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

KOKKARAGUNDI-3 (4D4A3I2b) MICRO WATERSHED

Shirahatti Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

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

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

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

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

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on "Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Kokkaragundi-3 Microwatershed, Shirahatti Taluk, Gadag District, Karnataka" for integrated development was taken up in collaboration with the State Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Kokkaragundi-3 Microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and the physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soil map shows the geographic distribution and extent, characterstics, classification and use potentials of the soils in the microwartershed.

The present study covers an area of 322 ha. in Kokkaragundi-3 microwatershed in Shirahatti taluk of Gadag district, Karnataka. The climate is semiarid and categorized as drought prone with an average annual rainfall of 633 mm.The north-east monsoon contributes about 165 mm and prevails from October to early December, maximum of 363 mm precipitation takes place during south–west monsoon period from June to September and the remaining 105 mm takes place during the rest of the year. An area of about 95 per cent is covered by soils, five per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 15 soil series and 26 soil phases (management units) and 6land management units.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 3rd week of November.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.*
- *About 95 per cent area is suitable for agriculture and 5 per cent is not suitable for agriculture but well suited for forestry, pasture, agro forestry, silvi-pasture, recreation, installation of wind mills and as habitat for wildlife.*
- *About 39 per cent of the soils are very deep (>150 cm), deep (100 - 150 cm) to moderately deep (75 - 100 cm), 41per cent are moderately shallow to shallow (25-75 cm) and about 15 per cent are very shallow (<25 cm) soils.*
- *About 39 per cent of the area has clay soils,32 per cent area has sandy clay and 21 per cent area has sandy clay loam soils at the surface.*
- *About 10 per cent of the area has non-gravelly soils, 52 per cent gravelly soils (15-35 % gravel) and 32 per cent very gravelly soils (35- 60% gravel).*
- *About 39 per cent of the area has soils that are very high (>200mm/m) in available water capacity, less than one per cent medium (100-150 mm/m) and about 56 per cent low (50-100 mm/m) and very low (<50mm/m).*
- *About 95 per cent of the area has nearly level (0-1%) to very gently sloping (1-3% slope) lands.*
- *An area of about 70 per cent has soils that are slightly eroded (e1) and26 per cent moderately eroded (e2).*

- *An area of about 13 per cent has soils that are neutral in reaction (pH 6.5 to 7.3), about 82 per cent area has slightly alkaline (pH 7.3-7.8) to very strongly alkaline (pH >9).*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1}indicating that the soils are non-saline.*
- *About 47 per cent medium (0.5-0.75%) and 48 per cent low (<0.5%) in organic carbon.*
- *Major area of 75 per cent has soils that are low (<23 kg/ha) and 20 per cent medium (23-57 kg/ha) in available phosphorus.*
- *About 80 per cent medium (145-337 kg/ha) and 5 per cent high (>337 kg/ha) in available potassium.*
- *Available sulphur is low (<10 ppm) in about 39per cent area, medium (10-20 ppm) in 38 per cent and 18 per cent high (>20 ppm).*
- *Available boron is low (<0.5 ppm) in about 43 per cent area and 52 per cent medium (0.5-1.0 ppm).*
- *About 18 per cent area has soils that are deficient (<4.5 ppm) in available iron and 78per cent sufficient (>4.5 ppm).*
- *Available manganese and copper are sufficient in all the soils.*
- *Available zinc content is deficient (<0.6 ppm) in the entire microwatershed area*
- *The land suitability for 21 major crops (agricultural and horticultural) grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, price and finally the demand and supply position.*

Land suitability for various crops in the microwatershed

Crop	*Suitability Area in ha (%)*			*Crop*	*Suitability Area in ha (%)*	
	Highly suitable (S1)	*Moderately suitable (S2)*			*Highly suitable (S1)*	*Moderately suitable (S2)*
Sorghum	*75 (23)*	*82 (25)*		*Jackfruit*	*-*	*13 (4)*
Maize	*-*	*32 (10)*		*Jamun*	*-*	*124 (37)*
Bengal gram	*69 (22)*	*132 (41)*		*Musambi*	*56 (17)*	*68 (21)*
Ground nut	*-*	*140 (43)*		*Lime*	*56 (17)*	*61 (19)*
Sunflower	*67 (21)*	*101 (31)*		*Cashew*	*-*	*-*
Cotton	*50 (15)*	*140 (28)*		*Custard apple*	*58 (17)*	*74 (24)*
Banana	*-*	*125 (39)*		*Amla*	*56 (17)*	*71(22)*
Pomegranate	*-*	*125 (39)*		*Tamarind*	*-*	*113 (35)*
Mango	*-*	*-*		*Marigold*	*-*	*150 (47)*
Guava	*-*	*-*		*Chrysanthamum*		*150 (47)*
Sapota	*-*	*-*				

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 6 identified LMUs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops that helps in maintaining the ecological balance in 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 sub-marginal lands and also in the hillocks, mounds and ridges.*

Chapter 1

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 uncultivated areas are facing various degrees of degradation, particularly soil erosion; salinity and alkalinity has emerged as a major problem (>3.5 lakh ha) in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. Added to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and uses 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 (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 been already been made to upscale the soil resource information from 1:250000 and 1:50000 scale to the LEU map in Goa and other states. Here, an attempt is being made to uplink the LRI data generated under Sujala-III Project to the Landscape Ecological Units (LEUs) map. For this, the major physiographic region, *i.e*., South Deccan Plateau is taken as an example.

The land resource inventory data and maps presented here aims to provide site specific database for Kokkaragundi-3microwatershed in ShirahattiTaluk, Gadag District, KarnatakaState for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological units (LEUs) map.

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

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Kokkaragundi-3 microwatershed (Belhatti subwatershed) is located in the central part of northern Karnataka in Shirahatti Taluk, Gadag District, Karnataka State (Fig.2.1). It comprises parts of Belhatti, Hosur, Bodihal and Balehosur villages. It lies between $15^{0}1'$ to $15^{0}3'$ North latitudes and $75^{0}36'$ to $75^{0}38'$ East longitudesand covers an area of 322ha. It is about 60km south of Gadag and is surrounded by Belhativillage on the north,Balehosurvillage in thesouth, Hosurvillage on the east and Bodihal village on the west.

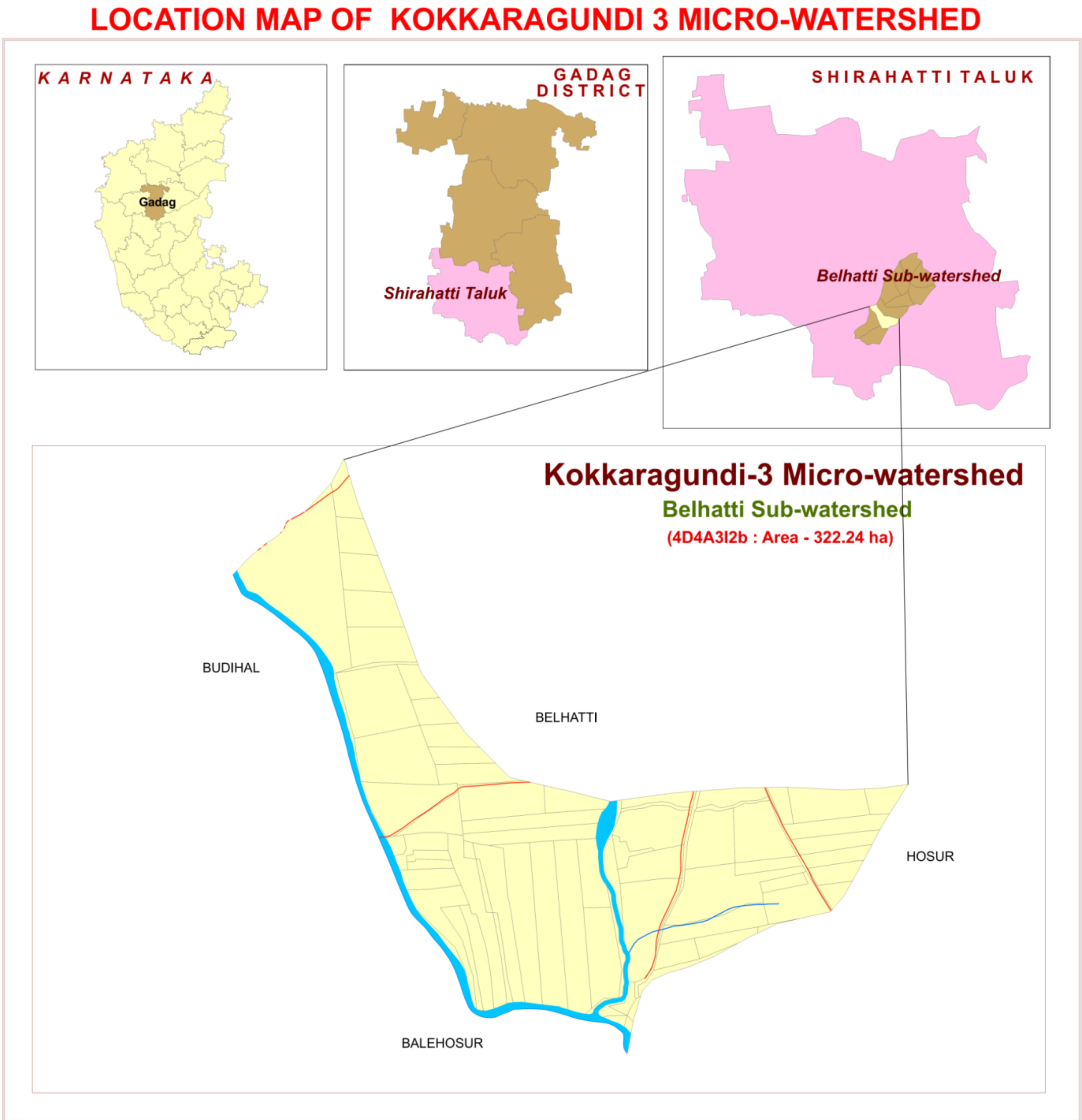


Fig.2.1 Location map of Kokkarahundi-3 Microwatershed

2.2 Geology

Major rock formations observed in the microwatershed are the Peninsular Gneiss (Fig.2.2a), Gadag Schist (Fig. 2.2b) with thick coating of iron oxides and Banded Ferruginous Quartzite (Fig.2.2c). The ridges have capping of Banded Ferruginous Quartzite (BFQ), whereas side slopes near the streams are dominated by schist. They are fine grained and show a distinct weathering pattern similar to that of basalt. Due to its fine texture, the soils formed from these rocks are mostly clay in nature. The presence of iron rich banded ferruginous quartzite is responsible for the dark red colour of the soils observed in the microwatersheds. The granite gneiss consists primarily of quartz, feldspar, biotite and hornblende.

Fig.2.2aGranite gneiss

Fig.2.2b Gadag Schist

Fig.2.2c Banded Ferrugenous Quartzite

2.3 Physiography

Physiographically, the area has been broadly divided into two landscapes based on geology. They are Granite gneiss and Schist. The microwatershed area has been further divided into mounds/ridges, summits, side slopes and very gently sloping uplandsbased on slope and its relief features. The ranges from 542 to 572 m in the gently sloping uplands. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

The area is drained by several small seasonal streams that join Dodd Halla along its course. Though, it is not a perennial one, during rainy season it carries large quantities of rain water.The microwatershed has only few small tanks which are not able to store water flowing during the rainy season. Due to this, the ground water recharge is very much affected in the villages. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing tanks and recharge structures at appropriate places in the village, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract of the state and is categorized as drought prone with average annual rainfall of 633 mm (Table 2.1). Of the total rainfall, maximum of 363 mm precipitation takes place during south–west monsoon period from June to September,north-east monsoon contributes about 165 mm and prevails from October to early December and the remaining 105 mm takes place during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 42°C and in December and January, the temperatures will go down to 16°C. Rainfall distribution is shown in Figure 2.3. The average Potential Evapotranspiration (PET) is 137 mm and varies from a low of 109 mm in December to 182 mm in the month of May. Generally, the Length of crop Growing Period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET at Shirahatti Taluk, Gadag District

Sl.No.	Months	Rainfall	PET	1/2 PET
1	January	0.80	122.20	61.10
2	February	1.50	131.40	65.70
3	March	15.20	172.00	86.00
4	April	30.10	178.80	89.40
5	May	57.60	182.00	91.00
6	June	87.10	146.20	73.10
7	July	79.90	130.80	65.40
8	August	87.80	130.80	65.40
9	September	108.70	123.20	61.60
10	October	121.00	113.10	56.55
11	November	36.00	112.70	56.35
12	December	7.80	108.70	54.35
TOTAL		633.50	137.65	

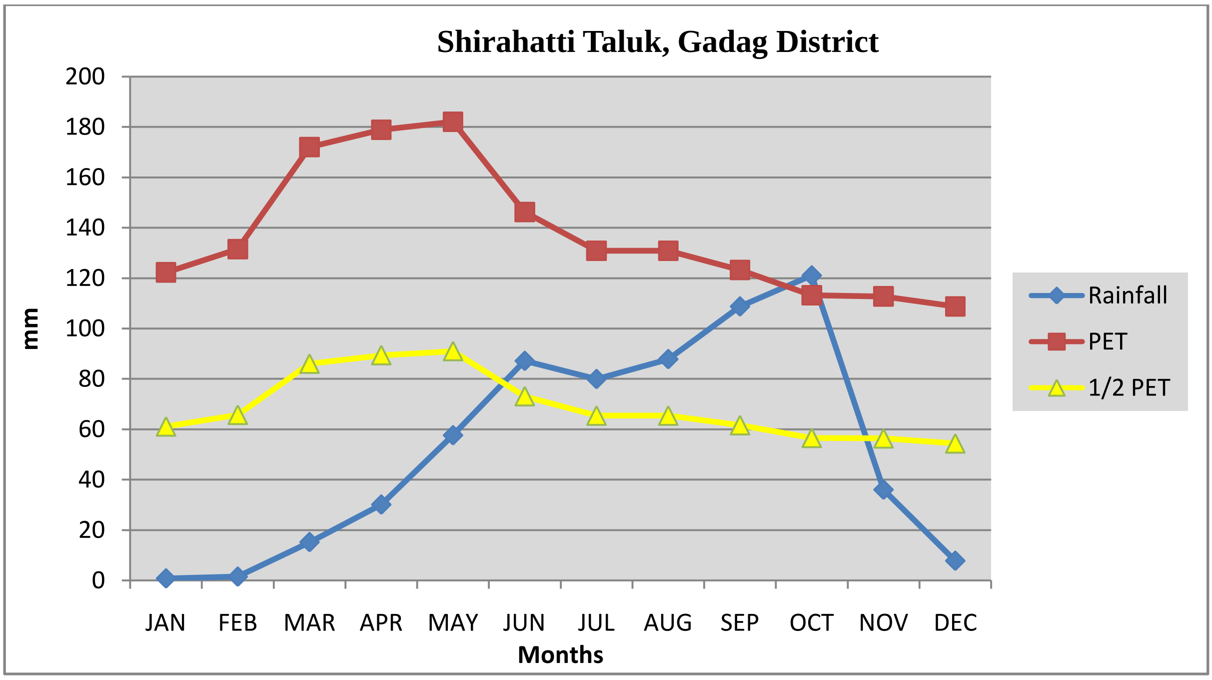


Fig. 2.3 Rainfall distribution in Shirahatti Taluk,Gadag District

2.6 Natural Vegetation

The natural vegetation is sparse comprising few tree species, shrubs and herbs. The mounds, ridges and bouldery areas occupy very sizeable areas which are under thin to moderately thick forest vegetation. Still, there are some remnants of the past forest cover which can be seen in patches in some ridges and hillocks in the microwatershed.

Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the micowatershed 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 and eventually resulting in the heavy siltation of few tanks and reservoirs in the microwatershed.

2.7 Land Utilization

About 77 per cent area (Table 2.2) in the Shirahatti taluk is cultivated at present and about 14 per cent of the area is sown more than once. An area of about 17 per cent is currently barren. Forests occupy a small area of about 1.6 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, safflower, sunflower, red gram, horse gram, onion, mulberry, sugarcane, bengal gram and groundnut (Fig.2.6a & b). While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is 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 Kokkaragundi-3 microwatershed is presented in Fig.2.4.

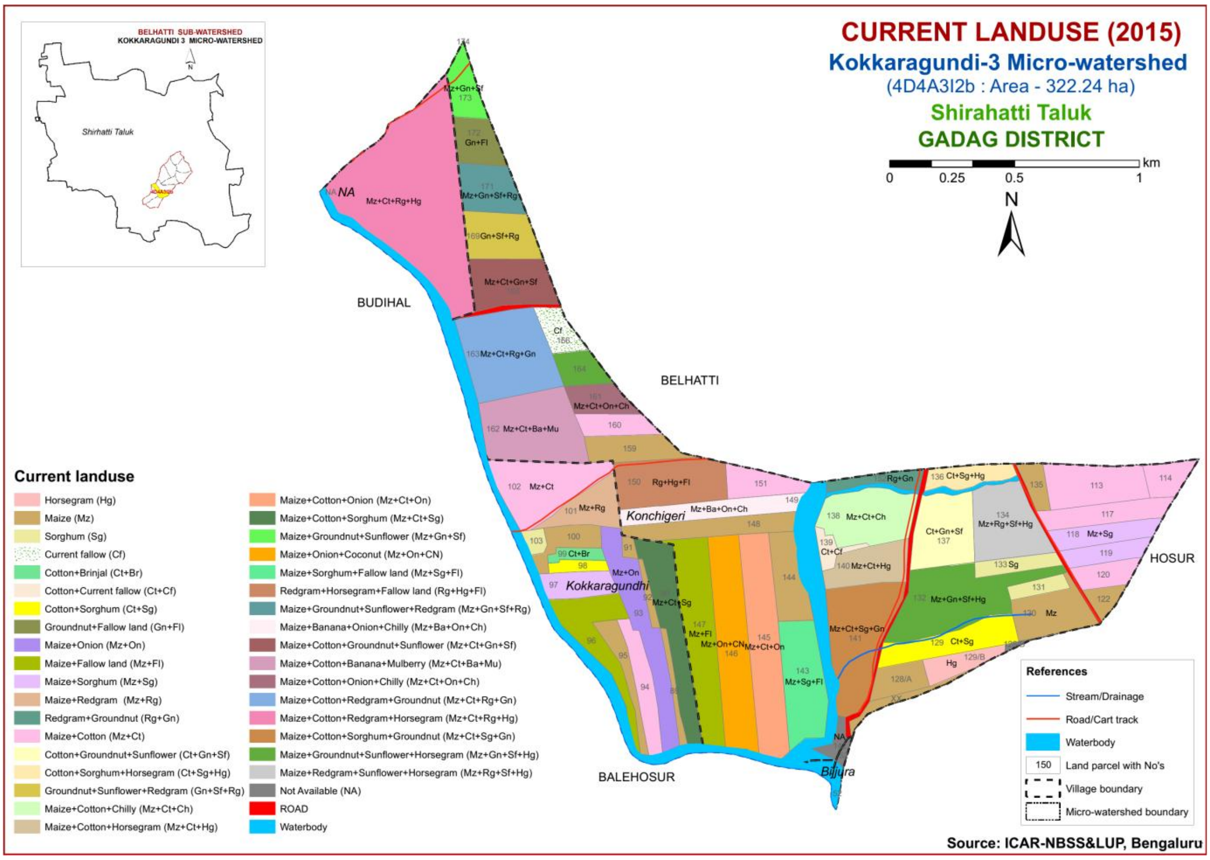


Fig.2.4 Current Land Use – Kokkaragundi-3 Microwatershed

Simultaneously, enumeration of wells (bore wells and open wells) and other soil and water conservation stuctures in the microwatershedis made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells, soil conservation structures and other water bodies in the Kokkaragundi-3 microwatershedis given Fig.2.5.

Table 2.2 Land Utilization in Shirahatti Taluk

Sl.No.	**Agricultural land use**	**Area (ha)**	**Per cent**
1	Total cultivated area	85004	77.0
2	Cultivable wasteland	291	0.26
3	Pasture land	1054	1.0
4	Forest area	1749	1.6
5	Area sown more than once	15366	14.0
6	Current Barren	18302	16.7
7	Total geographical area	109751	

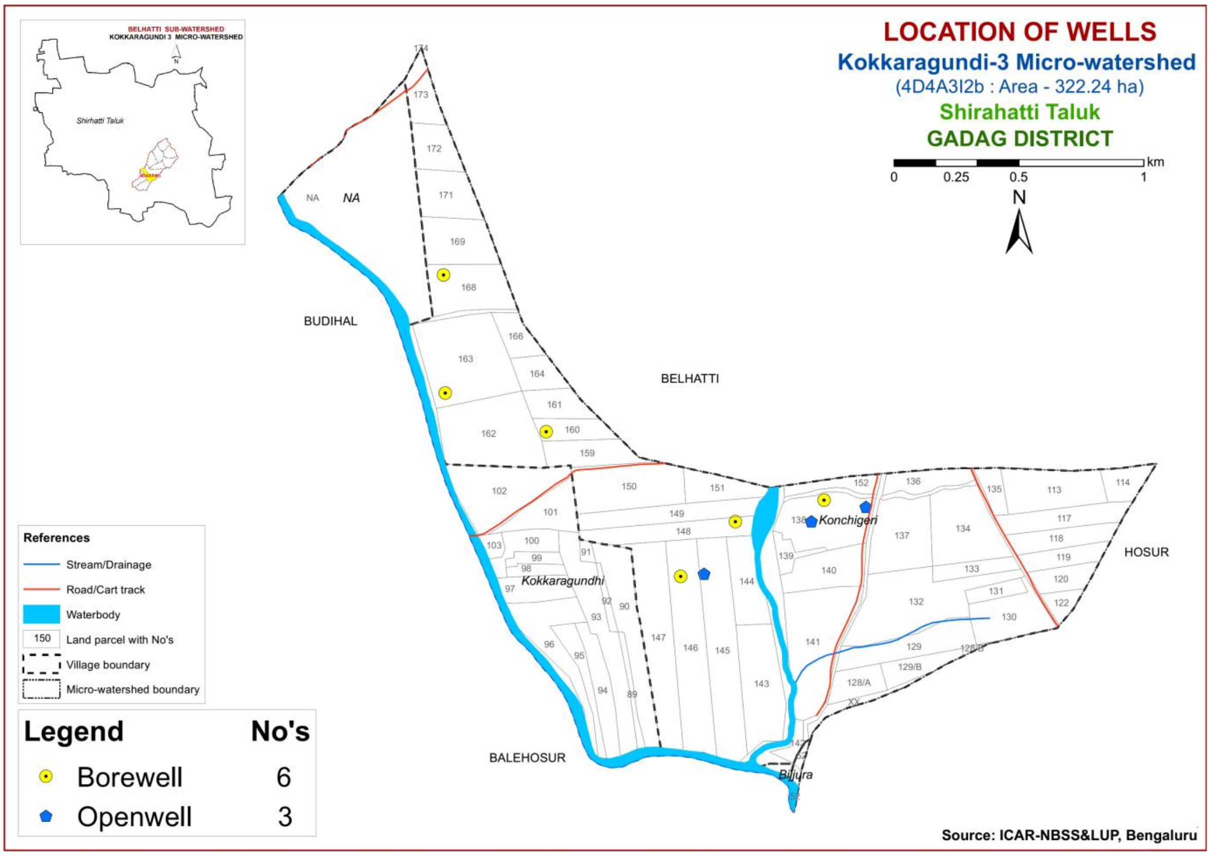


Fig.2.5Location of Wells and conservation structures of Kokkaragundi-3 Microwatershed

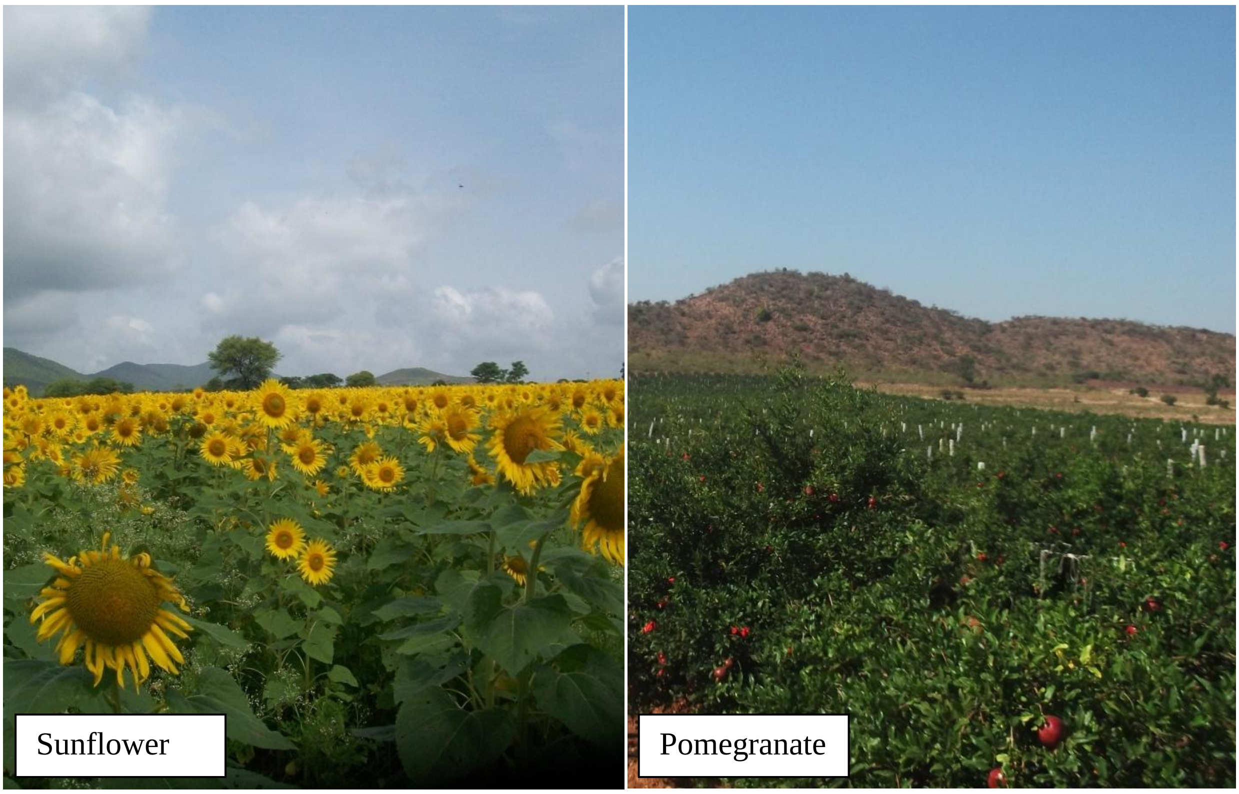


Fig. 2.6a: Different crops and cropping systems in Kokkanagundi-3 Microwatershed

Fig. 2.6b: Different crops and cropping systems in Kokkanagundi-3 Microwatershed

Chapter 3

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 Kokkanagundi-3 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site characteristics(slope of the land, erosion, drainage, occurrence of rock fragments etc.) and, followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in an area of 322 ha. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map 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 landscapes, landforms and other surface features. The imagery helped in the identification and delineation of boundaries between hills, uplands and lowlands, water bodies, forest and vegetated areas, roads, habitations and other cultural features of the area(Fig.3.2).The cadastral map was overlaid on the satellite imagery (Fig.3.3) that helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were also used for initial traversing, identification of geology and landforms, drainage features, present land use and also for selection of transects in the microwatershed.

3.2 Image Interpretation for Physiography

False Colour Composites (FCCs) of Cartosat-I and LISS-IV merged satellite data covering the microwatershed area was visually interpreted using image interpretation elements along with the geology map 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 a shaving granite gneiss landscape and is divided into land forms such as ridges, mounds and uplands based on slope and other relief features. They were further subdivided into physiographic/ image interpretation units based on image characteristics. The image interpretation legend for physiography is given below.

Image Interpretation Legend for Physiography

G- Granite gneiss landscape

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

S-Schist landscape

S1		Uplands
	S11	Summits, greenish blue
	S12	Side slopes, greenish grey
S2		Very gently sloping uplands
	S21	Very gently sloping uplands, greenish grey
	S22	Very gently sloping uplands, medium grey
	S23	Very gently sloping uplands, dark grey
	S24	Very gently sloping uplands, light green (scrub lands)
	S25	Very gently sloping uplands, grey and pink
	S26	Very gently sloping uplands, whitish grey (eroded)

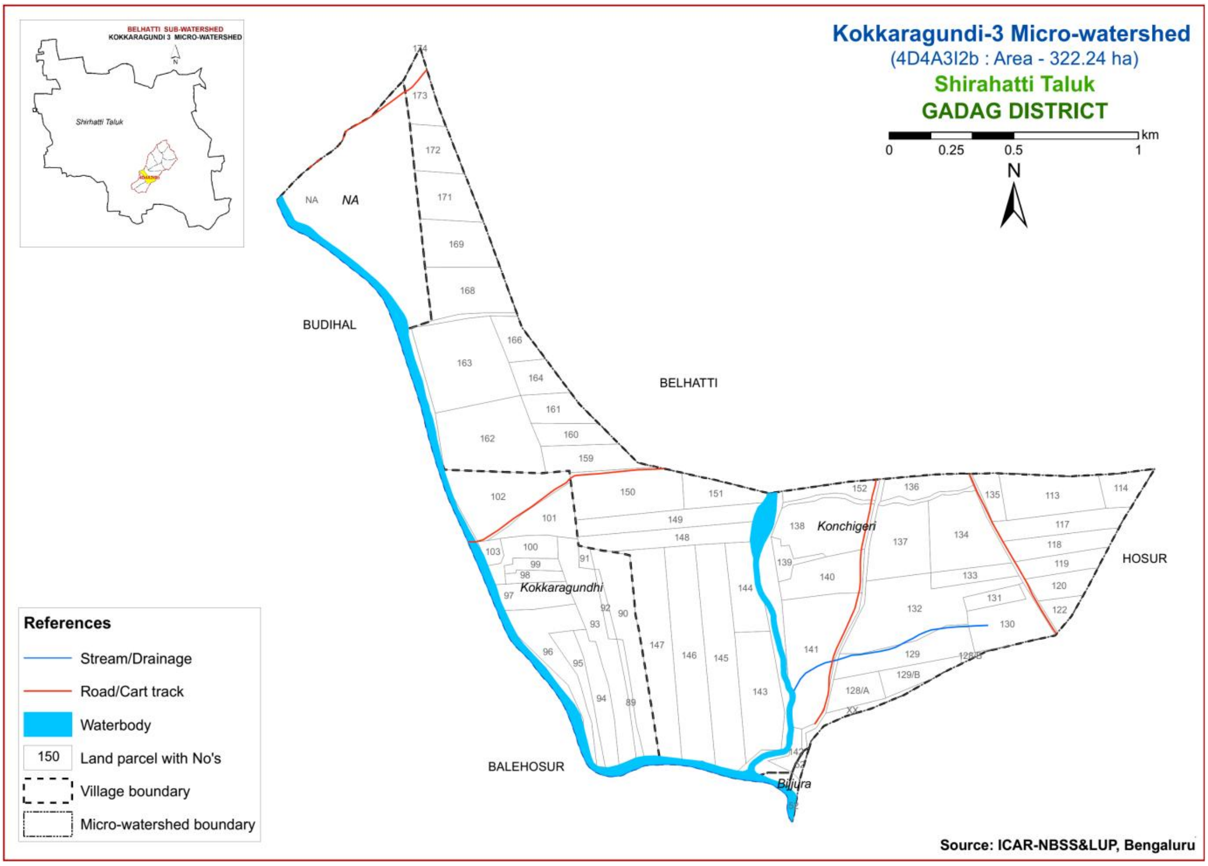


Fig 3.1 Scanned and Digitized Cadastral map of Kokkanagundi-3microwatershed

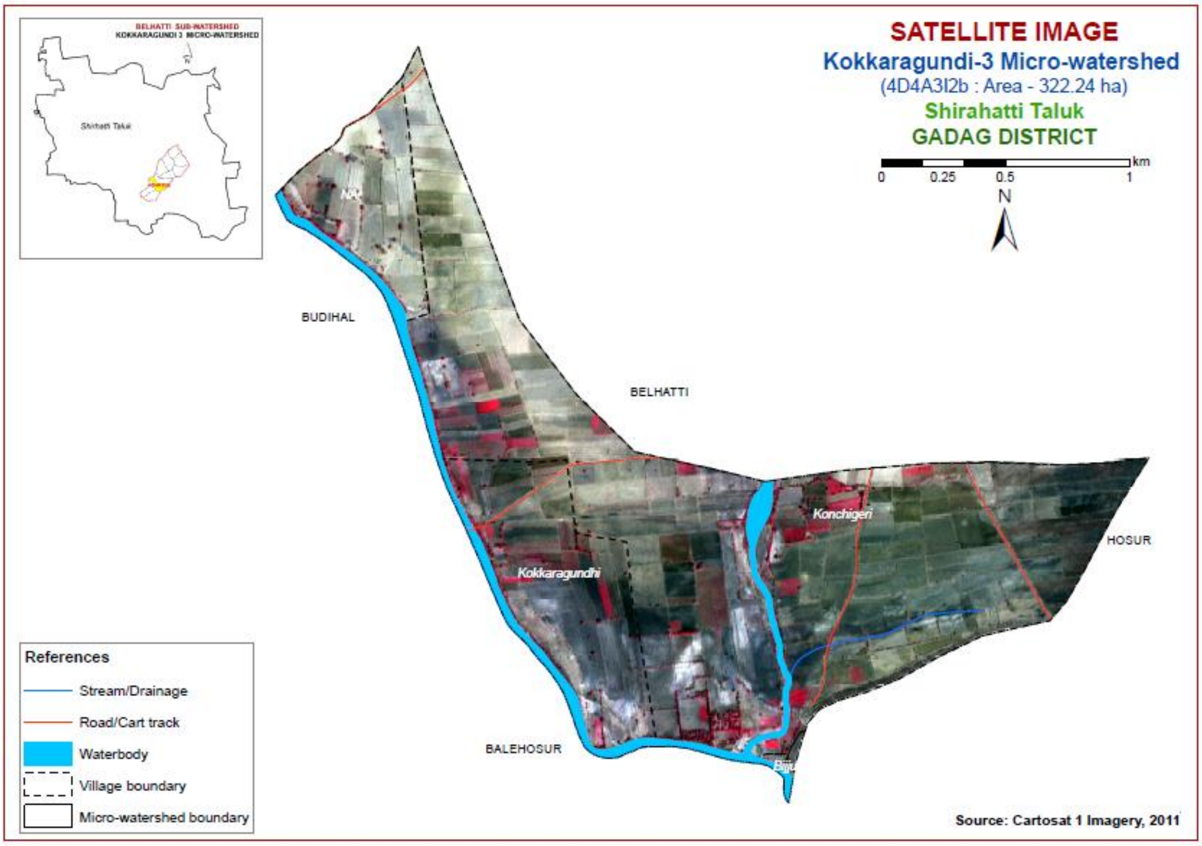


Fig.3.2 Satellite Image of Kokkaragundi-3 Microwatershed

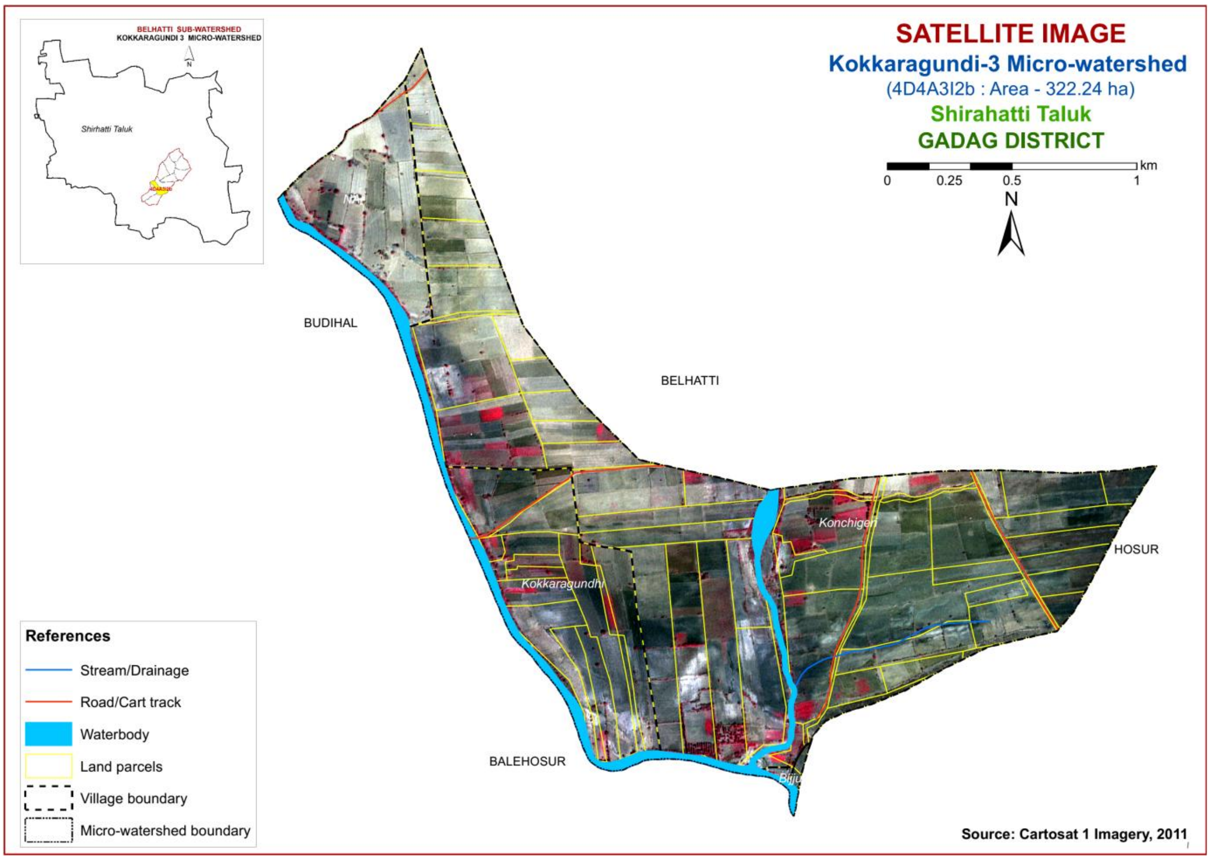


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Kokkaragundi-3 Microwatershed

3.3 Field Investigation

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, nallas, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Preliminary traverse of the microwatershed was carried out with the help of cadastral map, imagery and toposheets. While traversing, landforms and physiographic units identified were checked and preliminary soil legend was prepared by studying soils at few selected places.

Then, intensive traversing of each physiographic unit like hills, ridgesand uplands was carried out. Based on the variability observed on the surface, transects were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

In the selected transect, soil profiles 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, 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.

Based on the soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc., were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above 15 soil series were identified in the Kokkaragundi-3 microwatershed.

Table 3.1 Differentiating Characteristics used for identifying Soil Series

(Characteristics are of Series Control Section)

Sl.No	**Soil Series**	**Depth (cm)**	**Colour**	**Texture**	**Gravel (%)**	**Horizon sequence**	**Calca-reous-ness**
Soils of Granite gneiss Landscape							
1	Harve (HRV)	25-50	2.5YR3/65YR4/4	scl	>35	Ap-Bt-Cr-	
2	Lakkur (LKR)	50-75	2.5YR3/4, 3/6	scl-sc	40-60	Ap-Bt-Bc-Cr-	
3	Thammadahalli (TDH)	50-75	2.5YR2.5/4,3/6	sc-c	-	Ap-Bt-Cr	
4	Ravanaki (RNK)	50-75	7.5YR3/2,3/3,5/2,5/3 10YR3/1,3/2,4/1,4/2, 5/1,6/1	sc-c	15-35	Ap-Bw-Cr	e-ev
5	Budagumpa (BGP)	>150	7.5YR3/2,5/1 10YR4/1,4/4	c	10-20	Ap-Bw	es
6	Kabulayathkatti (KLK)	<25	5YR3/3,3/4 2.5YR4/6	scl	>35	Ap- Cr	-
7	Mahalingapur Tanda (MPT)	100-150	10YR2/2,3/1,3/2,3/3,4/2 7.5YR2.5/3,3/2	c	-	Ap-Bw-Crk	-
8	Kalasapur (KPR)	100-150	10YR2/1,2/2,3/1	c	<15	Ap-Bw-Cr	e
Soils of Schist Landscape							
9	Beladadi (BLD)	25-50	2.5YR2.5/3,2.5/4,3/3, 5YR3/3,3/4	scl	>35	Ap-Bw-Crk	-
10	Kabulayath-katti Tanda (KKT)	50-75	2.5YR2.5/3,2.5/4,3/3,3/4 5YR3/3	cl,sc,c	>35	Ap-Bw-Crk	-
11	Attikatti Tanda (ATT)	50-75	10YR2/2,3/1,4/2,5/4 7.5YR2.5/1,3/2	c	-	Ap-Bw-Crk	-
12	Jelligeri (JLG)	100-150	5YR4/6,3/4 7.5YR3/4,4/6	sc-c	<15	Ap-Bt-Bc-Cr	-

13	Nabhapur (NBP)	25-50	5YR2.5/2,3/3,3/4,4/3 2.5YR3/3,3/4,3/6	cl, c	>35	Ap-Bw-Cr	-
14	Attikatti (AKT)	25-30	2.5YR3/2,3/3 5YR4/4	cl, c	10-30	Ap-Bw-Cr	-
15	Nagavi Tanda (NGT)	>150	10YR2/1,2/2,3/1,3/2,3/3,4/1, 4/2,4/3 2.5Y3/1,4/2,4/3	c	<15	Ap-Bss	es-ev

3.4 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (63 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated for the microwatershed.

3.5 Finalization of Soil Map

The area under each soil series was further separated into 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.3.4) in the form of symbols. During the survey about 11 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. All the profile locations are indicated on the village cadastral map in the form of a triangle. 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 26 mapping units representing 15 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 26 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and they have to be treated accordingly.

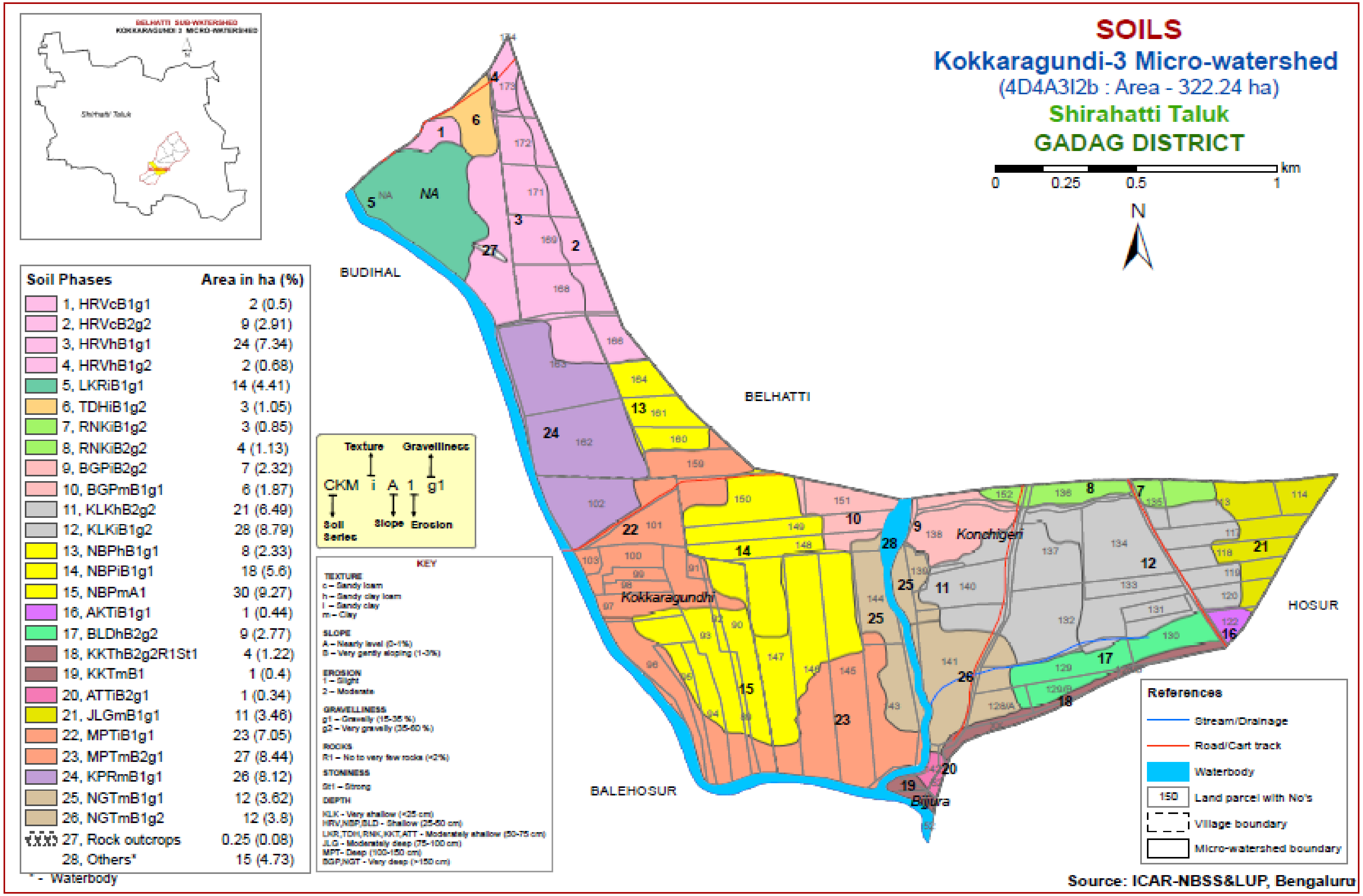


Fig 3.4 Soil Phase or Management Units- Kokkaragundi-3 Microwatershed

The 26 soil phases identified and mapped in the microwatershed were regrouped into 6 Land Management Units (LMU's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Management Units (LMUs) based on the management needs. One or more than one soil site characteristic having influence on the management have been chosen for identification and delineation of LMUs. For Kokkaragundi-3 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

Table 3.2 Soil map unit description of Kokkaragundi-3 microwatershed

Soil No	Soil Series	Soil Phases	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	HRV	Harve soils are shallow (25-50 cm), well drained, have reddish brown to dark red sandy clay loam soils occurring on very gently sloping uplands under cultivation		**36.85 (11.43)**
1		HRVcB1g1	Sandy loam surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)	1.62 (0.50)
2		HRVcB2g2	Sandy loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	9.37 (2.91)
3		HRVhB1g1	Sandy clay loam surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	23.67 (7.34)
4		HRVhB1g2	Sandy clay loam surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)	2.19 (0.68)
	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on very gently sloping uplands under cultivation		**14.20 (4.41)**
5		LKRiB1g1	Sandy clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	14.20 (4.41)
	TDH	Thammadahalli soils are moderately shallow (50 – 75 cm), well drained, have brown to very dark brown and dark reddish brown sandy clay to clay loam soils occurring on very gently sloping uplands under cultivation		**3.40 (1.05)**
6		TDHiB1g2	Sandy clay surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)	3.40 (1.05)
	RNK	Ravanki soils are moderately shallow (50-75 cm), well drained, black calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**6.38 (1.98)**
7		RNKiB1g2	Sandy clay surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)	2.73 (0.85)
8		RNKiB2g2	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60%)	3.65 (1.13)

	BGP	Budagumpa soils are very deep (>150 cm),moderately well drained, have light olive brown to very dark gray clayey soils occurring on very gently sloping uplands under cultivation		**13.51 (4.20)**
9		BGPiB2g2	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	7.49 (2.33)
10		BGPmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	6.02 (1.87)
	KLK	Kabulayathkatti soils are very shallow (<25 cm), well drained, have dark reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under rainfed cultivation		**49.23 (15.28)**
11		KLKhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	20.91 (6.49)
12		KLKiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60 %)	28.32 (8.79)
	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark grayish brown cracking clay soils occurring on very gently sloping uplands under cultivation		**49.91 (15.49)**
13		MPTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	22.72 (7.05)
14		MPTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	27.19 (8.44)
	KPR	Kalasapur soils are deep (100-150 cm), moderately well drained, have very dark gray to very dark grayish brown calcareous cracking clay soils occurring on very gently sloping uplands under cultivation		**26.15 (8.12)**
15		KPRmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	26.15 (8.12)
SOILS OF SCHIST LANDSCAPE				
	NBP	Nabhapur soils are shallow (25-50 cm), well drained, have reddish brown to dark reddish brown gravelly clay loam to gravelly clay soils occurring on gently to moderately sloping uplands under cultivation		**55.43 (17.20)**
16		NBPhB1g1	Sandy clay loam surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	7.52 (2.33)
17		NBPiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	18.04 (5.60)
18		NBPmA1	Clay surface, slope 0-1 %, slight erosion	29.87 (9.27)
	AKT	Attikatti soils are shallow (25-50 cm), well drained, have dark reddish brown to dusky red clay loam to clay soils occurring on very gently to gently sloping uplands under cultivation		**1.41 (0.44)**
19		AKTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	1.41 (0.44)

	BLD	Beladadi soils are shallow (25-50 cm), well drained, have dark brown to dark reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation		**8.94 (2.77)**
20		BLDhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	8.94 (2.77)
	KKT	Kabulayathakatti Tanda soils are moderately shallow (50-75 cm), well drained, dark reddish brown gravelly clay loam to gravelly clay soils occurring on very gently sloping uplands under cultivation		**5.21 (1.62)**
21		KKThB2g2R1St1	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %), few to fairly rocky (<2-10), stony (0.01-0.1%)	3.93 (1.22)
22		KKTmB1	Clay surface, slope 1-3%, slight erosion	1.28 (0.40)
	ATT	Attikatti Tanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation		**1.10 (0.34)**
23		ATTiB2g1	Sandy clay surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)	1.10 (0.34)
	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands under cultivation		**11.14 (3.46)**
24		JLGmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	11.14 (3.46)
	NGT	Nagavi Tanda soils are very deep (>150 cm), well drained, have very dark grayish brown cracking clay soils occurring on nearly level to very gently sloping uplands under cultivation		**23.90 (7.42)**
25		NGTmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	11.66 (3.62)
26		NGTmB1g2	Clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)	12.24 (3.80)
MISCELLANEOUS LANDS				
27		Rock outcrops		0.25 (0.08)
28		Waterbody		15.23 (4.73)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Kokkaragundi-3 microwatershed is provided in this chapter. The microwatershed area has been identified as Granite gneiss landscapes based on geology. In all,15 soil series are identified. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In both the landscapes, soil formation is dominantly influenced by the parent material, climate and relief. Maximum area of about 200 ha (62%) has soils that are developed from granite-gneiss followed by an area of about 107 ha (33%) under schist.

A brief description of each of the 15 soil series identified followed by 26 soil phases (management units) mapped under each series (Fig. 3.4) are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite gneiss Landscape

In this landscape, 15 soil series are identified and mapped. Of these, Nabhapur (NBP) soil series occupies maximum area of about 55 ha (17%) followed by Kabalayathkatti (KLK) 49 ha (15%) area. The brief description of each soil series and their phases identified in the microwatershed are given below.

4.1.1 Harve (HRV) Series: Harve soils are shallow (25-50 cm), well drained, have reddish brown to dark red sandy clay loam soils. They have developed from granite gneiss and occur on very gently to moderately sloping uplands.

The thickness of the solum ranges from 28 to 48 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5YR and 2.5 YR hue with value 3 to 4 and chroma 4 to 6. The texture varies from loamy sand to sandy loam with 20 to 60 per cent gravel. The thickness of B horizon ranges from 16 to 32 cm. Its colour is in 2.5 YR and 5 YR hue with value 3 to 4 and chroma 4 to 6. Its texture is sandy clay loam with gravel content of 35 to 50 per cent. The available water capacity is very low (<50mm/m).

Three phases were identified:

HRVcB1g1	Sandy loam surface, slope 1-3 %, slight erosion, gravelly (35-60 %)
HRVcB2g2	Sandy loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)
HRVhB1g1	Sandy clay loam surface, slope 1-3 %, slight erosion, gravelly (15-35 %)
HRVhB1g2	Sandy clay loam surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)

Landscape and Soil Profile Characteristics of Harve (HRV) Series

4.1.2 Lakkur (LKR) Series: Lakkur soil is moderately shallow (50-75 cm), well drained, have raddish brown to dark red gravelly sandy clay loam to sandy clay red soils. They have developed from granite gneiss and occur on nearly level to very gently and gently sloping uplands.

The thickness of the solum ranges from 51 to 74 cm. The thickness of A horizon ranges from 12 to 18 cm. Its colour is in 5YR and 2.5 YR hue with value 3 to 4 and chroma 4 to 6. The texture varies from loamy sand to sandy clay loam with 15 to 50 per cent gravel. The thickness of B horizon ranges from 39 to 58. Its colour is in 2.5 YR hue with value 3 to 4 and chroma 4 to 6. Texture varies from sandy clay loam to sandy clay with 40 to 60 per cent gravel. The available water capacity is low (50-100mm/m).

Only one phase was identified:

LKRiB1g1	Sandy clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)

4.1.3 Thammadahalli (TDH) Series: Thammadahalli soils are moderately shallow (50-75 cm), well drained, have brown to very dark brown and dark reddish brown sandy clay to clay soils. They have developed from granite gneiss and occur on nearly level to gently sloping uplands.

The thickness of the solum ranges from 54 to 75 cm. The thickness of A horizon ranges from 11 to 19 cm. Its colour is in 7.5 YR and 2.5 YR hue with value 2.5 to 4 and chroma 2 to 6. The texture varies from sandy loam to clay loam 10 to 20 per cent gravel. The thickness of B horizon ranges from 43 to 60 cm. Its colour is in 2.5 YR hue with value 3 and chroma 4 to 6.

Its texture is sandy clay loam to sandy clay with gravel content of 15 to 35 per cent. The available water capacity is medium (100-150 mm/m).

Only one phase was identified:

TDHiB1g2	Sandy clay surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)

4.1.4 Ravanaki (RNK) Series: Ravanaki soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark grayish brown, calcareous sandy clay to clay soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands.

The thickness of the solum ranges from 55 to 75 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in 7.5 YR and 10 YR hue with value 2 to 3 and chroma 2.5 to 4. The texture varies from sandy clay to clay with 10 to 15 per cent gravel. The thickness of B horizon ranges from 35 to 60 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 6 and chroma 2 to 4. Its texture is sandy clay to clay with gravel content of 15 to 35 per cent. The available water capacity is low (51-100 mm/m).

Two phases were identified:

RNKiB1g2	Sandy clay surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)
RNKiB2g2	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Ravanaki (RNK) Series

4.1.5 Budagumpa (BGP) Series: Budagumpa soils are very deep (>150 cm), well drained, light olive brown to very dark gray soils black calcareous sandy clay to clay soils. They have developed from granite gneiss and occur on very gently sloping uplands under cultivation.

The thickness of the solum ranges from 120 to 180 cm. The thickness of A horizon ranges from 16 to 26 cm. Its colour is in 7.5 YR and 10 YR hue with value 2 to 3 and chroma

2.5 to 4. The texture varies from sandy clay to clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 112 to 160 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 5 and chroma 1 to 4. Its texture is clay with gravel content of 10 to 20 per cent. These soils are calcareous that increases with depth. The available water capacity is very high (>200 mm/m).

Two phases were identified:

BGPiB2g2	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)
BGPmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)

4.1.6 Kabulayathkatti (KLK) Series: Kabulayathkatti soils are very shallow (<25cm), well drained, have reddish brown to dark red sandy clay loam soils. They have developed from schist and occur on very gently to moderately sloping uplands.

The thickness of the solum ranges from less than 23 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5YR and 2.5 YR hue with value 3 to 4 and chroma 4 to 6. The texture varies from sandy clay loam with 35 to 60 per cent gravel. The available water capacity is very low (<50mm/m).

Two phases were identified:

KLKhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)
KLKiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60 %)

Landscape and Soil Profile Characteristics of Kabulayathkatti (KLK) Series

4.1.7 Mahalingapur Tanda (MPT) Series: Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, very dark brown to very dark grayish brown craking clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 117 to 145 cm. The thickness of A horizon ranges from 13 to 21 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 104 to 124 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is very high (>200 mm/m).

Two phases were identified:

MPTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
MPTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)

Landscape and Soil Profile Characteristics of Mahalingapur Tanda (MPT) Series

4.1.8 Kalasapur (KPR) Series: Kalasapur soils are deep (100-150 cm), moderately well drained, very dark gray to very dark grayish brown, and calcareous cracking clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 102 to 148 cm. The thickness of A horizon ranges from 12 to 28 cm. Its colour is in 10 YR hue with value 2 to 3 and chroma 1 to 2. The texture varies from clay loam to clay. The thickness of B horizon ranges from 98 to 136 cm. Its colour is in 10 YR hue with value 2 to 3 and chroma 1 to 2. Its texture is clay. These soils are slightly effervescent with dilute HCL. The available water capacity is very high (>200 mm/m).

Only one phase was identified:

KPRmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)

Landscape and soil profile characteristics of Kalasapur (KPR) Series

4.1.9 Nabhapur (NBP) Series: Nabhapur soils are shallow (25-50 cm), well drained, have reddish brown to dark reddish brown gravelly clay loam to gravelly clay soils. They have developed from schist and occur on gently to moderately sloping uplands.

The thickness of the solum ranges from 30 to 50 cm. Thickness of A horizon ranges from 15 to 18 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 to 4 and chroma 3 to 6. The texture is clay loam to clay. The thickness of B horizon ranges from 15 to 35 cm. Its colour is in hue 5 YR and 2.5 YR with value 2.5 to 3 and chroma 4 to 6. Its texture is clay loam to clay. The available water capacity is very low (<50 mm/m).

Three phases were identified:

NBPhB1g1	Sandy clay loam surface, slope 1-3 %, slight erosion, gravelly (15-35 %)
NBPiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
NBPmA1	Clay surface, slope 0-1 %, slight erosion

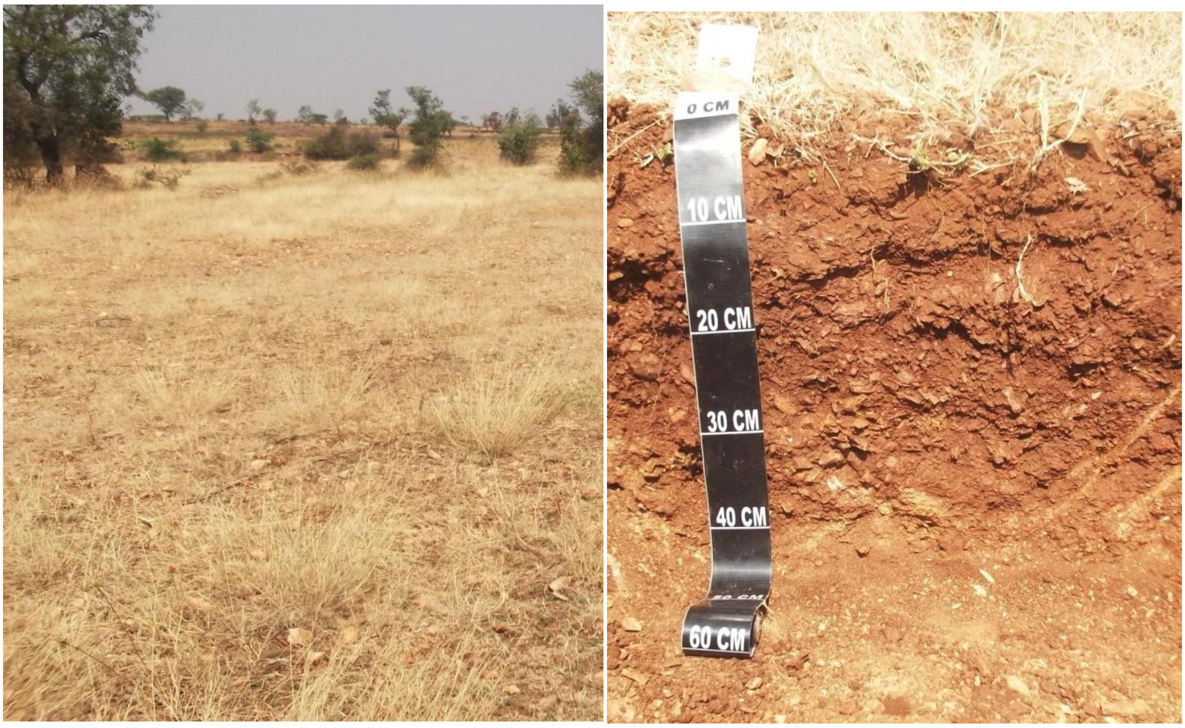
Landscape and Soil Profile Characteristics of Nabhapur (NBP) Series

4.1.10 Attikatti (AKT) Series: Attikatti soils are shallow (25-50 cm), well drained, have dark reddish brown to dusky red clay loam to clayey soils. They are developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 26 to 48 cm. Thickness of A horizon ranges from 12 to 18 cm. Its colour is in hue 5 YR and 2.5 YR with value 3 and chroma 3 to 4. The texture is clay loam to clay. The thickness of B horizon ranges from 14 to 30 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 to 4 and chroma 2 to 4. Its texture is dominantly clay. The available water capacity is very low (<50 mm/m).

Only one phase was identified:

AKTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)



Landscape and Soil Profile Characteristics of Attikatti (AKT) Series

4.1.11 Beladadi (BLD) Series: Beladadi soils are shallow (25-50 cm), well drained, have dark brown to dark reddish brown gravelly sandy clay loam soils. They have developed from schist and occur on very gently sloping uplands under cultivation

The thickness of the solum ranges from 26 to 48 cm. Thickness of A horizon ranges from 10 to 16 cm. Its colour is in hue 5 YR and 2.5 YR with value 2 to 3 and chroma 2 to 4. The texture is dominantly sandy clay loam. The thickness of B horizon ranges from 21 to 38 cm. Its colour is in hue 2.5 YR and 5 YR with value 2.5 to 3 and chroma 2 to 4. Its texture is dominantly sandy clay loam. The available water capacity is very low (<50 mm/m)

Only one phase was identified:

BLDhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)

4.1.12 Kabulayathkatti Tanda (KKT) Series: Kabulayathakatti Tanda soils are moderately shallow (50-75 cm), well drained, dark reddish brown gravelly clay loam to gravelly clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 53 to 72 cm. Thickness of A horizon ranges from 11 to 16 cm. Its colour is in hue 5 YR and 2.5 YR with value 2 to 3 and chroma 2 to 4. The texture is dominantly clay. The thickness of B horizon ranges from 41 to 56 cm. Its colour is in hue 2.5 YR and 5 YR with value 2.5 to 3 and chroma 3 to 4. Its texture is dominantly sandy clay to clay. The available water capacity is very low (<50 mm/m)

Two phases were identified:

KKThB2g2R1St1	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %), few to fairly rocky (<2-10), stony (0.01-0.1%)
KKTmB1	Clay surface, slope 1-3%, slight erosion

Landscape and Soil Profile Characteristics of Kabulayathakatti Tanda (KKT) Series

4.1.13 Attikatti Tanda (ATT) Series: Attikatti Tanda soils are moderately deep (50-75 cm), well drained, have dark brow to very dark brown clayey soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 51-73 cm. The thickness of A horizon ranges from 12 to 18 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 3 and chroma 1 to 3. The texture is dominantly clay. The available water capacity is low (50-100 mm/m).

Only one phase was identified:

ATTiB2g1	Sandy clay surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)

4.1.14 Jelligeri (JLG) Series: Jelligeri Tanda soils are moderately deep (75-100cm), moderately well drained, very dark brown to dark brown and black craking clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 78 to 98 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 63 to 78 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is high (150-200 mm/m).

Only one phase was identified:

JLGmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)

Landscape and Soil Profile Characteristics of Jelligeri (JLG) Series

4.1.15 Nagavi Tanda (NGT) Series: Nagavi Tanda soils are very deep (>150 cm), well drained, have very dark grayish brown cracking clay soils.They have developed from schist and occur on nearly level to very gently sloping uplands under cultivation.

The thickness of the solum more than 150 cm. The thickness of A horizon ranges from 12 to 28 cm. Its colour is in 10 YR hue with value 2 to 4 and chroma 1 to 2. The texture varies from clay. The thickness of B horizon ranges from 130 to >150 cm. Its colour is in 10 YR and 2.5 Y hue with value 2 to 4 and chroma 1 to 2. Its texture is clay. These soils are effervescent with dilute HCL. The available water capacity is very high (>200 mm/m).

Two phases were identified:

NGTmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
NGTmB1g2	Clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)

Chapter 5

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 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 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

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 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/alkalinity 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 26 soil map units identified in the Kokkaragundi-3microwatershed are grouped under 4 land capability classes and 7 land capability subclasses. About 95 per cent area in the microwatershed is suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover an areaof about 24 per cent area and are distributed in the western, northern and eastern part of the micowatershed with minor problems of soil and erosion. Moderately good cultivable lands (Class III) cover amaximum area of about 56 per cent and are distributed in the southern,central, northwesternpart of the microwatershed with moderate problems of erosion and soil. The fairly good cultivable lands (class IV) cover a very small area of about 15 per cent. They have severe limitations of erosion and soil and are distributed in the southwesternpart of the microwatershed.

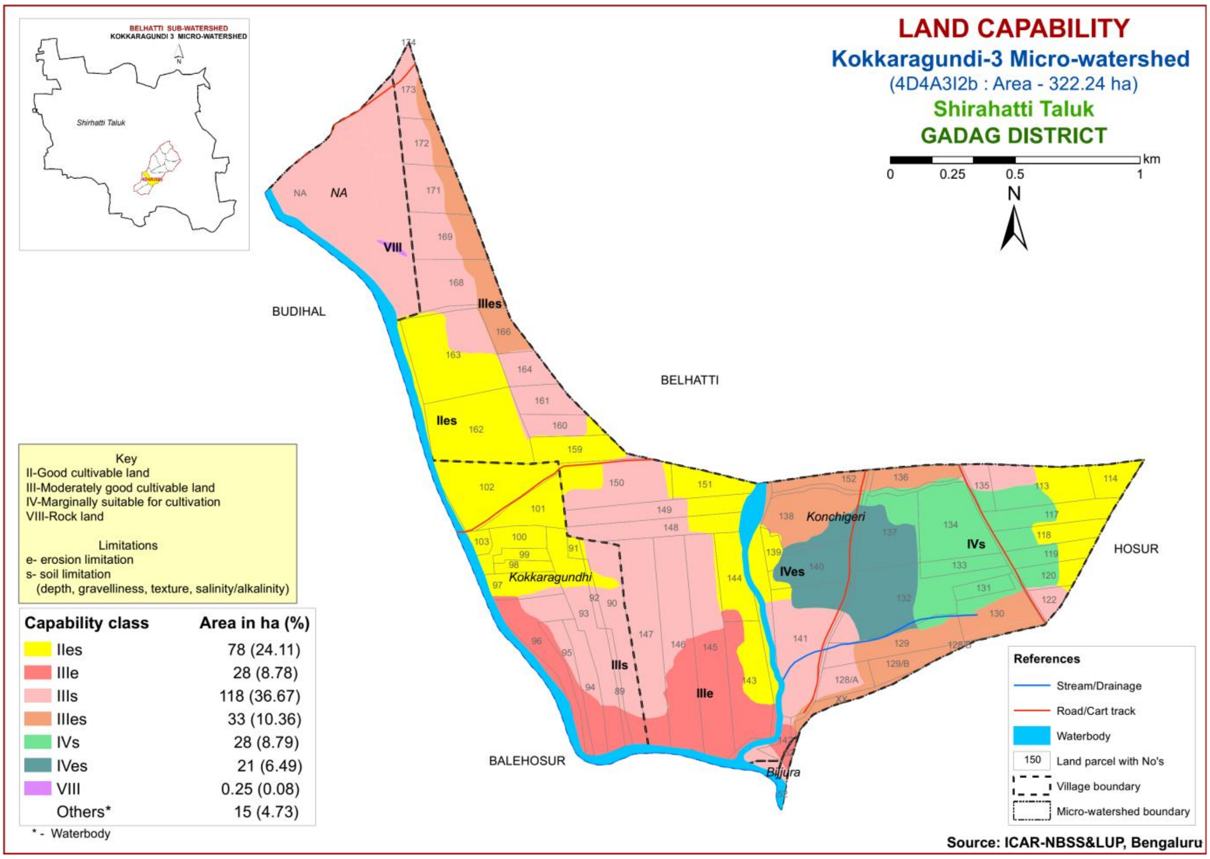


Fig. 5.1 Land Capability map of Kokkaragundi-3 Microwatershed

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 prepared (Fig. 5.2).

Very shallow (<25 cm) soils occur in an area of about 29 ha (15%) and are distributed in the central and eastern part of the microwatershed. Shallow (25-50 cm) soils occur in maximum area of about 103 ha (32%) and are distributed in the northern, southern and southwestern part of the microwatershed.Moderately shallow soils (50-75 cm) occupy about 30 ha (9%) in the eastern and southwestern part of the microwatershed. Moderately deep (75-100 cm) occur in an area of about 11 ha (3%) and are distributed in eastern part of microwatershed. Deep soils (100-150 cm) occur in an area of 76 ha (24%) and are distributed in the southern, western and central part of the microwatershed.Very deep soils (>150 cm) occupy a small area of about 37 ha (12%) and are distributed in the southern and central part of the microwatershed.

The most productive lands 113 ha (35%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep (100-150 cm depth) and very deep soils (>150 cm depth) occurring in the northern and southern part of the microwatershed.

The most problem lands with a maximum area of about 103 ha (32%) having shallow (25-50 cm) rooting depth occur in the northern, central and southern 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.

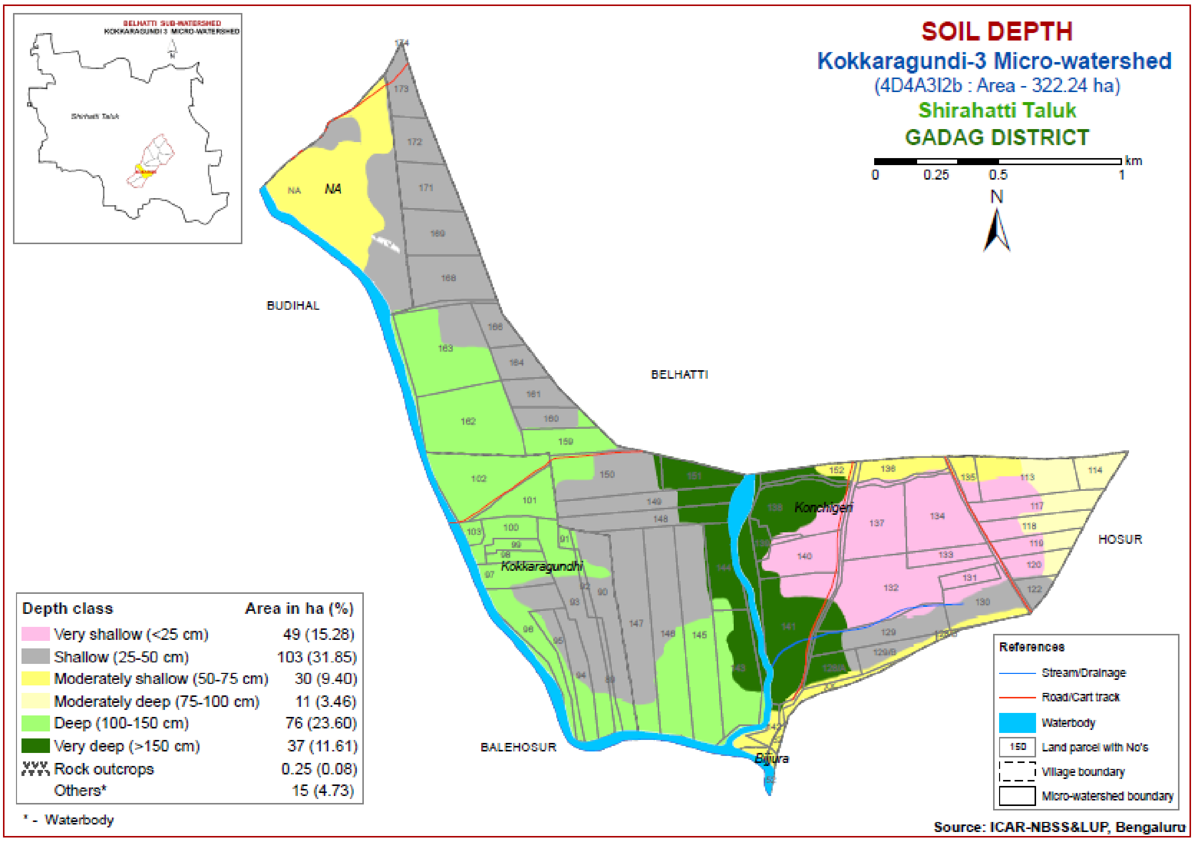


Fig. 5.2 Soil Depth map of Kokkaragundi-3 Microwatershed

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 map was prepared. The area extent and geographical distribution in the microwatershed is shown in fig 5.3.

Maximum area of 126 ha (39%) has soils that are clayey at the surface and are distributed in southern, southwestern, northern, central and easternpart of the microwatershed and about 103 ha (32%) area has soils that are sandy clay soils. They are distributed in the southwestern and northeastern part of the microwatershed (Fig. 5.3). An area of about 67 ha (21%) of soil has sandy clay loam and are distributed in southeastern and northwestern parts of microwatershed. A very small area 11 ha (3 %) has soil that is sandy loam and are distributed in northwestern part of microwatershed.

The most productive lands (39%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but have problems of drainage, infiltration, workability and other physical problems.

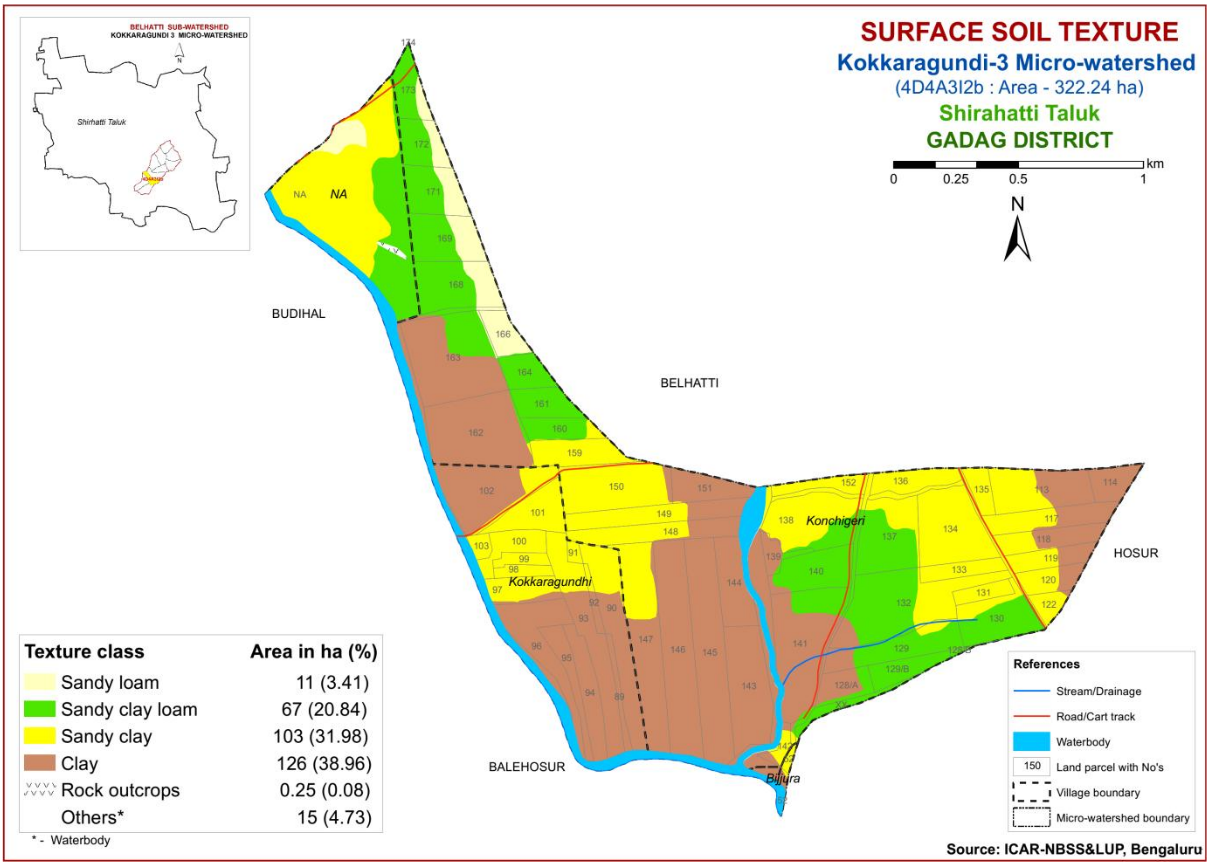


Fig. 5.3 Surface Soil Texture map of Kokkaragundi-3 Microwatershed

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 gravellinessclasses used for LRI were used to classify the soils and using these classes a gravelliness map was prepared. The area extent and geographical distribution in the microwatershed is shown in fig 5.4.

Maximum area in the microwatershed has soils that are gravelly (15-35%) cover about 172 ha (53%) and are distributed in all part of the microwatershed except southeastern and northeastern parts (Fig. 5.4) followed by soils that are very gravelly (35-60%) covering about 103 ha (32%) and are distributed in the northeastern, southeastern and southwestern part of the microwatershed. The soils that are non-gravelly (<15%) cover small area of about 31ha (10%) and are distributed in thecentral part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 10 %. They are non-gravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops. The problem soils (32%) that arevery gravelly (35-60%)where only short duration crops can be grown.

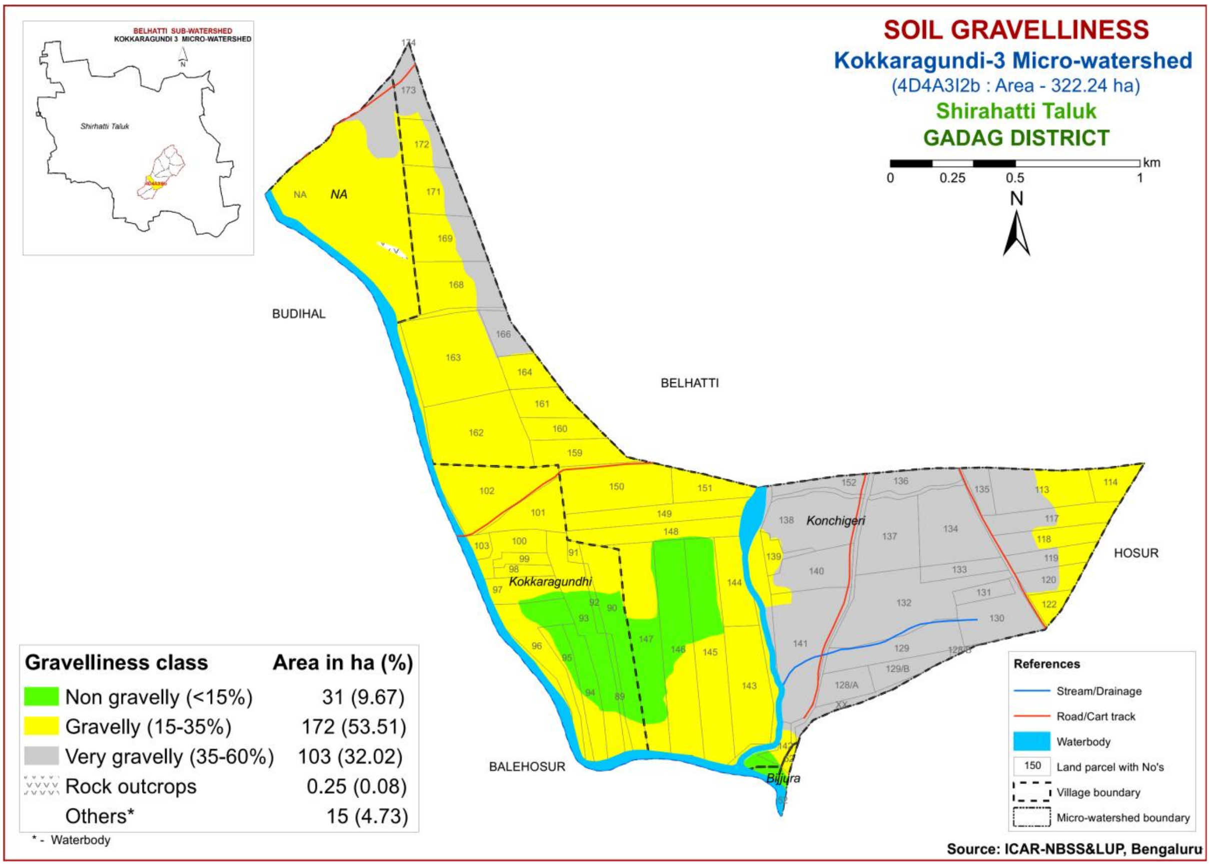


Fig. 5.4 Soil Gravelliness map of Kokkaragundi-3 Microwatershed

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 prepared. The area extent and geographical distribution of different AWC classes in the microwatershed is shown in fig 5.5.

Major area of about 171 ha (53%) in the microwatershed has soils that are very low (<50mm/m) in available water capacity and are distributed in all the parts of the microwatershed. A very small area of about 10 ha (3%) has soils that are low (50-100 mm/m) in available water capacity and are distributed in the northeastern and notrhwestern of the microwatershed. An area of 125 ha (39%) has soils that have very high (>200 mm/m) available water capacity and are distributed in the southern, northern, central western and eastern part of the microwatershed.

An area of about 125 ha (39%) has soils that have high potential (>200 mm/m) with regard to available water capacity where all climatically adapted long duration crops can be grown successfully.

About 171 ha (53%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only 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.

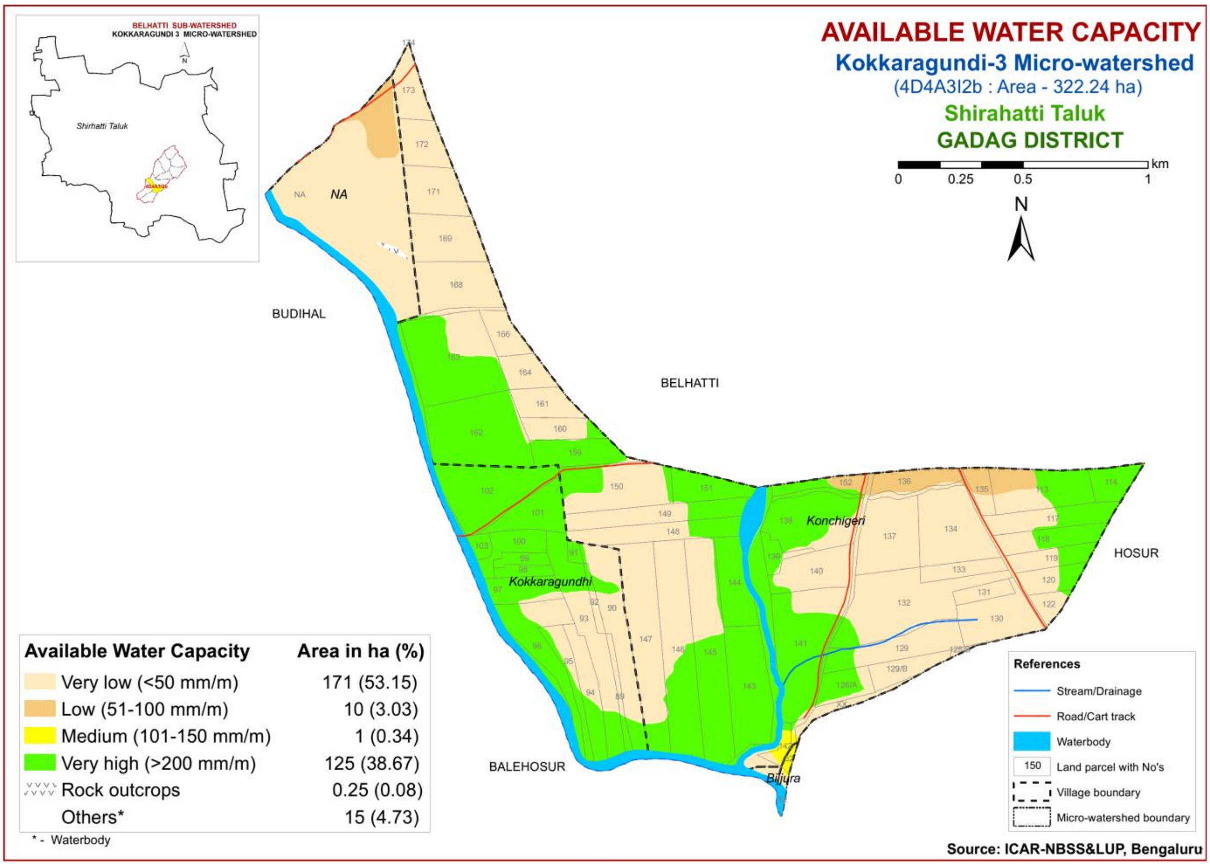


Fig. 5.5 Soil Available Water Capacity map of Kokkaragundi-3 Microwatershed

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 prepared showing the area extent and geographic distribution of different slope classes in the microwatershed (Fig. 5.6).

Major area of about 277 ha (86%) falls under very gently sloping (1-3% slope) lands and is distributed in all parts of the microwatershed. Nearly level (0-1% slope) it covers an area of about 30 ha (9%) and is distributed in thecentralpart of the microwatershed.

An area of about 307 ha (95%) in the microwatershed has soils that have high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

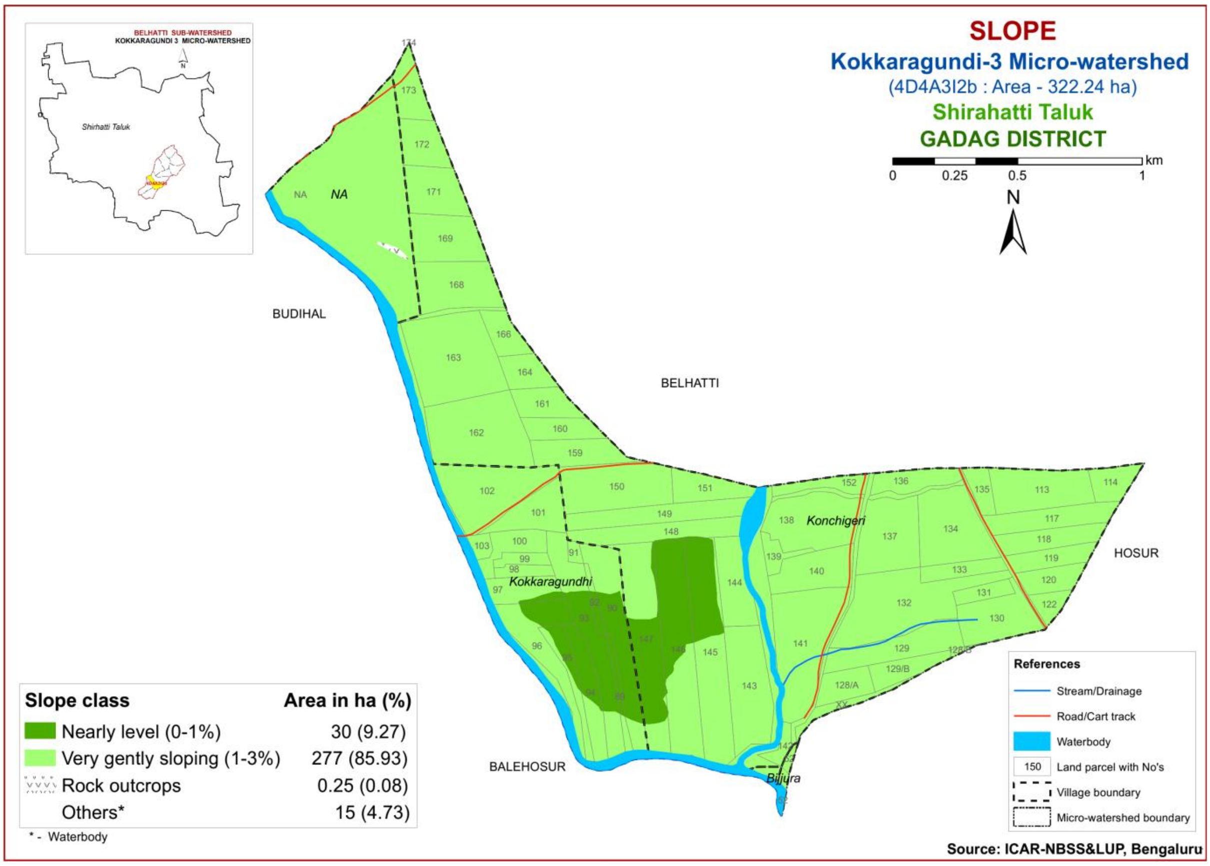


Fig. 5.6 Soil Slope map of Kokkaragundi-3 Microwatershed

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 prepared. The area extent and their spatial distribution in the microwatershed is given in Figure 5.7.

Soils that are slightly eroded (e1 class) cover a maximum area of about 224 ha (70%) in the microwatershed. They are distributed in all parts of the microwatershed. Moderately eroded (e2 class) soils cover an area of about 83 ha (26%) and are distributed in the southern, southeastern, northeastern part of the microwatershed.

If area has severe erosion in the microwatershed is problematic and top priority is to be given to these areas for taking up soil and water conservation and other land development measures. Next in priority would be an area of about 83 ha (26%) where the soils are moderately eroded.

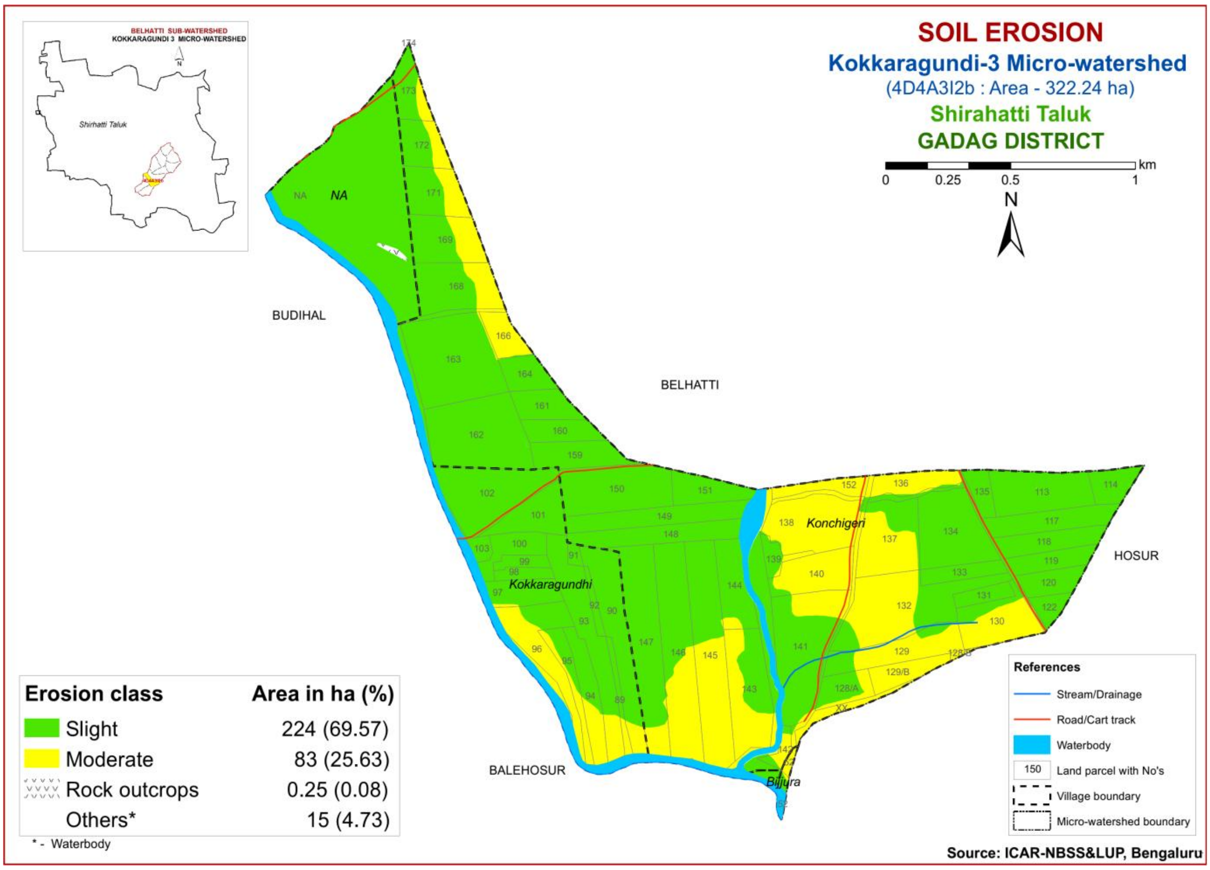


Fig. 5.7 Soil Erosion map of Kokkaragundi-3 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status. 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, boron, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil analysis of the Kokkaragundi-3 microwatershed for soil reaction (pH) showed that about 53 ha (16%) area is moderately alkaline (pH 7.8-8.4) and is distributed in the northeastern and northern part of the microwatershed. A very small area of about 8 ha (2%) is under slightly alkaline (pH 7.3-7.8) and is distributed in the northeastern part of the microwatershed. Maximum area of about 138 ha (43%) is under strongly alkaline (pH 8.4-9.0) and is distributed in the northern, western, eastern and southeastern part of the microwatershed followed bya area of about 66 ha (21%) under very strongly alkaline (pH >9.0) and is distributed in the southern part of the microwatershed. A small area of about 42 ha (13%) is under neutral (pH 6.5-7.3) and is distributed in the northeastern part of the microwatershed (Fig.6.1).

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content of the microwatershed is low (<0.5%) cover a maximum area of about154 ha (48%) and is distributed in the western and northwestern part of the microwatershed followed by an area of 153 ha (47%) is medium (0.5-0.75%) in organic carbon content and is distributed in the southern, northern, central and eastern part of the microwatershed (Fig.6.3).

6.4 Available Phosphorus

The soil analysis revealed that available phosphorus is low (<23 kg/ha) in maximum area of about243 ha (75%) (Fig.6.4) and is distributed in all partsof the microwatershed. 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 64 ha (20%) area is medium (23-57 kg/ha) in available phosphorus.

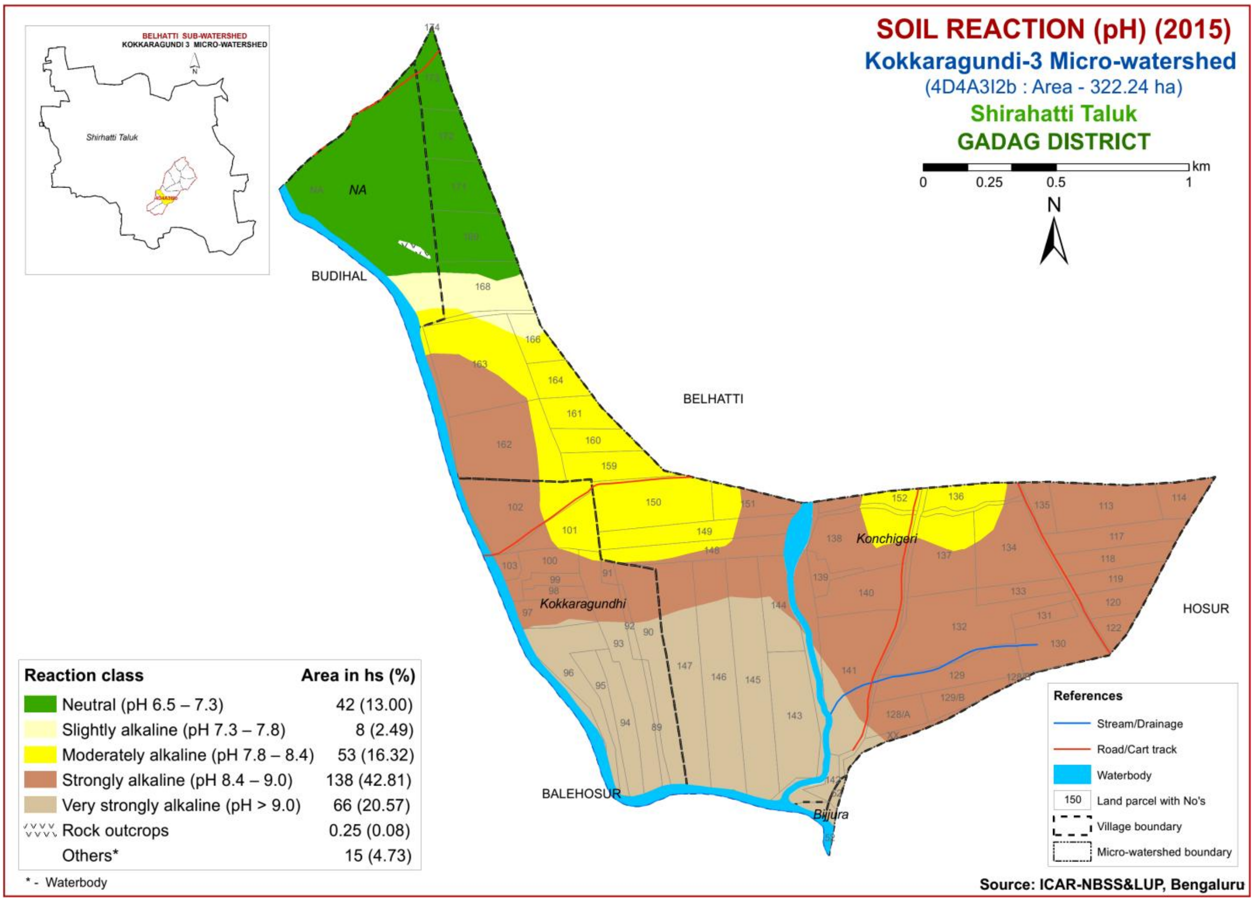


Fig.6.1 Soil Reaction (pH) map of Kokkaragundi-3 Microwatershed

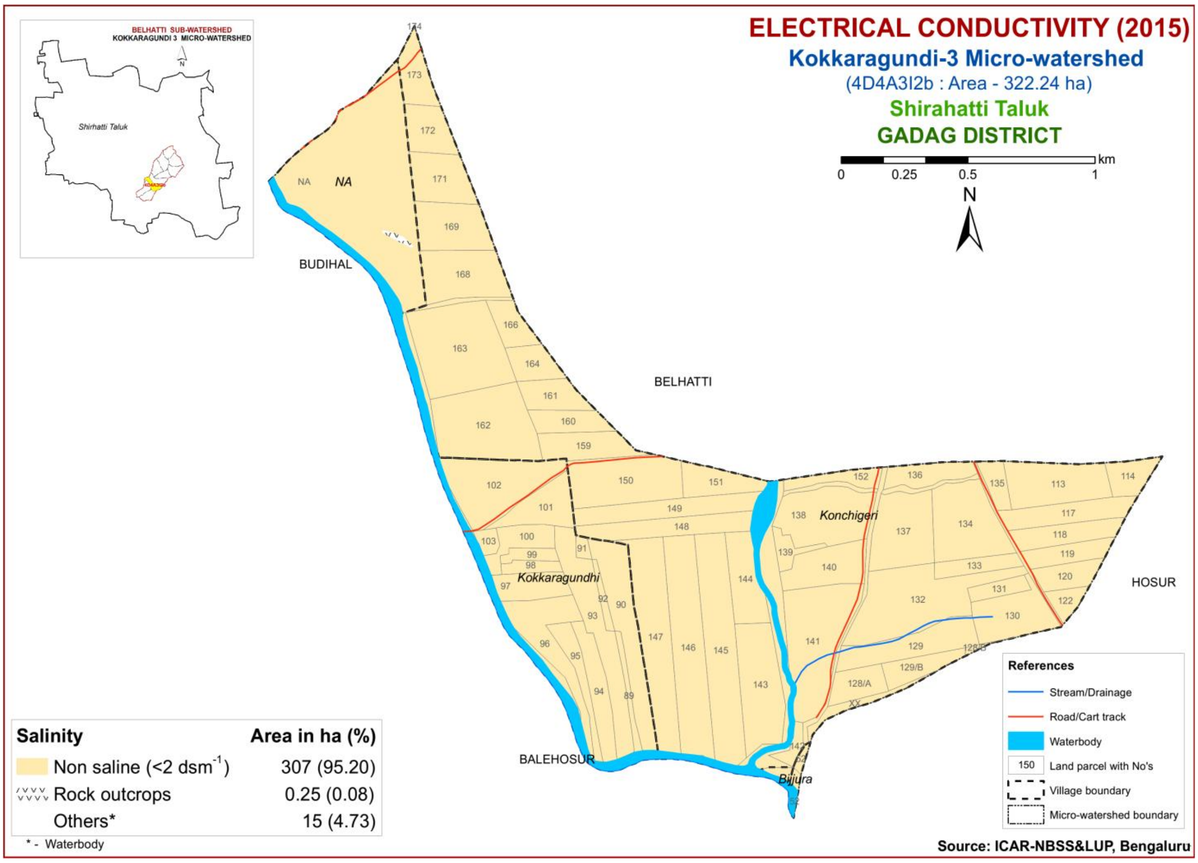


Fig.6.2Electrical Conductivity (EC) map of Kokkaragundi-3 Microwatershed

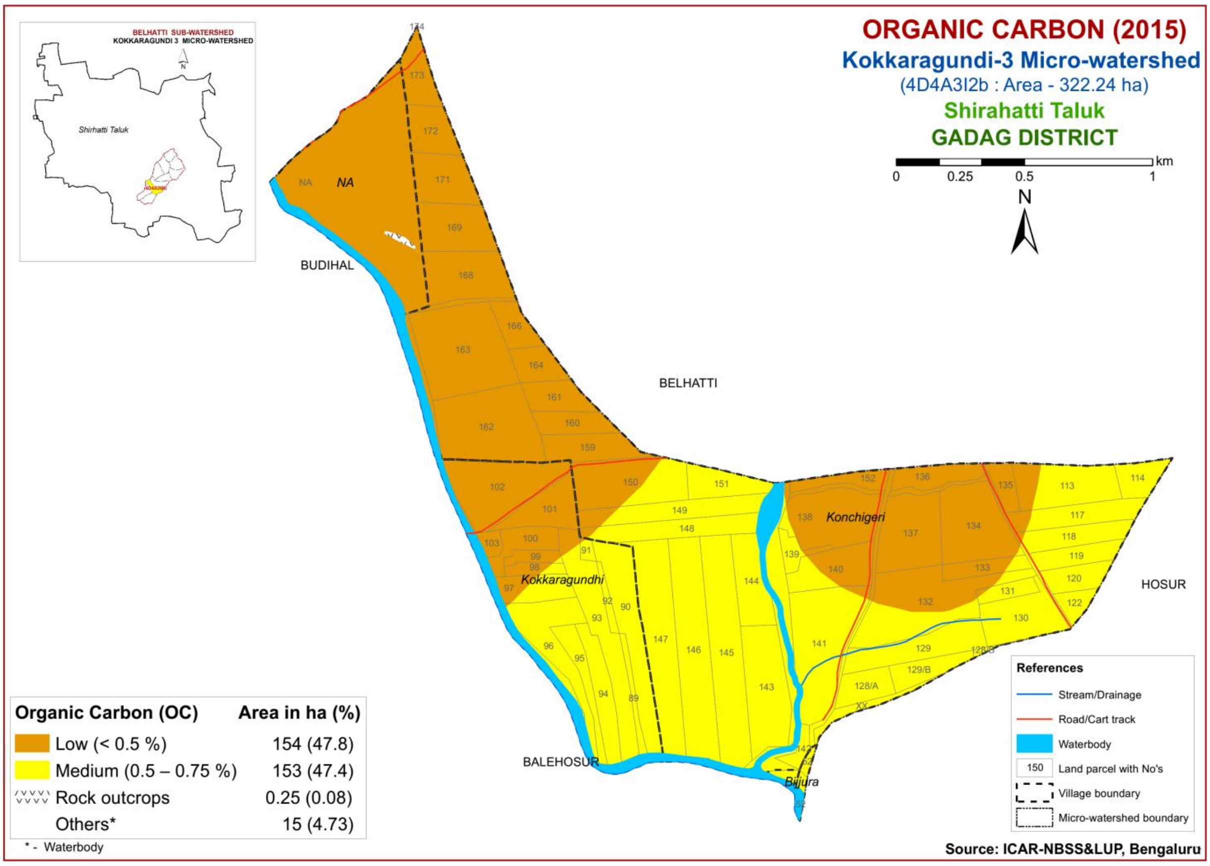


Fig.6.3Soil Organic Carbon map of Kokkaragundi-3 Microwatershed

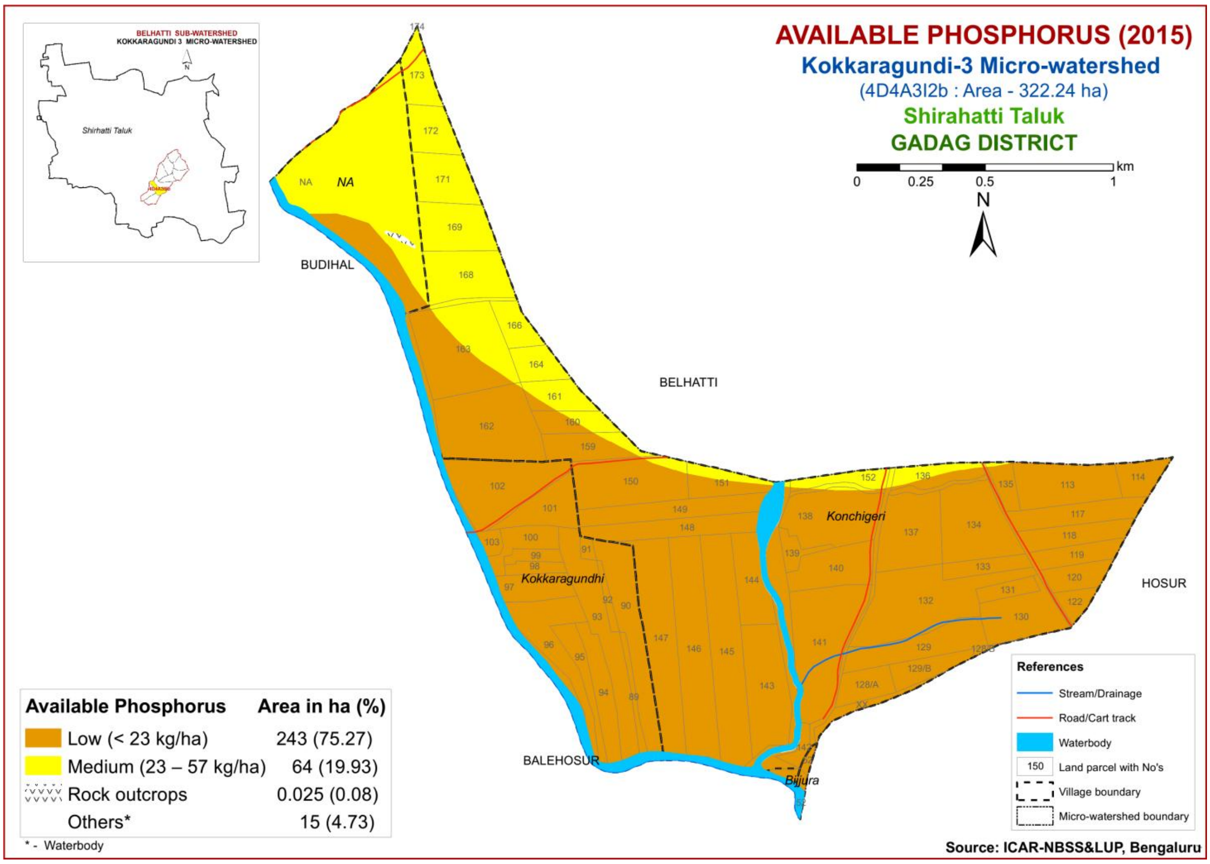


Fig.6.4 Soil available Phosphorus map of Kokkaragundi-3 Microwatershed

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in maximum area of about 259 ha (80%) and is distributed in all parts of the microwatershed (Fig.6.5). The available potassium content is low (<145 kg/ha) in a small area of 30 ha (9%) and is distributed in the northeastern and southwestern part of the microwatershed. A very small area of about 18 ha (5%) is high (>337 kg/ha) in available potassium and is distributed in the southern and central part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in maximum area 125 ha (39%) in the microwatershed and is distributed in the northwestern and northeastern part of the microwatershed. An area of about 123 ha (38%) is medium (10-20 ppm) in available sulphur and is distributed in the central part of the microwatershed. Available sulphur content is high (>20ppm) in an area of about 59 ha (18%) area and is distributed in the southern parts of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in the maximum area and is cover about 169 ha (52 %) and distributed in the southern, northern and central parts of microwatershed (Fig 6.7). An area of about 138 ha (43%) is low (<0.5 ppm) in available boron and is distributed in the northwestern and souheastern part of the microwatershed

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in maximum area of 250 ha (78%) and is distributed in all parts of the microwatershed and about 57 ha (18%) area is deficient in available iron content and is distributed in the northernand northeastern part 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 the entire microwatershed area (Fig 6.11).

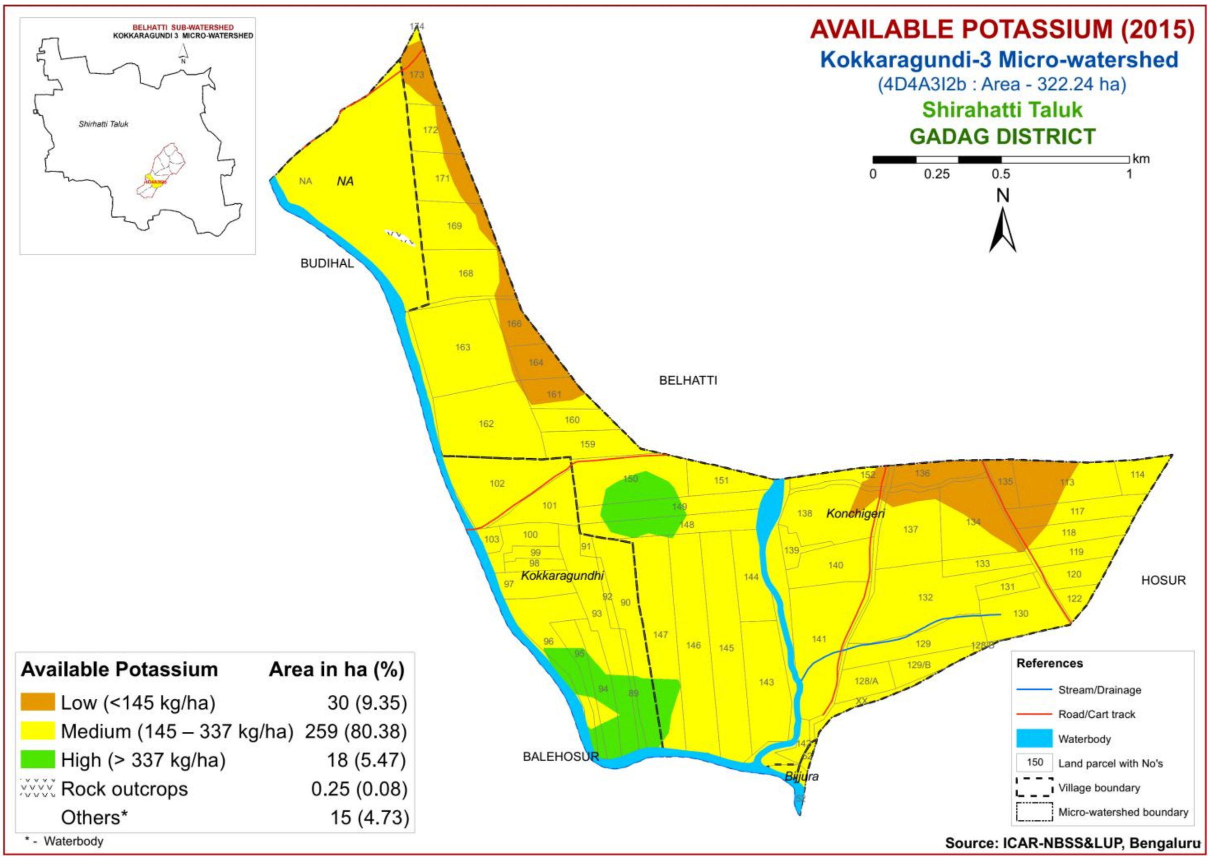


Fig.6.5Soil available Potassium map of Kokkaragundi-3 Microwatershed

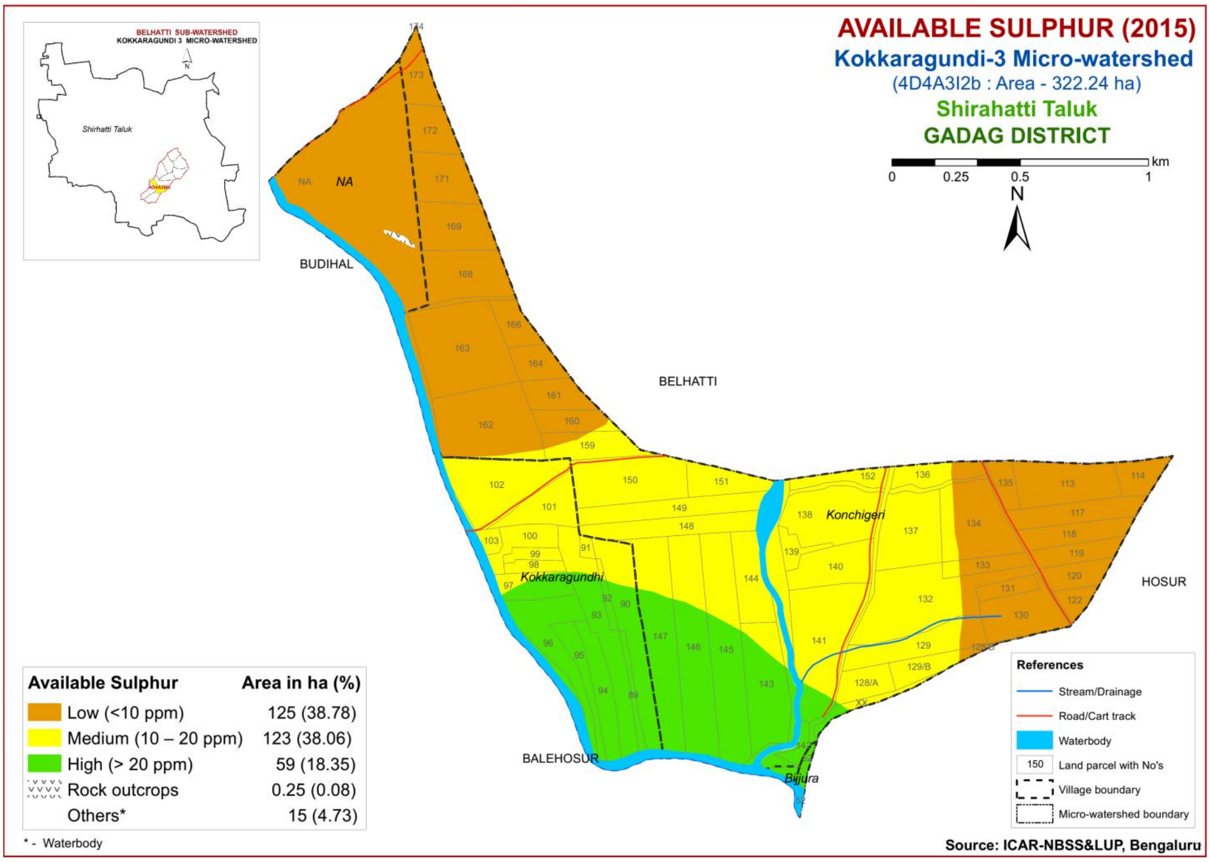


Fig.6.6Soil available Sulphur map of Kokkaragundi-3 Microwatershed

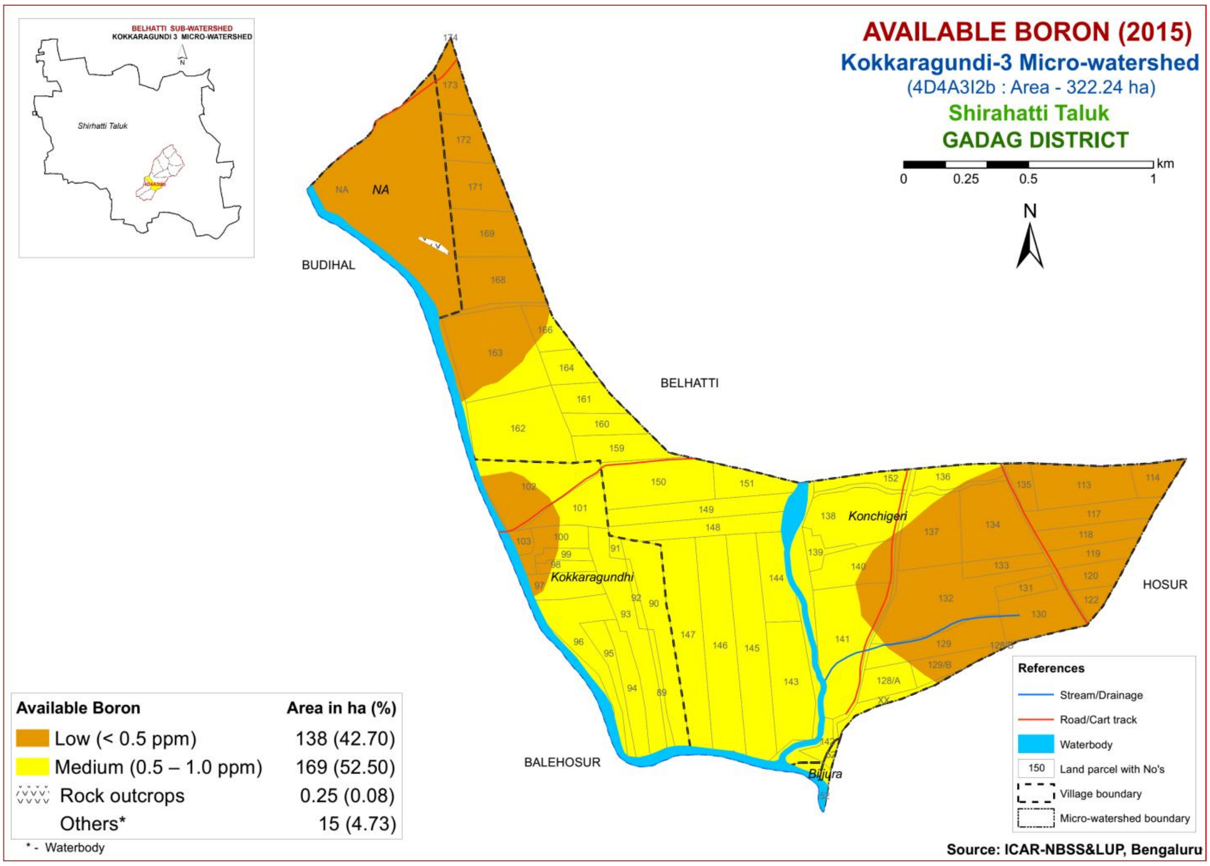


Fig.6.7Soil available Boron map of Kokkaragundi-3 Microwatershed

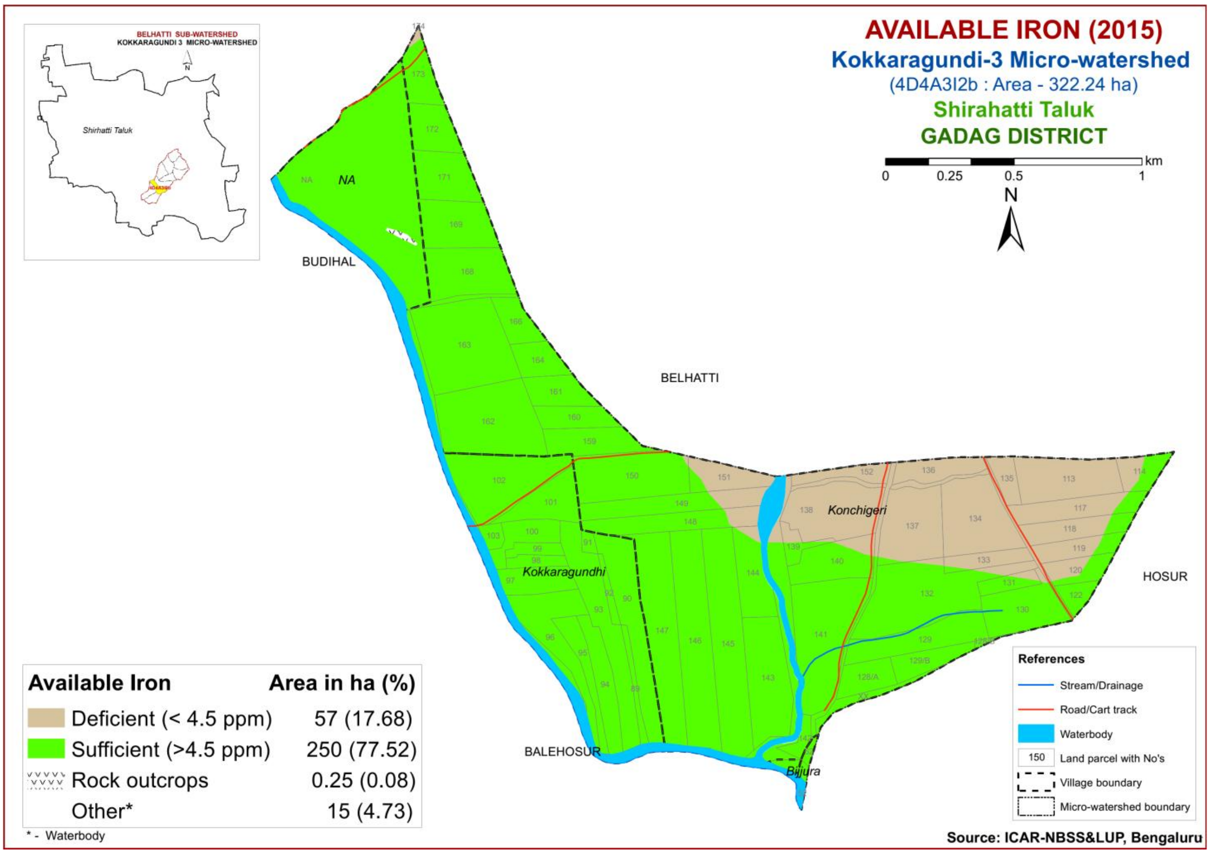


Fig.6.8 Soil available Iron map of Kokkaragundi-3 Microwatershed

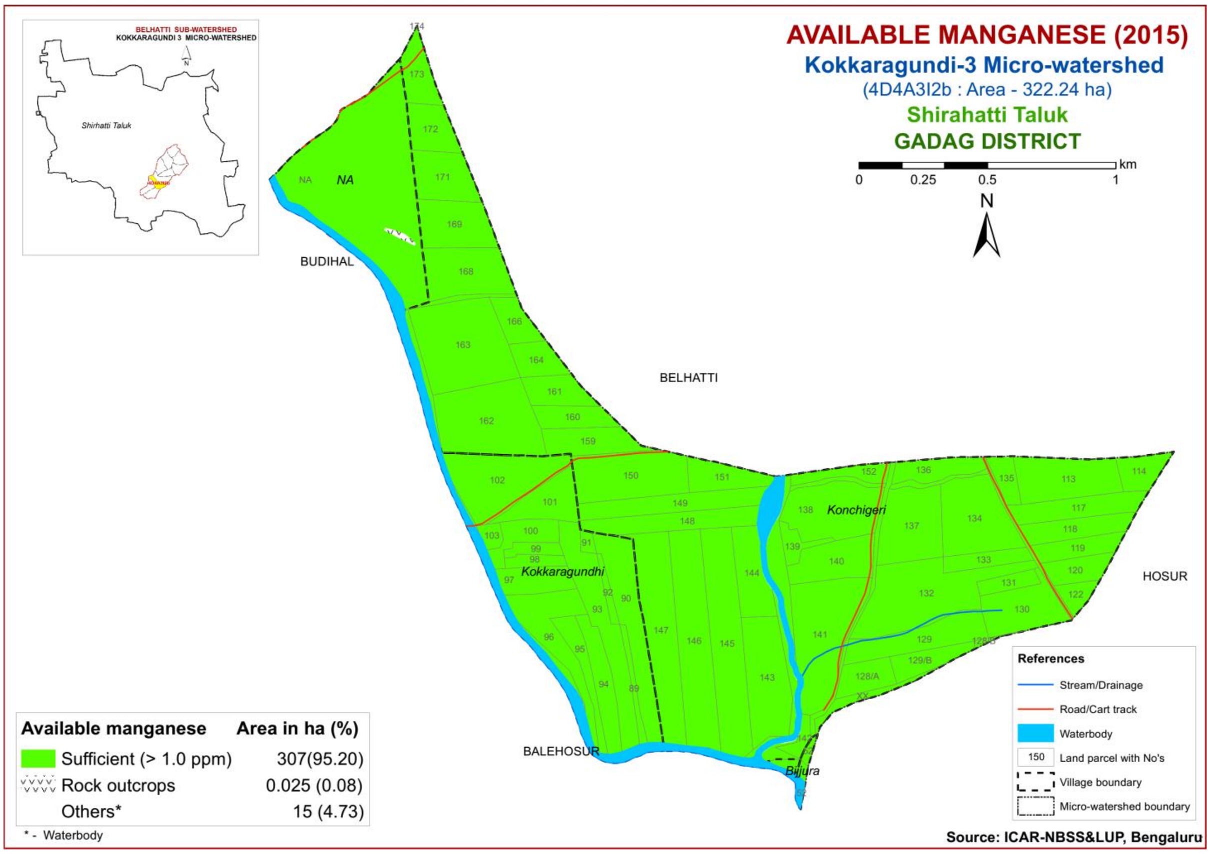


Fig.6.9 Soil available Manganese map of Kokkaragundi-3 Microwatershed

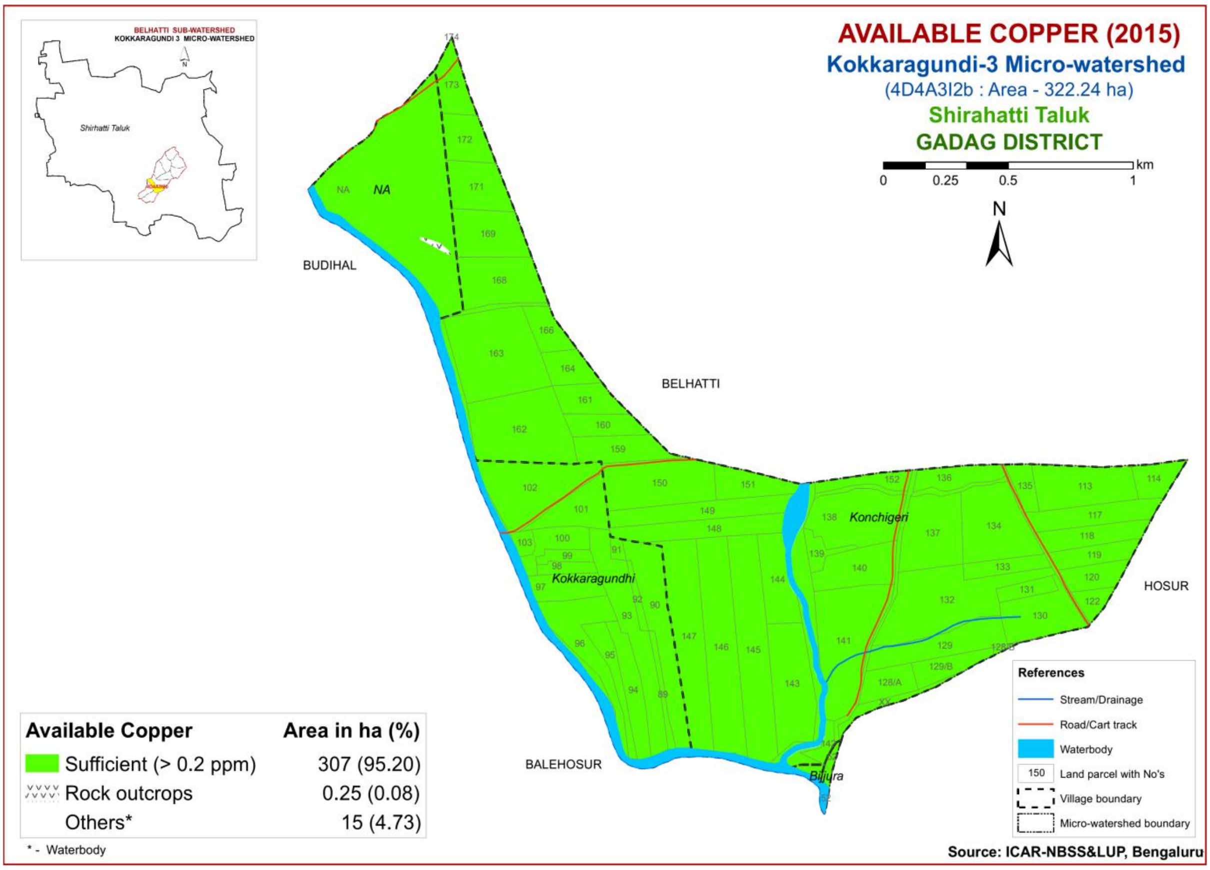


Fig.6.10 Soil available Copper map of Kokkaragundi-3 Microwatershed

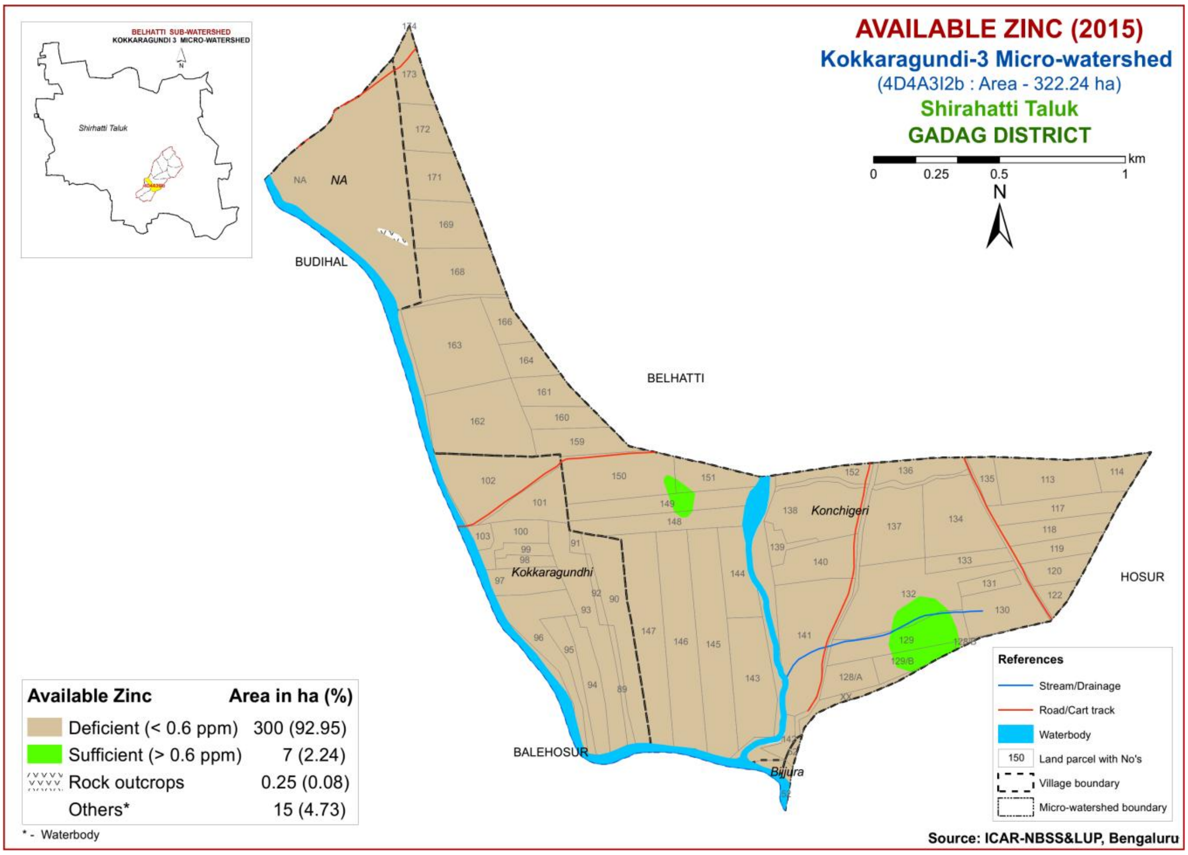


Fig.6.11 Soil available Zinc map of Kokkaragundi-3 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Kokkaragundi-3microwatershed were assessed for their suitability for growing food, fodder, fibre 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 crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S- Suitable and Order N- Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1- Highly Suitable, Class S2- Moderately Suitable and Class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 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 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 21 major annual and perennial 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 11.02 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Chamarajnagar districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing sorghum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure. 7.1.

An area of about 75 ha (23%) in the microwatershed has soils that are highly suitable (class S1) for growing sorghum crop. They have minor or no limitations for growing sorghum and are distributed mainly in the northern, southern, southwestern and eastern part of the microwatershed. An area of about 82 ha (25%) is moderately suitable (class S2) for growing sorghum and are distributed in the central, western, northwestern and southeastern part the microwatershed.

Table 7.1 Soil-Site Characteristics of Kokkaragundi-3 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol $(p^{+})kg^{-1}$]	BS (%)
					Surf-ace	Subsurface	Surface (%)	Subsurface (%)								
KNHhB1g1	633	150	WD	25-50	scl	sc	15-35	<15	<50	1-3	Slight					
HRVcB2g2	633	150	WD	25-50	sl	scl	35-60	>35	<50	1-3	Moderate					
MTLiB1g1	633	150	WD	25-50	sc	sc-c	15-35	15-35	51-100	1-3	Slight					
MTLmB1g1	633	150	WD	25-50	c	sc-c	15-30	15-35	51-100	1-3	Slight					
MTLmB2g2	633	150	WD	25-50	c	sc-c	35-60	15-35	51-100	1-3	Slight					
LKRiB1g2	633	150	WD	50-75	sc	scl-c	35-60	40-60	<50	1-3	Slight					
LKRiB2g2	633	150	WD	50-75	sc	scl-c	35-60	40-60	<50	1-3	Moderate					
KGHhB1g1	633	150	WD	50-75	scl	scl	15-35	15-35	15-35	1-3	Slight					
KGHhB2g2	633	150	WD	50-75	scl	scl	35-60	15-35	15-35	1-3	Moderate					
RNKmB1g1	633	150	WD	50-75	c	sc-c	15-35	15-35	15-35	1-3	Slight					
RNKmB2g1	633	150	WD	50-75	c	sc-c	15-35	15-35	15-35	1-3	Moderate					
GHTcB3g2	633	150	WD	75-100	sl	scl	35-60	15-35	15-35	1-3	Severe					
GHTcC3g2	633	150	WD	75-100	sl	scl	35-60	15-35	15-35	3-5	Severe					
GHTcC3g3	633	150	WD	75-100	sl	scl	60-80	15-35	15-35	3-5	Severe					
GHThB2g2	633	150	WD	75-100	scl	scl	35-60	15-35	15-35	1-3	Moderate					
GHThB2g3R1St1	633	150	WD	75-100	scl	scl	60-80	15-35	15-35	1-3	Moderate					
KKRiA1	633	150	WD	75-100	sc	cl-sc	-	-	-	0-1	Slight					
CKMiA1g1	633	150	WD	75-100	sc	sc	15-35	-	-	0-1	Slight					
BPRiB2g1	633	150	WD	100-150	sc	sc-c	15-35	>35	>35	1-3	Moderate					
BPRiB2g2	633	150	WD	100-150	sc	sc-c	35-60	>35	>35	1-3	Moderate					
BPRmB2g1	633	150	WD	100-150	c	sc-c	15-35	>35	>35	1-3	Moderate					
VDHiB1g1	633	150	WD	100-150	sc	sc-c	15-35	-	-	1-3	Slight					
LGDiA1	633	150	WD	100-150	sc	sc-c	-	<15	<15	1-3	Slight					
LGDmA1g1	633	150	WD	100-150	c	sc-c	15-35	<15	<15	0-1	Slight					
LGDmB1	633	150	WD	100-150	c	sc-c	-	<15	<15	1-3	Slight					
LGDmB1g1	633	150	WD	100-150	c	sc-c	15-35	<15	<15	1-3	Slight					

LGDmB2g2	633	150	WD	100-150	c	sc-c	35-60	<15	<15	1-3	Moderate					
BGPiB1	633	150	WD	>150	sc	c	-	10-20	10-20	1-3	Slight					
BGPiB1g1	633	150	WD	>150	sc	c	15-35	10-20	10-20	1-3	Slight					
BGPmB1	633	150	WD	>150	c	c	-	10-20	10-20	1-3	Slight					

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

They have minor limitations of gravelliness, calcareousness and rooting depth. Marginally suitable lands (class S3) for growing sorghum occupy a major area of about 101 ha (31%) and mainly occur in the central, northern, northeastern and northwestern part of the microwatershed. They have moderate limitations of rooting depth, calcareousness and gravelliness. A small area of about49 ha (15%) is not suitable for growing sorghum in the microwatershed and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

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. well drained	imperfect	Poorly/excessively	V. poorly
Soil reaction	pH	6.0-8.0	5.5-5.98.1-8.5	<5.58.6-9.0	>9.0
Surface soil texture	Class	C, cl, sicl, sc	l, sil, sic	Sl, ls	S, fragmental skeletal
Soil depth	Cm	100-75	50-75	30-50	<30
Gravel content	% vol.	5-15	15-30	30-60	>60
Salinity (EC)	dSm^{-1}	2-4	4-8	8-10	>10
Sodicity (ESP)	%	5-8	8-10	10-15	>15

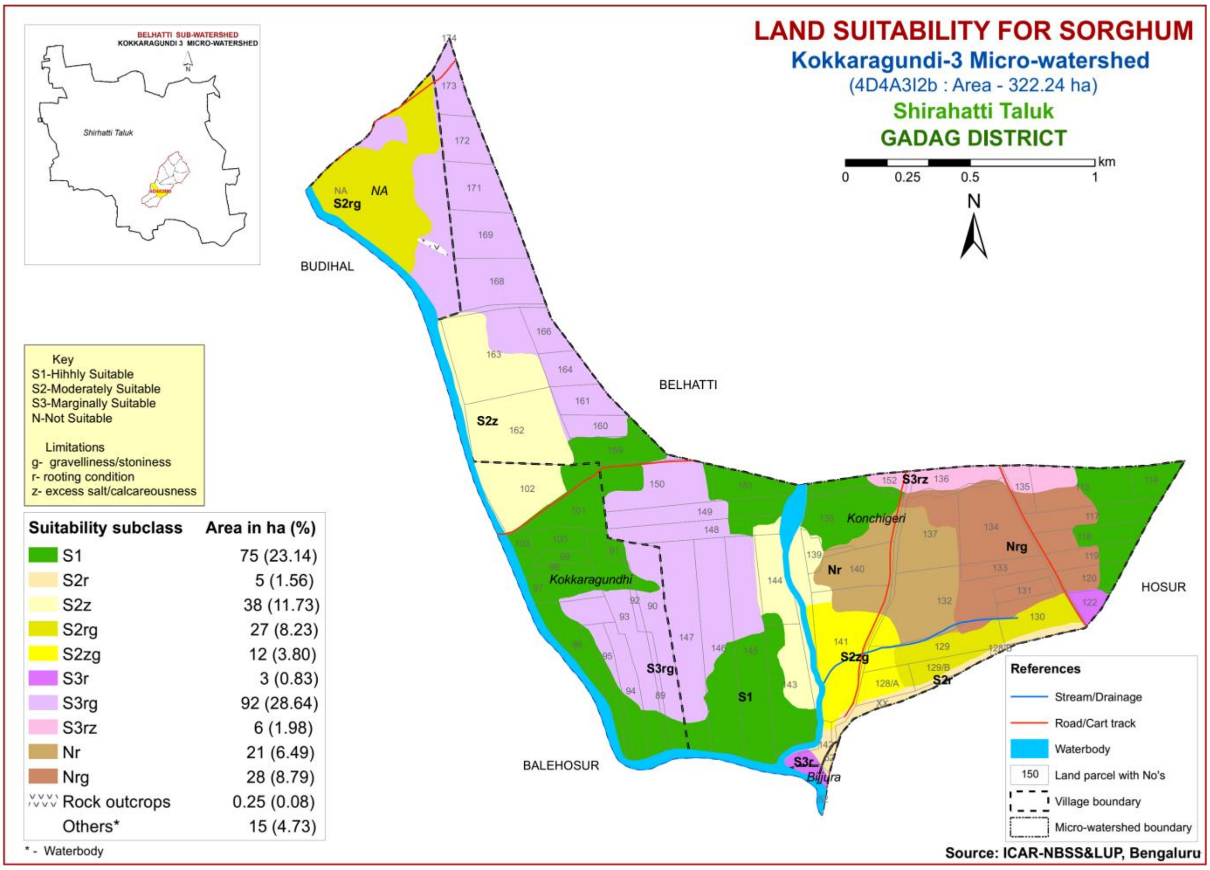


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.73 lakh ha in almost all the districts 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 and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

There is no highly suitable (class S1) lands available for growing maize in the microwatershed. A small area of about 32 ha (10%) in the microwatershed has soils that are moderately suitable (class S2) for growing maize crop. They have moderate limitations of gravelliness, texture and rooting depth and are distributed in the southeastern and northwestern part of the microwatershed. Maximum area of about 224ha (70%) is marginally suitable (class S3) for growing sorghum and are distributed in all the part the microwatershed. They have minor limitations of gravelliness, texture, calcareousness and rooting depth. About 49 ha (15%) area is not suitable for growing maize and occurs in the central part of the microwatershed. They have very severe limitations of gravelliness 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	

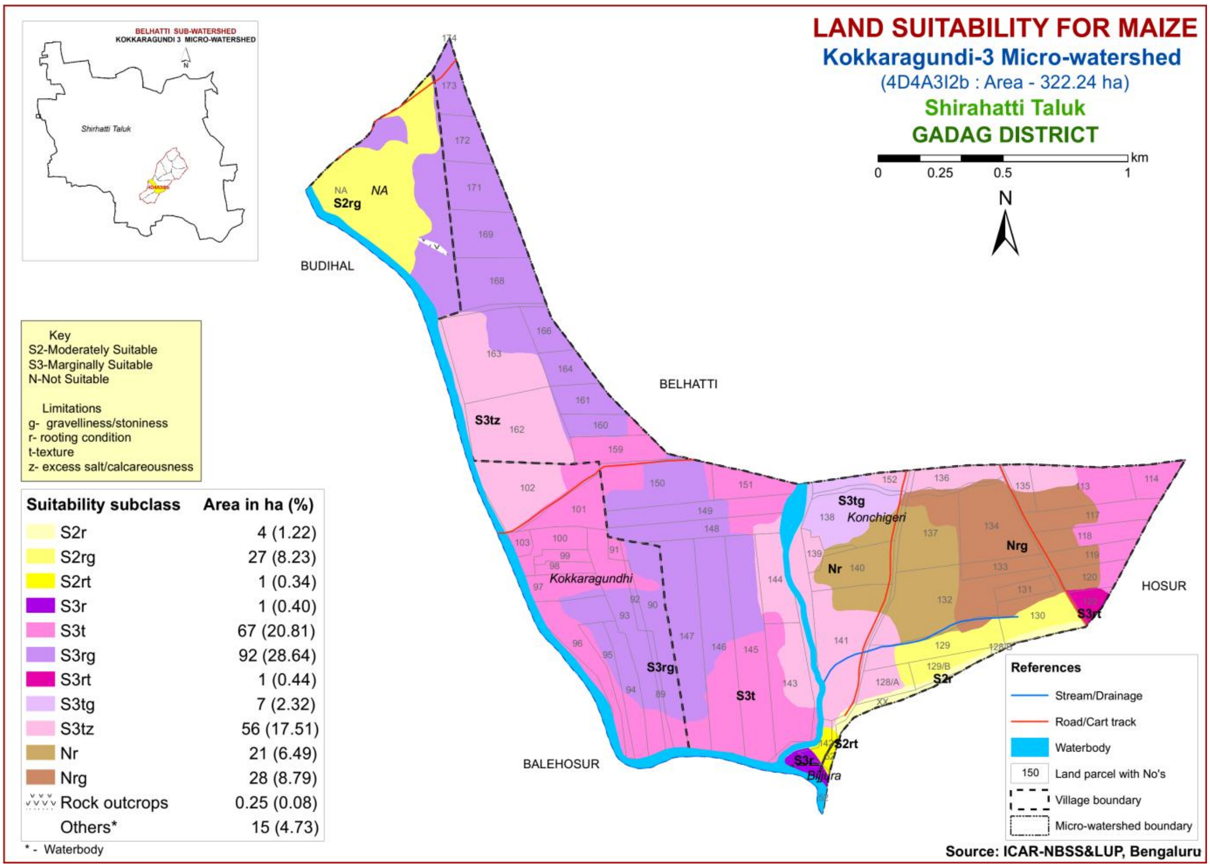


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for Bengalgram (*Cicer arietinum*)

Bengalgram is one of the major pulse crop grown in an area of 9.26 lakh ha in northern Karnataka in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing Bengalgram (Table 7.4) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing Bengalgram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.3.

An area of about 69 ha (22%) area in the microwatershed has soils that are highly suitable (class S1) for growing Bengalgram. They have minor or no limitations for growing Bengalgram and are distributed in the southern, northern and eastern part of the microwatershed. Major area of about132 ha (41%) area is moderately suitable (class S2) for Bengalgram. They are distributed in northwestern, central and northwestern parts of the microwatershed. They have minor limitations of calcareousness, gravelliness and rooting depth. Marginally suitable lands (class S3) for growing Bengalgram occupy a area of about 92 ha (29%) and mainly occur in the central and southeastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth.

Table 7.4 Crop suitability criteria for Bengalgram

Crop requirement		Rating			
Soil–site characteristics	unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	>100	90-100	70-90	<70
Soil drainage	class	Well drained	Mod. to well drained; Imperfectly drained	Poorly drained; excessively drained	Very Poorly drained
Soil reaction	pH	6.0-7.5	5.5-5.77.6-8.0	8.1-9.0;4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	Sl, c>60%	S, fragmental
Soil depth	Cm	>75	51-75	25-50	<25
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	

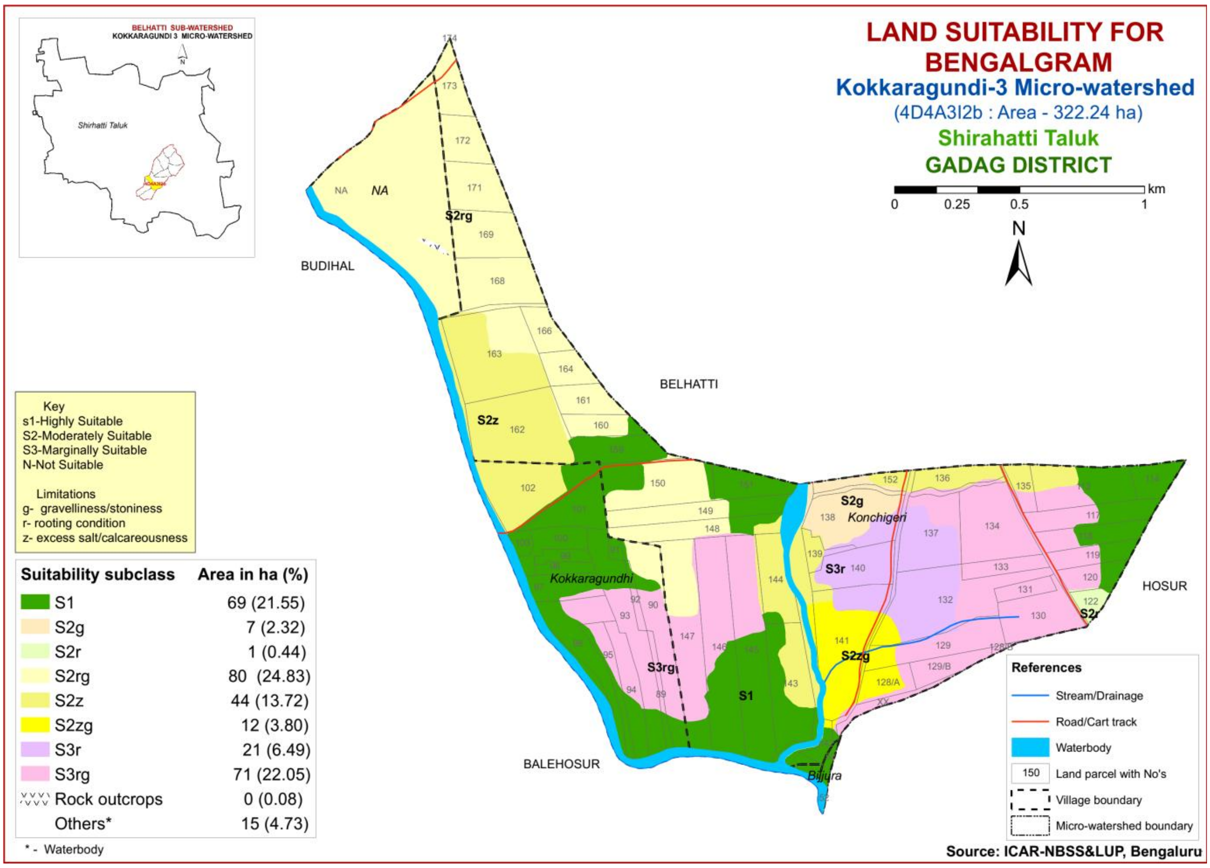


Fig. 7.3 Land Suitability map of Bengalgram

7.4 Land Suitability for Groundnut (*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.5 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.5) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing groundnut was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.4.

There is no highly suitable (class S1) lands available for growing groundnut in the microwatershed. A major area of about140 ha (43%) is moderately suitable (class S2) for groundnut and they are distributed in all the part of the microwatershed except northern part. They have minor limitations of calcareousness, rooting depth, gravelliness and texture. Marginally suitable lands (class S3) for growing groundnut occupy an area of about 117 ha (36%) and are distributed in the central, northern, northwestern and southwestern parts of the microwatershed. They have moderate limitations of rooting depth, gravelliness and texture. About 49 ha (15%) area is not suitable for growing ground nut and occurs in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.5 Crop suitability criteria for Groundnut

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

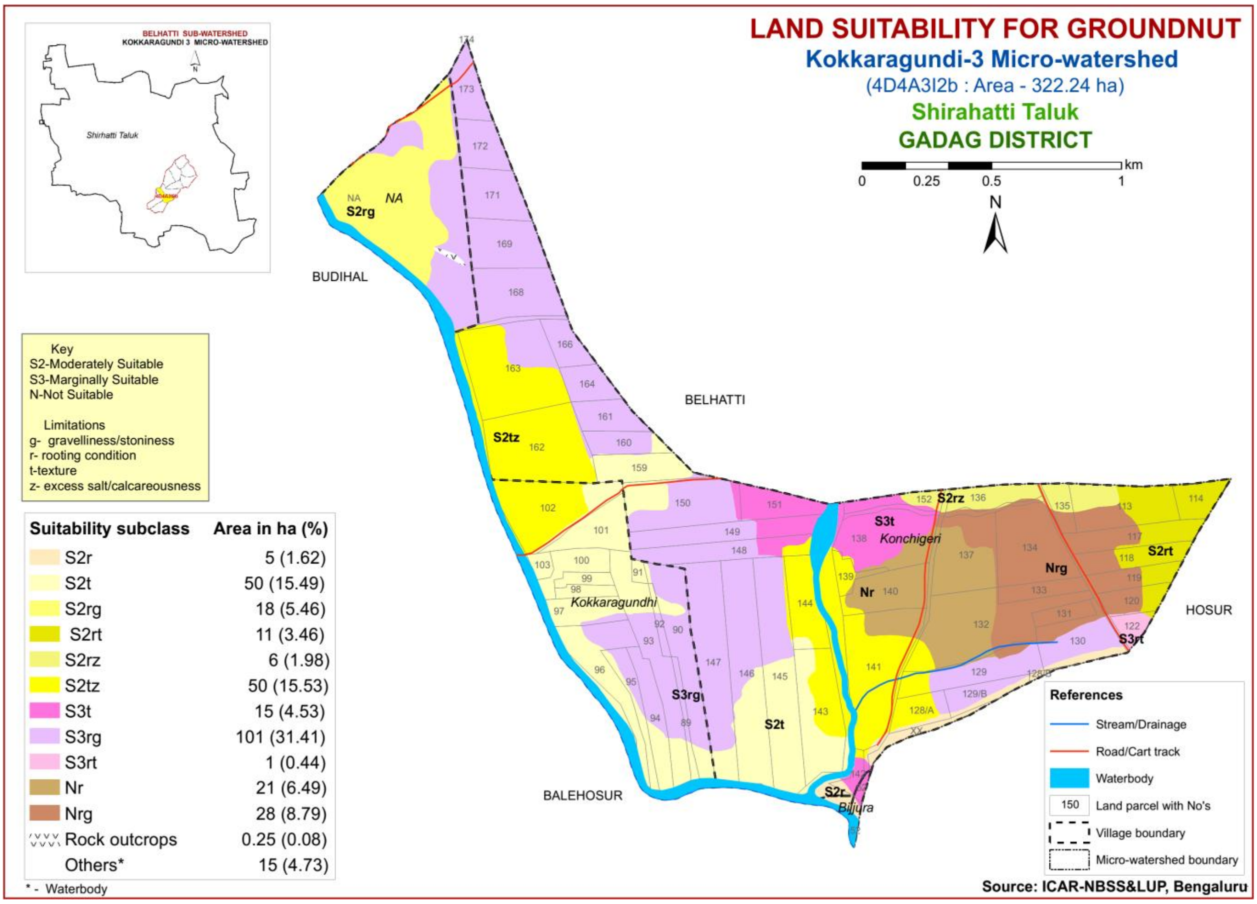


Fig. 7.4 Land Suitability map of Groundnut

7.5 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 4.1 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

An area of about 67 ha (21%) has soils that are highly suitable (class S1) for growing sunflower crop. They have minor or no limitations for growing sunflower and are distributed mainly in the central part of the microwatershed. Moderately suitable (class S2) lands cover an area of about 57ha (18%). They have minor limitations of gravelliness and calcareousness and are distributed incentral and western part of the microwatershed. The marginally suitable (class S3) lands are found to occur ina very small area of about30 ha (9%) and occur in north eastern and northwestern parts of the microwatershed. They have moderate limitations of gravelliness, rooting depth and calcareousness. A maximum area of about 152 ha (47%) is not suitable for growing sunflower and occur in the central, southeastern and northwestern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.6 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 rained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.55.5-6.4	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	

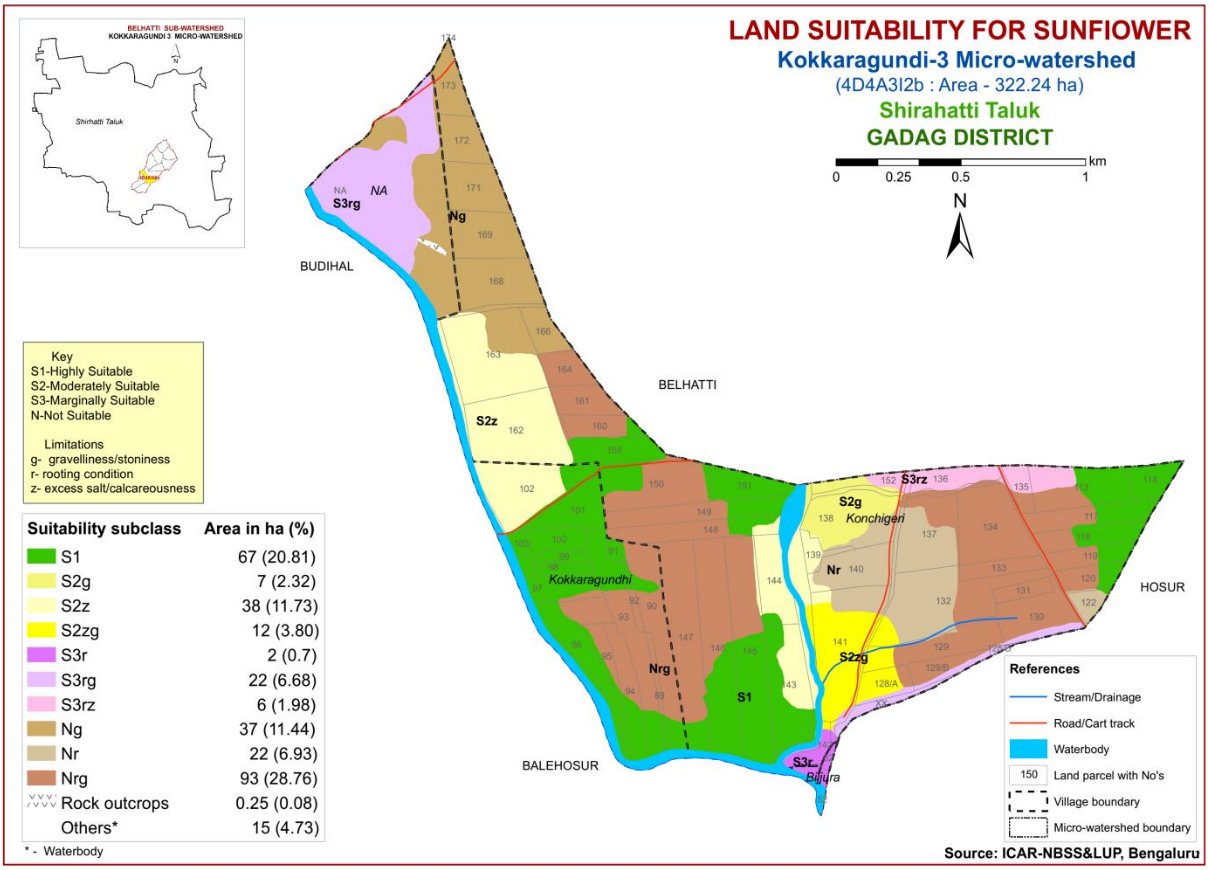


Fig. 7.5 Land Suitability map of Sunflower

7.6 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 6.6 lakh ha area in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.7) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cotton was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

Small area of about 50 ha (15%) in the microwatershed is highly suitable (class S1) for growing cotton. They have minor or no limitations for growing cotton and are distributed in the southeren and central parts of the microwatershed. An area of about 101 ha (31%) has soils that are moderately suitable (class S2) with minor limitations of gravelliness, calcareousness and rooting depth. They are distributed in central, northern, western and northwestern parts of the microwatershed. The marginally suitable (class S3) lands cover about 106 ha (33%) and occur in the central, northwestern and southeastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of 49ha (15%) is not suitable for growing cotton and mainly occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.7 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

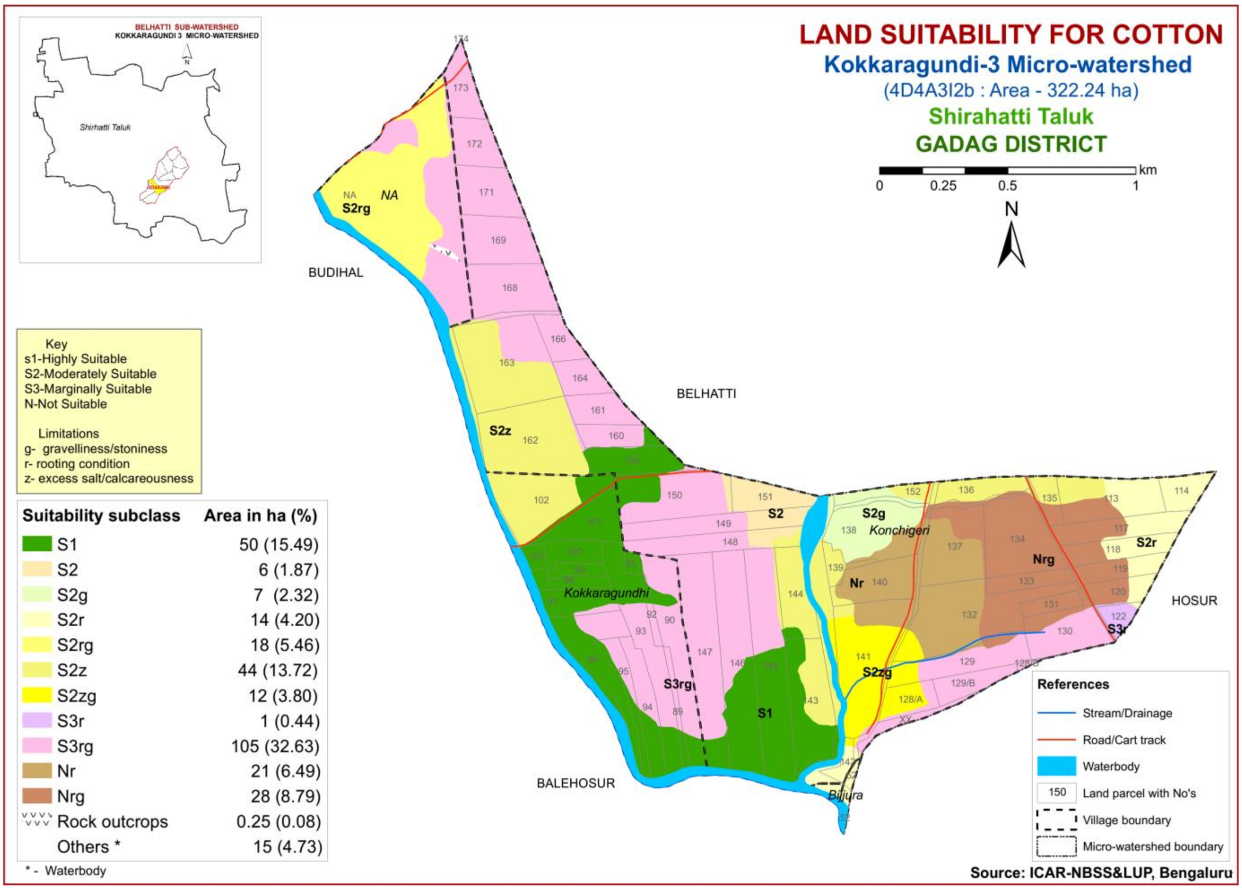


Fig. 7.6Land Suitability map of Cotton

7.7 Land Suitability for Banana (*Musa paradisiaca*)

Banana is one of the major fruit crop grown in an area of 1.02 lakh ha in Karnataka State. The crop requirements for growing banana (Table 7.8) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing banana was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.7.

There is no highly suitable (class S1) lands available for growing banana in the microwatershed. An area of about 125 ha (39%) is moderately suitable (class S2) for growing banana and are distributed in the southern, northern, eastern and western part of the microwatershed. They have minor limitations of calcareousness and texture. Marginally suitable (class S3) lands for growing banana occupy a small area of about 30 ha (9%) and are distributed in the northwestern, northeastern and southeastern parts of the microwatershed. They have minor limitations of rooting depth, calcareousness, texture and gravelliness. Major area of about152 ha (47%) is not suitable for growing banana in the microwatershed and occur in the central, northwestern and southeastern part of the microwatershed. They have very severe limitations of gravelliness, texture and rooting depth.

Table 7.8 Crop suitability criteria for Banana

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

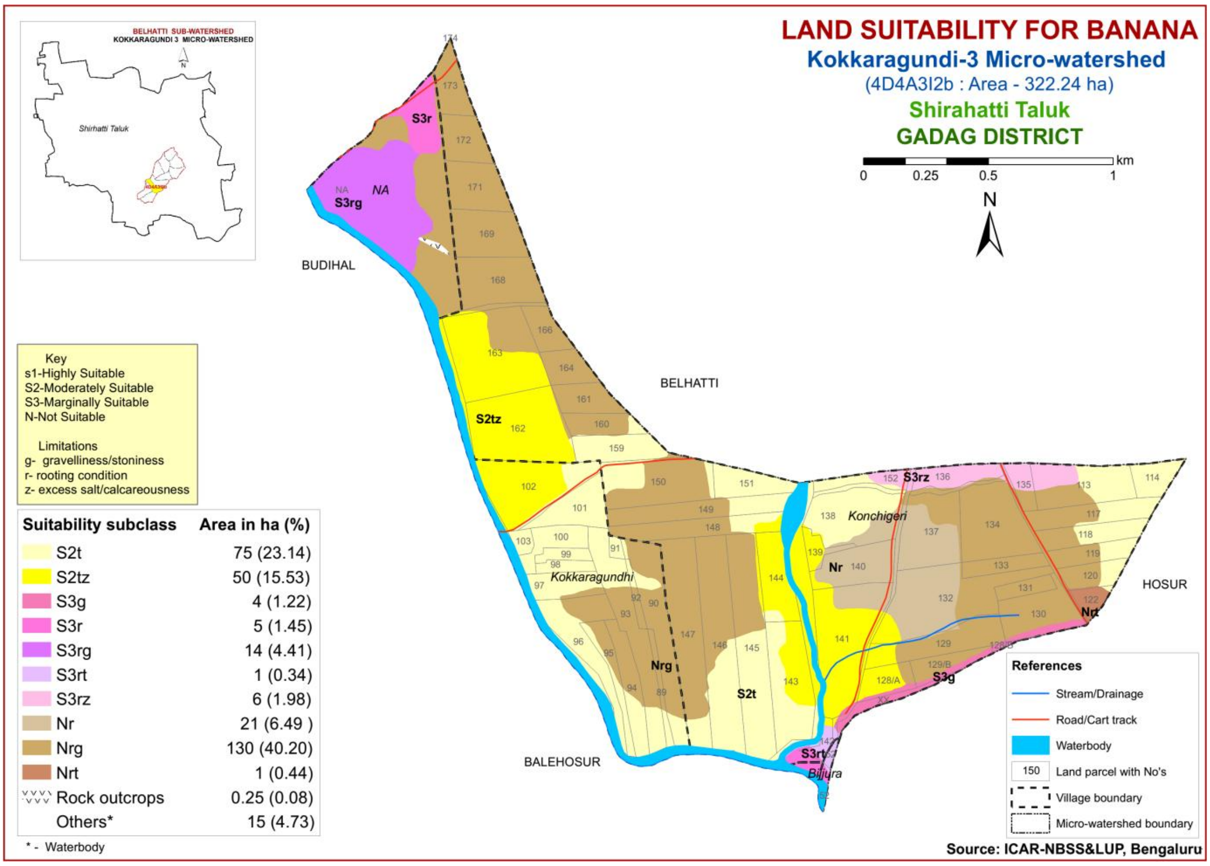


Fig. 7.7 Land Suitability map of Banana

7.8 Land Suitability for Pomegranate (*Punica granatum*)

Pomegranate is one of the commercially grown fruit crop in Karnataka in an area of 0.16 lakh ha mainly in Bijapur, Bagalkot, Koppal, Gadag and Chitradurga districts. The crop requirements for growing pomegranate (Table 7.9) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing pomegranate was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.8.

There are no highly suitable (class S1) lands available for growing pomegranate in the microwatershed. A major area of about 125ha (39%) is moderately suitable (class S2) for pomegranate and are distributed in southern, northern, eastern and western parts of the microwatershed. They have minor limitations of texture and calcareousness. Marginally suitable (class S3) lands for growing pomegranate occur in small area of about 30 ha (9%) and are distributed in the northwestern, northeastern and southeastern part of the microwatershed. They have moderate limitations of rooting depth, texture and gravelliness. An area of about 152 ha (47%) is not suitable for growing pomegranate and mainly occur in the central, northwestern and eastern part of the microwatershed. They have very severe limitations of gravelliness, texture and rooting depth.

Table 7.9 Crop suitability criteria for Pomegranate

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	30-34	35-38 25-29	39-40 15-24	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	class	Well drained	imperfectly drained		
Nutrient availability	Texture	Class	Sl, scl, l, cl	C, sic, sicl	Cl, s, ls	S, fragmental
Rooting conditions	pH	1:2.5	5.5-7.5	7.6-8.5	8.6-9.0	
	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	nil	15-35	35-60	>60
Soil toxicity	Salinity	dS/m	Nil	<9	>9	<50
	Sodicity	%	nil			
Erosion	Slope	%	<3	3-5	5-10	

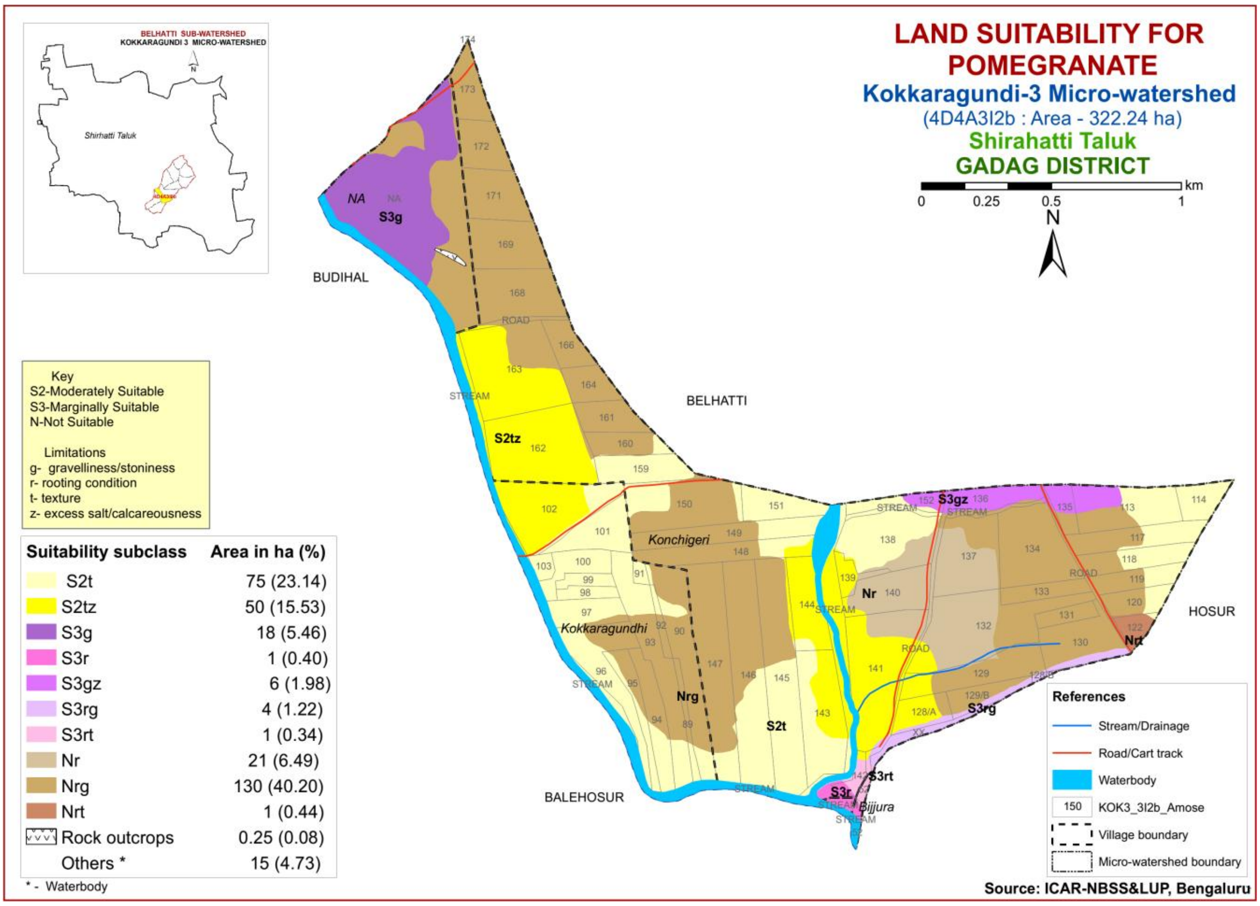


Fig. 7.8 Land Suitability map of Pomegranate

7.9 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in large area in almost all the districts of the State. The crop requirements (Table 7.10) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated (Fig. 7.9).

In Kokkaragundi-3 microwatershed, there are no highly (Class S1) and moderately (Class S2) suitable lands for growing mango. The marginally suitable (class S3) lands cover maximum area of about 124 ha (39%) and are distributed in northern, southern, western and eastern parts of the microwatershed. They have moderate limitations of texture, gravelliness and calcareousness. Major area of about 181 ha (57%) is not suitable for growing mango in the microwatershed and are distributed in the cental, northwestern and southeastern part of the microwatershed. They have very severe limitations of gravelliness, calcareousness and rooting depth.

Table 7.10 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	8.6-9.04.0-4.9	>9.0<4.0
	OC	%	High	medium	low	
	$CaCO_3$ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	%vol	Non-gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS/m	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

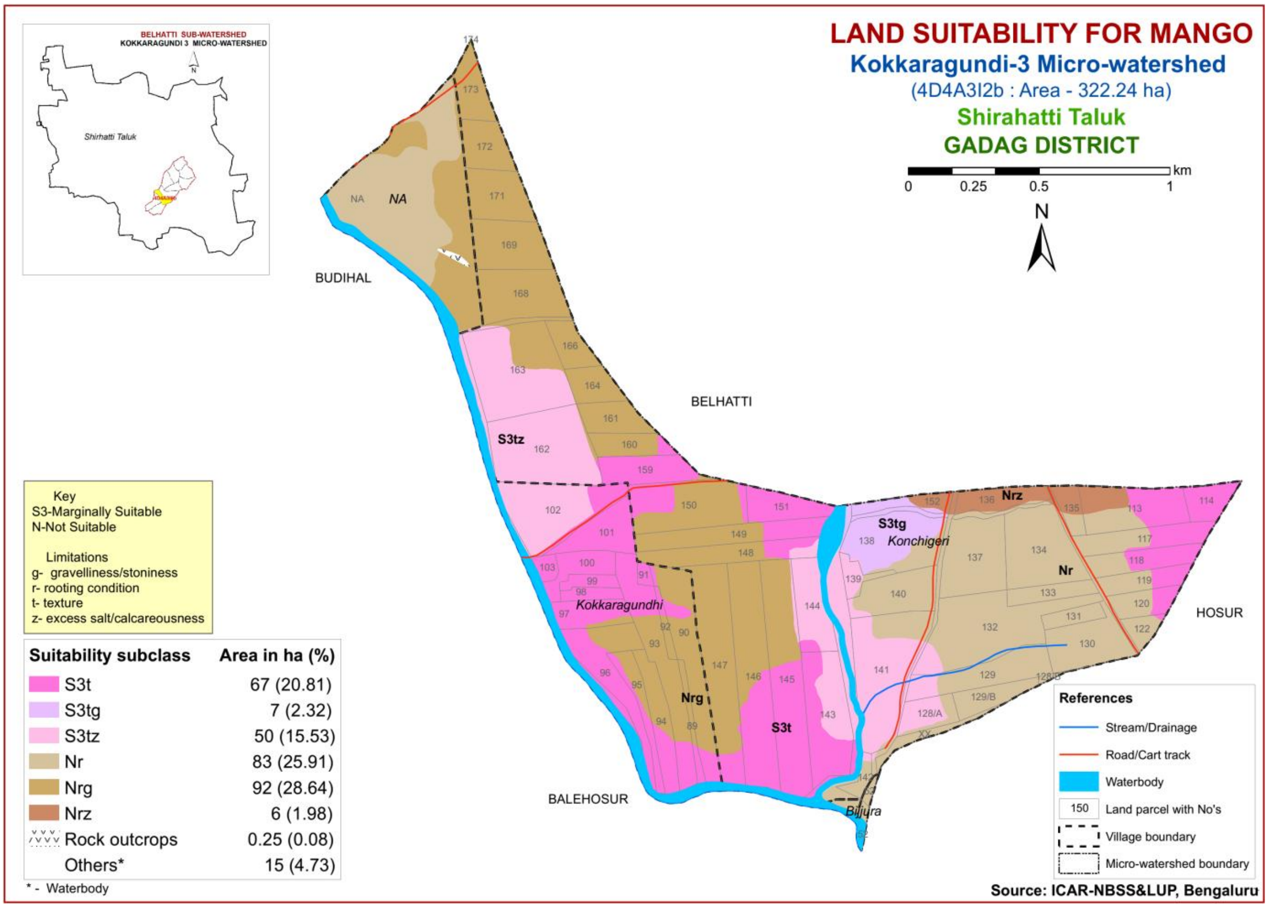


Fig. 7.9 Land Suitability map of Mango

7.10 Land suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 3.11 lakh ha in almost all the districts of the State. The crop requirements (Table 7.11) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated (Fig. 7.10).

There are no highly (Class S1) and moderately (Class S2) suitable lands available for growing sapota in the microwatershed. The marginally suitable (class S3) lands cover a maximum area of about 154 ha (41%) in the micowatershed and are distributed in all parts of the microwatershed. They have moderate limitations of gravellines, calcareousness, texture and rooting depth. Anarea of about 102 ha (31%) is not suitable for growing sapota and occurin the central, northwestern and southeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.11 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

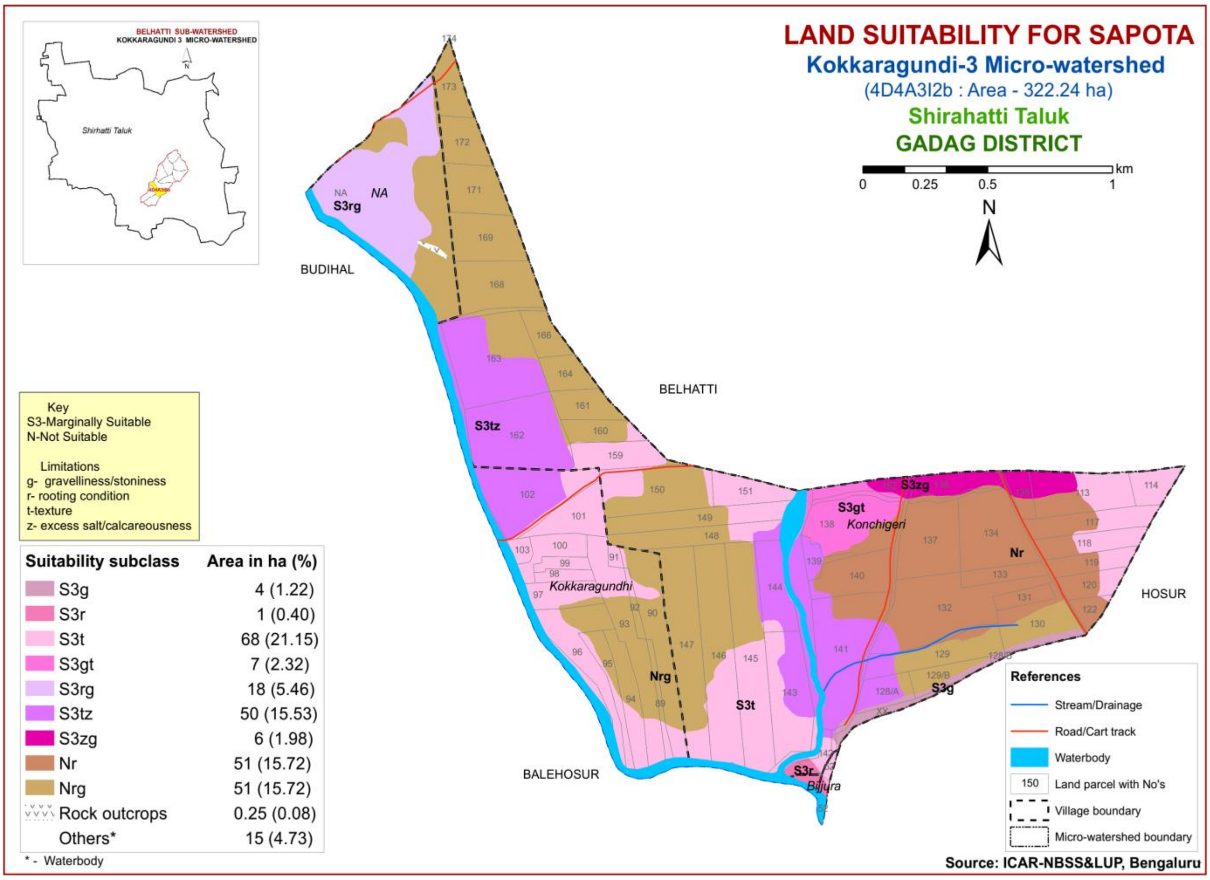


Fig. 7.10 Land Suitability map of Sapota

7.11 Land suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in an area of 0.64 lakh ha in almost all the districts of the State. The crop requirements (Table 7.12) for growing guava were matched with the soil-site characteristics (7.1) and a land suitability map for growing guava was generated (Fig. 7.11).

In Kokkaragundi-3 microwatershed, there are no highly (Class S1) and moderately (Class S2) suitable lands for growing guava. The marginally suitable (class S3) lands cover a maximum area of about 154 ha (48%) in the micowatershed and are distributed in all parts of the microwatershed. They have moderate limitations of gravelliness, calcareousness, texture and rooting depth. An area of about 152 ha (47%) is not suitable for growing sapota and occur in the central, northwestern and southeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.12 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

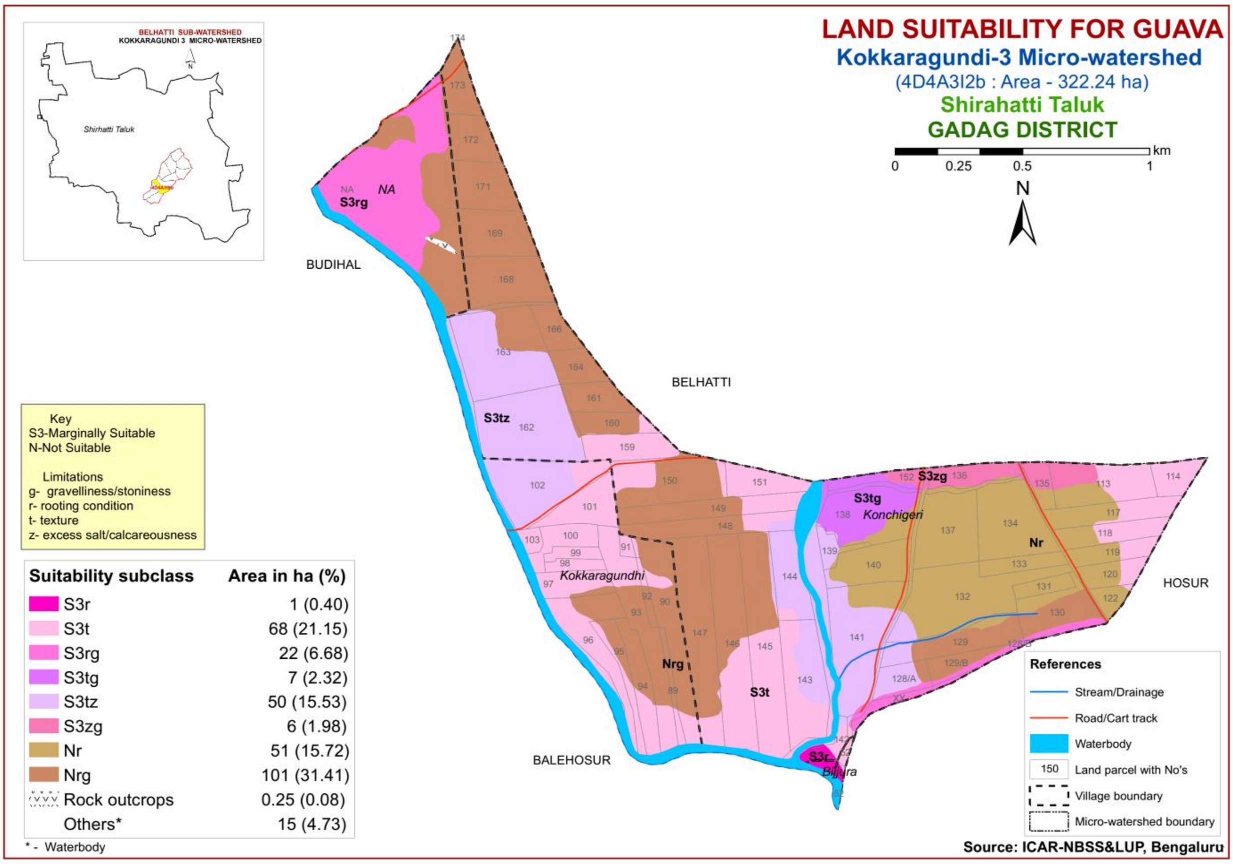


Fig. 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 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 (Fig. 7.12).

In Kokkaragundi-3 microwatershed, there is no highly (Class S1) lands for growing jackfruit. Small area of about 13 ha (4%) is moderately suitable (class S2) for growing jackfruit and are distributed in the northern part of the microwatershed. They have minor limitations of gravelliness and texture.The marginally suitable (class S3) lands cover a maximum area of about 141ha (44%) and occur in southern,western, eastern and northwestern parts of the microwatershed. They have moderate limitations of gravelliness, texture, rooting depth and calcareousness. An area of about 152 ha (47%) is not suitable for growing jackfruit andoccurin the central, northwestern and southeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

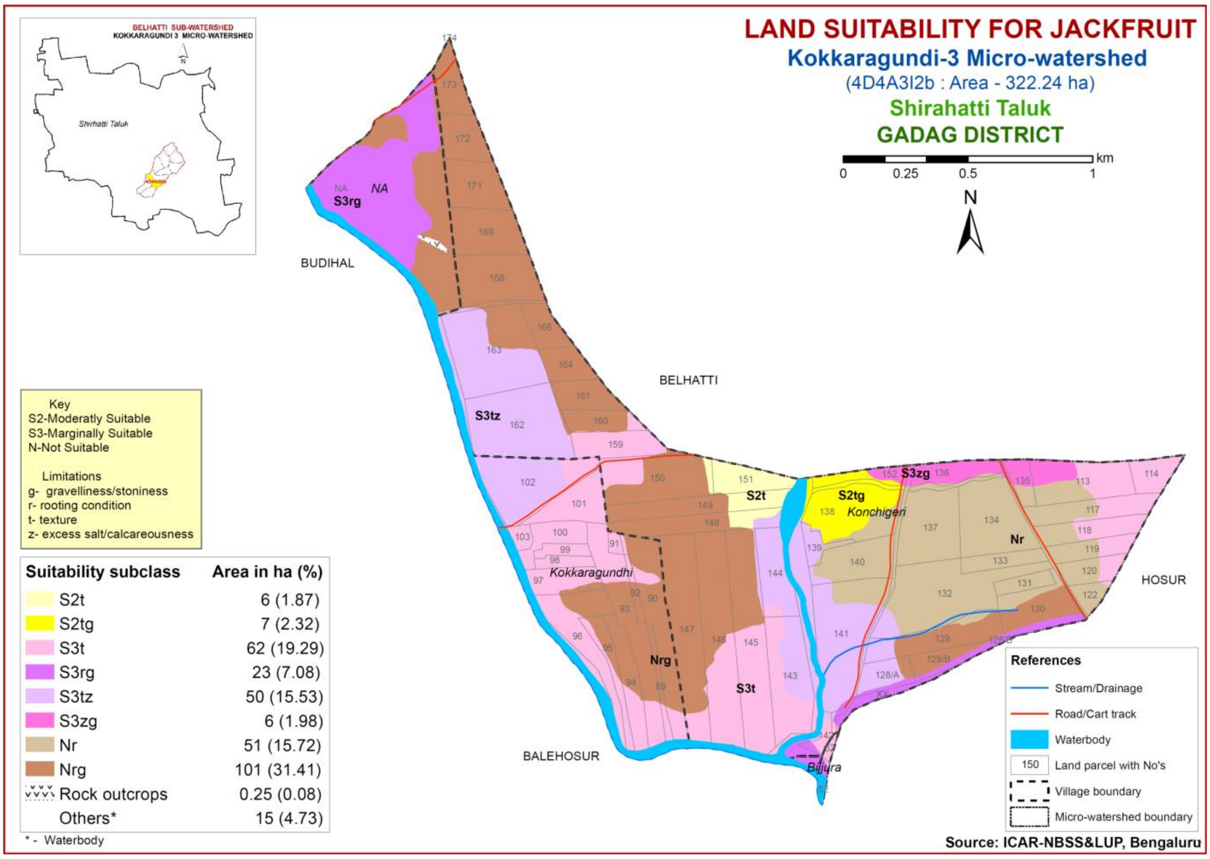


Fig. 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is an important fruit crop grown in almost all the districts of the State. The crop requirements for growing were matched with the soil-site characteristics and a land suitability map for growing jamun was generated (Fig. 7.13).

There is no highly (Class S1) suitable lands for growing jackfruit in the Kokkaragundi-3 microwatershed. An area of about 124 ha (37%) is moderately suitable (class S2) for growing jackfruit and are distributed in the southern, northern, western and eastern part of the microwatershed. They have minor limitations of gravelliness, texture and calcareousness. The marginally suitable (class S3) lands cover a small area of about 30 ha (9%) and occur in northwestern, northeastern and southeastern parts of the microwatershed. They have moderate limitations of gravelliness, rooting depth, texture and calcareousness. An area of about 152 ha (47%) is not suitable for growing jamun and occur in the northern, central, southeastern and northwestern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

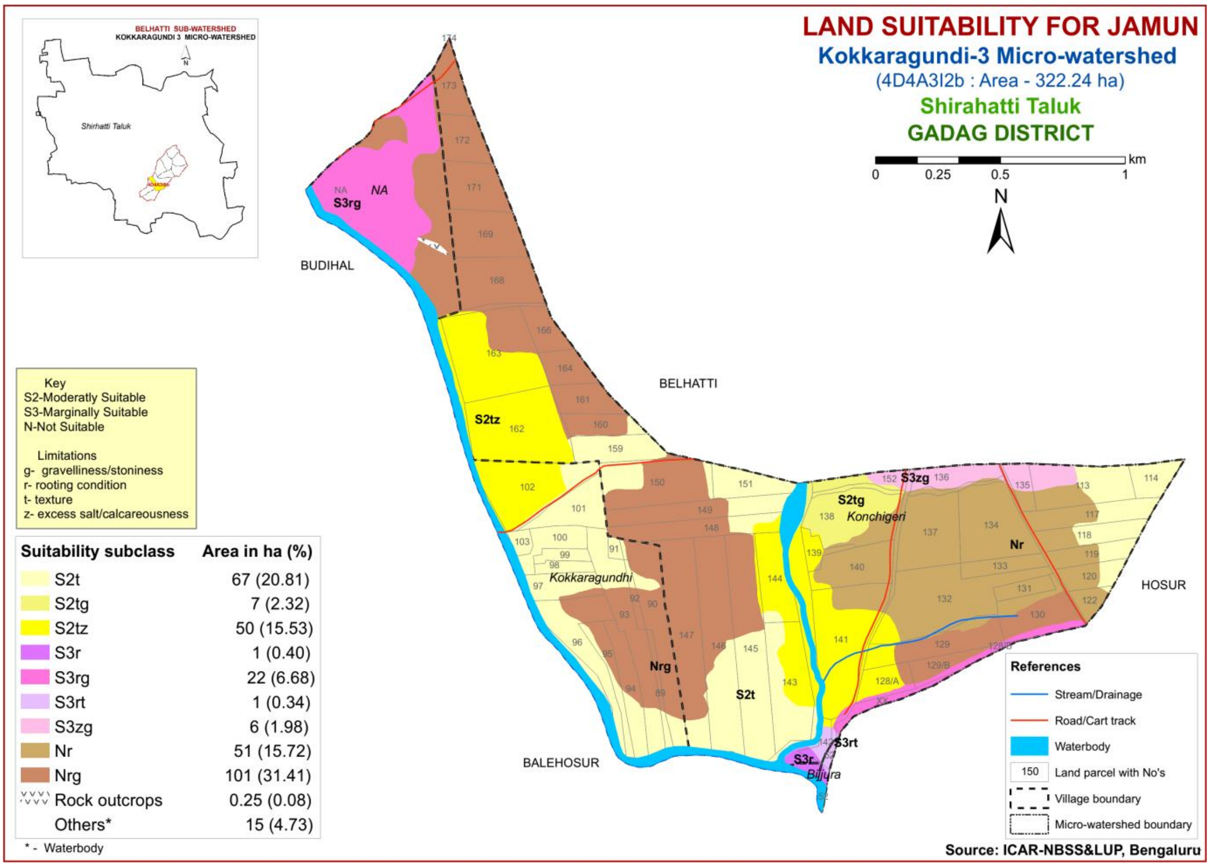


Fig. 7.13Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the important fruit crop grown in almost all the districts of the State. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated (Fig. 7.14).

An area of about56 ha (17%) in the microwatershed has soils that are highly suitable (class S1) for growing musambi crop. They have minor or no limitations for growing musambi and are distributed in the northern, southern and western part of the microwatershed. An area of about 68 ha (21%) has soils that are moderately suitable (class

S2) with minor limitations of rooting depth, gravelliness and calcareousness. They are distributed in the southwestern, central and eastern part of the microwatershed. The marginally suitable (class S3) lands cover a small area of about 30 ha (9%) and occur in the northwestern and northeastern part of the microwatershed. They have moderate limitations of gravelliness, calcareousness and rooting depth. A majorarea of about 152 ha (47%) is not suitable for growing musambi and are distributed in the central, northwestern and northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

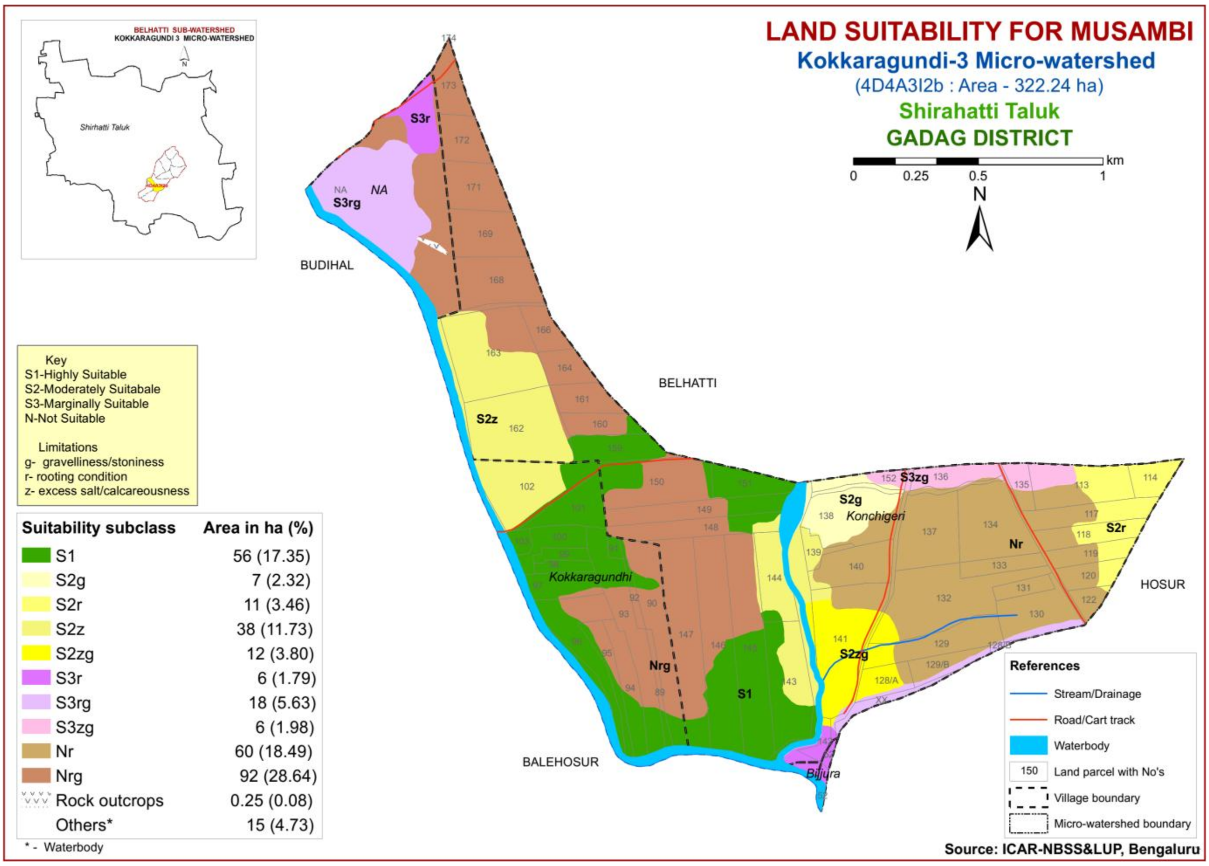


Fig. 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 0.11 lakh ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.13) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated (Fig. 7.15).

An area of about 56ha (17%) in the microwatershed has soils that are highly suitable (class S1) for growing lime. They have minor or no limitations for growing lime and are distributed in the southern, northern and southwestern part of the microwatershed. An area of about 61 ha (19%) has soils that are moderately suitable (class S2) with minor limitations of rooting depth, gravelliness and calcareousness and are distributed in the western, central and eastern part of the microwatershed. The marginally suitable (class S3) lands cover a small area of about 37 ha (12%) and are occur in the northwestern and northeastern part of the microwatershed They have moderate limitations of gravelliness, calcareousness and rooting depth. A major area of about 152 ha (47%) is not suitable for growing lime and occur in the central, northwestern and eastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.13 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	Temperature in growing season	^{0}C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

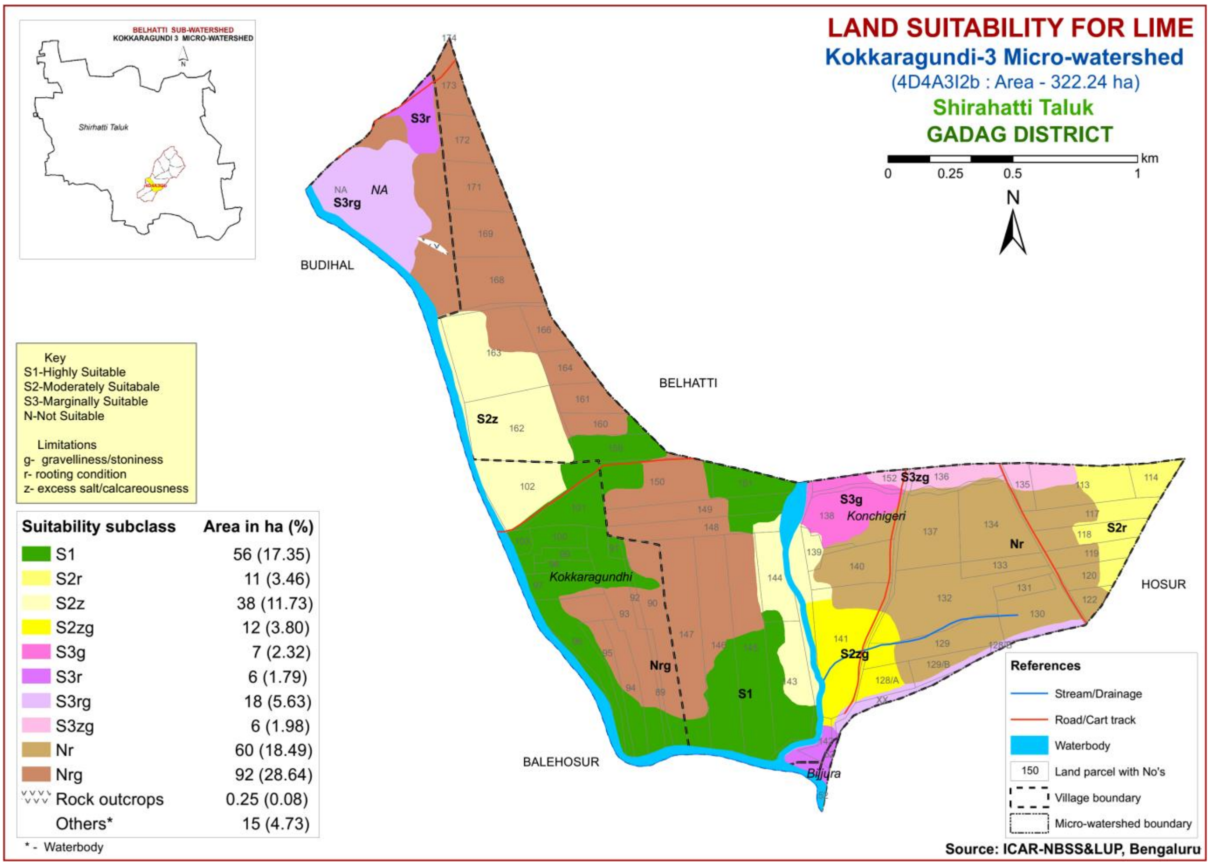


Fig. 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important fruit crop grown in an area of 1.24 lakh ha in almost all the districts of the State. The crop requirements for growing cashew were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cashew was generated (Fig. 7.16).

In Kokkaragundi-3 microwatershed, there are no highly (Class S1) and moderately (Class S2) suitable lands for growing cashew. A very small area of about 29 ha (9%) in the microwatershed has soils that are marginally suitable (class S3) with moderate limitations of rooting depth, gravelliness and calcareousness and distributed in the northwestern and northeatern part of the microwatershed. A major area of about 277 ha (86%) is not suitable for growing cashew and occur in all part of the microwatershed. They have very severe limitations of gravelliness, texture, calcareousness and rooting depth.

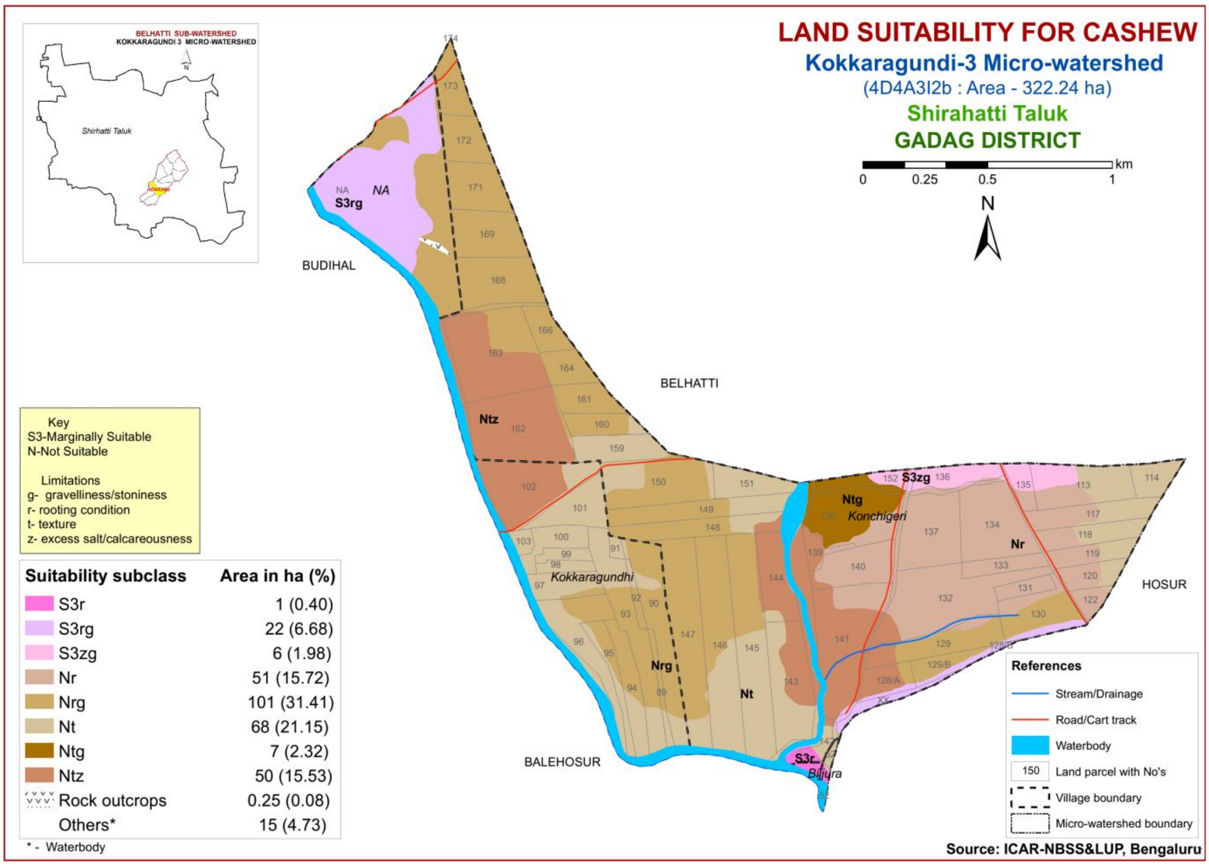


Fig. 7.16 Land Suitability map of Cashew

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

Custard apple is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing custard apple (were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple was generated (Fig. 7.17).

An area of about 58 ha (17%) in the microwatershed has soils that are highly suitable (class S1) for growing custard apple. They have minor or no limitations for growing custard apple and are distributed in the northern, southern and western part of the microwatershed. An area of about74 ha (24%) has soils that are moderately suitable (class S2) for growing custard apple with minor limitations of rooting depth, gravelliness and calcareousness and are distributed in southern and eastern parts of the microwatershed. The marginally suitable (class S3) lands cover about 89ha (28%) and occur in the central northwestern and southeastern part of the microwatershed. They have moderate limitations of gravelliness, calcareousness and rooting depth. About 86 ha (26%) area is not suitable for growing cashew and occur in northwestern and eastern part of the microwatershed. They have very severe limitations of rooting depth.

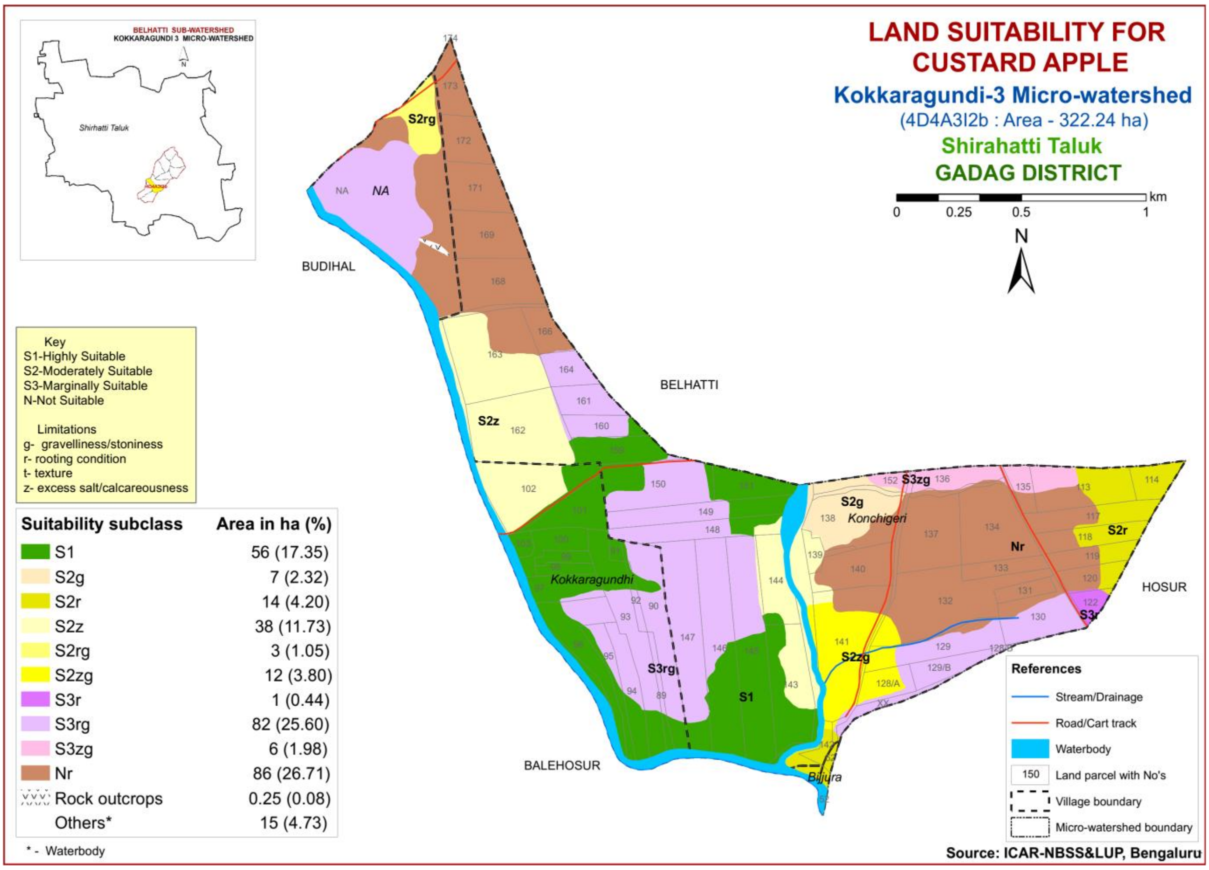


Fig. 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the fruit crop grown in almost all the districts of the State. The crop requirements for growing amla were matched with the soil-site characteristics and a land suitability map for growing amla was generated (Fig. 7.18).

An area of about 56 ha (17%) has soils that are highly suitable (class S1) for growing amla. They have minor or no limitations for growing amla and are distributed mainly in the southern, northern and central part of the microwatershed. An area of about 71 ha (22%) has soils that are moderately suitable (class S2) with minor limitations of texture and calcareousness and are distributed in central, northern, western and eastern parts of the microwatershed. The marginally suitable (class S3) lands cover about 93 ha (29%) area in the microwatershed and occur in central, northwestern and southeastern part of the microwatershed. They have moderate limitations of gravelliness, calcareousness and rooting depth. About 86 ha (26%) area is not suitable for growing cashew and occur in northwestern and eastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

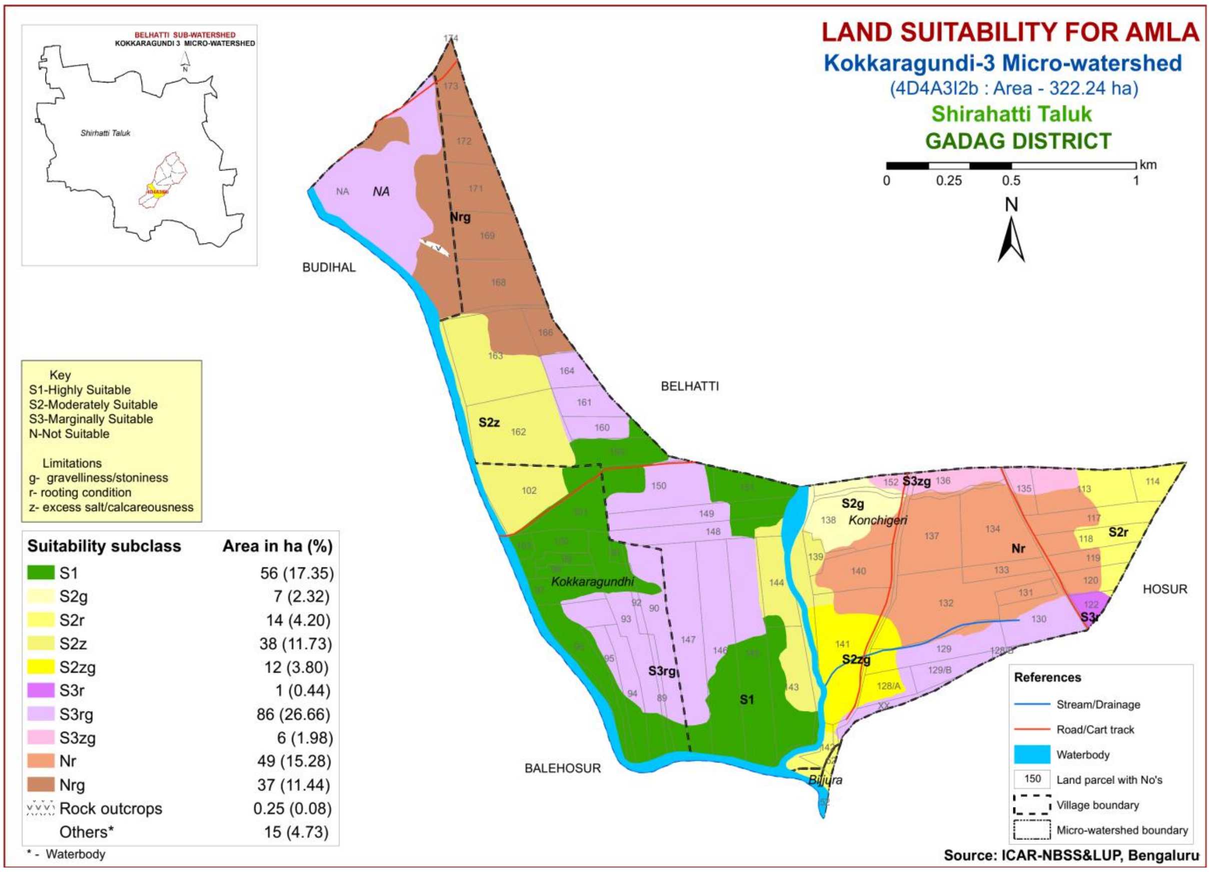


Fig. 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in almost 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 and geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.19.

There is no highly (Class S1) suitable lands for growing tamarind in Kokkaragundi-3 microwatershed. Area of about 113 ha (35%) has soils that are moderately suitable (class S2) with minor limitations of gravelliness and texture and are distributed in the western, southern and northern part of the microwatershed. The marginally suitable (class S3) lands cover a very small area of about 11 ha (3%) and occur in the eastern part of the microwatershed. They have moderate limitations of texture. Major area of about181 ha (56%) is not suitable for growing tamarind and occur in the northern, eastern, central, northwestern and southeastern part of the microwatershed. They have very severe limitations of rooting depth, calcareousness and gravelliness.

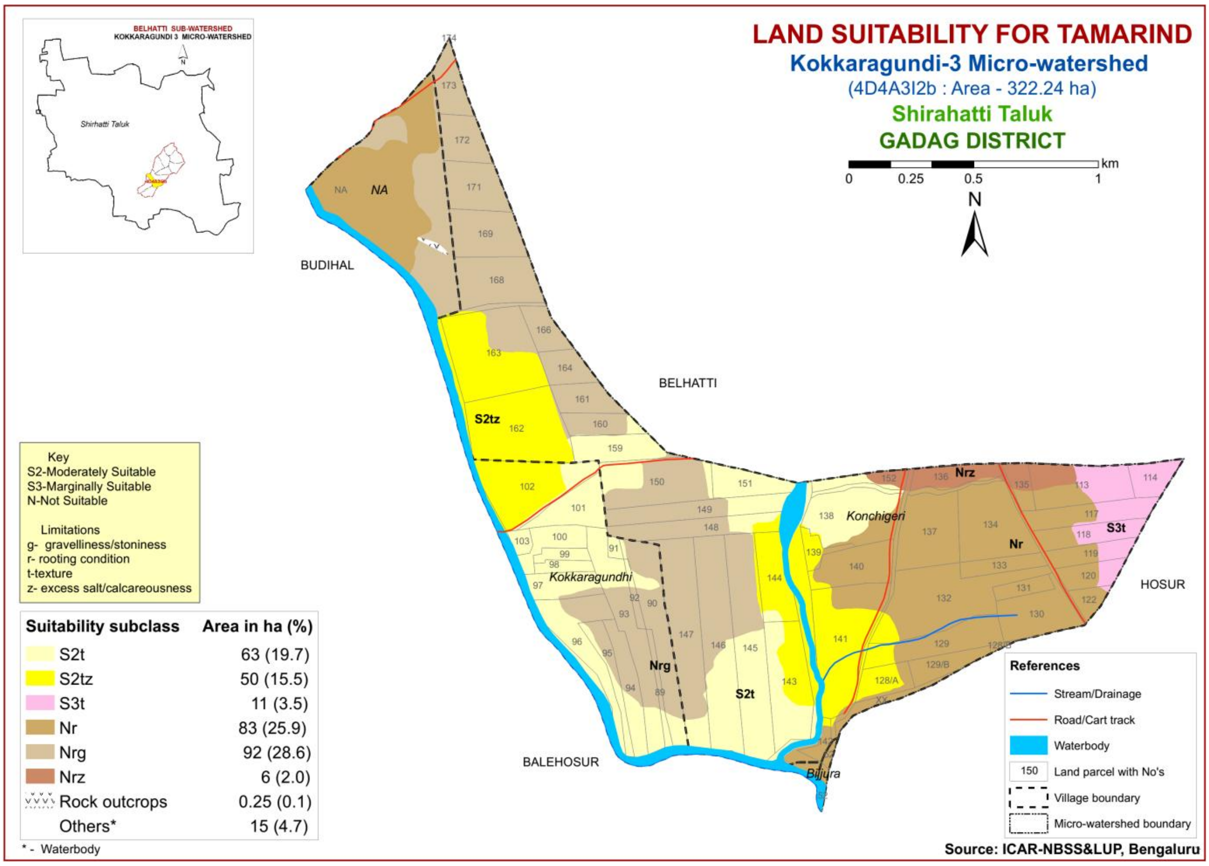


Fig. 7.19 Land Suitability map of Tamarind

7.20 Land Suitability for Marigold (*Tagetes erecta*)

Marigold is the most important flower crop grown in an area of 1858 ha in almost all the districts of the state. The crop requirements for growing marigold were matched with the soil-site characteristics and a land suitability map for growing marigold was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.20.

There is no highly (Class S1) suitable lands for growing marigold in Kokkaragundi-3 microwatershed. Major area of about150 ha (47%) has soils that are moderately suitable (class S2) with minor limitations of gravelliness, rooting depth, texture and calcareousness and are distributed in all parts of the microwatershed. The marginally suitable (class S3) lands cover anarea of about 106 ha (33%) area and occur in the central, northwestern and southeastern part of the microwatershed. They have moderate limitations of calcareousness, texture, rooting depth and gravelliness. A very small area of about 49 ha (15%) is not suitable for growing marigold and occur in the eastern part of the microwatershed. They have very severe limitation of gravelliness and rooting depth.

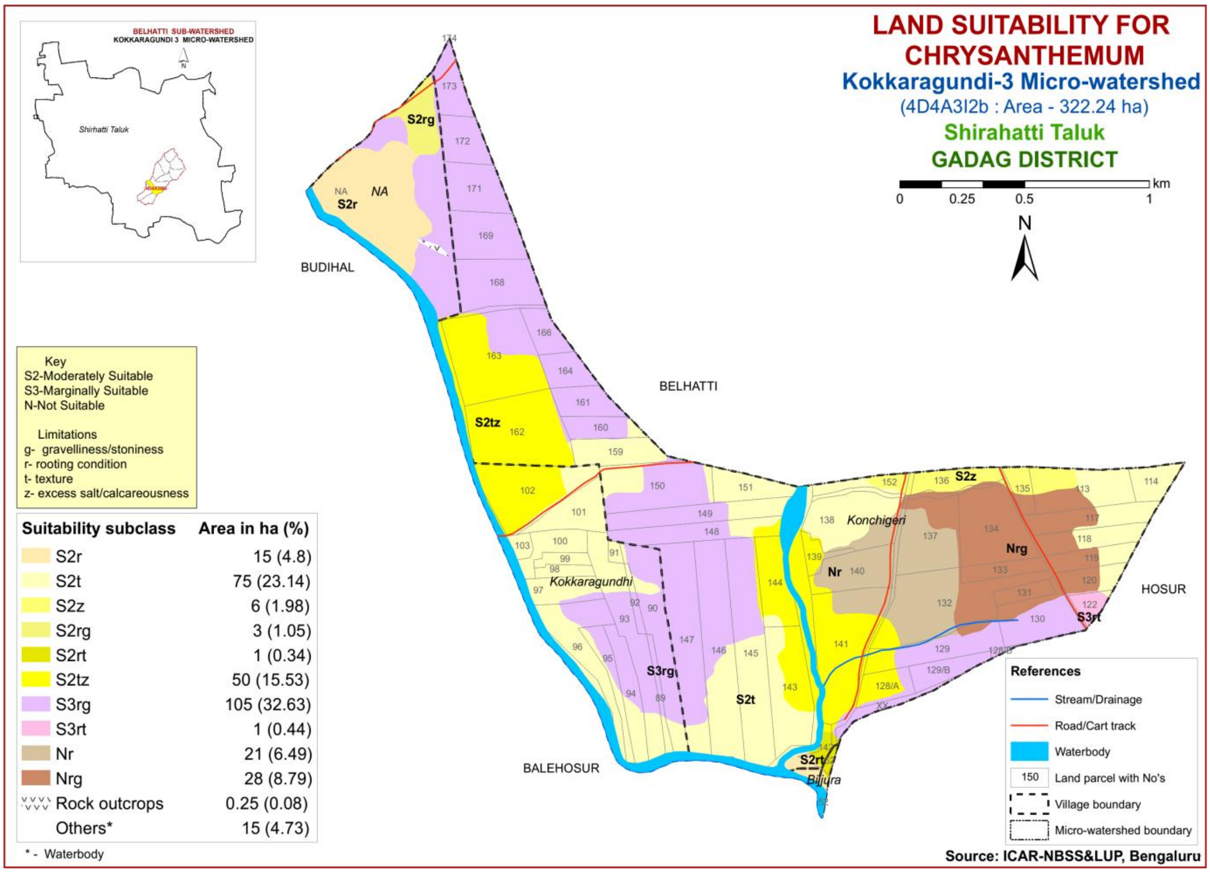


Fig. 7.20 Land Suitability map of Marigold

7.21 Land Suitability for Chrysanthemum (*Chrysanthemum indicum*)

Chrysanthemum is the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements for growing chrysanthemum were matched with the soil-site characteristics and a land suitability map for growing chrysanthemum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.21.

No highly (Class S1) suitable lands are available for growing chrysanthemum in Kokkaragundi-3 microwatershed. Major area of about 150 ha (47%) has soils that are moderately suitable (class S2) with minor limitations of gravelliness, rooing depth, texture and calcareousness and are distributed in all parts of the microwatershed. The marginally suitable (class S3) lands cover an area of about106 ha (33%) area and occur in the central, northwestern and southeastern part of the microwatershed. They have moderate limitations of rooting depth, texture, gravelliness and calcareousness. Avery small area of about 49 ha (15%) is not suitable for growing chrysanthemum and occur in the eastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

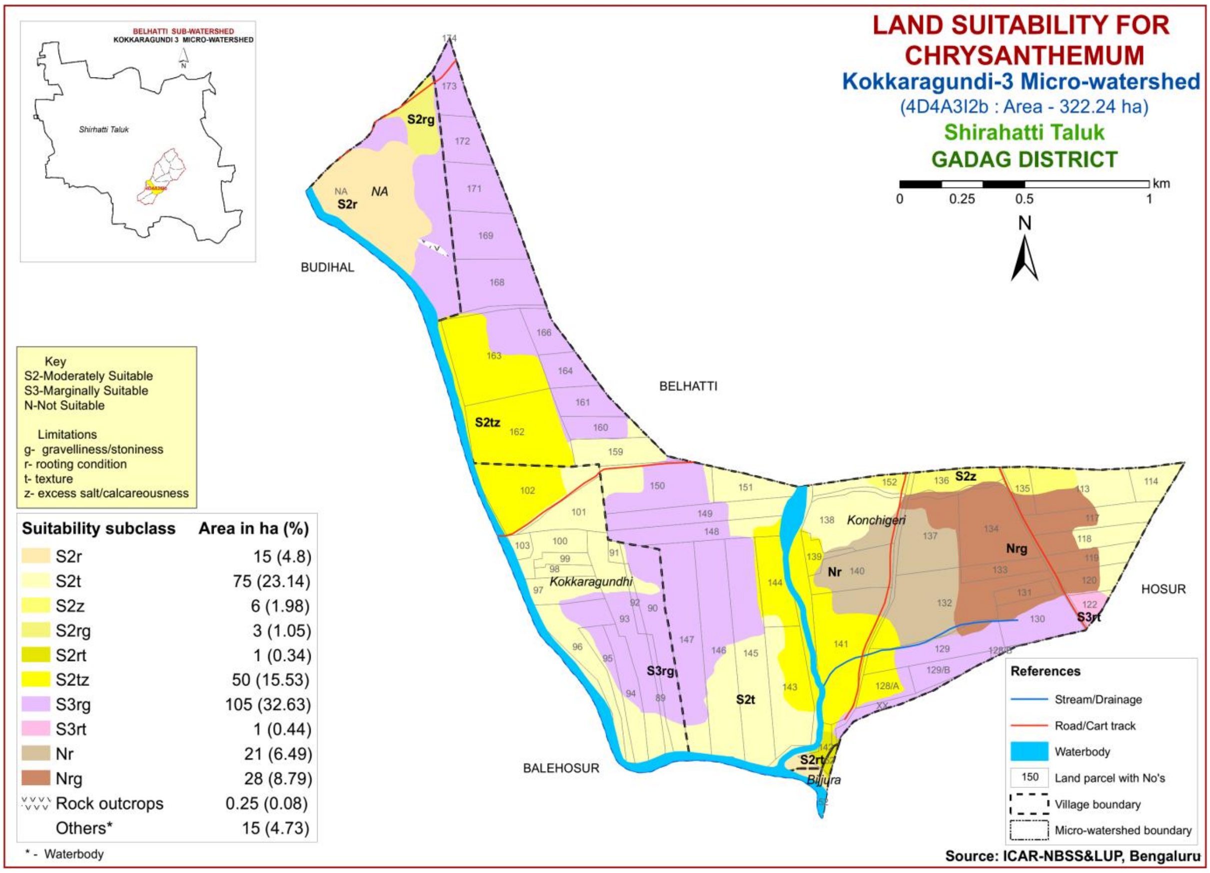


Fig. 7.21 Land Suitability map of Chrysanthemum

7.22 Land Management Units (LMUs)

The 26 soil map units identified in Kokkaragundi-3 microwatershed have been regrouped into 6Land Management Units (LMU's) for the purpose of preparing Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Units map (Fig.7.22) has been prepared. These Land Management Units are expected to behave similarly for a given level of management.

The map units that have been grouped into 6 land management units along with brief description of soil and site characteristics are given below.

LMUs	Soil map units	Soil and site characteristics
1	NGTmB1g1, NGTmB1g2	Very deep (>150 cm), black calcareous clayey soils with slopes of 1-3%, slight erosion and gravelly (15-60%)
2	SNHiB2g2, SNHmB1g1, MPTiB1g1, MPTmB2g1, KPRmB1g1	Deep (100-150cm), black clayey soils with slopes of 1-3%, slight to moderate erosion and gravelly to very gravelly (15-60%)
3	RNKiB1g2, RNKiB2g2, ATTiB2g1, JLGmB1g1	Moderately shallow to moderately deep (50-100 cm), black sandy clay to clay soils with slopes of 1-3%, slight to moderate erosion and gravelly to very gravelly (15-60%)

4	LKRiB1g1, TDHiB1g2, KKThB2g2R1St1, KKTmB1,	Moderately shallow (50-75 cm), gravelly red sandy clay to clay loam soils with slopes of 1-3%, slight to moderate erosion, gravelly to very gravelly (15-60%), few to fairly rocky (<2-10%) and strong stoniness (0.01-0.1%)
5	HRVcB1g1, HRVcB2g2, HRVhB1g1, HRVhB1g2 , NBPhB1g1, NBPiB1g1, NBPmA1, AKTiB1g1, BLDhB2g2	Shallow (25-50 cm), gravelly red clay loam to sandy clay loam soils with slopes of 0-3%, slight to moderate erosion and gravelly to very gravelly (15-60%)
6	KLKhB2g2, KLKiB1g2	Very shallow (<25 cm), gravelly red loamy soils with slopes of 1-3%, slight to moderate erosion and very gravelly (>35%)

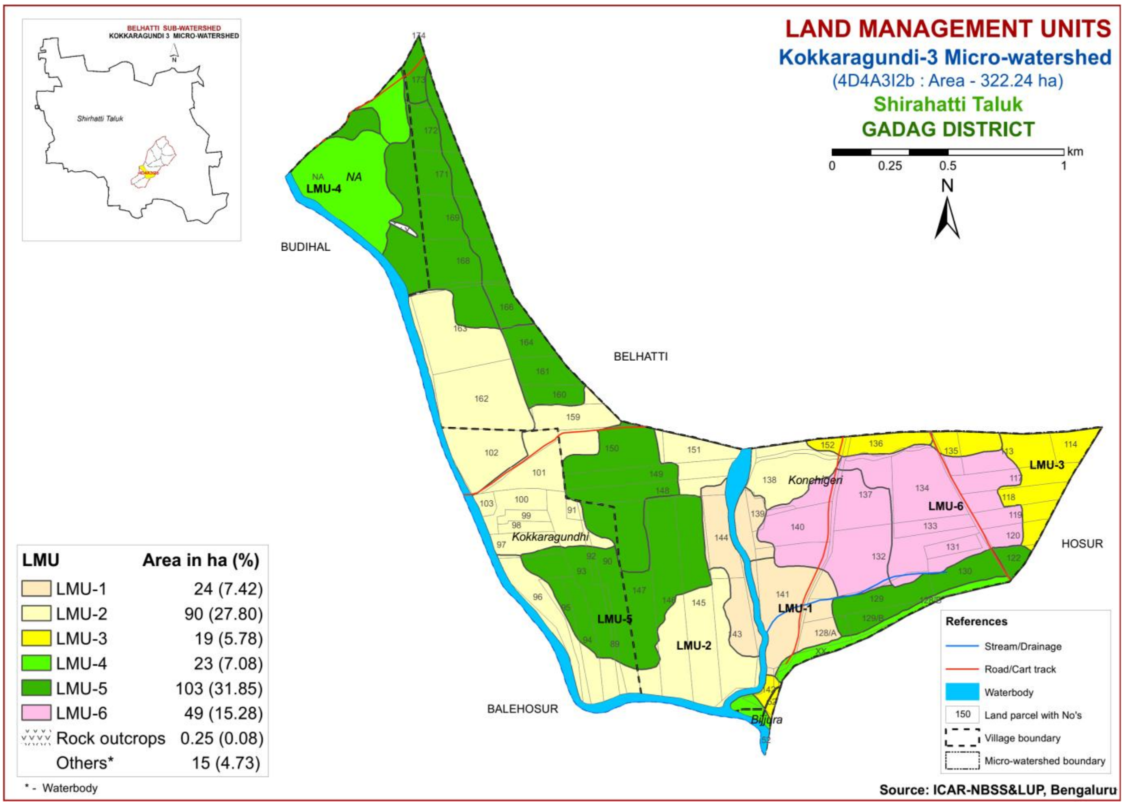


Fig. 7.22 Land Management Units Map- Kokkaragundi-3 Microwatershed

7.23 Proposed Crop Plan for Kokkaragundi-3 microwatershed

After assessing the land suitability for the 21 crops, the proposed crop plan has been prepared for the 6 identified LMUs by considering only the highly (class S1) and moderately (class S2) suitable lands for each of the 21 crops. The resultant proposed crop plan is presented below in Table 7.14

Table 7.14 Proposed Crop Plan for Kokkaragundi-3Microwatershed

LMU No	Mapping Units	Survey Number	Field Crops/Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Suitable Interventions
LMU1	25, 26 (>150 cm)	Konchigeri: 128/A,139,141, 144	Redgram, Sorghum, Bajra, Sunflower, Cotton, Safflower, Bengal gram **Multiple/crop rotation:** Redgram+Fodder, Sorghum, Pulses-Sorghum	**Vegetables**: Green Chillies, Bhendi, Drumstick, Onion **Flower crops:** Marigold, Gaillardia, Aster **Fruit crops:** Banana, lime, pomegranate	**Vegetables**: Chillies, Bhendi, Crucifers **Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LMU 2	9, 10, 22, 23, 24 (100-150 cm)	Konchigeri: 138,143,145,151, 152,159,162,163 Kokkaragundi: 91,95,96,97,98, 99,100,101,102, 103	Sorghum, Redgram, Cotton, Sunflower, Safflower, Linseed, Coriander, Bajra, Bengal gram **Multiple Crop rotation:** Redgram+Fodder jowar Pulses+Sorghum	**Vegetables:** Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	**Vegetables:** Chillies, Bhendi, Crucifers **Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	Drip irrigation, Mulching, suitable conservation practises

LMU 3	20, 21, 7, 8 (75-100 cm)	Konchigeri: 113,114,118,135, 136,142 Bijjura: 52	Sorghum, Bajra, Sunflower, Cotton, Safflower **Multiple/Crop rotation:** Redgram+Maize, Redgram+Fodder jowar, Pulses-Sorghum	**Vegetables:** Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	**Vegetables:** Chillies, Bhendi, Crucifers **Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	Drip irrigation, Mulching, suitable conservation practices
LMU 4	5, 6, 18, 19 (50-75 cm)	Konchigeri: 128/B	Ragi, Bajra, Horsegram, Groundnut	Bear, Custurd Apple **Vegetables:** Cluster Bean, Ridge Gouard, Ash Gouard	Fig, Aonla, Pomelo	Drip irrigation, Mulching, suitable conservation practices
LMU 5	1, 2,3, 4, 13, 14, 15, 16, 17 (25-50 cm)	Konchigeri: 122,129,129/B, 130,146,147,148, 149,150,160,161, 164,166,168,169, 171,172,173,174 Kokkaragundi: 89,90,92,93,94	Groundnut, Horsegram, Greengram **Silviculture:** Simaruba, *Acaciaauriculiformis*, Glyricidia, Subabul, Agave, Cassia sp.	**Vegetables:** Chillies, Tomato	Fig, Aonla, Pomelo	-do-
LMU 6	11, 12 (<25 cm)	Konchigeri: 117,119,120,131, 132,133,134,137, 140	Anjan Grass, Marvel Grass, *Styloxantheshamata*	-	-	-

Chapter 8

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 unfavorable conditions occur

Characteristics of Kokkaragundi-3 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of NBP (55 ha), MPT (50 ha), KLK (49 ha), HRV (37 ha), KPR (26 ha), NGT (24 ha), LKR (14 ha), BGP (13 ha), JLG (11 ha), BLD (9 ha), RNK (6 ha), KKT (5 ha),TDH (3 ha), AKT (1 ha) and ATT (1 ha).
- As per land capability classification, nearly 95 per cent area falls under arable land category (Class II, III and IV). The major limitations identified in the arable lands were soil and erosion.

- On the basis of soil reaction, about 53 ha (16%) area is moderately alkaline (pH 7.8-8.4), about 8 ha (2%) is under slightly alkaline (pH 7.3-7.8). Maximum area of about 138 ha (43%) is under strongly alkaline (pH 8.4-9.0) and by an area of about 66 ha (21%) is under very strongly alkaline (pH >9.0).A small area of about 42 ha (13%) is under neutral (pH 6.5-7.3).

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 (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of $ZnSO_4$ – 12.5 kg/ha (once in three years).
5. Application of Boron – 5kg/ha (once in three years).

Neutral soils

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

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

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total 322 ha area in the microwatershed, major area of 210 ha is suffering from moderate and severe erosion. These areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Disseminate information and communicate benefits.

Any large scale implementation of soil health management requires that supporting information is made available widely, particularly through channels familiar to farmers and extension workers. Given the very high priority attached to soil health especially by the

Central Government on issuing Soil-Health Cards to all the farmers, media outlets like regional, state and national newspapers, Radio and Dooradarshan programs in local languages but also modern information and communication technologies such as cellular phones and the Internet, which can be much more effective in reaching younger farmers.

Inputs for Net Planning and Interventions needed

Net planning in IWMP is focusing on preparation of Soil and Water Conservation Plans for each plot or farm.

1. Productivity enhancement measures/ interventions for existing crops/livestock/other farm enterprises.
2. Diversification of farming mainly with perennial horticultural crops and livestock.
3. Improving livelihood opportunities and income generating activities.

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

- ❖ **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops, either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.
- ❖ **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.
- ❖ **Gravelliness:** More gravel content is favorable for run-off harvesting but poor in soil moisture storage and nutrient availability. It is a significant parameter that decides the kind of crop to be raised.
- ❖ **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Kokkaragundi-3 microwatershed.
- ❖ **Organic Carbon:** The OC content is medium (0.5-0.75%) in about 153 ha (47%) area and it is low (<0.5%) in 154 ha (48%) 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.

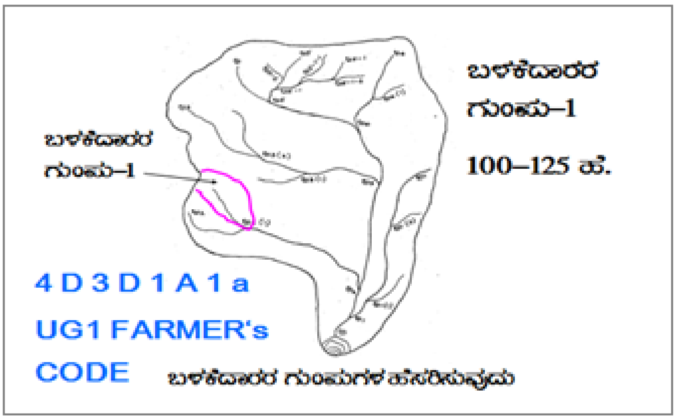
- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 65 ha area where OC is less than 0.5-0.75%. For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.
- **Available Phosphorus**: In 243 ha (75%), the available phosphorus is low and only64 ha (20%) area it is medium in available phosphorus, Hence for all the crops, 25% additional P-needs to be applied and it is high (>57 kg/ha) in 2 ha area.
- **Available Potassium:** Available potassium is medium in 259 ha (80%) area of the microwatershed and it is low in 30 ha (9%). Hence, in all these plots, for all crops, an additional 25 % potassium may be applied.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 125 ha (39%) area of the microwatershed and medium in 123 ha (38%).These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- **Available iron:** It is sufficient in an area of 250 ha (78%) in the microwatershed. It is deficient in the rest of 57 ha (18 %) area in the microwatershed.To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years.
- **Available Zinc:** It is deficient in entire area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied.
- **Soil alkalinity:** The microwatershed has 265 ha area has soils that are slightly tovery strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, 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.

Chapter 9

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Kokkaragundi-3 Microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were



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

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

Steps for Survey and Preparation of Treatment Plan

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

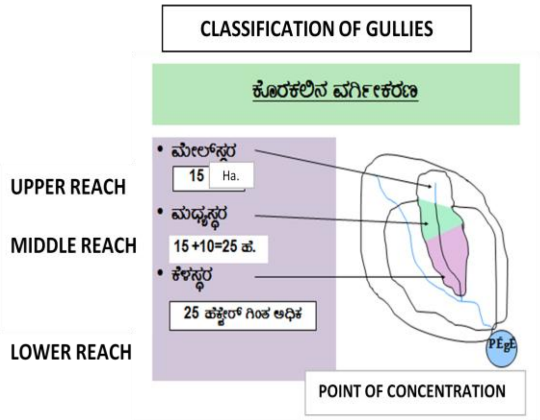
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

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

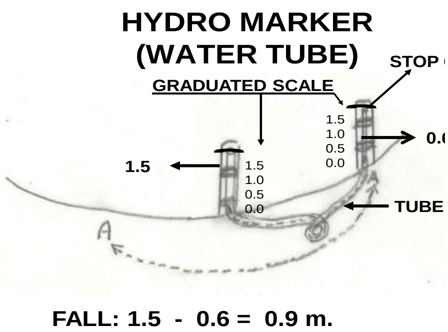
9.1.1 Arable Land Treatment

A. BUNDING

<table>
<tr><td colspan="2">Steps for Survey and Preparation of Treatment Plan</td><td rowspan="6">USER GROUP-1

</td></tr>
<tr><td colspan="2">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</td></tr>
<tr><td>Small gullies</td><td>(up to 5 ha catchment)</td></tr>
<tr><td>Medium gullies</td><td>(5-15 ha catchment)</td></tr>
<tr><td>Ravines</td><td>(15-25 ha catchment) and</td></tr>
<tr><td>Halla/Nala</td><td>(more than 25ha catchment)</td></tr>
</table>

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….) the intervals have to be decided.

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

Section of the Bund

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

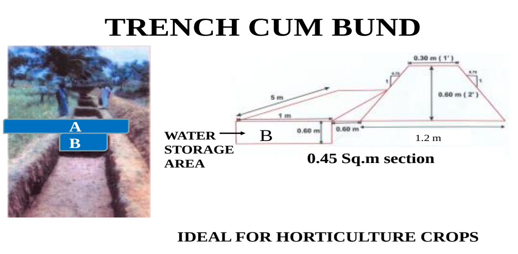
Recommended Bund Section

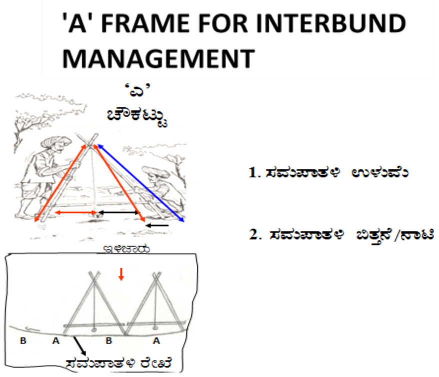
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soil	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3	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





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

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

B. Waterways

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

C. Farm Ponds

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

D. Diversion channel

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

9.1.2 Non-Arable Land Treatment

Depending on the gravelliness and crops preferred by the farmers, the concerned authorities can decide appropriate treatment plan. The recommended treatments may be Contour Trench, Staggered Trench, Crescent Bund, Boulder Bund or Pebble Bunds 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 drainge lines (gullies/ nalas/ hallas) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.
b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.
c) Considering the Catchment, Nala bed and bank conditions, suitable structures are decided.
d) Number of storage structures (Check dam/ Nala bund/ Percolation tank) will be decided considering the commitments and available runoff in water budgeting and quality of water in the wells and site suitability.
e) Detailed Levelling Survey using Dumpy Level / Total Station has to be carried out to arrive at the site-specific designs as shown in the Manual.
f) The location of ground water recharge structures are decided by examining the lineaments and fracture zones from geological maps.
g) Rainfall intensity data of the nearest Rain gauge station is considered for Hydrologic Designs.
h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and 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. An area of about 210 ha (45%) requires trench cum bunding and maximum area of about 249 ha (53%) area needs graded bunds or strengthening of existing 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.

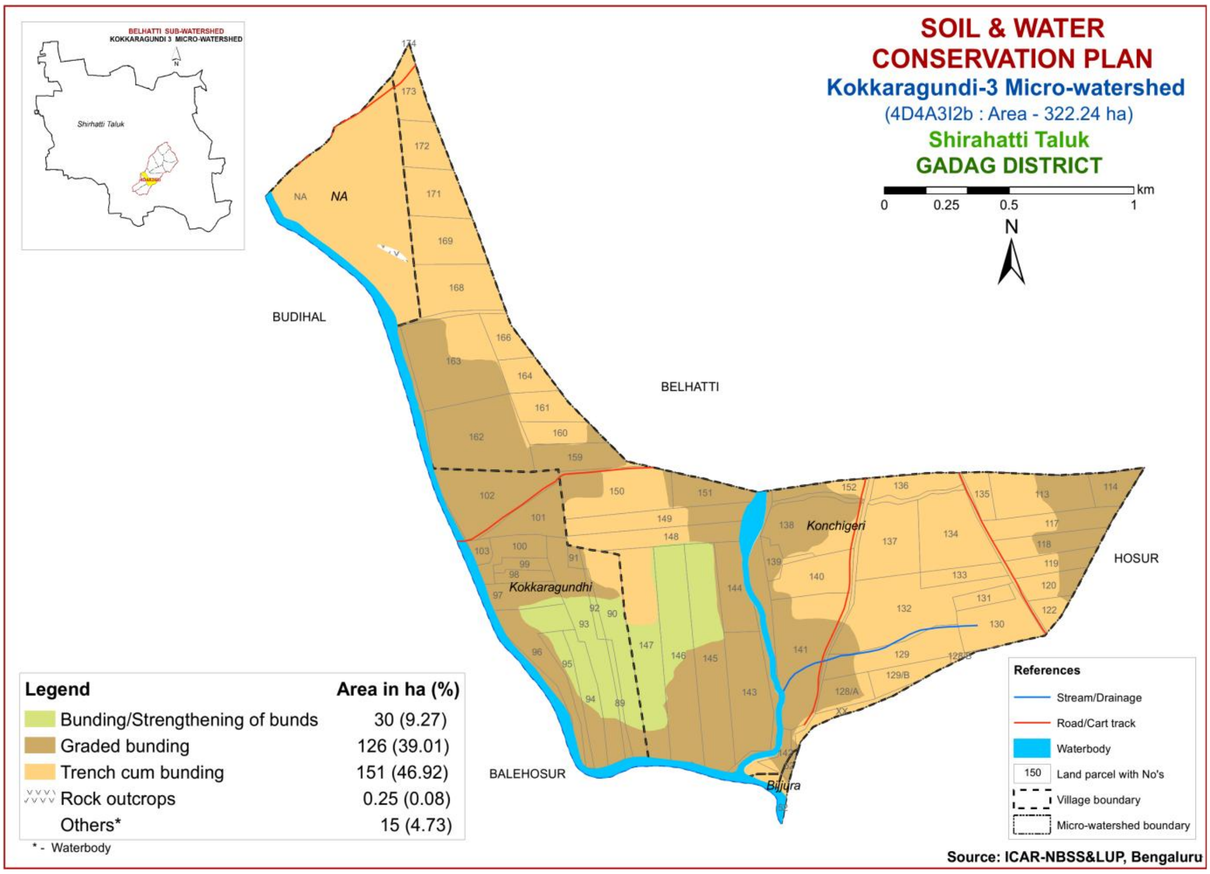


Fig. 9.1 Soil and Water Conservation Plan map of Kokkaragundi-3 Microwatershed

9.3 Greening of Microwatershed

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

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

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

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

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Appendix I

Soil Phase Information

Village	Survey No.	Total Area (ha)	Soils	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Bijjura	52	0.41	ATTiB2g1	LMU-3	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIe	Graded bunding
Bijjura	STREAM	0.5	Waterbody	Others	Others	Others	Others	Others	Others	Others	Waterbody	Not Available	Others	Others
Kokkaragundhi	89	1.04	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize (Mz)	Not Available	IIIs	Bunding/Strengthening of bunds
Kokkaragundhi	90	7.34	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize+Cotton+Sorghum (Mz+Ct+Sg)	Not Available	IIIs	Bunding/Strengthening of bunds
Kokkaragundhi	91	0.45	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Kokkaragundhi	92	0.7	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize (Mz)	Not Available	IIIs	Bunding/Strengthening of bunds
Kokkaragundhi	93	7.41	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize+Onion (Mz+On)	Not Available	IIIs	Bunding/Strengthening of bunds
Kokkaragundhi	94	3.65	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIIs	Bunding/Strengthening of bunds
Kokkaragundhi	95	2.37	MPTmB2g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIe	Graded bunding
Kokkaragundhi	96	6.1	MPTmB2g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Fallow land (Mz+Fl)	Not Available	IIIe	Graded bunding
Kokkaragundhi	97	2.99	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Sorghum (Mz+Sg)	Not Available	IIes	Graded bunding
Kokkaragundhi	98	1.08	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Sorghum (Ct+Sg)	Not Available	IIes	Graded bunding
Kokkaragundhi	99	1.04	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Brinjal (Ct+Br)	Not Available	IIes	Graded bunding
Kokkaragundhi	100	2.55	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Kokkaragundhi	101	3.79	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Redgram (Mz+Rg)	Not Available	IIes	Graded bunding
Kokkaragundhi	102	8.24	KPRmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Kokkaragundhi	103	0.77	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sorghum (Sg)	Not Available	IIes	Graded bunding

Village	Survey No.	Total Area (ha)	Soils	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Konchigeri	113	6.29	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Konchigeri	114	2.23	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Konchigeri	117	4.12	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IVs	Trench cum bunding
Konchigeri	118	3.34	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Sorghum (Mz+Sg)	Not Available	IIes	Graded bunding
Konchigeri	119	2.49	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Sorghum (Mz+Sg)	Not Available	IVs	Trench cum bunding
Konchigeri	120	2.33	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IVs	Trench cum bunding
Konchigeri	122	1.28	AKTiB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIIs	Trench cum bunding
Konchigeri	128/A	2.51	NGTmB1g2	LMU-1	Very deep (>150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIIs	Graded bunding
Konchigeri	128/B	0.22	KKThB2g2 R1St1	LMU-4	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIes	Trench cum bunding
Konchigeri	129	5.41	BLDhB2g2	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Sorghum (Ct+Sg)	Not Available	IIIes	Trench cum bunding
Konchigeri	129/B	2.43	BLDhB2g2	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Horsegram (Hg)	Not Available	IIIes	Trench cum bunding
Konchigeri	130	5.15	BLDhB2g2	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIes	Trench cum bunding
Konchigeri	131	1.4	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sorghum (Sg)	Not Available	IVs	Trench cum bunding
Konchigeri	132	11.3	KLKhB2g2	LMU-6	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Groundnut+Sunflower+Horsegram (Mz+Gn+Sf+Hg)	Not Available	IVes	Trench cum bunding
Konchigeri	133	2.01	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sorghum (Sg)	Not Available	IVs	Trench cum bunding
Konchigeri	134	7.56	KLKiB1g2	LMU-6	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Redgram+ Sunflower+Horsegram (Mz+Rg+Sf+Hg)	Not Available	IVs	Trench cum bunding
Konchigeri	135	1.55	RNKiB1g2	LMU-3	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIIs	Trench cum bunding
Konchigeri	136	2.72	RNKiB2g2	LMU-3	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Sorghum+Horsegram (Ct+Sg+Hg)	Not Available	IIIes	Trench cum bunding

Village	Survey No.	Total Area (ha)	Soils	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Konchigeri	137	6.75	KLKhB2g2	LMU-6	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Groundnut+Sunflower (Ct+Gn+Sf)	Not Available	IVes	Trench cum bunding
Konchigeri	138	7.43	BGPiB2g2	LMU-2	Very deep (>150 cm)	Sandy clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Chilly (Mz+Ct+Ch)	Openwell,Openwell,Borewell	IIIes	Graded bunding
Konchigeri	139	1.27	NGTmB1g1	LMU-1	Very deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Current fallow (Ct+Cf)	Not Available	IIes	Graded bunding
Konchigeri	140	4.67	KLKhB2g2	LMU-6	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Horsegram (Mz+Ct+Hg)	Not Available	IVes	Trench cum bunding
Konchigeri	141	10.6	NGTmB1g2	LMU-1	Very deep (>150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+ Sorghum+Groundnut+ Sunflower+Horsegram (Mz+Ct+Sg+Gn+Sf+Hg)	Not Available	IIIs	Graded bunding
Konchigeri	142	0.93	ATTiB2g1	LMU-3	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIe	Graded bunding
Konchigeri	143	7.57	MPTmB2g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Sorghum+Fallow land (Mz+Sg+Fl)	Not Available	IIIe	Graded bunding
Konchigeri	144	4.58	NGTmB1g1	LMU-1	Very deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	145	11.2	MPTmB2g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Onion (Mz+Ct+On)	Openwell	IIIe	Graded bunding
Konchigeri	146	11	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize+Onion+Coconut (Mz+On+CN)	Borewell	IIIs	Bunding/Strengthening of bunds
Konchigeri	147	10.1	NBPmA1	LMU-5	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Maize+Fallow land (Mz+Fl)	Not Available	IIIs	Bunding/Strengthening of bunds
Konchigeri	148	5.09	NBPiB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Borewell	IIIs	Trench cum bunding
Konchigeri	149	5.41	NBPiB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Banana+Onion +Chilly+Fallow land (Mz+Ba+On+Ch+Fl)	Not Available	IIIs	Trench cum bunding
Konchigeri	150	7.87	NBPiB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Horsegram +Fallow land (Rg+Hg+Fl)	Not Available	IIIs	Trench cum bunding
Konchigeri	151	3.13	BGPmB1g1	LMU-2	Very deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Konchigeri	152	1.92	BGPiB2g2	LMU-2	Very deep (>150 cm)	Sandy clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Groundnut (Rg+Gn)	Not Available	IIIes	Graded bunding
Konchigeri	159	3.7	MPTiB1g1	LMU-2	Deep (100-150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding

Village	Survey No.	Total Area (ha)	Soils	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Konchigeri	160	2.53	NBPhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Borewell	IIIs	Trench cum bunding
Konchigeri	161	2.77	NBPhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Onion +Chilly (Mz+Ct+On+Ch)	Not Available	IIIs	Trench cum bunding
Konchigeri	162	10.4	KPRmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Banana+Mulberry+Sorghum (Mz+Ct+Ba+Mu+Sg)	Not Available	IIes	Graded bunding
Konchigeri	163	11.4	KPRmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Redgram+Groundnut+ Mulberry (Mz+Ct+Rg+Gn+Mu)	Borewell	IIes	Graded bunding
Konchigeri	164	2.37	NBPhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+Sunflower+Horsegram (Mz+Gn+Sf+Hg)	Not Available	IIIs	Trench cum bunding
Konchigeri	166	2.24	HRVcB2g2	LMU-5	Shallow (25-50 cm)	Sandy loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Current fallow (Cf)	Not Available	IIIes	Trench cum bunding
Konchigeri	168	6.05	HRVhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Groundnut+Sunflower (Mz+Ct+Gn+Sf)	Borewell	IIIs	Trench cum bunding
Konchigeri	169	5.09	HRVhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Groundnut+Sunflower +Redgram (Gn+Sf+Rg)	Not Available	IIIs	Trench cum bunding
Konchigeri	171	4.3	HRVhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+Sunflower+Redgram (Mz+Gn+Sf+Rg)	Not Available	IIIs	Trench cum bunding
Konchigeri	172	3.16	HRVhB1g1	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Groundnut+Fallow land (Gn+Fl)	Not Available	IIIs	Trench cum bunding
Konchigeri	173	2.86	HRVhB1g2	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+Sunflower (Mz+Gn+Sf)	Not Available	IIIs	Trench cum bunding
Konchigeri	174	0	HRVhB1g2	LMU-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIIs	Trench cum bunding
Konchigeri	XX	1.3	KKThB2g2 R1St1	LMU-4	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIes	Trench cum bunding
NA	NA	30.1	LKRiB1g1	LMU-4	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Redgram+Horsegram+Groundnut+Fallow land (Mz+Ct+Rg+Hg+Gn+ Fl)	Not Available	IIIs	Trench cum bunding

Appendix II

Soil Fertility Information

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Bijjura	52	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	89	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	90	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	91	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Kokkaragundhi	92	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	93	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	94	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	95	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	96	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	97	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	98	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Kokkaragundhi	99	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Kokkaragundhi	100	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Kokkaragundhi	101	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	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)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Kokkaragundhi	102	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Kokkaragundhi	103	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	113	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	114	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	117	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	118	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	119	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	120	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	122	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	128/ A	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	128/ B	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	129	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Konchigeri	129/ B	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Konchigeri	130	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	131	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchigeri	132	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	133	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	134	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	135	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	136	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 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)
Konchigeri	137	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	138	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	139	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	140	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	141	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	142	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	143	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	144	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	145	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	146	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchigeri	147	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	148	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	149	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	150	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	151	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
Konchigeri	152	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	159	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Konchigeri	160	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	161	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	162	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	163	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	164	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	166	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	168	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	169	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchigeri	171	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	172	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	173	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	174	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	STREAM	Others	Non saline (<2 dsm)	Others	Low (< 23 kg/ha)	Others	Others	Others	Others	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	XX	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 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)
NA	NA	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (< 0.5 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Appendix III

Soil Suitability Information

VILLAGE	Sur vey No.	Sorg- hum	Mai -ze	Beng- al gram	Grou nd- nut	Sunfl ower	Cotton	Tom -ato	Oni on	Chil -ly	Gua -va	Man -go	Sap- ota	Jack fruit	Jam -un	Musa -mbi	Lime	Cas hew	Custa rd apple	Amla	Tama -rind	Pom e- gran ate	Ban- ana	Mari- gold	Chrys an- themu m
Bijjura	52	S2r	S2rt	S1	S3t	S3r	S2r	S2rt	S2rt	S2r	S3t	Nr	S3t	S3t	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S3rt	S3rt	S2rt	S2rt
Kokkara gundhi	89	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Kokkara gundhi	90	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Kokkara gundhi	91	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	92	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Kokkara gundhi	93	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Kokkara gundhi	94	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Kokkara gundhi	95	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	96	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	97	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	98	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	99	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	100	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	101	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Kokkara gundhi	102	S2z	S3tz	S2z	S2tz	S2z	S2z	S3tz	S3tz	S2z	S3tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Ntz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Kokkara gundhi	103	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Konchige ri	113	S1	S3t	S1	S2rt	S1	S2r	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S2r	S2r	Nt	S2r	S2r	S3t	S2t	S2t	S2t	S2t
Konchige ri	114	S1	S3t	S1	S2rt	S1	S2r	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S2r	S2r	Nt	S2r	S2r	S3t	S2t	S2t	S2t	S2t
Konchige ri	117	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg
Konchige ri	118	S1	S3t	S1	S2rt	S1	S2r	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S2r	S2r	Nt	S2r	S2r	S3t	S2t	S2t	S2t	S2t
Konchige ri	119	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg

VILLAGE	Survey No.	Sorg-hum	Mai-ze	Beng-al gram	Grou nd-nut	Sunfl ower	Cotton	Tom-ato	Oni on	Chil-ly	Gua-va	Man-go	Sap-ota	Jack fruit	Jam-un	Musa-mbi	Lime	Cas hew	Custa rd apple	Amla	Tama-rind	Pom e-gran ate	Ban-ana	Mari-gold	Chrys an-themu m
Konchigeri	120	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg
Konchigeri	122	S3r	S3rt	S2r	S3rt	Nr	S3r	S3rg	S3rg	S3rg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3r	S3r	Nr	Nrt	Nrt	S3rt	S3rt
Konchigeri	128/A	S2zg	S3tz	S2zg	S2tz	S2zg	S2zg	S3zg	S3zg	S2zg	S3tz	S3tz	S3tz	S3tz	S2tz	S2zg	S2zg	Ntz	S2zg	S2zg	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	128/B	S2r	S2r	S3rg	S2r	S3rg	S3rg	S2rg	S2rg	S2rg	S3rg	Nr	S3g	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3g	S3rg	S3rg
Konchigeri	129	S2rg	S2rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nrg	S3rg	S3rg	Nr	Nrg	Nrg	S3rg	S3rg
Konchigeri	129/B	S2rg	S2rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nrg	S3rg	S3rg	Nr	Nrg	Nrg	S3rg	S3rg
Konchigeri	130	S2rg	S2rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nrg	S3rg	S3rg	Nr	Nrg	Nrg	S3rg	S3rg
Konchigeri	131	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg
Konchigeri	132	Nr	Nr	S3r	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr
Konchigeri	133	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg
Konchigeri	134	Nrg	Nrg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nrg
Konchigeri	135	S3rz	S3tz	S2z	S2rz	S3rz	S2z	S3zg	S3zg	S2zg	S3zg	Nrz	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	Nrz	S3gz	S3rz	S2z	S2z
Konchigeri	136	S3rz	S3tz	S2z	S2rz	S3rz	S2z	S3zg	S3zg	S2zg	S3zg	Nrz	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	S3zg	Nrz	S3gz	S3rz	S2z	S2z
Konchigeri	137	Nr	Nr	S3r	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr
Konchigeri	138	S1	S3tg	S2g	S3t	S2g	S2g	S2tg	S2tg	S2g	S3tg	S3tg	S3gt	S2tg	S2tg	S2g	S3g	Ntg	S2g	S2g	S2t	S2t	S2t	S2t	S2t
Konchigeri	139	S2z	S3tz	S2z	S2tz	S2z	S2z	S3tz	S3tz	S2z	S3tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Ntz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	140	Nr	Nr	S3r	Nr	Nr	Nr	Nrg	Nrg	Nrg	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr
Konchigeri	141	S2zg	S3tz	S2zg	S2tz	S2zg	S2zg	S3zg	S3zg	S2zg	S3tz	S3tz	S3tz	S3tz	S2tz	S2zg	S2zg	Ntz	S2zg	S2zg	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	142	S2r	S2rt	S1	S3t	S3r	S2r	S2rt	S2rt	S2r	S3t	Nr	S3t	S3t	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S3rt	S3rt	S2rt	S2rt
Konchigeri	143	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Konchigeri	144	S2z	S3tz	S2z	S2tz	S2z	S2z	S3tz	S3tz	S2z	S3tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Ntz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	145	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t

VILLAGE	Survey No.	Sorg-hum	Mai-ze	Beng-al gram	Grou nd-nut	Sunfl ower	Cotton	Tom-ato	Oni on	Chil-ly	Gua-va	Man-go	Sap-ota	Jack fruit	Jam-un	Musa-mbi	Lime	Cas hew	Custa rd apple	Amla	Tama-rind	Pom e-gran ate	Ban-ana	Mari-gold	Chrys an-themu m
Konchigeri	146	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	147	S3rg	S3rg	S3rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	148	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	149	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	150	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	151	S1	S3t	S1	S3t	S1	S2	S2t	S2t	S1	S3t	S3t	S3t	S2t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Konchigeri	152	S1	S3tg	S2g	S3t	S2g	S2g	S2tg	S2tg	S2g	S3tg	S3tg	S3gt	S2tg	S2tg	S2g	S3g	Ntg	S2g	S2g	S2t	S2t	S2t	S2t	S2t
Konchigeri	159	S1	S3t	S1	S2t	S1	S1	S2t	S2t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t	S2t	S2t
Konchigeri	160	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	161	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	162	S2z	S3tz	S2z	S2tz	S2z	S2z	S3tz	S3tz	S2z	S3tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Ntz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	163	S2z	S3tz	S2z	S2tz	S2z	S2z	S3tz	S3tz	S2z	S3tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Ntz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	164	S3rg	S3rg	S2rg	S3rg	Nrg	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	166	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	168	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	169	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	171	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	172	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	173	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	174	S3rg	S3rg	S2rg	S3rg	Ng	S3rg	S3rg	S3rg	S3rg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg
Konchigeri	XX	S2r	S2r	S3rg	S2r	S3rg	S3rg	S2rg	S2rg	S2rg	S3rg	Nr	S3g	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3g	S3rg	S3rg
NA	NA	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2rg	S2rg	S2rg	S3rg	Nr	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	Nr	S3g	S3rg	S3rg	S2r

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

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

Methodology: *Kokkaragundi-3 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^{0}1'$ – $15^{0}3'$ North latitudes and $75^{0}36'$ – $75^{0}38'$ East longitudes, covering an area of about 322 ha, bounded by Budihal, Belhatti, Hosur and Balehosur villages with length of growing period* **(***LGP) 150-180 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 the Kokkaragundi-3 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) are presented here.*

Social Indicators;

- *Male and female ratio is 52.2 to 47.8 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 60.9 per cent to the total population.*
- *Literacy population is around 84.8 per cent.*
- *Social groups belong to scheduled caste (SC) is around 10 per cent.*
- *Liquefied petroleum gas is the major source of energy for a cooking among 70 per cent.*
- *About 50 per cent of households have a yashaswini health card.*
- *Majority of farm households (70 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 90 per cent.*
- *Swachha bharath program providing closed toilet facilities around 80 per cent of sample households.*
- *Rural migration to unban centre for employment is prevalent among 4.3 per cent of farm households.*
- *Women participation in decisions making is around among all the households were found.*

Economic Indicators;

- *The average land holding is 1.56 ha indicates that majority of farm households are belong to small and medium farmers. The dry land of 83.9 % and irrigated land 16.1 % of total cultivated land area among the sample farmers.*
- *Agriculture is the main occupation among 4.76 per cent and agriculture is the main and agriculture labour is subsidiary occupation for 83.33 per cent of sample households.*
- *The average value of domestic assets is around Rs.13417 per household. Mobile and television are popular mass media communication.*
- *The average value of farm assets is around Rs.137806 per household, about 40 per cent of sample farmers having plough and bullock cart.*
- *The average value of livestock is around Rs.17208 per household; about 53 per cent of household are having livestock.*
- *The average per capita food consumption is around 840 grams (1772.9 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 100 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs.12100 per household. About 80 per cent of farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs.1646.*

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. 443 per ha/year. The total cost of annual soil nutrients is around Rs. 136065 per year for the total area of 322.24 ha.*
- *The average value of ecosystem service for food grain production is around Rs 12662/ha/year in maize.*
- *The average value of ecosystem service for fodder production is around Rs. 3337/ ha/year in maize.*
- *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 in maize (Rs. 27169).*

Economic Land Evaluation;

- *The major cropping pattern is maize (100 %).*
- *In Kokkaragundi-3 micro-watershed, major soil is Kabulayathakatti (KLK) series is having very shallow soil depth cover around 15.28 % of area. On this soil farmers are presently growing maize, Attikatti (AKT) soils are also having shallow soil depth cover 0.44 %, Nabhapur (NBP) soil series having shallow*

soil depth cover around 17.20 % of areas, Harve (HRV) soil series having shallow soil depth cover around 11.43 % of area, Kalasapur (KPR) soil series are having deep soil depth cover around 8.12% of area, respectively and Nagavi Tanda (NGT) soil series are having very deep soil depth covers around 7.42 % of area, all these are soil series major crop is maize.

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for maize ranges between Rs.37277/ha in KPR soil (with BCR of 3.08) and Rs.9961/ha in HRV soil (with BCR of 2.85).*
- *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 is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in maize (33.4 to79.2%).*

Chapter 2

INTRODUCTION

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

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

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

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

Objectives of the study

1. To characterize socio-economic status of farm households

2. To evaluate the economic viability of land use and land related constraints

3. To estimate the ecosystem service provided by the watershed and

4. To suggest alternatives for sustainable agriculture production.

Chapter 3

METHODOLOGY

Study area

Kokkaragundi-3 micro-watershed located in northern transition zone of Karnataka (Figure 1) Extends over all area of 1.13 M ha of which 0.86 M ha is under cultivation. Nearly 0.052 M ha in the zone enjoys irrigation facilities. Elevation ranges between 450-900 m MSL with most parts situated between 800 and 900 m. Shallow to black soils and red loams are distributed in equal proportion. The average annual rainfall ranges from 620 to 1300 mm of which more than 60 per cent is received during the southwest monsoon (*kharif*). Sorghum, rice, groundnut, maize, chilli, pulses, sugarcane, tobacco and cotton are the major crops of the zone. It represents Agro Ecological Sub Region (AESR) 6.4 having LGP 150-180 days.

Kokkaragundi-3 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^{0}1'$ – $15^{0}3'$ North latitudes and $75^{0}36'$ – $75^{0}38'$ East longitudes, covering an area of about 322 ha, bounded by Budihal, Belhatti, Hosur and Balehosur 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 survry. The data collected from the representative farm households were analysed using Automated Land Potential Evalution System (Figure 2).

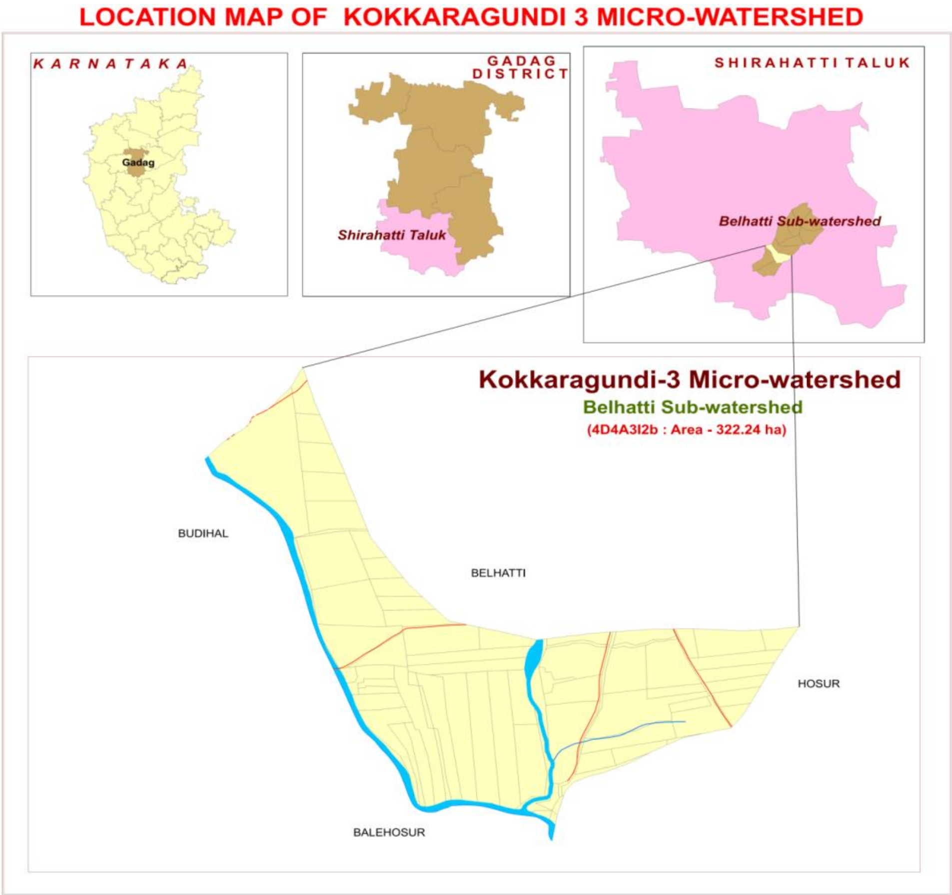

Figure 1: Location of study area

Steps followed in socio-economic assessment

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

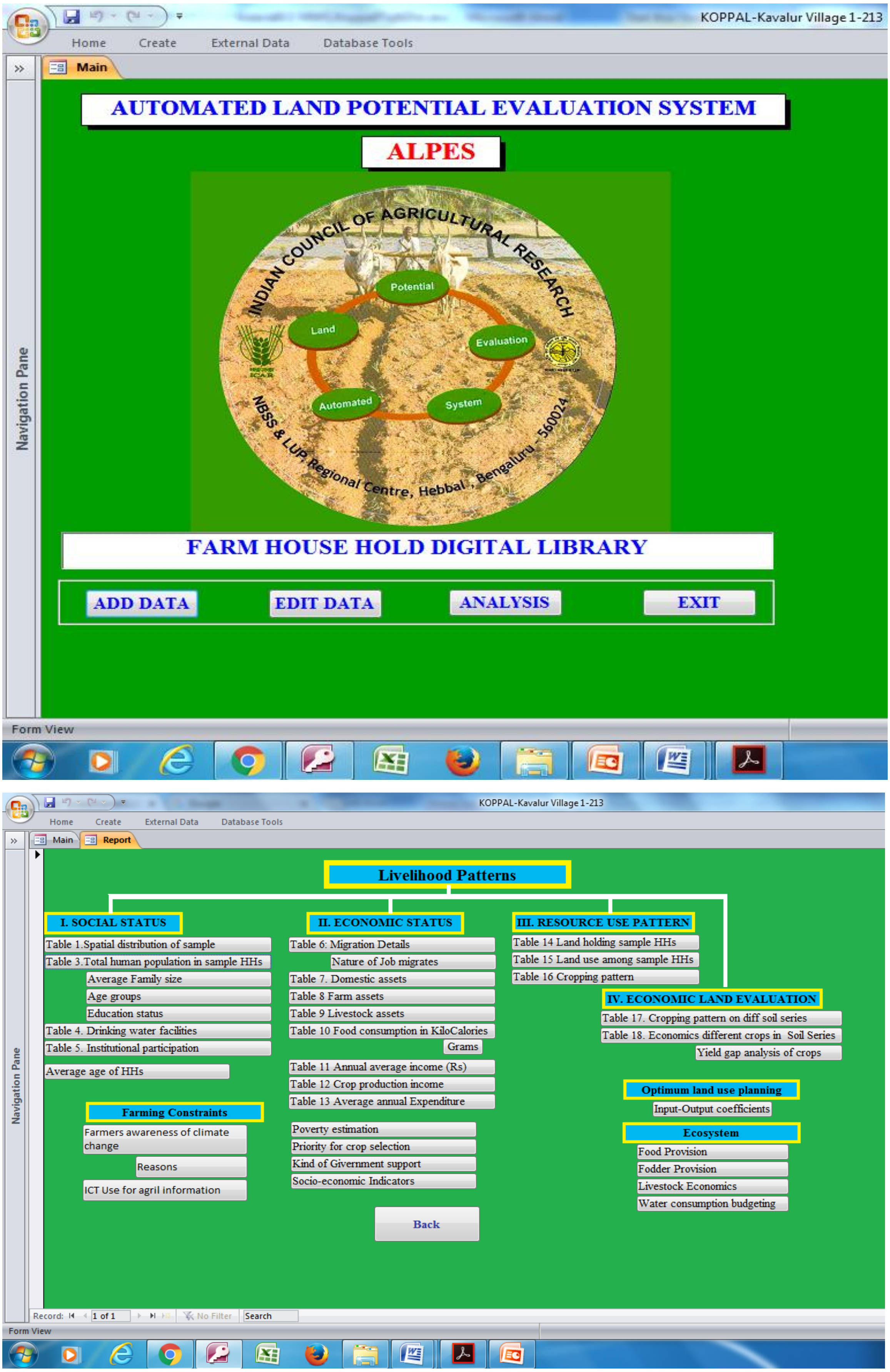

Figure 2: ALPES FRAMEWORK

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

Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.

Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)

Net returns = Gross returns-Operational cost.

Benefit Cost Ratio = Net returns/Total cost.

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

Economic Valuation of Soil ecosystem services:

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

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

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

Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 46, out of which 52.2 per cent were males and 47.8 per cent females. Average family size of the households is 4.7. 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 18 to 30 years (32.6 %) followed by 30 to 50 years (28.3 %), more than 50 years (28.3 %) and 0 to18 years (10.9 %). 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 84.8 per cent of respondents were literate and 15.2 per cent illiterate (Table 1).

Table 1: Human population among sample households in Kokkargundi-3 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	46
Male	% to total Population	52.2
Female	% to total Population	47.8
Average family size	Number	4.7
Age group		
0 to 18 years	% to total Population	10.9
18 to 30 years	% to total Population	32.6
30 to 50 years	% to total Population	28.3
>50 years	% to total Population	28.3
Average age	Age in years	39.5
Education Status		
Illiterates	% to total Population	15.2
Literates	% to total Population	84.8
Primary School (<5 class)	% to total Population	19.6
Middle School (6- 8 class)	% to total Population	23.9
High School (9- 10 class)	% to total Population	21.7
Others	% to total Population	19.6

The ethnic groups among the sample farm households found to be 80 per cent belonging to other backward castes (OBC) followed by 10 per cent belonging to general castes and scheduled castes (SC) of 10 per cent, each (Table 2 and Figure 3). About 70 per cent of sample households are using liquefied petroleum gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 50 per cent are sample households having health cards. Majority (73%) are having MNREGA job cards for employment generation. About 90 per cent of farm households are having ration cards for taking food grains from public distribution system. About 80 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Kokkargundi-3Microwatershed

Particulars	Units	Value
Social groups		
SC	% of Households	10.0
OBC	% of Households	80.0
General	% of Households	10.0
Types of fuel use for cooking		
Fire wood	% of Households	30.0
LPG Gas	% of Households	70.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	50.0
No	% of Households	50.0
MGNREGA Card		
Yes	% of Households	70.0
No	% of Households	30.0
Ration Card		
Yes	% of Households	90.0
No	% of Households	10.0
Households with toilet		
Yes	% of Households	80.0
No	% of Households	20.0
Drinking water facilities		
Tube Well	% of Households	100.00

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

The data on migration in Kokkargundi-3 Micro-watershed is given in Table 3. It indicated that around 4.3 per cent of samples households were migrated. The average distance travelled for seeking employment is 180 km.

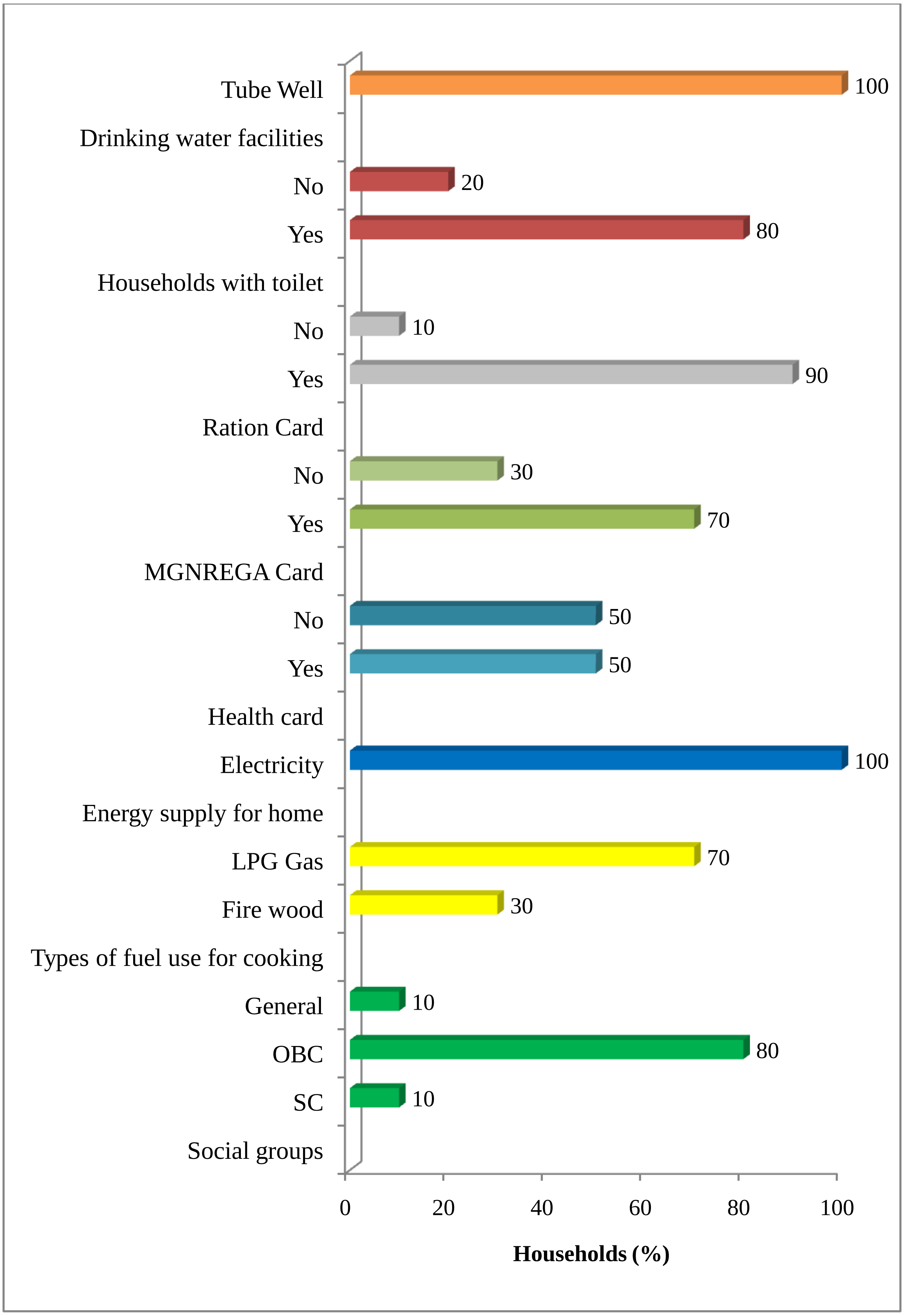

Figure 3: Basic needs of sample households in Kokkargundi-3 Microwatershed

Table 3: Migration details among the sample households in Kokkargundi-3 micro-watershed

Particulars	Value
% of households showing migration	4.3
% of persons migrating	10.0
No. of months migrated in a year	9.0
Average Distance of migration(Km)	180.0
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 4.4 per cent of farmers followed by subsidiary occupations like agricultural labour (76.1 %), private service (2.2%), self employed (2.2%) and government services as around 6.5 per cent of sample households. Around 8.7 per cent studying..

Table 4: Occupational pattern in sample population in Kokkargundi-3 Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	4.4
	Agriculture labour	76.1
	Govt. service	6.5
	Private service	2.2
	Self employed	2.2
Studying		8.7
Grand Total		100.0
Family labour availability		**Man days/month**
Male		40.00
Female		32.00
Average		72.00

The important assets especially with reference to domestic assets were analyzed and are given in Table 5and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (90%) followed by television (90%), motorcycle (40%) and mixer/grinder (20%). The average value of domestic assets is around Rs. 23479 per households.

Table 5: Domestic assets among the sample households in Kokkargundi-3 Microwatershed

Particulars	% of households	Average value in Rs
Mixer/grinder	20.0	1500
Mobile Phone	90.0	4222
Motorcycle	40.0	78750
Television	90.0	9444
Average Value	23479	

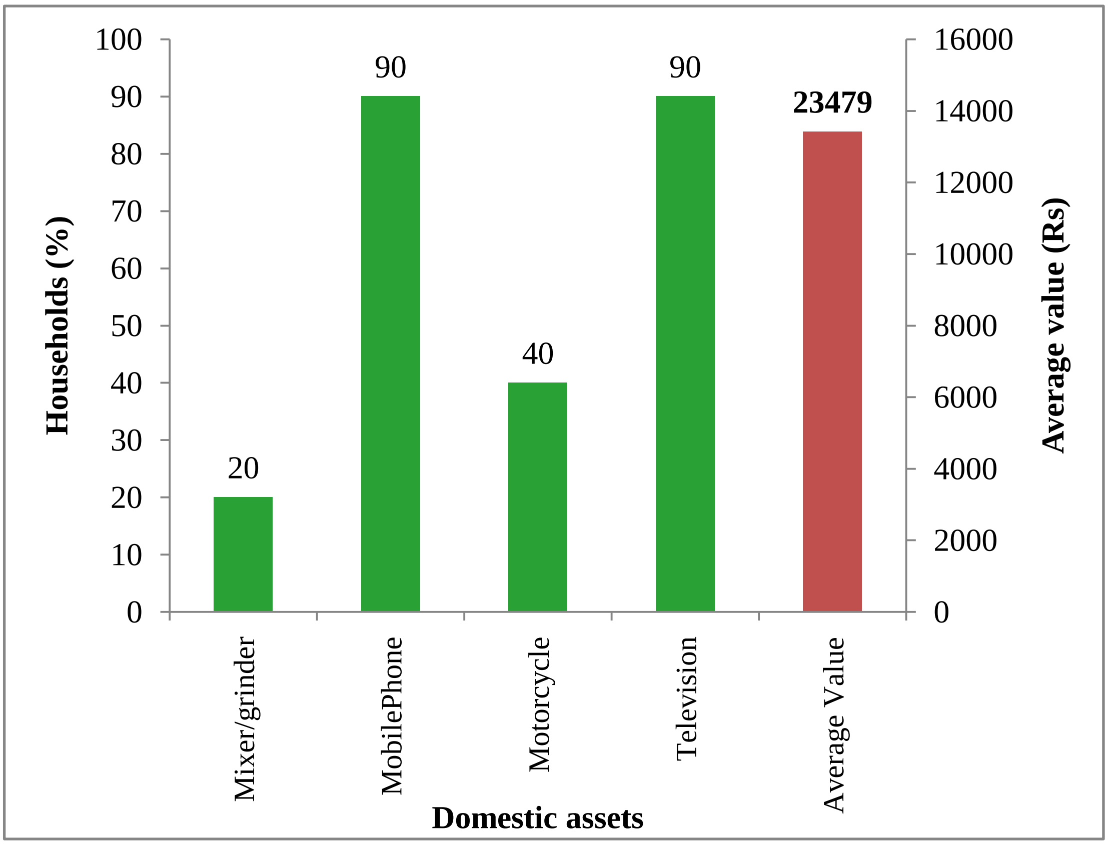

Figure 4: Domestic assets among the sample households in Kokkargundi-3 Microwatershed

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 plough (40 %), bullock cart (40 %), weeder (30 %), sprayer (10 %), tractor (10 %) and drip/sprinkler (10 %) was found highest among the sample farmers. The average value of farm assets is around Rs. 137806 per household (Table 6 and Figure 5).

Table 6 Farm assets among samples households in Kokkargundi-3 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	40.0	15500
Drip/Sprinkler	10.0	4800
Plough	40.0	4750
Sprayer	10.0	1450
Tractor	10.0	800000
Weeder	30.0	333
Average Value	137806	

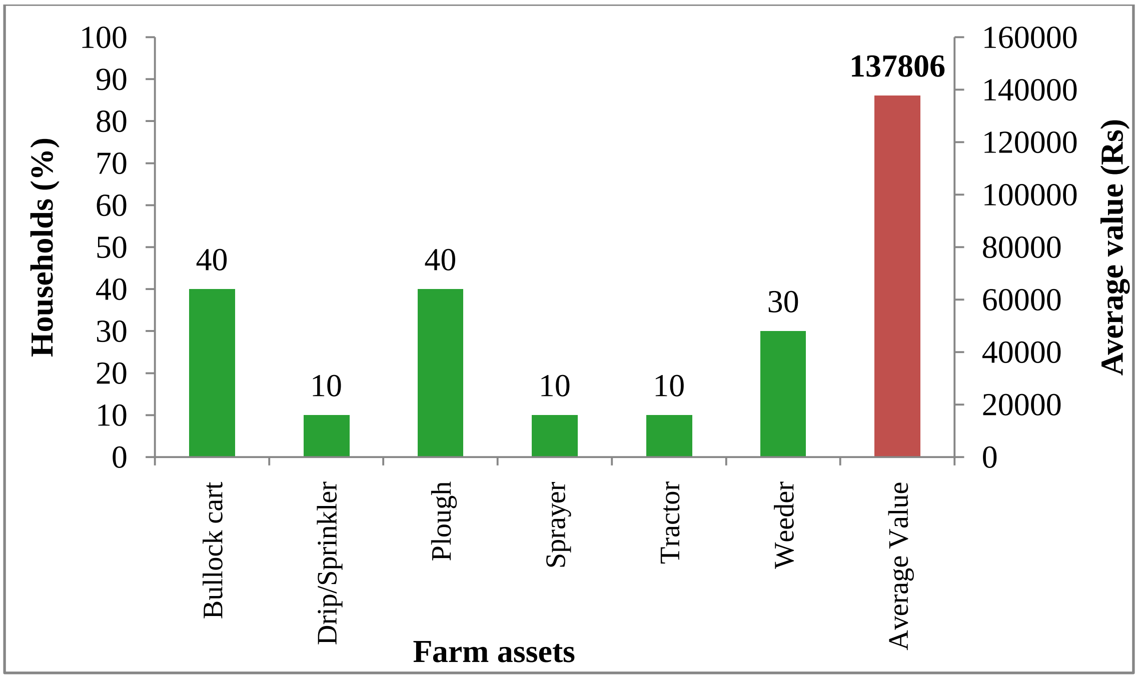

Figure5: Farm assets among samples households in Kokkargundi-3Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population is bullocks were around 37.5 per cent followed by local milching cow (37.5 %), local dry cow (12.5 %) and dry buffalos (12.5 %). The average livestock value was Rs 17208 per household.

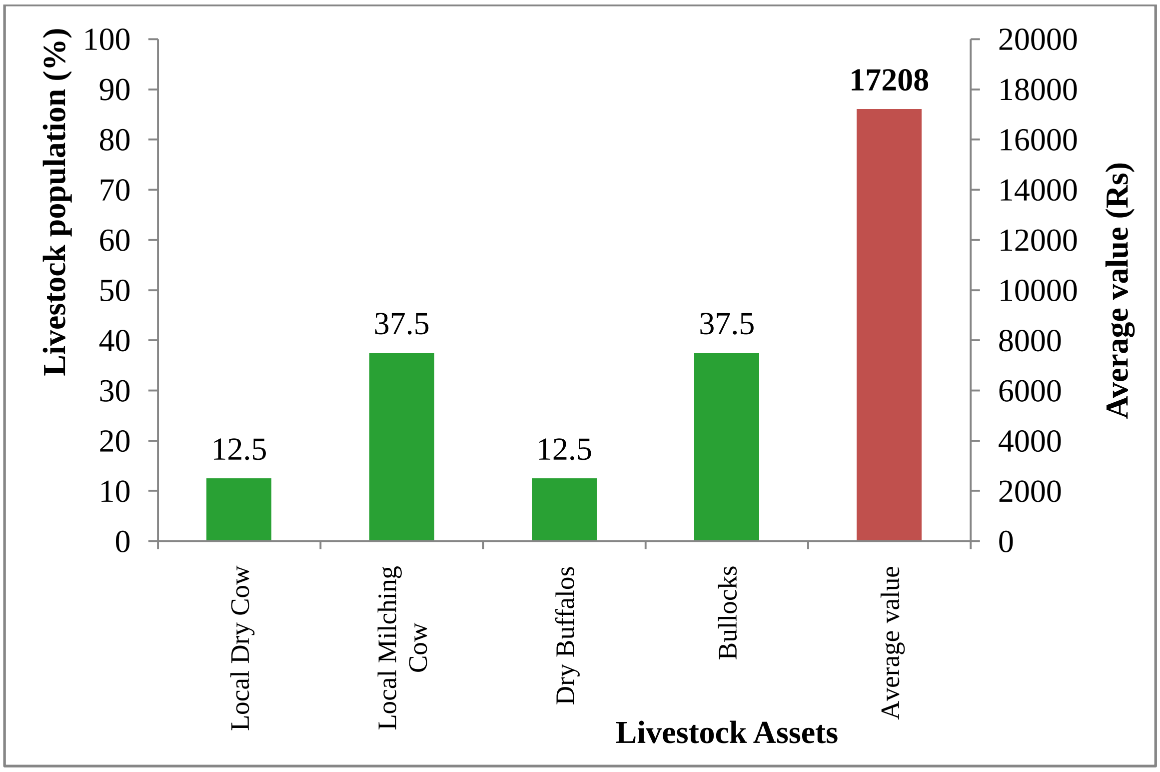

Figure 6: Livestock assets among sample households in Kokkargundi-3micro-watershed

Table 7: Livestock assets among sample households in Kokkargundi-3 Micro-watershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	12.5	8000
Local Milching Cow	37.5	18333
Dry Buffalos	12.5	2500
Bullocks	37.5	40000
Average value	17208	

Average milk produced in sample households is 600 litters/ annum. Among the farm households, maize is the main crops for domestic food and fodder for animals. About 3001kg /ha of average fodder is available per season for the livestock feeding (Table 9).

Table 8: Milk produced and fodder availability of sample households in Kokkargundi-3 Micro watershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	600
Average Milk Produced	600
Fodder produces	**Fodder yield (kg/ha.)**
Maize	3001
Livestock having households (%)	53
Livestock population (Numbers)	14

A woman participation in decision making is in this micro-watershed is presented in Table 9. Among all women earning for her family requirement and women taking decision in her family and agriculture related activities in these study area households.

Table 9: Women empowerment of sample households in Kokkargundi-3Microwatershed

% to Grand Total

Particulars	Yes	No
Women participation in local organization activities	0	100
Women elected as panchayat member	0	100
Women earning for her family requirement	100	0
Women taking decision in her family and agriculture related activities	100	0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1163.93 kcal per person. The other important food items consumed was pulses 160.26 kcal followed by cooking oil 146.93 kcal, milk 102.56

kcal, vegetables 38.47 kcal, egg 137.50 kcal and meat 23.3 kcal. In the sampled households, farmers were consuming less (1772.98 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample households in Kokkargundi-3 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	342.3	1163.93
Pulses	43	46.7	160.26
Milk	200	157.8	102.56
Vegetables	143	160.3	38.47
Cooking Oil	31	25.8	146.93
Egg	0.5	91.7	137.50
Meat	14.2	15.6	23.33
Total	**827.7**	**840.1**	**1772.98**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		70.0	100.0
% Above NIN		30.0	0

Note: * day/person

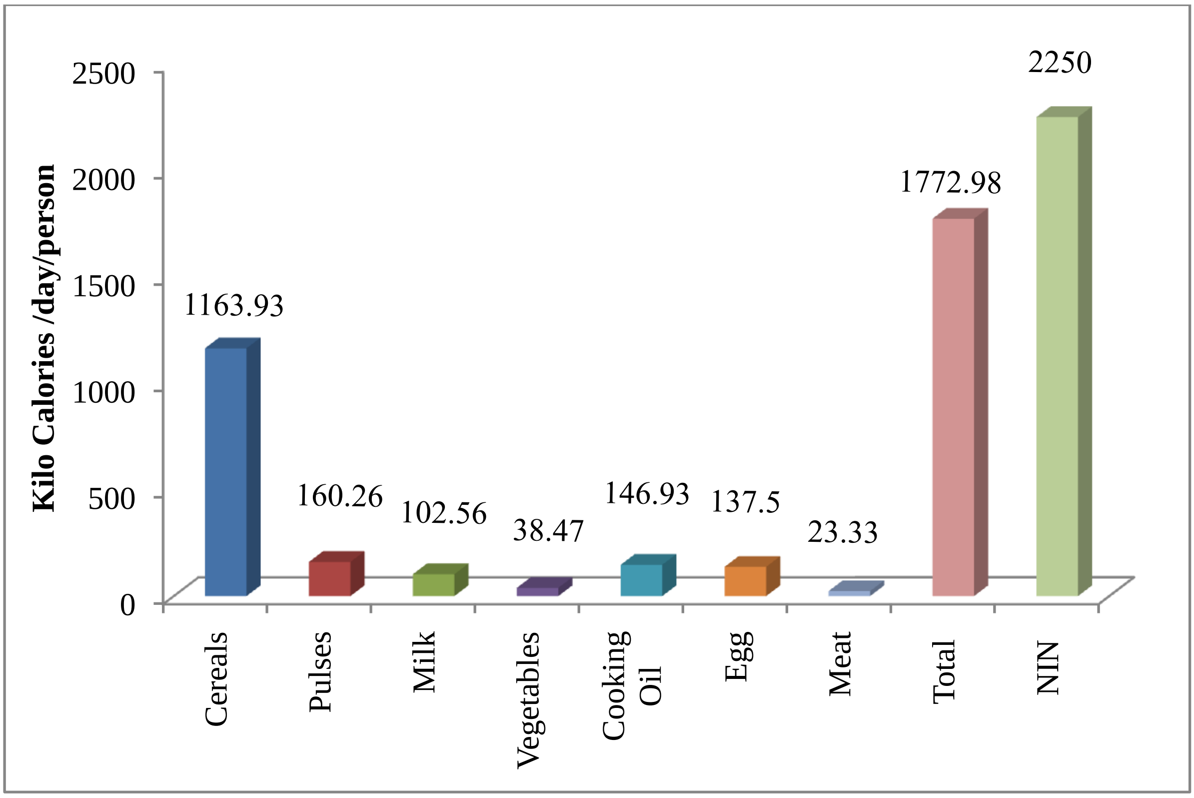

Figure 7: Per capita daily consumption of food among the sample households in Kokkargundi-3 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 12100. Major source of income to the farmers in the study area is from crop production (Rs 24818) followed by livestock (Rs. 7233). The income from Non farm income was Rs 4248. The monthly per capita income is Rs.657.60, 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 11).

Table 11: Annual average income of HHs from various sources in Kokkargundi-3 Micro watershed

Particulars	Income *
Nonfarm income (Rs)	4248 (10)
Livestock income (Rs)	7233 (30)
Crop Production (Rs)	24818 (100)
Total Annual Income (Rs)	***36299.7***
Average annual income	***12100***
Average monthly per capita income (Rs)	657.60
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. 43980) 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 1646 and about 80 per cent of farm households are below poverty line and 20 per of farm households are above poverty line (Table 12and Figure 8).

Table 12: Average annual expenditure of sample HHs in Kokkargundi-3 Microwatershed

Particulars	Value in Rupees	Per cent
Food	43980	48.4
Education	3700	4.1
Clothing	10400	11.4
Social functions	25500	28.1
Health	7300	8.0
Total Expenditure (Rs/year)	90880	100.0
Monthly per capita expenditure (Rs)	1646	

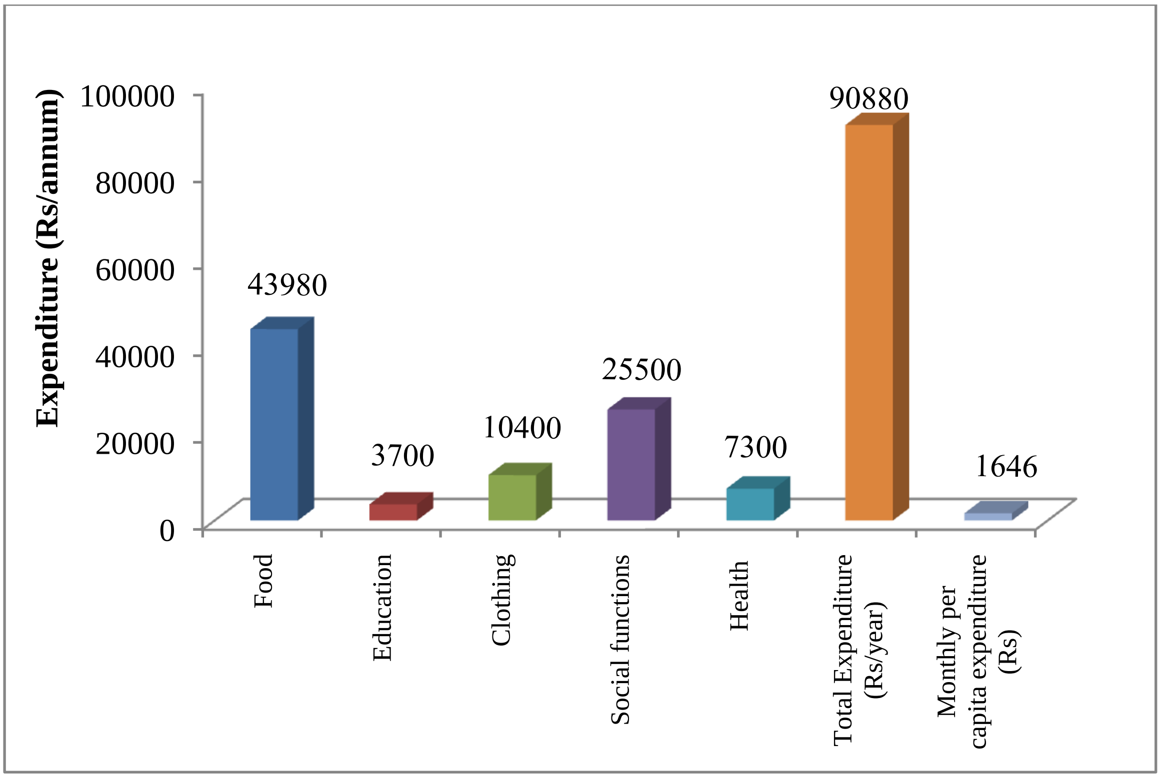

Figure 8: Average annual expenditure of sample HHs in Kokkargundi-3 Micro watershed

Land holding: A total sample households are total area cultivated by them is 15.65 ha. The average land holding of sample HHs is 1.56 ha. Large number of sample HHs (70 %) belong to small size group with an average holding size of 0.82 ha followed by medium farmers (20 %) with an average holding size of 2.73 ha and a large farmer (10 %) with a average land holding size of 4.45 ha (Table 13).

Table 13: Distribution of land holding among the sample households in Kokkaragundi-3 micro-watershed

Particulars	Units	Values
Small Farmers		
Total land	ha	5.74
sample size	per cent	70.0
Average land holding	ha	0.82
Medium Farmers		
Total land	ha	5.45
sample size	per cent	20.0
Average land holding	ha	2.73
Large Farmers		
Total land	ha	4.45
sample size	per cent	10.0
Average land holding	ha	4.45
Total sample farmers		
Total land	ha	15.65
sample size	per cent	100.0
Average land holding	ha	1.56

Land use: The total land holding in the Kokkargundi-3 micro-watershed is 15.6 ha (Table 14). Of which 13.1 ha is rain fed land and 2.5 ha is irrigated land. The average land holding per household is worked out to be 1.56 ha.

Table 14: Land use among samples households in Kokkargundi-3Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	16.1	2.5
Rain fed Land	83.9	13.1
Fallow Land	0.0	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 mango (62.5%) followed by neem trees (28.8 %) and coconut (8.8)(Table 15).

Table 15: Number of trees/plants covered in sample farm households in Kokkargundi-3 Micro watershed

Particulars	Number of Plants/trees	Per cent
Coconut	7	8.8
Mango	50	62.5
Neem trees	23	28.8
Grand Total	80	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 maize (96.3 %) and onion (3.7 %) which is taken during Kharif season. The cropping intensity was 100 percent (Table 16 and Figure 9).

Table 16: Present cropping pattern and cropping intensity in Kokkargundi-3 Micro watershed

% to Grand Total

Crops	Kharif	Grand Total
Maize	100.0	100

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 gap.

In Kokkargundi-3micro-watershed, 15 soil series are identified and mapped (Table 17). The distribution of major soil series are Nabhapur covering an area around 55.43 ha (17.20 %) followed by Mahalingapura Tanda 49.91 ha (15.79 %), Kabulayathakatti 49.23 ha (15.28 %), Harve 36.85 ha (11.43 %), Kalasapur 26.15 ha (8.12 %), Nagavi Tanda 23.90 ha (7.42%), Lakkur 14.20 ha (4.41 %), Shyanadrahali 13.51 ha (4.20 %), Jelligeri 11.14 ha (3.46 %), Beladadi 8.94 ha (2.77 %), Revanki 6.38 ha (1.98 %), Kabulayathakatti Tanda 5.21ha (1.62%), Tammadahalli 3.40 ha (1.05%), Attikatti 1.41 ha (0.44%), Attikatti Tanda 1.10 ha (0.34%), Rock out crops is 0.25 ha (0.08%) and Water body is 15.23 ha (4.73%).

Table 17: Distribution of soil series in Kokkargundi-3 Microwatershed

Sl. No.	Soil Series	Mapping Unit description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE			
1	HRV	Harve soils are shallow (25-50 cm), well drained, have reddish brown to dark red sandy clay loam soils occurring on very gently sloping uplands under cultivation	36.85 (11.43)
2	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on very gently sloping uplands under cultivation	14.20 (4.41)
3	TDH	Thammadahalli soils are moderately shallow (50 - 75cm), well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils occurring on very gently sloping uplands under cultivation	3.40 (1.05)
4	RNK	Ravanki soils are moderately shallow (50-75 cm), well drained, black calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation	6.38 (1.98)
5	SNH	Shyanadrahalli soils are deep (100-150 cm) well drained, have light olive brown to very dark gray soils occurring on very gently sloping uplands under cultivation	13.51 (4.20)
SOILS OF BANDED FERRUGINOUS QUARTZITE (BFQ) LANDSCAPE			
6	KLK	Kabulayathkatti soils are very shallow (<25 cm), well drained, have dark reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under rainfed cultivation	49.23 (15.28)
7	NBP	Nabhapur soils are shallow (25-50 cm), well drained, have reddish brown to dark reddish brown gravelly clay loam to gravelly clay soils occurring on gently to moderately sloping uplands under cultivation	55.43 (17.20)
8	AKT	Attikatti soils are shallow (25-50 cm), well drained, have dark reddish brown to dusky red clay loam to clay soils occurring on very gently to gently sloping uplands under cultivation	1.41 (0.44)
9	BLD	Beladadi soils are shallow (25-50 cm), well drained, have dark brown to dark reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation	8.94 (2.77)

10	KKT	Kabulayathakatti Tanda soils are moderately shallow (50-75 cm), well drained, dark reddish brown gravelly clay loam to gravelly clay soils occurring on very gently sloping uplands under cultivation	5.21 (1.62)
SOILS OF SCHIST LANDSCAPE			
11	ATT	Attikatti Tanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation	1.10 (0.34)
12	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands under cultivation	11.14 (3.46)
13	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark grayish brown cracking clay soils occurring on very gently sloping uplands under cultivation	49.91 (15.49)
14	KPR	Kalasapur soils are deep (100-150 cm), moderately well drained, have very dark gray to very dark grayish brown calcareous cracking clay soils occurring on very gently sloping uplands under cultivation	26.15 (8.12)
15	NGT	Nagavi Tanda soils are very deep (>150 cm), well drained, have very dark greyish brown cracking clay soils occurring on very gently sloping uplands under cultivation	23.90 (7.42)
		Rock outcrops	0.25(0.08)
		Water body	15.23(4.73)

Present cropping pattern on different soil series are given in Table 18. Crops grown on Kabulayathakatti soils are maize. Maize on Attikatti, Harve, Nabhapur, Kalasapur and Nagavi Tanda soils is grown.

Table 18: Cropping pattern on major soil series in Kokkargundi-3 micro-watershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Irrigated	Grand Total
			Kharif	Kharif	
AKT	Shallow (25-50 cm)	Maize	100	0.0	100
BGP	Very deep (>150 cm)	Maize	21.5	78.5	100
HRV	Shallow (25-50 cm)	Maize	100	0.0	100
KLK	Very shallow (<25 cm)	Maize	100	0.0	100
KPR	Deep (100-150 cm)	Maize	100	0.0	100
NBP	Shallow (25-50 cm)	Maize	100	0.0	100
NGT	Very deep (>150 cm)	Maize	100	0.0	100

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

Table 19: Alternative land use options for different size group of farmers (Benefit Cast Ratio) in Kokkargundi-3 Microwatershed.

Soil Series	Small farmers	Medium Farmers	Large farmers
KLK	Maize (2.22)		
AKT	Maize (2.88)	Maize (1.91)	
HRV			Maize (2.85)
NBP	Maize (0.97)		
KPR	Maize (3.08)		
BGP	Maize (0.98)	Maize (1.41)	
NGT	Maize (1.38)		

The productivity of different crops grown in Kokkargundi-3micro-watershed under potential yield of the crops is given in Table 20

The data on cost of cultivation and BCR of different crops is given in Tables 20. The total cost of cultivation in study area for Maize ranges between Rs.37277/ha in KPR soil (with BCR of 3.08) and Rs.9961/ha in HRV soil (with BCR of 2.85).

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 20. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the 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 90400/ha in maize.

Table 20: Economic land evaluation and bridging yield gap for different crops in Kokkargundi-3 micro-watershed

Particulars	KLK (<25cm)	HRV (25-50 cm)	NBP (25-50 cm)	AKT (25-50 cm)	KPR (100-150 cm)	BGP (>150 cm)	NGT (>150 cm)
	Maize	**Maize**	**Maize**	**Maize**	**Maize**	**Maize**	**Maize**
Total cost (Rs/ha)	14711	9961	26561	12840	37277	24813	19455
Gross Return (Rs/ha)	32225	28405	25688	31189	114652	27940	26758
Net returns (Rs/ha)	17514	18444	-873	18349	77376	3127	7304
BCR	2.22	2.85	0.97	2.40	3.08	1.20	1.38
Farmers Practices (FP)							
FYM (t/ha)	1.6	1.4	5.0	1.8	5.6	6.6	3.5
Nitrogen (kg/ha)	70.9	72.7	80.0	84.2	119.4	120.4	74.1
Phosphorus (kg/ha)	50.9	52.3	57.5	60.5	85.8	76.8	53.2
Potash (kg/ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	19.2	17.5	17.5	19.4	56.0	18.6	19.7
Price of Yield (Rs/Qtl)	1500	1500	1200	1500	2000	1350	1200
Soil test based fertilizer Recommendation (STBR)							
FYM (t/ha)	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Nitrogen (kg/ha)	154.4	154.4	123.5	123.5	154.4	154.4	123.5
Phosphorus (kg/ha)	77.2	61.8	77.2	77.2	77.2	69.5	77.2
Potash (kg/ha)	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Grain (Qtl/ha)	84.0	84.0	84.0	84.0	84.0	84.0	84.0
% of Adoption/yield gap (STBR-FP) / (STBR)							
FYM (%)	81.1	84.2	42.2	79.2	35.3	24.0	59.8
Nitrogen (%)	54.1	52.9	35.2	31.8	22.7	22.0	40.0
Phosphorus (%)	34.0	15.3	25.5	21.6	-11.2	-10.5	31.0
Potash (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Grain (%)	77.1	79.2	79.2	76.9	33.4	77.9	76.6
Value of yield and Fertilizer (Rs)							
Additional Cost (Rs/ha)	9815	9320	5675	8692	3730	2805	7462
Additional Benefits (Rs/ha)	97137	99720	79776	96861	56020	88312	77165
Net change Income (Rs/ha)	87322	90400	74101	88169	52290	85508	69703

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 21and Figure 9. The average value of soil nutrient loss is around Rs 443.21 per ha/year. The total cost of annual soil nutrients is around Rs 136065 per year for the total area of 322.24 ha.

Table 21: Estimation of onsite cost of soil erosion in Kokkargundi-3 micro-watershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	61.97	19025	390.42	119859
Phosphorous	0.04	11	1.62	499
Potash	0.79	241	15.71	4822
Iron	0.04	13	2.07	635
Manganese	0.09	27	23.85	7322
Cupper	0.01	3	5.09	1562
Zinc	0.00	1	0.15	45
Sulpher	0.10	32	4.18	1284
Boron	0.00	1	0.12	36
Total	49.12	19354	443.21	136065

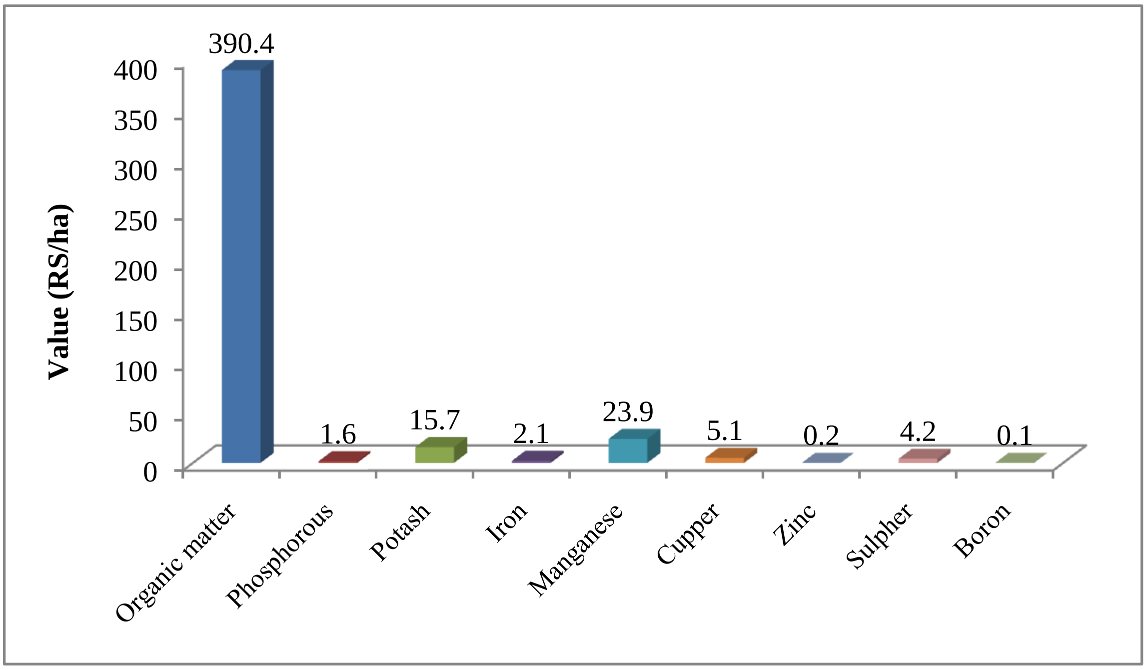

Figure 9: Estimation of onsite cost of soil erosion in Kokkargundi-3micro-watershed

The average value of ecosystem service for food grain production is around Rs 12662/ ha/year in maize (Rs 12662) (Table 22and Figure 11).

Table 22: Ecosystem services of food grain production in Kokkargundi-3Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Cereals	Maize	14.8	22	1460	32460	19798	12662

The average value of ecosystem service for fodder production is around Rs 3337/ ha/year in maize (Rs 3337/ha) (Table 23).

Table 23: Ecosystem services of fodder production in Kokkargundi-3Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	14.8	3.2	1030	3337

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 24 and Figure 12) in Maize (Rs 27169).

Table 24: Ecosystem services of water supply in Kokkargundi-3Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Maize	22.2	2717	27169	122

The main farming constraints in Kokkargundi-3 micro-watershed to be found are less rainfall, and damage of crops by wild animals, Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 25).

Table 25: Farming constraints related land resources of sample households in Kokkargundi-3 Microwatershed

Sl. no	Particulars	Per cent
1	Less Rainfall	70.0
2	Damage of crops by Wild Animals	100.0
3	Non availability of Plant Protection Chemicals	100.0
4	**Source of loan**	
	Bank	20.0
	Money Leander	80.0
5	**Market for selling**	
	Regulated	20.0
	Village market	80.0
6	**Sources of Agri-Technology information**	
	Newspaper	100.0

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.