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

NANDIHALLI (4D3D7B3b) MICROWATERSHED

Gubbi Taluk, Tumkur 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

ICAR - NBSS & LUP

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

Nagpur
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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

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

The present study covers an area of 354 ha in Gubbi taluk of Tumakuru district, Karnataka. The climate is semiarid and categorized as drought prone with an average annual rainfall of 813 mm, of which about 466 mm is received during south –west monsoon, 196 mm during north-east and the remaining 151 mm during the rest of the year. An area of about 57per cent is covered by soils. 41 per cent is covered by gullied lands and 2 per cent by others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 8 soil series and 13 soil phases (management units) and 6 land use classes.*
- *The length of crop growing period is about 150 days starting from 3rd week of June to third week of November.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing 34 major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.*
- *About 57 percent area is suitable for agriculture and 41 percent is not suitable for agriculture*
- *About 48 per cent of the soils are moderately deep (75-100 cm) to very deep (>150 cm) and 8 per cent of the soils are moderately shallow.*
- *About 10 per cent of the area has clayey soils at the surface and 47 per cent loamy soils.*
- *About 48 per cent of the soils are non gravelly, 7 per cent of the soils are gravelly (<15-35%) and one per cent of area has very gravelly soils (35-60%).*
- *An area of about 22 per cent are low (51-100 mm/m, 25 per cent medium (101-150 mm/m) and an area of 10 per cent has very high (>200 mm/m) available water capacity.*
- *About 52 per cent of the area has nearly level (0-1%) to very gently sloping (1-3% slope) lands and about 4 per cent of the area is gently sloping (3-5%).*

- *An area of about 36 per cent has soils that are slightly eroded (e1) and 19 per cent moderately eroded (e2). Very small area of about 1 per cent is severely eroded and 41 per cent is covered by gullied lands.*
- *Maximum area of about 70 per cent has soils that are slightly acidic to strongly acid (pH 5.0-6.5), 27 per cent area is neutral (pH 6.5-7.3) in reaction.*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1} indicating that the soils are non-saline.*
- *About 53 per cent of the soils are low (<0.5%), 41 per cent area of the soils are medium (0.5-0.75%) and 3 per cent of the area are high in organic carbon.*
- *About 37 per cent of the area is high (>57 kg/ha) in available phosphorus and 61 per cent area is medium (23-57 kg/ha).*
- *About 48 per cent of the soils are low (<145 kg/ha), medium (145-337 kg/ha) in 42 per cent area and 8 per cent of the soils are high (>337 kg/ha) in available potassium.*
- *Available sulphur is medium (10 -20 ppm) in an area of about 76 per cent and high (>20 ppm) in an area of 22 per cent.*
- *Available boron is low (0.5 ppm) in maximum area about 84 per cent and medium (0.5-1.0 ppm) in 14 per cent area.*
- *Available iron is sufficient (>4.5 ppm) in the entire area.*
- *Available manganese and copper are sufficient in all the soils of the microwatershed.*
- *Available zinc is deficient (<0.6 ppm) in 43 per cent and sufficient (>0.6 ppm) in 54 per cent of soils of the microwatershed.*
- *The land suitability for 34 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.*

Land suitability for various crops in the Microwatershed

Crop	Suitability Area in ha (%)			Crop	Suitability Area in ha (%)	
	Highly suitable (S1)	Moderately suitable (S2)			Highly suitable (S1)	Moderately suitable (S2)
Sorghum	110 (31)	41(12)		Guava	90(26)	32(9)
Fodder Sorghum	110 (31)	41(12)		Pomegranate	110 (31)	12(3)
Maize	56(16)	95(27)		Banana	110 (31)	12(3)
Upland paddy	110 (31)	41(12)		Jackfruit	110 (31)	12(3)
Finger millet	110 (31)	41(12)		Jamun	110 (31)	89(25)
Red gram	110 (31)	41(12)		Musambi	110 (31)	12(3)
Horse gram	121(34)	79 (22)		Lime	110 (31)	12(3)
Field bean	110 (31)	41(12)		Cashew	90(26)	32(9)
Cowpea	110 (31)	41(12)		Custard apple	110 (31)	89(25)
Groundnut	17(5)	163 (26)		Amla	110 (31)	89(25)
Sunflower	110 (31)	12(3)		Tamarind	110 (31)	-
Onion	76 (21)	75(21)		Marigold	110 (31)	89(25)
Chilli	110 (31)	41(12)		Chrysanthemum	110 (31)	89(25)
Brinjal	110 (31)	41(12)		Jasmine	110 (31)	89(25)
Tomato	110 (31)	41(12)		Coconut	90(26)	32(9)
Mango	110(31)	-		Arecanut	90(26)	32(9)
Sapota	110 (31)	12(3)		Mulbery	15(5)	107(30)

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

- *Maintaining soil-health is vital to crop production and conserve soil and land resource base for maintaining ecological balance and to mitigate climate change. For this, several ameliorative measures have been suggested to these problematic soils like saline/alkali, highly eroded, sandy soils etc.,*
- *Soil and water conservation treatment plan has been prepared that would help in identifying the sites to be treated and also the type of structures required.*
- *As part of the greening programme, several tree species have been suggested to be planted in marginal and submarginal lands, 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 an ecological balance and also contributes 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 uncultivated areas are facing various degrees of degradation, particularly soil erosion. Salinity and alkalinity has emerged as a major problem 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 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.,* soils, 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 the potential and problem areas, developing sustainable land use plans, estimation of surface run off and water harvesting potential, preparation of soil and water conservation plans, land degradation/desertification etc. The Bureau is presently engaged in developing an LRI methodology using high resolution satellite remote sensing data and Digital Elevation Model (DEM) data to prepare Landscape Ecological Units (LEU) map representing agro-ecosystem as a whole. The LEU is preferred over landform as the base map for LRI. LEU is the assemblage of landform, slope and land use.

The land resource inventory aims to provide site specific database for Nandihalli microwatershed in Gubbi Taluk, Tumakuru 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

Tumakuru District popularly known as *Kalpataru Nadu* (famous for production of Coconuts) is located in the southeastern part of Karnataka State. The Nandihalli microwatershed (Pillahalli subwatershed) is located in the southeastern part of Karnataka in Gubbi Taluk, Tumakuru District, Karnataka State (Fig.2.1). It comprises parts of Malamachanakunte and Nallur villages. It lies between 13^0 28' and 13^0 29' North latitudes and 76^0 53' and 76^0 55' East longitudes and covers an area of 354 ha. It is about 71 km south of Tumakuru and is surrounded by Malamachanakunte on the southwestern, nallur on the north and southeastern side.

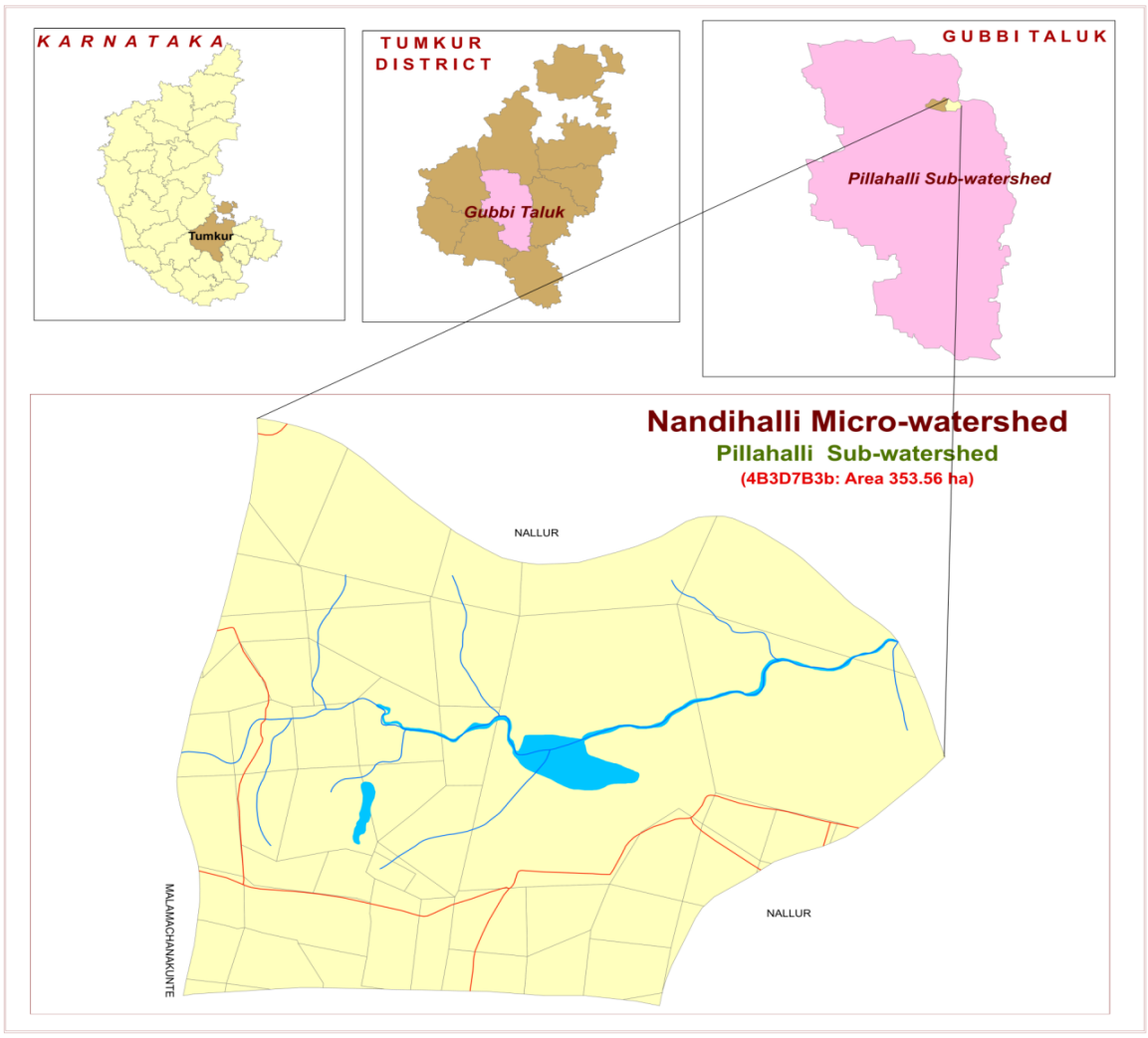


Fig.2.1 Location map of Nandihalli Microwatershed

2.2 Geology

Major rock formations observed in the microwatershed are granite gneiss and alluvium (Figs.2.2 and 2.3). Granite and gneisses are essentially pink to gray and are coarse to medium grained. They consist primarily of quartz, feldspar, biotite and hornblende. The gray granite gneisses are highly weathered, fractured and fissured upto a depth of about 10 m. The most widespread and characteristic development of alluvium in the watershed region lying in the Suvarnamukhi is a wide belt, the underlying formation is gneiss and alluvial soils occur over gneiss. The thickness of the alluvium generally is limited to less than a meter, except in river valleys where it is very deep extending to tens of meters.

Fig.2.2 Granite and granite gneiss rocks

Fig. 2.3 Alluvium

2.3 Physiography

Physiographically, the area has been identified as Granite Gneiss and Alluvial landscape based on geology. It has been further divided into three landforms *viz*; mounds/ ridges, uplands and lowlands based on slope and other relief features. They have been further subdivided into four physiographic units, *viz;* summits, side slopes, very gently sloping uplands and lowlands/valleys. The elevation ranges from 825-839 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

There are no perennial rivers flowing in Gubbi taluk. However, the area is drained by several small seasonal streams like Hosa *kaluve* which joins river Shimsha along its course. Though, they are not perennial, during rainy season, it carries large quantities of rain water. The microwatershed area has only few small tanks which are not capable of storing water that flows during the rainy season. Due to this, the ground water recharge is very much affected in the villages. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing 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 dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract and is categorized as drought - prone with average annual rainfall of 813 mm (Table 2.1). Of the total rainfall, a maximum of 466 mm is received during south–west monsoon period from June to September, north-east monsoon from October to early December contributes maximum of about 196 mm and the remaining 151 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 35°C and in December and January, the temperatures will go down to 20°C. Rainfall distribution is shown in Figure 2.4. The average Potential Evapo-Transpiration (PET) is 110 mm and varies from a low of 73 mm in December to 152 mm in the month of April. The PET is always higher than precipitation in all the months except in the months of August, September and October. Generally, the Length of crop Growing Period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET in Gubbi Taluk, Tumakuru District

Sl. No.	Months	Rainfall	PET	1/2 PET
1	JAN	6.50	78.30	39.15
2	FEB	7.00	102.70	51.35
3	MAR	24.40	142.60	71.30
4	APR	40.50	151.60	75.80
5	MAY	72.50	149.70	74.85
6	JUN	78.50	121.10	60.55
7	JUL	99.20	107.60	53.80
8	AUG	119.70	105.80	52.90
9	SEP	168.30	101.20	50.60
10	OCT	141.90	100.20	50.10
11	NOV	47.00	85.00	42.50
12	DEC	7.30	73.00	36.50
Total		812.80	109.90	

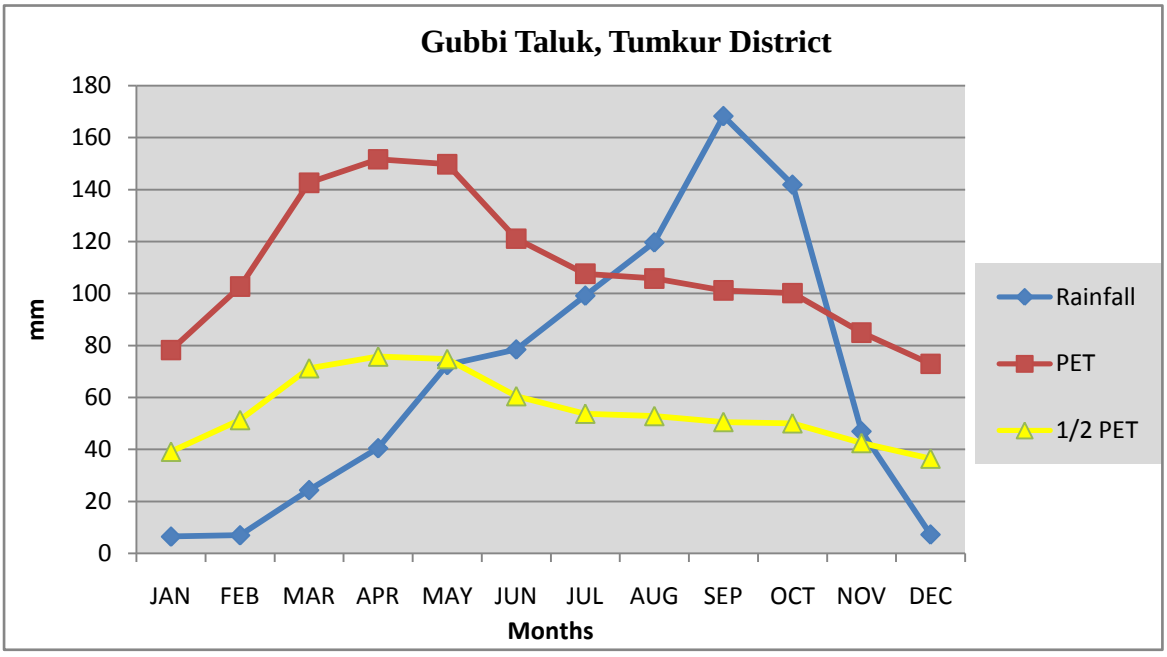


Fig 2.4 Rainfall distribution in Gubbi Taluk, Tumakuru District

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.

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. 2.5 Natural vegetation of Nandihalli Microwatershed

2.7 Land Utilization

About 64 per cent area (Table 2.2) in Gubbi taluk is cultivated at present. An area of about 4 per cent is currently barren. Forests occupy an area of about 8 per cent. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are Ragi, Groundnut, Maize, Sorghum, Sunflower, Red gram, Horse gram, Field bean, Cowpea, Mango, Banana, Mulberry and Plantation crops like, Coconut and Arecanut. The cropping intensity is 116 per cent in the taluk. 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 Nandihalli microwatershed is prepared. The current land use map generated shows the arable and non-arable lands, other land uses and different types of crops grown in the area Fig (2.6). The different crops and cropping systems adopted in the microwatershed is presented in Figures 2.8.a & b. 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 marked on the cadastral map. Map showing the location of wells and other water bodies and conservation structures in Nandihalli microwatershed is given in Fig.2.7.

Table 2.2 Land Utilization in Gubbi Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	122057	-
2.	Total cultivated area	78418	64.24
3.	Area sown more than once	12934	-
4.	Cropping intensity	-	116.49
5.	Trees and grooves	2811	2.30
6.	Forest	10090	8.26
7.	Cultivable wasteland	2731	2.23
8.	Permanent Pasture land	3850	3.15
9.	Barren land	4971	4.07
10.	Non- Agriculture land	17390	14.24

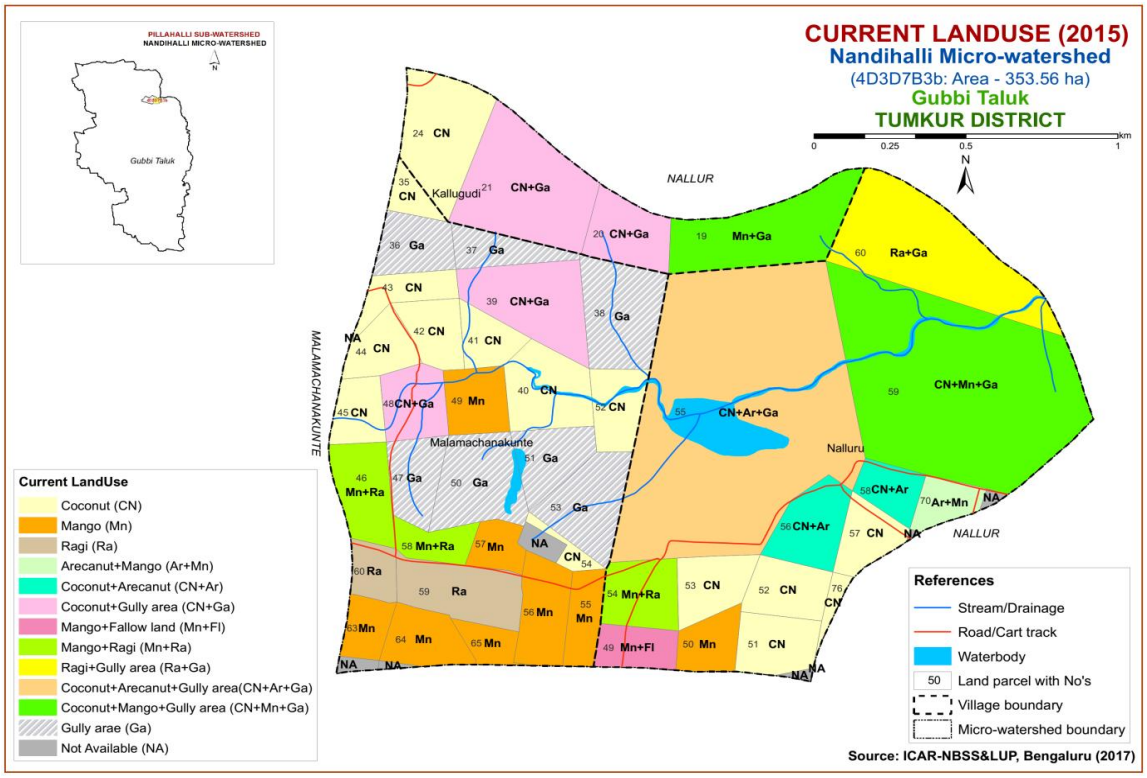


Fig.2.6 Current Land Use – Nandihalli Microwatershed

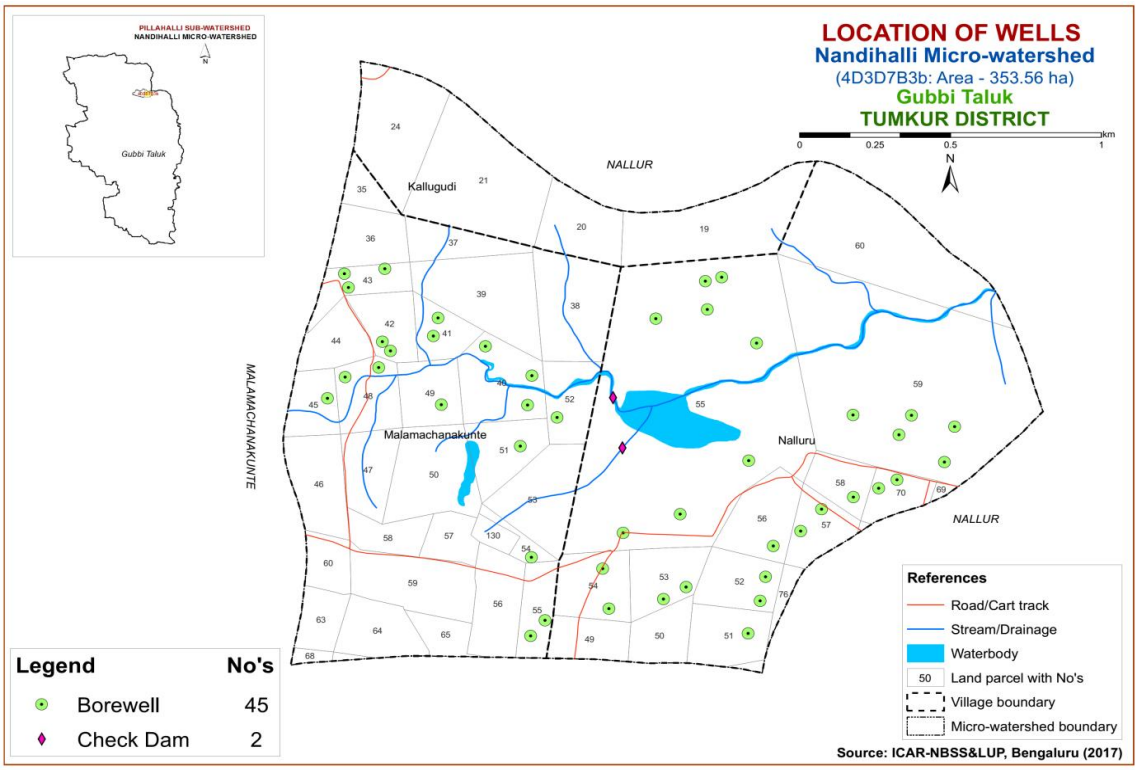


Fig.2.7 Location of Wells and Conservation Structures - Nandihalli Microwatershed

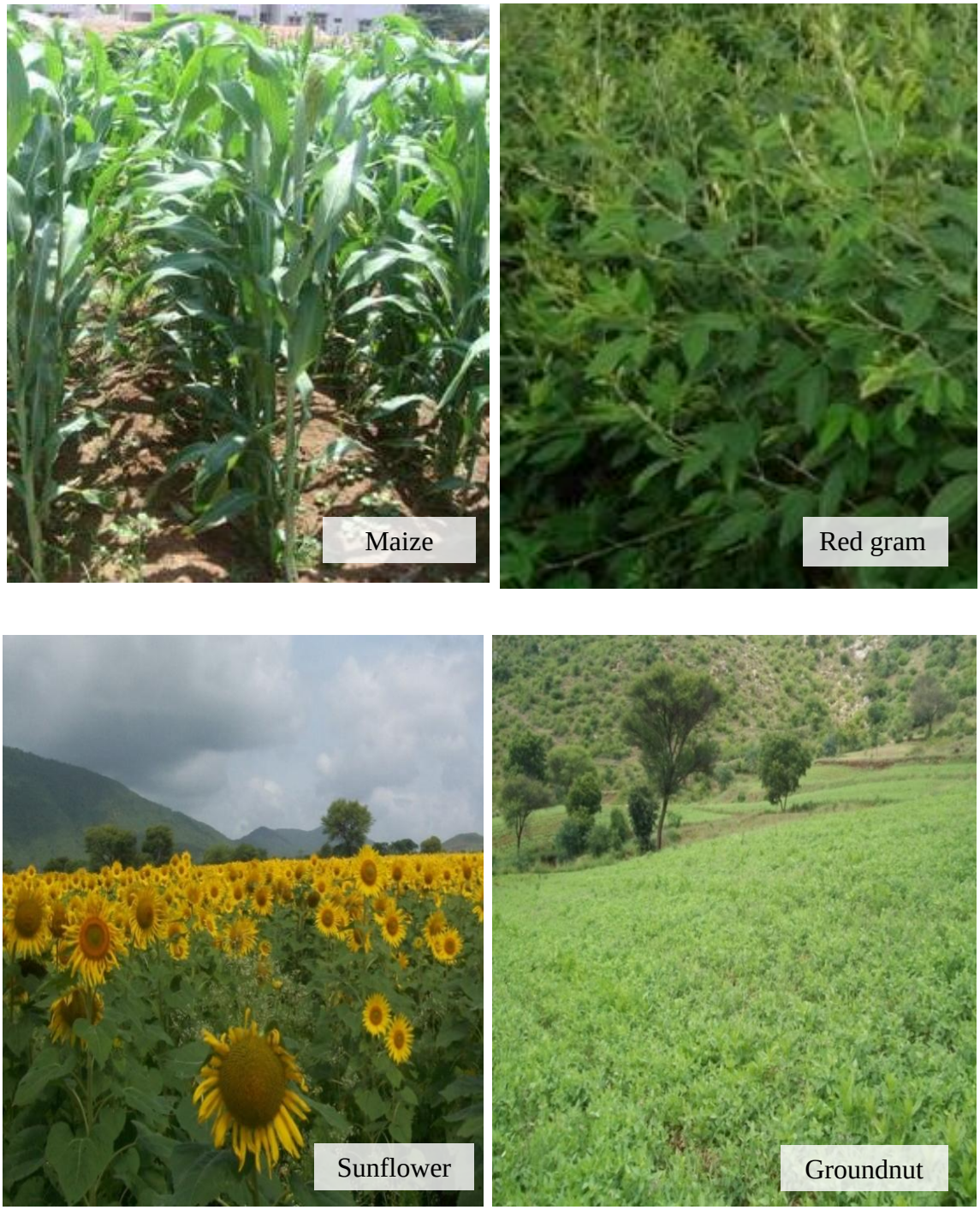


Fig.2.8.a Different crops and cropping systems in Nandihalli Microwatershed

Fig.2.8.b Different crops and cropping systems in Nandihalli Microwatershed

Chapter 3

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Nandihalli 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 354 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 geology, 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, landscapes, landforms, drainage features and 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 granite gneiss and alluvial landscapes and is divided into landforms such as ridges, mounds, uplands and valleys based on slope and other relief features. They were further subdivided into physiographic/ image interpretation units based on image characteristics. The image interpretation legend for physiography is given below.

Image Interpretation Legend for Physiography
G- Granite gneiss landscape

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

DSe – Alluvial landscape

DSe 1 – Summit
- DSe 11 –
- DSe 12 –

DSe 2 – Very genetly sloping
- DSe 21 – Very gently sloping, dark gray tone
- DSe 22 – Very gently sloping, medium gray tone
- DSe 23 – Very gently sloping, yellowish grey tone
- DSe 24 – Very gently sloping, whitish grey tone
- DSe 25 – Very gently sloping, whitish/ eroded/ calcareous tone
- DSe 26- Very gently sloping, medium pink

DSe 3 – Valley/ Lowland
- DSe 31 – Whitish gray/Calcareous
- DSe 32 – Gray with pink patches
- DSe 33 – Medium gray tone
- DSe 34 – Lightish gray tone
- DSe 35 – Dark gray tone

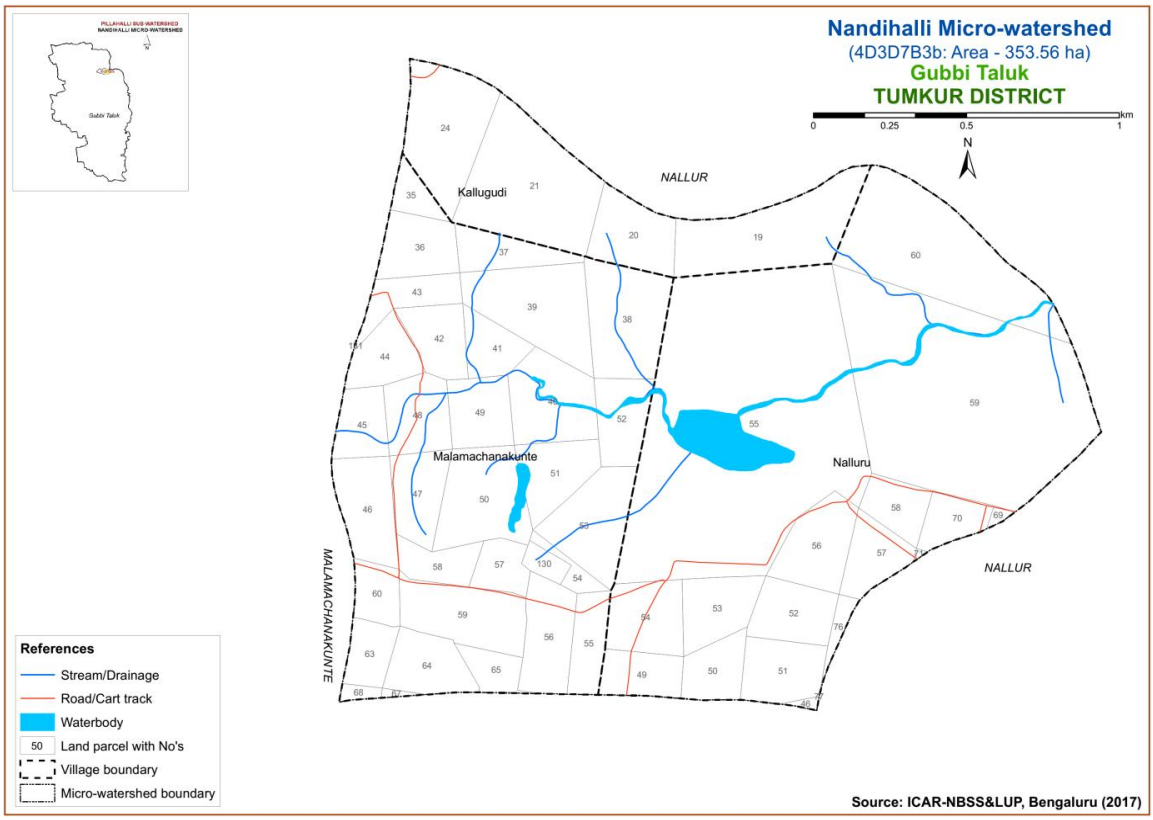


Fig 3.1 Scanned and Digitized Cadastral map of Nandihalli Microwatershed

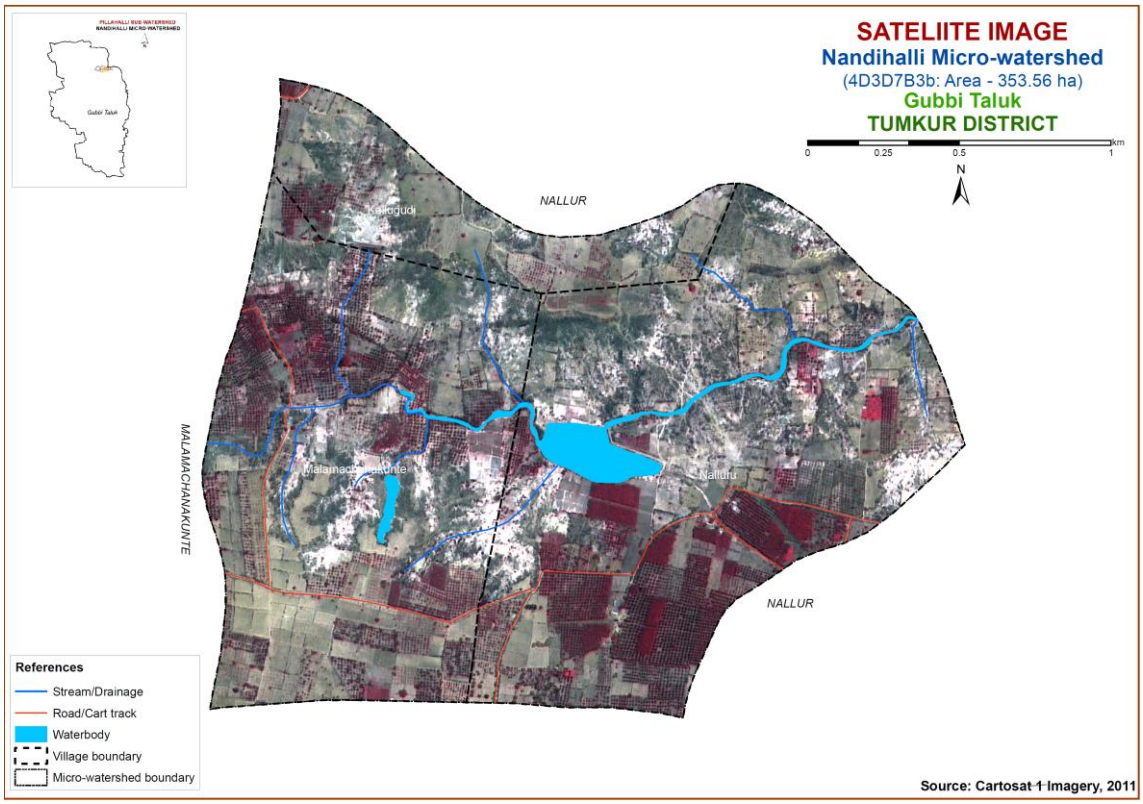


Fig.3.2 Satellite Image of Nandihalli Microwatershed

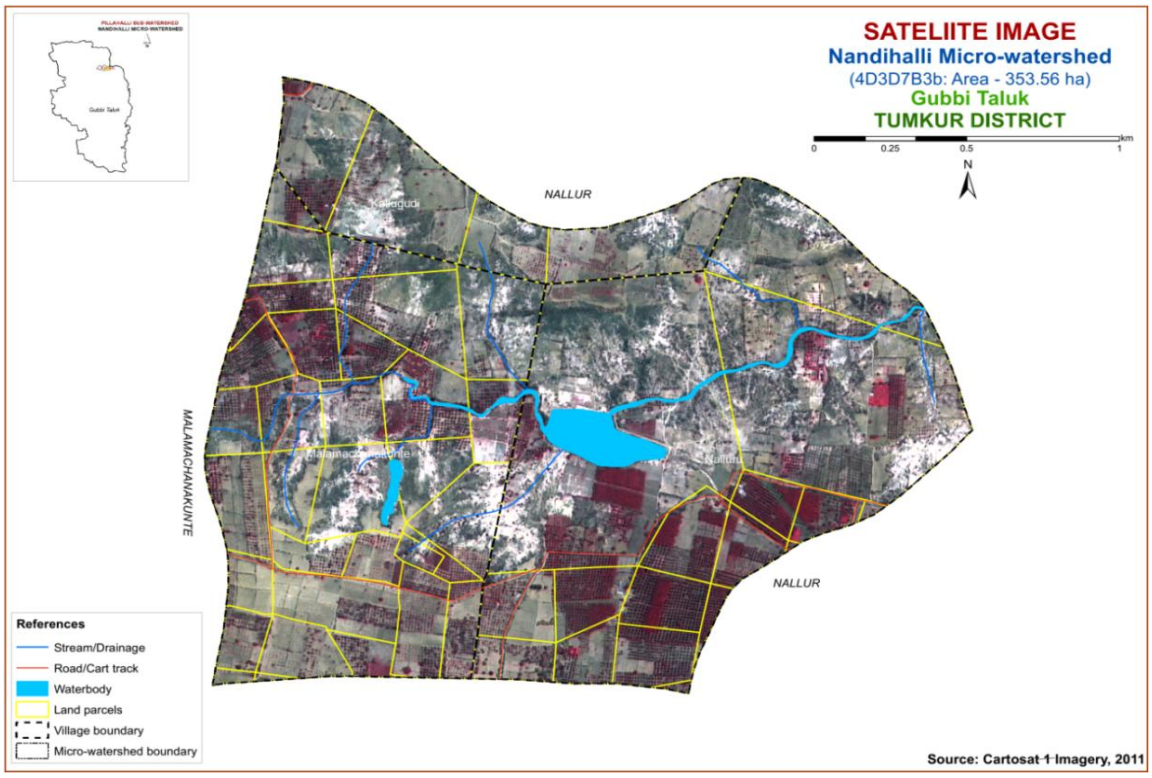


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Nandihalli Microwatershed

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, uplands and valleys 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).

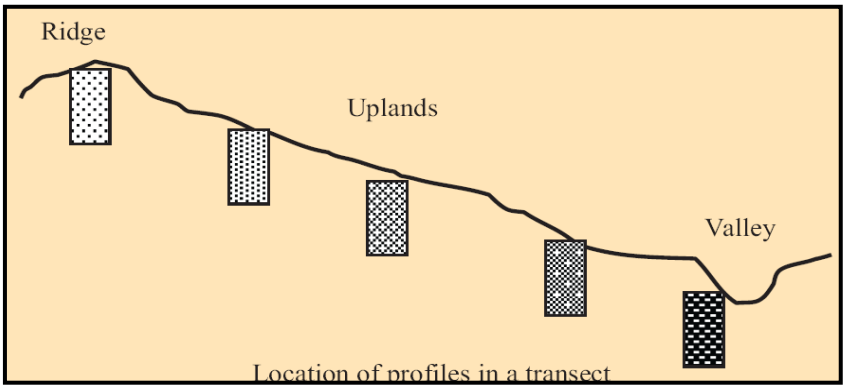


Fig: 3.4. Location of profiles in a transect

In the selected transect, soil profiles (Fig. 3.5) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, profiles (vertical cut showing the soil layers from surface to the rock) were opened up to 200 cm or to the depth limited by rock or hard substratum and studied in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all profile sites on a standard proforma as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff, 2012). Apart from the transect study, profiles were also studied at random, almost like in a grid pattern, outside the transect areas.

Based on soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 8 soil series were identified in the Nandihalli microwatershed.

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

Soils of Granite gneiss Landscape							
Sl. No	**Soil Series**	**Depth (cm)**	**Colour (moist)**	**Texture (control section)**	**Gravel (%) (control section)**	**Horizon & Horizon sequence**	**Calcareo-usness**
1	Thammadahalli (TDH)	50-75	2.5YR2.5/4,3/6	sc-c	-	Ap-Bt-Cr	-
2	Kutegoudanahundi (KGH)	50-75	7.5YR3/2, 3/3,3\4	scl	15-35	Ap-Bt-Cr	-
3	Kanchikere (KKR)	75-100	10YR3/3,4/2,5/2 7.5YR3/1,3/2,5/2	cl-sc	-	Ap-Bw-BC-Cr	-
4	Jedigere (JDG)	100-150	5YR 4/6, 3/4, 7.5YR 3/4, 4/6	sc-c	<15	Ap-Bt-BC-Cr	-
5	Hallikere (HLK)	>150	5YR3/3,3/4 7.5YR3/3,3/4	c	<15	Ap-Bt	-
6	Ranatur (RTR)	>150	2.5YR2.5/3,2.5/4, 3/3,4/6	c	-	Ap-Bt	-
7	Niduvalalu (NDL)	>150		sc	>35	Ap-Bt	-
Soils of Alluvial Landscape							
8	Kadagathur (KDT)	>150	10 YR 3/1,3/2, 3/3, 7.5YR 3/3, 3/4	sc-c	-	Ap-Bw	-

3.4 Soil Mapping

The area under each soil series was further separated into 13 soil phases and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, slope, erosion, presence of gravel, stoniness etc. A soil phase is a subdivision of soil series based mostly on surface features that affect its use and management. The soil mapping units are shown on the map (Fig.3.5) in the form of symbols. During the survey about 6 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map. The soil map shows the geographic distribution of 13 mapping units representing 8 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2. The soil phase map (management units) shows the distribution of 13 soil 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 13 soil phases identified and mapped in the microwatershed were regrouped into 6 Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Use Classes (LUCs) based on the management needs. One or more than one soil site characteristic having influence on the management have been chosen for identification and delineation of LUCs. For Nandihalli microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUCs. The Land Use Classes are expected to behave similarly for a given level of management.

3.5 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected in the year 2015 from farmer's fields (45 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated using kriging method for the microwatershed.

Table 3.2 Soil map unit description of Nandihalli Microwatershed (Soil Legend)

Soil No	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	TDH	Thammadahalli soils are moderately shallow (50-75cm), well drained, have dark red to dark reddish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**11 (3.18)**
1		TDHhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	11 (3.18)
	KGH	Kutegoudanahundi soils are moderately shallow (50-75 cm), well drained, have brown to dark brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation		**19 (5.21)**
2		KGHcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	4 (1.15)
3		KGHhB2	Sandy clay loam surface, slope 1-3%, moderate erosion	12 (3.34)
4		KGHhC3	Sandy clay loam surface, slope 3-5%, severe erosion	3 (0.72)
	KKR	Kanchikere soils are moderately deep (75-100 cm), well drained, have dark brown to very dark grayish brown clay loam to sandy clay soils occurring on gently sloping uplands under cultivation		**12 (3.26)**
5		KKRhC2	Sandy clay loam surface, slope 3-5%, moderate erosion	12 (3.26)
	JDG	Jedigere soils are deep (100-150 cm), well drained, have dark brown to dark reddish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**17 (4.77)**
6		JDGhB1	Sandy clay loam surface, slope 1-3%, slight erosion	17 (4.77)
	HLK	Hallikere soils are very deep (>150 cm), well drained, have dark brown to dark reddish brown clayey soils occurring on very gently sloping uplands under cultivation		**39 (11.09)**
7		HLKhB1	Sandy clay loam surface, slope 1-3%, slight erosion	39 (11.09)
	RTR	Ranatur soils are very deep (> 150 cm), well drained, have dark reddish brown to dark red clay soils occurring on very gently sloping uplands under cultivation		**20 (5.58)**
8		RTRhB2	Sandy clay loam surface, slope 1-3%, moderate erosion	20 (5.58)
	NDL	Niduvalalu soils are very deep (>150 cm), well drained, have red to dark reddish brown gravelly sandy clay soils occurring on very gently sloping uplands under cultivation		**48 (13.51)**
9		NDLcB1	Sandy loam surface, slope 1-3%, slight erosion	48 (13.51)
SOILS OF ALLUVIAL LANDSCAPE				
	KDT	Kadagathur soils are very deep (>150 cm), moderately well drained, have dark brown to very dark grayish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**35 (9.71)**
10		KDTiA1	Sandy clay surface, slope 0-1%, slight erosion	11 (2.98)
11		KDTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	14 (3.86)
12		KDTiB2	Sandy clay surface, slope 1-3%, moderate erosion	10 (2.87)
13	Gullies	Gullied land, very severely eroded gullies		147 (41.44)
	Others	Habitation & Water body		**8(2.24)**

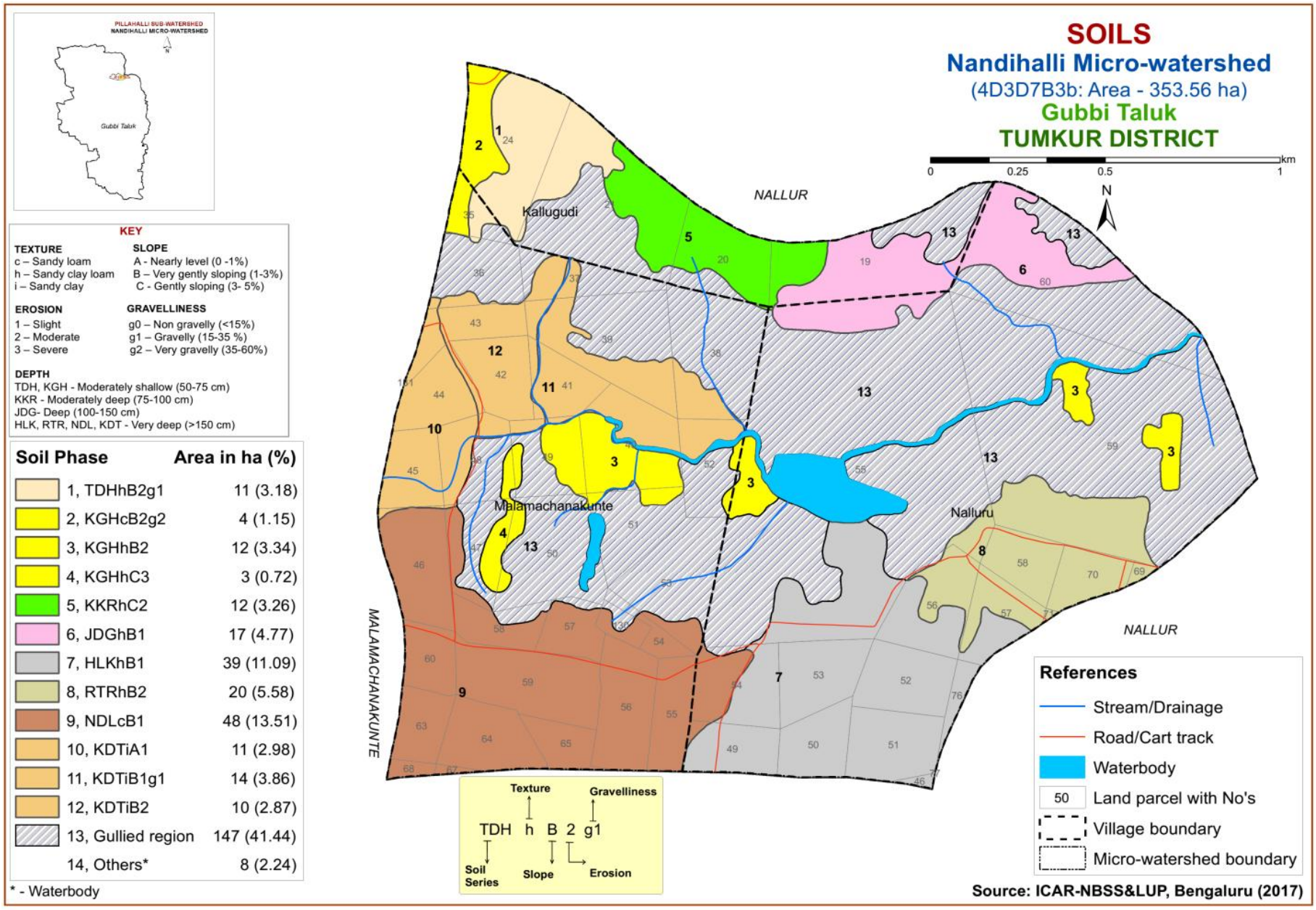


Fig 3.4 Soil Phase or Management Units Map - Nandihalli Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and their distribution of different kinds of soils occurring in Nandihalli microwatershed is provided in this chapter. The microwatershed area has been identified as granite gneiss and alluvial landscape based on geology. In all, 8 soil series are identified. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. The soil formation dominantly influenced by the parent material, climate and relief.

A brief description of each of the 8 soil series identified followed by 13 soil phases (management units) mapped under each series (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 characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite gneiss Landscape

In this landscape, 7 soil series are identified and mapped. Of these, Niduvalalu (NDL) soil series occupies maximum area of about 48 ha (13%) and Hallikere (HLK) 39 ha (11%) area. The brief description of each soil series and their phases identified in the microwatershed are given below. The mapping unit description (Soil Legend) of the soil phases identified and mapped under each series is given in Table 3.2.

4.1.1 Thammadahalli (TDH) Series: Thammadahalli soils are moderately shallow (50-75cm), well drained, have brown to very dark brown and dark reddish brown sandy clay to clay soils. They have developed from granite gneiss and occur on nearly level to gently sloping uplands.The Thammadahalli series has been classified as fine, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum ranges from 54 to 75 cm. The thickness of A horizon ranges from 11 to 19 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2.5 to 4 and chroma 2 to 6. The texture varies from sandy clay loam to clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 43 to 60 cm. Its colour is in 2.5 YR hue with value 3 and chroma 4 to 6. Its texture is sandy clay to clay. The available water capacity is medium (100-150 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Thammadahalli (TDH) Series

4.1.2 Kutegoudanahundi (KGH) Series: Kutegoudanahundi soils are moderatly shallow (50-75 cm), well drained, have brown to dark brown sandy clay loam soils. They have developed from granite gneiss and occur on very gently to gently sloping uplands. The Kutegoudanahundi series has been tentatively classified as a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustalfs.

The thickness of the solum ranges from 50 to 74 cm. The thickness of A horizon ranges from 12 to 22 cm. Its colour is in 7.5 YR and 10 YR hue with value and chroma 3 to 4. The texture varies from loamy sand to sandy loam with 15 to 30 per cent gravel. The thickness of B horizon ranges from 40 to 62 cm. Its colour is in 7.5 YR hue with value and chroma 3 to 4. Its texture is sandy clay loam with gravel content of 15 to 35 per cent. The available water capacity is medium (100-150 mm/m).Three Phases were identified and mapped.

Landscape and soil profile characteristics of Kutegoudanahundi (KGH) Series

4.1.3 Kanchikere (KKR) Series: Kanchikere soils are moderately deep (75-100 cm), well drained, have dark brown to very dark brown clay loam to sandy clay soils. These soils are developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Kanchikere series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 76 to 100 cm. The thickness of A horizon ranges from 11 to 20 cm. Its colour is in 7.5YR and 10 YR hue with value 3 to 5 and chroma 3 to 4. Texture varies from loamy sand to sandy clay. The thickness of B horizon ranges from 63 to 82 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 5 and chroma 1 to 3. Texture is clay loam to sandy clay. The available water capacity is medium (100-150 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Kanchikere (KKR) Series

4.1.4 Jedigere (JDG) Series: Jedigere soils are deep (100-150 cm) well drained, have yellowish red to strong brown soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands under cultivation.

The thickness of the solum ranges from 117 to 145 cm. The thickness of A horizon ranges from 13 to 21 cm. Its colour is in hue 5 YR and 7.5 YR with value 2 to 4 and chroma 2 to 6. Its texture is dominantly sandy clay and sand clay loam. The thickness of B horizon ranges from 104 to 124 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 3 to 6. Its texture is dominantly clay. The available water capacity is very high (>200mm/m). Only one phase was identified and mapped.

Landscape and Soil Profile Characteristics of Jedigere (JDG) Series

4.1.5 Hallikere (HLK) Series: Hallikere soils are very deep (>150 cm), well drained, have dark brown and dark reddish brown clayey soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands. The Hallikere series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Paleaustalfs.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 11 to 14 cm. Its colour is in 7.5 YR and 5 YR hue with value 3 to 4 and chroma 3 to 4. The texture varies from sandy loam to sandy clay loam. The thickness of B horizon is more than 150 cm. Its colour is in 7.5 YR and 5 YR hue with value and chroma 3 to 4. Its texture is clay. The available water capacity is high (150-200 mm/m). Only one phase was identified and mapped.

Landscape Soil Profile Characteristics of Hallikere (HLK) Series

4.1.6 Ranatur (RTR): Ranatur soils are very deep (> 150 cm), well drained, have dark reddish brown to dark red clayey soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Ranatur series has been classified as fine, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 8 to 14 cm. Its colour is in 5 YR and 2.5 YR hue with value 2.5 to 4 and chroma 3 to 6. The texture varies from sandy loam to sand clay. The thickness of B horizon is more than 150 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 3 to 6. Its texture is clay. The available water capacity is high (150-200 mm/m).Only one phase was identified and mapped.

Landscape and soil profile characteristics of Ranatur (RTR) Series

4.1.7 Niduvalalu (NDL) Series: Niduvalalu soils are very deep (>150 cm), well drained, have dark red and dark reddish brown sandy clay soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands under cultivation.

The thickness of the solum is more than 150 cm. The thickness of A-horizon ranges from 11 to 15 cm. Its colour is in 5 YR hue with value 3 to 4 and chroma 4 to 6. The texture varies from sandy loam to sandy clay loam with 10 to 30 per cent gravel. The thickness of B-horizon ranges from 150 to 160 cm. Its colour is in 2.5 YR and 5 YR hue with value 2.5 to 4 and chroma 4 to 6. Its texture is sandy clay and ranges from gravelly sandy clay with 20 to 75 per cent gravel. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

Landscape Soil Profile Characteristics of Niduvalalu (NDL) Series

4.2 Soils of Alluvial Landscape

In this landscape, only one soil series (Kadagathur) are identified and mapped. It covers about 35 ha in the microwatershed. The brief description of Kadagathur (KDT) series identified and mapped as one soil phase is given below.

4.2.1 Kadagathur (KDT) Series: Kadagathur soils are very deep (>150 cm), moderately well drained, have dark brown to very dark grayish brown sandy clay to clay soils. They have developed from weathered granite gneiss and occur on nearly level to very gently sloping uplands under cultivation.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 8 to 14 cm. Its colour is in 10 YR hue with value 3 and chroma 4. The texture varies is sandy loam. The thickness of B horizon is more than 150 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 and chroma 1 to 4. Its texture is sandy clay to clay. The available water capacity is very high (>200 mm/m).

Three phases were identified and mapped.

Landscape and soil profile characteristics of Kadagathur (KDT) 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 interpretative and thematic maps generated are described below.

5.1 Land Capability Classification

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

Soil characteristics: Depth, texture, gravel content, calcareousness.

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

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

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

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

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

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

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

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

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

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

Class VIII: Soil and other miscellaneous areas (rock lands) that have very severe limitations that nearly preclude their use for any crop production, but suitable for wildlife, recreation and installation 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 13 soil map units identified in the Nandihalli microwatershed are grouped under 4 land capability classes and 6 land capability subclasses. About 56 percent in the microwatershed is suitable for agriculture and about 41 percent is not suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover an area of about 80 ha (23%) and are distributed in the western, northern, central and southeastern part of the microwatershed with minor problem of soil. Moderately good cultivable lands (Class III) cover an area of about 116 ha (33%) and are distributed in the northern, northwestern and southwestern part of the microwatershed with moderate problems of erosion and soil. A very small area of about 3 ha (1%) is fairly suitable for agriculture (Class IV) and occur in the central part of the microwatershed. Maximum area of about 41 percent is not suitable (Class N) for cultivation because of gullies and occurs in major part of the microwatershed with severe limitation of erosion and soil.

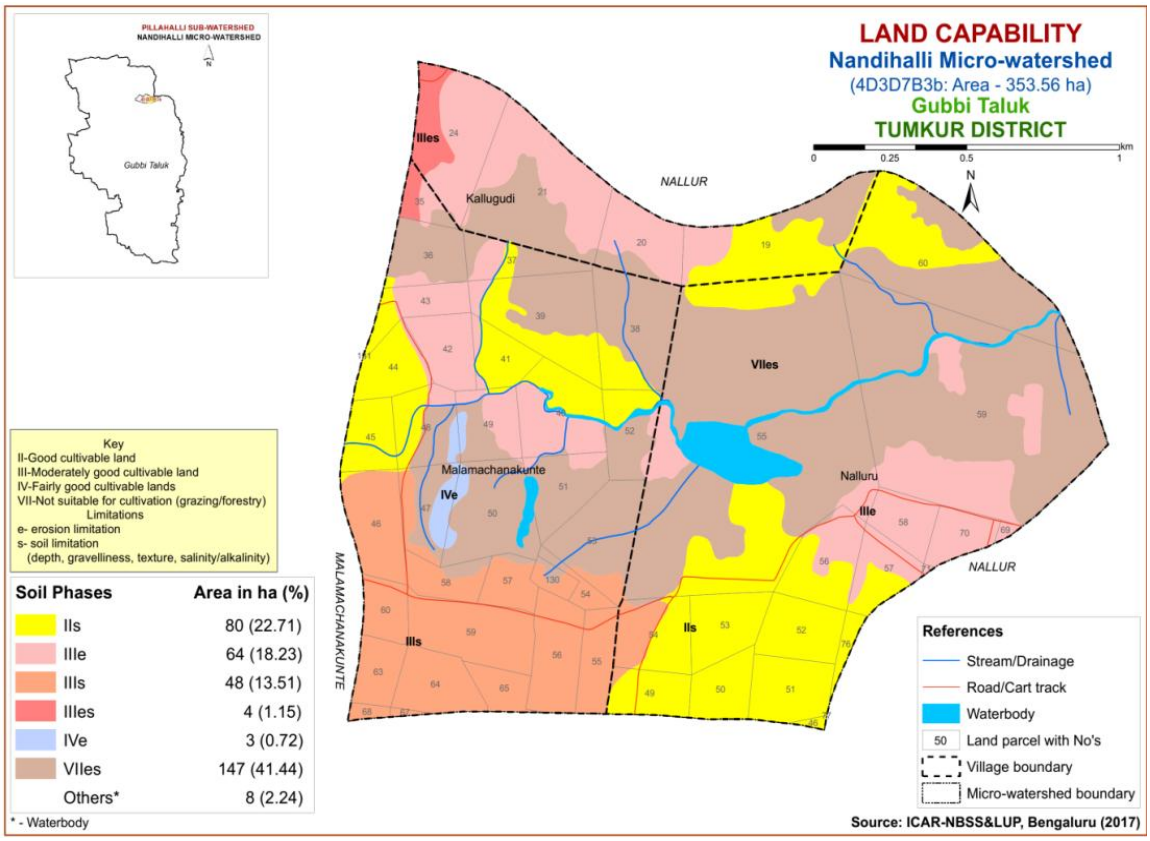


Fig. 5.1 Land Capability map of Nandihalli Microwatershed

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 given in Fig. 5.2.

An area of about 30 ha (8%) has moderately shallow (50-75 cm) soils and occur in the northwestern and central part of the microwatershed. Moderately deep (75-100 cm) soils occupy an area of about 12 ha (3%) and are distributed in the northern part of the microwatershed. Deep (100-150 cm) soils occupy an area of 17 ha (5%) and are distributed in the northern part of the microwatershed. Very deep (>150 cm) soils cover maximum area of 141 ha (40%) and are distributed in the western, southern and southeastern part of the microwatershed. An area of about 147 ha (41%) is occupied by gullied soils and occur in the northwestern, central and northeastern part of the microwatershed.

The most productive lands 158 ha (45%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are very deep (>150 cm depth) and deep (100-150 cm) occurring in the major parts of the microwatershed.

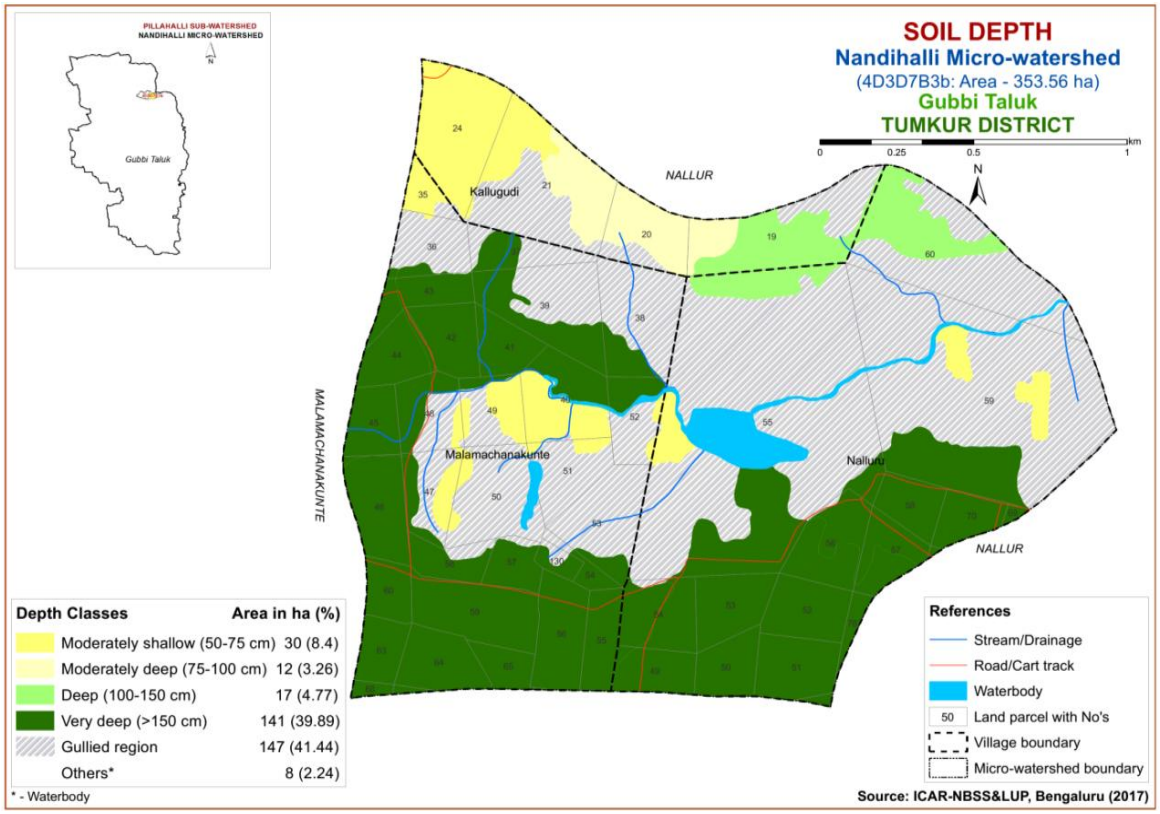


Fig. 5.2 Soil Depth map of Nandihalli Microwatershed

5.3 Surface Soil Texture

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

Maximum area of about 165 ha (47%) has soils that are loamy at the surface. They are distributed in the northern, central, southwestern and southeastern part of the microwatershed and an area of 34 ha (10%) has soils that are clayey at the surface and are distributed in the western part of the microwatershed (Fig. 5.3).

The most productive lands (10%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention

and availability, but have problems of drainage, infiltration, workability and other physical problems. The other most productive lands (47%) are loamy soils which also have high potential for AWC, nutrient availability but have no drainage or other physical problems.

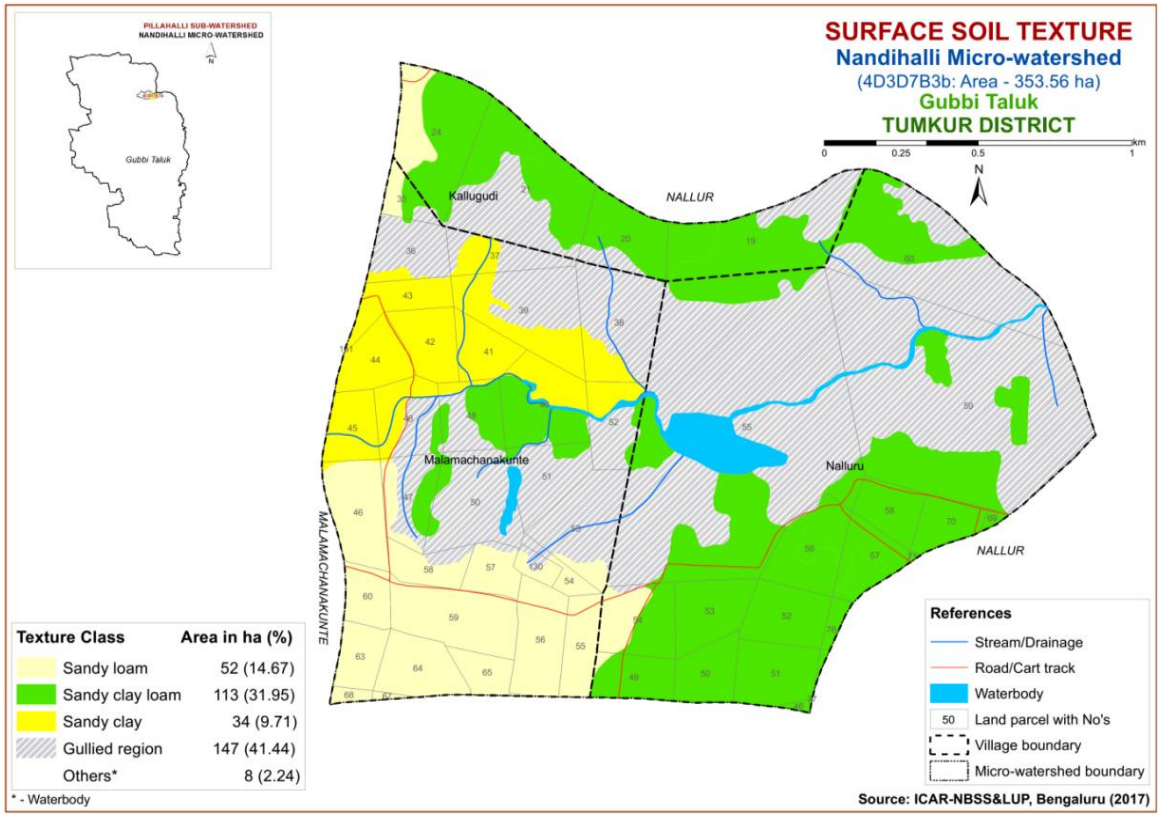


Fig. 5.3 Surface Soil Texture map of Nandihalli Microwatershed

5.4 Soil Gravelliness

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

Maximum area of about 170 ha (48%) is covered with non gravelly (<15%) soils and occur in the northern, central, southwestern and southeastern part of the microwatershed. An area of about 25 ha (7%) is gravelly (15-35%) and occur in the central and northwestern part of the microwatershed. A very small area of about 4 ha (1%) is covered with very gravelly (35-60%) and is distributed in the northwestern part of the microwatershed (Fig 5.4).

The problem soils (8%) that are gravelly to very gravelly (15-60%) where only short duration crops can be grown are distributed in the northwestern and central part of the microwatershed. The most productive soils (48%) that are non gravelly (<15%) are distributed in the northern, central, western and northeastern part of the microwatershed where all climatically adopted crops can be grown.

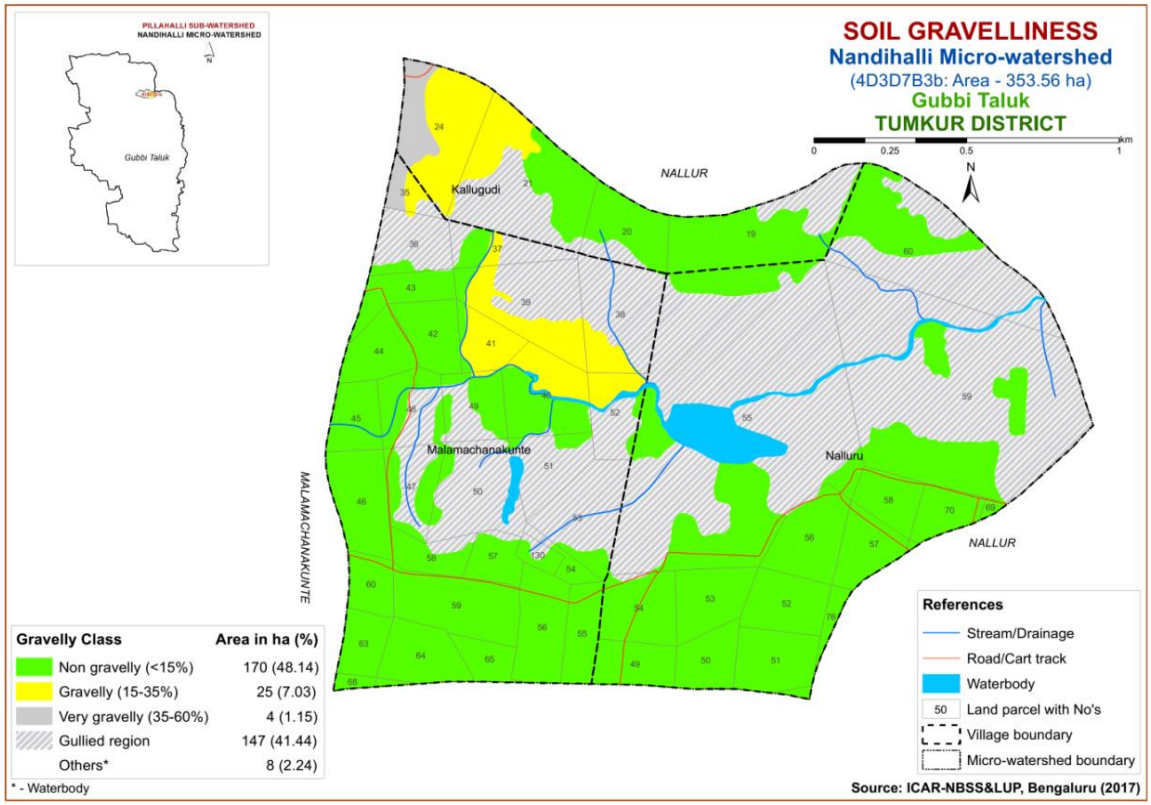


Fig. 5.4 Soil Gravelliness map of Nandihalli Microwatershed

5.5 Available Water Capacity

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

An area of about 77 ha (22%) are low (51-100 mm/m) in available water capacity and are distributed in the northwestern, southwestern and central part of the microwatershed. An area of about 87 ha (25%) is medium (101-150 mm/m) in available water capacity and are distributed in the northern and southeastern part of the

microwatershed. A small area of 34 ha (10%) is very high (>200 mm/m) in available water capacity and are distributed in the western part of the microwatershed.

About 164 ha (47%) 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 34 ha (10%) has high potential with respect to AWC, where all climatically adapted annual and perennial crops can be grown.

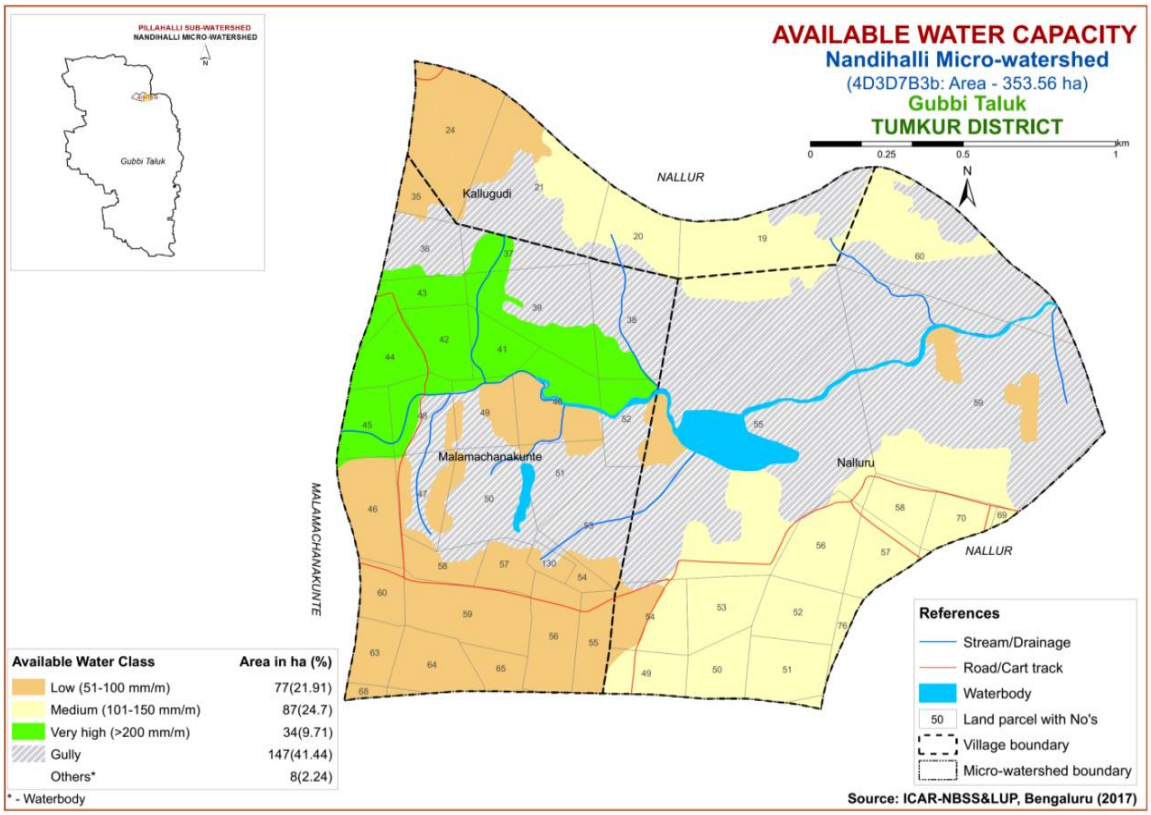


Fig. 5.5 Soil Available Water Capacity map of Nandihalli Microwatershed

5.6 Soil Slope

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

Major area of about 175 ha (49%) falls under very gently sloping (1-3% slope) lands and is distributed in the southern, central, northwestern and southwestern part of the microwatershed and a very small area of about 11 ha (3%) is under nearly level (0-1%)

and distributed in the western part of the microwatershed. An area of about 14 ha (4%) is gently sloping (3-5%) and occur in the northern and central part of the microwatershed.

About 52 per cent area in the microwatershed has soils that have high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

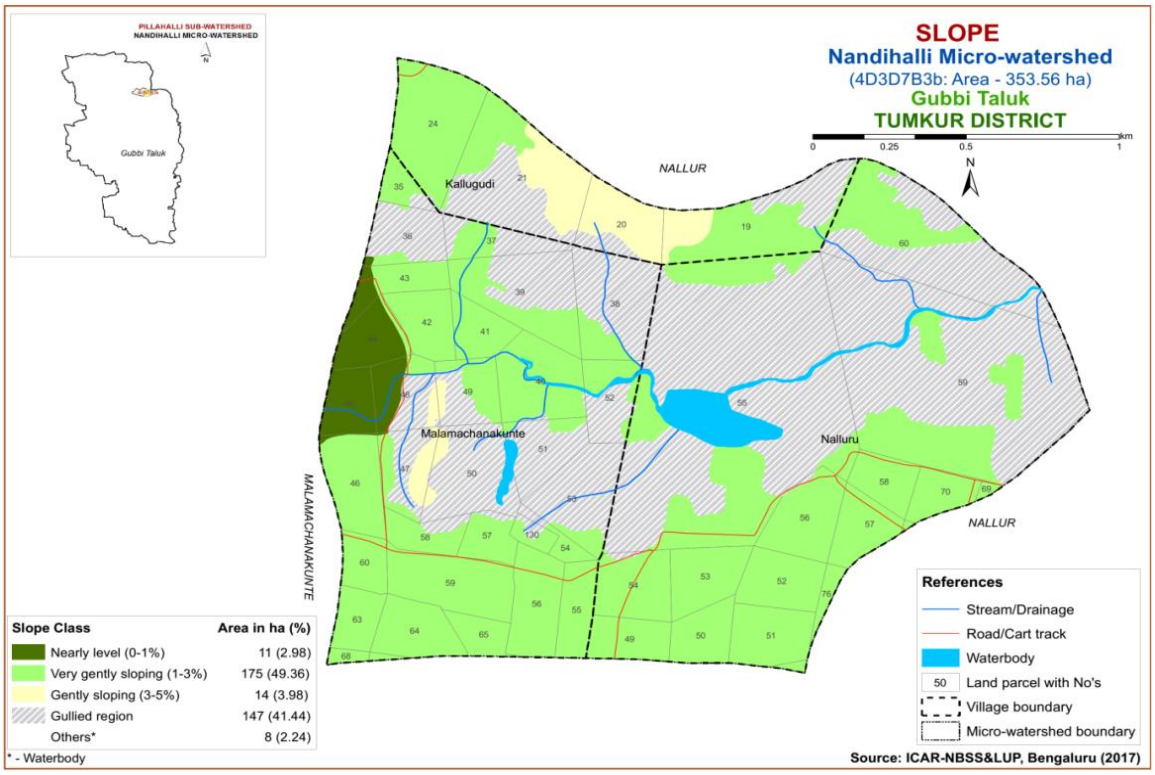


Fig. 5.6 Soil Slope map of Nandihalli Microwatershed

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 69 ha (19%) in the microwatershed. They are distributed in the northwestern, central and eastern part of the microwatershed. Slightly eroded (e1 class) soils cover a maximum area of about 128

ha (38%) and are distributed in the northern, central, southwestern and southeastern part of the microwatershed. A very small area of about 3 ha (1%) is severely eroded and occur in the central part of the microwatershed.

An area of about 72 ha (20%) in the microwatershed is problematic because of moderate and severe erosion. For these areas taking up soil and water conservation and other land development measures are needed.

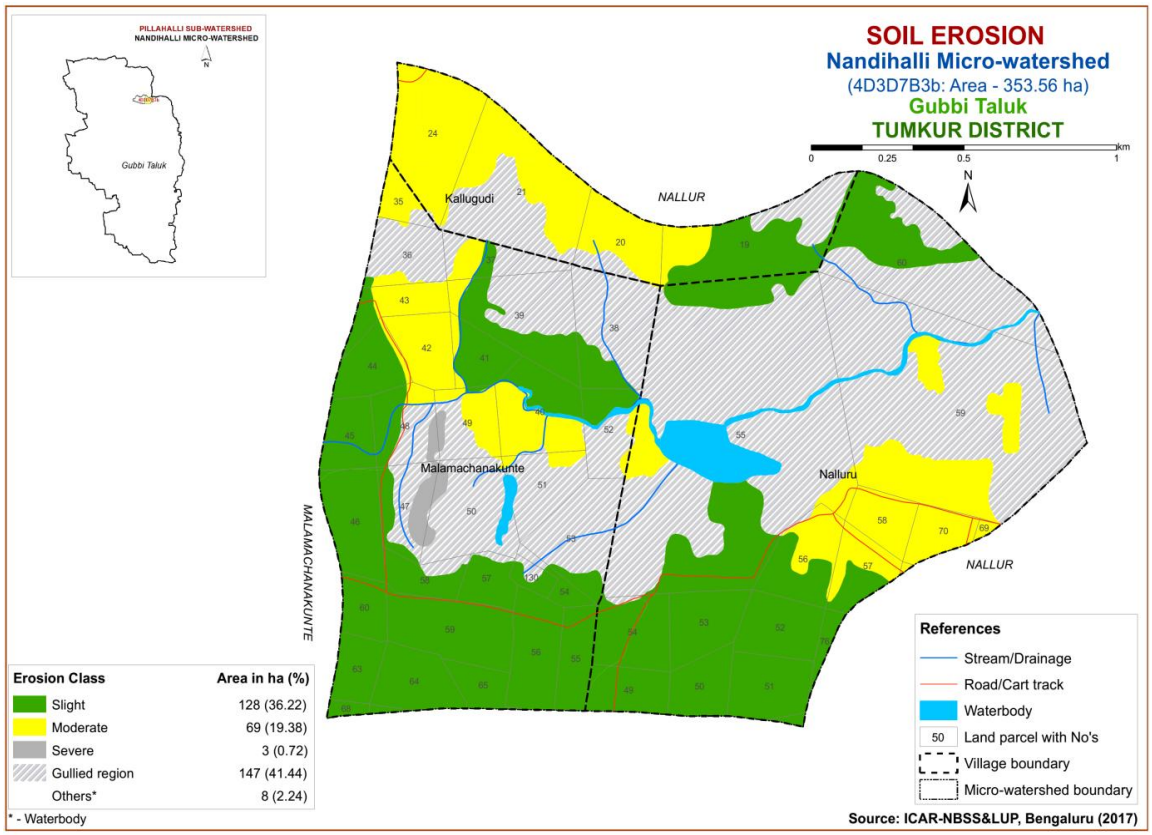


Fig. 5.7 Soil Erosion map of Nandihalli Microwatershed

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 the area is characterised by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium, and for micronutrients like zinc, 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 Nandihalli microwatershed for soil reaction (pH) showed that maximum area of about 95 ha (27%) is moderately acid (pH 5.5-6.0) and are distributed in the southern, central and northern part of the microwatershed. An area of 70 ha (20%) is strongly acid (pH 5.0-5.5) and are distributed in the southwestern and northern part of the microwatershed. An area of 84 ha (24%) is slightly acid (pH 6.0-6.5) and are distributed in the northwestern, eastern and southern part of the microwatershed and neutral (pH 6.5-7.3) occupy an area of about 97 ha (27%) and are distributed in the western and southeastern part of the microwatershed (Fig.6.1).

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content (an index of available Nitrogen) in the microwatershed is low (<0.5%) covering a maximum area of about 189 ha (53%) and is distributed in the northwestern, northern and southwestern part of the microwatershed and medium (0.5-0.75%) in an area of about 144 ha (41%) and distributed in the central, southeastern and eastern part of the microwatershed. A very small area of about 12 ha (3%) is high in organic carbon occurring in the southeastern part of the microwatershed (Fig.6.3).

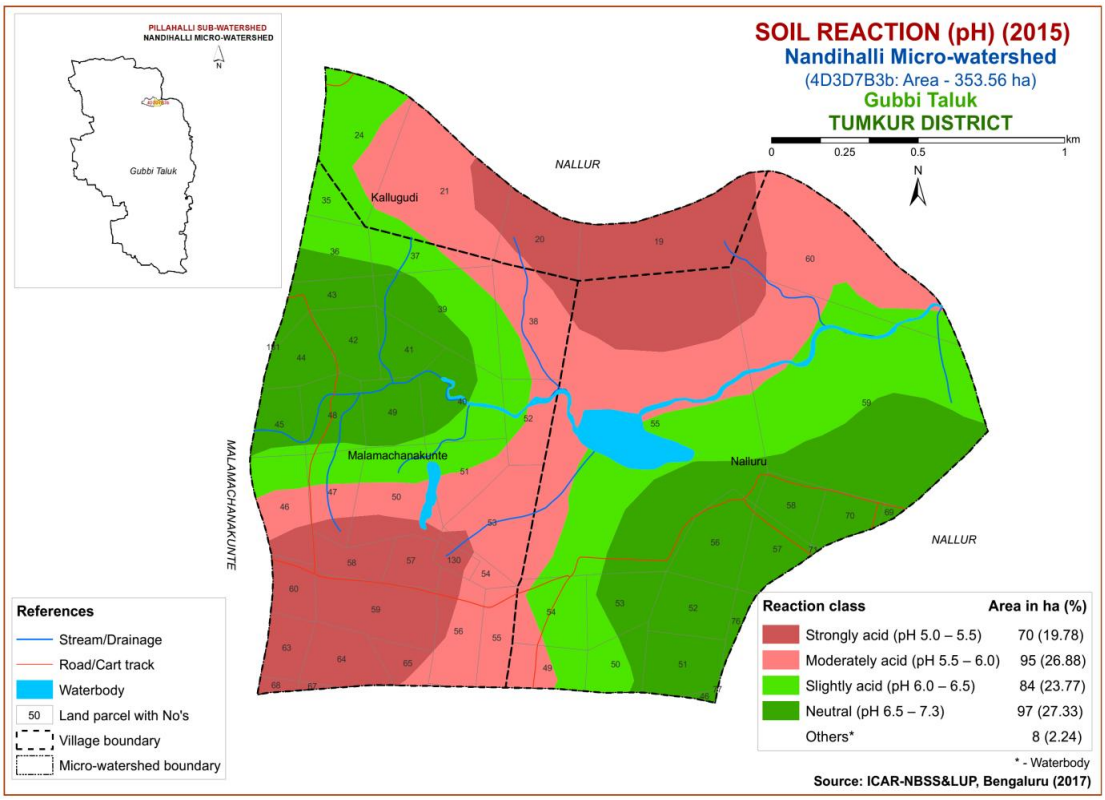


Fig.6.1 Soil Reaction (pH) map of Nandihalli Microwatershed

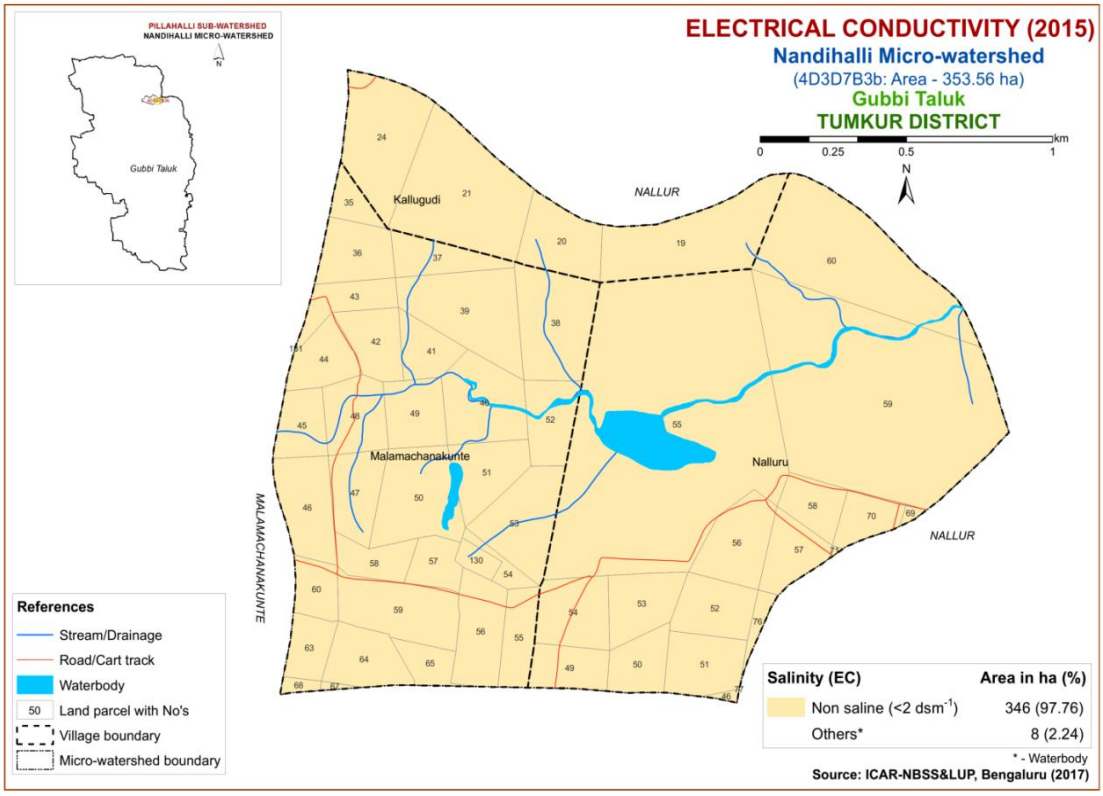


Fig.6.2 Electrical Conductivity (EC) map of Nandihalli Microwatershed

6.4 Available Phosphorus

Available phosphorus content is high (>57 kg/ha) in an area of about 130 ha (37%) and are distributed in the southern and eastern part of the microwatershed. Maximum area of about 216 ha (61%) is medium (23-57 kg/ha) in available phosphorous and occur in major part of the microwatershed (Fig 6.4).

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in an area of about 147 ha (42%) and is distributed in the northwestern, southern and eastern part of the microwatershed (Fig.6.5). Major area of about 171 ha (48%) is low in available potassium (< 145 kg/ha) and is distributed in the southwestern, central and northeastren part of the microwatershed. High available potassium (>337 kg/ ha) content occupies an area of about 27 ha (8%) and is distributed in the southeastern and a small patch in the northwestern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) in an area of about 270 ha (76%) covering maximum area and occur in all parts of the microwatershed. An area of about 76 ha (21%) is high in available sulphur (>20 ppm) and occur in the eastern part of the microwatershed (Fig.6.6).

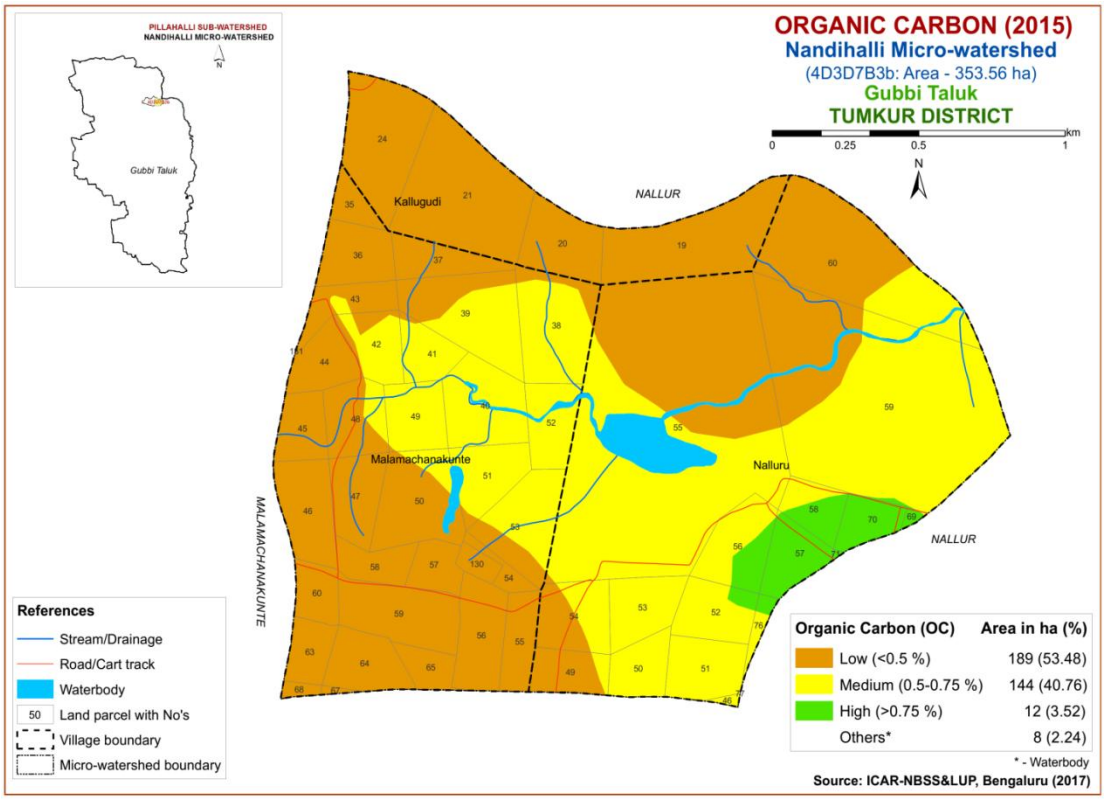


Fig.6.3 Soil Organic Carbon map of Nandihalli Microwatershed

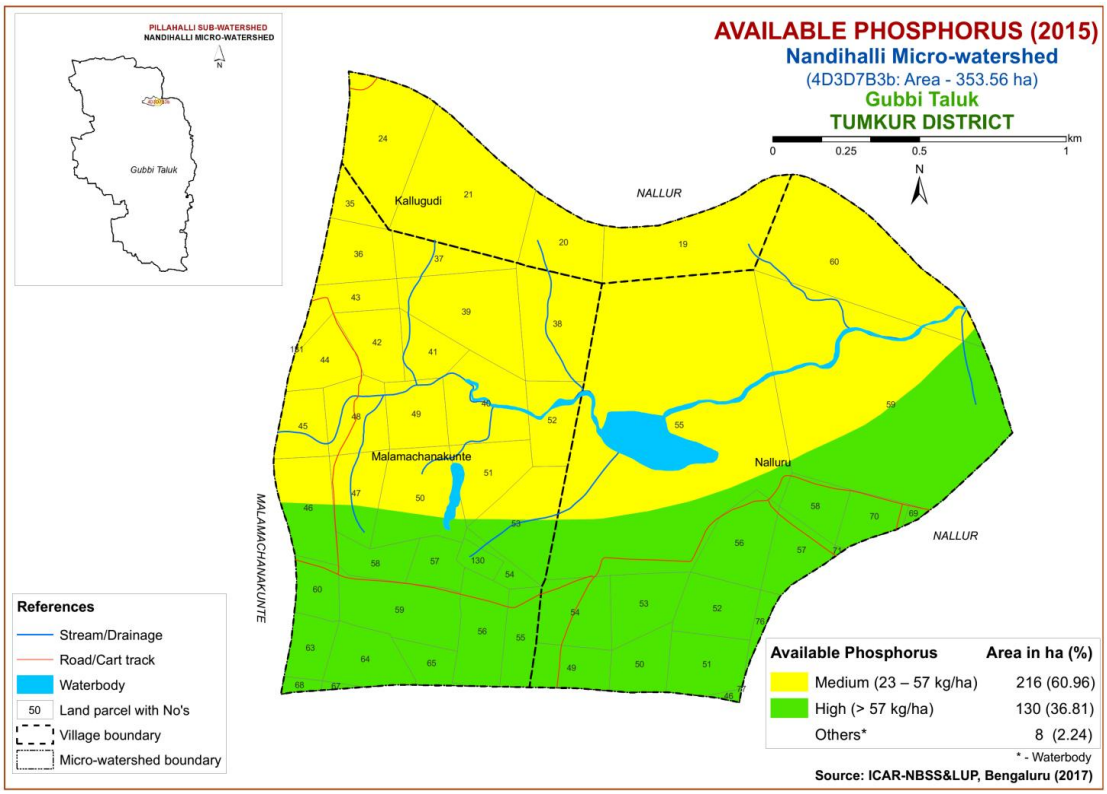


Fig.6.4 Soil Available Phosphorus map of Nandihalli Microwatershed

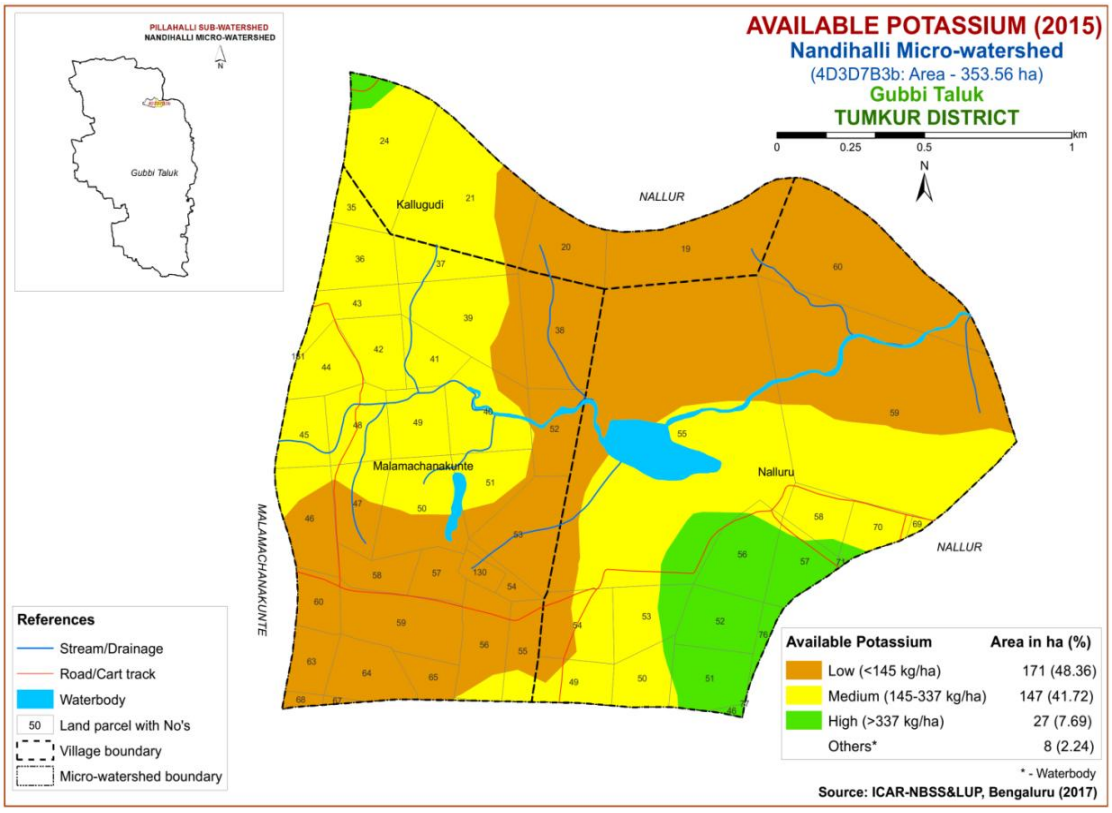


Fig.6.5 Soil Available Potassium map of Nandihalli Microwatershed

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in an area of 50 ha (14%) and is distributed in the western and southeastern part of the microwatershed. Maximum area of about 296 ha (84%) is low (<0.5 ppm) in available boron and is distributed in all parts of the microwatershed (Fig.6.7).

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in the entire area of the microwatershed (Fig 6.8).

6.9 Available Manganese

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

6.10 Available Copper

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

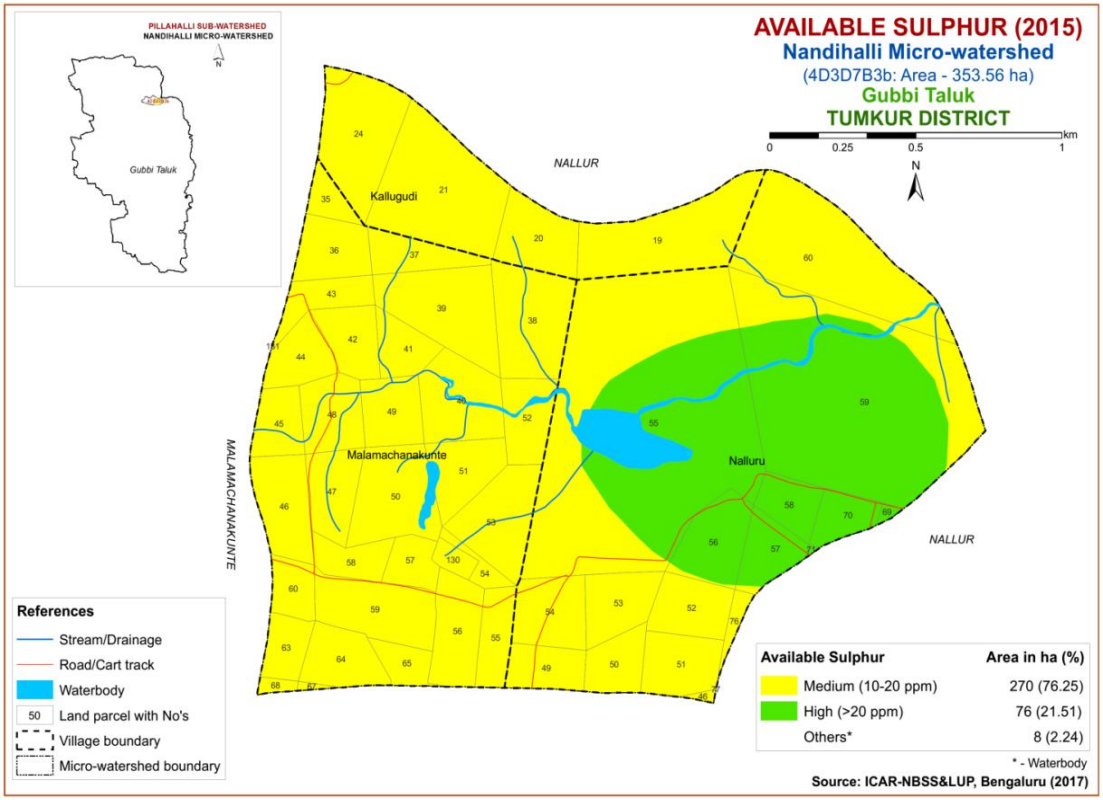


Fig.6.6 Soil Available Sulphur map of Nandihalli Microwatershed

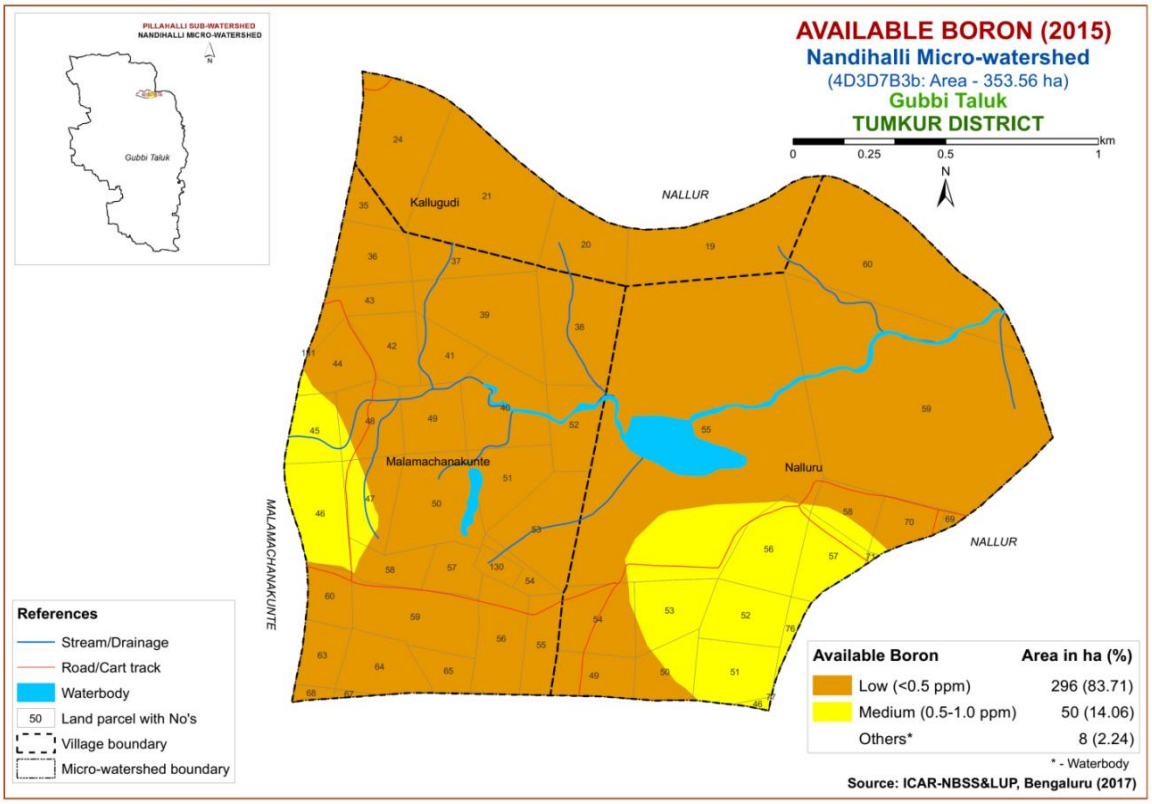


Fig.6.7 Soil Available Boron map of Nandihalli Microwatershed

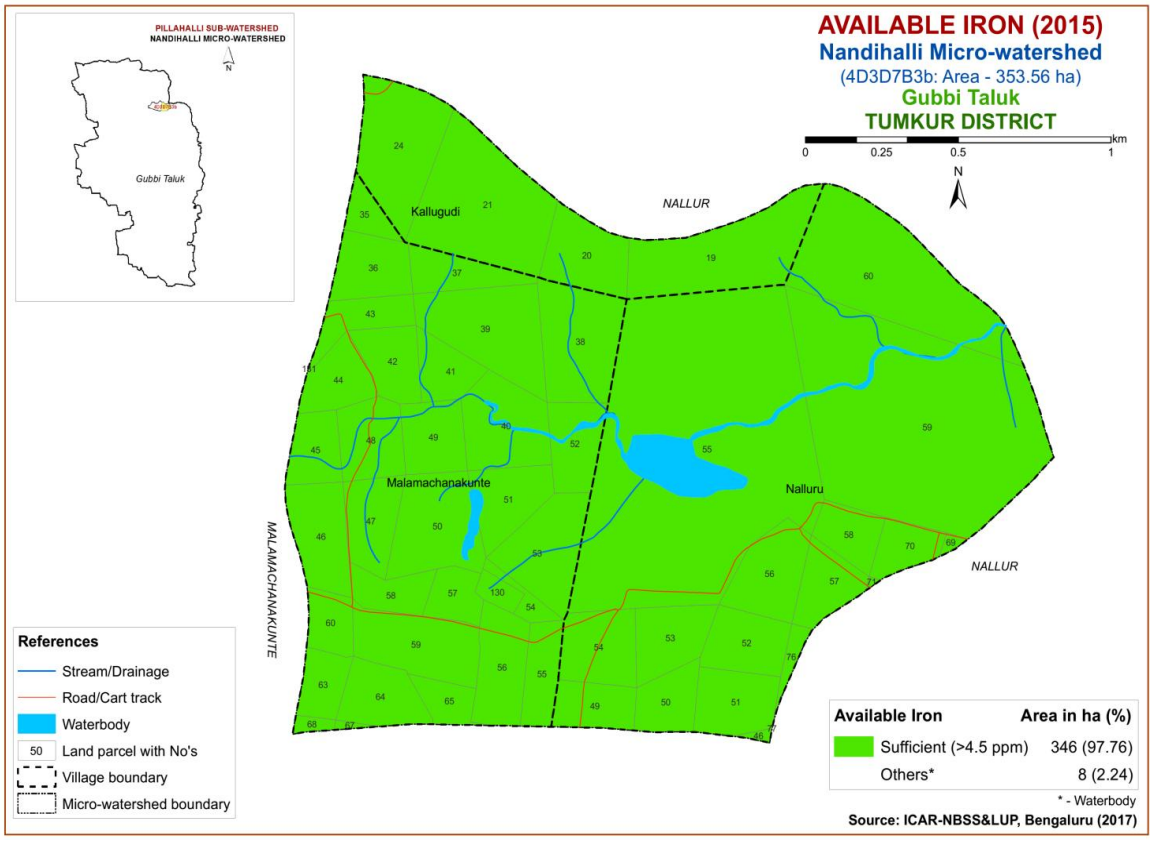


Fig.6.8 Soil Available Iron map of Nandihalli Microwatershed

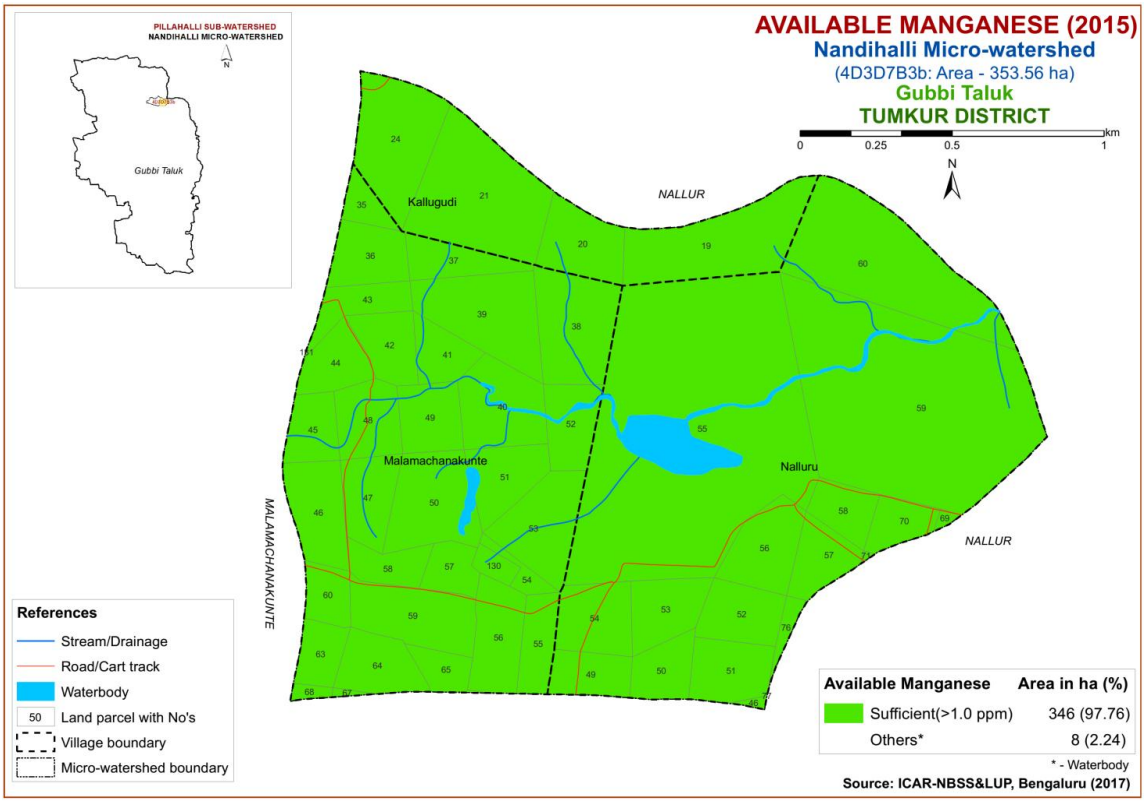


Fig.6.9 Soil Available Manganese map of Nandihalli Microwatershed

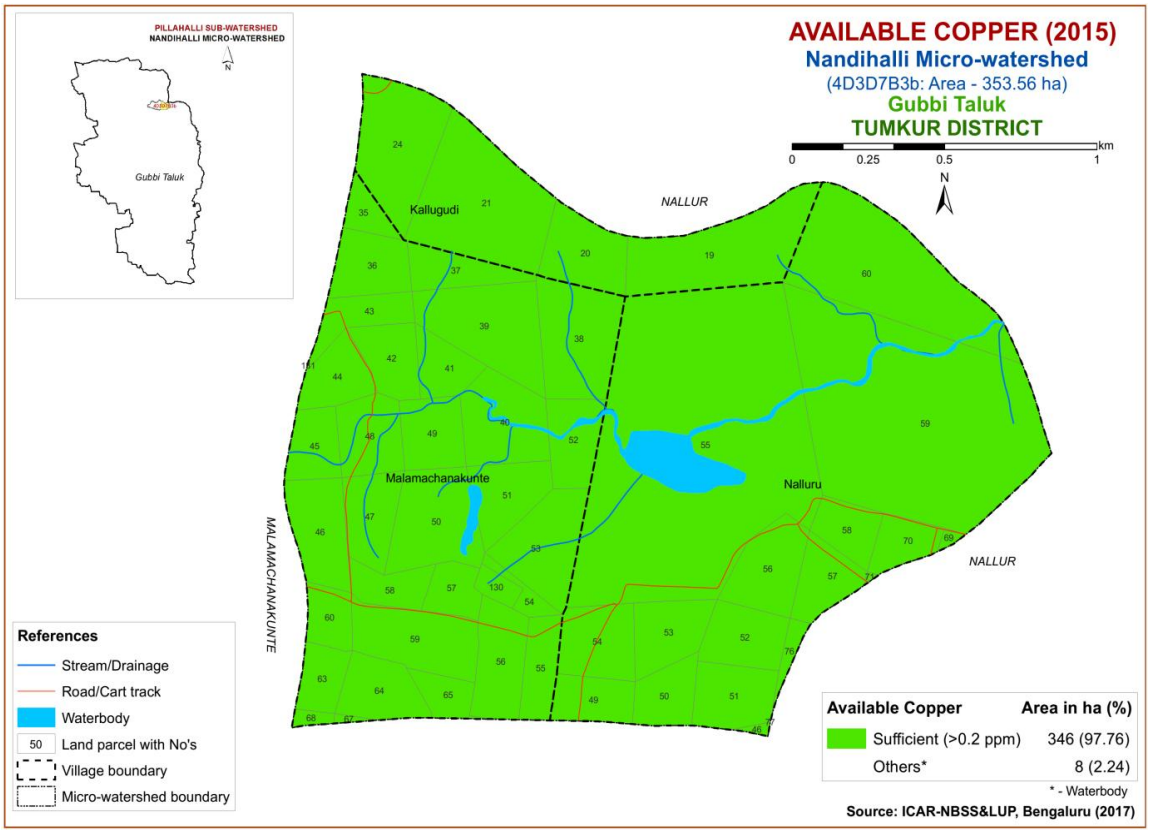


Fig.6.10 Soil Available Copper map of Nandihalli Microwatershed

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in an area of 154 ha (43%) and are distributed in the northern, northwestern, western and southwestern part of the microwatershed and major area of 192 ha (54%) is sufficient (>0.6 ppm) and are distributed in the major part of the microwatershed (Fig 6.11).

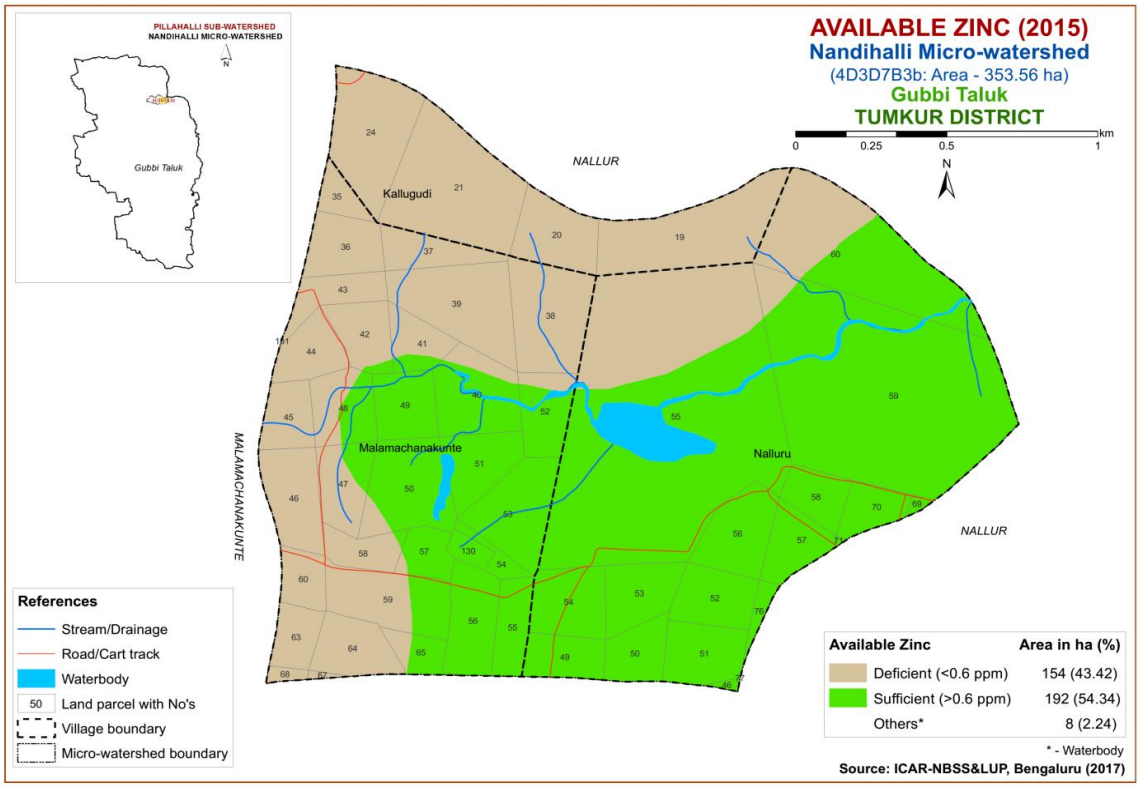


Fig.6.11 Soil Available Zinc map of Nandihalli Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Nandihalli 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, 'z' for calcareousness and 'w' for drainage. 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 34 major annual and perennial crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Tumakuru 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.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing sorghum and are distributed in the western, northern and southeastern part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) for growing sorghum and are distributed in the central and northern part the microwatershed.

Table 7.1 Soil-Site Characteristics of Nandihalli 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 (%)								
TDHhB2g1	813	150	WD	50-75	scl	sc - c	15-35	15-35	101-150	1-3	moderate					
KGHcB2g2	813	150	WD	50-75	sl	sc-c	35-60	15-35	101-150	1-3	moderate					
KGHhB2	813	150	WD	50-75	scl	sc-c	-	15-35	101-150	1-3	moderate					
KGHhC3	813	150	WD	50-75	scl	sc-c	-	15-35	101-150	3-5	severe					
KKRhC2	813	150	WD	75-100	scl	cl-sc	-	-	101-150	3-5	moderate					
JDGhB1	813	150	WD	100-150	scl	sc-c	-	<15	150-200	1-3	slight					
HLKhB1	813	150	WD	>150	scl	c	-	<15	51-100	1-3	slight					
RTRhB2	813	150	WD	>150	scl	c	-	-	51-100	1-3	moderate					
NDLcB1	813	150	WD	>150	sl	sc	-	>35	51-100	1-3	slight					
KDTiA1	813	150	MWD	>150	sc	sc-c	-	-	>150	0-1	slight					
KDTiB1g1	813	150	MWD	>150	sc	sc-c	15-35	-	>200	1-3	slight					
KDTiB2	813	150	MWD	>150	sc	sc-c	-	-	>200	1-3	slight					

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

They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing sorghum occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastren and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.2 Crop suitability criteria for Sorghum

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

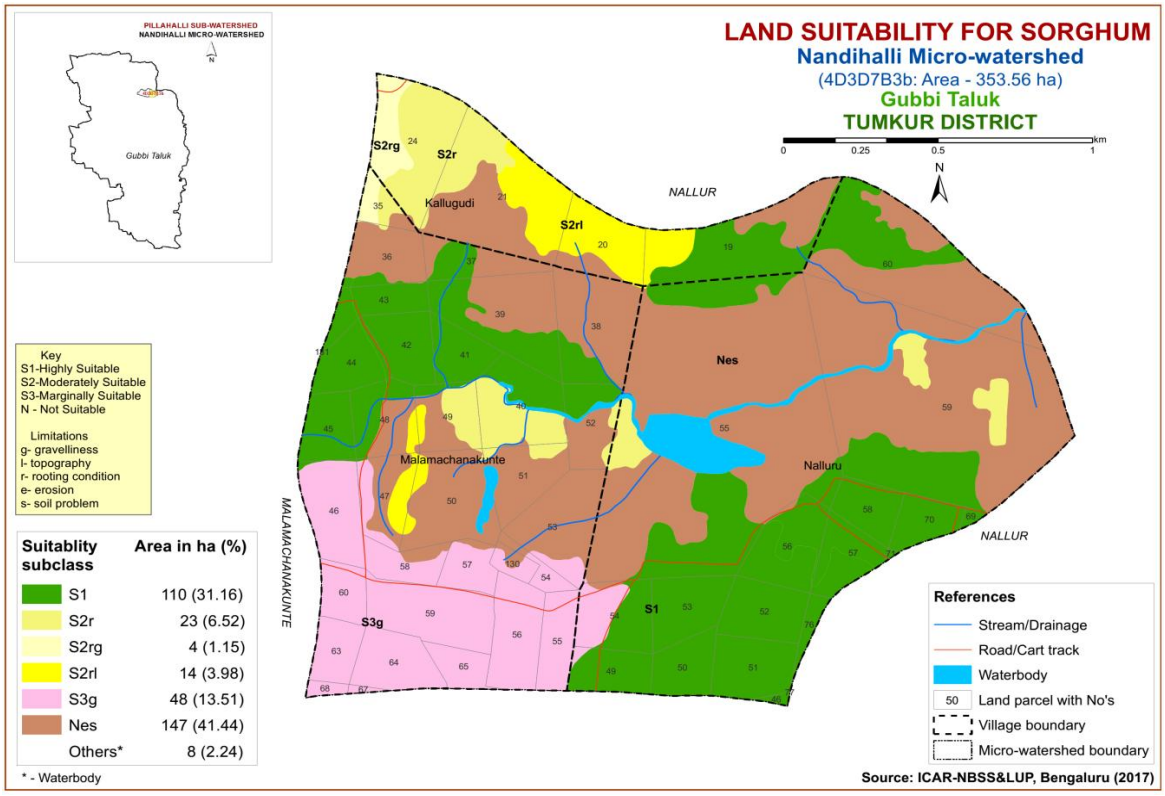


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Fodder Sorghum (*Sorghum bicolor*)

Fodder Sorghum is one of the major fodder crops grown in Southern Karnataka in Tumakuru, Chikkaballapur, Mysore, Mandya, Bengaluru Rural and Kolar districts. The crop requirements for growing Fodder sorghum (Table 7.3) 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 7.2.

Table 7.3 Crop suitability criteria for Fodder Sorghum

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

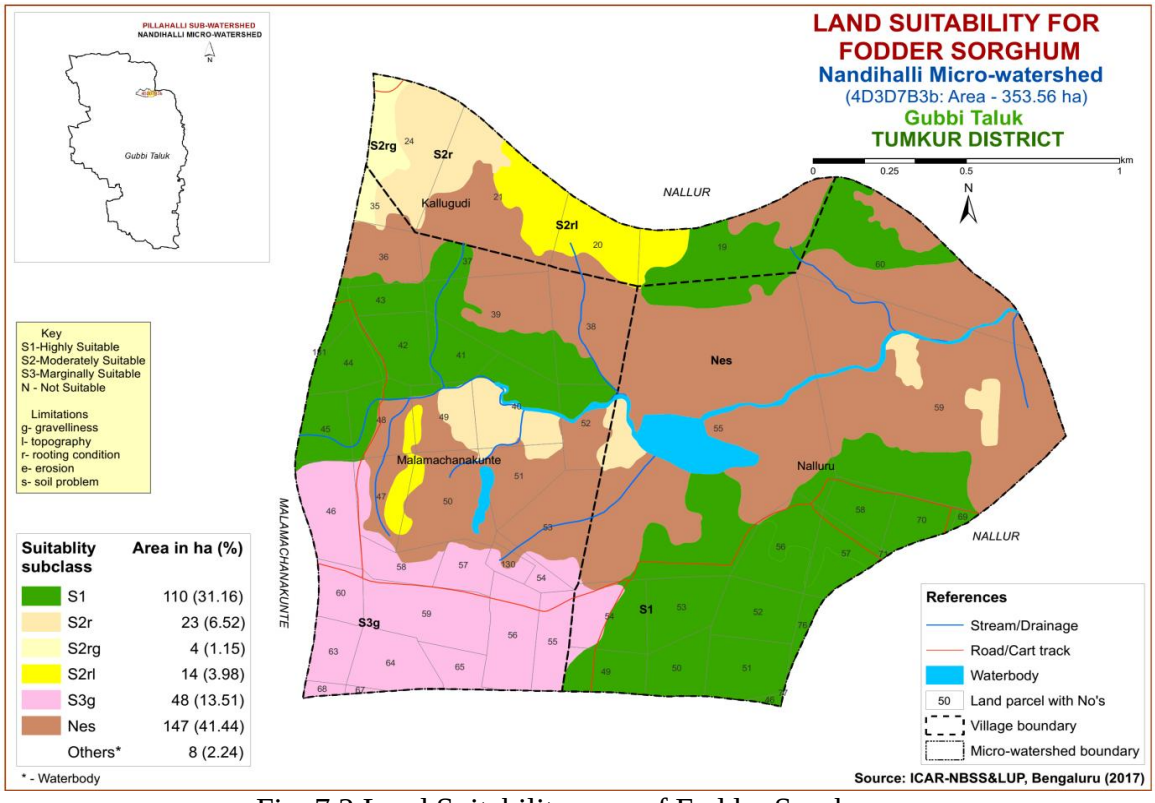


Fig. 7.2 Land Suitability map of Fodder Sorghum

An area of about 110 ha (31%) is highly suitable (Class S1) for growing fodder sorghum and are distributed in the western, northern and southeastern part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) for growing fodder sorghum and are distributed in the central and northern part the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing fodder sorghum occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

7.3 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 7.4) 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 7.3.

Highly suitable lands occupy an area of about 56 ha (16%) and are distributed in the northern and southeastern part of the microwatershed. An area of about 95 ha (27%) is moderately suitable (Class S2) for growing maize and are distributed in the western, northwestern and eastern part of the microwatershed. They have minor limitations rooting depth, texture, gravelliness and topography. Marginally suitable lands (Class S3) for growing maize occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.4 Crop suitability criteria for Maize

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

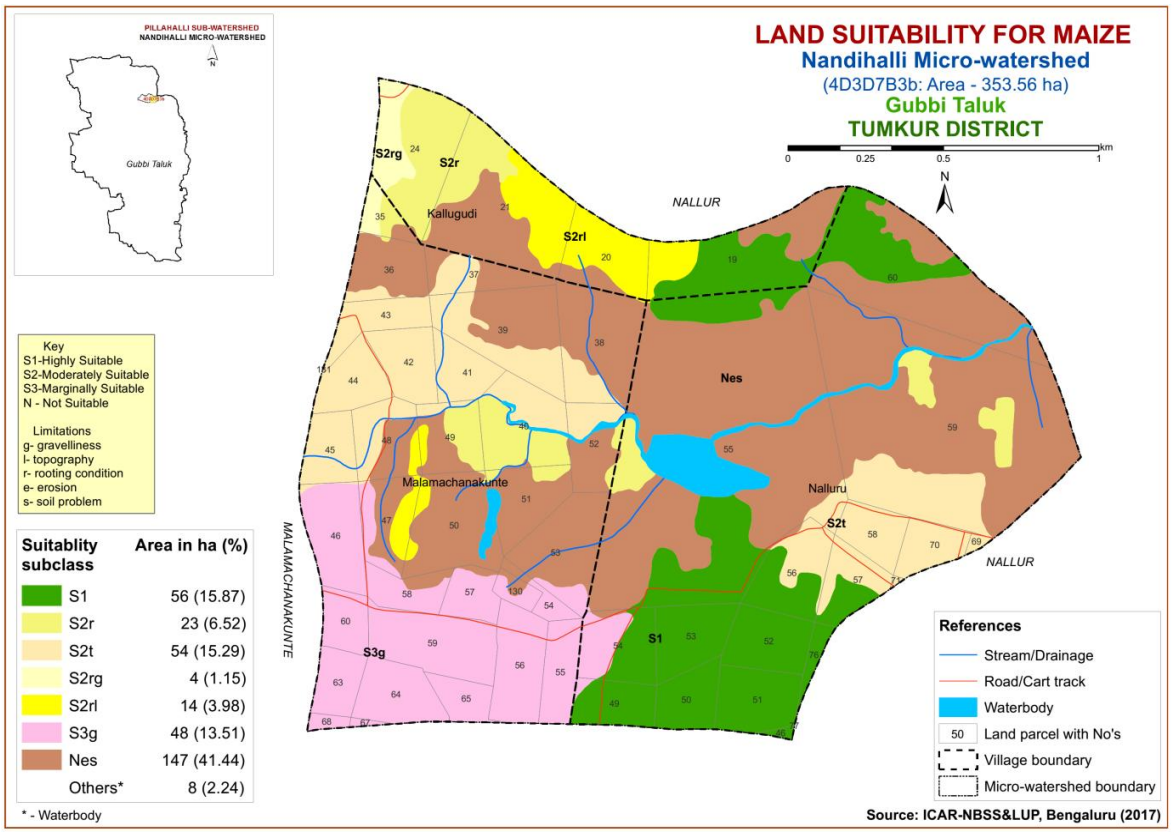


Fig. 7.3 Land Suitability map of Maize

7.4 Land Suitability for Upland Paddy (*Oryaza sativa*)

Upland paddy is an important food crop grown in all the districts of the State under rainfed conditions. The crop requirements for growing Upland paddy (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Upland paddy was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing Upland paddy and are distributed in the northern, southeastern and western part the microwatershed. An area of about 41 ha (12%) is moderately suitable (Class S2) for growing Upland paddy and are distributed in the central, northern and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.5 Land suitability criteria for Upland paddy

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately Suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	1-3	1-3	3-5	>5
Soil drainage	class	Well to mod.	poorly	Very poorly	
Soil reaction	pH	5.5-6.5	6.5-7.3 4.5-5.4	7.3-8.4	>8.4
Surface soil texture	Class	C, sic, cl, sicl, sc	Scl, sil, l	Sl, ls	S
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	60-80

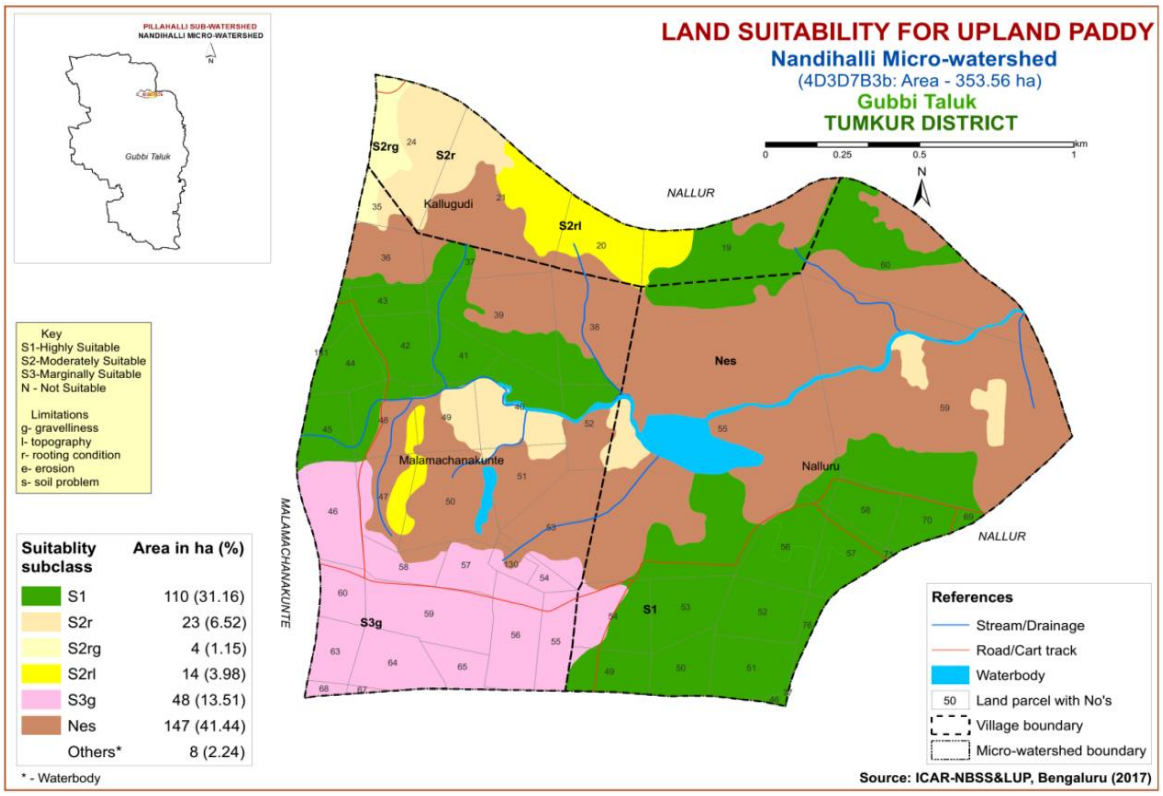


Fig. 7.4 Land Suitability map of Upland paddy

7.5 Land Suitability for Finger millet (*Eleusine coracana*)

Finger millet is the most important food crop grown in an area of 7.08 lakh ha in almost all the districts of south Karnataka. The crop requirements for growing Finger millet (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Finger millet was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing Finger millet and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha

(12%) and distributed in the central and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing Finger millet occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.6 Land suitability criteria for Finger millet

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	>110	90-110	60-90	<60
Soil drainage	class	Well to mod.drained	Imperfectly drained	Poorly/excessively	V.poorly
Soil reaction	pH	5.5-7.3	7.3-8.4	8.4-9.0	>9.0
Surface soil texture	Class	l, sil, sl, cl, sicl, scl	sic, c, sc	ls, s,c >60%	
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity (ESP)	%	<10	10-15	15-25	>25

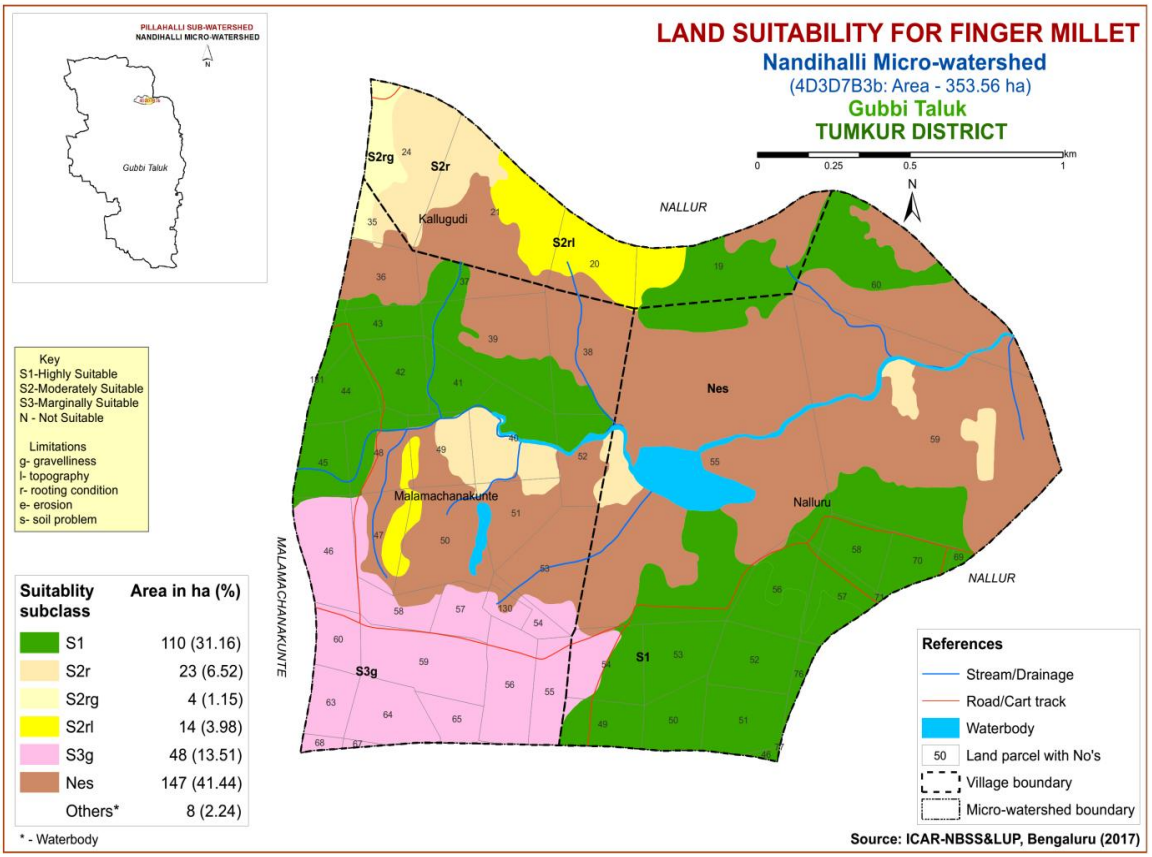


Fig. 7.5 Land Suitability map of Finger millet

7.6 Land suitability criteria for Red gram (*Cajanus cajan)*

Red gram 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 red gram (Table 7.7) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing red gram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

Table 7.7 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)	dsm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

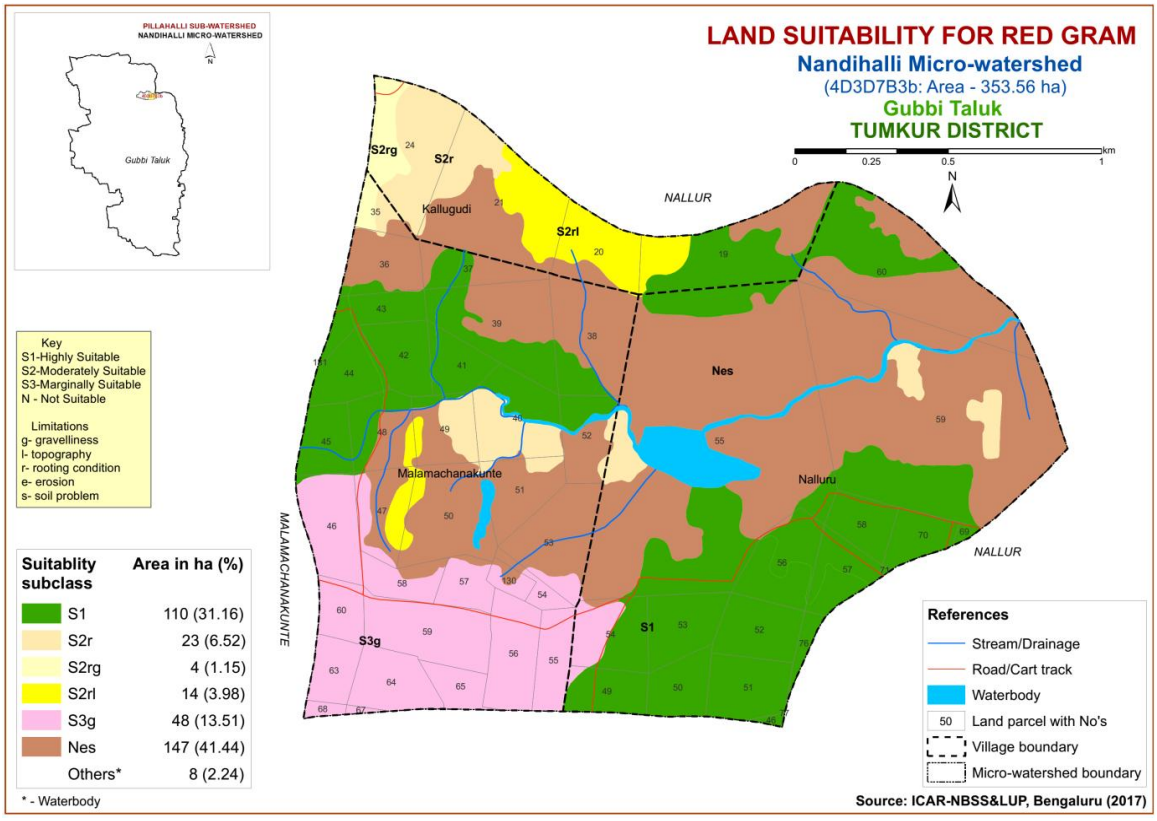


Fig. 7.6 Land Suitability map of Redgram

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) for growing redgram and are distributed in the western, southeastern and northern part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (11%) and are distributed in the northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) lands occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

7.7 Land suitability for Horse Gram (*Macrotyloma uniflorum*)

Horse gram is the most important pulse crop grown in an area of 1.8 lakh ha in almost all the districts of the State. The crop requirements (Table 7.8) for growing horse gram were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing horse gram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

An area of about 121 ha (34%) is highly suitable (Class S1) for growing horse gram and are distributed in the western, southeastern and northern part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 79 ha (22%) for growing horse gram and are distributed in the southwestern and northern part the microwatershed with minor limitations of gravelliness, topography and rooting depth. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.8 Land suitability criteria for Horse gram

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

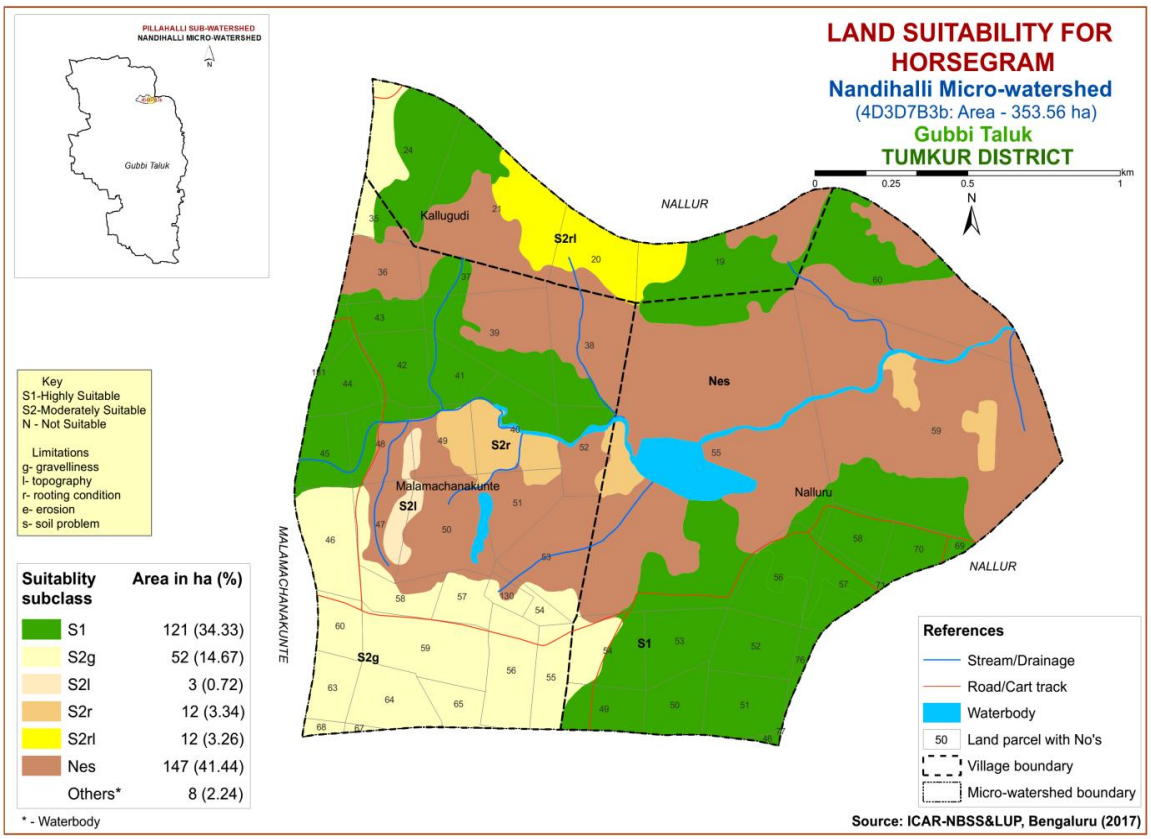


Fig. 7.7 Land Suitability map of Horse gram

7.8 Land suitability for Field Bean (*Dolichos lablab*)

Field Bean is the most important pulse crop grown in an area of 0.59 lakh ha in almost all the districts of the State. The crop requirements (Table 7.9) for growing field bean were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing field bean was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.8.

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) for growing field bean and are distributed in the western, southeastern and northern part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (11%) and are distributed in the northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.9 Land suitability criteria for Field Bean

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

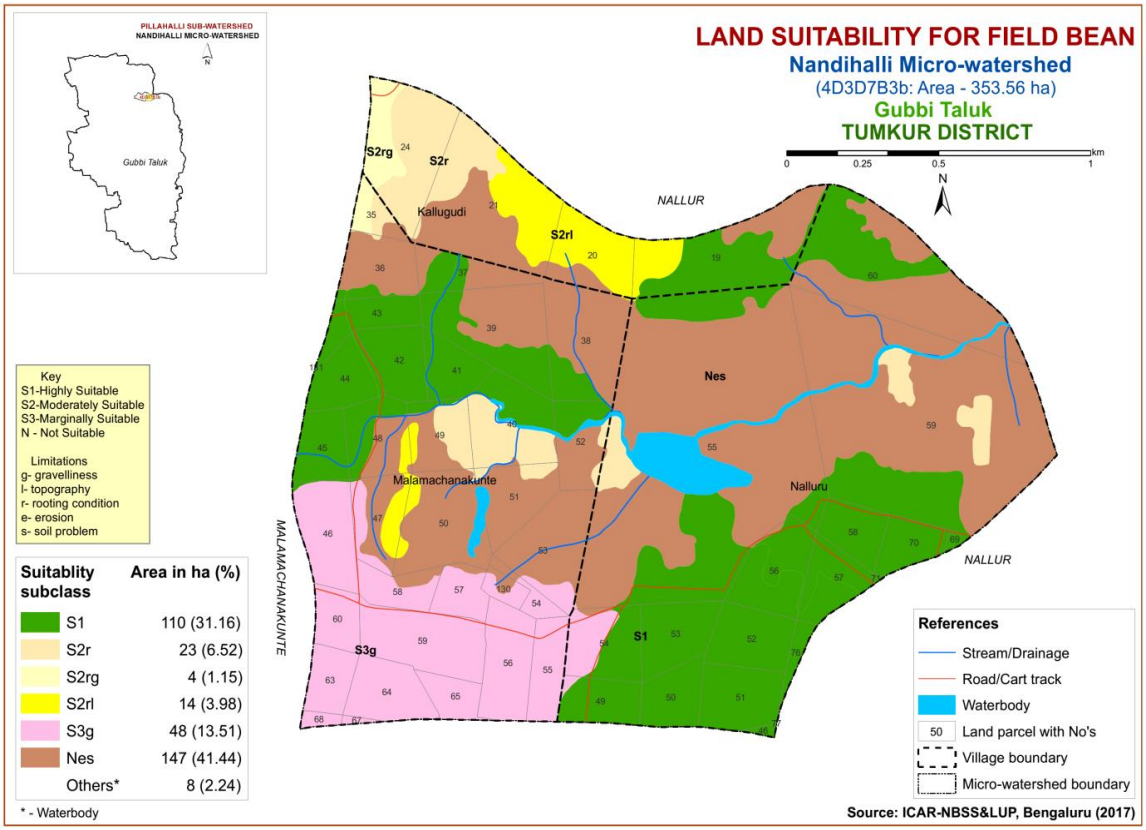


Fig. 7.8 Land Suitability map of Field bean

7. 9 Land Suitability for Cowpea (*Vigna radiata*)

Cowpea is the most important pulse crop grown in an area of 0.80 lakh ha in almost all the districts of the State. The crop requirements for growing cowpea were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cowpea was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.9.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing cowpea and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) and are distributed in the central and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing cowpea occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

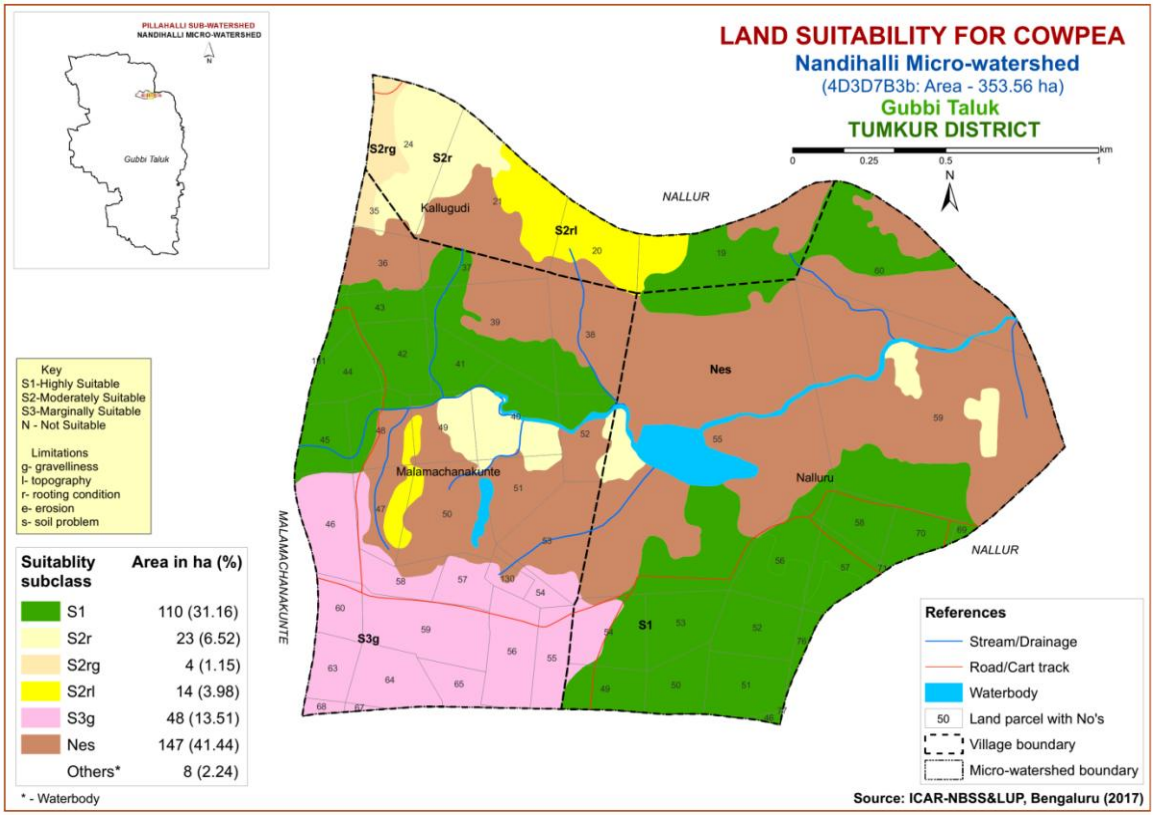


Fig. 7.9 Land Suitability map of Cowpea

7.10 Land Suitability for Groundnut (*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.54 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.10) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing groundnut was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.10.

A very small area of about 17 ha (5%) is highly suitable (Class S1) for growing Groundnut and are distributed in the northern part of the microwatershed. Maximum area of about 163 ha (46%) is moderately suitable (Class S2) for groundnut and are distributed

in major part of the microwatershed. They have minor limitations of rooting depth, gravelliness, topography and texture. Marginally suitable (Class S3) lands occupy an area of about 20 ha (6%) and are distributed in the eastern part of the microwatershed with moderate limitation of texture. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.10 Crop suitability criteria for Groundnut

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

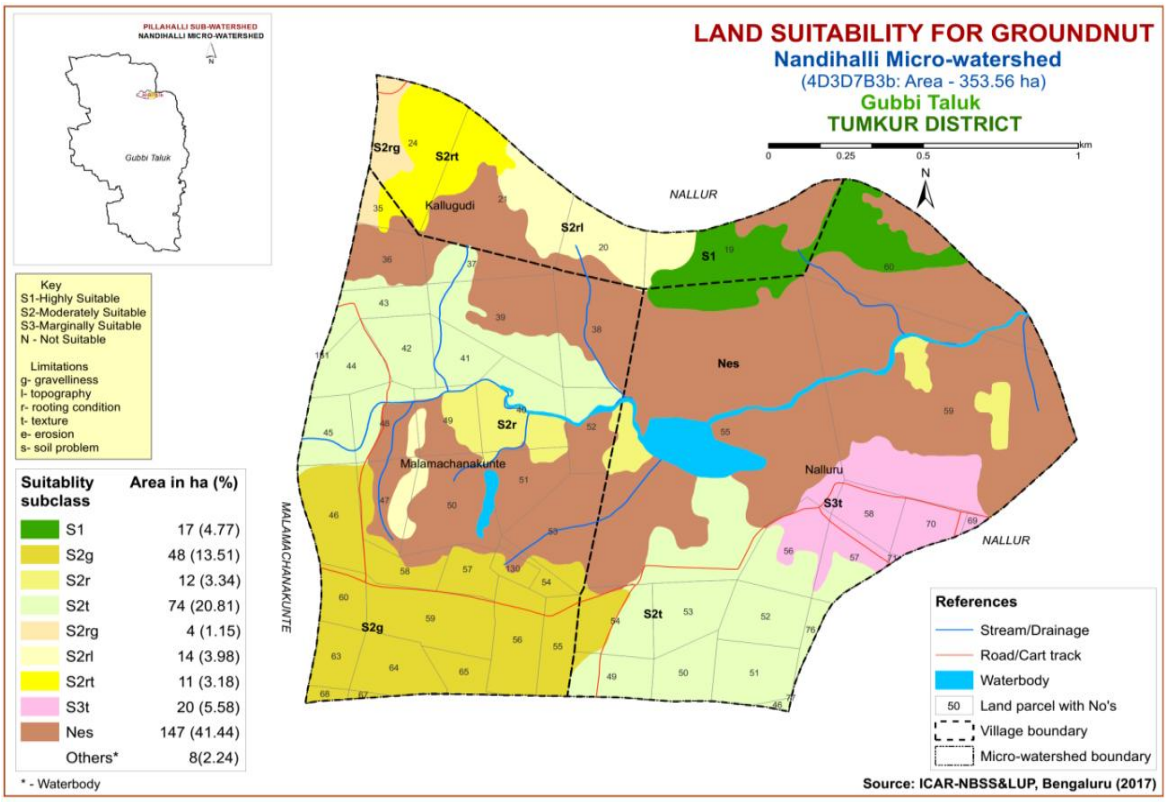


Fig. 7.10 Land Suitability map of Groundnut

7.11 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 7.11) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.11.

Table 7.11 Crop suitability criteria for Sunflower

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>90	80-90	70-80	<70
Soil drainage	Class	Well drained	Mod. well rained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.55.5-6.4	8.6-9.0;4.5-5.4	>9.0<4.5
Surface soil texture	Class	l, cl, sil, sc	Scl, sic, c,	c (>60%), sl	ls, s
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

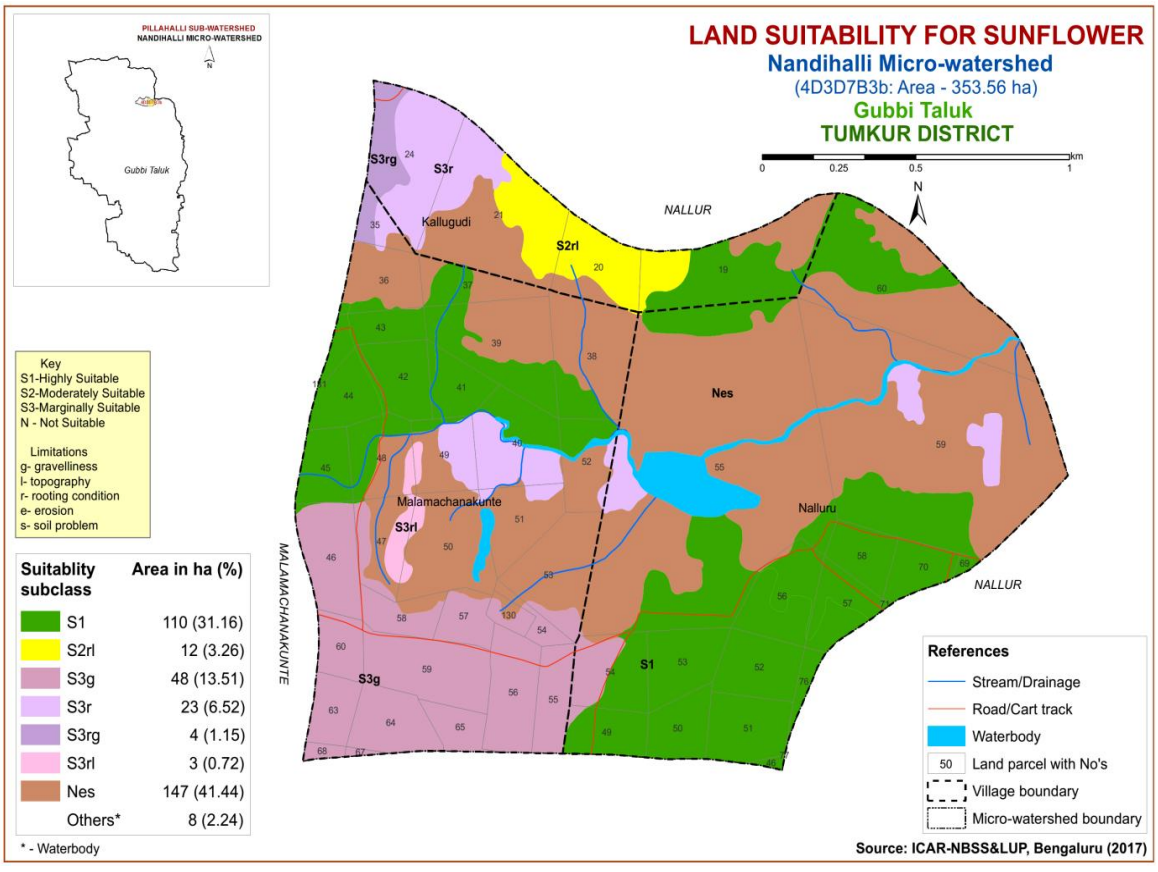


Fig. 7.11 Land Suitability map of Sunflower

An area of about 110 ha (31%) is highly suitable (Class S1) for growing sunflower and are distributed in the southeastern, northern and western part the microwatershed. A very small area of about 12 ha (3%) is moderately suitable (Class S2) and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and topography. Marginally suitable lands (Class S3) for growing sunflower occupy an area of about 78 ha (22%) and occur in the southwestern, central and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

7.12 Land Suitability for Onion (*Allium cepa*)

Onion is the most important vegetable crop grown in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Tumakuru districts. The crop requirements for growing onion (Table 7.12) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing onion was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.12.

Highly suitable (Class S1) lands occupy an area of about 76 ha (21%) and are distributed in the western, northern and southeastern part of the microwatershed. An area of about 75 ha (21%) has soils that are moderately suitable (Class S2) with minor limitations of rooting depth, texture, gravelliness and topography. They are distributed in the northwestern and central part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.12 Land suitability criteria for Onion

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

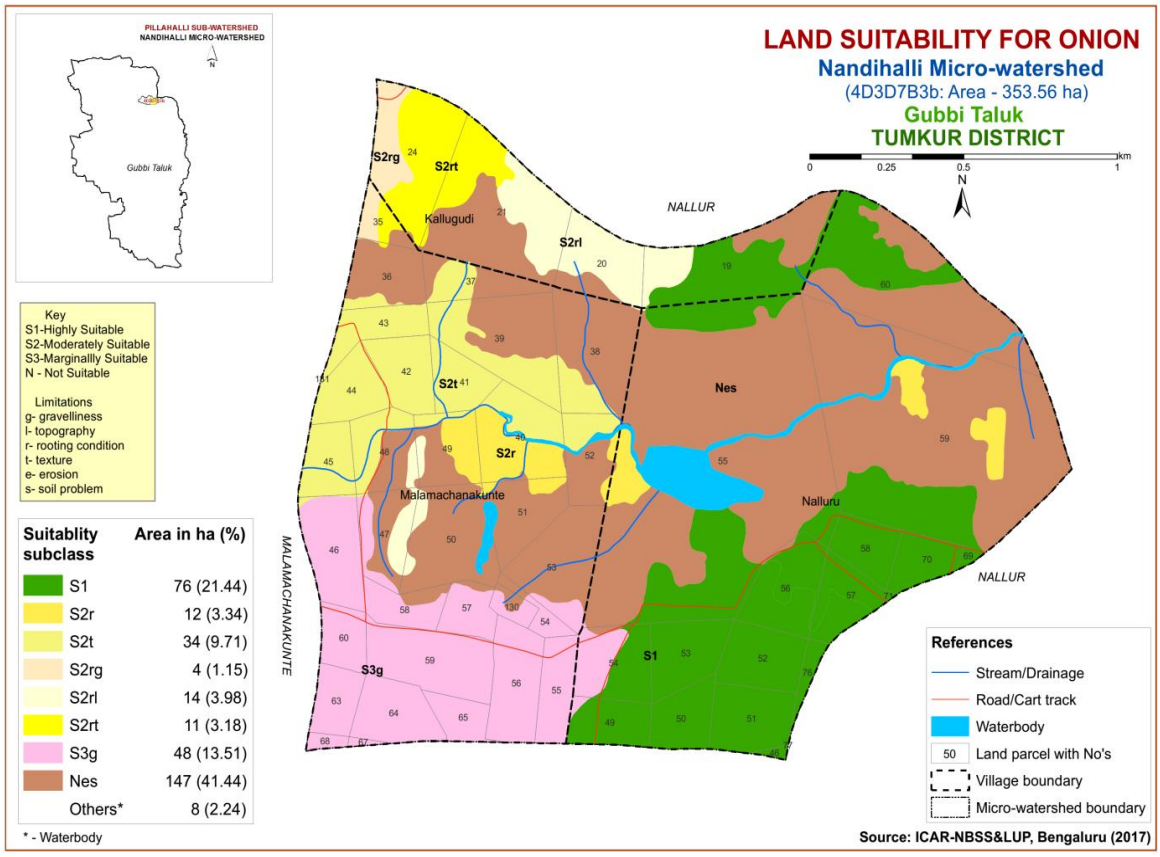


Fig. 7.12 Land Suitability map of Onion

7.13 Land Suitability for Chilli (*Capscicum annuum L.*)

Chilli is the most important commercial crop grown in an area of 0.42 lakh ha in the State in all the districts. The crop requirements for growing Chilli (Table 7.13) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Chilli was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing chilli and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) and distributed in the central and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing chilli occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.13 Land suitability criteria for chillies

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	
LGP	Days	>150	120-150	90-120	<90
Soil drainage	class	Well drained	Mod. to imperfectly drained	Poor drained/excessively	Very poorly drained
Soil reaction	pH	6.0-7.0	7.1-8.0	8.1-9.0,5.0-5.9	>9.0
Surface soil texture	Class	L, scl, cl, sil	sl, sc, sic,c(m/k)	C(ss), ls, s	
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	>35	
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	

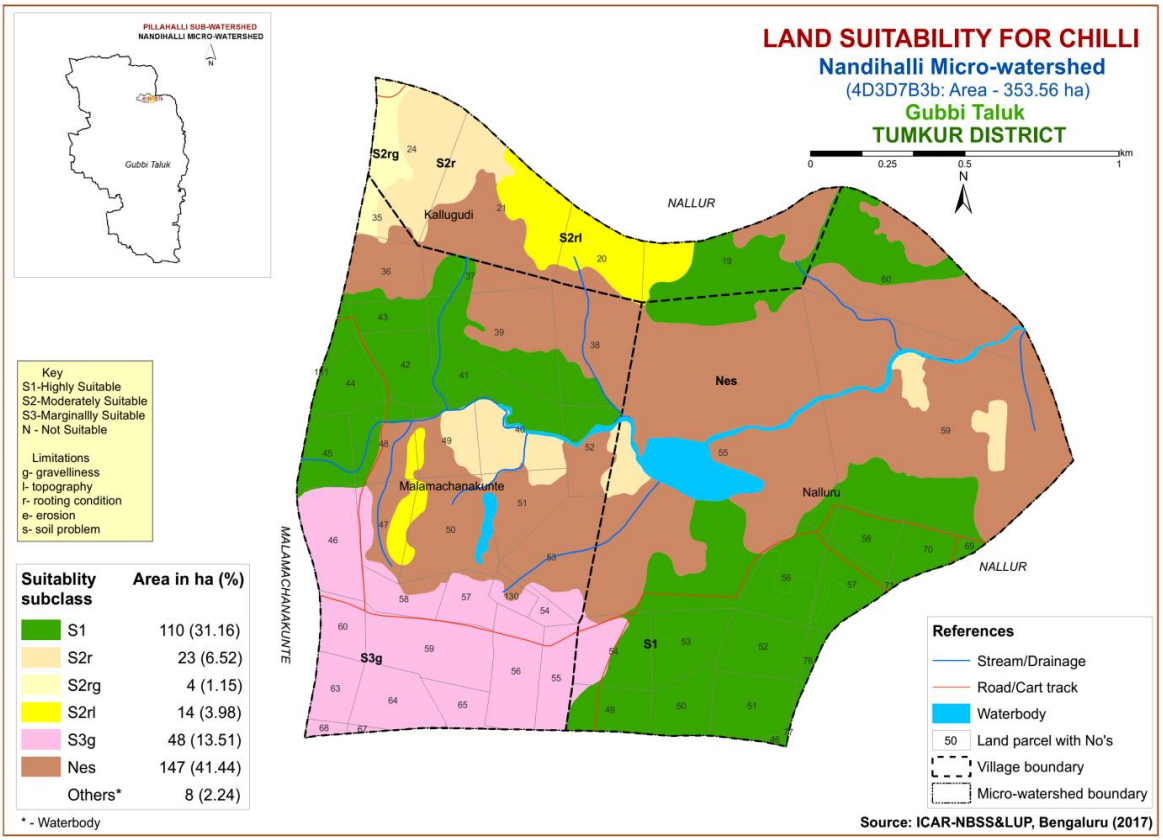


Fig. 7.13 Land Suitability map of Chilli

7.14 Land suitability for Brinjal (*Solanum melongena*)

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

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) for growing brinjal and are distributed in the southeastern, northern and western part the

microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) and distributed in the central and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing brinjal occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.14 Land suitability criteria for Brinjal

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	Moderately well drained	Poorly drained	V. Poorly drained
Nutrient availability	Texture	Class	Sl, scl, cl, sc	C (red)	Ls, c (black)	-
	pH	1:2.5	6.0-7.3	7.3-8.4 5.5-6.0	8.4-9.0	>9.0
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	35-60	>60
Erosion	Slope	%	0-3	3-5	5-10	>10

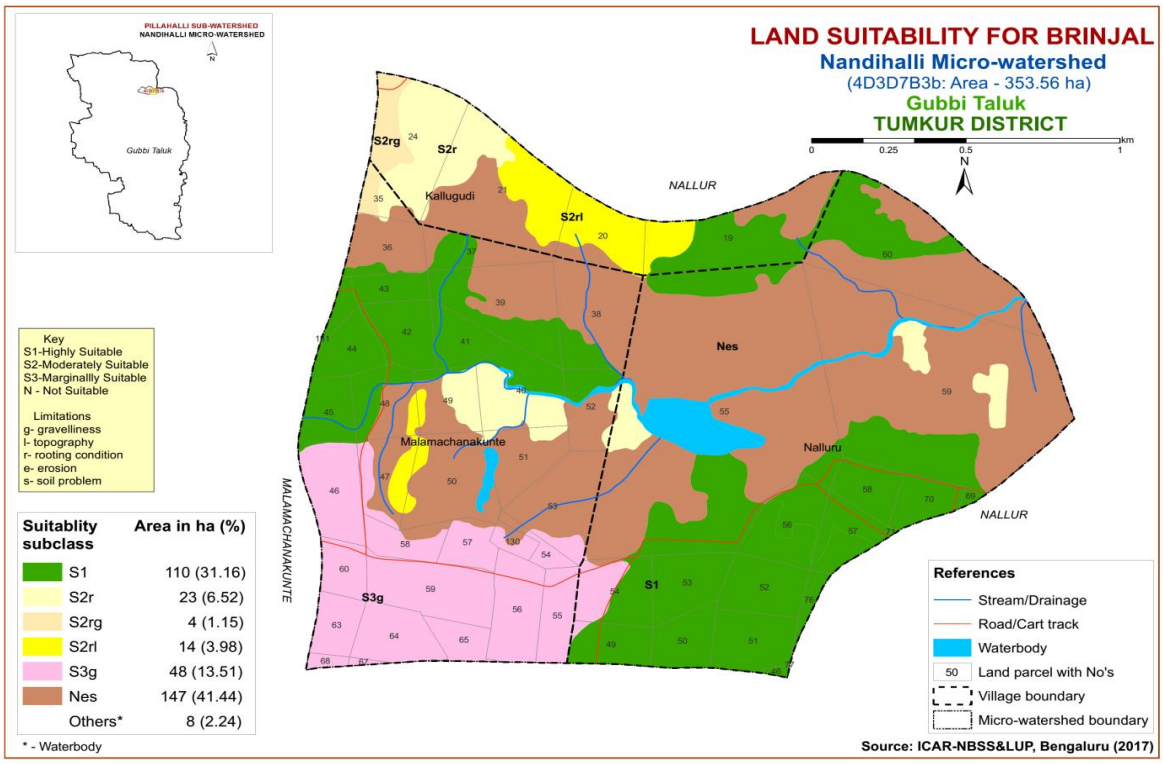


Fig. 7.15 Land Suitability map of Brinjal

7.15 Land suitability for Tomato (*Lycopersicon esculentum*)

Tomato is the most important vegetable crop grown in an area of 0.65 lakh ha in almost all the districts of the State. The crop requirements for growing Tomato (Table 7.15) were matched with the soil-site characteristics (Table 7.1) and a land suitability map

for growing Tomato was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.15.

Table 7.15 Land suitability criteria for Tomato

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	25-28	29-32 20-24	15-19 33-36	<15 >36
Soil moisture	Growing period	Days	>150	120-150	90-120	
Soil aeration	Soil drainage	class	Well drained	Moderately well drained	Poorly drained	V. poorly drained
Nutrient availability	Texture	Class	l, sl, cl, scl	Sic, sicl, sc, c(m/k)	C (ss), ls	s
	pH	1:2.5	6.0-7.3	5.5-6.0,7.3-8.4	8.4-9.0	>9.0
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strongly calcareous	
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	ds/m	Non saline	slight	strongly	
	Sodicity (ESP)	%	<10	10-15	>15	-
Erosion	Slope	%	1-3	3-5	5-10	>10

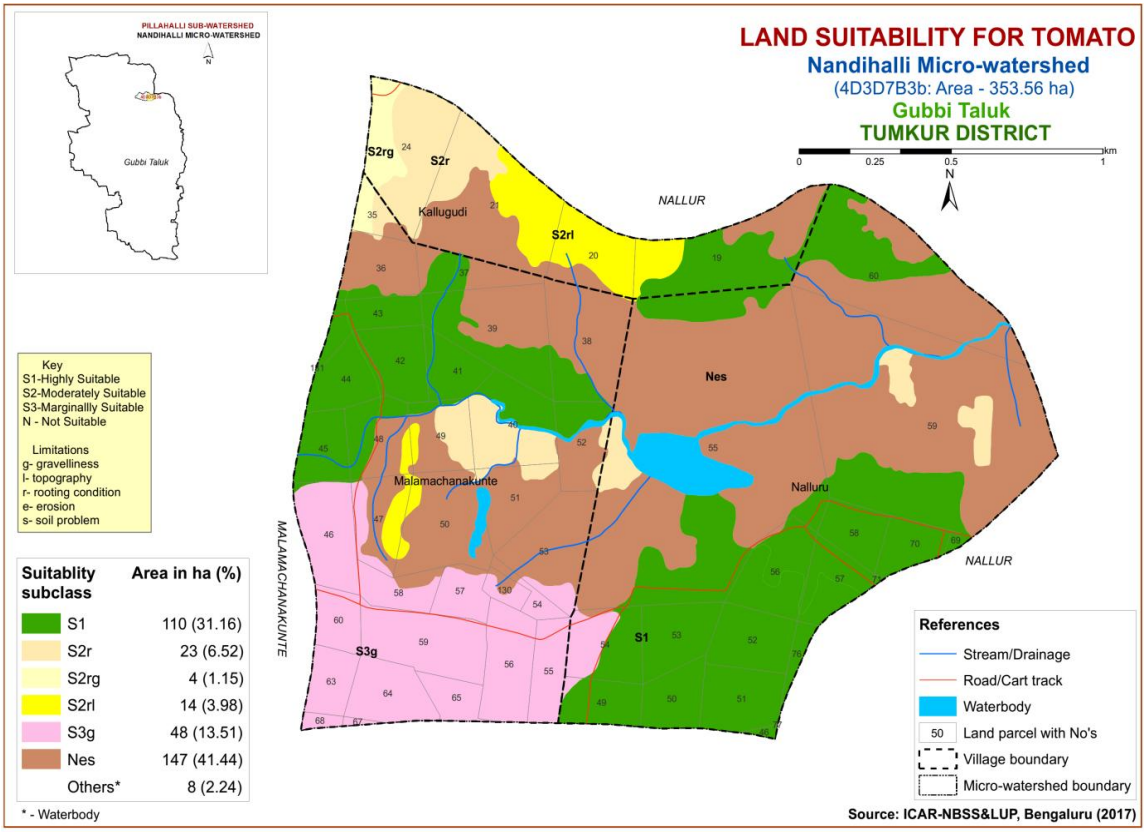


Fig. 7.15 Land Suitability map of Tomato

An area of about 110 ha (31%) is highly suitable (Class S1) for growing tomato and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 41 ha (12%) and distributed in the central and northwestern part of the microwatershed. They have minor limitations of rooting depth, gravelliness and topography. Marginally suitable lands (Class S3) for growing tomato occupy an area of about 48 ha (13%) and occur in the southwestern part of the microwatershed with moderate limitation of gravelliness. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

7.16 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in about 1.73 lakh ha area in almost all the districts of the State. The crop requirements (Table 7.16) 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 geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

Table 7.16 Crop suitability criteria for Mango

Crop requirement			Rating			
Soil-site characteristics		Unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable(N)
Climate	Temp. in growing season	^{0}C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^{0}C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	Class	Well drained	Mod. To imperfectly drained	Poor drained	Very poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	Sc, l, sil, cl	Sl, sc, sic, l, c	C (<60%)	C (>60%),
	pH	1:2.5	5.5-7.5	7.6-8.5,5.0-5.4	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	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

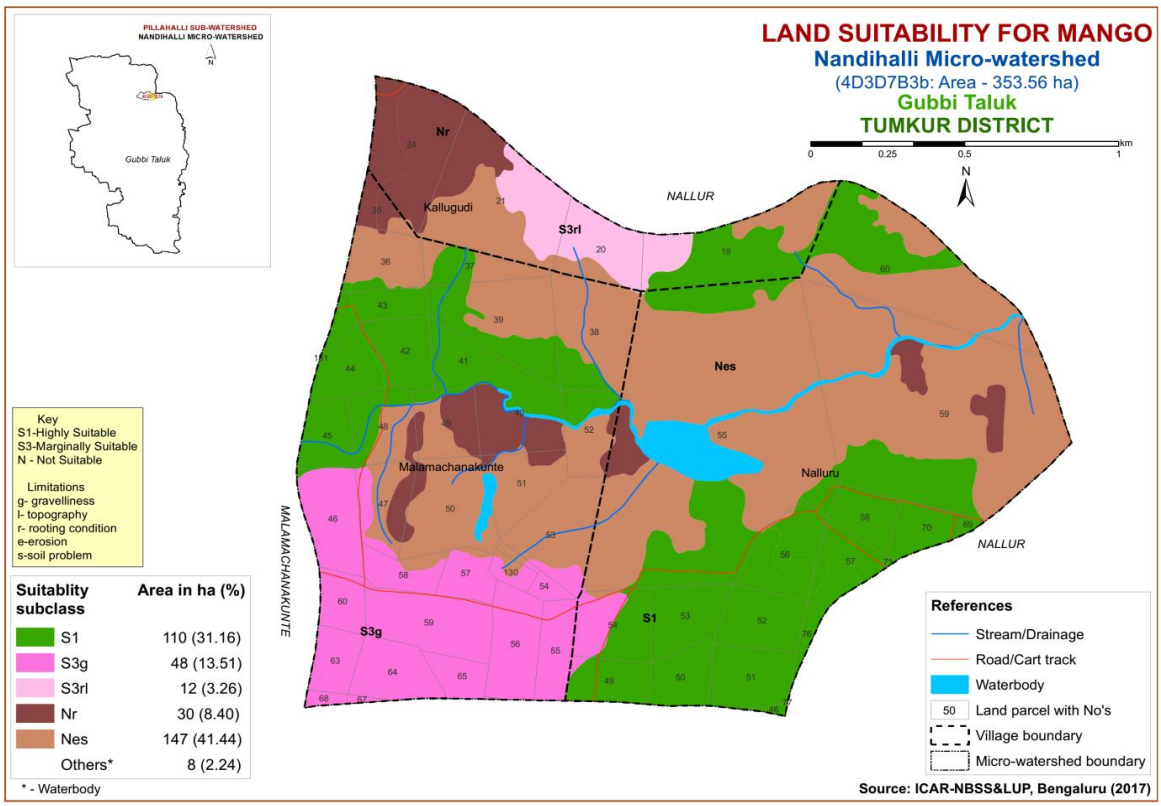


Fig. 7.16 Land Suitability map of Mango

An area of about 110 ha (31%) in the microwatershed is highly suitable (Class S1) for growing mango and are distributed in the southeastern, northern and western part of the microwatershed. The marginally suitable (Class S3) lands occupy an area of about 60 ha (17%) and are distributed in the southwestern and northern part of the microwatershed and have moderate limitations of gravelliness, rooting depth and topography. Major area of about 177 ha (50%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of rooting depth, erosion and soil.

7.17 Land suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 29373 ha in almost all the districts of the State. The crop requirements (Table 7.17) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.17.

An area of about 110 ha (31%) in the microwatershed is highly suitable (Class S1) for growing sapota and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy a very small area of about 12 ha (3%) and are distributed in the northern part the microwatershed. They have minor limitations of rooting depth and topography. The marginally suitable (Class S3) lands cover an area of about 78 ha (22%) and are distributed in the northwestern, central and southwestern part of the microwatershed with moderate limitations of gravelliness

and rooting depth. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

Table 7.17 Crop suitability criteria for Sapota

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

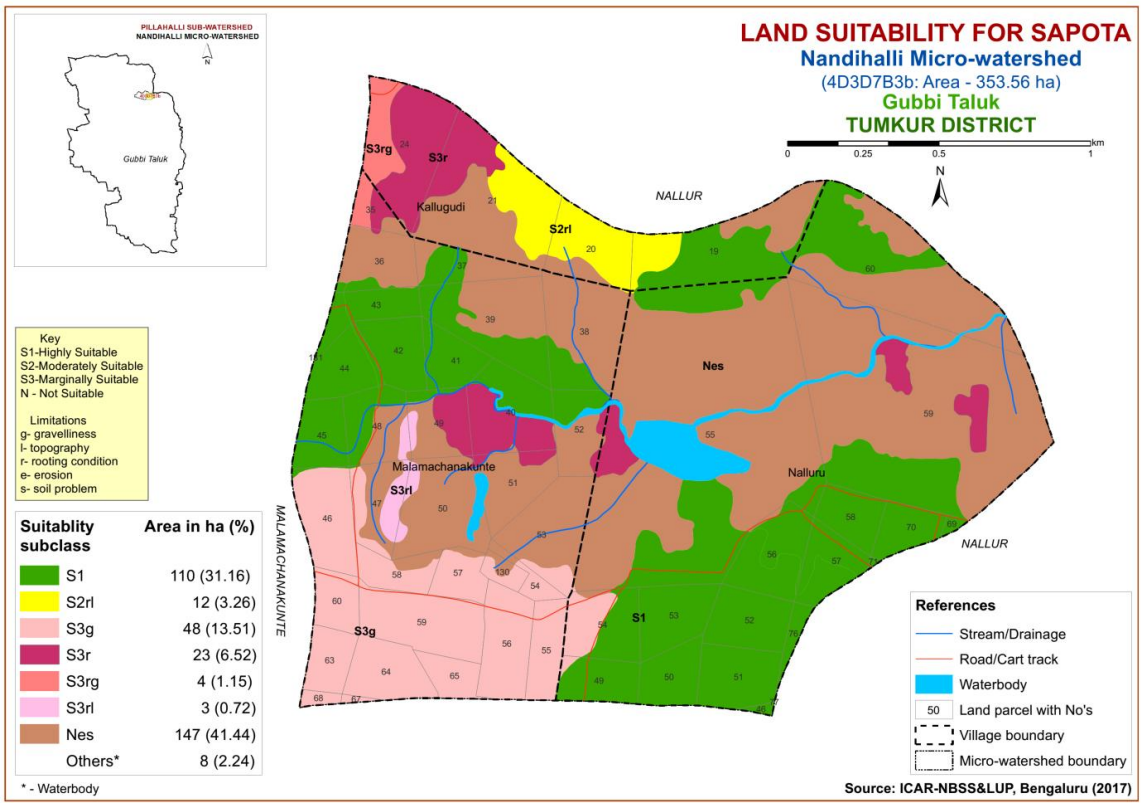


Fig. 7.18 Land Suitability map of Sapota

7.18 Land suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in an area of 6558 ha in almost all the districts of the State. The crop requirements (Table 7.18) for growing guava were matched with the soil-site characteristics (7.1) and a land suitability map for growing guava was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

Table 7.18 Crop suitability criteria for Guava

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

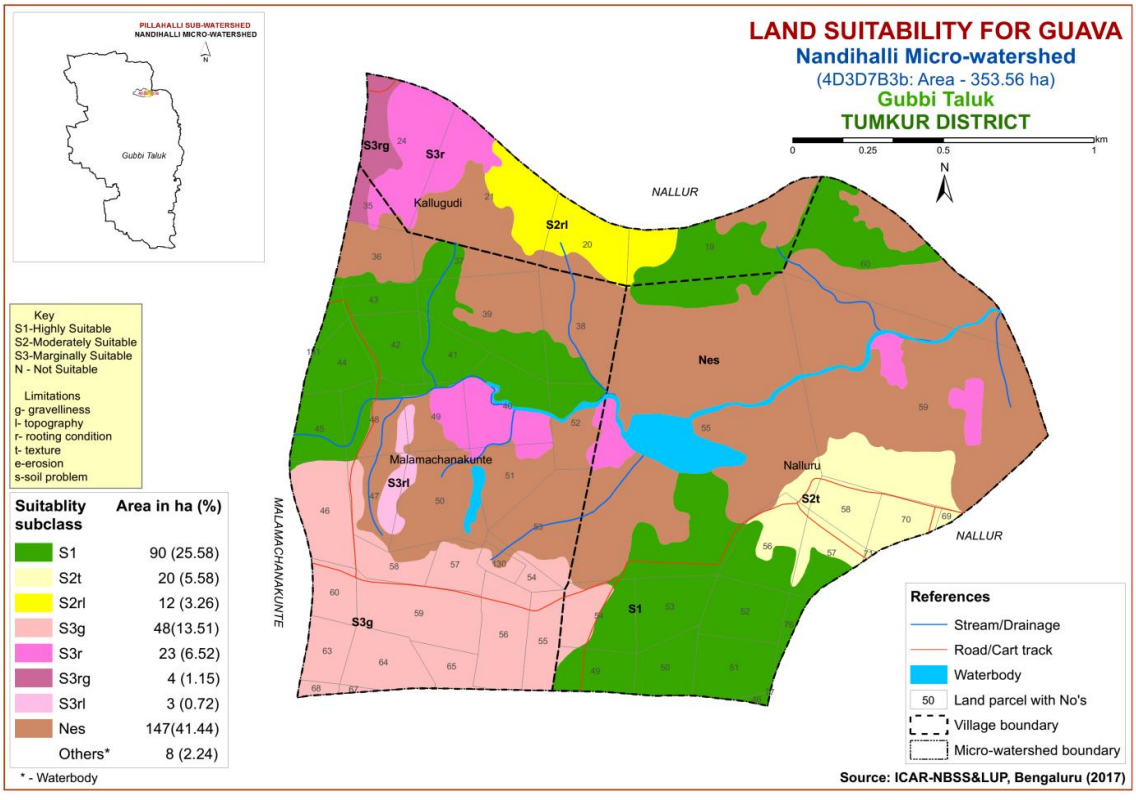


Fig. 7.18 Land Suitability map of Guava

An area of about 90 ha (26%) in the microwatershed is highly suitable (Class S1) for growing guava and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 32 ha (9%) and are distributed in the northern part and have minor limitations of texture, rooting depth and topography. The marginally suitable (Class S3) lands cover an area of about 78 ha (22%) and are distributed in the northwestern, central and southwestern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

7.19 Land Suitability for Pomegranate (*Punica granatum*)

Pomegranate is one of the commercially grown fruit crop in Karnataka in an area of 0.18 lakh ha mainly in Bijapur, Bagalkot, Koppal, Gadag and Chitradurga districts. The crop requirements for growing pomegranate (Table 7.19) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing pomegranate was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.19.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing pomegranate and are distributed in the southeastern, northern and western part the microwatershed. A very small area of about 12 ha (3%) is moderately suitable (Class S2) lands and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and topography. Marginally suitable lands (Class S3) occupy an area of about 78 ha (22%) and occur in the southwestern, central and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.19 Crop suitability criteria for Pomegranate

Crop requirement			**Rating**			
Soil –site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Climate	Temperature in growing season	^{0}C	30-34	35-38 25-29	39-40 15-24	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	class	Well drained	imperfectly drained		
Nutrient availability	Texture	Class	Sl, scl, l, cl	C, sic, sicl	Cl, s, ls	S, fragmental
Rooting conditions	pH	1:2.5	5.5-7.5	7.6-8.5	8.6-9.0	
	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	nil	15-35	35-60	>60
Soil toxicity	Salinity	dS/m	Nil	<9	>9	<50
	Sodicity	%	nil			
Erosion	Slope	%	<3	3-5	5-10	

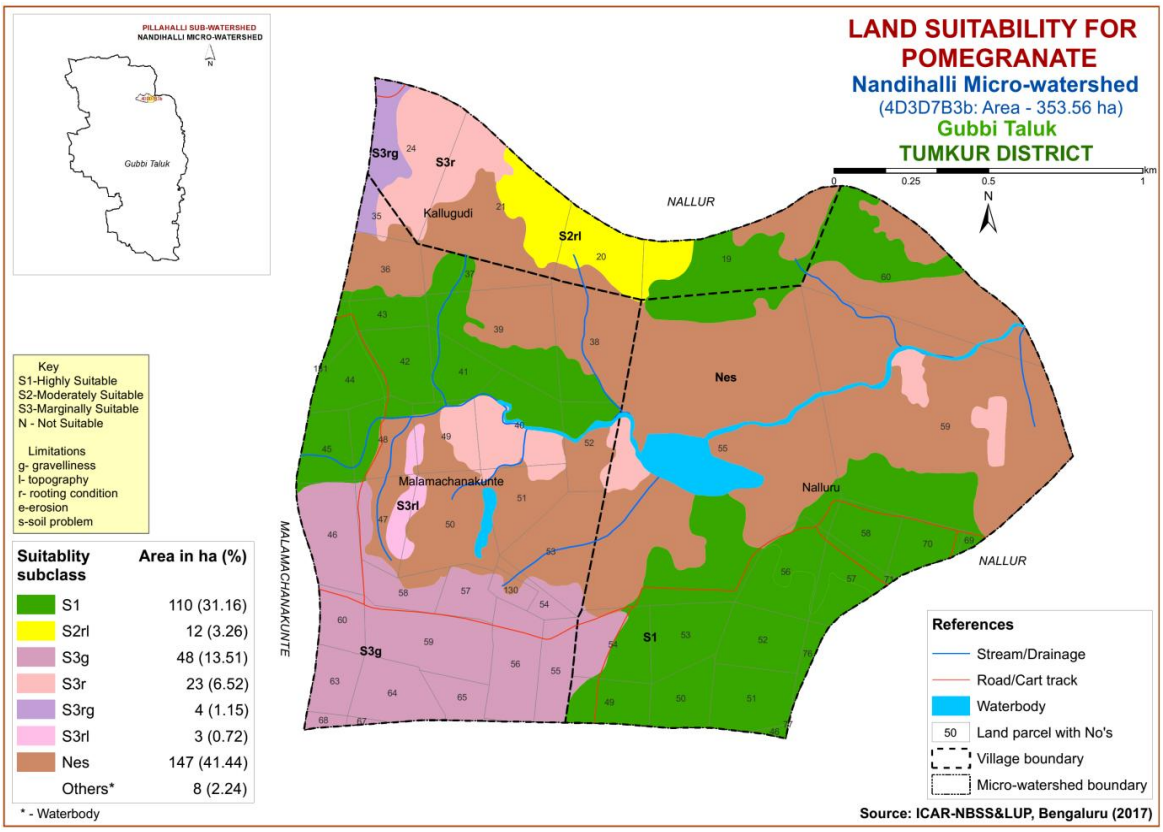


Fig. 7.19 Land Suitability map of Pomegranate

7.20 Land Suitability for Banana (*Musa paradisiaca*)

Banana is one of the major fruit crop grown in an area of 1.02 lakh ha in Karnataka State. The crop requirements for growing banana (Table 7.20) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing banana was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.20.

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) for growing banana and are distributed in the southeastern, northern and western part of the microwatershed. A very small area of about 12 ha (3%) is moderately suitable (Class S2) and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and topography. Marginally suitable lands (Class S3) for growing banana occupy an area of about 78 ha (22%) and occur in the southwestern, central and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed and have severe limitations of erosion and soil.

Table 7.20 Crop suitability criteria for Banana

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

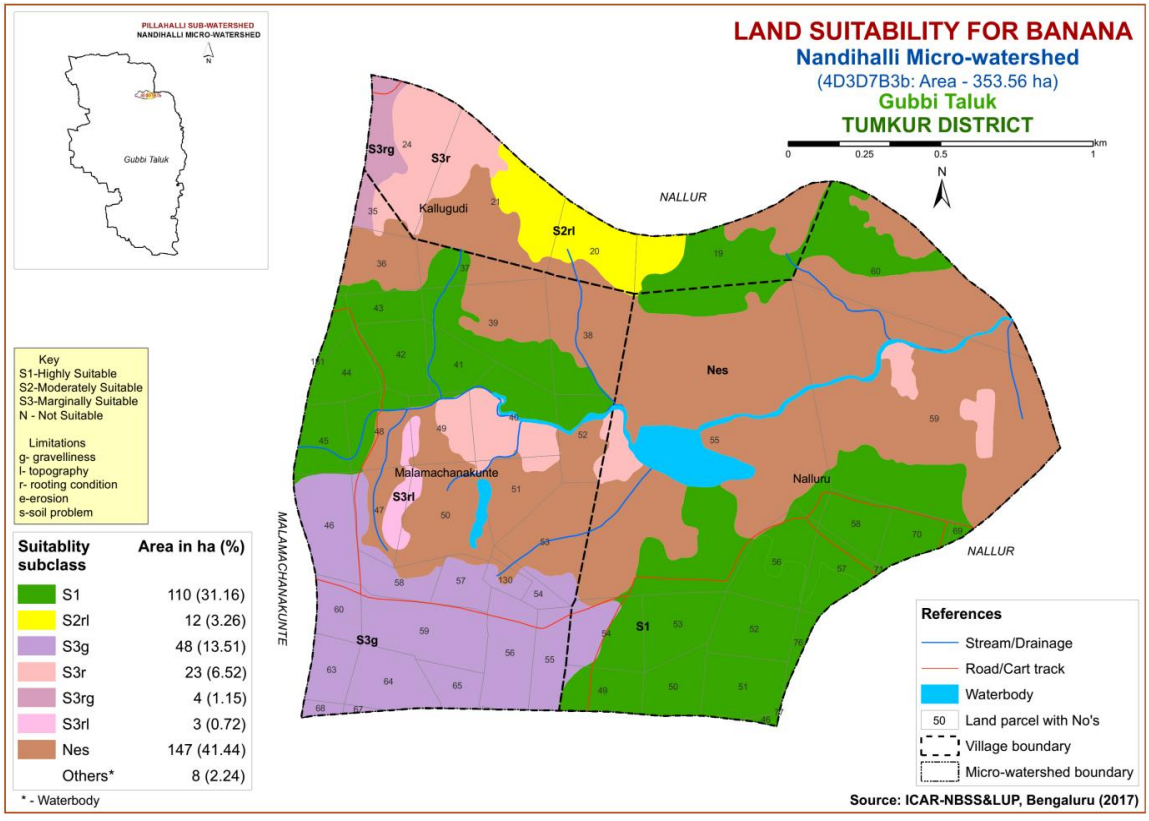


Fig. 7.20 Land Suitability map of Banana

7.21 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 5368 ha in all the districts of the state. The crop requirements for growing jackfruit were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing jackfruit (Table 7.21) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.21.

Highly suitable (Class S1) occupy an area of about 110 ha (31%) for growing Jackfruit and are distributed in the southeastern, northern and western part of the microwatershed. An area of about 12 ha (3%) is moderately suitable (Class S2) for growing Jackfruit and are distributed in the northern part of the microwatershed. They have minor limitations of rooting depth and topography. Marginally suitable (Class S3) lands for growing musambi occupy an area of about 78 ha (22%) and are distributed in the southern, southwestern, central and northwestern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.21 Land 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	-

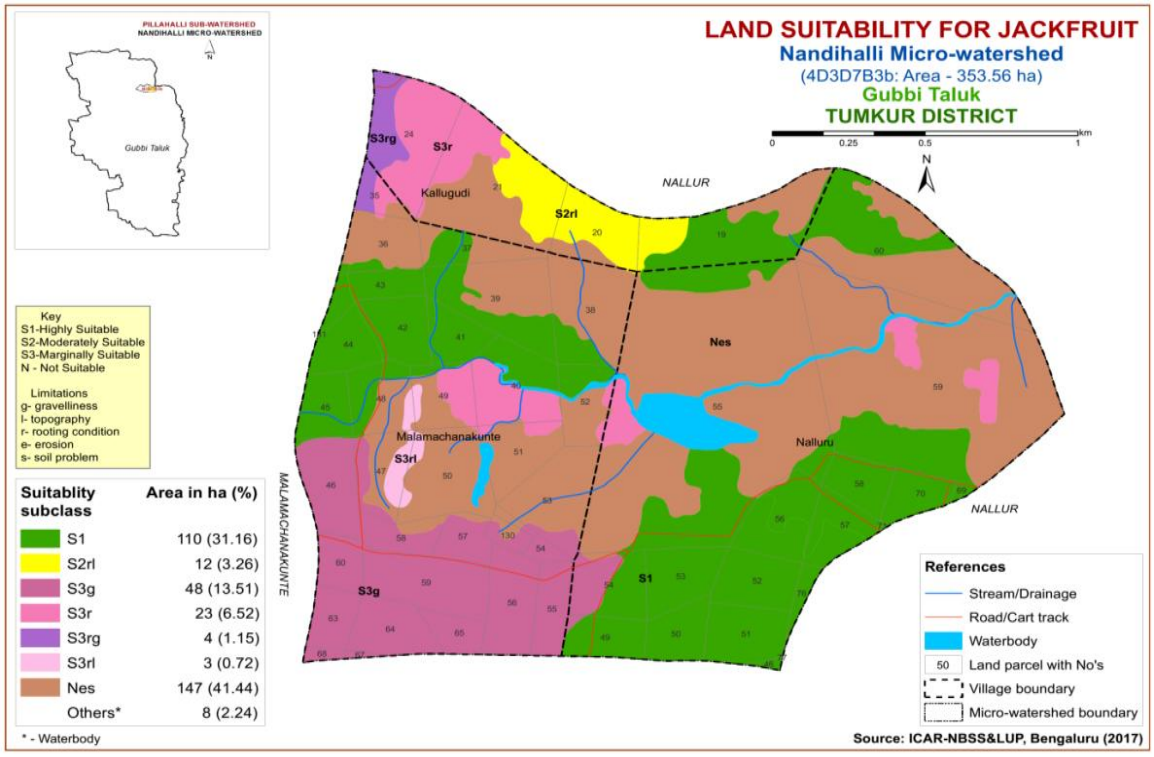


Fig. 7.21 Land Suitability map of Jackfruit

7.22 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 were matched with the soil-site characteristics

(Table 7.1) and a land suitability map for growing jamun (Table .22) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.22.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing jamun and are distributed in the southeastern, northern and western part of the microwatershed. Marginally suitable lands (Class S3) occupy an area of about 89 ha (25%) and occur in the southwestern, central, northern and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table .22 Land 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

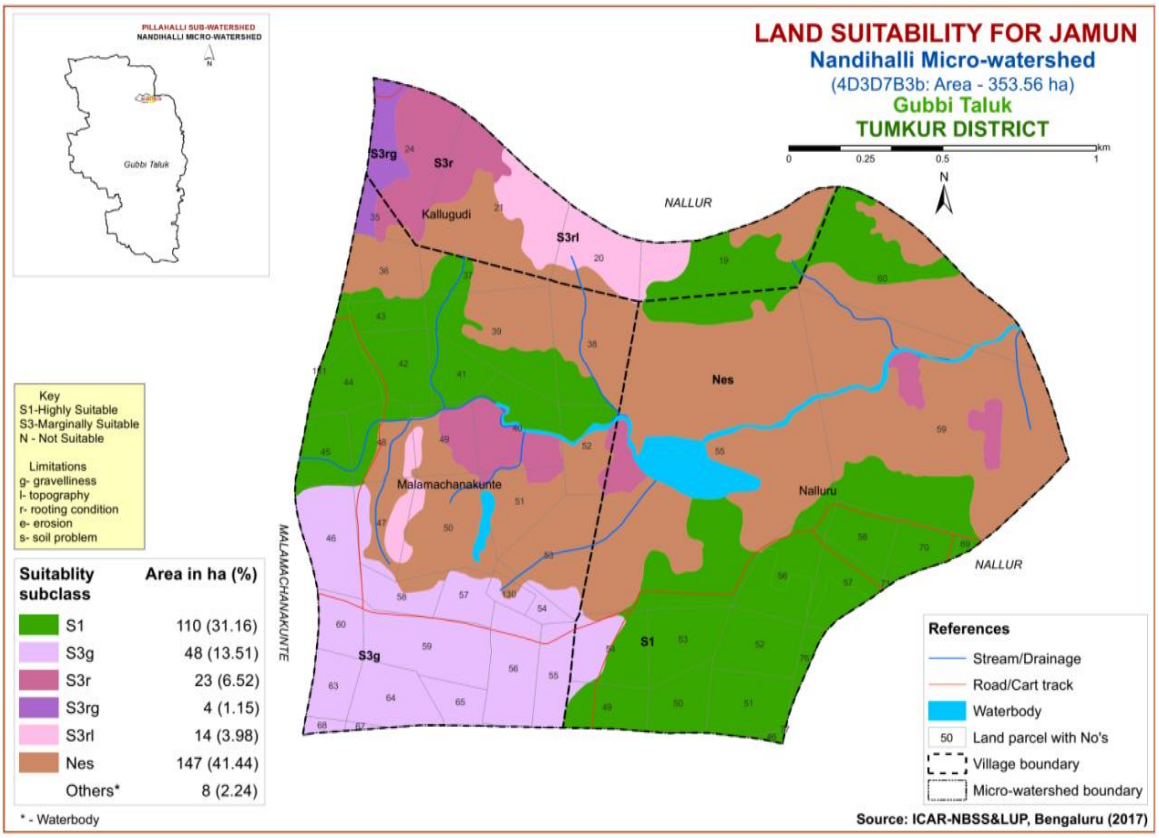


Fig. 7.22 Land Suitability map of Jamun

7.23 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing musambi (Table 7.23) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.23.

Table 7.23 Crop suitability criteria for Musambi

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. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4:8.1-8.5	<4.0:>8.5
Rooting conditions	Soildepth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Erosion	Slope	%	<3	3-5	5-10	

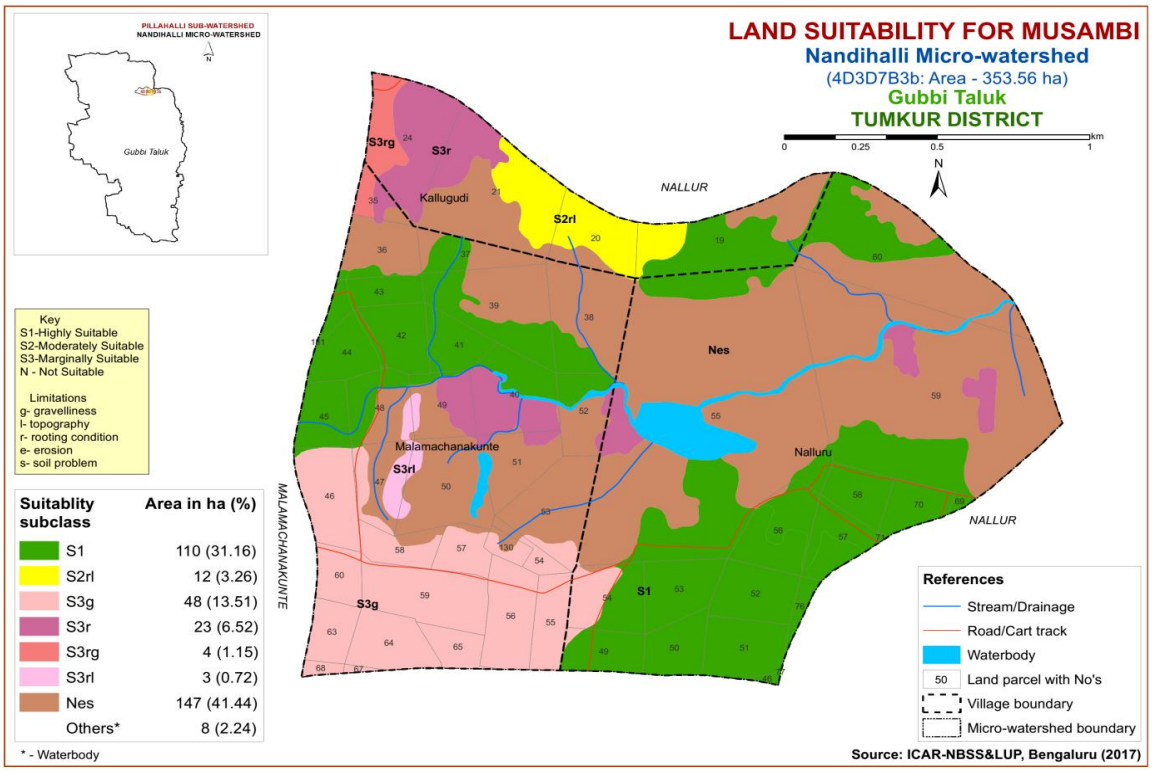


Fig. 7.23 Land Suitability map of Musambi.

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) is for growing musambi and are distributed in the southeastern, northern and western part of the microwatershed. An area of about 12 ha (3%) is moderately suitable (Class S2) and are distributed in the northern part of the microwatershed. They have minor limitations of

rooting depth and topography. Marginally suitable (Class S3) lands for growing Jackfruit occupy an area of about 78 ha (22%) and are distributed in the southern, southwestern, central and northwestern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

7.24 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 11752 ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.24) 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7. 24.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing lime and are distributed in the southeastern, northern and western part of the microwatershed. A very small area of about 12 ha (3%) is moderately suitable (Class S2) and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and topography. Marginally suitable lands (Class S3) occupy an area of about 78 ha (22%) and occur in the southwestern, central and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.24 Crop suitability criteria for Lime

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Climate	Temperature in growing season	^{0}C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. To imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl,s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4:8.1-8.5	<4.0:>8.5
	$CaCO_3$ in root zone	%	Non 34calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

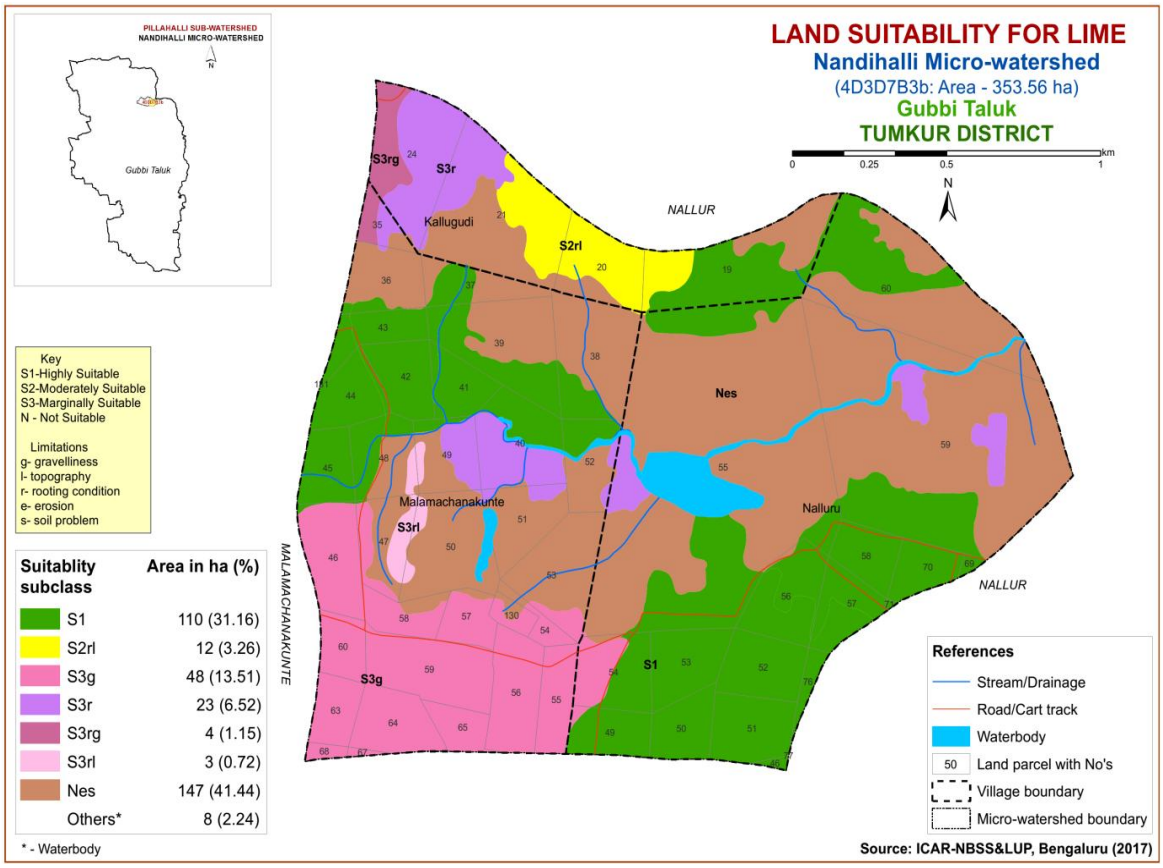


Fig. 7.24 Land Suitability map of Lime

7.25 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important fruit and nut crop grown in an area of 7052 ha in almost all the districts of the State. The crop requirements for growing cashew were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cashew (Table 7.25) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.25.

An area of about 90 ha (26%) has soils that are highly suitable (Class S1) for growing cashew and are distributed in the northern, southeastern and western part of the microwatershed. An area of about 32 ha (9%) has soils that are moderately suitable (Class S2) with minor limitations of gravelliness, rooting depth and topography. They are distributed in the northern and eastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 78 ha (22%) and occur in the southwestern and northern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern, central and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.25 Land suitability criteria for Cashew

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 drainage
Nutrient availability	Texture	Class				
	pH	1:2.5	5.5-6.5	5.0-5.5:6.5-7.3	7.3-7.8	>7.8
Rooting conditions	Soil depth	Cm	>100	75-100	50-75	<50
	Gravelcontent	% vol.	<15	15-35	35-60	>60
Erosion	Slope	%	0-3	3-10	>10	

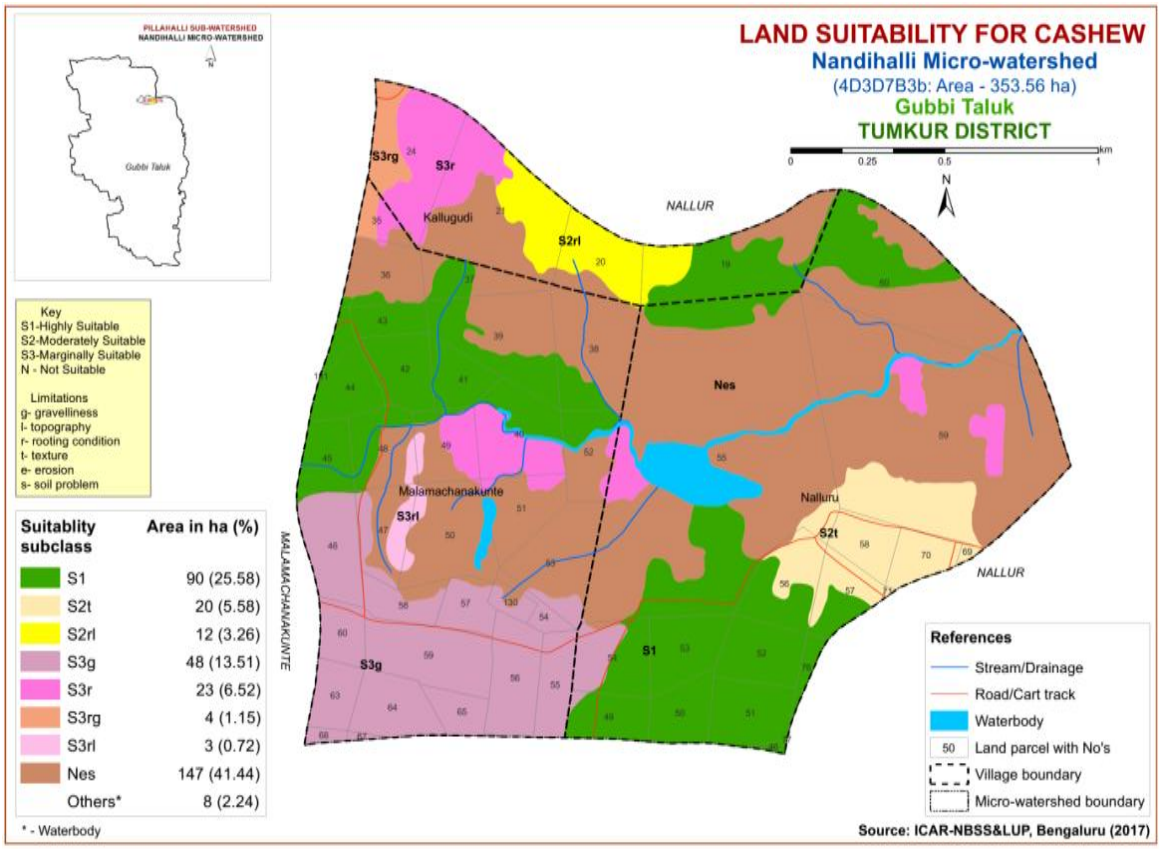


Fig. 7.25 Land Suitability map of Cashew

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

Custard apple is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing custard apple were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple (Table 26) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.26.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing custard apple and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 89 ha (25%) and occur in the southwestern, central, northern and northwestern part of the

microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.26 Land 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
	Gravel content	% vol.	<15-35	35-60	60-80	-
Erosion	Slope	%	0-3	3-5	>5	

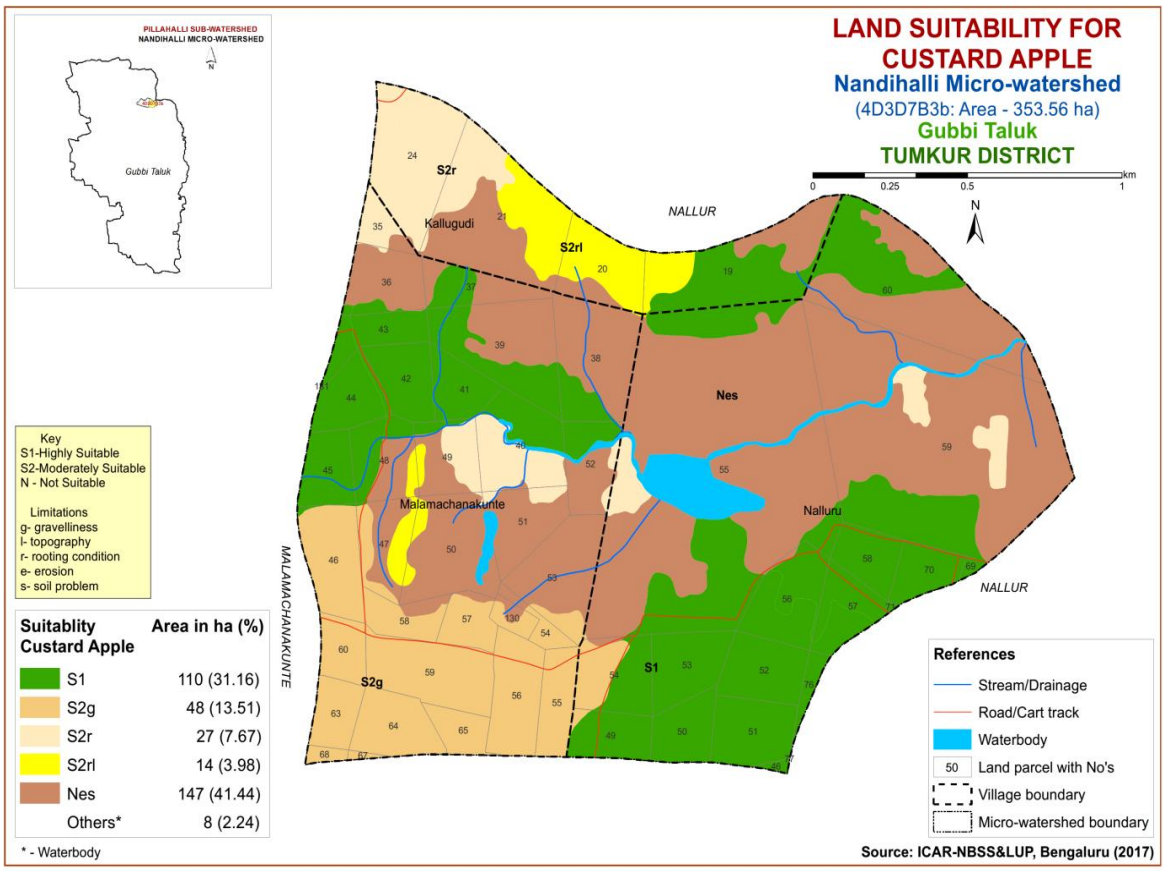


Fig. 7.26 Land Suitability map of Custard Apple

7.27 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 (Table 7.27) for growing amla 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.27.

Table 7. 27 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

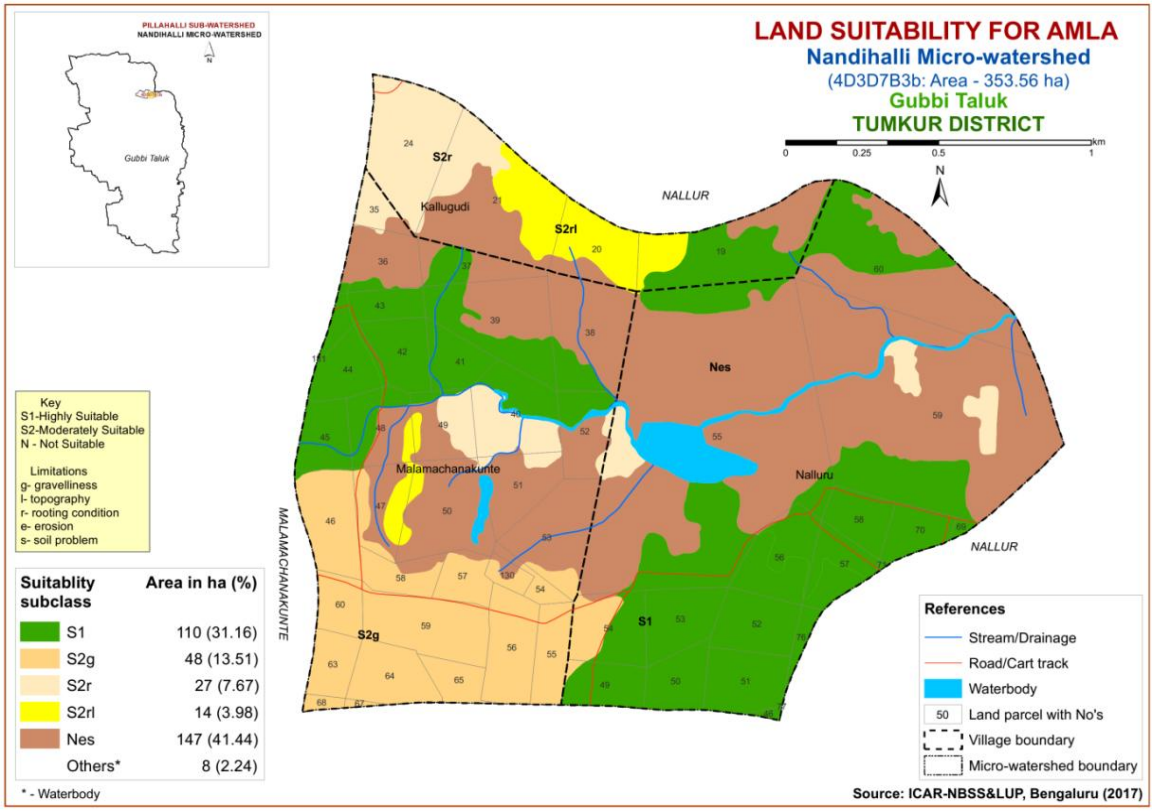


Fig. 7.27 Land Suitability map of Amla

An area of about 110 ha (31%) is highly suitable (Class S1) for growing Alma and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable lands (Class S2) occupy an area of about 89 ha (25%) and occur in

the southwestern, central, northern and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil

7.28 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in 14897 ha in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing tamarind (Table 7.28) was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.28.

Table 7.28 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	<50
	Gravel content	% vol.	<15	15-35	35-60	60-80
Erosion	Slope	%	0-3	3-5	5-10	>10

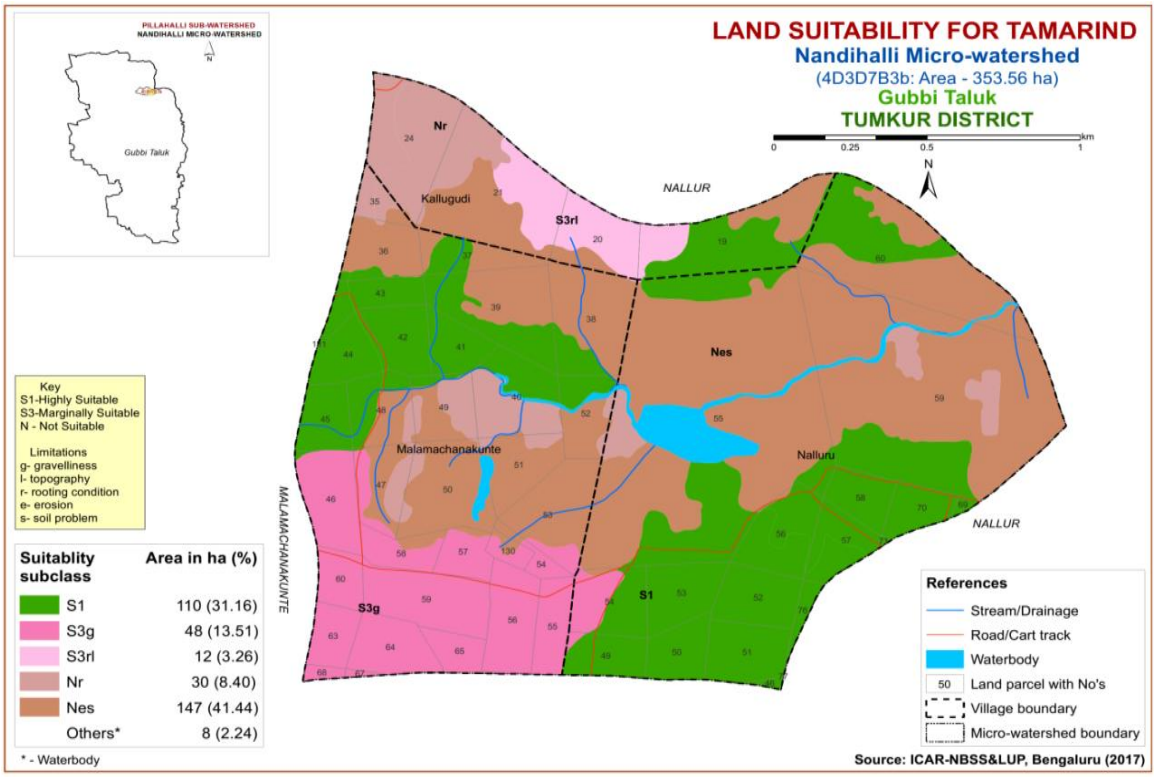


Fig. 7.28 Land Suitability map of Tamarind

An area of about 110 ha (31%) in the microwatershed is highly suitable (Class S1) for growing tamarind and are distributed in the southeastern, northern and western part of the microwatershed. The marginally suitable (Class S3) lands occupy an area of about 60 ha (17%) and are distributed in the southwestern and northern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (50%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of rooting depth, erosion and soil.

7.29 Land suitability for Marigold (*Tagetes sps*.)

Marigold is the most important flower crop grown in an area of 9108 ha in almost all the districts of the state. The crop requirements (Table 7.29) for growing marigold were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing marigold was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.29.

An area of about 110 ha (31%) is highly suitable (Class S1) for growing marigold and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 89 ha (25%) and occur in the southwestern, central, northern and northwestern part of the microwatershed with minor limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.29 Land suitability criteria for Marigold

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

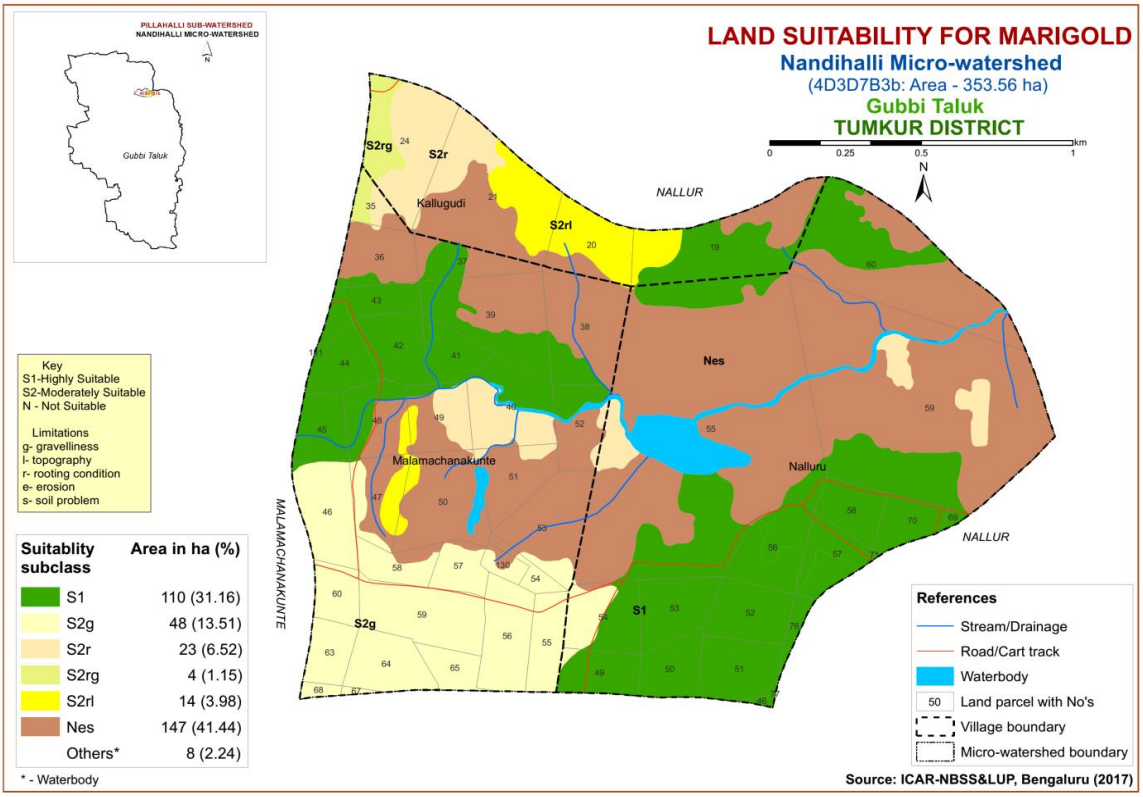


Fig. 7.29 Land Suitability map of Marigold

7.30 Land Suitability for Chrysanthemum (*Dendranthema grandiflora*)

Chrysanthemum is the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements (Table 7.30) for growing chrysanthemum were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing chrysanthemum was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.30.

Table 7.30 Land suitability criteria for Chrysanthemum

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

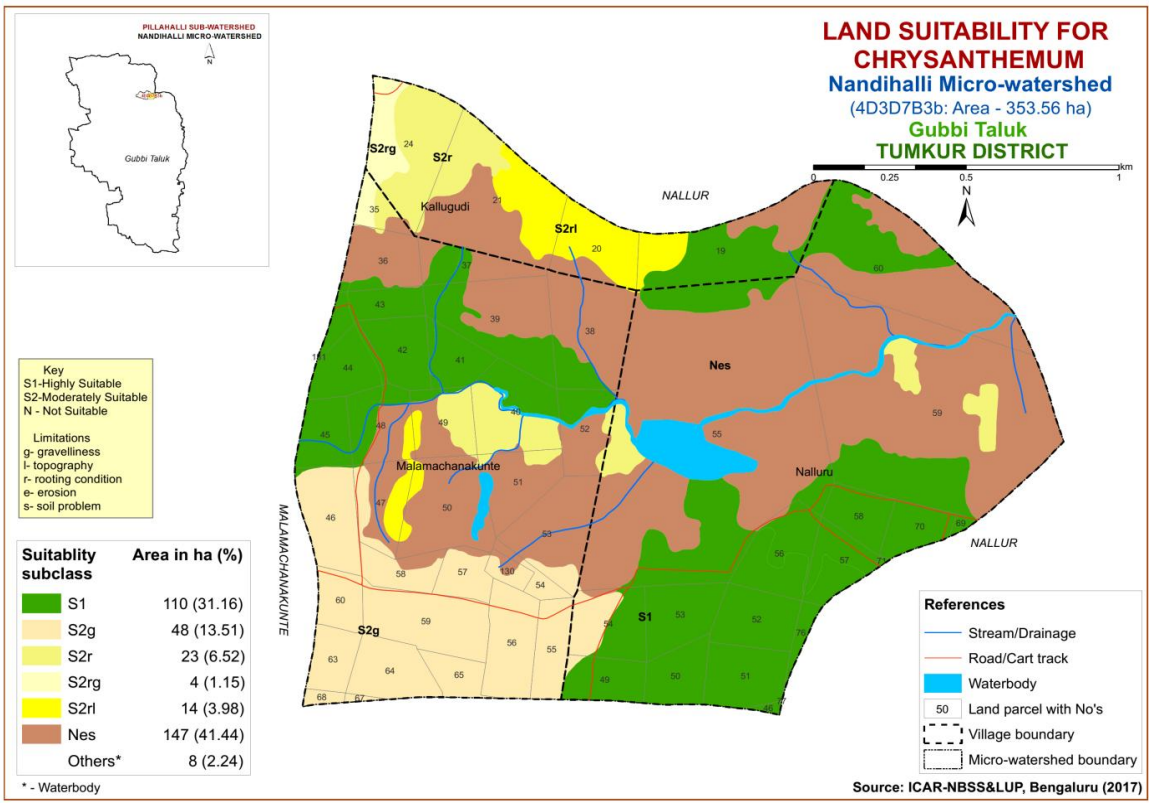


Fig. 7.30 Land Suitability map of Chrysanthemum

An area of about 110 ha (31%) is highly suitable (Class S1) for growing chrysanthemum and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 89 ha

(25%) and occur in the southwestern, central, northern and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

7. 31 Land Suitability for Jasmine *(Jasminum sp.)*

Jasmine is the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements (Table 7.31) for growing Jasmine were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Jasmine was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.31.

Highly suitable (Class S1) lands occupy an area of about 110 ha (31%) for growing jasmine and are distributed in the southeastern, northern and western part the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 89 ha (25%) and occur in the southwestern, central, northern and northwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed. They have severe limitations of erosion and soil.

Table 7.31 Land suitability criteria for jasmine (irrigated)

Crop requirement			**Rating**			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable(N)**
Climate	Temperature in growing season		18-23	17-15 24-35	35-40 10-14	
Soil aeration	Soil drainage	Class	Well drained	Moderately drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	Scl, l, scl, cl, sil	sicl, sc, sic, c (m/k)	C(ss),	ls, s
	pH	1:2.5	6.0-7.5	5.5-5.9 7.6-8.5	<5 >8.5	
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strong calcareous	
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	ds/m	Non saline	Slight	Strongly	
	Sodicity	%	Non sodic	Slight	Strongly	
Erosion	Slope	%	1-3	3-5	5-10	

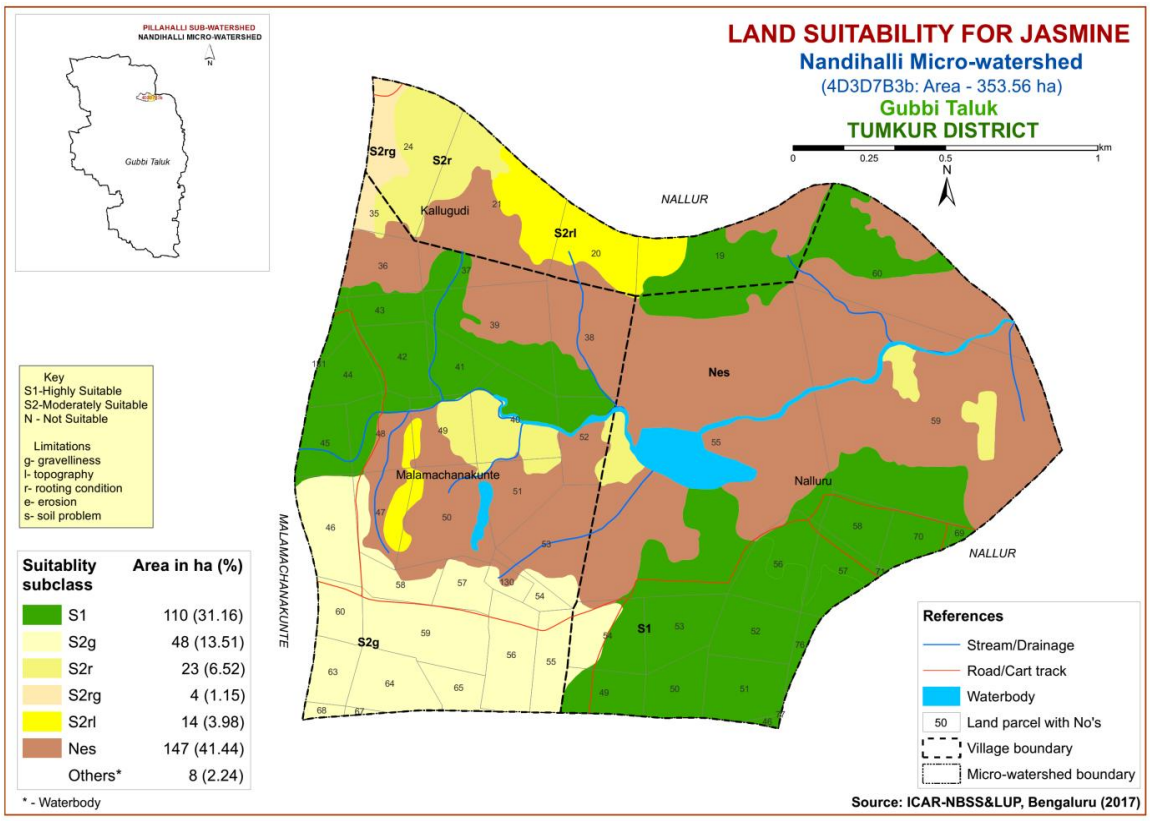


Fig. 7.31 Land Suitability map of Jasmine

7.32 Land Suitability for Coconut (*Cocos nucifera*)

Coconut is the most important nut crop grown in almost all the districts of the State. The crop requirements (Table 7.32) for growing Coconut were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Coconut was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.32.

An area of about 90 ha (26%) in the microwatershed is highly suitable (Class S1) for growing coconut and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 32 ha (9%) and are distributed in the northern part and have minor limitations of texture, rooting depth and topography. The marginally suitable (Class S3) lands cover an area of about 78 ha (22%) and are distributed in the northwestern, central and southwestern part of the microwatershed with moderate limitations of gravelliness, rooting depth and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

Table 7. 32 Land suitability criteria for Coconut

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	0-3	3-5	5-10	>10
Soil drainage	class	Well drained	Mod. drained	Poorly	Very poorly
Soil reaction	pH	5.1-6.5	6.6-7.5	7.6-8.5	-
Surface soil texture	Class	Sc, cl, scl	C (red), sl	C (black), ls	-
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60

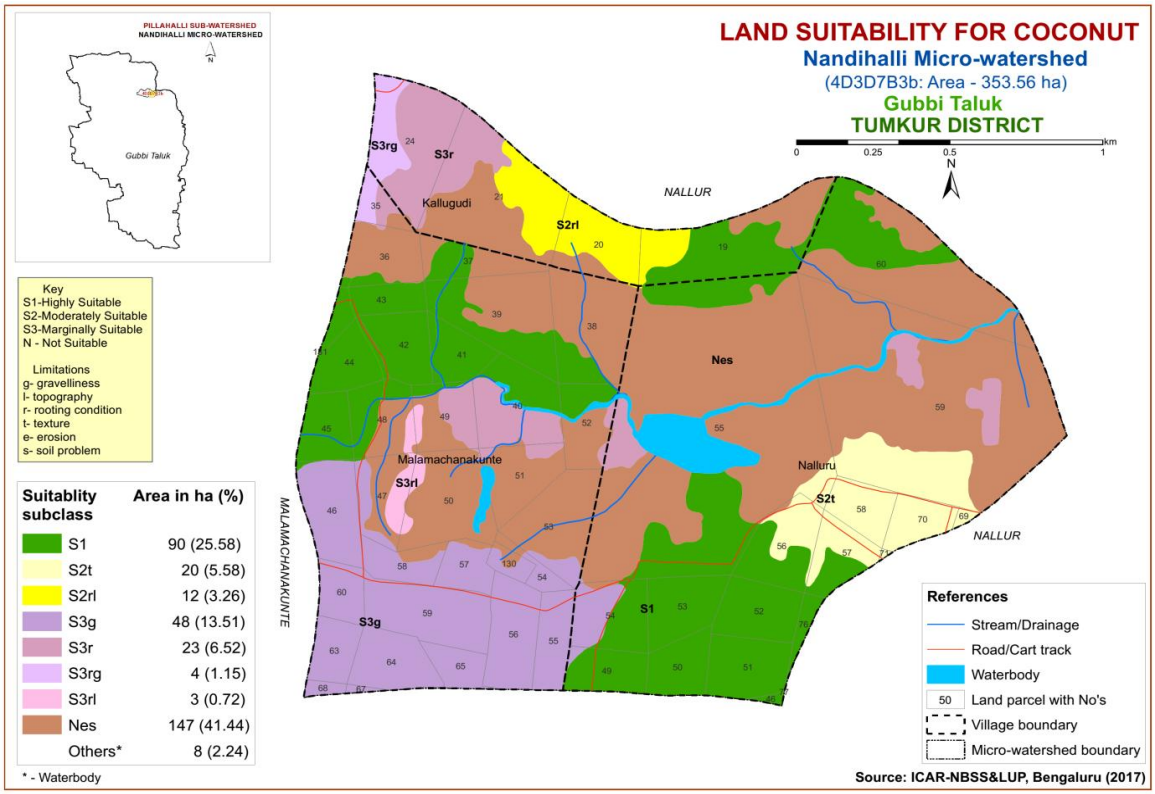


Fig. 7.32 Land Suitability map of Coconut

7.33 Land Suitability for Areca nut (*Areca catechu*)

Areca nut is the most important plantation crop commonly called as *betel nut* that is used for mastication with betel leaf grown in almost all the districts of the State. The crop requirements (Table 7.33) for growing Areca nut were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Areca nut was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.33.

An area of about 90 ha (26%) in the microwatershed is highly suitable (Class S1) for growing areca nut and are distributed in the southeastern, northern and western part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 32 ha (9%) and are distributed in the northern part and have minor limitations of rooting depth, texture and topography. The marginally suitable (Class S3) lands cover an area of about

78 ha (22%) and are distributed in the northwestern, central and southwestern part of the microwatershed with moderate limitations of rooting depth, gravelliness and topography. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

Table 7.33 Land suitability criteria for Areca nut

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Slope	%	0-3	3-5	5-10	>10
Soil drainage	class	Well drained	Mod. to poorly drained	-	Very poorly
Soil reaction	pH	5.0-6.5	6.6-7.5	7.6-8.5	
Surface soil texture	Class	Sc, cl, scl	C (red), sl	C (black), ls	-
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60

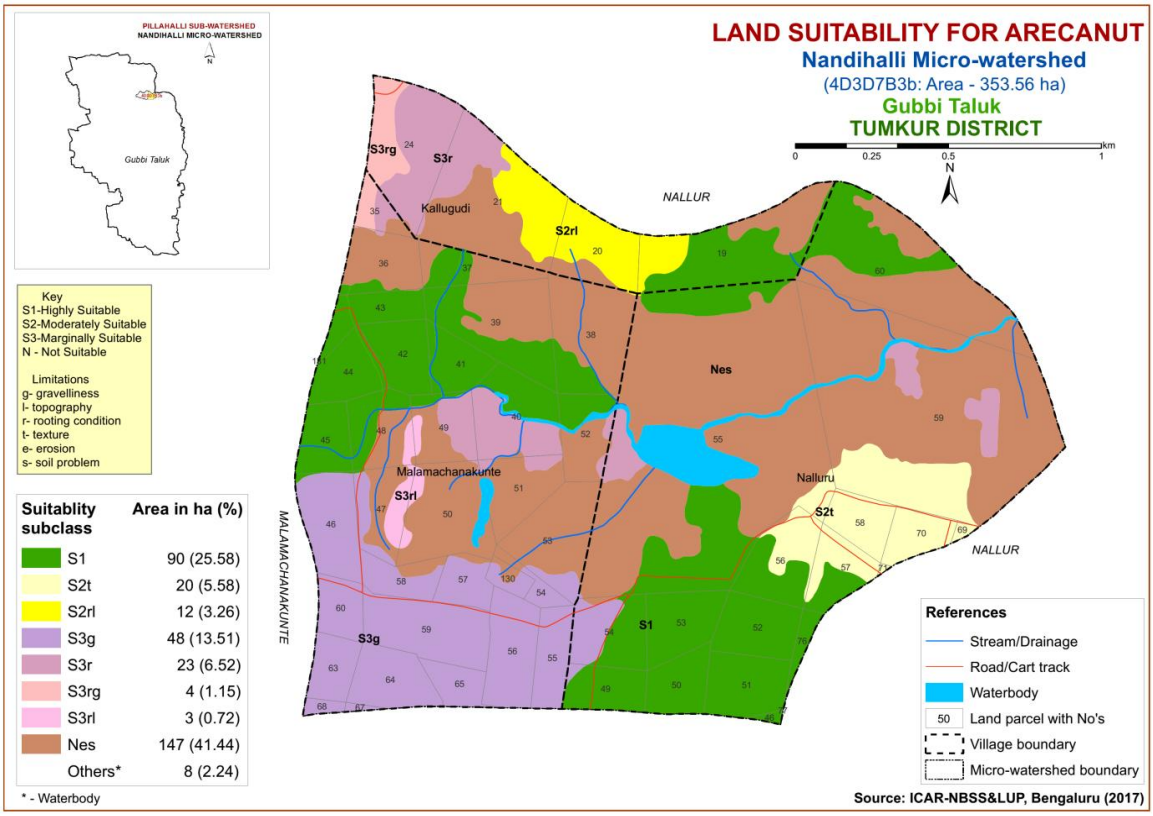


Fig. 7.33 Land Suitability map of Areca nut

7.34 Land Suitability for Mulbery (*Morus nigra*)

Mulbery is the most important crop grown in about 1.66 lakh ha in all the districts of the state for feeding silkworm. The crop requirements for growing mulbery (Table 7.34) were matched with the soil-site characteristics (Table 7.1) and a land suitability map

for growing mulbery was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.11.

Highly suitable (Class S1) lands occupy an area of about 17 ha (5%) for growing mulbery and occur in the northern part of the microwatershed. Moderately suitable (Class S2) lands occupy maximum area of about 107 ha (30%) and occur in the southwestern and southeastern part of the microwatershed. They have minor limitations of gravelliness and texture. Marginally suitable lands cover an area of about 76 ha (21%) and occur in the northwestern and western part of the microwatershed and have moderate limitations of rooting depth and texture. Major area of about 147 ha (41%) is not suitable (Class N) and is distributed in the central, northwestern, northeastern and eastern part of the microwatershed with severe limitations of erosion and soil.

Table 34 Land suitability criteria for Mulberry

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	Moderately well drained	Poorly drained	V. Poorly drained
Nutrient availability	Texture	Class	Sc, cl, scl	C (red)	C (black), sl, ls	-
	pH	1:2.5				
Rooting conditions	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	0-35	35-60	60-80	>80
Erosion	Slope	%	0-3	3-5	5-10	>10

Note: Suitability evaluation only for Mulberry leaf not for Silk worm rearing

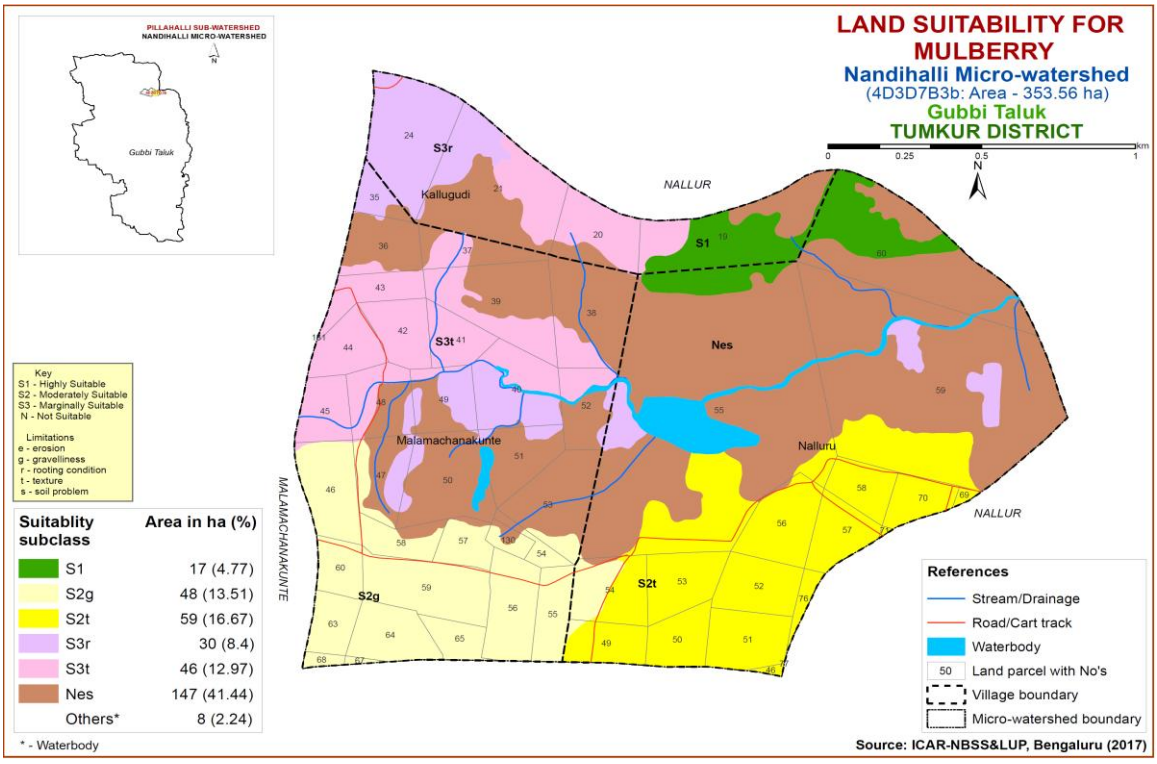


Fig. 7.34 Land Suitability map of Mulbery

7.35 Land Use Classes (LUCs)

The 13 soil map units identified in Nandihalli microwatershed have been regrouped into 6 Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan. Land Use Classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Use Classes map (Fig.7.35) 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 6 Land Use Classes along with brief description of soil and site characteristics are given below.

LUC NO.	Soil map units	Soil and site characteristics
1	HLKhB1 RTRhB2	Very deep (>150 cm), red clayey soils with slopes of 1-3 % and slight to moderate erosion
2	KDTiA1 KDTiB1g1 KDTiB2	Very deep (>150cm), black clayey soils with slopes of 0-3%, gravelly (15-35%) and slight to moderate erosion
3	NDLcB1	Very deep (>150 cm), gravelly red clayey soils with slopes of 1-3% and slight erosion
4	KKRhC2 JDGhB1	Moderately shallow (50-75 cm), sandy clay to sandy clay loam soils with slopes of 0-5% and slight to moderate erosion
5	TDHhB2g1 KGHcB2g2 KGHhB2 KGHhC3	Moderately shallow (50-75 cm), sandy clay to sandy clay loam soils with slope of 1-5%, gravelly to very gravelly (15-60%) and slight to severe erosion
6	Gullied land	Cut up gullied land

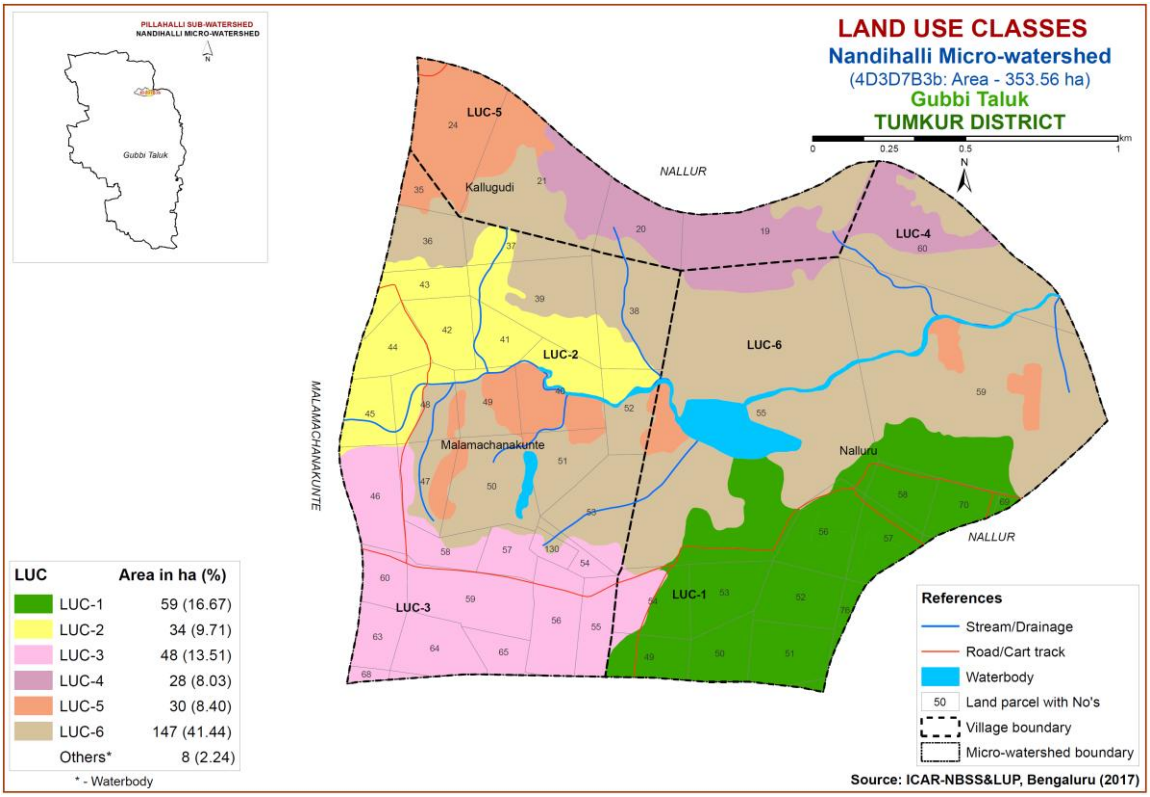


Fig. 7.35 Land Use Classes Map- Nandihalli Microwatershed

7.36 Proposed Crop Plan for Nandihalli Microwatershed

After assessing the land suitability for the 34 crops, a proposed crop plan has been prepared for the 6 identified LUCs by considering only the highly (Class S1) and moderately (Class S2) suitable lands for each of the 34 crops. The resultant proposed crop plan is presented below in Table 7.34.

Table 7.35 Proposed Crop Plan for Nandihalli Microwatershed

LUC No	Mapping Units	Survey Number	Field Crops	Soil and site characteristics	Forestry/ Grasses	Horticulture Crops with suitable interventions	Suitable Interventions
LUC1 (59 ha.)	7,8	**Nalluru:** 46,49,50,51,52,53,54,56,57,58,69,70,71,76,77	**Sole Crops:** Ragi, Upland paddy, Maize, Sorghum,Fodder sorghum,Sunflower, Groundnut, Redgram, Fieldbean, Cowpea **Intercropping:** Redgram+Fodder sorghum,Ragi+Cowpea, Ragi+Redgram Ragi+Fieldbean	Very deep (>150 cm), red clayey soils with slopes of 1-3 % and slight to moderate erosion	Neem, Silver Oak **Grasses** *Styloxanthes hamata, Styloxanthes Scabra,* Hybrid Napier, Sesbania,	**Vegetables**: Onion, Tomato, Brinjal Chillies, Coriander, Drumstick **Flower crops:** Jasmine, Chrysanthemum, China aster, Marigold, Crossandra **Fruit crops/ Plantation crops:** Mango, Sapota, Guava, Cashew, Jackfruit, Pomegranate, Musambi, Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LUC 2 (34 ha.)	10,11,12	**Malamachanakunte:** 41,42,43,44,45,48,131	**Sole crops**: Sorghum, Sunflower, Fodder sorghum, Redgram, Field bean, Horsegram **Intercropping:** Redgram+Fodder sorghum	Very deep (>150cm), black clayey soils with slopes of 0-3%, gravelly (15-35%) and slight to moderate erosion	Hebbevu, Silveroak **Grasses:** *Styloxanthes hamata, Styloxanthes scabra,* Hybrid napier	**Vegetables:** Brinjal, Tomato, chillies, Cucurbits **Flower crops:** Marigold, Chrysanthemum **Fruit crops:** Pomegranate, Tamarind, Custard Apple, Amla, Lime, Musambi, Arecanut, Coconut	Application of FYM and micronutrients, drip irrigation, mulching, use of medium duration varieties, suitable conservation practises
LUC 3 (48 ha.)	9	**Malamachanakunte:** 46,54,55,56,57,58,59,60,63,64,65,67,68,130	**Sole Crops:** Ragi, Upland paddy, Maize, Sorghum, Fodder sorghum, Groundnut, Redgram, Fieldbean, Cowpea **Intercropping:** Redgram+Fodder sorghum,Ragi+Cowpea, Ragi+Redgram Ragi+Fieldbean	Very deep (>150 cm), gravelly red clayey soils with slopes of 1-3% and slight erosion	Neem, Silver Oak **Grasses** *Styloxanthes hamata, Styloxanthes Scabra,* Hybrid Napier, Sesbania,	**Vegetables**: Onion, Tomato, Brinjal Chillies, Coriander, Drumstick **Flower crops:** Chrysanthemum, Jasmine, China aster, Marigold **Fruit crops/ Plantation crops:** Mango, Sapota, Guava, Cashew, Custard apple, Amla, Pomegranate Jackfruit, Musambi, Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)

LUC 4 (28 ha.)	5, 6	**Kallugudi:** 19,20	**Sole crops**: Upland paddy, Ragi, Maize, Sorghum, Groundnut, Sunflower, Fieldbean, Cowpea, Fodder sorghum **Intercropping:** Redgram+Fodder sorghum Ragi+Cowpea Ragi+Redgram	Moderately shallow (50-75 cm), sandy clay to sandy clay loam soils with slopes of 0-5% and slight to moderate erosion	Glyricidia, Subabul, Hebbevu **Grasses:** *Styloxanthes hamata, Styloxanthes scabra*, Hybrid napier	**Vegetables:** Onion, Tomato, chillies, Brinjal, Cucurbits **Flower crops:** Chrysanthemum, Jasmine, Crossandra, China aster **Fruit crops/ Plantation crops:** Musambi, Sapota, Pomegranate, Banana, Amla, Lime, Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LUC 5 (30 ha.)	1, 2, 3, 4	**Kallugudi:** 24 Malamachanakunte: 35,40,49	**Sole crops:** Ragi, Groundnut, Fodder sorghum, Cowpea, Horse gram	Moderately shallow (50-75 cm), sandy clay to sandy clay loam soils with slope of 1-5%, gravellyto very gravelly (15-60%)and moderate to severe erosion	Glyricidia, **Grasses** *Styloxanthes hamata, Styloxanthes scabra*	**Vegetables:** Tomato, Onion, Chillies, Curry leaf **Fruit crops:** Custard apple, Amla, Bael	Use of short duration varieties, application of tank silt, sowing across slope and drip irrigation is recommended
LUC 6 (147 ha.)	13	**Kallugudi:** 21 **Malamachanakunte:** 36,37,38,39,47,50,51,52,53 **Nalluru:** 55,59,60	Gullied area-growing of cover crops like glyricidia, sesbania, subabul, hybrid napier, styloxanthes hamata etc.				Gully plugging with live hedges and earth boulders, levelling, sowing across the slope, contour bunding

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

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

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

The most important characteristics of a healthy soil are

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

Characteristics of Nandihalli Microwatershed

- The soil phases identified in the microwatershed belonged to the soil series of NDL 48 ha (13%), HLK 39 ha (11%), KDT 35 ha (10%), RTR 20 ha (6%), KGH 19 ha (5%), JDG 17 ha (5%), KKR 12 ha (3%) and TDH 11 ha (3 %).
- As per land capability classification, about 56 per cent area in the microwatershed falls under arable land category (Class II & III) and 41 per cent non arable lands (Class VIII). The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, maximum area of about 249 ha (70%) is strongly to moderately and slightly acid (pH 5.0 -6.5). An area of about 97 ha (27%) is under neutral (pH 6.5-7.3).

Soil Health Management

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

Acid soils

1. Growing Crops suitable for particular soil pH.
2. Ameliorating soils through the application of amendments (liming materials).

Liming materials:

1. $CaCO_3$ (Calcium Carbonate). More than 90% use in India.
2. Dolomite [Ca Mg $(Co_3)_2$]
3. Quick lime (Cao)
4. Slaked lime [Ca $(OH)_2$]

For normal pH and pH-4.8 (35 t/ha) and pH -6 .0-7.0 (4 t/ha) lime is required.

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

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

Neutral soils

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

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

Soil Degradation

Soil erosion is one of the major factors affecting the soil health in the microwatershed. Out of total 354 ha area in the microwatershed, an area of about 72 ha is suffering from moderate to severe erosion. An area of 147 ha (41%) is under gullied land. These areas need to be levelled and cover crops to be grown for stabilizing the gullies.

Moderately to severely 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 (Saturation Plan) and Interventions needed

Net planning in IWMP is focusing on preparation of

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

In this connection, how various outputs of Sujala-III are of use in addressing these objectives of Net Planning (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 Nandihalli microwatershed.
- **Organic Carbon:** The OC content is medium (0.5-0.75%) in about 144 ha (41%) area and low (<0.5%) in about 189 ha (53%). 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. An area of about 12 ha (3%) is high in organic carbon.
- **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 144 ha area where OC is medium (0.5-0.75%) and 189 ha is 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 130 ha (36%) area, the available phosphorus is high (>57 kg/ha) and an area of 216 ha (61%) is medium (23-57 kg/ha). Hence for the crops, 25% additional P-needs to be applied in 216 ha area where available phosphorus is medium.
- **Available Potassium:** Available potassium is low (<145 kg/ha) in maximum area of 171 ha (49%) in the microwatershed and an area of about 27 ha (8%) is high (>337 kg/ha) in available potassium. An area of about 147 ha (42 %) is medium in available potassium (145-337 kg/ha). Hence, in all these plots, where available potassium is low and medium, for all the crops, additional 25 % potassium may be applied.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. Medium in an area of about 270 ha (76%). These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected. High in an area of about 76 ha (21%).
- **Available Boron:** Available boron is low in 296 ha (84%) and 50 ha (14%) medium in the microwatershed. These areas need to be applied with sodium borate @ 10 kg/ha as soil application or 0.2% borax as foliar application to correct the boron deficiency.
- **Available Iron:** Entire area is sufficient (>4.5 ppm) in available iron in the microwatershed.
- **Available Manganese and Available Copper:** Entire area in the microwatershed is sufficient for both available manganese and copper.

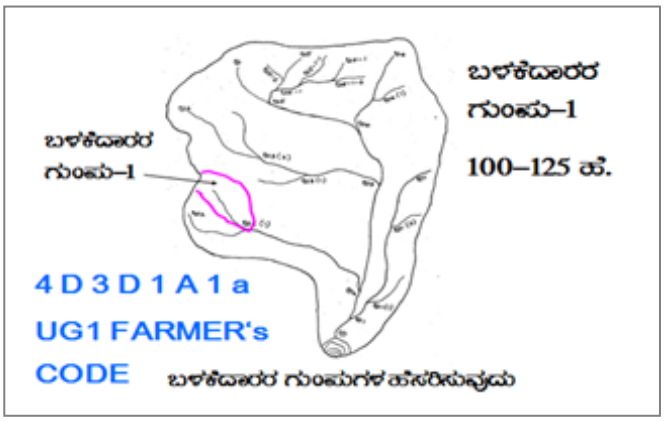
- **Available Zinc:** It is deficient (<0.6 ppm) in 154 ha (43%) area of the microwatershed. Application of zinc sulphate @25 kg/ha is to be recommended and about 192 ha (54%) area is sufficient (>0.6 ppm) in available Zinc.
- **Soil acidity:** The microwatershed has 249 ha (70%) area with soils that are slightly to strongly acid. These areas need application of lime (Calcium Carbonate).
- **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 Nandihalli microwatershed, the land resource inventory database prepared 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) prepared were

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



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

Steps for Survey and Preparation of Treatment Plan

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

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

9.1 Treatment Plan

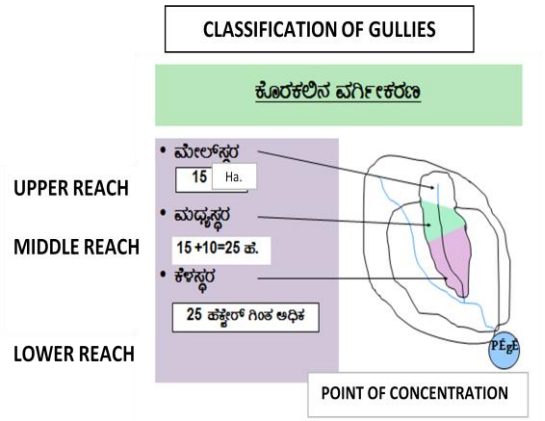
The treatment plan recommended for arable lands is briefly described below.

9.1.1 Arable Land Treatment

A. BUNDING

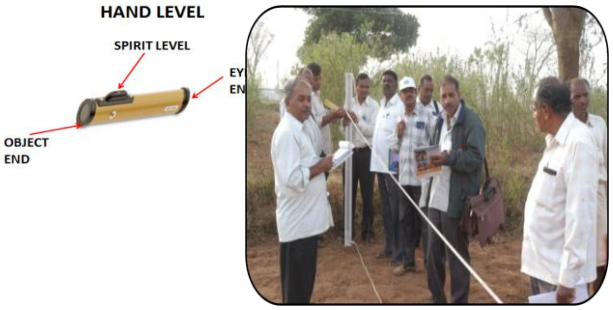
Steps for Survey and Preparation of Treatment Plan	
• Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale • Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale • Drainage lines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

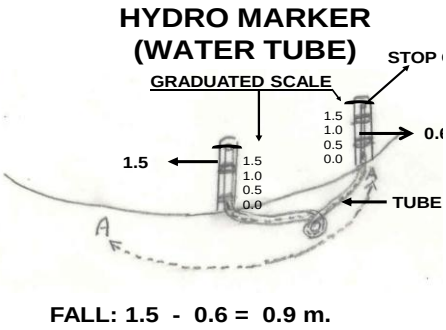
USER GROUP-1



Measurement of Land Slope

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





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

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

Note: i) The above intervals are maximum.

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

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

Section of the Bund

Bund section is decided considering the soil texture class and gravelliness class (bg0...b= loamy sand, g_0= <15% gravel). The recommended sections for different soils are given below.

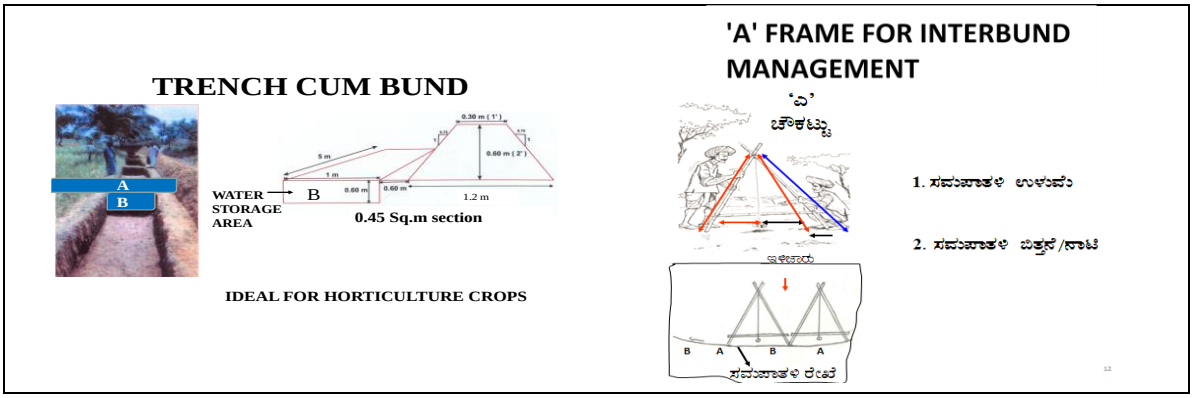
Recommended Bund Section

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 water budgeting and quality of water in the wells and site suitability.
e) Detailed Levelling Survey using Dumpy Level / Total Station has to be carried out to arrive at the site-specific designs as shown in the Manual.
f) The location of ground water recharge structures are decided by examining the lineaments and fracture zones from geological maps.
g) Rainfall intensity data of the nearest Rain Gauge station is considered for Hydrologic Designs.
h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and earthern checks in the natural water course. Location and design details are given in the Manual.

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 165 ha (47%) requires trench cum bunding, about 11 ha (3%) area is Bunding / Strengthening of existing bunds and an area of about 24 ha (7%) requires Graded Bunding. An area of 147 ha under gullied land needs gully plugging and vegetative checks. The conservation plan generated may be presented to all the stakeholders including farmers and after noting their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

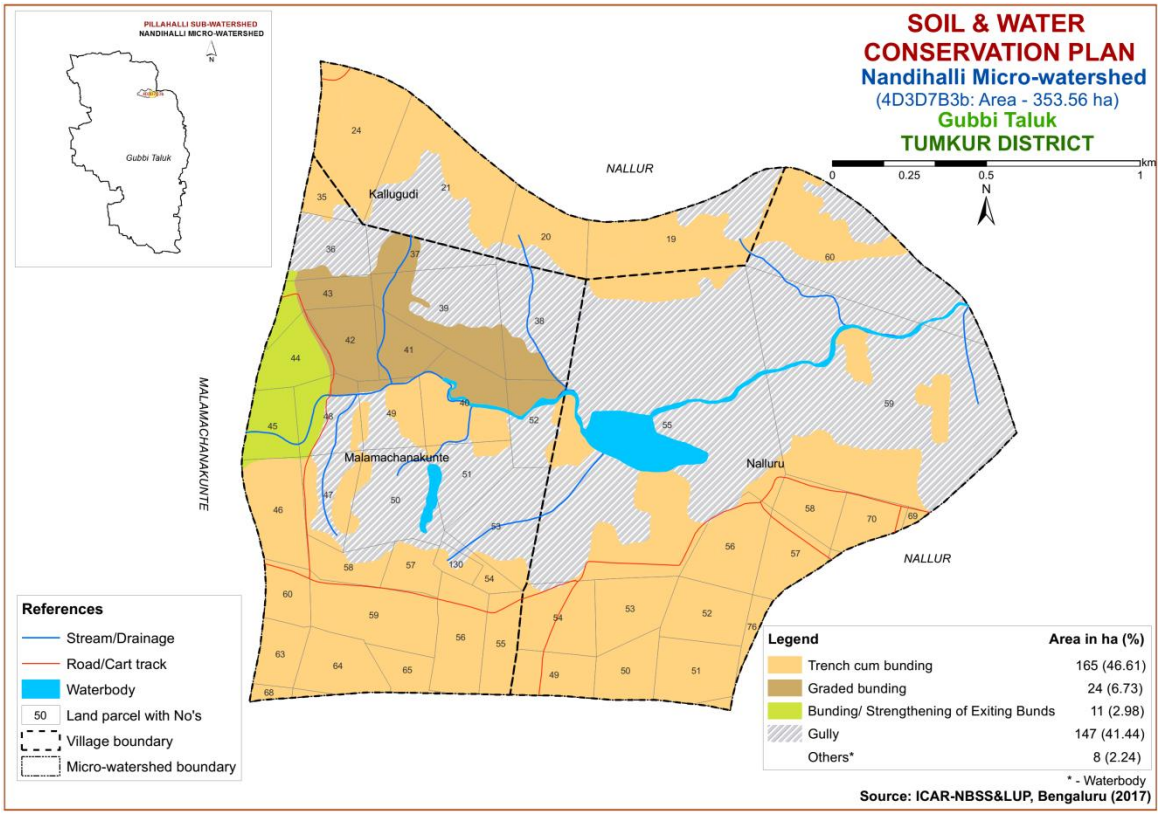


Fig. 9.1 Soil and Water Conservation Plan map of Nallur Microwatershed

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

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; waterlogged areas are recommended to be planted with species like Neral (*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

Nandihalli Micro-watershed

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
Malamachana kunte	35	1.91	KGHcB2g2	LUC-5	Moderately shallow (50-75 cm)	Sandy loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	Not Available	IIIes	Trench cum bundig
Malamachana kunte	36	4.72	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	37	3.73	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	38	8.95	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	39	9.79	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Coconut+Gully area (CN+Ga)	Not Available	VIIes	Gully
Malamachana kunte	40	7.27	KGHhB2	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	3 Borewell	IIIe	Trench cum bundig
Malamachana kunte	41	3.32	KDTiB1g1	LUC-2	Very deep (>150 cm)	Sandy clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	2 Borewell	IIs	Graded bunding
Malamachana kunte	42	4.11	KDTiB2	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	2 Borewell	IIIe	Graded bunding
Malamachana kunte	43	3.47	KDTiB2	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	3 Borewell	IIIe	Graded bunding
Malamachana kunte	44	3.94	KDTiA1	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Coconut (CN)	Not Available	IIs	Bunding/ Strengthening of Exiting Bunds
Malamachana kunte	45	3.61	KDTiA1	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Coconut (CN)	1 Borewell	IIs	Bunding/ Strengthening of Exiting Bunds
Malamachana kunte	46	5.89	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango+Ragi (Mn+Ra)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	47	4.77	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	48	5.03	KDTiA1	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Coconut+Gully area (CN+Ga)	2 Borewell	IIs	Bunding/ Strengthening of Exiting Bunds
Malamachana kunte	49	4.54	KGHhB2	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Mango (Mn)	1 Borewell	IIIe	Trench cum bundig
Malamachana kunte	50	8.31	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	51	4.98	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	1 Borewell	VIIes	Gully
Malamachana kunte	52	4.55	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Coconut (CN)	1 Borewell	VIIes	Gully
Malamachana kunte	53	7.28	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Gully arae (Ga)	Not Available	VIIes	Gully
Malamachana kunte	54	1.23	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	1 Borewell	IIIs	Trench cum bundig
Malamachana kunte	55	3.57	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	2 Borewell	IIIs	Trench cum bundig

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
Malamachana kunte	56	5.73	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	57	2.72	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	58	3.04	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango+Ragi (Mn+Ra)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	59	7.61	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Ragi (Ra)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	60	2.81	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Ragi (Ra)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	63	2.96	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	64	4.74	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	65	2.28	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	67	0.23	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	68	0.59	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	130	1.19	NDLcB1	LUC-3	Very deep (>150 cm)	Sandy loam	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIIs	Trench cum bundig
Malamachana kunte	131	0.01	KDTiA1	LUC-2	Very deep (>150 cm)	Sandy clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	Bunding/ Strengthening of Exiting Bunds
Nalluru	46	0.27	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Trench cum bundig
Nalluru	49	3.73	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mango+Fallow land (Mn+Fl)	Not Available	IIs	Trench cum bundig
Nalluru	50	3.7	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mango (Mn)	Not Available	IIs	Trench cum bundig
Nalluru	51	5.09	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	1 Borewell	IIs	Trench cum bundig
Nalluru	52	4.9	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	2 Borewell	IIs	Trench cum bundig
Nalluru	53	4.87	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	2 Borewell	IIs	Trench cum bundig
Nalluru	54	5.58	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mango+Ragi (Mn+Ra)	2 Borewell	IIs	Trench cum bundig
Nalluru	55	62.3	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Coconut+Arecanut+Gullyarea(CN+Ar+Ga)	8Borewell, 2CheckDam	VIIes	Gully
Nalluru	56	5.93	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut+Arecanut (CN+Ar)	1 Borewell	IIs	Trench cum bundig
Nalluru	57	4.03	RTRhB2	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	2 Borewell	IIIe	Trench cum bundig
Nalluru	58	3.36	RTRhB2	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut+Arecanut (CN+Ar)	1 Borewell	IIIe	Trench cum bundig

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
Nalluru	59	44.29	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Coconut+Mango+ Gully area (CN+Mn+Ga)	5 Borewell	VIIes	Gully
Nalluru	60	18.92	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Ragi+Gully area (Ra+Ga)	Not Available	VIIes	Gully
Nalluru	69	0.31	RTRhB2	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIe	Trench cum bundig
Nalluru	70	2.98	RTRhB2	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Arecanut+Mango (Ar+Mn)	2 Borewell	IIIe	Trench cum bundig
Nalluru	71	0.09	RTRhB2	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIe	Trench cum bundig
Nalluru	76	1.01	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut (CN)	Not Available	IIs	Trench cum bundig
Nalluru	77	0	HLKhB1	LUC-1	Very deep (>150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Trench cum bundig
Kallugudi	19	12.36	JDGhB1	LUC-4	Deep (100-150 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Coconut+Mango+ Gully area (CN+Mn+Ga)	Not Available	IIs	Trench cum bundig
Kallugudi	20	5.8	KKRhC2	LUC-4	Moderately deep (75-100 cm)	Sandy clay loam	Non gravelly (<15%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Coconut+Gully area (CN+Ga)	Not Available	IIIe	Trench cum bundig
Kallugudi	21	15.11	Gully	LUC-6	Gullied region	Gullied region	Gullied region	Gully	Gullied region	Gullied region	Coconut+Gully area (CN+Ga)	Not Available	VIIes	Gully
Kallugudi	24	10.08	TDHhB2g1	LUC-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Coconut (CN)	Not Available	IIIe	Trench cum bundig

Appendix II

Soil Fertility Information

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Malamachana kunte	35	Slightly acid (pH 6.0 – 6.5)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)
Malamachana kunte	36	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	37	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	38	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	39	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	40	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23 – 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	41	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23 – 57 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)
Malamachana kunte	42	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23 – 57 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)
Malamachana kunte	43	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)
Malamachana kunte	44	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)
Malamachana kunte	45	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Malamachana kunte	46	Moderately acid (pH 5.5 – 6.0)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	47	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	48	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)
Malamachana kunte	49	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23 – 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	50	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	51	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	52	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	53	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully	Gully
Malamachana kunte	54	Moderately acid (pH 5.5 – 6.0)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	55	Moderately acid (pH 5.5 – 6.0)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	56	Moderately acid (pH 5.5 – 6.0)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Malamachana kunte	57	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	58	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	59	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	60	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	63	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	64	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	65	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	67	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	68	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 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)
Malamachana kunte	130	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Malamachana kunte	131	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)
Nalluru	46	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	49	Moderately acid (pH 5.5 – 6.0)	Non saline (<2 dsm)	Low (<0.5 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	50	Slightly acid (pH 6.0 – 6.5)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	51	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	52	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	53	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	54	Slightly acid (pH 6.0 – 6.5)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	55	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region
Nalluru	56	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	57	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	58	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	59	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region
Nalluru	60	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Nalluru	69	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	70	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (> 57 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient(>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Nalluru	71	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	76	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Nalluru	77	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	High (> 57 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)	Sufficient (>0.6 ppm)
Kallugudi	19	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 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)
Kallugudi	20	Strongly acid (pH 5.0 – 5.5)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 kg/ha)	Low (<145 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)
Kallugudi	21	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region	Gullied region
Kallugudi	24	Slightly acid (pH 6.0 – 6.5)	Non saline (<2 dsm)	Low (<0.5 %)	Medium (23 – 57 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)

Appendix III

Soil Suitability Information

Village	Survey No	Mango	Maize	Sapota	Sorgham	Coconut	Guava	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Banana	Horsegram	Field-bean	Arecanut	Finger-Millet	Brinjal	Fodder-Sorghum	Upland-Paddy	Jasmine	Cowpea
Malamachanakunte	35	Nr	S2rg	S3rg	S2rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2r	S3rg	S2r	S3rg	S3rg	S3rg	S2rg	S2rg	S2rg	S2rg	S2rg	S2rg	S3rg	S3rg	S2g	S2rg	S3rg	S2rg	S2rg	S3rg	S2rg	S2rg	S2rg
Malamachanakunte	36	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	37	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	38	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	39	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	40	Nr	S2r	S3r	S2r	S3r	S3r	Nr	S3r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S3r	S2r	S2r	S2r	S2r	S2r	S2r	S3r	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2r	S2r	S2r
Malamachanakunte	41	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	42	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	43	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	44	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	45	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	46	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	47	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	48	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Malamachanakunte	49	Nr	S2r	S3r	S2r	S3r	S3r	Nr	S3r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S3r	S2r	S2r	S2r	S2r	S2r	S2r	S3r	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2r	S2r	S2r
Malamachanakunte	50	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	51	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	52	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	53	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Malamachanakunte	54	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	55	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	56	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g

Village	Survey No	Mango	Maize	Sapota	Sorgham	Coconut	Guava	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Banana	Horsegram	Field-bean	Arecanut	Finger-Millet	Brinjal	Fodder-Sorghum	Upland-Paddy	Jasmine	Cowpea
Malamachanakunte	57	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	58	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	59	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	60	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	63	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	64	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	65	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	67	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	68	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	130	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g	S2g	S3g	S3g	S3g	S2g	S3g	S3g	S3g	S2g	S2g	S3g	S3g	S2g	S3g	S3g	S3g	S3g	S3g	S3g	S2g	S3g
Malamachanakunte	131	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	46	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	49	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	50	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	51	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	52	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	53	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	54	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	55	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Nalluru	56	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Nalluru	57	S1	S2t	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S3t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1
Nalluru	58	S1	S2t	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S3t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1
Nalluru	59	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Nalluru	60	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Nalluru	69	S1	S2t	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S3t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1
Nalluru	70	S1	S2t	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S3t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1
Nalluru	71	S1	S2t	S1	S1	S2t	S2t	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S3t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1
Nalluru	76	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1

Village	Survey No	Mango	Maize	Sapota	Sorgham	Coconut	Guava	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Groundnut	Onion	Chilly	Tomato	Marigold	Chrysanthemum	Pomegranate	Banana	Horsegram	Field-bean	Arecanut	Finger-Millet	Brinjal	Fodder-Sorghum	Upland-Paddy	Jasmine	Cowpea
Nalluru	77	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S2t	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Kallugudi	19	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Kallugudi	20	S3rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S3rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S3rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl	S2rl
Kallugudi	21	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes	Nes
Kallugudi	24	Nr	S2r	S3r	S2r	S3r	S3r	Nr	S3r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S3r	S2rt	S2rt	S2r	S2r	S2r	S2r	S3r	S3r	S3r	S1	S2r	S3r	S2r	S2r	S3r	S2r	S2r	S2r

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

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

Methodology: *Nandihalli micro-watershed (Pillahalli sub-watershed, Gubbi taluk, Tumkur district) is located in between $13^0$28' – $13^0$29' North latitudes and $76^0$53' – $76^0$55' East longitudes, covering an area of about 353.56 ha, bounded by Malamachanakunte and Nallur villages with an 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 the Nandihalli micro-watershed (Pillahalli sub-watershed, Gubbi taluk, Tumkur district) presented here.*

Social Indicators;

- *Male and female ratio is 57.1 to 42.9 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 59.2 per cent to the total population.*
- *Literacy population is around 71.5 per cent.*
- *Social groups belong to other backward caste OBC is around 50.0 per cent.*
- *Liquefied petroleum gas (LPG) is the source of energy for a cooking among 90.0 per cent.*
- *About 80.0 per cent of households have a yashaswini health card.*
- *Majority of farm households (70.0 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 90.0 per cent.*
- *Swach bharath program providing closed toilet facilities around 70 per cent of sample households.*
- *Institutional participation is only 6.12 per cent of sample households.*
- *Women participation in decisions making are around 30 per cent of households were found.*

Economic Indicators;

- *The average land holding is 1.98 ha indicates that majority of farm households are belong to small and medium farmers. The dry land of 54.7 % and irrigated land 45.3 % of total cultivated land among the sample farmers.*
- *Agriculture is the main occupation among 82.1 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 7.8 per cent of sample households.*
- *The average value of domestic assets is around Rs. 10528 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 126927 per household, about 40 per cent of sample farmers having plough and sprayer.*
- *The average value of livestock is around Rs. 23229 per household; about 40 per cent of household are having livestock.*
- *The average per capita food consumption is around 659.9 grams (1380.4 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Among all sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 113300 per household. About 60.0 per cent of farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs. 1233.*

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. 634 per ha/year. The total cost of annual soil nutrients is around Rs. 125033 per year for the total area of 348 ha.*
- *The average value of ecosystem service for food grain production is around Rs 307802/ ha/year. Per hectare food production services is maximum in mango (Rs 378917) followed by areca nut (Rs. 193859), coconut (Rs. 65339), sorghum (Rs. 14607), horse gram (Rs. 7705), ragi (Rs. 7297), greengram (Rs. 4482).*
- *The average value of ecosystem service for fodder production is around Rs. 1520/ ha/year. Per hectare fodder production services is maximum in greengram (Rs. 2100) followed by horse gram (Rs 1630), ragi (Rs. 1610) and sorghum (Rs. 741).*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in coconut (Rs.*

291170), sorghum (Rs. 48936), green gram (Rs. 34116), horse gram (Rs. 21794), ragi (Rs. 12918) and arecanut (Rs. 10284).

Economic Land Evaluation;

- *The major cropping pattern is coconut (29.0 %) followed by ragi (24.0 %), arecanut (16.7 %), sorghum (5.4 %), mango (3.2 %) and greengram (7.2 %) and horse gram (19.0 %).*
- *In Nandihalli micro-watershed, major soil is Hallikere (HLK) soil series are having very deep soil depth cover around 11.09 per cent of areas. On present farmers growing crops are arecanut (15.4 %), coconut (26.4 %), horse gram (16.2 %) and, ragi (38.5 %). Kadagathur (KDT) and Niduvalalu (NDL) soils are also very deep soil depth covers around 9.71 per cent and 13.51 per cent of areas, respectively; the crops are arecanut (8.1 %), coconut (39.8 %), green gram (6.6 %), horse gram (9.9), ragi (22.3 %) and sorghum (13.3 %).*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for arecanut ranges between Rs. 170736/ha in KDT soil (with BCR of 2.27) and Rs. 44110/ha in HLK soil (with BCR of 4.90).*
- *In coconut the cost of cultivation ranges between Rs. 104051/ha in NGP soil (with BCR of 1.71) and Rs. 53371/ha in HLK soil (with BCR of 1.90).*
- *In horse gram the cost of cultivation range between Rs. 21154/ha in HLK soil (with BCR of 1.23) and Rs. 17249/ha in KDT soil (with BCR of 1.79).*
- *In ragi the cost of cultivation range between Rs. 26647/ha in KDT soil (with BCR of 1.56) and Rs. 15725/ha in HLK soil (with BCR of 1.02).*
- *In sorghum the cost of cultivation is Rs. 22319/ha in KDT soil (with BCR of 1.69) and mango the cost of cultivation is Rs. 32750/ha in NDL soil (with BCR of 12.57).*
- *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 arecanut (86.1 to 76.5 %), ragi (75.7 to 60.2 %), coconut (53.5 to 18.7 %), horse gram (39.3 to 15.7 %), green gram (42.2 %), mango (47.3 %) and sorghum (42.8 %).*

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

Nandihalli micro-watershed is located in Eastern Dry Zone of Karnataka (Figure 1): The zone covers entire Bangalore and Kolar districts and 2 taluks of Tumkur. It has an area of 1.80 M ha with 0.85 M ha under cultivation. About 0.23 M ha are irrigated mainly from tanks and wells. Elevation ranges from 800 to 1500m MSL with major area falling between 800 and 900m. The major soil type is non-gravelly red loam with a narrow belt of lateritic soil. Average annual rainfall ranges between 680 and 890mm. The principal crops of the zone are ragi, rice, pulses, maize, oil seeds and mulberry. A sizeable area is also under vegetables and flowering plants. It's represented Agro Ecological Region (AER) – 8.2 having LGP 120-150 days.

Nandihalli micro-watershed (Pillahalli sub-watershed, Gubbi taluk, Tumkur district) is located in between $13^0$28' – $13^0$29' North latitudes and $76^0$53' – $76^0$55' East longitudes, covering an area of about 353.56 ha, bounded by Malamachanakunte and Nallur villages.

Sampling Procedure:

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

Sources of data and analysis:

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

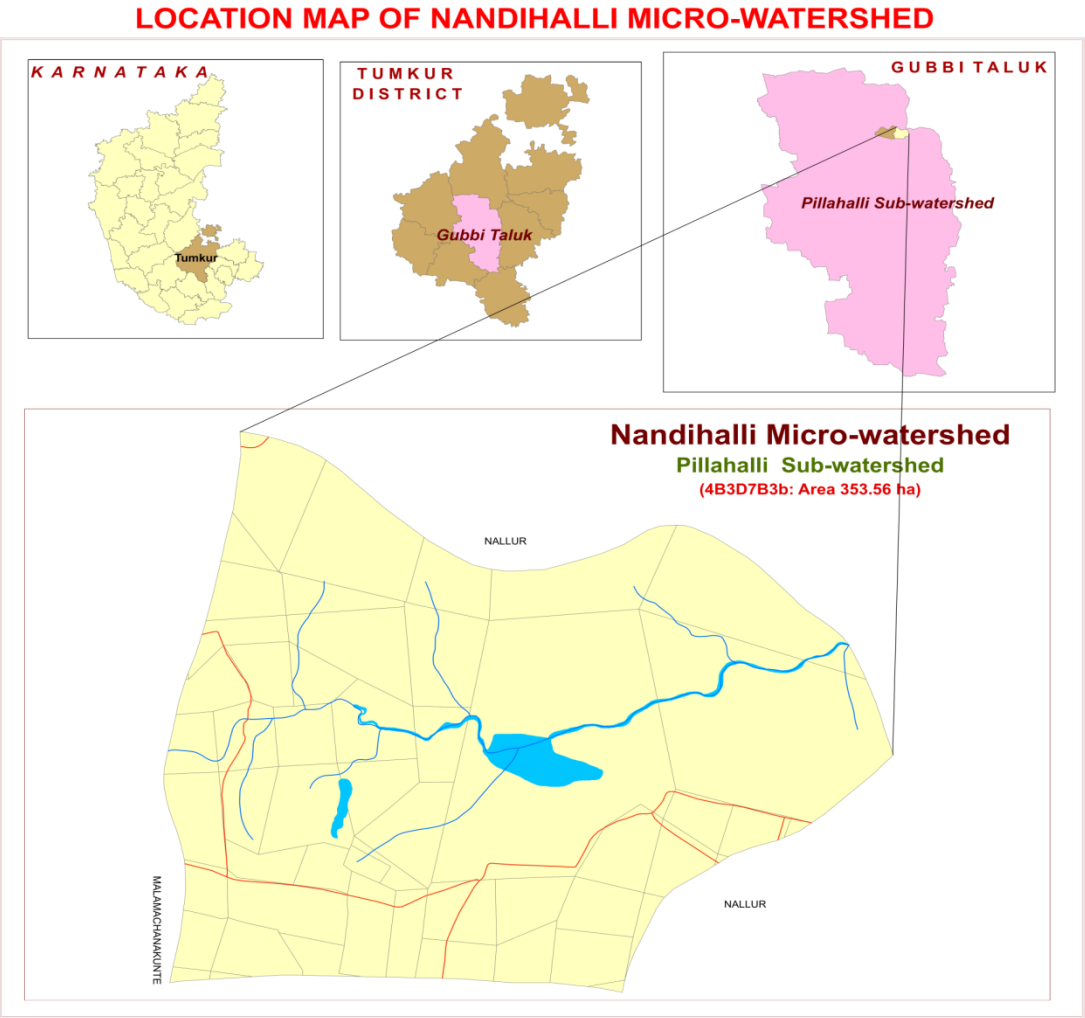


Figure 1: Location of study area

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 .

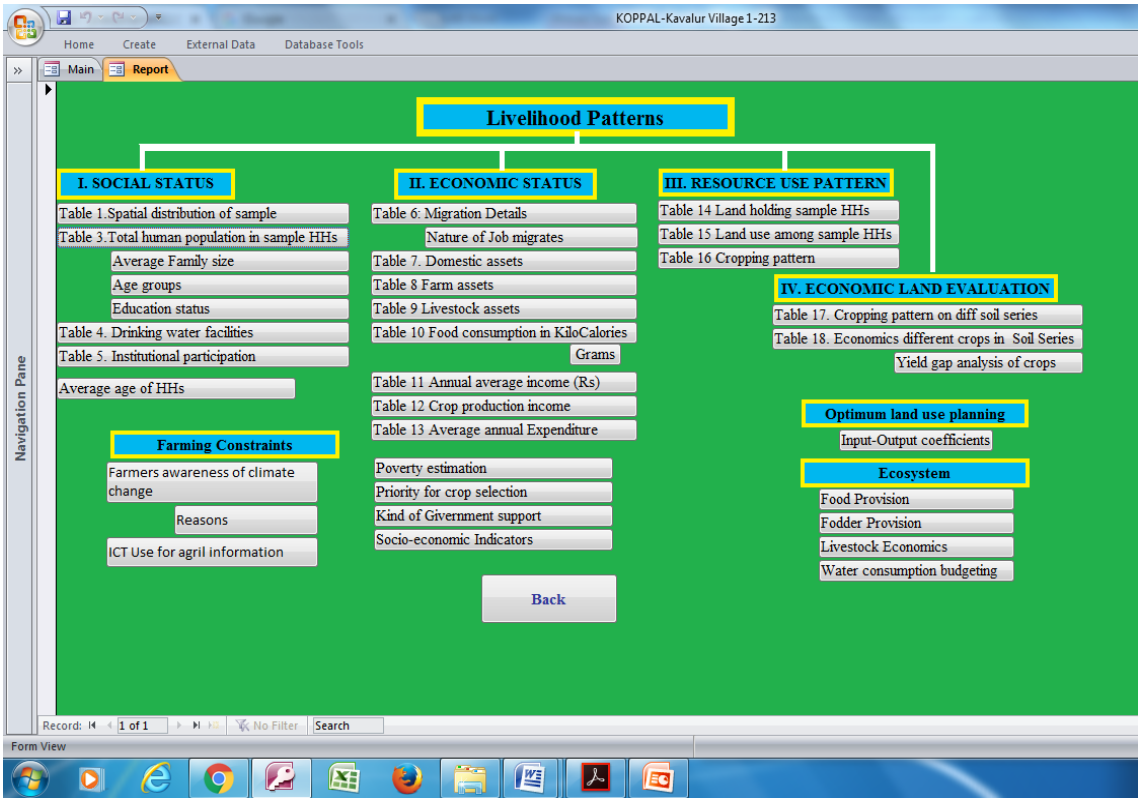


Figure 2: ALPES FRAMEWORK

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.

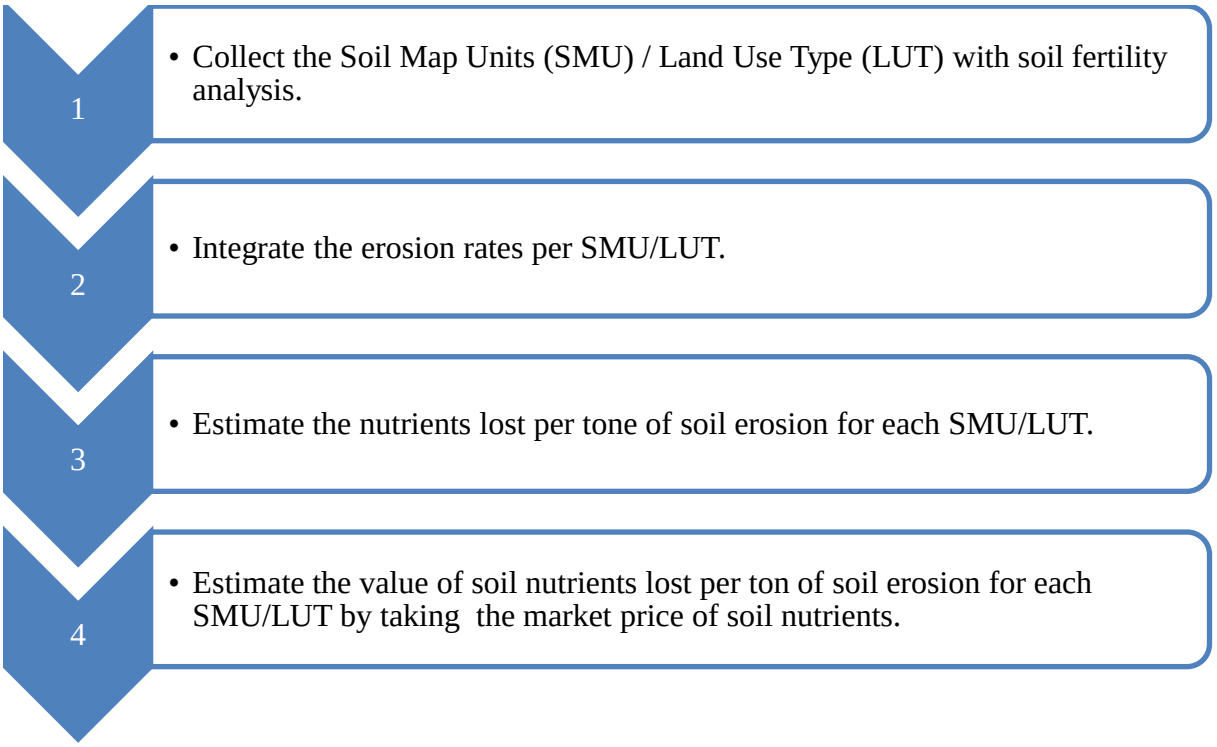
Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.
Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)
Net returns = Gross returns-Operational cost.
Benefit Cost Ratio = Net returns/Total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



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 49, out of which 57.1 per cent were males and 42.9 per cent females. Average family size of the households is 4.9. 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 30 to 50 years (34.7 %) followed by more than 50 years (24.5 %), 18 to 30 years (24.5 %) and 0 to 18 years (16.3 %). 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 28.5 per cent of respondents were illiterate and 71.5 per cent literate (Table 1).

Table 1: Human population among sample households in Nandihalli Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	49.0
Male	% to total Population	57.1
Female	% to total Population	42.9
Average family size	Number	4.9
Age group		
0 to 18 years	% to total Population	16.3
18 to 30 years	% to total Population	24.5
30 to 50 years	% to total Population	34.7
>50 years	% to total Population	24.5
Average age	Age in years	37.6
Education Status		
Illiterates	% to total Population	28.5
Literates	% to total Population	71.5
Primary School (<5 class)	% to total Population	26.0
Middle School (6- 8 Class)	% to total Population	6.0
High School (9- 10 Class	% to total Population	10.0
Others	% to total Population	28.1

The ethnic groups among the sample farm households found to be 50.0 per cent belonging to Other Backward Castes (OBC) followed by 20.0 per cent belonging to General Castes (Table 2 and Figure 3). About 90.0 per cent of sample households are

using gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 80.0 per cent are sample households having health cards. Majority (70 %) are having MNREGA job cards for employment generation. About 90.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 70.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Nandihalli Microwatershed

Particulars	**Units**	**Value**
Social groups		
SC	% of Households	20.0
ST	% of Households	10.0
OBC	% of Households	50.0
Others	% of Households	20.0
Types of fuel use for cooking		
Fire wood	% of Households	10.0
Gas	% of Households	90.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	80.0
No	% of Households	20.0
MGNREGA Card		
Yes	% of Households	70.0
No	% of Households	30.0
Ration Card		
Yes	% of Households	90.0
No	% of Households	10.0
Households with toilet		
Yes	% of Households	70.0
No	% of Households	30.0
Drinking water facilities		
Tube Well	% of Households	60.00
Tank	% of Households	40.00

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 (60 %) and tank (40%).

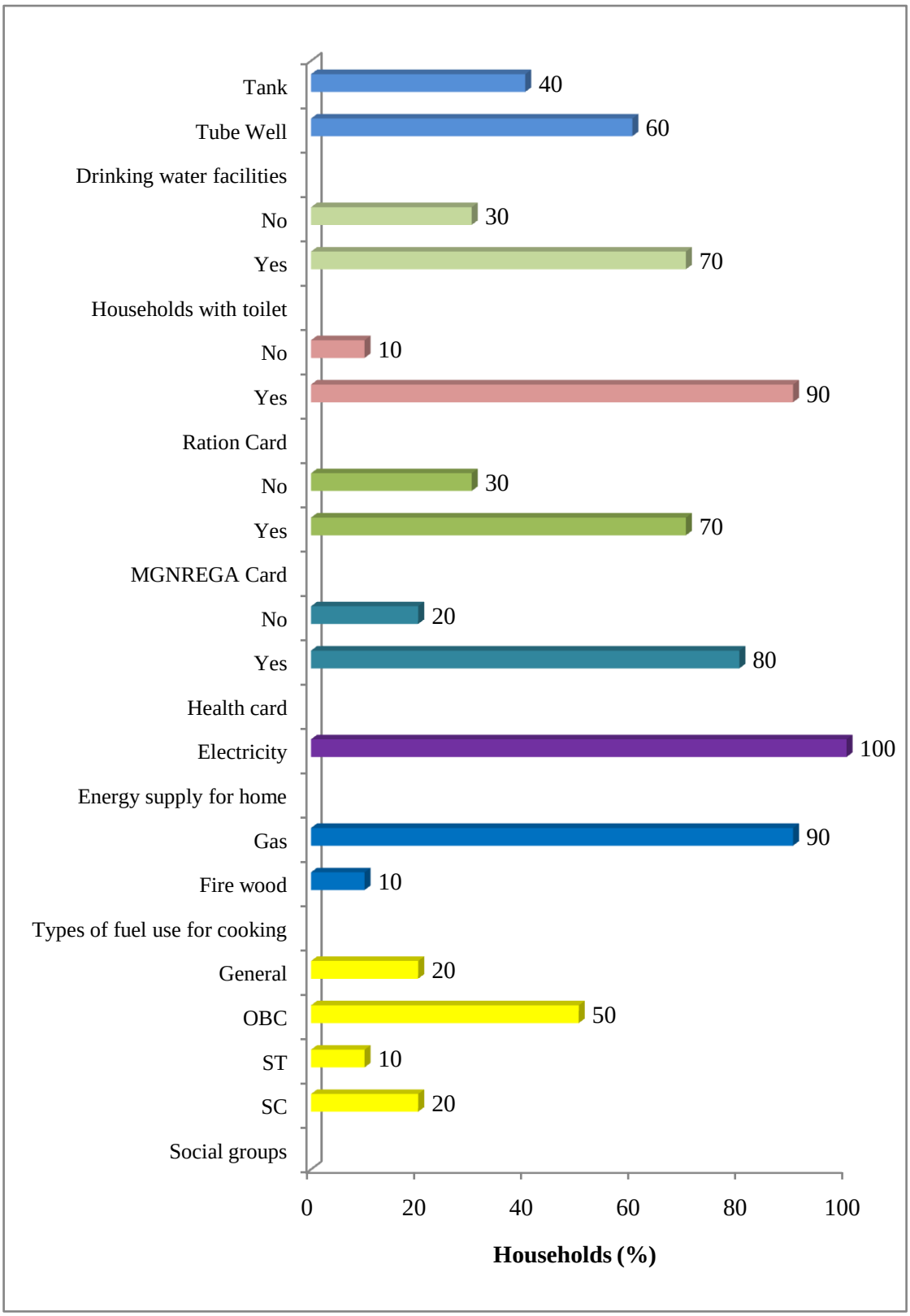


Figure 3: Basic needs of sample households in Nandihalli Microwatershed

Only 6.12 per cent of the farmers are participating in community based organizations (Table 3). Among them majority were participating in co-operative societies - marketing (2.04 %), village panchayath (2.04 %) and users groups (2.04 %).

Table 3: Institutional participation among the sample population in Nandihalli Microwatershed

Particulars	Units	Value
No. Of people participating	% to total	6.12
Co-operative Societies - Marketing	% to total	2.04
Village Panchayath	% to total	2.04
Users groups	% to total	2.04
No. Of people not participating	% to total	93.88

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 82.1 per cent of farmers followed by agriculture is the main and agricultural labour is a subsidiary occupation of 5.1 per cent. The main occupation were agriculture labour (5.8 %) and government services is (2.6 %), private service is (2.6 %) and fisheries is (2.6 %).

Table 4: Occupational pattern in sample population in Nandihalli Microwatershed

Occupation		**% to total**
Main	**Subsidiary**	
Agriculture	Agriculture	82.1
	Agriculture Labour	5.1
Agriculture Labour		5.8
Govt. service		2.6
Private service		2.6
Fisheries		2.6
Family labour availability		**Man days/month**
Male		40.00
Female		27.50
Total		67.50

The important assets especially with reference to domestic assets were analyzed and are given in Table 5 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (80 %) followed by television (90 %), bicycle (20 %), mixer/grinder (60 %) and motorcycle (50 %), landline phone (10 %) and microwave (10 %). The average value of domestic assets is around Rs 10528 per households.

Table 5: Domestic assets among the sample households in Nandihalli Microwatershed

Particulars	% of households	Average value in Rs
Bicycle	20.0	1250
Mixer/grinder	60.0	1833
Microwave	10.0	2000
MobilePhone	80.0	5000
Television	90.0	7611
Landline Phone	10.0	8000
Motorcycle	50.0	48000
Average Value	10528	

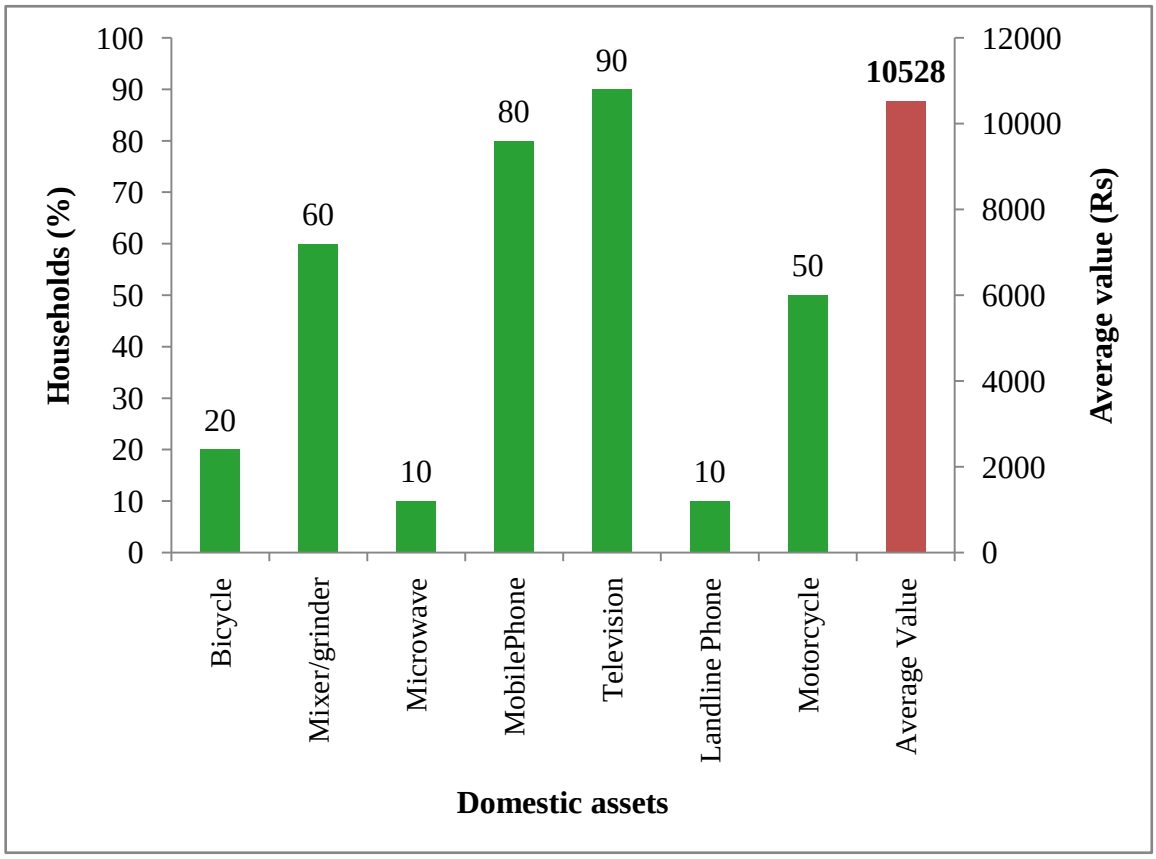


Figure 4: Domestic assets among the sample households in Nandihalli Micro watershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned Plough (40 %), weeder (30 %) was found highest among the sample farmers. The average value of farm assets is around Rs 126927 per households (Table 6 and Figure 5)

Table 6 : Farm assets among samples households in Nandihalli Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	10.0	30000
Plough	40.0	2150
Sprayer	10.0	2400
Tractor	10.0	600000
Weeder	30.0	83
Average Value	126927	

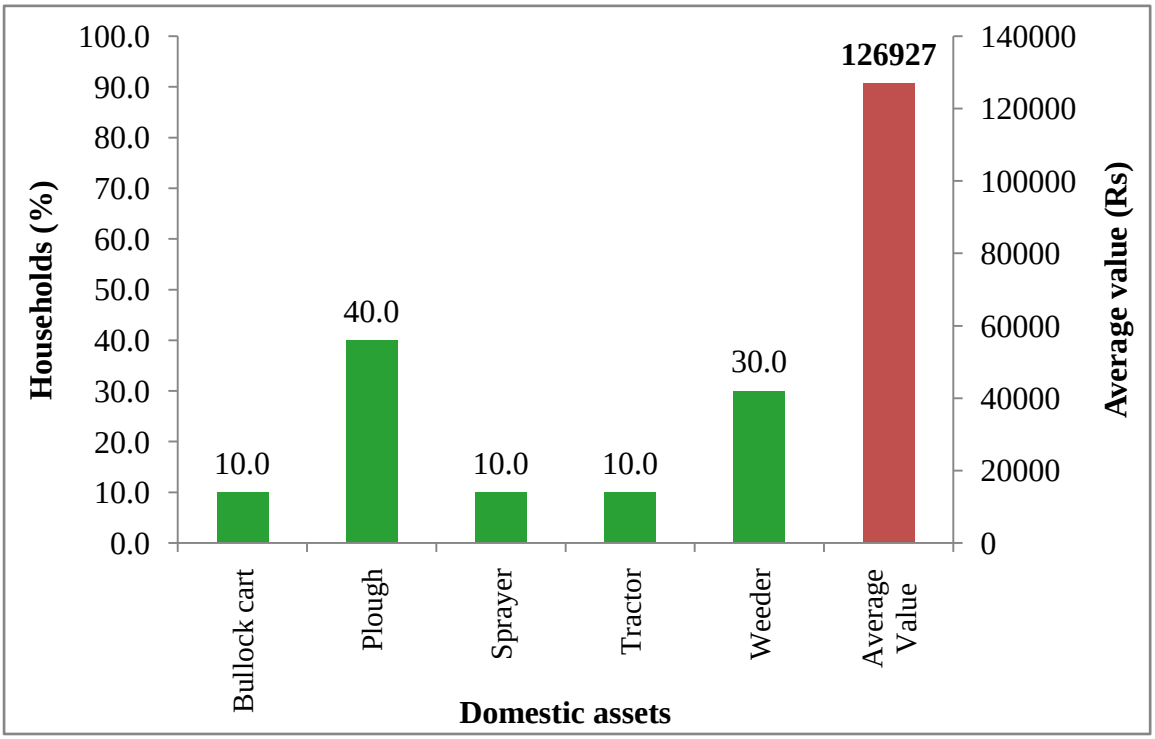


Figure5: Farm assets among samples households in Nandihalli Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population is crossbred milching cow were around 40.0 per cent followed by dry buffalos (30.0 %), milching buffalos (20.0 %) and crossbred dry cow (10.0 %). The average livestock value was Rs 23229 per households.

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

Particulars	% of livestock population	Average value in Rs
Crossbred Dry Cow	10.0	6000
Crossbred Milching Cow	40.0	38250
Dry Buffalos	30.0	26667
Milching Buffalos	20.0	22000
Average value	23229	

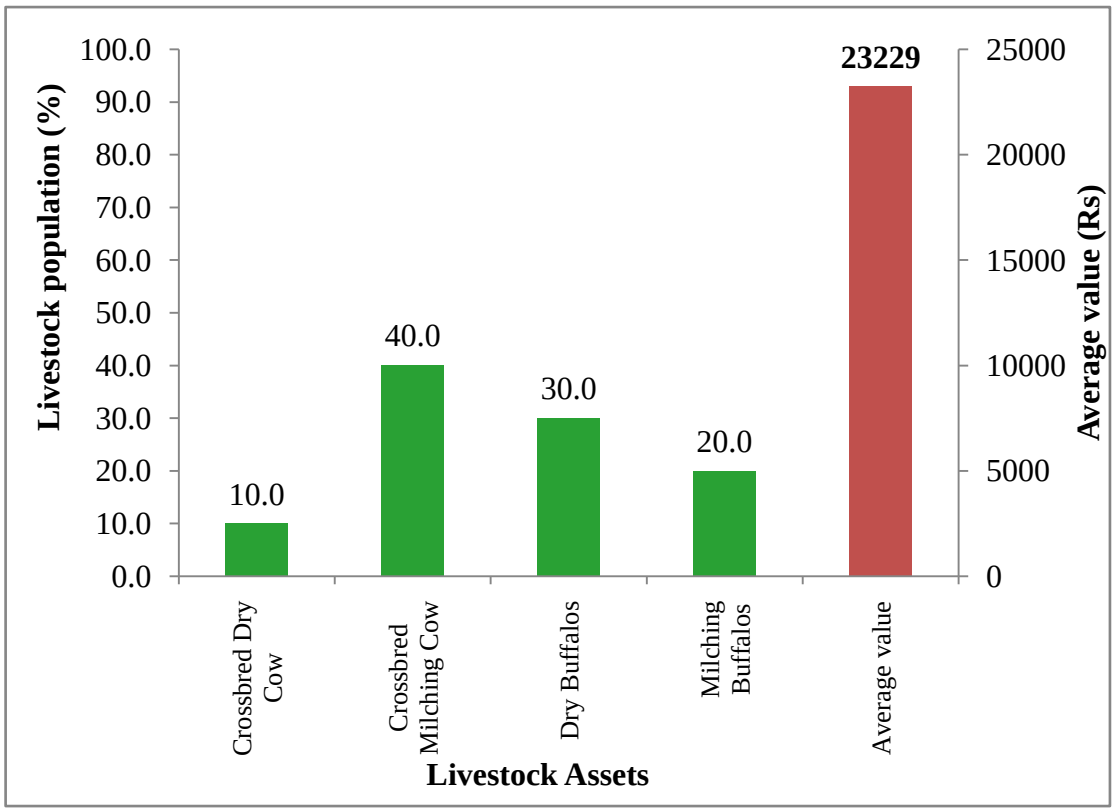


Figure 6: Livestock assets among sample households in Nandihalli micro-watershed

Average milk produced in sample households is 1470 litters/ annum. Among the farm households of fodder crops are sorghum, groundnut and horse gram are the main crops for domestic food and fodder for animals. About 1468 kg /ha of average fodder is available per season for the livestock feeding (Table 8).

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

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Crossbred Milching Cow	1950
Milching Buffalos	990
Average Milk produced	1470
Fodder produces	**Fodder yield (kg/ha.)**
Sorghum	1563
Groundnut	1667
Horse gram	1174
Average fodder availability	1468
Livestock having households (%)	77
Livestock population (Numbers)	13

A woman participation in decision making is in this micro-watershed is presented in Table 9. About 30 per cent of women taking decision in her family and agriculture related activities, 30 per cent of women participation in local organization activities, 10 per cent Women earning for her family requirement and 10 per cent of women elected as panchayat member

Table 9: Women empowerment of sample households in Nandihalli Microwatershed

% to Grand Total

Particulars	**Yes**	**No**
Women participation in local organization activities	30.0	70.0
Women elected as panchayat member	10.0	90.0
Women earning for her family requirement	10.0	90.0
Women taking decision in her family and agriculture related activities	30.0	70.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals are consumed by sample farmers which accounted for 845.9 kcal per person. The other important food items consumed was pulses 96.41 kcal followed by cooking oil 187.6 kcal, milk 115.9 kcal, vegetables 23.6 kcal, egg 84.8 kcal and meat 26.8 kcal. In the sampled households, farmers were consuming less (1380.4 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample Households in Nandihalli Microwatershed

Particulars	**NIN recommendation (gram/ per day/ person)**	**Present level of consumption (gram/ per day/ person)**	**Kilo Calories /day/person**
Cereals	396	248.8	845.87
Pulses	43	28.1	96.41
Milk	200	177.5	115.38
Vegetables	143	98.3	23.58
Cooking Oil	31	32.9	187.56
Egg	0.5	56.5	84.82
Meat	14.2	17.8	26.75
Total	827.7	659.9	1380.36
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		100.0	90.0
% Above NIN		0.0	10.0

Note: * day/person

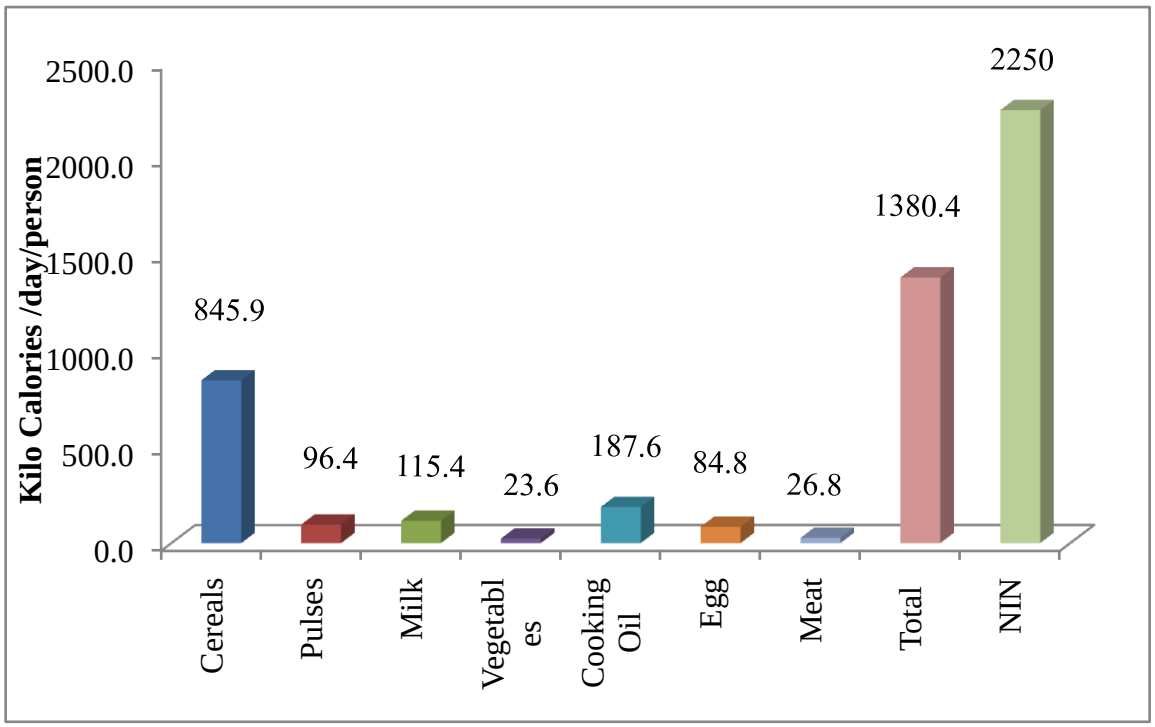


Figure 7: Per capita daily consumption of food among the sample households in Nandihalli Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 113300. Major source of income to the farmers in the study area is from crop production (Rs 69556) followed by livestock (Rs. 43744). The monthly per capita income is Rs. 1927 which is more than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

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

Particulars	**Income ***
Nonfarm income (Rs)	0 (0)
Livestock income (Rs)	43744 (50)
Crop Production (Rs)	69556 (100)
Total Annual Income (Rs)	***113300***
Average monthly per capita income (Rs)	1927
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	60.0
% of households above poverty line	40.0

* 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. 39774) followed by education, clothing, social function and health. Now a days 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 1233 and about 40 per cent of farm households are above poverty line (Table 12 and Figure 8).

Table 12: Average annual expenditure of sample HHs in Nandihalli Microwatershed

Particulars	Value in Rupees	Per cent
Food	39774	54.8
Education	11600	16.0
Clothing	5750	7.9
Social functions	7800	10.8
Health	7600	10.5
Total Expenditure (Rs/year)	72524	100.0
Monthly per capita expenditure (Rs)	1233	

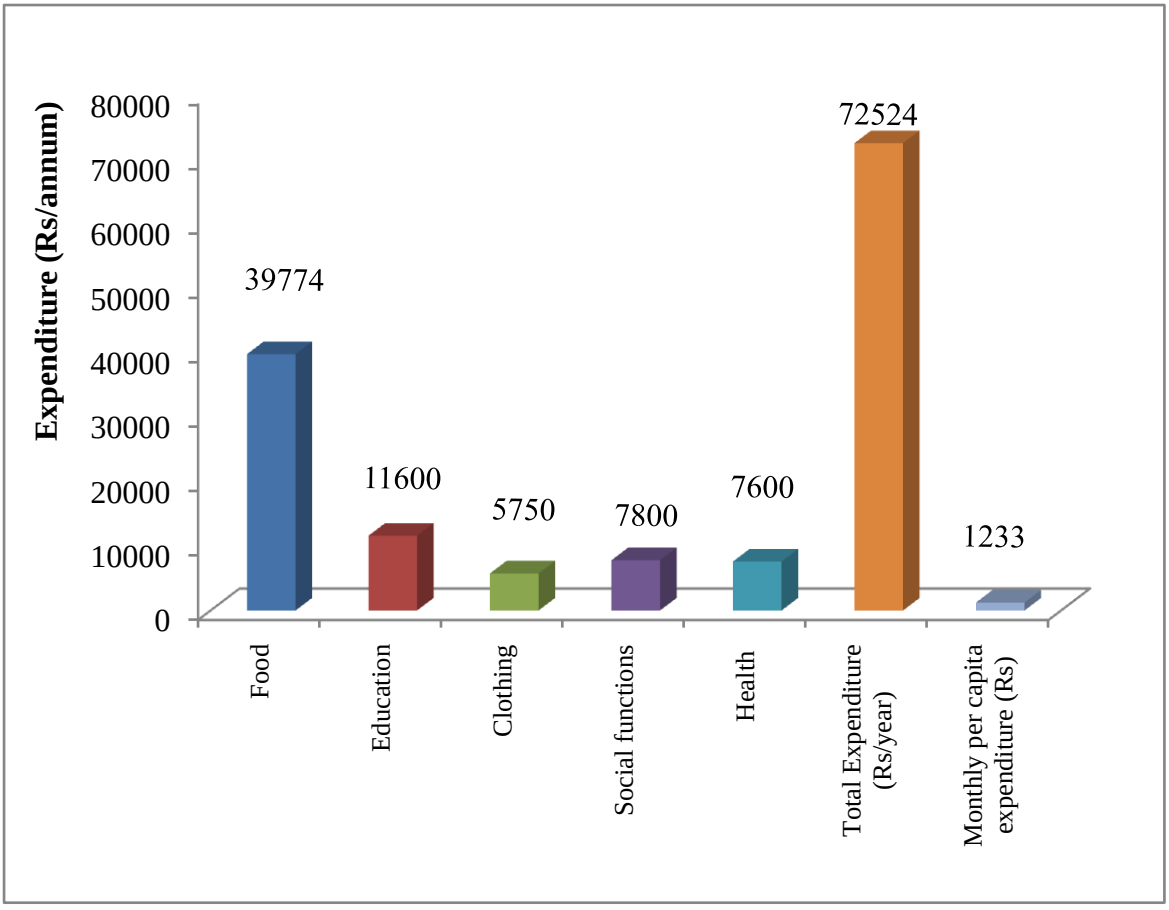


Figure 8: Average annual expenditure of sample HHs in Nandihalli Microwatershed

Land use: The total land holding in the Nandihalli micro-watershed is 11.9 ha (Table 13). Of which 5.4 ha is rain fed land and 6.5 ha is irrigated land. The average land holding per household is worked out to be 1.19 ha.

Table 13: Land use among samples households in Nandihalli Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	54.7	6.5
Rainfed Land	45.3	5.4
Fallow Land	0.0	0.0
Total land holding	100.0	11.9
Average land holding	1.19	

In the micro-watershed, the prevalent present land uses under perennial plants are coconut (77.8 %) followed by mango (13.6 %), tamarind (3.1 %), rosewood (3.3), teak (0.7), honge (0.7 %) ,lime (0.2) and banyan tree(alada) (0.2) (Table 14).

Table 14: Number of trees/plants covered in sample farm households in Nandihalli Microwatershed

Particulars	Number of Plants/trees	Per cent
Banyan tree(Alada)	1	0.2
Coconut	350	77.8
Lime	1	0.2
Mango	61	13.6
Neem trees	2	0.4
Tamarind	14	3.1
Honge	3	0.7
Rosewood	15	3.3
Teak	3	0.7
Grand Total	450	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 Coconut (29.0 %) followed by ragi (24.0 %), arecanut (16.7 %), sorghum (5.4 %), mango (3.2 %) and greengram (2.7 %) which are taken during kharif and horse gram (19.0 %) during Rabi season respectively. The cropping intensity was 129.4 per cent (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Nandihalli Microwatershed

% to Grand Total

Crops	Kharif	Rabi	Grand Total
Arecanut	16.7	0.00	16.7
Coconut	29.0	0.0	29.0
Greengram	2.7	0.0	2.7
Horsegram	0.0	19.0	19.0
Mango	3.2	0.0	3.2
Ragi	20.4	3.7	24.0
Sorghum	5.4	0.0	5.4
Grand Total	77.3	22.7	100.0
Cropping intensity (%)	129.4		

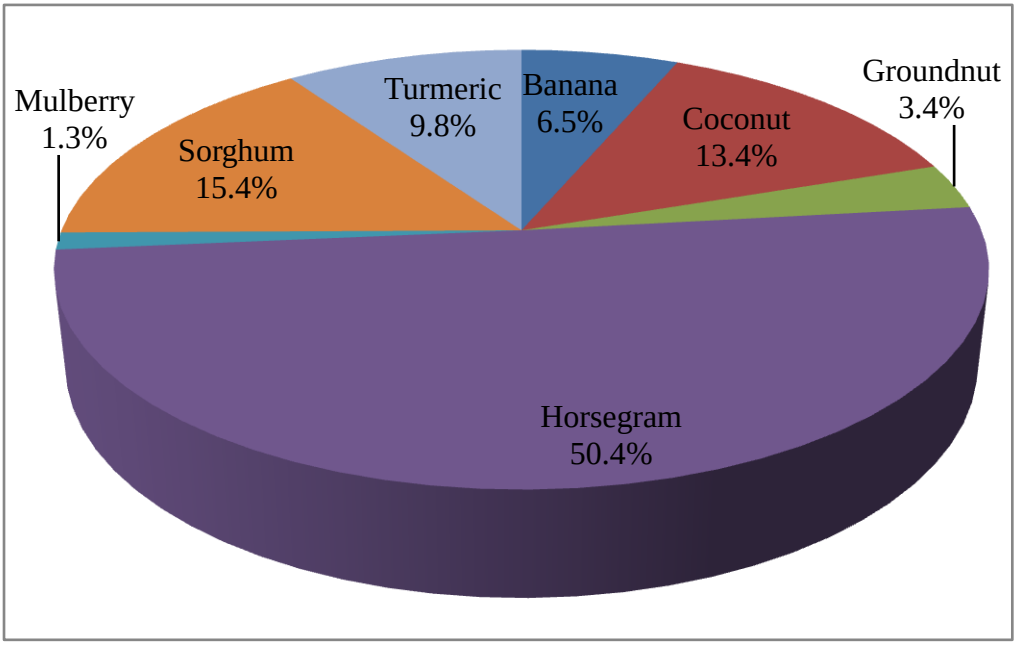


Figure 9: Present cropping pattern in Nandihalli Microwatershed

Economic land evaluation

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

In Nandihalli micro-watershed, 8 soil series are identified and mapped (Table 16). The distribution of major soil series are Niduvalalu covering an area around 48 ha (13.51 %) followed by Hallikere 39 ha (11.09 %), Kadagathur 35 ha (9.71 %), Ranatur 20 ha (5.58 %), Kutegoudanahundi 19 ha (5.21 %), Jidigere 17 ha (4.77 %), Kanchikere 12 ha (2.26 %) and Thammadahalli 11 ha (3.18 %), gully region 147 ha (41.44 %).

Table 16: Distribution of soil series in Nanadihalli Microwatershed

Soil No	Soil Series	Mapping Unit Description	Area in ha (%)
1	TDH	Thammadahalli soils are moderately shallow (50-75cm), well drained, have dark red to dark reddish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation	11 (3.18)
2	KGH	Kutegoudanahundi soils are moderately shallow (50-75 cm), well drained, have brown to dark brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation	19 (5.21)
3	KKR	Kanchikere soils are moderately deep (75-100 cm), well drained, have dark brown to very dark grayish brown clay loam to sandy clay soils occurring on gently sloping uplands under cultivation	12 (3.26)
4	JDG	Jedigere soils are deep (100-150 cm), well drained, have dark brown to dark reddish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation	17 (4.77)
5	HLK	Hallikere soils are very deep (>150 cm), well drained, have dark brown to dark reddish brown clayey soils occurring on very gently sloping uplands under cultivation	39 (11.09)
6	RTR	Ranatur soils are very deep (> 150 cm), well drained, have dark reddish brown to dark red clay soils occurring on very gently sloping uplands under cultivation	20 (5.58)
7	NDL	Niduvalalu soils are very deep (>150 cm), well drained, have red to dark reddish brown gravelly sandy clay soils occurring on very gently sloping uplands under cultivation	48 (13.51)
8	KDT	Kadagathur soils are very deep (>150 cm), moderately well drained, have dark brown to very dark grayish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation	35 (9.71)
9	Gully		147 (41.44)
10	Others		8 (2.24)
TOTAL			348 ha

Present cropping pattern on different soil series are given in Table 17. Crops grown on NGP soils are coconut, arecanut, coconut, horsegram and ragi on (HLK) hallikere soils is grown. arecanut, coconut, greengram, horsegram, ragi and sorghum on (KDT) kadagathur soils are grown. Mango on (NDL) niduvalalu soils is grow.

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

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Irrigated	Grand Total
			Kharif	Rabi	Kharif	
NGP	Deep (100-150 cm)	Coconut	0.0	0.0	100.0	100.0
HLK (Hallikere)	Very deep (>150 cm)	Arecanut	0.0	0.0	15.4	15.4
		Coconut	0.0	0.0	26.9	26.9
		Horsegram	0.0	19.2	0.0	19.2
		Ragi	38.5	0.0	0.0	38.5
KDT (Kadagathur)	Very deep (>150 cm)	Arecanut	0.0	0.0	8.1	8.1
		Coconut	0.0	0.0	39.8	39.8
		Greengram	6.6	0.0	0.0	6.6
		Horsegram	0.0	9.9	0.0	9.9
		Ragi	13.3	9.1	0.0	22.3
		Sorghum	13.3	0.0	0.0	13.3
NDL (Niduvalalu)	Very deep (>150 cm)	Mango	100.0	0.0	0.0	100.0

Land is used for agricultural use for growing cereals, pulse, oilseeds and commercial crops. The soil/ land potential are measures in terms of physical yield and net income. The alternative land use options for each micro-watershed are given below (Table 18).

Table 18: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Nandihalli Microwatershed.

Soil Series	Small Farmers	Medium Farmers
NGP	Coconut (1.71)	
HLK		Arecanut (4.90), Coconut (1.90), Horsegram (1.23), Ragi (1.02)
KDT	Arecanut (2.27), Coconut (2.12), Greengram (1.33), Ragi (1.56), Horsegram (1.78), Sorghum (1.69)	
NDL	Mango (12.57)	

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

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 19. The total cost of cultivation in study area for arecanut ranges between Rs. 170736/ha in KDT soil (with BCR of 2.27) and Rs. 44110/ha in HLK soil (with BCR of 4.90), coconut ranges between 104051/ha in NGP soil (with BCR of 1.71) and Rs. 53371/ha in HLK soil (with BCR of 1.90), horse gram range between Rs 21154/ha in HLK soil (with of 1.23) and Rs. 17249/ha in KDT soil (with BCR of 1.79), ragi range between Rs. 26647/ha in KDT soil (with BCR of 1.56) and Rs. 15725/ha in HLK soil (with BCR of 1.02), sorghum cost of cultivation is Rs. 22319/ha in KDT soil (with BCR of 1.69) and mango cost of cultivation is Rs. 32750/ha in NDL soil (with BCR of 12.57).

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

Particulars	NGP (100-150 cm)	HLK (>150 cm)				KDT (>150 cm)						NDL (>150 cm)
	Coconut	Areca nut	Coco nut	Horse gram	Ragi	Areca nut	Coco nut	Green gram	Horse gram	Ragi	Sor ghum	Mango
Total cost (Rs/ha)	104051	44110	53371	21154	15725	170736	61518	20218	17249	26647	22319	32750
Gross Return (Rs/ha)	177840	216125	101623	26083	16006	375517	130367	26800	30628	41242	37668	411667
Net returns (Rs/ha)	73789	172015	48251	4929	280	204781	68849	6581	13379	14594	15348	378917
BCR	1.71	4.90	1.90	1.23	1.02	2.27	2.12	1.33	1.78	1.56	1.69	12.57
Farmers Practices (FP)												
FYM (t/ha)	7.5	0.0	5.0	0.0	0.0	10.2	3.8	0.0	0.0	3.1	2.5	0.0
Nitrogen (kg/ha)	87.5	60.1	60.1	72.5	72.5	76.5	35.3	108.1	108.1	36.1	108.1	129.2
Phosphorus (kg/ha)	157.5	106.7	106.7	54.5	54.5	184.4	76.6	63.9	63.9	36.1	63.9	170.8
Potash (kg/ha)	192.5	81.3	81.3	8.5	8.5	7.1	7.1	0.0	0.0	36.1	0.0	62.5
Grain (Qtl/ha)	150.0	6.3	85.7	6.0	7.5	10.6	117.7	5.0	8.3	12.3	16.3	52.1
Price of Yield (Rs/Qtl)	1200	35000	1200	4000	2000	35000	1300	5000	3600	3300	2300	8000
Soil test based fertilizer Recommendation (STBR)												
FYM (t/ha)	10.0	6.8	10.0	0.0	8.6	6.8	10.0	7.4	0.0	8.6	7.4	61.8
Nitrogen (kg/ha)	128.1	100.0	102.5	30.9	92.6	125.0	128.1	23.2	30.9	92.6	101.9	231.6
Phosphorus (kg/ha)	48.8	56.3	48.8	27.8	32.4	56.3	48.8	27.8	27.8	32.4	42.6	37.1
Potash (kg/ha)	306.3	30.0	183.8	24.7	44.5	43.3	245.0	37.1	24.7	50.0	39.5	216.1
Grain (Qtl/ha)	184.5	45.0	184.5	9.9	30.9	45.0	184.5	8.6	9.9	30.9	28.4	98.8
% of Adoption/yield gap (STBR-FP) / (STBR)												
FYM (%)	25.0	100.0	50.0	0.0	100.0	-51.2	61.7	100.0	0.0	64.4	66.3	100.0
Nitrogen (%)	31.7	39.9	41.3	-134.8	21.7	38.8	72.5	-366.6	-250.0	61.1	-6.1	44.2
Phosphorus (%)	-223.1	-89.8	-119.0	-96.1	-68.1	-227.8	-57.1	-129.9	-129.9	-11.2	-49.9	-361.1
Potash (%)	37.1	-171.0	55.8	65.6	80.9	83.7	97.1	100.0	0.0	27.9	100.0	71.1
Grain (%)	18.7	86.1	53.5	39.3	75.7	76.5	36.2	42.2	15.7	60.2	42.8	47.3
Value of yield and Fertilizer (Rs)												
Additional Cost (Rs/ha)	478	3981	5006	-1351	8634	-7788	10815	5544	-2021	6368	4690	60165
Additional Benefits (Rs/ha)	41400	1356250	118543	15520	46750	1204948	86883	18225	5568	61300	27957	373733
Net change Income (Rs/ha)	40923	1352269	113537	16871	38116	1212736	76069	12681	7589	54932	23266	313569

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 20. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs 1212736 in turmeric and a minimum of Rs 7589in beans cultivation

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 20 and Figure 10. The average value of soil nutrient loss is around Rs 634.68 per ha/year. The total cost of annual soil nutrients is around Rs 125033 per year for the total area of 348 ha.

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

Particulars	**Quantity(kg)**		**Value (Rs)**	
	Per ha	**Total**	**Per ha**	**Total**
Organic matter	89.78	17686	565.61	111425
Phosphorus	0.20	39	8.74	1722
Potash	0.81	159	16.18	3188
Iron	0.08	17	4.03	793
Manganese	0.11	21	29.04	5721
Cupper	0.01	1	3.48	686
Zinc	0.01	3	0.55	108
Sulphur	0.17	34	6.89	1358
Boron	0.00	1	0.16	31
Total	91.17	17961	634.68	125033

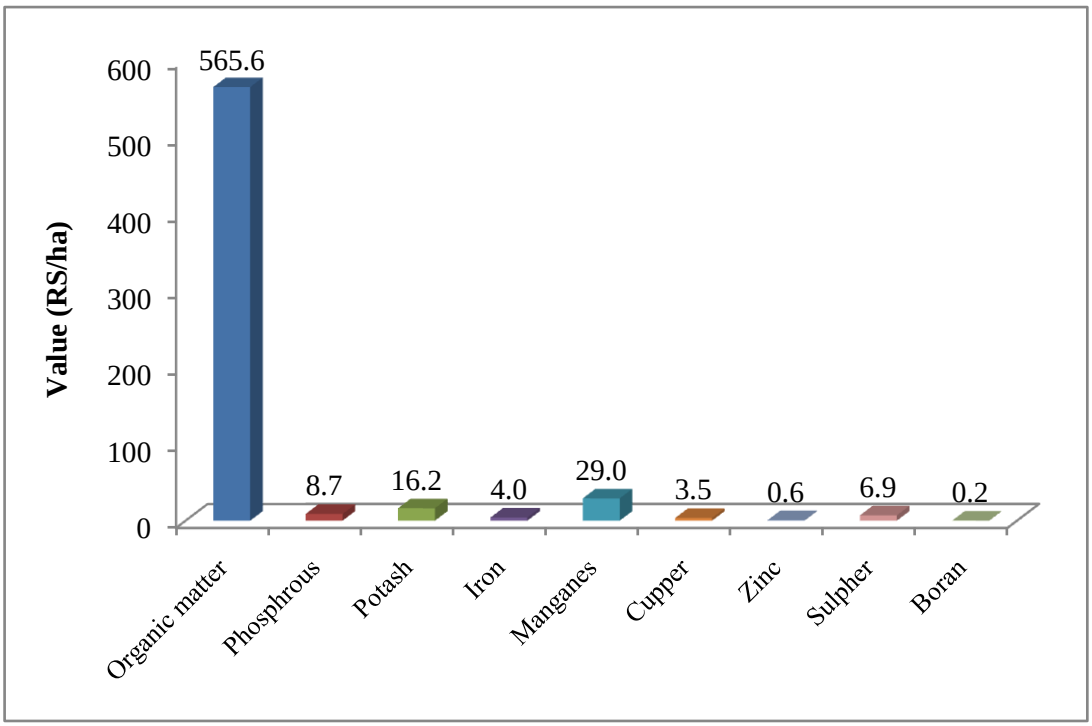


Figure 10: Estimation of onsite cost of soil erosion in Nandihalli micro-watershed

The average value of ecosystem service for food grains production is around Rs 307802/ ha/year (Table 21 and Figure 11). Per hectare food grain production services is maximum in mango (Rs 378917) followed by arecanut (Rs 193859), coconut (Rs 65339), sorghum (Rs 14607), horse gram (Rs 7705), ragi (Rs 7297) and greengram (Rs 4482).

Table 21: Ecosystem services of food grain production in Nandihalli 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)**
Cereals	Ragi	3.4	11	2867	30304	23007	7297
	Sorghum	0.8	16	2300	36927	22319	14607
Pulses	Greengram	0.4	5	5000	24700	20218	4482
	Horsegram	1.6	7	3800	26907	19202	7705
Oil seeds	Coconut	4.3	108	1250	135453	70114	65339
Commercial Crops	Arecanut	1.3	9	35000	322386	128528	193859
Fruits	Mango	0.5	51	8000	411667	32750	378917
Average value		12.3	39	9433	364385	56583	307802

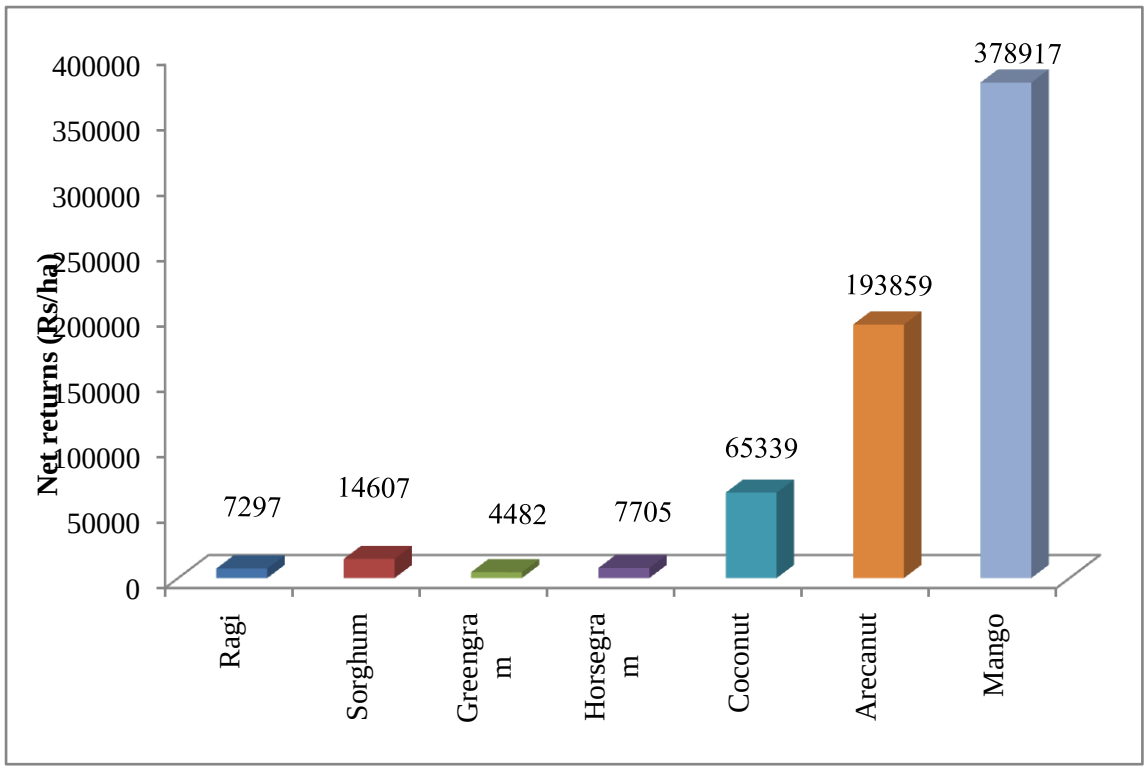


Figure 11: Ecosystem services of food grain production in Nandihalli Microwatershed

The average value of ecosystem service for fodder production is around Rs 1520/ ha/year (Table 22). Per hectare fodder production services is maximum in greengram (Rs 2100) followed by horse gram (Rs 1630), ragi (Rs 1610) and sorghum (Rs 714).

Table 22: Ecosystem services of fodder production in Harve 1Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Ragi	3.4	1.3	1200	1610
	Sorghum	0.8	1.2	600	741
Pulses	Greengram	0.4	2.5	850	2100
	Horsegram	1.6	1.8	900	1630
Average value		6.2	1.7	888	1520

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 23 and Figure 12) in coconut (291170), sorghum (Rs 48936), greengram (Rs 34116), horse gram (Rs 21794), ragi (Rs 12918) and arecanut (Rs 10284).

Table 23: Ecosystem services of water supply in Nandihalli Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Arecanut	9.2	1028	10284	112
Coconut	108.4	29117	291170	269
Greengram	4.9	3412	34116	691
Horsegram	7.1	2179	21794	308
Mango	51.5	9263	92625	180
Ragi	10.6	1292	12918	122
Sorghum	16.1	4894	48936	305
Average value	38.6	9690	96903	251

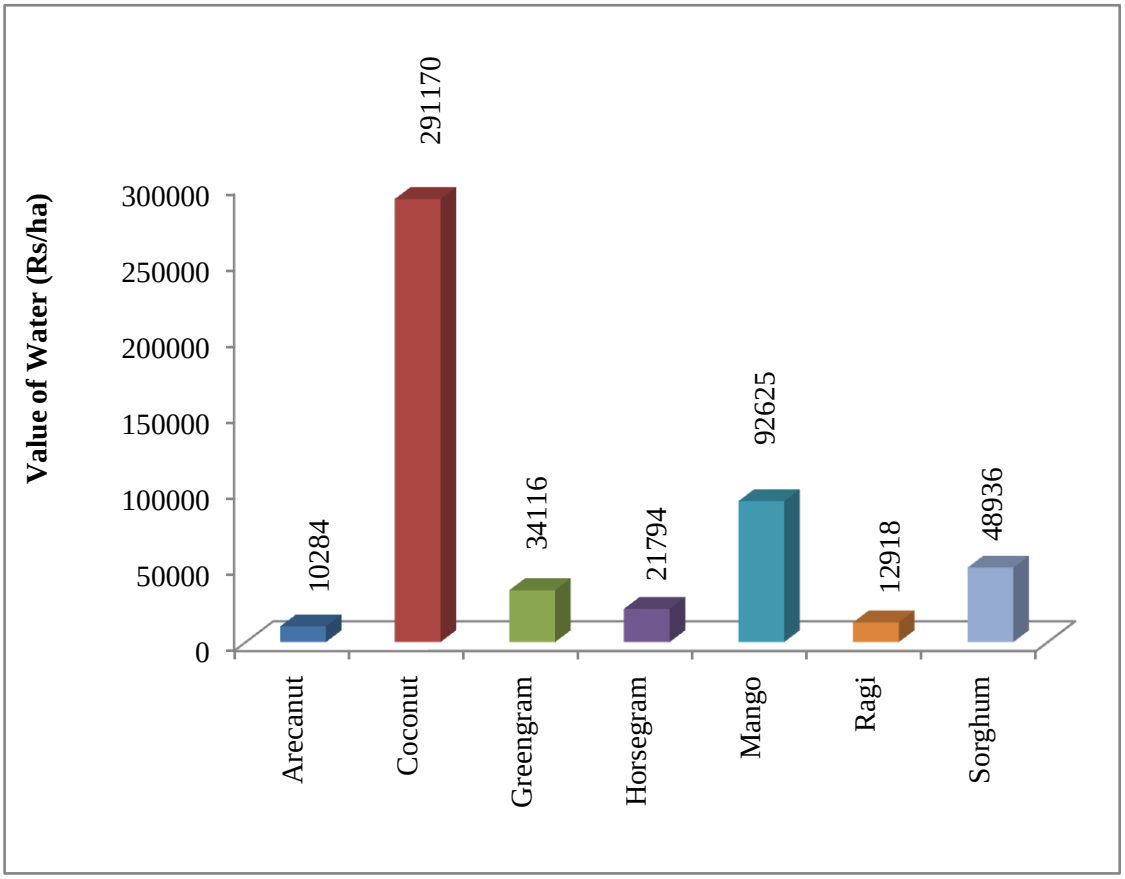


Figure 12: Ecosystem services of water supply in Nandihalli Microwatershed

The main farming constraints in Nandihalli micro-watershed to be found are less rainfall, lack of good quality seeds, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting

timely support/extension services from the concerned development department (Table 24).

Table 24: Farming constraints related land resources of sample households in Nandihalli Microwatershed

Sl. No	Particular	Percentage
1	Less Rainfall	100.0
2	Lack of good quality seeds	20.0
3	Lack of storage	10.0
4	Damage of crops by Wild Animals	90.0
5	Non availability of Plant Protection Chemicals	90.0
6	**Source of loan**	
	Money Lender	100.0
7	**Market for selling**	
	Village market	100.0
8	**Sources of Agri-Technology information**	
	Newspaper	90.0
	Television	10.0

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