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

CHIK HANGARGI-3 (4D5A3Q2d) MICROWATERSHED

Jewargi Taluk, Gulbarga 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 Chik Hangargi-3 Microwatershed, Jewargi Taluk, Gulbarga District, Karnataka” for integrated development was taken up in collaboration with then State Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

Nagpur **S.K. SINGH**

Date: 26.05.2018 Director, ICAR - NBSS&LUP, Nagpur

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The Crop resource inventory of Chik Hangargi-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 these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soil map shows the geographic distribution and extent, characteristics, classification, behaviour and use potentials of the soils in the microwartershed.

The present study covers an area of 561 ha in Chik Hangargi-3 microwatershed in Jewargi taluk of Gulbarga district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 751 mm, of which about 538 mm is received during south–west monsoon, 138 mm during north-east and the remaining 75 mm during the rest of the year. 98 per cent area is covered by soils and 2 per cent is by habitation and waterbodies. The salient findings from the Crop resource inventory are summarized briefly below.

- *The soils belong to 5 soil series and 14 soil phases (management units) and 4 Crop use classes.*
- *The length of Crop growing period is about 150 days starting from the 1st week of June to 1st week of October.*
- *From the master soil map, several interpretative and thematic maps like Crop 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.*
- *Crop suitability for growing 19 major agricultural and horticultural Crops were assessed and maps showing the degree of suitability along with the constraints were generated.*
- *98 per cent area is suitable for agriculture and 2 per cent is not suitable.*
- *About 42 per cent of the soils are very deep (>150 cm) and 29 per cent is deep (100-150 cm), 1 per cent is moderately deep (75-100 cm), 19 per cent is shallow (25-50 cm) and 6 per cent are very shallow (<25cm) soils.*
- *An area of 93 per cent in the microwatershed has clayey soils at the surface and about 5 per cent loamy at the surface.*
- *About 79 per cent of the area has non-gravelly (<15%) and 19 per cent are gravelly (15-35%) soils.*
- *About 42 per cent of the area has soils that are very high (>200mm/m) and 30 per cent medium (101-150 mm/m) in available water capacity. About 19 per cent low (50-100 mm/m) and very low (<50 mm/m) in 6 per cent area.*
- *About 78 per cent of the area has very gently sloping (1-3%) Crops and 20 per cent nearly level (0-1%) Crops.*
- *An area of about 50 per cent has soils that are slightly eroded (e1), 48 per cent moderately eroded (e2) soils.*
- *An area of about 77 per cent has soils that are strongly alkaline (pH 8.4-9.0) and 20 per cent very strongly alkaline (>9.0).*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dS m^{-1} indicating that the soils are non-saline.*

- *About 285 ha (51%) area is low (<0.5%) in organic carbon and medium (0.5-0.75%) in about 264 ha (47%) in organic carbon.*
- *Major area of 98 per cent has soils that are low (<23 kg/ha) in available phosphorus.*
- *About 87 per cent high (>337 kg/ha) and 11 per cent medium (145-337 kg/ha) in available potassium.*
- *Available sulphur is medium (10-20 ppm) in 38 per cent, 50 per cent high (>20 ppm) and 10 per cent low (<10).*
- *Available boron is low (<0.5 ppm) in about 11 per cent area, medium (0.5-1.0 ppm) in about 79 per cent area and high (>1.0 ppm) in about 7%.*
- *Major area is sufficient (>4.5 ppm) and 3 per cent is deficient (<4.5ppm) in available iron.*
- *Available manganese and copper are sufficient in all the soils.*
- *Entire area is deficient (<0.6 ppm) in available zinc.*
- *The Crop suitability for 19 major Crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various Crops but what specific Crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.*

Crop 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	*406 (72)*	*-*		*Guava*	*-*	*238 (42)*
Maize	*-*	*-*		*Jackfruit*	*-*	*-*
Red gram	*-*	*406 (72)*		*Jamun*	*-*	*402 (71)*
Soybean	*242 (43)*	*164 (29)*		*Musambi*	*402 (71)*	*4 (1)*
Bengalgram	*406 (72)*	*107 (19)*		*Lime*	*402 (71)*	*4 (1)*
Sunflower	*406 (72)*	*-*		*Cashew*	*-*	*-*
Cotton	*402 (71)*	*4 (1)*		*Custard apple*	*406 (72)*	*-*
Sugarcane	*-*	*-*		*Amla*	*406 (72)*	*-*
Mango	*-*	*-*		*Tamarind*	*-*	*402 (71)*
Sapota	*-*	*238 (42)*				

Apart from the individual Crop suitability, a proposed Crop plan has been prepared for the 4 identified LUCs by considering only the highly and moderately suitable Crops for different Crops and Cropping systems with food, fodder, fibre and horticulture Crops that helps in maintaining the productivity and ecological balance in the microwatershed.

- *Maintaining soil-health is vital to Crop production and conserve soil and Crop resource base for maintaining ecological balance and to mitigate climate change. For this, several ameliorative measures have been suggested to these problematic soils like saline/alkali, highly eroded, sandy soils etc.*
- *Soil and water conservation treatment plan has been prepared that would help in identifying the sites to be treated and also the type of structures required.*

- *As part of the greening programme, several tree species have been suggested to be planted in marginal and submarginal Crops, field bunds and also in the hillocks, mounds and ridges that would help in supplementing the farm income, provide fodder and fuel and generate lot of biomass.This would help in maintaining ecological balance and contribute to mitigating the climate change.*

Chapter 1

INTRODUCTION

Land is a scarce resource and basic unit for any material production. It can support the needs of the growing population, provided they use the land in a rational and judicious manner. But what is happening in many areas of the state is a cause for concern to everyone involved in the management of land resources at the grassroots level. 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. The limited land area is under severe stress and strain due to increasing population pressure and competing demands of various land uses. Due to this, every year there is significant diversion of farm lands and water resources for non-agricultural purposes. Apart from this, due to lack of interest in farmers for farming, large tracts of cultivable lands are turning into fallows in many areas and this trend is continuing at an alarming rate.

Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the state. Soil erosion alone has degraded about 35 lakh ha. Almost all the areas are facing various degrees of degradation, particularly soil erosion. Salinity and alkalinity has emerged as a major problem in more than 3.5 lakh ha in the irrigated areas of the state. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. The continued neglect and unscientific use of the resources for a long time has led to the situation observed at present in the state. It is a known fact and established beyond doubt by many studies in the past that the cause for all kinds of degradation is the neglect and irrational use of the land resources. Hence, there is an urgent need to generate a 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 not only the surface but also consider the other parameters which are critical for productivity *viz.*, soil, climate, water, minerals and rocks, topography, geology, hydrology, vegetation, crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed.

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

The land resource inventory aims to provide site specific database for Chik Hangargi-3 micro-watershed, Chik Hangargi sub-watershed in Jewargi taluk, Kalaburagi district, Karnataka State for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological Units (LEUs) map.

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

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Chik Hangargi-3 microwatershed (Chik Hangargi sub-watershed) is located in the northern part of Karnataka in Jewargi Taluk, Kalaburagi District, Karnataka State (Fig. 2.1). It comprises parts of Sumbada and Yedrami villages. It lies between $16^{0}47'$ and $16^{0}49'$ North latitudes and $76^{0}32'$ and $76^{0}34'$ East longitudes and covers an area of 561 ha. It is about 80 km south of Kalaburagi and is surrounded by Sumbada village on the northern, southern, western and eastern part of the microwatershed.

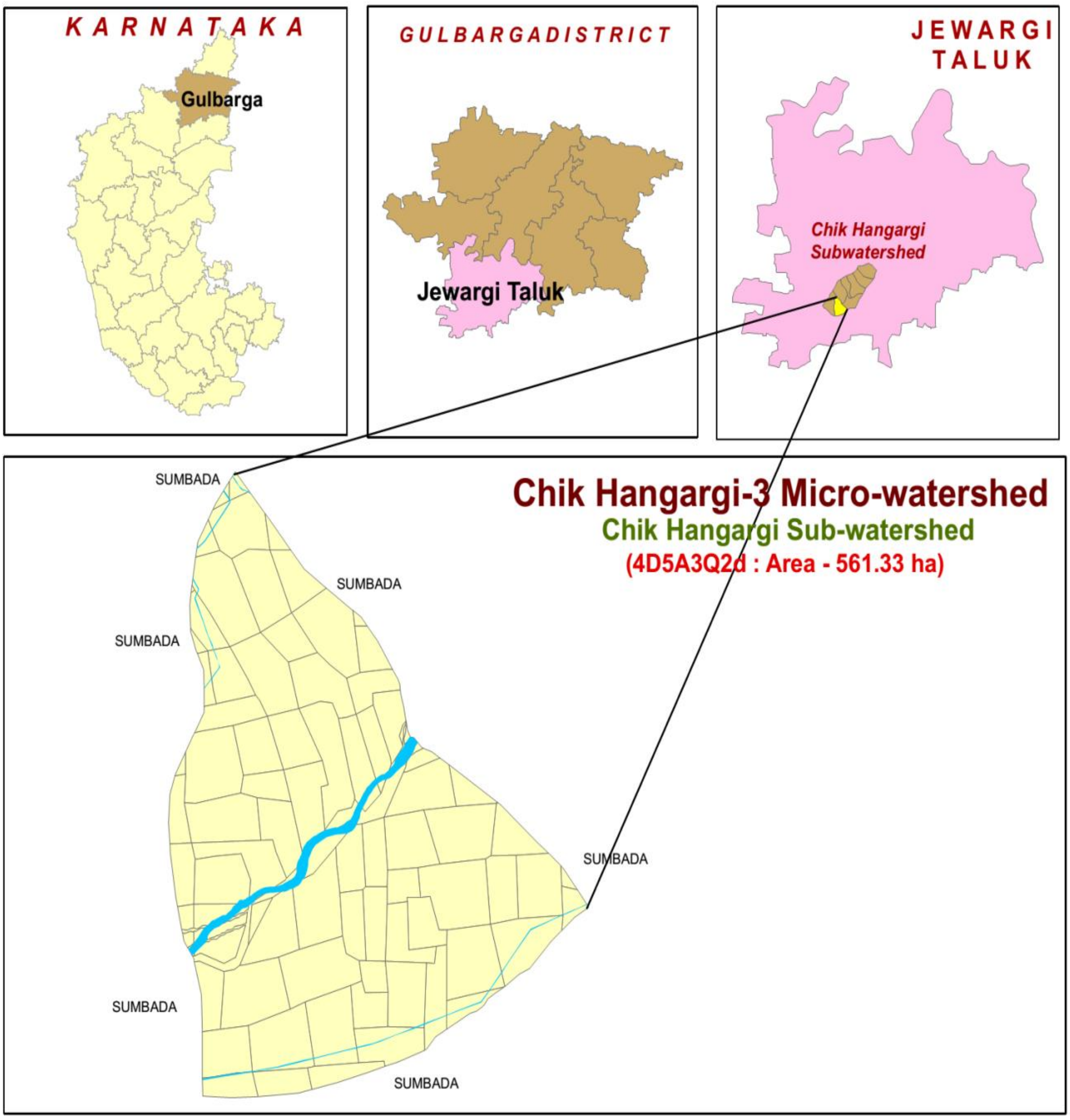


Fig. 2.1 Location map of Chik Hangargi-3 Microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Basalt or Deccan trap (Fig. 2.2). The Deccan Traps cover the whole of Bidar, parts of Kalaburgi, Bijapur and Belgaum districts. In all eight lava flows have been identified in Karnataka horizontally overlying the older formations. The thickness of the individual flows averages about five meters. It is relatively uniform in petrographic character. The most common type is augite basalt. Dominant colour is grayish green and texture ranges from cryptocrystalline to glassy. The rock is often vesicular and scoriaceous filled up with secondary minerals like coloured agate, quartz, calcite and a large variety of zeolites. The Deccan Traps form an excellent building material and also used as road-metal and railway ballast.

Fig. 2.2 Basalt rock

2.3 Physiography

Physiographically, the area has been identified as basalt landscape based on geology. Based on slope and its relief features, the area has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands. The elevation ranges from 435 to 455 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

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

2.5 Climate

The district falls under semiarid tract and is categorized as drought-prone with average annual rainfall of 751 mm (Table 2.1). Of the total rainfall, a maximum of 538 mm is received during south-west monsoon period from June to September, north-east monsoon from October to early December contributes about 138 mm and the remaining

75 mm is received during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 42° C and in December and January, the temperatures will go down to 16° C.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET in Jewargi Taluk, Kalaburagi District

Sl. no.	Months	Rainfall	PET	1/2 PET
1	JAN	3.40	126.80	63.40
2	FEB	2.00	143.90	71.95
3	MAR	12.70	189.90	94.95
4	APR	21.90	209.80	104.90
5	MAY	34.60	232.20	116.10
6	JUN	109.20	186.40	93.20
7	JUL	128.20	152.80	76.40
8	AUG	141.30	147.60	73.80
9	SEP	159.00	131.70	65.85
10	OCT	104.90	145.50	72.75
11	NOV	28.60	129.80	64.90
12	DEC	4.90	114.80	57.40
Total		**750.70**	**159.27**	

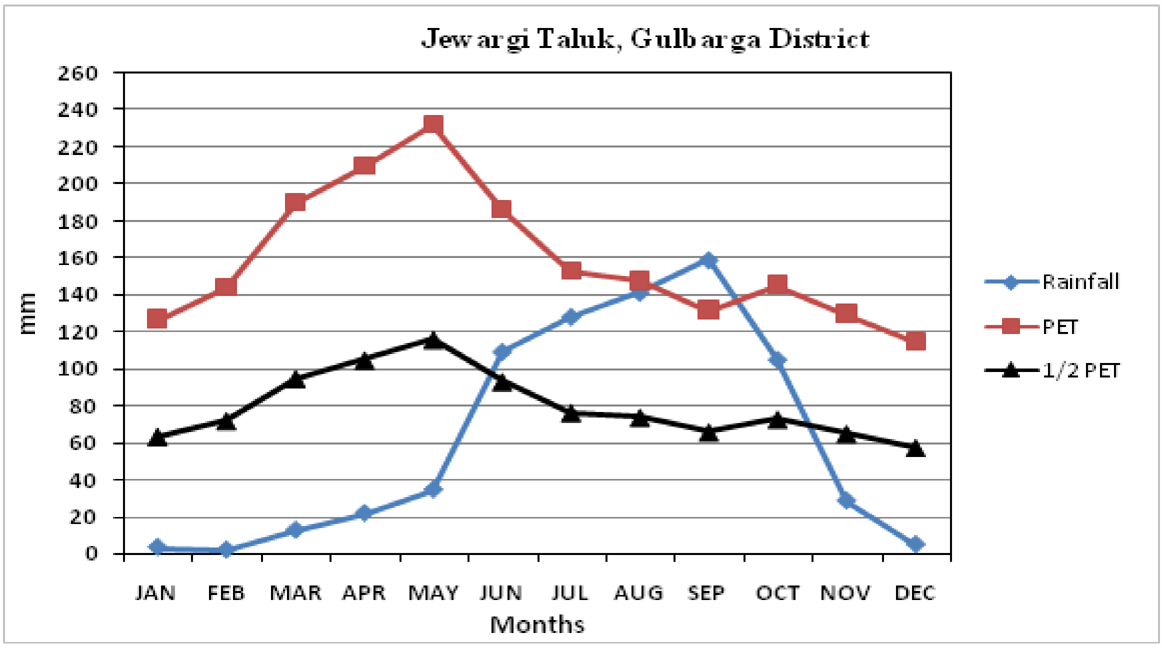


Fig 2.3 Rainfall distribution in Jewargi Taluk, Kalaburagi District

Rainfall distribution is shown in Figure 2.3. The average Potential Evapo-transpiration (PET) is 159 mm and varies from a low of 115 mm in December to 232 mm in the month of May. The PET is always higher than precipitation in all the months except in September. Generally, the Length of crop Growing Period (LGP) is 150 days and starts from 1st week of June to 1st week of October.

2.6 Natural Vegetation

The natural vegetation is sparse comprising few tree species, shrubs and herbs. The mounds, ridges and boulders occupy very sizeable areas which are under thin to moderately thick forest vegetation. Still, there are some remnants of the past forest cover which can be seen in patches in some ridges and hillocks in the microwatershed (Fig. 2.4).

Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the microwatershed is causing vegetative degradation of whatever little vegetation left in the area. The uncontrolled grazing has left no time for the regeneration of the vegetative cover. This leads to the accelerated rate of erosion on the hill slopes, resulting in the formation of deep gullies in the foot slopes that eventually result in the heavy siltation of tanks and reservoirs in the microwatershed.

Fig. 2.4. Natural Vegetation of Chik Hangargi-3 Microwatershed

2.7 Land Utilization

About 84 per cent area (Table 2.2) in Jewargi taluk is cultivated at present. An area of about 4 per cent is permanently under pasture, one per cent each under non agricultural land and currently barren. Forests occupy an area of about less than one 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, Soybean, Cotton, Redgram and Sapota. The cropping intensity in the taluk is 106 per cent. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is generated. The current land use map generated shows the arable and non-arable lands, other land uses and different types of crops grown (Figure 2.5). Simultaneously, enumeration of wells (bore wells and open wells) and existing conservation structures in the microwatershed are made and their location in different survey numbers is located on the cadastral map. No wells are existing in the microwatershed. Map showing the location of conservation structures and other water bodies in Chik Hangargi-3 microwatershed is given in Figure 2.6.

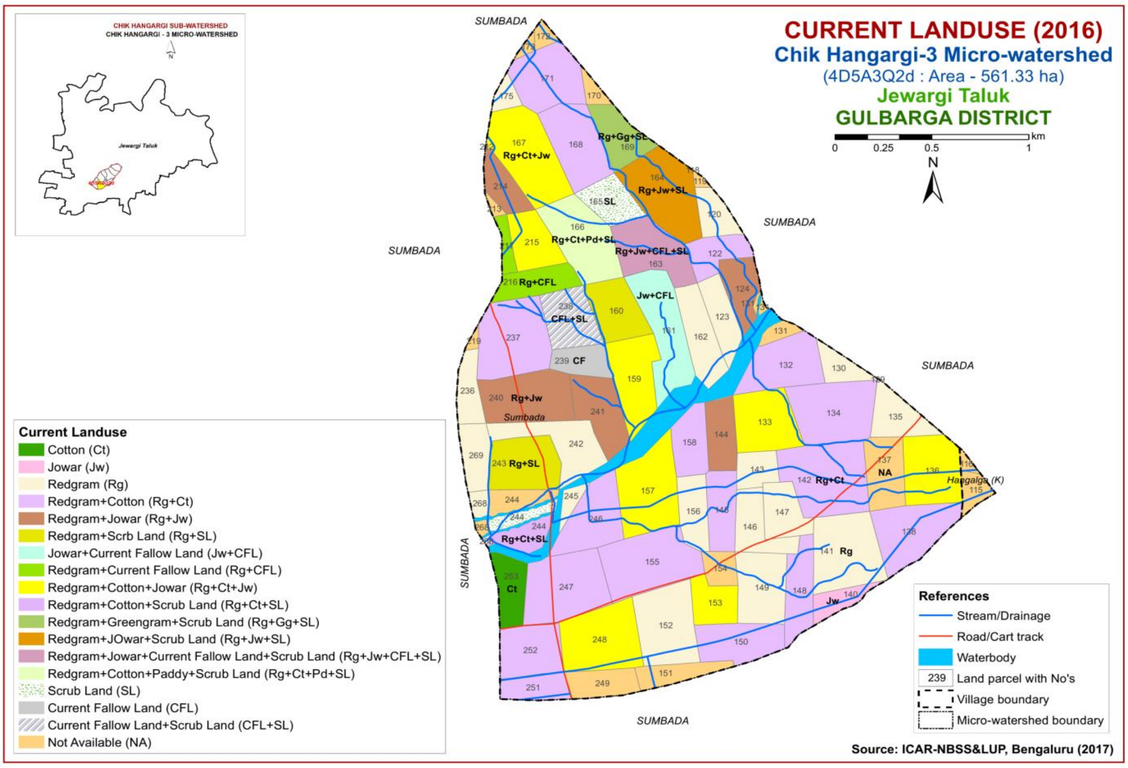


Fig.2.5 Current Land Use - Chik Hangargi-3 Microwatershed

Table 2.2 Land Utilization in Jewargi Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	182313	-
2.	Total cultivated area	153142	83.99
3.	Area sown more than once	8695	-
4.	Cropping intensity	-	105.67
5.	Trees and grooves	62	0.034
6.	Forest	310	0.17
7.	Cultivable wasteland	294	0.16
8.	Permanent Pasture land	6486	3.55
9.	Barren land	1838	1.00
10.	Non- Agriculture land	5317	2.91

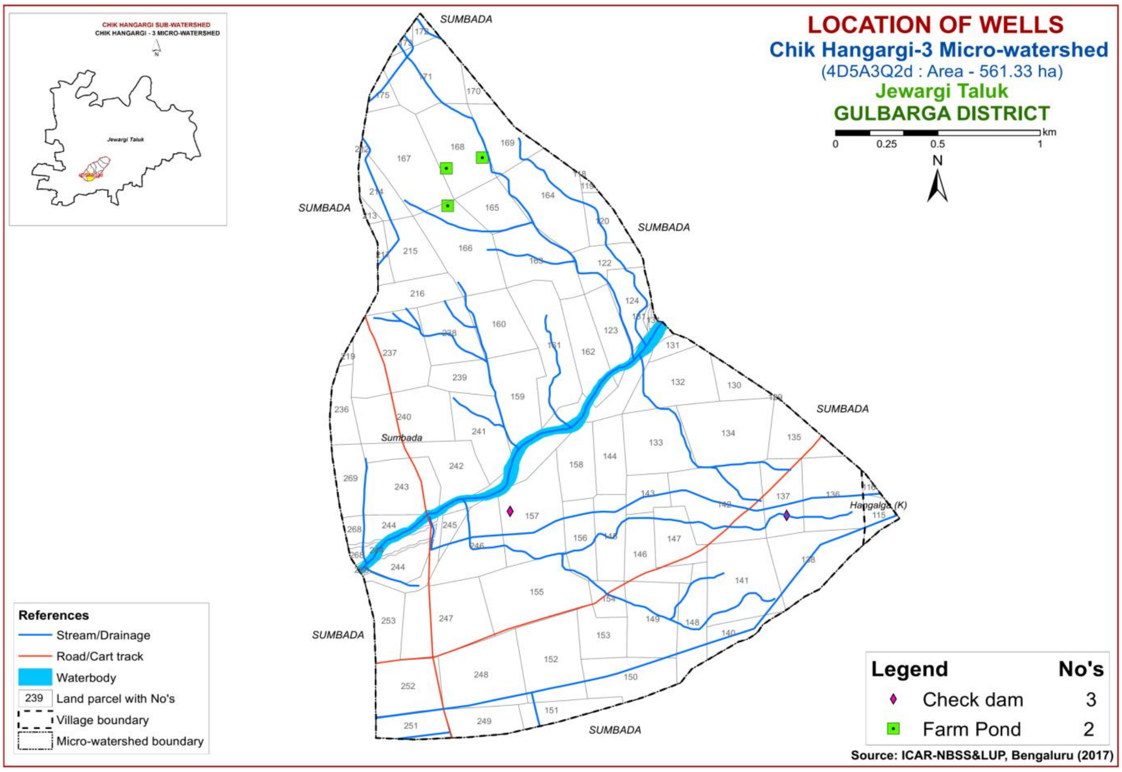


Fig. 2.6. Location of conservation structures in Chik Hangargi-3 Micro-watershed.

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 Chik Hangargi-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 561 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 as basalt landscape and is divided into landforms such as ridges, mounds and uplands based on slope and other relief features. They were further subdivided into physiographic/ image interpretation units based on image characteristics.

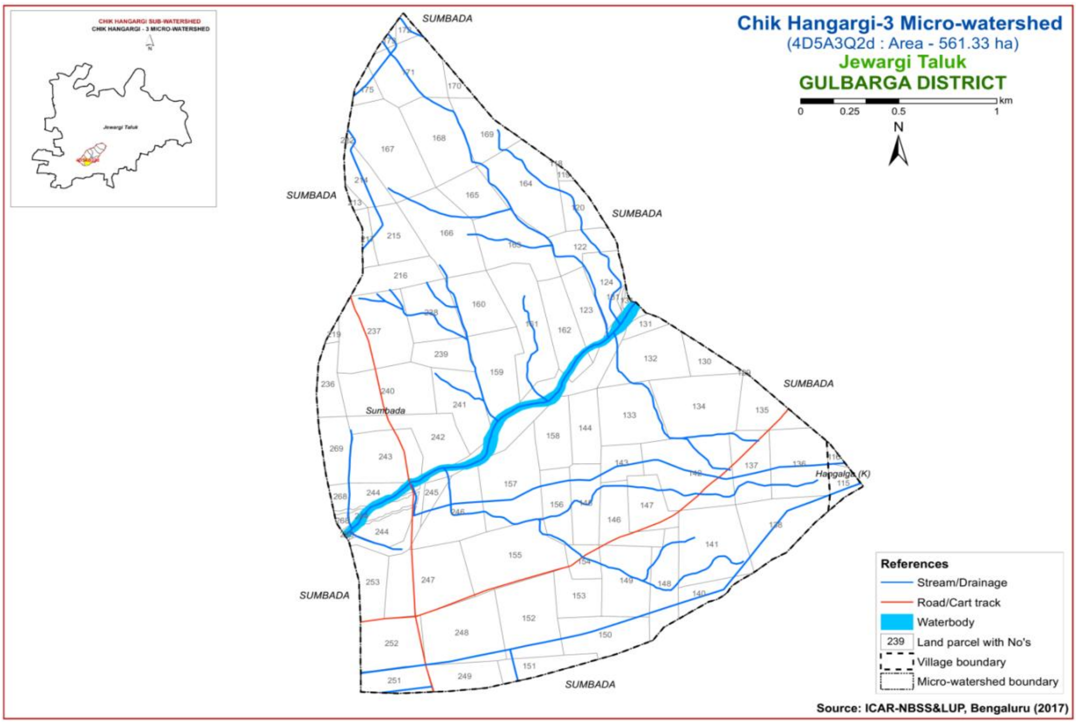


Fig 3.1 Scanned and Digitized Cadastral map of Chik Hangargi-3 Microwatershed

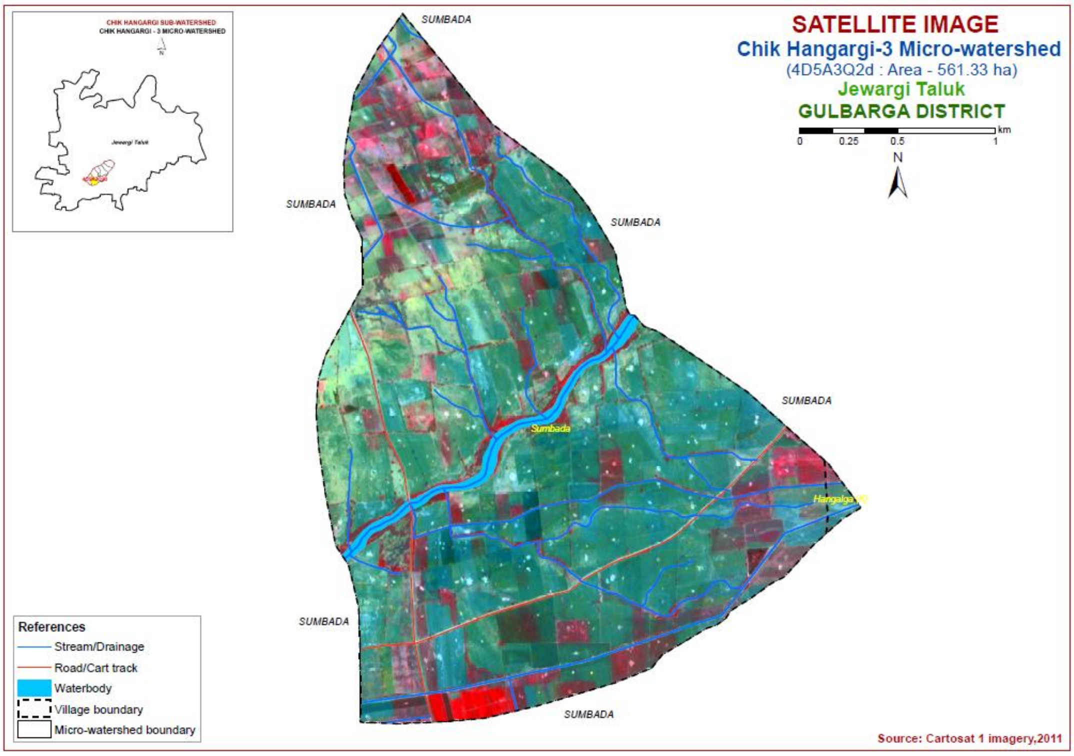


Fig. 3.2 Satellite Image of Chik Hangargi-3 Microwatershed

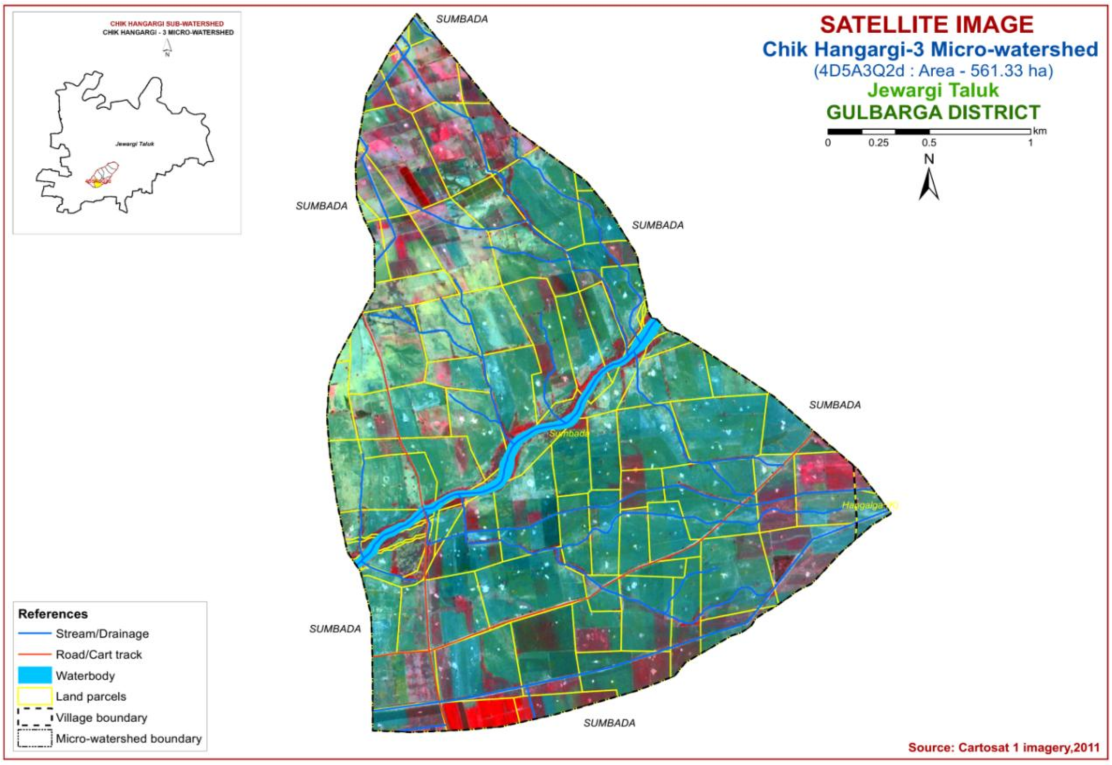


Fig. 3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Chik Hangargi-3 Microwatershed

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, ridges and uplands was carried out. Based on the variability observed on the surface, transects (Fig. 3.4) were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

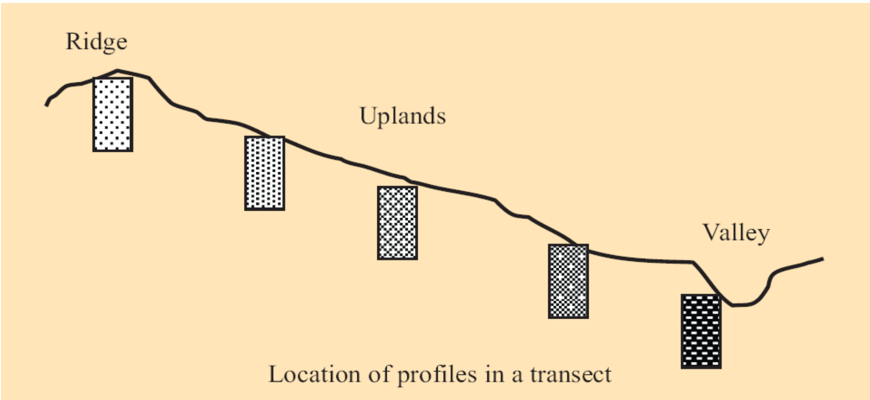


Fig: 3.4. Location of profiles in a transect

In the selected transect, soil profiles (Fig. 3.4) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, 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 the 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, calcareousness nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 5 soil series were identified in the Chik Hangargi-3 microwatershed.

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

	Soils of Basalt Landscape						
Sl No.	Series	Depth (cm)	Colour (moist)	Texture	Gravel (%)	Horizon sequence	Effer vesence
1.	Margutti (MGT)	<25	10YR3/3,4/3,5/4 7.5YR 4/3	c	15-35	Ap-R/cr	-
2.	Novinihala (NHA)	25-50	10YR3/2,3/1,4/2 7.5YR3/4	cl	15-35	Ap-Bw-cr/R	-
3.	Nirgudi (NIR)	75-100	10YR3/2,3/1	c	<15	Ap--Bss-cr	e-es
4.	Dimal (DIM)	100-150	10YR3/2,3/1	c	<15	Ap--Bss-cr	e-es
5.	Mannur(MAR)	>150	10YR3/2,3/1,4/3	c	<15	Ap-Bss	e-es

3.4 Soil Mapping

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. 3.5) in the form of symbols. During the survey about 19 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.The soil map shows the geographic distribution of 14 mapping units representing 5 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2. The soil phase map (management units) shows the distribution of 14 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and have to be treated accordingly.

The 14 soil phases identified and mapped in the microwatershed were grouped into 4 Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Use Classes (LUC's) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LUCs. For Chik Hangargi-3 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUSs. The land use classes are expected to behave similarly for a given level of management.

3.5 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (91 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 by using kriging method for the microwatershed.

Table 3.2 Soil map unit description of Chik Hangargi-3 Microwatershed

Soil map unit no.	Soil series	Soil phase	Mapping Unit Description	Area in ha(%)
	MGT		Margutti soils are very shallow (<25 cm), well drained, have very dark grayish brown to dark brown clayey soils occurring on very gently sloping to moderately sloping uplands.	**37 (6.45)**
1		MGThB1g1	Clay loam surface, 1-3% slope, slight erosion, gravelly(15-35%)	26 (4.55)
2		MGTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly(15-35%)	11 (1.9)
	NHA		Novinihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clayey soils occurring on very gently sloping to moderately sloping uplands	**107 (19.04)**
3		NHAmB1	Clay surface, 1-3% slope, slight erosion	29 (5.1)
4		NHAmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	13 (2.4)
5		NHAmB2	Clay surface, 1-3% slope, moderate erosion	29 (5.15)
6		NHAmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly(15-35%)	36 (6.36)
	NIR		Nirgudi soils are moderately deep (75-100 cm), moderately well drained, have very dark grayish brown to very dark gray calcareous cracking clay soils occurring on nearly level to very gently sloping uplands	**4 (0.8)**
7		NIRmB2	Clay surface, 1-3% slope, moderate erosion	4 (0.8)
	DIM		Dimal soils are deep (100-150 cm), moderately well drained, have very dark grayish brown to very dark gray calcareous cracking clay soils occurring on nearly level to very gently sloping and moderately sloping uplands	**164 (29.22)**
8		DIMmA1	Clay surface, 0-1% slope, slight erosion	67(11.99)
9		DIMmB1	Clay surface, 1-3% slope, slight erosion	26 (4.57)
10		DIMmB2	Clay surface, 1-3% slope, moderate erosion	50 (8.86)
11		DIMmB2g1	Clay surface,1-3% slope, moderate erosion, gravelly(15-35%)	21 (3.8)
	MAR		Mannur soils are very deep (>150 cm), moderately well drained, have very dark gray to brown calcareous cracking clay soils occuring on nearly level to very gently sloping uplands	**237 (42.33)**
12		MARmA1	Clay surface, 0-1% slope, slight erosion	44 (7.88)
13		MARmB1	Clay surface, 1-3% slope, slight erosion	77(13.79)
14		MARmB2	Clay surface, 1-3% slope, moderate erosion	116 (20.66)
15		Others	Habitation & waterbody	12 (2.18)

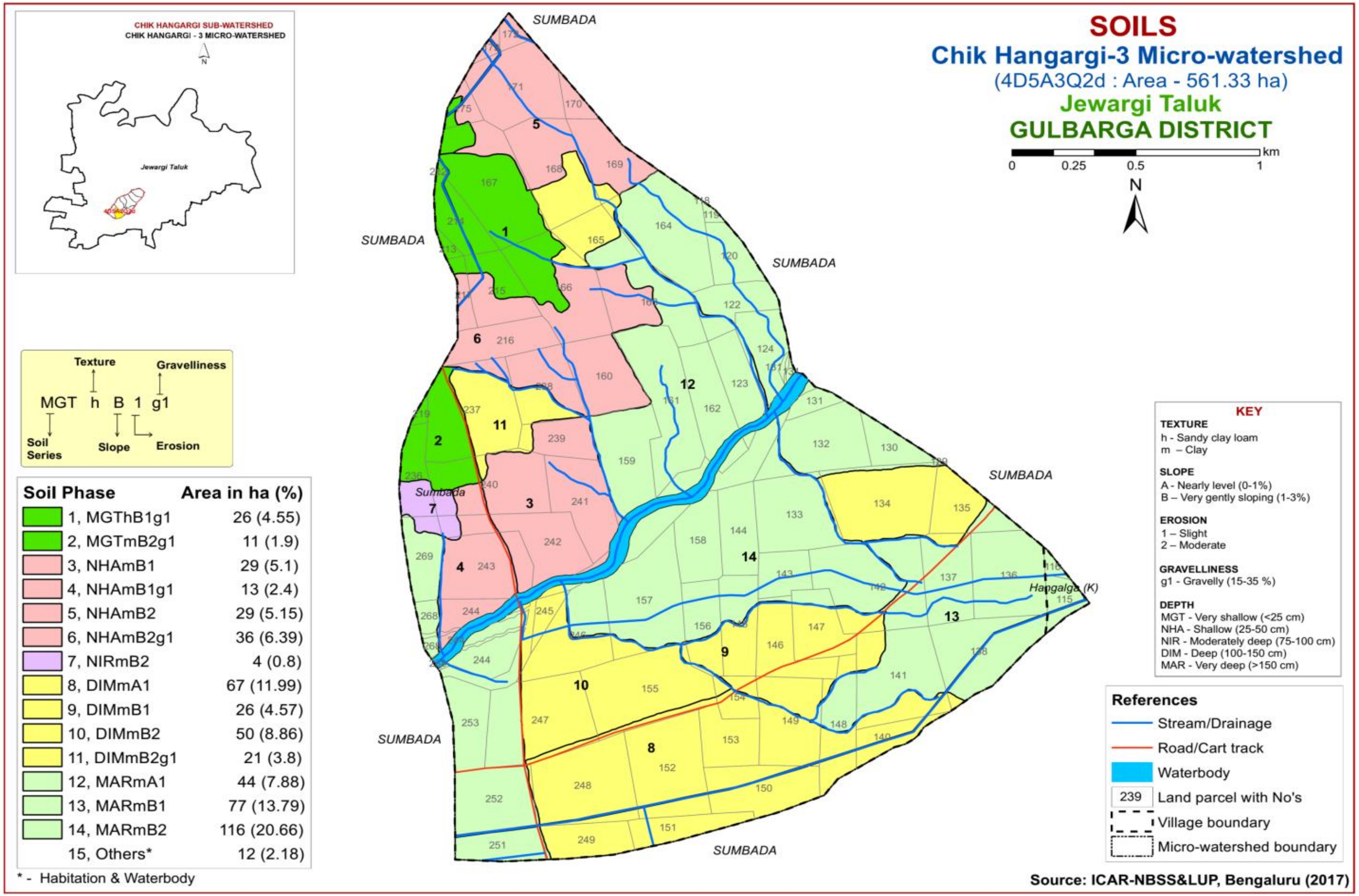


Fig 3.5 Soil Phase or Management Units - Chik Hangargi-3 Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Chik Hangargi-3 microwatershed is provided in this chapter. The microwatershed area has been identified as basalt landscape based on geology. In all, 5 soil series are identified. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. Soil formation in the basalt landscape is dominantly influenced by the parent material, climate and relief.

A brief description of each of the 5 soil series identified followed by 14 soil phases (management units) mapped (Fig. 3.5) 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 characteristic that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of the Basalt landscape

In this landscape, 5 soil series are identified and mapped. Brief description of each series and their phases identified are given below. Of these, Mannur (MAR) soil series occupies major area of about 237 ha (42%) followed by Dimal (DIM) soil series 164 ha (29%), Novinihala (NHA) soil series 107 ha (19%), Marguti (MGT) soil series 37 ha (6%) and Nirgudi (NIR) soil series 4 ha (0.8%) area in the microwatershed.

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

The total depth of the soil ranges from 10 to 23 cm. The thickness of A horizon ranges from 7 to 24 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. The texture is clay with 15 to 35 per cent gravel. The available water capacity is very low (<50 mm/m). Two phases were identified and mapped.

Landscape and Soil Profile characteristics of Margutti (MGT) Series

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

The thickness of the solum ranges from 27 to 48 cm. The thickness of A horizon ranges from 12 to 20 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from sandy clay to clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 22 to 37 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with gravel content of 10-15 per cent. The available water capacity is low (51-100 mm/m). Four phases were identified and mapped.

Landscape and Soil Profile characteristics of Novinihala (NHA) Series

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

The thickness of the solum ranges from 73 to 100 cm. The thickness of A horizon ranges from 10 to 22 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 2. The texture is clay. The thickness of B horizon ranges from 63 to 79 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 1. Its texture is clay and are calcareous with gravel content of less than 15 per cent. The available water capacity is medium (101-150 mm/m). Only one phase was identified and mapped.


Landscape and Soil Profile characteristics of Nirgudi (NIR) Series

4.1.4 Dimal (DIM) Series: Dimal soils are deep (100-150 cm), moderately well drained, have very dark grayish brown to very dark gray calcareous cracking clay soils. They have developed from basalt and occur on nearly level to very gently sloping and moderately sloping uplands.

The thickness of the solum ranges from 101 to 148 cm. The thickness of A horizon ranges from 14 to 23 cm. Its colour is in 10 YR hue with value 3 and chroma 1. The texture is clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 85 to 130 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 2. Its texture is clay with gravel content of less than 15 per cent and are calcareous. The available water capacity is very high (>200 mm/m). Four phases were identified and mapped.

Landscape and Soil Profile characteristics of Dimal (DIM) Series

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

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 18 to 25 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 1. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 128 to 175 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 3. Its texture is clay with gravel content of less than 15 per cent and are calcareous. The available water capacity is very high (>200 mm/m). Three phases were identified and mapped.

Landscape and Soil Profile Characteristics of Mannur (MAR) Series

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

Soil Characteristics: Depth, texture, gravelliness, calcareousness.

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

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

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

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

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

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

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

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

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

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

Class VIII: Soil and other miscellaneous areas (rock lands) that have very severe limitations that nearly preclude their use for any crop production, but suitable for wildlife, recreation and installation of 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 14 soil map units identified in the Chik Hangargi-3 microwatershed are grouped under 3 land capability classes and five subclasses. An entire area in the microwatershed is suitable for agriculture (Fig. 5.1).

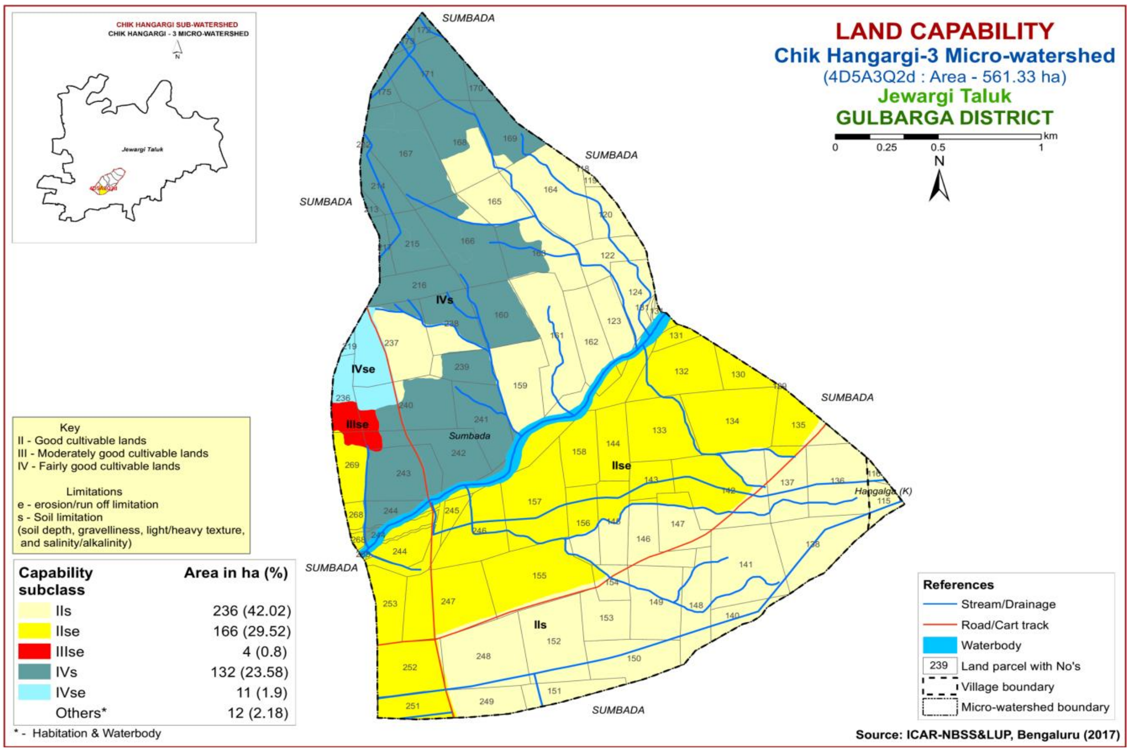


Fig. 5.1 Land Capability map of Chik Hangargi-3 Microwatershed

Good cultivable lands (Class II) cover an area of about 72 per cent area and are distributed in the southern and southeastern part of the micowatershed with minor problems of soil. The moderately good cultivable lands (Class III) cover a small area of about one per cent. They have moderate limitations of soil and erosion. They are distributed in the southern, southwestern, southeastern, central, eastern and small area in the northeastern part of the microwatershed. The fairly good cultivable lands (Class IV) cover a large area of about 25 per cent. They have severe limitations of soil and are distributed in the northwestern and western part of the microwatershed.

5.2 Soil Depth

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

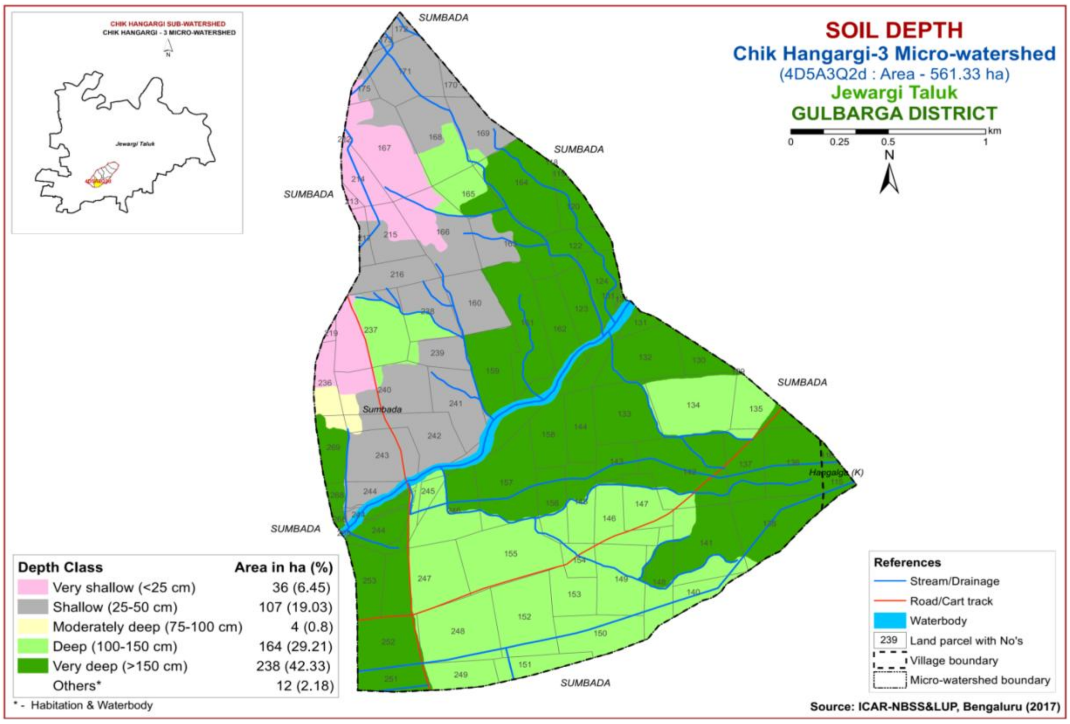


Fig. 5.2 Soil Depth map of Chik Hangargi-3 Microwatershed

Moderately deep soils (75-100 cm) cover an area of about 4 ha (1%) and are distributed in a small area of western part of the microwatershed. Very deep (>150 cm) soils covers major area of 238 ha (42%) and are distributed in the southwestern, southeastern, central and eastern part of the microwatershed. An area of about 164 ha (29%) is deep (100-150 cm) soils and are distributed in the eastern, southern, western and northern part of the microwatershed. The most productive lands of 402 ha (71%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are very deep (>150 cm) and deep (100-150 cm) occurring in major part of the microwatershed.

The most problem lands with an area of about 107 ha (19%) having shallow (25-50 cm) rooting depth occur in the western and northern, and 36 ha (6%) with very shallow (<25 cm) soils occur in the northwestern and western part of the microwatershed. They are not suitable for growing agricultural crops but well suited for pasture, forestry or other recreational purposes.

5.3 Surface Soil Texture

Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of primary particles of sand, silt and clay. It has a direct bearing on the structure, porosity, adhesion and consistence. The surface layer of a soil to a depth of about 25 cm is the layer that is most used by crops and plants. The surface soil textural class provides a guide to understanding soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behaviour, microbial activity and crop suitability. The textural classes used for LRI were used to classify the soils and a surface soil texture map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.3. Major area in the microwatershed is clayey at the surface (Fig. 5.3). About 26 ha (4%) area is loam in texture and distributed in the northwestern part of the microwastershed.

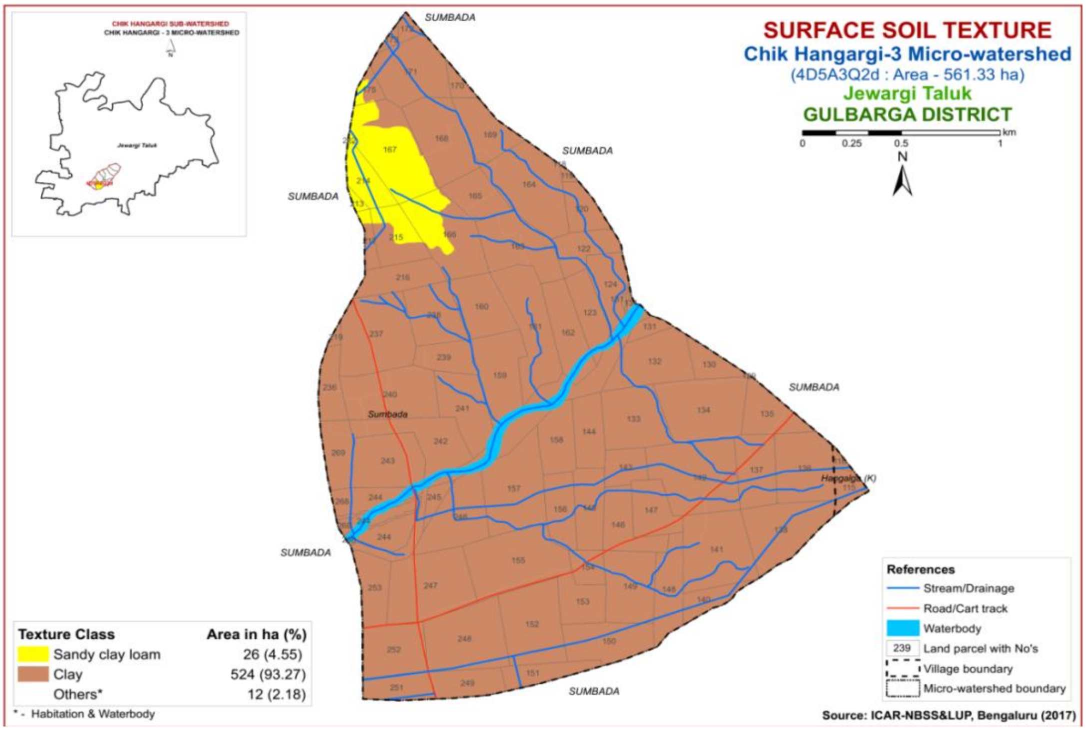


Fig. 5.3 Surface Soil Texture map of Chik Hangargi-3 Microwatershed

Entire area has most productive lands (93%) with respect to surface soil texture where they are clayey 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.

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization. The gravelliness classes used in LRI were used to classify the soils and using these classes a gravelliness map was generated. The area extent and their geographic distribution in the microwatershed is shown in Figure 5.4.

Major area of about 442 ha (79%) is non gravelly (<15%) and are distributed in all parts of the microwaterhsed. An area of 107 ha (19%) is gravelly distributed in the northwestern part of microwatershed.

The most productive lands with respect to soil gravelliness are found to be 79 per cent and distributed in major part of the microwatershed. They are non gravelly (<15% gravel) and have high potential for growing both annual and perennial crops.

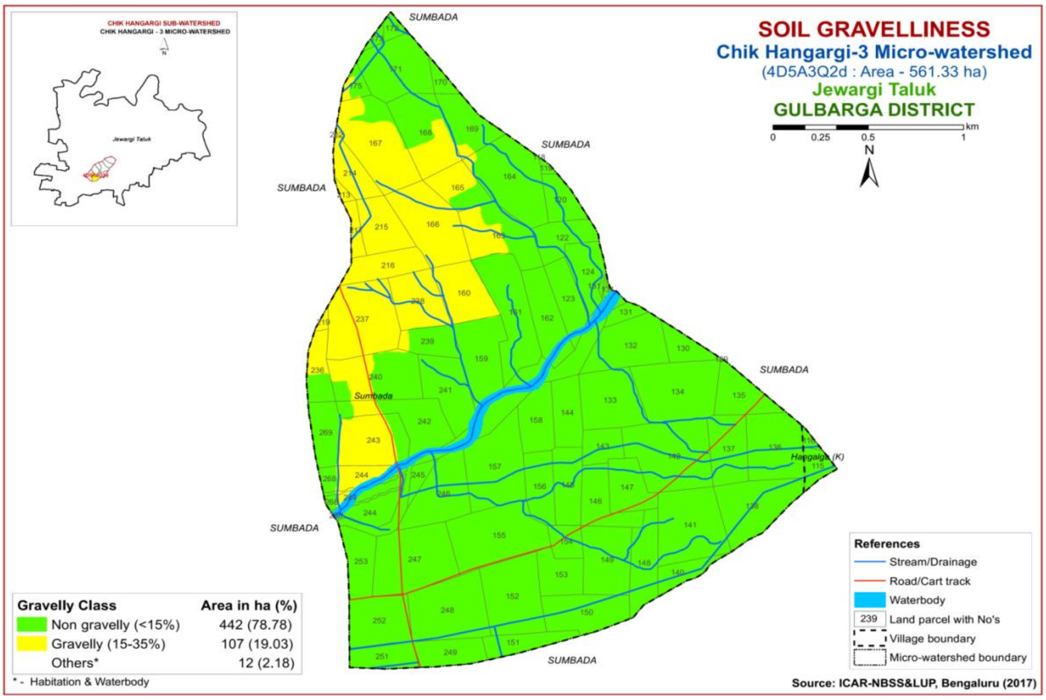


Fig. 5.4 Soil Gravelliness map of Chik Hangargi-3 Microwatershed

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 (51-100 mm/m), medium (100-150 mm/m), high (150-200 mm/m) and very high (>200 mm/m) and using these values, an AWC map was generated. The area extent and their geographic distribution of different AWC classes in the microwatershed is given in Figure 5.5.

A small area of about 36 ha (6%) is very low (<50 mm/m) and are distributed in the western and northwestern part of the microwatershed. An area of about 107 ha (19%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the northeastern and western part of the microwatershed. About 168 ha (30%) areas are medium in available water capacity and are distributed in the southern eastern, western and northern part of the microwatershed. An area of about 238 ha (42%) is very high (>200 mm/m) in available water capacity and are distributed in the southwestern, central, eastern and southeastern parts of the microwateshed.

An area about 143 ha (25%) 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. An area of about 238 ha (42%) 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.

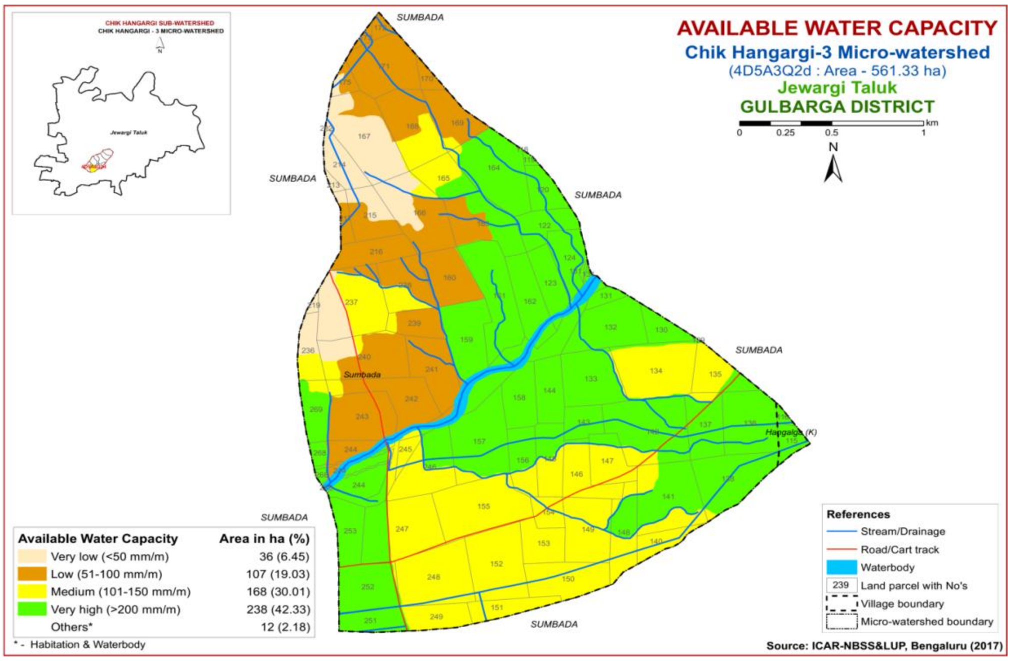


Fig. 5.5 Soil Available Water Capacity map of Chik Hangargi-3 Microwatershed

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 generated. The area extent and their geographic distribution of different slope classes in the microwatershed is given in Figure 5.6).

About 112 ha (20%) is under nearly level (0-1%) lands and are distributed in the southern and eastern part of the microwatershed. Major area of about 438 ha (78%) falls under very gently sloping (1-3% slope) lands and are distributed in all parts of the microwatershed. The most productive lands with respect to soil slopes cover entire area where all climatically adapted annual and perennial crops can be grown without much soil and water conservation, and other land development measures.

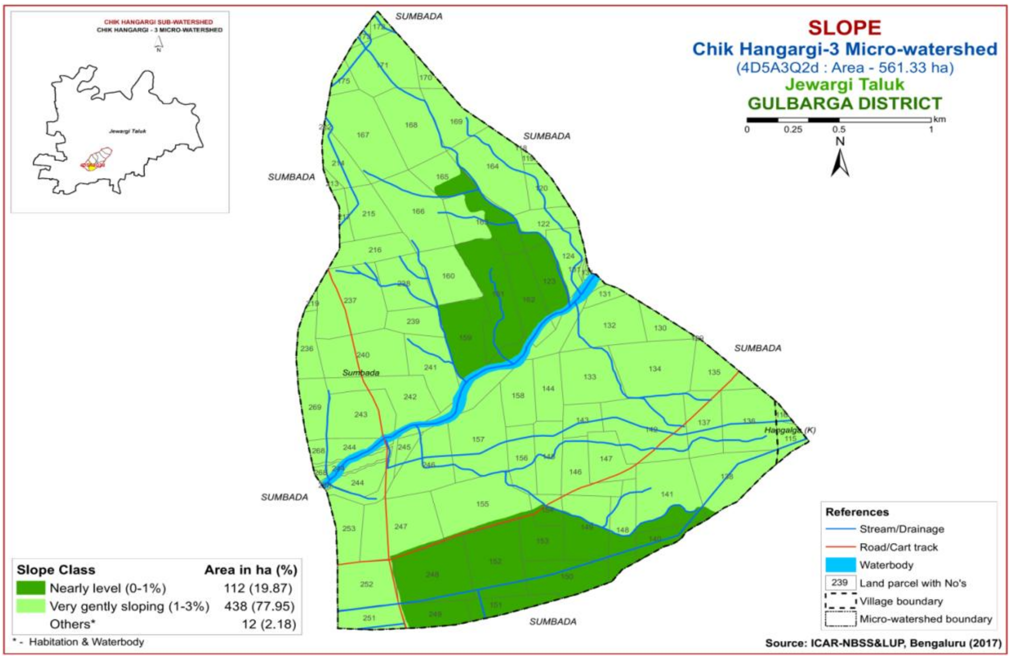


Fig. 5.6 Soil Slope map of Chik Hangargi-3 Microwatershed

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 a soil erosion map generated. The area extent and their spatial distribution in the microwatershed is given in Figure 5.7.

Soils that are moderately eroded (e2 class) cover an area of about 267 ha (47%) and distributed in the western, central, southwestern, southeastern and northeastern part of the microwatershed. Slightly eroded (e1 class) soils cover an area of about 282 ha (50%)

and are distributed in the southern, southeastern, northwestern, northestern and central part of the microwatershed.

An area of about 267 ha (47%) in the microwatershed is problematic because of moderate erosion. These areas need soil and water conservation and other land development measures for restoring the soil health.

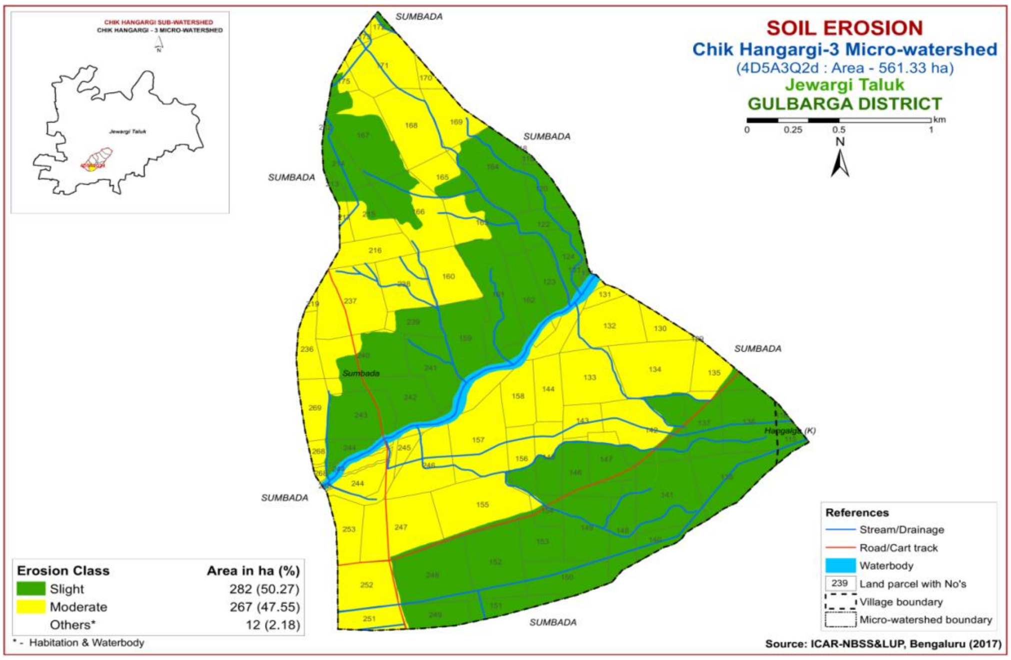


Fig. 5.7 Soil Erosion map of Chik Hangargi-3 Microwatershed

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 as these areas are characterised by low rainfall and high temperature. 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 (89 samples) from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2016 were analysed for pH, EC, organic carbon, available phosphorus and potassium, and for micronutrients like zinc, boron, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil analysis of the Chik Hangargi-3 microwatershed for soil reaction (pH) showed that an area of about 434 ha (77%) is strongly alkaline (pH 8.4-9.0) and occur in the major part of the microwatershed. Very strongly alkaline (pH >9.0) soils cover an area of 115 ha (20%) and occur in the central and southern part of the microwatershed (Fig. 6.1). Thus, all the soils in the microwaterhsed are alkaline in reaction.

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content (an index of available Nitrogen) in the soils of the microwatershed is low (<0.5%) in an area of about 285 ha (51%) and are distributed in the northern, northwestern, northeastern, western and small area is southern and southwestern part of the microwatershed. An area of 264 ha (47%) medium (0.5-0.75%) in organic carbon content and is distributed in the southern, southeastern, southwestern and small area is northern and northeastern part of the microwatershed (Fig. 6.3).

6.4 Available Phosphorus

Available phosphorus content is low (<23 kg/ha) in the entire area of 549 ha (98%) and is distributed in all parts of the microwatershed. (Fig. 6.4).

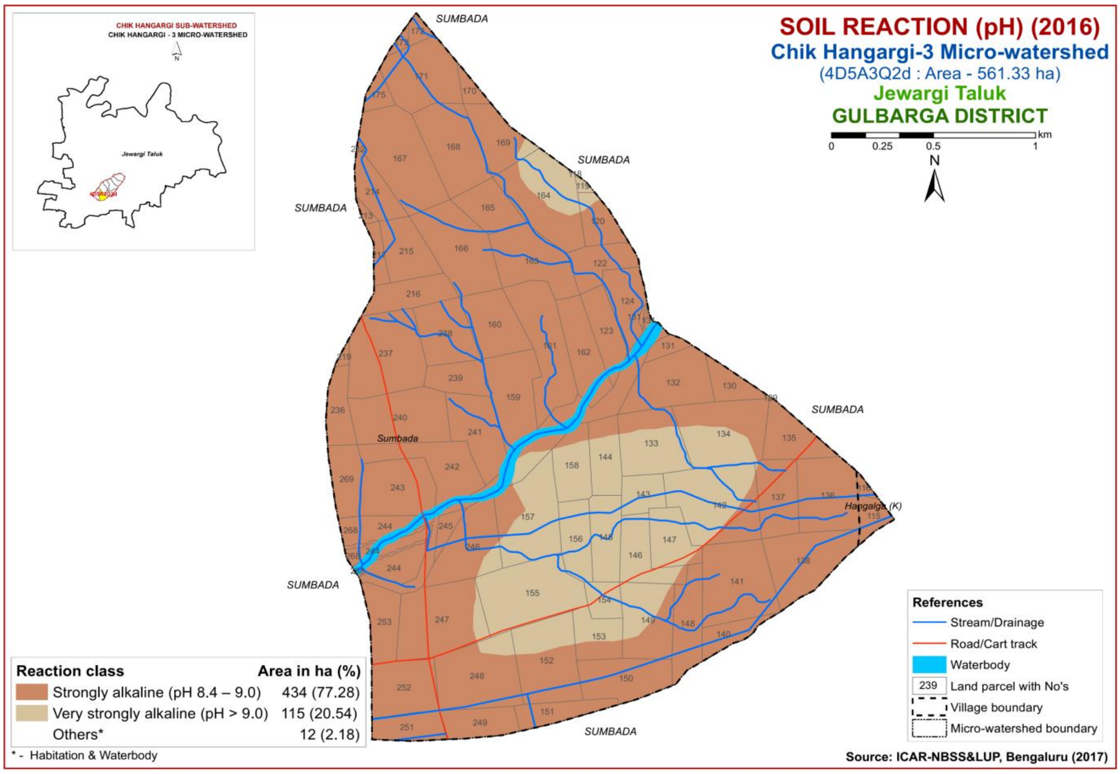


Fig. 6.1 Soil Reaction (pH) map of Chik Hangargi-3 Microwatershed

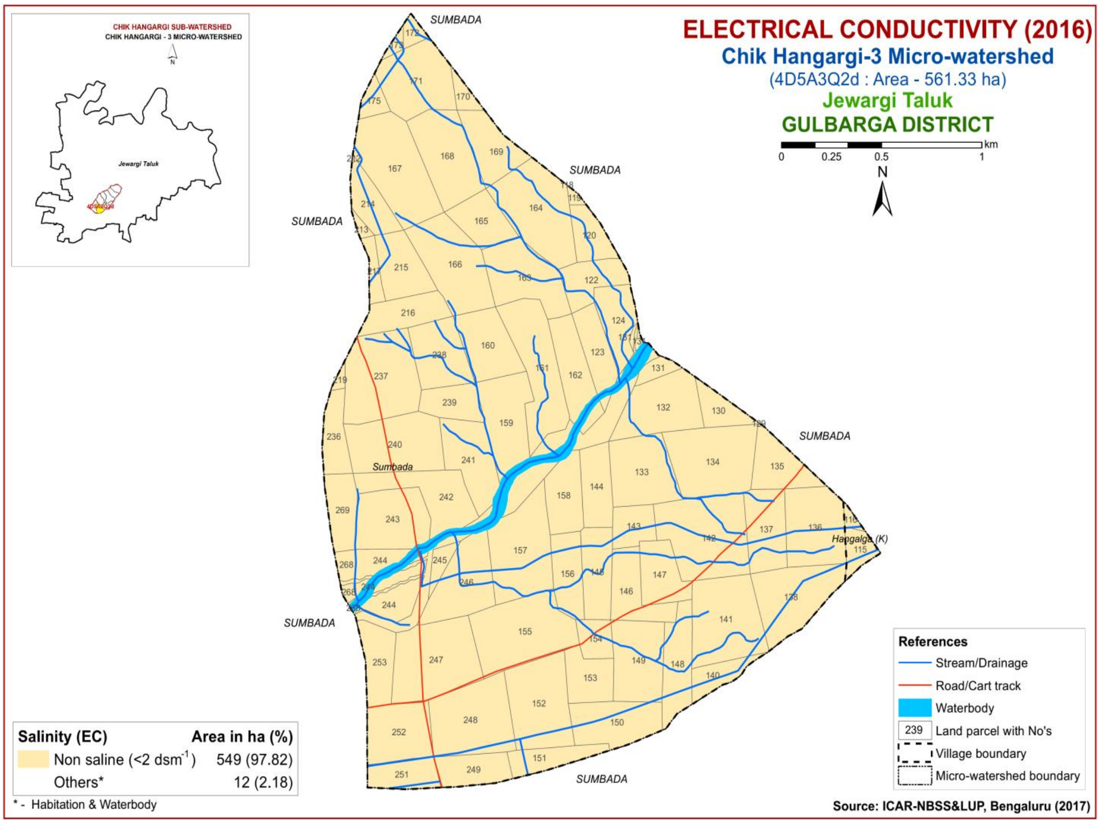


Fig. 6.2 Electrical Conductivity (EC) map of Chik Hangargi-3 Microwatershed

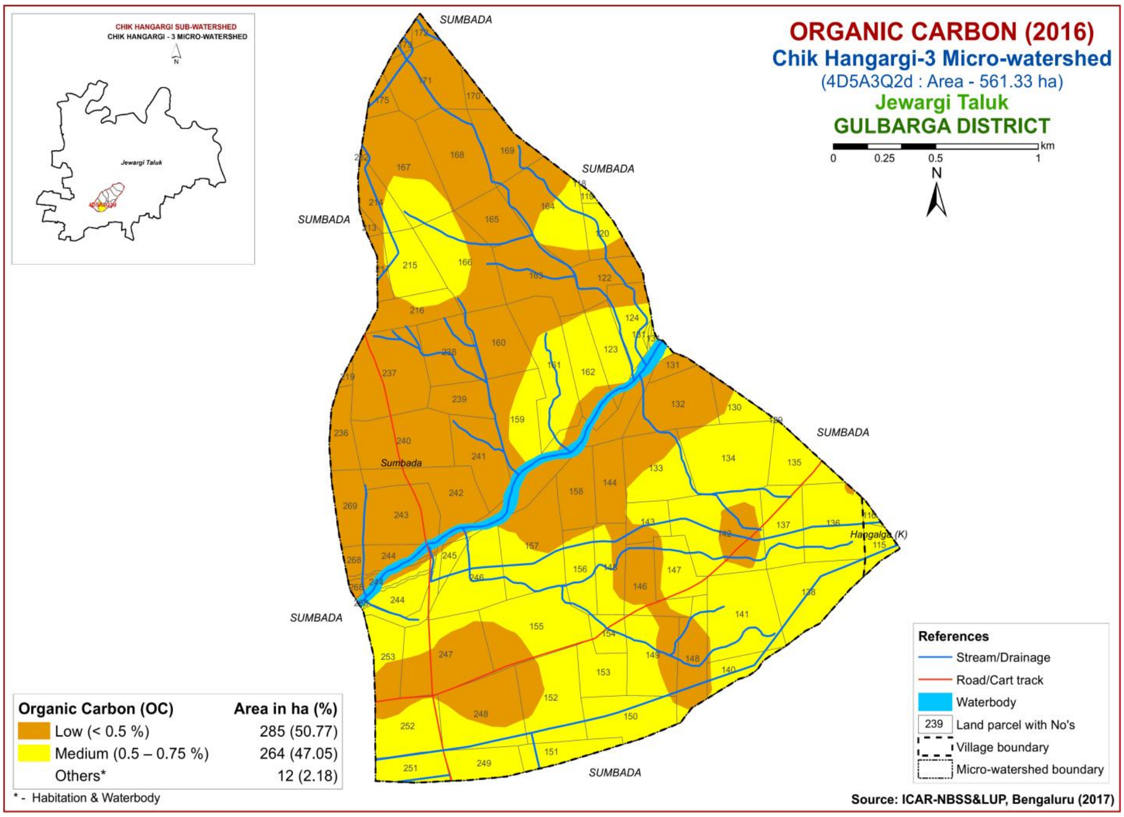


Fig.6.3 Soil Organic Carbon map of Chik Hangargi-3 Microwatershed

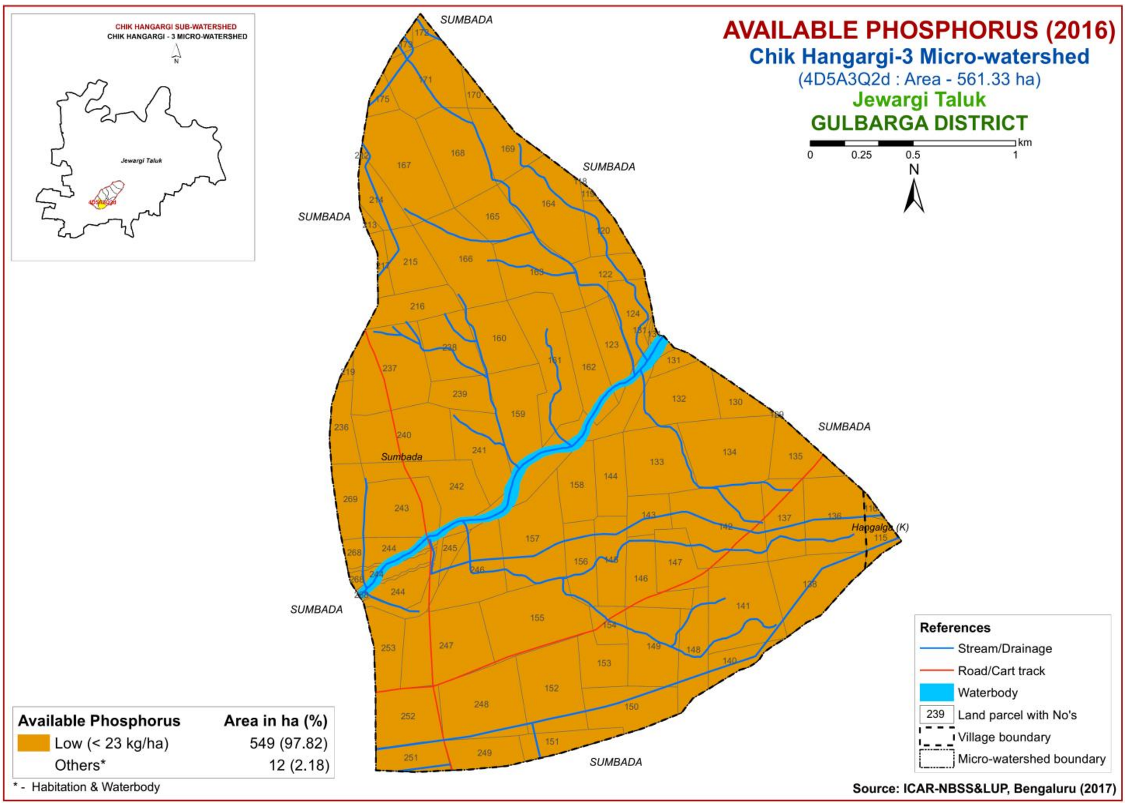


Fig. 6.4 Soil Available Phosphorus map of Chik Hangargi-3 Microwatershed

6.5 Available Potassium

It is high in available potassium (>337 kg/ ha) in maximum area of 490 ha (87%) and is distributed in all parts of the microwatershed and medium (145-337 kg/ha) in about 60 ha (10%) area and occurs in the northern and northwestern part of the microwatershed (Fig. 6.5).

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) with a area of about 214 ha (38%) and is distributed in the fringes of northwestern, eastern, southwestern, southestern and central part of the microwatershed. An area of about 281 ha (50%) is high (>20 ppm) in available sulphur and are distributed in the southwestrn, southeastern, northern and northwestern part of the microwatershed. Low (<10 ppm) available sulphur with an area of 54 ha (10%) are distributed in the southeastern and a small area in the western part of the microwatershed (Fig. 6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in an area of 443 ha (79%) in the microwatershed and are distributed in the major part of the microwatershed. An area of 64 ha (11%) is low (<0.5 ppm) in available boron and are distributed in the southeastern, northern and a small area in western part of the microwatershed (Fig. 6.7). High (>1.0 ppm) boron content with an area of 42 ha (7%) occurring in the northeastern part of microwatershed (Fig. 6.7).

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in the major area of 532 ha (95%) and deficient (<4.5 ppm) with an area of 17 ha (3%) occuring in the northwestern part of 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 area of 549 ha (98%) of microwatershed (Fig. 6.11).

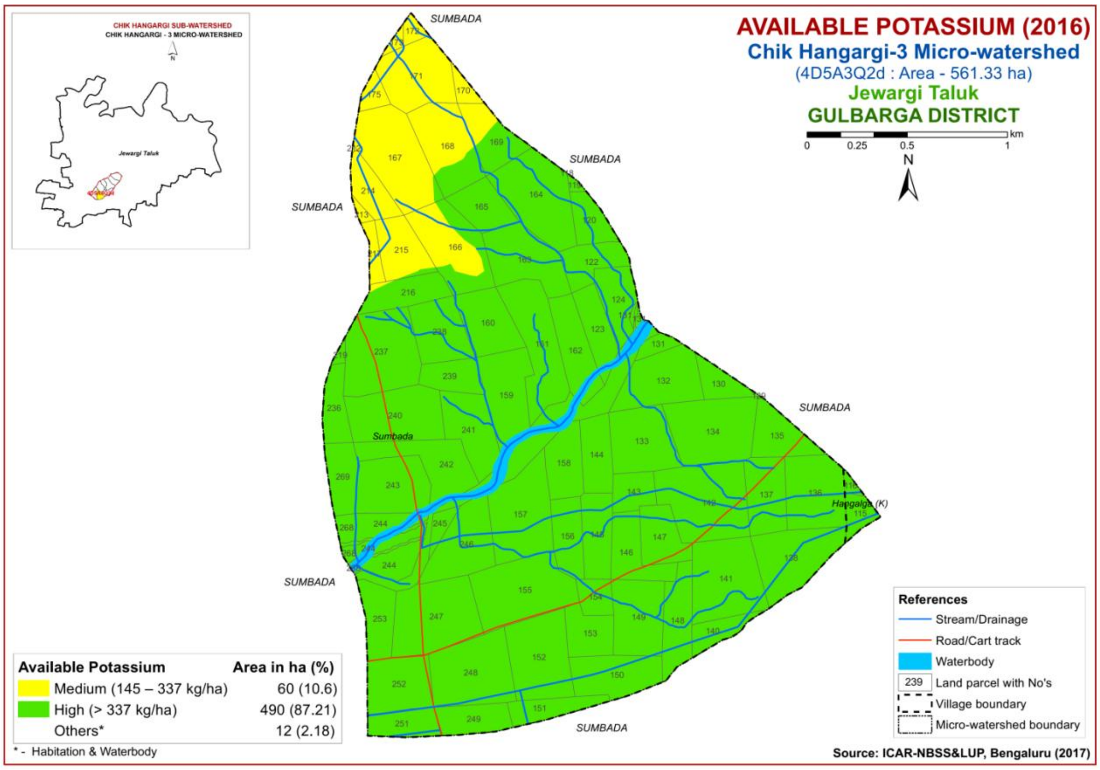


Fig. 6.5 Soil Available Potassium map of Chik Hangargi-3 Microwatershed

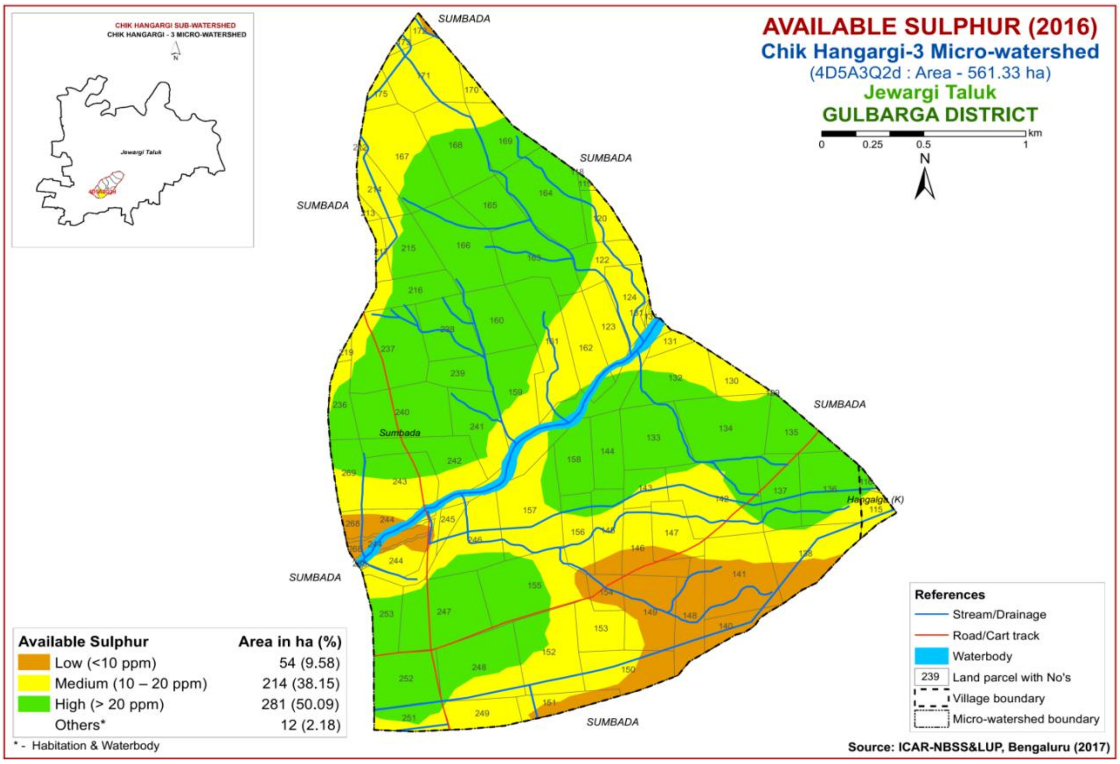


Fig. 6.6 Soil Available Sulphur map of Chik Hangargi-3 Microwatershed

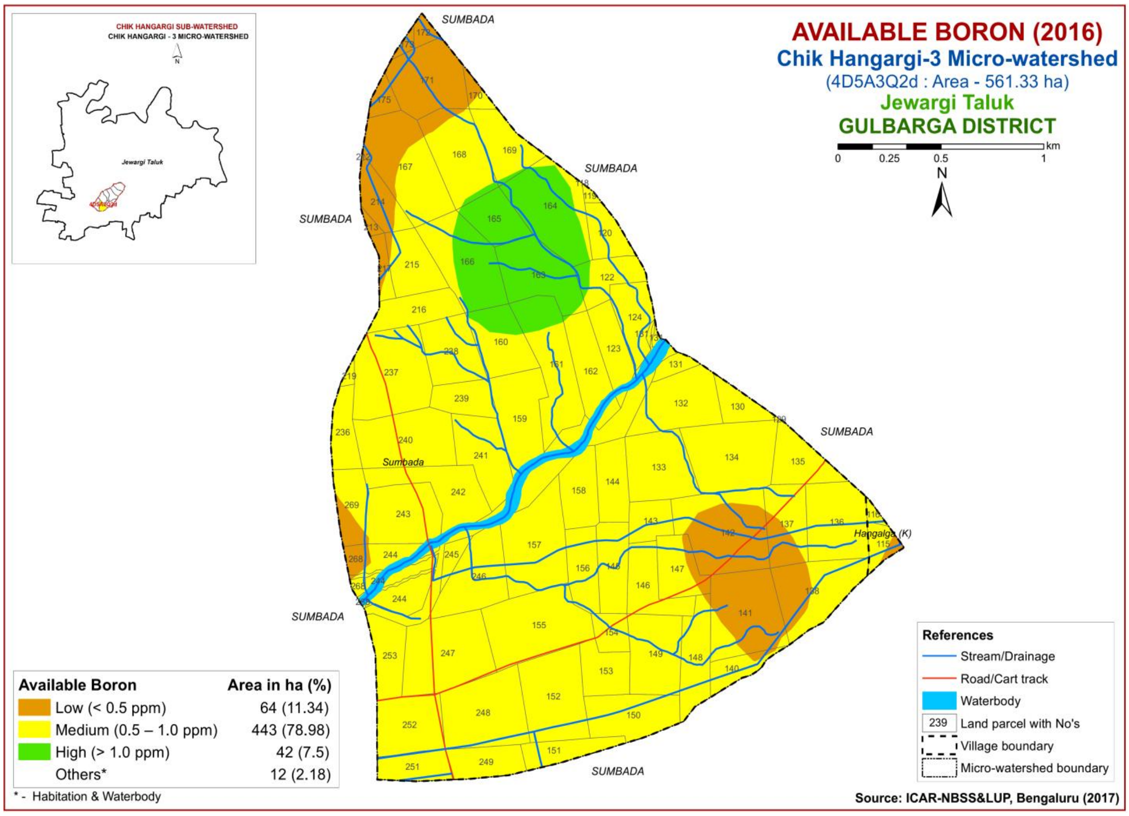


Fig. 6.7 Soil Available Boron map of Chik Hangargi-3 Microwatershed

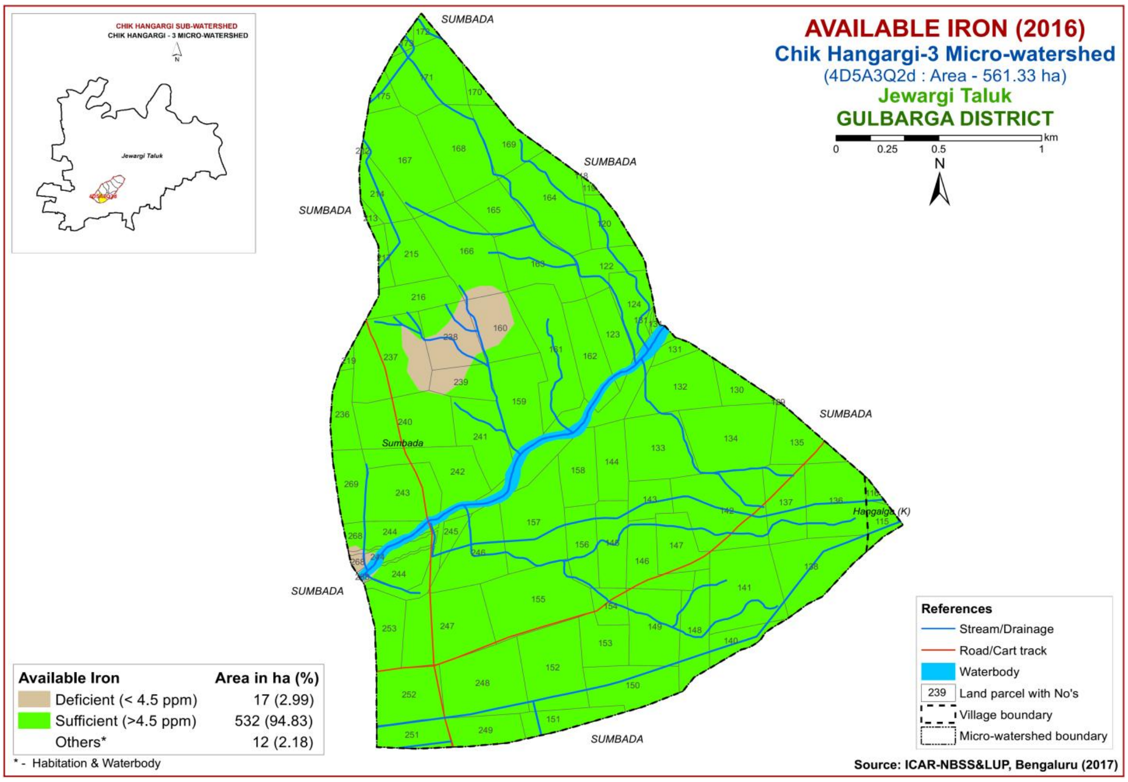


Fig. 6.8 Soil Available Iron map of Chik Hangargi-3 Microwatershed

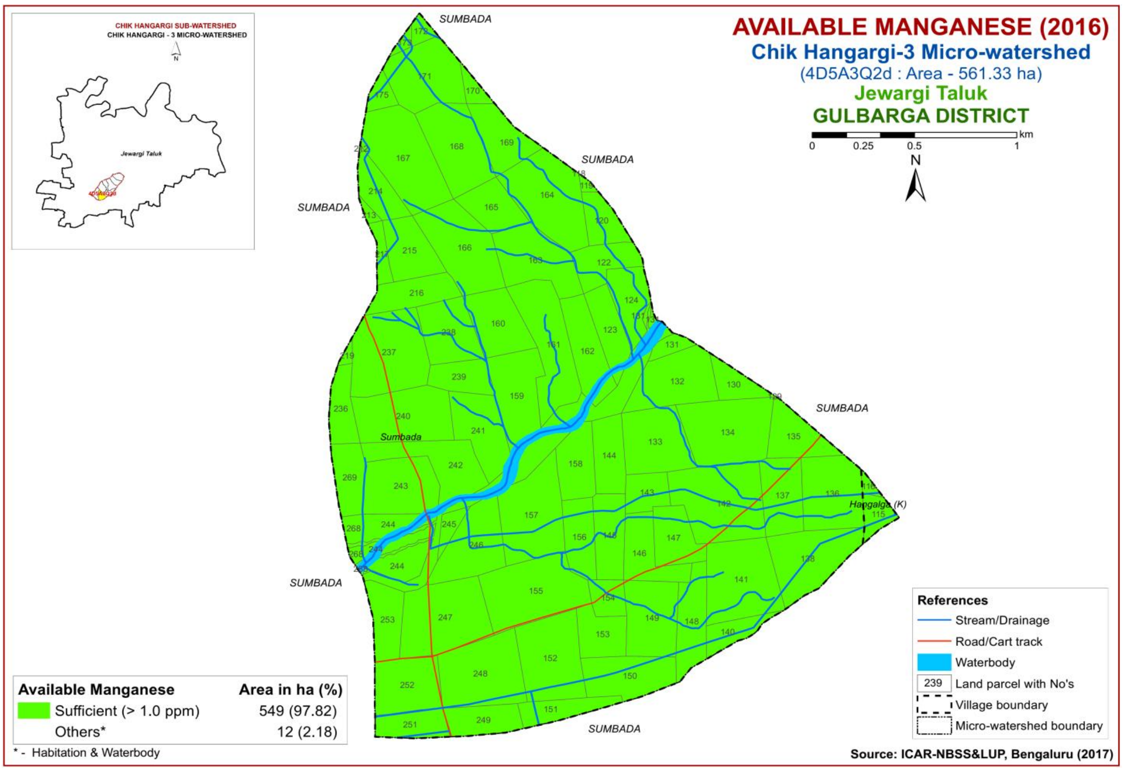


Fig. 6.9 Soil Available Manganese map of Chik Hangargi-3 Microwatershed

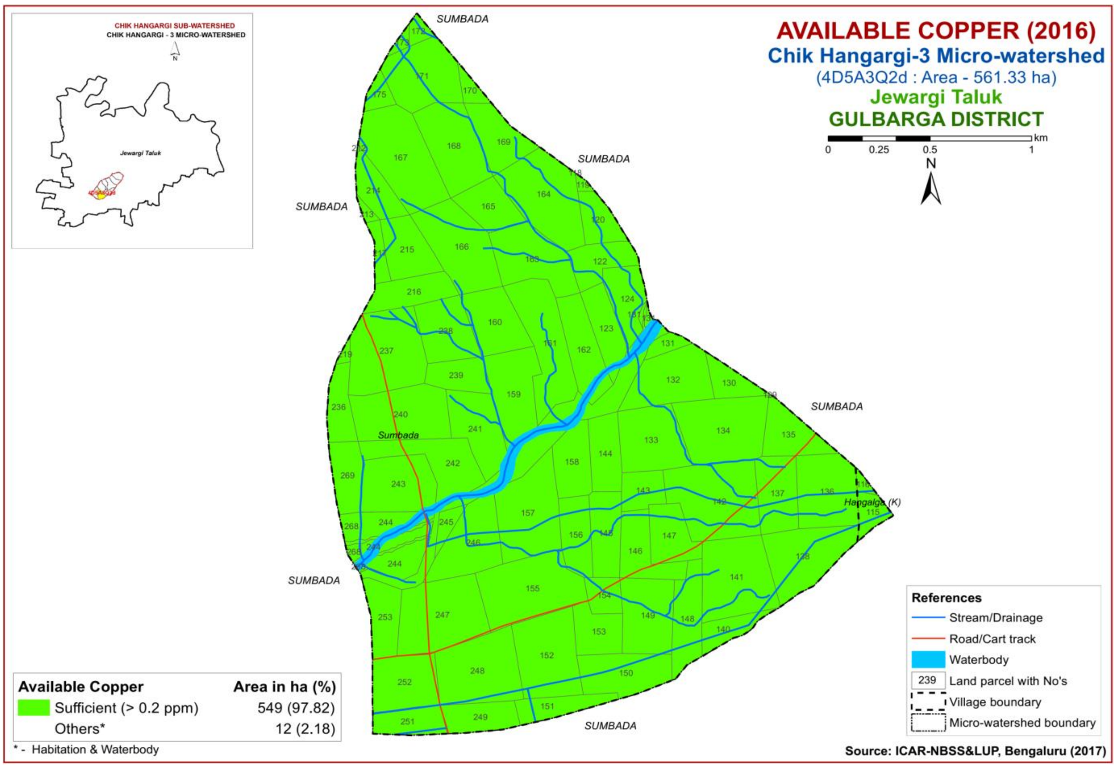


Fig. 6.10 Soil Available Copper map of Chik Hangargi-3 Microwatershed

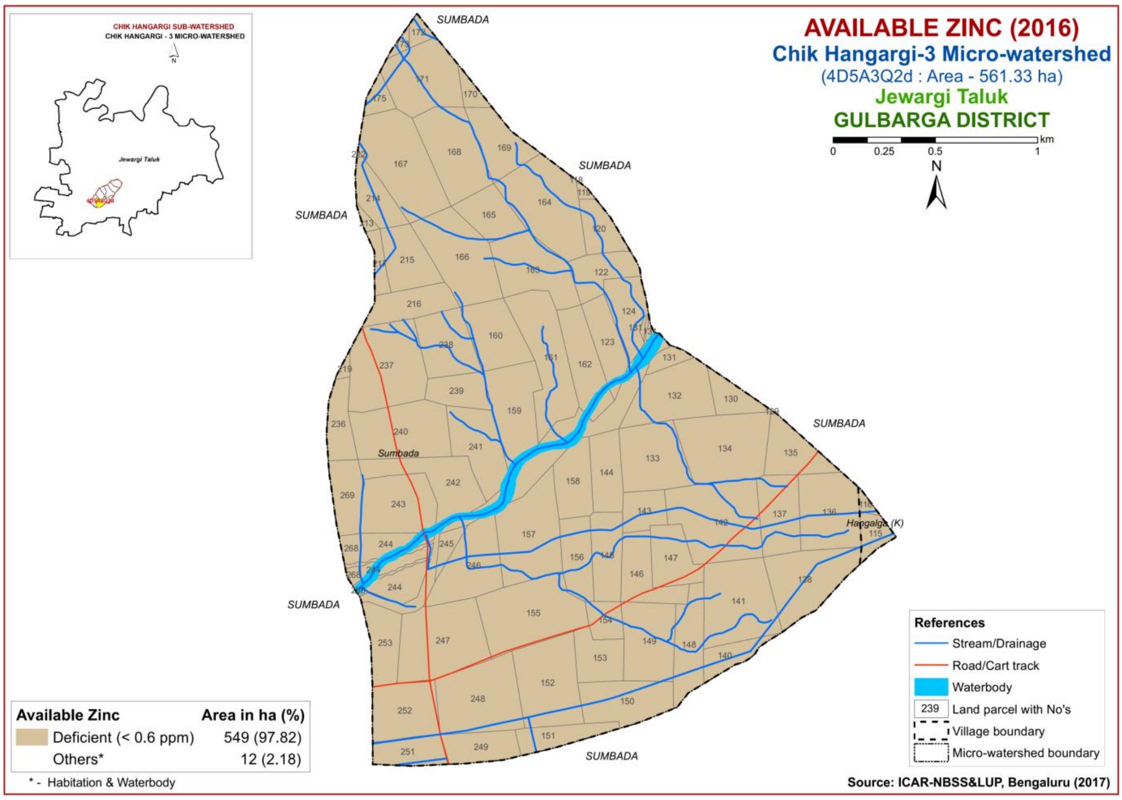


Fig. 6.11 Soil Available Zinc map of Chik Hangargi-3 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Chik Hangargi-3 microwatershed 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 and 'z' for calcareousness. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable lands with the limitations of soil depth and erosion are designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 19 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in 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 a 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.

Table 7.1 Soil-Site Characteristics of Chik Hangargi-3 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC (dS/m)	ESP	CEC [Cmol (p^+) kg^{-1}]	BS (%)
					Surface	Subsurface	Surface (%)	Subsurface (%)								
MGThB1g1	751	150	WD	<25	c	c	15-35	15	<50	1-3	Slight	7.12	0.19	0.35	46.32	100
MGTmB2g1	751	150	WD	<25	c	c	15-35	15	<50	1-3	Moderate	7.12	0.19	0.35	46.32	100
NHAmB1	751	150	WD	25-50	c	c	-	<15	51-100	1-3	Slight	7.42	0.16	0.58	59.81	100
NHAmB1g1	751	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Slight	7.42	0.16	0.58	59.81	100
NHAmB2	751	150	WD	25-50	c	c	-	<15	51-100	1-3	Moderate	7.42	0.16	0.58	59.81	100
NHAmB2g1	751	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Moderate	7.42	0.16	0.58	59.81	100
NIRmB2	751	150	MWD	75-100	c	c	>15	<15	101-150	1-3	Moderate	8.6	1.79	0.58	68.04	100
DIMmA1	751	150	MWD	100-150	c	c	>15	<15	>200	0-1	Slight	8.27	3.07	31.32	64.04	100
DIMmB1	751	150	MWD	100-150	c	c	>15	<15	>200	1-3	Slight	8.27	3.07	31.32	64.04	100
DIMmB2	751	150	MWD	100-150	c	c	>15	<15	>200	1-3	Moderate	8.27	3.07	31.32	64.04	100
DIMmB2g1	751	150	MWD	100-150	c	c	15-35	<15	>200	1-3	Moderate	8.27	3.07	31.32	64.04	100
MARmA1	751	150	MWD	>150	c	c	>15	<15	>200	0-1	Slight	8.63	2.41	33.40	65.77	100
MARmB1	751	150	MWD	>150	c	c	>15	<15	>200	1-3	Slight	8.63	2.41	33.40	65.77	100
MARmB2	751	150	MWD	>150	c	c	>15	<15	>200	1-3	Moderate	8.63	2.41	33.40	65.77	100

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

Major area of 406 ha (72%) is highly suitable (Class S1) for growing sorghum and are distributed in the southern, southeastern, southwestern and northeastern and small area in the western part of the microwatershed. An area with marginally suitable (S3) lands occur in about 107 ha (19%) and are distributed in the northern, northwestern and western part of the microwastershed. They have moderate limitation of rooting depth. An area of about 36 ha (6%) is not suitable (Class N) for growing sorghum crop.

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/excessi vely	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,fragment al skeletal
Soil depth	Cm	100-75	50-75	30-50	<30
Gravel content	% vol.	5-15	15-30	30-60	>60
Salinity (EC)	dS m^{-1}	2-4	4-8	8-10	>10
Sodicity (ESP)	%	5-8	8-10	10-15	>15

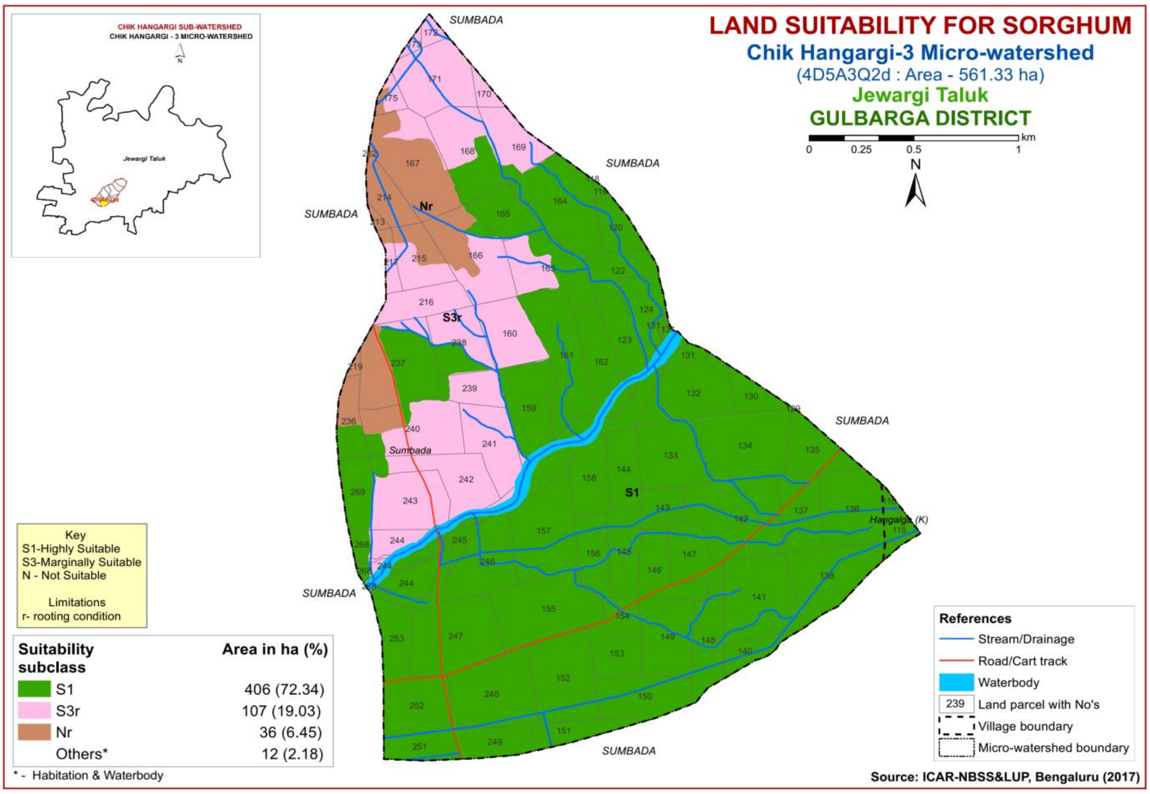


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.37 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 extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

No highly and moderately suitable lands are available for growing maize in the microwaterhsed. Entire area of about 513 ha (91%) is marginally suitable (Class S3) for growing maize and are distributed in all parts of the microwatershed. They have moderate limitations of rooting depth and texture. An area of about 36 (6%) is not suitable (Class N) forgrowing maize crop.

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
Gravelcontent	% vol.	<15	15-35	35-50	>50
Salinity (EC)	dS m^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity(ESP)	%	<10	10-15	>15	

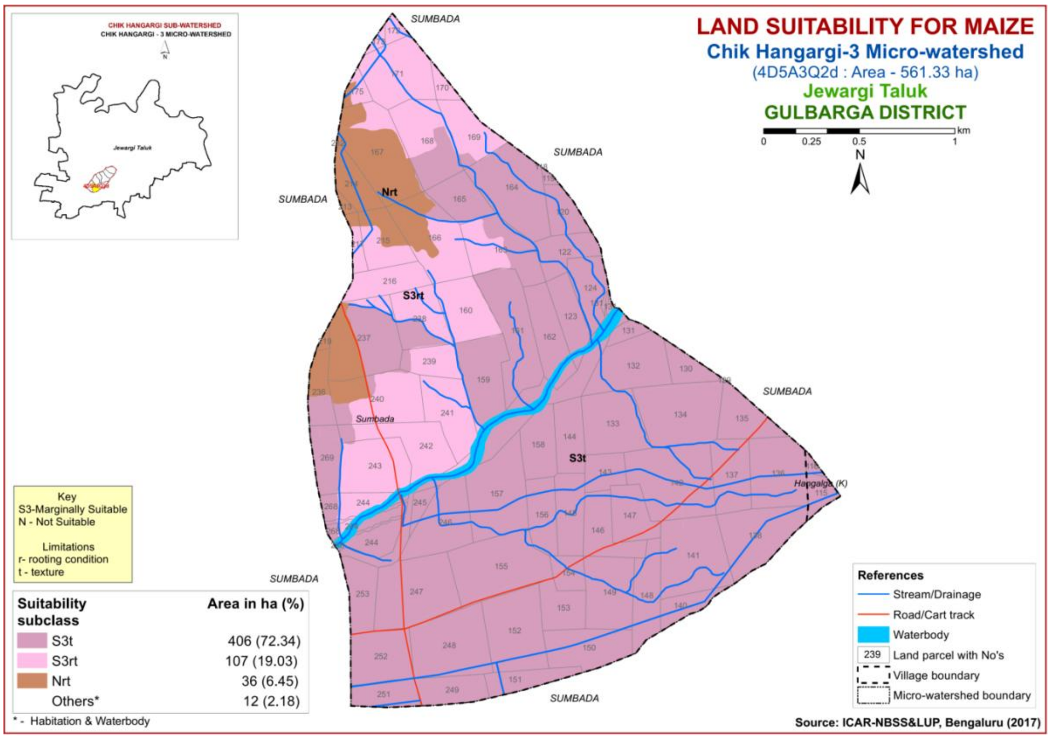


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for Redgram (*Cajanus cajan*)

Redgram is the most important pulse crop grown in an area of 7.28 lakh ha in almost all the districts of the State. The crop requirements for growing redgram (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing redgram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

Table 7.4 Land suitability criteria for Red gram

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>210	180-210	150-180	<150
Soil drainage	class	Well drained	Mod. well drained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-7.5	5.0-6.5,7.6-8.0	8.0-9.0	>9.0
Sub Surface soil texture	Class	l, scl, sil, cl, sl	sicl, sic, c(m)	ls	
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	3-60	>60
Salinity (EC)	dS m^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

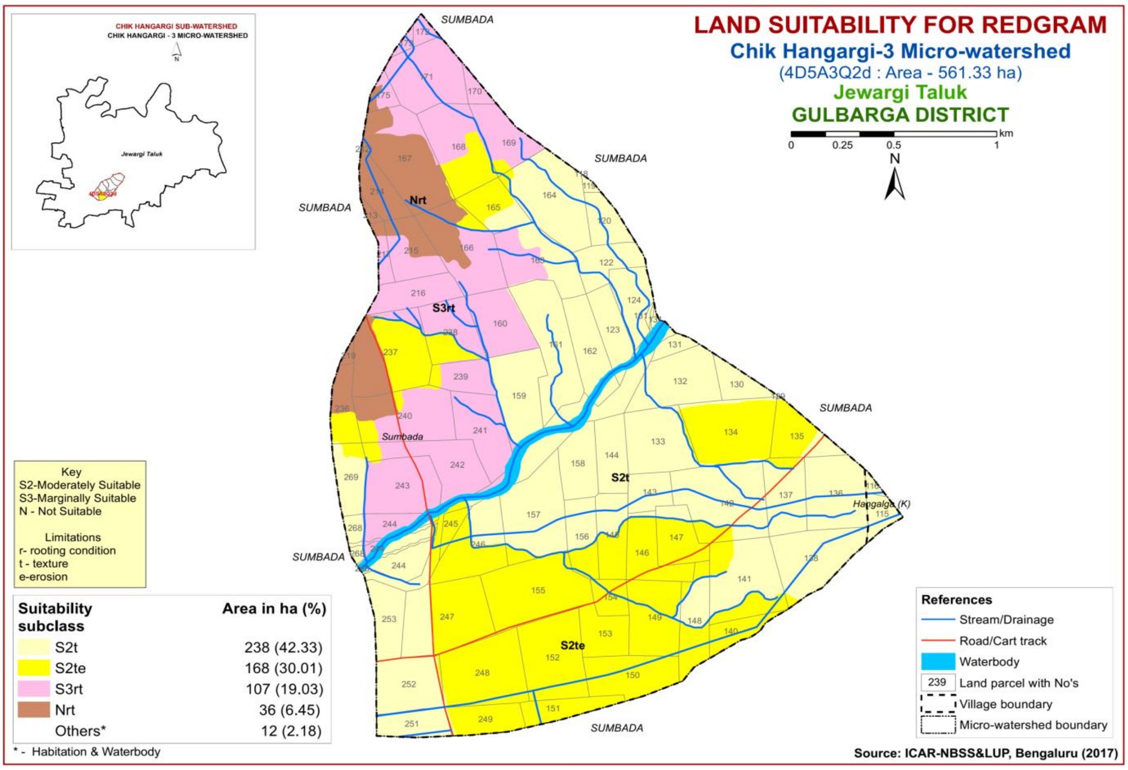


Fig. 7.3 Land Suitability map of Redgram

An area of about 406 ha (72%) is moderately suitable (Class S2) for growing redgram and occur in the notheastern, southwestern, southern, southeastern and small area in the western part of the microwatershed. They have minor limitations of texture and erosion. Marginally suitable (class S3) lands are found to occur in an area of 107 ha (19%) and are distributed in the northern and northwestern part of the microwatershed with moderate limitations of rooting depth and texture. An area of 36 ha (6%) is not suitable (Class N) for growing redgram crop.

7.4 Land Suitability for Soybean (*Glycine max*)

Soybean is the most important pulse and oil seed crop grown in about 2.56 lakh ha area in Bijapur, Raichur, Kalaburgi, Dharwad, Belgaum and Bellary districts. The crop requirements for growing soybean were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing soybean was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

Highly suitable (Class S1) lands are found to occur in an area of 242 ha (43%) and are distributed in the western, southwestern, southestern, northeastern and central part of the microwatershed. An area about of 164 ha (29%) is moderately suitable (Class S2) for growing soybean and occur in the southern and small area in the southeastern, western and northern part of the microwatershed with minor limitation of erosion. Marginally suitable (Class S3) lands are found to occur in an area of 107 ha (19%) and are distributed in the northern and northwestern part of the microwatershed. They have moderate limitation of rooting condition for growing soybean. An area of about 36 ha (6%) is not suitable (Class N) for grwoing soybean crop.

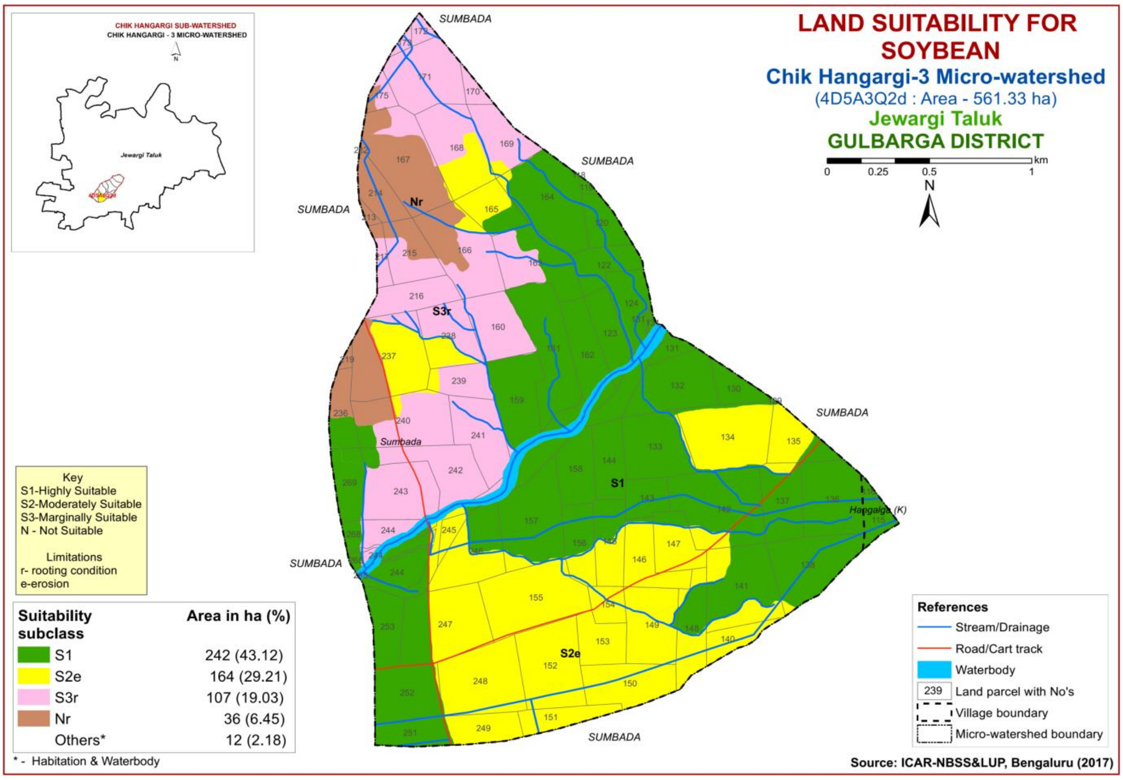


Fig. 7.4 Land Suitability map of Soybean

7.5 Land Suitability for Bengal gram (*Cicer arietinum*)

Bengal gram is one of the major pulse crop grown in an area of 9.39 lakh ha in northern Karnataka in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing Bengal gram (Table 7.5) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing Bengal gram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.5.

Table 7.5 Crop suitability criteria for Bengal gram

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>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)	dS m^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

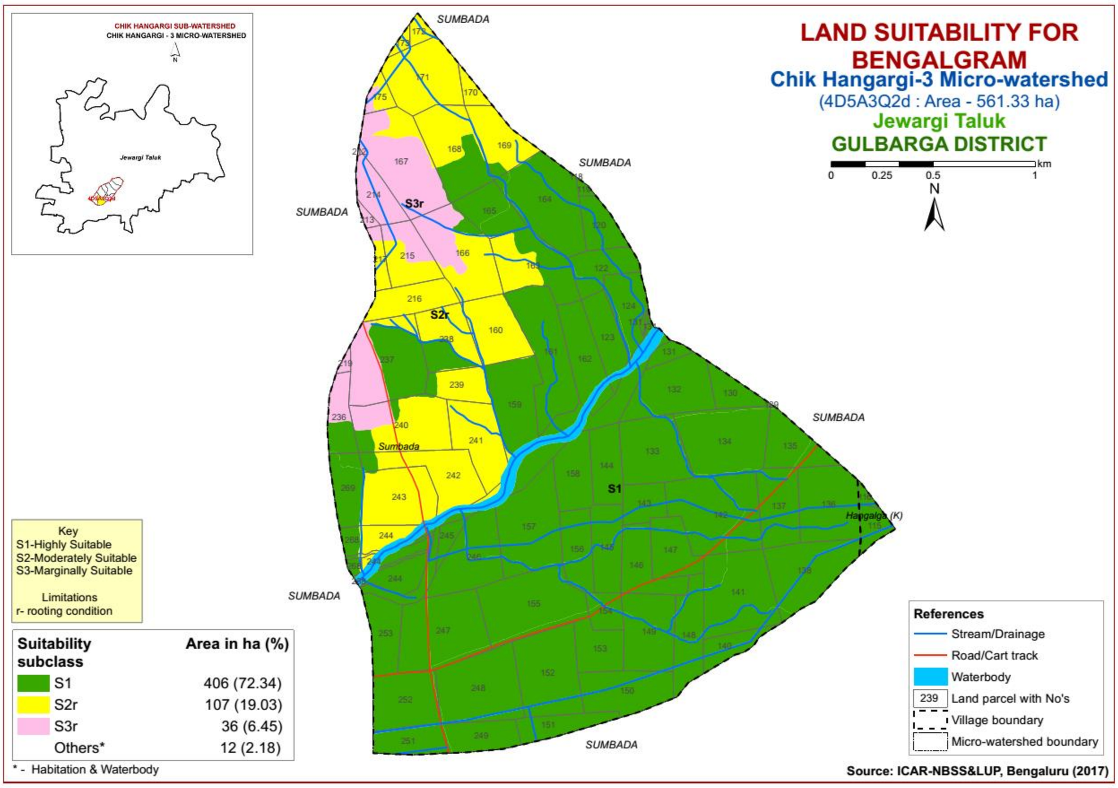


Fig. 7.5 Land Suitability map of Bengalgram

Major area about of 406 ha (72%) is highly suitable (Class S1) for growing bengalgram and occur in the southern, southeastern, southwestern, northeastern and small area in the western part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of 107 ha (19%) and are distributed in the western, northern and northwestern part of the microwatershed. They have minor limitation of rooting condition. Marginally suitable (Class S3) lands are found in an area of 36 ha (6%) and are distributed in the northwestern part of the microwatershed. They have moderate limitations of rooting depth for growing bengalgram.

7.6 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 3.56 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area extent and their geographical distribution of different suitability subclasses in the micro watershed is given in Figure 7.6.

An area of 406 ha (72%) is highly suitable (Class S1) for growing sunflower and are distributed in the southern, southeastern, southwestern, northeastern and a small area in the western part of the microwatershed. They have minor or no limitations for growing sunflower. An area of 143 ha (25%) is not suitable (Class N) for growing sunflower crop.

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)	dS m^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity ESP)	%	<10	10-15	>15	

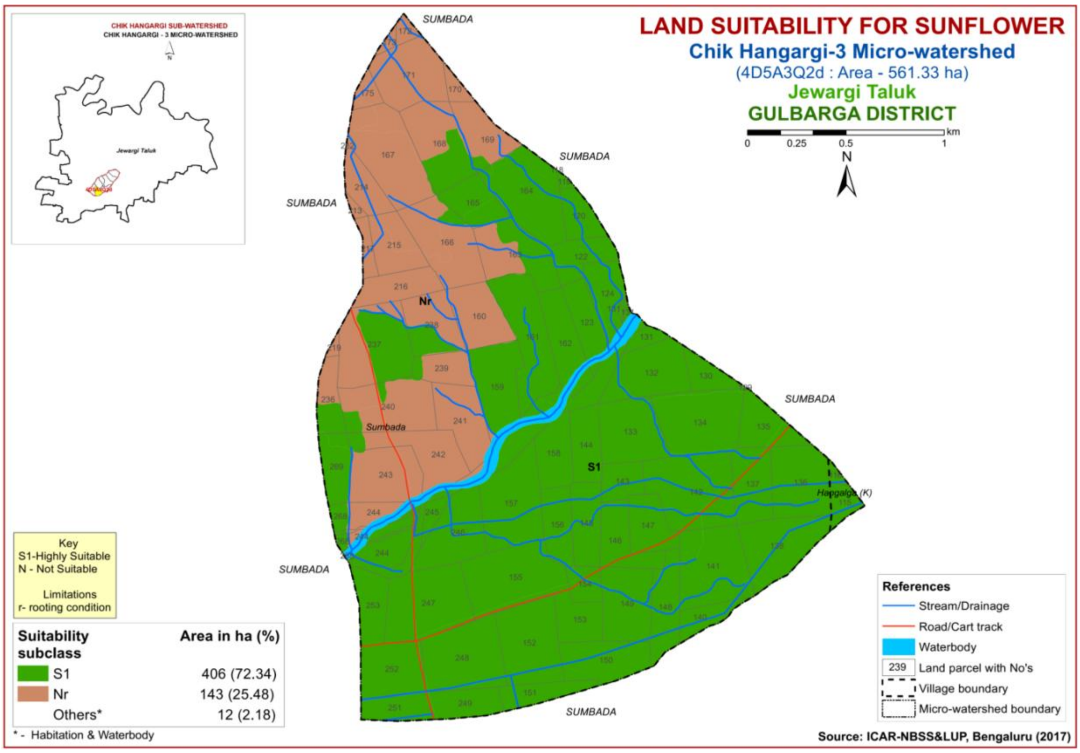


Fig. 7.6 Land Suitability map of Sunflower

7.7 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 8.75 lakh ha area in Raichur, Dharwad, Belgaum, 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 extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

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)	dS m^{-1}	2-4	4.0-8.0	8.0-12	>12
Sodicity (ESP)	%	5-10	10-20	20-30	>30

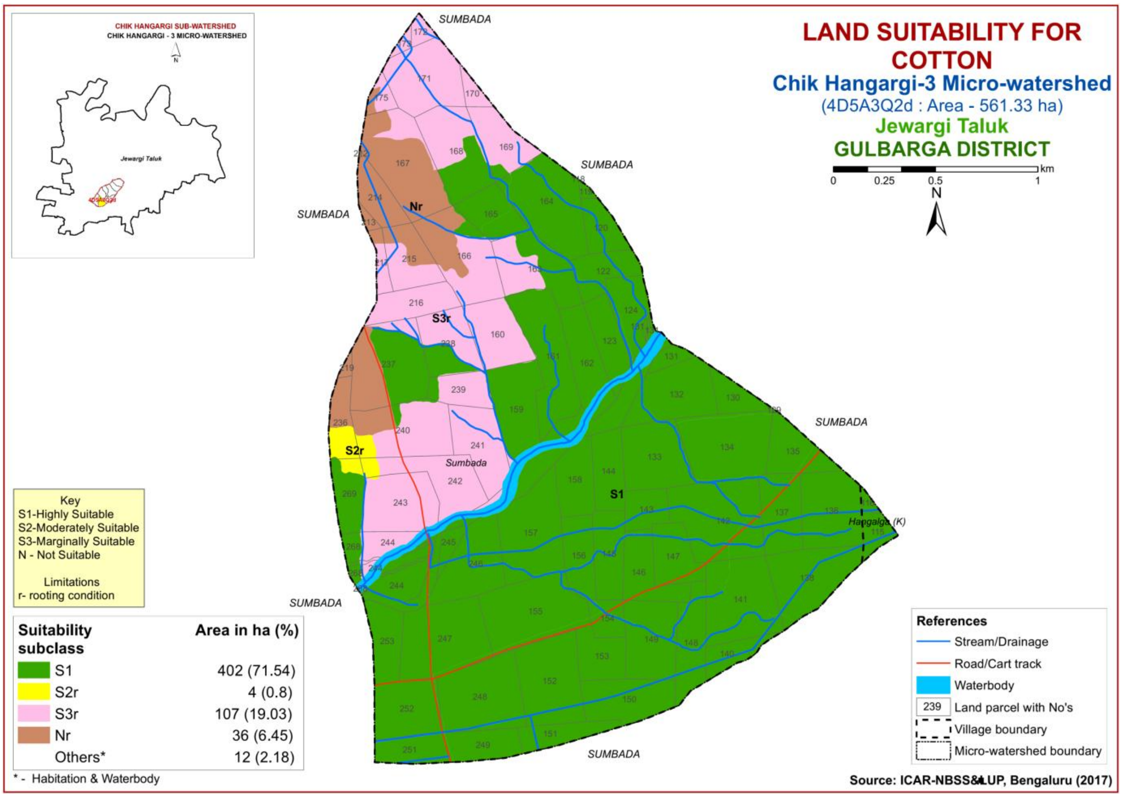


Fig. 7.7 Land Suitability map of Cotton

An area is about 402 ha (72%) has soils that are highly suitable (Class S1) for cotton and are distributed in the southern, southwestern, southeastern, northeastern, central and small area in the western part of the microwatershed with minor or no limitations. A minor area of 4 ha (1%) of moderately suitable (Class S2) and occur in the western part; marginally suitable (Class S3) lands are found in an area of 107 ha (19%) and are distributed in the northwestern part of the microwatershed. They have moderate limitations of rooting depth for growing cotton. An area of 36 ha (6%) is not suitable (Class N) for grwoing cotton crop.

7.8 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.91 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, Chamarajanagar and Mandya districts. The crop requirements for growing sugarcane (Table 7.8) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sugarcane was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

No highly and moderately suitable lands are available for growing sugarcane in the microwatershed. Major area with marginally suitable (Class S3) lands cover about 406 ha (72%) and mainly occur in the southern, southwestern, southeastern, northeastern, central and a small area in the western part of the microwatershed. They have moderate limitation of texture. An area of about 143 ha (25%) is not suitable (Class N) for growing sugarcane crop.

Table 7.8 Crop suitability criteria for Sugarcane

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-8	>8
Soil drainage	class	Well drained	Mod./imperfectly drained	Poorly drained	V.poor/excessively drained
Soil reaction	pH	7.0-8.0	6.0-6.9, 8.1-9.0	4.0-5.9 9.1-9.5	<4.0, >9.5
Surface soil texture	Class	l, cl, sil, sicl	C(m/k), sl	C+(ss)	
Soil depth	cm	>100	100-75	75-50	<50
stoniness	%	<15	15-35	35-50	>50
Salinity (EC)	dS m^{-1}	<2.0	2.0-4.0	4.0-9.0	>9
Sodicity(ESP)	%	<10	10-15	15-25	>25

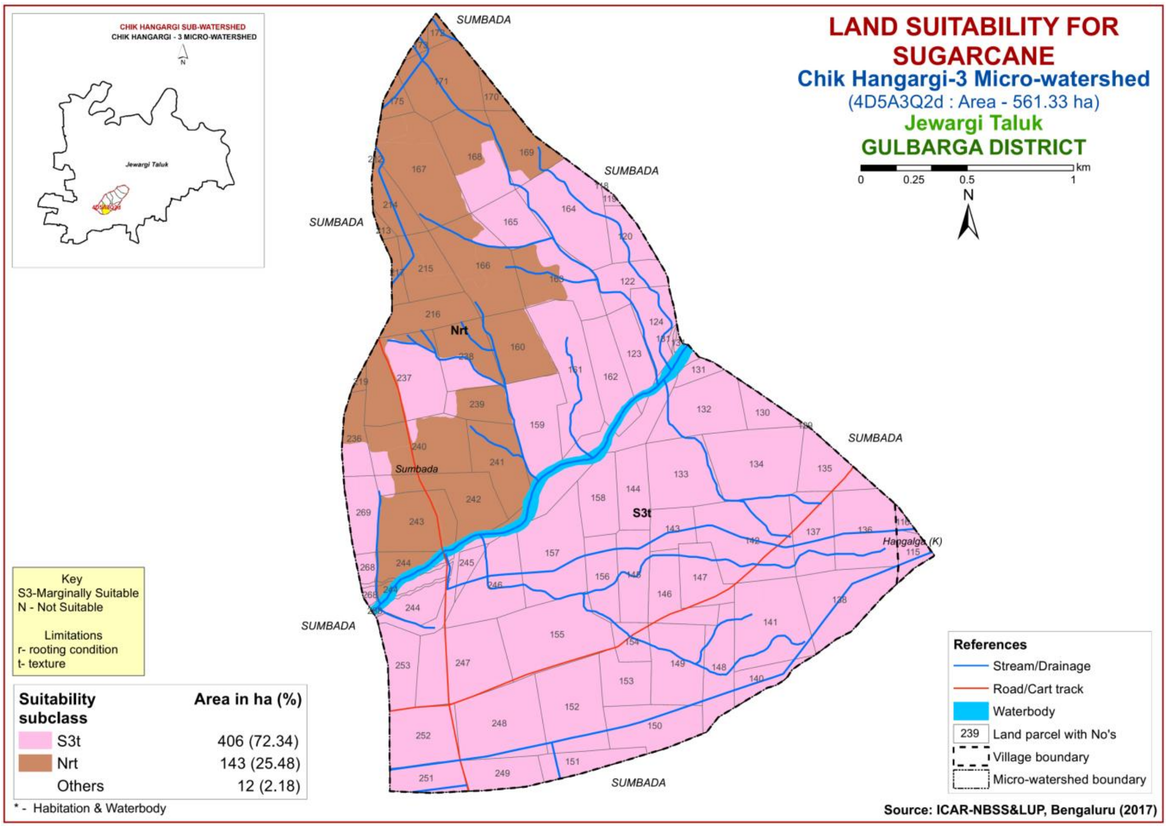


Fig. 7.8 Land Suitability map of Sugarcane

7.9 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in an area of about 1.73 lakh ha in almost all the districts of the State. The crop requirements (Table 7.9) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.9.

No highly and moderately suitable lands are available for growing mango in the microwatershed. An area with marginally suitable (Class S3) lands cover 406 ha (72%) and are distributed in the southern, southwestern, southeastern, northeastern, central and a small area in the western part of the microwatershed. They have moderate limitation of texture. An area of about 143 ha (25%) is not suitable (Class N) for growing mango crop.

Table 7.9 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.ingrowing 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	7.6-8.5, 5.0-5.4	8.6-9.0,4.0-4.9	>9.0,<4.0
	OC	%	High	medium	low	
	$CaCO_3$ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	%vol	Non-gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS m^{-1}	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

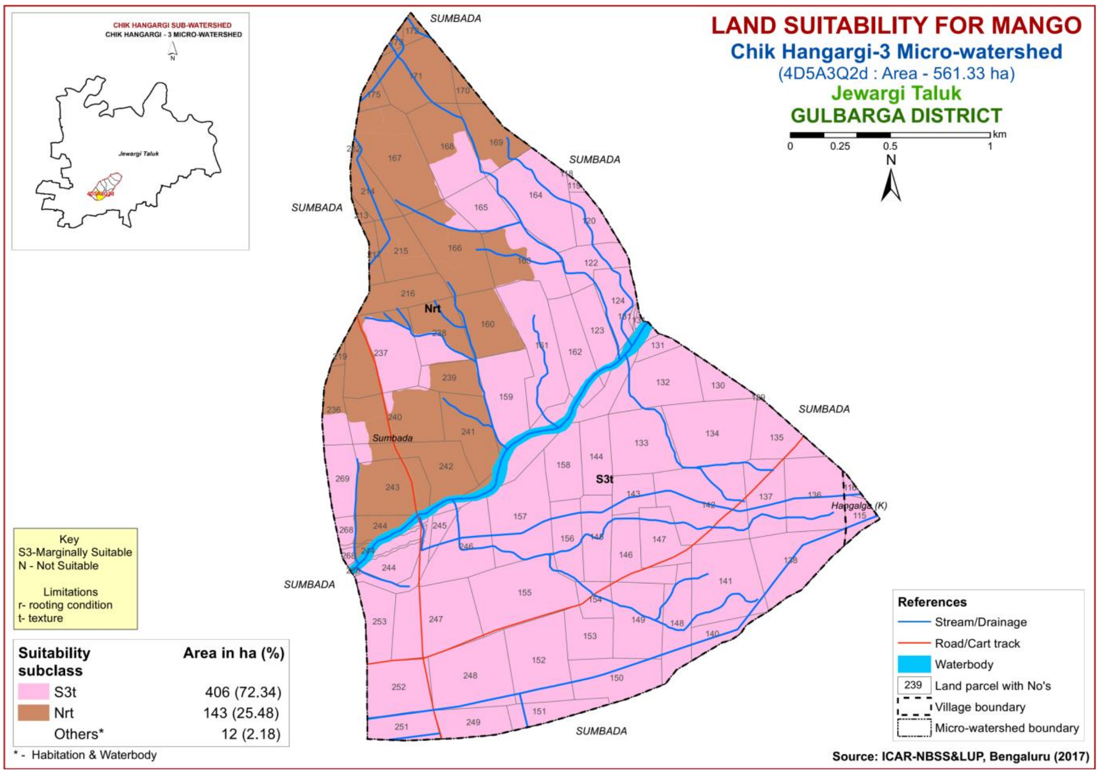


Fig. 7.9 Land Suitability map of Mango

7.10 Land suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 29373 lakh ha in almost all the districts of the State. The crop requirements (Table 7.10) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.10.

Table 7.10 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^{-1}	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

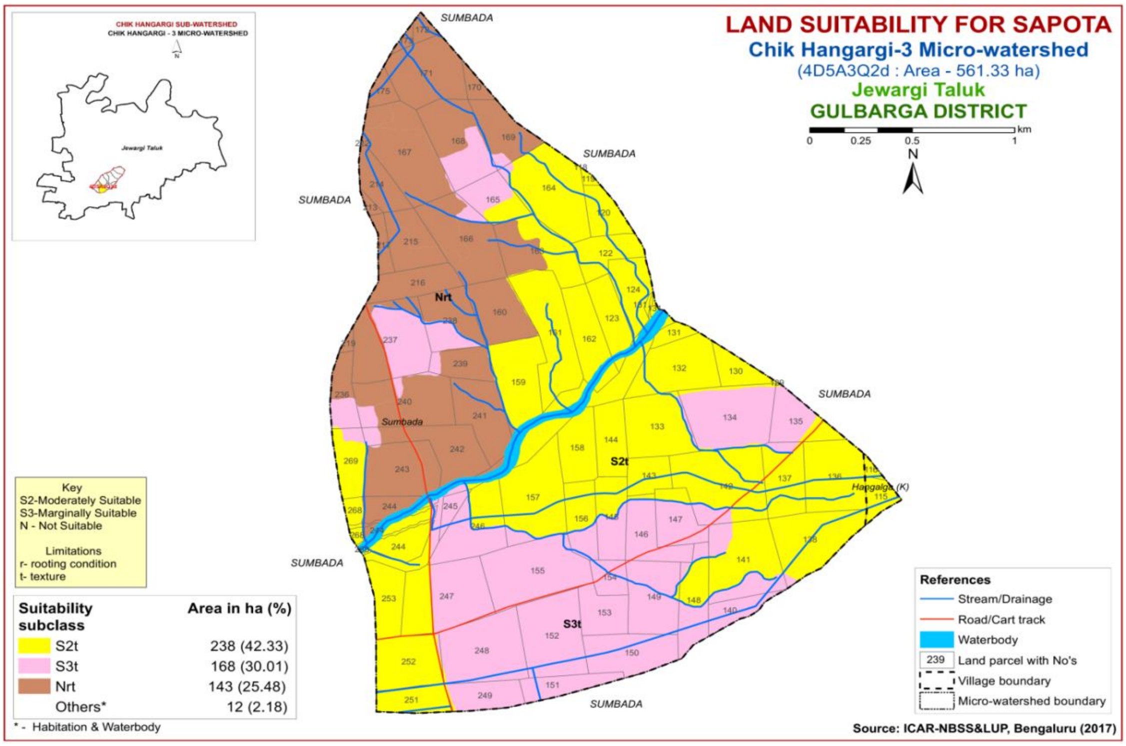


Fig. 7.10 Land Suitability map of Sapota

No highly suitable lands are available for growing sapota in the microwatershed. An area of 238 ha (42%) moderately suitable (Class S2) and are distributed in the southwestern, central, northestern and southeastern part of microwatershed with minor limitation of texture. An small area of 168 ha (30%) is marginally suitable (Class S3) and are distributed in the southern and small area in the eastern, western and northeastern part of microwatershed with moderate limitation of texture. An area of 143 ha (25%) is not suitable (Class N) for growing 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 7.11) for growing guava were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing guava was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.11.

No highly suitable lands are available for growing guava in the microwatershed. An area of 238 ha (42%) is moderately suitable (Class S2) and are distributed in the southwestern, southeastern, central and northeastern part of microwatershed with minor limitation of texture. About 168 ha (30%) area is marginally suitable (Class S3) and distributed in the southern, southwestern and small area in the western, eastern and northeastern part of microwatershed. They have moderate limitation of texture. An area of 143 (25%) is not suitable (Class N) for growing guava.

Table 7.11 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^{-1}	<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

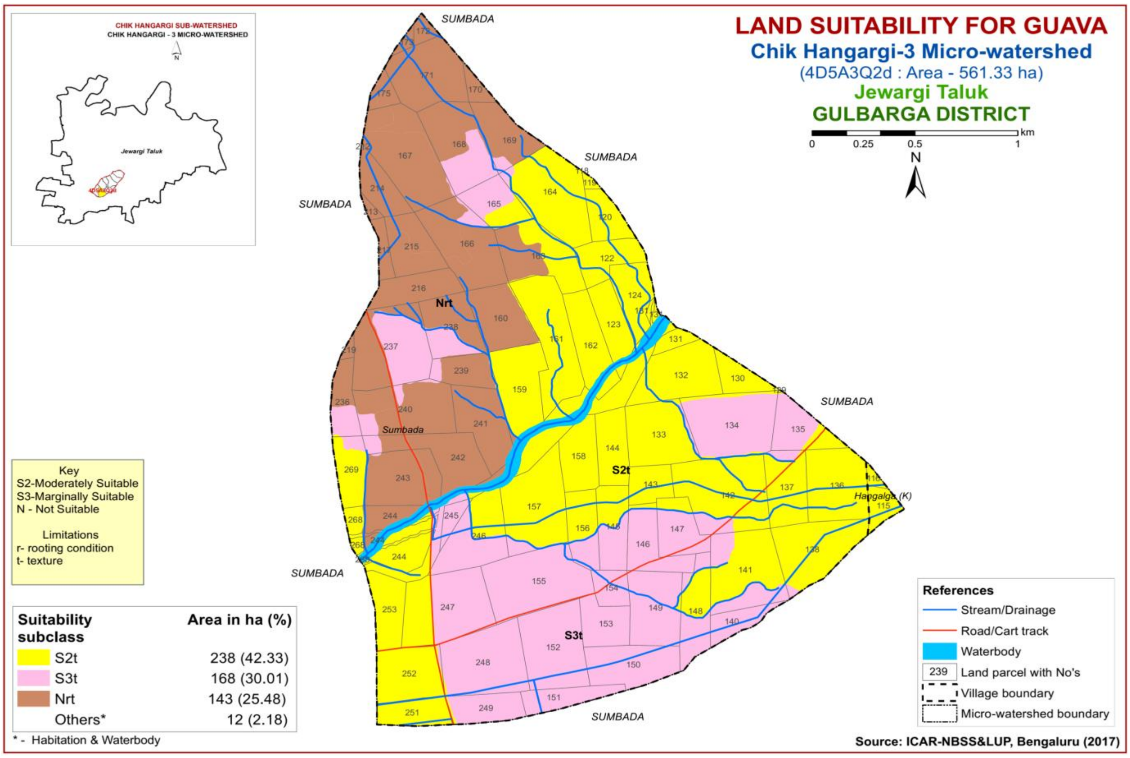


Fig. 7.11 Land Suitability map of Guava

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 (Table 7.12) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing jackfruit was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.12.

No highly and moderately suitable lands are available for growing jackfruit in the microwatershed. Major area is marginally suitable (Class S3) for growing jackfruit and occupy an area of about 406 ha (72%) and are distributed in the southwestern, southern, southeastern, eastern, northeastern, central and a small area in the western part of the microwatershed. They have moderate limitation of texture. An area of about 143 ha (25%) is not suitable (Class N) for growing jackfruit.

Table 7.12 Crop suitability criteria for Jackfruit

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Soil aeration	Soil drainage	class	well	Mod. well	Poorly	V. Poorly
Nutrient availability	Texture	Class	Scl,cl,sc,c(red)	-	Sl,ls,c(black)	-
	pH	1:2.5	5.5-7.3	5.0-5.5,7.3-7.8	7.8-8.4	>8.4
Rooting conditions	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	%vol.	<15	15-35	35-60	>60
Erosion	Slope	%	0-3	3-5	>5	-

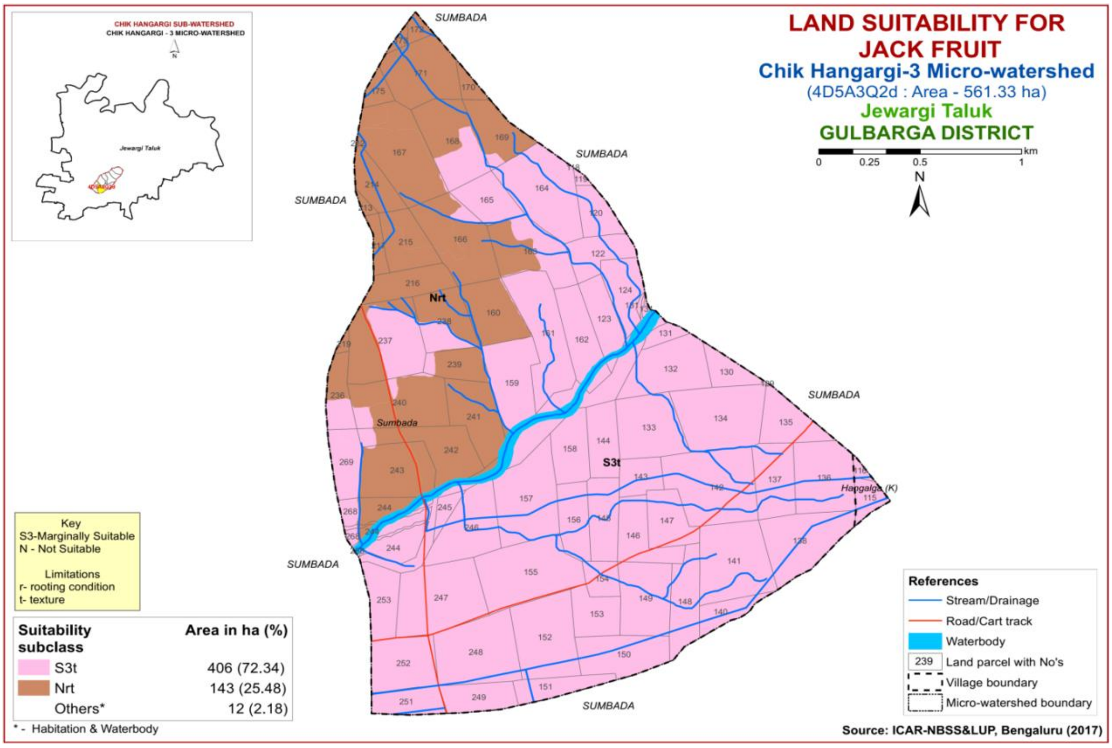


Fig. 7.12 Land Suitability map of Jackfruit

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 jamun (Table 7.13) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing jamun was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.13.

No highly suitable lands are available for growing jamun in the microwatershed. An area of 402 ha (71%) is moderately suitable (Class S2) for growing jamun and are distributed in the southern, southwestern, southeastern, central, northeastern, eastern and a small area in the western part of the microwatershed. They have minor limitation of texture. A minor area of 4 ha (1%) is found marginally suitable (Class S3) and occurs in the western part of the microwatershed with moderate limitations of rooting condition and texture. An area of about 143 ha (25%) is not suitable (Class N) for growing jamun.

Table 7.13 Crop suitability criteria for Jamun

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Soil aeration	Soil drainage	Class	Well	Mod. well	Poorly	V.Poorly
Nutrient availability	Texture	Class	Scl,cl,sc,C(red)	Sl,C (black)	ls	-
	pH	1:2.5	6.0-7.8	5.0-6.0	7.8-8.4	>8.4
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	%vol.	<15	15-35	35-60	>60
Erosion	Slope	%	0-3	3-5	5-10	>10

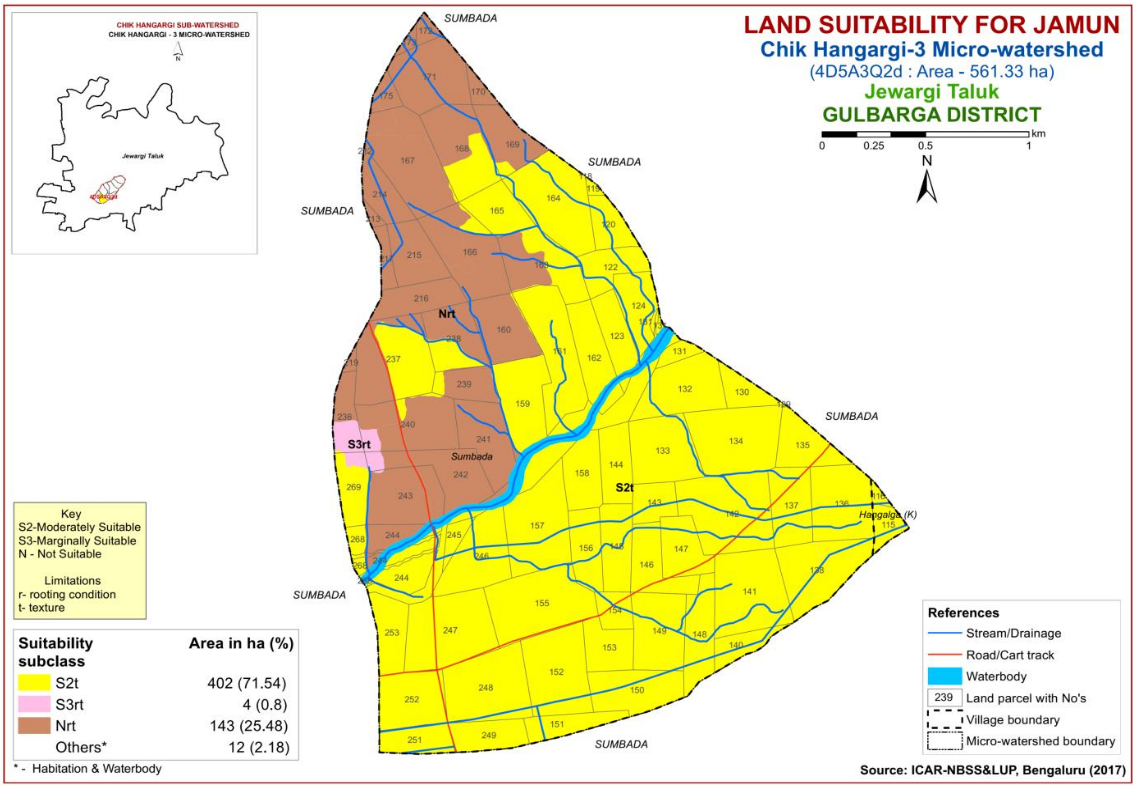


Fig. 7.13 Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

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

Table 7.14 Crop suitability criteria for Musambi

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temperature in growing season	^0C	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.toimperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl,l,sicl,cl,s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4,7.6-8.0	4.0-5.4,8.1-8.5	<4.0,>8.5
	$CaCO_3$ in root zone	%	Non34 calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Nongravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS m^{-1}	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Nonsodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

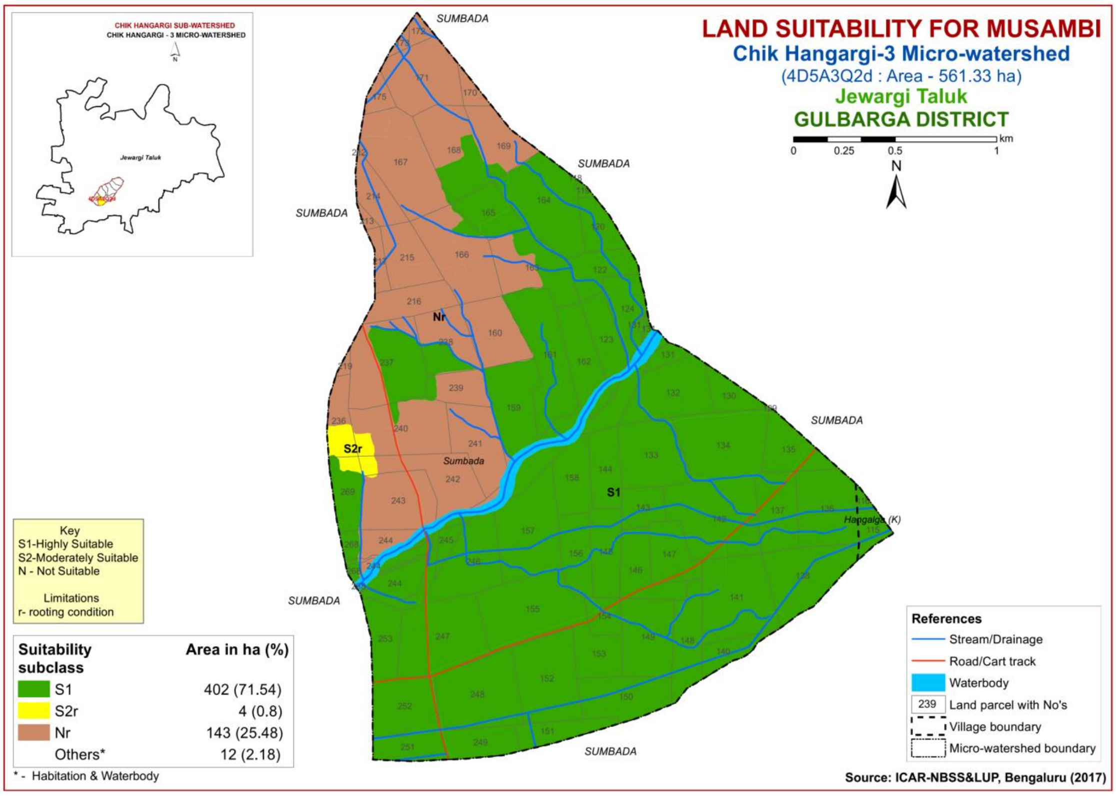


Fig. 7.14 Land Suitability map of Musambi

An area of 402 ha (71%) are highly suitable (Class S1) for growing musambi and are distributed in the southern, southwestern, southeastern, eastern, northestern, central and a small area in the western part of the microwatershed. Moderately suitable (Class S2) lands occupy a minor area of 4 ha (1%) in the western part of the microwatershed. An area of about 143 ha (25%) are not suitable (Class N) for growing 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 7.15) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.15.

An area of 402 ha (71%) has soils that are highly suitable (Class S1) for growing lime and are distributed in the southern, southwestern, southeastern, eastern, northestern, central and a small area in the western part of the microwatershed. Moderately suitable lands (Class S2) occupy a minor area of 4 ha (1%) in the western part of the microwatershed. An area of about 143 ha (25%) is not suitable (Class N) for growing lime.

Table 7.15 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.toimperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl,l,sicl,cl,s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4,7.6-8.0	4.0-5.4,8.1-8.5	<4.0,>8.5
	$CaCO_3$ in root zone	%	Non 34 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	$dS\ m^{-1}$	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	

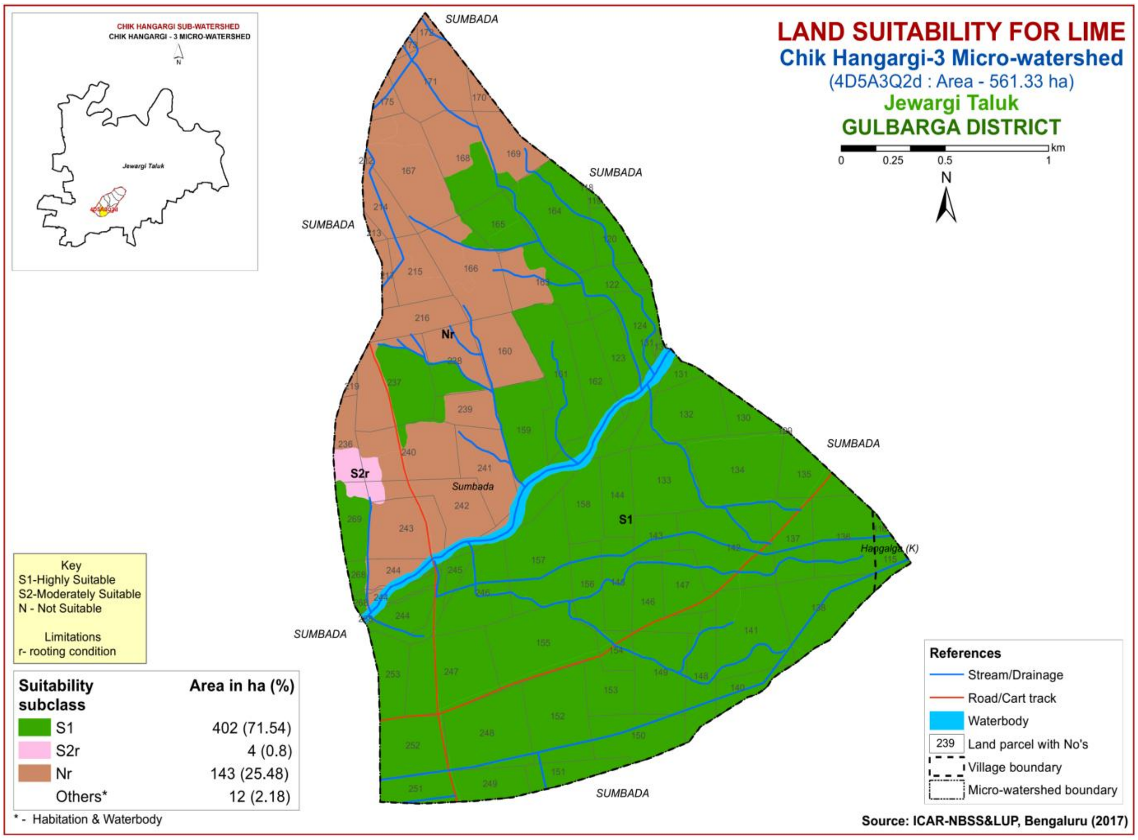


Fig. 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale*)

Cashew is one of the most important nut crop grown in an area of 1.24 lakh ha in almost all the districts of the State. The crop requirements for growing cashew (Table 7.16) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cashew was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.16.

No highly, moderately and marginally suitable lands are available for growing cashew in the microwatershed. Entire area of 545 ha (98%) is not suitable (Class N) for growing cashew in the microwatershed. They have very severe limitations of texture and rooting condition etc.

Table 7.16 Crop suitability criteria for cashew

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<5	5-15	15-30	
LGP	Days	>210	150-210	90-150	
Soil drainage	class	Well drained	moderately well drained	imperfectly drained	poorly drained
Soil reaction	pH	6.3-7.3	5.6-6.2	5.1-5.5,7.4-8.0	<5.0
Surface soil texture	Class	l, sl, scl	Cl, sil, ls, s	Sic, c (non swelling)	S (swelling)
Soil depth	Cm	>150	76-150	50-75	<50
Gravel content	% vol.	<15	15-35	35-50	>50

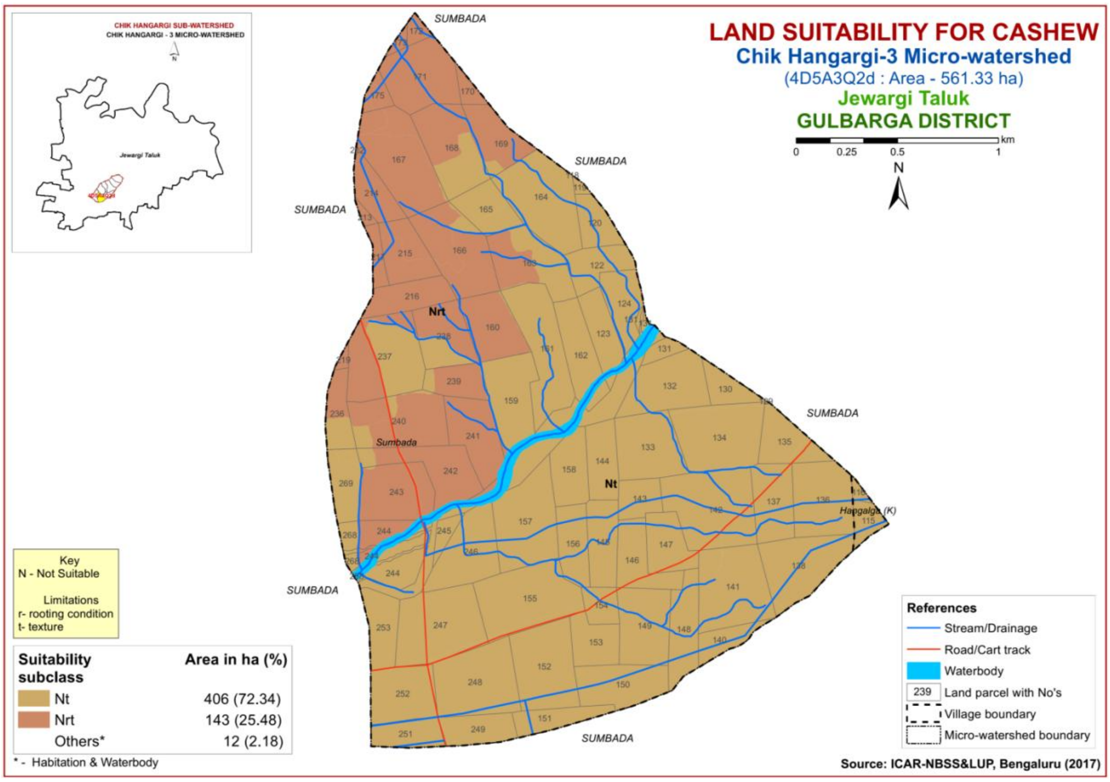


Fig. 7.16 Land Suitability map of Cashew

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 (Table 17) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.17.

An area of about 406 ha (72%) has soils that are highly suitable (Class S1) for growing custard apple and are distributed in the southern, southwestern, southeastern, eastern, northestern, central and a small area in the western part of the microwatershed. No moderately suitable lands are available for growing custard apple in the microwatershed. The marginally suitable (Class S3) lands cover an area of 107 ha (19%) and are distributed in the northern, western and northeastern parts of the microwatershed. They have moderate limitation of rooting depth. An area of 36 (6%) is not suitable (Class N) for growing custard apple crop.

Table 7.17 Crop suitability criteria for Custard Apple

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Soil aeration	Soil drainage	Class	Well drained	Mod. well drained	Poorly drained	V. Poorly drained
Nutrient availability	Texture	Class	Scl, cl, sc, c (red), c (black)	-	Sl, ls	-
	pH	1:2.5	6.0-7.3	7.3-8.4	5.0-5.5,8.4-9.0	>9.0
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravelcontent	% vol.	<15-35	35-60	60-80	-
Erosion	Slope	%	0-3	3-5	>5	-

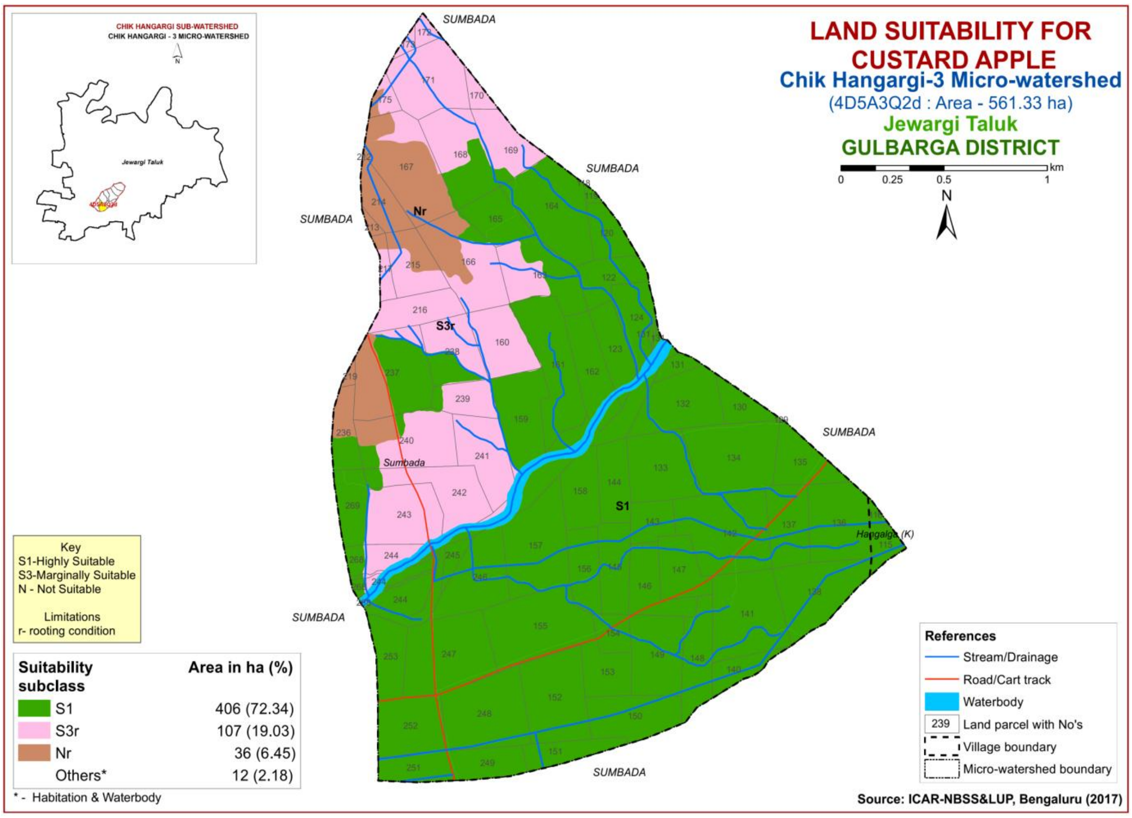


Fig. 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the fruit and medicinal crop grown in almost all the districts of the State. The crop requirements for growing amla (Table 18) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing amla was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.18.

An area of 406 ha (72%) has soils that are highly suitable (Class S1) for growing amla and are distributed in the southern, southwestern, southeastern, eastern, northestern, central and a small area in the western part of the microwatershed. Marginally suitable (Class S3) lands cover about 107 ha (19%) are distributed in the western, northwestern and northern part of microwastershed. They have moderate limitation of rooting depth for growing amla. An area of about 36 (6%) is not suitable (Class N) for growing Amla.

Table 7.18 Land suitability criteria for Amla

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately Suitable(S2)	Marginally suitable(S3)	Not suitable (N)
Soil aeration	Soil drainage	Class	Well drained	Mod.well drained	Poorly drained	V. Poorly drained
Nutrient availability	Texture	Class	Scl,cl,sc,c(red)	C (black)	ls, sl	-
	pH	1:2.5	5.5-7.3	5.0-5.5	7.8-8.4	>8.4
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15-35	35-60	60-80	
Erosion	Slope	%	0-3	3-5	5-10	>10

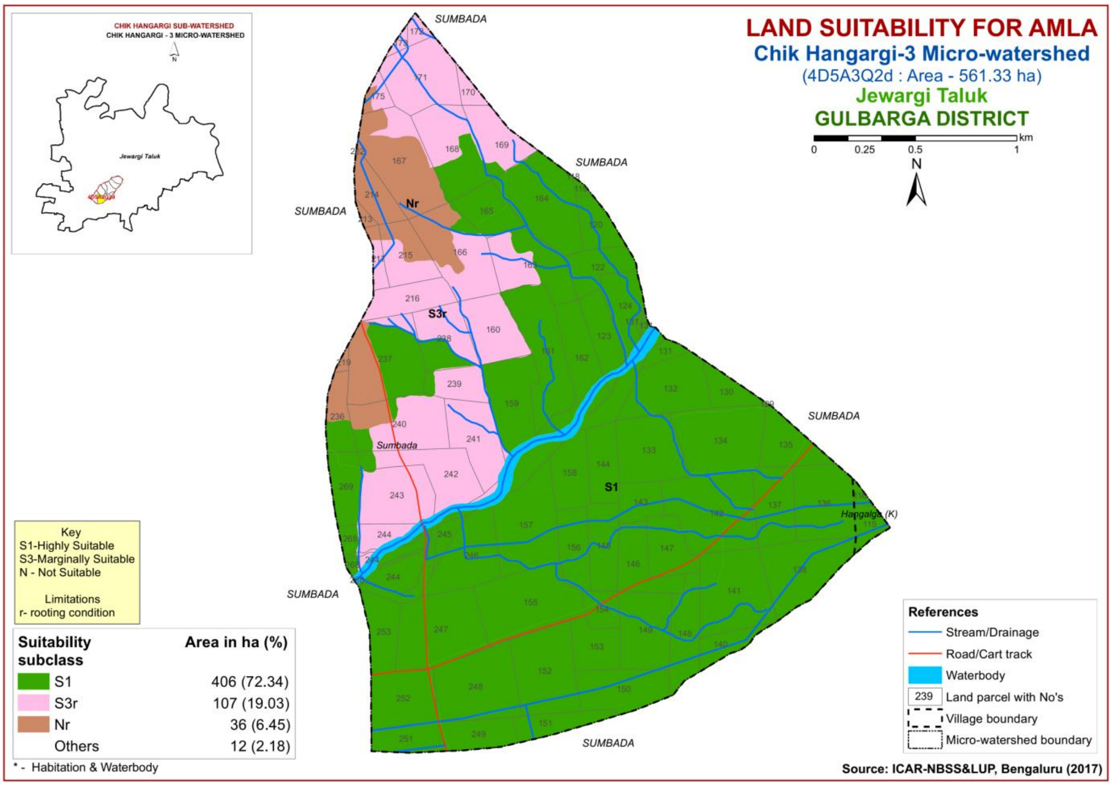


Fig. 7.18 Land Suitability map of Amla

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 (Table 7.19) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing tamarind was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

No highly suitable lands are available for growing tamarind in the microwatershed. An area of about 402 ha (71%) has soils that are moderately suitable (Class S2) and are distributed in the southern, southwestern, southeastern, eastern, northestern, central and small area in the western part of the microwatershed with minor limitations of rooting condition and texture. Marginally suitable (Class S3) lands occupy a small area 4 ha (1%) in the western part of the microwatershed. An area of about 143 (25%) is not suitable (Class N) for growing tamarind.

Table 7.19 Land suitability criteria for Tamarind

Crop requirement			Rating			
Soil –site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Soil aeration	Soil drainage	Class	Well drained	Mod.well drained	Poorly drained	V.Poorly drained
Nutrient availability	Texture	Class	Scl,cl,sc,c(red)	Sl, c (black)	ls	-
	pH	1:2.5	6.0-7.3	5.0-6.0,7.3-7.8	7.8-8.4	>8.4
Rooting conditions	Soil depth	Cm	>150	100-150	75-100	<75
	Gravel content	% vol.	<15	15-35	35-60	60-80
Erosion	Slope	%	0-3	3-5	5-10	>10

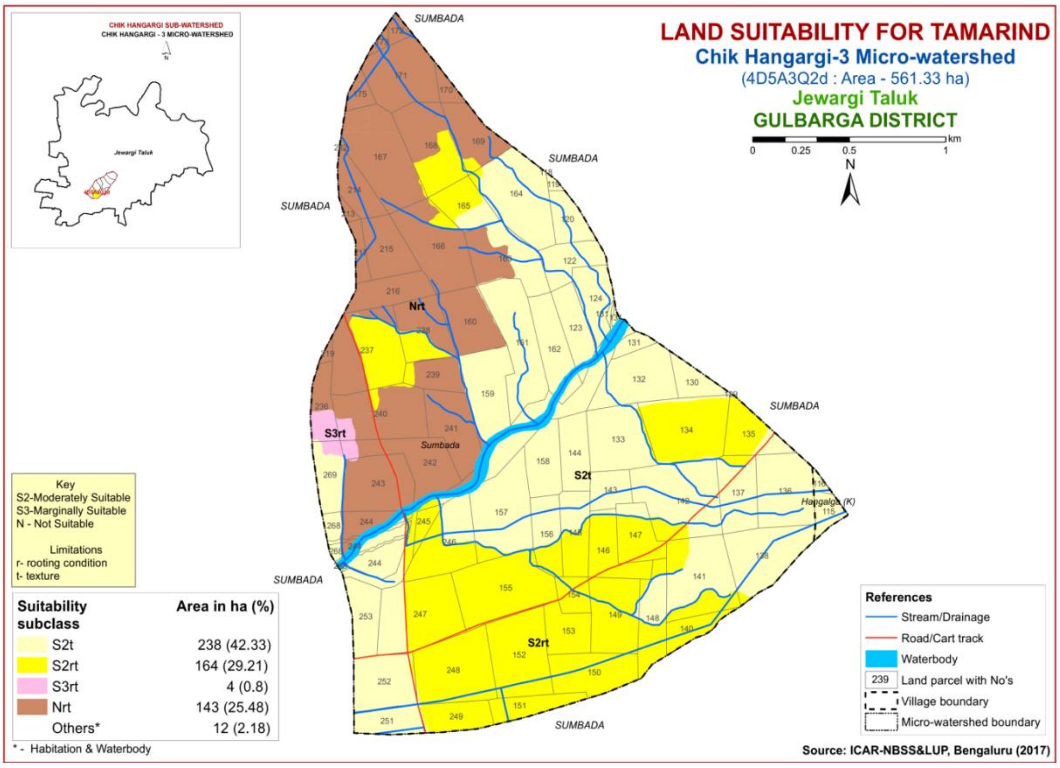


Fig. 7.19 Land Suitability map of Tamarind

7.20 Land Use Classes (LUCs)

The 14 soil map units identified in Chik Hangargi-3 microwatershed have been regrouped into 4 Land Use Classes (LUCs) for the purpose of preparing a Proposed Crop Plan. Land Use Classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Use Classes (Fig. 7.20) map has been generated. These Land Use Classes are expected to behave similarly for a given level of management.

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

LUCs	Soil map units	Soil and site characteristics
1	1 MGThB1g1 2 MGTmB2g1	Very shallow black soils (<25 cm), slight gravelly, 1-3 % slopes, slight to moderate erosion
2	3 NHAmB1 4 NHAmB1g1 5 NHAmB2 6 NHAmB2g1	Shallow black soils (25-50 cm), 1-3 % slopes, nil to slightly gravelly, slight to moderate erosion
3	7 NIRmB2	Moderately shallow black soils (50-75 cm) 1-3 % slopes, moderate erosion.
4	8 DIMmA1 9 DIMmB1 10 DIMmB2 11 DIMmB2g1 12 MARmA1 13 MARmB1 14 MARmB2	Deep to very deep black soils (100- 150 cm), 0-3 % slopes, slight to moderate erosion

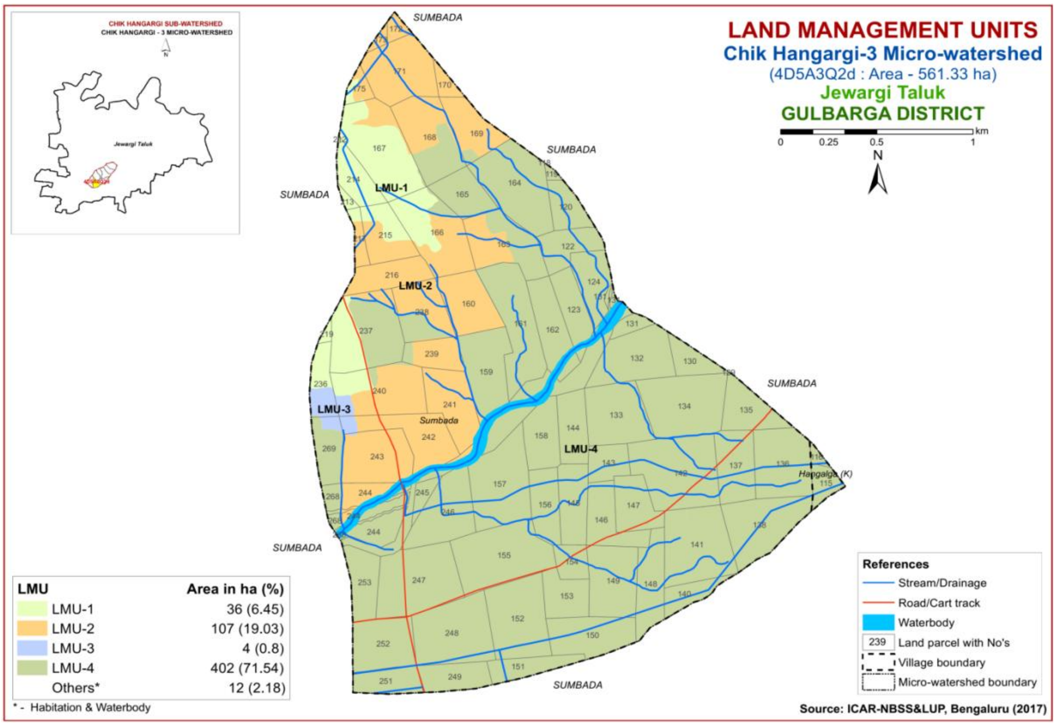


Fig. 7.20 Land Use Classes Map-Chik Hangargi-3 Microwatershed

7.21 Proposed Crop Plan for Chik Hangargi-3 Microwatershed

After assessing the land suitability for the 19 crops, the proposed crop plan has been generated for the 4 identified LUCs by considering only the highly (Class S1) and moderately (Class S2) suitable lands for each of the 19 crops. The resultant proposed crop plan is presented below in Table 7.20.

Table 7.20 Proposed Crop Plan for Chik Hangargi-3 Microwatershed

LUC	Mapping unit	Survey No's	Soil Characteristics	Crops proposed				Suitable Intervention
				Field crops	Forestry Crop/ Grasses	Horticulture crops(Rainfed Condition)	Horticulture crops with suitable intervention	
LUC-1 36 ha (6%)	1 MGThB1g1 2 MGTmB2g1	Sumbada: 167,212,213,214, 219,236	Very shallow black soils(<25 cm), slight gravelly, 1-3 % slopes, slight to moderate erosion	Horse gram, Green gram, Chick pea	Neem, Glyricydia , Silviculture, Agave, Simaroba	-	-	Cresent bunds
LUC-2 107 ha (19%)	3 NHAmB1 4 NHAmB1g1 5 NHAmB2 6 NHAmB2g1	Sumbada: 160, 163, 166, 168, 169, 170, 171, 172, 173, 175, 215, 216, 217, 238, 239, 240, 241, 242, 243, 244	Shallow black soils (25-50cm), 1-3% slopes nil to slightly gravelly, slight to moderate erosion	Bajra, Linseed, Green gram, Black gram, Chick pea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber,Amla **Vegetables**: Ladies finger, Brinjal, Cowpea, **Flowers**: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla **Vegetables**: Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers**: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip
LUC-3 4 ha (1%)	7 NIRmB2	Sumbada:	Moderately shallow black soils (50-75 cm) 1-3 % slopes, moderate erosion	Sorghum, Cotton,Sesame, RedGram, Black gram, Green gram, Soybean, Sunflower, Safflower **Rabi:** Sorghum, Chickpea	Subabul, Neem, Teak	Custard apple, Charoli, Ber, Amla **Vegetables**: Ladies finger, Brinjal, Cowpea, **Flowers**: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus **Vegetables**: Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers**: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip Graded bunds, Strengthening of field bunds
LUC-4 402 ha (71%)	8 DIMmA1 9 DIMmB1 10 DIMmB2 11 DIMmB2g1 12 MARmA1	Hangala: 115, 116 Sumbada: 118, 119, 120, 122, 123, 124, 129, 130,	Deep to very deep black soils (100->150 cm), 0-3 % slopes, slight to moderate erosion	Sorghum, Cotton, Red Gram Black gram, Green gram,	-	**Vegetables**: Ladies finger, Brinjal, Cowpea, Coriander **Field crops:** Sorghum, Cotton,	Banana, Papaya, Lime. Mosambi, Guava, Tamrind **Vegetables**: Onion, Tomato, Brinjal,	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip, Graded

	13 MARmB1 14 MARmB2	131, 132, 133, 134, 135, 136, 137, 138, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 161, 162, 163, 164, 165, 237, 244, 245, 246, 247, 248, 249, 251, 252, 253, 268, 269		Soybean, Sesame, Sunflower, Safflower, Rabi: Sorghum, Chickpea		Red Gram, Sunflower, Safflower, **Perennial component**: Guava, Tamarind, Sapota, Lime, Mosambi **Flowers**: Marigold, Chrysanthemum	Chillies, Bhendi **Flowers**: Marigold, Chrysanthemum	bunds, Strengthening of field bunds

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 characterististics of a healthy soil are

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

Characteristics of Chik Hangargi-3 Microwatershed

- ❖ The soil phases with sizeable area identified in the microwatershed belonged to the soil series of (MGT) 37 ha, (NHA) 107 ha, (NIR) 4 ha, (DIM) 164 ha and (MAR) 237 ha.
- ❖ As per land capability classification, 98 % area in the microwatershed 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, 77% area is strongly alkaline (pH 8.4 - 9.0) and 20% area is very strongly alkaline (>9.0) in the microwatershed.

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

(strongly alkaline to very strongly 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 561 ha area in the microwatershed, about of 267 ha is suffering from moderate erosion and 282 ha slight erosion. The moderately eroded areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Dissemination of information and communication of benefits

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

Inputs for Net Planning and Interventions needed

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

1. Soil and Water Conservation Plans for each plot or farm.

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

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

- **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops, either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.
- **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, 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 Chik Hangargi-3 microwatershed.
- **Organic Carbon:** The OC content (an index of available Nitrogen) is low (<0.5%) in maximum area of about 285 ha (51%) and medium (0.5-0.75%) is 264 ha (47%). 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 549 ha area where OC is medium (0.5-0.75%) and low (<0.5%). 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 549 ha area, the available phosphorus is low (<23 kg/ha). Hence for all the crops, 25% additional P-needs to be applied.

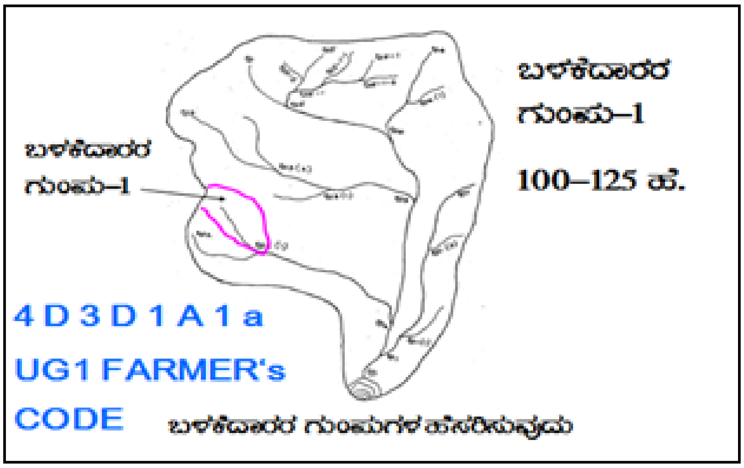
- **Available Potassium:** Available potassium is high (>337 kg/ha) in maximum area 490 ha (87%) and medium (145-337 kg/ha) in 60 ha (10%) in the microwatershed for the area that are medium in available potassium, an additional 25% potassium needs to be applied.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is medium (10-20 ppm) in an area of about 214 ha (38%), high (>20 ppm) in about 281 ha (50%) and low in an area of about 54 ha (9%). The areas which are low and medium in available sulphur 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 deficient in a small area of 17 ha (3%) in the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years.
- **Available Zinc:** It is deficient (<0.6 ppm) in maximum area 549 ha (98%) of the microwatershed. Application of zinc sulphate @25kg/ha is recommended, for areas that are deficient in available zinc.
- **Soil alkalinity:** The entire microwatershed area of 549 ha (98%) has soils that are strongly to very 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 Chik Hangargi-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 /land cover
- Crop suitability
- Rainfall
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features-network of waterways, pothissa boundaries, cut up/ minor terraces etc.
- Cadastral map (1:7920 scale)
- Satellite imagery (1:7920 scale)

Apart from these, Hand Level/ Hydro Marker/ Dumpy Level/ Total Station and Kathedars' List needs 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.

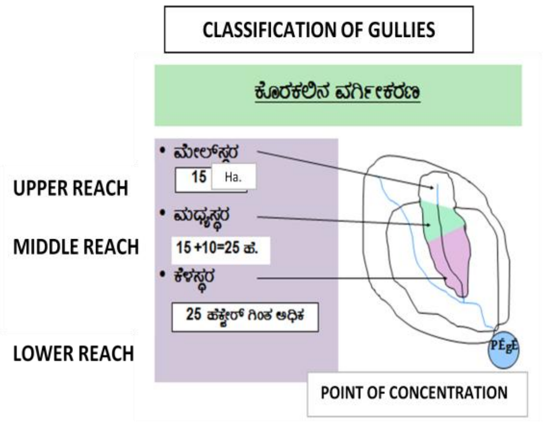
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

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

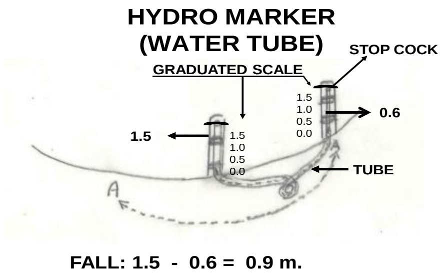
9.1.1 Arable Land Treatment

A. BUNDING

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



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

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

Note: i) The above intervals are maximum.

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

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

Section of the Bund

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

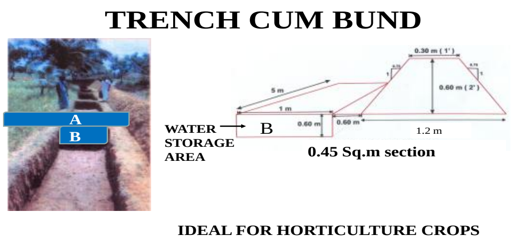
Recommended Bund Section

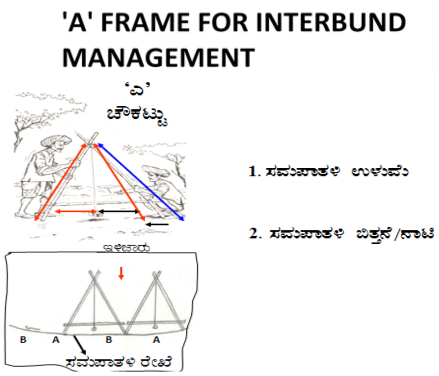
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soils	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below





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

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

B. Waterways

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 Bund are formed in the field.

9.1.3 Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of 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 from the 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 the available geological maps.
g) Rainfall intensity data of the nearest Rain Gauge Station is considered for Hydrologic Designs.
h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and earthern checks in the natural water course. Location and design details are given in the Manual.

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 406 ha (72%) needs graded bunds or strengthening of existing field bunds and about 143 ha (25%) area requires crescent bunding or trench cum bund. The conservation plan generated may be presented to all the stakeholders including the farmers and after considering their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

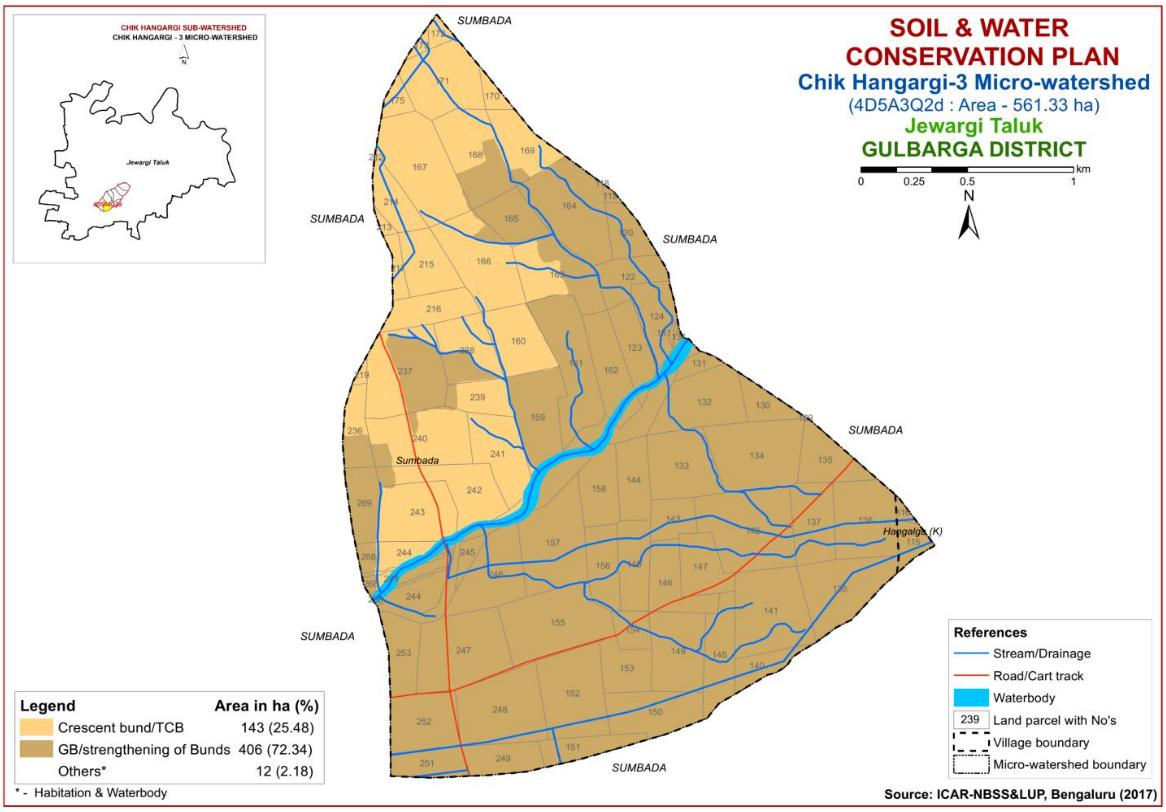


Fig. 9.1 Soil and Water Conservation Plan map of Chik Hangargi-3 Microwatershed

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, VII and VIII) and also the lands that are not suitable or marginally suitable for growing annual and perennial crops. The method of planting these trees is given below.

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

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

Dry Deciduous Species			Temp (°C)	Rainfall (mm)
1.	Bevu	*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			**Temp (°C)**	**Rainfall (mm)**
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

Chik Hangargi-3 Microwatershed

Soil Phase Information

Village	Survey No.	Total Area(ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sumbada	118	0	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	119	0.45	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	120	4.1	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	122	5.22	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	123	5.49	MARmA1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	124	5.7	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar (Rg+Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	129	0	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	130	3.41	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	131	2.01	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	132	10.05	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	133	9.89	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	134	13.22	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	135	6.12	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	136	10.48	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	137	7.46	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	1 Check dam	IIs	GB/strengthening of Bunds
Sumbada	138	11.21	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	140	3.43	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Nearly level (0-1%)	Slight	Jowar (Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	141	13.38	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	142	15.44	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	143	3.92	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	144	5.74	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	145	6.31	DIMmB1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds

Village	Survey No.	Total Area(ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sumbada	146	6.5	DIMmB1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	147	5.97	DIMmB1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	148	7.12	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	149	9.52	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	150	8.59	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	151	4.38	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	152	12.31	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	153	5.24	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	154	3.04	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	155	14.34	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	156	5.67	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	157	13.01	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	1 Check dam	IIse	GB/strengthening of Bunds
Sumbada	158	6.13	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	159	10.07	MARmA1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	160	7.81	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Scrb Land (Rg+SL)	Not Available	IVs	Crescent bund/TCB
Sumbada	161	12.62	MARmA1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Jowar+Current Fallow Land (Jw+CFL)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	162	7.78	MARmA1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	163	10.02	MARmA1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Jowar+Current Fallow Land +Scrub Land (Rg+Jw+CFL+SL)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	164	13.51	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+JOwar+ Scrub Land(Rg+Jw+SL)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	165	5.51	DIMmB2g1	LUC-4	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Medium (101-150mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	166	12.19	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton+ Paddy+Scrub Land (Rg+Ct+Pd+SL)	1 Farm Pond	IVs	Crescent bund/TCB
Sumbada	167	14.16	MGThB1g1	LUC-1	Very shallow (<25 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IVs	Crescent bund/TCB
Sumbada	168	10.93	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	2 Farm Pond	IVs	Crescent bund/TCB

Village	Survey No.	Total Area(ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sumbada	169	6.49	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram+ Scrub Land (Rg+Gg+SL)	Not Available	IVs	Crescent bund/TCB
Sumbada	170	1.47	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Sumbada	171	10.64	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IVs	Crescent bund/TCB
Sumbada	172	1.21	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Sumbada	173	0.68	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Sumbada	175	1.81	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sumbada	212	0.06	MGThB1g1	LUC-1	Very shallow (<25 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Sumbada	213	0.58	MGThB1g1	LUC-1	Very shallow (<25 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Sumbada	214	4.6	MGThB1g1	LUC-1	Very shallow (<25 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar (Rg+Jw)	Not Available	IVs	Crescent bund/TCB
Sumbada	215	6.54	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IVs	Crescent bund/TCB
Sumbada	216	5.82	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Current Fallow Land (Rg+CFL)	Not Available	IVs	Crescent bund/TCB
Sumbada	217	1.88	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Current Fallow Land (Rg+CFL)	Not Available	IVs	Crescent bund/TCB
Sumbada	219	0.5	MGTmB2g1	LUC-1	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVse	Crescent bund/TCB
Sumbada	236	4.37	MGTmB2g1	LUC-1	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Sumbada	237	14.16	DIMmB2g1	LUC-4	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	238	7.82	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Current FallowLand+ Scrub Land (CFL+SL)	Not Available	IVs	Crescent bund/TCB
Sumbada	239	4.51	NHAmB1	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Current Fallow Land (CFL)	Not Available	IVs	Crescent bund/TCB
Sumbada	240	11.94	NHAmB1	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar (Rg+Jw)	Not Available	IVs	Crescent bund/TCB
Sumbada	241	8.51	NHAmB1	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar (Rg+Jw)	Not Available	IVs	Crescent bund/TCB
Sumbada	242	9.58	NHAmB1	LUC-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Sumbada	243	9.85	NHAmB1g1	LUC-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Scrb Land (Rg+SL)	Not Available	IVs	Crescent bund/TCB
Sumbada	244	9.37	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton+ Scrub Land (Rg+Ct+SL)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	245	1.58	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	246	9.84	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds

Village	Survey No.	Total Area(ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sumbada	247	14.08	DIMmB2	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	248	13.08	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton+ Jowar (Rg+Ct+Jw)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	249	5.18	DIMmA1	LUC-4	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Sumbada	251	4.57	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	252	8.56	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	253	5.57	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	268	1.94	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Sumbada	269	5	MARmB2	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strengthening of Bunds
Hangalga (K)	115	2.51	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds
Hangalga (K)	116	0.65	MARmB1	LUC-4	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	GB/strengthening of Bunds

Appendix II

Chik Hangargi-3 Microwatershed

Soil Fertility Information

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sumbada	118	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)
Sumbada	119	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)
Sumbada	120	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	122	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	123	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	124	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	129	Strongly alkaline (pH 8.4 – 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)
Sumbada	130	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	131	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	132	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	133	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)
Sumbada	134	Strongly alkaline (pH 8.4 – 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)
Sumbada	135	Strongly alkaline (pH 8.4 – 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)
Sumbada	136	Strongly alkaline (pH 8.4 – 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)
Sumbada	137	Strongly alkaline (pH 8.4 – 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)
Sumbada	138	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	140	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	141	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	142	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 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)
Sumbada	143	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	144	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	145	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sumbada	146	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	147	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	148	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	149	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	150	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	151	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	152	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	153	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	154	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	155	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)
Sumbada	156	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	157	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	158	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	159	Strongly alkaline (pH 8.4 – 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)
Sumbada	160	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	161	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	162	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	163	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	High (> 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	164	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	High (> 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	165	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	High (> 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	166	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)	High (> 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	167	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)
Sumbada	168	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	169	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sumbada	170	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)
Sumbada	171	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)
Sumbada	172	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)
Sumbada	173	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)
Sumbada	175	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)
Sumbada	212	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)
Sumbada	213	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)
Sumbada	214	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)
Sumbada	215	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)
Sumbada	216	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	217	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)
Sumbada	219	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	236	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	237	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	238	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	239	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	240	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	241	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	242	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	243	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	244	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	245	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	246	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	247	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sumbada	248	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Sumbada	249	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	251	Strongly alkaline (pH 8.4 – 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)
Sumbada	252	Strongly alkaline (pH 8.4 – 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)
Sumbada	253	Strongly alkaline (pH 8.4 – 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)
Sumbada	268	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	269	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	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)
Hangalga (K)	115	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Hangalga (K)	116	Strongly alkaline (pH 8.4 – 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)

Appendix III

Chik Hangargi-3 Microwatershed
Soil Suitability Information

Village	Survey No.	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean
Sumbada	118	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	119	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	120	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	122	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	123	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	124	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	129	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	130	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	131	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	132	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	133	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	134	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	135	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	136	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	137	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	138	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	140	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	141	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	142	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	143	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	144	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	145	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	146	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	147	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	148	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	149	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	150	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	151	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	152	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e

Village	Survey No.	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean
Sumbada	153	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	154	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	155	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	156	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	157	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	158	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	159	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	160	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	161	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	162	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	163	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	164	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	165	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	166	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	167	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	168	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	169	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	170	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	171	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	172	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	173	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	175	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	212	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	213	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	214	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	215	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	216	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	217	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	219	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	236	Nrt	Nrt	Nrt	Nr	Nrt	Nr	Nrt	Nr	S3r	Nr	Nrt	Nr	Nrt	Nr	Nrt	Nrt	Nr	Nrt	Nr
Sumbada	237	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	238	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r

Village	Survey No.	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean
Sumbada	239	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	240	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	241	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	242	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	243	Nrt	S3rt	Nrt	S3r	Nrt	S3r	Nrt	Nr	S2r	Nr	S3rt	S3r	Nrt	S3r	Nrt	Nrt	Nr	Nrt	S3r
Sumbada	244	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	245	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	246	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	247	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	248	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	249	S3t	S3t	S3t	S1	S3t	S1	S2rt	S1	S1	S1	S2te	S1	S3t	S1	Nt	S2t	S1	S3t	S2e
Sumbada	251	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	252	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	253	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	268	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sumbada	269	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Hangalga (K)	115	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Hangalga (K)	116	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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: *Chick Hangargi-3 Microwatershed (Chick Hangargi sub-watershed, Jewargi taluk, and Gulbarga district) is located in between $16^{0}47'$ – $16^{0}49'$ North latitudes and $76^{0}32'$ – $76^{0}34'$ East longitudes, covering an area of about 561.33 ha, bounded by Sumbada village with length of growing period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for Chick Hangargi-3 micro-watershed, (Chick Hangargi sub-watershed, Jewargi taluk, and Gulbarga district) are presented here.*

Social Indicators;

- *Male and female ratio is 54.9 to 45.1 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 47.1 per cent to the total population.*
- *Literacy population is around 64.7 per cent.*
- *Social groups belong to other backward caste (OBC) among the sample households.*
- *Fire wood and liquefied petroleum gas (LPG) is the source of energy for a cooking among 90 per cent.*
- *About 40 per cent of households have a yashaswini health card.*
- *Majority of farm households (20 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system among the all sample households.*
- *Swach bharath program providing closed toilet facilities among the all sample households.*
- *Women participation in decisions making in agriculture production of households were found.*

Economic Indicators;

- *The average land holding is 1 .7 ha indicates that majority of farm households are belong to small and medium farmers. The total cultivated land by dry land condition among the sample farmers.*
- *Agriculture is the main occupation among 62.8 per cent and agriculture as a main and agriculture labour is a subsidiary occupation is 35.2 per cent of sample households.*
- *The average value of domestic assets is around Rs. 16445 per household. Mobile and television are popular media mass communication.*
- *The average value of livestock is around Rs. 14750 per household; about 67 per cent of household are having livestock.*
- *The average per capita food consumption is around 842.1 grams (211.9 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 80 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 30968 per household. About 80.0 per cent of farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs. 1850.*

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. 586 per ha/year. The total cost of annual soil nutrients is around Rs. 321621 per year for the total area of 549 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 8692/ ha/year. Per hectare food grain production services is maximum in cotton (Rs 15737) followed by red gram (Rs. 9993) and green gram (Rs. 346).*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in red gram (Rs. 65777) followed by cotton (Rs. 52738) and greengram (Rs. 39669).*

Economic Land Evaluation;

- *The major cropping pattern is cotton (51.5 %) followed by red gram (44.9 %) and green gram (3.6%).*
- *In Chick Hangargi-3 micro-watershed, major soils are of Marguti (MGT) series is having very shallow soil depth cover around 6.45 % of area. On this soil farmers are presently growing cotton (77 %) and red gram (23 %). Novinihala (NHA) are having shallow soil depth cover 19.04 % of area, the crops are red*

gram, Dimal (DIM) soil series having deep soil depth cover around 29.22 % of area, crops grown are cotton (36 %) and redgram (64 %), Mannur (MAR) soil series having very deep soil depth cover around 42.33 % of area, crops grown are cotton (62 %), green gram (16 %) and red gram (22 %).

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for cotton range between Rs. 52418/ha in DIM soil (with BCR of 1.13) and Rs 41561/ha in MGT soil (with BCR of 1.43).*
- *In redgram the cost of cultivation range between Rs. 42881/ha in MAR soil (with BCR of 1.09) and Rs 36388/ha in DIM soil (with BCR of 1.39).*
- *In greengram the cost of cultivation in MAR soil Rs 28949/ha (with BCR of 1.01).*
- *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 cotton (32.0 to 19.3 %) and green gram (32.7 %) and red gram (4.3 %).*

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

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

Chick Hangargi-3 micro-watershed (Chick Hangargi sub-watershed, Jewargi taluk, Gulbarga district) is located in between $16^{0}47'$ – $16^{0}49'$ North latitudes and $76^{0}32'$ – $76^{0}34'$ East longitudes, covering an area of about 561.33 ha, bounded by Sumbada village.

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).

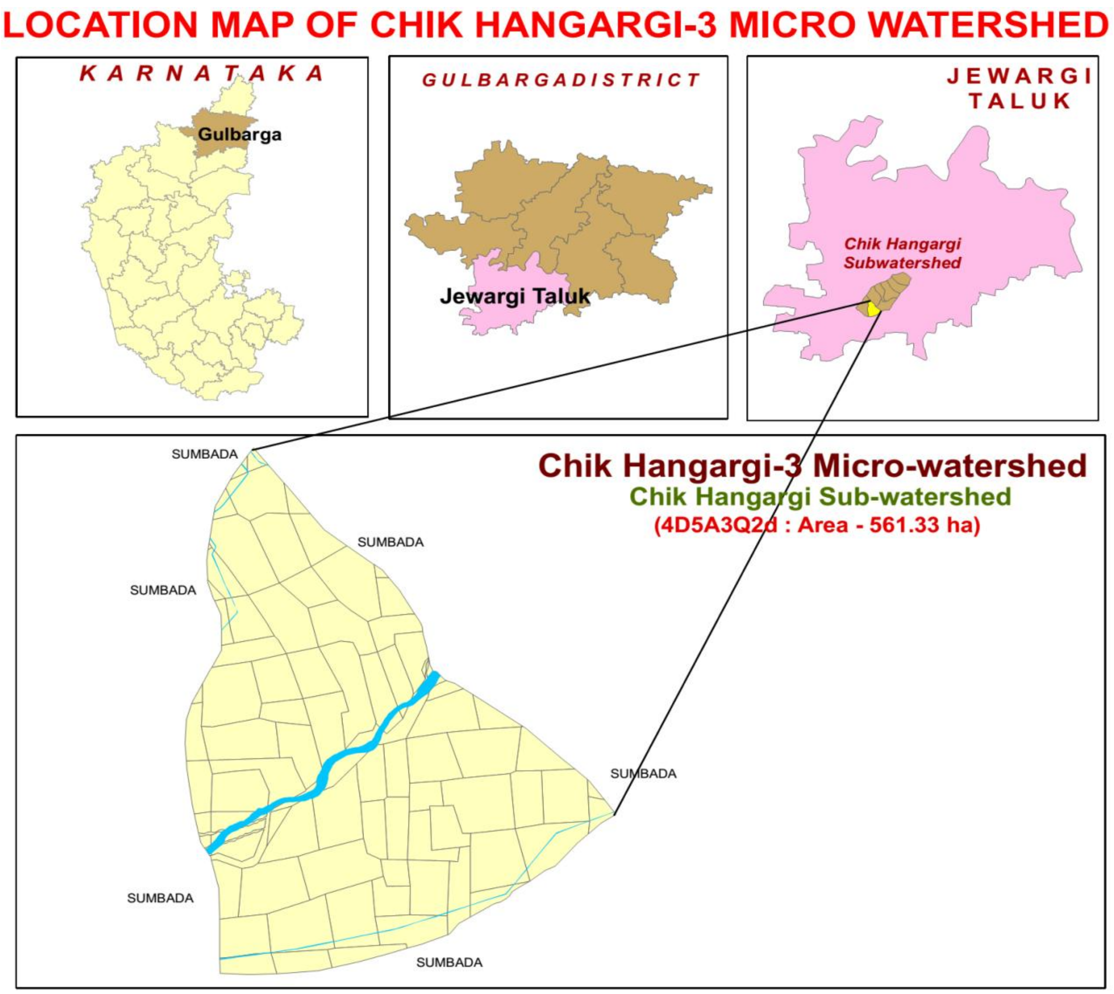

Figure 1: Location of study area

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 .

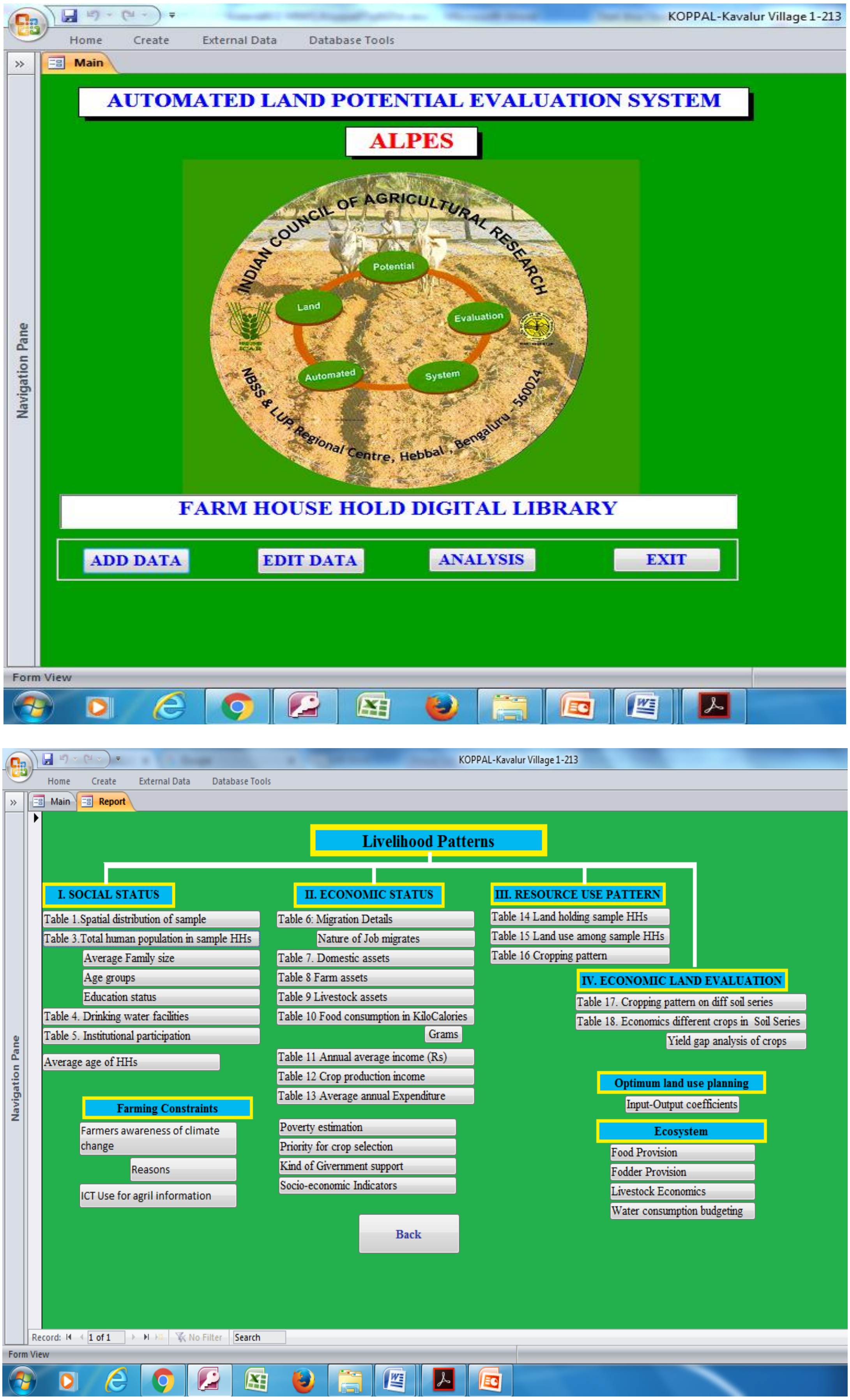

Figure 2: ALPES FRAMEWORK

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 51, out of which 54.9 per cent were males and 45.1 per cent females. Average family size of the households is 5.1. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 0 to 18 years (47.1 %) followed by 30 to 50 years (31.4 %), 18 to 30 years (15.7 %) and more than 50 years (5.9 %). 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 64.7 per cent of respondents were illiterate and 35.3 per cent literate (Table 1).

Table 1: Human population among sample households in Chick Hangargi 3 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	51
Male	% to total Population	54.9
Female	% to total Population	45.1
Average family size	Number	5.1
Age group		
0 to 18 years	% to total Population	47.1
18 to 30 years	% to total Population	15.7
30 to 50 years	% to total Population	31.4
>50 years	% to total Population	5.9
Average age	Age in years	24.5
Education Status		
Illiterates	% to total Population	35.3
Literates	% to total Population	64.7
Primary School (<5 class)	% to total Population	5.9
Middle School (6- 8 class)	% to total Population	19.6
High School (9- 10 class)	% to total Population	23.5
Others	% to total Population	15.7

The ethnic groups among the sample farm households found to all sample farm households belonging to other backward caste (OBC) (Table 2 and Figure 3). About 90 per cent of sample households are using both fire wood and gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 40.0 per cent are sample households having health cards. Majority (20.0 %) are having MNREGA job cards for employment generation. About all sample farm households are having ration cards for taking food grains from public distribution system. About 20.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Chick Hangargi 3 Microwatershed

Particulars	**Units**	**Value**
Social groups		
OBC	% of Households	100
Types of fuel use for cooking		
Fire wood & Gas	% of Households	90.0
Gas	% of Households	10.0
Energy supply for home		
Electricity	% of Households	100
Number of households having Health card		
Yes	% of Households	40.0
No	% of Households	60.0
MGNREGA Card		
Yes	% of Households	20.0
No	% of Households	80.0
Ration Card		
Yes	% of Households	100
No	% of Households	0.0
Households with toilet		
Yes	% of Households	20.0
No	% of Households	80.0
Drinking water facilities		
Tube Well	% of Households	100

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well source for water supply for domestic purpose (100 %).

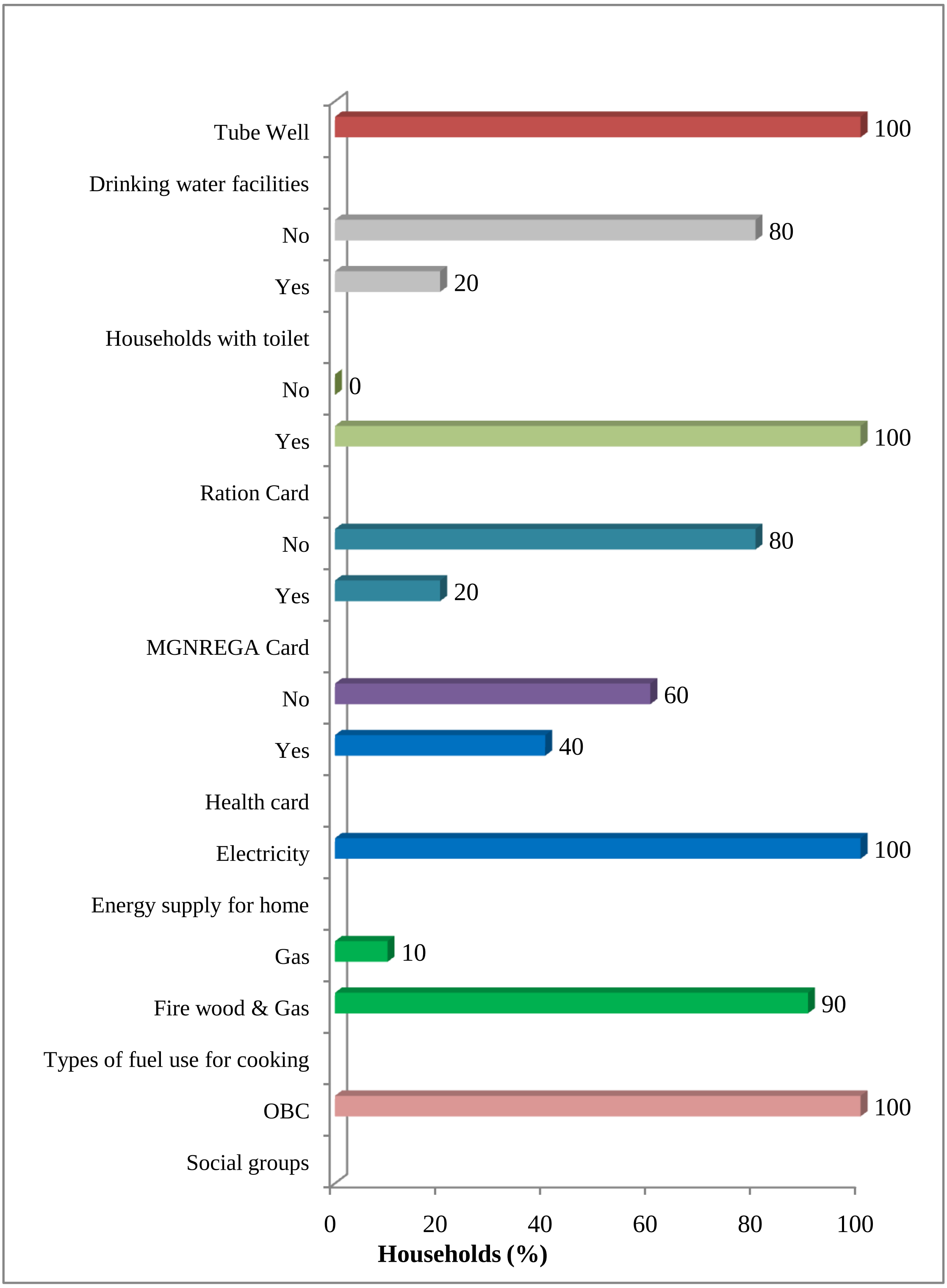

Figure 3: Basic needs of sample households in Chick Hangargi 3 Microwatershed

The occupational pattern (Table 3) among sample households shows that agriculture is the main occupation around 62.8 per cent of farmers followed by subsidiary occupations like agriculture labour (35.3 %). The self employed is a main occupation among of 2.0 per cent.

Table 3: Occupational pattern in sample population in Chick Hangargi 3 Microwatershed

Occupation		**% to total**
Main	**Subsidiary**	
Agriculture	Agriculture	62.8
	Agriculture Labour	35.3
Self employed		2.0
Grand total		100
Family labour availability		**Man days/month**
Male		30.0
Female		20.0
Total		50.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 4 and Figure 4. The important domestic assets possessed by all categories of farmers are mixer/grinder (100 %) followed by television (100 %), motorcycle (100 %), mobile phones (90.0 %), computer/laptop (10.0 %) and bicycle (10.0 %). The average value of domestic assets is around Rs 16445 per households.

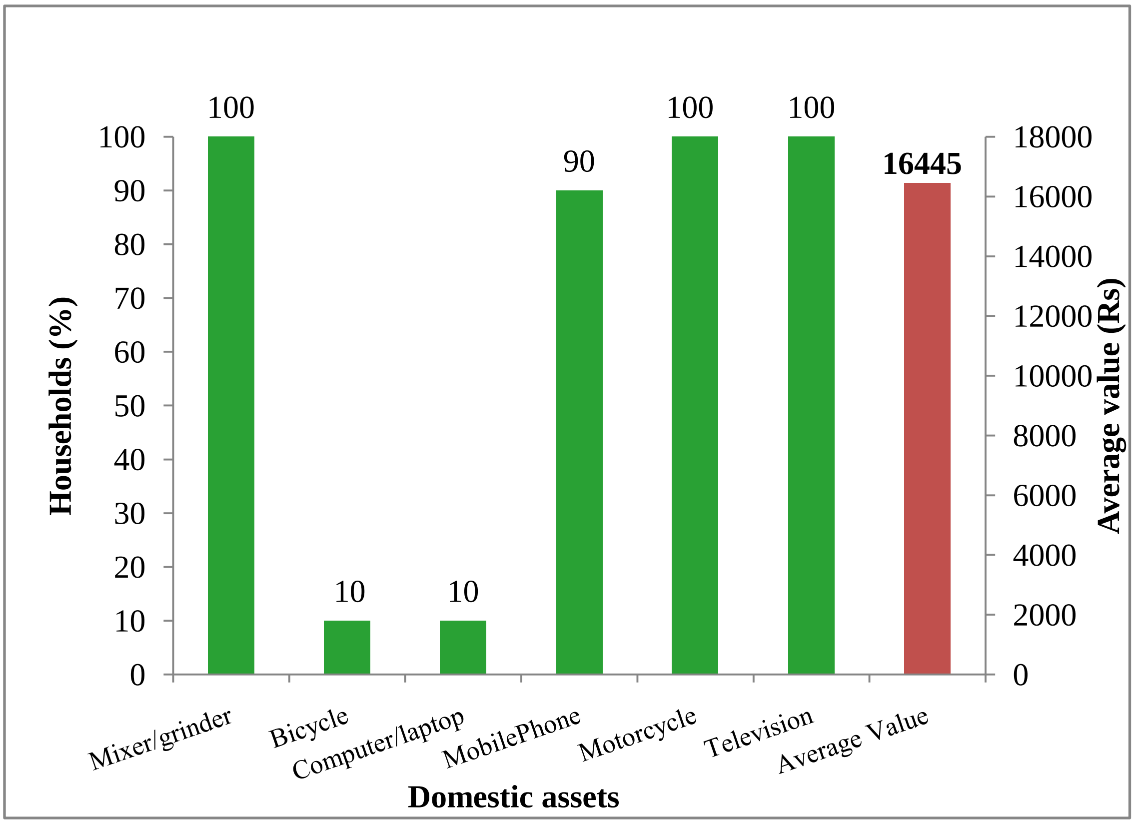

Figure 4: Domestic assets among the sample households in Chick Hangargi 3 Micro watershed

Table 4: Domestic assets among the sample households in Chick Hangargi 3 Microwatershed

Particulars	% of households	Average value in Rs
Mixer/grinder	100.0	1600
Bicycle	10.0	1000
Computer/laptop	10.0	20000
Mobile Phone	90.0	6667
Motorcycle	100.0	60500
Television	100.0	8900
Average Value	16445	

Livestock is an integral component of the conventional farming systems (Table 5 and Figure 5). The highest livestock population is local milching cow were around 62.5 per cent fallowed by local dry cow (12.5 %), goats (12.5 %) and sheeps (12.5 %). The average livestock value was Rs 14750 per household.

Table 5: Livestock assets among sample households in Chick Hangargi 3 Microwatershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	12.5	15000
Local Milching Cow	62.5	19000
Goats	12.5	20000
Sheeps	12.5	5000
Average value	14750	

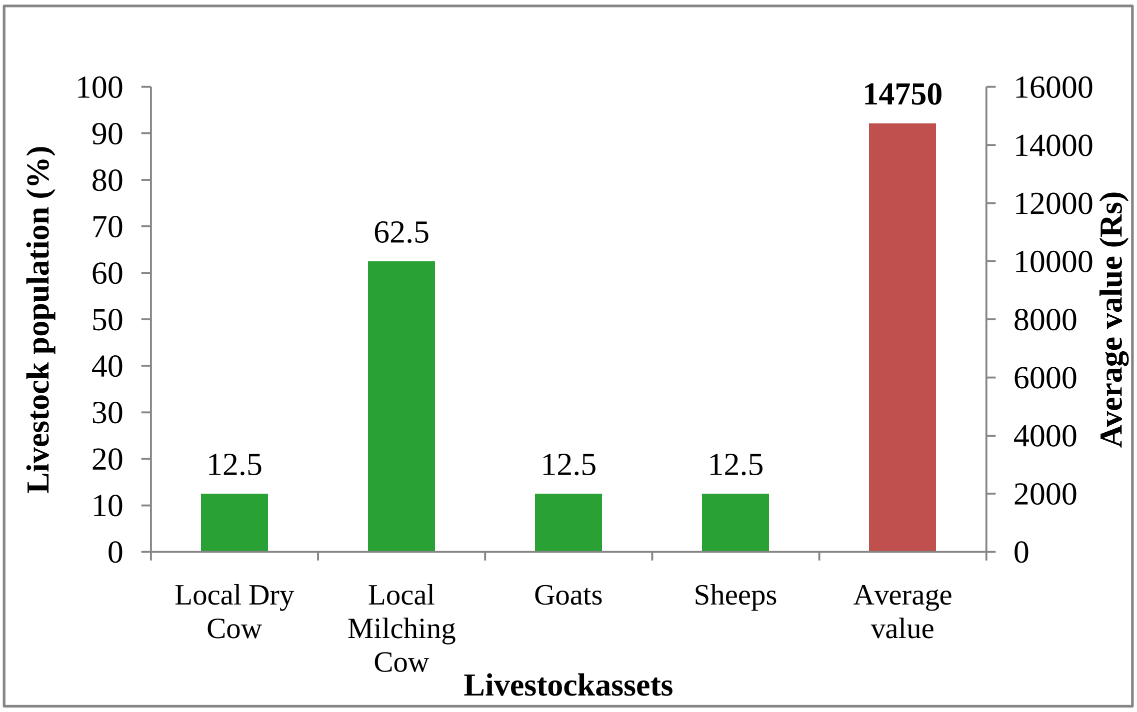

Figure 5: Livestock assets among sample households in Chick Hangargi 3 Microwatershed

Average milk produced in sample households is 708 litters/ annum is milching buffalos (Table 6). The livestock having households among the sample households is 67 per cent.

Table 6: Milk produced of sample households in Chick Hangargi 3 Microwatershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	708
Livestock having households (%)	67.0
Livestock population (Numbers)	12

A woman participation in decision making is in this micro-watershed is presented in Table 7. About 100 per cent of women taking decision in her family and agriculture related activities, and women earning for her family requirement.

Table 7: Women empowerment of sample households in Chick Hangargi 3 Microwatershed

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

Table 8: Per capita daily consumption of food among the sample households in Chick Hangargi 3 Microwatershed:

Particulars	**NIN recommendation (gram/ per day/ person)**	**Present level of consumption (gram/ per day/ person)**	**Kilo Calories /day/person**
Cereals	396	439.1	1493.0
Pulses	43	44.8	153.7
Milk	200	152.6	99.2
Vegetables	143	88.0	21.1
Cooking Oil	31	42.0	239.6
Egg	0.5	66.0	99.1
Meat	14.2	9.5	14.2
Total	**827.7**	**842.1**	**2119.9**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		80.0	70.0
% Above NIN		20.0	30.0

* Day/person

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 8 and Figure 6. More quantity of cereals is consumed by sample farmers which accounted for 1493.0 kcal per person. The other important food items consumed was pulses 153.7 kcal followed by cooking oil 239.6 kcal, milk 99.2 kcal, vegetables 21.1 kcal, egg 99.1 kcal and meat 14.2 kcal. In the sampled households, farmers were consuming less (2119.9 kcal) than NIN- recommended food requirement (2250 kcal).

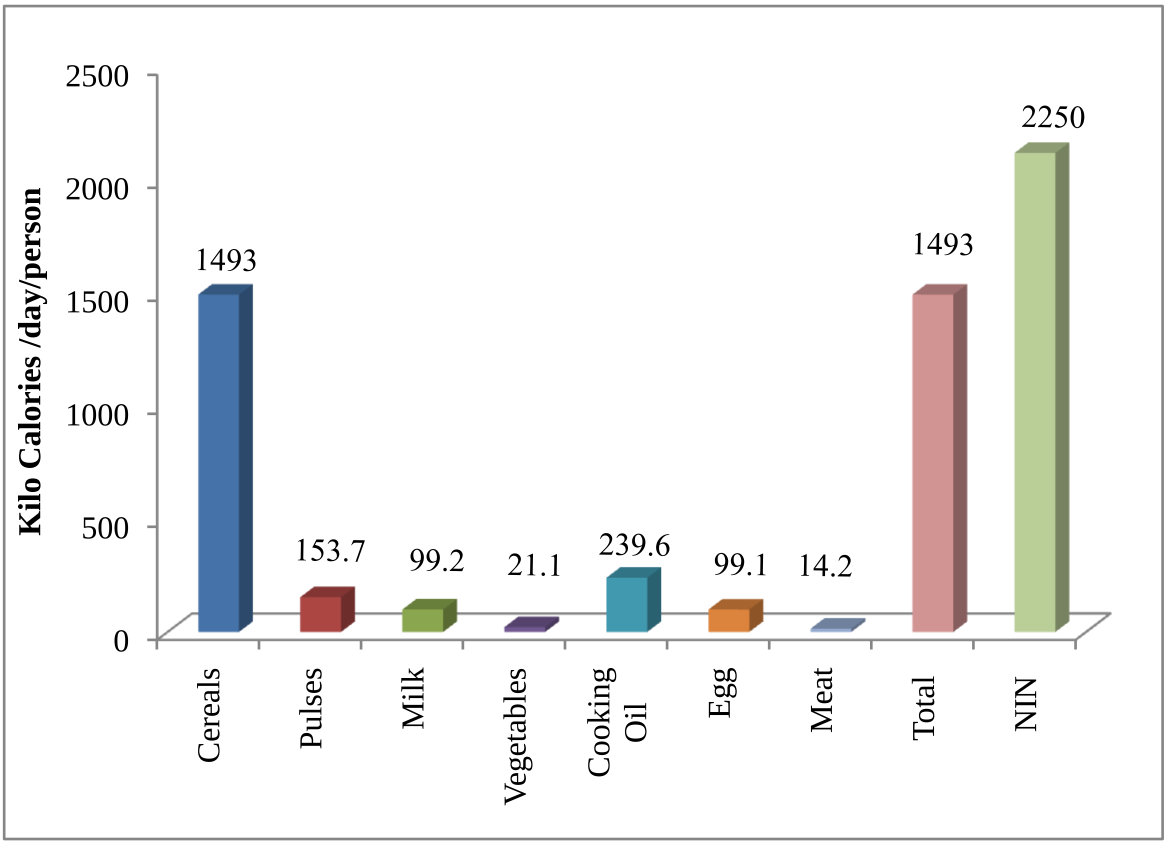

Figure 6: Per capita daily consumption of food among the sample farmers in Chick Hangargi 3 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 30968. Major source of income to the farmers in the study area is from crop production (Rs 22560) followed by livestock (Rs. 8408). The monthly per capita income is Rs. 506 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 9).

Table 9: Annual average income of HHs from various sources in Chick Hangargi 3 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	0 (0)
Livestock income (Rs)	8408 (50)
Crop Production (Rs)	22560 (100)
Total Annual Income (Rs)	***30968***
Average monthly per capita income (Rs)	506
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. 46908) 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 1850 and about 80.0 per cent of farm households are below poverty line and 20.0 per cent of farm households are above poverty line (Table 10 and Figure 7).

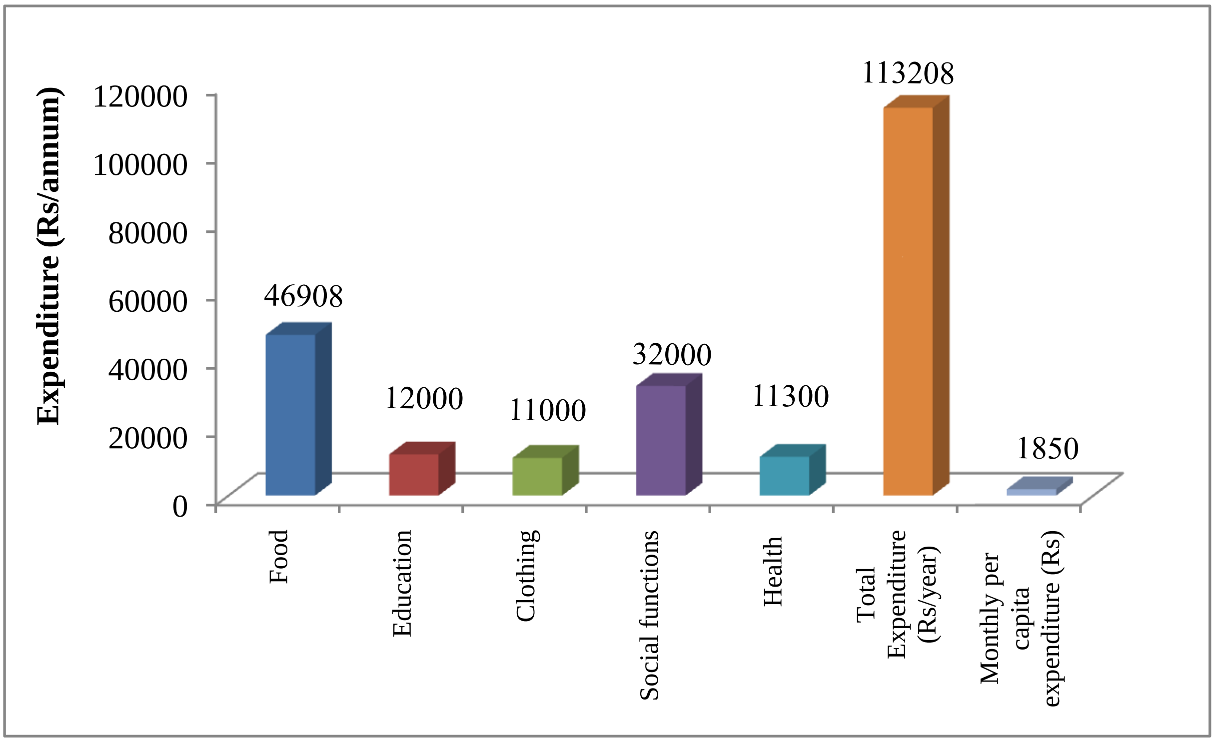

Figure 7: Average annual expenditure of sample HHs in Chick Hangargi 3 Microwatershed

Table 10: Average annual expenditure of sample HHs in Chick Hangargi 3 Microwatershed

Particulars	Value in Rupees	Per cent
Food	46908	41.4
Education	12000	10.6
Clothing	11000	9.7
Social functions	32000	28.3
Health	11300	10.0
Total Expenditure (Rs/year)	113208	100
Monthly per capita expenditure (Rs)	1850	

Land holding: Total area cultivated by them is 16.5 ha. The average land holding of sample HHs is 1.7 ha. Large number of sample HHs (70 %) belong to small size group with an average holding size of 1.1 ha followed by medium (20 %) farmer with a average land holding size of 2.2 ha and large farmers (10 %) with a average land holding size of 4.2 ha (Table 11)

Table 11: Distribution of land holding among the sample households in Chick Hangargi 3 Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	8.0
Sample size	Per cent	70.0
Average land holding	ha	1.1
Medium farmers		
Total land	ha	4.3
Sample size	Per cent	20.0
Average land holding	ha	2.2
Large farmers		
Total land	ha	4.2
Sample size	Per cent	10.0
Average land holding	ha	4.2
Total sample households		
Total land	ha	16.5
Sample size	Per cent	100.0
Average land holding	ha	1.7

Land use: The total land holding in the Chick Hangargi-3 micro-watershed is 16.5 ha is rain fed land (Table 12). The average land holding per household is worked out to be 1.7 ha.

Table 12: Land use among samples households in Chick Hangargi 3 Microwatershed

Particulars	**Per cent**	**Area in ha**
Irrigated land	0.0	0.0
Rain fed Land	100.0	16.5
Fallow Land	0.0	0.0
Total land holding	100.0	16.5
Average land holding	1.7	

In the micro-watershed, the prevalent present land uses under perennial plants are lime (55.6 %) followed by neem trees (41.0 %), jalli (2.8 %) and tamarind (0.6 %) (Table 13).

Table 13: Number of trees/plants covered in sample farm households in Chick Hangargi 3 Microwatershed

Particulars	**Number of Plants/trees**	**Per cent**
Jalli	5	2.8
Lime	100	55.6
Neem trees	74	41.0
Tamarind	1	0.6
Grand Total	180	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 cotton (51.5 %) and red gram (44.9 %) and green gram (3.6 %) (Table 14).

Table 14: Present cropping pattern and cropping intensity in Chick Hangargi 3 Microwatershed %to Grand Total

Crops	**Kharif**	**Grand Total**
Cotton	51.5	51.5
Redgram	44.9	44.9
Green gram	3.6	3.6
Total	100.0	100.0

Economic land evaluation

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

In Chick Hangargi-3 micro-watershed, 5 soil series are identified and mapped (Table 15). The distribution of major soil series are Mannur (MAR) covering an area around 237 ha (42.33 %) followed by Dimal (DIM) 164 ha (29.22 %), Novinihala (NHA) 107 ha (19.04 %), Marguti (MGT) 37 ha (6.45 %) and Nirgudi (NIR) 4 ha (0.8 %).

Table 15: Distribution of soil series in Chick Hangargi 3 Microwatershed

Sl. No	**Map unit**	**Description**	**Area in ha (%)**
1	MGT	Marguti soils are very shallow (<25cm), well drained. They have very dark grayish brown to dark brown, clayey soils and occur on very gently sloping to moderately sloping uplands	37 (6.45)
2	NHA	Novinihala soils are shallow (25-50 cm), well drained. They have very dark grayish brown to dark brown clayey soils and occur on very gently sloping to moderately sloping uplands	107 (19.04)
3	NIR	Nirgudi soils are moderately deep (75-100 cm), moderately well drained. They have very dark grayish brown to very dark gray, calcareous, clayey soils and occur on nearly level to very gently sloping uplands	4 (0.8)
4	DIM	Dimal soils are deep (100-150 cm), moderately well drained. They have very dark grayish brown to very dark gray clayey soils and occur on nearly level to very gently sloping to moderately sloping uplands	164 (29.22)
5	MAR	Mannur soils are very deep (>150 cm), moderately well drained. They have very dark gray to brown clayey soils and occur on nearly level to very gently sloping uplands	237 (42.33)

Present cropping pattern on different soil series are given in Table 16. Crops grown on Marguti (MGT) soils are cotton and red gram. Red gram on Novinihala (NHA) soils, cotton and red gram on Dimal (DIM) and cotton, green gram and red gram on Mannur (MAR) soils.

Table 16: Cropping pattern on major soil series in Chick Hangargi 3 Microwatershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Rain fed	Grand Total
			Kharif	
MGT	Very shallow (<25 cm)	Cotton	77	77
		Redgram	23	23
NHA	Shallow (25-50 cm)	Redgram	100	100
DIM	Deep (100-150 cm)	Cotton	36	36
		Redgram	64	64
MAR	Very deep (>150 cm)	Cotton	62	62
		Greengram	16	16
		Redgram	22	22

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 17).

Table 17: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Chick Hangargi 3 Microwatershed

Soil Series	Small Farmers	Medium Farmers	Large Farmers
MGT	Redgram (1.23)		Cotton (1.43)
NHA		Redgram (1.28)	
DIM	Cotton (1.13), Redgram (1.39)		
MAR	Cotton (1.34), Greengram (1.01) Redgram (1.09)	Cotton (1.43)	

The productivity of different crops grown in Chick Hangargi-3 micro-watershed under potential yield of the crops is given in Table 18.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 18. The total cost of cultivation in study area for cotton range between Rs 52418/ha in DIM soil (with BCR of 1.13) and Rs 41561/ha in MGT soil (with BCR of 1.43), followed by red gram range between Rs. 42881/ha in MAR soil (with BCR of 1.09) and Rs 36388/ha in DIM soil (with BCR of 1.39) and green gram cost of cultivation in MAR soil Rs 28949/ha (with BCR of 1.01).

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 18. 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 16903 in cotton and a minimum of Rs 7924 in green gram cultivation.

Table 18: Economic land evaluation and bridging yield gap for different crops in Chick Hangargi 3 Microwatershed

Particulars	MGT (<25 cm)		NHA (25-50 cm)	DIM (100-150cm)		MAR (>150 cm)		
	Cotton	**Red gram**	**Red gram**	**Cotton**	**Red gram**	**Cotton**	**Green gram**	**Red gram**
Total cost (Rs/ha)	41561	38212	36609	52418	36388	49160	28949	42881
Gross Return (Rs/ha)	59280	46930	46930	59280	49687	68285	29295	46930
Net returns (Rs/ha)	17719	8718	10321	6862	13300	19125	346	4049
BCR	1.43	1.23	1.28	1.13	1.39	1.39	1.01	1.09
Farmers Practices (FP)								
FYM (t/ha)	2.9	3.3	4.6	3.3	2.3	2.7	1.2	2.5
Nitrogen (kg/ha)	41.7	80.0	78.2	39.2	64.1	51.1	20.9	60.8
Phosphorus (kg/ha)	95.6	57.5	63.9	74.2	46.1	67.9	53.5	57.5
Potash (kg/ha)	19.6	0.0	0.0	16.7	0.0	12.0	0.0	0.0
Grain (Qtl/ha)	11.8	12.5	12.5	13.3	11.8	13.9	5.8	12.5
Price of Yield (Rs/Qtl)	5100	3800	3800	4500	4250	4950	5100	3800
Soil test based fertilizer Recommendation (STBR)								
FYM (t/ha)	12.4	7.4	7.4	12.4	7.4	12.4	7.4	7.4
Nitrogen (kg/ha)	185.3	30.9	30.9	185.3	30.9	185.3	23.2	30.9
Phosphorus (kg/ha)	74.1	61.8	61.8	92.6	61.8	92.6	46.3	61.8
Potash (kg/ha)	74.1	18.5	24.7	74.1	18.5	55.6	27.8	18.5
Grain (Qtl/ha)	17.3	12.4	12.4	17.3	12.4	17.3	8.6	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)								
FYM (%)	76.2	55.0	37.5	73.0	68.9	78.4	84.3	66.3
Nitrogen (%)	77.5	-159.1	-153.4	78.9	-107.5	72.4	9.6	-97.0
Phosphorus (%)	-29.0	6.9	-3.5	19.9	25.4	26.7	-15.5	6.9
Potash (%)	73.5	100.0	100.0	77.5	100.0	78.4	100.0	100.0
Grain (%)	32.0	-1.2	-1.2	22.9	4.3	19.3	32.7	-1.2
Value of yield and Fertilizer (Rs)								
Additional Cost (Rs/ha)	11276	4045	2612	12731	5769	13245	6514	5108
Additional Benefits (Rs/ha)	28179	-570	-570	17805	2240	16543	14438	-570
Net change Income (Rs/ha)	16903	-4615	-3182	5075	-3529	3297	7924	-5678

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 19 and Figure 8. The average value of soil nutrient loss is around Rs 586 per ha/year. The total cost of annual soil nutrients is around Rs 321621 per year for the total area of 561.33 ha.

Table 19: Estimation of onsite cost of soil erosion in Chick Hangargi 3 Microwatershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	77.74	42679	489.76	268878
Phosphorus	0.04	21	1.69	928
Potash	2.76	1516	55.23	30324
Iron	0.06	31	2.72	1492
Manganese	0.04	22	11.07	6080
Cupper	0.01	8	7.87	4323
Zinc	0.00	2	0.12	67
Sulphur	0.43	234	17.06	9364
Boron	0.01	4	0.30	166
Total	81.09	44517	585.83	321621

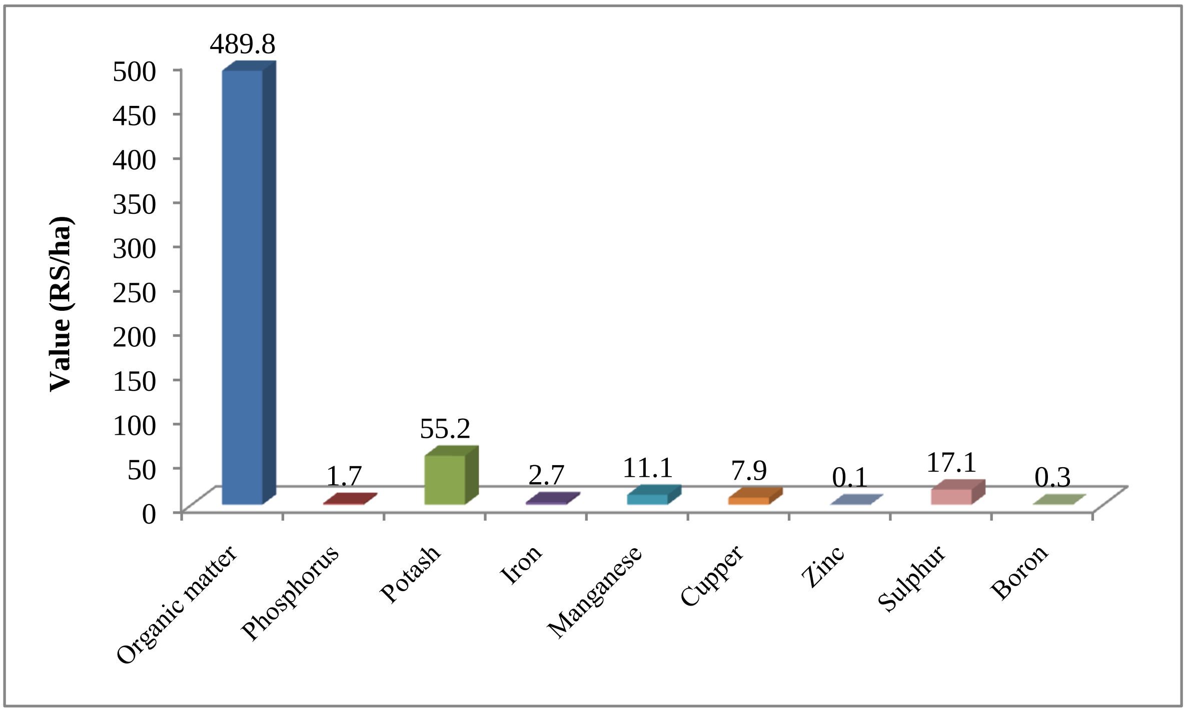

Figure 8: Estimation of onsite cost of soil erosion in Chick Hangargi 3 Microwatershed

The average value of ecosystem service for food grain production is around Rs 8692/ ha/year (Table 20 and Figure 9). Per hectare food grain production services is maximum in cotton (Rs 15737) followed by red gram (Rs 9993) and green gram (Rs 346).

Table 20: Ecosystem services of food grain production in Chick Hangargi 3 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Pulses	Greengram	0.9	6	5100	29295	28949	346
	Redgram	6.8	12	3980	48088	38096	9993
Commercial Crops	Cotton	8.8	13	4875	63812	48074	15737
Average value		16.4	10	4652	47065	38373	8692

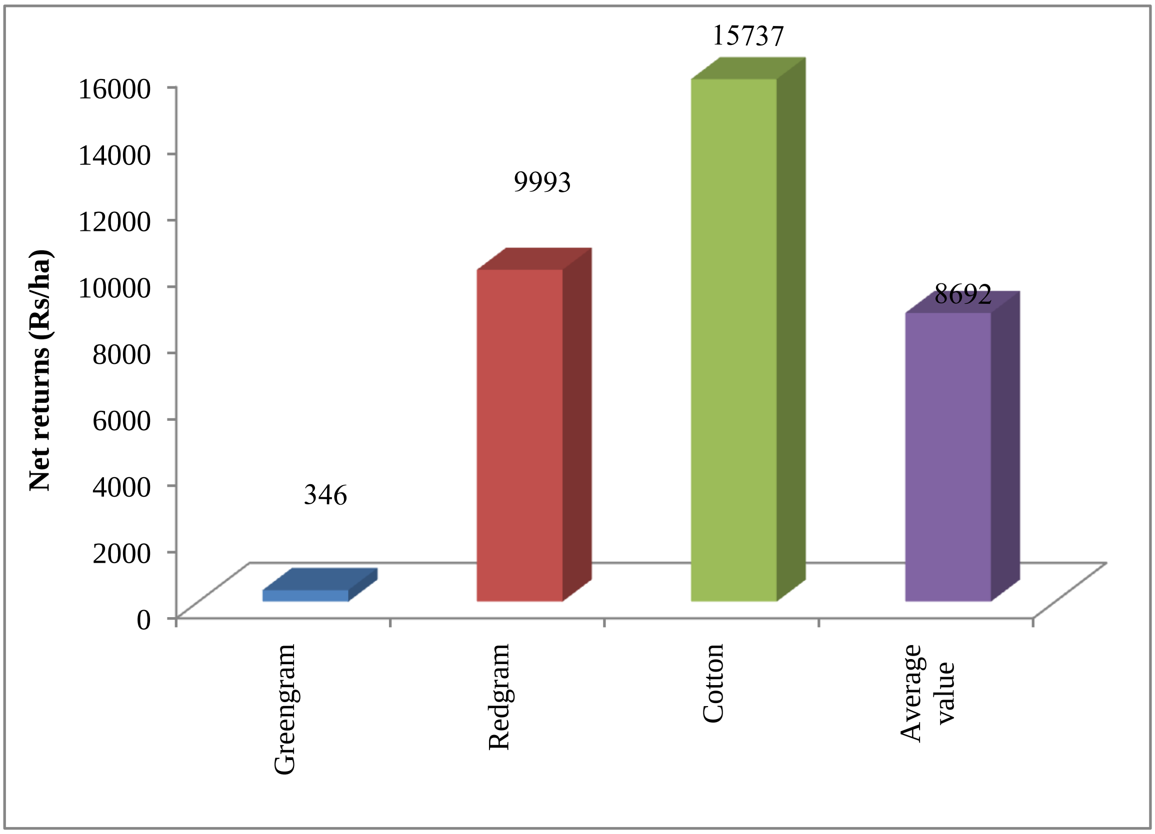

Figure 9: Ecosystem services of food grain production in Chick Hangargi 3 Microwatershed

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 21 and Figure 10) in red gram (Rs 65777), cotton (Rs 52738) and green gram (Rs 39669).

Table 21: Ecosystem services of water supply in Chick Hangargi 3 Microwatershed

Crops	**Yield (Qtl/ha)**	**Virtual water (cubic meter) per ha**	**Value of Water (Rs/ha)**	**Water consumption (Cubic meters/Qtl)**
Cotton	13.1	5274	52738	403
Greengram	5.7	3967	39669	691
Redgram	12.1	6578	65777	544
Grand Total	11.9	5795	57951	489

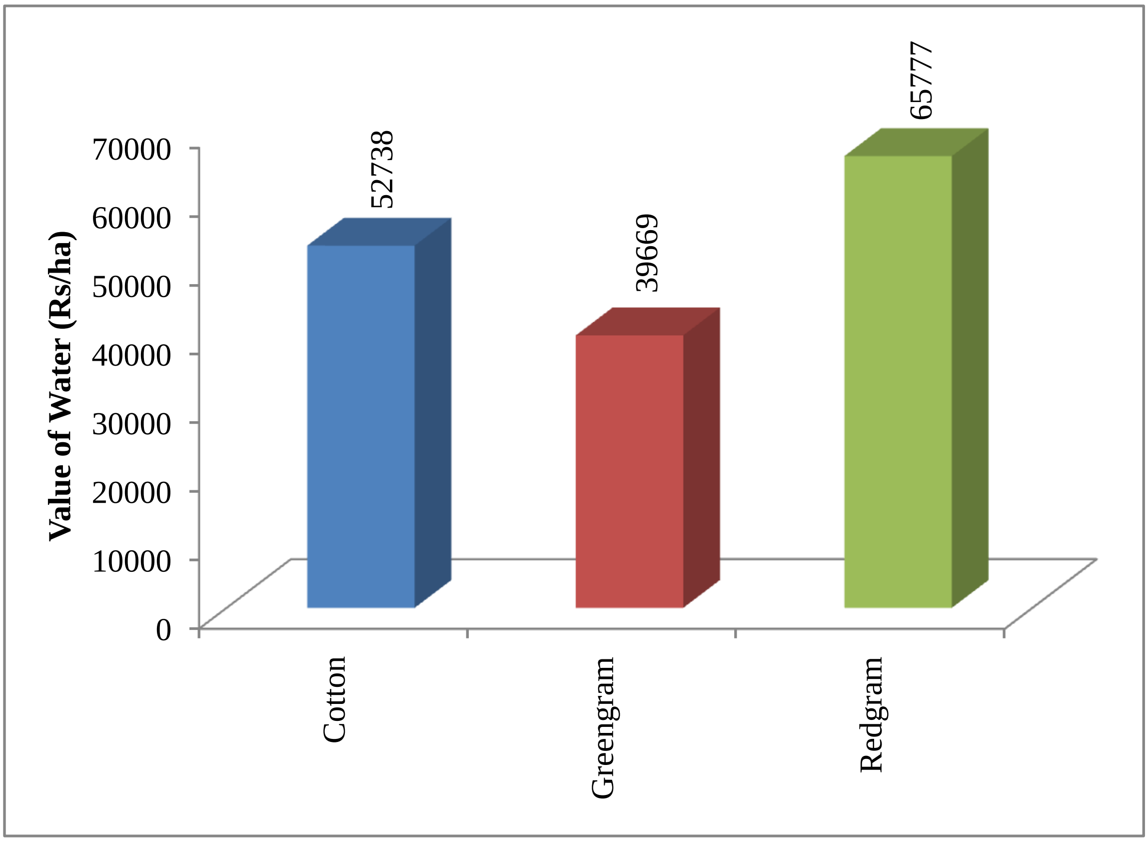

Figure 10: Ecosystem services of water supply in Chick Hangargi 3 Microwatershed

The main farming constraints in Chick Hangargi-3 micro-watershed to be found are less rainfall, lack of good quality seeds, non availability fertilizers, animal pests & diseases , lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on village merchants of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through regulated and the farmers getting the agriculture related information on television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 22).

Table 22: Farming constraints related land resources of sample households in Chick Hangargi-3 Microwatershed

Sl. No	Particulars	Per cent
1	Less Rainfall	100
2	Lack of good quality seeds	40.0
3	Non availability Fertilizers	20.0
5	Animal Pests & Diseases	10.0
6	Lack of transportation	20.0
7	Lack of storage	30.0
8	Damage of crops by Wild Animals	90.0
9	Non availability of Plant Protection Chemicals	100
10	**Source of loan**	
	Bank	30.0
	Money Leander	10.0
	Village merchants	60.0
11	**Market for selling**	
	Regulated	100
12	**Sources of Agri-Technology information**	
	Television	100

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