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

SONATH-1 (4D5B7G2b) MICROWATERSHED

Gulbarga Taluk, Gulbarga District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project



ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING



ICAR - NBSS & LUP



**WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE**



About ICAR - NBSS&LUP

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. The challenges 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 Inventory. 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 Sonath-1 Microwatershed, Gulbarga Taluk, Gulbarga District, Karnataka” for integrated development was taken up in collaboration with the State Agricultural Universities, IISC, KRSRAC, 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 randomly selected representing landed and landless class of farmers in the microwatershed. 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, agricultural extension 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

Date: 05.02.2018

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Sonath-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 these 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 boundaries. The soil map shows the geographic distribution and extent, characteristics, classification, behaviour and use potentials of the soils in the microwatershed.

The present study covers an area of 445 ha in Sonath -1 microwatershed in Gulbarga taluk of Gulbarga district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 740 mm, of which about 540 mm is received during south-west monsoon, 126 mm during north-east and the remaining 74 mm during the rest of the year. An area of about 96 per cent is covered by soils, four per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- ❖ The soils belong to 5 soil series and 14 soil phases (management units) and 5 land use classes.
- ❖ The length of crop growing period is about 120-150 days starting from the 3rd week of May to 1st week of October.
- ❖ 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 19 major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.
- ❖ About 80 per cent area is suitable for agriculture and 16 per cent is not suitable for agriculture.
- ❖ About 65 per cent area has very shallow (<25 cm) to shallow (25-50 cm) and about 31 per cent are moderately deep (75-100 cm) to very deep (>150 cm) soils.
- ❖ About 72 per cent of the area has clayey soils and about 24 % loamy soils at the surface.
- ❖ About 55 per cent of the area has non-gravelly soils, 12 per cent gravelly to very gravelly soils (15-60 % gravel) and 29 per cent extremely gravelly soils (60-80%).
- ❖ About 65 per cent of the area has soils that are very low (<50mm/m) to low (51-100 mm/m), 7 per cent medium (100-150 mm/m) and about 24 per cent very high (>200 mm/m) in available water capacity.
- ❖ About 67 per cent of the area has very gently sloping (1-3%), about 13 per cent area is gently sloping (3-5%) and about 16 per cent area has moderately sloping (5-10%) lands.
- ❖ An area of about 34 per cent has soils that are slightly eroded (e1), 33 per cent moderately eroded (e2) and 29 per cent severely eroded (e3).
- ❖ An area of about 23 per cent has soils that are slightly alkaline (pH 7.3 to 7.8), about 37 per cent moderately alkaline (pH 7.8-8.4), about 15 per cent strongly alkaline (pH 8.4-9.0) and 22 per cent area is neutral (pH 6.5-7.3) in soil reaction.

- ❖ *The Electrical Conductivity (EC) of the soils are dominantly $<2 \text{ dsm}^{-1}$ indicating that the soils are non-saline.*
- ❖ *About 21 per cent medium (0.5-0.75%) and 76 per cent high ($>0.75\%$) in organic carbon.*
- ❖ *Major area of 47 per cent has soils that are low ($<23 \text{ kg/ha}$), 46 per cent medium (23-57 kg/ha) and 4 per cent high ($>57 \text{ kg/ha}$) in available phosphorus.*
- ❖ *About 7 per cent low ($<145 \text{ kg/ha}$), 67 per cent medium (145-337 kg/ha) and 23 per cent high ($>337 \text{ kg/ha}$) in available potassium.*
- ❖ *Available sulphur is low ($<10 \text{ ppm}$) in about 16 per cent area and medium (10-20 ppm) in 81 per cent area.*
- ❖ *Available boron is low ($<0.5 \text{ ppm}$) in about 52 per cent area and 44 per cent medium (0.5-1.0 ppm).*
- ❖ *About 11 per cent area has soils that are deficient ($<4.5 \text{ ppm}$) in available iron and 86 per cent sufficient ($>4.5 \text{ ppm}$).*
- ❖ *Available manganese and copper are sufficient in all the soils.*
- ❖ *About 82 per cent area has soils that are deficient ($<0.6 \text{ ppm}$) in available zinc and 14 per cent sufficient ($>0.6 \text{ ppm}$).*
- ❖ *The land suitability for 19 major crops grown in the microwatershed was 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, market 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)
<i>Sorghum</i>	140 (31)	-	<i>Sapota</i>	-	-
<i>Maize</i>	-	-	<i>Jackfruit</i>	-	-
<i>Red gram</i>	-	140 (31)	<i>Jamun</i>	-	107 (24)
<i>Sunflower</i>	140 (31)	-	<i>Musambi</i>	107 (24)	33 (7)
<i>Cotton</i>	107 (24)	33 (7)	<i>Lime</i>	107 (24)	33 (7)
<i>Sugarcane</i>	-	-	<i>Cashew</i>	-	-
<i>Soybean</i>	140 (31)	-	<i>Custard apple</i>	140 (31)	-
<i>Bengal gram</i>	140 (31)	75 (17)	<i>Amla</i>	140 (31)	-
<i>Guava</i>	-	-	<i>Tamarind</i>	-	107 (24)
<i>Mango</i>	-	-			

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 5 identified LUCs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops that helps in sustained production and also maintaining in the ecological balance in the microwatershed.

- ❖ *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, field bunds and also in the hillocks, mounds and ridges. This would help in not only supplementing the farm income but also provides fodder and fuel and generate lot of biomass. This helps in maintaining an ecological balance and also contributes to mitigating the climate change.*

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socioeconomic development of its people. Soils provide food, fodder, fibre and fuel for meeting the basic human and animal needs. With the ever increasing growth in human and animal population, the demand on soil for more food and fodder production is on the increase. 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. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. 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 in more than 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 the 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 like 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 map for LRI. LEU is the assemblage of landform, slope and land use. An attempt has already been made to upscale the soil resource information from 1:250000 and 1:50000 scale to the LEU map in Goa and in some other states. Here, an attempt will be made later to uplink the LRI data generated under Sujala-III Project to the Landscape Ecological Units (LEUs) map.

The land resource inventory aims to provide site specific database for Sonath-1 microwatershed in Gulbarga Taluk, Gulbarga 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.

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.

GEOGRAPHICAL SETTING

2.1 Location and Extent

The study area of Sonath-1 microwatershed (Sonath subwatershed) is located in the northern part of Karnataka in Gulbarga Taluk, Gulbarga District, Karnataka State (Fig.2.1). It comprises parts of Mormanchi, Malsapur, Sonath, Kinhi, Chengta and Margutti villages. It lies between $17^{\circ} 35'$ and $17^{\circ} 37'$ North latitude and between $77^{\circ} 05'$ and $77^{\circ} 07'$ East longitude and covers an area of 445 ha. It is about 50 km from Gulbarga town and is surrounded by Mormanchi on the northwest, Malsapur on the northeast, Kinhi on the southeast, Sonath on the east, Chengta on the south and Margutti village on the west.

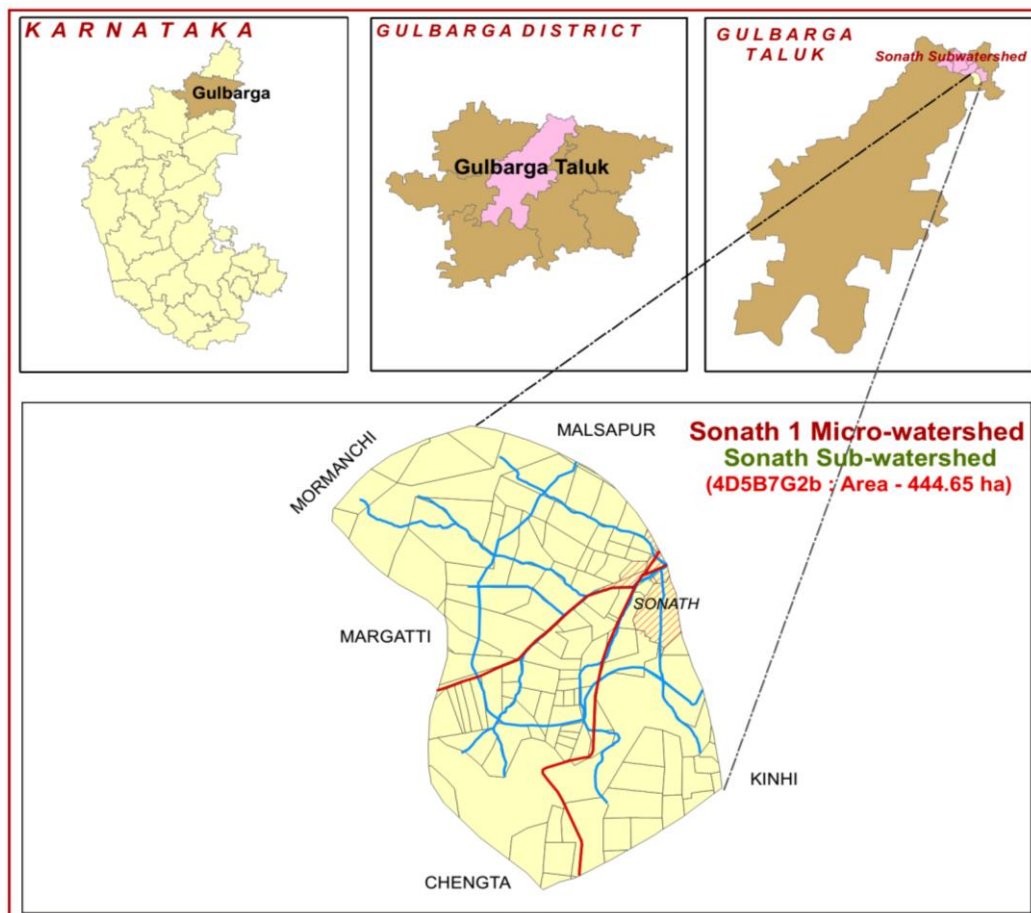


Fig.2.1 Location map of Sonath-1 Microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Basalt (Fig.2.2) or Deccan Trap. The Deccan Traps cover the whole of Bidar, parts of Gulbarga, Bijapur and Belgaum districts. In all, eight lava flows have been identified in Karnataka horizontally overlying the older formations. The thickness of the individual flows averages about five meters. It is relatively uniform in petrographic character. The most common type is augite

basalt. Dominant colour is grayish green and texture ranges from cryptocrystalline to glassy. The rock is often vesicular and scoriaceous filled up with secondary minerals like coloured agate, quartz, calcite and a large variety of zeolites. The Deccan Traps form an excellent building material and also used as road-metal and railway ballast.



Fig. 2.2 Basalt rocks

2.3 Physiography

Physiographically, the area has been identified as basalt landscape based on geology. The area has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands based on slope and its relief features. The elevation ranges from 590 to 673 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

The area is drained by several small parallel streams that join Monia nala which further down stream joins Awarja river 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 the water that flows during the rainy season. Due to this, the ground water recharge is very much affected. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing new tanks and recharge structures at appropriate places in the villages, then the drinking and irrigation needs of the area can be easily met. The drainage network is parallel to sub parallel and dendritic.

2.5 Climate

The Gulbarga district lies in the northern plains of Karnataka and falls under semiarid tract of the state and is categorized as drought- prone with average annual

rainfall of 740 mm (Table 2.1). Of the total rainfall, maximum of 540 mm is received during the south–west monsoon period from June to September, the north-east monsoon from October to early December contributes about 126 mm and the remaining 74 mm during the rest of the year. December is the coldest month with mean daily maximum and minimum temperatures being 29.5⁰C and 15⁰ to 10⁰C respectively. During peak summer, temperatures shoot up to 45⁰C. Relative humidity varies from 26 per cent in summer to 62 per cent in winter. Rainfall distribution is shown in Figure 2.3. The average Potential Evapo -Transpiration (PET) is 159 mm and varies from a low of 115 mm in December to 232 mm in the month of May. The PET is always higher than precipitation in all the months except in the month of August to September. Generally, the Length of crop Growing Period (LGP) is 120-150 days and starts from 3rd week of May to first week of October.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET at Gulbarga Taluk

Sl.No.	Months	Rainfall	PET	1/2 PET
1	January	5.7	126.8	63.40
2	February	3.6	143.9	71.95
3	March	13.2	189.9	94.95
4	April	17.4	209.8	104.9
5	May	33.6	232.2	116.1
6	June	90.4	186.4	93.2
7	July	138.0	152.8	76.4
8	August	150.4	147.6	73.8
9	September	161.2	131.7	65.85
10	October	102.8	145.5	72.75
11	November	18.7	129.8	64.9
12	December	4.4	114.8	57.4
Total		739.4	159.2	

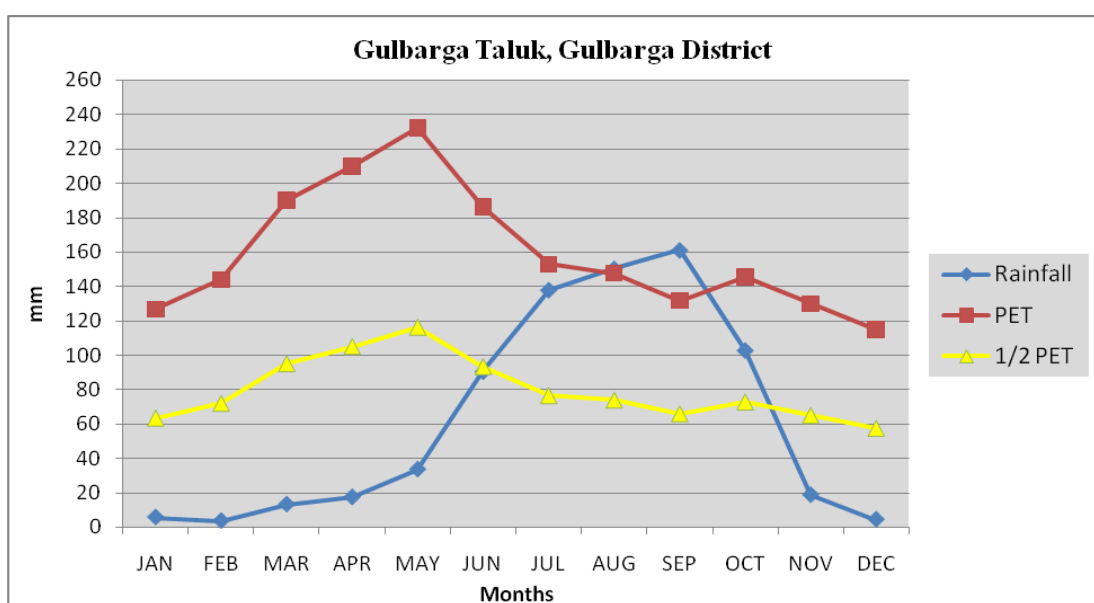


Fig 2.3 Rainfall distribution in Gulbarga Taluk

2.6 Natural Vegetation

The natural vegetation is sparse comprising few tree species, shrubs and herbs. The forest occupy an area of about 2 per cent. The mounds, ridges and boulders occupy very sizeable area which is 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).

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 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 that eventually result in the heavy siltation of tanks and reservoirs in the microwatershed.



Fig. 2.4 Natural Vegetation (Scrub) of Sonath-1 Microwatershed

2.7 Land Utilization

About 77 per cent area (Table 2.2) in Gulbarga taluk is cultivated at present. An area of about 2 per cent is permanently under pasture, 11 per cent under current fallows, 5 per cent under nonagricultural land and 2 per cent under currently barren. Forests occupy an area of about 2 per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are sorghum, maize, cotton, sugarcane, red gram and sapota. The cropping intensity is about 102 per cent. 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 prepared. The current land use map prepared shows the arable and

non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Sonath-1 microwatershed is presented in Fig.2.5. Simultaneously, enumeration of wells (bore wells and open wells) and existing conservation structures in the microwatershed was made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells, conservation structures and other water bodies in Sonath-1 microwatershed is given in Fig.2.6.

Table 2.2 Land Utilization in Gulbarga Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	173165	
2.	Total cultivated area	132954	76.77
3.	Area sown more than once	2510	1.44
4.	Cropping intensity	-	101.89
5.	Trees and grooves	67	0.038
6.	Forest	4121	2.37
7.	Cultivable wasteland	78	0.045
8.	Permanent Pasture land	4322	2.49
9.	Barren land	4223	2.43
10.	Non- Agriculture land	8150	4.70
11.	Current Fallows	18760	10.8

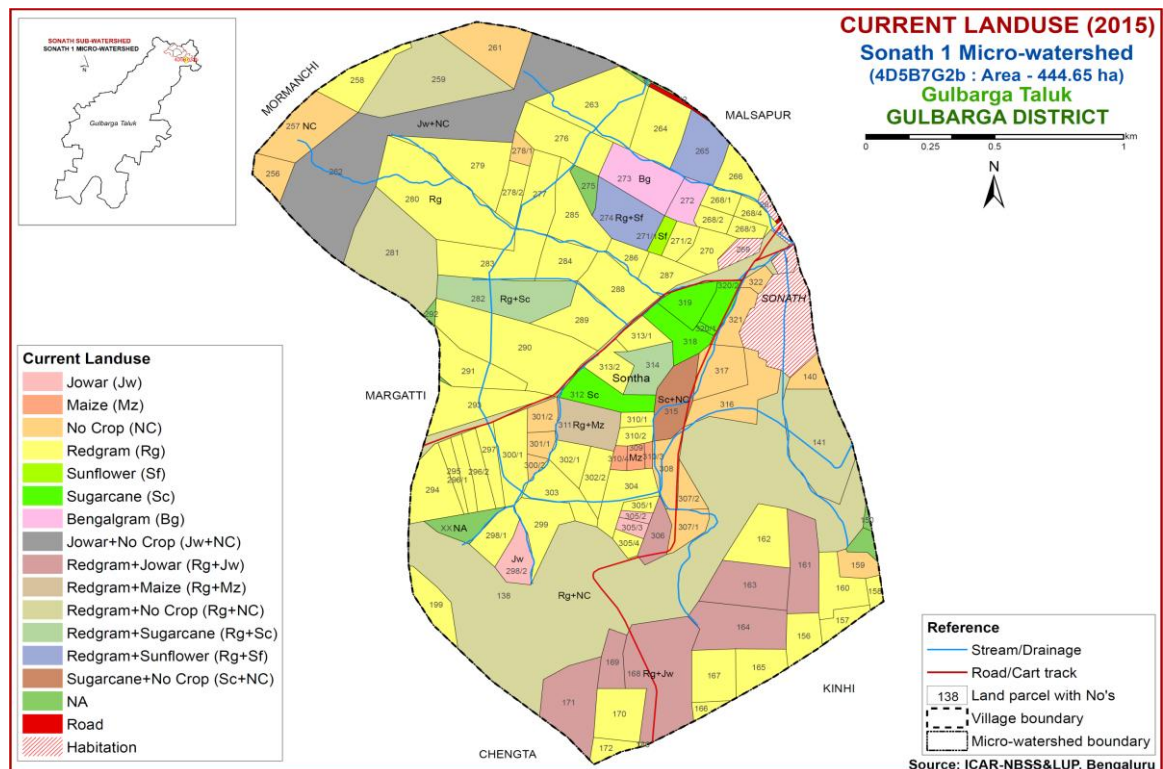


Fig.2.5 Current Land Use map of Sonath-1 Microwatershed

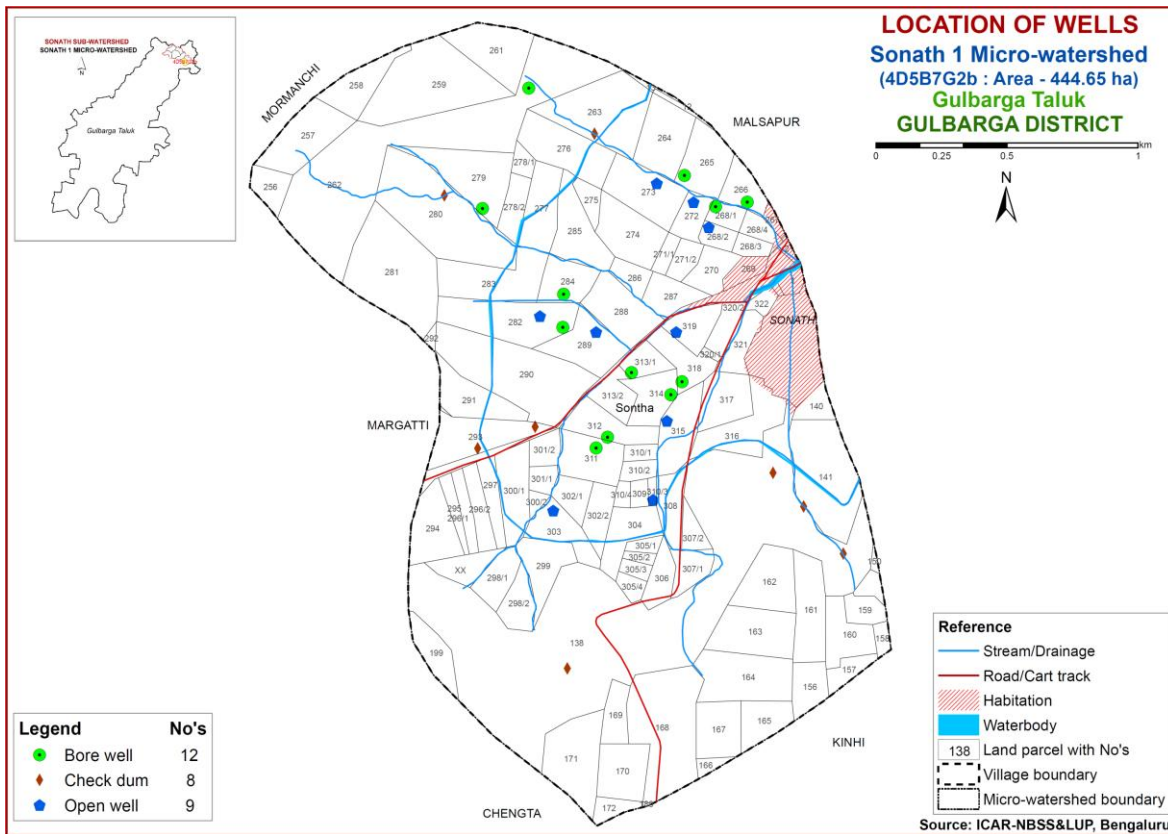


Fig.2.6 Location of Wells and Structures in Sonath-1 Microwatershed

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 Sonath-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 (slope of the land, 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 area extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in 445 ha area. 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 as a base. 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 rock types, 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 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 (FCCs) of Cartosat-I and LISS-IV merged satellite data covering 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 basalt landscape. It was divided into three landforms, *viz.*; ridges and mounds, uplands and lowlands based on slope and image characteristics. They were further subdivided into physiographic/image interpretation units based on image characteristics.

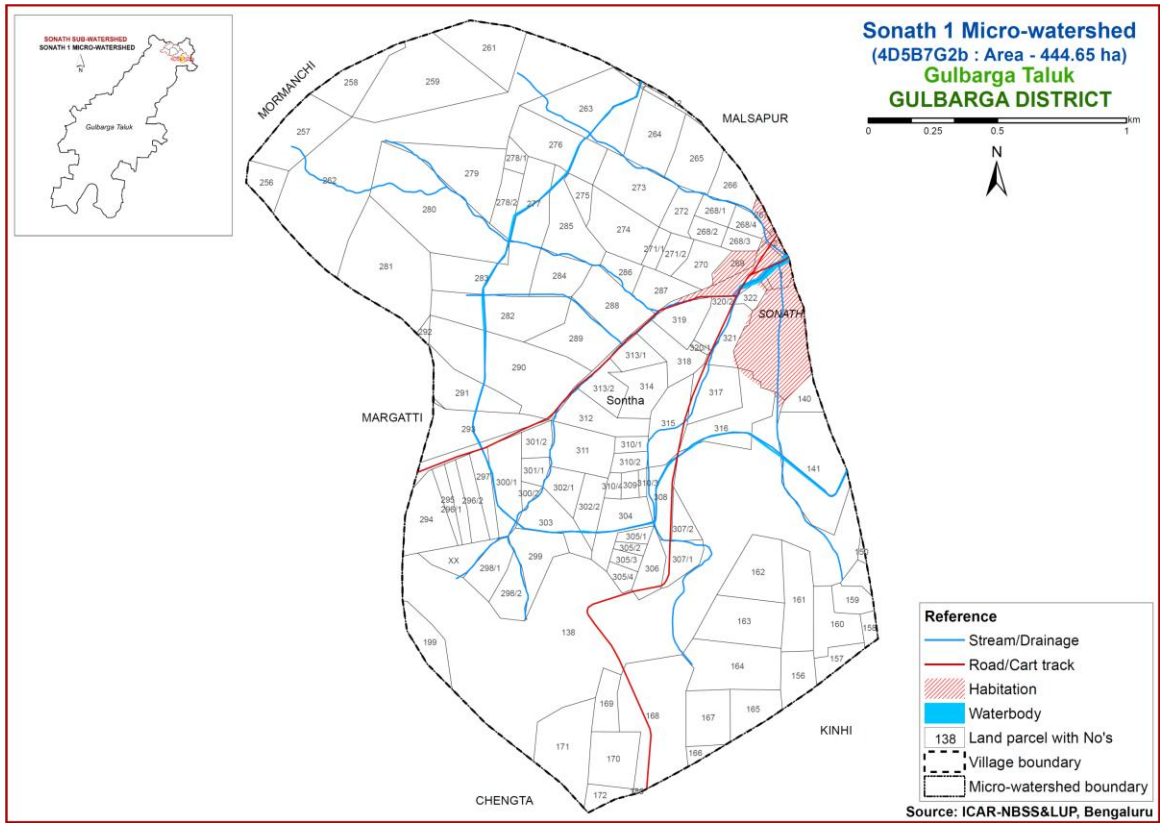


Fig 3.1 Scanned and Digitized Cadastral map of Sonath-1 Microwatershed

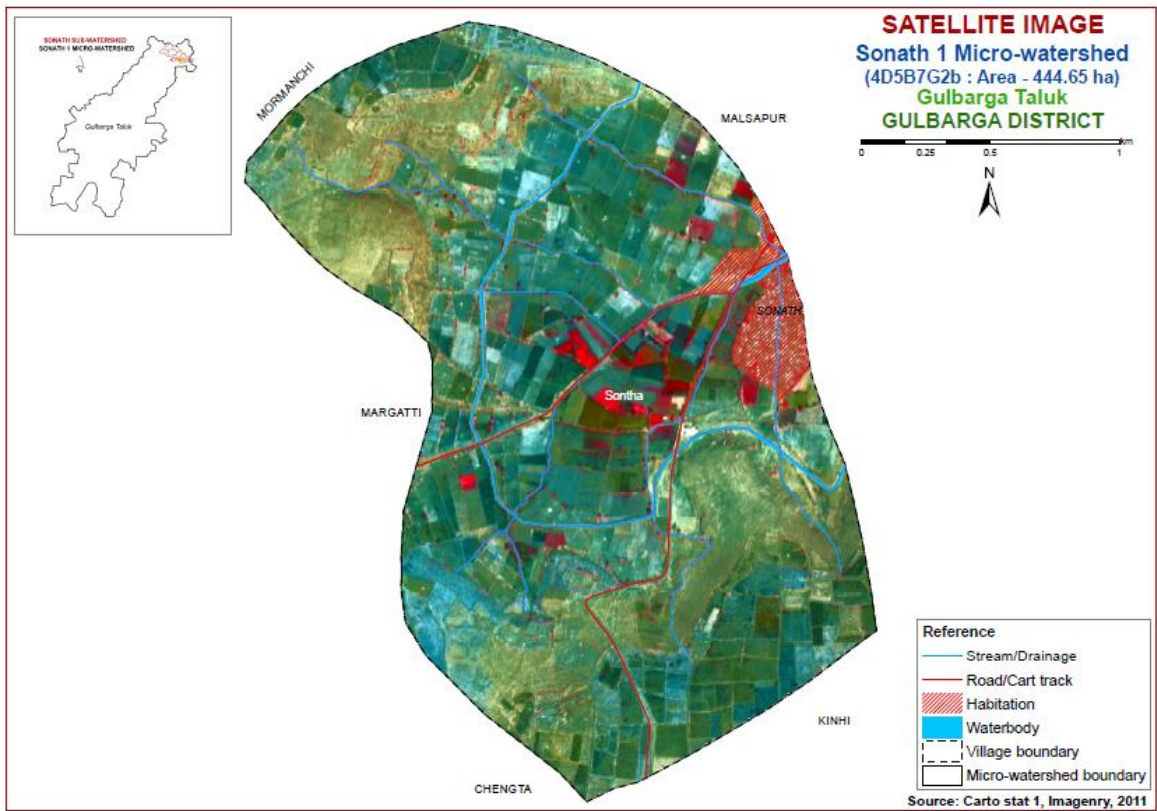


Fig.3.2 Satellite Image of Sonath-1 Microwatershed

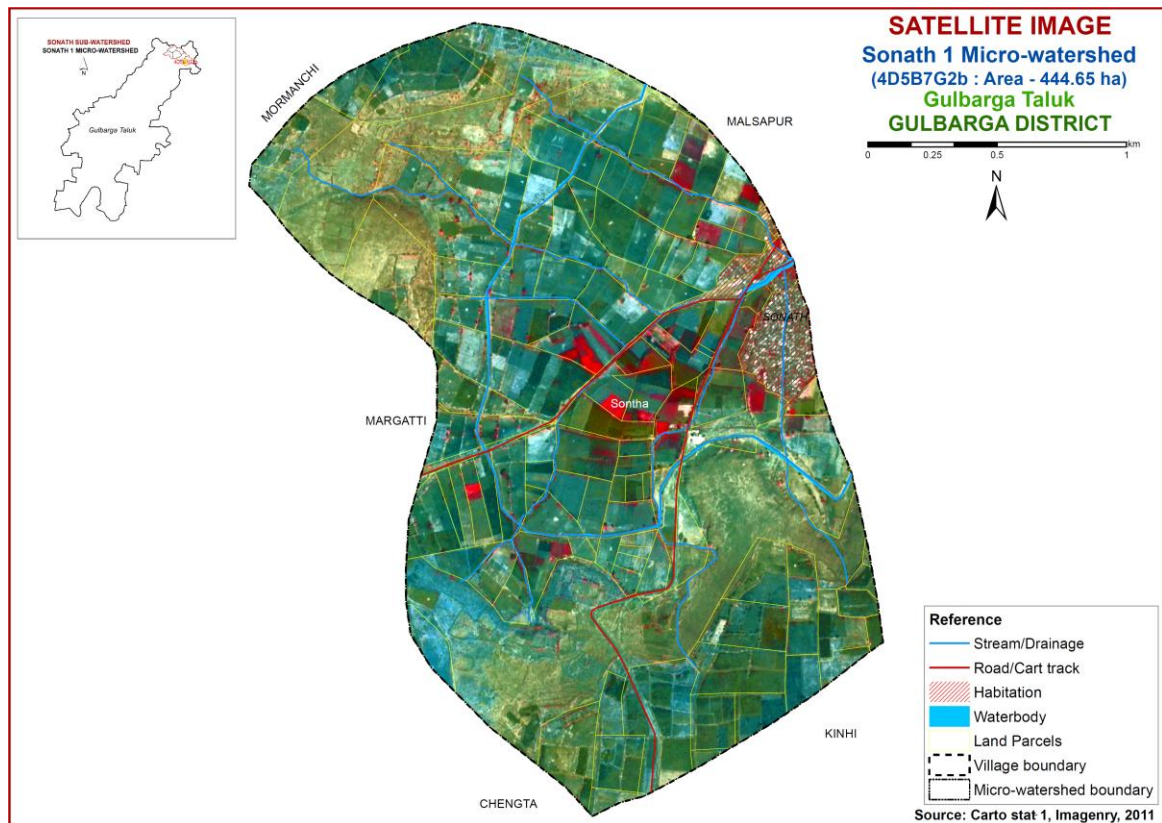


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Sonath-1 Microwatershed

3.3 Field Investigation

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 prepared by studying soils at a few selected places. 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. 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).

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.

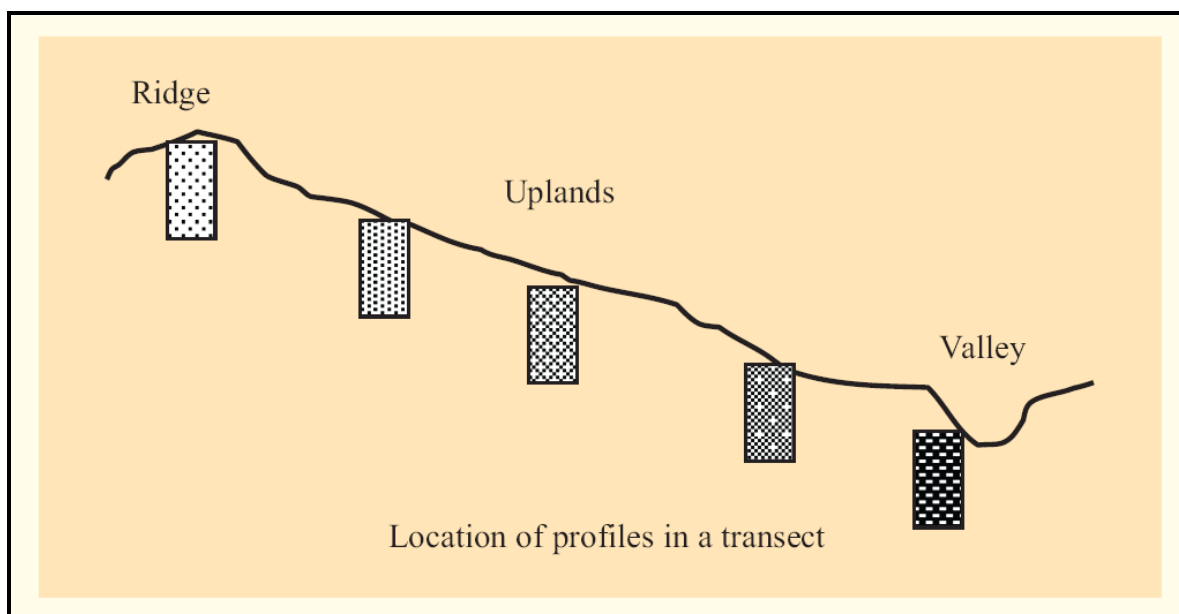


Fig: 3.4. Location of profiles in a transect

Based on the soil-site 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, calcareousness etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying soil series are given in Table 3.1. Based on the above characteristics, 5 soil series were identified in the Sonath-1 microwatershed.

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

SOILS OF BASALT LANDSCAPE							
Sl. No.	Soil Series	Depth (cm)	Colour (moist)	Texture	Gravel (%)	Horizon sequence	Calcareousness
1	Margutti (MGT)	<25	10YR 3/3,4/3,5/4 7.5YR 4/3	c	15-35	Ap- cr	-
2	Matki (MAT)	<25	5YR 3/2,3/3,3/4	c-sc	15-35	Ap-R	-
3	Novinihala (NHA)	25-50	10YR 3/2,3/1,4/2 7.5YR 3/4	c	<15	Ap- Bw- cr	-
4	Nirgudi (NIR)	75-100	10YR 3/2,3/1	c	<15	Ap- BA- Bss-cr	e-es
5	Mannur (MAR)	>150	10YR 3/2,3/1,4/3	c	<15	Ap- BA- Bss	e-es

3.4 Soil Mapping

The area under each soil series was further separated and mapped as 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 about 14 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 14 mapping units representing 5 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 14 phases identified and 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 have to be treated accordingly.

The 14 soil phases identified and mapped in the microwatershed were grouped into 5 Land Use Classes (LUC'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 Use Classes (LUCs) based on the management needs. One or more than one soil site characteristic having influence on the management have been chosen for identification and delineation of LUCs. For Sonath-1 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUCs. The land use classes are expected to behave similarly for a given level of management.

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 in the year 2015 from farmers fields (67 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory. (Katyral and Rattan, 2003) By linking the soil fertility data to the survey numbers through GIS using kriging method, soil fertility maps for 11 elements including pH and EC were generated for the microwatershed.

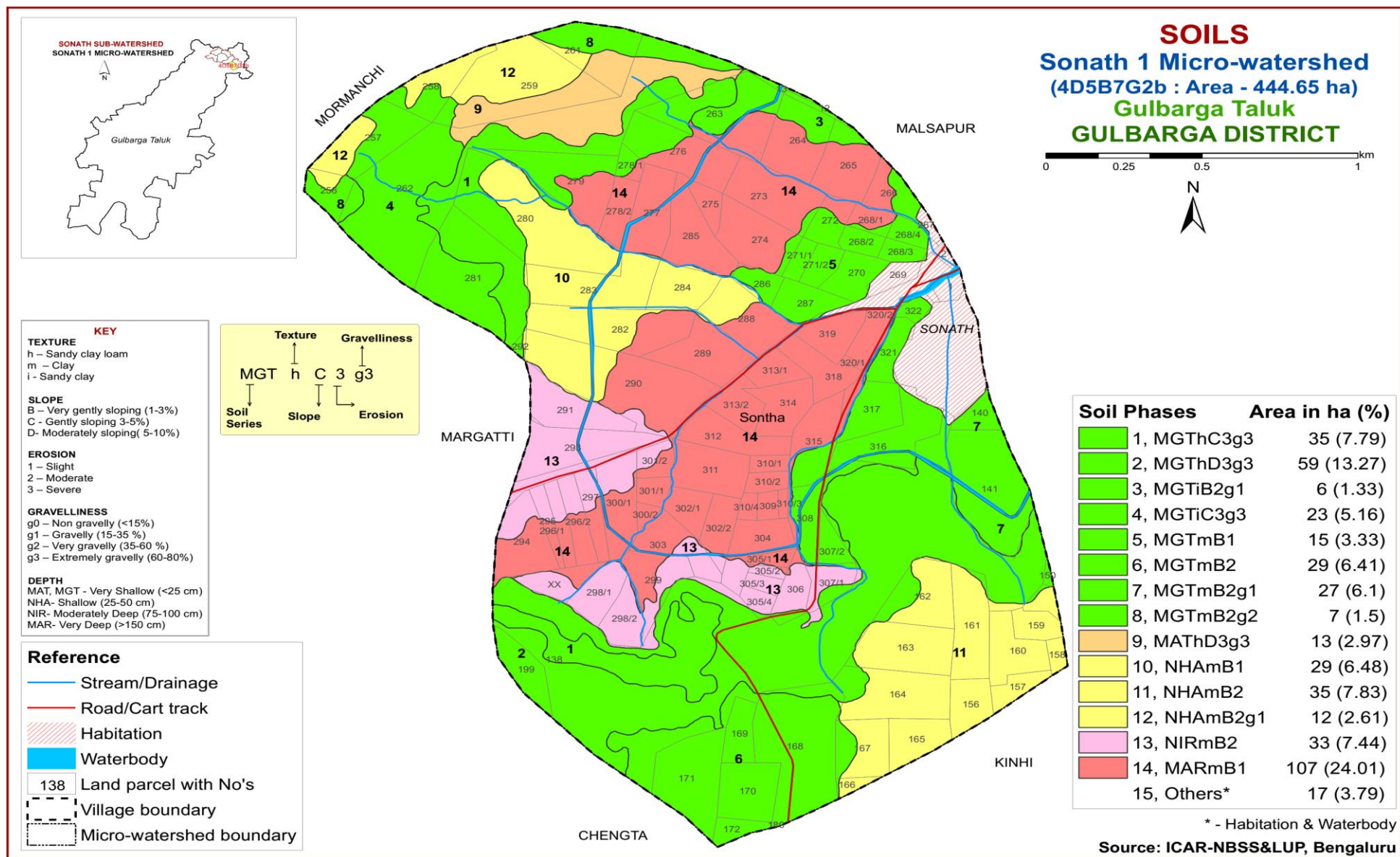


Fig 3.5 Soil phase or management units map of Sonath-1 Microwatershed

**Table 3.2 Soil Map Unit Description of Sonath-1 Microwatershed
(Soil Legend)**

Soil Map Unit No.	Soil Series	Soil Phases	Mapping Unit description	Area in ha (%)
Soils of Basalt Landscape				
	MGT		Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clay soils occurring on very gently sloping to moderately sloping uplands.	102.53 (15.79)
1		MGThC3g3	Sandy clay loam surface, 3-5 % slope, severe erosion, extremely gravelly (60-80 %)	34.63 (7.79)
2		MGThD3g3	Sandy clay loam surface, 5-10 % slope, severe erosion, extremely gravelly (60-80 %)	58.99 (13.27)
3		MGTiB2g1	Sandy clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	5.93 (1.33)
4		MGTiC3g3	Sandy clay surface, 3-5 % slope, severe erosion, extremely gravelly (60-80 %)	22.93 (5.16)
5		MGTmB1	Clay surface, 1-3% slope, slight erosion	14.80 (3.33)
6		MGTmB2	Clay surface, 1-3% slope, moderate erosion	28.50 (6.41)
7		MGTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	27.11 (6.10)
8		MGTmB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)	6.68 (1.50)
	MAT		Matki soils are very shallow (<25cm), well drained, have dark reddish brown to dark reddish gray clay soils occurring on moderately sloping uplands	13.22 (2.97)
9		MAThD3g3	Sandy clay loam surface, 5-10 % slope, severe erosion, extremely gravelly (60-80 %)	13.22 (2.97)
	NHA		Novinihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clay soils and occurring on very gently sloping uplands	75.19 (16.92)
10		NHAmB1	Clay surface, 1-3% slope, slight erosion	28.80 (6.48)
11		NHAmB2	Clay surface, 1-3% slope, moderate erosion	34.80 (7.83)
12		NHAmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	11.59 (2.61)
	NIR		Nirgudi soils are moderately deep (75-100 cm), moderately well drained, have very dark grayish brown to very dark gray calcareous cracking clay soils occurring on very gently sloping uplands	33.07 (7.44)
13		NIRmB2	Clay surface, 1-3% slope, moderate erosion	33.07 (7.44)
	MAR		Mannur soils are very deep (>150 cm), moderately well drained, have very dark gray to brown calcareous cracking clay soils occurring on very gently sloping uplands	106.75 (24.01)
14		MARmB1	Clay surface, 1-3% slope, slight erosion	106.75 (24.01)

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Sonath-1 microwatershed is provided in this chapter. The microwatershed area has been identified as basalt landscape. In all, 5 soil series were identified in this landscape. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In the basalt landscape, it is by parent material, relief and climate. Brief description of each of the 5 soil series identified and mapped and their soil phases are furnished below. The soil phases identified and mapped under each soil series are described and given in Table 3.2. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristic 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 Basalt Landscape

In this landscape, 5 soil series are identified and mapped as soil phases. Of this, Margutti (MGT) soil series occupies maximum area of about 200 ha (45%) followed by Mannur (MAR) 107 ha (24%). The brief description of each series identified and mapped is given below.

4.1.1 Margutti (MGT) Series: Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clay soils. They have developed from basalt and occur on very gently sloping to moderately sloping uplands.

The total depth of the soil ranges from 10 to 21 cm. The thickness of A horizon ranges from 10 to 24 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 3. Its texture is clay with 15 to 35 per cent gravel. The available water capacity is very low (<50 mm/m). Eight phases were identified and mapped.



Landscape and Soil Profile Characteristics of Margutti (MGT) Series

4.1.2 Matki (MAT) Series: Matki soils are very shallow (<25cm), well drained, have dark reddish brown to dark reddish gray clay soils. They have developed from basalt and occur on moderately sloping uplands.

The total depth of the soil is <25 cm. The thickness of A horizon ranges from 7 to 20 cm. Its colour is in 5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with 15 to 35 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 Matki (MAT) Series

4.1.3 Novanihala (NHA) Series: Novanihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 28 to 50 cm. The thickness of A horizon ranges from 8 to 15 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from sandy clay to clay with 10 to 20 per cent gravel.

The thickness of B horizon ranges from 32 to 40 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with gravel content of 10-15 per cent. The available water capacity is low (51-100 mm/m). Three phases were identified and mapped.



Landscape and Soil Profile Characteristics of Novanihala (NHA) Series

4.1.4 Nirgudi (NIR) Series: Nirgudi soils are moderately deep (75-100 cm), moderately well drained, have very dark grayish brown to very dark gray calcareous cracking clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 78 to 95 cm. The thickness of A horizon ranges from 10 to 22 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 2. The texture is clay. The thickness of B horizon ranges from 63 to 79 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 1. Its texture is clay and calcareous with gravel content of less than 15 per cent. The available water capacity is medium (101-150 mm/m). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Nirgudi (NIR) Series

4.1.5 Mannur (MAR) Series: Mannur soils are very deep (>150 cm), moderately well drained, have very dark gray to brown calcareous cracking clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 14 to 25 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 1. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 128 to 147 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 1. Its texture is clay and calcareous with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Mannur (MAR) Series

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

The most important soil and site characteristics that affect the land use and conservation needs of an area are land capability, soil depth, soil 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 interpretative and thematic maps are generated. These would help in identifying the areas suitable for growing crops and, soil and water conservation measures and structures needed thus helping to maintain good soil health for sustained crop production. The various interpretative and 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: Depth, texture, gravel content, calcareousness.

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: They are very good lands that have no limitations or very few limitations that restrict their use.

Class II: They are good lands that have minor limitations and require moderate conservation practices.

Class III: They are moderately good lands that have moderate limitations that reduce the choice of crops or that require special conservation practices.

Class IV: They are fairly good lands that have very severe limitations that reduce the choice of crops or that require very careful management.

Class V: Soils in these lands are not likely to erode, but have other limitations like wetness that are impractical to remove and as such not suitable for agriculture, but suitable for pasture or forestry with minor limitations.

Class VI: The lands have severe limitations that make them generally unsuitable for cultivation, but suitable for pasture or forestry with moderate limitations.

Class VII: The lands have very severe limitations that make them unsuitable for cultivation, but suitable for pasture or forestry with major limitations.

Class VIII: Soil and other miscellaneous areas (rock lands) that have very severe limitations that nearly preclude their use for any crop production, but suitable for wildlife, recreation and installation wind mills.

The land capability subclasses are recognised based on the dominant limitations observed within a given land 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/alkali 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 thus identified 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 14 soil map units identified in the Sonath-1 microwatershed are grouped under 4 land capability classes and 5 land capability subclasses. About 80 per cent area in the microwatershed is suitable for agriculture (Fig. 5.1) and 16 per cent is not suitable for agriculture.

Of the lands suitable for agriculture, good cultivable lands (Class II) cover about 24 per cent area and are distributed in the western, central and northeastern part of the microwatershed with minor problems of soil. Moderately good cultivable lands (Class III) cover an area of about 7 per cent and are distributed in the western and central part of the microwatershed with moderate problems of soil and erosion. The fairly good cultivable lands (Class IV) cover an area of about 48 per cent and are distributed in all parts of the microwatershed. They have severe limitations of erosion and soil. Lands not suitable for agriculture (Class VI) cover an area of about 16 per cent and are distributed in the southwestern, southeastern and northern part of the microwatershed. They are well suited for pasture, forestry, wild life and recreation with severe limitations of soil and erosion.

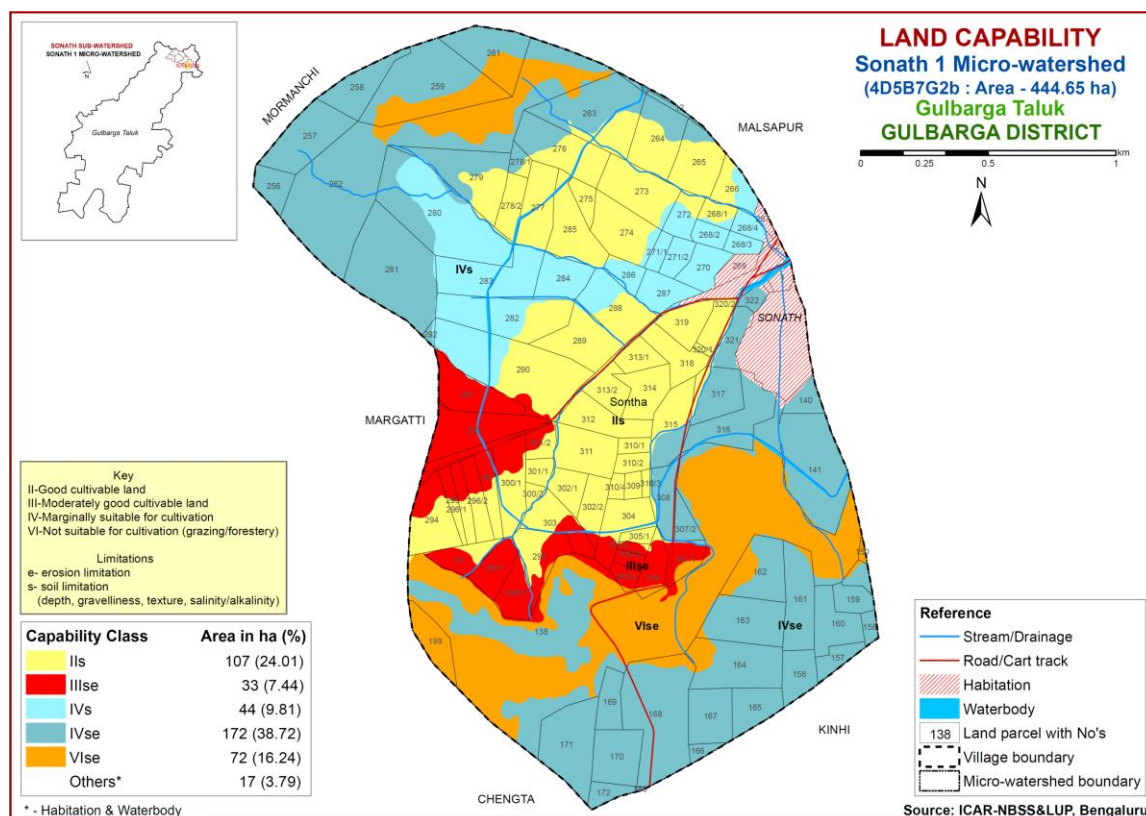


Fig. 5.1 Land Capability map of Sonath-1 Microwatershed

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 the Figure 5.2.

Major area of about 213 ha (48%) has very shallow soils (<25 cm) and are distributed in all parts of the microwatershed. Shallow soils (25-50 cm) occupy an area of about 75 ha (17%) and are distributed in the southeastern, central and northern part of the microwatershed. Moderately deep soils (75-100 cm) occupy an area of about 33 ha (7%) are distributed in the western and central part of the microwatershed. Very deep soils (75-100 cm) occupy an area of about 107 ha (24%) and are distributed in the western, northeastern and central part of the microwatershed.

The most problem lands with an area of about 288 ha (65%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occur in the southern, central, western and southeastern part of the microwatershed. They are not suitable for growing

agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal. The most potential soils cover an area of about 107 ha area that have very deep soils where all climatically adopted crops can be grown.

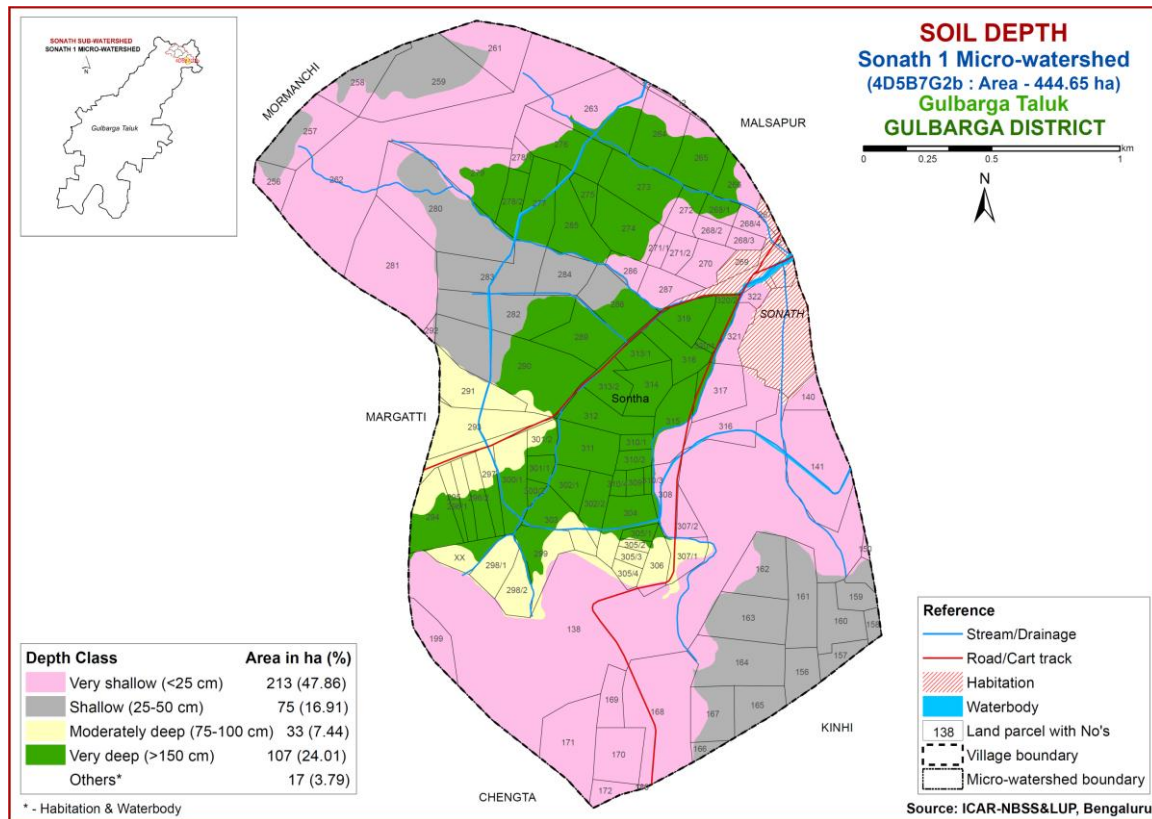


Fig. 5.2 Soil Depth map of Sonath-1 Microwatershed

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 and a surface soil texture map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.3.

Maximum area of about 321 ha (72%) are clayey at the surface and are distributed in all parts of the microwatershed. Loamy soils occupy an area of about 107 ha (24%) and are distributed in the southwestern, southeastern, central and northern part of the microwatershed.

All soils in the microwatershed are the most productive (72%) with respect to surface soil texture. They have high potential for soil-water retention and availability, and nutrient retention and availability, but clayey soils have more problems of drainage, infiltration, workability and other physical problems.

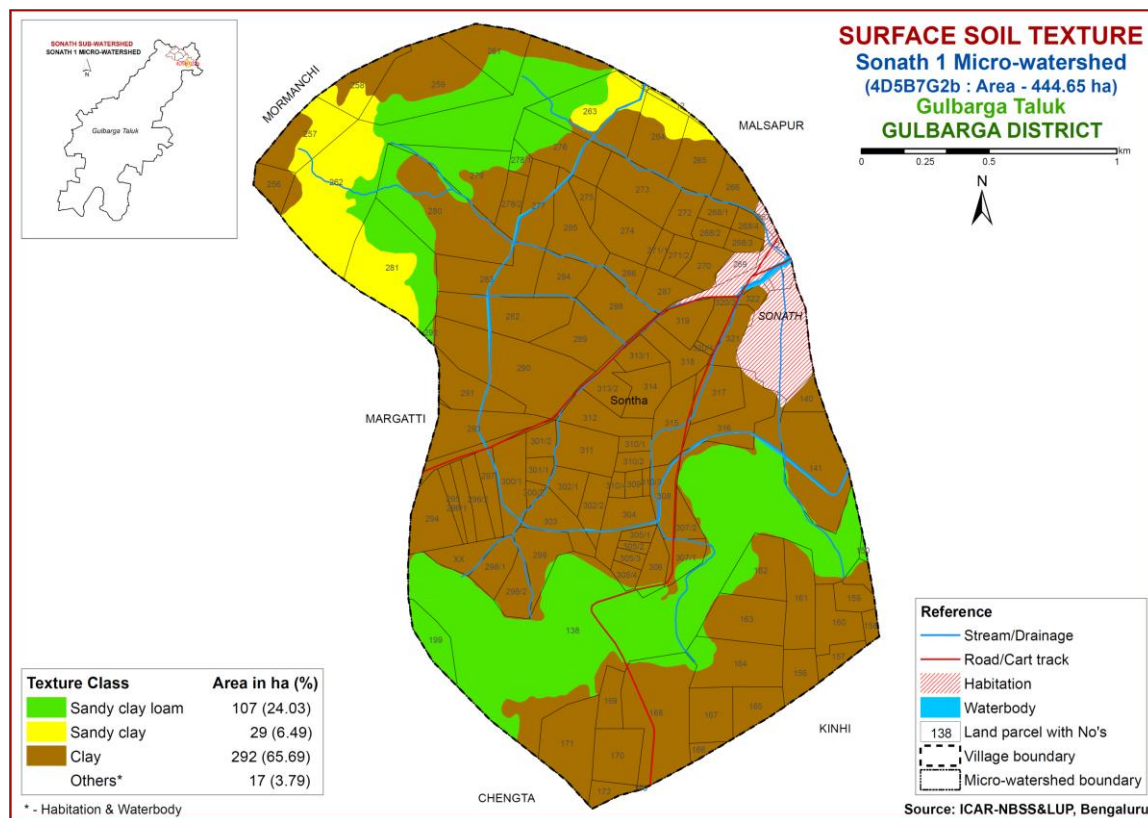


Fig. 5.3 Surface Soil Texture map of Sonath-1 Microwatershed

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 geographical distribution in the microwatershed is shown in Figure 5.4.

The soils that are gravelly (15-35%) cover about 45 ha (10%) and are distributed in the eastern and northern part of the microwatershed. Maximum area of 247 ha (55%) in the microwatershed has soils that are non gravelly (<15%) and are distributed in the central, southern, northeastern and western part of the microwatershed. Very gravelly (35-60%) soils covering only 7 ha (1%) are distributed in the northern part of the microwatershed. An area has soils that are extremely gravelly (60-80%) covering about

130 ha (29%) and are distributed in the southwestern, southeastern, northern, northeastern and northwestern part of the microwatershed

The most productive lands with respect to gravelliness are found to be 66 per cent. They are non gravelly (<15%) and gravelly (15-35%) and have potential for growing both annual and perennial crops. The problem soils that are very gravelly (35-60%) to extremely gravelly (60-80%) are found to cover about 31 per cent area, where only short duration crops can be grown.

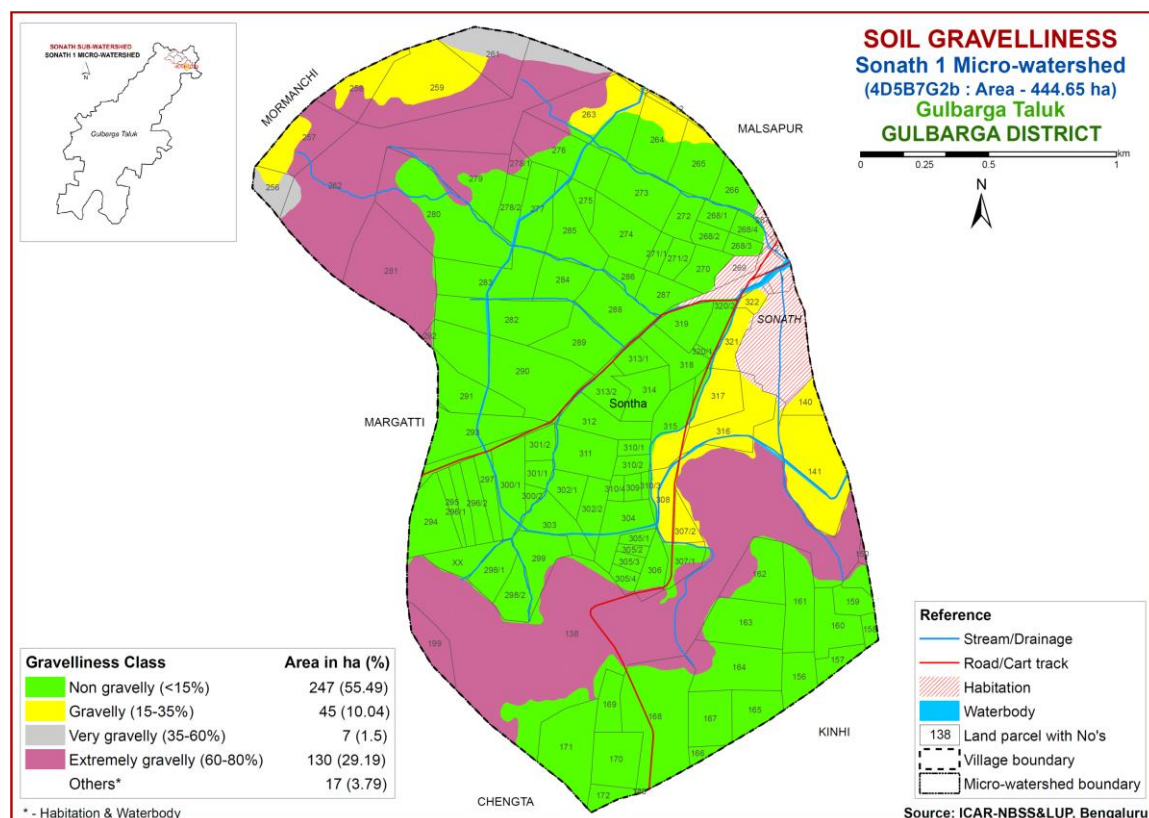


Fig. 5.4 Soil Gravelliness map of Sonath-1 Microwatershed

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 geographical distribution in the microwatershed is shown in Figure 5.5.

Maximum area of about 213 ha (48%) has soils that are very low (<50 mm/m) in available water capacity and are distributed in all parts of the microwatershed. An area of about 75 ha (17%) has soils that are low (51-100 mm/m) in available water capacity and

are distributed in the southeastern, central and northern part of the microwatershed. An area in the microwatershed has soils that are medium (101-150 mm/m) in available water capacity. They occur in area of about 33 ha (7%) and are distributed in the central and western part of the microwatershed. An area of about 107 ha (24%) has soils that are very high (>200 mm/m) in available water capacity and are distributed in the central, western and northeastern part of the microwatershed.

About 288 ha (65%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only the short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses. An area of about 107 (24%) have high potential in respect of AWC which all climatically adopted annual and perennial crops can be grown.

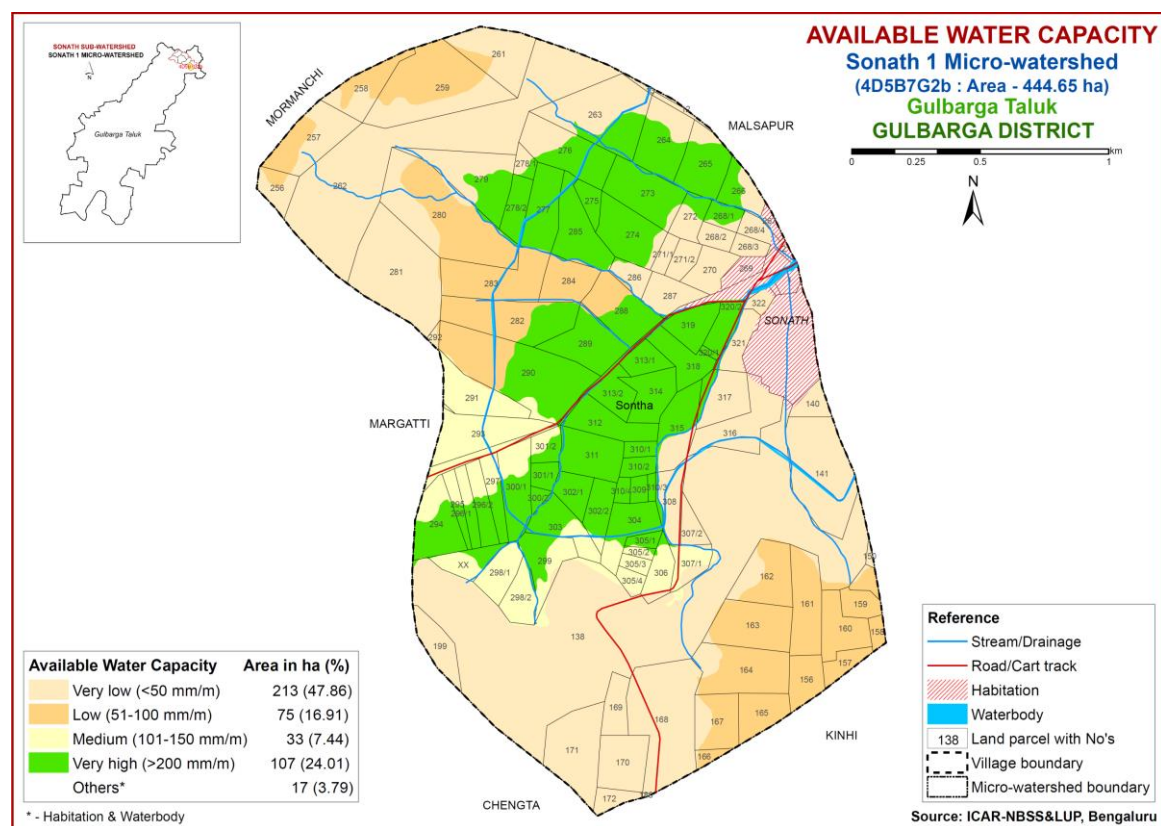


Fig. 5.5 Soil Available Water Capacity map of Sonath-1 Microwatershed

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. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.6.

Major area of the microwatershed falls under very gently sloping (1-3% slopes) lands. It covers maximum area of about 298 ha (67%) and is distributed in all parts of the microwatershed. An area of about 58 ha (13%) falls under gently sloping (3-5% slopes) lands and is distributed in the northern, northwestern and southwestern part of the microwatershed. Moderately sloping (5-10% slopes) lands cover an area of about 72 ha (16%) and is distributed in the southwestern, southeastern and northern part of the microwatershed.

An area of about 298 ha (67%) 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. An area of about 72 ha (16%) are problematic with respect to slopes and requires soil and water conservation and other land development measures.

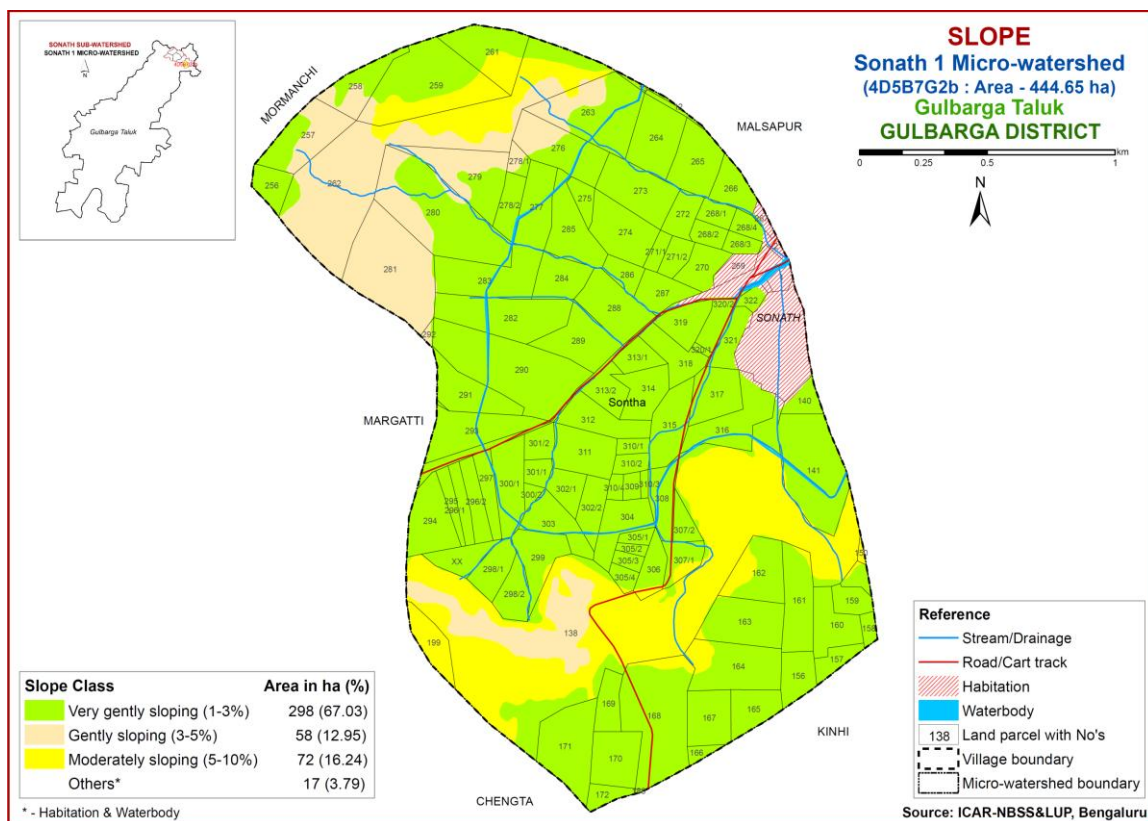


Fig. 5.6 Soil Slope map of Sonath-1 Microwatershed

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 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 was 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 an area of about 150 ha (34%) and are distributed in the central and western part of the microwatershed. Soils that are moderately eroded (e2 class) cover an area of about 148 ha (33%) and are distributed in the southern, central, western, eastern and northern part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 130 ha (29%) and are distributed in the southwestern, southeastern, northern and northwestern part of the microwatershed.

Top priority is to be given to 130 ha area where they are severely eroded for taking up soil and water conservation and other land development measures followed by moderately eroded lands that cover about 148 ha.

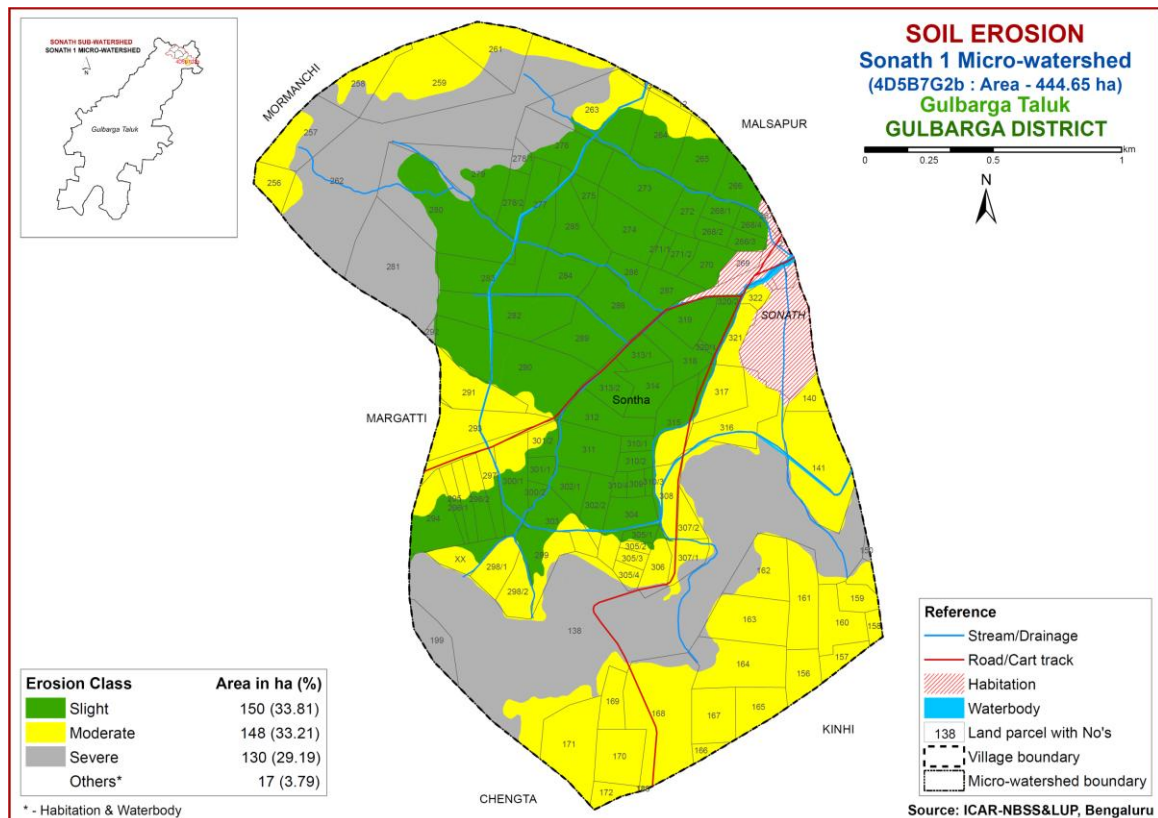


Fig. 5.7 Soil Erosion map of Sonath-1 Microwatershed

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 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, 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 fertility analysis of the Sonath-1 microwatershed for soil reaction (pH) showed that an area of about 97 ha (22%) is neutral (pH 6.5-7.3) in reaction and is distributed in the southern and northern part of the microwatershed (Fig.6.1). An area of about 100 ha (23%) is slightly alkaline (pH 7.3-7.8) and is distributed in the southwestern, southeastern, northwestern and northeastern part of the microwatershed. Moderately alkaline (pH 7.8-8.4) cover major area of 166 ha (37%) and is distributed in the central, western and eastern part of the microwatershed. An area of about 67 ha (15%) is strongly alkaline (pH 8.4-9.0) and is distributed in the central and northeastern part of the microwatershed.

6.2 Electrical Conductivity (EC)

The Electrical Conductivity of the soils of the entire microwatershed area is $<2 \text{ dSm}^{-1}$ (Fig 6.2) and as such the soils in the microwatershed are nonsaline.

6.3 Organic Carbon

The organic carbon content (an index of available N) of the soils in the microwatershed (Fig.6.3) is high ($>0.75\%$) in maximum area of about 338 ha (76%) and are distributed in all parts of the microwatershed. Medium (0.5-0.75%) organic carbon content accounts an area of about 93 ha (21%) and is distributed in the western, northeastern, northwestern and central part of the microwatershed.

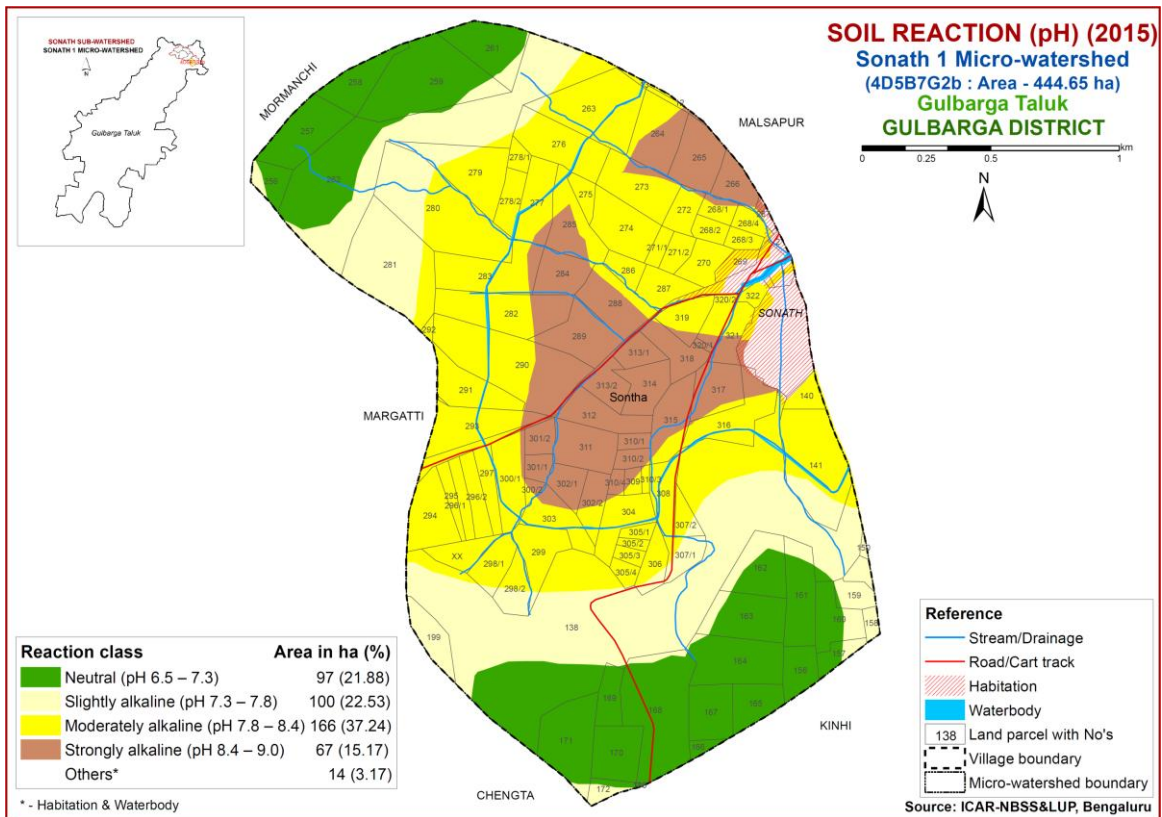


Fig.6.1 Soil Reaction (pH) map of Sonath-1 Microwatershed

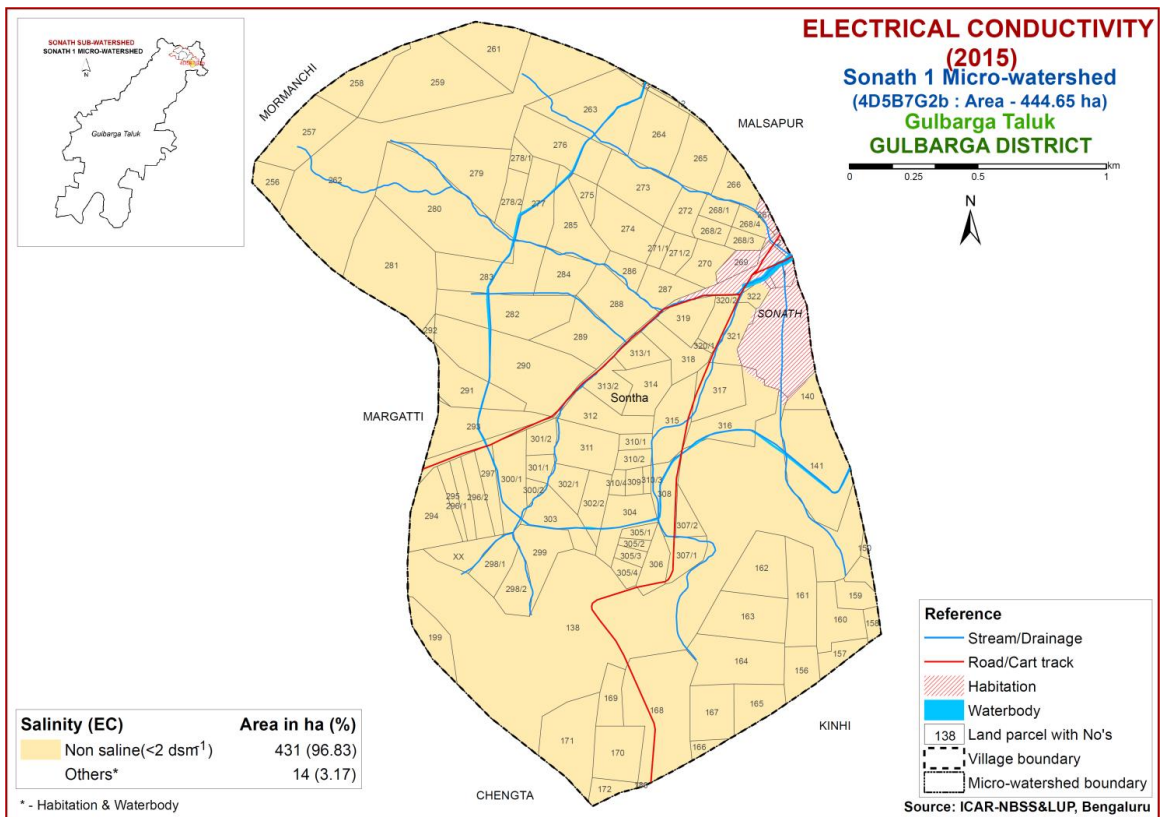


Fig.6.2 Electrical Conductivity (EC) map of Sonath-1 Microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in major area of about 210 ha (47%) and is distributed in all parts of the microwatershed (Fig.6.4). There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. An area of about 202 ha (46%) is medium (23-57 kg/ha) in available phosphorus and is distributed in the southeastern, central, northeastern, northwestern and southern part of the microwatershed. A small area of about 18 ha (4%) is high (>57 kg/ha) in available phosphorus and is distributed in the western part of the microwatershed.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in major area of about 297 ha (67%) and is distributed in all parts of the microwatershed (Fig.6.5) except central part. Low available potassium (<145 kg/ha) content accounts for an area of 32 ha (7%) and is distributed in the northern part of the microwatershed. High available potassium (>337 kg/ha) content accounts for an area of 102 ha (23%) and is distributed in the western, eastern and central part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) in major area of about 360 ha (81%) and is distributed in all parts of the microwatershed. Available sulphur is low (<10 ppm) in an area of 71 ha (16%) and is distributed in the northern part of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in an area of about 197 ha (44%) and is distributed in the central, southern, southeastern and southwestern part of the microwatershed. Major area of about 233 ha (52%) is low (<0.5 ppm) in available boron and are distributed in the central, northwestern, northeastern, western, eastern and northern part of the microwatershed.

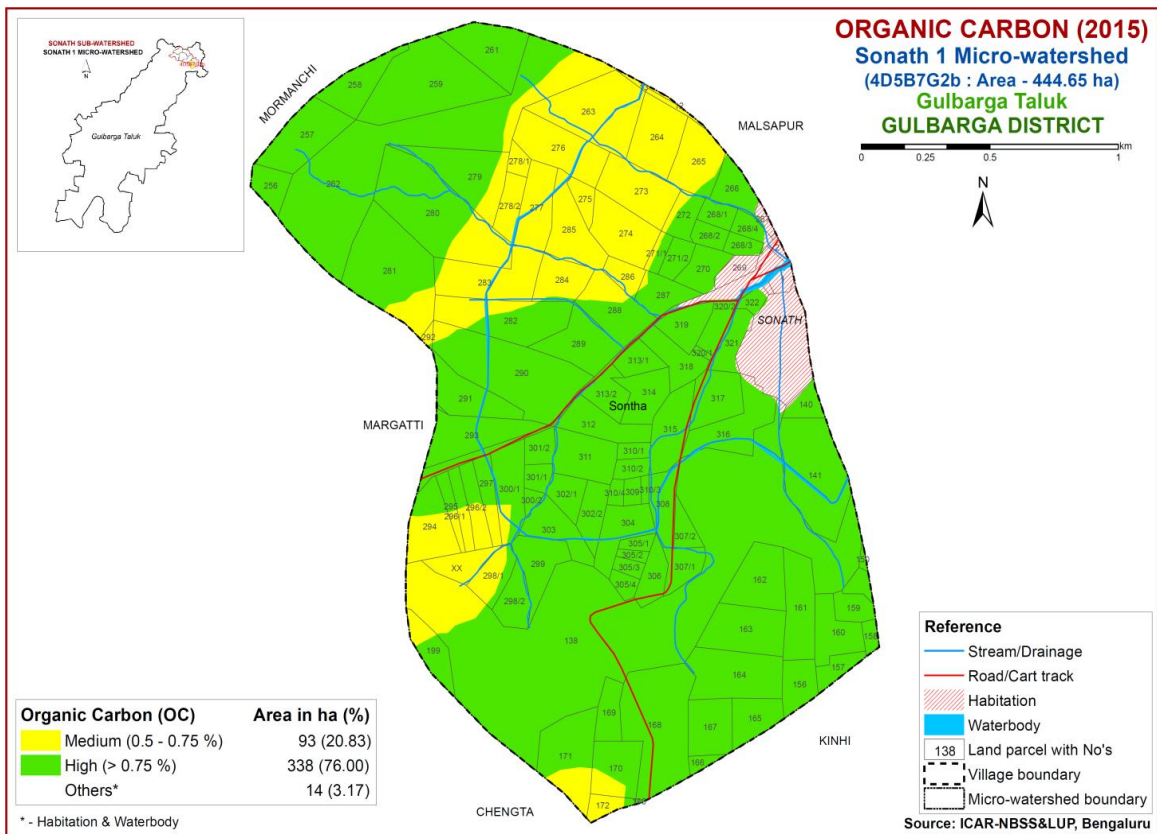


Fig.6.3 Soil Organic Carbon map of Sonath-1 Microwatershed

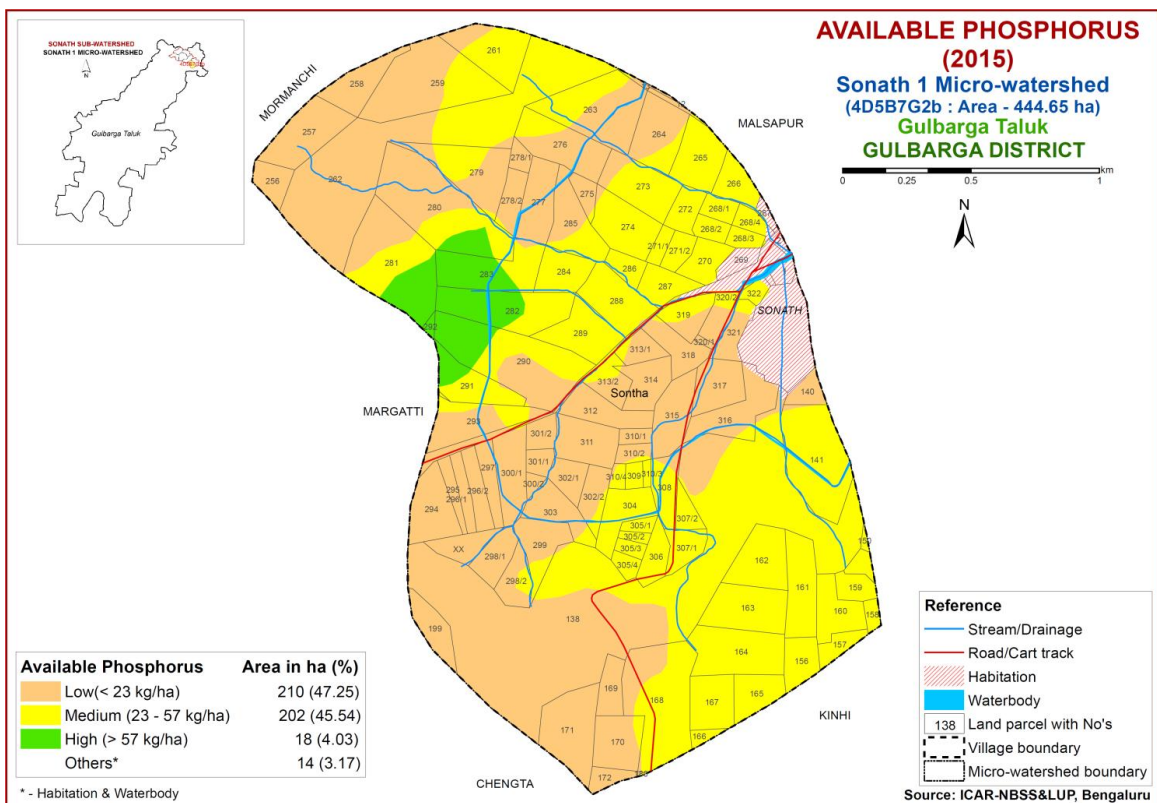


Fig.6.4 Soil available Phosphorus map of Sonath-1 Microwatershed

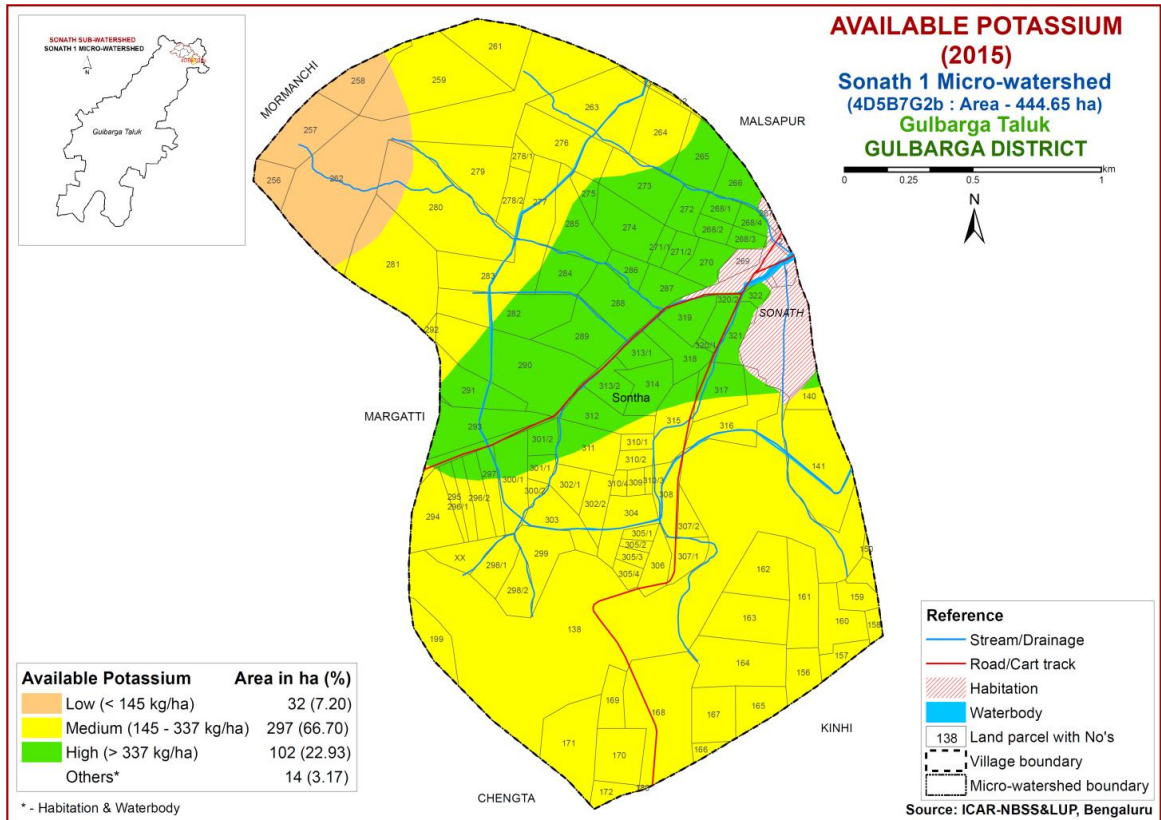


Fig.6.5 Soil available Potassium map of Sonath-1 Microwatershed

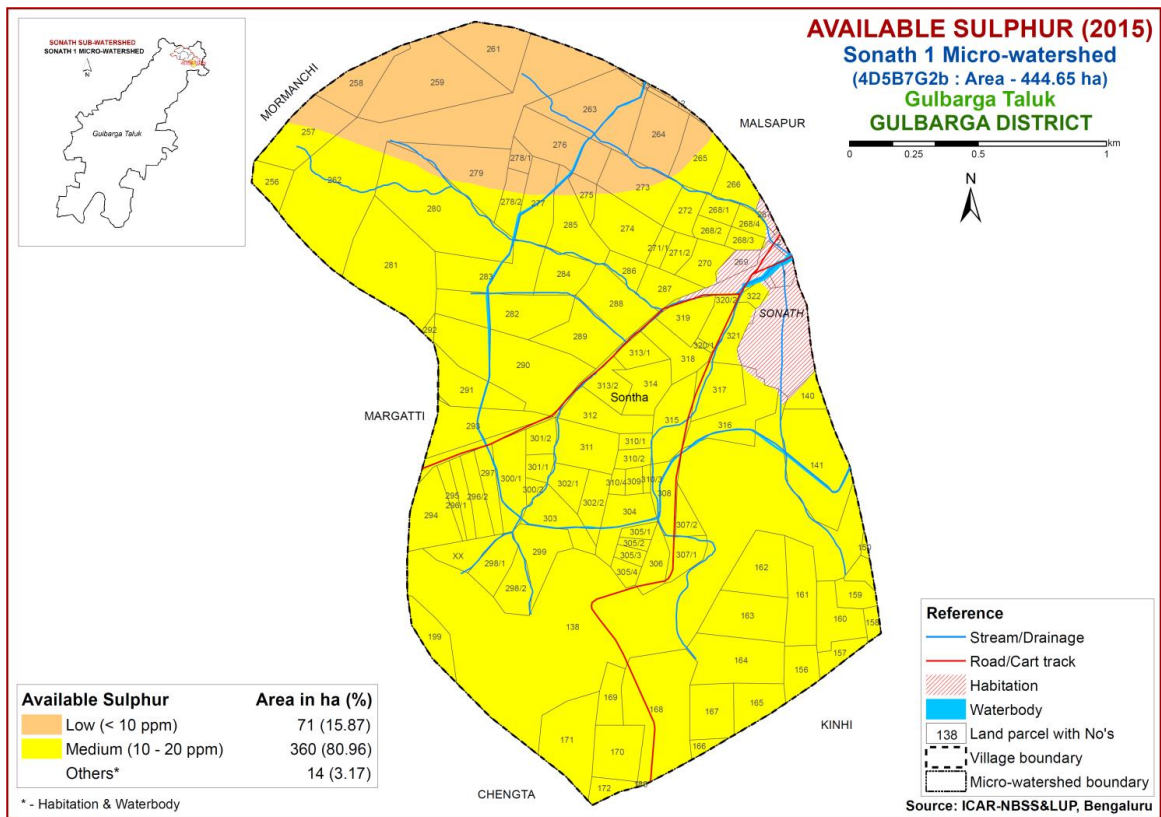


Fig.6.6 Soil available Sulphur map of Sonath-1 Microwatershed

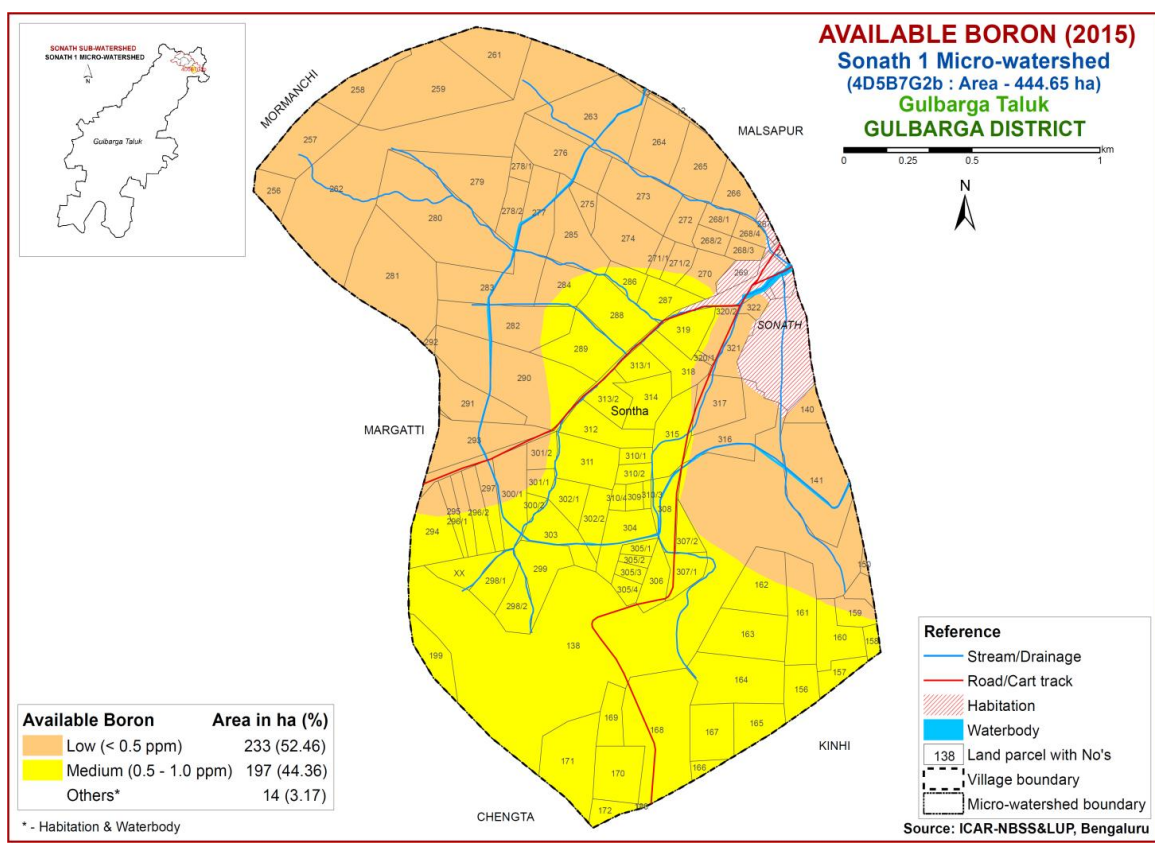


Fig.6.7 Soil available Boron map of Sonath-1 Microwatershed

6.8 Available Iron

Available iron content is deficient (<4.5 ppm) in an area of about 50 ha (11%) and is distributed in the eastern part of the microwatershed. It is sufficient (>4.5 ppm) in major area of about 381 ha (86%) 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 major area of about 366 ha (82%) and is distributed in all parts of the microwatershed. It is sufficient (>0.6 ppm) in an area of about 64 ha (14%) (Fig 6.11) and is distributed in the southern and northern part of the microwatershed.

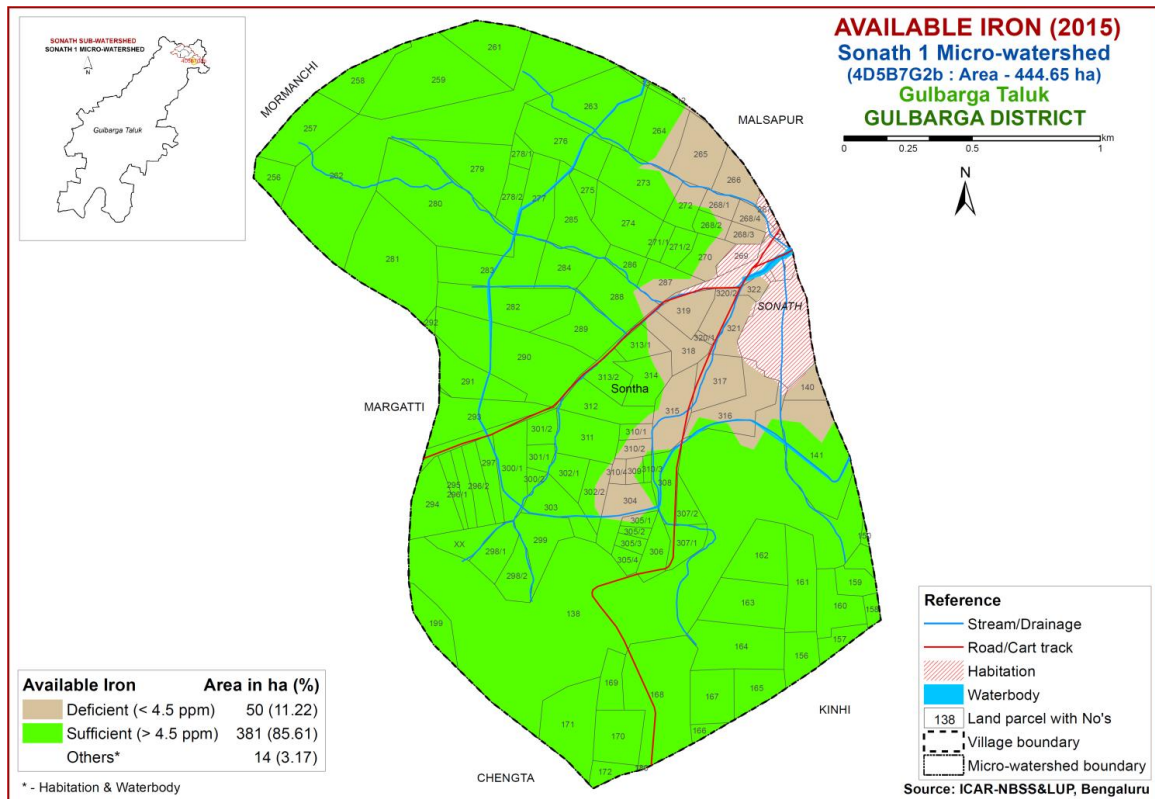


Fig.6.8 Soil available Iron map of Sonath-1 Microwatershed

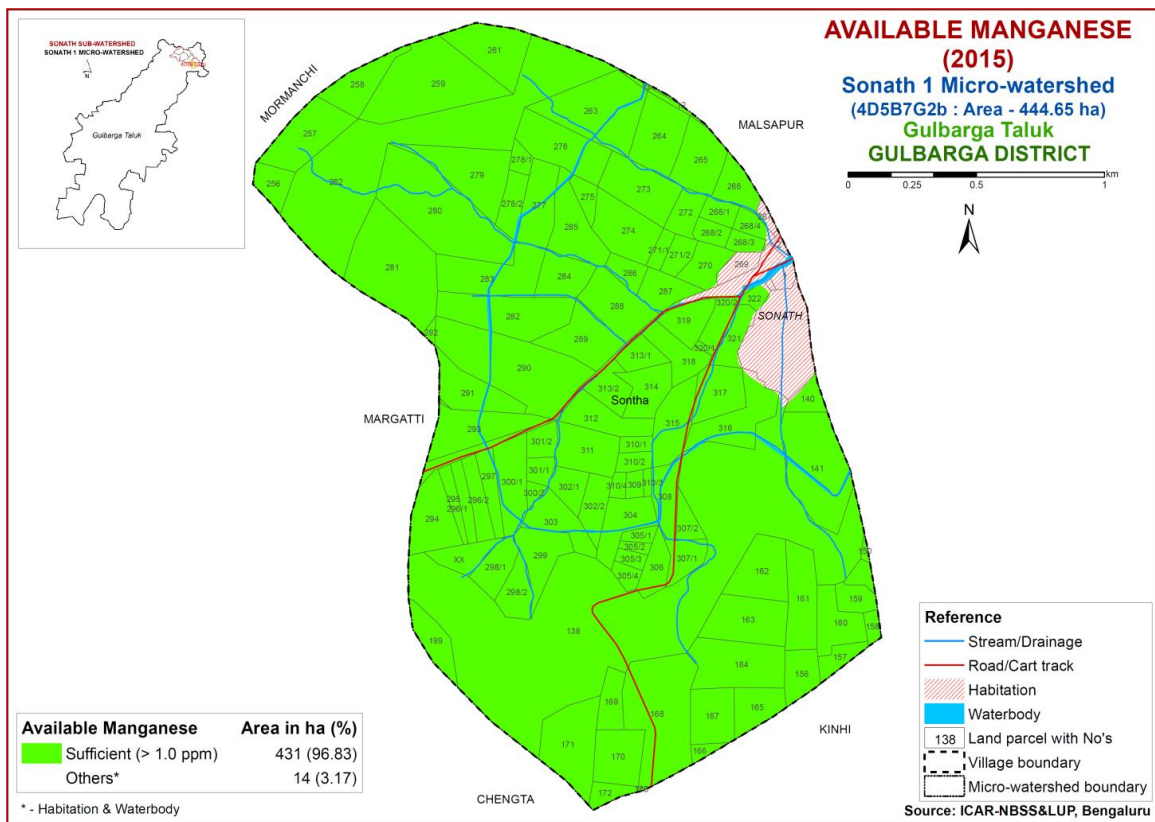


Fig.6.9 Soil available Manganese map of Sonath-1 Microwatershed

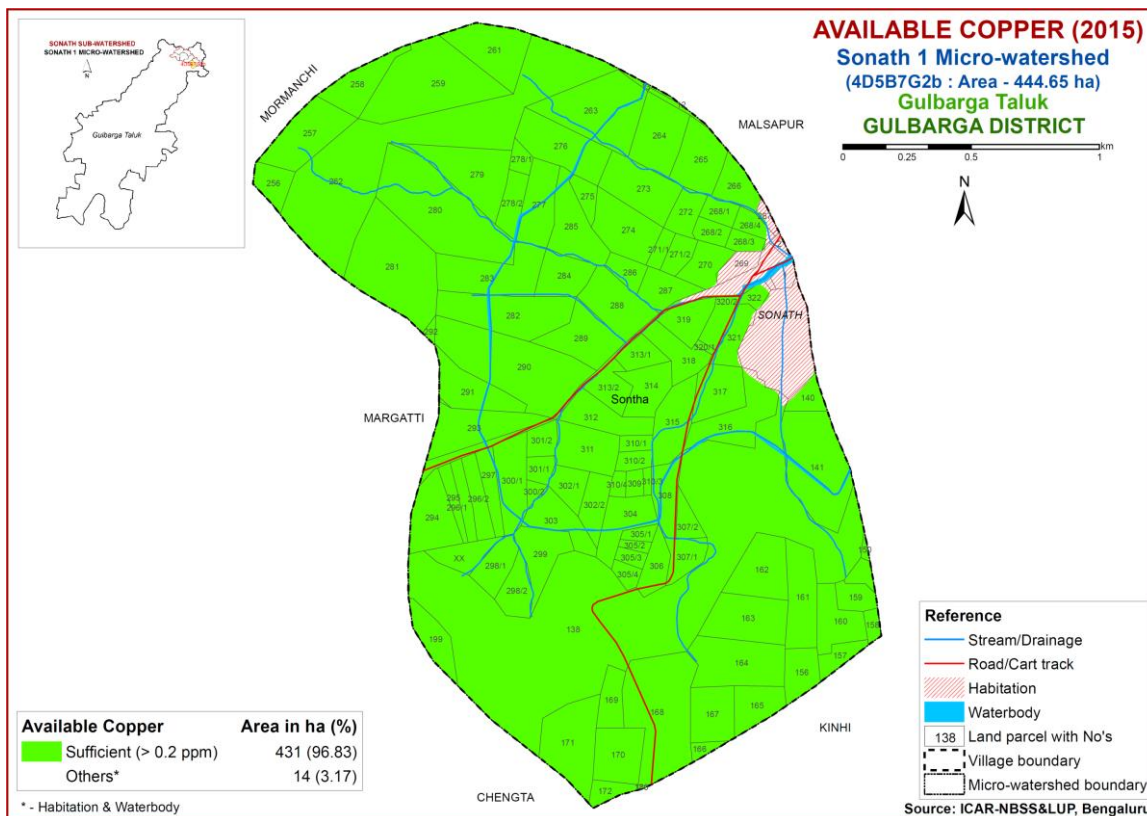


Fig.6.10 Soil available Copper map of Sonath-1 Microwatershed

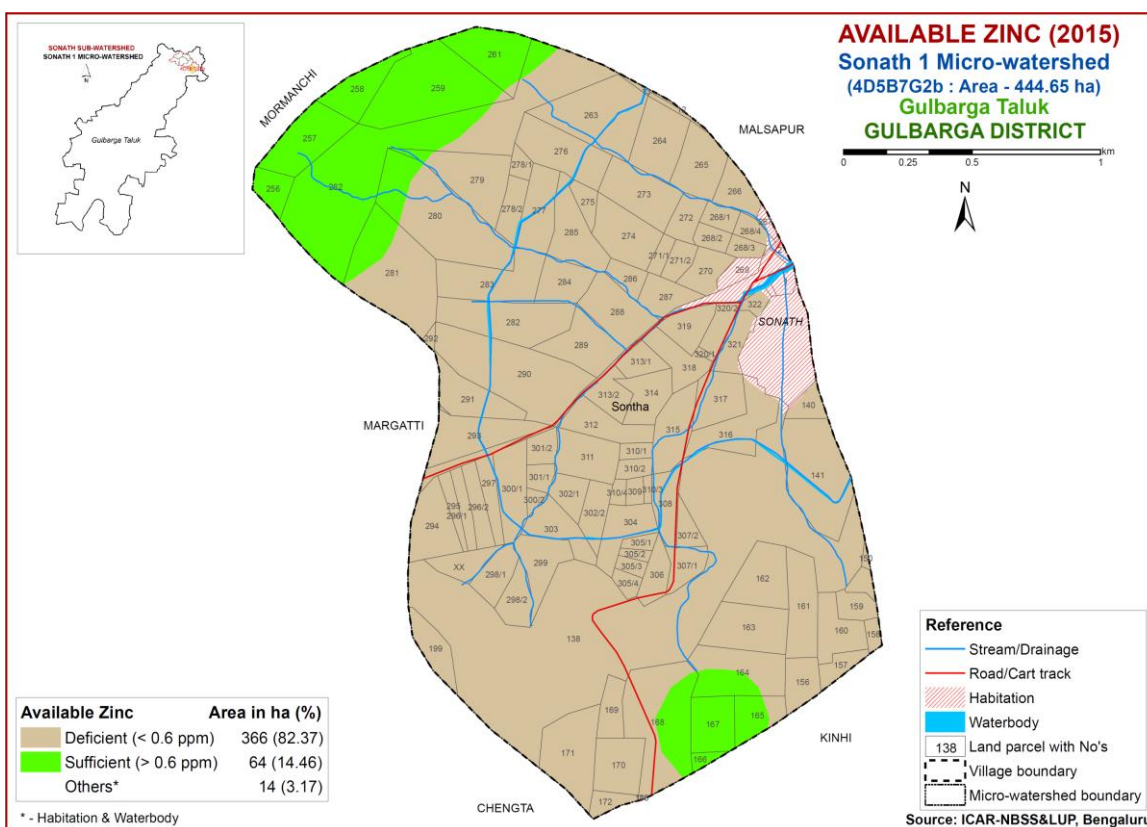


Fig.6.11 Soil available Zinc map of Sonath-1 Microwatershed

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Sonath-1 microwatershed were assessed for their suitability for growing food, fibre, fodder and other 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, and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The soil and land characteristics (Table 7.1) were matched with the crop requirements 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 and S3 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 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 19 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 crops 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 a 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.

Table 7.1 Soil-Site Characteristics of Sonath-1 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p ⁺) kg ⁻¹]	BS (%)
					Surface	Sub-surface	Surface (%)	Subsurface (%)								
MGThC3g3	740	150	WD	<25	scl	c	60-80	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGThD3g3	740	150	WD	<25	scl	c	60-80	15-35	<50	5-10	Severe	6.8	0.3	0.2	46	100
MGTiB2g1	740	150	WD	<25	sc	c	15-35	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTiC3g3	740	150	WD	<25	sc	c	60-80	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGTmB1	740	150	WD	<25	c	c	-	15-35	<50	1-3	Slight	6.8	0.3	0.2	46	100
MGTmB2	740	150	WD	<25	c	c	-	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTmB2g1	740	150	WD	<25	c	c	15-35	15-35	<50	1-3	Moderate	7.2	0.1	0.3	40	100
MGTmB2g2	740	150	WD	<25	c	c	35-60	15-35	<50	1-3	Moderate	7.2	0.1	0.3	40	100
MAThD3g3	740	150	WD	<25	sc	c-sc	60-80	15-35	<50	5-10	Severe	7.2	0.1	0.3	40	100
NHAmB1	740	150	WD	25-50	c	c	-	<15	51-100	1-3	Slight	7.2	0.1	0.3	40	100
NHAmB2	740	150	WD	25-50	c	c	-	<15	51-100	1-3	Moderate	7.2	0.1	0.3	40	100
NHAmB2g1	740	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Moderate	7.2	0.1	0.3	40	100
NIRmB2	740	150	WD	75-100	c	c	-	<15	101-150	1-3	Moderate	7.0	0.1	0.2	28	100
MARmB1	740	150	WD	>150	c	c	-	<15	>200	1-3	Slight	7.0	0.1	0.3	62	100

*Symbols and abbreviations are according to Field Guide for LRI under Sujala-III Project, Karnataka

Table 7.2 Crop 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. 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, siel, 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

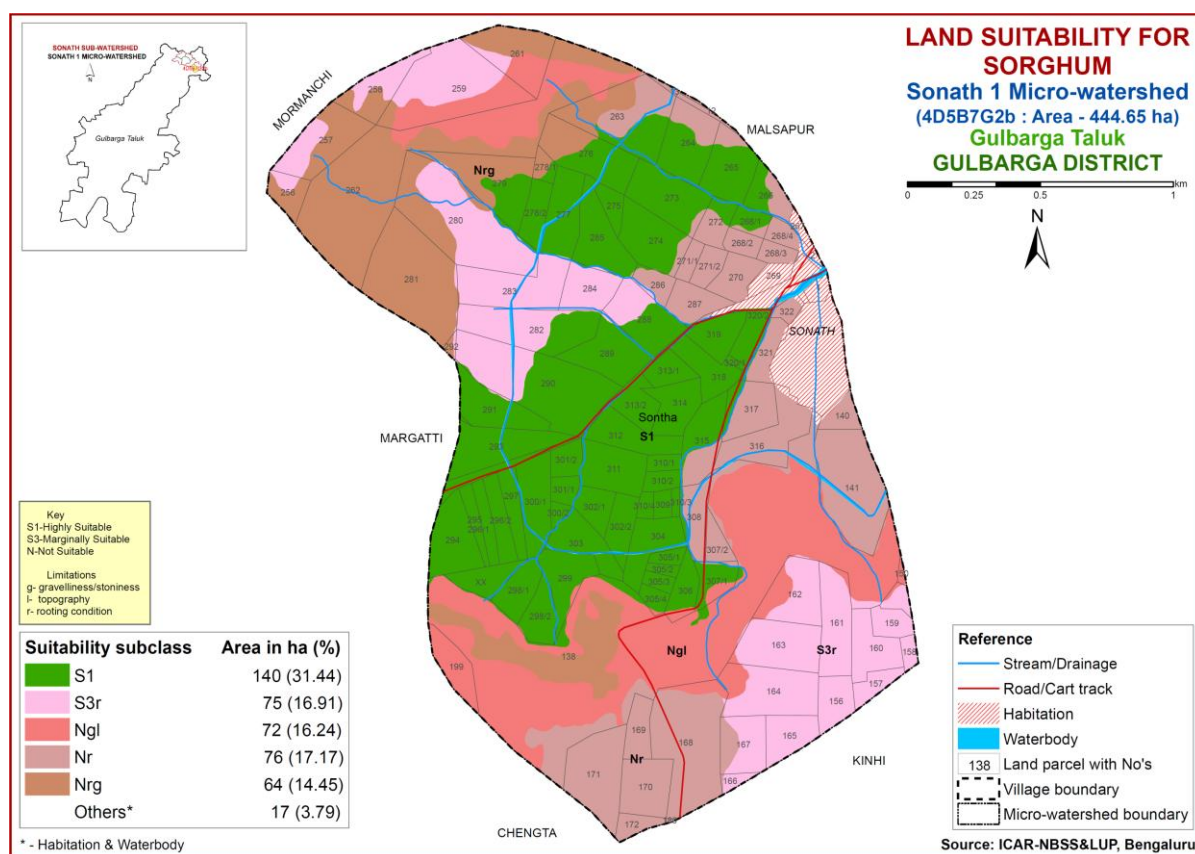


Fig. 7.1 Land Suitability map of Sorghum

An area of about 140 ha (31%) is highly suitable (Class S1) for growing sorghum and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing sorghum. Marginally suitable lands (Class

S3) occupy an area of about 75 ha (17%) and are distributed in the northern, central and southern part of the microwatershed. They have moderate limitation of rooting depth. An area of about 212 ha (48%) is not suitable (Class N) for growing sorghum and are distributed in the northwestern, northeastern, southwestern and eastern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

7.2 Land Suitability for Maize (*Zea mays*)

Maize is 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.

In Sonath-1 microwatershed, there are no lands that are highly (Class S1) and moderately (Class S2) suitable for growing maize. Marginally suitable lands (Class S3) occupy major area of about 215 ha (48%) and are distributed in all parts of the microwatershed. They have moderate limitations of texture and rooting depth. An area of about 212 ha (48%) is not suitable (Class N) for growing maize and are distributed in the southwestern, southeastern, northwestern and northeastern part of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

Table 7.3 Crop 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	

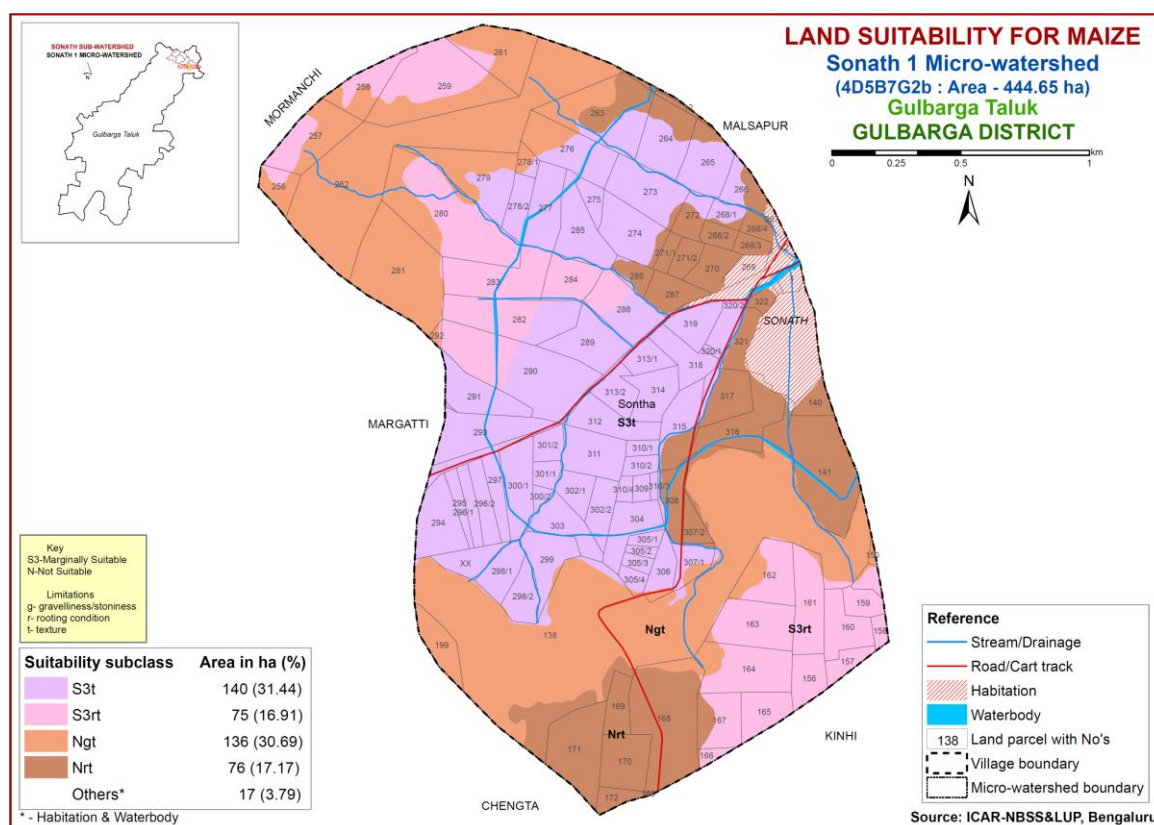


Fig. 7.2 Land Suitability map of Maize

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.

Table 7.4 Crop 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	

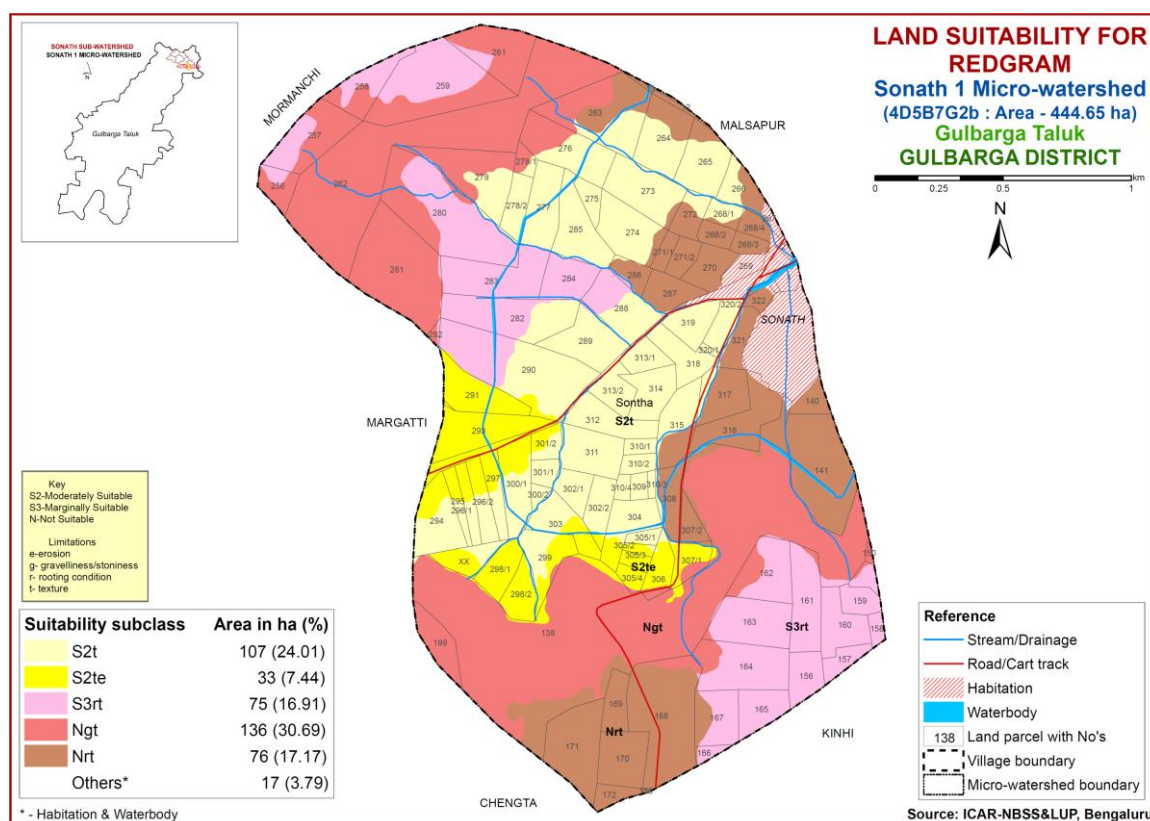


Fig. 7.3 Land Suitability map of Red gram

In Sonath-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing redgram. An area of about 140 ha (31%) is moderately suitable (Class S2) for

growing redgram and are distributed in the western, central and northeastern part of the microwatershed. They have minor limitations of texture and erosion. Marginally suitable lands (Class S3) occupy an area of about 75 ha (17%) and are distributed in the northern, central and southern part of the microwatershed. They have moderate limitations of rooting depth and texture. An area of about 212 ha (48%) is not suitable (Class N) for growing redgram and are distributed in the northwestern, northeastern, southwestern and eastern part of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

7.4 Land Suitability for Sunflower (*Helianthus annuus*)

Sunflower is the most important oilseed crop grown in an area of 3.56 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.5) 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 7.4.

An area of about 140 ha (31%) is highly suitable (Class S1) for growing sunflower and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing sunflower. In Sonath-1 microwatershed, there are no lands that are moderately (Class S1) and marginally (Class S1) suitable for growing sunflower. Major area of about 288 ha (65%) is not suitable (Class N) for growing sunflower and occur in all parts of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

Table 7.5 Crop 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	

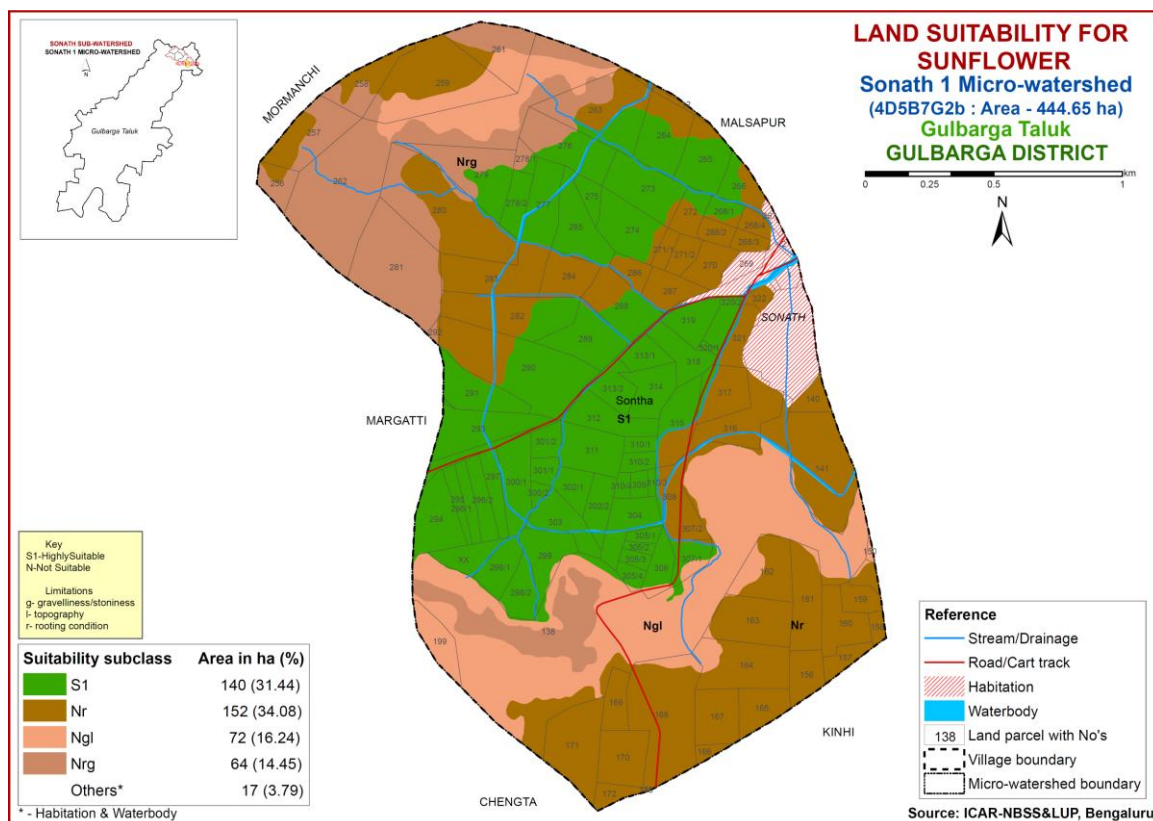


Fig. 7.4 Land Suitability map of Sunflower

7.5 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 8.75 lakh ha area in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.6) 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 7.5.

An area of about 107 ha (24%) is highly suitable (Class S1) for growing cotton and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing cotton. An area of about 33 ha (7%) is moderately suitable (Class S2) for growing cotton and are distributed in the western part of the microwatershed. They have minor limitations of rooting depth. Marginally suitable lands (Class S3) occupy an area of about 75 ha (17%) and are distributed in the southeastern, western, central and northern part of the microwatershed. They have moderate limitation of rooting depth. Major area of 212 ha (48%) is not suitable (Class N) for growing cotton and is distributed in the southern, southwestern, southeastern, eastern, northeastern and northwestern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

Table 7.6 Crop 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

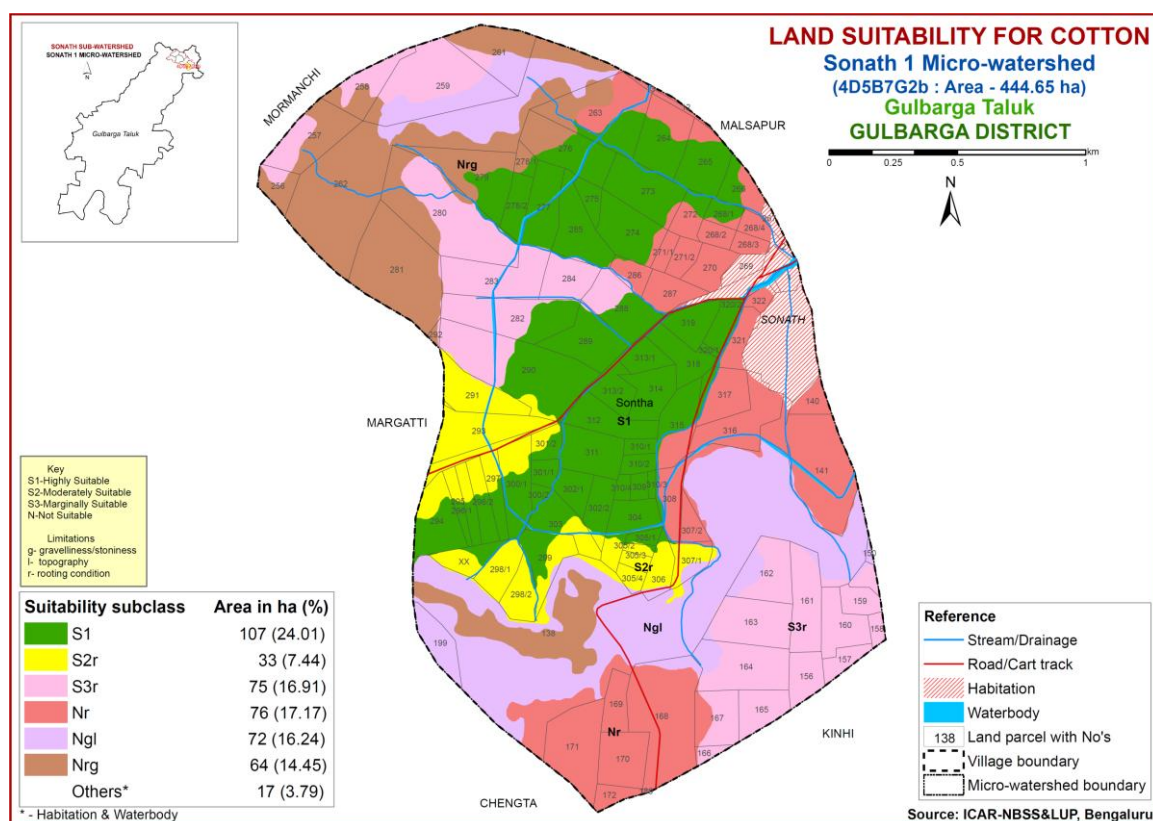


Fig. 7.5 Land Suitability map of Cotton

7.6 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.9 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, Chamarajanagar and Mandya districts under irrigated conditions. The crop requirements for growing sugarcane (Table 7.7) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sugarcane was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

Table 7.7 Crop suitability criteria for Sugarcane

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	>8
Soil drainage	class	Well drained	Mod./ imperfectly drained	Poorly drained	V.poor/ excessively drained
Soil reaction	pH	7.0-8.0	6.0-6.9 8.1-9.0	4.0-5.9 9.1-9.5	<4.0/ >9.5
Surface soil texture	Class	l, cl, sil, silcl	C(m/k), sl	C+(ss)	
Soil depth	cm	>100	100-75	75-50	<50
stoniness	%	<15	15-35	35-50	>50
Salinity (EC)	dSm ⁻¹	<2.0	2.0-4.0	4.0-9.0	>9
Sodicity (ESP)	%	<10	10-15	15-25	>25

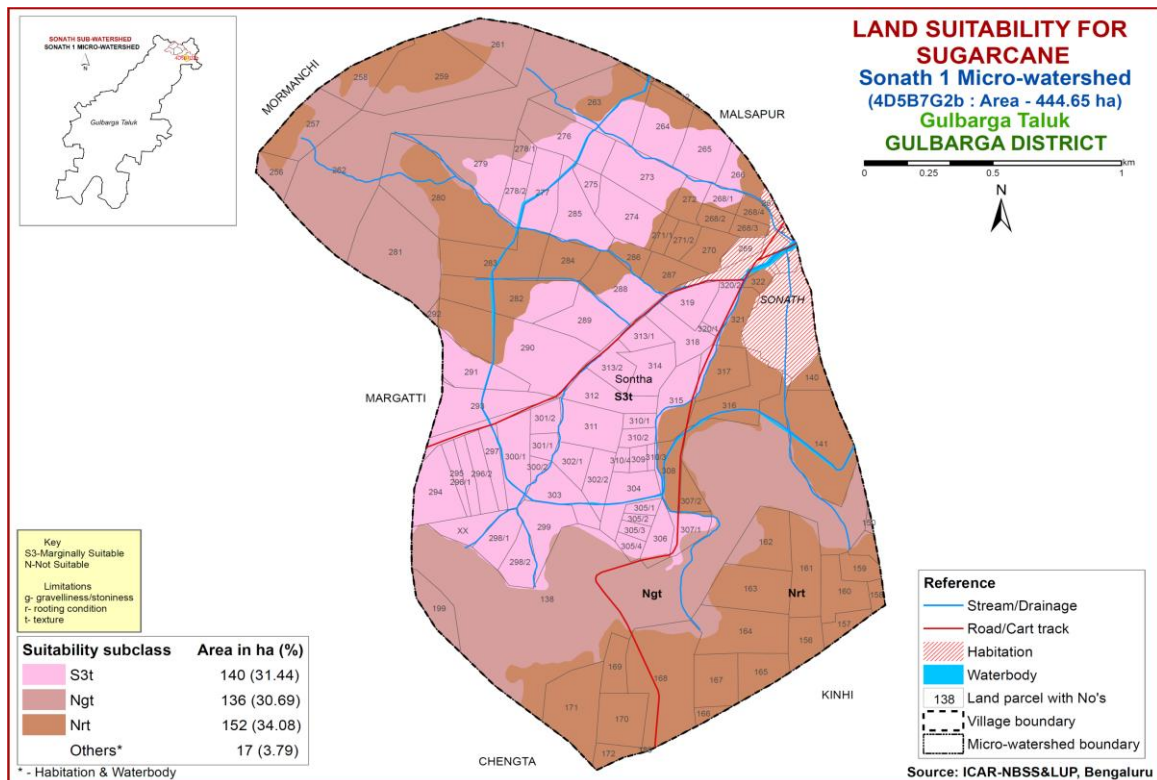


Fig. 7.6 Land Suitability map of Sugarcane

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing sugarcane in Sonath-1 microwatershed. Marginally suitable (Class S3) lands are found to occur an area of about 140 ha (31%). The soils have moderate limitation of texture. They are distributed in the western, central and northeastern part of the microwatershed. Major area of 288 ha (65%) is not suitable (Class N) for growing sugarcane and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

7.7 Land Suitability for Soybean (*Glycine max*)

Soybean is the most important pulse and oil seed crop grown in about 2.56 lakh ha area in Bijapur, Raichur, Kalaburgi, Dharwad, Belgaum and Bellary districts. The crop requirements for growing soybean were matched with the soil-site characteristics and a land suitability map for growing soybean was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

An area of about 140 ha (31%) is highly suitable (Class S1) for growing soybean and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing soybean. Marginally suitable lands (Class S3) occupy an area of about 75 ha (17%) and are distributed in the northern, central and southern part of the microwatershed. They have moderate limitation of rooting depth. An area of about 212 ha (48%) is not suitable (Class N) for growing soybean and are distributed in the northwestern, northeastern, southwestern and eastern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

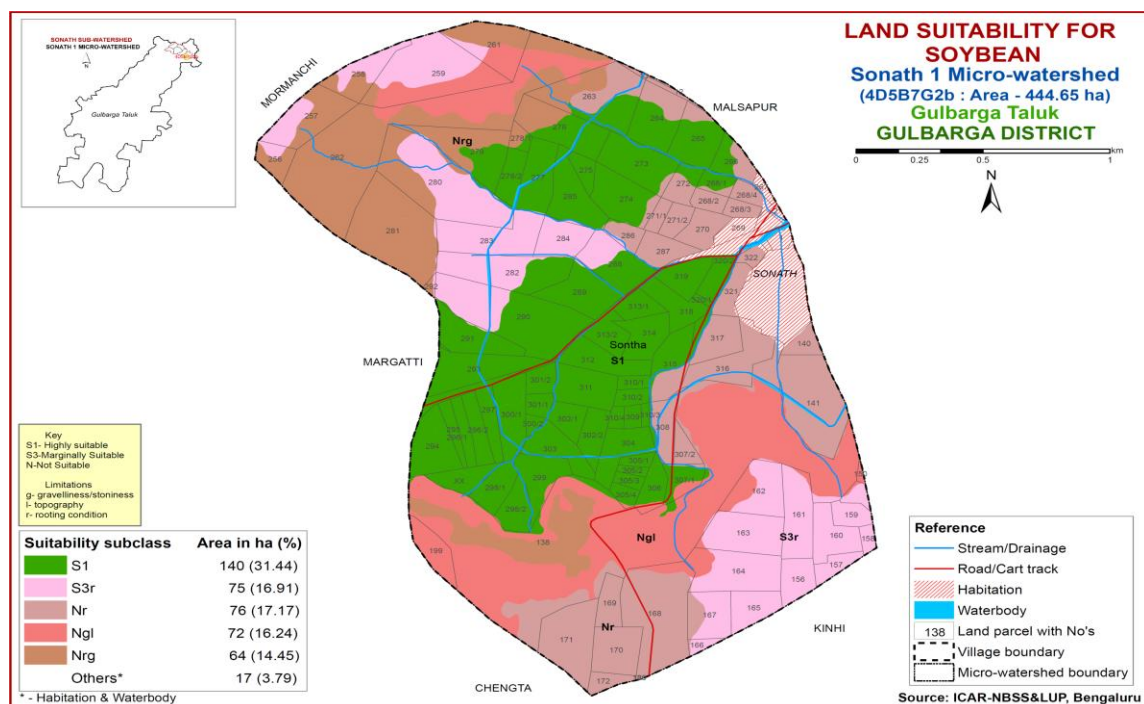


Fig. 7.7 Land Suitability map of Soybean

7.8 Land Suitability for Bengal gram (*Cicer aerativum*)

Bengal gram is the most important pulse crop grown in about 9.39 lakh ha area in Bijapur, Raichur, Kalaburgi, Dharwad, Belgaum and Bellary districts. The crop requirements for growing Bengal gram were matched with the soil-site characteristics and a land suitability map for growing Bengal gram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

Highly suitable (Class S1) lands are found to occur in a major area of 140 ha (31%). They have minor or no limitations for growing bengalgram and are distributed in the western, central and northeastern part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 75 ha (17%). The soils have minor limitation of rooting depth. They are distributed in the southern, central and northern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 83 ha (19%) and are distributed in the southern, central, eastern and northeastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 130 ha (29%) is not suitable (Class N) for growing bengalgram and occur in the southwestern, southeastern, northern and northwestern part of the microwatershed. They have severe limitations of gravelliness and topography.

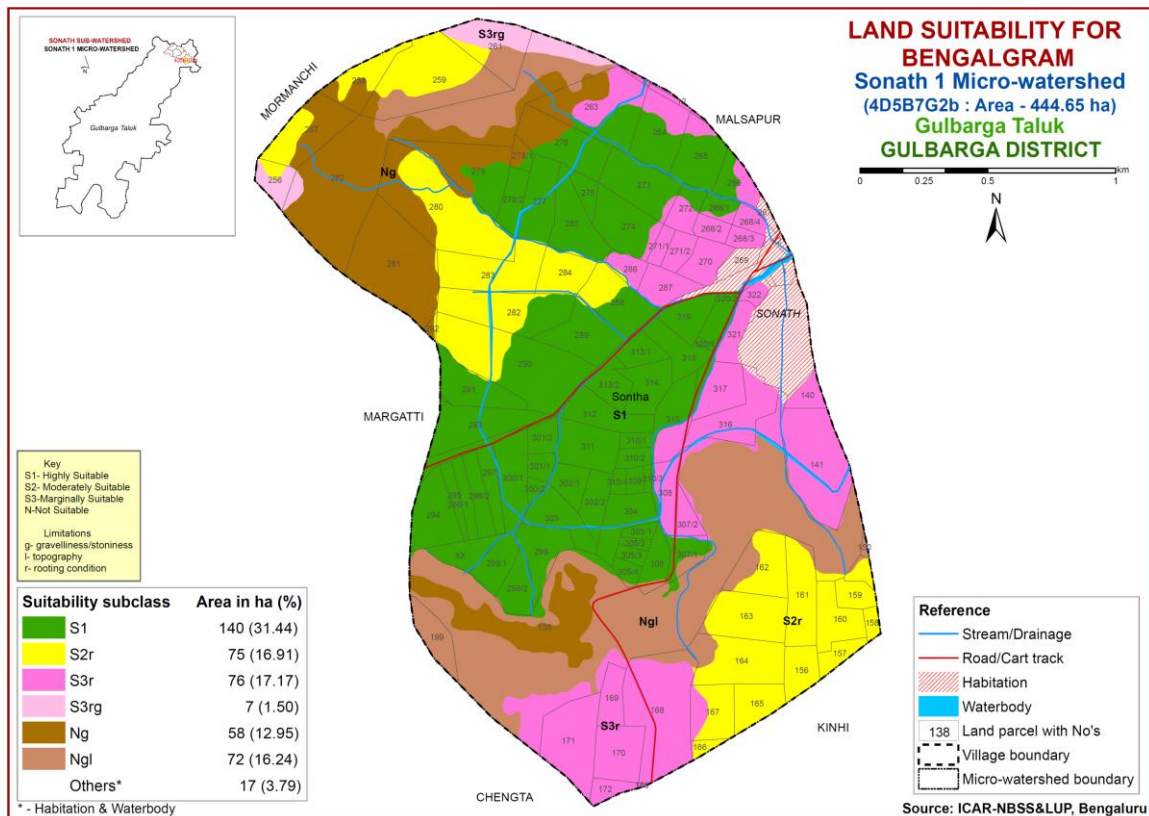


Fig. 7.8 Land Suitability map of Bengalgram

7.9 Land Suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in about 1.73 lakh ha in all the districts of the State. The crop requirements for growing mango (Table 7.8) 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 is given in Figure 7.9.

No highly (Class S1) and moderately (Class S2) suitable lands are available for growing mango in the Sonath-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in an area of about 140 ha (31%). The soils have moderate limitation of texture. They are distributed in the western, central and northeastern part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing mango and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

Table 7.8 Crop 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	⁰ C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	⁰ C	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 imperfectly drained	Poor drained	Very 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	8.6-9.0 4.0-4.9	>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	

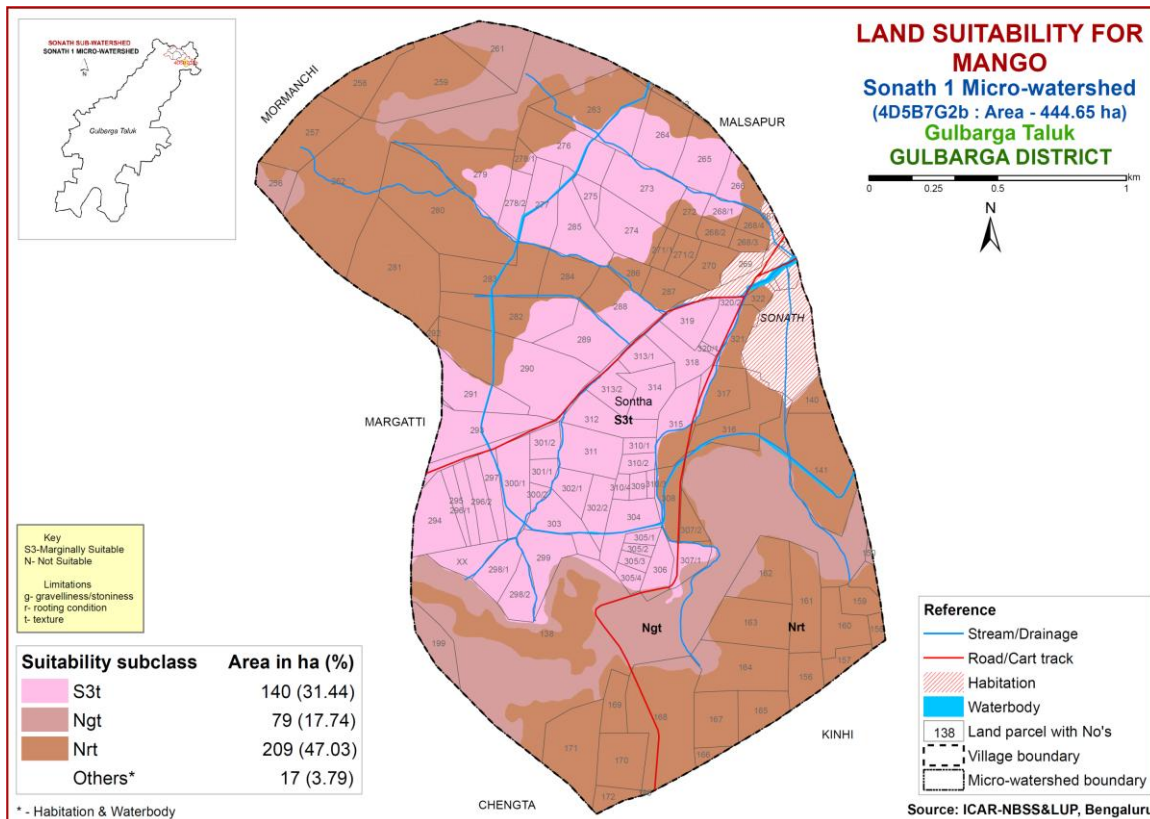


Fig. 7.19 Land Suitability map of Mango

7.10 Land Suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in 29373 ha in almost all the districts of the state. The crop requirements for growing sapota (Table 7.9) 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 is given in Figure 7.10.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing sapota in Sonath-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in an area of about 140 ha (31%). The soils have moderate limitation of texture. They are distributed in the western, central and northeastern part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing sapota and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

Table 7.9 Crop suitability criteria for Sapota

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	>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 availability	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

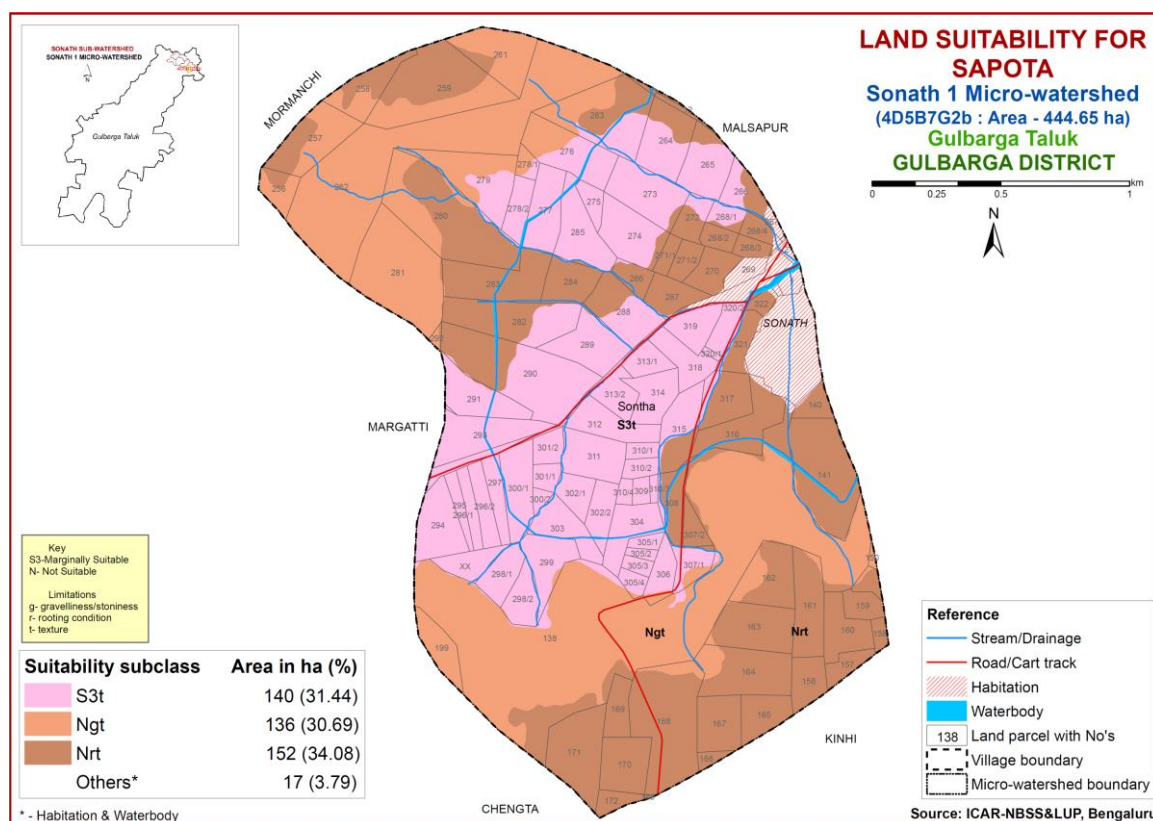


Fig. 7.10 Land Suitability map of Sapota

7.11 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in about 6558 ha in the State in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga, Bangalore and Chamarajnar districts. The crop requirements for growing guava (Table 7.10) were matched with the soil-site characteristics (Table 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 is given in Figure 7.11.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing guava in Sonath-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in an area of about 140 ha (31%). The soils have moderate limitation of texture. They are distributed in the western, central and northeastern part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing guava and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

Table 7.10 Crop 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

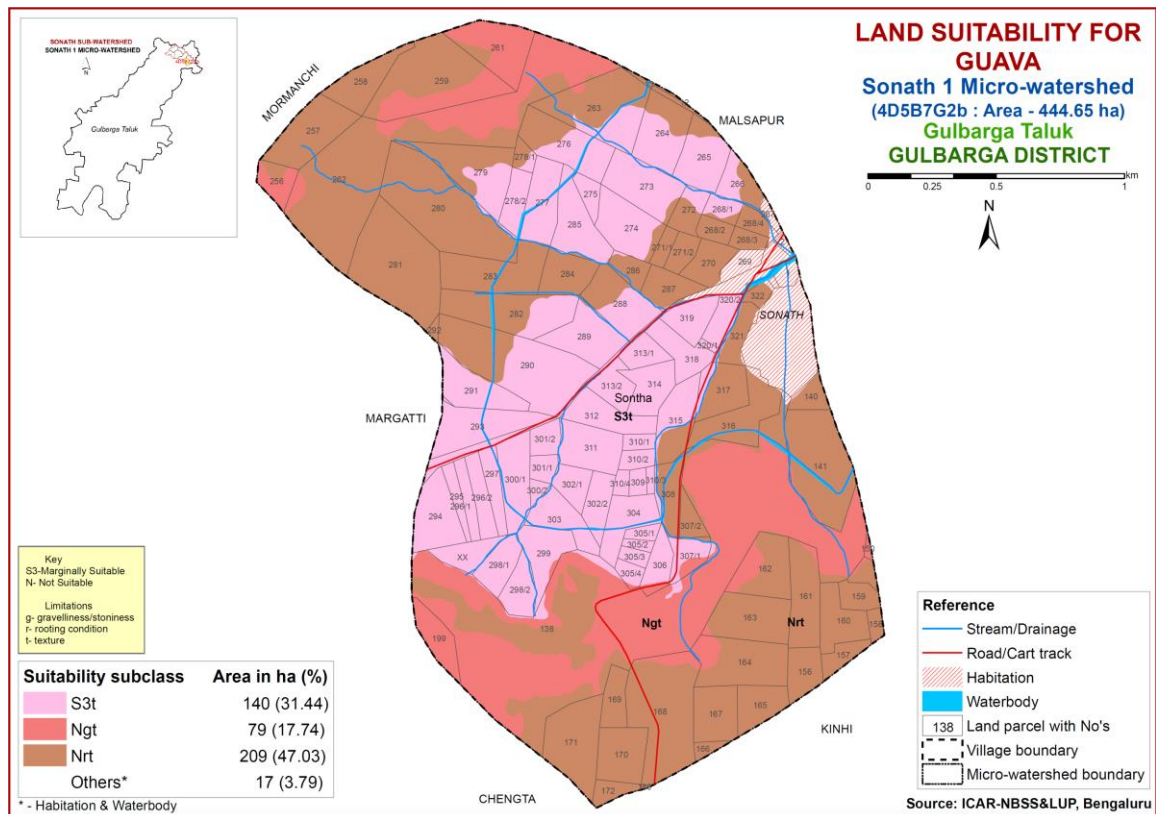


Fig 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 5368 ha 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 is given in Figure 7.12.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing jackfruit in Sonath-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in an area of about 140 ha (31%). The soils have moderate limitation of texture. They are distributed in the western, central and northeastern part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing jackfruit and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

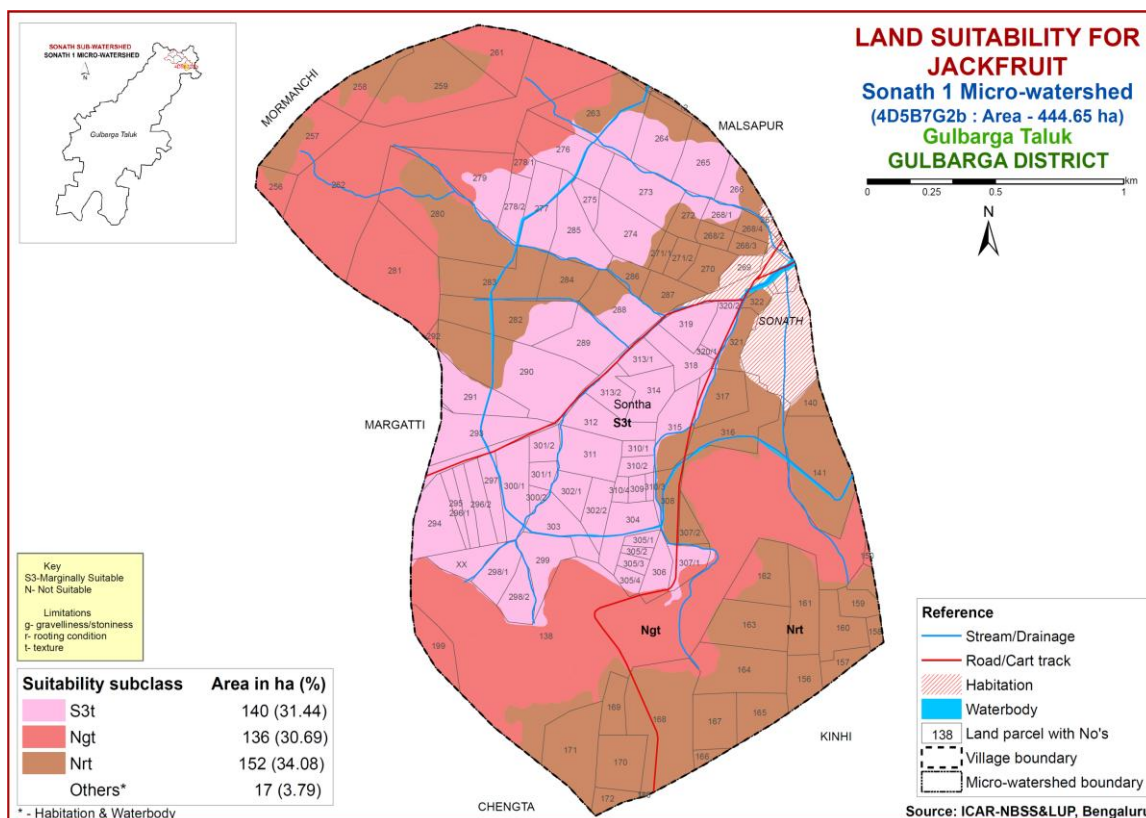


Fig 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is 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 7.13.

Highly (Class S1) suitable lands are not available for growing jamun in Sonath-1 microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 107 ha (24%). The soils have minor limitation of texture. They are distributed in the western, central and eastern part of the microwatershed. Marginally suitable (Class S3) lands are found to occur in a small area of about 33 ha (7%). The soils have moderate limitations of rooting depth and texture. They are distributed in the western part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing jamun and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

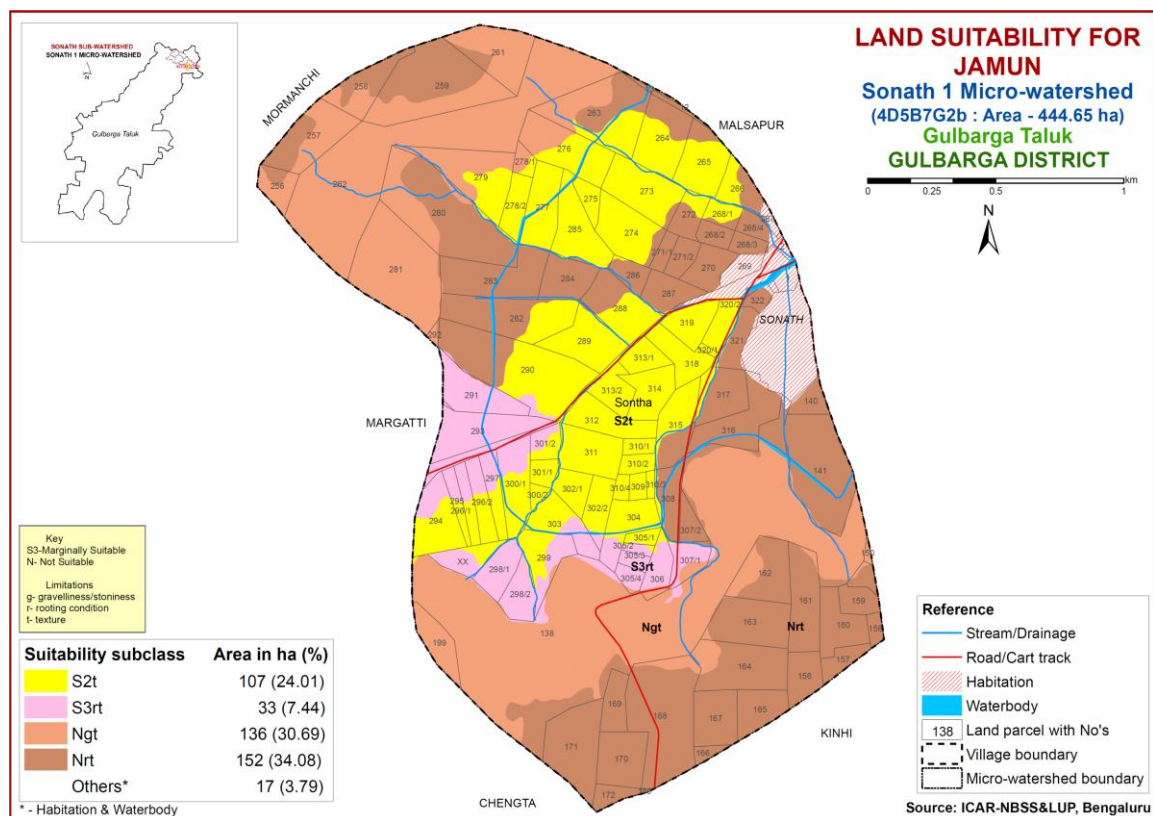


Fig 7.13 Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha 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 7.14.

Highly suitable (Class S1) lands are found to occur in an area of about 107 ha (24%). They have minor or no limitations for growing musambi and are distributed in the western, central and eastern part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in a small area of about 33 ha (7%). The soils have minor limitation of rooting depth. They are distributed in the western part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing musambi and occur in all parts of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

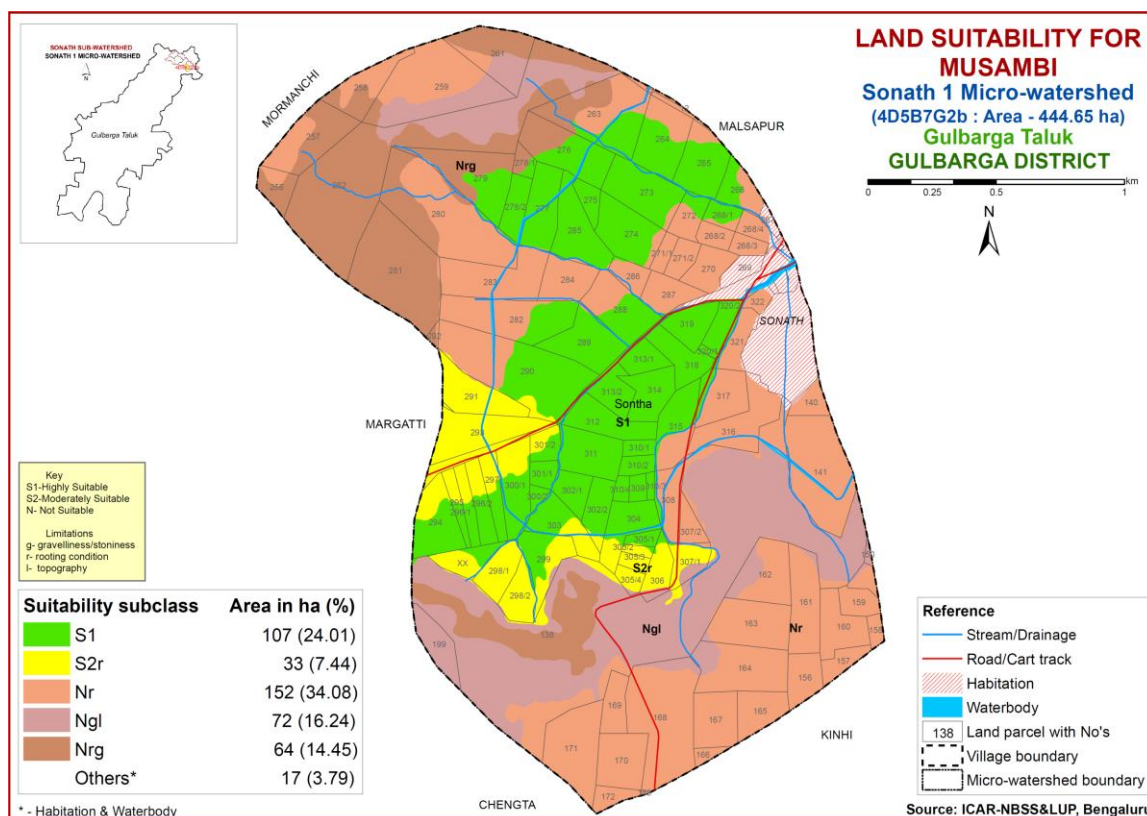


Fig 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is the most important fruit crop grown in 11752 ha in almost all the districts of the state. The crop requirements for growing lime (Table 7.11) 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 7.15.

Highly suitable (Class S1) lands are found to occur in an area of about 107 ha (24%). They have minor or no limitations for growing lime and are distributed in the western, central and eastern part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in a small area of about 33 ha (7%). The soils have minor limitation of rooting depth. They are distributed in the western part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing lime and occur in all parts of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

Table 7.11 Crop 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
	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C (>70%)	S, ls
Nutrient availability	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
	Soil depth	cm	>150	100-150	50-100	<50
Rooting condition	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
Soil toxicity	Sodicity	%	Non sodic	5-10	10-15	>15
	Slope	%	<3	3-5	5-10	

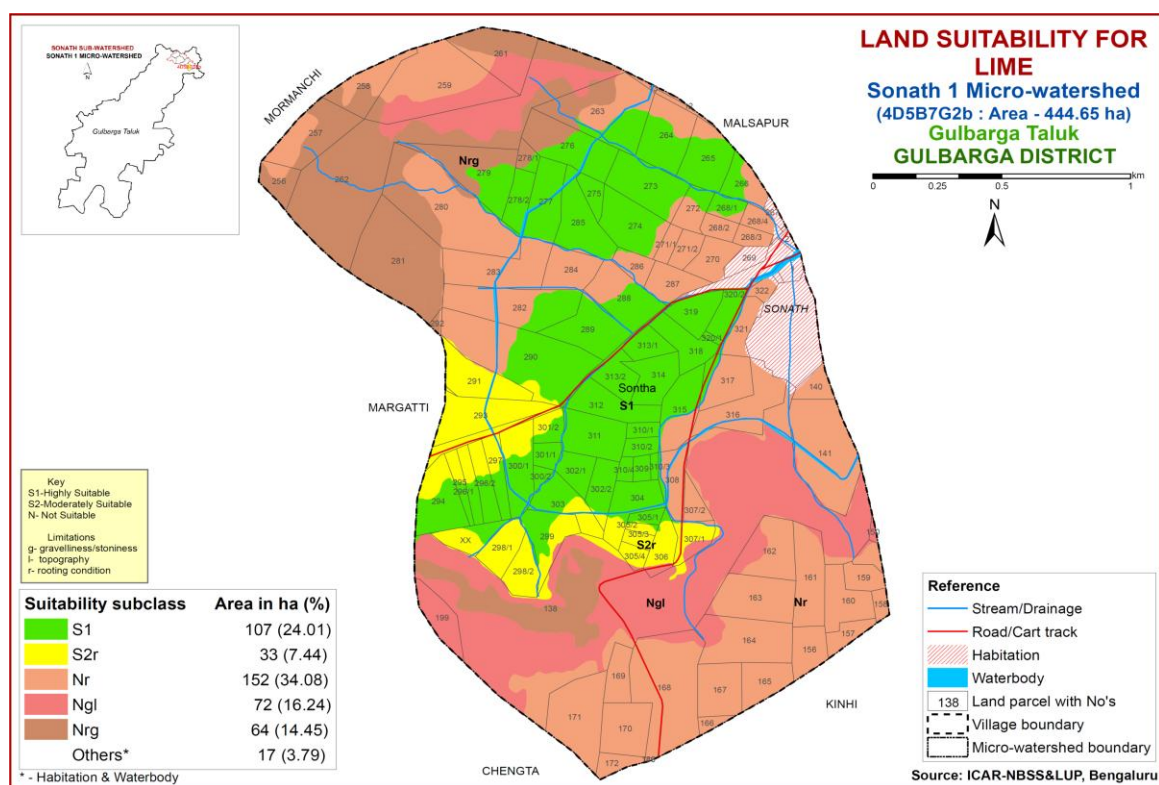


Fig 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale*)

Cashew is the most important plantation nut crop grown in an area of about 70552 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 and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

Entire area of 428 ha (96%) is not suitable (Class N) for growing cashew in the microwatershed.

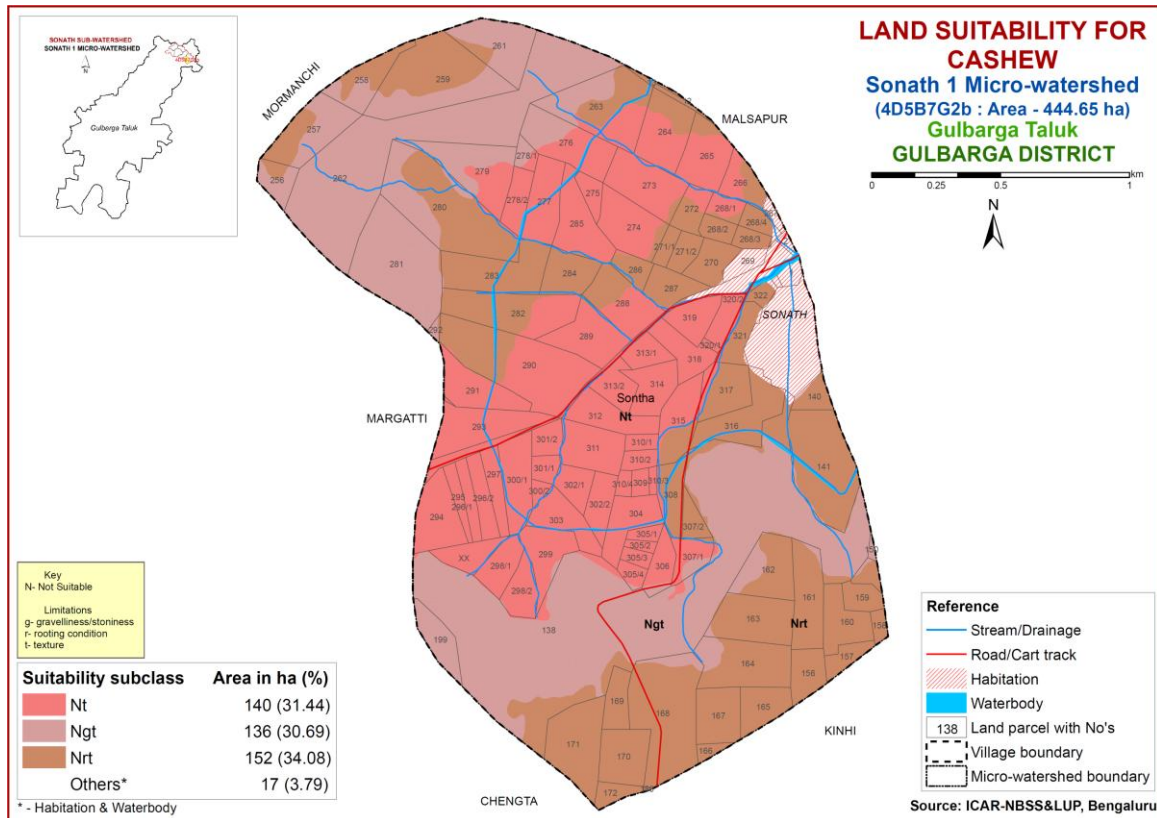


Fig 7.16 Land Suitability map of Cashew

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

Custard apple is the most important fruit crop grown in 1426 ha 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 7.17.

An area of about 140 ha (31%) is highly suitable (Class S1) for growing custard apple and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing custard apple. Marginally suitable lands (Class S3) occupy an area of about 75 ha (17%) and are distributed in the northern, central and southern part of the microwatershed. They have moderate limitation of rooting depth. An area of about 212 ha (48%) is not suitable (Class

N) for growing custard apple and are distributed in the northwestern, northeastern, southwestern and eastern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

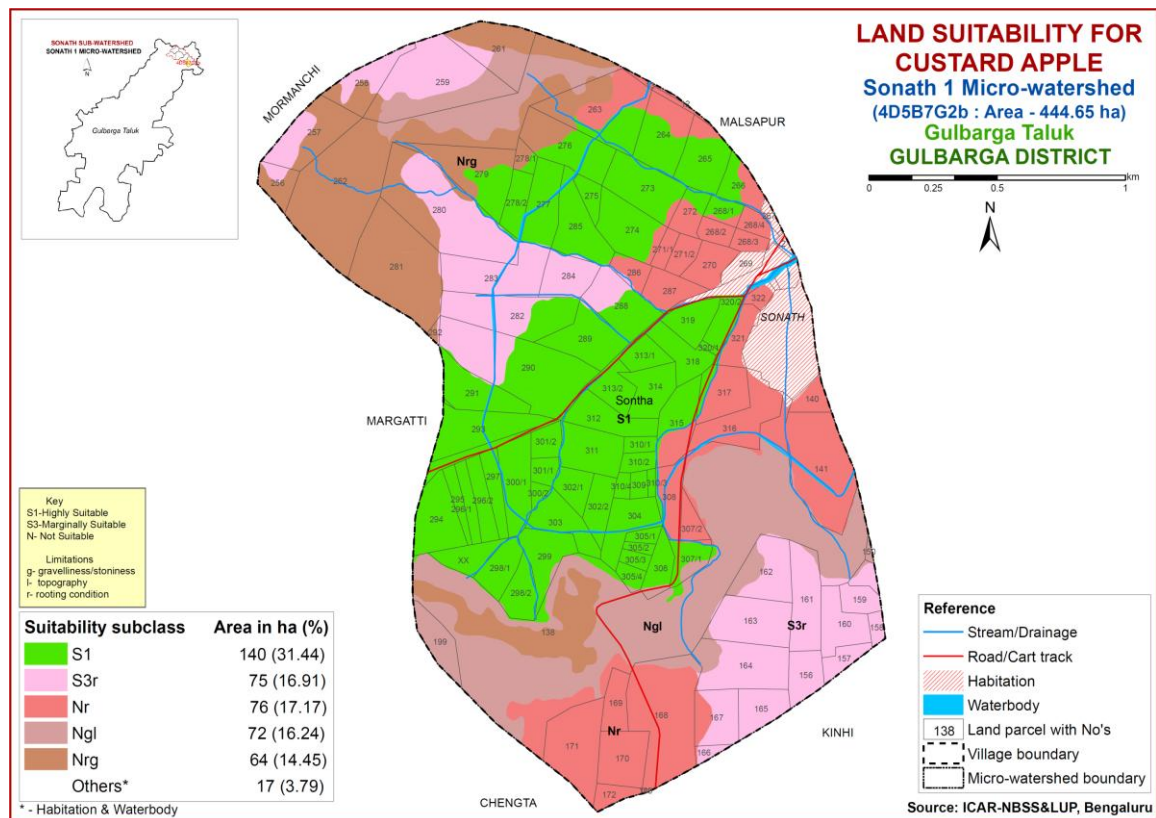


Fig 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is the most important fruit and medicinal crop grown in 151 ha 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 7.18.

An area of about 140 ha (31%) is highly suitable (Class S1) for growing amla and are distributed in the western, central and northeastern part of the microwatershed. They have minor or no limitations for growing amla. Marginally suitable lands (Class S3) occupy an area of about 75 ha (17%) and are distributed in the northern, central and southern part of the microwatershed. They have moderate limitation of rooting depth. An area of about 212 ha (48%) is not suitable (Class N) for growing amla and are distributed in the northwestern, northeastern, southwestern and eastern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

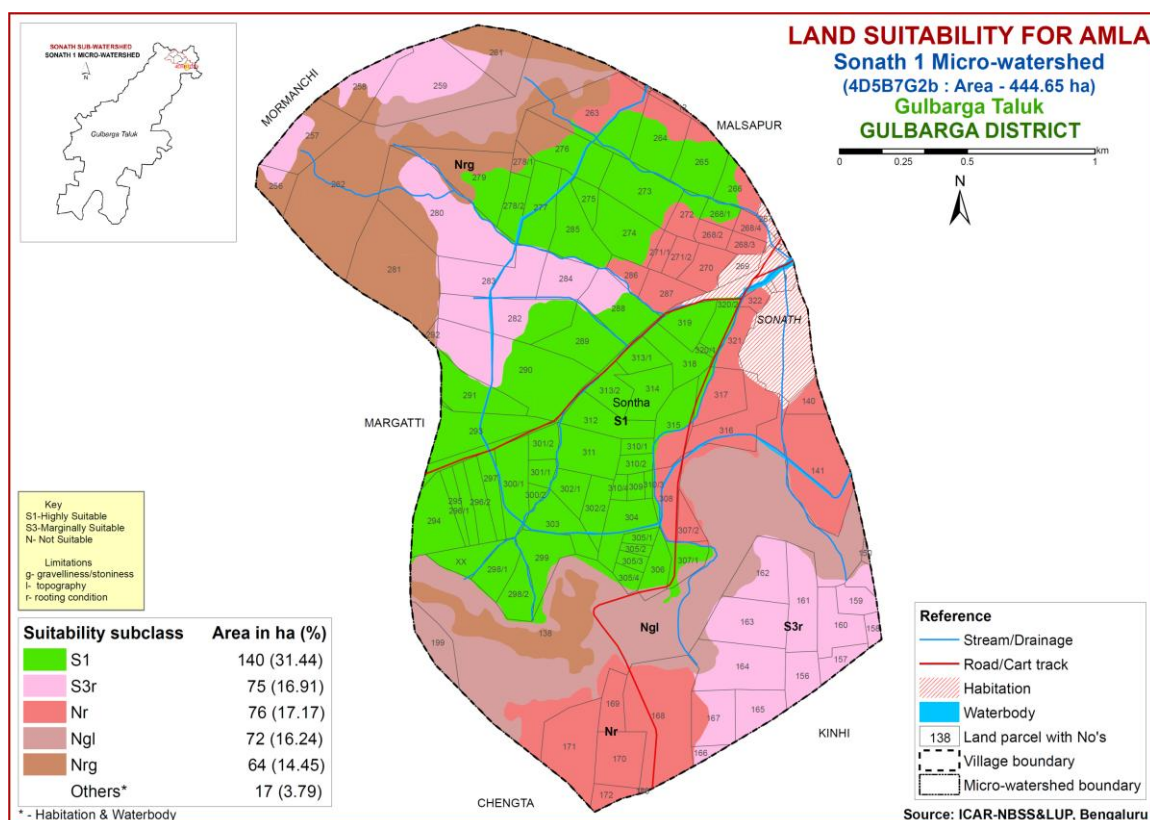


Fig 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop raised in 14897 ha 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 7.19.

Highly (Class S1) suitable lands are not available for growing tamarind in Sonath-1 microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 107 ha (24%). The soils have minor limitation of texture. They are distributed in the western, central and eastern part of the microwatershed. Marginally suitable (Class S3) lands are found to occur in a small area of about 33 ha (7%). The soils have moderate limitations of rooting depth and texture. They are distributed in the western part of the microwatershed. Major area of about 288 ha (65%) is not suitable (Class N) for growing tamarind and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

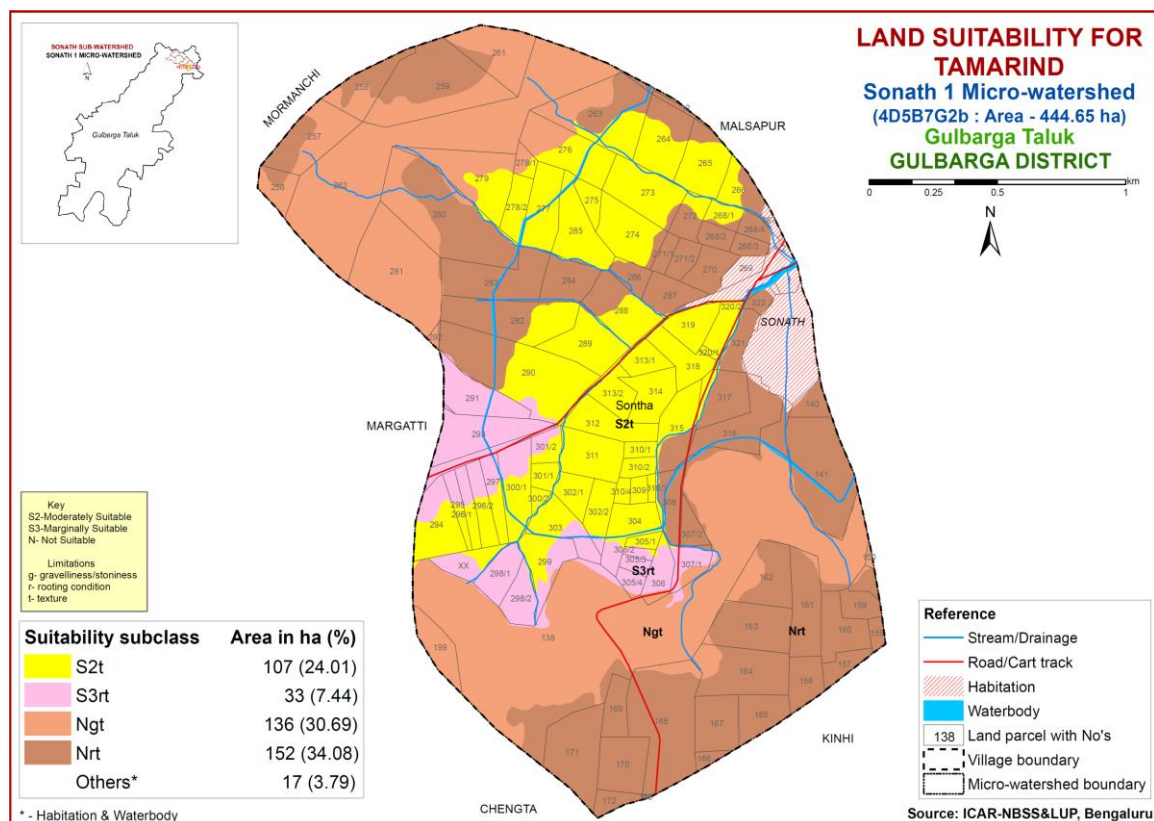


Fig 7.19 Land Suitability map of Tamarind

7.20 Land Use Classes (LUCs)

The 14 soil map units identified in Sonath-1 microwatershed have been grouped into 5 Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan. Land Use Classes 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 Use Classes map (Fig.7.20) has been generated. These Land Use Classes are expected to behave similarly for a given level of management.

The map units that have been grouped into 5 land use classes along with brief description of soil and site characteristics are given below.

LMUs	Soil map units	Soil and site characteristics
1	MGThC3g3, MGThD3g3 MGTiC3g3, MATHD3g3	Very shallow black soils with 3-10% slopes, extremely gravelly (60-80%) and severe erosion
2	MGTiB2g1, MGTmB1 MGTmB2, MGTmB2g1 MGTmB2g2	Very shallow black soils with 1-3% slopes, gravelly to very gravelly (15-60%) and slight to moderate erosion.
3	NHAmB1, NHAmB2 NHAmB2g1	Shallow black soils with 1-3 % slopes, gravelly (15-35%) and slight to moderate erosion
4	NIRmB2	Moderately shallow black soils with 1-3 % slopes and moderate erosion
5	MARmB1	Deep to very deep black soils with 1-3 % slopes and slight erosion.

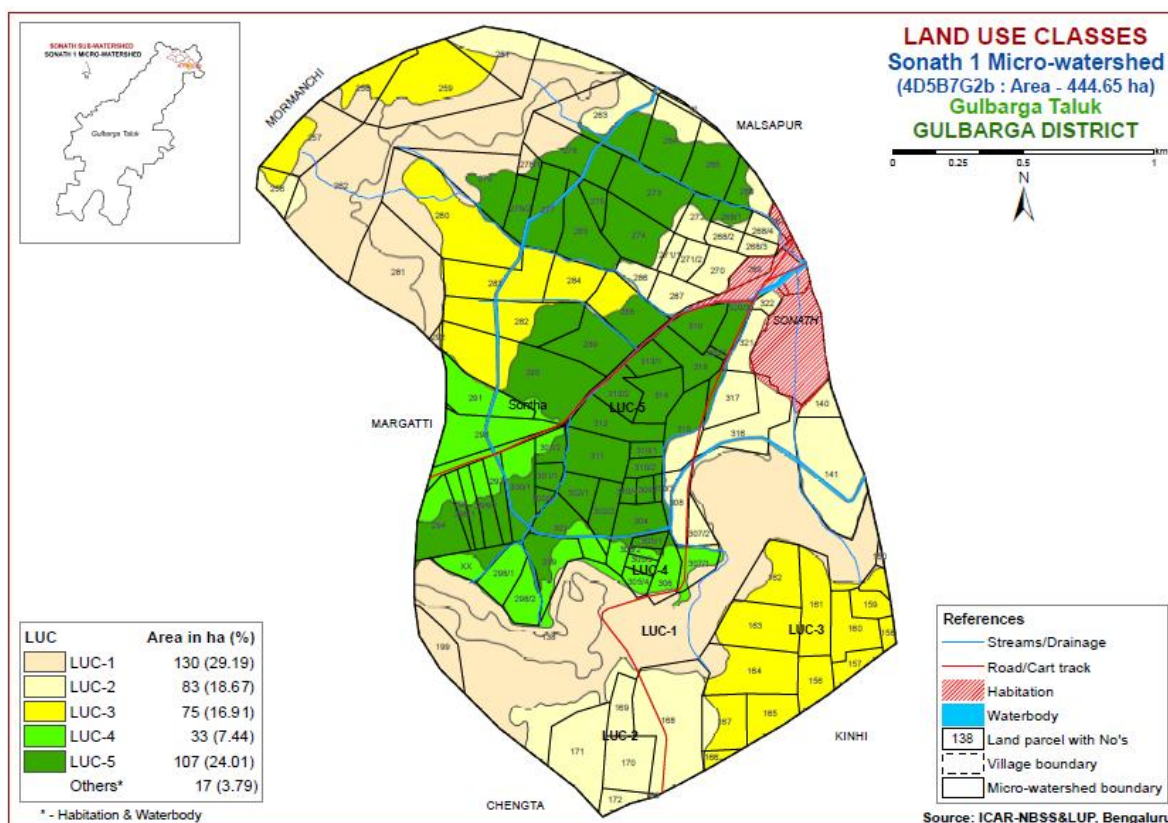


Fig. 7.20 Land Use Classes map of Sonath -1 Microwatershed

7.21 Proposed Crop Plan for Sonath-1 Microwatershed

After assessing the land suitability for the 19 crops, a proposed crop plan has been prepared for the 5 identified LUCs by considering only the highly (Class S1) and moderately (Class S2) suitable lands for each of the nineteen crops. The resultant proposed crop plan is presented below in Table 7.12

Table 7.12 Proposed Crop Plan for Sonath-1 Microwatershed

	Mapping unit	Survey No	Characters	Crop Proposed				Suitable Intervention
				Field crops	Forestry Crop/Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops with suitable intervention	
LUC-1	1 MGThC3g3 2 MGThD3g3 4 MGTiC3g3 9 MAThD3g3	Sonatha: 138,150,199,257, 262,278/1,279,281, 292	Very shallow black soils with 3-10% slopes, extremely gravelly (60-80%) and severe erosion	-	Neem, Glyricydia, Silviculture, Agave, Simaroba	-	-	Crescent bunds
LUC-2	3 MGTiB2g1 5 MGTmB1 6 MGTmB2 7 MGTmB2g1 8 MGTmB2g2	Sonatha: 12,13,140,141,168, 169,170,171,172,180, 256,261,263,268/2, 268/3,268/4,270,271/1,27 1/2,272,286,287,307/2,30 8, 316, 317,321,322	Very shallow black soils with 1-3% slopes, gravelly to very gravelly (15-60%) and slight to moderate erosion.	Horse gram, Green gram, chick pea	Neem, Glyricydia , Silviculture, Agave, Simaroba	-	-	Crescent bunds
LUC-3	10 NHAmB1 11 NHAmB2 12 NHAmB2g1	Sonatha: 156,157,158,159,160, 161,162,163,164,165, 166,167,258,259,280, 282,283,284	Shallow black soils with 1-3 % slopes, gravelly (15-35%) and slight to moderate erosion	Bajra, Linseed, Green gram, Black gram, Chick pea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea. Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip

LUC-4	13 NIRmB2	Sonatha: 291,293,295,298/1,298/2, 305/2,305/3,305/4, 306,307/1,XX	Moderately shallow black soils with 1-3 % slopes and moderate erosion	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower Rabi: Sorghum, Chickpea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea, Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip, Graded bunds, Strengthening of field bunds
LUC-5	14 MARmB1	Sonatha: 264,265,266,268/1,273,274,275,276,277,278/2,285,288,289,290,294,296/1,296/2,297,299,300/1,300/2,301/1,301/2,302/1,302/2,303,304,305/1,309,310/1,310/2,310/3,310/4,311,312,313/1,313/2,314,315,318,319,320/1,320/2	Deep to very deep black soils with 1-3 % slopes and slight erosion.	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower, Linseed Rabi: Sorghum, Chickpea, Coriander	-	Vegetables: Ladies finger, Brinjal, Cowpea, Coriander Field crops: Sorghum, Cotton, Red Gram, Sunflower, Safflower, Perennial component: Guava, Tamarind, Sapota, Lime, Musambi Flowers: Marigold, Chrysanthemum	Banana, Papaya, Lime, Musambi, Guava, Tamarind Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip, graded bunds, strengthening of field bunds

SOIL HEALTH MANAGEMENT

8.1 Soil 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 characteristics 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 Sonath-1 Microwatershed

- The soil phases identified in the microwatershed belonged to the soil series of MGT (200 ha), MAR (107 ha), NHA (75 ha), NIR (33 ha) and MAT (13 ha).
- As per land capability classification, nearly 80 per cent area comes under arable land category (Class II, III and IV) and 16 per cent area belongs to nonarable land (Class VI) category. The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, about 166 ha (37%) area is moderately alkaline (pH 7.8-8.4) followed by slightly alkaline (pH 7.3-7.8) soils in 100 ha (23%). An area of about 97 ha (22%) is neutral (pH 6.5-7.3) in reaction and 67 ha (15%) is strongly

alkaline (pH 8.4-9.0) in reaction. Thus, about 75 per cent of the soils in the microwatershed are alkaline in reaction.

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)

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 (Azospirillum, Azotobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of ZnSO₄ – 12.5 kg/ha (once in three years).
5. Application of Boron – 5kg/ha (once in three years).

Neutral soils

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, (Azospirillum, 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 area of 445 ha in the microwatershed, major area of 278 ha is suffering from either moderate or severe erosion. These areas need immediate soil and water conservation and other 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 the younger farmers.

Inputs for Net Planning (Saturation Plan) and Interventions needed

Net planning (Saturation Plan) in IWMP is focusing on preparation of

1. Soil and Water Conservation Plan 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 (Saturation Plan) are briefly presented below.

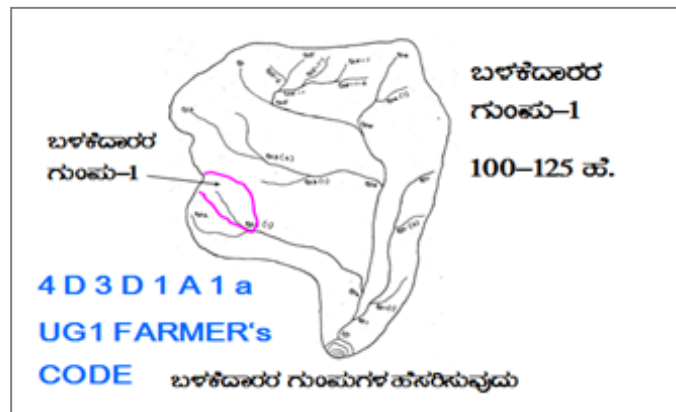
- ❖ **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth 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, radish, 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 may 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 Sonath-1 microwatershed.
- ❖ **Organic Carbon:** In about 93 ha (21%) area, the OC content is medium (0.5-0.75%) and in about 338 ha (76%) area, it is high (>0.75%). The areas that are low and 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 cost 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 93 ha area where OC is low. 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 210 ha (47%) area, the available phosphorus is low, an area of about 202 ha (46%) is medium and an area of about 18 ha (4%) high in the microwatershed. Hence for all the crops, 25% additional P-needs to be applied.
- ❖ **Available Potassium:** Available potassium is medium in 297 ha (67%) area, low in 32 ha (7%) area. Hence, in all these plots, where available potassium is medium to low, for all crops an additional 25% potassium may be applied. It is high in 102 ha (23%) area of the microwatershed.
- ❖ **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 71 ha (16%) area of the microwatershed and medium in 360 ha (81%). These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- ❖ **Available iron:** It is deficient in 50 ha (11%) area of the microwatershed and is sufficient in 381 ha (66%) area in the microwatershed.
- ❖ **Available Zinc:** It is deficient in 366 ha (82%) area. Application of zinc sulphate @25kg/ha is to be applied. It is sufficient in 64 ha (14%) area in the microwatershed.
- ❖ **Soil alkalinity:** The microwatershed has 333 ha area with soils that are alkaline in reaction. 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 and marginally 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 Sonath-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
- Available water capacity
- Soil slope
- Soil gravelliness
- Land capability
- Present land use and 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 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		USER GROUP-1
<ul style="list-style-type: none"> • 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 25ha catchment)	

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 % slope, 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 (bg₀, b=loamy sand, g₀ = <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 soil	
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:

TRENCH CUM BUND

WATER STORAGE AREA

0.45 Sq.m section

IDEAL FOR HORTICULTURE CROPS

'A' FRAME FOR INTERBUND MANAGEMENT

1. ಸಮವಾತಳ ಉಳುವೆ

2. ಸಮವಾತಳ ಬಿತ್ತನೆ/ನಾಟಿ

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
			L(m)	W(m)	D(m)	QUANTITY (m ³)		
m ²	m	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. Water Ways

- Existing waterways are marked on the cadastral map (1:7920 scale) and their dimensions are recorded.
- Considering the contour plan of the MWS, additional waterways/ modernization of the existing ones can be thought of.
- 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 Bund are formed in the field.

9.1.3 Treatment of Natural Water Course/ Drainage Lines

- a) The cadastral map has to be updated as regards the network of drainage 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 from 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 earthen 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 prepared which shows the spatial distribution and extent of area. Major area of about 288 ha (65%) requires crescent bunds and 140 ha (31%) area requires for GB/ strengthening of bunds.

The conservation plan prepared may be presented to all the stakeholders including farmers and after including their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

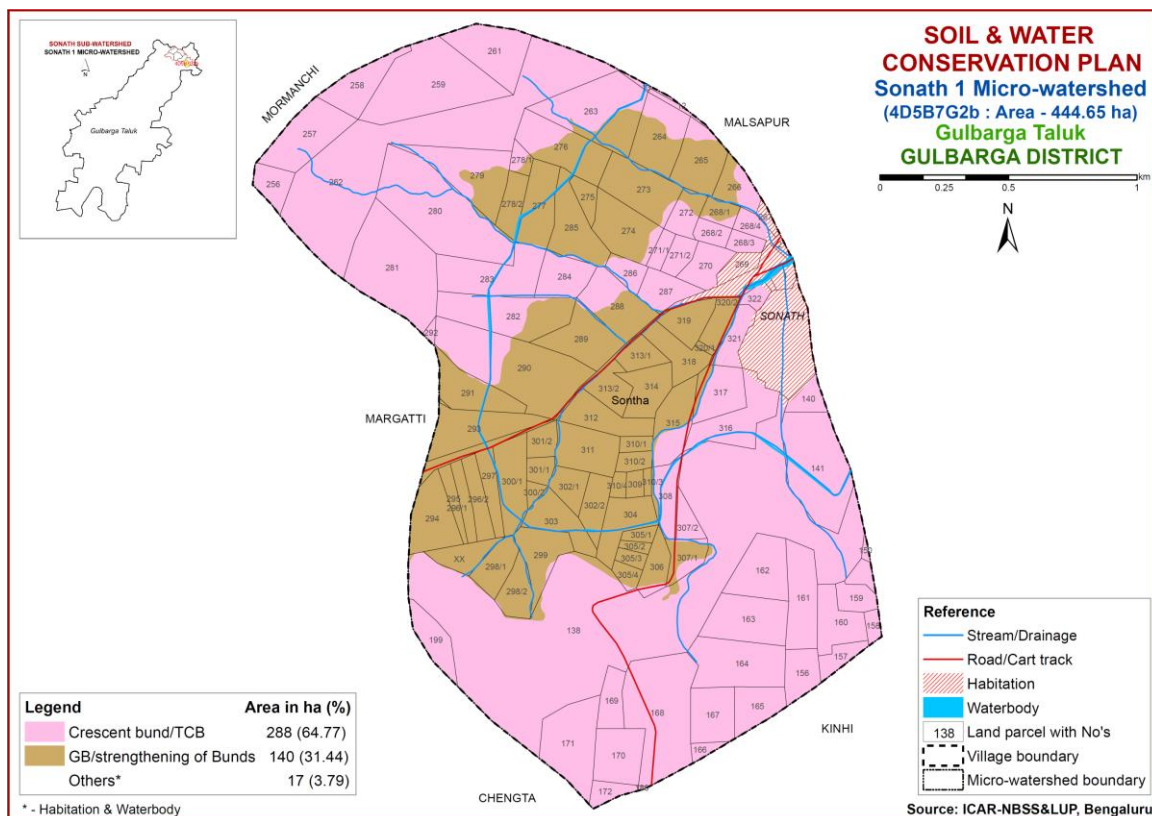


Fig. 9.1 Soil and Water Conservation Plan map of Sonath-1 Microwatershed

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, VII and VIII) and also the lands that are not suitable or marginally suitable and field bunds 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 (*Syzgium cumini*) and Bamboo. Dry areas are to be planted with species like Honge, Bevu, Seetaphal *etc.*

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

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Appendix I
Sonath-1 Microwatershed
Soil Phase Information

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	1	0.82	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Sontha	2	0.34	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Sontha	12	0	MGTiB2g1	LMU-2	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Road	Not Available	IVse	Crescent bund/TCB
Sontha	13	0.29	MGTiB2g1	LMU-2	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	Crescent bund/TCB
Sontha	138	73.94	MGTThD3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram+No Crop (Rg+NC)	Check dum,	VIse	Crescent bund/TCB
Sontha	140	1.39	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	141	9.16	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+No Crop (Rg+NC)	Not Available	IVse	Crescent bund/TCB
Sontha	150	0.2	MGTThD3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIse	Crescent bund/TCB
Sontha	156	2.4	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	157	1.41	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	158	0.67	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	159	1.55	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	160	3.36	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	161	4.63	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	162	4.6	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	163	5.32	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	164	6.37	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	165	2.81	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	166	0.6	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	167	3.62	NHAmB2	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	168	10.92	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	169	2.05	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	170	3.88	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	171	6.22	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Sontha	172	1.16	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	180	0.04	MGTmB2	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	199	2.58	MGTThD3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram (Rg)	Not Available	VIse	Crescent bund/TCB
Sontha	256	1.89	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	257	5.33	MGTiC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	258	3.47	NHAmB2g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sontha	259	10.81	NHAmB2g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+No Crop (Rg+NC)	Not Available	IVse	Crescent bund/TCB
Sontha	261	5.12	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	262	28.02	MGTiC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Jowar+No Crop (Jw+NC)	Bore well	IVse	Crescent bund/TCB
Sontha	263	8.29	MGTiB2g1	LMU-2	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Check dum	IVse	Crescent bund/TCB
Sontha	264	4.85	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sontha	265	4.22	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sunflower (Rg+Sf)	Bore well	IIs	GB/strengthening of Bunds
Sontha	266	2.32	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Bore well	IIs	GB/strengthening of Bunds
Sontha	267	0.47	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Sontha	268/1	1.22	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Bore well	IIs	GB/strengthening of Bunds
Sontha	268/2	1.14	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Open well	IVs	Crescent bund/TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	268/3	0.99	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	268/4	1.16	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	269	1.22	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Sontha	270	2.36	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	271/1	0.87	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sunflower (Sf)	Not Available	IVs	Crescent bund/TCB
Sontha	271/2	1.37	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	272	1.89	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Open well	IVs	Crescent bund/TCB
Sontha	273	4.99	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Open well	IIs	GB/strengt hening of Bunds
Sontha	274	4.67	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sunflower (Rg+Sf)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	275	1.14	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	GB/strengt hening of Bunds
Sontha	276	5.51	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	277	3.95	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	278/1	0.84	MGTThC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	278/2	2	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	279	6.1	MGTThC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram (Rg)	Bore well	IVse	Crescent bund/TCB
Sontha	280	12.5	NHAmB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Check dum	IVs	Crescent bund/TCB
Sontha	281	11.16	MGTiC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram+No Crop (Rg+NC)	Not Available	IVse	Crescent bund/TCB
Sontha	282	7.07	NHAmB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Bore well,Open well	IVs	Crescent bund/TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	283	6.07	NHAmB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	284	3.08	NHAmB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Bore well	IVs	Crescent bund/TCB
Sontha	285	4.53	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	286	1.44	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	287	2.43	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sontha	288	4.57	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	289	4.45	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Open well	IIs	GB/strengt hening of Bunds
Sontha	290	11.96	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	291	3.99	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	292	0.33	MGTmC3g3	LMU-1	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	NA	Not Available	IVse	Crescent bund/TCB
Sontha	293	5.02	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Check dum,Check dum	IIIse	GB/strengt hening of Bunds
Sontha	294	4.35	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	295	1.13	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	296/1	1.39	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	296/2	2.02	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	297	1.87	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	298/1	2.43	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	GB/strengt hening of Bunds

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	298/2	2.36	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	299	3.42	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	300/1	3.98	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	300/2	0.48	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	No Crop (NC)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	301/1	1.03	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	No Crop (NC)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	301/2	1.4	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	No Crop (NC)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	302/1	1.88	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	302/2	2.25	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	303	3.22	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Open well	IIs	GB/strengt hening of Bunds
Sontha	304	3.42	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	305/1	0.67	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengt hening of Bunds
Sontha	305/2	0.46	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	305/3	0.68	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	305/4	0.84	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	306	2.01	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IIIse	GB/strengt hening of Bunds
Sontha	307/1	2.04	NIRmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IIIse	GB/strengt hening of Bunds

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	307/2	1.25	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	308	2.68	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	309	0.7	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIs	GB/strengthening of Bunds
Sontha	310/1	0.78	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sontha	310/2	0.98	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sontha	310/3	0.33	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Open well	IIs	GB/strengthening of Bunds
Sontha	310/4	0.56	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIs	GB/strengthening of Bunds
Sontha	311	4.05	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Maize (Rg+Mz)	Bore well	IIs	GB/strengthening of Bunds
Sontha	312	3.38	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Bore well	IIs	GB/strengthening of Bunds
Sontha	313/1	1.69	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Bore well	IIs	GB/strengthening of Bunds
Sontha	313/2	2.18	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sontha	314	3.07	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Bore well	IIs	GB/strengthening of Bunds
Sontha	315	3.98	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+No Crop (Sc+NC)	Open well	IIs	GB/strengthening of Bunds
Sontha	316	4.84	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	317	3.6	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	318	2.75	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Bore well	IIs	GB/strengthening of Bunds
Sontha	319	2.5	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Open well	IIs	GB/strengthening of Bunds

VILLAGE	Survey Number	Area (ha)	Soils phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Sontha	320/1	0.18	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Not Available	IIs	GB/strengthening of Bunds
Sontha	320/2	1.79	MARmB1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Not Available	IIs	GB/strengthening of Bunds
Sontha	321	2.03	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB
Sontha	322	0.75	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	No Crop (NC)	Not Available	IVse	Crescent bund/TCB

VILLAGE	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sontha	310/3	Moderately alkaline (pH 7.8 – 8.4)	Non saline(<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	310/4	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	311	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	312	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	313/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	313/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	314	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	315	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	316	Moderately alkaline (pH 7.8 – 8.4)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	317	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	318	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	319	Moderately alkaline (pH 7.8 – 8.4)	Non saline(<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	320/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	320/2	Moderately alkaline (pH 7.8 – 8.4)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	321	Strongly alkaline (pH 8.4 – 9.0)	Non saline(<2 dsm)	High (> 0.75 %)	Low(< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sontha	322	Moderately alkaline (pH 7.8 – 8.4)	Non saline(<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Appendix III
Sonath-1 Microwatershed
Soil Suitability Information

VILLAGE	Survey Number	Sorghum	Maize	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custardapple	Amla	Tamarind	Sugarcane	Redgram	Bengalgram	Sunflower	Soyabean	
Sontha	1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sontha	2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sontha	12	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	13	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	138	Ngl	Ngt	Ngl	Ngt	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngl	Ngl	Ngl	
Sontha	140	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	141	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	150	Ngl	Ngt	Ngl	Ngt	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngl	Ngl	Ngl	
Sontha	156	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	157	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	158	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	159	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	160	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	161	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	162	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	163	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	164	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	165	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	166	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	167	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	168	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	169	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	170	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	171	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	172	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	180	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	199	Ngl	Ngt	Ngl	Ngt	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngl	Ngl	Ngl	
Sontha	256	Nrg	Ngt	Nrg	Ngt	Ngt	Ngt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	S3rg	Nrg	Nrg	
Sontha	257	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg	
Sontha	258	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	259	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r	
Sontha	261	Nrg	Ngt	Nrg	Ngt	Ngt	Ngt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	S3rg	Nrg	Nrg	
Sontha	262	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg	
Sontha	263	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	264	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1	
Sontha	265	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1	
Sontha	266	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1	
Sontha	267	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sontha	268/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1	
Sontha	268/2	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	268/3	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	268/4	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr	
Sontha	269	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

VILLAGE	Survey Number	Sorghum	Maize	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custardapple	Amla	Tamarind	Sugarcane	Red gram	Bengal gram	Sunflower	Soyabean
Sontha	270	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	271/1	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	271/2	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	272	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	273	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	274	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	275	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	276	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	277	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	278/1	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg
Sontha	278/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	279	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg
Sontha	280	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r
Sontha	281	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg
Sontha	282	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r
Sontha	283	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r
Sontha	284	S3r	S3rt	S3r	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	Nrt	S3rt	S2r	Nr	S3r
Sontha	285	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	286	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	287	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	288	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	289	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	290	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	291	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	292	Nrg	Ngt	Nrg	Nrt	Ngt	Nrt	Ngt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ngt	Ngt	Ng	Nrg	Nrg
Sontha	293	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	294	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	295	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	296/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	296/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	297	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	298/1	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	298/2	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	299	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	300/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	300/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	301/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	301/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	302/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	302/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	303	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	304	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	305/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	305/2	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	305/3	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	305/4	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	306	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1

VILLAGE	Survey Number	Sorghum	Maize	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard apple	Amla	Tamarind	Sugarcane	Red gram	Bengal gram	Sunflower	Soyabean
Sontha	307/1	S1	S3t	S2r	S3t	S3t	S3t	S3t	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S3t	S2te	S1	S1	S1
Sontha	307/2	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	308	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	309	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	310/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	310/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	310/3	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	310/4	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	311	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	312	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	313/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	313/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	314	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	315	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	316	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	317	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	318	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	319	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	320/1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	320/2	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S3t	S2t	S1	S1	S1
Sontha	321	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr
Sontha	322	Nr	Nrt	Nr	Nrt	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	S3r	Nr	Nr

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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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: *Sonath-1 micro-watershed (Sonath-1 sub-watershed, Gulbarga taluk and district) is located in between 17^o35'–17^o37' North latitudes and 77^o5'–77^o7' East longitudes, covering an area of about 445 ha, bounded by Mormanchi, Malsapur, Kinhi, Chengta and Margatti villages with 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 ecosystem services were quantified.*

Results: *The socio-economic outputs for Sonath-1 micro-watershed (Sonath sub-watershed, Gulbarga taluk, Gulbarga district) are presented here.*

Social Indicators;

- ❖ *Male and female ratio is 60.5 to 39.5 per cent to the total sample population.*
- ❖ *Younger age 18 to 50 years group of population is around 62.8 per cent to the total population.*
- ❖ *Literacy population is around 72.1 per cent.*
- ❖ *Social groups belong to general caste is around 50 per cent.*
- ❖ *Wood is the source of energy for a cooking among 50 per cent.*
- ❖ *About 10 per cent of households have a yashaswini health card.*
- ❖ *Dependence on ration cards for food grains through public distribution system is around 60 per cent.*
- ❖ *Swach bharrath program providing closed toilet facilities around 30 per cent of sample household.*
- ❖ *Women participation in decisions making is among all the households were found.*

Economic Indicators;

- ❖ *The average land holding 1.6 ha indicates that majority of farm households are belonging to marginal and small and large farmers. The rain fed land is the total cultivated land area among all the sample farmers.*

- ❖ *Agriculture is the main occupation among 72.1 per cent and agriculture is the main and agriculture labour is subsidiary occupation around 11.6 per cent of sample households.*
- ❖ *The average value of domestic assets is around Rs.75901 per household. Mobile and television are popular mass media communication.*
- ❖ *The average farm assets value is around Rs. 181375 per household, about 50 per cent of sample farmers having bullock cart, plough, sprayer and tractor.*
- ❖ *The average livestock value is around Rs. 71250 per household; among the all sample household are having livestock.*
- ❖ *The average per capita food consumption is around 823 grams (1811.5 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 60 per cent of sample farmers are consuming less than the NIN recommendation.*
- ❖ *The annual average income is around Rs. 55519 per household. About 80 per cent of farm households are below poverty line.*
- ❖ *The per capita monthly average expenditure is around Rs. 2428.*

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. 628 per ha/year. The total cost of annual soil nutrients is around Rs. 345861 per year for the total area of 444.65 ha.*
- ❖ *The average value of ecosystem service for food grain production is around Rs. 8286/ha/year. Per hectare food grain production services is maximum in redgram (Rs. 19003) followed by black gram (Rs. 3970) and green gram (Rs. 1886).*
- ❖ *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 redgram (Rs. 57451) followed by green gram (Rs. 48847) and black gram (Rs. 45488).*

Economic Land Evaluation;

- ❖ *The major cropping pattern is redgram (86.0 %) followed by black gram (8.2 %) and green gram (5.7 %).*
- ❖ *Sonath-1 micro-watershed, major soil is Marguti (DDT) series having very shallow soil depth cover around 44.9 % of area. On this soil farmers are presently growing redgram, Novinihala (DGR) are having shallow soil depth cover around*

16.9 % of area, the crops are red gram and Mannur soil series having very deep soil depth cover around 24.0 % of area; major crops are black gram, red gram and green gram.

- ❖ *The total cost of cultivation and benefit cost ratio (BCR) in study area for red gram ranges between Rs. 23799/ha in MAR soil (with BCR of 1.46) and Rs.19508/ha in NHA soil (with BCR of 2.53).*
- ❖ *In green gram the cost of cultivation Rs 38785/ha in MAR soil (with BCR of 1.06) and black gram the cost of cultivation in MAR soil Rs.22377/ha (with BCR of 1.18).*
- ❖ *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 in deeper soil to maximize returns.*

Suggestions;

- ❖ *Involving farmers in watershed planning helps in strengthening 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 strengthening agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- ❖ *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in red gram (0 to 21.2 %), green gram (18.5 %) and black gram (32.5 %).*

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.

METHODOLOGY

Study area

Sonath-1 micro-watershed is located in north-eastern dry zone of Karnataka (Figure 1). The total geographic area of this zone is about 1.76 M ha covering 8 taluks of Gulbarga district and 3 taluks of Raichur. Net cultivated area in the zone is about 1.31 M ha of which about 0.09 M ha are irrigated. The mean elevation of the zone is 300-450 m MSL. The main soil type is deep to very deep soils with small pockets of shallow to medium black soils. The zone is cropped predominantly during rabi due to insufficient rainfall (465-785 mm). The principal crops of the zone are jowar, bajra, oilseeds, pulses, cotton and sugarcane. It represents Agro Ecological Sub Region (AESR) 6.2 having LGP 120-150 days.

Sonath-1 micro-watershed (Sonath sub-watershed, Gulbarga taluk, Gulbarga district) is located in between 17^o35'–17^o37' North latitudes and 77^o5'–77^o7' East longitudes, covering an area of about 445 ha, bounded by Mormanchi, Malsapur, Kinhi, Chengta and Margatti villages.

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 survey. The data collected from the representative farm households were analysed using Automated Land Potential Evaluation System (Figure 2).

LOCATION MAP OF SONATH-1 MICRO WATERSHED

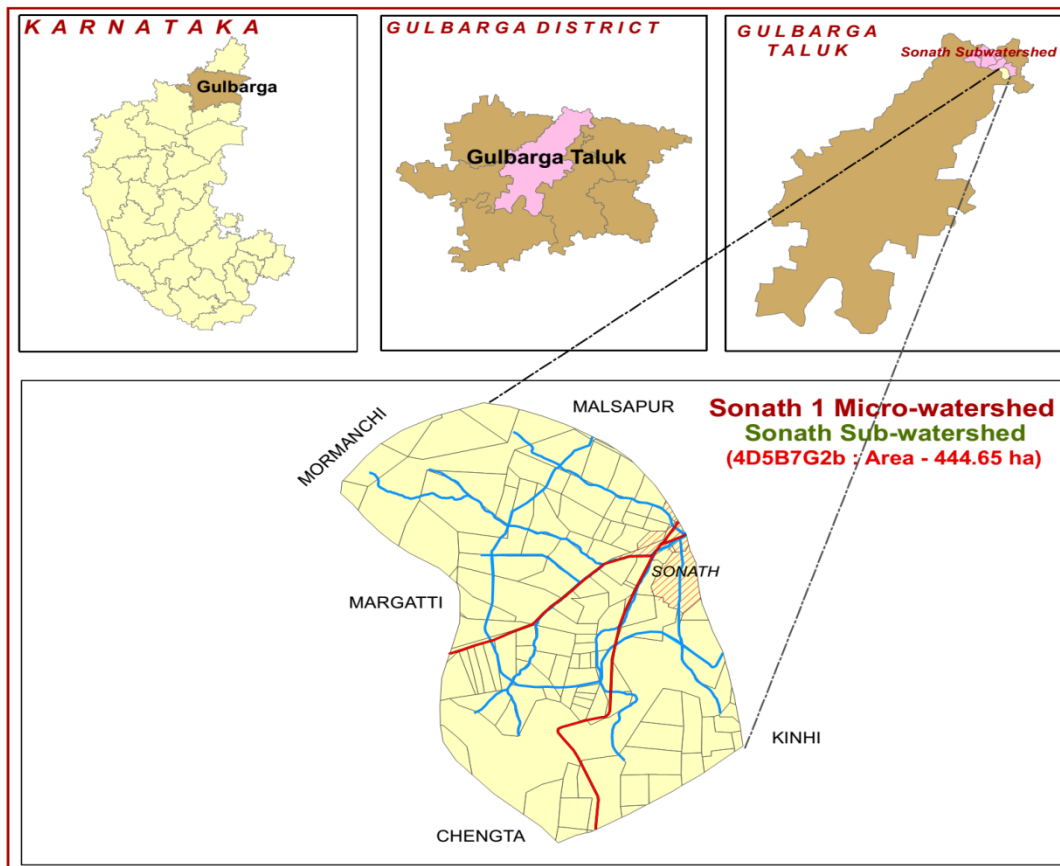


Figure 1: Location of study area

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 .

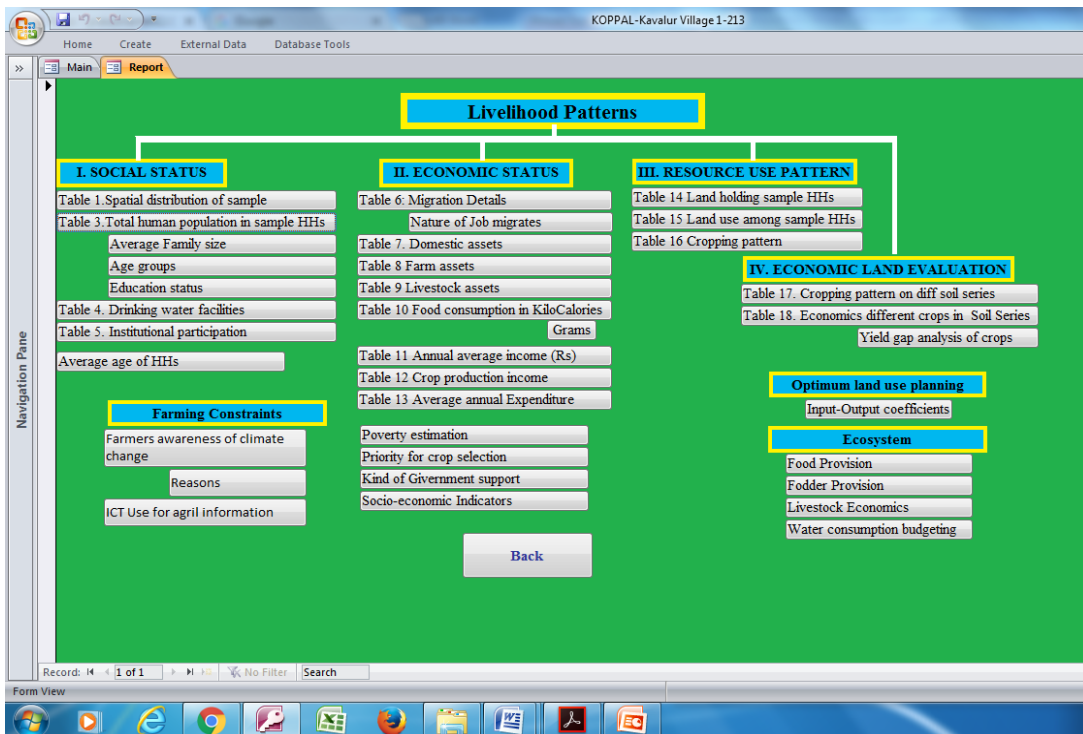


Figure 2: ALPES FRAMEWORK

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.

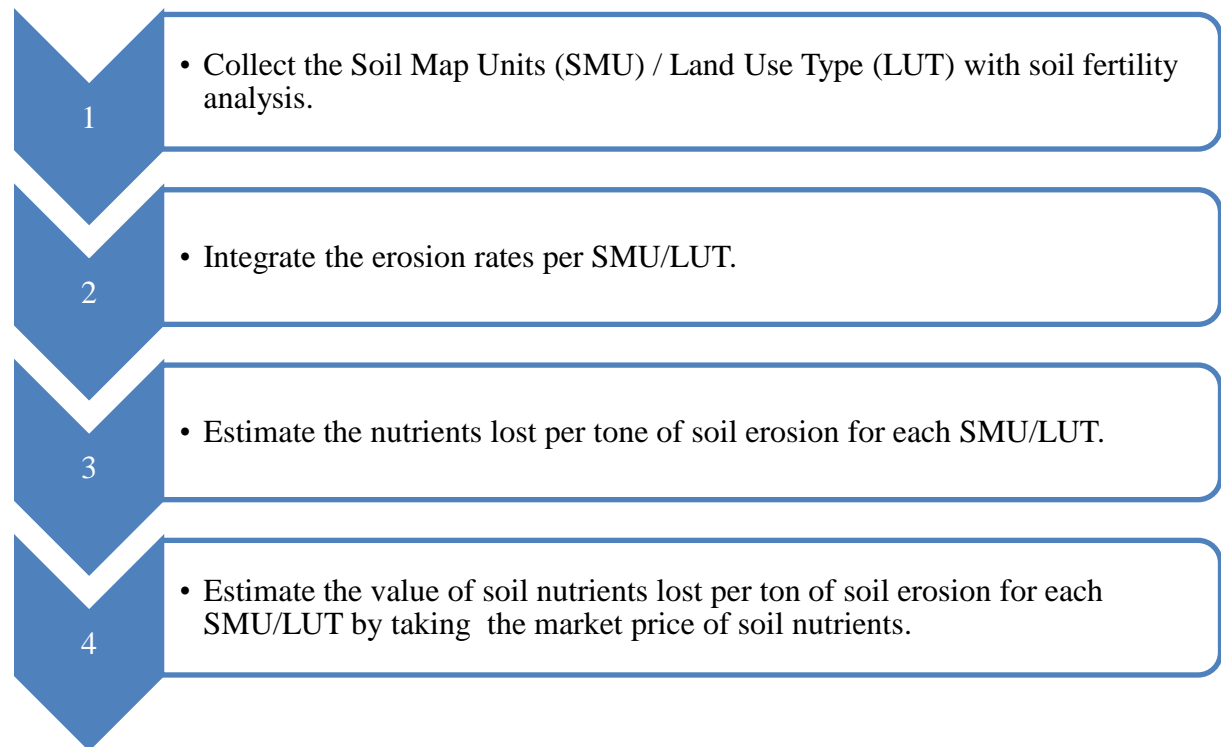
Benefit Cost Ratio = Net returns/Total cost.

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 divided 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 methods 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



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 43, out of which 60.5, per cent were males and 39.3, per cent females. Average family size of the households is 4.3. 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 of more than 50 years (42.6 %) followed by 18 to 30 years (30.2 %), 30 to 50 years (25.6 %) and 0 to 18 years (7.0 %). 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 27.9 per cent of respondents were illiterate and 72.1 per cent literate (Table 1).

Table 1: Human population among sample households in Sonath-1 Micro watershed

Particulars	Units	Value
Total human population in sample HHs	Number	43
Male	% to total Population	60.5
Female	% to total Population	39.5
Average family size	Number	4.3
Age group		
0 to 18 years	% to total Population	7.0
18 to 30 years	% to total Population	30.2
30 to 50 years	% to total Population	25.6
>50 years	% to total Population	37.2
Average age	Age in years	42.6
Education Status		
Illiterates	% to total Population	27.9
Literates	% to total Population	72.1
Primary School (<5 class)	% to total Population	4.7
Middle School (6- 8 class)	% to total Population	14.0
High School (9- 10 class)	% to total Population	11.6
Others	% to total Population	41.9

The ethnic groups among the sample farm households found to 50 percent belonging to general castes followed by 30 percent belonging to scheduled caste (SC) and 20 per cent belonging to other backward castes (OBC) (Table 2 and Figure 3). About 50 per cent of sample households are using fire wood and gas 50 per cent as source of fuel for cooking. All the sample farmers are having electricity connection. About 10 per cent are sample households having health cards. All the sample households are having MNREGA job cards for employment generation. About 60 per cent of farm households are having ration cards for taking food grains from public distribution system. About 60 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Sonath-1 Micro watershed

Particulars	Units	Value
Social groups		
SC	% of Households	30.0
OBC	% of Households	20.0
General	% of Households	50.0
Types of fuel use for cooking		
Fire wood	% of Households	50.0
Gas	% of Households	50.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	10.0
No	% of Households	90.0
MGNREGA Card		
Yes	% of Households	0.0
No	% of Households	100.0
Ration Card		
Yes	% of Households	60.0
No	% of Households	40.0
Households with toilet		
Yes	% of Households	60.0
No	% of Households	40.0
Drinking water facilities		
Tube Well	% of Households	100.0

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

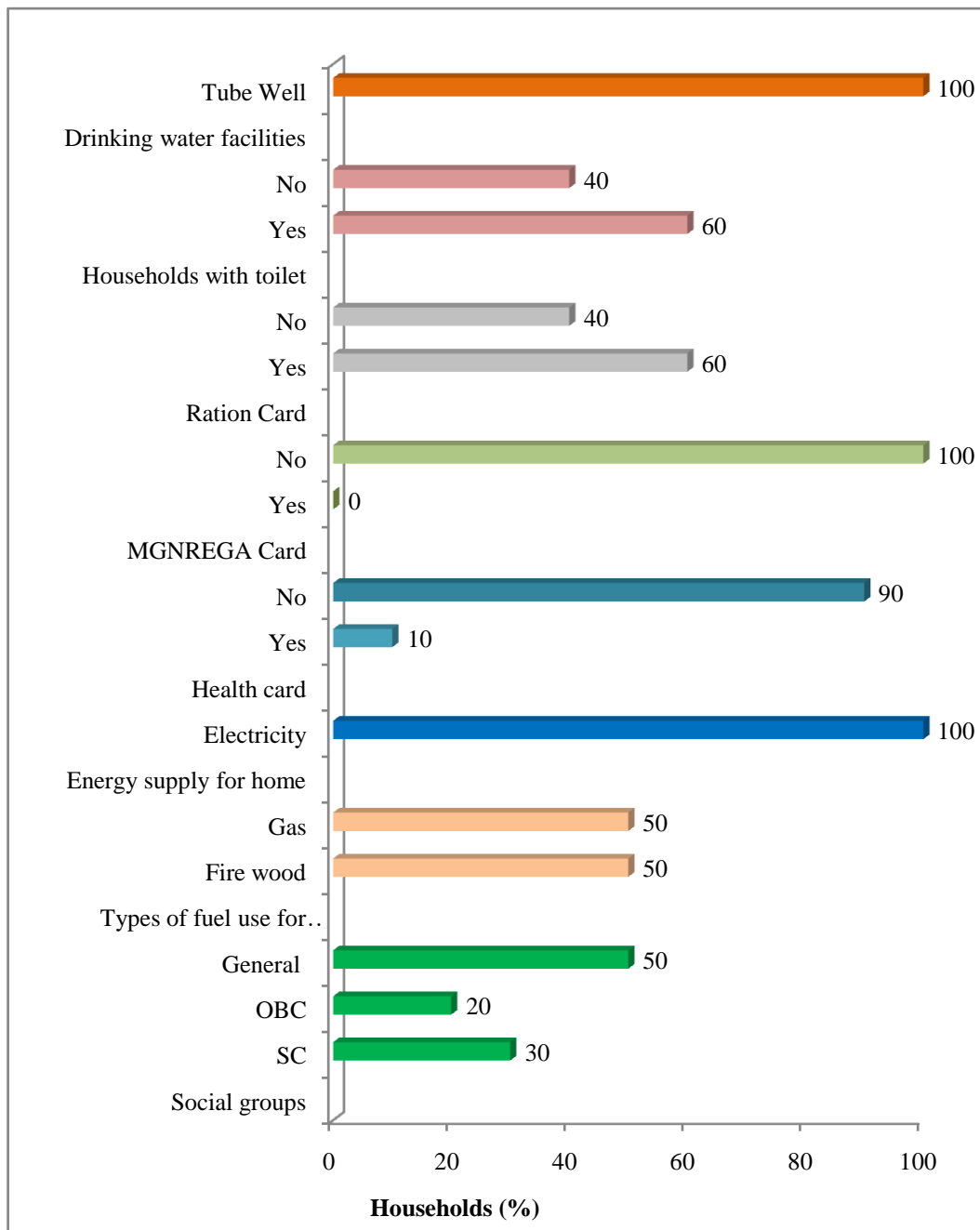


Figure 3: Basic needs of sample households in Sonath-1 Micro watershed

The occupational pattern (Table 3) among sample households shows that agriculture is the main occupation around 72.1 per cent of farmers followed by subsidiary occupations like agricultural labour (11.6 %), private services (2.3 %) and main occupation is private service. trade and business and professional (doctor/engineer) for households.

Table 3: Occupational pattern in sample population in Sonath-1 Micro watershed

Occupation		% to total
Main	Subsidiary	
Agriculture	Agriculture	72.1
	Agriculture Labour	11.6
	Private service	2.3
Trade and business		4.7
Private service		7.0
Professional(Doctor/Engineer)		2.3
Grand Total		100
Family labour availability		Man days/month
Male		27.5
Female		22.5
Total		50.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 4 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (100 %) followed by television (100 %), mixer/grinder (50 %), motorcycle (30 %), refrigerator (10 %), four wheeler (10 %), landline phone (10 %), radio (10 %) and dvd/vcd (9.9 %). The average value of domestic assets is around Rs 75901 per households.

Table 4: Domestic assets among the sample households in Sonath-1 Micro watershed

Particulars	% of households	Average value in Rs
Dvd/Vcd	9.9	3000
Four wheeler	10.0	600000
Landline Phone	10.0	1500
Mixer/grinder	50.0	2100
Mobile Phone	100.0	6100
Motorcycle	30.0	50000
Radio	10.0	800
Refrigerator	10.0	10000
Television	100.0	9611
Average value	75901	

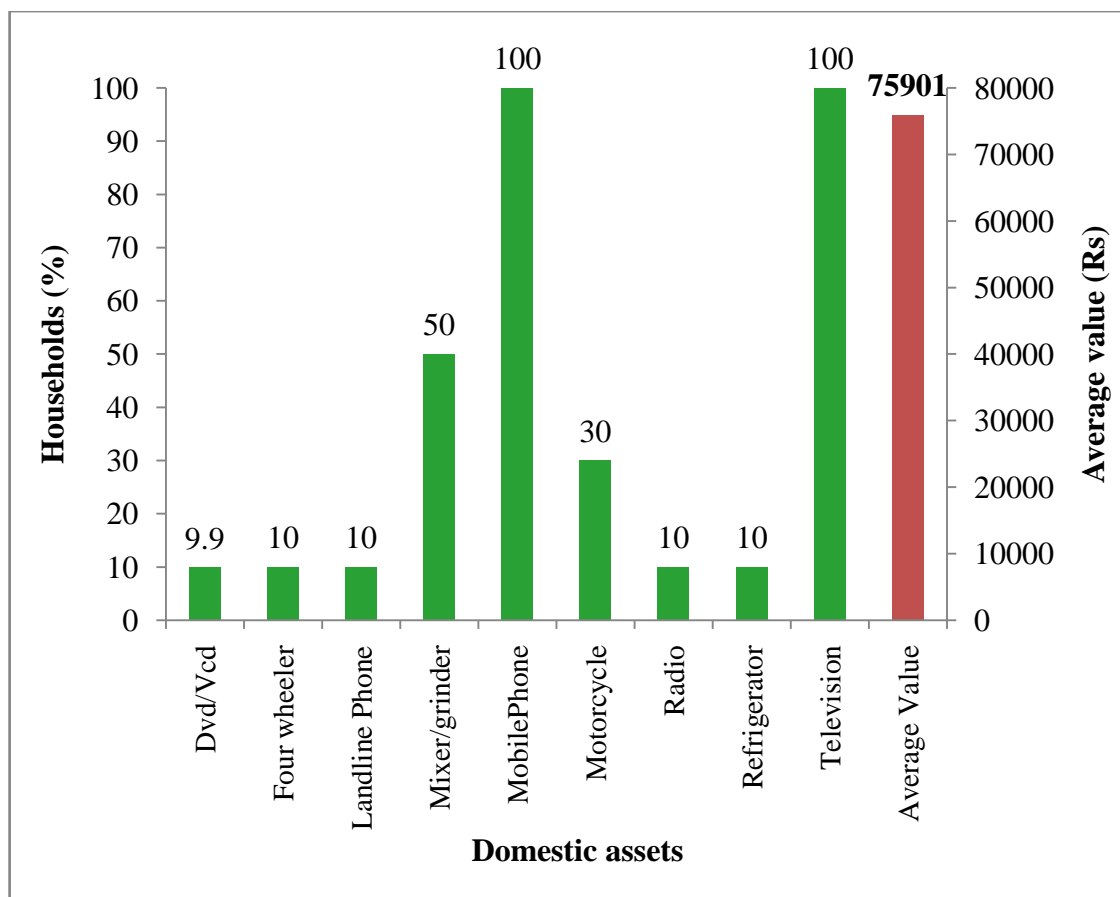


Figure 4: Domestic assets among the sample households in Sonath-1 Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned bullock cart (10 %), plough (20 %), sprayer (10 %) and tractor (10 %) found highest among the sample farmers. the average value of farm assets is around Rs 181375 per households (Table 5 and Figure 5).

Table 5: Farm assets among samples households in Sonath-1 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	10.0	22000
Plough	20.0	1500
Sprayer	10.0	2000
Tractor	10.0	700000
Average Value		181375

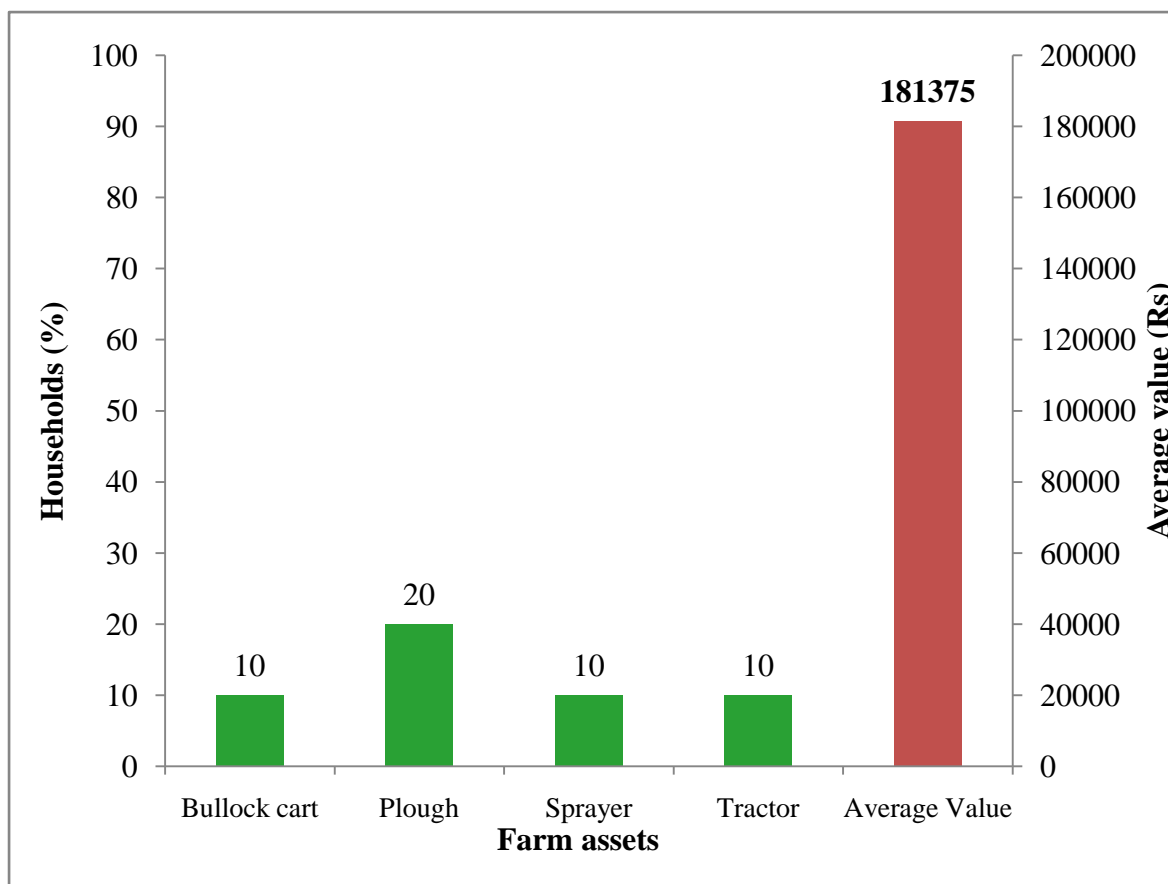


Figure5: Farm assets among samples households in Sonath-1 Micro watershed

Livestock is an integral component of the conventional farming systems (Table 6 and Figure 6). The highest livestock population is bullocks were around 33.3 per cent followed by local dry cow (33.3 %), local milching cow (16.7 %) and crossbred dry cow (16.7%). the average livestock value was Rs 71250 per households.

Table 6: Livestock assets among sample households in Sonath-1 Microwatershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	33.3	20000
Local Milching Cow	16.7	50000
Crossbred Dry Cow	16.7	65000
Bullocks	33.3	150000
Average value	71250	

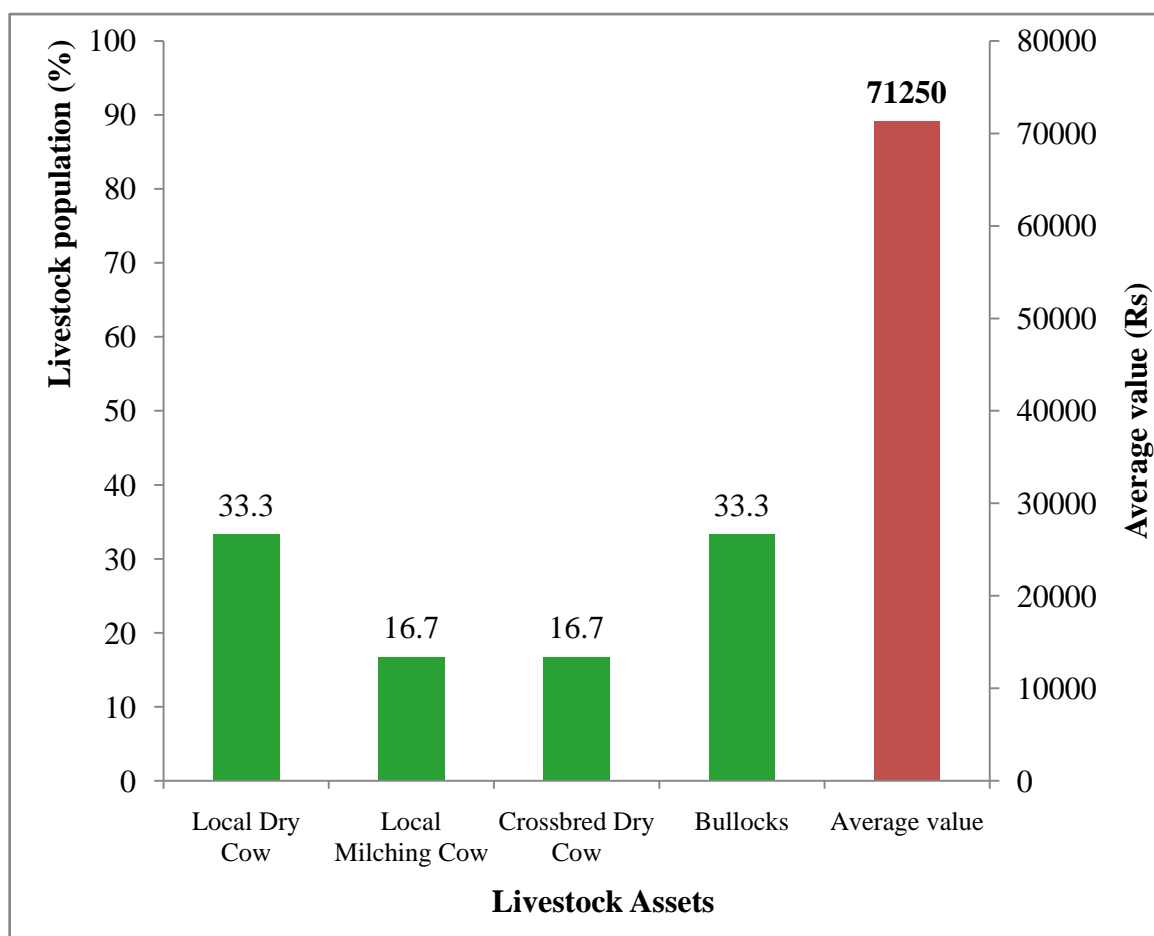


Figure 6: Livestock assets among sample households in Sonath-1 micro-watershed

Average milk produced in sample households is 2100 liters/ annum. Among the farm households, green gram, and red gram are the main crops for domestic food and fodder for animals (Table 7).

Table 7: Milk produced and fodder availability of sample households in Sonath-1 Microwatershed

Particulars	
Name of the Livestock	Ltr./Lactation/animal
Local Milching Cow	2100
Average Milk Produced	2100
Fodder produces	Fodder yield (kg/ha.)
Livestock having households (%)	43.0
Livestock population (Numbers)	13

A woman participation in decision making in this micro-watershed is presented in Table 8. About 90 per cent women earning for her family requirement and among all sample households women taking decision in her family and agriculture related activities.

Table 8: Women empowerment of sample households in Sonath-1 Micro watershed
% to grand total

Particulars	Yes	No
Women participation in local organization activities	0.0	100.0
Women elected as panchayat member	0.0	100.0
Women earning for her family requirement	90.0	10.0
Women taking decision in her family and agriculture related activities	100.0	0.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 9 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1235.7 kcal per person. The other important food items consumed was pulses 158.43 kcal followed by cooking oil 202.94 kcal, milk 105.34 kcal, vegetables 41.11 kcal, egg 57.86 kcal and meat 10.10 kcal. In the sampled households, farmers were consuming less (1811.48 kcal) than NIN- recommended food requirement (2250 kcal).

Table 9: Per capita daily consumption of food among the sample households in Sonath-1 Micro watershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	363.4	1235.7
Pulses	43	46.2	158.4
Milk	200	162.1	105.3
Vegetables	143	171.3	41.1
Cooking Oil	31	35.6	202.9
Egg	0.5	38.6	57.9
Meat	14.2	6.7	10.1
Total	827.7	823.9	1811.5
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		60.0	90.0
% Above NIN		40.0	10.0

Note: * day/person

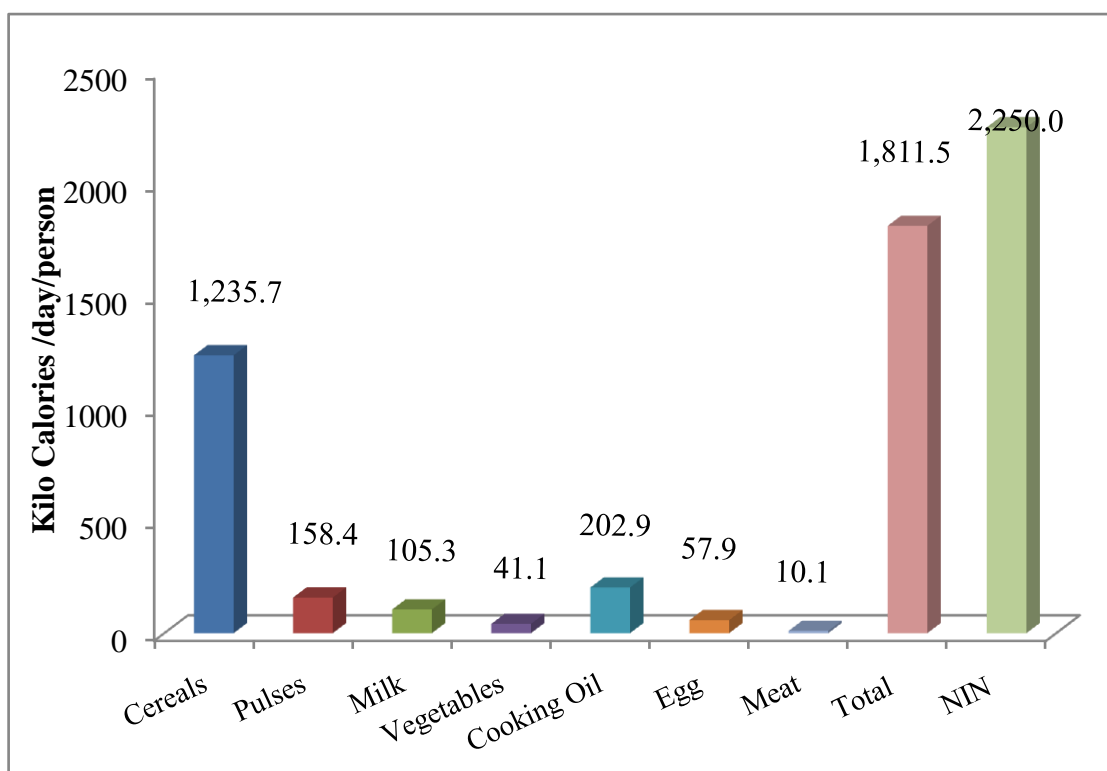


Figure 7: Per capita daily consumption of food among the sample households in Sonath-1 Micro watershed

Annual income of the sample HHs: The average annual household income is around Rs 55519. Major source of income to the farmers in the study area is from crop production (Rs 29319) followed by livestock (Rs. 26200). The monthly per capita income is Rs. 1076 which is less 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 10).

Table 10: Annual average income of HHs from various sources in Sonath-1 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	0 (0)
Livestock income (Rs)	26200 (10)
Crop Production (Rs)	29319 (100)
Total Annual Income (Rs)	55519
Average monthly per capita income (Rs)	1076
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	80.0
% of households above poverty line	20.0

* Figure in the parenthesis indicates % of Households

The average annual expenditure of farm households indicated that farmers in the study area spend highest on food (Rs.125280) 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 2428 and about 80 per cent of farm households are below poverty line, and above poverty line 20 per cent (Table 11 and Figure 8).

Table 11: Average annual expenditure of sample HHs in Sonath-1 Micro watershed

Particulars	Value in Rupees	Per cent
Food	38880	31.0
Education	500	0.4
Clothing	6700	5.3
Social functions	56700	45.3
Health	22500	18.0
Total Expenditure (Rs/year)	125280	100.0
Monthly per capita expenditure (Rs)	2428	

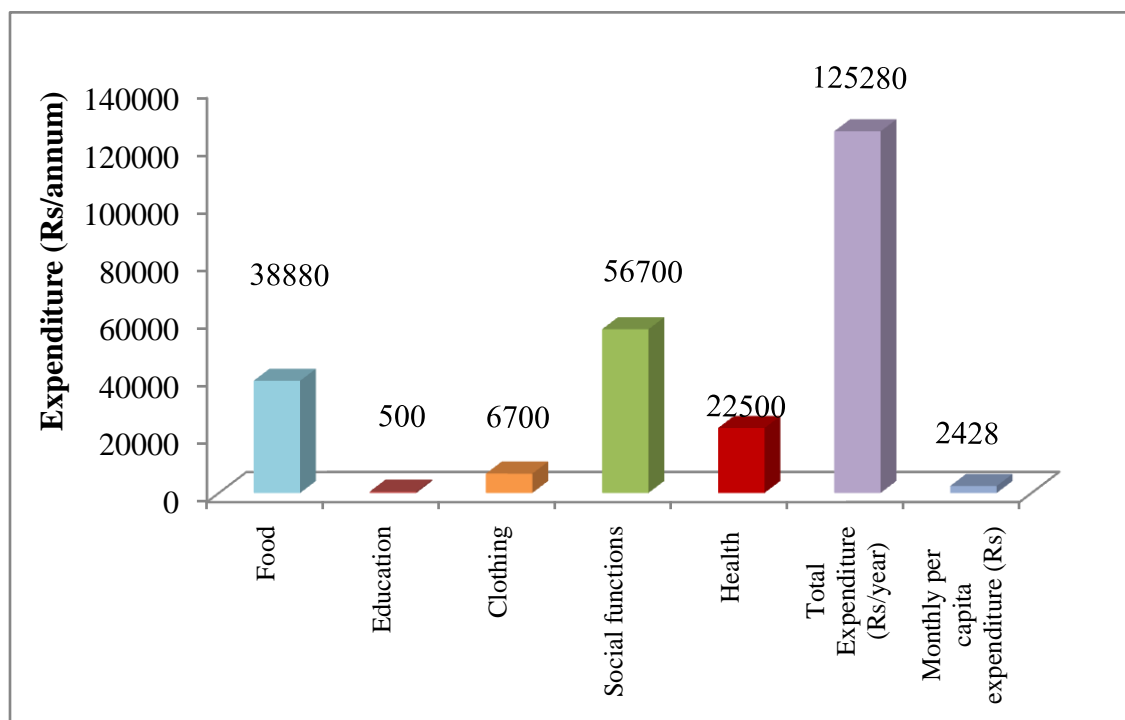


Figure 8: Average annual expenditure of sample HHs in Sonath-1 Micro watershed

Land holding: Total area cultivated by them is 15.6 ha. The average land holding of sample HHs is 1.6 ha. Large number of HHs (70 %) belonging to small size group with

an average land holding size of 0.9 ha and the medium farmer (30 %) with an average land holding group of 3.1 (Table 12).

Table 12: Distribution of land holding among the sample households in Sonath-1 micro watershed

Particulars	Units	Values
Small farmers		
Total land	ha	6.3
Sample size	Per cent	70.0
Average land holding	ha	0.9
Medium farmers		
Total land	ha	9.3
Sample size	Per cent	30.0
Average land holding	ha	3.1
Total sample households		
Total land	ha	15.6
Sample size	Per cent	100.0
Average land holding	ha	1.6

Land use: The total land holding in the Sonath-1 micro-watershed is 15.6 ha rain fed land (Table 13). Of which rain fed land is 15.6 ha. The average land holding per household is worked out to be 1.56 ha.

Table 13: Land use among samples households in Sonath-1 Micro watershed

Particulars	Per cent	Area in ha
Irrigated land	0	0
Rainfed Land	100.0	15.6
Fallow land	0	0
Total land holding	100.0	15.6
Average land holding	1.56	

In the micro-watershed, the prevalent present land uses under perennial plants are neem trees (92.3 %) and tamarind (7.7 %) (Table 14)

Table 14: Number of trees/plants covered in sample farm households in Sonath-1 Micro watershed

Particulars	Number of Plants/trees	Per cent
Neem trees	24	92.3
Tamarind	2	7.7
Grand Total	26	100.0

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 red gram (86%) followed by black gram (8.2%), and green gram (5.7%) which are taken during Kharif season (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Sonath-1 Micro watershed
% to Grand Total

Crops	Kharif	Grand Total
Black gram	8.2	8.2
Green gram	5.7	5.7
Red gram	86.0	86.0
Grand Total	100.0	100.0

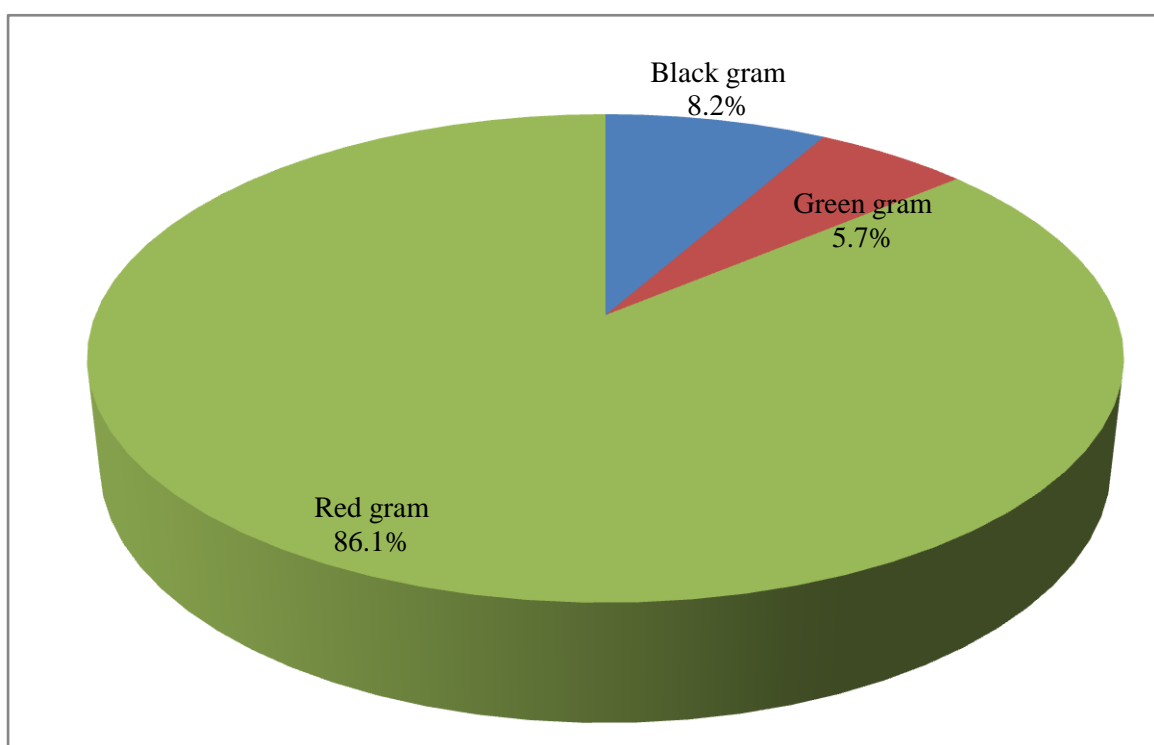


Figure 9: Present cropping pattern in Sonath-1 Microwatershed

Economic land evaluation

The main purpose to characterise the socio-economic systems 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.

In Sonath-1 Microwatershed, 5 soil series are identified and mapped (Table 16). The distribution of major soil series are Marguti covering an area around 199.6 ha (44.9

%) followed by Matki 13.22 ha (2.97 %), Novinihala 75.2 ha (16.9 %), Nirgudi 33.07 ha (7.44 %) and Mannur 106.75 ha (24.01 %).

Table 16: Distribution of soil series in Sonath-1 Micro watershed

Sl. No	Soil unit	Description	Area in ha. (%)
1	MGT	Marguti soils are very shallow (<25cm), well drained. They have very dark grayish brown to dark brown, clayey soils and occur on very gently sloping to moderately sloping uplands	199.6 (44.9)
2	MAT	Matki soils are very shallow (<25cm), well drained. They have dark reddish brown to dark reddish gray, clayey soils and occur on very gently sloping to moderately sloping uplands	13.22 (2.97)
3	NHA	Novinihala soils are shallow (25-50 cm), well drained. They have very dark grayish brown to dark brown clayey soils and occur on very gently sloping to moderately sloping uplands	75.2 (16.9)
4	NIR	Nirgudi soils are moderately deep (75-100 cm), moderately well drained. They have very dark grayish brown to very dark gray, calcareous, clayey soils and occur on nearly level to very gently sloping uplands	33.07 (7.44)
5	MAR	Mannur soils are very deep (>150 cm), moderately well drained. They have very dark gray to brown, calcareous, clayey soils and occur on nearly level to very gently sloping uplands	106.75 (24.01)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Matki and Novinihal soils are red gram. Black gram, green gram and redgram on Mannur soil are growing.

Table 17: Cropping pattern on major soil series in Sonath-1 micro-watershed

Soil Series	Soil Depth	Crops	Dry	Grand Total
			Kharif	
MGT	Very shallow (<25 cm)	Red gram	100.0	100.0
NHA	Shallow (25-50 cm)	Red gram	100.0	100.0
MAR	Very deep (>150 cm)	Black gram	26.6	26.6
		Green gram	18.7	18.7
		Red gram	54.7	54.7

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 18).

Table 18: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Sonath-1 Micro watershed

Soil Series	Small Farmers	Medium Farmers
NHA		Redgram (2.53)
MAR	Black gram (1.18), Green gram (1.06) & Redgram (1.46)	
MGT	Redgram 1.86	Redgram (2.02)

The productivity of different crops grown in Sonath-1 micro-watershed under potential yield of the crops is given in Table 19.

Table 19: Economic land evaluation and bridging yield gap for different crops in Sonath-1 micro-watershed

Particulars	MGT (<25cm)	NHA (25-50cm)	MAR (>150 cm)		
	Red gram	Red gram	Black gram	Green gram	Red gram
Total cost (Rs/ha)	23693	19508	22377	38785	23799
Gross Return (Rs/ha)	44383	49400	26347	40755	35304
Net returns (Rs/ha)	20690	29892	3970	1970	11505
BCR	1.94	2.53	1.18	1.06	1.46
Farmers Practices (FP)					
FYM (t/ha)	2.0	3.1	3.3	3.2	2.2
Nitrogen (kg/ha)	28.3	51.3	57.2	45.6	50.4
Phosphorus (kg/ha)	53.9	57.5	54.9	55.8	50.0
Potash (kg/ha)	0.0	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	10.9	12.5	6.7	7.0	9.7
Price of Yield (Rs/Qtl)	4125	4000	4000	5667	3833
Soil test based fertilizer Recommendation (STBR)					
FYM (t/ha)	7.4	7.4	7.4	7.4	7.4
Nitrogen (kg/ha)	18.5	18.5	13.9	13.9	20.6
Phosphorus (kg/ha)	58.7	49.4	46.3	46.3	53.5
Potash (kg/ha)	24.7	24.7	18.5	27.8	22.6
Grain (Qtl/ha)	12.4	12.4	9.9	8.6	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)					
FYM (%)	73.6	57.8	55.0	57.1	70.9
Nitrogen (%)	-52.7	-176.7	-311.7	-228.4	-144.8
Phosphorus (%)	8.1	-16.4	-18.5	-20.4	6.6
Potash (%)	100.0	100.0	100.0	100.0	100.0
Grain (%)	11.4	-1.2	32.5	18.5	21.2
Value of yield and Fertilizer (Rs)					
Additional Cost (Rs/ha)	6043	4030	3550	3987	5501
Additional Benefits (Rs/ha)	5827	-600	12853	9064	10031
Net change Income (Rs/ha)	-217	-4630	9303	5077	4530

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 19. The total cost of cultivation in study area for red gram ranges between Rs.23799/ha in MAR soil (with BCR of 1.46) and Rs 19508 /ha in NHA soil (with BCR of 2.53), green gram the cost of cultivation in MAR soil is Rs 38785 /ha (with BCR of 1.06) and black gram the cost of cultivation in MAR soil is Rs 22377 /ha (with BCR of 1.18).

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 19. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. 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 9303in black gram and a minimum of Rs 4530in red gram, 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.

Table 20: Estimation of onsite cost of soil erosion in Sonath-1 micro-watershed

Particular	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	290.46	124316	1829.89	783193
Phosphorous	0.21	90	9.24	3955
Potash	1.63	699	32.65	13973
Iron	0.66	282	31.62	13534
Manganese	0.47	203	130.19	55720
Copper	0.08	35	45.72	19570
Zinc	0.01	5	0.44	188
Sulphur	0.23	100	9.32	3988
Boron	0.01	4	0.37	158
Total	293.77	125733	2089.44	894280

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 20 and Figure 10. The average value of soil nutrient loss is around Rs 2089.44 per ha/year. The total cost of annual soil nutrients is around Rs 894280 per year for the total area of 444.65 ha.

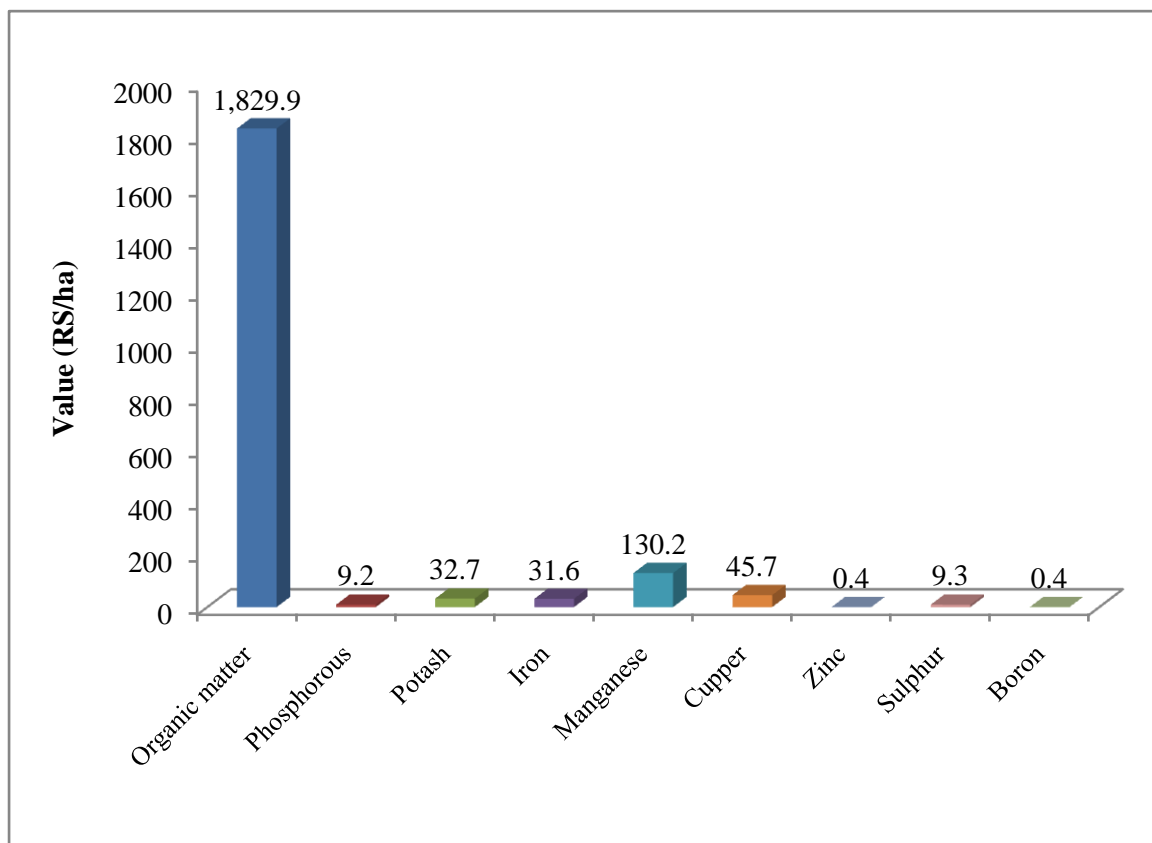


Figure 10: Estimation of onsite cost of soil erosion in Sonath-1 micro-watershed

The average value of ecosystem service for food grain production is around Rs 15315 ha/year (Table 21 and Figure 11). Per hectare food grain production services is maximum in redgram (Rs 19003 /ha) followed by green gram (Rs 1886) and black gram (Rs.3970).

Table 21: Ecosystem services of food grain production in Sonath-1 Micro watershed

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)
Pulses	Black gram	1.2	7	4000	26347	22377	3970
	Greengram	0.9	7	5750	40671	38785	1886
	Redgram	13.0	11	4000	42212	23210	19003
Average value		15.1	8	4583	36410	28124	8286

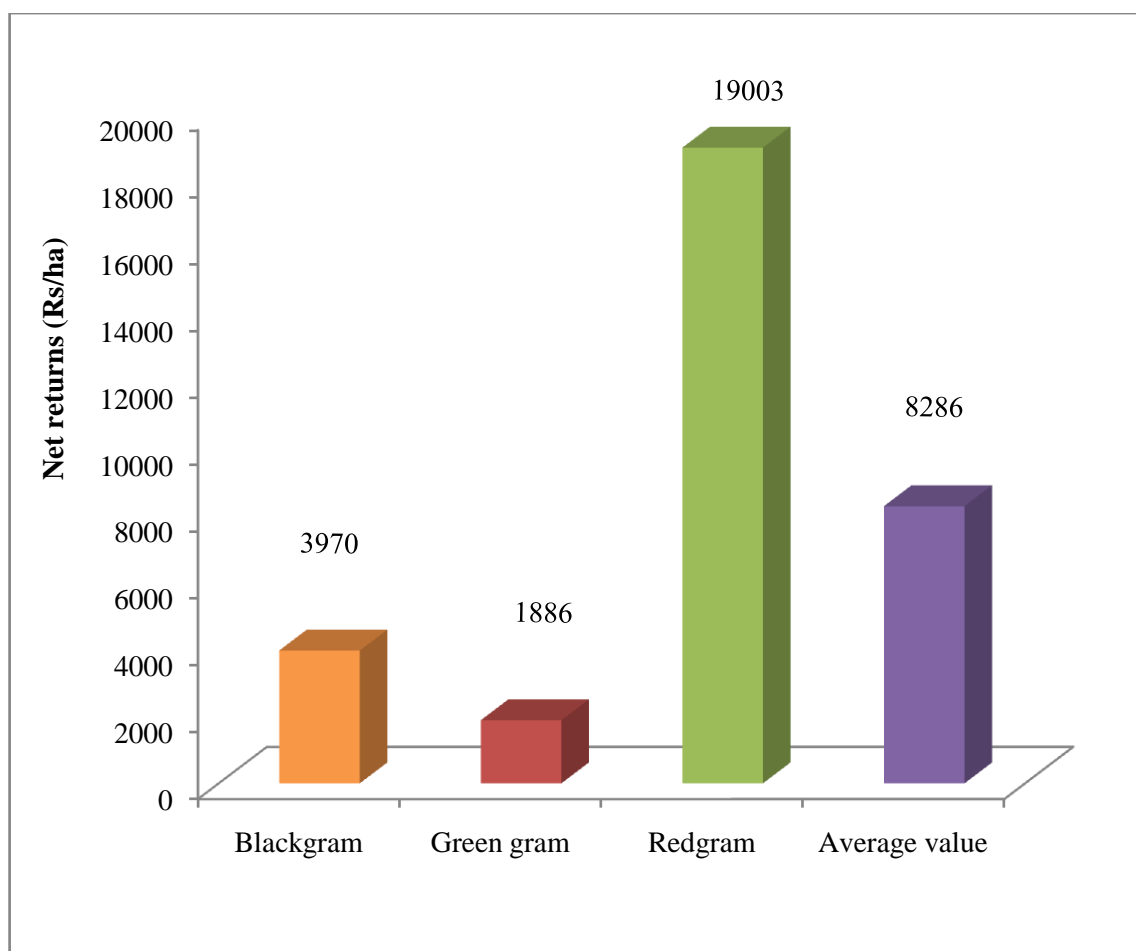


Figure 11: Ecosystem services of food production in Sonath-1 Microwatershed

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 22 and Figure 12) in redgram (Rs 57451) followed by green gram (Rs 48847) and black gram (Rs. 45488).

Table 22: Ecosystem services of water supply in Sonath-1 Micro watershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Black gram	6.6	4549	45488	691
Green gram	7.1	4885	48847	691
Redgram	10.6	5745	57451	544
Average value	8.1	5060	50595	642

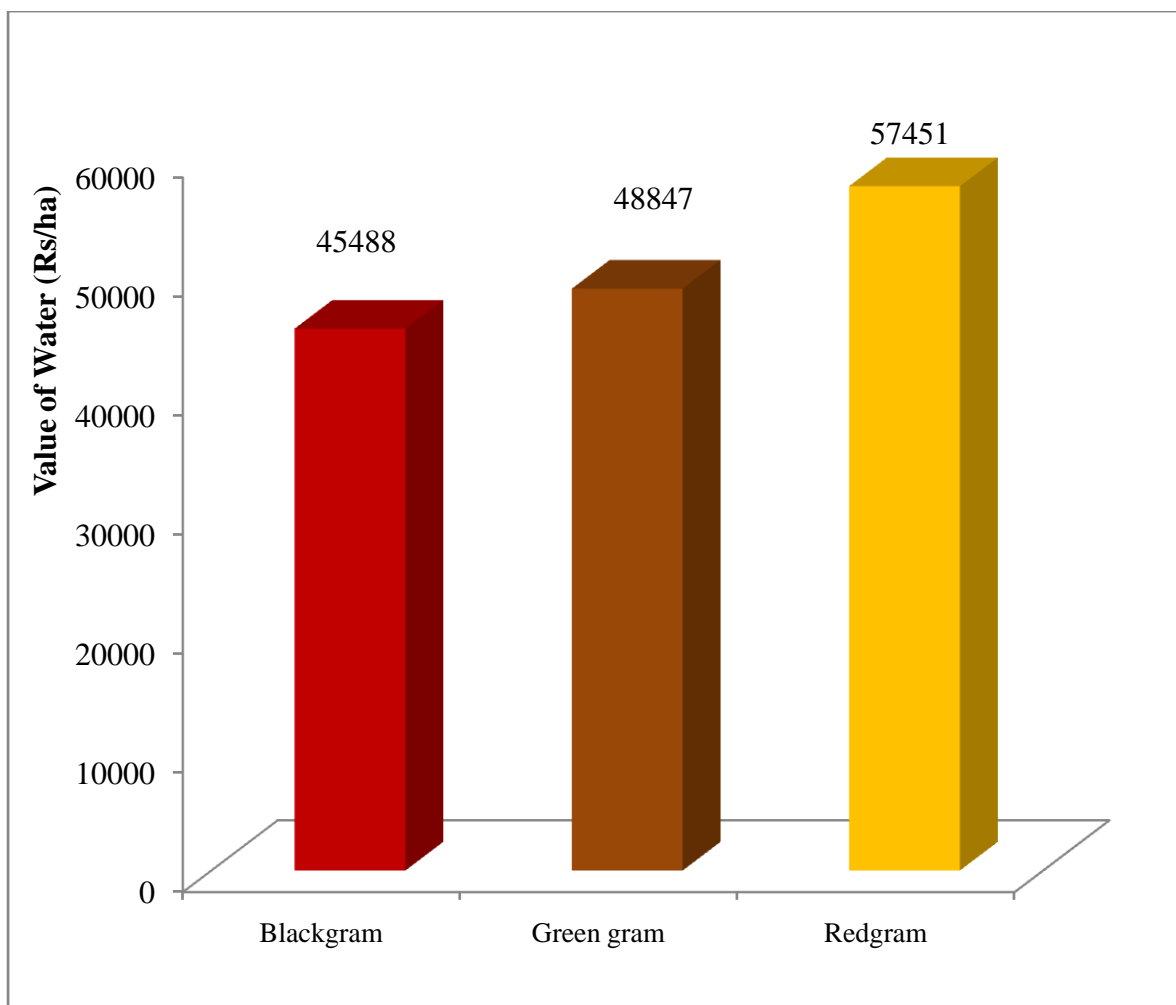


Figure 12: Ecosystem services of water supply in Sonath-1 Micro watershed

The main farming constraints in Sonath-1 Microwatershed to be found are less rainfall, lack of good quality seeds, high crop pests & diseases, lack of transportation, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on bank 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 23).

Table 23: Farming constraints related land resources of sample households in Sonath-1 Microwatershed

Sl. No	Particulars	Per cent
1	Less Rainfall	70.0
2	Lack of good quality seeds	10.0
4	High Crop Pests & Diseases	20.0
6	Lack of transportation	60.0
7	Lack of storage	20.0
8	Damage of crops by Wild Animals	50.0
9	Non availability of Plant Protection Chemicals	100.0
10	Source of loan	
	Bank	80.0
	Money Leander	10.0
	Village merchants	10.0
11	Market for selling	
	Village market	100.0
12	Sources of Agro-Technology information	
	Newspaper	40.0
	Television	60.0

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.