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LAND RESOURCE INVENTORY AND SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS FOR WATERSHED PLANNING AND DEVELOPMENT

MADDUR-1 (4B3E2E1d) MICRO WATERSHED

Gundlupet Taluk, Chamarajanagara District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

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The ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up during 1976 with the objective to prepare soil resource maps at national, state and district levels and to provide research inputs in soil resource mapping and its applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country.

The Bureau has been engaged in carrying out soil resource survey, agro-ecological and soil degradation mapping at the country, state and district levels for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the soil potentials and problems, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey, land evaluation and soil survey interpretations for land use planning. The Bureau in collaboration with Panjabrao Krishi Vidyapeeth, Akola is running post-graduate teaching and research programme in land resource management, leading to M.Sc. and Ph.D. degrees.

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PREFACE

In Karnataka, as in other Indian States, the livelihoods of rural people are intertwined with farming pursuits. Thechallenges in agriculture are seriously threatening the livelihood of a large number of farmers as they have been practicing farming in contextual factors beyond their control. Climatic factors are the most important ones and have become much more significant in recent times due to rapid climate changes induced by intensive anthropogenic activities affecting our ecosystem in multiple ways. Climate change has become the reality, it is happening and efforts to evolve and demonstrate climate resilient technologies have become essential. Due to the already over stressed scenario of agrarian sector, the climate change is resulting in manifold increase in the complexities, pushing the rural mass to face more and more unpredictable situations. The rising temperatures and unpredictable rainfall patterns are going to test seriously the informed decisions farmers have to make in order to survive in farming and sustain their livelihood.

It is generally recognized that impacts of climate change shall not be uniform across the globe. It is said that impact of climate change is more severe in South Asia. Based on the analysis of meteorological data, it is predicted that in India, there will be upward trend in mean temperature, downward trend in relative humidity, annual rainfall and number of wet days in a year. Also, in general, phenomena like erratic monsoon, spread of tropical diseases, rise in sea levels, changes in availability of fresh water, frequent floods, droughts, heat waves, storms and hurricanes are predicted. Each one of these adverse situations are already being experienced in various parts of India and also at the global level. Decline in agricultural productivity of small and marginal farmers becoming more vulnerable is already witnessed.

In Karnataka, more than 60 per cent of the population live in rural areas and depend on agriculture and allied activities for their livelihood. Though the state has achieved significant progress in increasing the yield of many crops, there is tremendous pressure on the land resources due to the growing and competing demands of various land uses. This is reflected in the alarming rate of land degradation observed. Already more than 50 per cent of the area is affected by various forms of degradation. If this trend continues, the sustainability of the fragile ecosystem will be badly affected. The adverse effects of change in the climatic factors are putting additional stress on the land resources and the farmers dependent on this.

The natural resources (land, water and vegetation) of the state need adequate and constant care and management, backed by site-specific technological interventions and investments particularly by the government. Detailed database pertaining to the nature of the land resources, their constraints, inherent potentials and suitability for various land based rural enterprises, crops and other uses is a prerequisite for preparing location-specific action plans, which are in tune with the inherent capability of the resources. Any effort to evolve climate resilient technologies has to be based on the baseline scientific database. Then only one can expect effective implementation of climate resilient technologies, monitor the progress, make essential review of the strategy, and finally evaluate the effectiveness of the implemented programs. The information available at present on the land resources of the state are of general nature and useful only for general purpose planning. Since the need of the hour is to have site-specific information suitable for farm level planning and detailed characterization and delineation of the existing land resources of an area into similar management units is the only option.

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component-1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on "Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Maddur-1 Microwatershed, Gundlupet Taluk and Chamarajanagar District, Karnataka" for integrated development was taken up in collaboration with the State Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the Microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

It is hoped that this database will be useful to the planners, administrators and developmental agencies working in the area in not only for formulating location specific developmental schemes but also for their effective monitoring at the village/watershed level.

Nagpur **S.K. SINGH**
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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Maddur-1 Microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and the physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundries. The soil map shows the geographic distribution and extent, characterstics, classification and use potentials of the soils in the microwartershed.

The present study covers an area of 396 ha in Gundlupet taluk of Chamarajanagar district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 734 mm, of which about 254 mm is received during south–west monsoon, 268 mm during the north-east and the remaining 212 mm during the rest of the year. An area of about 33 per cent is covered by soils, 67 per cent by forest and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 6 soil series and 13 soil phases (management units) and 6 land management units.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 3rd week of November.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.*
- *About 33 per cent area is suitable for agriculture.*
- *About 3 per cent of soils are shallow (25-50 cm), 19 per cent are moderately shallow (50-75 cm), 9 per cent of the soils are moderately deep (75-100 cm) to deep (100-150 cm) and 3 per cent are very deep (>150 cm).*
- *About 12 per cent of the area has clayey soils at the surface, 19 per cent area has loamy soil and 2 per cent area sandy soils.*
- *About 26 per cent of the area has non-gravelly soils and 7 per cent gravelly soils (15-35 % gravel) soils.*
- *About 4 per cent has soils that are very low (<50 mm/m), 26 per cent are low (51-100 mm/m) in available water capacity and an area of 3 per cent has very high (>200 mm/m) available water capacity.*
- *Entire area of about 33 per cent has very gently sloping (1-3% slope) lands.*
- *An area of about 12 per cent has soils that are slightly eroded (e1) and 22 per cent soils are moderately eroded (e2).*

- *An area of about 2 per cent has soils that are neutral (pH 6.5-7.3), an area of about 10 per cent has soils that are slightly alkaline (pH 7.3 to 7.8) and 21 per cent has soils that are moderately alkaline (pH 7.8 to 8.4).*
- *The Electrical Conductivity (EC) of the soils are <2 dsm^{-1}indicating that the soils are non-saline.*
- *About 2 per cent of the soils are medium (0.5-0.75%) and 31 per cent of the soils are high (>0.75%) in organic carbon.*
- *About 12 per cent of the soils are low (<23 kg/ha) and 21 per cent are medium (23-57 kg/ha) in available phosphorus.*
- *About 21 per cent of the soils are medium (145-337 kg/ha) and 13 per cent are high (>337 kg/ha) in available potassium.*
- *Available sulphur is low (<10 ppm) in the entire area.*
- *Available boron is low (<0.5 ppm) in about 18 per cent and medium (0.5-1.0 ppm) in 15 per cent area.*
- *Available iron is sufficient in the entire area of the microwatershed.*
- *Available manganese and copper are sufficient in the entire area of the microwatershed.*
- *Available zinc is deficient (<0.6 ppm) in 17 per cent and sufficient (>0.6 ppm) in 17 per cent.*
- *The land suitability for 27 major crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, price and finally the demand and supply position.*

Land suitability for various crops in the Microwatershed

Crop	*Suitability Area in ha (%)*			*Crop*	*Suitability Area in ha (%)*	
	Highly suitable(S1)	*Moderately suitable(S2)*			*Highly suitable(S1)*	*Moderately suitable(S2)*
Sorghum	*11 (3)*	*103 (26)*		*Sapota*	*6 (1)*	*35 (9)*
Maize	*6 (1)*	*103 (26)*		*Guava*	*34 (9)*	*7 (2)*
Redgram	*6 (1)*	*40 (10)*		*Banana*	*6 (1)*	*33 (8)*
Horsegram	*6 (1)*	*115 (29)*		*Jackfruit*	*6 (1)*	*28 (7)*
Field bean	*6 (1)*	*108 (27)*		*Jamun*	*11 (3)*	*28 (7)*
Groundnut	-	*116 (29)*		*Musambi*	*11 (3)*	*28 (7)*
Sunflower	*6 (1)*	*5 (1)*		*Lime*	*11 (3)*	*28 (7)*
Cotton	*11 (3)*	*103 (26)*		*Cashew*	*6 (1)*	*35 (9)*
Onion	*6 (1)*	*108 (27)*		*Custard apple*	*23 (10)*	*82 (21)*
Potato	*6 (1)*	*103 (26)*		*Amla*	*39 (10)*	*80 (21)*
Field Beans	*6 (1)*	*108 (27)*		*Tamarind*	*11 (3)*	*28 (7)*
Beetroot	*6 (1)*	*103 (26)*		*Marigold*	*6 (1)*	*115 (29)*
Turmeric	*6 (1)*	*103 (26)*		*Chrysanthemum*	*6 (1)*	*108 (27)*
Mango	*6 (1)*	*28 (7)*				

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 6 identified LMUs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fodder, fibre and horticulture crops.

- *Maintaining soil-health is vital to crop production and conserve soil and land resource base for maintaining ecological balance and to mitigate climate change. For this, several ameliorative measures have been suggested to these problematic soils like saline/alkali, highly eroded, sandy soils etc.,*
- *Soil and water conservation treatment plan has been prepared that would help in identifying the sites to be treated and also the type of structures required.*
- *As part of the greening programme, several tree species have been suggested to be planted in marginal and submarginal lands and also in the hillocks, mounds and ridges.*

Chapter 1

INTRODUCTION

Soil is a finite natural resource that is central to sustainable agriculture and food security. Over the years, this precious resource is faced with the problems of erosion, salinity, alkalinity, degradation, depletion of nutrients and even decline in availability of land for agriculture. It is a known fact, that it takes thousands of years to form a few centimetres of soil, thus, soil is a precious gift of nature. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agroclimatic setting, and use and management. There is therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. As much as 121 m ha of land is reportedly degraded which leads to impaired soil quality. It is imperative that steps are urgently taken to check and reverse land degradation without any further loss of time. The improvements in productivity will have to come from sustainable intensification measures that make the most effective use of land and water resources. Soil erosion alone has degraded about 35 lakh ha. Almost all the areas are facing various degrees of degradation, particularly soil erosion. Salinity and alkalinity has emerged as a major problem (>3.5 lakh ha) in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. Added to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and use potential, which is very important for developing an effective land use and cropping systems for augmenting agricultural production on a sustainable basis.

The soil and land resource inventories made so far in Karnataka had limited utility because the surveys were of different types, scales and intensities carried out at different times with specific objectives. Hence, there is an urgent need to generate detailed site-specific farm level database on various land resources for all the villages/watersheds in a time bound manner that would help to protect the valuable soil and land resources and also to stabilize farm production. Therefore, the land resource inventory required for farm level planning is the one which investigates all the parameters which are critical for productivity *viz.,* soils, site characteristics (slope, erosion, gravelliness and stoniness) climate, water, topography, geology, hydrology, vegetation, crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be 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.

The Land Resource Inventory is basically done for identifying potential and problem areas, developing sustainable land use plans, estimation of surface run off and water harvesting potential, preparation of soil and water conservation plans, land degradation/desertification etc. The Bureau is presently engaged in developing an LRI methodology using high resolution satellite remote sensing data and Digital Elevation Model (DEM) data to prepare Landscape Ecological Units (LEU) map representing agro-ecosystem as a whole. The LEU is preferred over landform as the base for LRI. LEU is the assemblage of landform, slope and land use. An attempt has been made to upscale the soil resource information from 1:250000 and 1:50000 scale to the LEU map in Goa and other states.

The land resource inventory data and maps presented here aims to provide site-specific database for Maddur-1 microwatershed in Gundlupet Taluk, Chamarajanagar District, Karnataka state for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological Units (LEUs) map.

The study was organized and executed by the ICAR- National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore under Generation of Land Resource Inventory Data Base Component-1 of the Sujala-III Project funded by the World Bank.

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Maddur-1 microwatershed (Gopalpur subwatershed) is located in the southern part of Karnataka in Gundlupet Taluk, Chamarajanagara District, Karnataka State (Fig. 2.1). It comprises of Channamallipur, Bachannahalli and Maddur villages and Berimbadi State Forest. It lies between 11^{0}44' to 11^{0}47' North latitudes and 76^{0}35' to 76^{0}38' East longitudes and covers an area of 396 ha. It is about 20 km south of Gundlupet and is surrounded by Channamallipur villages on the east, Maddur on the east and central, and Bachannahalli village on the south and Birainbadi state forest on the west and northern side.

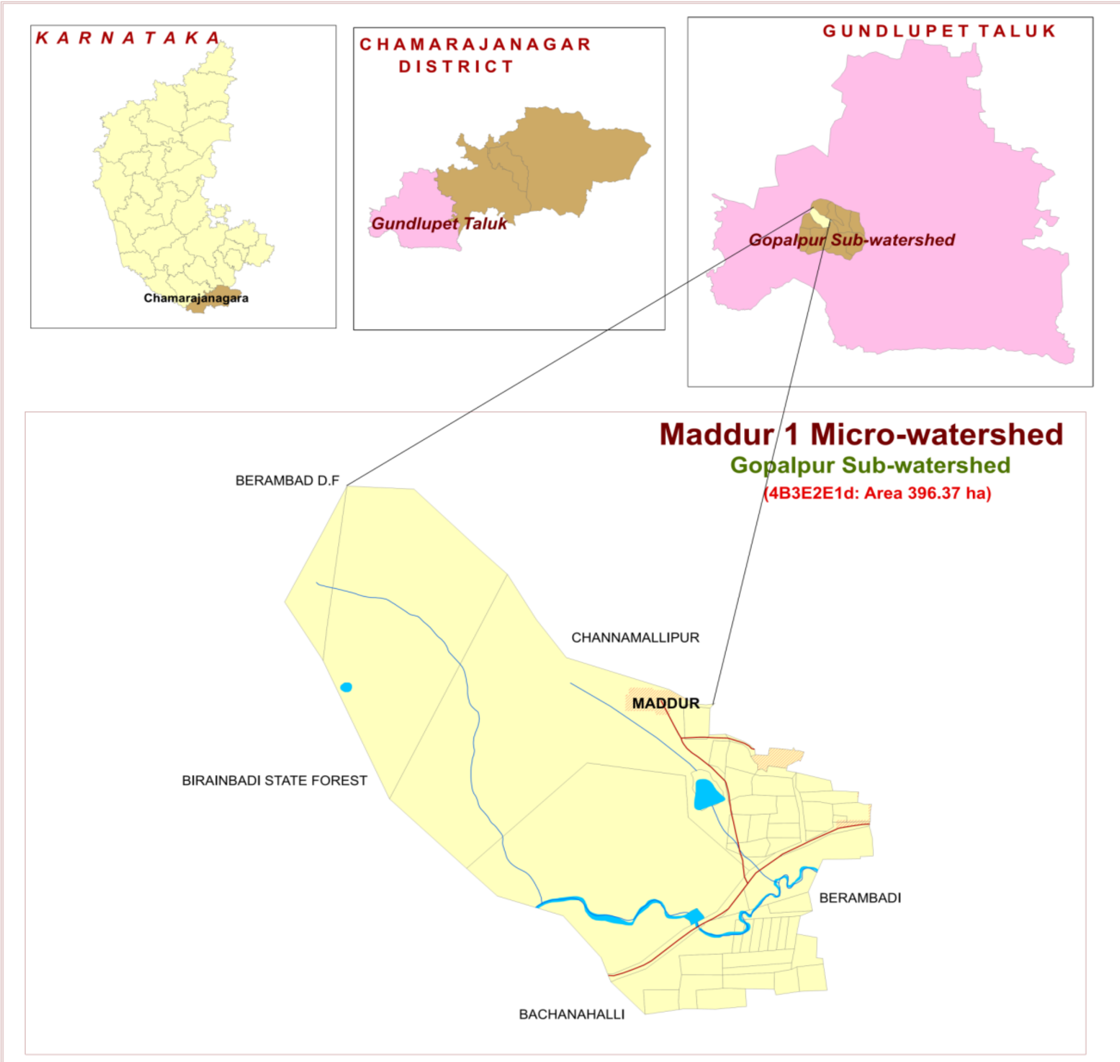


Fig. 2.1 Location map of Maddur-1 Microwatershed

2.2 Geology

Major rock formations observed in the micowatershed are of Archaean age and comprise of (Fig. 2.2a and 2.2b) granite and gneiss. They are essentially pink to gray granite gneisses. The rocks are coarse to medium grained. They consist primarily of quartz, feldspar, biotite and hornblende. The gray granite gneisses are highly weathered, fractured and fissured upto a depth of about 10 m. Dolerite dykes and quartz veins are common with variable width and found to occur in the microwatershed.

Fig. 2.2 Granite and granite gneiss rocks

Fig. 2.2 b Granite rocks

2.3 Physiography

Physiographically, the area has been as granite gneiss landscape based on geology. The microwatershed area has been further divided into mounds/ ridges, summits, side slopes and very gently sloping uplands based on slope and relief features. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

There are no perennial rivers flowing in Gundlupet taluk. However, the area is drained by several small seasonal streams like Gundluhole along its course. Though, it is not a perennial one, during rainy season, it carries large quantities of rain water. The microwatershed has only a few small tanks which are not capable of storing water that flows during the rainy season. Due to this, the ground water recharge is very much affected in the villages. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing tanks and recharge structures at appropriate places in the villages, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract and is categorized as drought-prone with average annual rainfall of 734 mm (Table 2.1). Of the total rainfall, a maximum of 254 mm is received during the south–west monsoon period from June to September, north-east monsoon from October to early December contributes maximum about 268 mm and the remaining 212 mm is received during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 42 °C and in December and January, the temperatures will go down to 16 °C. Rainfall distribution is shown in Figure 2.3. The average Potential Evapotranspiration (PET) is 128 mm and varies from a low of 106 mm in November to 165 mm in the month of March. The PET is always higher than precipitation in all the months except in the last week of September to first week of November. Generally, the length of crop growing period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET in Gundlupet Taluk, Chamarajanagara District

Sl. no.	Months	Rainfall	PET	1/2 PET
1	JAN	0.80	129.10	64.55
2	FEB	6.80	133.80	66.90
3	MAR	26.90	164.90	82.45
4	APR	73.60	153.80	76.90
5	MAY	103.90	147.20	73.60
6	JUN	56.00	124.60	62.30
7	JUL	50.40	116.40	58.20
8	AUG	55.80	117.10	58.55
9	SEP	92.00	116.80	58.40
10	OCT	164.10	111.10	55.55
11	NOV	80.50	106.20	53.10
12	DEC	23.50	109.90	54.95
Total		**734.30**	**127.57**	

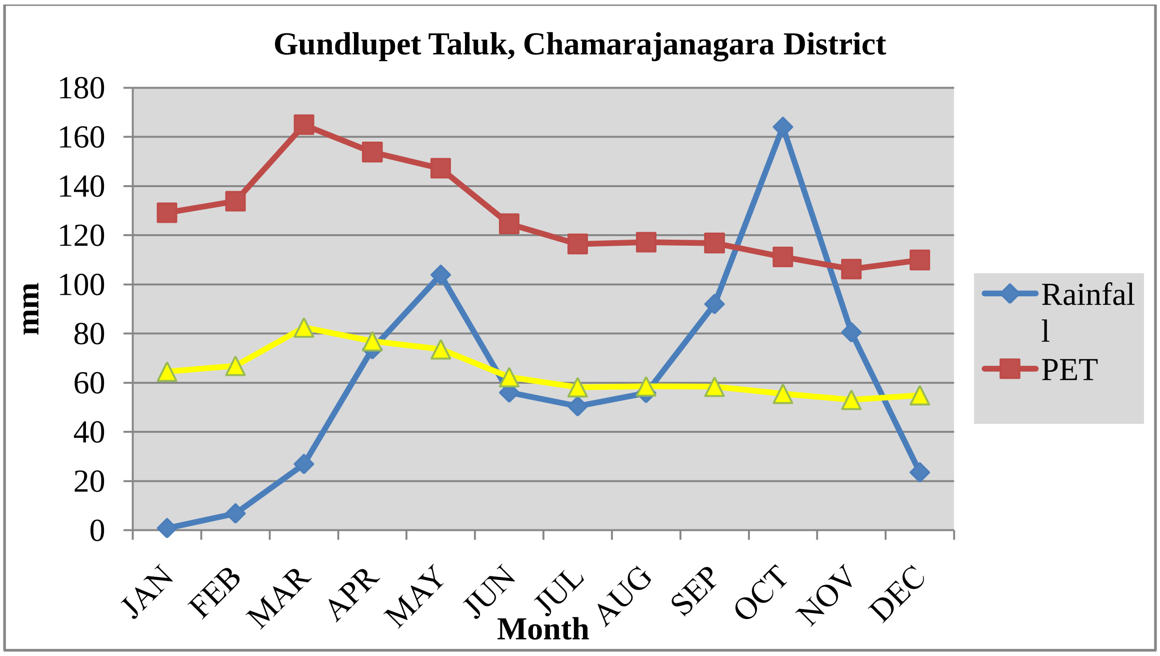


Fig 2.3 Rainfall distribution in Gundlupet Taluk, Chamarajanagara District

2.6 Natural Vegetation

Forests occupy about 32 per cent area in Gundlupet taluk. The major area of these forests are found in Bandipur National Park and Himavad Gopalaswamy Betta. The rest of the area in the taluk has sparse natural vegetation comprising few tree species, shrubs and herbs. The mounds, ridges and boulders occupy very sizeable areas which are under thin to moderately thick forest vegetation. Still, there are some remnants of the past forest cover which can be seen in patches in some ridges and hillocks in the microwatershed.

Fig. 2.4 Natural vegetation of Maddur-1 Microwatershed

Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the microwatershed 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. This leads to the accelerated rate of erosion on the hill slopes, resulting in the formation of deep gullies in the foot slopes and eventually resulting in the heavy siltation of few tanks and reservoirs in the microwatershed.

2.7 Land Utilization

About 48 per cent area (Table 2.2) in Gundlupet taluk is cultivated at present. An area of about 6 per cent is currently barren. Forests occupy an area of about 32 per cent and the tree cover is in a very poor state except in Bandipura National Park and Gopalaswamy Betta. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are sorghum, maize, cotton, onion, sugarcane, groundnut, red gram, horse gram and sapota (Fig. 2.5 a & b). While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is generated. The current land use map generated shows the arable and non-arable lands, other land uses and different types of crops grown in the area (Fig. 2.6). Simultaneously, enumeration of wells (bore wells and open wells) and existing conservation structures in the microwatershed are made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells and other water bodies in Maddur-1 microwatershed is given in Figure 2.7.

Table 2.2 Land Utilization in Gundlupet Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	140607	
2.	Total cultivated area	67339	47.84
3.	Area sown more than once	13532	
4.	Cropping intensity	-	120.09
5.	Trees and grooves	3485	2.47
6.	Forest	44859	31.98
7.	Cultivable wasteland	3265	2.32
8.	Permanent Pasture land	10287	7.31
9.	Barren land	7988	5.68
10.	Non- Agriculture land	3384	2.40

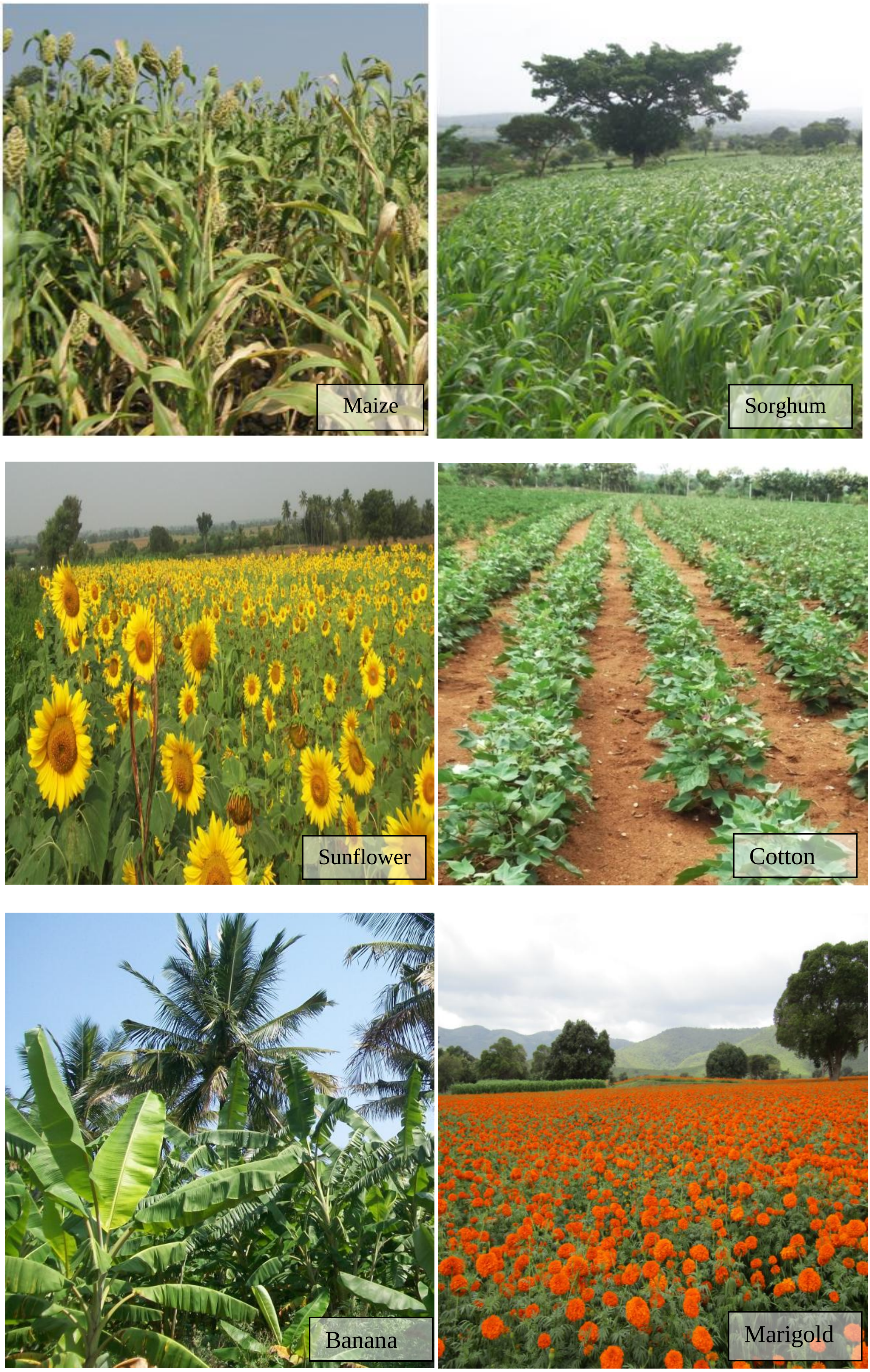


Fig. 2.5.. Different crops and cropping systems in Maddur-1 Microwatershed

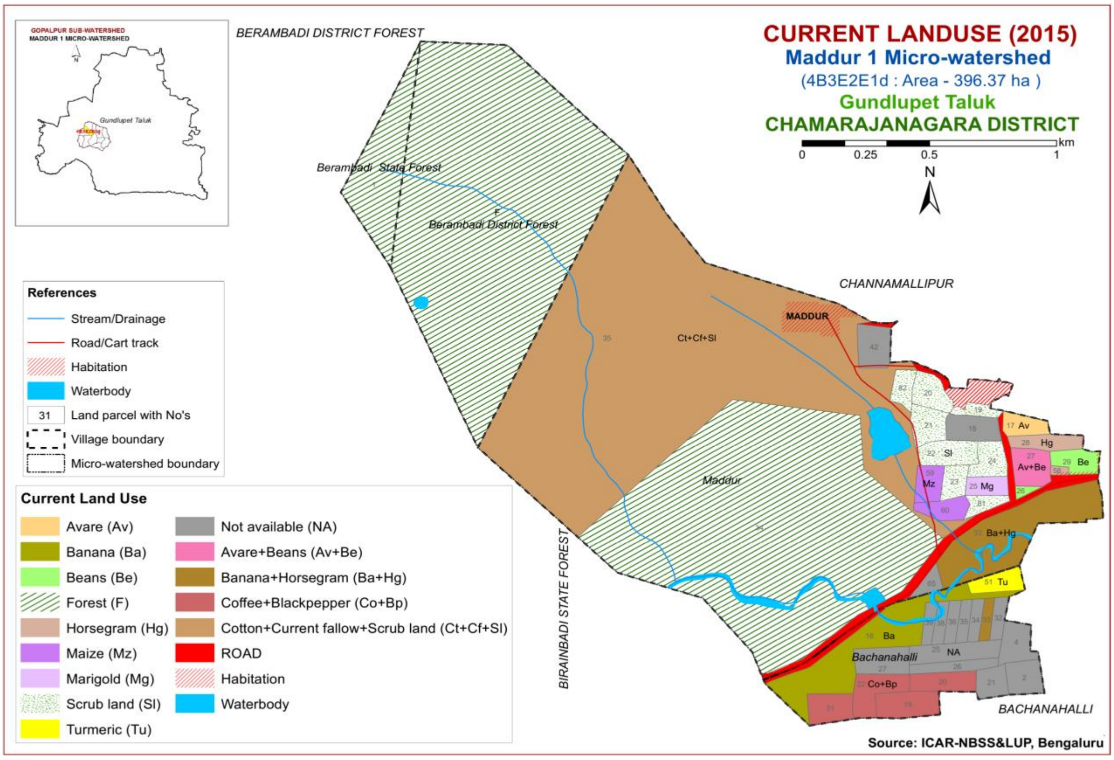


Fig. 2.6 Current Land Use map of Maddur-1 Microwatershed

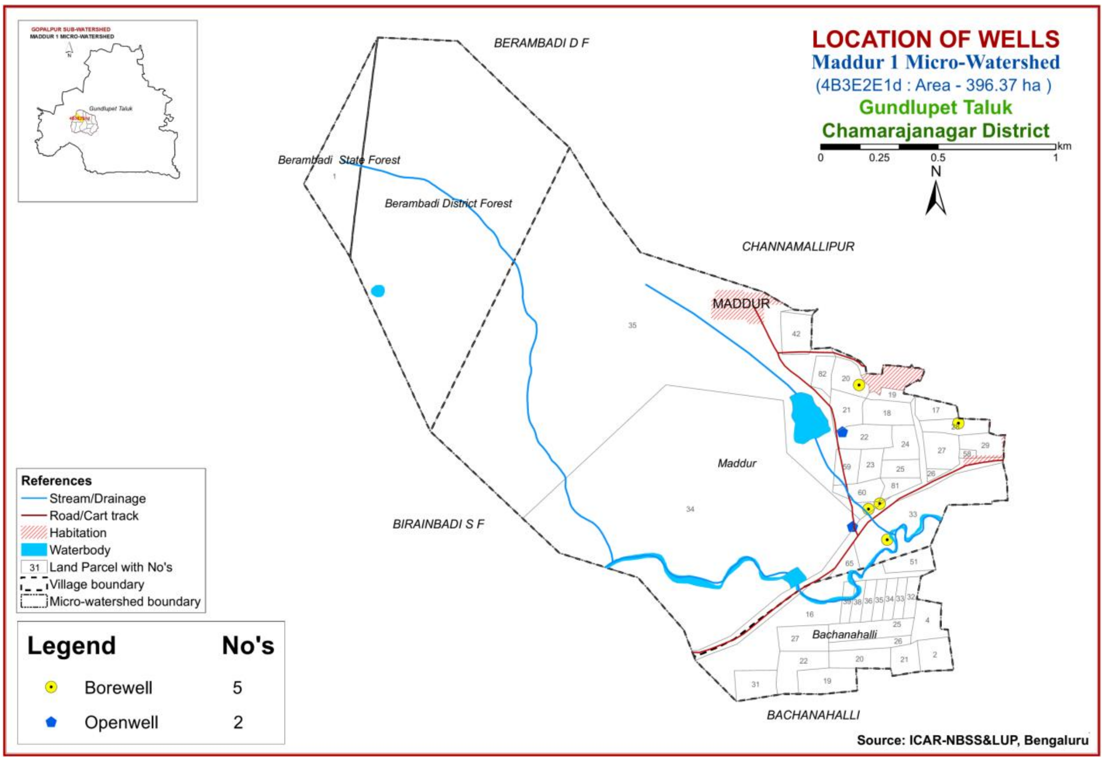


Fig. 2.7 Location of Wells and Conservation Structures map of Maddur-1 Microwatershed

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Maddur-1 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.), and site characteristics (slope, erosion, drainage, occurrence of rock fragments etc.) followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units, and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed soil survey at 1:7920 scale was carried out in an area of 396 ha. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.*, 2015) which is briefly described below.

3.1 Base Maps

The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map and satellite imagery as a base supplied by the KSRSAC. The cadastral map shows field boundaries with their survey numbers, location of tanks, streams and other permanent features of the area (Fig. 3.1). Apart from the cadastral map, remote sensing data products from Cartosat-1 and LISS IV merged at the scale of 1:7920 were used in conjunction with the cadastral map to identify the landscapes, landforms and other surface features. The imagery 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 (Fig. 3.2). The cadastral map was overlaid on the satellite imagery (Fig. 3.3) that helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were also used for initial traversing, identification of geology and landforms, drainage features, present land use and also for selection of transects in the microwatershed.

3.2 Image Interpretation for Physiography

False Colour Composites (FCC) of Cartosat-I and LISS-IV merged satellite data covering the microwatershed area was visually interpreted using image interpretation elements and all the available collateral data with local knowledge. The delineated physiographic boundaries were transferred on to a cadastral map overlaid on satellite imagery. Physiographically, the area has been identified as granite gneiss landscape. They were divided into landforms such as ridges, mounds and uplands based on slope and other relief features. They were further subdivided into physiographic/image interpretation units based on image characteristics. The image interpretation legend for physiography is given below.

Image Interpretation Legend for Physiography

G - Granite gneiss landform

G1			Hills/ Ridges/ Mounds
	G11		Summits
	G12		Side slopes
		G121	Side slopes with dark grey tones
G2			Uplands
	G21		Summits
	G22		Gently sloping uplands
		G221	Gently sloping uplands, yellowish green (eroded)
		G222	Gently sloping uplands, yellowish white (severely eroded)
	G23		Very gently sloping uplands
		G231	Very gently sloping uplands, yellowish green
		G232	Very gently sloping uplands, medium green and pink
		G233	Very gently sloping uplands, pink and green (scrub land)
		G234	Very gently sloping uplands, medium greenish grey
		G235	Very gently sloping uplands, yellowish white (eroded)
		G236	Very gently sloping uplands, dark green
		G237	Very gently sloping uplands, medium pink (coconut garden)
		G238	Very gently sloping uplands, pink and bluish white (eroded)
	G24		Valleys/ lowlands
		G241	Valleys, pink tones
		G242	Valleys gray mixed with pink tones

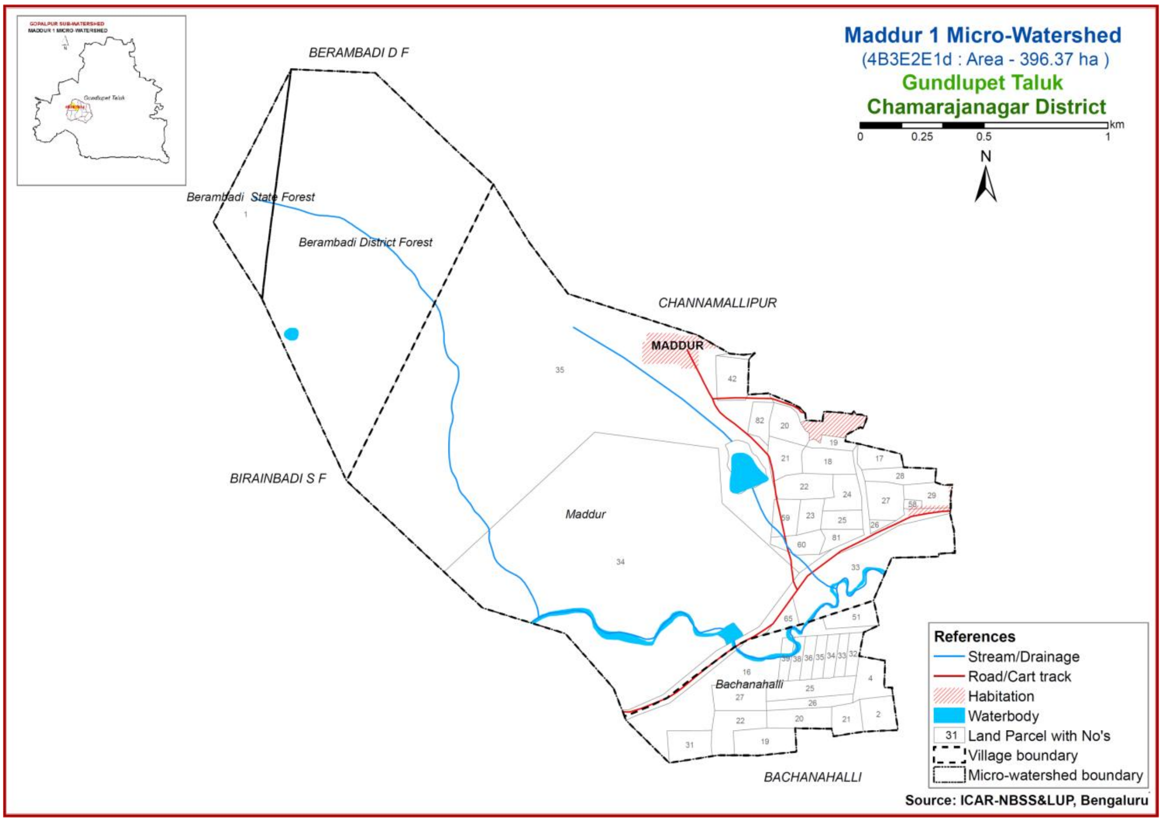


Fig 3.1 Scanned and Digitized Cadastral map of Maddur-1 Microwatershed

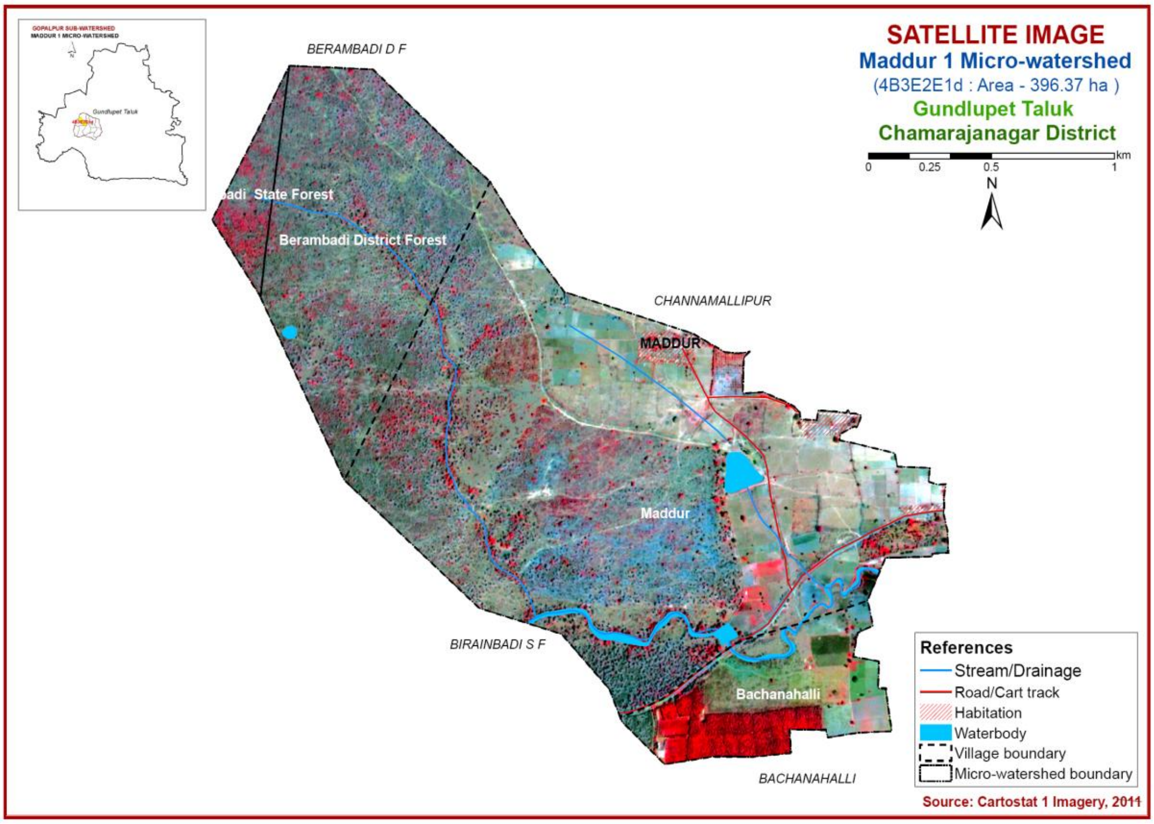


Fig. 3.2 Satellite Image of Maddur-1 Microwatershed

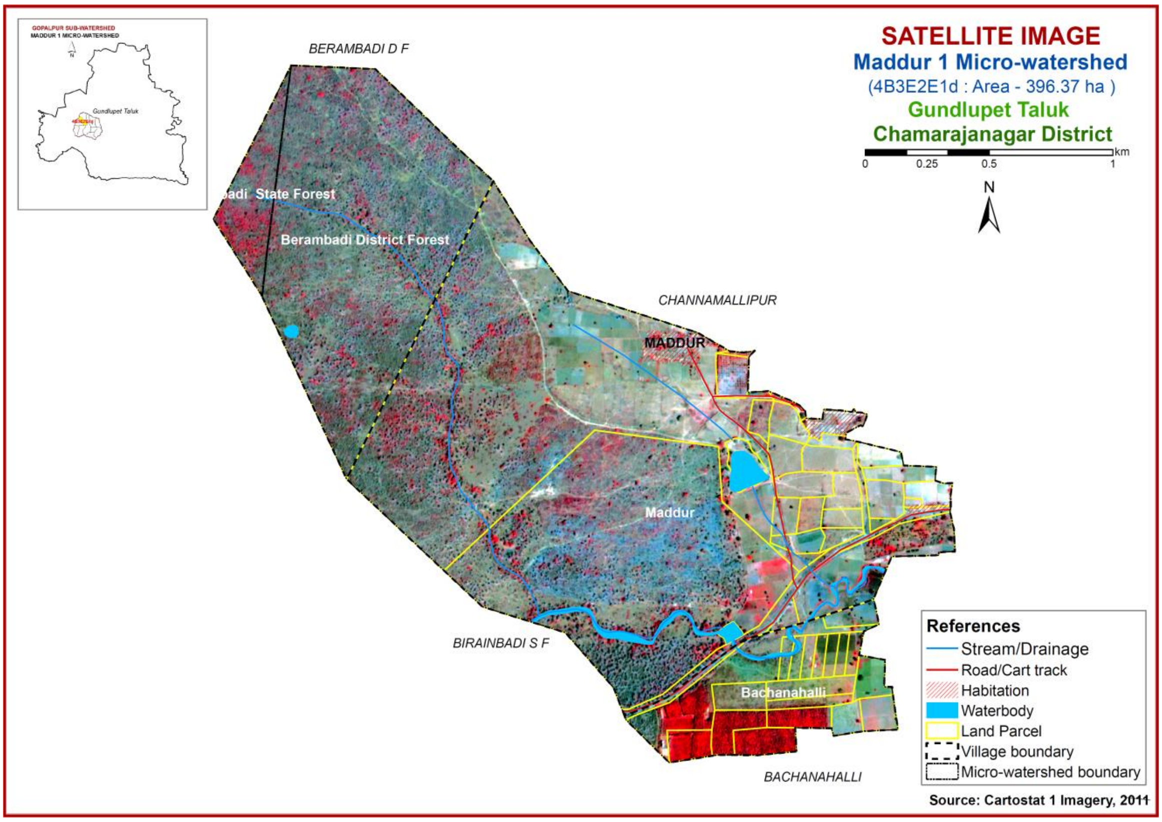


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Maddur-1 Microwatershed

3.3 Field Investigation

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, *nallas*, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Preliminary traverse of the microwatershed was carried out with the help of cadastral map, imagery and toposheets. While traversing, landforms and physiographic units identified were checked and preliminary soil legend was generated by studying soils at few selected places. Then, intensive traversing of each physiographic unit like hills, ridges and uplands was carried out. Based on the variability observed on the surface, transects (Fig. 3.4) were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

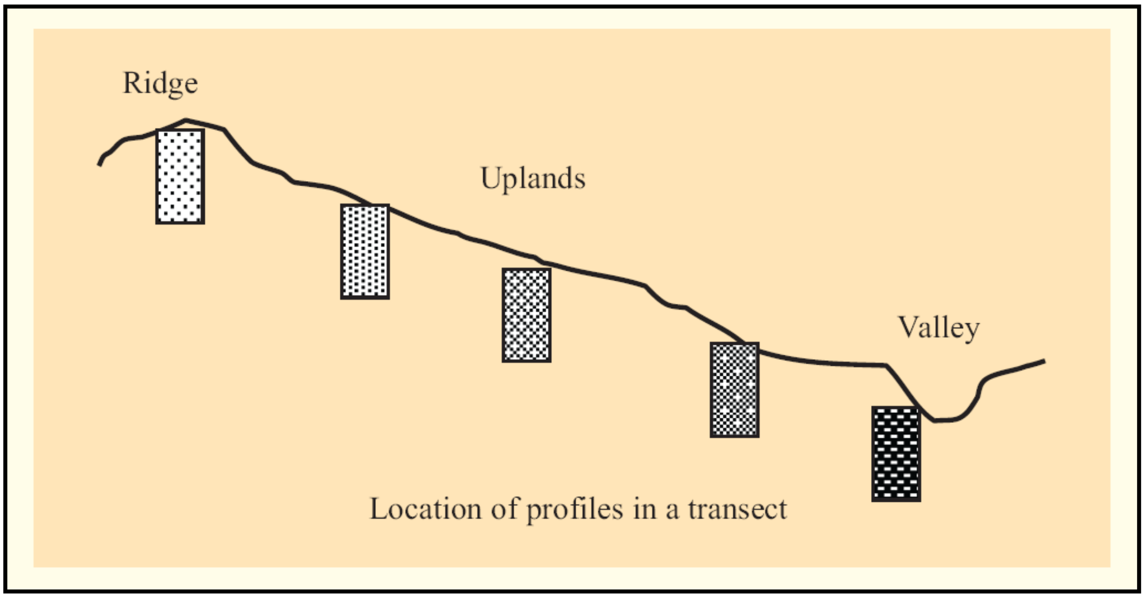


Fig. 3.4 Location of profiles in a transect

In the selected transect, soil profiles (Fig. 3.4) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, soil profiles (vertical cut showing the soil layers from surface to the rock) were opened up to 200 cm or to the depth limited by rock or hard substratum and studied in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all profile sites on a standard proforma as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff, 2012). Apart from the transect study, profiles were also studied at random, almost like in a grid pattern, outside the transect areas to validate the soil map unit boundariers.

Based on the soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 6 soil series were identified in the Maddur-1 microwatershed.

Table 3.1 Differentiating Characteristics used for identifying Soil Series (Characteristics are of Series Control Section)

Soils of Granite gneiss Landscape						
Sl. no	**Soil Series**	**Depth (cm)**	**Colour (Moist)**	**Texture**	**Gravel (%)**	**Horizon sequence**
1	Annurkeri (ARK)	>150	2.5YR2.5/2,3/2, 2.5/3,3/3,2.5/4,3/4	sc-c	<15	Ap-Bt
2	Beemanabeedu (BMB)	>150	10YR2/1,2/2,3/1, 3/2,4/1	sc-c	-	Ap-Bw
3	Berambadi (BMD)	25-50	10YR3/3,4/2, **7.5YR3/2,3/3,**	scl	<15	Ap-Bw-Cr
4	Hullipura (HPR)	50-75	7.5YR2.5YR2.5/2, 3/2	gscl	15-35	AP-Bw-Cr
5	Kannigala (KNG)	75-100	2.5YR2.5/4,3/4,3/6	gscl	>35	AP-Bt-Cr
6	Maddinahundi (MDH)	100-150	2.5YR2.5/4,3/4	gsc-c	>35	AP-Bt-Cr

3.4 Soil Mapping

The area under each soil series was further separated into 13 soil 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 gravel, stoniness etc. A soil phase is a subdivision of soil series based mostly on surface features that affect its use and management.

The soil mapping units are shown on the map (Fig. 3.5) in the form of symbols. During the survey 13 soil profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map. The soil map shows the geographic distribution of 13 mapping units representing 6 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2. The soil phase map (management units) shows the distribution of 13 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and they have to be treated accordingly.

3.5 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (16 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated using Kriging method for the microwatershed.

Table 3.2 Soil map unit description of Maddur-1 Microwatershed

Soil No	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
1	ARK	Annurkeri soils are very deep (>150 cm), well drained, have dark reddish brown to very dusky red sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**5.69 (1.43)**
		ARKhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	5.69 (1.43)
	BMB	Beemanabeedu soils are very deep (>150 cm), moderately well drained, have very dark greyish brown to dark grey and very dark brown clayey soils occurring on very gently sloping lowlands under cultivation		**5.31 (1.34)**
2		BMBmB1	Clay surface, slope 1-3%, slight erosion	5.31 (1.34)
	BMD	Berambadi soils are shallow (25-50 cm), well drained, dark brown to dark greyish brown sandy clay loam soils occurring on very gently sloping uplands under cultivation		**10.61 (2.68)**
3		BMDhB2	Sandy clay loam surface, slope 1-3%, moderate erosion	10.61 (2.68)
	HPR	Hullipura soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown gravelly sandy clay loam soils occurring on very gently sloping uplands under cultivation		**75.04 (18.94)**
4		HPRbB1g1	Loamy sand surface, slope 1-3%, slight erosion, gravelly (15-35%)	7.94 (2.00)
5		HPRcB1	Sandy loam surface, slope 1-3%, slight erosion	5.85 (1.48)
6		HPRcB2	Sandy loam surface, slope 1-3%, moderate erosion	24.87 (6.27)
7		HPRhB1	Sandy clay loam surface, slope 1-3%, slight erosion	10.55 (2.66)
8		HPRhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	10.66 (2.69)
9		HPRiB1	Sandy clay surface, slope 1-3%, slight erosion	6.16 (1.56)
10		HPRiB2g1	Sandy clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	5.37 (1.36)
11		HPRmB1	Clay surface, slope 1-3%, slight erosion	3.64 (0.92)
	KNG	Kannigala soils are moderately deep (75-100 cm), well drained, have dark reddish brown to dark red gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation		**6.75 (1.70)**
12		KNGhB1	Sandy clay loam surface, slope 1-3%, slight erosion	6.75 (1.70)
	MDH	Maddinahundi soils are deep (100-150 cm), well drained, have dark reddish brown gravelly sandy clay soils occurring on very		**28.30 (7.14)**

		gently sloping uplands under cultivation		
13		MDHiB2	Sandy Clay surface, slope 1-3%, moderate erosion	28.30 (7.14)
14		Forest		**253.40 (63.93)**
15		Others	Habitation and Waterbody	**11.28 (2.85) (0.26)**

*Soil map unit numbers are continuous for the taluk, not the microwatersheds

3.6 Land Management Units

The 13 soil phases identified and mapped in the microwatershed were regrouped into 6 Land Management Units (LMU's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Management Units (LMUs) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LMUs. For Maddur-1 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

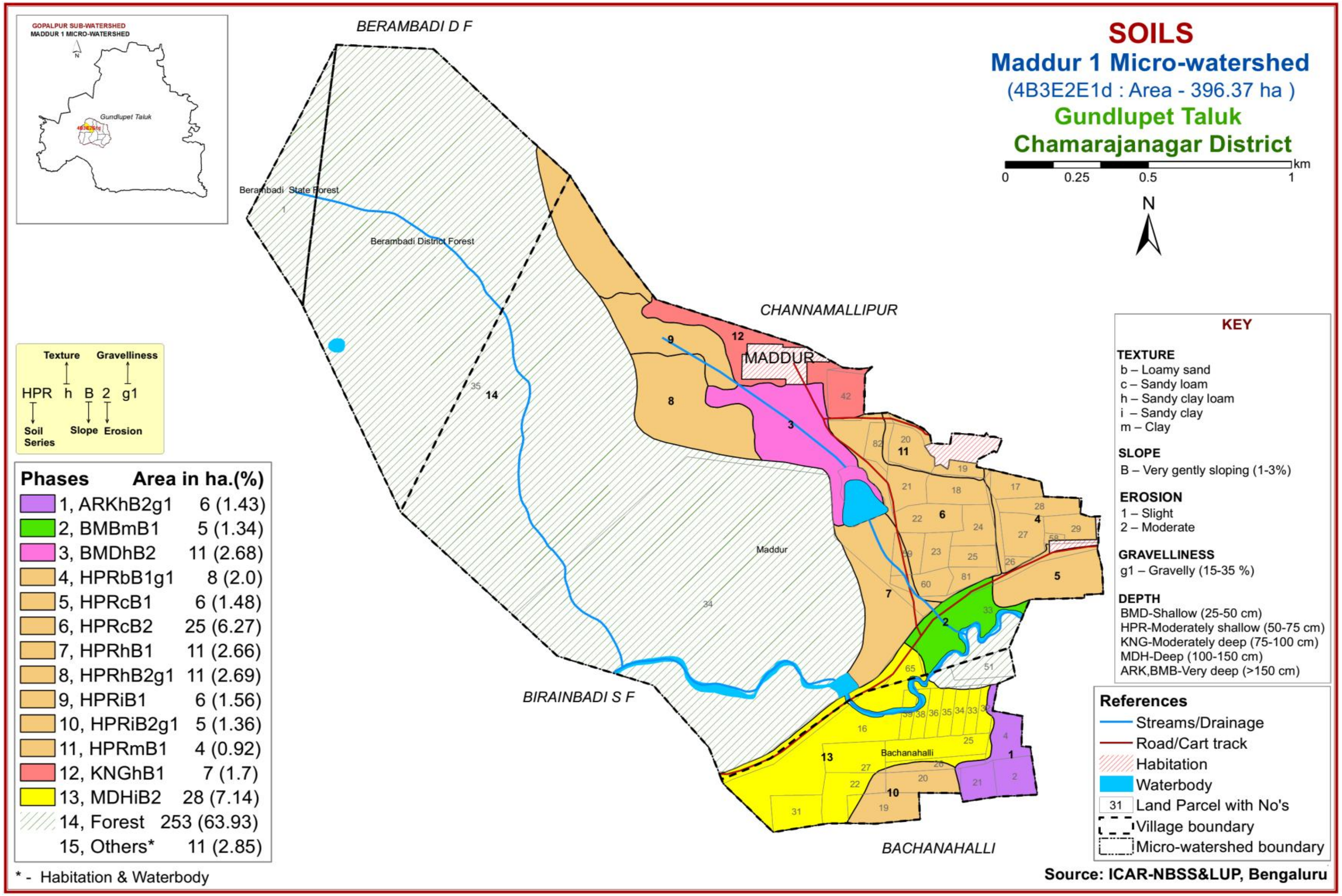


Fig 3.5 Soil Phase or Management Units Map of Maddur-1 Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Maddur-1 microwatershed is provided in this chapter. The microwatershed area has been identified as granite gneiss landscape based on geology. In all, 6 soil series were identified in different landforms. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In the granite gneiss landform, it is by parent material, relief and climate.

A brief description of each of the 6 soil series identified followed by 13 soil phases (management units) mapped (Fig. 3.5) are furnished below. The physical and chemical characteristics of soil series identified in Maddur-1 microwatershed along with soil classification are given in Table 4.1. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite gneiss Landscape

In this landscape, 6 soil series are identified and mapped. Of these, Hullipura (HPR) soil series occupies maximum area of about 75 ha (19%) followed by Maddinahundi (MDH) soil series 28 ha (7%), Berambadi (BMD) soil series 11 ha (3%), Kannigala (KNG) 7 ha (2%), Annurkeri (ARK) 6 ha (1%) and Beemanabeedu (BMB) soil series 5 ha (1%). The brief description of each soil series along with the soil phases identified and mapped is given below.

4.1.1 Annurkeri (ARK) Series: Annurkeri soils are very deep (>150 cm), well drained, have dark reddish brown to very dusky red sandy clay to clay soils. They are developed from weathered granite gneiss and occur on very gently sloping uplands. The Annurkeri series has been classified as a member of the fine, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 11 to 18 cm. Its colour is in 5YR and 2.5 YR hue with value 3 and chroma 3 to 4. The texture varies from sandy clay to clay with 10 to 15 per cent gravel. The thickness of B horizon is more than 150 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 2 to 4. Texture is dominantly sandy clay to clay with less than 15 per cent gravel. The available water capacity is very high (200 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Annurkeri (ARK) Series

4.1.2 Beemanabeedu (BMB) Series: Beemanabeedu soils are very deep (>150 cm), moderately well drained, have very dark greyish brown to dark grey and very dark brown sandy clay to clay soils. They are developed from weathered granite gneiss and occur on very gently sloping lowlands. The Beemanabeedu series has been classified as a member of the fine, mixed, isohyperthermic family of Typic Haplustepts.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 10 YR and 7.5 YR hue with value 2.5 to 4 and chroma 2 to 4. The texture varies from sandy clay to clay with 10 to 12 per cent gravel. The thickness of B horizon is more than 150 cm. Its colour is in 10 YR hue with value 2 to 4 and chroma 1to 2. Texture is sandy clay to clay. The available water capacity is very high (200 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Beemanabeedu (BMB) series

4.1.3 Berambadi (BMD) Series: Berambadi soils are shallow (25-50 cm), well drained, have very dark gray to dark brown sandy clay loam soils. They have developed from weathered granite gneiss and occur on very gently to moderately sloping uplands under cultivation. The Berambadi series has been classified as a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 30 to 50 cm. The thickness of A-horizon ranges from 10 to 17 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 3. The texture varies from sandy loam to sandy clay with 15 to 25 per cent gravel. The thickness of B horizon ranges from 30 to 40 cm. Its colour is in 10YR and 7.5YR hue with value 3 to 4 and chroma 2 to 4. Its texture is sandy clay loam with gravel content of 10 to 15 per cent. The available water capacity is low (50-100 mm/m). Only one soil phase was identified and mapped.

4.1.4 Hullipura (HPR) Series: Hullipura soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown gravelly sandy clay loam soils. They have developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Hullipura series has been classified as a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 51 to 71 cm. The thickness of A horizon ranges from 13 to 18 cm. Its colour is in 7.5YR and 10 YR hue with value 2.5 to 3 and chroma 2 to 4. The texture varies from gravelly sandy loam to gravelly clay with 15 to 25 per cent gravel. The thickness of B horizon ranges from 38 to 52 cm. Its colour is in 2.5 YR and 7.5 YR hue with value 2.5 to 3 and chroma 2. Its texture is gravelly sandy clay loam with gravel content of 15 to 35 per cent. The available water capacity is low (75 mm/m). Eight phases were identified and mapped.

Landscape and soil profile characteristics of Hullipura (HPR) series

4.1.5 Kannigala (KNG) Series: Kannigala soils are moderately deep (75-100 cm), well drained, have dark reddish brown to dark red gravelly sandy clay loam soils. They have developed from weathered granite gneiss and occur on very gently to strongly sloping uplands. The Kannigala series has been classified as a member of the loamy-skeletal, mixed, isohyperthermic family of Typic Haplustalfs.

The thickness of the solum ranges from 78 to 94 cm. The thickness of A horizon ranges from 12 to 15 cm. Its colour is in 5YR, 2.5 YR and 7.5 YR hue with value 3 and chroma 3 to 4. The texture varies from gravelly loamy sand to clay with 15 to 25 per cent gravel. The thickness of B horizon ranges from 69 to 80 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4 to 6. Texture varies from gravelly sandy clay loam with 40 to 60 per cent gravel. The available water capacity is very low (50 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Kannigala (KNG) Series

4.1.6 Maddinahundi (MDH) Series: Maddinahundi soils are deep (100-150 cm), well drained, have dark reddish brown gravelly sandy clay to clay soils. They have developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Maddinahundi series has been classified as a member of the clayey skeletal, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 102 to 150 cm. The thickness of A horizon ranges from 12 to 25 cm. Its colour is in 7.5 YR, 5 YR and 2.5 YR hue with value 3and chroma 2 to 6. The texture varies from gravelly sandy loam to gravelly sandy clay with 15 to 30 per cent gravel. The thickness of B horizon ranges from 90 to 138 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4. Its texture is gravelly sandy clay to clay with gravel content of >35 per cent. The available water capacity is medium (100 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Maddinahundi (MDH) Series

Table: 4.1 Physical and Chemical Characteristics of Soil Series identified in Maddur-1microwatershed

Soil Series: Annurkeri (ARK) (Pedon: RM-83)

Location: 11^{0}43'17.6"N, 76^{0}38'74" (**4B3E2G2c**) Siddhapura village, Gundlupet Taluk and Chamarajanagara District

Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Fine, mixed, isohyperthermic Rhodic Paleustalfs

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-25	Ap	79.05	5.82	15.13	3.64	15.38	21.46	25.61	12.96	<5	sl	-	-
25-46	A2	78.83	7.26	13.91	2.42	6.35	25.60	29.84	14.62	<5	sl	-	-
46-77	Bt1	55.15	5.36	39.49	2.60	16.34	14.36	13.94	7.91	<5	sc	-	-
77-102	Bt2	52.89	8.50	38.61	3.00	10.54	18.90	12.71	7.75	<5	sc	-	-
102-126	Bt3	48.90	7.24	43.86	1.15	3.97	18.18	15.26	10.34	<5	sc	-	-
126-156	Bt4	47.75	10.71	41.54	3.25	10.16	12.36	13.93	8.06	<5	sc	-	-
156-180	Bt5	45.27	11.65	43.08	3.82	9.68	12.07	11.97	7.70	<5	sc	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-25	7.17	-	-	0.16	0.51	0.00	-	-	0.74	0.13	-	4.79	0.32	100	2.71
25-46	7.09	-	-	0.11	0.47	0.00	-	-	0.37	0.06	-	5.81	0.42	100	1.03
46-77	7.33	-	-	0.06	0.47	0.00	-	-	0.27	0.07	-	15.96	0.40	100	0.44
77-102	7.21	-	-	0.07	0.55	0.00	-	-	0.21	0.09	-	15.62	0.40	100	0.58
102-126	7.22	-	-	0.07	0.47	0.00	-	-	0.23	0.22	-	15.39	0.35	100	1.43
126-156	7.27	-	-	0.07	0.43	0.00	-	-	0.56	0.51	-	14.93	0.36	100	3.42
156-180	7.33	-	-	0.09	0.39	0.00	-	-	0.42	0.51	-	14.82	0.34	100	3.44

Contd…

Soil Series: Bheemanabeedu (BMB), **Pedon**: RM-34

Location: $11^{0}43'45.9''N$, $76^{0}37'18.6''E$, (4B3E2F1c) Honnegaudanahalli village, Gundlupet Taluk**,** Chamarajanagara District

Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Fine, mixed, isohyperthermic Typic Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-13	Ap	63.25	17.32	19.42	3.89	9.31	13.61	19.14	17.30	5	sc	-	-
13-32	Bw1	61.95	18.00	20.05	3.18	12.21	13.54	18.56	14.46	-	sc	-	-
32-53	Bw2	54.42	20.16	25.42	3.89	9.79	12.63	14.95	13.16	-	sc	-	-
53-76	Bw3	40.54	20.40	39.05	2.40	8.25	9.82	11.91	8.15	-	c	-	-
76-114	Bw4	35.54	17.90	46.56	2.00	7.36	8.94	9.88	7.36	-	c	-	-
114-146	Bw5	28.31	19.25	52.44	2.55	5.73	6.68	6.89	6.47	-	c	-	-
146-180	Bw6	19.43	27.91	52.66	1.61	2.35	3.84	6.06	5.57	-	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-13	7.59	-	-	0.48	0.78	0.59	-	-	1.04	0.17	-	10.83	0.56	100	1.57
13-32	7.94	-	-	0.18	0.66	0.35	-	-	0.62	0.26	-	11.74	0.59	100	2.21
32-53	8.11	-	-	0.13	0.58	0.76	-	-	0.41	0.59	-	14.71	0.58	100	4.01
53-76	8.34	-	-	0.12	0.54	0.71	-	-	0.49	0.92	-	25.31	0.65	100	3.63
76-114	8.21	-	-	0.20	0.50	1.59	-	-	0.64	0.82	-	28.39	0.61	100	2.89
114-146	8.37	-	-	0.27	0.46	2.47	-	-	0.51	0.65	-	30.55	0.58	100	2.13
146-180	8.46	-	-	0.27	0.35	5.28	-	-	0.57	0.94	-	35.34	0.67	100	2.66

Contd…

Soil Series: Berambadi (BMD), **Pedon:** RM-125

Location: 11^{0}43'17"N, 76^{0}41' 41.4"E, (4B3E2J2a) Hundipur village, Gundlupet Taluk, Chamarajanagara District

Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Fine, loamy, Mixed, isohyperthermic Typic Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-12	Ap	64.81	10.27	24.92	5.78	13.11	18.99	17.54	9.39	15	scl	-	-
12-30	A1	63.68	11.19	25.13	5.52	12.59	16.86	19.98	8.74	<10	scl	-	-
30-43	Bw	55.49	10.87	33.65	17.55	10.76	11.29	10.14	5.75	<10	scl	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-12	8.28	-	-	0.23	0.74	1.02	-	-	0.73	0.15	-	18.13	0.73	100	0.83
12-30	8.61	-	-	0.18	0.70	1.14	-	-	0.98	0.54	-	19.61	0.78	100	2.75
30-43	8.68	-	-	0.20	0.51	2.28	-	-	0.48	0.58	-	19.15	0.57	1003	3.03

Contd…

Soil Series: Hullipura (HPR), **Pedon:** RM-126

Location: $11^0$43'21.8"N, $76^0$41' 28.1"E, (4B3E2J2a) Hundipur village, Gundlupet Taluk, Chamarajanagara District

Analysis at: NBSS&LUP, Regional Centre, Bangalore **Classification:** Fine-loamy, mixed, isohyperthermic Typic Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-15	Ap	47.38	17.57	35.05	7.38	9.95	8.98	10.80	10.27	15	sc	-	-
15-28	Bw1	49.95	18.96	31.10	7.21	10.29	9.97	12.51	9.97	15	scl	-	-
28-55	Bc	70.38	11.41	18.21	6.23	13.18	14.20	21.45	15.32	20	sl	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-15	8.36	-	-	0.36	0.60	2.34	-	-	0.93	0.43	-	24.17	0.69	100	1.78
15-28	8.36	-	-	0.37	0.72	3.30	-	-	1.10	0.61	-	6.16	0.20	100	9.90
28-55	8.73	-	-	0.23	0.24	0.84	-	-	0.41	0.85	-	16.30	0.90	100	5.21

Contd…

Soil Series: Kannigala (KNG), **Pedon:** TR-26/1

Location: $11^0$47'25.9"N, $76^0$34'11"E, (4B3E2E2f) Channamallipura village, Gundlupet Taluk, Chamarajanagaraja District

Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Loamy-skeletal, mixed, isohyperthermic Typic haplustalfs

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-15	Ap	65.41	16.99	17.60	4.18	6.02	15.71	25.61	13.88	20	sl	-	-
15-38	BA	63.15	10.36	26.48	11.98	15.56	11.26	14.43	9.93	15	scl	-	-
38-72	Bt1	61.51	9.22	29.28	22.20	11.00	10.79	10.49	7.03	>35	scl	-	-
72-100	Bt2	50.82	16.19	32.99	10.25	8.20	12.50	9.32	10.55	>35	scl	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-15	5.41	-	-	0.23	0.76	0.06	4.23	1.11	0.32	0.04	5.70	6.82	0.39	84	0.59
15-38	6.61	-	-	0.09	0.60	0.09	6.69	1.40	0.15	0.11	8.34	8.74	0.33	95	1.26
38-72	7.01	-	-	0.05	0.32	0.12	-	-	0.20	0.27	-	6.82	0.23	100	3.96
72-100	6.66	-	-	0.05	0.28	0.24	-	-	0.12	0.38	-	1.15	0.03	100	33.04

Contd…

Soil Series: Maddinahundi (MDH) (Pedon: RM205)

Location: (4B3E2E2g) Kannigala village, Gundlupet Taluk and Chamarajanagara District

Analysis at: NBSS&LUP, Regional Centre, Bangalore **Classification:** Clayey-skeletal, mixed, isohyperthermic Typic Rhodustalfs

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-20	Ap	81.73	9.04	9.24	5.92	15.36	21.08	24.90	14.46	20	ls	-	-
20-40	Bt1	58.51	9.25	32.24	10.19	11.11	13.25	15.19	8.77	20	scl	-	-
40-64	Bt2	41.16	9.23	49.61	9.25	7.48	9.77	9.25	5.41	40	c	-	-
64-92	Bt3	42.49	8.06	49.46	6.74	7.67	11.19	10.05	6.84	45	c	-	-
92-112	Bt4	42.53	12.73	44.74	5.92	15.36	21.08	24.90	14.46	45	c	-	-
112-134	Bc	50.77	11.92	37.31	10.19	11.11	13.25	15.19	8.77	25	sc	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-20	4.49	-	-	0.18	0.43	0.00	0.91	0.44	0.21	0.28	1.83	1.82	0.20	100	15.38
20-40	5.28	-	-	0.05	0.51	0.00	5.55	2.00	0.23	0.17	7.95	11.17	0.35	71	1.52
40-64	5.95	-	-	0.04	0.47	0.47	-	-	0.25	0.27	-	13.00	0.26	100	2.08
64-92	6.69	-	-	0.05	0.39	0.45	-	-	0.24	0.32	-	14.48	0.29	100	2.21
92-112	7.41	-	-	0.06	0.15	0.76	-	-	0.26	0.41	-	13.00	0.29	100	3.15
112-134	7.64	-	-	0.06	0.19	0.45	-	-	0.24	0.42	-	14.36	0.38	100	2.92

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

The most important soil and site characteristics that affect land use and conservation needs of an area are land capability, land irrigability, soil depth, texture, coarse fragments, available water capacity, soil slope, soil erosion, soil reaction etc. These are interpreted from the data base generated through land resource inventory and several thematic maps are generated. These would help in identifying the areas suitable for growing crops and conservation structures needed thus helping to maintain good soil health for sustained crop production. The various thematic maps generated are described below.

5.1 Land Capability Classification

Land capability classification is an interpretative grouping of soil map units (soil phases) mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, forestry, or other uses on a sustained basis (IARI, 1971). The land and soil characteristics used to group the land resources in an area into various land capability classes, subclasses and units are

Soil characteristics: Soil depth, texture, gravelliness, soil reaction, available water capacity, calcareousness, salinity/alkali *etc*.

Land characteristics: Slope, erosion, drainage, rock outcrops.

Climate: Total rainfall and its distribution, and length of crop growing period.

The Land capability classification system is divided into land capability classes, subclasses and units based on the level of information available. Eight land capability classes are recognized. They are

Class I: The soil map units have few or very few limitations that restrict their use.

Class II: The soil map units have moderate limitations that reduce the choice of crops or that require moderate conservations practices.

Class III: The soil map units have severe limitations that reduce the choice of crops or that require special conservation practices.

Class IV: The soil map units have severe limitations that reduce the choice of crops or that require very careful management.

Class V: Soils in the mapping units are not likely to erode, but have other limitations that are impractical to remove and as such not suitable for agriculture.

Class VI: The lands have severe limitations that make them generally unsuitable for cultivation.

Class VII: The lands have very severe limitations that make them unsuitable for cultivation.

Class VIII: Soil and other miscellaneous areas that have very severe limitations that nearly preclude their use for any crop production.

The land capability subclasses are recognised based on the dominant limitations observed within the given capability class. The subclasses are designated by adding a lower case letter like ‘e’, ‘w’, ‘s’, or ‘c’ to the class numeral. The subclass “e” indicates that the main hazard is risk of erosion, “w” indicates drainage or wetness as a limitation for plant growth, “s” indicates shallow soil depth, coarse or heavy textures, calcareousness, salinity/alkaline or gravelliness and “c” indicates limitation due to climate.

The land capability subclasses have been further subdivided into land capability units based on the kinds of limitations present in each subclass. Ten land capability units are used in grouping the soil map units. They are stony or rocky (0), erosion hazard (slope, erosion) (1), coarse texture (sand, loamy sand, sandy loam (2), fine texture (cracking clay, silty clay), (3) slowly permeable subsoil (4), coarse underlying material (5), salinity/alkali (6), stagnation, overflow, high ground water table (7), soil depth (8) and fertility problems (9). The capability units have similar soil and land characteristics that respond similarly to a given level of management. The soils of the microwatershed have been classified upto land capability subclass level.

The 13 soil map units identified in Maddur-1 microwatershed are grouped under 2 land capability classes and 4 land capability subclasses (Fig. 5.1).

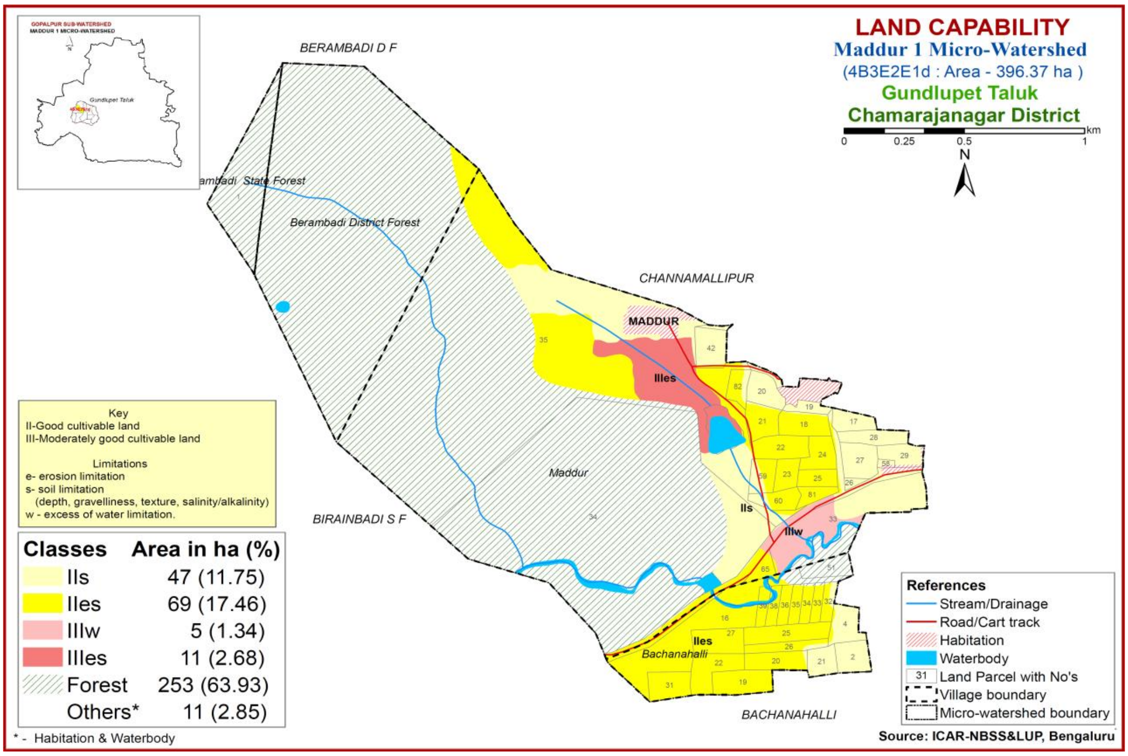


Fig. 5.1 Land Capability map of Maddur-1 Microwatershed

Of the lands suitable for agriculture, about 29 per cent are good cultivable lands (Class II) with minor limitations of soil and erosion and are distributed in the northern, eastern and western part of the microwatershed. About 4 per cent are moderately good cultivable lands (Class III) with moderate limitations of wetness, soil and erosion and are distributed in the eastern part of the microwatershed. About 64 per cent area is under State forest and 3 per cent under habitation and water bodies.

5.2 Soil Depth

Soil depth refers to the depth of the soil occurring above the parent material or hard rock. The depth of the soil determines the effective rooting depth for plants and in accordance with soil texture, mineralogy and gravel content, the capacity of the soil column to hold water and nutrient availability. Soil depth is one of the most important soil characteristic that is used in differentiating soils into different soil series. The soil depth classes used in identifying soils in the field are very shallow (<25 cm), shallow (25-50 cm), moderately shallow (50-75 cm), moderately deep (75-100 cm), deep (100-150 cm) and very deep (>150 cm). They were used to classify the soils into different depth classes and a soil depth map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.2.

Shallow (25-50 cm) soils cover an area of 11 ha (3%) and are distributed in the eastern part of the microwatershed. Moderately shallow (50-75 cm) soils occupy about 75 ha (19%) and are distributed in the northern, eastern and southern parts of the microwatershed. Moderately deep (75-100 cm) soils occupy about 7 ha (2%) and are distributed in the northern part of the microwatershed. Deep (100-150 cm) soils occur in an area of 28 ha (7%) and are distributed in the southern part of the microwatershed. An area of about 11 ha (3%) that are very deep (>150 cm) occur in the southern and eastern part of the microwatershed.

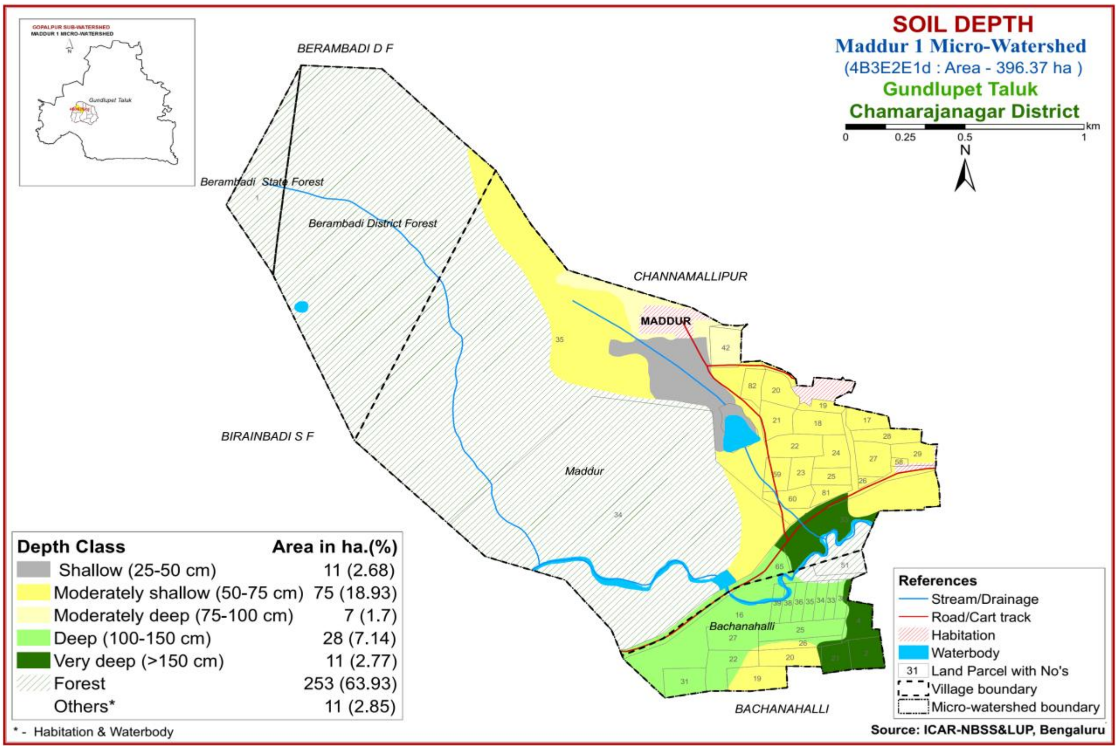


Fig. 5.2 Soil Depth map of Maddur-1 Microwatershed

The problematic lands cover 11 ha (3%) that are moderately shallow (25-50 cm) rooting depth. They are suitable for growing short duration agricultural crops but well suited for pasture, forestry or other recreational purposes. The most productive lands cover about 39 ha (10%) where all climatically adapted long duration crops be grown.

5.3 Surface Soil Texture

Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of primary particles of sand, silt and clay. It has a direct bearing on the structure, porosity, adhesion and consistence. The surface layer of a soil to a depth of about 25 cm is the layer that is most used by crops and plants. The surface soil textural class provides a guide to understanding soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behaviour, microbial activity and crop suitability. The textural classes used for LRI were used to classify the soils and a surface soil texture map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.3.

An area of 8 ha (2%) has soils that are sandy and are distributed in the eastern and southern part of the microwatershed. An area of 75 ha (19%) has loamy soils and are distributed in the major part of the microwatershed. An area of about 49 ha (12%) and are distributed in the northern, eastern and southern parts of the microwatershed (Fig. 5.3).

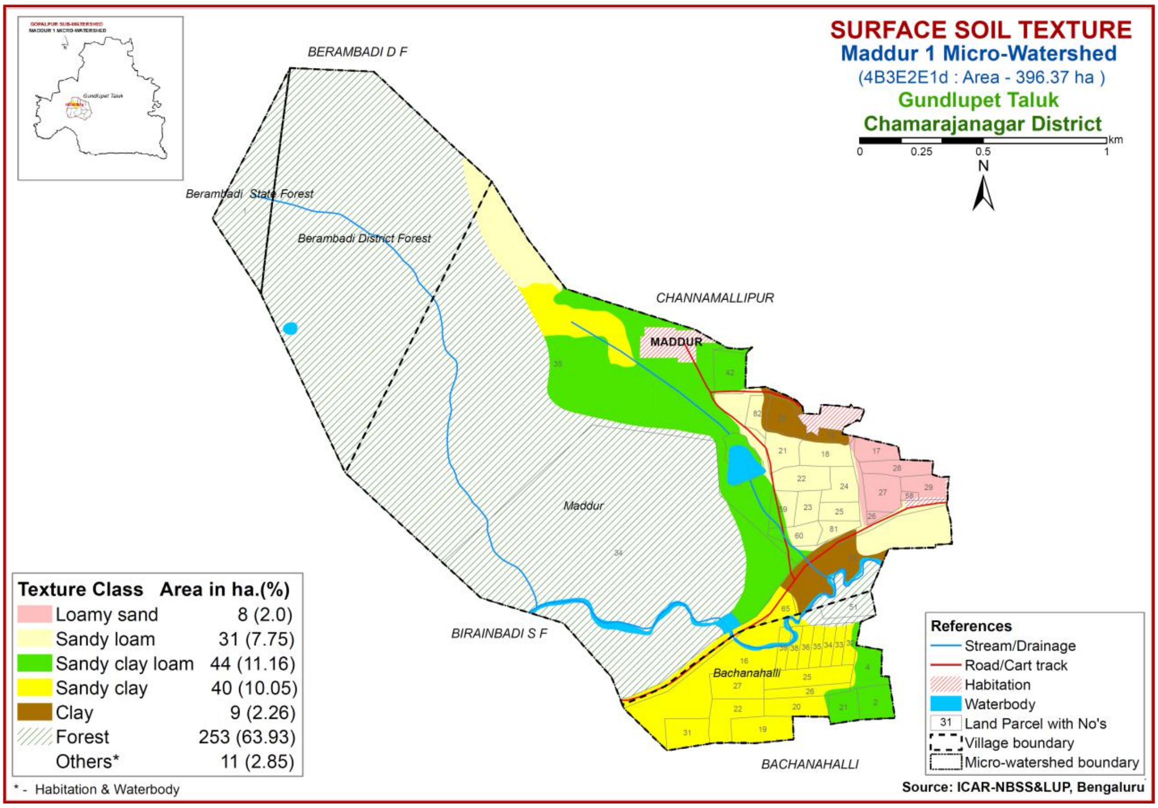


Fig. 5.3 Surface Soil Texture map of Maddur-1 Microwatershed

The productive lands 124 ha (31%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but have problems of drainage, infiltration, workability and other physical problems in clayey soils but not in loamy soils. The problematic lands 8 ha (2%) having sandy at the surface have problems like low soil-water retention and availability, and nutrient retention and availability. Here only short duration crops can be grown if the rainfall is normal and distributed well during crop growing period.

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 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 gravelliness classes used in LRI were used to classify the soils and using these classes a gravelliness map was generated. The area extent and their geographic distribution in the microwatershed is shown in Figure 5.4.

The soils that are gravelly (15-35%) cover an area of about 30 ha (7%) and are distributed in the major part of the microwatershed (Fig. 5.4). The soils that are non-gravelly (<15%) cover about 102 ha (26%) and are distributed in the northern, southern and eastern part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 26 per cent. They are non-gravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops.

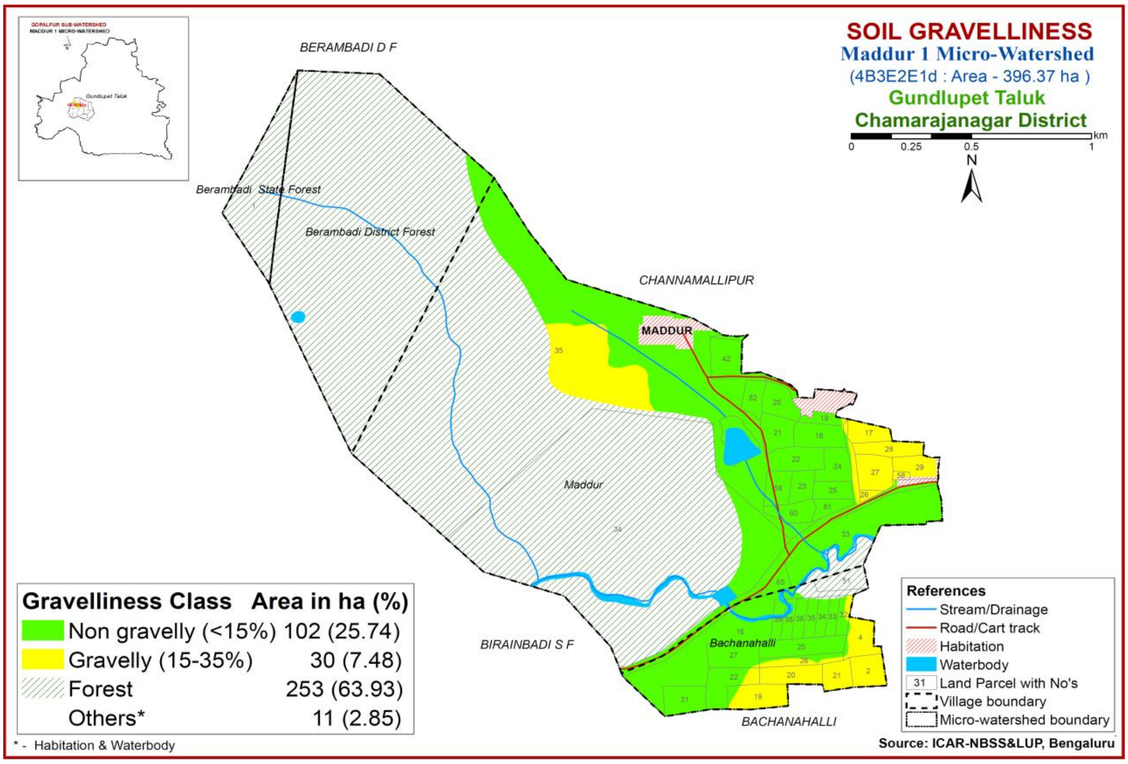


Fig. 5.4 Soil Gravelliness map of Maddur-1 Microwatershed

5.5 Available Water Capacity

The soil available water capacity (AWC) is estimated based on the ability of the soil column to retain water between the tensions of 0.33 and 15 bar in a depth of 100 cm or the entire solum if the soil is shallower. The AWC of the soils (soil series) as estimated by considering the soil texture, mineralogy, soil depth and gravel content (Sehgal *et al.*, 1990) and accordingly the soil map units were grouped into five AWC classes *viz*, very low (<50 mm/m), low (50-100 mm/m), medium (100-150 mm/m), high (150-200 mm/m) and very high (>200 mm/m) and using these values, an AWC map was generated. The area extent and their geographic distribution of different AWC classes in the microwatershed is given in Figure 5.5.

An area of about 17 ha (4%) has soils that are very low (<50 mm/m) in available water capacity and are distributed in the northern part of the microwatershed. Maximum area of 103 ha (26%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the major part of the microwatershed. An area of about 11 ha (3%) are very high in available water capacity (>200 mm/m) and are distributed in the southern part of the microwatershed.

About 17 ha (4%) area in the microwatershed has soils that are problematic (<50 mm/m) with regard to available water capacity. Here, only short duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses. The potential soils respect to AWC cover about 11 ha (3%) that have very high AWC, where all climatically adapted long duration crops can be grown.

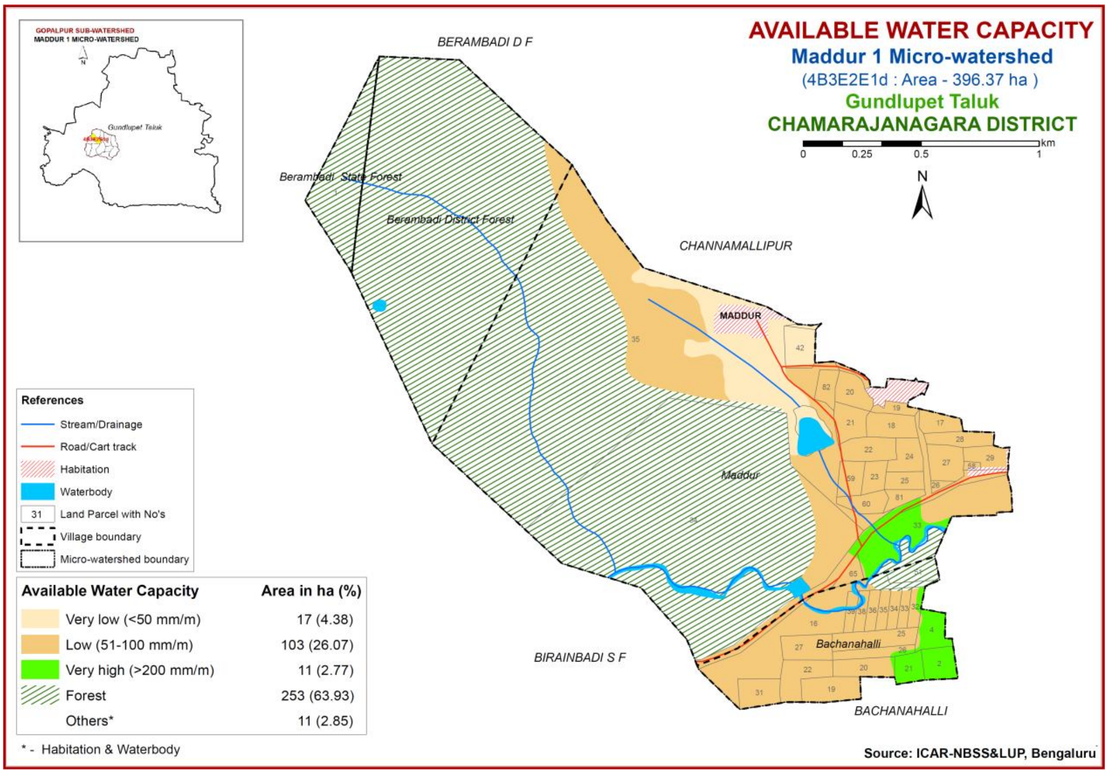


Fig. 5.5 Soil Available Water Capacity map of Maddur-1 Microwatershed

5.6 Soil Slope

Soil slope refers to the inclination of the surface of the land. It is defined by gradient, shape and length, and is an integral feature of any soil as a natural body. Slope is considered important in soil genesis, land use and land development. The length and gradient of slope influences the rate of runoff, infiltration, erosion and deposition. The soil map units were grouped into four slope classes and a slope map was generated showing the area extent and their geographic distribution in the microwatershed (Fig. 5.6).

The entire cultivated area of the microwatershed falls under very gently sloping (1-3% slope) class. It covers an area of about 132 ha (33%) and are distributed in the entire part of the microwatershed.

An area of about 132 ha (33%) in the microwatershed has soils that have high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

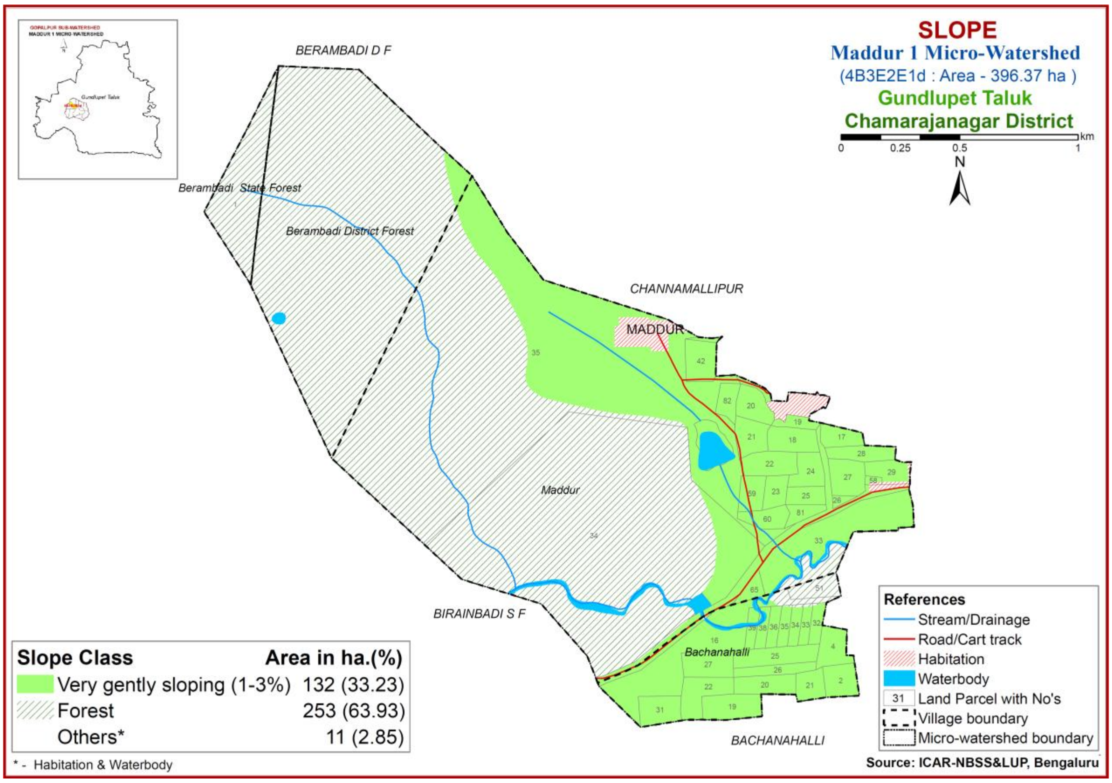


Fig. 5.6 Soil Slope map of Maddur-1 Microwatershed

5.7 Soil Erosion

Soil erosion refers to the wearing away of the earth's surface by the forces of water, wind and ice involving detachment and transport of soil by raindrop impact. It is used for accelerated soil erosion resulting from disturbance of the natural landscape by burning, excessive grazing and indiscriminate felling of forest trees and tillage, all usually by man. The erosion classes showing an estimate of the current erosion status as judged from the field observations in the form of rills, gullies or a carpet of gravel on the surface are recorded. Four erosion classes, viz, slight erosion (e1), moderate erosion (e2), severe erosion (e3) and very severe erosion (e4) are recognized. The soil map units were grouped into different erosion classes and soil erosion map generated. The area extent and their spatial distribution in the microwatershed is given in Figure 5.7.

Soils that are slightly eroded (e1 class) cover a maximum area of about 46 ha (12%) in the microwatershed. They are distributed in the northern, eastern and central part of the microwatershed. Moderately eroded (e2 class) soils cover an area of about 85 ha (22%) and are distributed in the major part of the microwatershed.

An area of about 85 ha (22%) in the microwatershed is problematic because of moderate erosion. These areas need soil and water conservation and other land development measures for restoring the soil health.

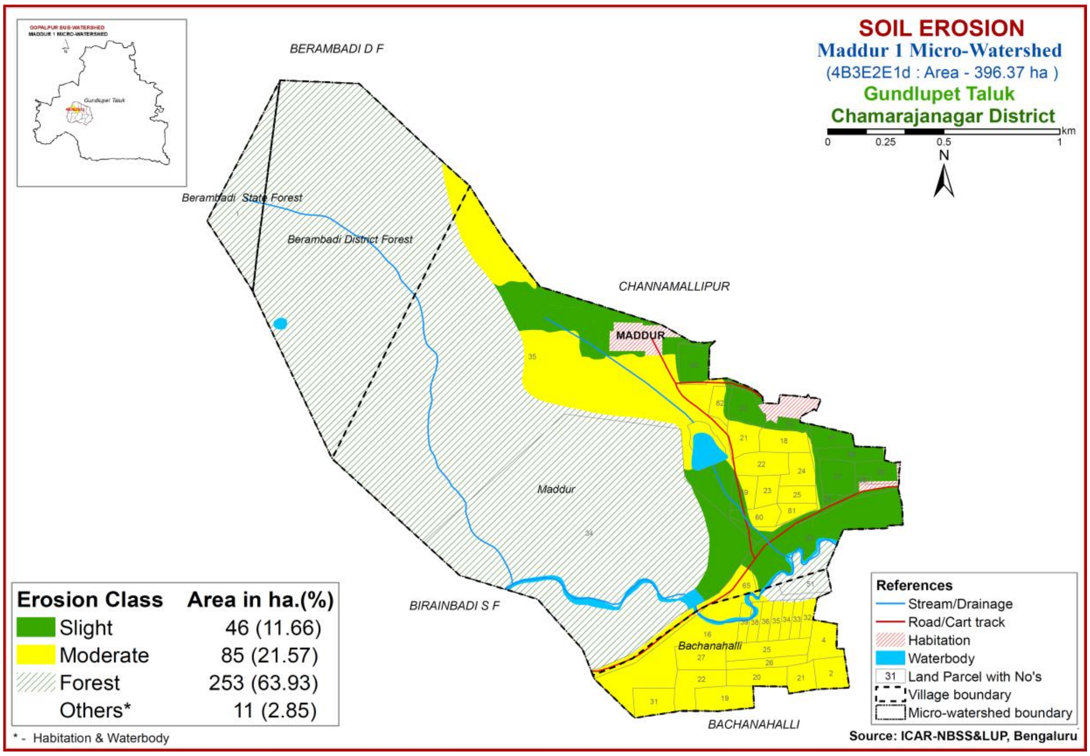


Fig. 5.7 Soil Erosion map of Maddur-1 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status as these areas are characterised by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m grid interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium, and for micronutrients like zinc, boron, copper, iron and manganese, and secondary nutrient sulphur.

Soil fertility data generated has been assessed and individual maps for all the nutrients for the microwatershed have been generated using Kriging method under GIS. The village/survey number wise fertility data for the microwatershed is given in Appendix-II.

6.1 Soil Reaction (pH)

The soil analysis of the Maddur-1 microwatershed for soil reaction (pH) showed that an area of 10 ha (2%) is under neutral (pH 6.5-7.3) in reaction and is distributed in the northern and southern parts of the microwatershed. About 38 ha (10%) area is slightly alkaline (pH 7.3-7.8) and is distributed in the northern, eastern and southern part of the microwatershed. About 84 ha (21%) area falls under moderately alkaline (pH 7.8-8.4) in reaction and is distributed in the major part of the microwatershed.

6.2 Electrical Conductivity (EC)

The Electrical Conductivity of the soils of the entire microwatershed area is <2 dSm^{-1} (Fig 6.2) and as such the soils are non saline.

6.3 Organic Carbon

The soil organic carbon content of the microwatershed area is medium (0.5-0.75%) covering about 8 ha (2%) and is distributed in the eastern part of the microwatershed (Fig. 6.3). Maximum area of about 123 ha (31%) soils are high in organic carbon (>0.75%) and is distributed in the major part of the microwatershed.

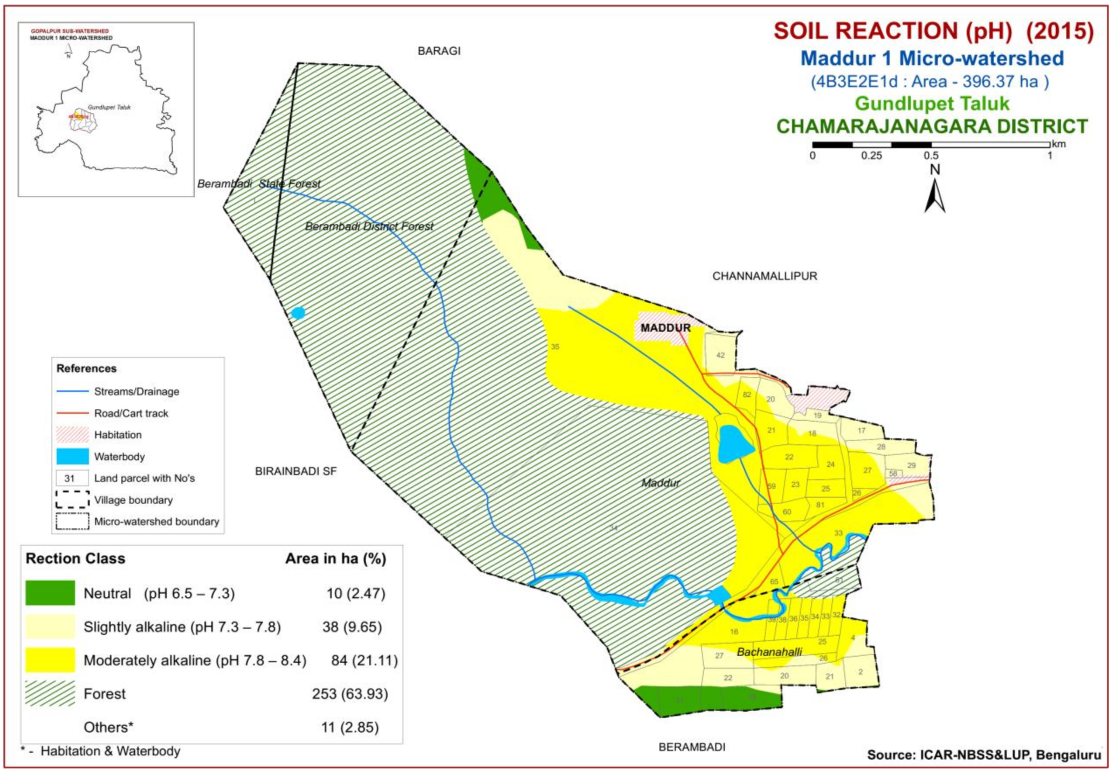


Fig. 6.1 Soil Reaction (pH) map of Maddur-1 Microwatershed

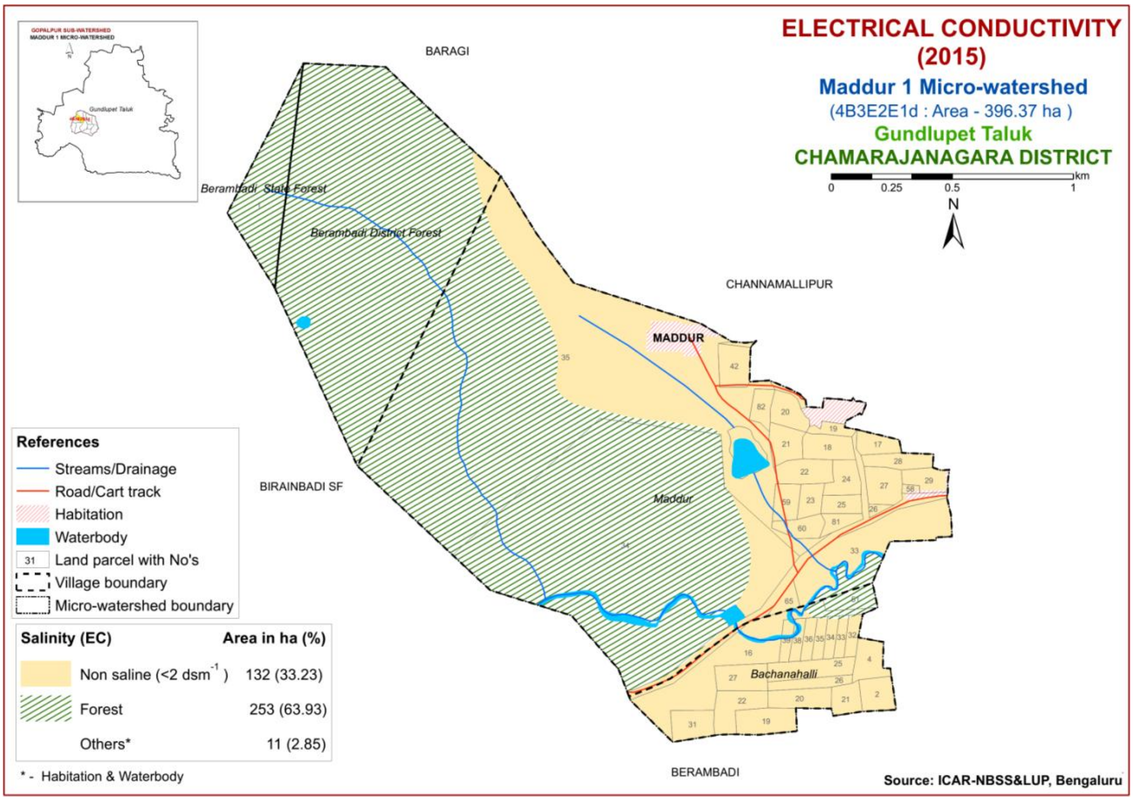


Fig. 6.2 Electrical Conductivity (EC) map of Maddur-1 Microwatershed

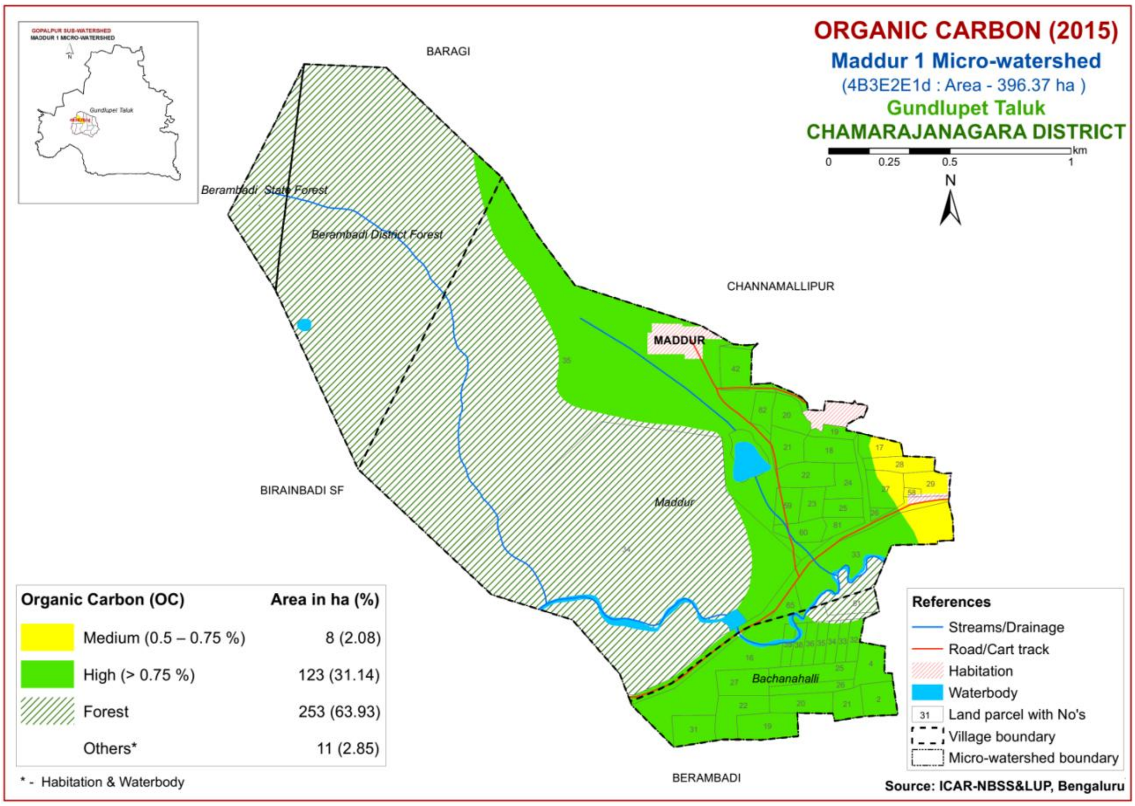


Fig. 6.3 Soil Organic Carbon map of Maddur-1 Microwatershed

6.4 Available Phosphorus

The soil analysis revealed that the available phosphorus is low (<23 kg/ha) in an area of about 47 ha (12%) and is distributed in the northeastern part of the microwatershed. Maximum area of about 84 ha (21%) is medium (23-57 kg/ha) in available phosphorous and are distributed in the eastern and southern part of the microwatershed (Fig 6.4). There is an urgent need to increase the dose of phosphorus for all the crops by 25 per cent over the recommended dose to realize better crop performance in low and medium areas.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in an area of about 82 ha (21%) and is distributed in the northern and eastern part of the microwatershed. An area of 50 ha (13%) is high (>337 kg/ha) and are distributed in the southern and eastern parts of the microwatershed (Fig 6.5).

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in the entire area of about 132 ha (33%) and is distributed in all parts of the microwatershed (Fig. 6.6).

6.7 Available Boron

Available boron content is low (<0.5 ppm) in an area of about 71 ha (18%) and is distributed in the northern, eastern and southern part of the microwatershed. An area of 60 ha (15%) is medium (0.5-1.0 ppm) and is distributed in the southern and eastern part of the microwatershed (Fig. 6.7).

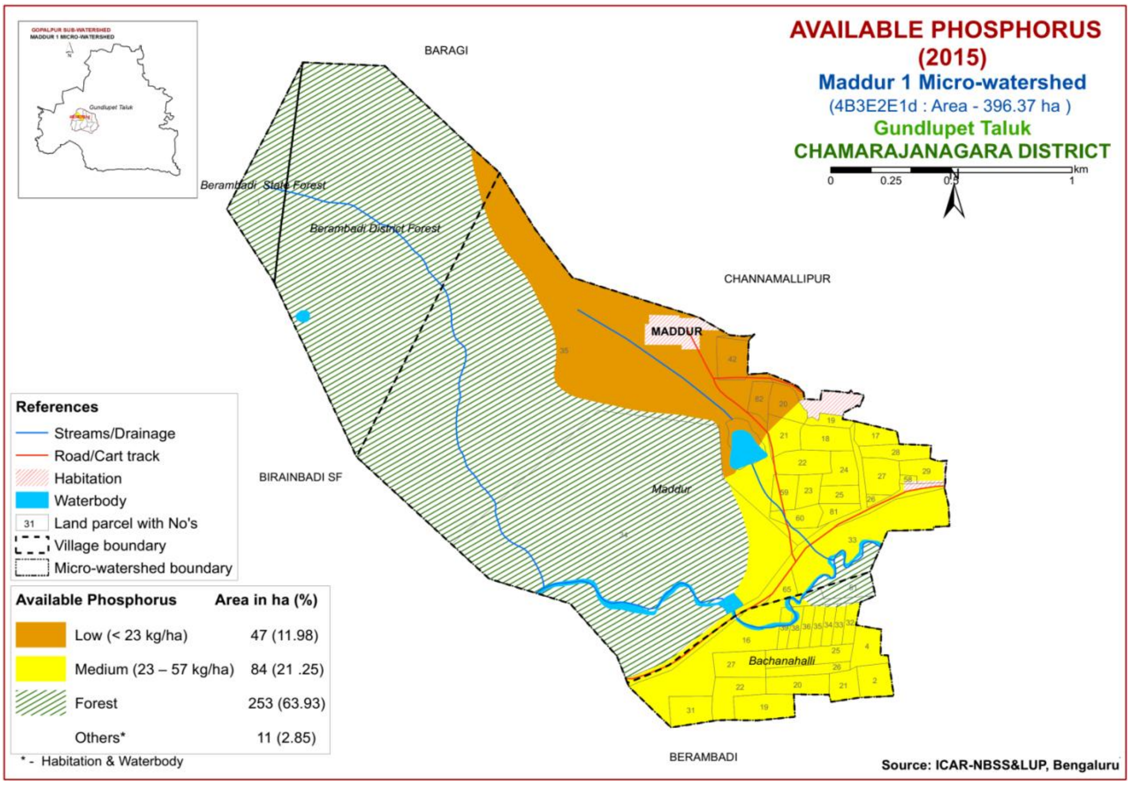


Fig. 6.4 Soil available Phosphorus map of Maddur-1 Microwatershed

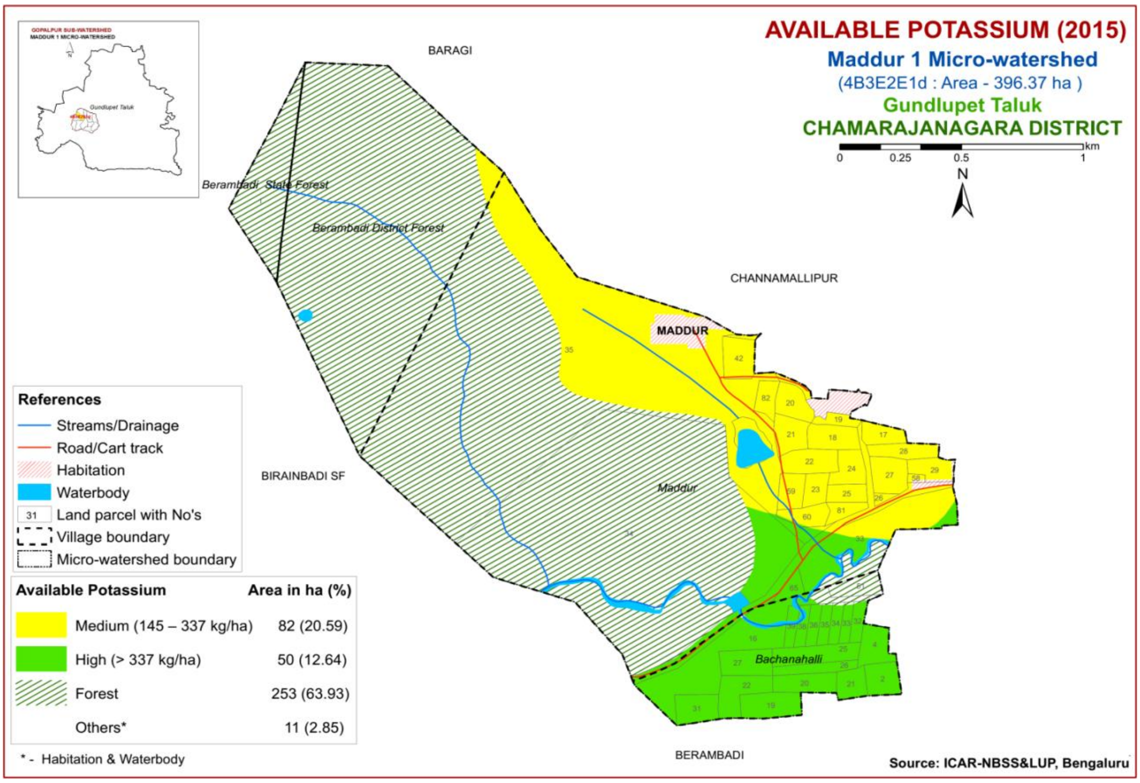


Fig. 6.5 Soil available Potassium map of Maddur-1 Microwatershed

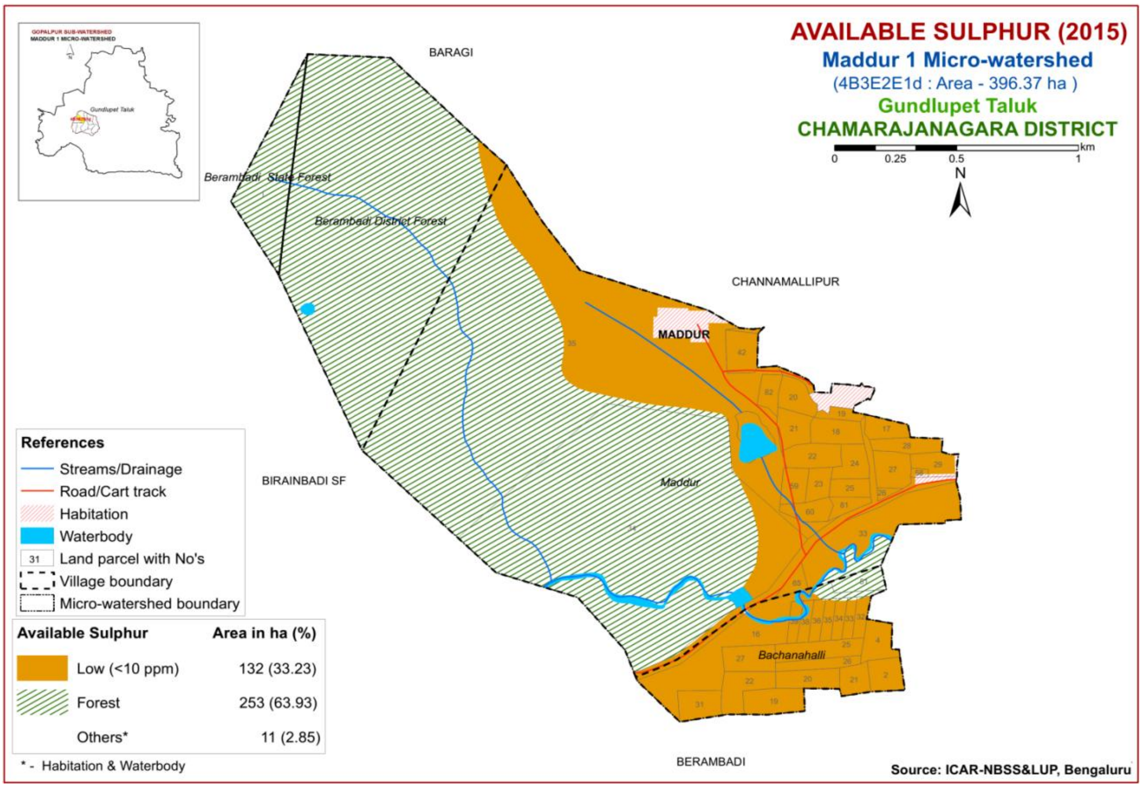


Fig. 6.6 Soil available Sulphur map of Maddur-1 Microwatershed

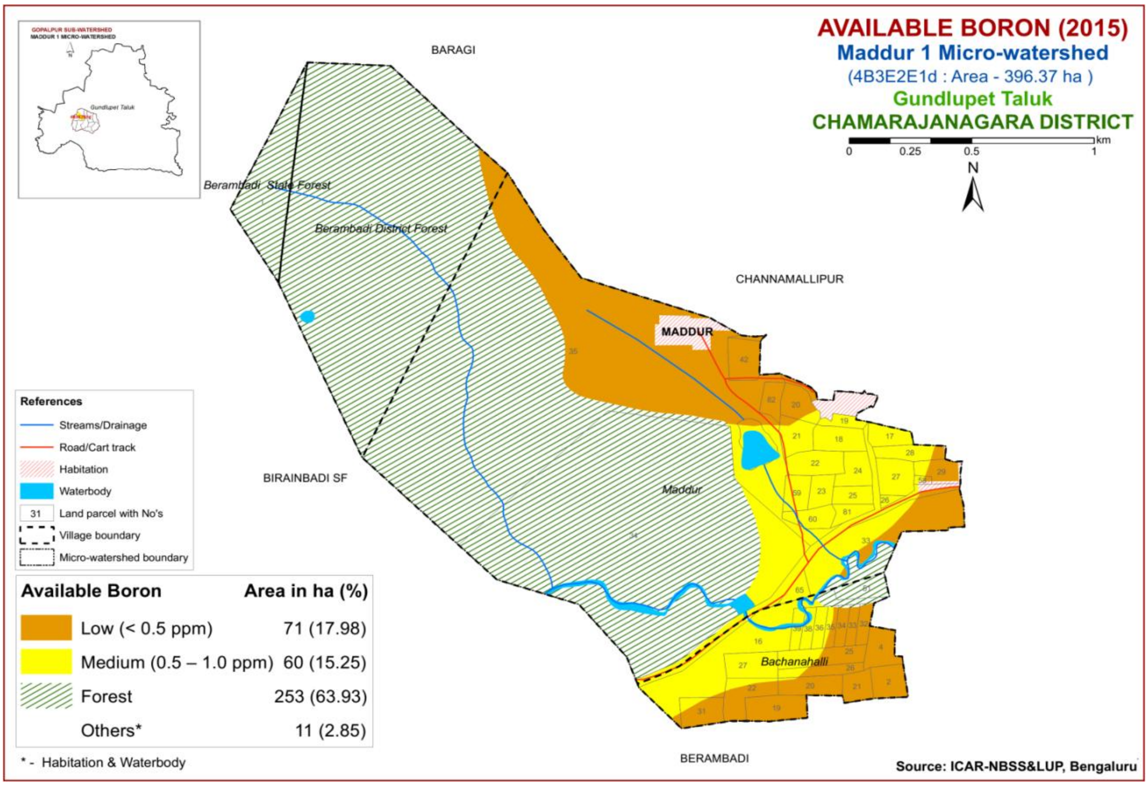


Fig. 6.7 Soil available Boron map of Maddur-1 Microwatershed

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in the entire area of about 132 ha (33%) and is distributed in all parts of the microwatershed (Fig 6.8).

6.9 Available Manganese

Available manganese content is sufficient (>1.0 ppm) in the entire microwatershed area (Fig 6.9).

6.10 Available Copper

Available copper content is sufficient (>0.2 ppm) in the entire microwatershed area (Fig 6.10).

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in an area of 66 ha (17%) and are distributed in the northern and eastern part of the microwatershed. Sufficient (>0.6 ppm) in available zinc content cover an area of about 66 ha (17%) and are distributed in the central and southern part of the microwatershed (Fig 6.11).

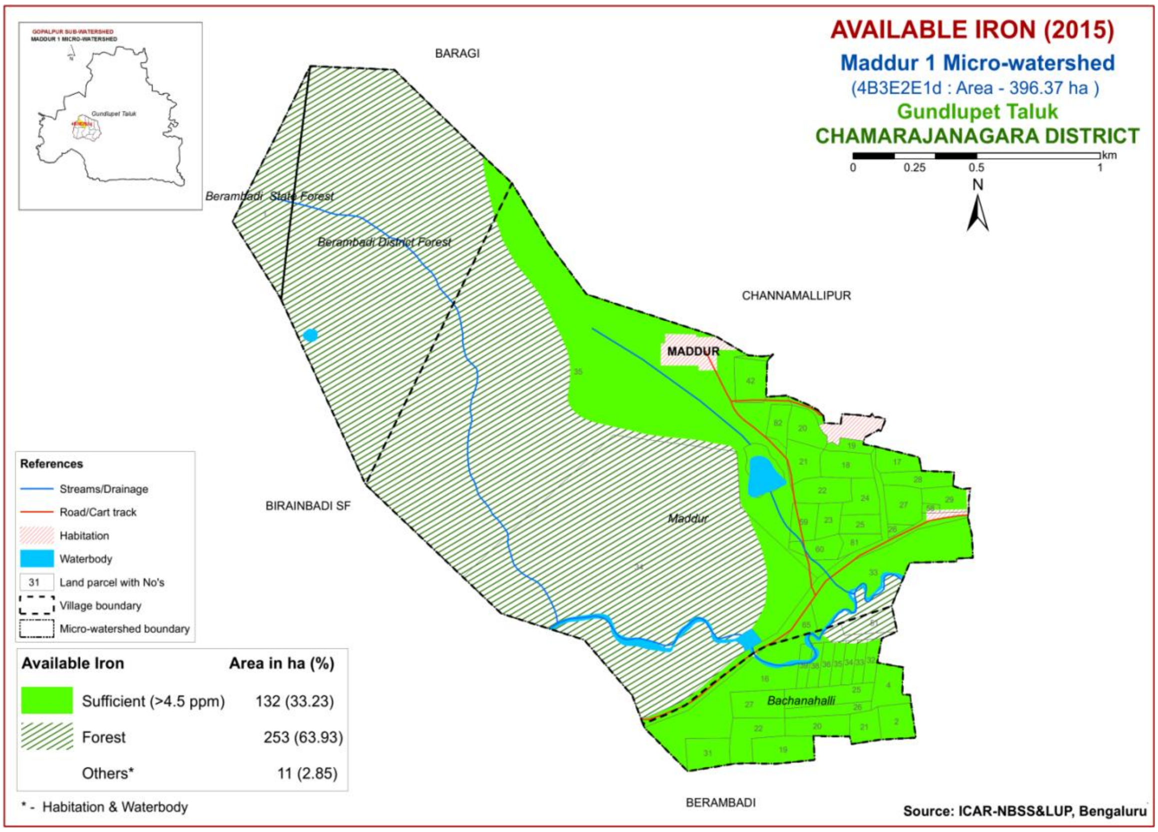


Fig. 6.8 Soil available Iron map of Maddur-1 Microwatershed

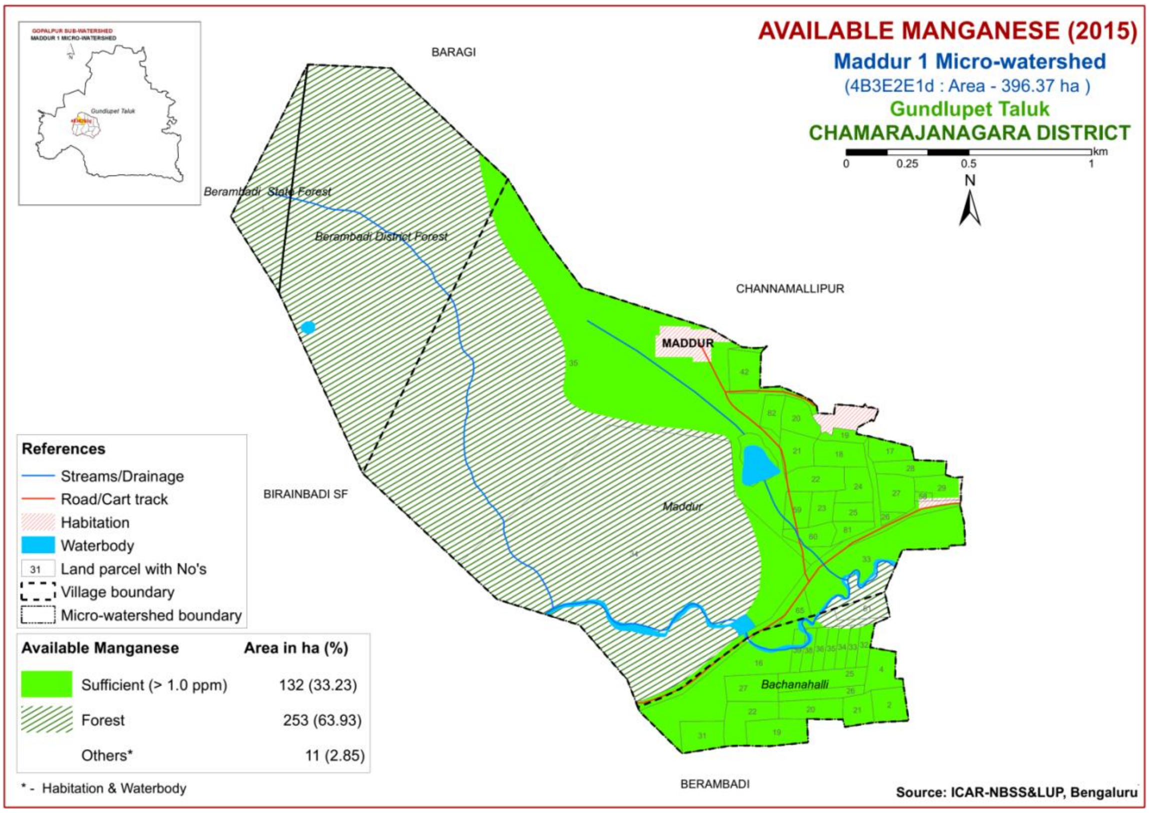


Fig. 6.9 Soil available Manganese map of Maddur-1 Microwatershed

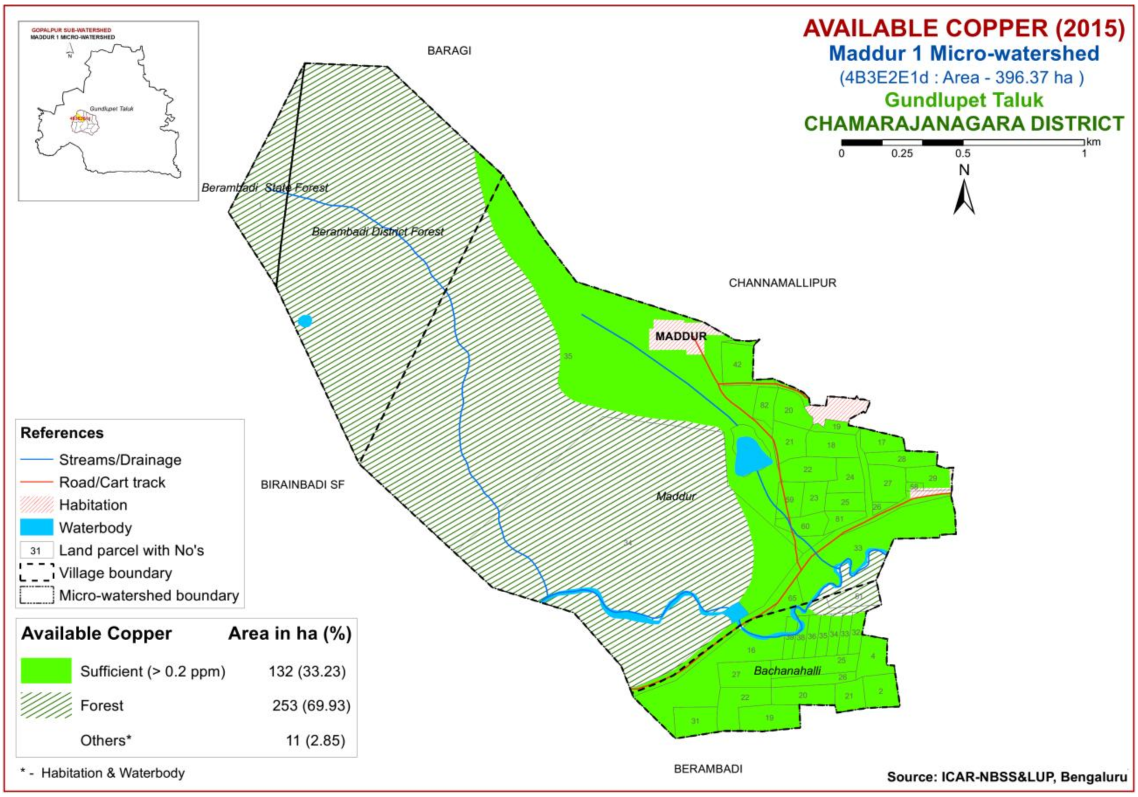


Fig.6.10 Soil available Copper map of Maddur-1 Microwatershed

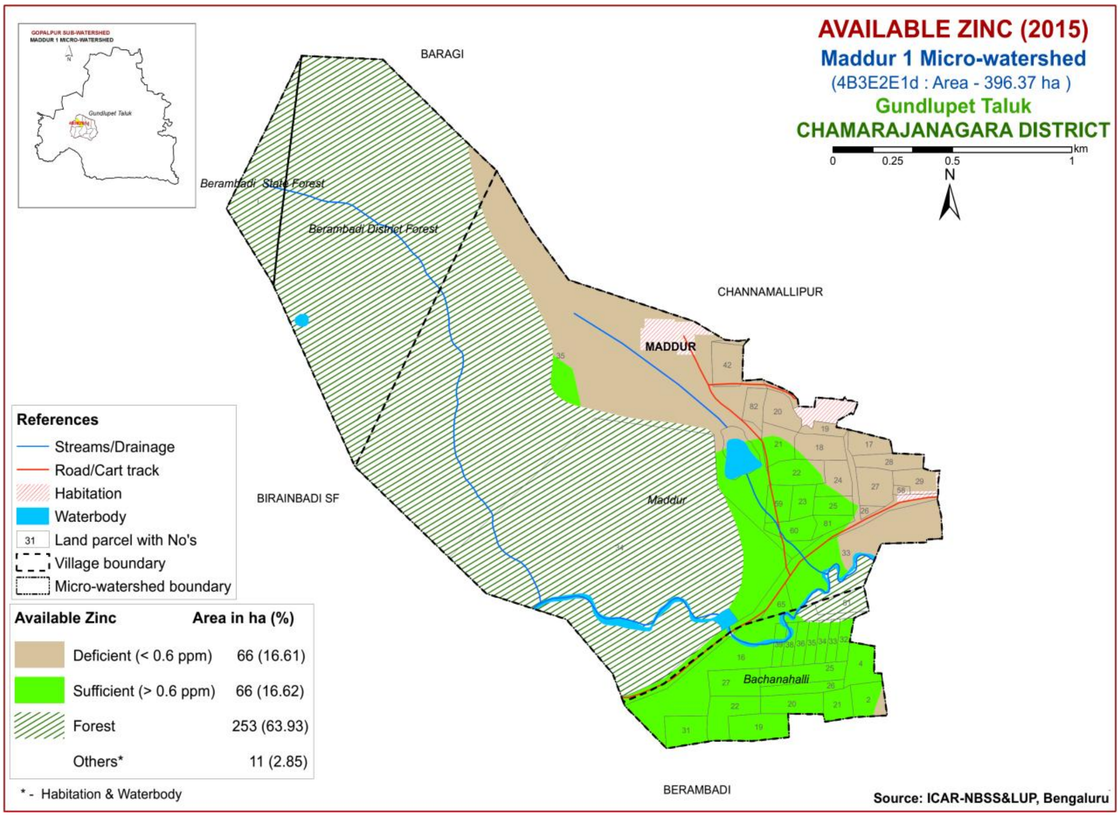


Fig. 6.11 Soil available Zinc map of Maddur-1 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Maddur-1microwatershed were assessed for their suitability for growing food, fodder, fibre and horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data, Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S-Suitable and Order N-Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1-Highly Suitable, Class S2-Moderately Suitable and Class S3-Marginally Suitable. Order N has two classes, N1-Currently not Suitable and N2-Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2, S3 and N1 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are ‘c’ for erratic rainfall and its distribution and length of growing period (LGP), ‘e’ for erosion hazard, ‘r’ for rooting condition, ‘t’ for lighter or heavy texture, ‘g’ for gravelliness or stoniness, ‘n’ for nutrient availability, ‘l’ for topography, ‘m’ for moisture availability, ‘z’ for calcareousness, ‘s’ for sodium and ‘w’ for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 27 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crop grown in Karnataka in an area of 10.47 lakh ha in northern Karnataka in Bijapur, Kalaburgi, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing sorghum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.1.

An area of about 11 ha (3%) is highly suitable (Class S1) for growing sorghum and are distributed in the eastern and southeastern part of the microwatershed. About 103 ha (26%) has soils that are moderately suitable (Class S2) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth and

Table 7.1 Soil-Site Characteristics of Maddur-1 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p+)kg-1]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Sub surface (%)								
ARKhB2g1	734	150	WD	>150	scl	sc	15-35	<15	200	1-3	Moderate	7.17	0.16	2.71	4.79	100
BMBmB1	734	150	MWD	>150	c	sc-c	-	-	200	1-3	Slight	7.59	0.48	1.57	0.56	100
BMDhB2	734	150	WD	>150	scl	scl	-	<15	50-100	1-3	Moderate	8.28	0.23	0.83	18.13	100
HPRbB1g1	734	150	WD	50-75	ls	gscl	15-35	15-35	75	1-3	Slight	8.36	0.36	1.78	24.17	100
HPRcB1	734	150	WD	50-75	sl	gscl	-	15-35	75	1-3	Slight	8.36	0.36	1.78	24.17	100
HPRcB2	734	150	WD	50-75	sl	gscl	-	15-35	75	1-3	Moderate	8.36	0.36	1.78	24.17	100
HPRhB1	734	150	WD	50-75	scl	gscl	-	15-35	75	1-3	Slight	8.36	0.36	1.78	24.17	100
HPRhB2g1	734	150	WD	50-75	scl	gscl	15-35	15-35	75	1-3	Moderate	8.36	0.36	1.78	24.17	100
HPRiB1	734	150	WD	50-75	sc	gscl	-	15-35	75	1-3	Slight	8.36	0.36	1.78	24.17	100
HPRiB2g1	734	150	WD	50-75	sc	gscl	15-35	15-35	75	1-3	Moderate	8.36	0.36	1.78	24.17	100
HPRmB1	734	150	WD	50-75	c	gscl	-	15-35	75	1-3	Slight	8.36	0.36	1.78	24.17	100
KNGhB1	734	150	WD	75-100	scl	gscl	-	>35	50	1-3	Slight	5.41	0.23	0.59	6.82	84
MDHiB2	734	150	WD	100-150	sc	gsc-c	-	>35	100	1-3	Moderate	4.49	0.18	15.3	1.82	100

*Symbols and abbreviations are according to Field Guide for LRI under Sujala-III Project, Karnataka gravelliness. Marginally suitable (Class S3) lands cover an area of 18 ha (4%) and are distributed in the northern part of the microwatershed.

Table 7.2 Land suitability criteria for Sorghum

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	2-3	3-8	8-15	>15
LGP	Days	120-150	120-90	<90	
Soil drainage	Class	Well to mod. Well drained	imperfect	Poorly/ excessively	V. poorly
Soil reaction	pH	6.0-8.0	5.5-5.9 8.1-8.5	<5.5 8.6-9.0	>9.0
Surface soil texture	Class	c, cl, sicl, sc	l, sil, sic	sl, ls	s, fragmental skeletal
Soil depth	cm	100-75	50-75	30-50	<30
Gravel content	% vol.	5-15	15-30	30-60	>60
Salinity (EC)	dSm^{-1}	2-4	4-8	8-10	>10
Sodicity (ESP)	%	5-8	8-10	10-15	>15

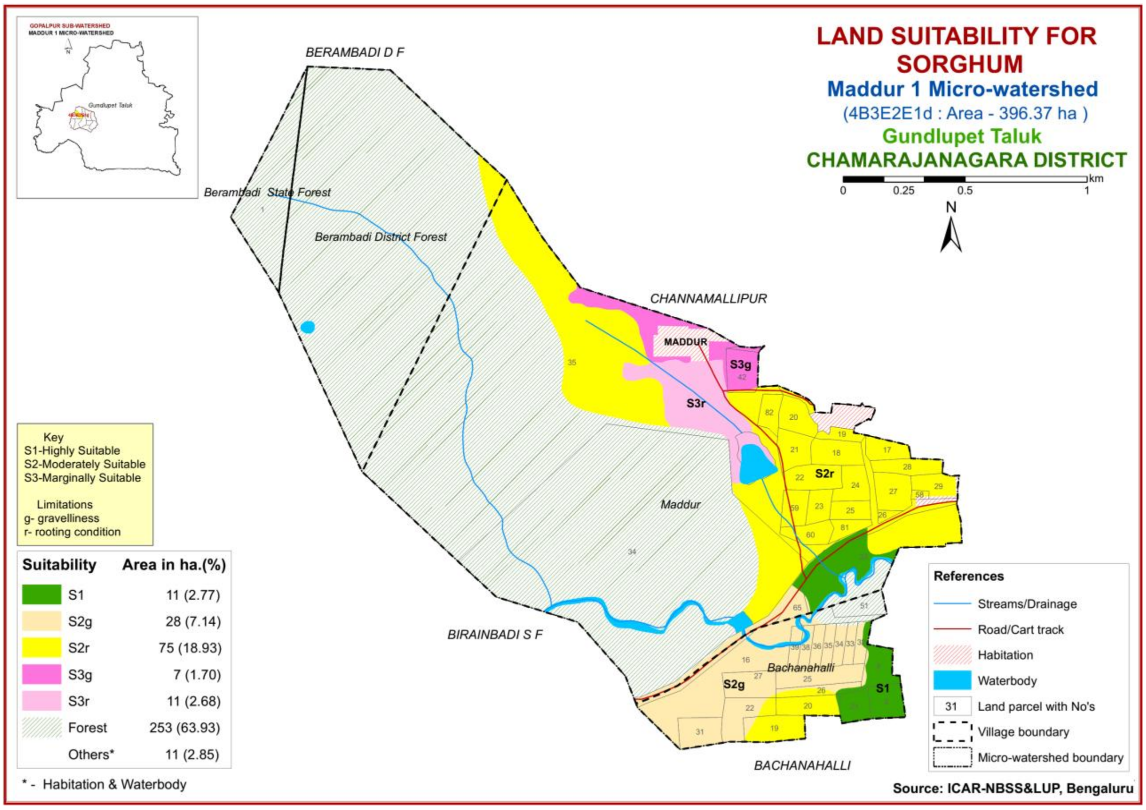


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is one of the most important food crop grown in an area of 13.37 lakh ha in all the district of the state. The crop requirements for growing maize (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing maize was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

An area of about 6 ha (1%) in the microwatershed has soils that are highly suitable (Class S1) for growing maize and are distributed in the southeastern part of the microwatershed. About 103 ha (26%) has soils that are moderately suitable (Class S2) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth and gravelliness. The marginally suitable (Class S3) lands cover an area of about 23 ha (6%) and occur in the northern and eastern part of the microwatershed. They have moderate limitations of texture, rooting depth, drainage and gravelliness.

Table 7.3 Land suitability criteria for Maize

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3.5	5-8	
LGP	Days	>100	100-80	60-80	
Soil drainage	Class	Well drained	Mod. to imperfectly	Poorly/excessively	V. poorly
Soil reaction	pH	5.5-7.5	7.6-8.5	8.6-9.0	
Surface soil texture	Class	l, cl, scl, sil	sl, sicl, sic	c (s-s), ls	s, fragmental
Soil depth	cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-50	>50
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity (ESP)	%	<10	10-15	>15	

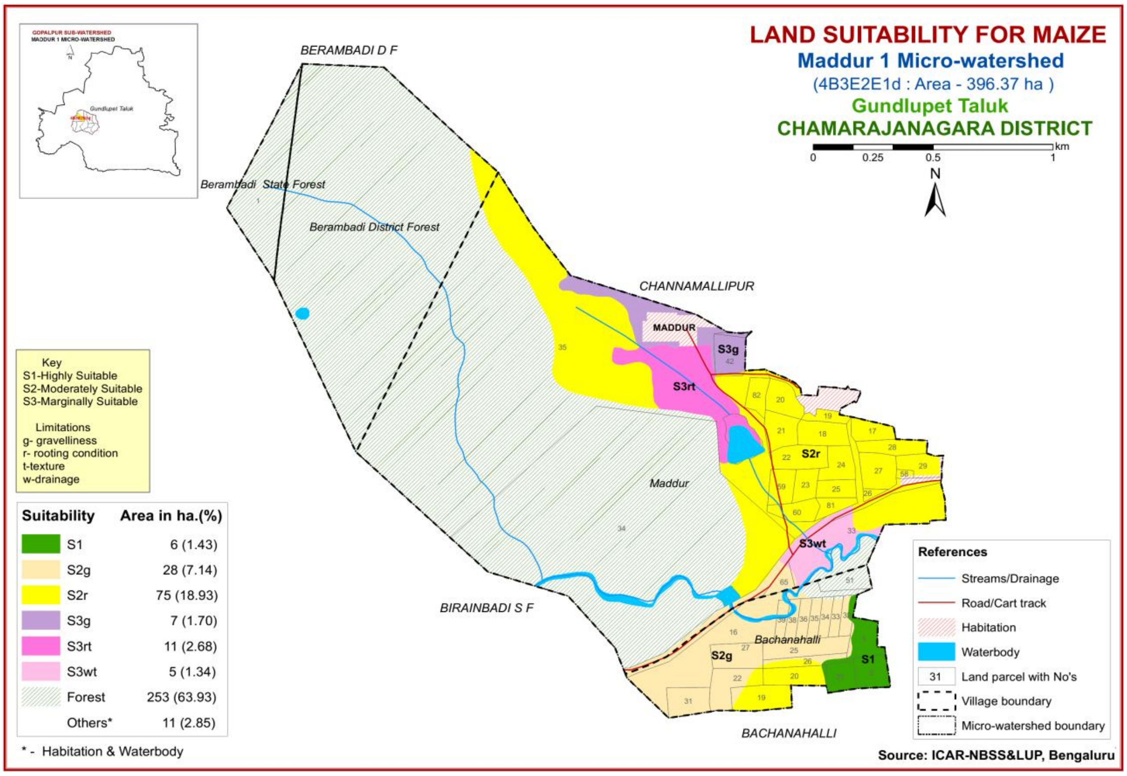


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for Red gram (*Cajanus cajan*)

Red gram is one of the major pulse crop grown in an area of 7.28 lakh ha mainly in northern Karnataka in Bijapur, Kalaburgi, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing red gram (Table 7.4) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing red gram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

The highly suitable (Class S1) lands for growing red gram occupy about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. An area of about 40 ha (10%) is moderately suitable (Class S2) for red gram and are distributed in the northern and southern parts of the microwatershed. They have minor limitations of gravelliness and drainage. Marginally suitable lands (Class S3) for growing red gram occupy maximum area of about 75 ha (19%) and occur in the major part of the microwatershed. They have moderate limitation of root depth. Currently not suitable (Class N1) lands occur in an area of 11 ha (3%) and are distributed in the northern part of the microwatershed with severe limitation of rooting depth and texture.

Table 7.4 Land suitability criteria for Red gram

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>210	180-210	150-180	<150
Soil drainage	Class	Well drained	Mod. to well drained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-7.5	5.0-6.5 7.6-8.0	8.0-9.0	>9.0
Surface soil texture	Class	l, scl, sil, cl, sl	sicl, sic, c(m)	ls	s, fragmental
Soil depth	cm	>100	85-100	40-85	<40
Gravel content	% vol.	<20	20-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

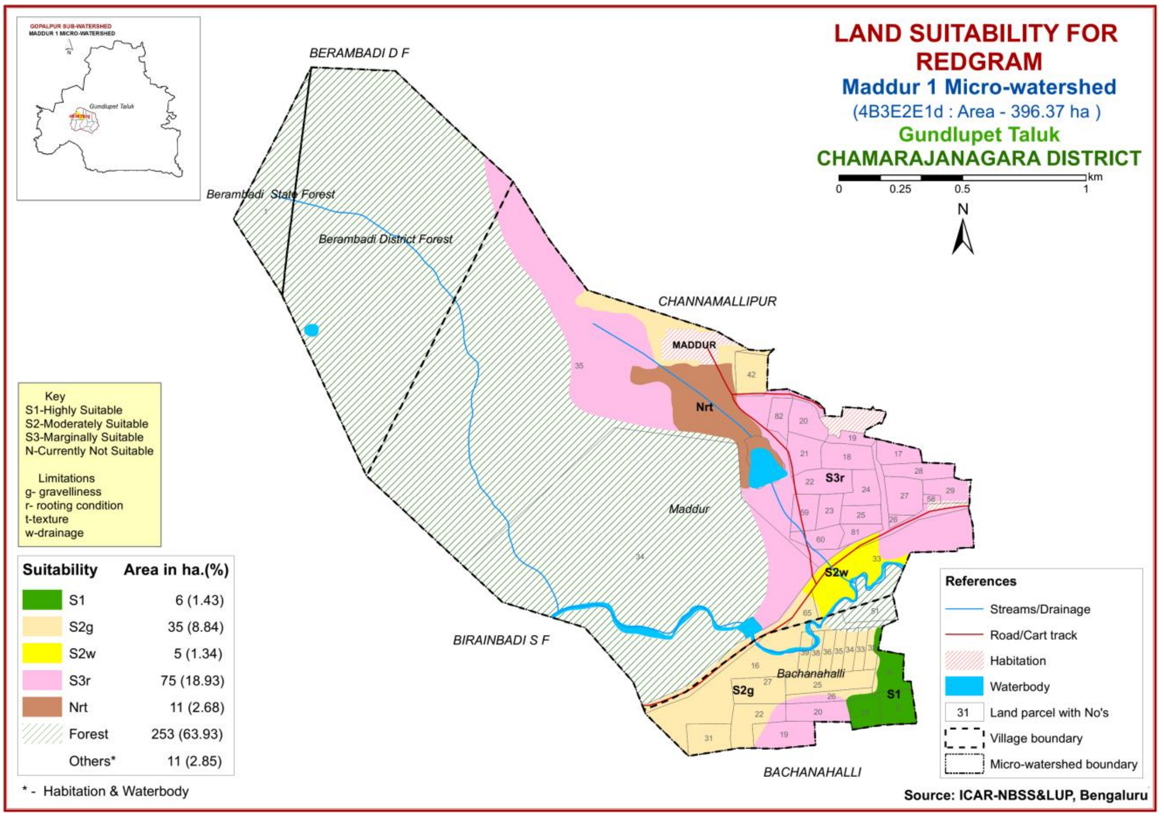


Fig. 7.3 Land Suitability map of Red gram

7.4 Land Suitability for Horse gram (*Macrotyloma uniflorum*)

Horse gram is one of the most important pulse crop grown in an area of 1.8 lakh ha in almost all the districts of the State. The crop requirements for growing horsegram (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing horse gram was generated and the area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

The highly suitable (Class S1) lands for growing horse gram occupy about 6 ha (1%) area and are distributed in the southeastern part of the microwatershed. A major area of about 115 ha (29%) is moderately suitable (Class S2) for horse gram and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth, gravelliness and drainage. An area of 11 ha (3%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with severe limitation of rooting depth.

Table 7.5 Land suitability criteria for Horse gram

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately Suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days				
Soil drainage	Class	Well drained/mod. well drained	imperfectly drained	Poorly drained	Very Poorly drained
Soil reaction	pH	6.0-8.5	8.5-9.0 5.5-5.9	9.1-9.5 5.0-5.4	>9.5
Surface soil texture	Class	l, sl, scl, cl, sc	ls, sic, sicl, c, ls	Heavy clays (>60%)	-
Soil depth	cm	50-75	25-50	<25	-
$CaCO_3$ in root zone	% vol.	<15	15-25	25-30	>30
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	-

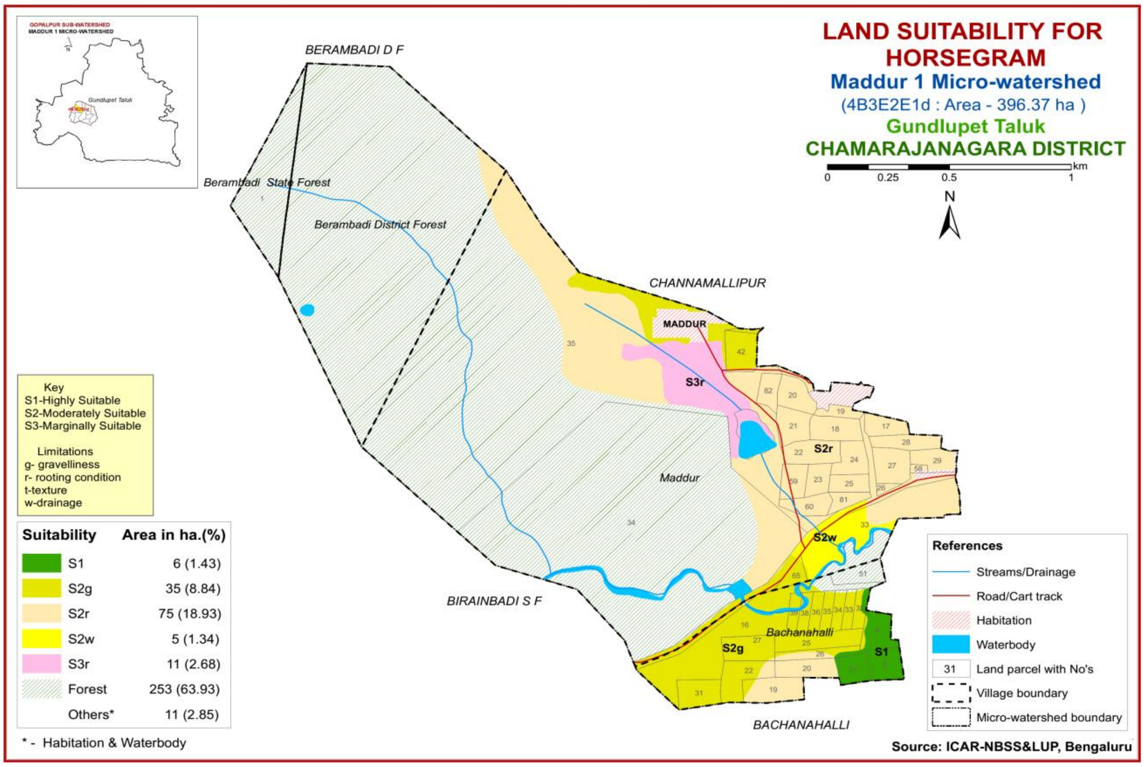


Fig. 7.4 Land Suitability map of Horse gram

7.5 Land Suitability for Field bean (*Dolichos lablab*)

Field Bean is one of the most important pulse crop grown in an area of 0.68 lakh ha in almost all the districts of the State. The crop requirements (Table 7.4) for growing field bean were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing field bean was generated. The area extent and their geographical distribution of different suitability subclasses in different microwatersheds is given in Figure 7.5.

The highly suitable (Class S1) for growing field bean occupy a small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. Maximum area of about 108 ha (27%) is moderately suitable (Class S2) for field bean and are distributed in the major part of the microwatershed. They have minor limitations of gravelliness, rooting depth and drainage. An area of about 18 ha (4%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with moderate limitations of gravelliness and rooting depth.

Table 7.6 Land suitability criteria for Field Bean

Crop requirement		**Rating**			
Soil –site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>120	90-120	70-90	<70
Soil drainage	Class	Well drained/mod. well drained	imperfectly drained	Poorly drained	Very Poorly drained
Soil reaction	pH	6.0-8.5	8.5-9.0 5.5-5.9	9.1-9.5 5.0-5.4	>9.5
Sub Surface soil texture	Class	l, sl, scl, cl, sc	sic, sicl, c	Heavy clays (>60%), ls	s
Soil depth	cm	>75	50-75	25-50	<25
$CaCO_3$ in root zone	% vol.	<15	15-35	35-50	>50
Salinity (EC)	dsm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	15-20	>20

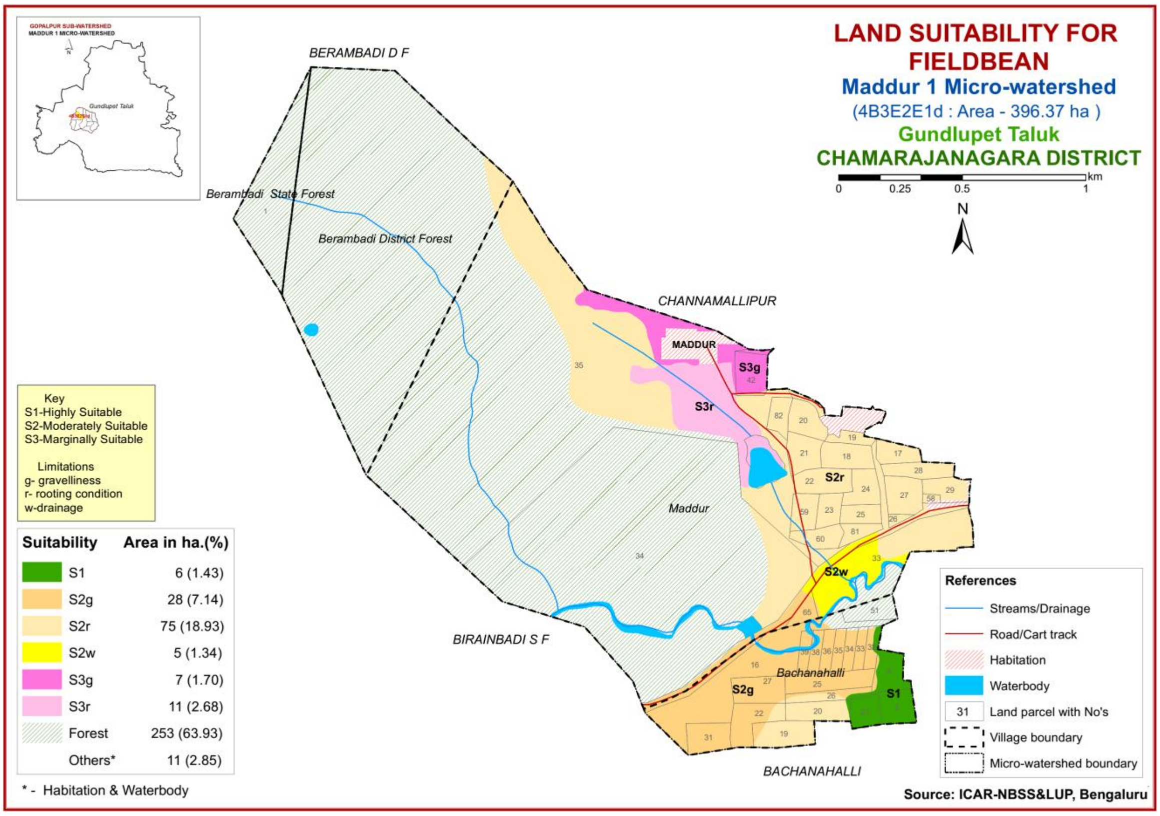


Fig. 7.5 Land Suitability map of Field Bean

7.6 Land Suitability for Groundnut (*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.5 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.7) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing groundnut was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.6.

There are no highly suitable (Class S1) lands available for growing groundnut in the microwatershed. A maximum area of about 116 ha (29%) is moderately suitable (Class S2) for growing groundnut and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth, gravelliness and texture. Marginally suitable lands (class S3) for growing groundnut occupy an area of about 16 ha (4%) and are distributed in southern and eastern parts of the microwatershed. They have moderate limitations of drainage, rooting depth and texture.

Table 7.7 Land suitability criteria for Groundnut

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	100-125	90-105	75-90	
Soil drainage	class	Well drained	mod. well rained	imperfectly drained	Poorly drained
Soil reaction	pH	6.0-8.0	8.1-8.5 5.5-5.9	>8.5 <5.5	
Surface soil texture	Class	l, cl, sil, sc, sicl	sc, sic, c,	s, ls, sl c (>60%)	s, fragmental
Soil depth	cm	>75	50-75	25-50	<25
Gravel content	% vol.	<35	35-50	>50	
$CaCO_3$ in root zone	%	high	medium	low	
Salinity (EC)	dSm^{-1}	<2.0	2.0-4.0	4.0-8.0	
Sodicity (ESP)	%	<5	5-10	>10	

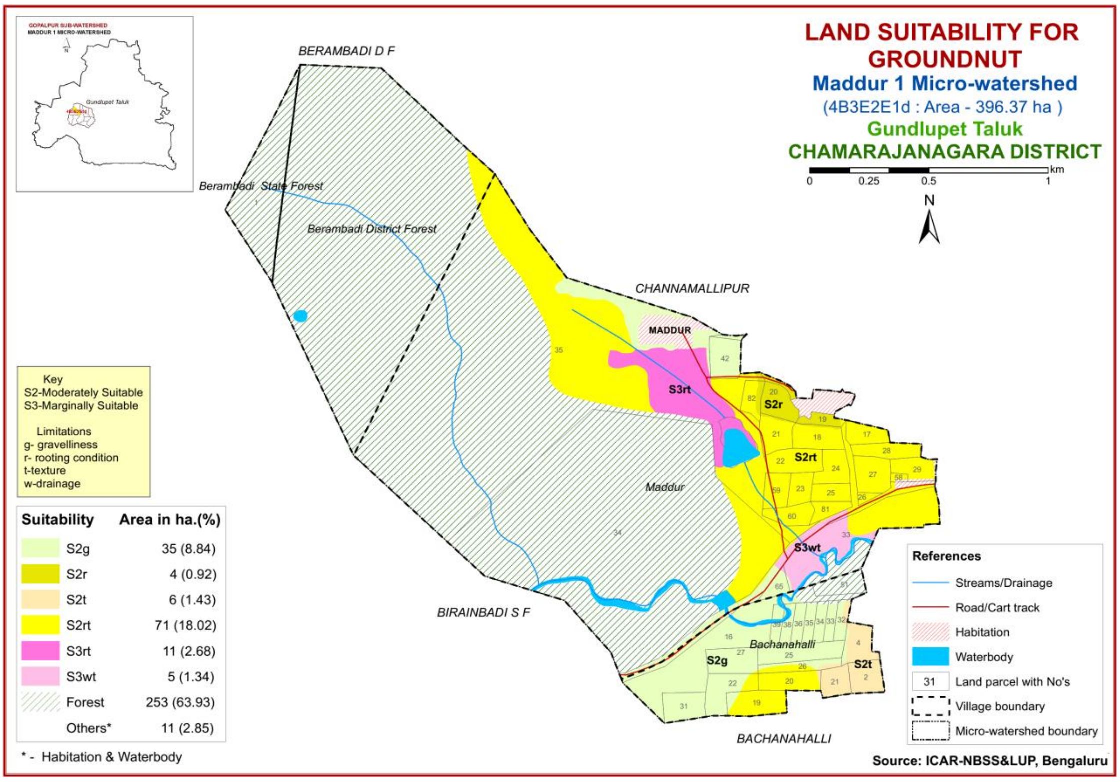


Fig. 7.6 Land Suitability map of Ground nut

7.7 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is one of the most important oilseed crop grown in an area of 4.1 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.8) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

A small area of 6 ha (1%) is highly suitable (Class S1) for growing sunflower and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 5 ha (1%) and are distributed in the eastern part of the microwatershed. They have minor limitation of drainage. The marginally suitable (Class S3) lands cover about 110 ha (28%) and occur in the major part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. Currently not suitable (Class N1) lands cover an area of about 11 ha (3%) and are distributed in the northern part of the microwatershed with severe limitations of rooting depth and texture.

Table 7.8 Land suitability criteria for Sunflower

Crop requirement		**Rating**			
Soil–site characteristics	**unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>90	80-90	70-80	<70
Soil drainage	class	Well drained	Mod. well drained	imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.5 5.5-6.4	8.6-9.0;4.5-5.4	>9.0 <4.5
Surface soil texture	Class	l, cl, sil, sc	scl, sic, c,	c (>60%), sl	ls, s
Soil depth	cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

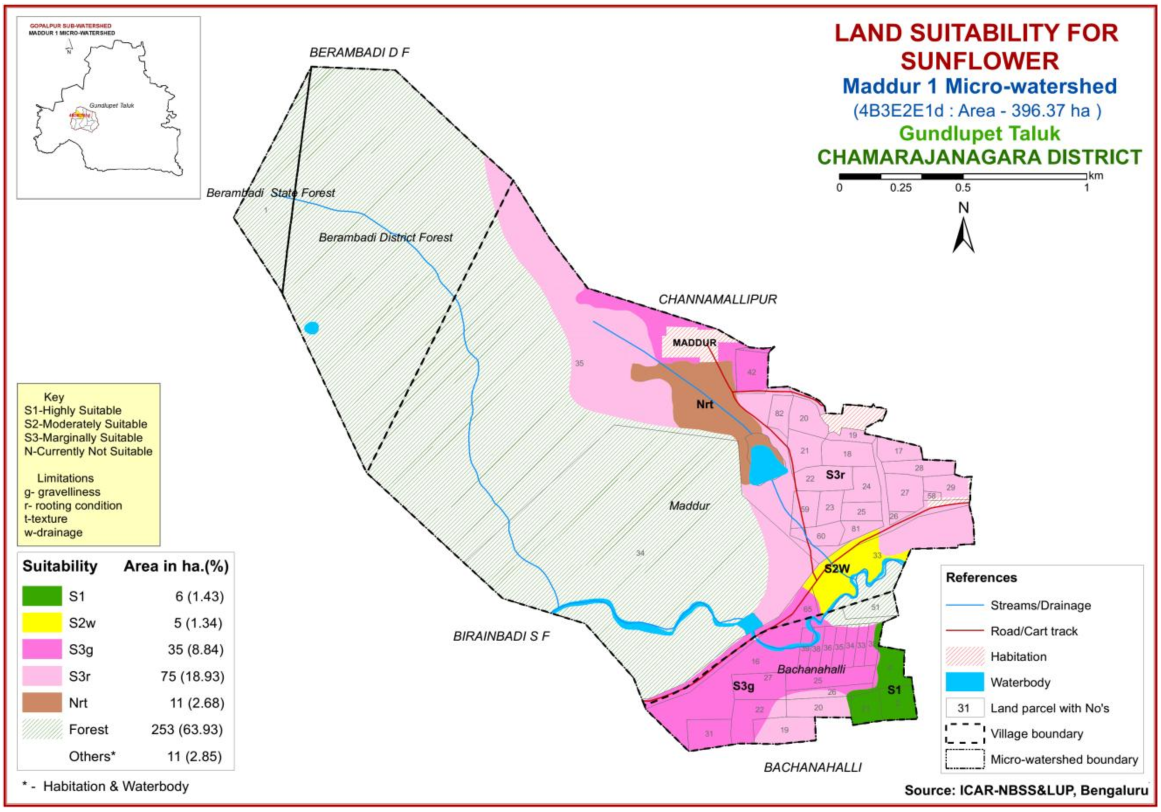


Fig. 7.7 Land Suitability map of Sunflower

7.8 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is one of the most important fibre crop grown in the State in about 6.6 lakh ha area in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.9) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cotton was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

The highly suitable (Class S1) lands for growing cotton is about 11 ha (3%) and are distributed in the eastern and southeastern part of the microwatershed. An area of about 103 ha (26%) has soils that are moderately suitable (Class S2) for growing cotton and are distributed in the major part of the microwatershed with minor limitations of rooting depth and texture. The marginally suitable (Class S3) lands cover an area of about 18 ha (4%) and are distributed in the northern part of the microwatershed with moderate limitations of gravelliness and rooting depth.

Table 7.9 Land suitability criteria for Cotton

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	1-2	2-3	3-5	>5
LGP	Days	180-240	120-180	<120	
Soil drainage	class	Well to moderately well	imperfectly drained	Poor somewhat excessive	Stagnant/ excessive
Soil reaction	pH	6.5-7.5	7.6-8.0	8.1-9.0	>9.0 >6.5
Surface soil texture	Class	sic, c	sicl, cl	si, sil, sc, scl, l	sl, s,ls
Soil depth	cm	100-150	60-100	30-60	<30
Gravel content	% vol.	<5	5-10	10-15	15-35
$CaCO_3$ in root zone	%	<3	3-5	5-10	10-20
Salinity (EC)	dSm^{-1}	2-4	4.0-8.0	8.0-12	>12
Sodicity (ESP)	%	5-10	10-20	20-30	>30

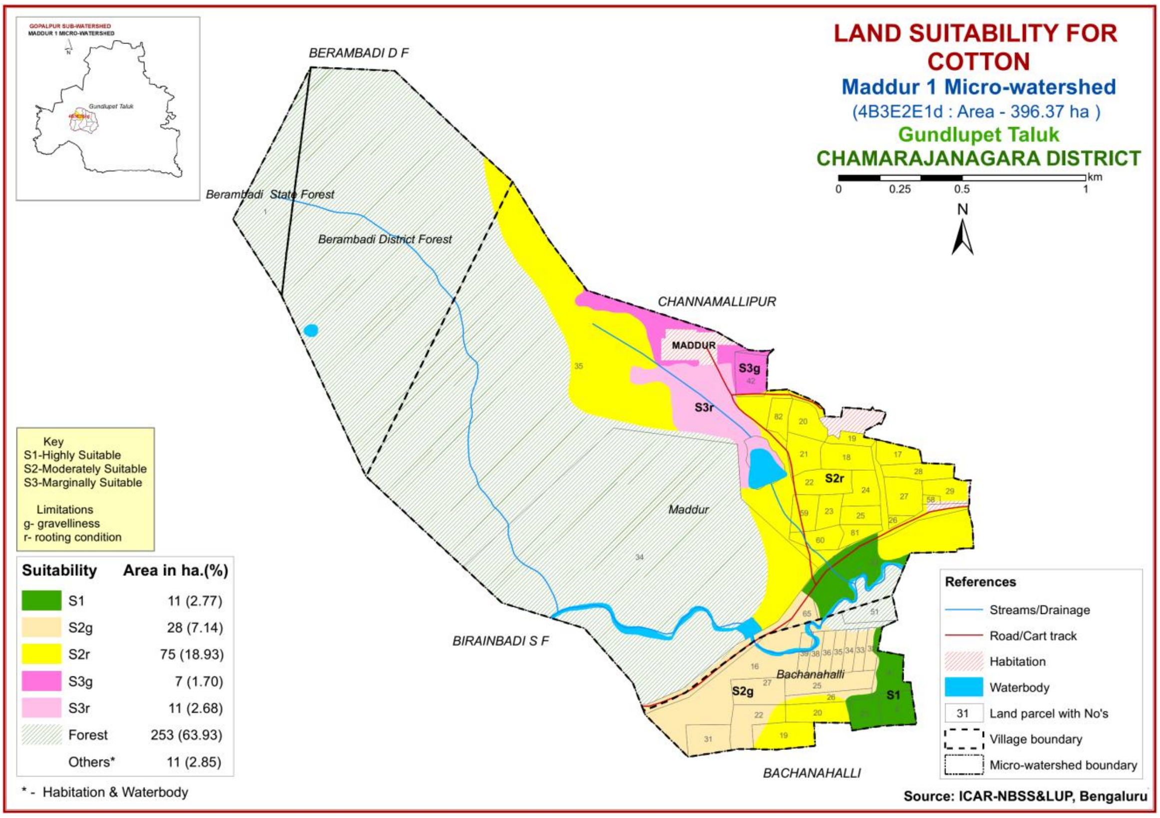


Fig. 7.8 Land Suitability map of Cotton

7.9 Land Suitability for Onion (*Allium cepa*)

Onion is one of the most important vegetable crop grown in an area in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing Onion (Table 7.10) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Onion was generated and the area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.9.

The highly suitable (Class S1) lands for growing onion occur in about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. A maximum area of about 108 ha (27%) has soils that are moderately suitable (Class S2) for growing onion with minor limitations of gravelliness, rooting depth, drainage and texture. They are distributed in the major part of the microwatershed. An area of about 18 ha (4%) are distributed in the northern part of the microwatershed with severe limitations of gravelliness, rooting depth and texture.

Table 7.10 Land suitability criteria for Onion

Crop requirement		**Rating**			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Mean temperature in growing season	^{0}C	20-30	30-35	35-40	>40
Slope	%	<3	3-5	5-10	>10
Soil drainage	class	Well drained	Moderately /imperfectly	Poor drained	Very poorly drained
Soil reaction	pH	6.5-7.3	7.3-7.8 5.0-5.4	7.8-8.4 <5.0	>8.4
Surface soil texture	Class	scl, sil, sl	sc, sicl, c (red soil)	sc, c (black soil)	ls
Soil depth	cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	60-80
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	>15

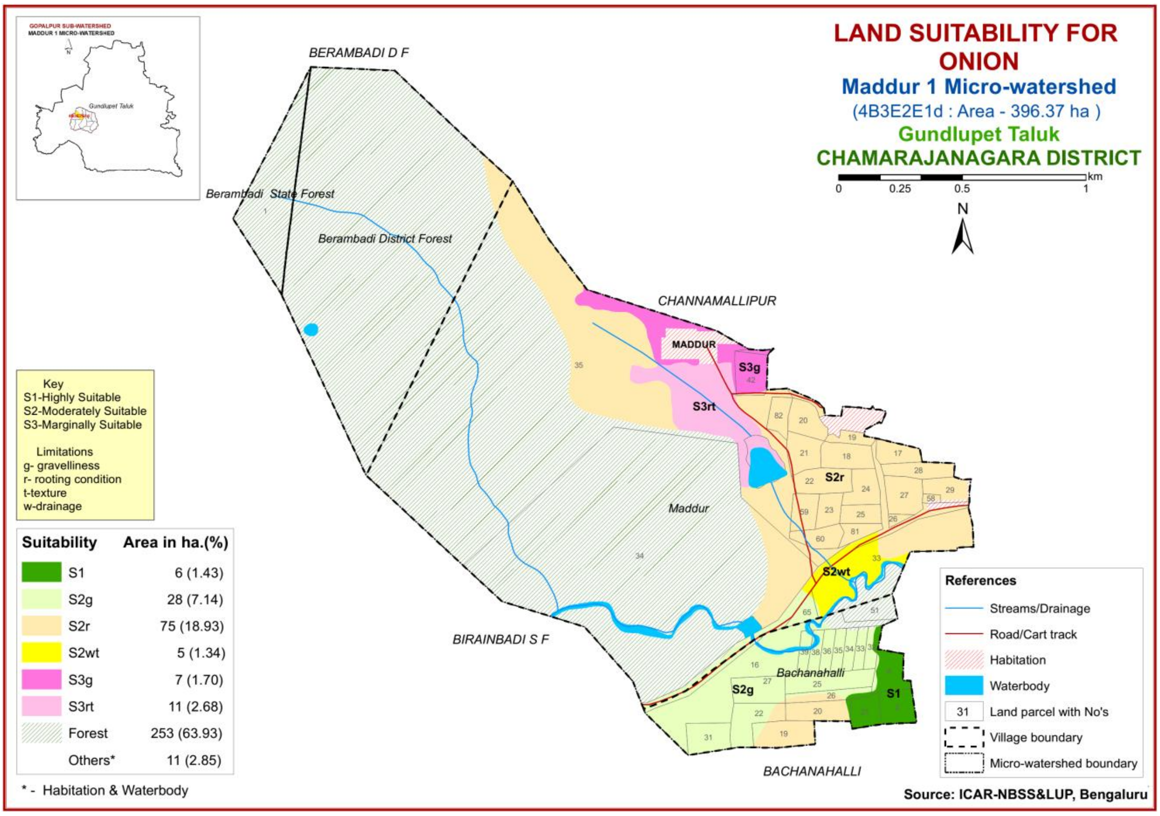


Fig. 7.9 Land Suitability map of Onion

7.10 Land Suitability for Potato (*Solanum tuberosum*)

Potato is one of the most important vegetable crop grown in Raichur, Dharwad, Belgaum, Chikkaballapur, Kolar, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing Potato (Table 7.11) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Potato was generated and the area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.10.

The highly suitable (Class S1) lands for growing potato occupy small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. An area of about 103 ha (26%) is moderately suitable (Class S2) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth and gravelliness. Marginally suitable lands (Class S3) for growing potato occupy an area of about 23 ha (6%) and occur in the northern and eastern part of the microwatershed. They have moderate limitations of texture, rooting depth and drainage.

Table 7.11 Land suitability criteria for Potato

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	Hills	%	<5	5-10	10-15	>15
	Plains	%	<3	3-5	5-8	>8
Mean temperature in growing season		^{0}c	16-25	26-30 13-15	31-32 10-12	>32 <10
Soil drainage		Class	Well drained	Moderately /imperfectly	Poor drained	Very poorly drained
Soil reaction		pH	5.5-6.5	6.6-8.2 5.0-5.4	>8.2 <5.0	-
Surface soil texture		Class	scl, sil	s, sil	s	
Soil depth		cm	75-100	50-75	25-50	<25
Stoniness		%	0-10	10-15	15-35	>35
Salinity (ECe)		dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	>4.0
Sodicity (ESP)		%	<10	10-15	>15	-

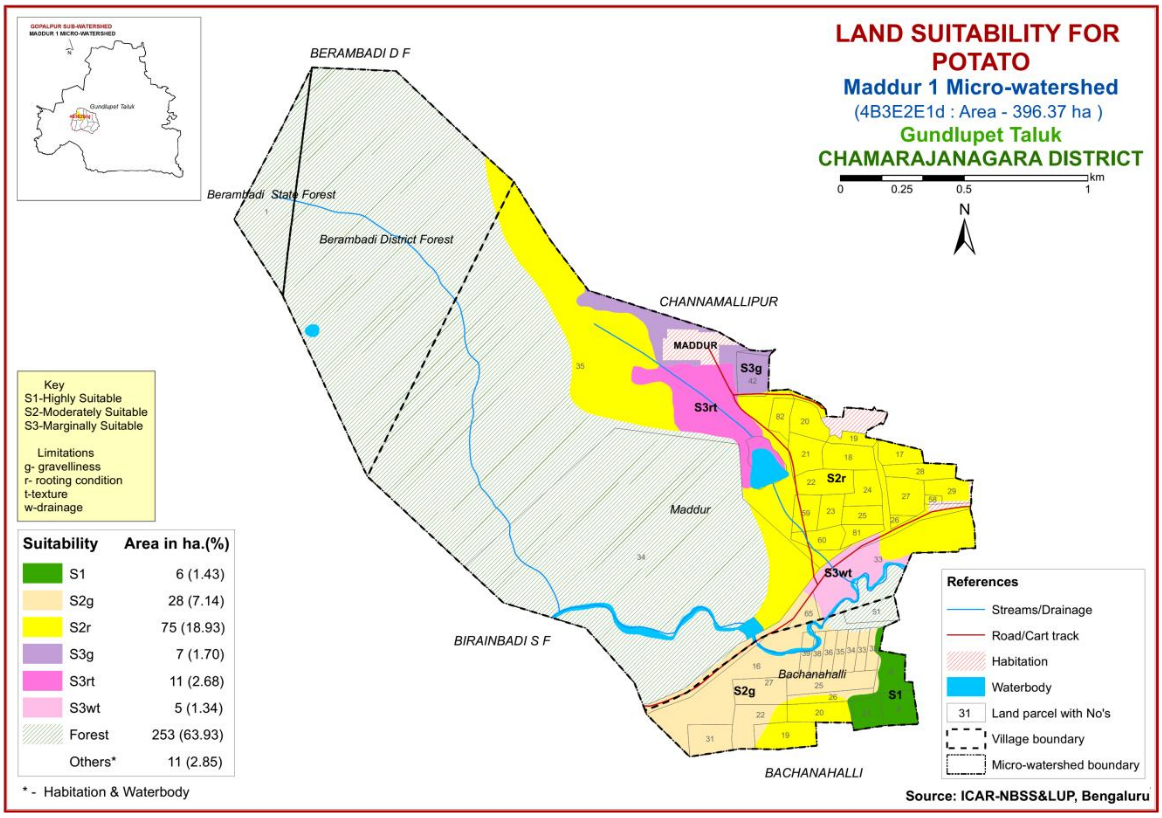


Fig. 7.10 Land Suitability map of Potato

7.11 Land Suitability for Beans (*Phaseolus vulgaris*)

French Beans are the most important vegetable crop grown in almost all the districts of Karnataka. The crop requirements for growing beans were matched with the soil–site characteristics and a land suitability map for growing beans was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.11.

The highly suitable (Class S1) lands for growing French beans cover a small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in a major area of about 108 ha (27%). They have minor limitations of gravelliness, texture, rooting depth and drainage. An area of about 17 ha (4%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with severe limitations of gravelliness, rooting depth and texture.

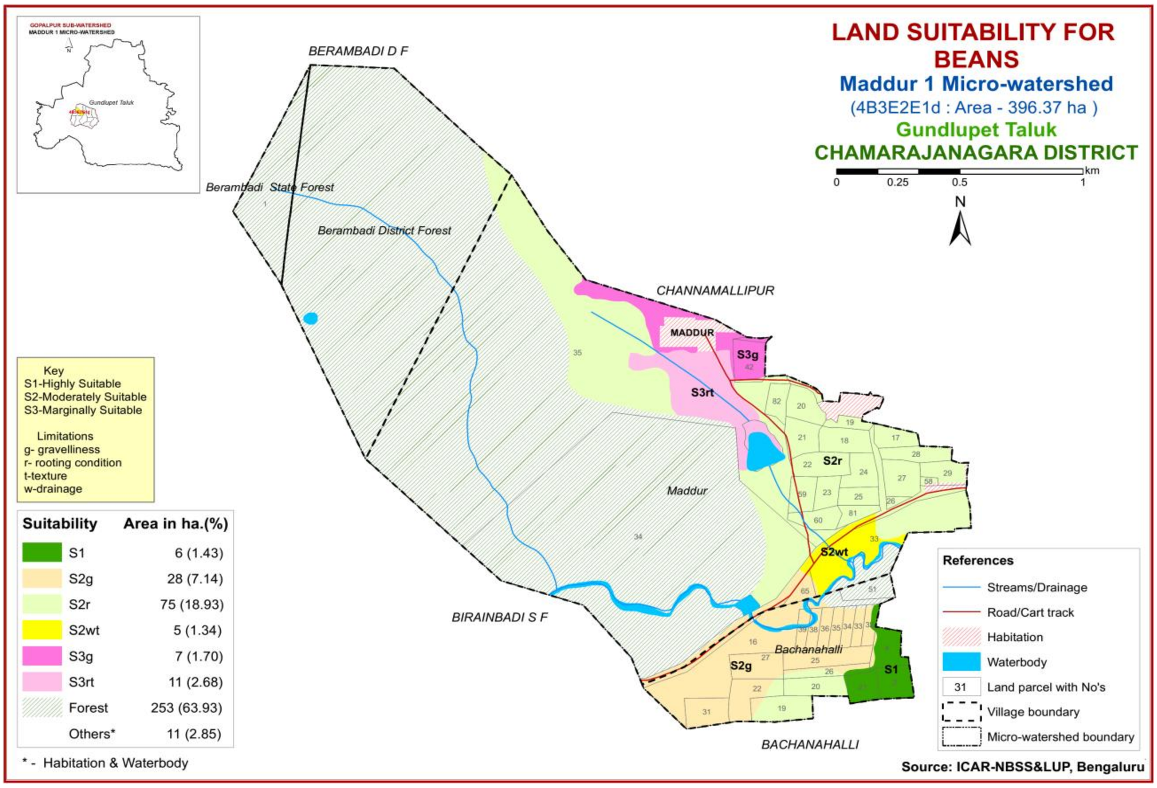


Fig. 7.11 Land Suitability map of Beans

7.12 Land Suitability for Beetroot (*Beta vulgaris*)

Beetroot is one of the most important vegetable crop grown in almost all the districts of Karnataka. The crop requirement for growing beetroot were matched with the soil site characteristics and a land suitability map for growing beetroot was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.12.

The highly suitable (Class S1) lands for growing beetroot cover a small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 103 ha (26%) and are distributed in the major part of the microwatershed. They have minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover an area of about 23 ha (6%) and occur in the northern part of the microwatershed. They have moderate limitations of texture, gravelliness, rooting depth and drainage.

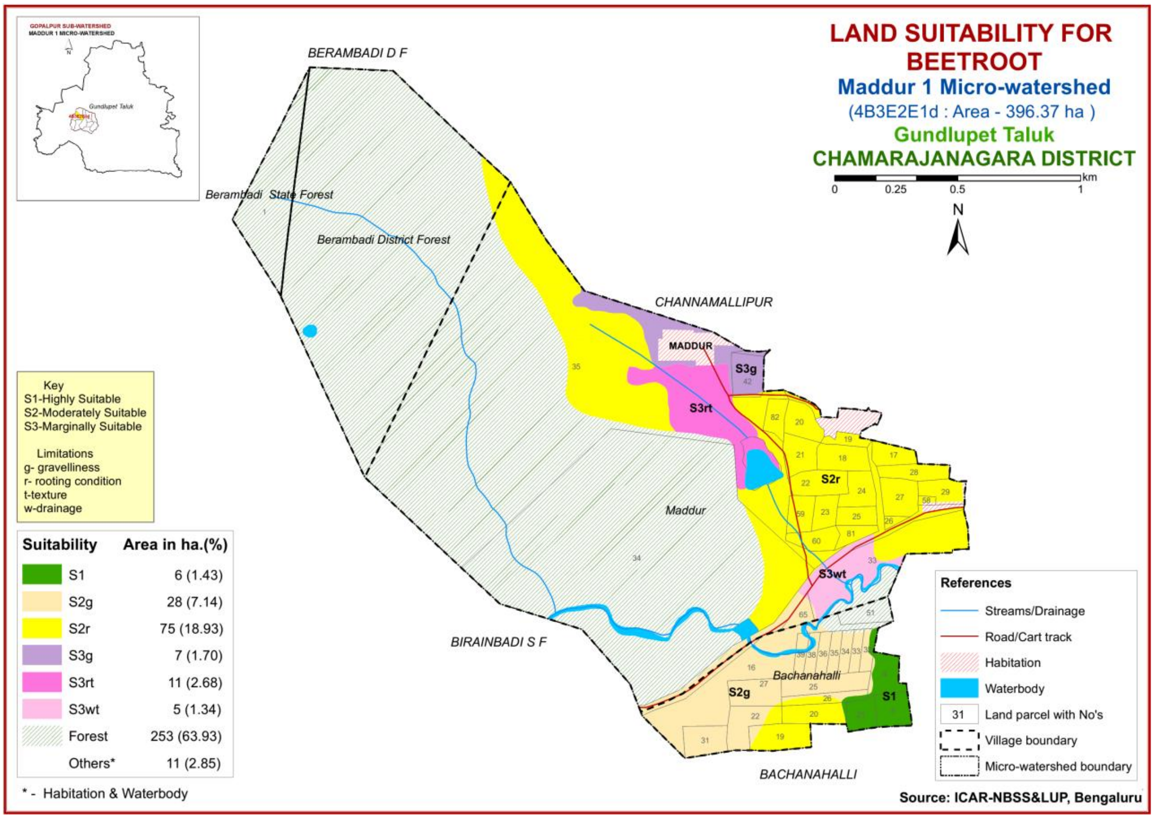


Fig. 7.12 Land Suitability map of Beetroot

7.13 Land suitability for Mango (*Mangifera indica*)

Mango is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements (Table 7.13) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.13.

The highly suitable (Class S1) lands for growing mango cover a small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. An area of 28 ha (7%) is moderately suitable (Class S2) and are distributed in the southern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 7 ha (2%) and occur in the northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. Major area of about 91 ha (23%) is currently not suitable (Class N1) for growing mango and are distributed in all parts of the microwatershed.

Table 7.12 Land suitability criteria for Mango

Crop requirement			Rating			
Soil-site characteristics		Unit	Highly suitable(S1)	Moderately Suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temp. in growing season	^0C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^0C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	class	Well drained	Mod. To imp.drained	Poor drained	V.poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	sc, l, sil, cl	sl, sc, sic, l, c	c (<60%)	c(>60%),
	pH	1:2.5	5.5-7.5	7.6-8.55.0-5.4	8.6-9.04.0-4.9	>9.0<4.0
	OC	%	High	medium	low	
	$CaCO_3$ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	%vol	Non gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS/m	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

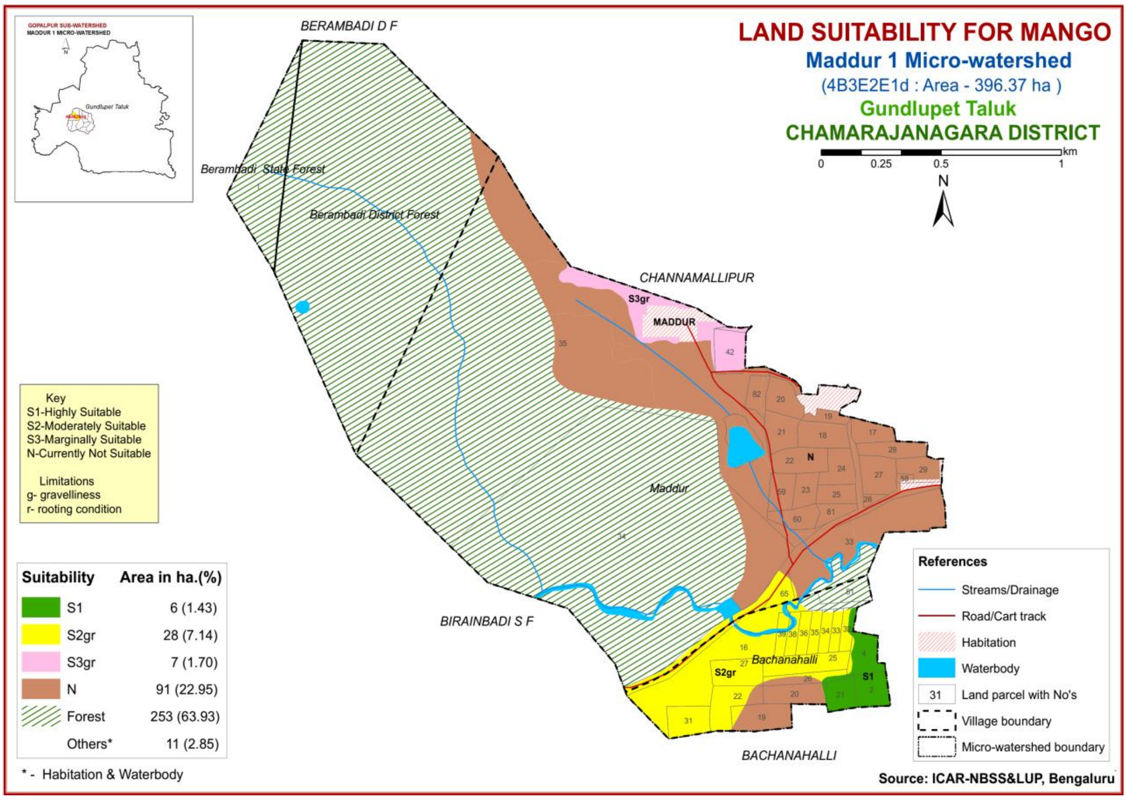


Fig. 7.13 Land Suitability map of Mango

7.14 Land suitability for Sapota (*Manilkara zapota*)

Sapota is one of the most important fruit crop grown in an area of 3.11 lakh ha in almost all the districts of the State. The crop requirements (Table 7.14) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.14.

The highly suitable (class S1) lands for growing sapota cover about 6 ha (1%) area and are distributed in the southeastern part of the microwatershed. The moderately suitable (class S2) lands are found to occur in an area of about 35 ha (9%) and are distributed in the northern and southern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. The marginally suitable (class S3) lands cover a major area of about 80 ha (20%) and are distributed in the major part of the microwatershed. They have moderate limitations of texture, drainage and rooting depth. An area of 11 ha (3%) is currently not suitable (Class N1) and are distributed in the northern part of the microwatershed.

Table 7.13 Land suitability criteria for Sapota

Crop requirement			**Rating**			
Soil –site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable(N)**
Climate	Temp.in growing season	^{0}C	28-32	33-36 24-27	37-42 20-23	>42 <18
Soil moisture	Growing period	Days	>150	120-150	90-120	<120
Soil aeration	Soil drainage	Class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient availabiliy	Texture	Class	scl, l, cl, sil	sl, sicl, sc	c (<60%)	ls, s, c (>60%)
	pH	1:2.5	6.0-7.5	7.6-8.0 5.0-5.9	8.1-9.0 4.5-4.9	>9.0 <4.5
	$CaCO_3$ in root zone	%	Non calcareous	<10	10-15	>15
Rooting conditions	Soil depth	cm	>150	75-150	50-75	<50
	Gravel content	% vol.	Non gravelly	<15	15-35	<35
Soil toxicity	Salinity	dS/m	Non saline	Up to 1.0	1.0-2.0	2.0-4.0
	Sodicity	%	Non sodic	10-15	15-25	>25
Erosion	Slope	%	<3	3-5	5-10	>10

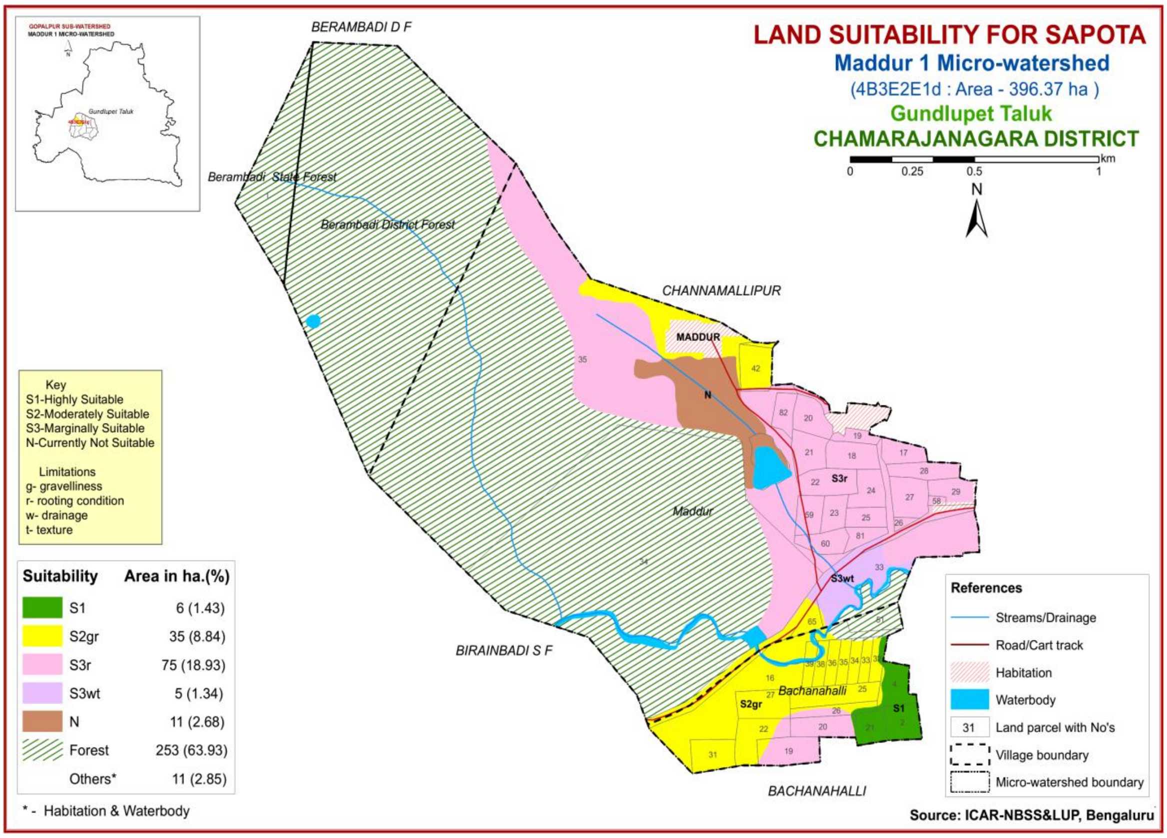


Fig. 7.14 Land Suitability map of Sapota

7.15 Land suitability for Guava (*Psidium guajava*)

Guava is one of the most important fruit crop grown in an area of 0.64 lakh ha in almost all the districts of the State. The crop requirements (Table 7.15) for growing guava were matched with the soil-site characteristics (7.1) and a land suitability map for growing guava was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.15.

The highly suitable (Class S1) lands for growing guava cover about 34 ha (9%) area and are distributed in the southern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 7 ha (2%) and are distributed in the northern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. The marginally suitable (Class S3) lands cover a major area of about 75 ha (19%) and are distributed in the major part of the microwatershed. They have moderate limitation of rooting depth. About 16 ha (4%) area is currently not suitable (Class N1) for growing guava and are distributed in the eastern and northern part of the microwatershed.

Table 7.14 Land suitability criteria for Guava

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable(N)
Climate	Temperature in growing season	^{0}C	28-32	33-36 24-27	37-42 20-23	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly	poor	Very poor
Nutrient availability	Texture	Class	scl, l, cl, sil	sl,sicl,sic.,sc,c	c (<60%)	c (>60%)
	pH	1:2.5	6.0-7.5	7.6-8.0:5.0-5.9	8.1-8.5:4.5-4.9	>8.5:<4.5
	$CaCO_3$ in root zone	%	Non calcareous	<10	10-15	>15
Rooting conditions	Soil depth	cm	>100	75-100	50-75	<50
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	dS/m	<2.0	2.0-4.0	4.0-6.0	
	Sodicity	%	Non sodic	10-15	15-25	>25
Erosion	Slope	%	<3	3-5	5-10	>10

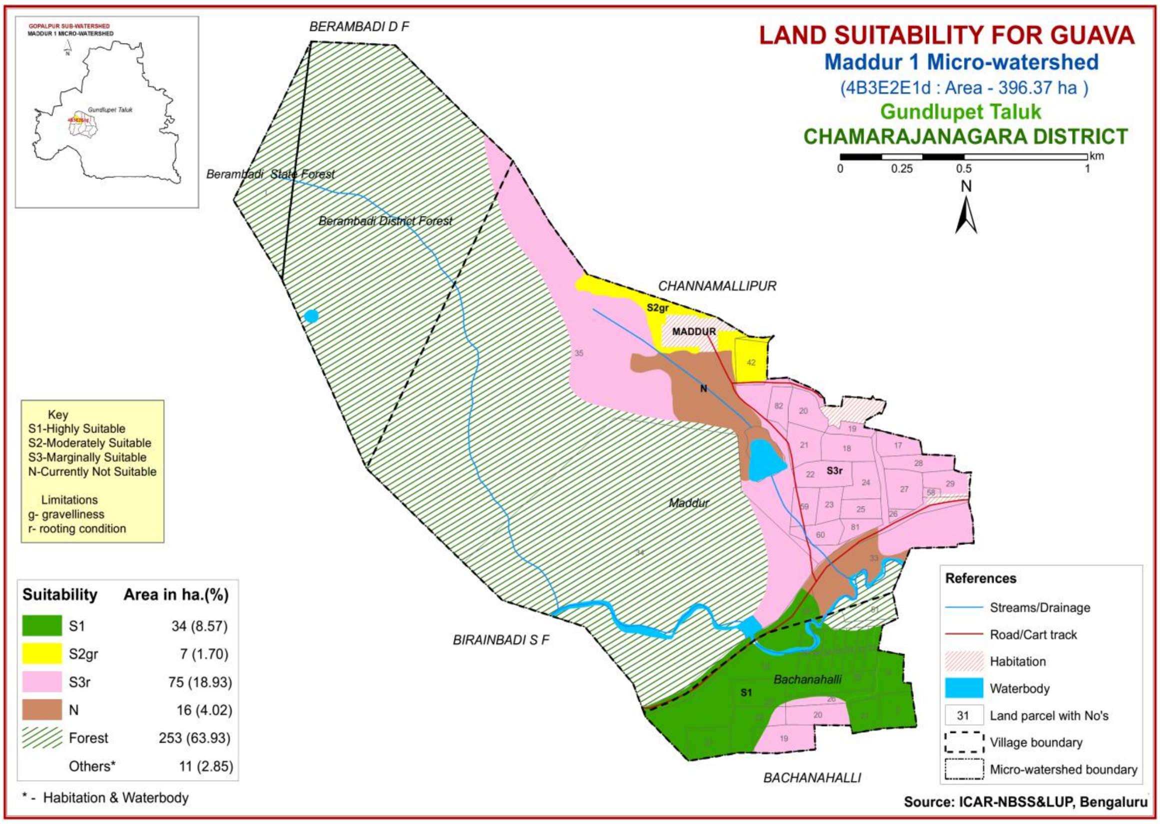


Fig. 7.15 Land Suitability map of Guava

7.16 Land Suitability for Banana (*Musa paradisiaca*)

Banana is one of the major fruit crop grown in an area of 1.02 lakh ha in Karnataka State. The crop requirements for growing banana (Table 7.16) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing banana was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.16.

The highly suitable (Class S1) lands for growing banana cover about 6 ha (1%) area and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 33 ha (8%) and are distributed in the southern part of the microwatershed. They have minor limitations of gravelliness, rooting depth and drainage. The marginally suitable (Class S3) lands cover an area of about 80 ha (21%) and are distributed in the major part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. Currently not suitable (Class N1) lands cover an area of 11 ha (3%) and are distributed in the northern part of the microwatershed with severe limitations of rooting depth and texture.

Table 7.15 Land suitability criteria for Banana

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temperature in growing season	^{0}C	26-33	34-36 24-25	37-38	>38
Soil aeration	Soil drainage	Class	Well drained	Moderately to imperfectly drained	Poorly drained	Very poorly drained
Nutrient availability	Texture	Class	l,cl, scl,sil	sicl, sc, c(<45%)	c (>45%), sic, sl	ls, s
	pH	1:2.5	6.5-7.0	7.1-8.5 5.5-6.4	>8.5 <5.5	
Rooting conditions	Soil depth	cm	>125	76-125	50-75	<50
	Stoniness	%	<10	10-15	15-35	>35
Soil toxicity	Salinity	dS/m	<1.0	1-2	>2	
	Sodicity	%	<5	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-15	>15

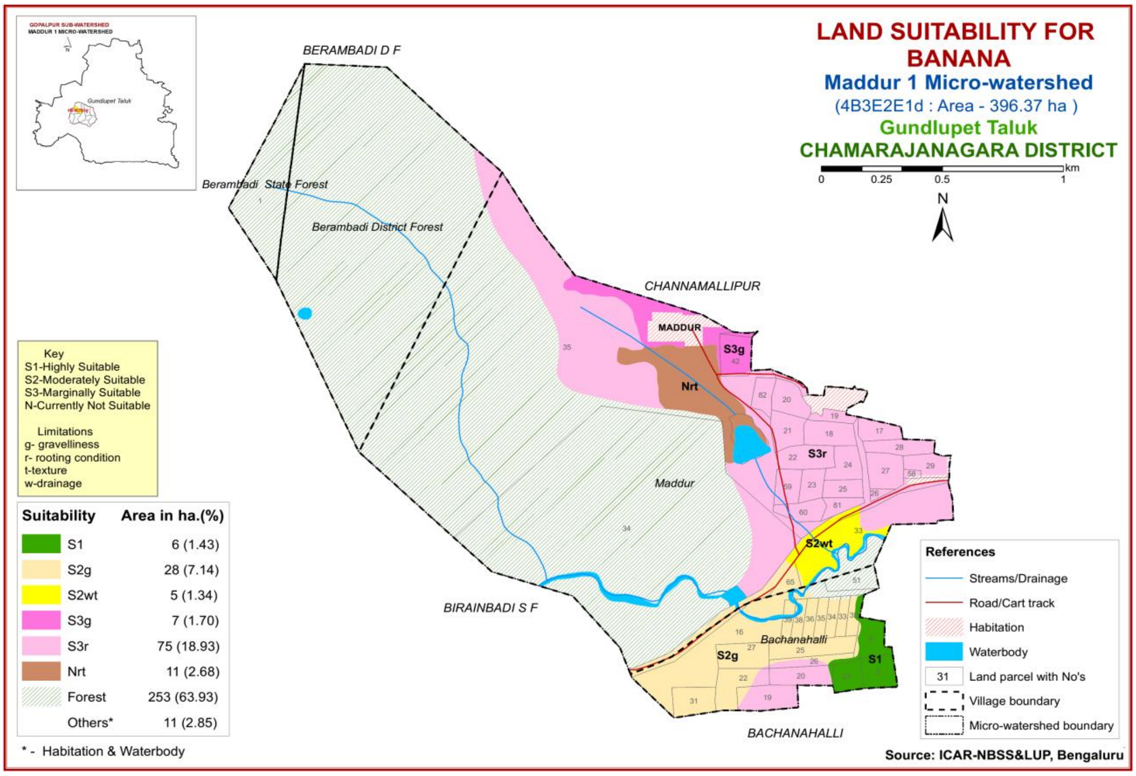


Fig. 7.16 Land Suitability map of Banana

7.17 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing jackfruit were matched with the soil-site characteristics and a land suitability map for growing jackfruit was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.17.

The highly suitable (Class S1) lands for growing jackfruit cover about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. An area of 28 ha (7%) and are distributed in the southern part of the microwatershed with minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover a maximum area of about 80 ha (21%) and are distributed in the major part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. About 16 ha (4%) is currently not suitable (Class N1) for growing jackfruit and are distributed in the northern and eastern part of the microwatershed.

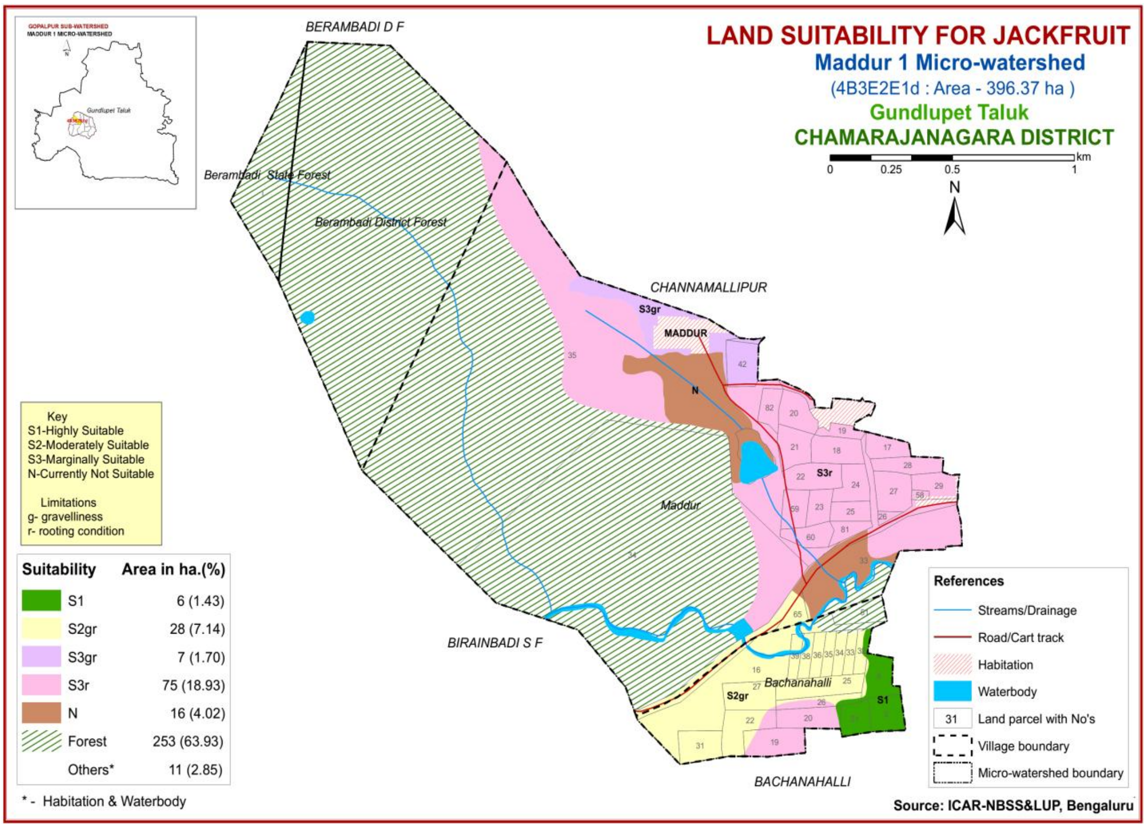


Fig. 7.17 Land Suitability map of Jackfruit

7.18 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is one of the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing jamun were matched with the soil-site characteristics and a land suitability map for growing jamun was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

The highly suitable (Class S1) lands for growing jamun cover about 11 ha (3%) and are distributed in the southeastern and southern part of the microwatershed. An area of 28 ha (7%) is moderately suitable (Class S2) and are distributed in the southern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover a major area of about 80 ha (21%) and are distributed in the major part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 11 ha (3%) is currently not suitable (Class N1) and are distributed in the northern part of the microwatershed.

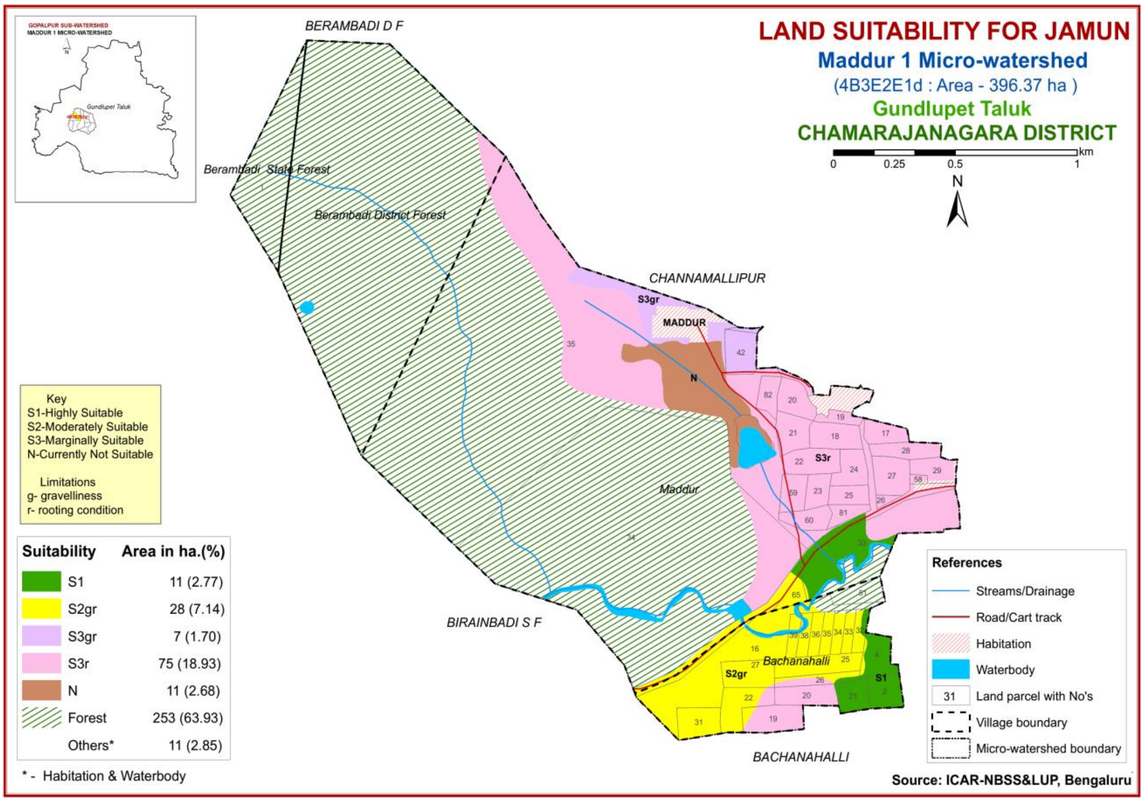


Fig. 7.18 Land Suitability map of Jamun

7.19 Land Suitability for Musambi (*Citrus limetta*)

Musambi is one of the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

The highly suitable (Class S1) lands for growing Musambi cover about 11 ha (3%) area and are distributed in the southern and southeastern part of the microwatershed. An area of 28 ha (7%) is moderately suitable (Class S2) and are distributed in the southern part of the microwatershed with minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover a major area of about 80 ha (21%) and are distributed in the major part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 11 ha (3%) is currently not suitable (Class N1) and are distributed in the northern part of the microwaterhsed.

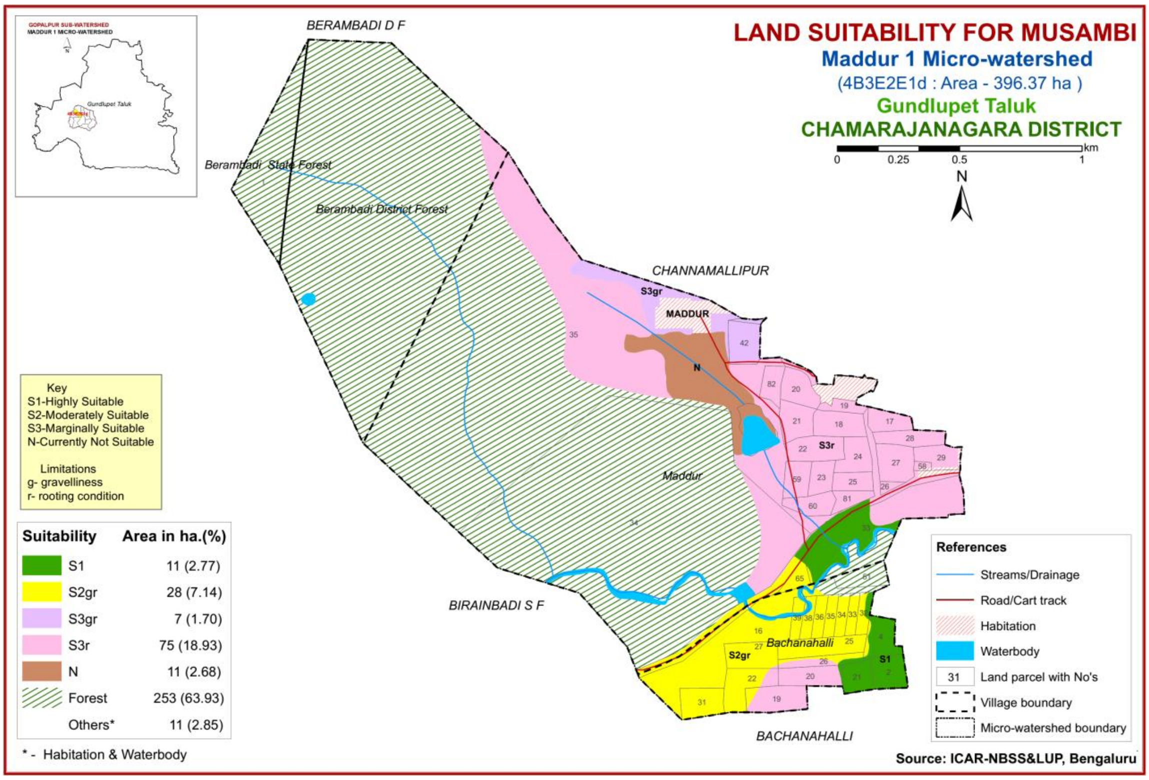


Fig. 7.19 Land Suitability map of Musambi

7.20 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 0.11 lakh ha in almost all the districts of the state. The crop requirements for growing lime (Table 7.17) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.20.

The highly suitable (Class S1) lands for growing lime cover about 11 ha (3%) area and are distributed in the southeastern and southern part of the microwatershed. An area of 28 ha (7%) is moderately suitable (Class S2) and are distributed in the southern part of the microwatershed with minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover a major area of about 80 ha (21%) and are distributed in the southern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 11 ha (3%) is currently not suitable (Class N1) and are distributed in the northern part of the microwatershed.

Table 7.16 Land suitability criteria for lime

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately Suitable (S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temp. in growing season	^{0}C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	scl, l, sicl, cl, s	sc, sc, c	c (>70%)	s, ls
	pH	1:2.5	6.0-7.5	5.5-6.4 7.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

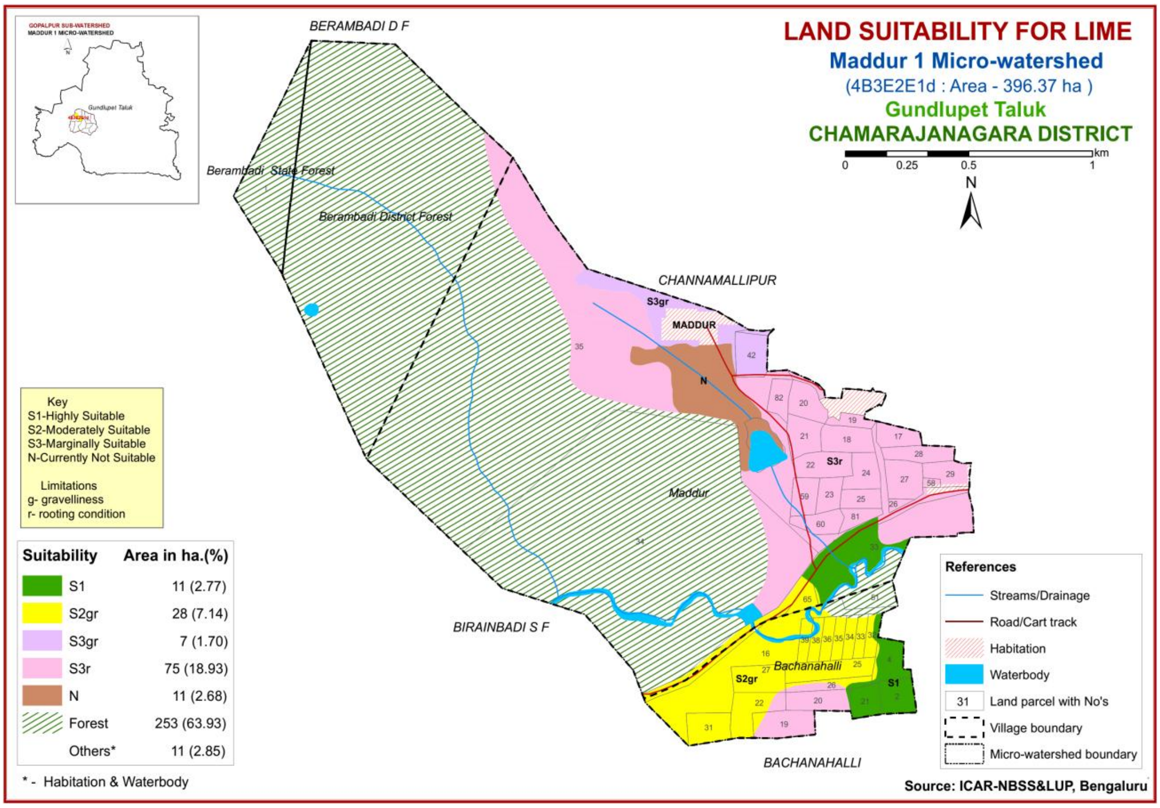


Fig. 7.20 Land Suitability map of Lime

7.21 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important plantation crop grown in an area of 1.24 lakh ha in almost all the districts. The crop requirements for growing Cashew were matched with the soil-site characteristics and a land suitability map for growing Cashew was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.21.

The highly suitable (Class S1) lands for growing cashew cover about 6 ha (1%) area and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 35 ha (9%) and are distributed in the northern and southern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. The marginally suitable (Class S3) lands cover an area of about 75 ha (19%) and are distributed in the major part of the microwatershed. They have moderate limitation of rooting depth. About 16 ha (4%) is currently not suitable (Class N1) for growing cashew and are distributed in the northern and eastern part of the microwatershed.

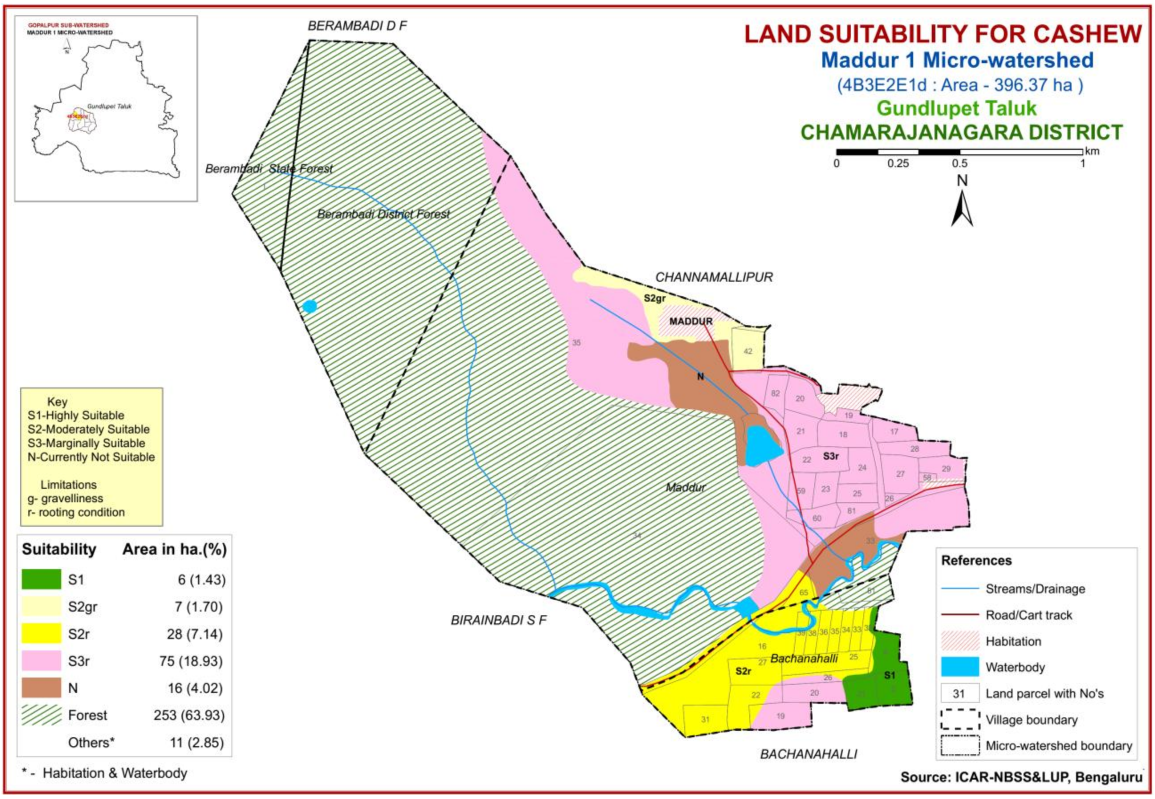


Fig. 7.21 Land Suitability map of Cashew

7.22 Land Suitability for Custard Apple (*Annona reticulata*)

Custard apple is one of the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing custard apple were matched with the soil-site characteristics and a land suitability map for growing custard apple was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.21.

The highly suitable (Class S1) lands for growing custard apple cover about 23 ha (10%) area and are distributed in the southern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 82 ha (21%) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth and gravelliness. An area of 11 ha (3%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with moderate limitation of rooting depth.

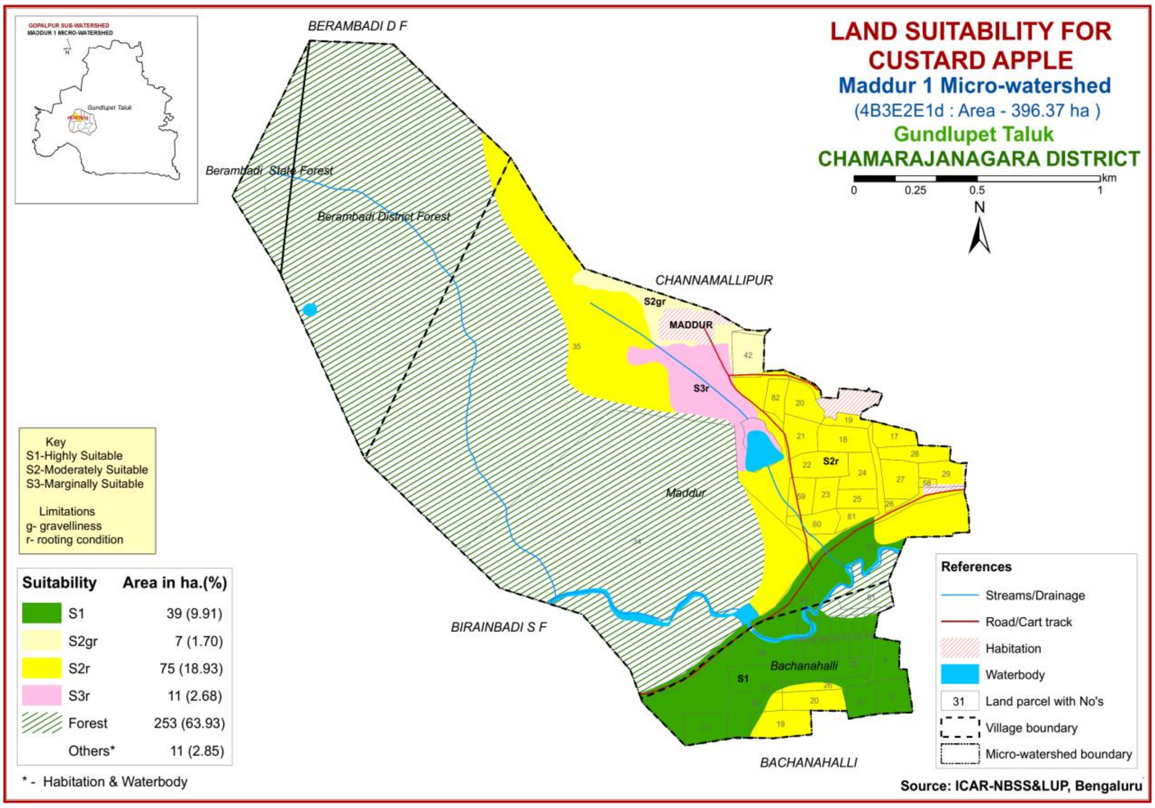


Fig. 7.22 Land Suitability map of Custard Apple

7.23 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the most important medicinal fruit crop grown in almost all the districts of the state. The crop requirements for growing amla were matched with the soil-site characteristics and a land suitability map for growing amla was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.23.

The highly suitable (Class S1) lands for growing amla cover about 39 ha (10%) area and are distributed in the southern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 80 ha (21%) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth and gravelliness. An area of 11 ha (3%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with moderate limitation of rooting depth.

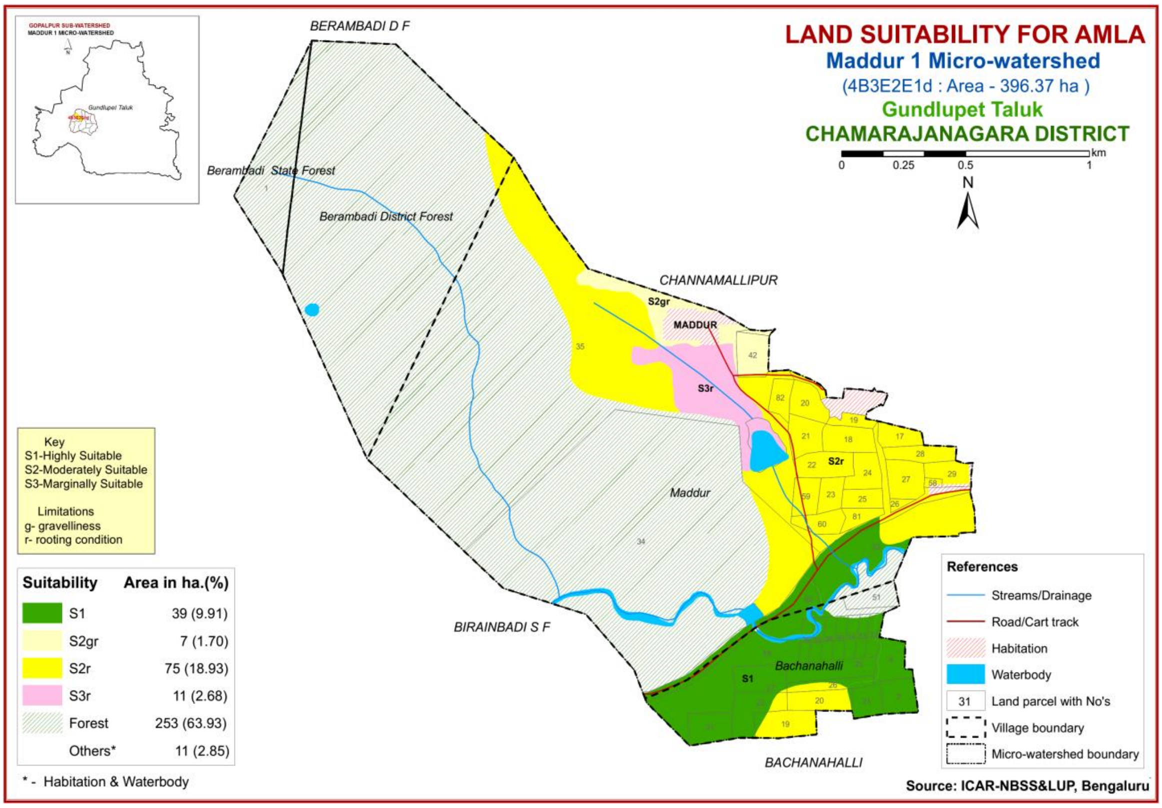


Fig. 7.23 Land Suitability map of Amla

7.24 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is one of the most important spice crop raised in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.24.

The highly suitable (Class S1) lands for growing tamarind cover about 11 ha (3%) area and are distributed in the southeastern part of the microwatershed. An area of 28 ha (7%) is moderately suitable (Class S2) and are distributed in the southern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover a maximum area of about 78 ha (20%) and are distributed in the major part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of 14 ha (4%) is currently not suitable (Class N1) and are distributed in the northern part of the microwatershed.

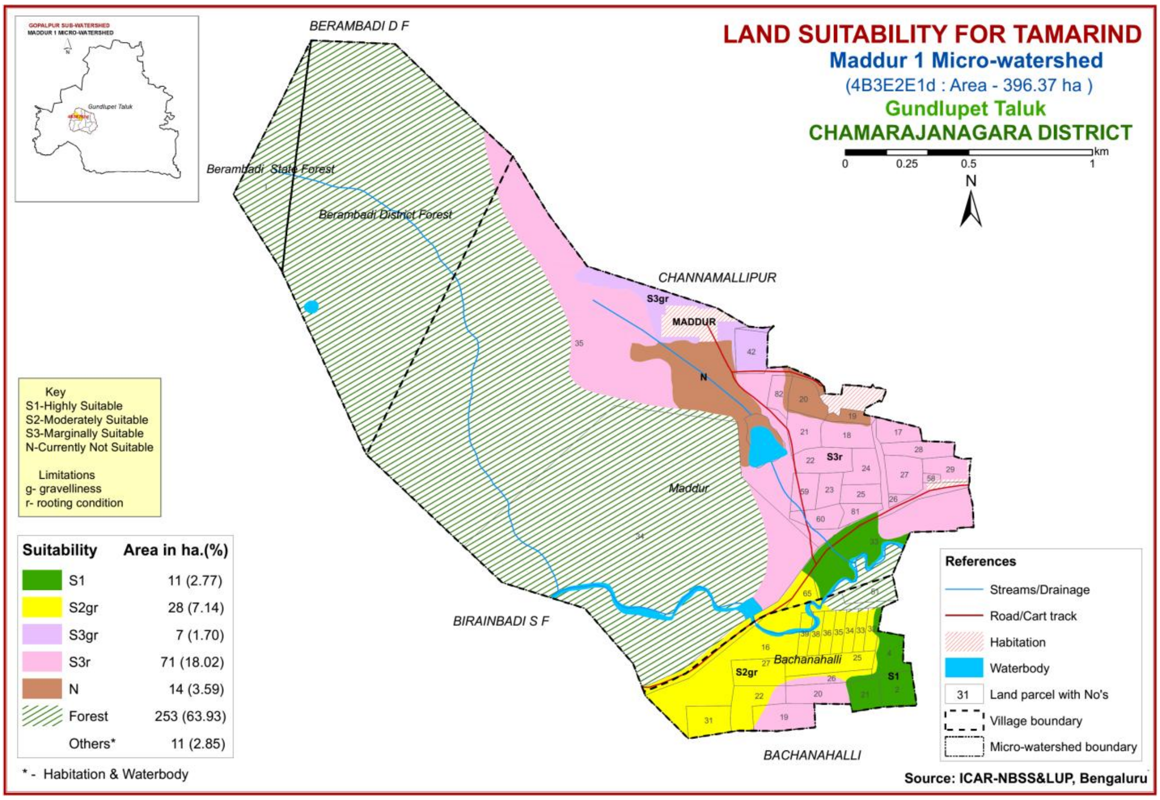


Fig. 7.24 Land Suitability map of Tamarind

7.25 Land Suitability for Marigold (*Tagetes erecta*)

Marigold is one of the most important flower crop grown in an area of 1858 ha in almost all the districts of the State. The crop requirements (Table 7.18) for growing marigold were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing marigold was prepared. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.25.

The highly suitable (Class S1) lands for growing marigold cover about 6 ha (1%) area and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 115 ha (29%) and are distributed in the major part of the microwatershed. They have minor limitations of rooting depth, texture and drainage. An area of 11 ha (3%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with moderate limitations of rooting depth and texture.

Table 7.17 Land suitability criteria for Marigold

Crop requirement			Rating			
Soil–site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Climate	Temperature in growing season		18-23	17-15 24-35	35-40 10-14	>40 <10
Soil aeration	Soil drainage	class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	l ,sl, scl, cl, sil	sicl, sc, sic, c	c	ls, s
	pH	1:2.5	7.0-7.5	5.5-5.9 7.6-8.5	<5 >8.5	-
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strongly calcareous	-
Rooting conditions	Soil depth	cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	-
Soil toxicity	Salinity	ds/m	Non saline	Slightly	Strongly	-
	Sodicity (ESP)	%	<10	10-15	>15	-
Erosion	Slope	%	1-3	3-5	5-10	-

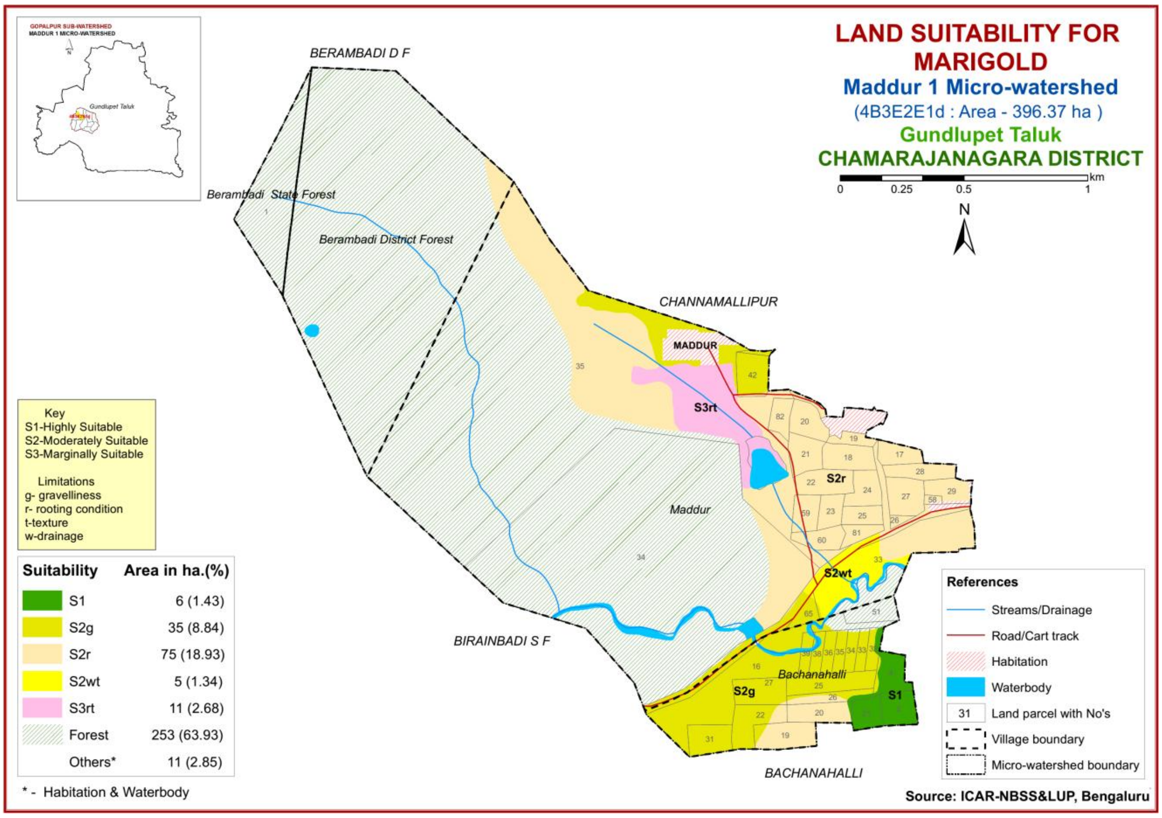


Fig. 7.25 Land Suitability map of Marigold

7.26 Land Suitability for Chrysanthemum (*Chrysanthemum indicum*)

Chrysanthemum is one of the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements (7.19) for growing chrysanthemum were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing chrysanthemum was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.26.

The highly suitable (Class S1) lands for growing chrysanthemum covers a small area of about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in a major area of about 108 ha (27%) and are distributed in the major part of the microwatershed. They have minor limitations of gravelliness, rooting depth, texture and drainage. An area of 18 ha (4%) is marginally suitable (Class S3) and are distributed in the northern part of the microwatershed with moderate limitations of gravelliness, rooting depth and texture.

Table 7.18 Land suitability criteria for Chrysanthemum

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temperature in growing season		18-23	17-15 24-35	35-40 10-14	>40 <10
Soil aeration	Soil drainage	class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	l ,sl, scl, cl, sil	sicl, sc, sic, c	c	ls, s
	pH	1:2.5	7.0-7.5	5.5-5.9 7.6-8.5	<5 >8.5	
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strongly calcareous	
Rooting conditions	Soil depth	cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	ds/m	Non saline	slightly	strongly	
	Sodicity (ESP)	%	<10	10-15	>15	-
Erosion	Slope	%	1-3	3-5	5-10	

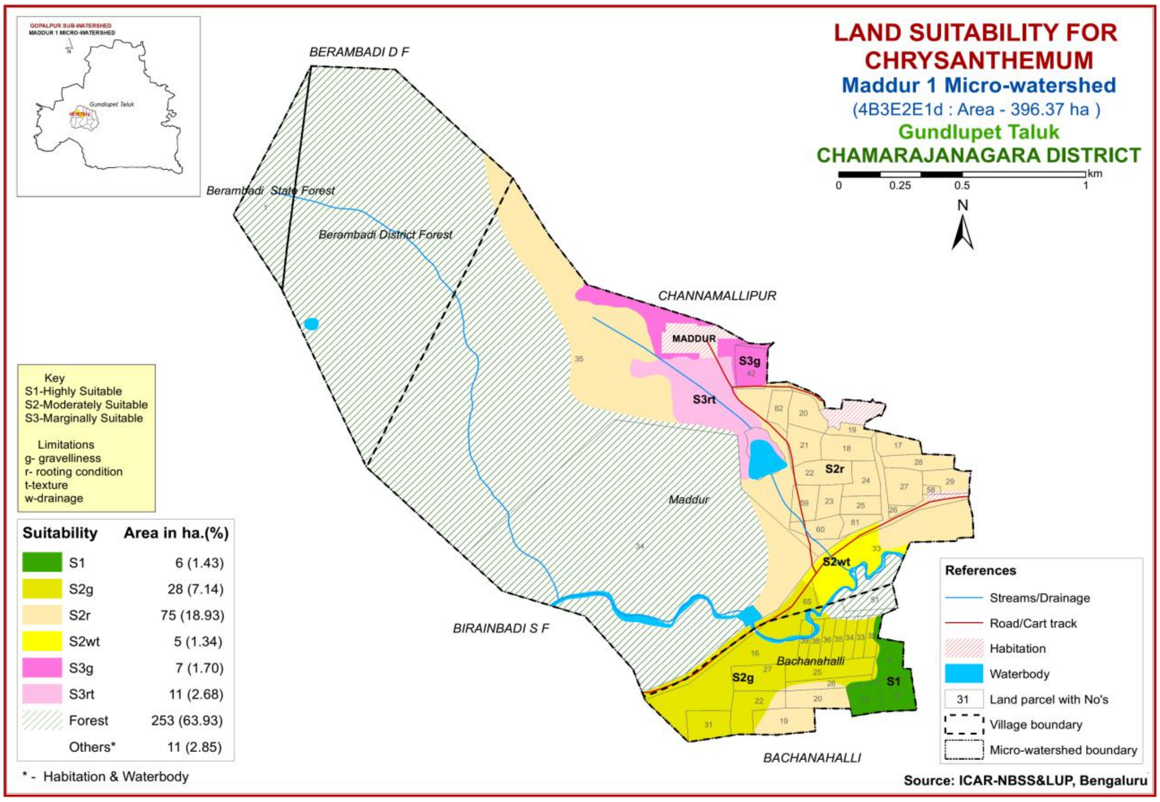


Fig. 7. 26 Land suitability map of Chrysanthemum

7.27 Land Suitability for Turmeric (*Curcuma longa*)

Turmeric is one of the most important spice crop grown in an area of 1.39 lakh ha in almost all the districts of the State. The crop requirements for growing turmeric (Table 7.12) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing turmeric was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.27.

The highly suitable (Class S1) lands for growing turmeric cover a small area about 6 ha (1%) and are distributed in the southeastern part of the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 103 ha (26%) and are distributed in the major part of the microwatershed. They have minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover an area of about 23 ha (6%) and occur in the northern and eastern part of the microwatershed. They have moderate limitations of gravelliness, drainage, rooting depth and texture.

Table 7.19 Land suitability criteria for Turmeric

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Climate	Temperature in growing season	^{0}C	28-32	20-27 33-37	10-19 38-40	<10 >40
Soil aeration	Soil drainage	Class	Well drained	Mod. well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	l, cl, scl, sl	Sc, sic, sicl	c(40-60%), ls	Stony heavy clay>60%
	pH	1:2.5				
	Available nutrient status (NPK)	Fertility rating class	high	medium	low	
Rooting conditions	Soil depth	cm	>75	50-75	25-50	<25
Erosion	Slope	%	<3	3-8	8-15	>15mm

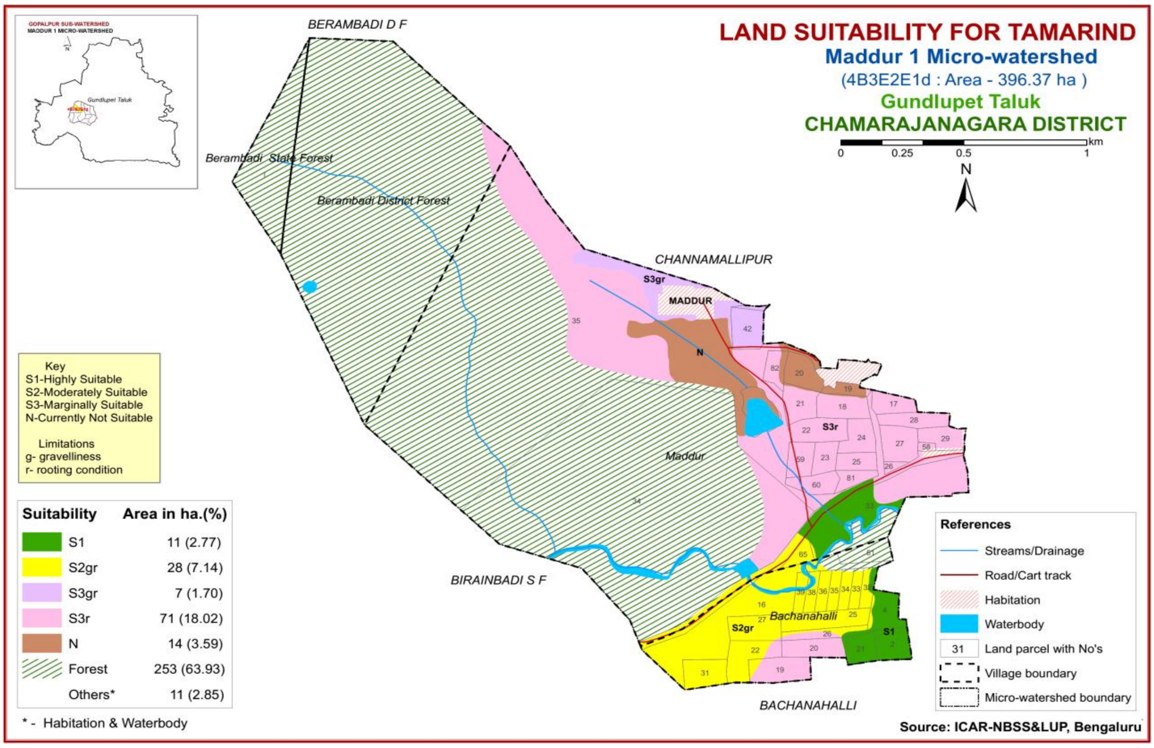


Fig. 7.27 Land Suitability map of Turmeric

7.28 Land Management Units (LMUs)

The 13 soil map units identified in Maddur-1 microwatershed have been regrouped into 6 Land Management Units (LMU's) for the purpose of preparing a Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Units map (Fig. 7.28) has been generated. These Land Management Units are expected to behave similarly for a given level of management. The map units that have been grouped into 4 land management units along with brief description of soil and site characteristics are given below.

LMU	Soil map units number	Mapping unit	Soil and site characteristics
1	1	ARKhB2g1	deep (>150 cm), dark reddish brown to very dusky red sandy soils
2	2	BMBmB1	very deep (>150 cm), very dark greyish brown to dark grey and very dark brown clayey soils
3	13	MDHiB2	deep (100-150 cm), dark reddish brown gravelly sandy clay soils
4	12	KNGhB1	moderately deep (75-100 cm), dark reddish brown to dark red gravelly sandy clay loam to sandy clay soils
5	4, 5, 6, 7, 8, 9, 10, 11	HPRbB1g1, HPRcB1, HPRcB2, HPRhB1, HPRhB2g1, HPRiB1, HPRiB2g1, HPRmB1	shallow (50-75 cm), dark brown to very dark brown gravelly sandy clay loam to sandy clay soils
6	3	BMDhB2	shallow (25-50 cm), dark brown to dark greyish brown clayey soils

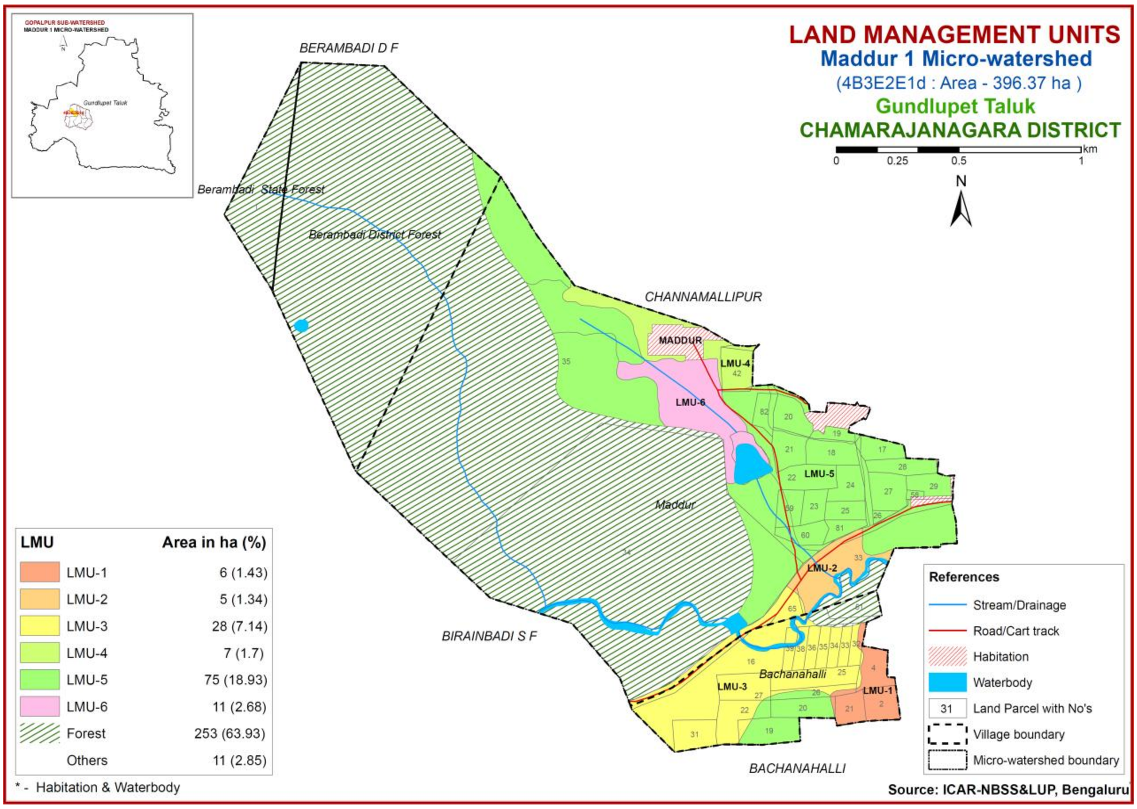


Fig. 7.28 Land Management Units Map- Maddur-1 Microwatershed

After assessing the land suitability for the 27 crops, the proposed crop plan has been generated for the 7 identified LMUs by considering only the highly (class S1) and moderately (class S2) suitable lands for each of the 27 crops. The resultant proposed crop plan is presented below in Table 7.20.

Table 7.20 Proposed Crop Plan for Maddur-1 Microwatershed

LMU No	Mapping Units	Survey Number	Field Crops/Forestry	Horticulture Crops (Irrigated)	Horticulture Crops with suitable Interventions	Suitable Interventions
1	1 (>150 cm)	Bachanahalli: 2,21,4	Maize, Sorghum, Redgram, Cotton, Sugarcane, Sunflower, **Multiple crop rotation:** Redgram+Maize Redgram+Groundnut Pulses+Ragi Pulses+Sorghum	Mango, Sapota, Guava, Turmeric, Banana, Lime, Tomato, Beans, Bhendi	**Flower crops:** Marigold, Chrysanthemum **Perennial components:** Mango, Sapota, Custard apple, Amla, Lime, Musambi **Vegetables:** Chillies, Bhendi	Drip irrigation, Mulching, crop suitable conservation practices
2	2 (>150 cm)	Maddur: 33	Sorghum, Redgram, Cotton, Sunflower, Sugarcane **Multiple crop rotation:** Redgram+Fodder sorghum Pulses+Sorghum	**Vegetables:** Beetroot, Banana, Lime, Tomato, Beans, Bhendi	**Flower crops:** Marigold, Chrysanthemum **Perennial components:** Custard apple, Amla, Lime, **Vegetables:** Chillies, Bhendi	Drip irrigation, Mulching, crop suitable conservation practices
3	13 (100-150 cm)	Bachanahalli: 16,22,25,27,31,32,33, 34,35,36,38,39 Maddur: 65	Maize, Sorghum, Redgram, Cotton, Sugarcane, Sunflower **Multiple crop rotation:** Redgram+Maize Redgram+Groundnut Pulses+Sorghum	**Vegetables:** Tomato, Beetroot, Potato, Beans, Bhendi, Turmeric	**Perennial components:** Sapota, Lime **Flower crops:** Marigold, Chrysanthemum **Vegetables:** Chillies, Bhendi	Drip irrigation, Mulching, Crop suitable conservation practices
4	12 (75-100 cm)	Maddur: 42	Maize, Sorghum, Cotton, Ragi, Sunflower, Pulses+Sorghum	Fieldbean, Beetroot, Onion, Turmeric, Tomato	**Perennial components:** Sapota, Guava **Flower crops:** Marigold, Chrysanthemum **Vegetables:** Bhendi, Chillies	Drip irrigation, Mulching, Crop suitable conservation practices

5	4, 5, 6, 7, 8, 9, 10, 11 (50-75 cm)	Bachanahalli: 19,20,26 Maddur: 17,18,19,20,21,22,23,24,25,26,27,28,29,33,58,59,60,81,82	Ragi, Groundnut, Maize, Sorghum, Cotton, Pulses+Sorghum	Fieldbean, Beetroot, Onion, Turmeric, Tomato, Banana	Custard apple, Ber, Aonla **Flower crops:** Marigold, Chrysanthemum, Gaillardia **Vegetables:** Bhendi, Cluster bean	Drip irrigation, Mulching, Crop suitable conservation practices
6	3 (25-50 cm)	Maddur: 35	Bengal gram, Horsegram	Custard apple, Amla	Custard apple, Ber	Drip irrigation, Mulching, Crop suitable conservation practises

SOIL HEALTH MANAGEMENT

Soil Health

Soil health is basic to plant health and plant health is basic to human and bovine health. Soil is fundamental to crop production. Without soil, no food could be produced nor would livestock be fed on a large scale. Because it is finite and fragile, soil is a precious resource that requires special care from its users.

Soil health or the capacity of the soil to function is critical to human survival. Soil health has been defined as: “the capacity of the soil to function as a living system without adverse effect on the ecosystem”. Healthy soils maintain a diverse community of soil organisms that help to form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive repercussions for soil, water and nutrient holding capacity and ultimately improve crop production and also contribute to mitigating climate change by maintaining or increasing its carbon content.

Functional interactions of soil biota with organic and inorganic components, air and water determine a soil’s potential to store and release nutrients and water to plants and to promote and sustain plant growth. Thus, maintaining soil health is vital to crop production and conserve soil resource base for sustaining agriculture.

The most important characterististics of a healthy soil are

- Good soil tilth
- Sufficient soil depth
- Good water storage and good drainage
- Adequate supply, but not excess of nutrients
- Large population of beneficial organisms
- Small proportion of plant pathogens and insect pests
- Low weed pressure
- Free of chemicals and toxins that may harm the crop
- Resistance to degradation
- Resilience when unfavourable conditions occur

Characteristics of Maddur-1Microwatershed

- The soil phases identified in the microwatershed belonged to the soil series of HPR (75 ha), MDH (28 ha), BMD (11 ha), KNG (7 ha), ARK (6 ha) and BMB (5 ha).
- As per land capability classification, about 33 per cent area in the microwatershed falls under land category (Class II and III). The major limitations identified in the arable lands were soil, wetness and erosion.
- On the basis of soil reaction, an area of about 10 ha (2%) is under neutral (pH 6.5-7.3) , 38 ha (10%) is slightly alkaline (ph 7.3-7.8) and an area of about 84 ha (21%) is under moderately alkaline (pH 7.3-8.4).

Soil Health Management

The following actions are required to improve the current land husbandry practices that provide a sound basis for the successful adoption of sustainable crop production system.

Alkaline soils

Slightly alkaline to moderately alkaline soils cover about 122 ha in the microwatershed

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of $ZnSO_4$ – 12.5 kg/ha (once in three years).
5. Application of Boron – 5kg/ha (once in three years).

Neutral soils

Neutral soils cover about 10 ha area in the microwatershed.

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers, (Azospirullum, Azotobacter, Rhizobium).
3. Application of 100 per cent RDF.
4. Need based micronutrient applications.

Besides the above recommendations, the best transfer of technology options are also to be adopted.

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total 396 ha area in the microwatershed, about 85 ha is suffering from moderate erosion. These areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Dissemination of Information and Communication of Benefits

Any large scale implementation of soil health management requires that supporting information is made available widely, particularly through channels familiar to farmers and extension workers. Given the very high priority attached to soil health especially by the Central Government on issuing Soil-Health Cards to all the farmers, media outlets like Regional, State and National Newspapers, Radio and Dooradarshan programs in local languages but also modern information and communication technologies such as cellular phones and the Internet, which can be much more effective in reaching younger farmers.

Inputs for Net Planning and Interventions needed

Net planning in IWMP is focusing on preparation of

1. Soil and Water Conservation Plans for each plot or farm.
2. Productivity enhancement measures/ interventions for existing crops/livestock/other farm enterprises.
3. Diversification of farming mainly with perennial horticultural crops and livestock.
4. Improving livelihood opportunities and income generating activities.

In this connection, how various outputs of Sujala-III are of use in addressing these objectives of Net Planning are briefly presented below.

- ❖ **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops, either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.
- ❖ **Surface Soil Texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.
- ❖ **Gravelliness:** More gravel content is favorable for run-off harvesting but poor in soil moisture storage and nutrient availability. It is a significant parameter that decides the kind of crop to be raised.
- ❖ **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Maddur-1 microwatershed.
- ❖ **Organic Carbon:** The OC content is medium (0.5-0.75%) in about 8 ha (2%) area and it is high (>0.75%) in 123 ha (31%). The areas that are medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.
- ❖ **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The

practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 8 ha area where OC is medium (0.5-0.75%). For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.

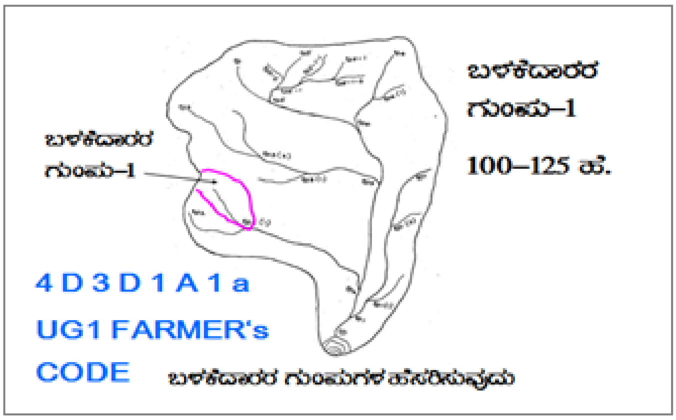
- **Available Phosphorus**: In 47 ha (12%) area, the available phosphorus is low (<23 kg/ha) and about 84 ha (21%) medium (23-57 kg/ha). Hence for all the crops, 25% additional P-needs to be applied, where it is low and medium.
- **Available Potassium:** Available potassium is medium (145-337 kg/ha) in 82 ha (21%) and about 50 ha (13%) is high (>337 kg/ha) in the microwatershed. Hence, in all those plots where available potassium is medium, for all the crops, additional 25 % potassium may be applied.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in a maximum of 132 ha (33%) area of the microwatershed. These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- **Available Boron:** An area of about 71 ha (18%) is low (<0.5 ppm) and medium (0.5-1.0 ppm) in 60 ha (15%) in available boron content. The areas with low and medium in boron content need to be applied with sodium borate @ 10kg/ha as soil application or 0.2% borax as foliar spray to correct the deficiency.
- **Available Iron:** Available iron is sufficient (>4.5 ppm) in the entire cultivated area. To manage iron deficiency, iron sulphate @ 25 kg /ha needs to be applied for 2-3 years.
- **Available manganese**: It is sufficient in the entire area of the microwatershe**d.**
- **Available copper:** It is sufficient in the entire area of the microwatershed**.**
- **Available Zinc:** It is deficient (<0.6 ppm) in 66 ha (17%) and about 66 ha (17%) sufficient (>0.6 ppm) in the microwatershed. Application of zinc sulphate @ 25 kg/ha is recommended for the deficient areas.
- **Soil alkalinity:** The microwatershed has 122 ha (31%) area with soils that are slightly to moderately alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acacia, Neem, Ber etc, are recommended.

Land Suitability for various crops: Areas that are highly, moderately, marginally suitable and currently not suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and salinity/alkalinity are the major constraints in various plots. With suitable management interventions, the productivity can be enhanced. In order to increase water holding capacity of light textured soils, growing of green manure crops and application of organic manure is recommended.

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Maddur-1 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were

- Soil depth
- Surface soil texture
- Soil gravelliness
- Available water capacity
- Soil slope
- Soil erosion
- Land capability
- Present land use /land cover
- Crop suitability
- Rainfall
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features- Network of waterways, pothissa boundaries, cut up/ minor terraces etc.
- Cadastral map (1:7920 scale)
- Satellite imagery (1:7920 scale)



Apart from these, Hand Level/ Hydro Marker/ Dumpy Level/ Total Station and Kathedars' List has to be collected.

Steps for Survey and Preparation of Treatment Plan

The boundaries of Land User Groups' and Survey No. boundaries are traced in the field.

- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge structures

9.1 Treatment Plan

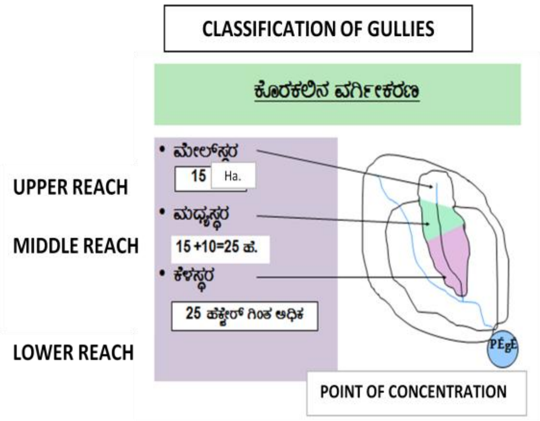
The treatment plan recommended for arable lands is briefly described below.

9.1.1 Arable Land Treatment

A. BUNDING

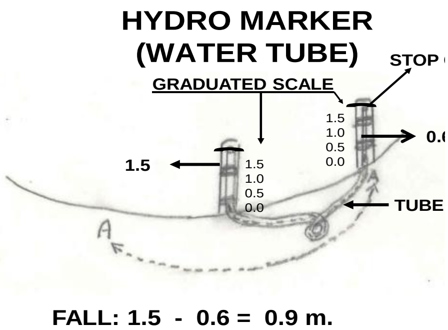
Steps for Survey and Preparation of Treatment Plan	
Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale Drainage lines are demarcated into	
Small gullies	(up to 5 ha catchment)
Medium gullies	(5-15 ha catchment)
Ravines	(15-25 ha catchment) and
Halla/Nala	(more than 25 ha catchment)

USER GROUP-1



Measurement of Land Slope

Land slope is estimated or determined by the study and interpretation of contours or by measurement in the field using simple instruments like Hand level or Hydromarker.



Vertical and Horizontal intervals between bunds as recommended by the Watershed Development Department.

Slope percentage	Vertical interval (m)	Corresponding Horizontal Distance (m)
2 - 3%	0.6	24
3 - 4%	0.9	21
4 - 5%	0.9	21
5 - 6%	1.2	21
6 - 7%	1.2	21

Note: i) The above intervals are maximum.

(ii) Considering the slope class and erosion status (A1…A=0-1%, 1= slight erosion)) the intervals have to be decided.

Bund length recording: Considering the contour plan and the existing grass belts/partitions, the bunds are aligned and lengths are measured.

Section of the Bund

Bund section is decided considering the soil texture class and gravelliness class (bg_0–b = loamy sand, g_0=<15% gravel). The recommended Sections for different soils are given below.

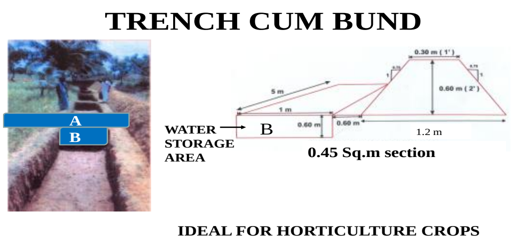
Recommended Bund Section

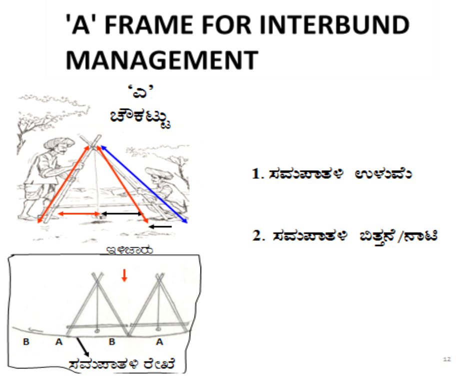
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soils	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3	2.1	0.6	1.5:1	0.72	Very shallow black soils	
0.45	2	0.75	01:01	0.92		
0.45	2.4	0.75	1.3:1	1.07	Shallow black soils	
0.6	3.1	0.7	1.78:1	1.29	Medium black soils	
0.5	3	0.85	1.47:1	1.49		

Formation of Trench cum Bund

Dimensions of the Borrow Pits/ Trenches to be excavated (machinery are decided considering the Bund Section).

Details of Borrow Pit dimensions are given below





Size of Borrow Pits/ Trench recommended for Trench cum Bund (by machinery)

Bund section	Bund length	Earth quantity	Pit				Berm (pit to pit)	Soil depth class
m^2	**m**	**m^3**	**L(m)**	**W(m)**	**D(m)**	**Quantity (m^3)**	**m**	
0.375	6	2.25	5.85	0.85	0.45	2.24	0.15	Shallow
0.45	6	2.7	5.4	1.2	0.43	2.79	0.6	Shallow
0.45	6	2.7	5	0.85	0.65	2.76	1	Moderately Shallow
0.54	5.6	3.02	5.5	0.85	0.7	3.27	0.1	Moderately shallow
0.54	5.5	2.97	5	1.2	0.5	3	0.5	Shallow
0.72	6.2	4.46	6	1.2	0.7	5.04	0.2	Moderately shallow
0.72	5.2	3.74	5.1	0.85	0.9	3.9	0.1	Moderately deep

B. Waterways

1. Existing waterways are marked on the cadastral map (1:7920 scale) and their dimensions are recorded.
2. Considering the contour plan of the MWS, additional waterways/ modernization of the existing ones can be thought of.
3. The design details are given in the Manual.

C. Farm Ponds

Waterways and the catchment area will give an indication on the size of the Farm Pond. Location of the pond can be decided based on the contour plan/ field condition and farmers' need/desire.

D. Diversion Channel

Existing EPT/ CPT are marked on the cadastral map. Looking to the need, these can be modernized or fresh diversion channel can be proposed and runoff from this can be stored in *Gokatte*/ Recharge ponds.

9.1.2 Non-Arable Land Treatment

Depending on the gravelliness and crops preferred by the farmers, the concerned authorities can decide appropriate treatment plan. The recommended treatments may be Contour Trench, Staggered Trench, Crescent Bund, Boulder Bund or Pebble Bunds.

9.1.3 Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of drainge lines (gullies/ *nalas/ hallas*) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.

b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.

c) Considering the Catchment, *Nala* bed and bank conditions, suitable structures are decided.

d) Number of storage structures (Check dam/ *Nala* bund/ Percolation tank) will be decided considering the commitments and available runoff in water budgeting and quality of water in the wells and site suitability.

e) Detailed Levelling Survey using Dumpy Level / Total Station has to be carried out to arrive at the site-specific designs as shown in the Manual.

f) The location of ground water recharge structures are decided by examining the lineaments and fracture zones from geological maps.

g) Rainfall intensity data of the nearest Rain Gauge Station is considered for Hydrologic Designs.

h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and earthern checks in the natural water course. Location and design details are given in the Manual.

9.2 Recommended Soil and Water Conservation Measures

The appropriate conservation structures best suited for each of the land parcel/ survey number (Appendix-I) are selected based on the slope per cent, severity of erosion, amount of rainfall, land use and soil type. The different kinds of conservation structures recommended are

1. Graded / Strengthening of bunds
2. Trench cum Bunds (TCB)
3. Trench cum Bunds / Strengthening
4. Crescent Bunds

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 126 ha (32%) requires Trench cum bunding and 5 ha (1%) area needs Graded Bunds or strengthening of existing bunds. The conservation plan generated may be presented to all the stakeholders including farmers and after considering their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

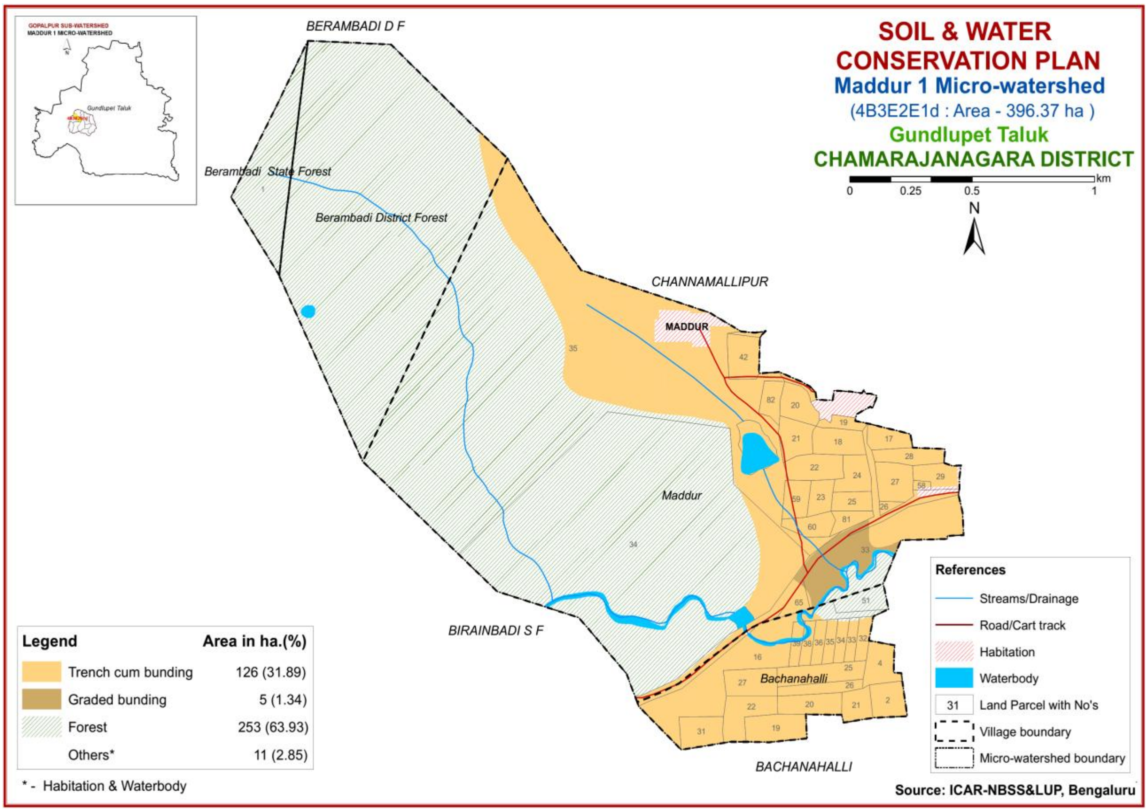


Fig. 9.1 Soil and Water Conservation Plan map of Maddur-1 Microwatershed

9.3 Greening of Microwatershed

As part of the greening programme in the watersheds, it is envisaged to plant a variety of horticultural and other tree plants that are edible, economical and produce lot of biomass which helps to restore the ecological balance in the watersheds. The lands that are suitable for greening programme are non-arable lands (land capability classes V, VI and VII) and also the lands that are not suitable or marginally suitable for growing annual and perennial crops. The method of planting these trees is given below.

It is recommended to open pits during the 1st week of March along the contour and heap the dug out soil on the lower side of the slope in order to harness the flowing water and facilitate weathering of soil in the pit. Exposure of soil in the pit also prevents spread of pests and diseases due to scorching sun rays. The pits should be filled with mixture of soil and organic manure during the second week of April and keep ready with sufficiently tall seedlings produced either in poly bags or in root trainer nurseries so that planting can be done during the 2nd or 3rd week of April depending on the rainfall.

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; waterlogged areas are recommended to be planted with species like Neral (*Sizyziumcumini*) and Bamboo. Dry areas are to be planted with species like Honge, Bevu, Seetaphal *etc*.

Dry Deciduous Species			Temp (°C)	Rainfall(mm)
1.	Bevu	*Azadiracta indica*	21–32	400 –1,200
2.	Tapasi	*Holoptelia integrifolia*	20-30	500 - 1000
3.	Seetaphal	*Anona Squamosa*	20-40	400 - 1000
4.	Honge	*Pongamia pinnata*	20 -50	500–2,500
5.	Kamara	*Hardwikia binata*	25 -35	400 - 1000
6.	Bage	*Albezzia lebbek*	20 - 45	500 - 1000
7.	Ficus	*Ficus bengalensis*	20 - 50	500–2,500
8.	Sisso	*Dalbargia Sissoo*	20 - 50	500 -2000
9.	Ailanthus	*Ailanthus excelsa*	20 - 50	500 - 1000
10.	Hale	*Wrightia tinctoria*	25 - 45	500 - 1000
11.	Uded	*Steriospermum chelanoides*	25 - 45	500 -2000
12.	Dhupa	*Boswella Serrata*	20 - 40	500 - 2000
13.	Nelli	*Emblica Officinalis*	20 - 50	500 -1500
14.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 2000
Moist Deciduous Species				
15.	Teak	*Tectona grandis*	20 - 50	500-5000
16.	Nandi	*Legarstroemia lanceolata*	20 - 40	500 - 4000
17.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 3000
18.	Mathi	*Terminalia alata*	20 -50	500 - 2000
19.	Shivane	*Gmelina arboria*	20 -50	500 -2000
20.	Kindal	*T.Paniculata*	20 - 40	500 - 1500
21.	Beete	*Dalbargia latifolia*	20 - 40	500 - 1500
22.	Tare	*T. belerica*	20 - 40	500 - 2000
23.	Bamboo	*Bambusa arundinasia*	20 - 40	500 - 2500
24.	Bamboo	*Dendrocalamus strictus*	20 – 40	500 – 2500
25.	Muthuga	*Butea monosperma*	20 - 40	400 - 1500
26.	Hippe	*Madhuca latifolia*	20 - 40	500 - 2000
27.	Sandal	*Santalum album*	20 - 50	400 - 1000
28.	Nelli	*Emblica officinalis*	20 - 40	500 - 2000
29.	Nerale	*Sizyzium cumini*	20 - 40	500 - 2000
30.	Dhaman	*Grevia tilifolia*	20 - 40	500 - 2000
31.	Kaval	*Careya arborea*	20 - 40	500 - 2000
32.	Harada	*Terminalia chebula*	20 - 40	500 - 2000

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Appendix I

Maddur1 2E1d Appendix
Soil Phase Information

Village	Survey No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Bachanahalli	2	1.86	ARKhB2g1	LMU-1	Very deep (>150 cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIs	Trench cum bunding
Bachanahalli	4	1.98	ARKhB2g1	LMU-1	Very deep (>150 cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIs	Trench cum bunding
Bachanahalli	16	10.78	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Banana (Ba)	Not Available	IIes	Trench cum bunding
Bachanahalli	19	2.57	HPRiB2g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coffee+Blackpepper (Co+Bp)	Not Available	IIes	Trench cum bunding
Bachanahalli	20	2.06	HPRiB2g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coffee+Blackpepper (Co+Bp)	Not Available	IIes	Trench cum bunding
Bachanahalli	21	1.47	ARKhB2g1	LMU-1	Very deep (>150 cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIs	Trench cum bunding
Bachanahalli	22	2.57	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coffee+Blackpepper (Co+Bp)	Not Available	IIes	Trench cum bunding
Bachanahalli	25	2.65	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	26	1.42	HPRiB2g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	27	2.3	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	31	2.06	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coffee+Blackpepper (Co+Bp)	Not Available	IIes	Trench cum bunding
Bachanahalli	32	0.89	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	33	0.71	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Banana+Horsegram (Ba+Hg)	Not Available	IIes	Trench cum bunding
Bachanahalli	34	0.8	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	35	0.77	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	36	0.82	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	38	0.79	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	39	0.78	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Bachanahalli	51	1.62	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Turmeric (Tu)	Not Available	Forest	Forest
Berambadi State Forest	1	10.68	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest (F)	Not Available	Forest	Forest
Berambadi District Forest	XX	89.72	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest (F)	Not Available	Forest	Forest
Maddur	settle ment	1.95	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others

Village	Survey No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Maddur	TANK	2.83	Waterbody	Others	Others	Others	Others	Others	Others	Others	Waterbody	Not Available	Others	Others
Maddur	17	1.42	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Avare (Av)	Not Available	IIs	Trench cum bunding
Maddur	18	2.13	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Maddur	19	0.8	HPRmB1	LMU-5	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	Not Available	IIs	Trench cum bunding
Maddur	20	1.85	HPRmB1	LMU-5	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	1 Borewell	IIs	Trench cum bunding
Maddur	21	1.93	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	Trench cum bunding
Maddur	22	2.27	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	1 Openwell	IIes	Trench cum bunding
Maddur	23	1.28	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	Trench cum bunding
Maddur	24	1.77	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	Trench cum bunding
Maddur	25	1.25	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Marigold (Mg)	Not Available	IIes	Trench cum bunding
Maddur	26	0.3	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Beans (Be)	Not Available	IIs	Trench cum bunding
Maddur	27	2.21	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Avare+Beans (Av+Be)	Not Available	IIs	Trench cum bunding
Maddur	28	1.71	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Horsegram (Hg)	1 Borewell	IIs	Trench cum bunding
Maddur	29	1.63	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Beans (Be)	Not Available	IIs	Trench cum bunding
Maddur	33	11.78	HPRcB1	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Banana+Horsegram (Ba+Hg)	1 Borewell	IIs	Trench cum bunding
Maddur	34	88.15	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest (F)	1 Openwell	Forest	Forest
Maddur	35	116.15	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Cotton+Currentfallow+Scrub land	2 Borewell	Forest	Forest
Maddur	42	2.2	KNGhB1	LMU-4	Moderately deep (75-100 cm)	Sandy clay loam	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not available (NA)	Not Available	IIs	Trench cum bunding
Maddur	58	0.25	HPRbB1g1	LMU-5	Moderately shallow (50-75 cm)	Loamy sand	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Horsegram (Hg)	Not Available	IIs	Trench cum bunding
Maddur	59	1.55	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	Trench cum bunding
Maddur	60	1.52	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	Trench cum bunding
Maddur	65	0.85	MDHiB2	LMU-3	Deep (100-150 cm)	Sandy clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not available (NA)	Not Available	IIes	Trench cum bunding
Maddur	81	0.98	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	Trench cum bunding
Maddur	82	1.19	HPRcB2	LMU-5	Moderately shallow (50-75 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	Trench cum bunding

Appendix II

Maddur1 2E1d Appendix

Soil Fertility Information

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Bachanahalli	2	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	4	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	16	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	19	Neutral (pH 6.5-7.3)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	20	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	21	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	22	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	25	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	26	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	27	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	31	Neutral (pH 6.5-7.3)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	32	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	33	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	34	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	35	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	36	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	38	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	39	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Bachanahalli	51	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Berambadi State Forest	1	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Berambadi District Forest	XX	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	SETTLE MENT	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Maddur	TANK	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Maddur	17	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	18	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	19	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	20	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	21	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	22	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	23	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	24	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	25	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	26	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	27	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	28	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	29	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	33	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	34	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	35	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	42	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	58	Slightly alkaline (pH 7.3-7.8)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Maddur	59	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	60	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	65	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	High (>337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Maddur	81	Moderately alkaline (pH 7.8-8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23-57 kg/ha)	Medium (145-337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)

Appendix III

Maddur1 2E1d Appendix

Soil Suitability Information

Village	Survey Number	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Red gram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Groundnut	Onion	Marigold	Chrysanthemum	Banana	Horse gram	Field-bean	Turmeric	Beetroot	Potato	Beans
Bachanahalli	2	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Bachanahalli	4	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Bachanahalli	16	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	19	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Bachanahalli	20	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Bachanahalli	21	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Bachanahalli	22	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	25	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	26	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Bachanahalli	27	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	31	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	32	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	33	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	34	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	35	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	36	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	38	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	39	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Bachanahalli	51	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Berambadi State Forest	1	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Berambadi District Forest	XX	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	settlement	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Maddur	tank	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Maddur	17	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	18	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	19	N	S2r	S3r	S2r	S3r	S2r	N	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2r	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	20	N	S2r	S3r	S2r	S3r	S2r	N	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2r	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	21	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	22	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	23	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	24	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	25	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	26	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	27	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	28	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	29	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r

Village	Survey Number	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Red gram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Groundnut	Onion	Marigold	Chrysanthemum	Banana	Horse gram	Field-bean	Turmeric	Beetroot	Potato	Beans
Maddur	33	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	34	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	35	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
Maddur	42	S3gr	S3g	S2gr	S3g	S2gr	S3g	S3gr	S3gr	S3g	S2g	S2gr	S3gr	S2gr	S2gr	S3gr	S3gr	S2g	S3g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g
Maddur	58	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	59	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	60	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	65	S2gr	S2g	S2gr	S2g	S1	S2g	S2gr	S2gr	S3g	S2g	S1	S2gr	S1	S2r	S2gr	S2gr	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g	S2g
Maddur	81	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r
Maddur	82	N	S2r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S3r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2r	S2r	S2r	S3r	S2r	S2r	S2r	S2r	S2r	S2r

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

Baseline socioeconomic characterisation is prerequisite to prepare action plan for program implementation and to assess the project performance before making any changes in the watershed development program. The baseline provides appropriate policy direction for enhancing productivity and sustainability in agriculture.

Methodology: *Maddur-1 micro-watershed (Gopalapur sub-watershed, Gundlupet taluk, Chamarajanagar district) is located in between $11^{0}45'$ – $11^{0}47'$ North latitudes and $76^{0}31'$ – $76^{0}33'$ East longitudes, covering an area of about 396 ha, bounded by Channamallipur, Bachanahalli villages and Berambadi State Forest with a length of growing period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and eco system services were quantified.*

Results: *The socio-economic outputs for the Maddur 1 micro-watershed in (Gopalapur sub-watershed) Gundlupet taluk, Chamarajanagar district are presented here.*

Social Indicators;

- *Male and female ratio is 58.5 to 41.5 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 60.9 per cent to the total population.*
- *Literacy population is around 72.9 per cent.*
- *Social groups belong to scheduled caste (SC) is around 10 per cent.*
- *Liquefied petroleum gas (LPG) is the main source of energy for a cooking among the all sample households.*
- *About 90 per cent of households have a yashaswini health card.*
- *Dependence on ration cards for food grains through public distribution system is around 70 per cent.*
- *Swach bharath program providing closed toilet facilities around 60.0 per cent.*
- *Rural migration to unban centre for employment is prevalent among 7.3 per cent.*
- *Women participation in decisions making are around 23.3 per cent were found.*

Economic Indicators;

- *The average land holding is 1.0 ha indicates that majority of farm households are belong to marginal and small farmers. The dry land account for 92.4 % and irrigate land is 7.6 % of total cultivated land among the sample farmers.*

- *Agriculture is the main occupation among 70.7 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 7.3 per cent of the sample households.*
- *The average value of domestic assets is around Rs. 53685 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 2260 per household, among all of sample farmers are owing plough.*
- *The average value of livestock is around Rs. 24285 per household; about 50.0 per cent of household are having livestock.*
- *The average per capita food consumption is around 648.0 grams (1414.4 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Majority of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 76242 per household. Around 40 per cent of farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs. 1254.*

Environmental Indicators-Ecosystem Services;

- *The value of ecosystem service helps to support investment to decision on soil and water conservation and in promoting sustainable land use.*
- *The onsite cost of different soil nutrients lost due to soil erosion is around Rs. 1406 per ha/year. The total cost of annual soil nutrients is around Rs. 184249 per year for the total area of 396.37 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 32001/ha/year. Per hectare food grain production services is maximum in garlic (Rs. 107469), coconut (Rs. 76392), cotton (Rs. 21891), groundnut (Rs. 16116), horse gram (Rs. 12142) and maize (Rs. 11625), marigold (Rs. 6101) and sorghum (Rs. 4274).*
- *The average value of ecosystem service for fodder production is around Rs. 812/ ha/year. Per hectare fodder production services is maximum in maize (Rs. 1270), followed by sorghum (Rs. 741), horse gram (Rs. 618) and groundnut (Rs. 618).*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in coconut (Rs. 127878), cotton (Rs. 54734), sorghum (Rs. 41407), maize (Rs. 36004), groundnut (Rs. 27486), horse gram (Rs. 22808) and garlic (Rs. 18185).*

Economic Land Evaluation;

- *The major cropping pattern is maize (20.8 %) followed by marigold (20.8 %), horse gram (15.7 %), coconut (13.9 %), sorghum (10.9 %), cotton (7.9 %), garlic (5.0 %) and groundnut (5.0 %).*

- *In Maddur 1 micro-watershed, major soil of Annurkeri (ARK) series is having very deep soil depth covered around 1.4 % of area. On this soil farmers are presently growing cotton (16.7 %), horse gram (50 %) and sorghum (33.3 %). Soil of moderately shallow soil depth of Hullipura (HPR) are having moderately shallow soil depth covered around 18.9 % of area, the crops are groundnut (9.9 %), horse gram (5.0 %) and maize (44.7%). Kannigala (KNG) soils are moderately deep soil depth covered around 1.7 % of areas crops are coconut. Maddinahundi (MDH) soil series are having deep soil depth cover around 7.1 % of area, they major crops grown are cotton, garlic and maize.*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for cotton ranges between Rs. 41361/ha in ARK soil (with BCR of 1.19) and Rs. 28477/ha in MDH soil (with BCR of 2.26).*
- *In horse gram the cost of cultivation range between Rs. 17522/ha in HPR soil (with of 1.4) and Rs.7841/ha in ARK soil (with BCR of 3.37).*
- *In maize the cost of cultivation range between Rs. 32741/ha in HPR soil (with BCR of 1.44) and Rs. 28596/ha in MDH soil (with BCR of 1.85).*
- *In sorghum the cost of cultivation in ARK soil is Rs. 20179/ha (with BCR of 1.25).*
- *In marigold the cost of cultivation in HPR soil is Rs. 37626/ha (with BCR of 1.25).*
- *In coconut the cost of cultivation in KNG soil is Rs. 18791/ha (with BCR of 5.07).*
- *In garlic the cost of cultivation in MDH soil is Rs.77781/ha (with BCR of 2.38) and groundnut the cost of cultivation in HPR soil series is Rs. 21057/ha (with BCR of 1.79).*
- *The land management practices reported by the farmers are crop rotation, tillage practices, fertilizer application and use of farm yard manure (FYM). Due to higher wages farmer are following labour saving strategies is not prating soil and water conservation measures. Less ownership of livestock limiting application of FYM.*
- *It was observed soil quality influences on the type and intensity of land use. More fertilizer applications on deeper soil to maximize returns.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income.*

- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in cotton (27.9 %), horse gram (24.1 %), maize (61.8 %), sorghum (51.6 %), groundnut (49.4 %) and garlic (60.5 %).*

Chapter 2

INTRODUCTION

Watershed Development program aim to restore degraded watersheds in rainfed regions to increase their capacity to capture and store rain water, reduce soil erosion, and improved soil nutrients and carbon contents so they can produce greater agricultural yields and other benefits. As majority of rural poor live in these regions and dependent on natural resources for their livelihood and sustenance, improvements in agricultural yields improve human welfare and simultaneously improve national food security.

Sujala–III watershed development project conceptualised and implemented by the Watershed Development Department of Government of Karnataka with tripartite cost-sharing arrangements. The World Bank through International Development Association provided major portion of plan outlay as a loan to Government of India and in turn loan to Government of Karnataka.

The objectives of Sujala-III is to demonstrate more effective watershed management through greater integration of programs related to rain fed agriculture, innovative and science based approaches and strengthened institutions and capacities. The project is implemented in 11 districts of Bidar, Vijayapura, Gulbarga, Yadgir, Koppal, Gadag, Raichur, Davanagere, Tumkur, Chikkamangalur and Chamarajanagar which have been identified by the Watershed Development Department based on rainfall and socio-economic conditions. The project will be implemented over six years and linked with the centrally financed integrated watershed management programme.

Economic evaluations can better guide in watershed planning and implementation, as well as raise awareness of benefits of ecosystem restoration for food security and poverty alleviation program. The present study aims to characterize socio-economic status of farm households, assess the land and water use status, evaluate the economic viability of land use, prioritize farming constraints and suggest the measures for soil and water conservation for sustainable agriculture.

Objectives of the study

1. To characterize socio-economic status of farm households
2. To evaluate the economic viability of land use and land related constraints
3. To estimate the ecosystem service provided by the watershed and
4. To suggest alternatives for sustainable agriculture production.

Chapter 3

METHODOLOGY

Study area

Maddur-1 micro-watershed is located in Southern Dry Zone of Karnataka (Figure 1). It has a total geographical area of 1.56 M ha with 0.74 M ha under cultivation of which 0.22 M ha is irrigated. The mean elevation ranges from 450 to 900 m MSL; most part of the zone is situated at 800-900 m. The major soils are red loams with pockets of black soils in Kollegal, Yalandur and T.N. Pura taluks of Mysore district. The average annual rainfall ranges from 670 to 890 mm, of which about 55 to 75 per cent is received during the kharif season. The major crops grown are rice, ragi, sugarcane, pulses and minor millets. It's represented Agro Ecological Sub Region (AESR) 8.2 having LGP 120-150 days.

Maddur-1 micro-watershed (Gopalapur sub-watershed, Gundlupet taluk, Chamaraja-nagar district) is located in between $11^0$45' – $11^0$47' North latitudes and $76^0$31' – $76^0$33' East longitudes, covering an area of about 396 ha, bounded by Channamallipur, Bachanahalli villages and Berambadi State Forest.

Sampling Procedure:

In this study we have followed soil variability as criterion for sampling the farm households. In each micro-watershed the survey numbers and associated soil series are listed. Minimum three farm households for each soil series were taken and summed up to arrive at total sample for analysis.

Sources of data and analysis:

For evaluating the specific objectives of the study, primary data was collected from the sample respondents by personal interview method with the help of pre-tested questionnaire. The data on socio-economic characteristics of respondents such as family size and composition, land holdings, asset position, occupational pattern and education level was collected. The present cropping pattern and the level of input use and yields collected during survry. The data collected from the representative farm households were analysed using Automated Land Potential Evalution System (Figure 2).

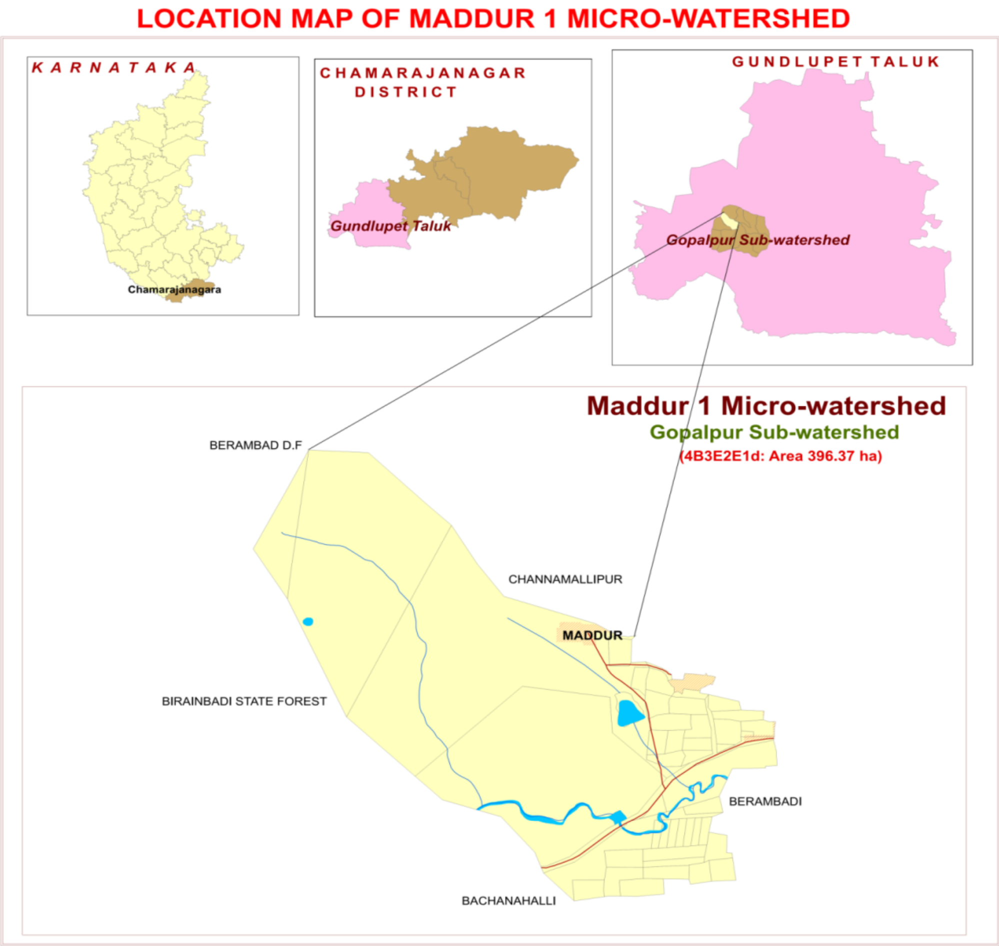

Figure 1: Location of study area

Steps followed in socio-economic assessment

1. •After the completion of soil profile study link the cadastral number to the soil profile in the micro watershed.
2. • Download the names of the farmers who are owning the land for each cadastral number in the Karnataka BHOOMI Website.
3. • Compiling the names of the farmers representing for all the soil profiles studied in the micro watershed for socio-economic Survey.
4. • Conducting the socioeconomic survey of selected farm households in the micro watershed .
5. • Farm households database created using the Automated Land Potential Evaluation System (ALPES) for analysis of socio economic status for each micro watershed .
6. • Synthesis of tables and preparation of report for each micro watershed .

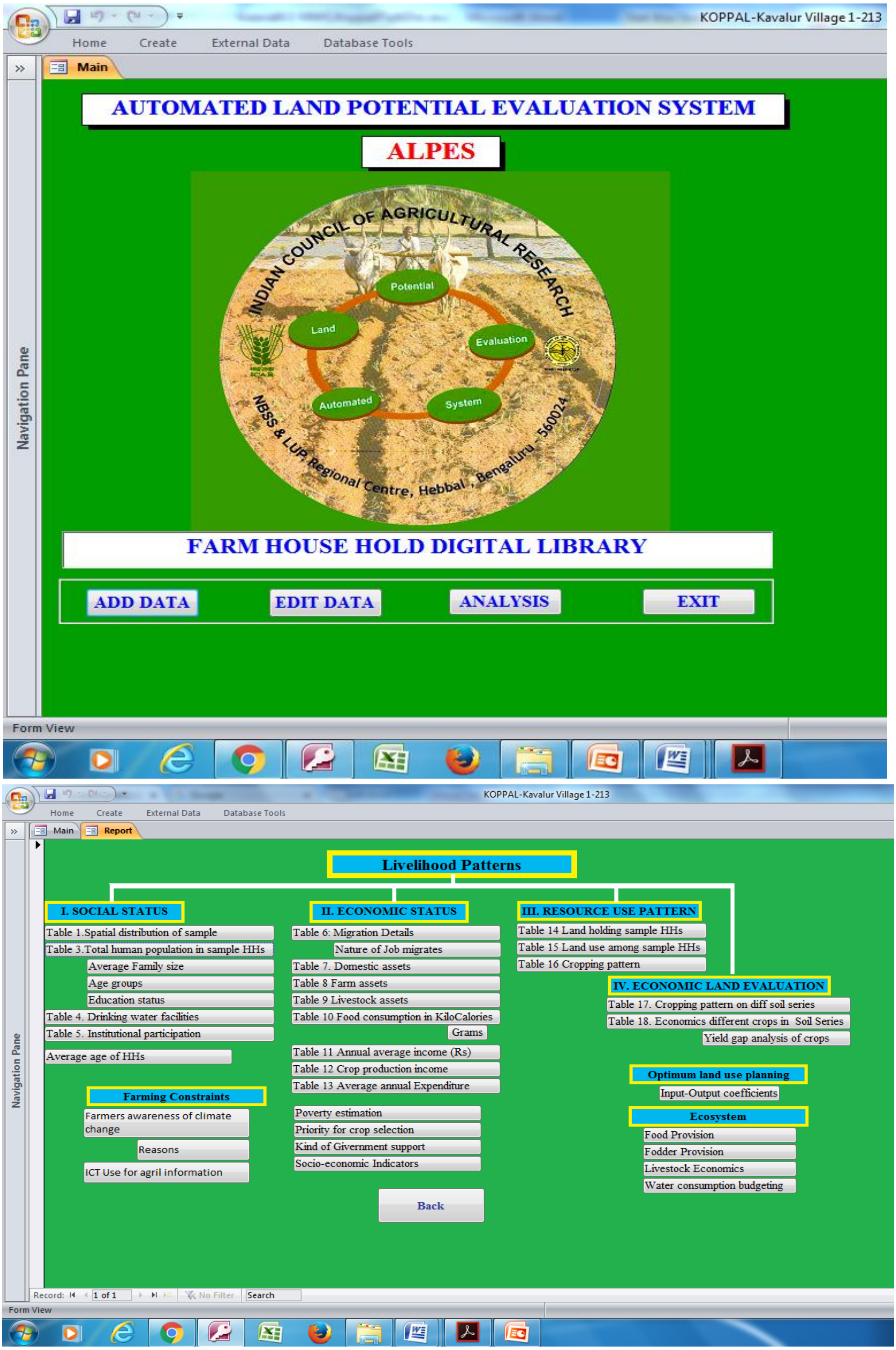

Figure 2: ALPES FRAMEWORK

The sample farmers were post classified in to marginal and small (0.0 to <=2 ha), medium and semi medium (>2 to <=10 ha) and large (>10 ha). The steps involved in estimation of soil potential involve estimation of total cost of cultivation, the yield/gross returns and net income per hectare. The cost of inputs such seed, manure and fertilizer, plant protection chemicals, payment towards human and bullock labour and interest on working capita are included under operational costs. In the case of perennial crops, the cost of establishment was estimated by using actual physical requirements and prevailing market prices. Estimation cost included maintenance cost up to bearing period. The value of main product and by product from the crop enterprise at the market rates were the gross returns of the crop. Net returns were worked out by deducting establishment and maintained cost from gross returns.

Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.
Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)
Net returns = Gross returns-Operational cost.

Benefit Cost Ratio = Net returns/Total cost.

Economic suitability classes: once each land use –land area combination has been assigned an economic value by the land evaluation, the question arises as to its 'suitability', that is, the degree to which it satisfies the land user. The FAO framework defines two suitability orders: 'S'(suitable if benefit cost ratio (BCR)>1) and 'N'(not suitable if (BCR<1), which are dived into five economic suitability classes:'S1'(highly suitable if BCR>3), 'S2'(suitable if BCR>2 and <3),'S3'(Marginally suitable if BCR >1 and <2), 'N1'(Not suitable for economic reasons but physically suitable) and 'N2'(not suitable for physical reasons). The limit between 'S3' and 'N1'must be at least at the point of financial feasibility (i.e. net returns, NPV, or IRR>0 and BCR>1). The other limits depend on social factors such as farm size, family size, alternative employment or investment possibilities and wealth expectations; these need to be specified for the Soil series.

Economic Valuation of Soil ecosystem services:

The replacement cost approach was followed for estimating the onsite cost of soil erosion, Market price method was followed for estimating the value of food and fodder production. Value transfer menthods was followed for estimating the value of water demand by different crops in the micro watershed.

Steps followed in Replacement cost methods for estimation of onsite cost of soil erosion

1. Collect the Soil Map Units (SMU) / Land Use Type (LUT) with soil fertility analysis.
2. Integrate the erosion rates per SMU/LUT.
3. Estimate the nutrients lost per tone of soil erosion for each SMU/LUT.
4. Estimate the value of soil nutrients lost per ton of soil erosion for each SMU/LUT by taking the market price of soil nutrients.

Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 41, out of which 58.5 per cent were males and 41.5 per cent females. Average family size of the households is 4.1. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group 30 to 50 years (31.7%) followed by 18 to 30 years (29.2%), more than 50 years (24.5%) and 0 to 18 years (14.6 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 27.1 per cent of respondents were illiterate and 72.9per cent literate (Table 1).

Table 1: Human population among sample households in Maddur 1 Microwatershed

Particulars	Units	Value
Total human population in sample HHs	Number	41
Male	% to total Population	58.5
Female	% to total Population	41.5
Average family size	Number	4.1
Age group		
0 to 18 years	% to total Population	14.6
18 to 30 years	% to total Population	29.2
30 to 50 years	% to total Population	31.7
>50 years	% to total Population	24.5
Average age	Age in years	37.5
Education Status		
Illiterates	% to total Population	27.1
Literates	% to total Population	72.9
Primary School (<5 class)	% to total Population	17.0
Middle School (6- 8 class)	% to total Population	17.0
High School (9- 10 class)	% to total Population	14.6
Others	% to total Population	24.3

The ethnic groups among the sample farm households found to be 50.0 per cent belonging to general caste followed by 40.0 per cent belonging to other backward caste

(OBC) and 10 per cent belongs to scheduled caste (SC) (Table 2 and Figure 3). All the sample households are using LPG gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 90 per cent are sample households having health cards. About 70.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 60.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Maddur 1 Microwatershed

Particulars	**Units**	**Value**
Social groups		
SC	% of Households	10.0
OBC	% of Households	40.0
General	% of Households	50.0
Types of fuel use for cooking		
Gas	% of Households	100
Energy supply for home		
Electricity	% of Households	100
Number of households having Health card		
Yes	% of Households	90.0
No	% of Households	10.0
MGNREGA Card		
Yes	% of Households	0.0
No	% of Households	100
Ration Card		
Yes	% of Households	70.0
No	% of Households	30.0
Households with toilet		
Yes	% of Households	60.0
No	% of Households	40.0
Drinking water facilities		
Tube well	% of Households	90.0
Lake	% of Households	10.0

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well source for water supply for domestic purpose.

The data on migration in Maddur 1 Micro-watershed is given in Table 3. It indicated that around 20.0 per cent of samples households were migrated. The average distance travelled for seeking employment is 17.5 km.

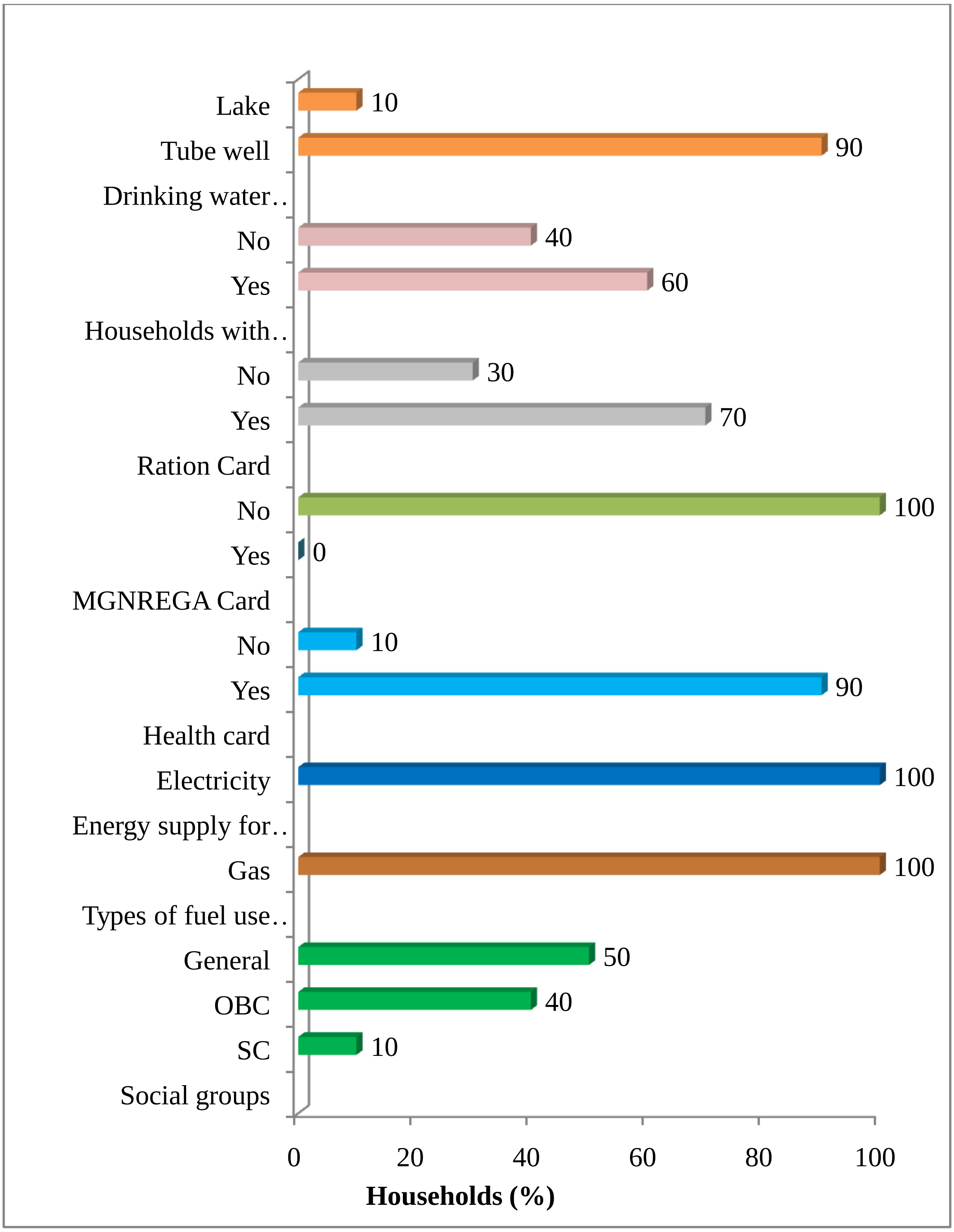

Figure 3: Basic needs of sample households in Maddur 1 Microwatershed

Table 3: Migration details among the sample households in Maddur 1 Micro-watershed

Particulars	**Value**
% of households showing migration	20
% of persons migrating	7.3
No. of months migrated in a year	20.0
Average Distance of migration(Km)	17.5
Nature of job (%)	
Job/wage/work	100

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 70.7 per cent of farmers and Agricultural is a main and agricultural labour is a subsidiary occupation is 7.3 per cent. Private service is a main occupation of 7.3 per cent of sample households.

Table 4: Occupational pattern in sample population in Maddur 1Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	70.7
	Agriculture labor	7.3
Private service		7.3
Studying		14.7
Grand Total		100.0
Family labour Availability		**Man days/Month**
Male		45.0
Female		25.0
Total		70.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 5 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (90 %) followed by mixer/grinder (90 %), motorcycle 50 %), television (100 %) and refrigerator (10 %). The average value of domestic assets is around Rs. 53685 per household.

Table 5: Domestic assets among the sample households in Maddur 1 Microwatershed

Particulars	% of households	Average value in Rs
Bicycle	30.0	2866
Mixer/grinder	90.0	2111
Mobile phone	90.0	7422
Motorcycle	50.0	35600
Television	100.0	9800
Refrigerator	10.0	18000
Four wheeler	10	300000
Average value	53685	

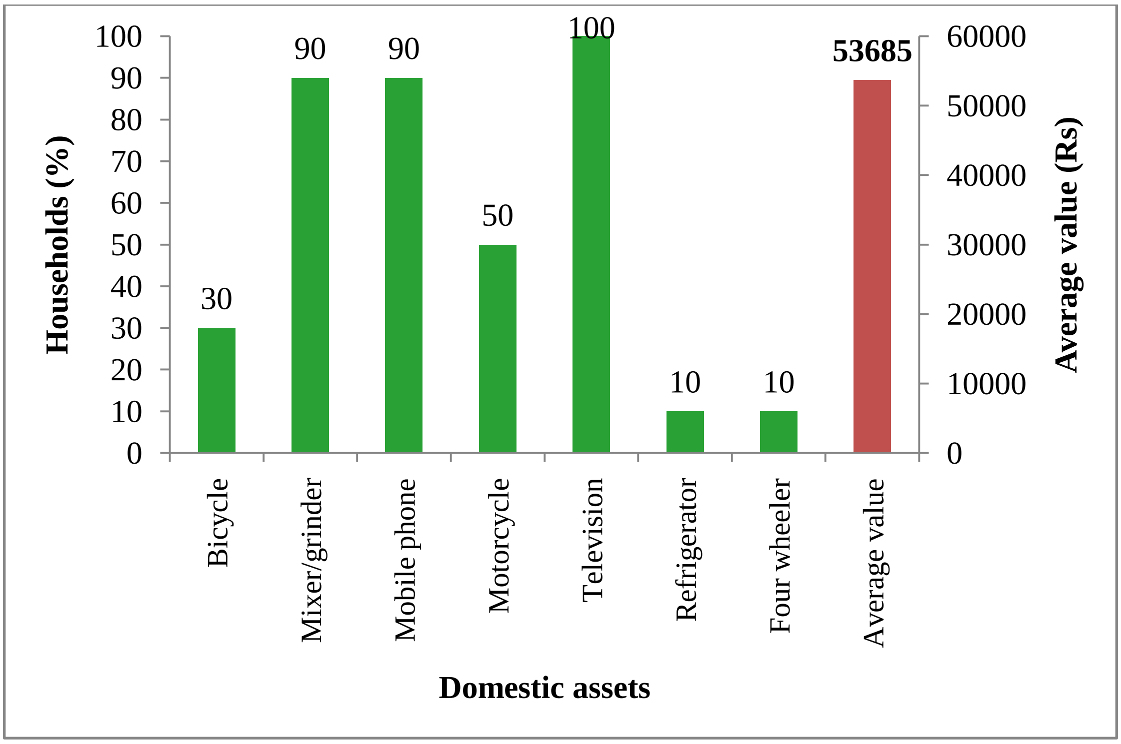

Figure 4: Domestic assets among the sample households in Maddur 1 Microwatershed

The most popularly owned farm equipments were plough, bullock cart, and sprayer were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned plough (100 %), bullock cart (20 %), sprayer (30 %), was found highest among the sample farmers. The average value of farm assets is around Rs. 2260 per households (Table 6 and Figure 5).

Table 6: Farm assets among samples households in Maddur 1 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	20	25000
Plough	100	2142
Sprayer	30	2700
Drip/Sprinkler	310	8500
Average value	2260	

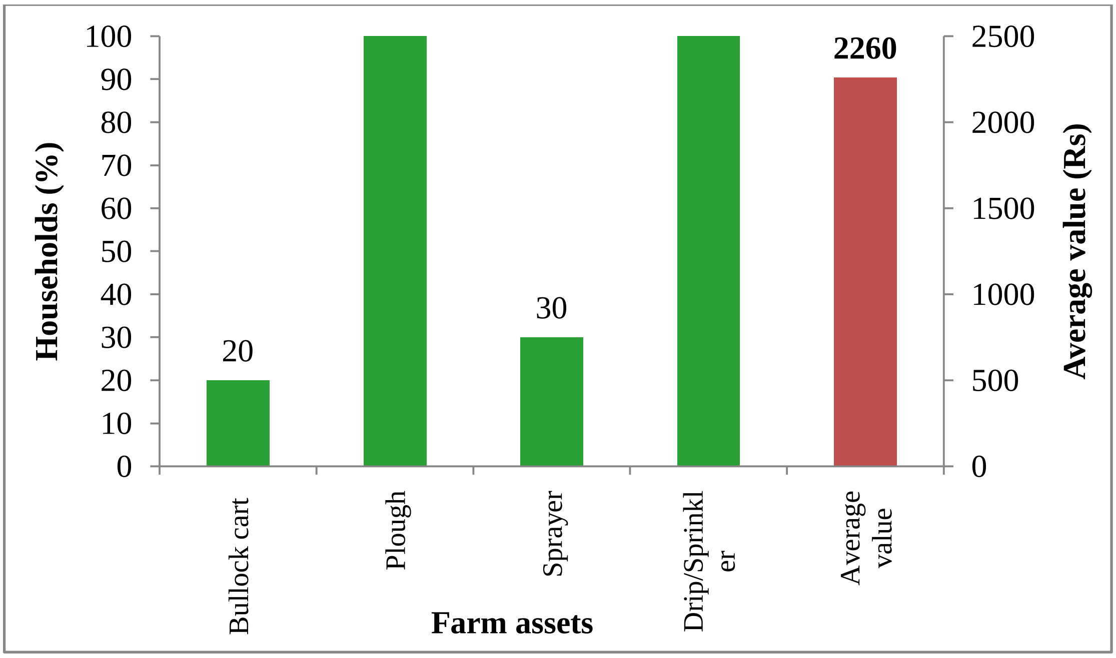

Figure5: Farm assets among samples households in Maddur 1 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). Livestock population is crossbred milching cow were around 28.5 per cent and local dry cow (71.5 %). The average livestock value was Rs. 24285 per household.

Table 7: Livestock assets among sample households in Maddur 1 micro-watershed

Particulars	% of livestock population	Average value in Rs
Crossbred Milching Cow	28.5	28000
Local Dry Cow	71.5	15000
Average value	24285	

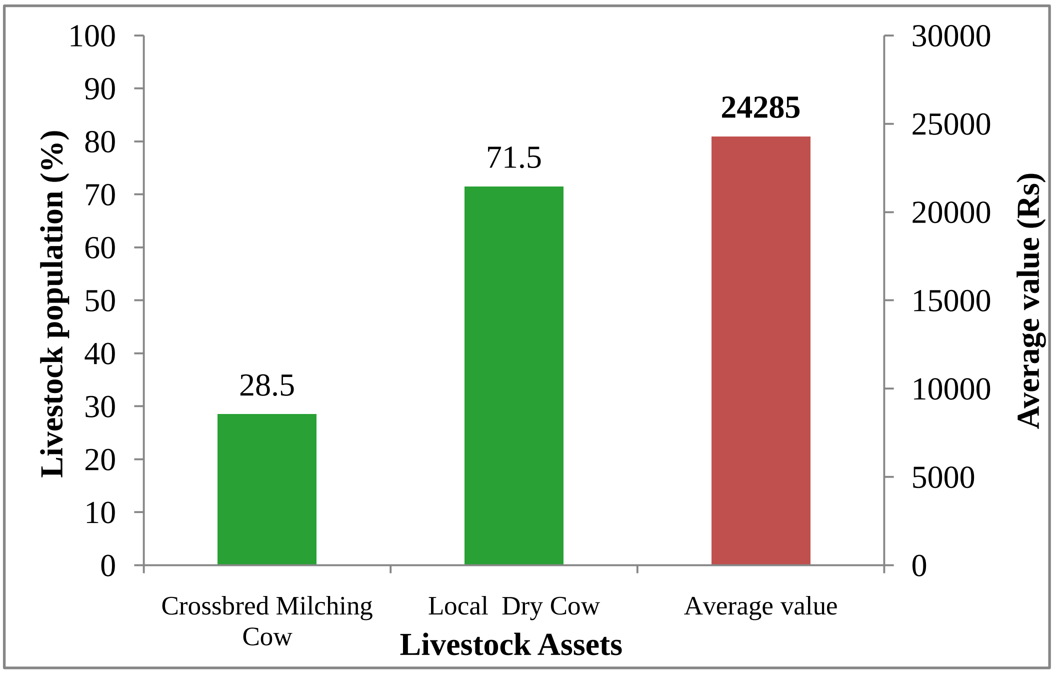

Figure 6: Livestock assets among sample households in Maddur 1 Micro-watershed

Average milk produced in sample households is 1440 ltr/ annum. Among the farm households, maize sorghum, groundnut, and Horsegram are the main crops for domestic food and fodder for animals. About 1914.0 kg /ha of average fodder is available per season for the livestock feeding (Table 8).

Table 8: Milk produced and fodder availability of sample households in Maddur 1 Microwatershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Crossbred Milching Cow	1440
Fodder produces	**Fodder yield (kg/ha.)**
Maize	2500
Sorghum	2031
Groundnut	1250
Horsegram	1666
Average fodder availability	1914
Livestock having households (%)	50.0
Livestock population (Numbers)	12

A woman participation in decision making is in this micro-watershed is presented in Table 9. Around 10 per cent women earning for her family requirement, about 30.0 per cent of women taking decision in her family and agriculture related activities each.

Table 9: Women empowerment of sample households in Maddur 1 Microwatershed

% to Grand Total

Particulars	**Yes**	No
Women participation in local organization activities	30.0	70.0
Women elected as panchayat member	0.0	100
Women earning for her family requirement	10.0	90
Women taking decision in her family and agriculture related activities	30.0	70.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 887.5 kcal per person. The other important food items consumed was pulses 106.3 kcal followed by cooking oil 229.9 kcal, milk 119.7 kcal, vegetables 24.0 kcal, egg 36.6 kcal and meat 10.1 kcal. In the sampled households, farmers were consuming less (1414.4 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample households in Maddur 1 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396.0	261.0	887.5
Pulses	43.0	31.0	106.3
Milk	200.0	184.1	119.7
Vegetables	143.0	100.0	24.0
Cooking Oil	31.0	40.3	229.9
Egg	0.5	24.4	36.6
Meat	14.2	6.7	10.1
Total	**827.7**	**648.0**	**1414.4**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		100	100
% Above NIN		0.0	0.0

Note: * day/person

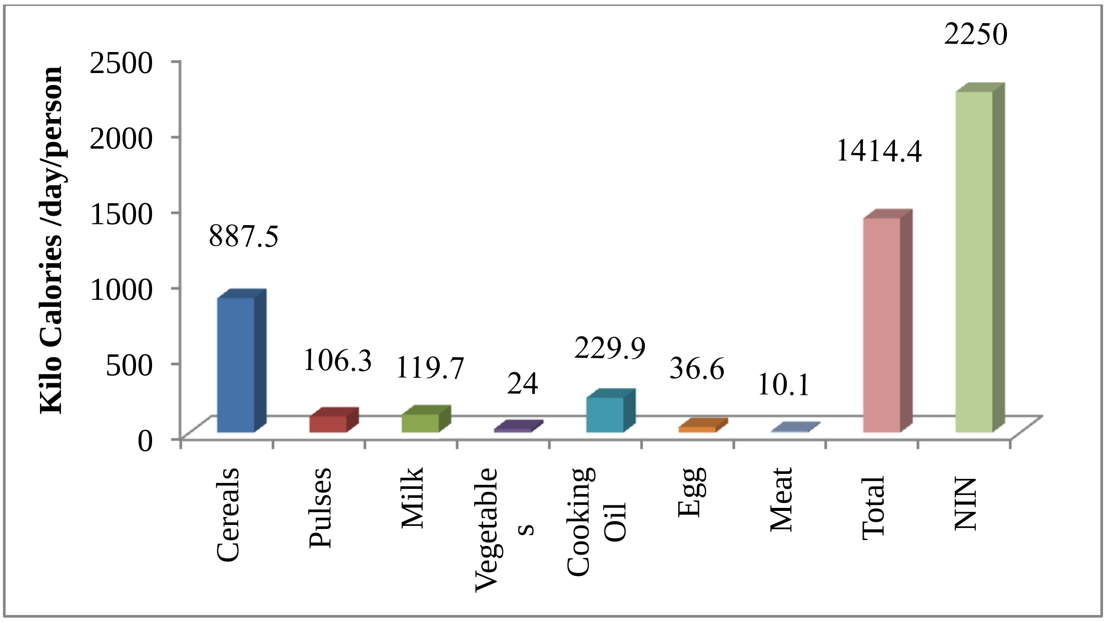

Figure 7: Per capita daily consumption of food among the sample households in Maddur 1 Microwatershed

Table 11: Annual average income of HHs from various sources in Maddur 1Microwatershed

Particulars	Income *(%)
Nonfarm income	8260 (20)
Livestock income (Rs)	27388 (50)
Crop Production (Rs)	40594(100)
Total Annual Income (Rs)	***76242***
Average monthly per capita income (Rs)	1549
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	40.0
% of households above poverty line	60.0

* Figure in the parenthesis indicates % of Households

Annual income of the sample HHs: The average annual household income is around Rs. 76243 .Major source of income to the farmers in the study area is from crop production (Rs. 40594) followed by livestock income (Rs. 27388), nonfarm income (Rs. 8260). The monthly per capita income is Rs. 1549 per cent which is more than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

The average annual expenditure of farm households indicated that farmers in the study area spend highest on food (Rs. 32028) followed by education, clothing, social function and health. Now a day's education is most important among all of us. In today's competitive world, education is a necessity for man after food, clothing, and shelter. It is the only fundamental way by which a desired change in the society can happen. The average per capita monthly expenditure is around Rs. 1254 and 60 per cent of farm households are above poverty line (Table 12 and Figure 8).

Table 12: Average annual expenditure of sample HHs in Maddur 1Microwatershed

Particulars	Value in Rupees	Per cent
Food	32028	51.9
Education	7600	12.3
Clothing	4600	7.5
Social functions	7600	12.3
Health	9900	16.0
Total Expenditure (Rs/year)	61728	100
Monthly per capita expenditure (Rs)	1254	

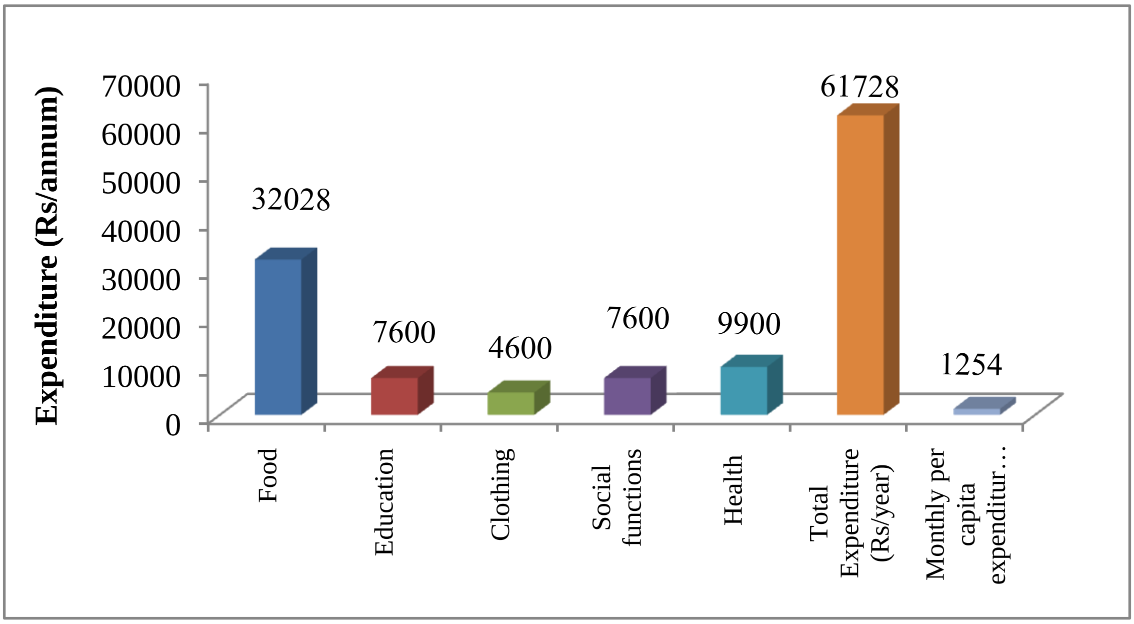

Figure 8: Average annual expenditure of sample HHs in Maddur 1Microwatershed

Land holding: Total area cultivated by them is 10.6 ha. The average land holding of sample HHs is 1.1 ha. Large number of sample HHs (90 %) belong to small size group with an average holding size of 1.0 ha and medium farmers (10 %) with an average holding size of 2.1 ha (Table 13).

Table 13: Distribution of land holding among the sample households in Maddur 1 micro-watershed

Particulars	Units	Values
Small farmers		
Total land	ha	8.6
Sample size	Per cent	90.0
Average land holding	ha	1.0
Medium farmers		
Total land	ha	2.1
Sample size	Per cent	10.0
Average land holding	ha	2.1
Total sample households		
Total land	ha	10.7
Sample size	Per cent	100.0
Average land holding	ha	1.1

Land use: The total land holding in the Maddur 1micro-watershed is 10.6 ha (Table 14) of which 7.6 ha is Irrigated land and 92.4 per cent of rain fed land. The average land holding per household is worked out to be 1.0 ha.

Table 14: Land use among samples households in Maddur 1 Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	7.6	0.8
Rain fed Land	92.4	9.8
Fallow land	0.0	0.0
Total land holding	100	10.6
Average land holding	1.0	

Table 15: Number of trees/plants covered in sample farm households in Maddur 1 Microwatershed

Particulars	Number of Plants/trees	Per cent
Coconut	80	48.1
Jalli	2	1.2
Mango	1	0.6
Neem trees	18	10.8
Tamarind	3	1.8
Guava	3	1.8
Jack fruit	2	1.2
Sapota	4	2.4
Teak	53	31.9
Grand Total	166	100

In the micro-watershed, the prevalent present land uses under perennial plants are coconut trees (48.1 %) followed by, teak (31.9), neem trees (10.8%), sapota (2.4%), tamarind (1.8 %), guava (1.8 %), jack fruit (1.2 %), jalli (1.2 %) and mango (0.6 %).

The land use decisions are usually based on experience of farmers, tradition, expected profit, personal preferences, resources and social requirements. The present dominant crops grown in dry lands in the study area were by marigold (20.8 %) followed by coconut (13.9 %), maize (13.0 %), sorghum (10.9 %), cotton (7.9 %) which are taken during *kharif* and horse gram (15.7 %), maize (7.8 %), groundnut (5.0 %) during *Rabi* season respectively. The cropping intensity was 139.8 per cent (Table 16 and Figure 9).

Table 16: Present cropping pattern and cropping intensity in Maddur 1 Microwatershed

% to Grand Total

Crops	Kharif	Rabi	Grand Total
Coconut	13.9	0.0	13.9
Cotton	7.9	0.0	7.9
Garlic	5.0	0.0	5.0
Groundnut	0.0	5.0	5.0
Horsegram	0.0	15.7	15.7
Maize	13.0	7.8	20.8
Marigold	20.8	0.0	20.8
Sorghum	10.9	0.0	10.9
Grand Total	71.5	28.5	100
Cropping intensity	139.8		

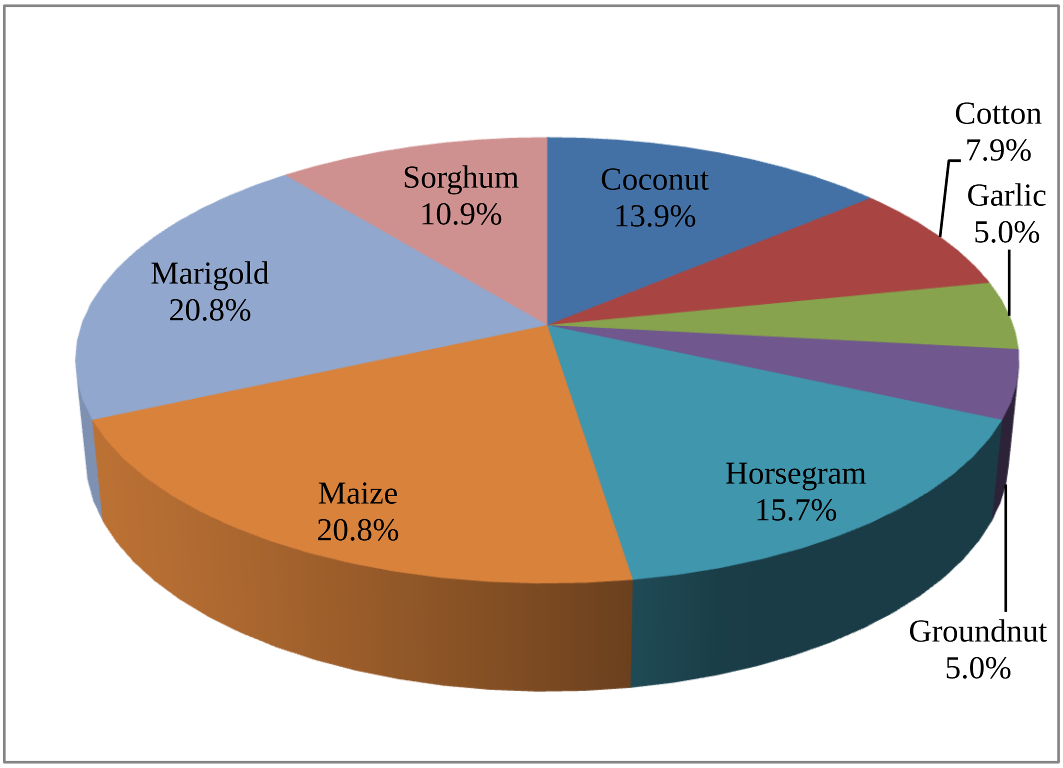

Figure 9: Present cropping pattern in Maddur 1 Microwatershed

Economic land evaluation

The main purpose of economic land evaluation in the watershed is to identify the existing production constraints and propose the potential/alternate options for agro-technology transfer and for bridging the adoption and yield gap.

In Maddur 1 micro-watershed, 6 soil series are identified and mapped (Table 17). The distribution of major soil series are Annurkeri covering an area around 5.6 ha (1.4%) followed by Beemanabeedu 5.3 ha (1.3 %), Berambadi 10.6 ha (2.6 %), Hullipura 75.0 ha (18.9 %), Kannigala 6.7 ha (1.7%), Maddinahundi 28.30 ha (7.1 %).

Table 17: Distribution of soil series in Maddur 1Microwatershed

Sl. No	Soil series	Mapping Unit Description	Area in ha (%)
1	ARK	Annurkeri soils are very deep (>150 cm), well drained, have dark reddish brown to very dusky red sandy clay to clay soils occurring on very gently sloping uplands under cultivation	5.6 (1.4)
2	BMB	Beemanabeedu soils are very deep (>150 cm), moderately well drained, have very dark greyish brown to dark grey and very dark brown clayey soils occurring on very gently sloping lowlands under cultivation	5.3 (1.3)
3	BMD	Berambadi soils are shallow (25-50 cm), well drained, dark brown to dark greyish brown clayey soils occurring on very gently sloping uplands under cultivation	10.6 (2.6)
4	HPR	Hullipura soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown gravelly sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation	75.0 (18.9)
5	KNG	Kannigala soils are moderately deep (75-100 cm), well drained, have dark reddish brown to dark red gravelly sandy clay loam to sandy clay soils occurring on very gently sloping uplands and strongly sloping mounds and ridges	6.7 (1.7)
6	MDH	Maddinahundi soils are deep (100-150 cm), well drained, have dark reddish brown gravelly sandy clay soils occurring on very gently sloping uplands under cultivation	28.3 (7.1)
7	Forest		253.4 (63.9)
8	Habitation		11.2 (2.8)

Present cropping pattern on different soil series are given in Table 18. Crops grown on Annurkeri soil are cotton, horsegram and sorghum. Groundnut, horsegram, maize and marigold on Hullipura soil are grown. Coconut is grown on Kannigala soil. Cotton, garlic and maize on Maddinahundi soil are grown.

Table 18: Cropping pattern on major soil series in Maddur 1 micro-watershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Irrigated		Grand Total
			Kharif	Rabi	Kharif	Rabi	
HPR	Moderately shallow (50-75 cm)	Groundnut	0.0	9.9	0.0	0.0	9.9
		Horsegram	0.0	5.0	0.0	0.0	5.0
		Maize	39.7	5.0	0.0	0.0	44.7
		Marigold	40.4	0.0	0.0	0.0	40.4
KNG	Moderately deep (75-100 cm)	Coconut	100.0	0.0	0.0	0.0	100.0
MDH	Deep (100-150 cm)	Cotton	33.3	0.0	0.0	0.0	33.3
		Garlic	0.0	0.0	33.3	0.0	33.3
		Maize	0.0	0.0	0.0	33.3	33.3
ARK	Very deep (>150 cm)	Cotton	16.7	0.0	0.0	0.0	16.7
		Horse gram	0.0	50.0	0.0	0.0	50.0
		Sorghum	33.3	0.0	0.0	0.0	33.3

Land is used for agricultural use for growing cereals, pulse, oilseeds and commercial crops. The soil/ land potential are measures in terms of physical yield and net income. The alternative land use options for each micro-watershed are given below (Table 19).

Table 19: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Maddur 1 Microwatershed.

Soil Series	Small Farmers	Medium Farmers
HPR	Groundnut 2.0), Maize (1.2), Marigold (1.4)	
KNG		Coconut (4.8)
MDH	Cotton (2.6)	
ARK	Horse gram(3.3), Sorghum (1.2)	

The productivity of different crops grown in Maddur 1 micro-watershed under potential yield of the crops is given in Table 20.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 20. The total cost of cultivation in study area for cotton ranges between Rs.41361/ha in ARK soil (with BCR of 1.19) and Rs.28477/ha in MDH soil (with BCR of 2.26), horse gram the cost of cultivation range between Rs 17522 /ha in HPR soil (with of 1.4) and Rs.7841/ha in ARK soil (with BCR of 3.37), maize the cost of cultivation range between Rs. 32741/ha in HPR soil (with BCR of 1.44) and Rs. 28596/ha in MDH soil (with BCR of 1.85), marigold the cost of cultivation in HPR soil is Rs.37626/ha (with BCR of 1.25), garlic the cost of cultivation in MDH soil is Rs.77781/ha (with BCR of 2.38) and groundnut the cultivation in HPR soil series is Rs. 21057/ha (with BCR of 1.79).

Table 20: Economic land evaluation and bridging yield gap for different crops in Maddur 1micro-watershed

Particulars	HPR (50-75 cm)				KNG (75-100 cm)	MDH (100-150 cm)			ARK (>150 cm)		
	Groundnut	Horsegram	Maize	Marigold	Coconut	Cotton	Garlic	Maize	Cotton	Horsegram	Sorghum
Total cost (Rs/ha)	21057	17522	32741	37626	18791	28477	77781	28596	41361	7841	20179
Gross Return (Rs/ha)	37791	24453	43184	44317	95183	64220	185250	52858	49400	26429	25194
Net returns (Rs/ha)	16734	6931	10443	6691	76392	35743	107469	24262	8039	18588	5015
BCR	1.79	1.40	1.44	1.25	5.07	2.26	2.38	1.85	1.19	3.37	1.25
Farmers Practices (FP)											
FYM (t/ha)	0.0	0.0	2.2	1.4	2.4	1.3	3.8	0.0	0.0	0.0	2.5
Nitrogen (kg/ha)	51.3	42.3	72.4	68.3	63.1	11.3	62.5	62.5	85.0	85.0	85.0
Phosphorus (kg/ha)	57.5	60.1	100.1	85.8	12.5	28.8	86.3	86.3	57.2	57.2	57.2
Potash (kg/ha)	37.5	57.2	24.7	26.6	57.8	75.0	56.3	56.3	18.9	18.9	18.9
Grain (Qtl/ha)	8.8	7.5	32.1	61.1	48.2	12.5	31.3	32.5	12.5	7.5	13.8
Price of Yield (Rs/Qtl)	4300	3200	1444	690	2000	5200	6000	1600	4000	3500	1800
Soil test based fertilizer Recommendation (STBR)											
FYM (t/ha)	8.6	0.0	8.6	19.8	10.0	12.4	24.7	8.6	12.4	0.0	7.4
Nitrogen (kg/ha)	18.5	24.7	116.6	212.2	76.9	111.2	92.6	92.6	111.2	18.5	61.1
Phosphorus (kg/ha)	61.8	37.1	61.8	59.3	81.3	74.1	61.8	61.8	74.1	37.1	56.8
Potash (kg/ha)	23.2	24.7	31.2	59.3	245.0	55.6	46.3	24.1	55.6	18.5	29.6
Grain (Qtl/ha)	17.3	9.9	84.0	98.8	184.5	17.3	79.0	84.0	17.3	9.9	28.4
% of Adoption/yield gap (STBR-FP) / (STBR)											
FYM (%)	100.0	00	74.3	93.1	75.9	89.9	84.8	100.0	100.0	00	66.3
Nitrogen (%)	-176.7	-71.3	37.9	67.8	17.9	89.9	32.5	32.5	23.5	-358.8	-39.0
Phosphorus (%)	6.9	-62.3	-62.2	-44.8	84.6	61.2	-39.7	-39.7	22.8	-54.4	-0.7
Potash (%)	-61.9	-131.7	21.0	55.2	76.4	-35.0	-21.5	-133.6	0.0	-2.0	36.3
Grain (%)	49.4	24.1	61.8	38.2	73.9	27.7	60.5	61.3	27.7	24.1	51.6
Value of yield and Fertilizer (Rs)											
Additional Cost (Rs/ha)	8152	-1878	5396	19610	14525	13906	20035	7285	14140	-1693	4820
Additional Benefits(Rs/ha)	36722	7616	74962	26046	272661	24908	286740	82368	19160	8330	26379
Net change Income(Rs/ha)	28570	9494	69566	6436	258136	11002	266705	75083	5020	10023	21559

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 20. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soil. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs 258136 in coconut and a minimum of Rs 5020 in cotton cultivation.

Economic valuation of Ecosystem Services (ES) was aimed at combining use and non-use values to determine Total Economic Value (TEV) of ES. Ecosystem Services (ES) were valued based on their annual flow or utilization in common monetary units, Rs/year. The valuation of ES was based on market price in 2017 or market cost approaches whichever is applicable, and in other cases on value or benefit transfer from previous valuation studies.

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 21 and Figure 10. The average value of soil nutrient loss is around Rs. 1406 per ha/year. The total cost of annual soil nutrients is around Rs. 184249 per year for the total area of 396.4 ha.

Table 21: Estimation of onsite cost of soil erosion in Maddur 1 micro-watershed

Particulars	**Quantity(kg)**		**Value (Rs)**	
	Per ha	**Total**	**Per ha**	**Total**
Organic matter	185.7	24324	1169.8	153241
Phosphorus	0.1	16	5.4	708
Potash	2.0	258	39.4	5162
Iron	0.5	65	23.8	3114
Manganese	0.5	71	148.0	19392
Cupper	0.0	4	16.5	2162
Zinc	0.0	1	0.4	54
Sulpher	0.1	10	3.0	387
Boron	0.0	1	0.2	30
Total	66.0	24749	1406.5	184249

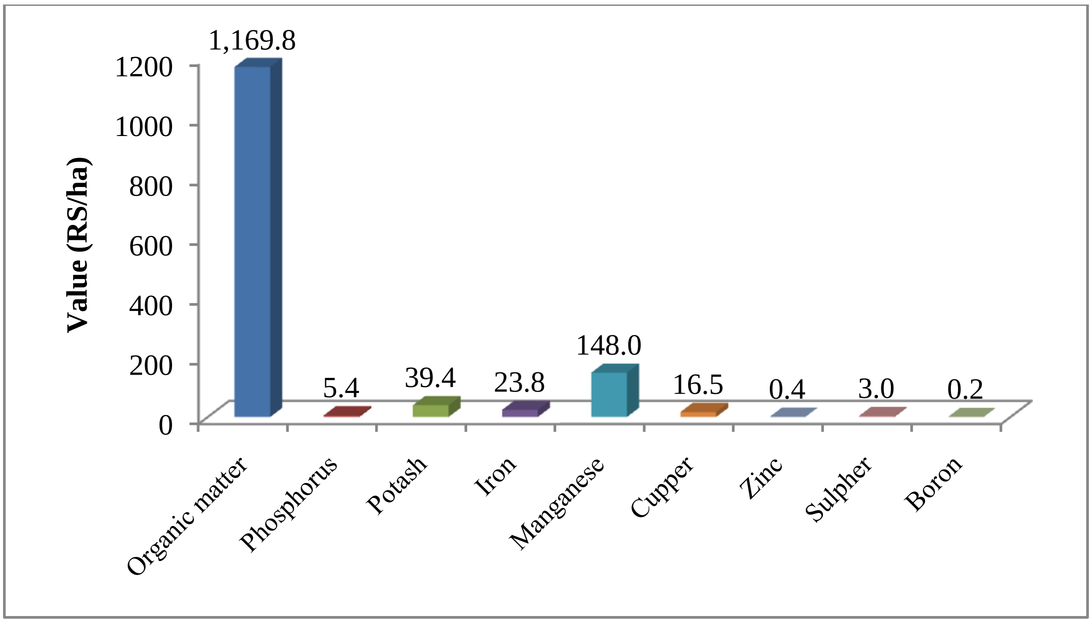

Figure 10: Estimation of onsite cost of soil erosion in Maddur 1micro-watershed

The average value of ecosystem service for food grain production is around Rs. 32001/ ha/year (Table 22 and Figure 11). Per hectare food production services is maximum in garlic (Rs. 107469), coconut (Rs. 76392), cotton (Rs. 21891), groundnut (Rs. 16116), horsegram (Rs. 12142) and maize (Rs. 11625), marigold (Rs. 6101) and sorghum (Rs. 4274).

Table 22: Ecosystem services of food grain production in Maddur 1Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Cereals	Maize	4.5	29.5	1486	43774	32149	11625
	Sorghum	0.8	13.6	1800	24453	20179	4274
Pulses	Horsegram	1.6	7.4	3350	24824	12682	12142
Oil seeds	Coconut	2.1	47.6	2000	95183	18791	76392
	Groundnut	0.8	8.6	4300	37174	21057	16116
Commercial Crops	Cotton	1.2	12.4	4600	56810	34919	21891
	Marigold	3.3	62.6	698	43727	37626	6101
Spice crops	Garlic	0.8	30.9	6000	185250	77781	107469
Average value		15.1	26.6	3029	63899	31898	32001

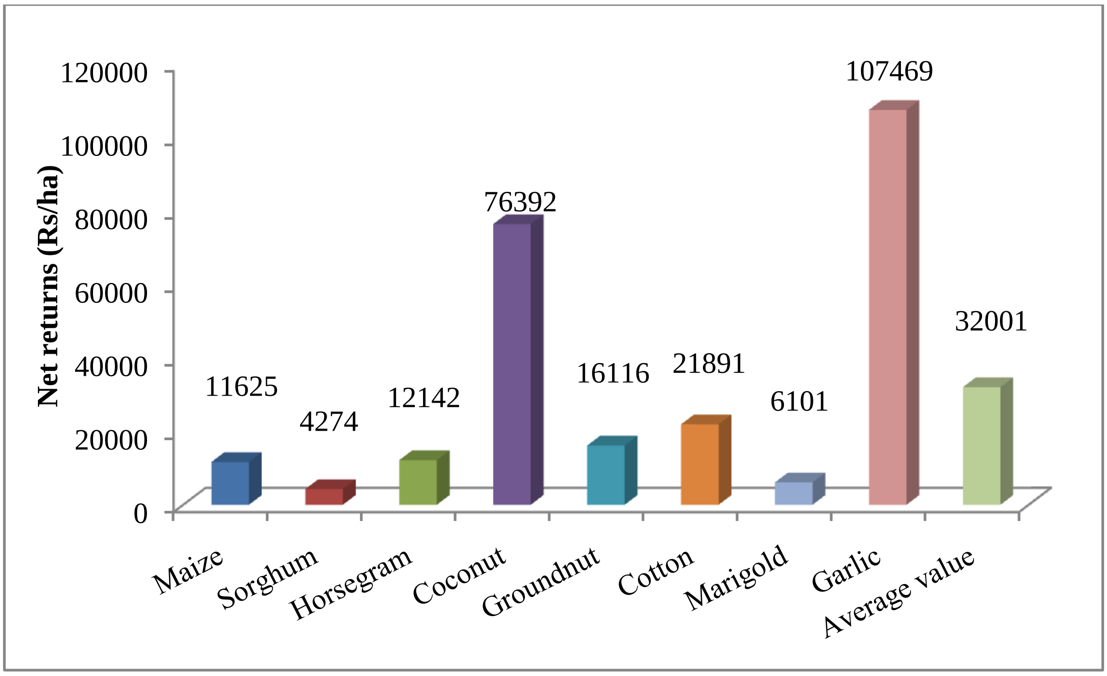

Figure 11: Ecosystem services of food grain production in Maddur 1Microwatershed

The average value of ecosystem service for fodder production is around Rs. 812 / ha/year (Table 23). Per hectare fodder production services is maximum in maize (Rs 1270), followed by sorghum (Rs 741), horse gram (Rs 618), and groundnut (Rs 618).

Table 23: Ecosystem services of fodder production in Maddur 1 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	4.45	2.12	600	1270
	Sorghum	0.81	1.24	600	741
Pulses	Horsegram	1.62	1.03	600	618
Oil seeds	Groundnut	0.81	1.24	500	618
Average value		7.69	1.40	575	812

Table 24: Ecosystem services of water supply in Maddur 1 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Coconut	47.6	12787	127878	268
Cotton	12.4	4975	49758	402
Garlic	30.9	1818	18185	58
Groundnut	8.7	2405	24050	278
Horsegram	7.4	2280	22808	307
Maize	29.5	3600	36004	122
Sorghum	13.6	4140	41407	304
Average value	23.1	4057	40579	175

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 25 and Figure 12) in coconut (Rs. 127878), cotton (Rs. 49758), sorghum (Rs. 41407), maize (Rs. 36004), groundnut (Rs. 24050), horse gram (Rs. 22808) and garlic (18185).

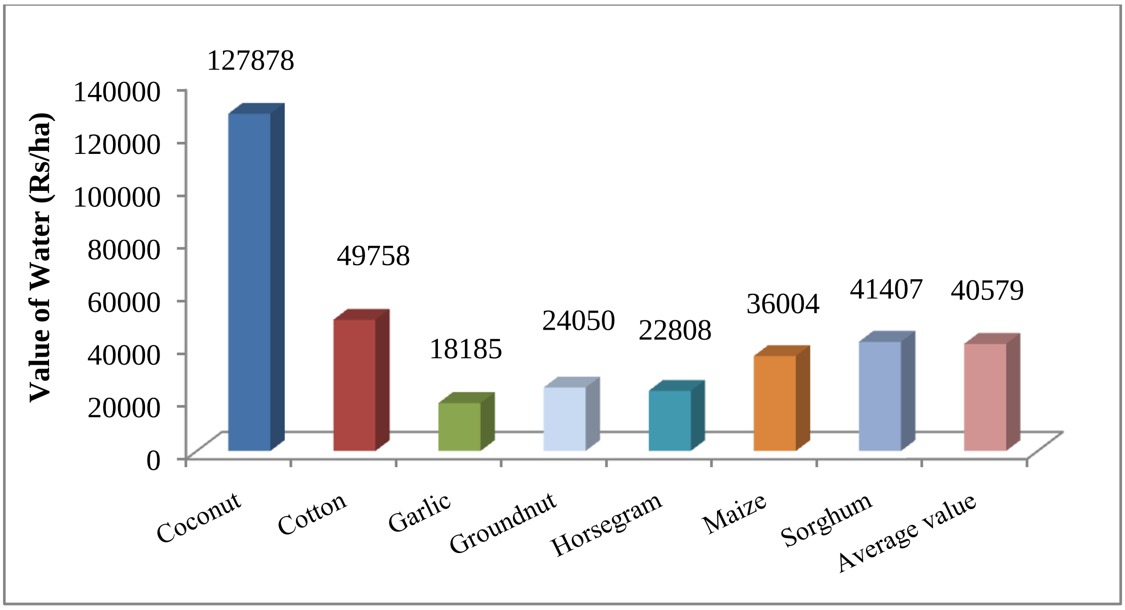

Figure 12: Ecosystem services of water supply in Maddur 1 Micro watershed

The main farming constraints in maddur 1 micro-watershed to be found are less rainfall, lack of good quality seeds, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 25).

Table 25: Farming constraints related land resources of sample households in Maddur 1 Microwatershed.

Sl.No	Particulars	Per cent
1	Less Rainfall	80.0
2	Lack of good quality seeds	10.0
3	Non availability Fertilizers	10.0
4	Lack of transportation	10.0
5	Damage of crops by Wild Animals	100
6	**Source of loan**	
	Money Leander	100
7	**Market for selling**	
	Village market	100
8	**Sources of Agri-Technology information**	
	Newspaper	100

The findings of the study would be very much useful to the planners and policy makers of the study area to identify the irrationality in the existing production pattern and to suggest appropriate production plans for efficient utilization of their scarce resources resulting in increased net farm incomes and employment. The study also throws light on future potentialities of increasing net farm income and employment under different situations viz., with existing and recommended technology.