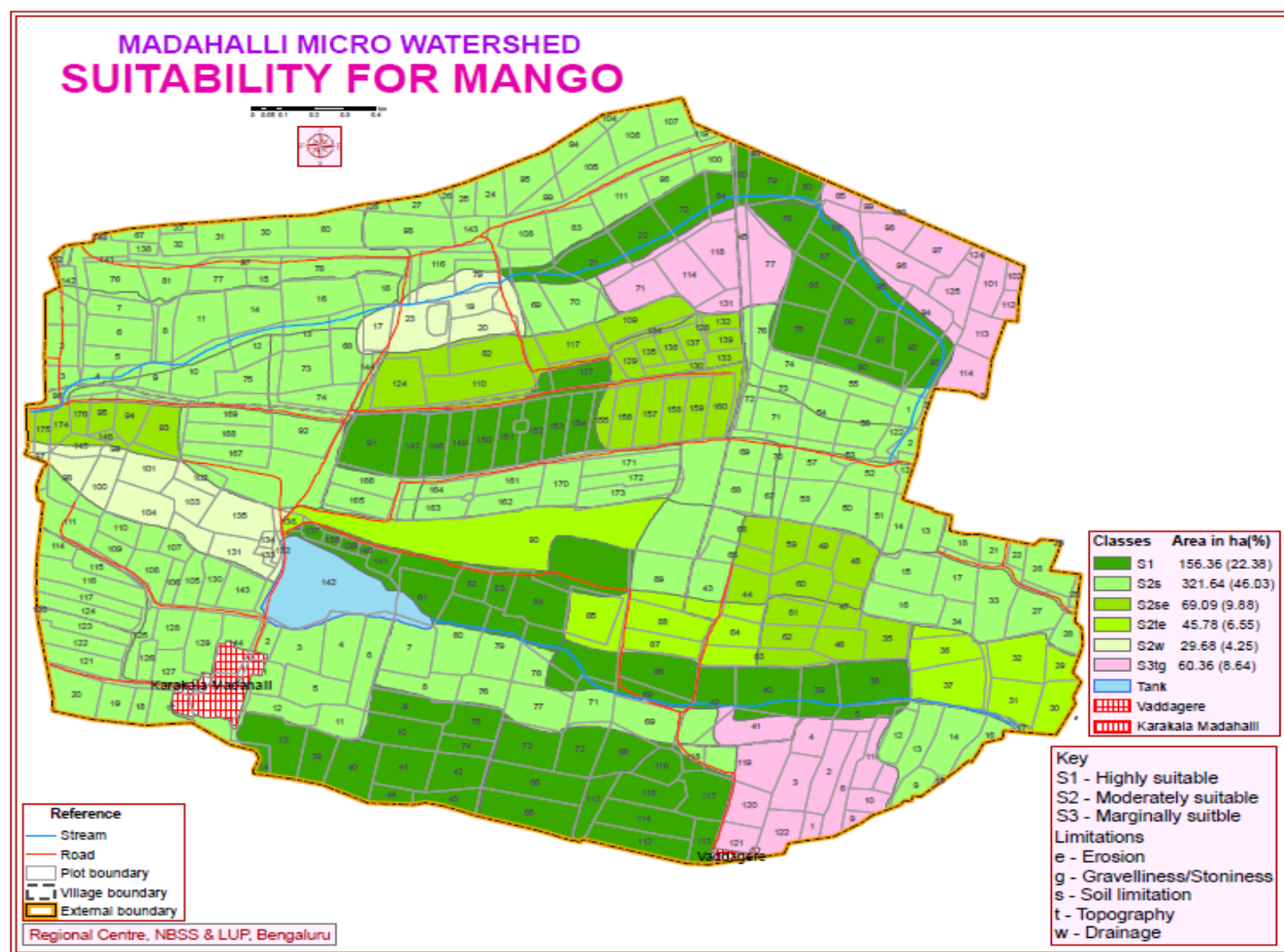


Fig. 6.7 Land suitability map for Mango in Madahalli micro-watershed

Madahalli (M1) Series

The M-1 series is a member of Clayey-skeletal, mixed, isohyperthermic family of Typic Rhodoustalfs. Typically M-1 series has sandy loam A horizon followed by gravelly sand clay B horizon. They have developed from granite gneiss and occur on very gently to gently sloping uplands with 1-5 per cent slopes with an elevation of 870 m above MSL.

Typifying Pedon: Madahalli sandy loam cultivated.

Ap 0-18 cm	Strong brown (7.5YR 4/6 (D) and brown (7.5YR 4/4M); sandy loam; weak medium, subangular blocky structure; slightly hard, friable, non sticky and non plastic; 10 per cent fine and coarse gravel; common very fine roots; few fine pores; abrupt smooth boundary.
Bt1 18-27 cm	Reddish brown (2.5YR 4/4 M); sandy clay; moderate medium, subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; 5-10 per cent fine gravel; thin patchy argillans; common very fine roots; few fine and medium pores; clear smooth boundary.
Bt2 29-48 cm	Dark reddish brown (2.5YR 3/4 M); gravelly sandy clay; 60 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans; few fine pores; clear smooth boundary.
Bt3 48-69 cm	Dark red (2.5YR 3/6M); gravelly sandy clay loam; 25 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans.
Cr 69+ cm	Weathered granite gneiss

Type Location: 11° 44' 2.1" N, 76°46' 40.8." E, Survey no 93(169), Madahalli village, Gudalpet taluk Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum is ranges from 61 to 75 cm. The thickness of A horizon varies from 10 to 18 cm. Its colour is 7.5YR, and 2.5YR hues with

value 3 to 4 and chroma 4 to 6. Texture varies from sandy loam to sandy clay loam with 5 to 30 per cent gravel. The thickness of B horizon ranges from 45 to 65 cm. Its colour is 2.5YR hues with value 3 to 4 and chroma 3 to 6. Its texture is gravelly sandy clay loam to gravelly sandy clay with 35 to 50 per cent gravel.

Drainage and Permeability: Well drained with moderately rapid permeability

Land Use and Vegetation: Mostly under groundnut, pigeon pea, maize

Natural Vegetation: Pongamia, Neem, Lontana.

Distribution and Extent:

Interpretation: Interpretative Groupings

Madahalli (M2) Series

The M-2 series is a member of Clayey-skeletal, mixed, isohyperthermic family of Typic Rhodustalfs. Typically M-2 series have sandy loam to sandy clay loam A horizon followed by gravelly sandy clay loam to gravelly sandy clay B horizon. They have

developed from granite gneiss and occur on very gently sloping to gently sloping uplands on 1-5 per cent slopes with an elevation of 885 m above MSL.

Typifying Pedon: Madahalli sandy clay loam cultivated.

Ap 0-22 cm	Reddish brown (5YR 4/6 (D) and Dark reddish brown (5YR 3/4M); sandy clay loam; weak medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few fine pores; clear smooth boundary.
Bt1 22-46 cm	Dark red (2.5YR 3/6 M); gravelly sandy clay; moderate medium subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; 50 per cent fine gravel; thin patchy argillans; common very fine roots; few fine and medium pores; gradual smooth boundary.
Bt2 46-74 cm	Dark red (2.5YR 3/6 M); gravelly sandy clay; 45 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans; few fine pores; gradual smooth boundary.
Bt3 74-96 cm	Dark reddish brown (2.5YR 3/4M); gravelly sandy clay; 25 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans.
Cr 96+ cm	Weathered granite gneiss

Type Location: 11° 44' 25.5" N, 76°47' 25.5." E, Survey no 22, Madahalli village, Gundlupet taluk Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum is ranges from 87 to 96 cm. The thickness of A horizon varies from 10 to 22 cm. Its colour is 7.5YR, 5YR and 2.5YR hues with value 3 to 4 and chroma 4 to 6. Texture varies from sandy loam to sandy clay loam with 5 to 10 per cent gravel. The thickness of B horizon ranges from 53 to 82 cm. Its colour is

2.5YR hues with value 3 and chroma 4 to 6. Texture is gravelly sandy clay loam to gravelly sandy clay with 35 to 60 per cent gravel.

Drainage and Permeability: Well drained with moderately rapid permeability

Land Use and Vegetation: Mostly under groundnut, pigeon pea, maize, cotton

Natural Vegetation: Pongamia, Neem, Begonia, Lontana.

Distribution and Extent:

Madahalli (M3) Series

The M-3series is a member of Clayey-skeletal, mixed, isohyperthermic family of Typic Rhodustalfs. Typically M-3 series have sandy loam to sandy clay loam A horizon

followed by gravelly sand clay to gravelly clay B horizon. They have developed from granite gneiss and occur on moderately very gently sloping to gently sloping uplands with 5-10 per cent slopes with an elevation of 895 m above MSL.

Typifying Pedon: Madahalli sandy loam cultivated.

Ap 0-13 cm	Strong brown 7.5YR 4/6 (D) and Dark brown (7.5YR 3/4M); sandy loam; weak medium, subangular blocky structure; slightly hard, friable, non sticky and non plastic; many very fine to fine roots; common fine pores; clear smooth boundary.
Bt1 13-41 cm	Dark reddish brown (2.5YR 3/4 M); sandy clay; moderate medium subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; 10 per cent fine gravel; thin patchy argillans; few very fine to fine roots; few fine and medium pores; clear wavy boundary.
Bt2 41-83 cm	Dark reddish brown (2.5YR 3/4 M); gravelly sandy clay; 60 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; moderately thick broken argillans; few fine pores; gradual smooth boundary.
Cr 83+ cm	Weathered granite gneiss

Type Location: 11° 43' 22.4" N, 76°47' 20.6." E, Survey no.172, Madahalli village, Gundlupet taluk, Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum is ranges from 87 to 100 cm. The thickness of A horizon varies from 13 to 19 cm. Its colour is in 7.5YR, and 2.5YR hues with value 3 to 4 and chroma 4 to 6. Texture varies from sandy loam to sandy clay loam with 5 to 10 per cent gravel. The thickness of B horizon ranges from 69 to 81 cm. Its colour is 2.5YR hues with value 3 and 4 chroma 4 to 6. Texture is gravelly sandy clay to gravelly clay with 35 to 60 per cent gravel. Occurrence of 35-60 per cent gravels start mostly after 25 cm depth or within 50cm depth.

Drainage and Permeability: Well drained with moderately rapid permeability

Land Use and Vegetation: Mostly under groundnut, pigeon pea, sunflower, ragi, maize

Natural Vegetation: Pongamia, Neem, Begonia, Lontana.

Distribution and Extent:

Madahalli (M4) Series

The M-4 series is a member of Clayey-skeletal, mixed, isohyperthermic family of Typic Rhodustalfs. Typically M-4 series have loamy sand to sandy loam A horizon followed by gravelly sandy clay to gravelly clay B horizon. They have developed from granite gneiss and occur on very gently to gently sloping uplands with 1-5 per cent slopes with an elevation of 925 m above MSL.

Typifying Pedon: Madahalli loamy sand cultivated.

Ap 0-13 cm	Strong brown (7.5YR 4/6 (D) and brown (7.5YR 4/4M); loamy sand; weak fine subangular blocky structure; slightly hard, friable, non sticky and non plastic; common very fine roots; few fine pores; clear smooth boundary.
Bt1 13-36 cm	Dark red (2.5YR 3/6 M); gravelly sandy clay; moderate medium subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; 50 per cent fine gravel; thin patchy argillans; common very fine roots; few fine and medium pores; gradual smooth boundary.
Bt2 36-61 cm	Dark red (2.5YR 3/6 M); gravelly sandy clay; 45 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans; few fine pores; gradual smooth boundary.
Bt3 61-83 cm	Dark reddish brown (2.5YR 3/4M); gravelly sandy clay; 25 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans.
Cr 83+ cm	Weathered granite gneiss

Type Location: 11° 44' 2.6" N, 76° 47' 47.1" E, Survey no 54, Madahalli village, Gudalpet taluk Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum ranges from 101 to 108 cm. The thickness of A horizon varies from 13 to 20 cm. Its colour is 7.5YR, 5YR and 2.5YR hues with value 4 and chroma 3 to 6. Texture varies from loamy sand to sandy loam with 5 to 20 per cent gravel. The thickness of B horizon ranges from 86 to 93 cm. Its colour is 2.5YR and 5YR hues with value 3 to 5 and chroma 4 to 6. Texture is gravelly sandy clay to gravelly clay with 35 to 60 per cent gravel.

Drainage and Permeability: Well drained with moderately rapid permeability

Land Use and Vegetation: Mostly under groundnut, pigeon pea, maize, vegetables, turmeric

Natural Vegetation: Pongamia, Neem, Begonia, Lontana.

Distribution and Extent:

Madahalli (M5) Series

The M-5 series is a member of Fine, mixed, isohyperthermic family of Typic Rhodoustalfs. Typically M-5 series have sandy loam to sandy clay loam A horizon followed by sandy clay loam to clay B horizon. They have developed from granite gneiss and occur on very gently to gently sloping uplands with 1-5 per cent slopes with an elevation of 890 m above MSL.

Typifying Pedon: Madahalli loamy sand cultivated.

Ap 0-20 cm	Reddish brown (5YR 4/4(D) and dark reddish brown (5YR 3/4M); sandy clay loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few fine pores; clear smooth boundary.
Bt1 20-38 cm	Reddish brown (5YR 4/4 M); sandy clay loam; moderate medium

	subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; thin patchy argillans; common very fine roots; few fine and medium pores; gradual smooth boundary.
Bt2 38-69 cm	Dark red (2.5YR 3/6 M); sandy clay; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans; few fine pores; gradual smooth boundary.
Bt3 69-98 cm	Dark reddish brown (2.5YR 3/4M); gravelly sandy clay; 40 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans.
Bt3 98-134 cm	Dark reddish brown (2.5YR 3/4M); gravelly sandy clay; 50 percent fine and coarse gravels; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy argillans.
Cr 138+	Weathered granite gneiss

Type Location: 11° 43' 25.3" N, 76° 47' 18.5" E, Survey no 73, Madahalli village, Gundalpet taluk Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum is ranges from 126 to 150 cm. The thickness of A horizon varies from 15 to 20 cm. Its colour is in 5YR hues with value 3 and 4 and chroma 3 to 6. Its texture varies from sandy loam sand to sandy clay loam. The thickness of B horizon ranges from 111 to 134 cm. Its colour is 2.5YR and 5YR hues with value 3 to 4 and chroma 3 to 6. Its texture is sandy clay loam to gravelly clay with 35 to 60 per cent gravel which mostly start after 50 cm depth.

Drainage and Permeability: Well drained with moderately rapid permeability

Land Use and Vegetation: Mostly under vegetable (tomato, chillies, onion, beat root), termeric banana, sugarcane.

Natural Vegetation: Pongamia, Neem, Begonia, Lontana.

Distribution and Extent:

Madahalli (M6) Series

The M-6 series is a member of Fine, mixed, isohyperthermic family of Haplustepts. Typically M-6 series have sandy clay loam A horizon followed by sandy loam to clay B horizon. They have developed from both colluvium and alluvium deposits and occur on nearly leveled lower slopes of uplands with 0-1 per cent slopes with an elevation of 880 m above MSL.

Typifying Pedon: Madahalli loamy sand cultivated.

Ap 0-26 cm	Yellowish brown (10YR 5/8(D) and dark yellowish brown (10YR 4/4M); sandy clay loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; few fine pores; clear smooth boundary.
Bw1 26-51cm	Dark yellowish brown (10YR 4/6 M); sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and non plastic; common very fine roots; few fine and medium pores; gradual smooth boundary.

Bw2 51-72cm	Dark yellowish brown (10YR 4/6 M); sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and non plastic; common very fine roots; few fine and medium pores; gradual smooth boundary.
Bw3 72-104 cm	Dark yellowish brown (10YR 4/4M); clay; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium pores; gradual smooth boundary.
Bw4 104-138 cm	Dark brown (10YR 4/3M); clay; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium pores; gradual smooth boundary.
Bw5 138-170	Dark brown (10YR 3/3M); sandy clay; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; few fine and medium pores

Type Location: 11° 44' 13.7" N, 76° 47' 11.0" E, Survey no 20, Madahalli village, Gudalpet taluk Chamrajnagar District, Karnataka.

Range in Characteristics: The thickness of solum is more than 150 cm. The thickness of A horizon varies from 11 to 26 cm. Its colour is in 10YR hues with value 4 and chroma 3 to 4. Its texture varies from sandy loam sand to sandy clay loam. The thickness of B horizon is more than 150cm. Its colour is 10YR hues with value 3 to 4 and chroma 3 to 6. Its texture is sandy clay loam to clay .

Drainage and Permeability: Well drained with slow permeability

Land Use and Vegetation: Mostly under coconut, areca nut, sugarcane, banana, vegetables

Natural Vegetation: Pongamia, Neem, Lontana, Tamarind, Soapnut tree, ficas religiosa