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

BELHATTI-4 (4D4A3I1d) MICROWATERSHED

Shirhatti Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

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

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

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on “Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Belhatti-4 Microwatershed, Gadag TalukandDistrict, Karnataka” for integrated development was taken up in collaboration with theState Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

Nagpur **S.K. SINGH**

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Belhatti-4 microwatershedwas conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundries. The soil map shows the geographic distribution and extent, characterstics, classification and use potentials of the soils in the microwartershed.

The present study covers an area of 400 ha in Shirahatti taluk of Gadag district, Karnataka. The climate is semiarid and categorized as drought prone with an average annual rainfall of 633 mm of which about 363 mm is received during south –west monsoon, 165 mm during north-east and the remaining 105 mm during the rest of the year. An area of about 98 per cent is covered by soils, two per cent by rock lands, waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 11 soil series and 20 soil phases (management units) and 6 land management units.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 1rd week of October.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing major agricultural and horticultural crops were assessed and maps showing degree of suitability along with constraints were generated.*
- *About 98 per cent area is suitable for agriculture and two per cent is not suitable for agriculture but well suited for forestry, pasture, agroforestry, silvi-pasture, installation of wind mills and as habitat for wildlife.*
- *About 35 per cent of the soils are very deep (>150 cm) to deep (100 - 150 cm), 27 per cent are moderately shallow to shallow (25-75 cm) and about 36 per cent are moderately deep (75-100 cm) soils.*
- *About 86 per cent of the area has clayey soils at the surface and 13 per cent loamy soils.*
- *About 15 per cent of the area has non-gravelly soils, 60 per cent gravelly soils (15-35 % gravel) and 24 per cent very gravelly (35- 60% gravel) soils.*
- *About 35 per cent of the area has soils that are very high (>200mm/m) in available water capacity, 47 per cent medium (100-150 mm/m) and about 16 per cent low (50-100 mm/m) and very low (<50mm/m).*
- *About 98 per cent of the area has nearly level (0-1%) to very gently sloping (1-3% slope) lands.*
- *An area of about 48 per cent has soils that are slight erosion (e1), 35 per cent moderately eroded (e2) and 15 per cent soils are severe eroded (e3).*
- *An area of about 12 per cent has soils that are moderately alkaline (pH 7.8 to 8.4) and 86 per cent strongly to very strongly alkaline (pH 8.4 to >9.0).*

- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1}indicating that most of the soils are non-saline.*
- *About 97 per cent medium (0.5-0.75%) in organic carbon.*
- *Major area of 95 per cent has soils that are low (<23 kg/ha) in available phosphorus.*
- *About 86 per cent medium (145-337 kg/ha) and 11 per cent high (>337 kg/ha) in available potassium.*
- *Available sulphur is low (<10 ppm) in about 21 per cent area, medium (10-20 ppm) in about 74 per cent area and about 3 per cent area is high (>20 ppm).*
- *Available boron is low (0.5 ppm) in about 58 per cent area, 27 per cent medium (0.5-1.0 ppm) and 13 per cent high (>1.0 ppm).*
- *Available iron, manganese and copper are sufficient in all the soils.*
- *About 70 per cent area has soils that are deficient (<0.6 ppm) in available zinc and 29 per cent is sufficient (>0.6 ppm).*
- *The land suitability for 21 major crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, price and finally the demand and supply position.*

Land suitability for various crops in the microwatershed

Crop	*Suitability Area in ha (%)*			*Crop*	*Suitability Area in ha (%)*	
	Highly suitable (S1)	*Moderately suitable (S2)*			*Highly suitable (S1)*	*Moderately suitable (S2)*
Sorghum	*114 (28)*	*232 (58)*		*Jackfruit*	*-*	*15 (4)*
Maize	*5 (1)*	*-*		*Jamun*	*-*	*213 (55)*
Bengalgram	*185 (46)*	*161 (40)*		*Musambi*	*-*	*179 (46)*
Groundnut	*-*	*5 (1)*		*Lime*	*15 (4)*	*189 (48)*
Sunflower	*88 (22)*	*180 (45)*		*Cashew*	*-*	*36 (9)*
Cotton	*90 (22)*	*268 (65)*		*Custard Apple*	*17 (4)*	*225 (58)*
Banana	*-*	*5 (1)*		*Amla*	*17 (4)*	*217(56)*
Pomegranate	*5 (1)*	*312 (78)*		*Tamarind*	*15 (4)*	*198 (51)*
Mango	*13 (3)*	*-*		*Marigold*	*5 (1)*	*346 (87)*
Sapota	*-*	*144 (36)*		*Chrysanthemum*	*5 (1)*	*346 (87)*
Guava	*-*	*113 (28)*				

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

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

Chapter 1

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socioeconomic development of its people. Soils provide food, fodder and fuel for meeting the basic human and animal needs. With the ever increasing growth in human and animal population, the demand on soil for more food and fodder production is on the increase. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agro-climatic setting, and use and management. There is, therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource.

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

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state.

Added to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands for a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and use potential, which is very important for developing an effective land use and cropping systems for augmenting agricultural production on a sustainable basis.

The soil and land resource inventories made so far in Karnataka had limited utility because the surveys were of different types, scales and intensities carried out at different times with specific objectives. Hence, there is an urgent need to generate detailed site-specific farm level database on various land resources for all the villages/watersheds in a time bound manner that would help to protect the valuable soil and land resources and also to stabilize the farm production.

Therefore, the land resource inventory required for farm level planning is the one which investigates all the parameters which are critical for productivity *viz.*, soils, site characteristics like slope, erosion, gravelliness and stoniness, climate, water, topography, geology, hydrology, vegetation, crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed.

The Land Resource Inventory is basically done for identifying potential and problem areas, developing sustainable land use plans, estimation of surface run off and water harvesting potential, preparation of soil and water conservation plans, land degradation/desertification etc. The Bureau is presently engaged in developing an LRI methodology using high resolution satellite remote sensing data and Digital Elevation Model (DEM) data to prepare Landscape Ecological Units (LEU) map representing agro-ecosystem as a whole. The LEU is preferred over landform as the base map for LRI. LEU is the assemblage of landform, slope and land use. An attempt was made to upscale the soil resource information from 1:250000 and 1:50000 scale to the LEU map in Goa and other states. Here, an attempt is being made to uplink the LRI data generated under Sujala-III Project to the Landscape Ecological Units (LEUs) map. For this, the major physiographic region, *i.e*., South Deccan Plateau is taken as an example.

The Karnataka state has been divided into three major physiographic divisions, namely the Deccan Plateau, Hill Ranges and Coastal Plain (NATMO, 1980). These divisions have been subdivided into four regions based on their geographic location, namely the South Deccan Plateau, Western Ghats, Eastern Ghats and West Coast Plains.

The South Deccan Plateau has been divided into five landscapes (Shiva Prasad *et. al.,* 1998) based on geological formations. They are granite and granite gneiss, basalt, laterite, sedimentary and metamorphic.

The South Deccan Plateau locally known as the Karnataka Plateau, covers an area of about 15.8 m ha. The major part of the Plateau is peneplain in various stages of development and destruction. The Plateau is divided into *Malnad* (Hilly area) and *Maidan* (Plains). *Malnad* is an area of rolling to undulating uplands with many valleys and is a transitional zone between the Western Ghats and the *Maidan*. It covers an area of about 6.2 mha. The *Maidan* has a rolling surface with altitude of 900-1150 m, 600-850 m, 450-550 m and 300-

400 m above MSL. The highest surface is in the southwestern part of the state. The lowest surface is in the northeast in the valleys of the Tungabhadra and Hagari rivers.

The northern part of the Plateau is drained by the Krishna river and its tributaries, the Bhima, Malaprabha, Ghataprabha and Tungabhadra and the southern part by the Cauvery river and its tributaries, the Hemavathi, Kabini and Lakshmanthirtha.

The plateau has been divided into five landscapes, namely,

1. Granite and gneiss landscape (Dsa)
2. Basalt landscape (Dsb)
3. Laterite landscape (Dsc)
4. Metamorphic landscape (Dsd 1) and
5. Sedimentary landscape (Dsd 2)

The climate of the South Deccan Plateau is hot with dry summers and mild winters. The annual rainfall ranges from 600-1000 mm in most of the plateau region except in parts of Bellary, Raichur and Bijapur districts in northern Karnataka where the rainfall ranges from as low as 350-580 mm. The length of crop growing period ranges from 120-150 days and less than 90 days in the arid regions. Dominant rainfed crops grown in the Plateau region are sorghum, finger millet, groundnut, maize, sunflower, cotton and pulses. The important irrigated crops are paddy, sugarcane, vegetables and flowers.

The land resource inventory aims to provide site specific database for Belhatti-4 microwatershed in Shirahatti Taluk, Gadag District, Karnataka State for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological Units (LEUs) map.

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

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Belhatti-4 microwatershed (Belhatti subwatershed) is located in the central part of northern Karnataka in Shirahtti Taluk, Gadag District, Karnataka State (Fig.2.1). It lies between 15^0 2’ to 15^0 4’ North latitudes and 75^0 37’ to 75^0 39’ East longitudes and covers an area of 390 ha. It is about 60 km south of Gadag and is surrounded by Belhatti village on the northeast, Konchigeri in the southeast, Narayanapur on the east and Chikkasavanur on the southwest.

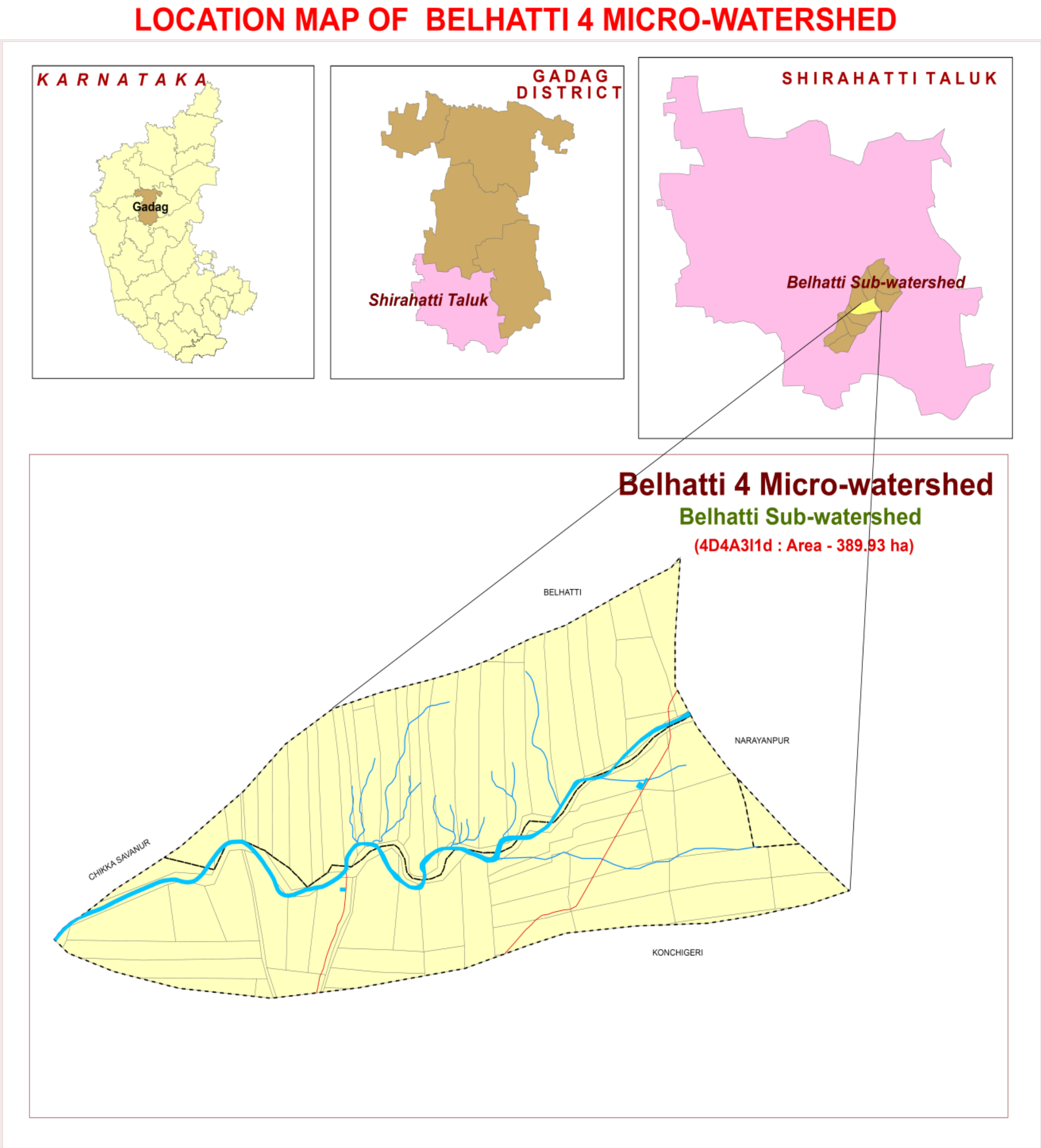


Fig.2.1 Location map of Belhatti-4 microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Peninsular Gneiss (Fig.2.2). The rocks are coarse to medium grained. They consist primarily of quartz, feldspar, biotite and hornblende. The gray granite gneisses are highly weathered, fractured and fissured upto a depth of about 10 m.

Fig.2.2 Granite gneiss

2.3 Physiography

Physiographically, the area has been identified asGranite gneiss landscapes based on geology. Based on slope and its relief features, the microwatershed area has been further divided into mounds/ridges, summits, side slopes and very gently sloping uplands. The elevation ranges from 564 to 581 m in the gently sloping uplands. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

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

2.5 Climate

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

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

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

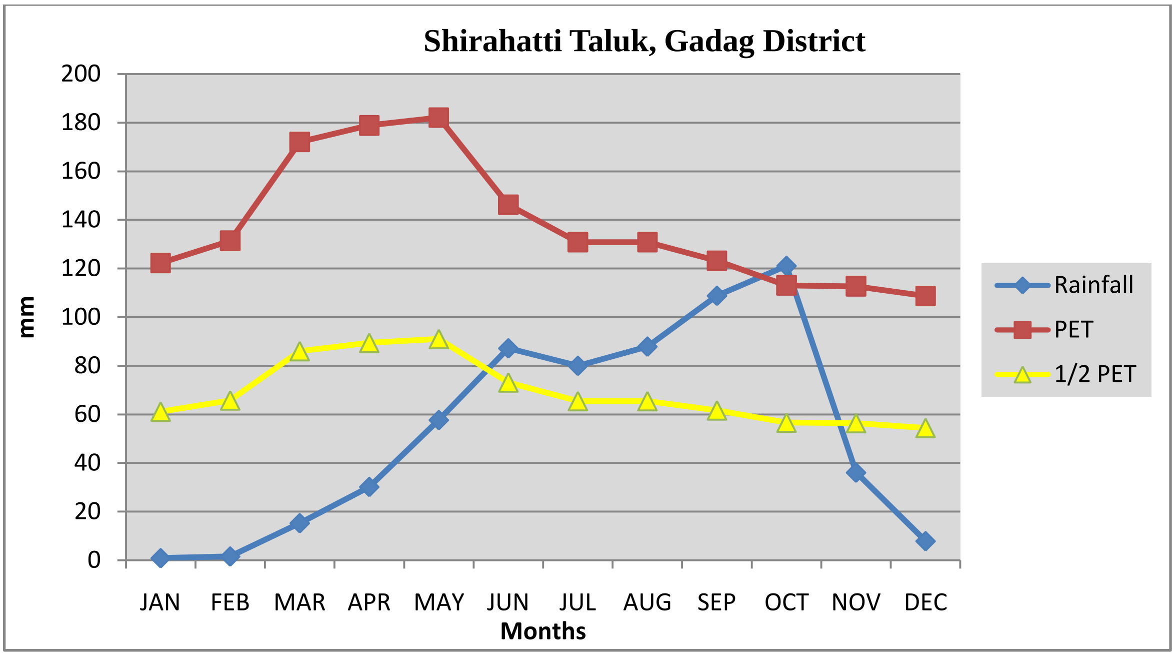


Fig. 2.3 Rainfall distribution in Shirahatti Taluk,Gadag District

2.6 Natural Vegetation

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

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

2.7 Land Utilization

About 77 per cent area (Table 2.2) in the Shirahatti taluk is cultivated at present and about 14 per cent of the area is sown more than once. An area of about 17 per cent is currently barren. Forests occupy a small area of about 1.6 per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are sorghum, maize, cotton, safflower, sunflower, onion, sugarcane, bengal gram and groundnut. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is prepared. The current land use map prepared shows the arable and non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Belhatti-4 microwatershed is presented in Fig.2.4.

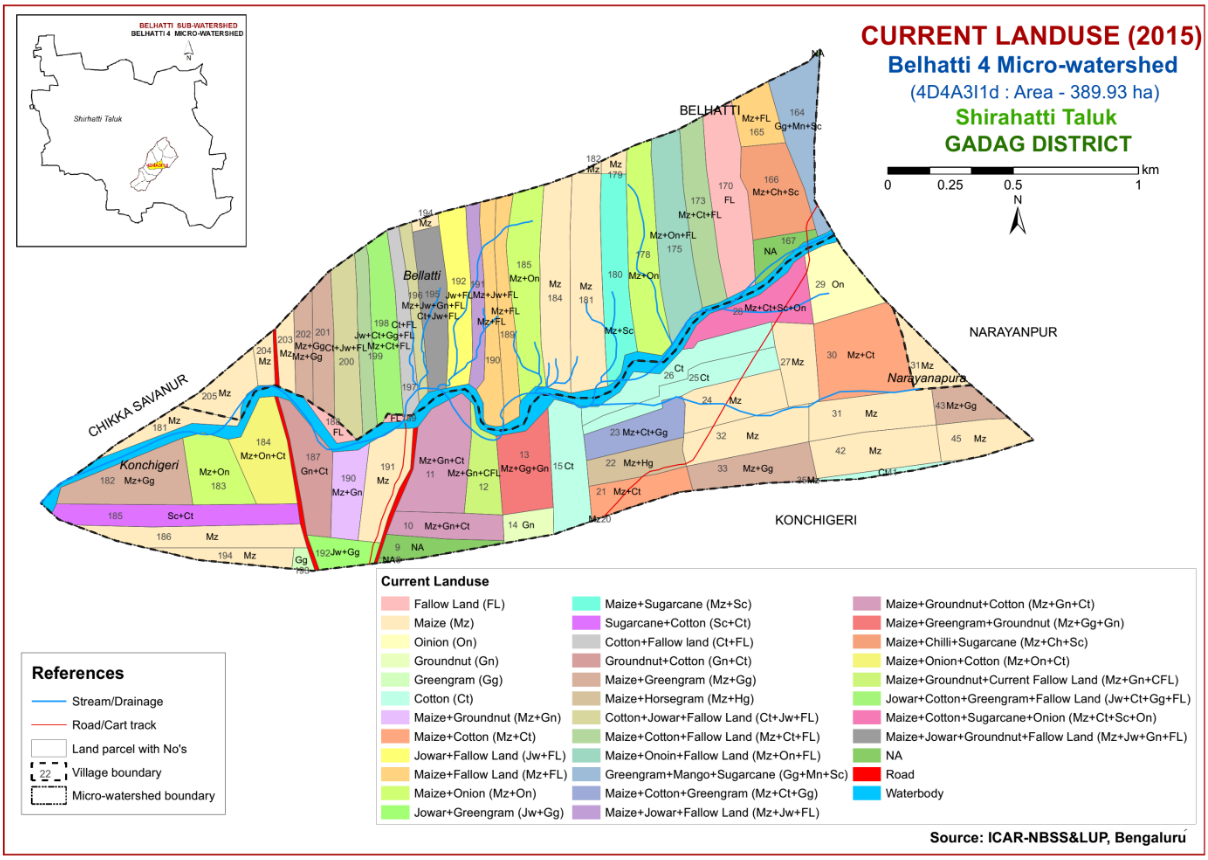


Fig.2.4 Current Land Use – Belhatti-4 microwatershed

Simultaneously, enumeration of wells (bore wells and open wells) in the microwatershed is made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells and other water bodies in the Belhatti-4 microwatershed in is given Fig.2.5.

Table 2.2 Land Utilization in Shirahatti Taluk

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

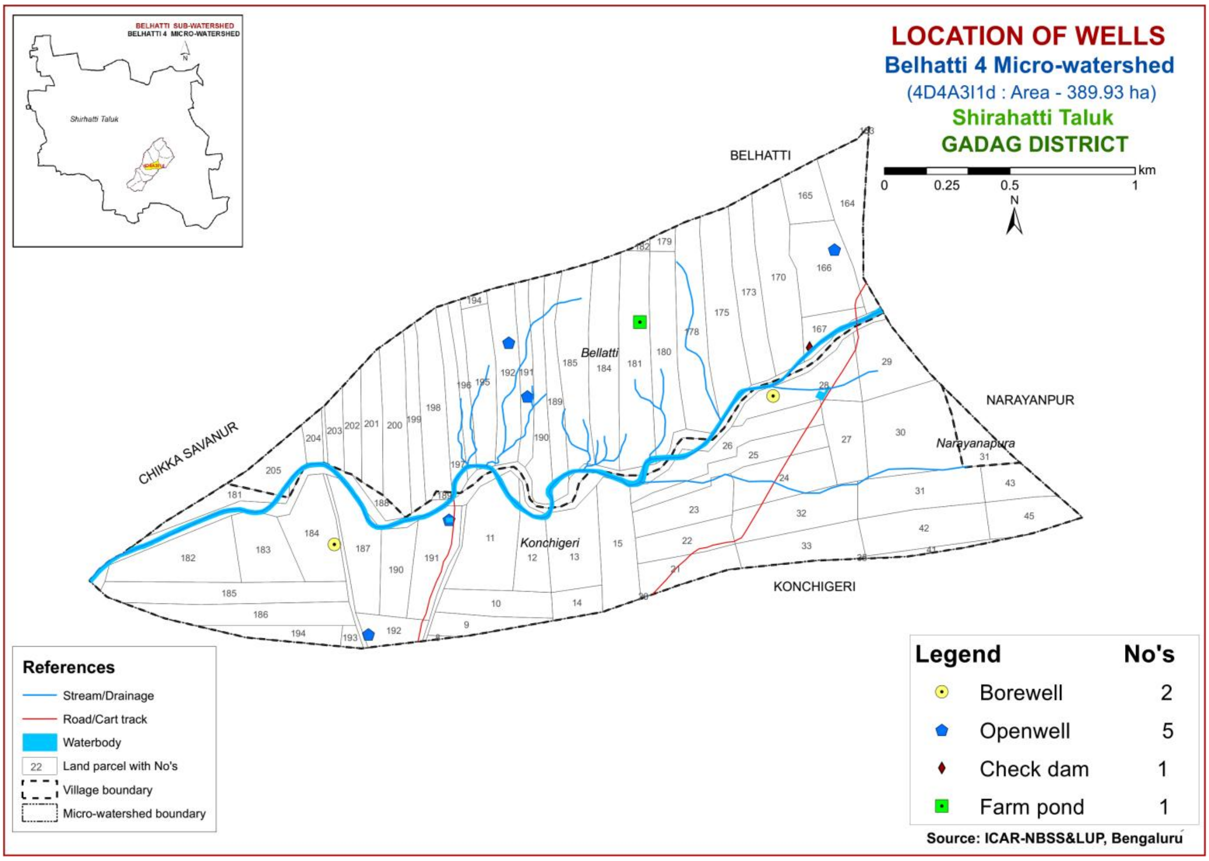
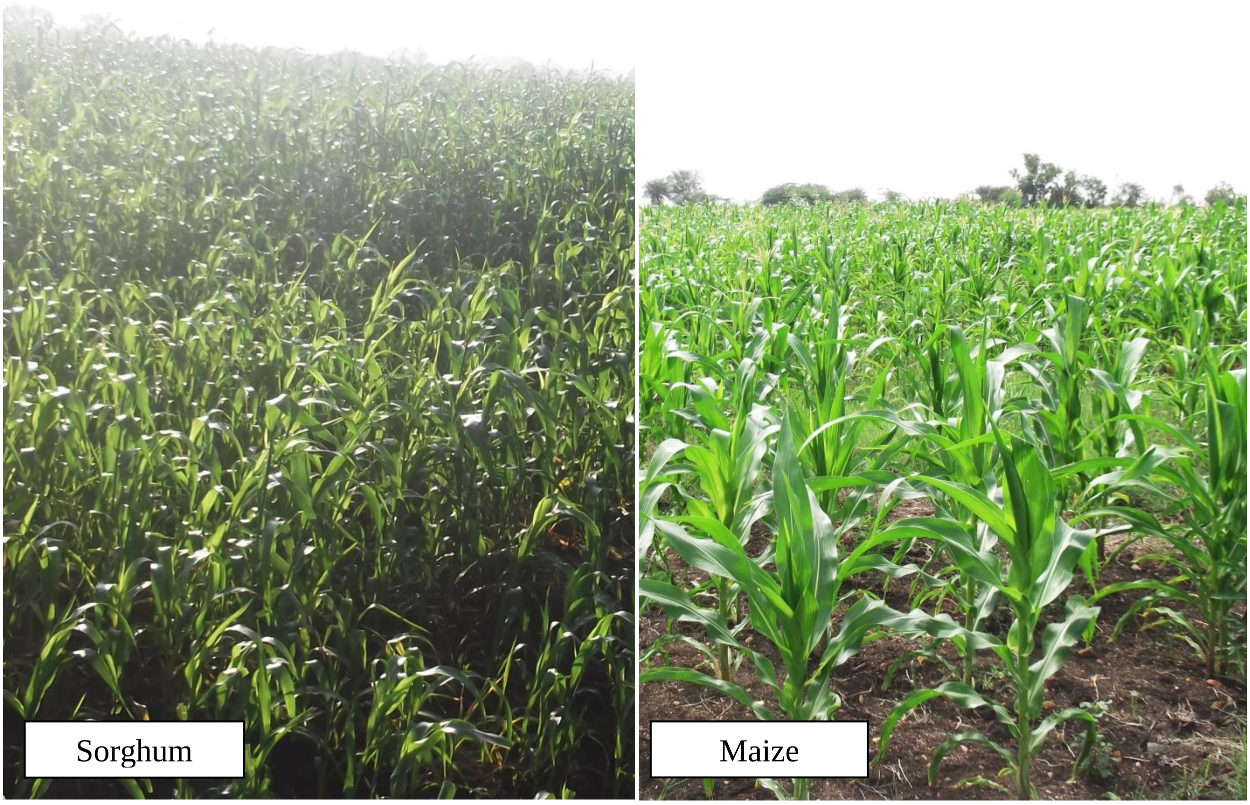
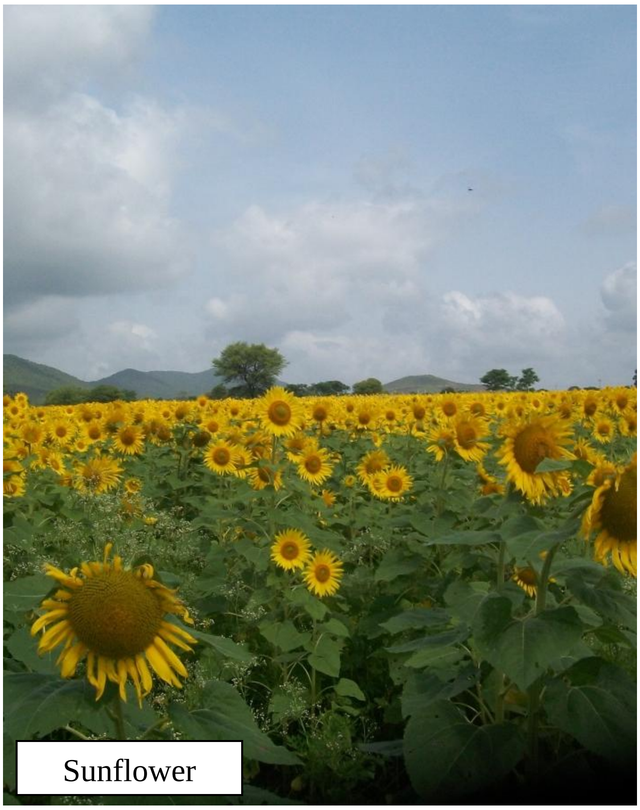


Fig.2.5 Location of Wells- Belhatti-4 microwatershed



Different crops and cropping systems in Belhatti-4 microwatershed



Different crops and cropping systems in Belhatti-4 microwatershed

Mango and Chillies

Pomegranate

Banana

Different crops and cropping systems in Belhatti-4 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 Belhatti-4 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.) 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 390 ha area. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

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

3.2 Image Interpretation for Physiography

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

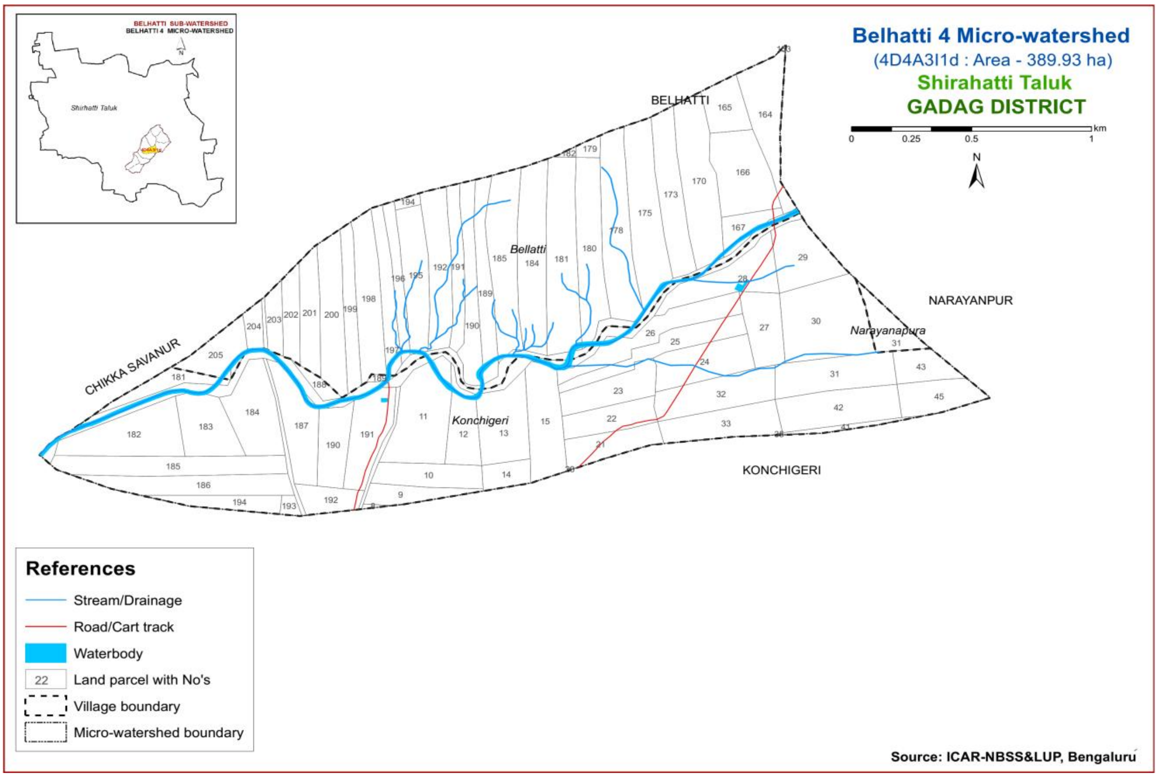


Fig 3.1 Scanned and Digitized Cadastral map of Belhatti-4 microwatershed

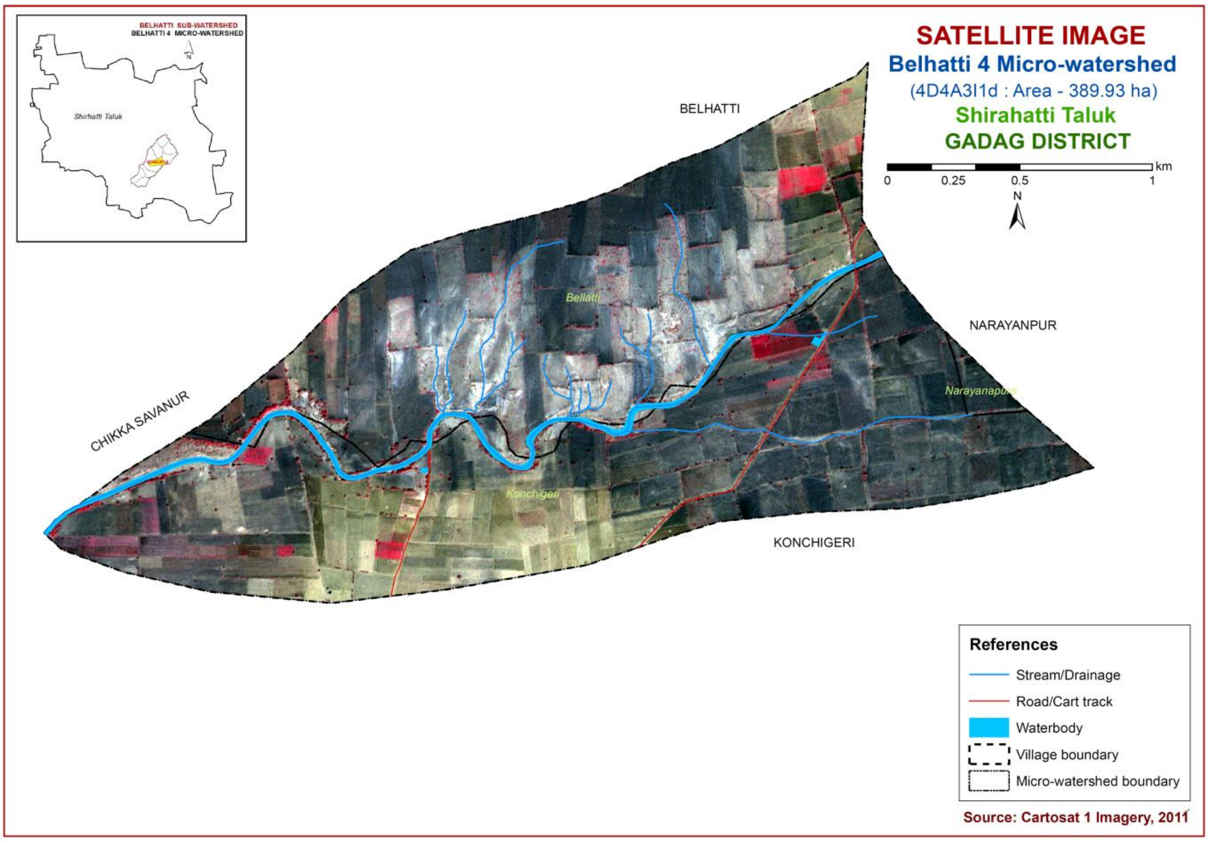


Fig.3.2 Satellite Image of Belhatti-4 microwatershed

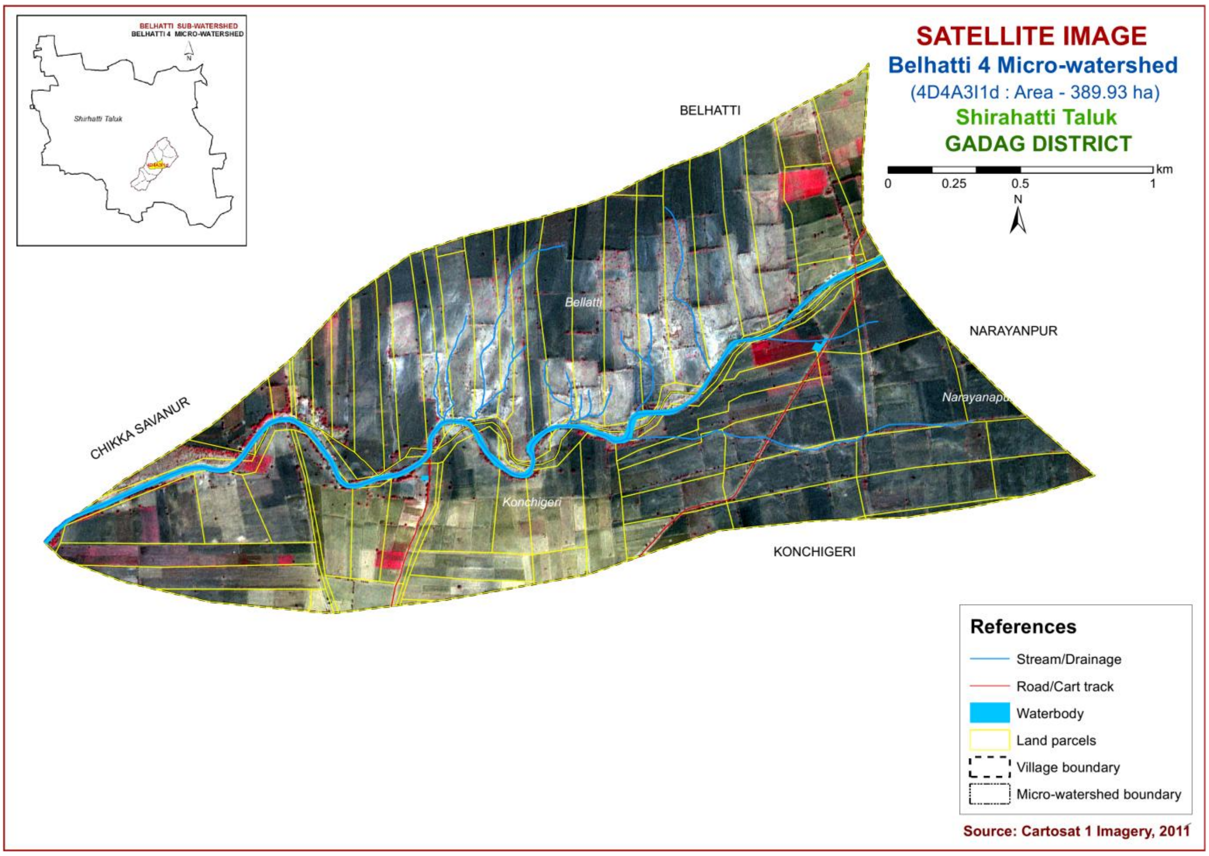


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Belhatti-4 microwatershed

3.3 Field Investigation

Preliminary traverse of the microwatershed was carried out with the help of cadastral map, imagery and toposheets. While traversing, landforms and physiographic units identified were checked and preliminary soil legend was prepared by studying soils at few selected places.

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, nallas, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Then, intensive traversing of each physiographic unit like hills, ridges and uplands was carried out. Based on the variability observed on the surface, transects were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

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

Based on the soil-site characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum 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 Belhatti-4 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**	**Text -ure**	**Gravel (%)**	**Horizon sequence**	**Calcare-ousness**
1	Muttal (Mtl)	25-50	10YR3/2,3/3,4/2 7.5YR3/2,3/3,6/4	sc-c	15-35	Ap-Bw-Ck	e-ev
2	Kutegouda-nahundi (Kgh)	50-75	7.5YR3/2	scl	15-35	Ap-Bt-Cr	-
3	Mukhadahalli (Mkh)	50-75	5YR3/3,3/4,4/3,5/4,6/6 2.5YR3/4	scl	>35	Ap-Bt-Cr	-

4	Ravanaki (Rnk)	50-75	7.5YR3/2,3/3,5/2,5/3 10YR3/1,3/2,4/1,4/2,5/1,6/1	sc-c	15-35	Ap-Bw-Cr	e-ev
5	Chikkame-gheri (Ckm)	75-100	2.5YR2.5/3,3/4, 3/6	sc	-	Ap-Bt-Cr	-
6	Balapur (Bpr)	100-150	2.5YR2.5/4,3/4	sc-c	>35	Ap-Bt-Cr	-
7	Lakshman-gudda (Lgd)	100-150	10YR3/1,3/2,4/1,4/2, 7.5YR3/1,3/2,5/1, 2.5Y5/2,5/3,6/3	sc-c	<15	Ap-Bss-Ck	e-es
8	Budagumpa (Bgp)	>150	7.5YR3/2,5/1 10YR4/1,4/4	c	10-20	Ap-Bw	es

3.4 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (65 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory. (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated for the microwatershed.

3.5 Finalization of Soil Maps

The area under each soil series was further separated into soil phases and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, slope, erosion, presence of gravel, stoniness etc. A soil phase is a subdivision of soil series based mostly on surface features that affect its use and management.

The soil mapping units are shown on the map (Fig.3.4) in the form of symbols. During the survey about 10 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. All the profile locations are indicated on the village cadastral map in the form of a triangle. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.

The soil map shows the geographic distribution of 17 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 17 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and they have to be treated accordingly.

The 17 soil phases identified and mapped in the microwatershed were regrouped into 7 Land Management Units (LMU's) for the purpose of preparing a proposed land use plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Management Units (LMUs) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LMUs. For Belhatti-4 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

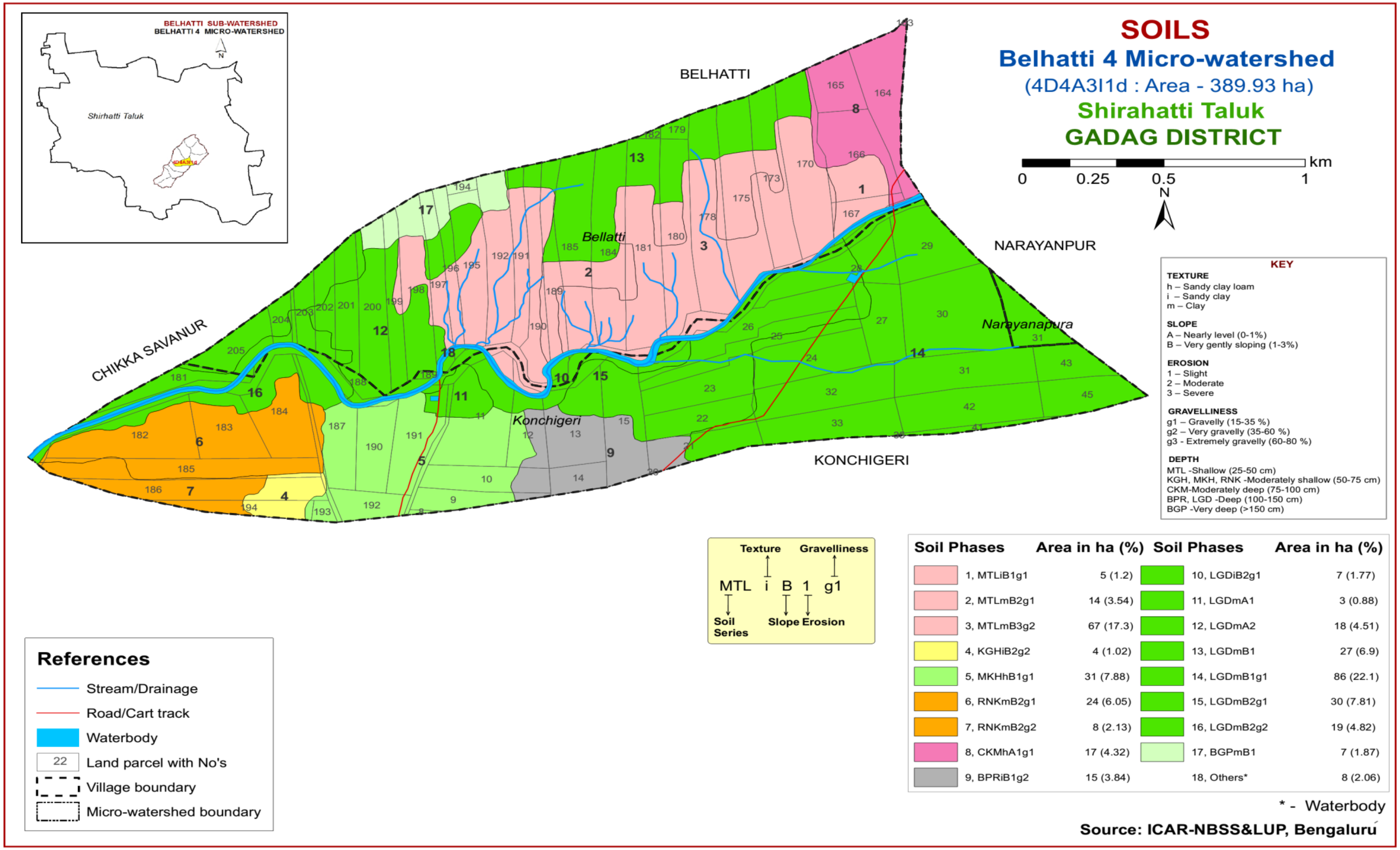


Fig 3.4 Soil Phase or management units- Belhatti-4 microwatershed

Table 3.2 Soil Legend

Soil map unit No.	Soil Series	Soil Phases	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	MTL	Muttal soils are shallow (25-50 cm), well drained, have dark brown to very dark greyish brown calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**85.95 (22.04)**
1		MTLiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	4.69 (1.20)
2		MTLmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	13.80 (3.54)
3		MTLmB3g2	Clay surface, slope 1-3%, severe erosion, very gravelly (35-60%)	67.46 (17.30)
	KGH	Kutegoudanahundi soils are moderately shallow (50-75 cm), well drained, have brown to dark brown loamy sand to sandy loam soils occurring on very gently sloping uplands under cultivation		**3.97 (1.01)**
4		KGHiB2g2	Sandy clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	3.97 (1.01)
	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under cultivation		**30.71 (7.87)**
5		MKHhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	30.71 (7.87)
	RNK	Ravanaki soils are moderately shallow (50-75 cm), well drained, black calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**31.90 (8.18)**
6		RNKmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	23.59 (6.05)
7		RNKmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	8.31 (2.13)
	CKM	Chikkamegheri soils are moderately deep (75-100 cm), well drained, have dark brown to dark reddish brown sandy clay soils occurring on nearly level uplands under cultivation		**16.83 (4.31)**
8		CKMhA1g1	Sandy clay loam surface, slope 0-1%, slight erosion, gravelly (15-35%)	16.83 (4.31)
	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**14.98 (3.84)**

9		BPRiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)	14.98 (3.84)
	LGD	Lakshmangudda soils are deep (100-150 cm), well drained, have light olive brown to very dark gray calcareous clay soils occurring on nearly level to very gently sloping uplands under cultivation		**135.42 (48.76)**
10		LGDiB2g1	Sandy clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	6.89 (1.76)
11		LGDmA1	Clay surface, slope 0-1%, slight erosion	3.43 (0.88)
12		LGDmA2	Clay surface, slope 0-1%, moderate erosion	17.60 (4.51)
13		LGDmB1	Clay surface, slope 1-3%, slight erosion	26.92 (6.90)
14		LGDmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	86.19 (22.10)
15		LGDmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	30.44 (7.80)
16		LGDmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	18.79 (4.81)
	BGP	Budagumpa soils are very deep (>150 cm), moderately well drained, black calcareous clay soils occurring on very gently sloping uplands under cultivation		**7.29 (1.86)**
17		BGPmB1	Clay surface, slope 1-3%, slight erosion	7.29 (1.86)
18		Waterbody		8.03 (2.05)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Belhatti-4 microwatershed is provided in this chapter. The microwatershed area has been identified as Granite gneiss landscape based on geology. In all, 8 soil series were identified in the Granite gneiss landscape. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In granite gneiss landscape, soil formation is dominantly influenced by the parent material, climate and relief.

A brief description of each of the 8 soil series identified followed by 17 soil phases (management units) mapped under each series (Fig. 3.4) are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite gneiss Landscape

In this landscape, 8 soil series are identified and mapped. Of these, Lakshmangudda (LGD) soil series occupies maximum area of about 135 ha (49%). The brief description of each soil series and their phases identified in the microwatershed are given below.

4.1.1 Muttal (MTL) Series: Muttal soils are shallow (25-50 cm), well drained, have dark brown to very dark grayish brown, calcareous sandy clay to clay soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands.

The thickness of the solum ranges from 30 to 50 cm. The thickness of A horizon ranges from 15 to 18 cm. Its colour is in 7.5 YR and 10 YR hue with value 2 to 3 and chroma 2.5 to 4. The texture varies from sandy clay to clay with 10 to 15 per cent gravel. The thickness of B horizon ranges from 18 to 32 cm. Its colour is in 10 YR and 7.5 YR hue with value 2 to 6 and chroma 2 to 4. Its texture is sandy clay to clay with gravel content of 15 to 35 per cent. The available water capacity is very low (<50 mm/m).

Three phases identified are briefly described below:

MTLiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
MTLmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)
MTLmB3g2	Clay surface, slope 1-3%, severe erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Muttal (MTL) Series

4.1.2 Kutegoudanahundi (KGH) Series: Kutegoudanahundi soils are moderatly shallow (50-75 cm), well drained, have brown to dark brown loamy sand to sandy loam soils. They have developed from granite gneiss and occur on very gently sloping uplands.

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 very low (<50 mm/m).

Only one phase was identified:

KGHiB2g2	Sandy clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Kutegoudanahundi (KGH) Series

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

The thickness of the solum ranges from 51 to 72 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from loamy sand to sandy loam with 20 to 45 per cent gravel. The thickness of B horizon ranges from 40 to 68 cm. Its colour is in 2.5 YR and 5 YR hue with value and chroma 3 to 6. Texture is sandy clay loam to sandy clay with 35 to 50 per cent gravel. The available water capacity is very low (<50 mm/m).

Only one phase was identified:

MKHhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)

Landscape and Soil Profile Characteristics of Mukhadahalli (MKH) Series

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

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

Two phases identified:

RNKmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)
RNKmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Ravanaki (RNK) Series

4.1.5 Chikkamegheri (CKM) Series: Chikkamegheri soils are moderately deep (75-100 cm), well drained, have dark brown to dark reddish brown sandy clay soils. They have developed from granite gneiss and occur on nearly level uplands under cultivation.

The thickness of the solum ranges from 78 to 99 cm. The thickness of A horizon ranges from 12 to 19 cm. Its colour is in 2.5 YR and 5 YR hue with value 2 to 3 and chroma 3 to 4. The texture varies from sandy clay loam to sandy clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 68 to 88 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 3 to 6. Its texture is sandy clay to clay with gravel content of <15 per cent. The available water capacity is low (51-100 mm/m).

Only one phase was identified:

CKMhA1g1	Sandy clay loam surface, slope 0-1%, slight erosion, gravelly (15-35%)

Landscape and Soil Profile Characteristics of Chikkamegheri (CKM) Series

4.1.6 Balapur (BPR) Series: Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils. They are developed from weathered granite gneiss and occur on very gently to gently sloping uplands.

The thickness of the solum ranges from 102 to 147 cm. The thickness of A horizon ranges from 12 to 17cm. Its colour is in 5 YR and 2.5 YR hue with value and chroma 3 to 4. The texture ranges from loamy sand to sandy clay with 15 to 50 per cent gravel. The thickness of B horizon ranges from 90 to 132 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 4 to 6. Texture is sandy clay to clay with 35 to 50 per cent gravel. The available water capacity is low (51-100 mm/m).

Only one phase was identified:

BPRiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Balapur (BPR) Series

4.1.7 Lakshmangudda (LGD) Series: Lakshmangudda soils are deep (100-150 cm), moderately well drained, have light olive brown to very dark gray, calcareous clay soils. They have developed from granite gneiss and occur on very gently sloping uplands.

The thickness of the solum ranges from 108 to 149 cm. The thickness of A horizon ranges from 16 to 20 cm. Its colour is in 7.5 YR and 10 YR hue with value and chroma 3 to 4. The texture varies from sandy clay to clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 90 to 130 cm. Its colour is in 2.5 Y, 10 YR and 7.5 YR hue with value 3 to 6 and chroma 1 to 3. Its texture is sandy clay to clay. These soils are calcareous that increase with depth. The available water capacity is very high (>200 mm/m).

Seven phases were identified:

LGDiB2g1	Sandy clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)
LGDmA1	Clay surface, slope 0-1%, slight erosion
LGDmA2	Clay surface, slope 0-1%, moderate erosion
LGDmB1	Clay surface, slope 1-3%, slight erosion
LGDmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
LGDmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)
LGDmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Lakshmangudda (LGD) Series

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

The thickness of the solum ranges from 120 to 180 cm. The thickness of A horizon ranges from 16 to 26 cm. Its colour is in 7.5 YR and 10 YR hue with value 2 to 3 and chroma 2 to 4. The texture varies from sandy clay to clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 135 to 170 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 5 and chroma 1 to 4. Its texture is clay with gravel content of 10 to 20 per cent. These soils are calcareous that increase with depth. The available water capacity is very high (>200 mm/m).

Only one phase was identified:

BGPmB1	Clay surface, slope 1-3%, slight erosion

Landscape and Soil Profile Characteristics Budagumpa (BGP) 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, texture, coarse fragments, available water capacity, soil slope, soil erosion, soil reaction etc., are interpreted from the data base generated through the land resource inventory and several thematic maps are generated. These would help in identifying the areas suitable for growing crops and conservation structures needed thus helping to maintain good soil health for sustained crop production. The various interpretative and theme maps generated are described below.

5.1 Land Capability Classification

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The 17 soil map units identified in the Belhatti-4 microwatershed are grouped under 3 land capability classes and 6 land capability subclasses (Fig. 5.1). About 98 per cent area in the microwatershed is suitable for agriculture and about 2 percent not suitable for agriculture but well suited to pasture, forestry, silvi-pastoral system, agri-horti-silvipastoral system, mining, quarrying, location of wind mills and as habitat for wildlife and recreation.

Of the lands suitable for agriculture, about 141 ha (36%) are good cultivable lands (Class II) with minor limitations of soil characteristics and soil erosion and are distributed in the weastern, eastern and southeastern part of the microwatershed.

Moderately good cultivable lands (Class III) cover an area of about 174 ha (45%) and are distributed in the central, western and northern part of the microwatershed with moderate problems of erosion and soil.

The fairly good lands (class IV) cover about 67 ha (17%). They have very severe limitations of erosion and shallow rooting depth and are distributed in the central part of the microwatershed.

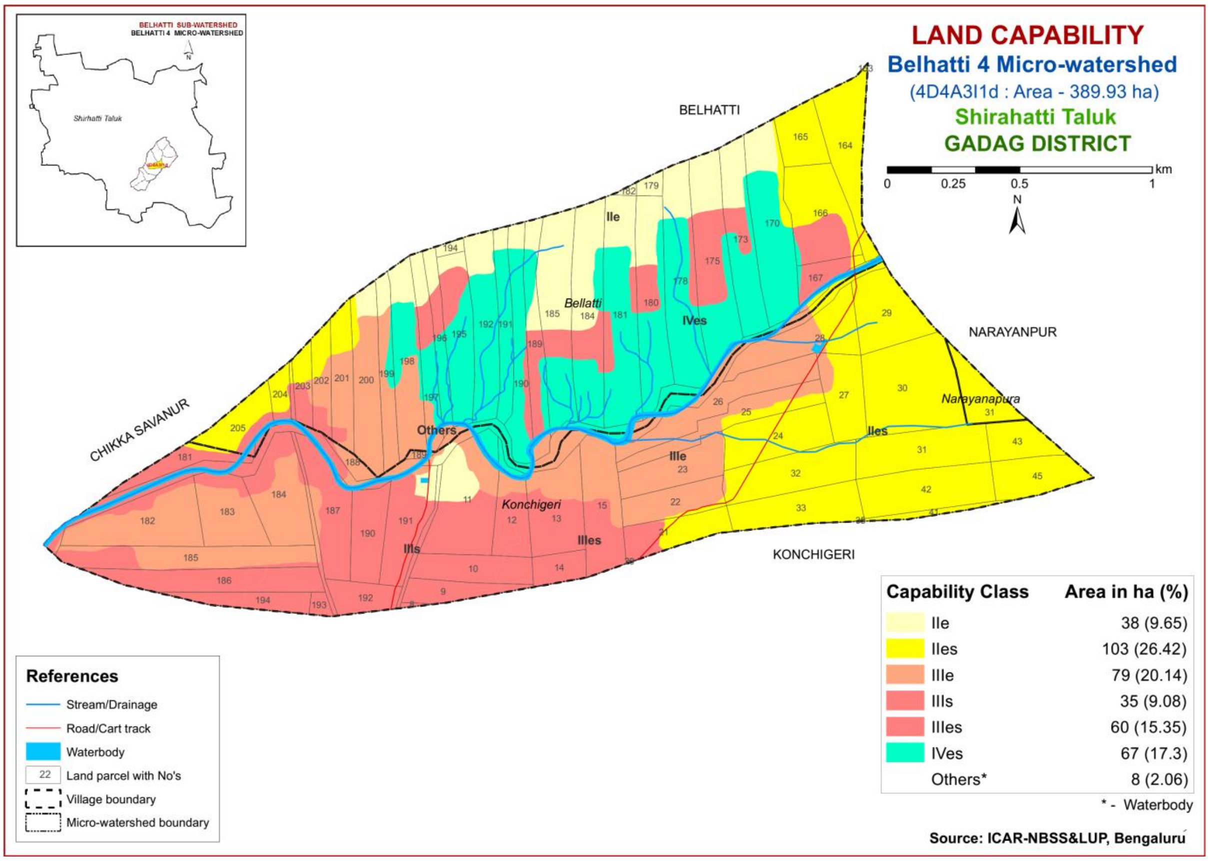


Fig. 5.1 Land Capability map of Belhatti-4 microwatershed

5.2 Soil Depth

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

Deep soils (100-150 cm) occupy maximum area of about 205 ha (53%) and are distributed all over the microwatershed. Moderately shallow (50-75 cm) soils occupy about 67 ha (17%) and are distributed in the southwestern part of the microwatershed. Moderately deep (75-100 cm) soils occupy a small area of about 17 ha (4%) in the northeastern part of the microwatershed. Very deep soils (>150 cm) occur in small extent of about 7 ha (2%) and are distributed in the northern part of the microwatershed. Shallow soils (25-50 cm) occupy about 86 ha (22%) in the central part of the microwatershed.

The most productive lands (55%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep soils (100 to >150 cm depth) occurring in all parts of the microwatershed.

The most problematic lands (22%) having shallow (25-50 cm) rooting depth occur in the central part of the microwatershed. They are not suitable for growing agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal.

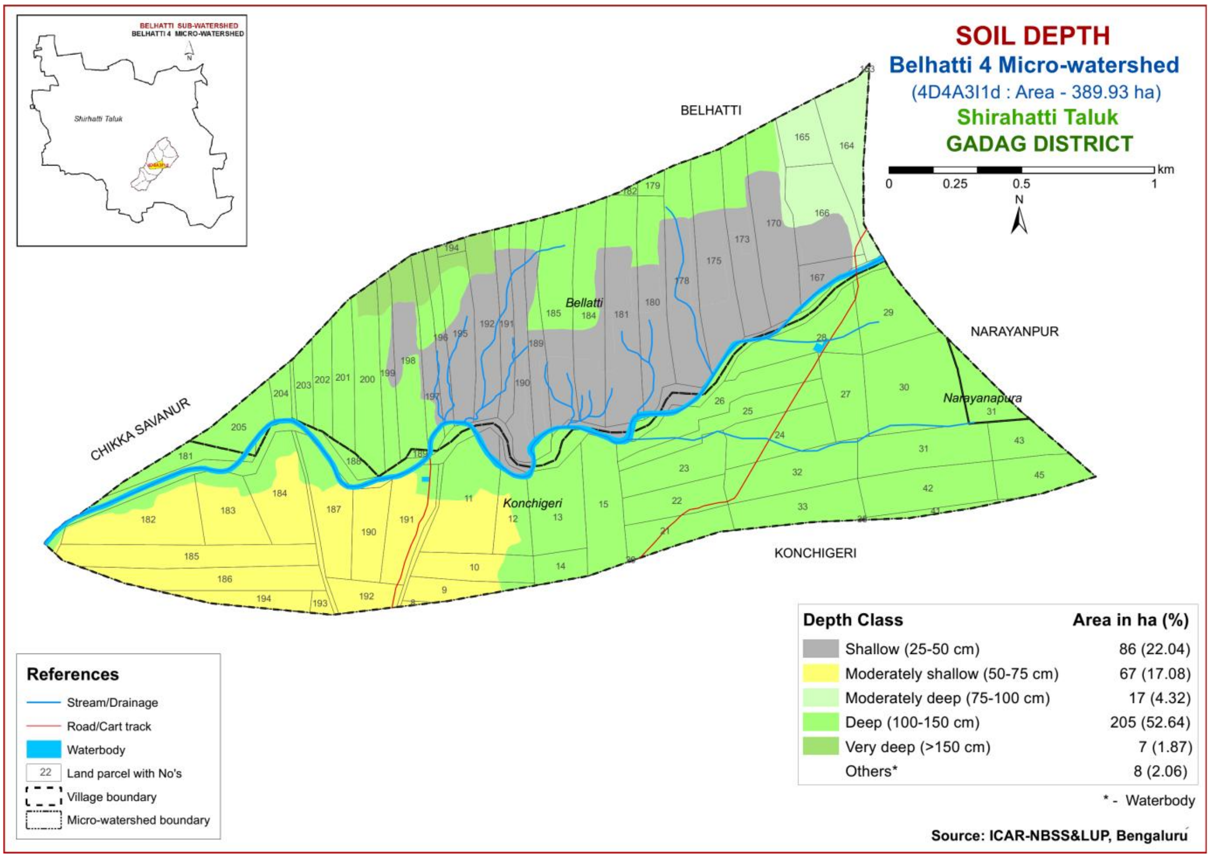


Fig. 5.1 Soil Depth map of Belhatti-4 microwatershed

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.

Maximum area of 335 ha (86%) has soils that are clayey at the surface and are distributed all over the microwatershed and minor area has soils that are sandy clay loam (48 ha, 12%). They are distributed in the southern and northeastern part of the microwatershed (Fig. 5.3).

The most productive lands (86%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but have problems of drainage, infiltration, workability and other physical problems.

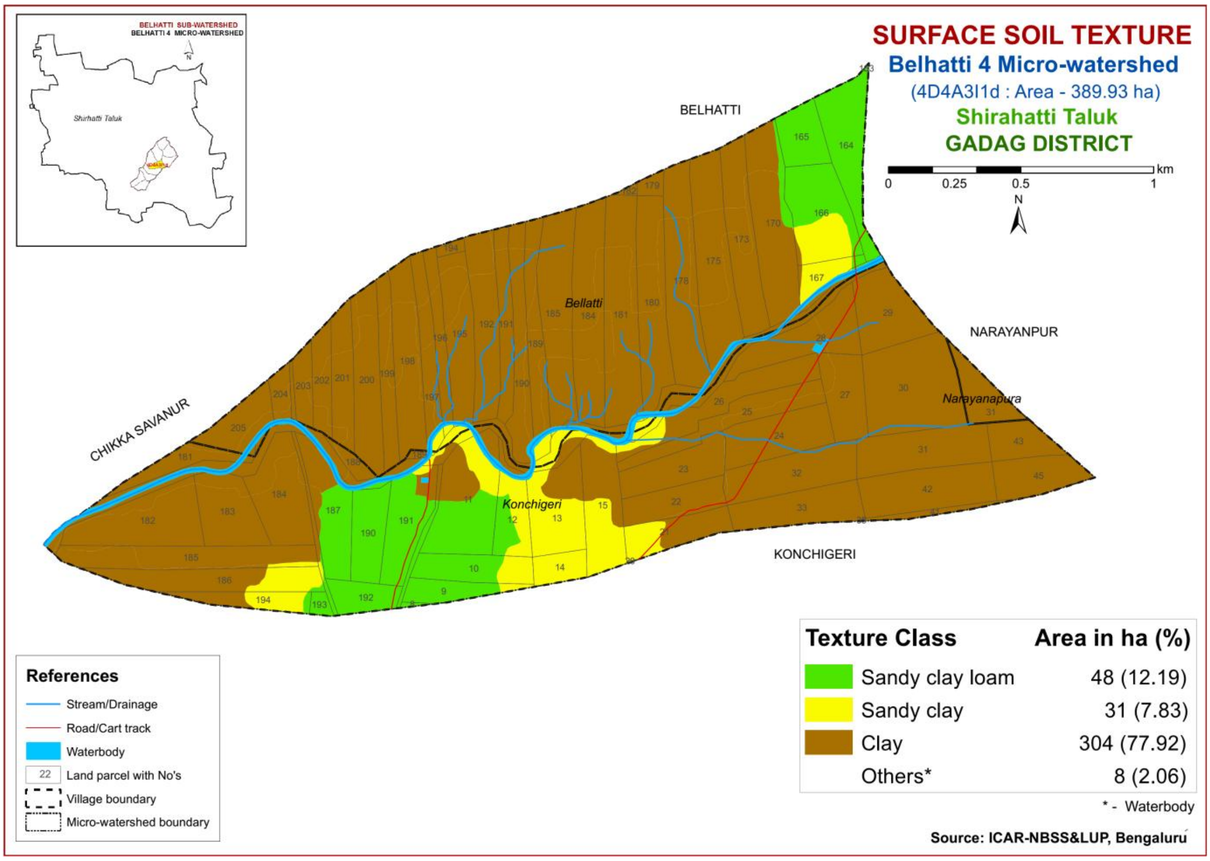


Fig. 5.3 Surface Soil Texture map of Belhatii-4 microwatershed

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.

Maximum area in the microwatershed has soils that are gravelly (15-35%) covering about 213 ha (55%) and are distributed in all parts of the microwatershed (Fig. 5.4) followed by soils that are very gravelly (35-60%) covering about 114 ha (29%) and are distributed in the central, western and southern part of the microwatershed. The soils that are nongravelly (<15%) covering about 55 ha (14%) are distributed in the northern and central part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 15 %. They are non-gravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops. The problem soils (29%) that are very gravelly (35-60%) where only short duration crops can be grown.

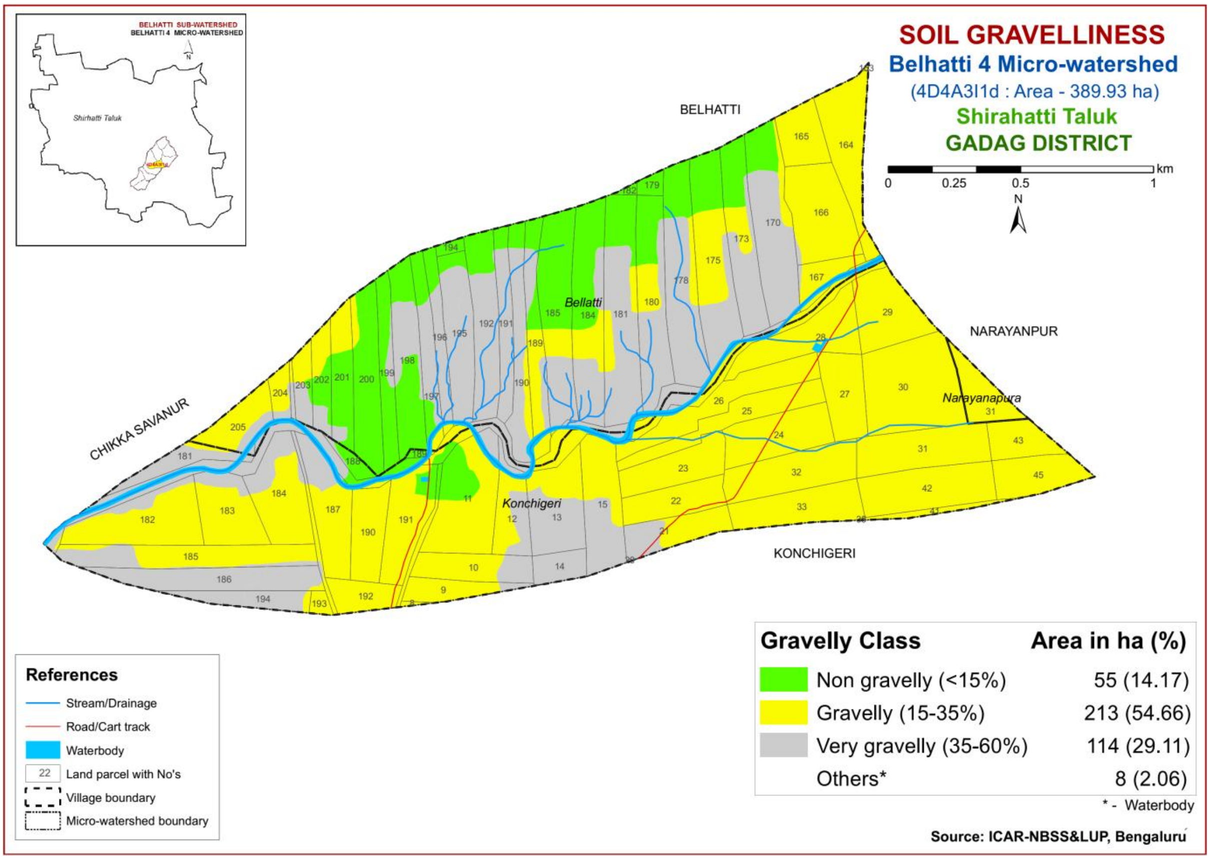


Fig. 5.4 Soil Gravelliness map of Belhatti-4 microwatershed

5.5 Available Water Capacity

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

Major area of about 198 ha (51%) in the microwatershed has soils that have very high (>200 mm/m) available water capacity and are distributed in the western, southeastern and northern part of the microwatershed.

An area of about 154 ha (39%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the western, central and northeastern part of the microwatershed. A small area of about 31 ha (8%) has soils that are very low (<50 mm/m) in available water capacity in the microwatershed.

About 185 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 about 198 ha (51%) has soils that have very high (>200 mm/m) with regard to available water capacity where all climatically adapted long duration crops can be grown successfully.

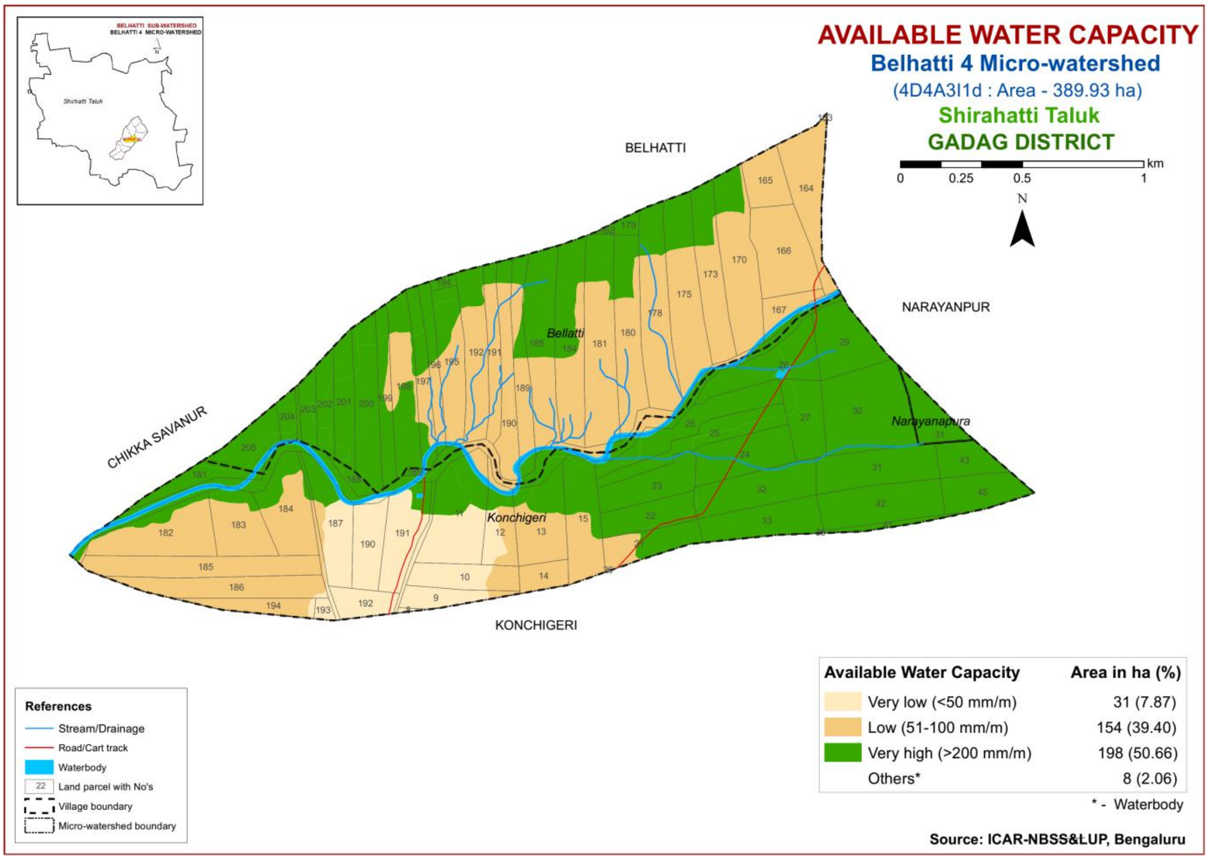


Fig. 5.5 Soil Available Water Capacity map of Belhatti-4 microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3% slope) class. It covers an area of about 344 ha (88%) and is distributed in all parts of the microwatershed. It is followed by nearly level (0-1% slope) slope class. It covers small area of about 38 ha (10%) and is distributed in the northeastern and central part of the microwatershed.

An area of about 98 per cent 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.

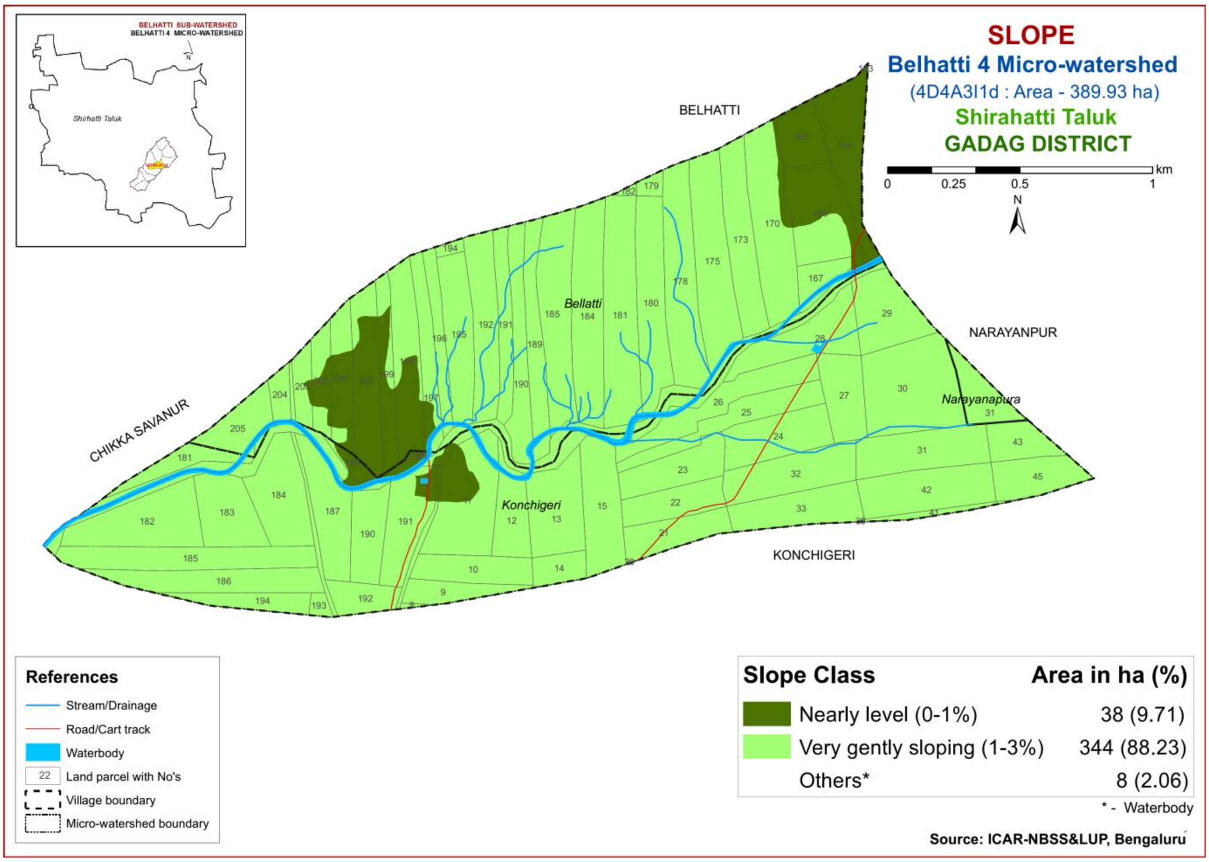


Fig. 5.6 Soil Slope map of Belhatti-4 microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover an area of about 191 ha (49%) in the microwatershed. They are distributed in the northern, eastern and southern part of the microwatershed. Moderately eroded (e2 class) soils cover an area of about 123 ha (32%) and are distributed in the central and western part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 67 ha (17%) and are distributed in the central part of the microwatershed.

An area of about 191 ha (49%) is relatively stable terrain which needs minimum soil and water conservation measures.

An area of about 67 ha (17%) in the microwatershed is problematic because of severe erosion. Top priority is to be given to these areas for taking up soil and water conservation and other land development measures. Next in priority would be an area of about 123 ha (32%) where the soils are moderately eroded.

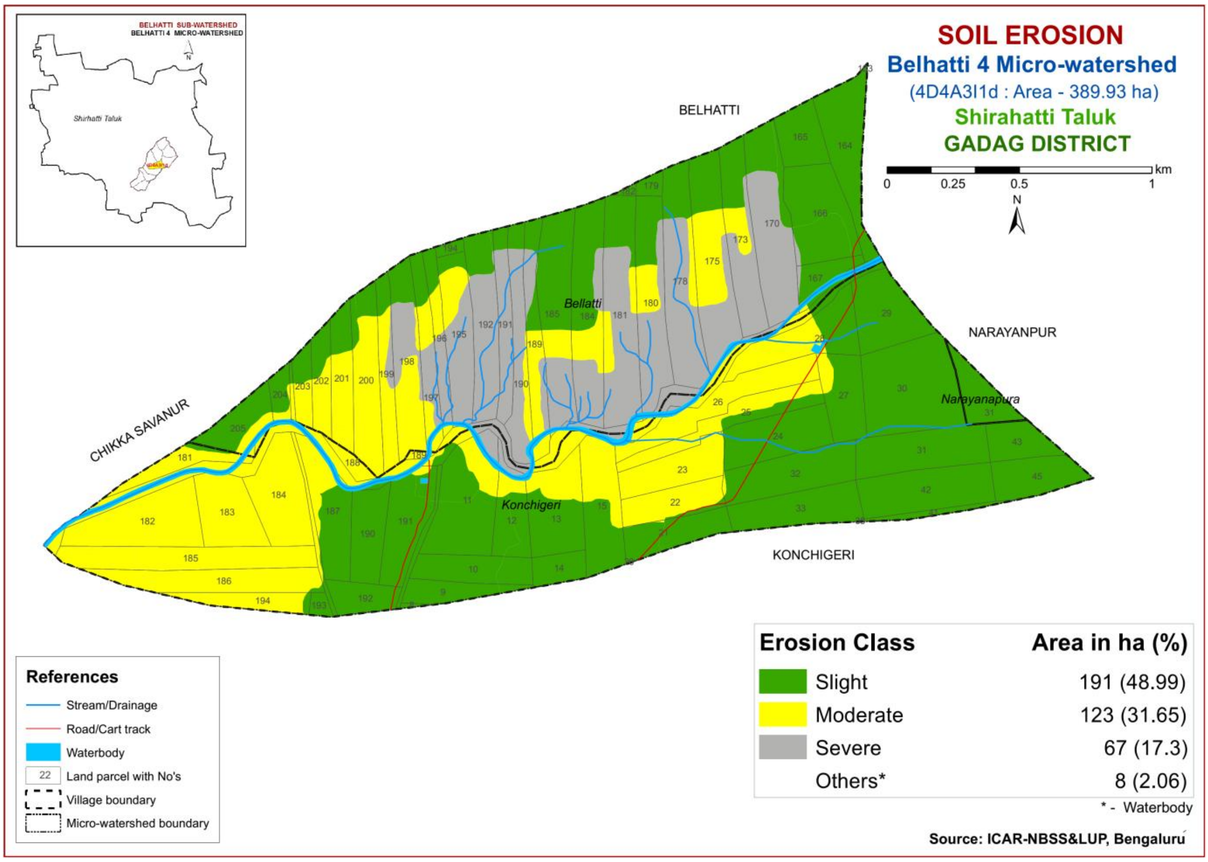


Fig. 5.7 Soil Erosion map of Belhatti-4 microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, 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 prepared. The village/survey number wise fertility data for the microwatershed is given in Appendix-II.

6.1 Soil Reaction (pH)

The soil fertility analysis of the Belhatti-4 microwatershed for soil reaction (pH) showed that about small area of 56 ha (14%) is moderately alkaline (pH 7.8-8.4) and is distributed in the northeastern and central part of the microwatershed. About 155 ha (40%) area (Fig.6.1) is under strongly alkaline (pH 8.4-9.0) and is distributed in all parts of the microwatershed followed by an area of about 139 ha (36%) is under very strongly alkaline (pH >9.0) and is distributed in the central, northern and southeastern part of the microwatershed. A very small area of 21 ha (5%) is slightly alkaline (pH 7.3-7.8) and is distributed in the southern part of the microwatershed and about 11 ha (3%) area is neutral (pH 6.5-7.3) in reaction and is distributed in the southern part of the microwatershed.

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content in the microwatershed area is medium (0.5-0.75%) covering about 227 ha (58%) and is distributed in all parts of the microwatershed. The low organic carbon content accounts for 155 ha (40%) area and is distributed in the central, northern and southern part of the microwatershed (Fig.6.3).

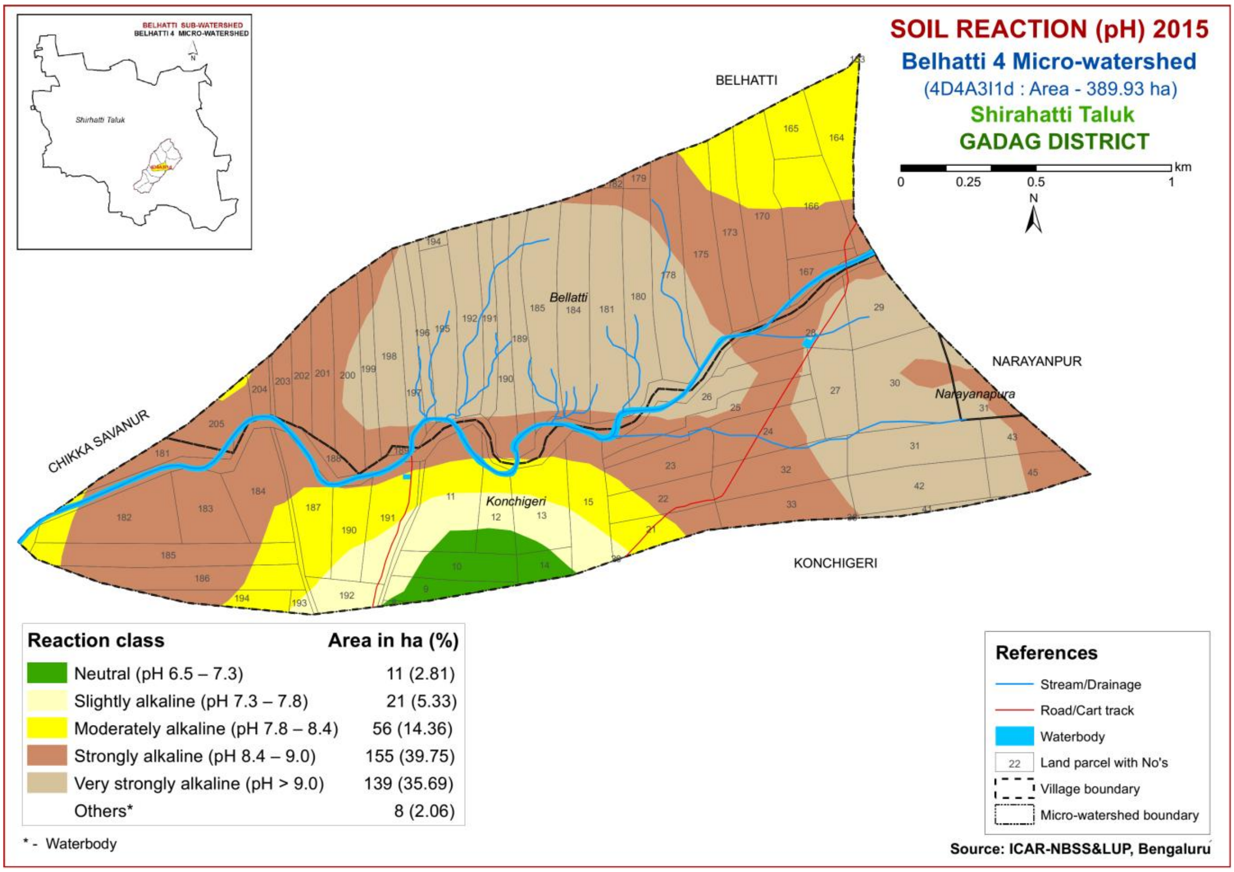


Fig.6.1 Soil Reaction (pH) map of Belhatti-4 microwatershed

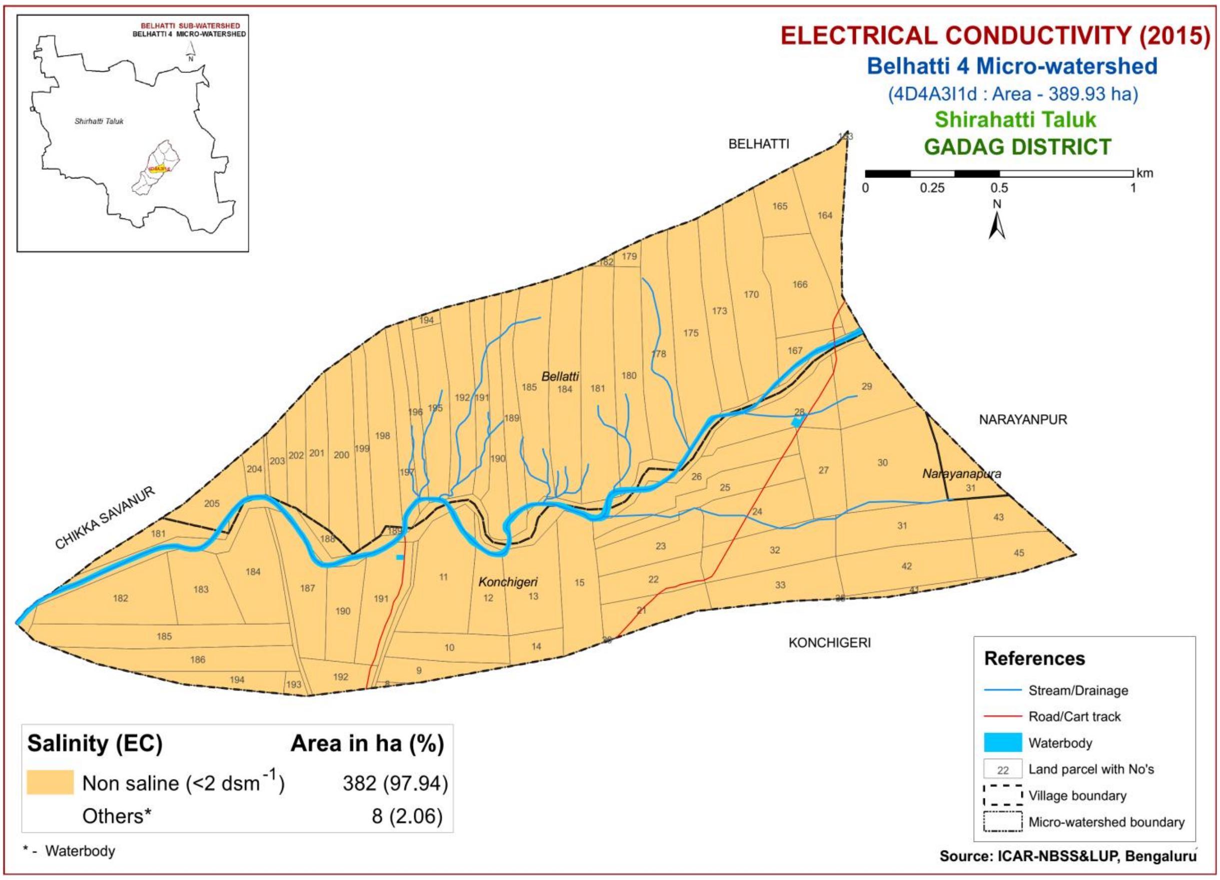


Fig.6.2 Electrical Conductivity (EC) map of Belhatti-4 microwatershed

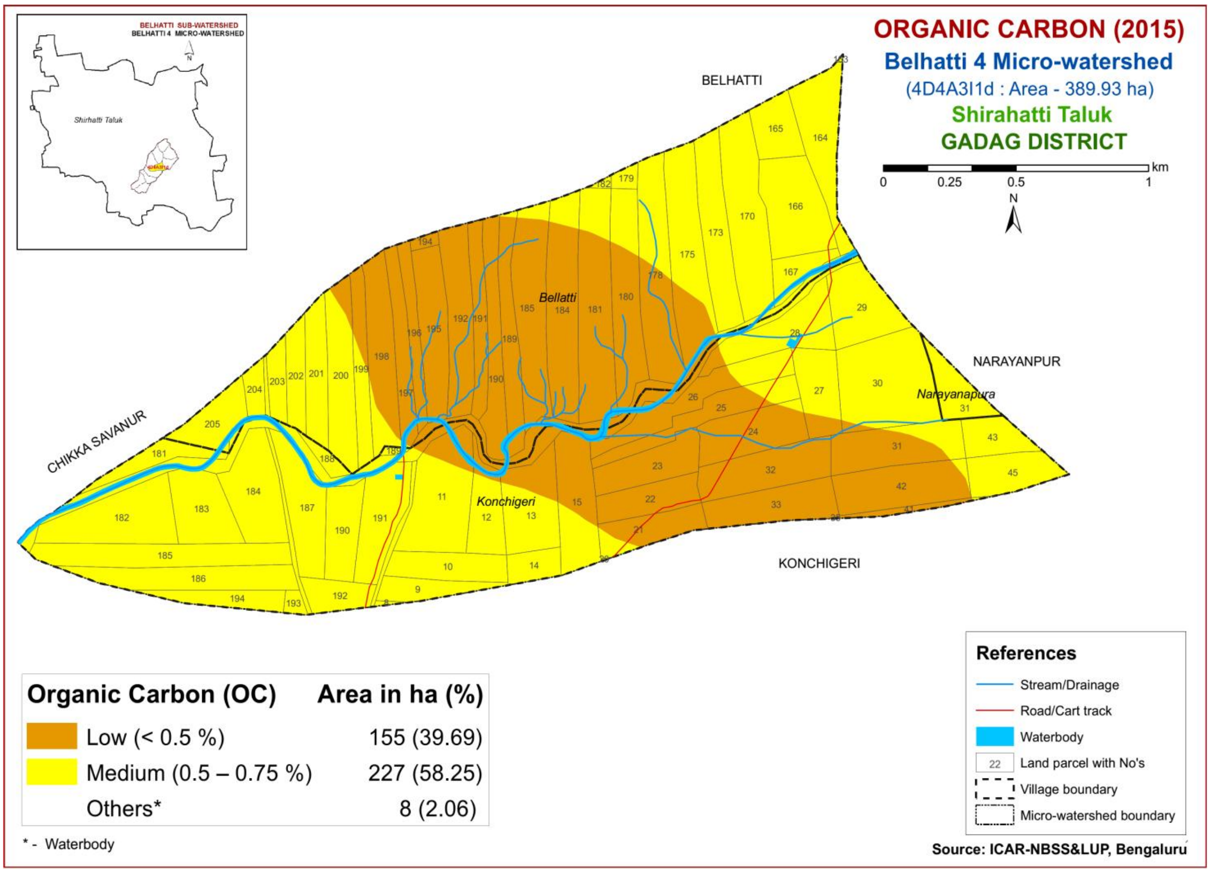


Fig.6.3 Soil Organic Carbon map of Belhatti-4 microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in major area of 353 ha (91%) and is distributed in all parts of the microwatershed (Fig.6.4). There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. A small area of 29 ha (7%) is medium in available phosphorus (23-57 kg/ha) and is distributed in the northwestern part of the microwatershed.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in 166 ha (43%) area and is distributed in the western and southern part of the microwatershed (Fig.6.5); high available potassium (>337 kg/ ha) content accounts for major area of 216 ha (55%) and is distributed in the southeastern, northern and northeastern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in small area of 12 ha (3%) and is distributed in the southern part of the microwatershed. Maximum area of about 205 ha (52%) is medium (10-20 ppm) in available sulphur and is distributed in all parts of the microwatershed (Fig.6.6). Available sulphur is high (>20 ppm) in area of about 166 ha (42%) and is distributed in the northern and eastern part of the microwatershed.

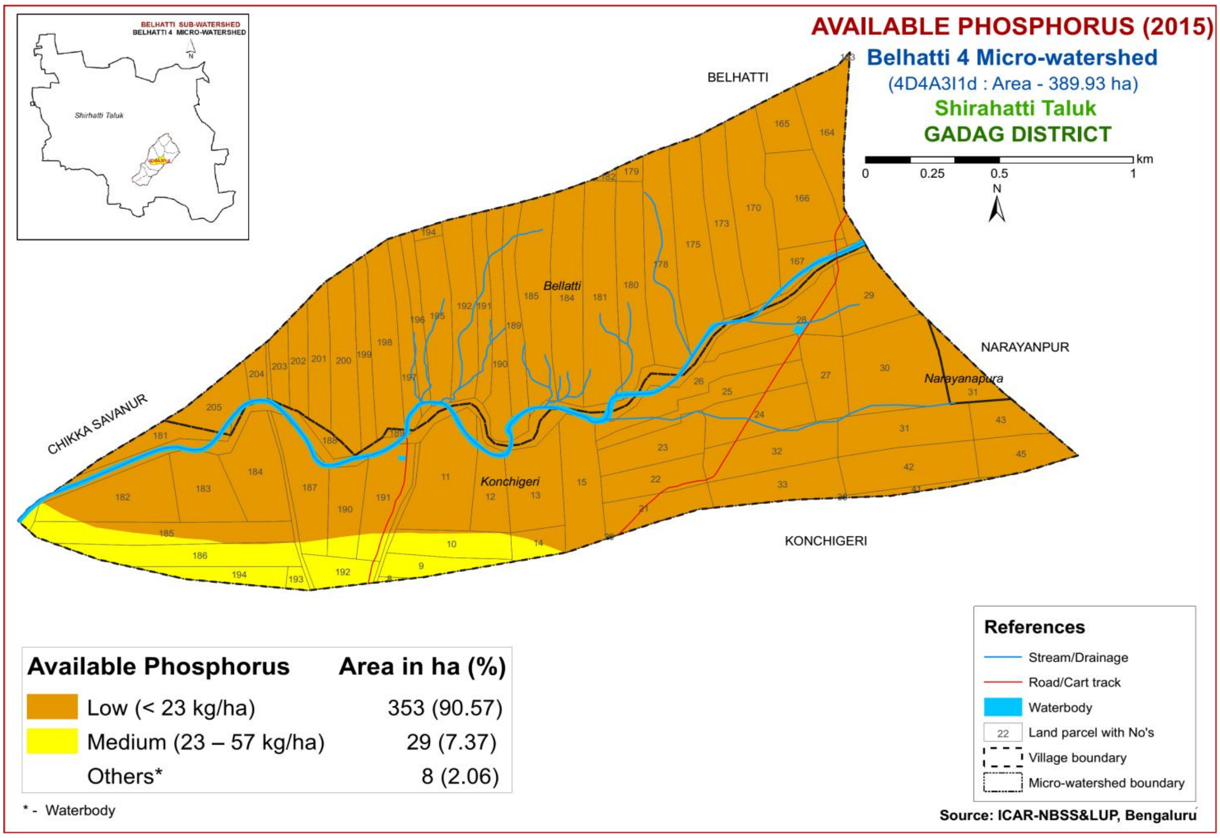


Fig.6.4 Soil available Phosphorus map of Belhatti-4 microwatershed

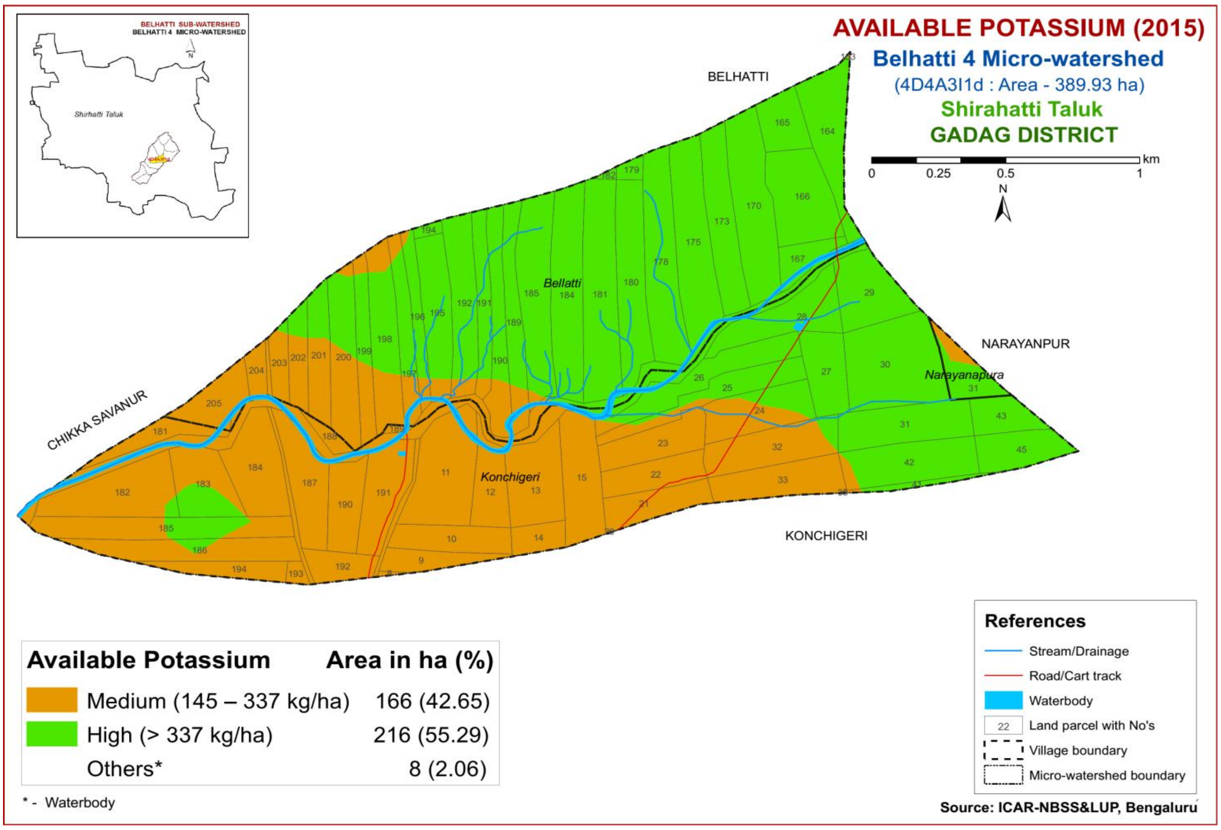


Fig.6.5 Soil available Potassium map of Belhatti-4 microwatershed

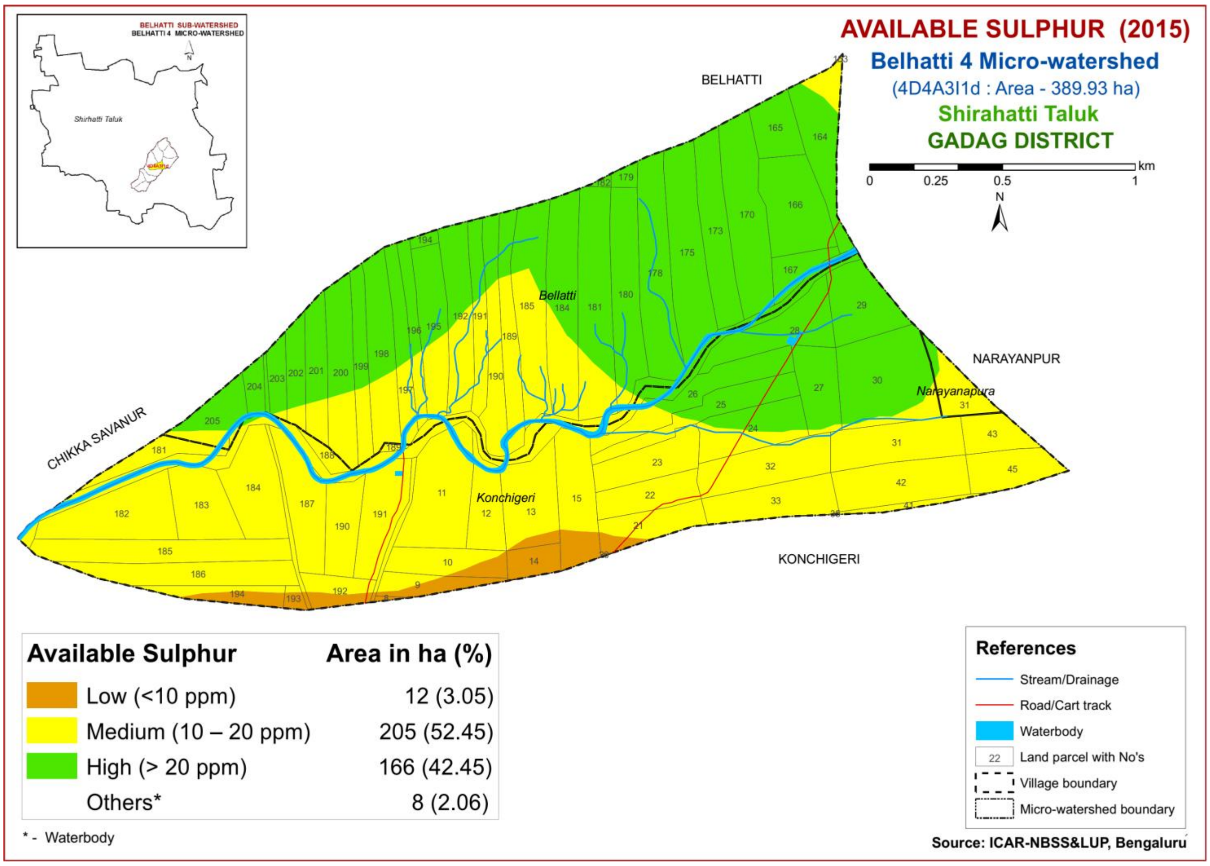


Fig.6.6 Soil available Sulphur map of Belhatti-4 microwatershed

6.7 Available Boron

Available boron content is low (<0.5 ppm) in the entire microwatershed covering about 380 ha (98%) area and is distributed in all parts of the microwatershed. About one ha (<1%) has soils that are medium (0.5-1.0 ppm) in available boron (Fig 6.7) and is distributed in the southeastern part of the microwatershed.

6.8 Available Iron

Available iron content is deficient (<4.5 ppm) in small area of 22 ha (6%) and is distributed in the western part of the microwatershed. It is sufficient (>4.5 ppm) in the rest of the area of 360 ha (92%) and is distributed in all parts of the microwatershed (Fig 6.8).

6.9 Available Manganese

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

6.10 Available Copper

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

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in major area of about 360 ha (92%) and is distributed in all parts of the microwatershed. It is sufficient (>0.6 ppm) in 22 ha (6%) area (Fig 6.11) and is distributed in the eastern part of the microwatershed.

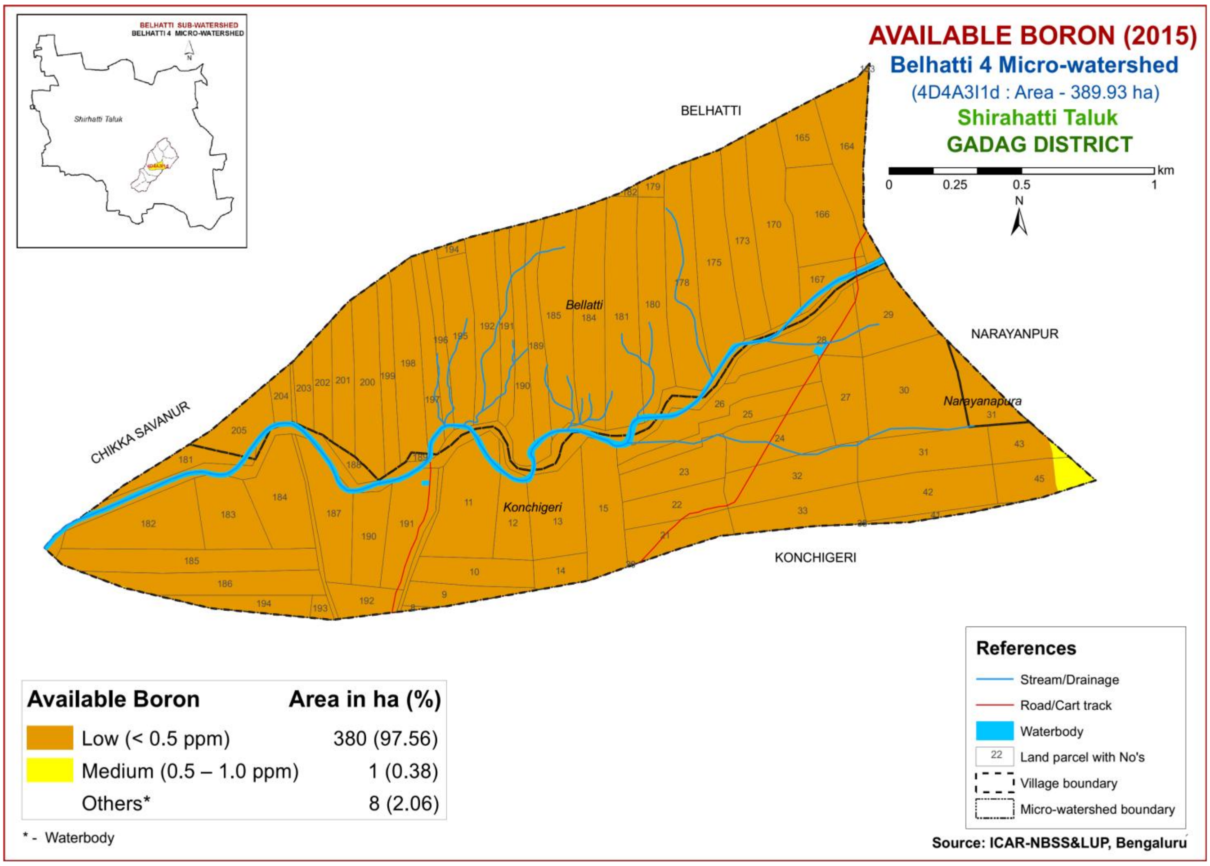


Fig.6.7 Soil available Boron map of Belhatti-4 microwatershed

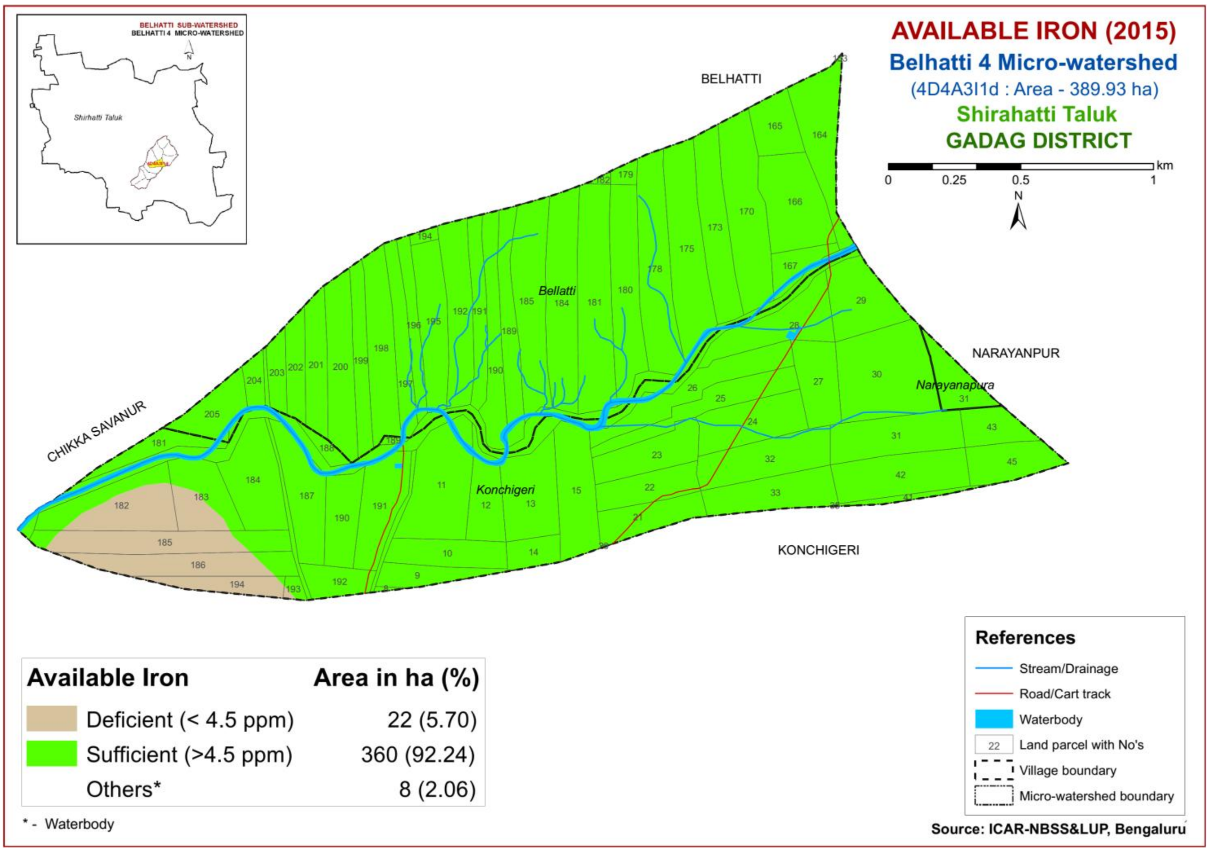


Fig.6.8 Soil available Iron map of Belhatti-4 microwatershed

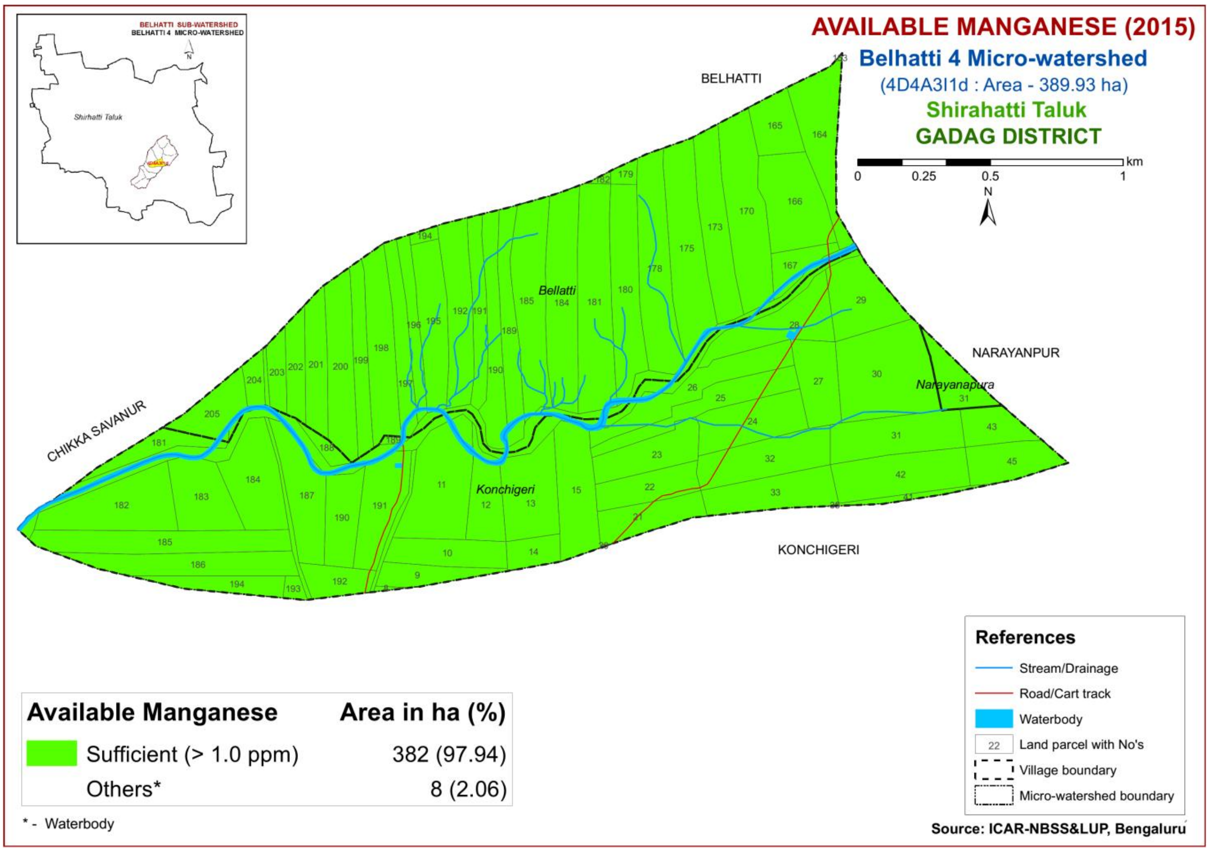


Fig.6.9 Soil available Manganese map of Belhatti-4 microwatershed

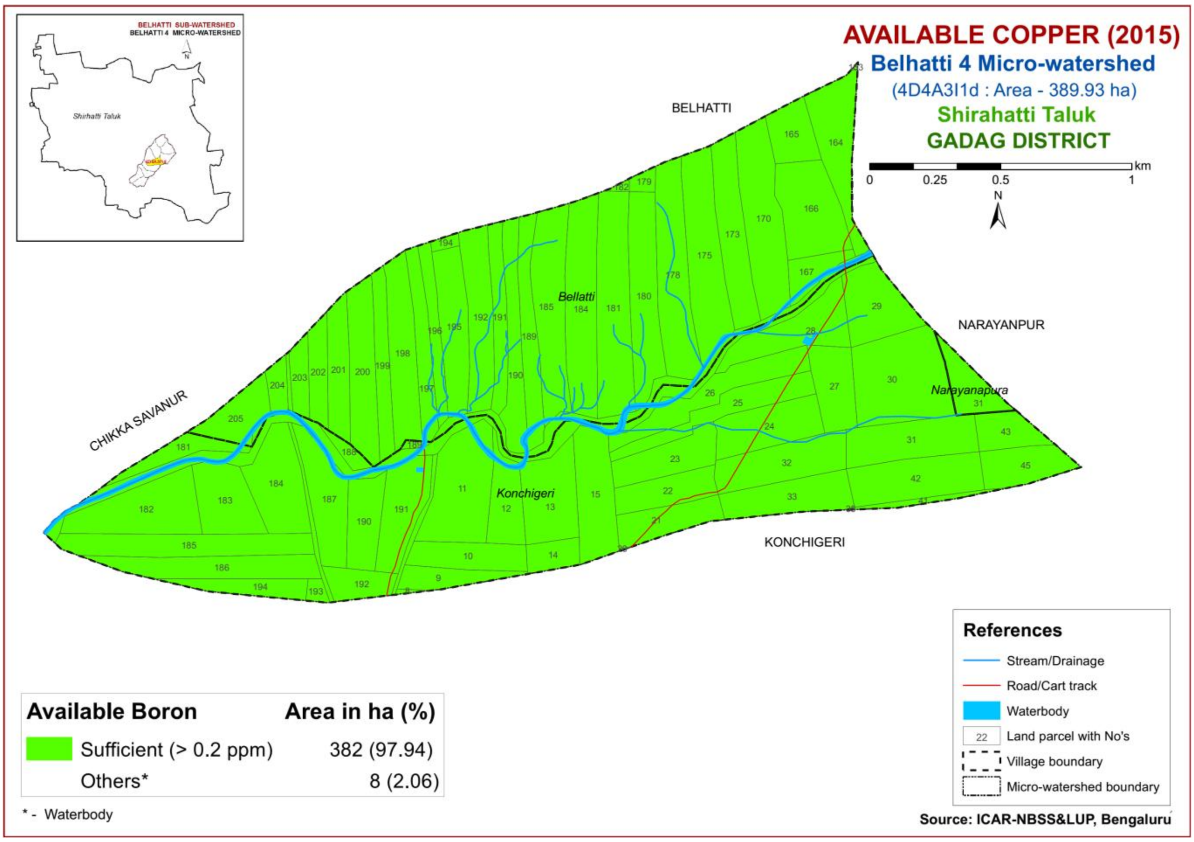


Fig.6.10 Soil available Copper map of Belhatti-4 microwatershed

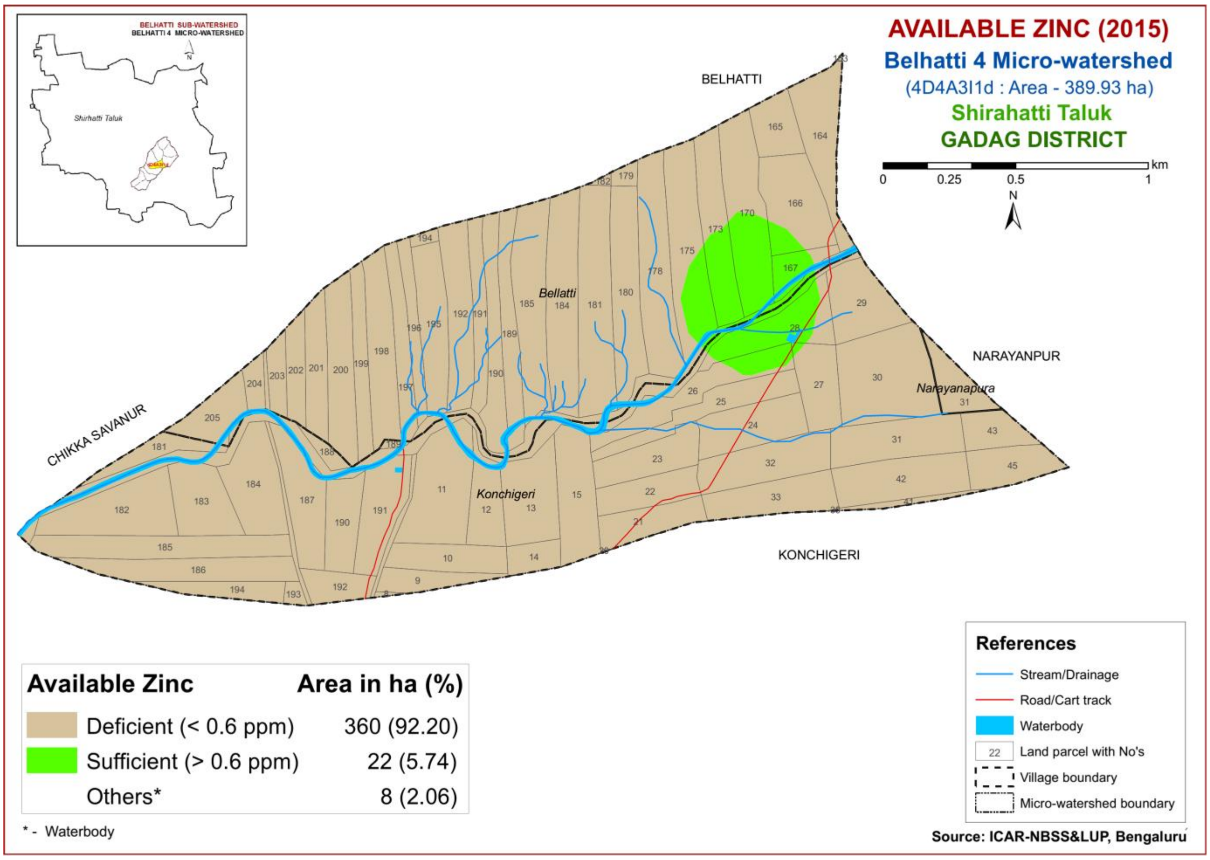


Fig.6.11 Soil available Zinc map of Belhatti-4 microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Belhatti-4 microwatershed were assessed for their suitability for growing food, fibre, fodder and horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data, Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S- Suitable and order N- Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1- Highly Suitable, Class S2- Moderately Suitable and Class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability and 'w' for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level only; land suitability units are not worked out.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 21 major annual and perenneal crops were prepared. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 11.02 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Chamarajnagar districrts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing sorghum was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.1.

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing sorghum crop. They are distributed mainly in the northeastern part of the microwatershed. Major area of about 248 ha (63%) is moderately suitable (class S2) for growing sorghum and are distributed in the central, northern and southeastern part the microwatershed.

They have major limitations of gravelliness, calcareousness and rooting depth. Marginally suitable lands (class S3) for growing sorghum occupy about 118 ha (30%) and mainly occur in the central and western part of the microwatershed. They have severe limitation of rooting depth and calcareousness.

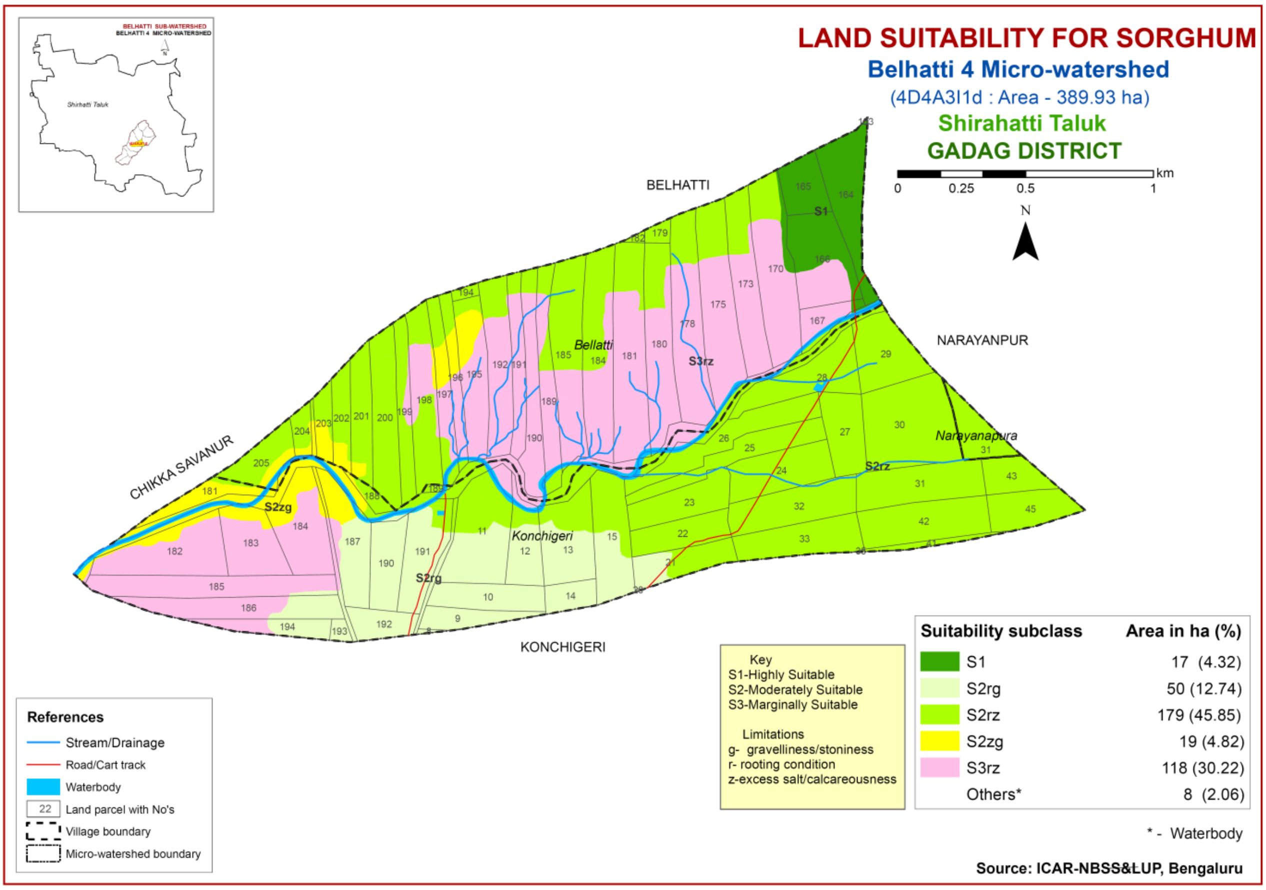


Fig. 7.1 Land Suitability map of Sorghum

Table 7.1 Soil-Site Characteristics of Belhatti-4 microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol $(p^{+})kg^{-1}$]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Subsur-face (%)								
MTLiB1g1	633	150	WD	25-50	sc	sc-c	15-35	15-35	<50	1-3	slight					
MTLmB2g1	633	150	WD	25-50	c	sc-c	15-35	15-35	<50	1-3	moderate					
MTLmB3g2	633	150	WD	25-50	c	sc-c	35-60	15-35	<50	1-3	severe					
KGHiB2g2	633	150	WD	50-75	sc	scl	35-60	15-35	<50	1-3	moderate					
MKHhB1g1	633	150	WD	50-75	scl	scl	15-35	>35	<50	1-3	slight					
RNKmB2g1	633	150	WD	50-75	c	sc-c	15-35	15-35	51-100	1-3	moderate					
RNKmB2g2	633	150	WD	50-75	c	sc-c	35-60	15-35	51-100	1-3	moderate					
CKMhA1g1	633	150	WD	75-100	scl	sc	15-35	-	51-100	0-1	slight					
BPRiB1g2	633	150	WD	100-150	sc	sc-c	35-60	>35	51-100	1-3	slight					
LGDiB2g1	633	150	MWD	100-150	sc	sc-c	15-35	<15	>200	1-3	moderate					
LGDmA1	633	150	MWD	100-150	c	sc-c	-	<15	>200	0-1	slight					
LGDmA2	633	150	MWD	100-150	c	sc-c	-	<15	>200	0-1	moderate					
LGDmB1	633	150	MWD	100-150	c	sc-c	-	<15	>200	1-3	slight					
LGDmB1g1	633	150	MWD	100-150	c	sc-c	15-35	<15	>200	1-3	slight					
LGDmB2g1	633	150	MWD	100-150	c	sc-c	15-35	<15	>200	1-3	moderate					
LGDmB2g2	633	150	MWD	100-150	c	sc-c	35-60	<15	>200	1-3	moderate					
BGPmB1	633	150	MWD	>150	c	c	-	10-20	>200	1-3	slight					

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

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

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.73 lakh ha in almost all the districts of the State. The crop requirements for growing maize (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing maize was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing maize crop. They are distributed mainly in the northeastern part of the microwatershed. About 50 ha (13%) area is moderately suitable (class S2) for growing maize and are distributed in the southern part the microwatershed.

The marginally suitable (class S3) lands cover maximum about 315 ha (81%) in the microwatershed and occur in all parts of the microwatershed. They have severe limitations of texture and calcareousness.

Table 7.3 Crop suitability criteria for Maize

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

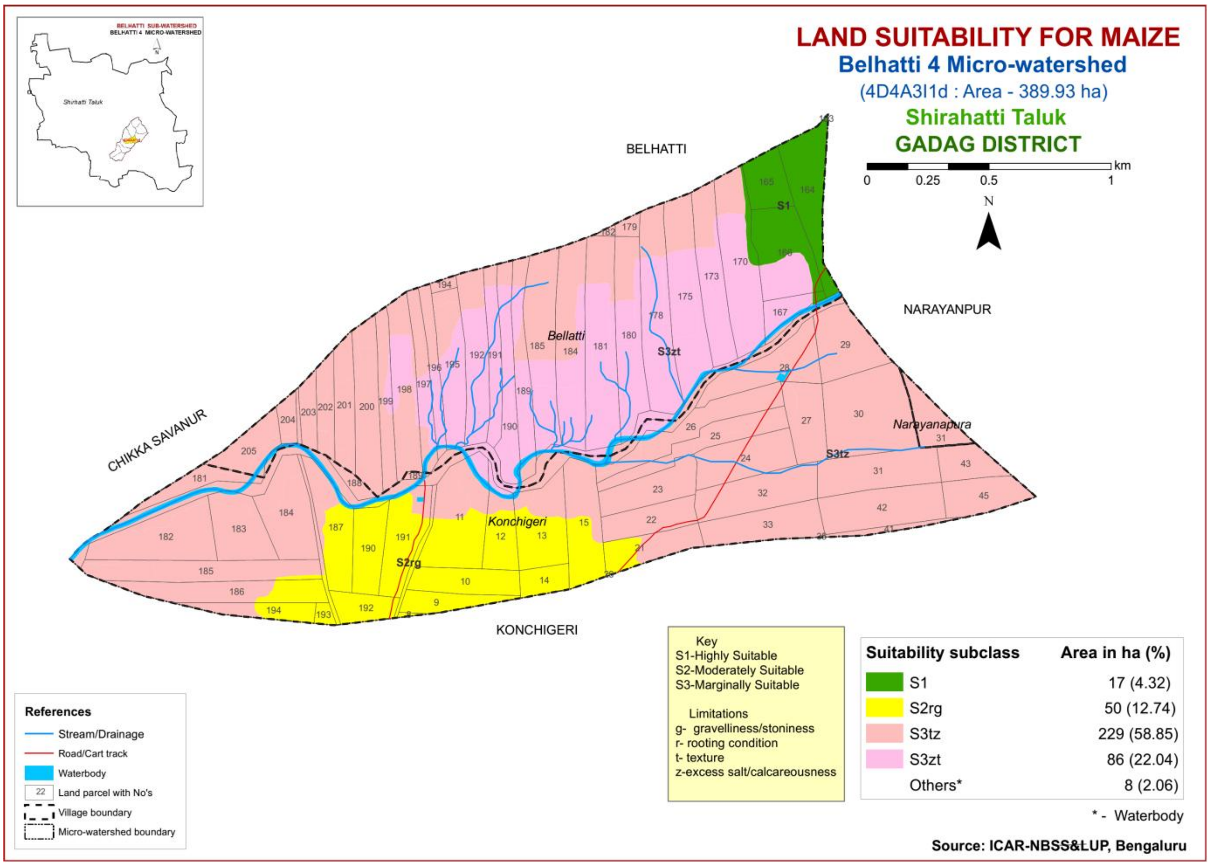


Fig. 7.2 Land Suitability map of Maize

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

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

Maximum area of about 265 ha (68%) is moderately suitable (class S2) for Bengal gram and they are distributed in all parts of the microwatershed. They have major limitations of texture, calcareousness and rooting depth. Marginally suitable lands (class S3) for growing Bengal gram occupy about 118 ha (30%) and occur in the northern and central part of the microwatershed. They have severe limitations of calcareousness and rooting depth.

Table 7.4 Crop suitability criteria for Bengal gram

Crop requirement		Rating			
Soil–site characteristics	unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	>100	90-100	70-90	<70
Soil drainage	class	Well drained	Mod. to well drained;imperfectly drained	Poorly drained; excessively drained	Very Poorly drained
Soil reaction	pH	6.0-7.5	5.5-5.7 7.6-8.0	8.1-9.0;4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	Sl, c>60%	S, fragmental
Soil depth	Cm	>75	51-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

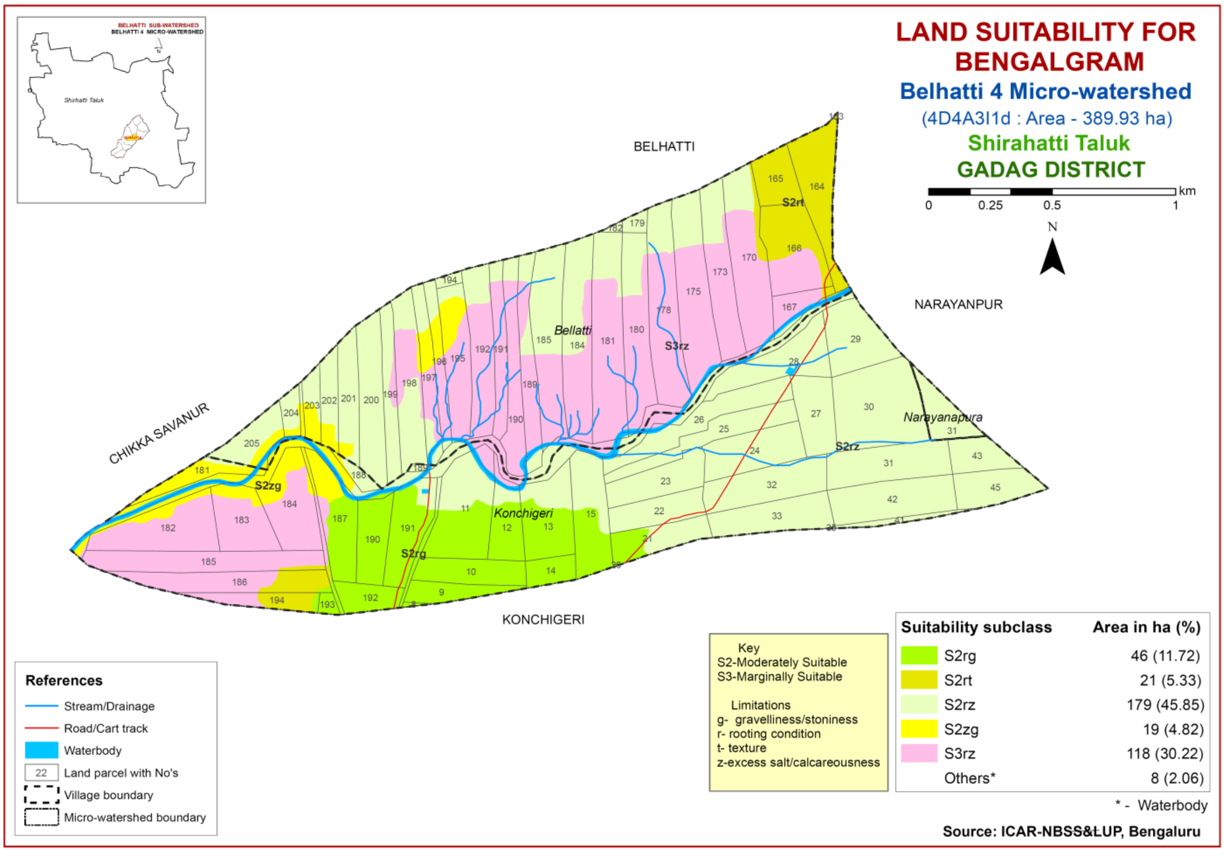


Fig. 7.3 Land Suitability map of Bengal gram

7.4 Land Suitability for Groundnut (*Arachis hypogaea*)

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

A small area of 67 ha (17%) is moderately suitable (class S2) for groundnut and these areas are distributed in the southern and northeastern part of the microwatershed. They have moderate limitations of texture, rooting depth and gravelliness. Marginally suitable lands (class S3) for growing groundnut occupy major area of about 315 ha (81%) and are distributed in all parts of the microwatershed. They have severe limitations of calcareousness and texture.

Table 7.5 Crop suitability criteria for Groundnut

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

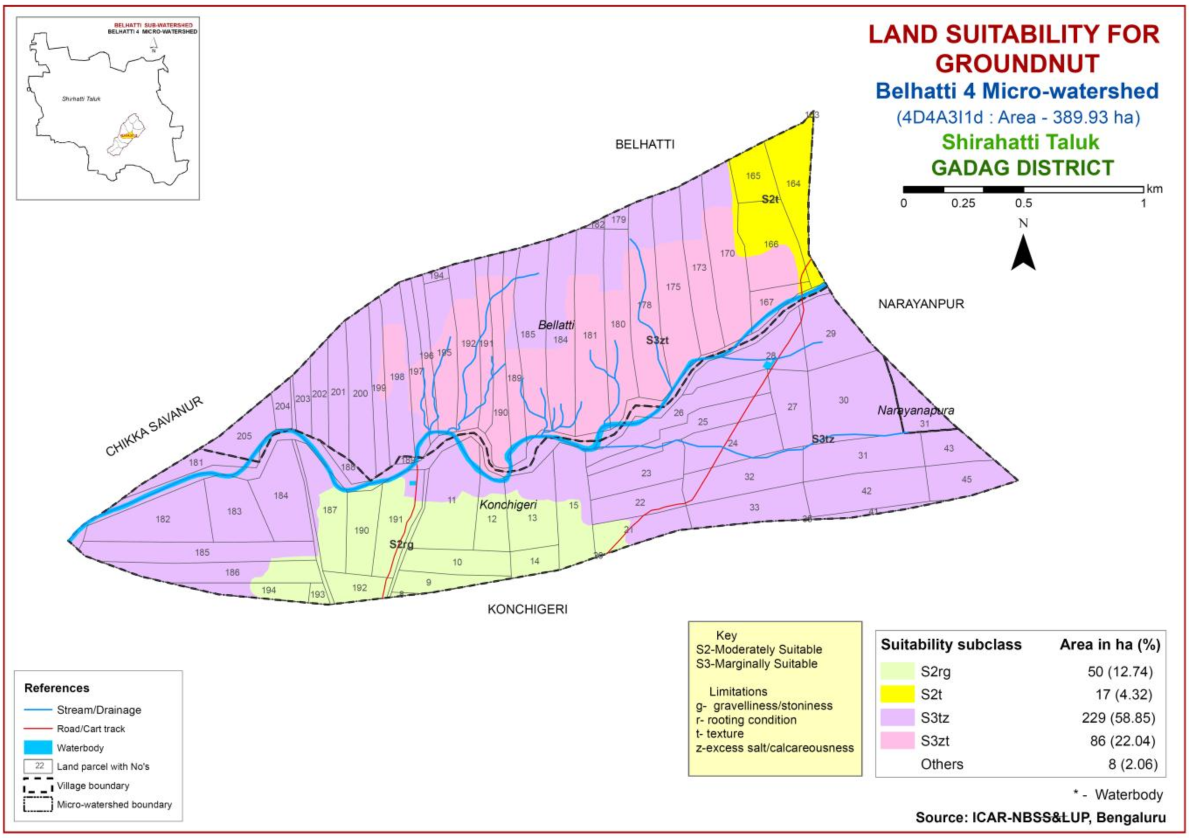


Fig. 7.4 Land Suitability map of Groundnut

7.5 Land Suitability for Sunflower (*Helianthus annus*)

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

Moderately suitable (class S2) lands are found to occur in major area of about 230 ha (59%). They have moderate limitations of gravelliness, calcareousness and rooting depth. and are dominantly distributed in all parts of the microwatershed. The marginally suitable (class S3) lands cover about 67 ha (17%) area and occur in the western and southern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth. About 86 ha (22%) area is not suitable for growing sunflower and occur in the central part of the microwatershed. They have very severe limitations of calcareousness and rooting depth.

Table 7.6 Crop suitability criteria for Sunflower

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

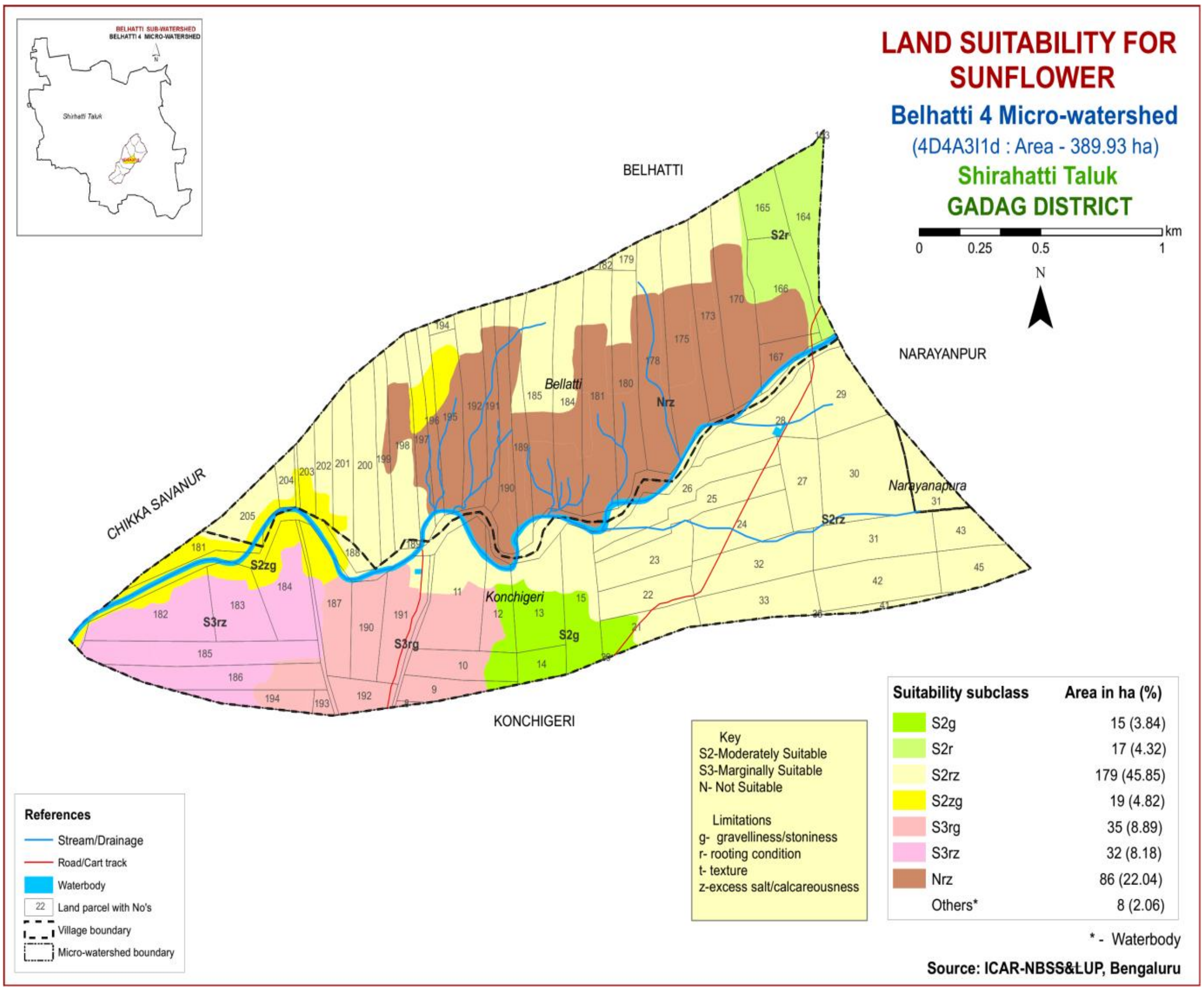


Fig. 7.5 Land Suitability map of Sunflower

7.6 Land Suitability for Cotton (*Gossypium hirsutum*)

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

The marginally suitable (class S3) lands cover a small area of about 86 ha (22%) in the microwatershed and occur in the central part of the microwatershed. They have severe limitations of calcareousness and rooting depth. Major area of about 297 ha (76%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, calcareousness and rooting depth. They are distributed in all parts of the microwatershed.

Table 7.7 Crop suitability criteria for Cotton

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

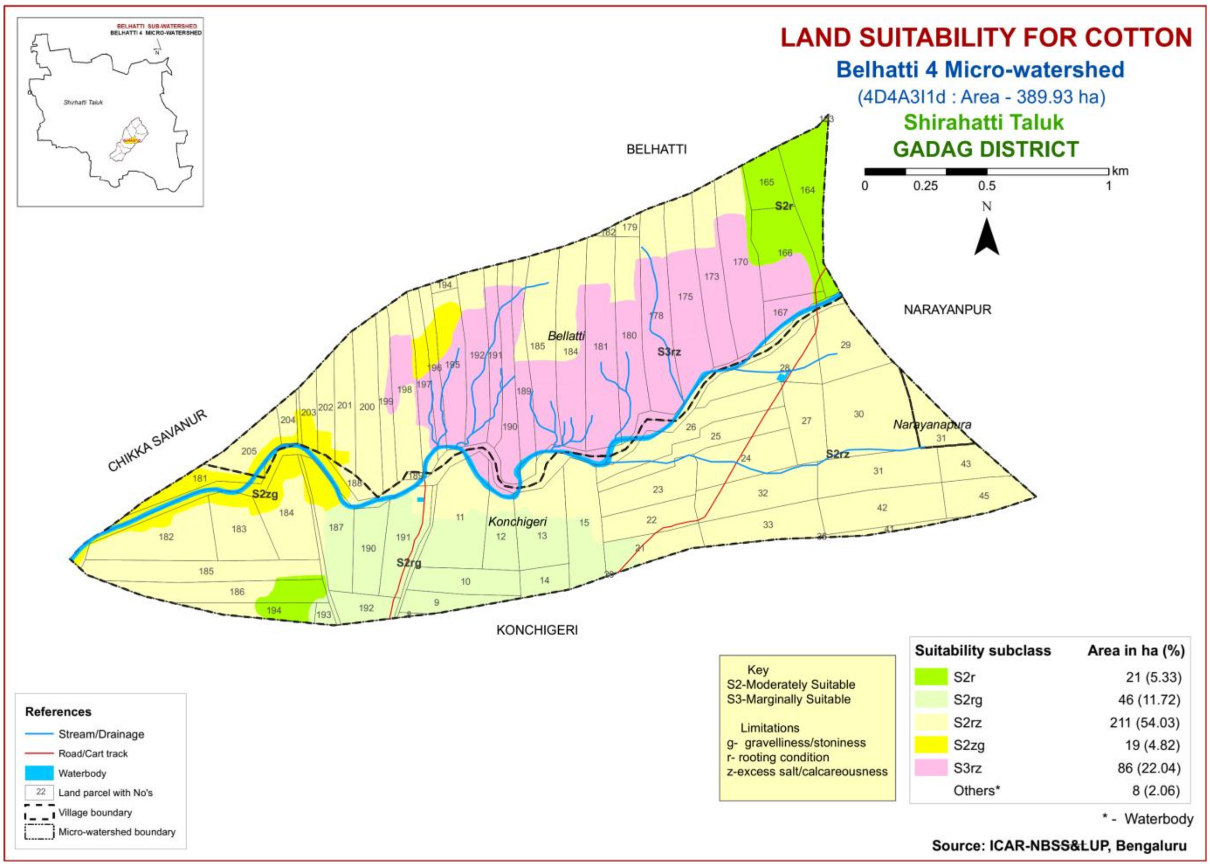


Fig. 7.6 Land Suitability map of Cotton

7.7 Land Suitability for Banana (*Musa paradisiaca*)

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

Major area of about 230 ha (59%) is moderately suitable (class S2) for growing banana and they are distributed in all parts of the microwatershed. They have major limitations of rooting depth, gravelliness and calcareousness. Marginally suitable (class S3) lands for growing banana occupy about 67 ha (17%) and are distributed in the western and southern part of the microwatershed. They have severe limitations of rooting depth, calcareousness and gravelliness. An area of about 86 ha (22%) is not suitable for growing banana in the microwatershed and occur in the central part of the microwatershed. They have very severe limitations of calcareousness and texture.

Table 7.8 Crop suitability criteria for Banana

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

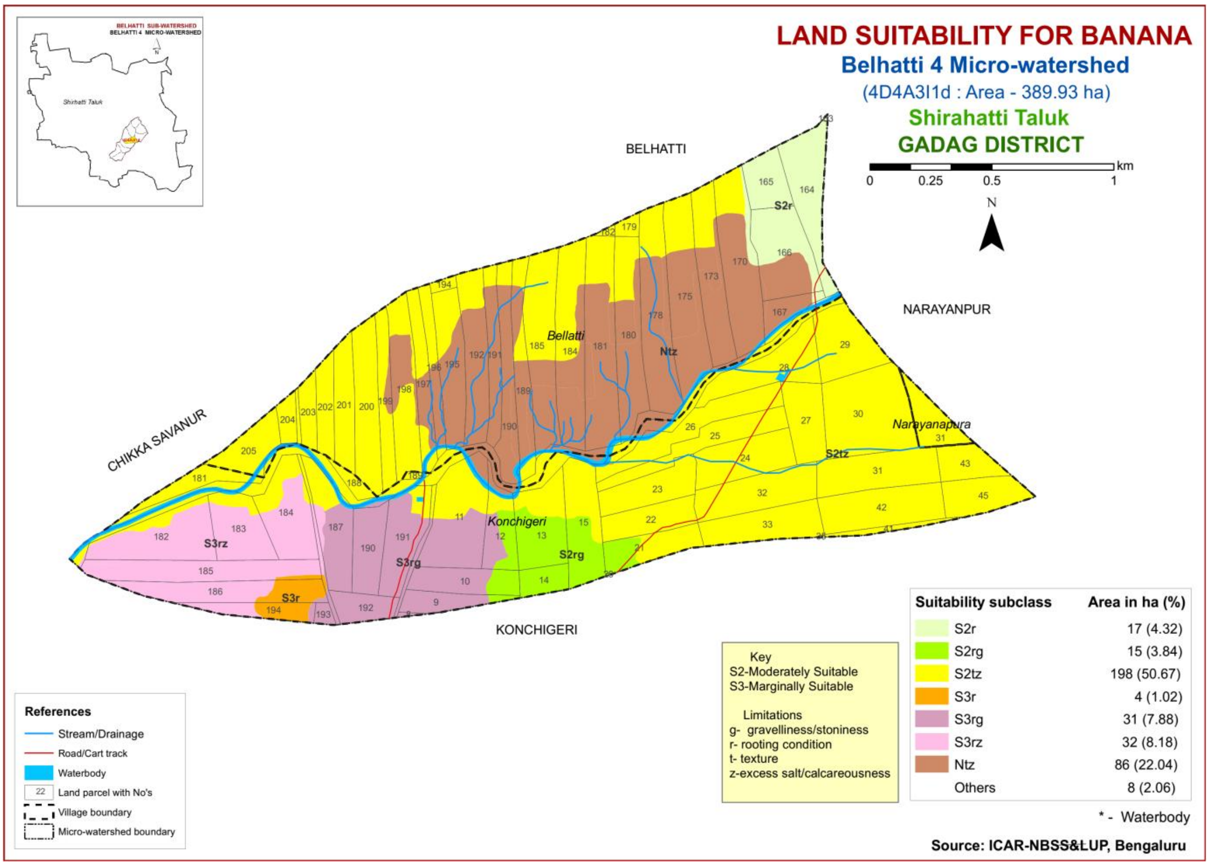


Fig. 7.7 Land Suitability map of Banana

7.8 Land Suitability for Pomegranate (*Punica granatum*)

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

Major area of about 230 ha (59%) is moderately suitable (class S2) for pomegranate and are distributed in all parts of the microwatershed. They have moderate limitations of texture, calcareousness and gravelliness. Marginally suitable (class S3) lands for growing pomegranate occur in about 67 ha (17%) mainly in the southwestern and central part of the microwatershed. They have severe limitations of rooting depth, calcareousness and gravelliness. An area of about 86 ha (22%) is not suitable for growing pomegranate in the microwatershed and mainly occur in the central part of the microwatershed. They have very severe limitations of calcareousness and texture.

Table 7.9 Crop suitability criteria for Pomegranate

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

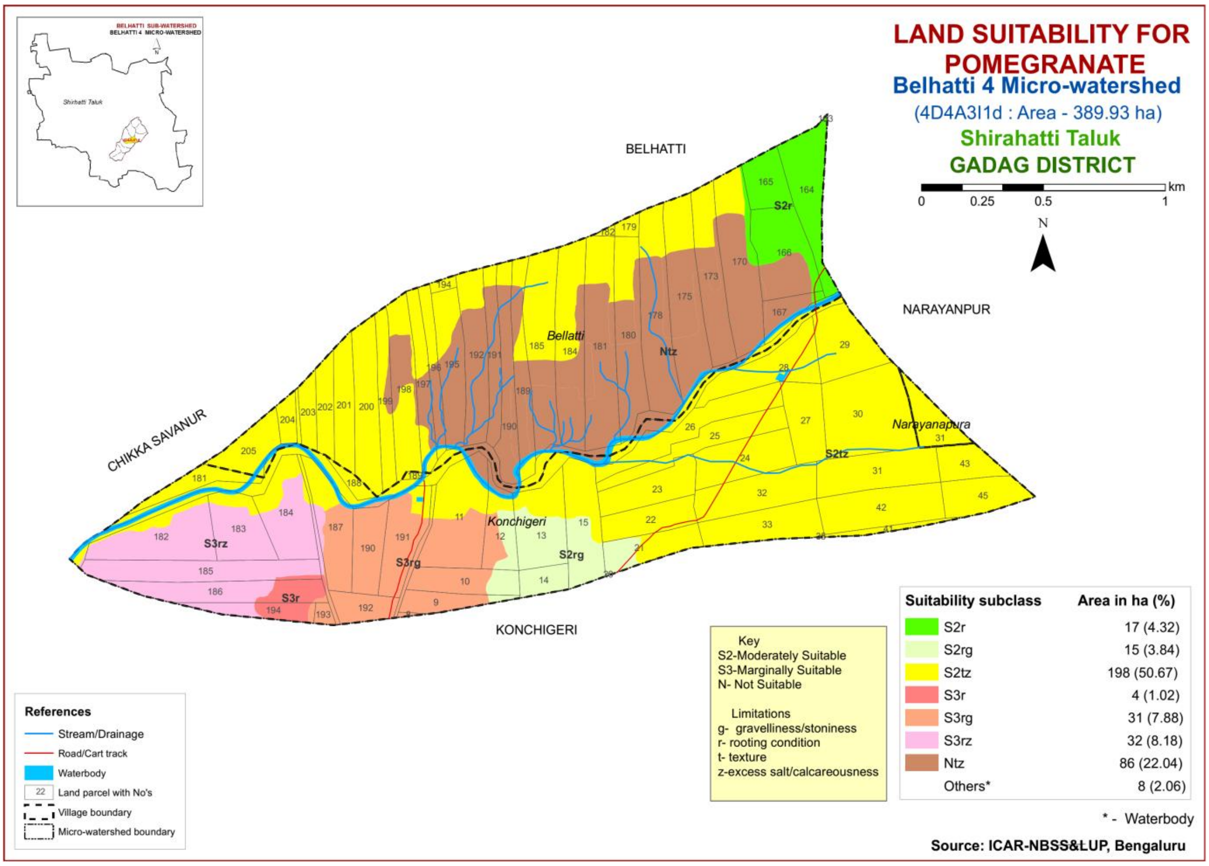


Fig. 7.8 Land Suitability map of Pomegrante

7.9 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in an area of 18.53 lakh ha in almost all the districts of the State. The crop requirements (Table 7.10) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated (Fig. 7.9).

The marginally suitable (class S3) lands cover maximum area about 215 ha (55%) and are distributed in all parts of the microwatershed. They have severe limitations of texture, rooting depth, gravelliness and calcareousness. About 15 ha (4%) is moderately suitable (class S2) for mango and are distributed in the southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness.

An area of about 152 ha (39%) is not suitable for growing mango in the microwatershed and occur in the western, central and southern part of the microwatershed. They have very severe limitations of gravelliness, calcareousness and rooting depth.

Table 7.10 Crop suitability criteria for Mango

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

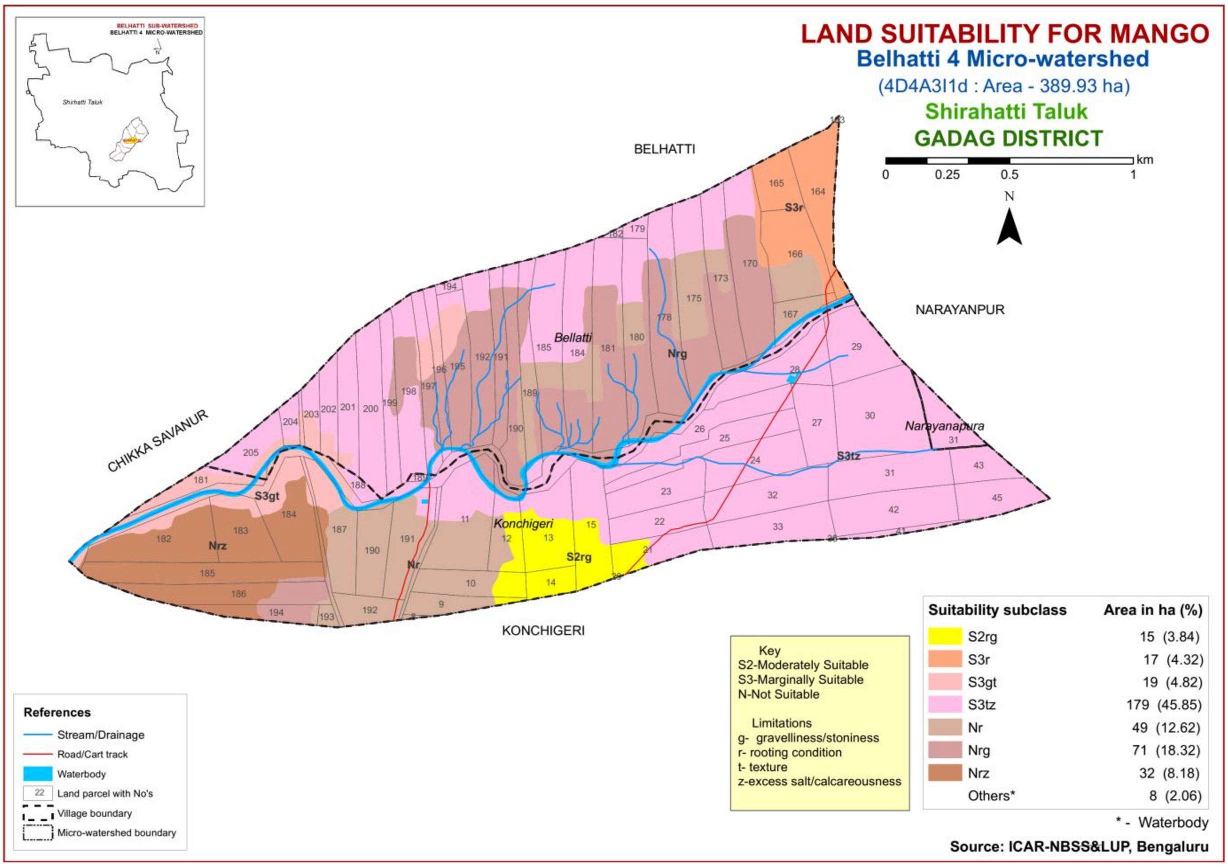


Fig. 7.9 Land Suitability map of Mango

7.10 Land suitability for Sapota (*Manilkara zapota*)

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

The marginally suitable (class S3) lands cover maximum area of about 297 ha (76%) and are distributed in all parts of the microwatershed. They have severe limitations of gravelliness, texture, calcareousness and rooting depth.

An area of about 85 ha (22%) is not suitable for growing sapota and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.11 Crop suitability criteria for Sapota

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

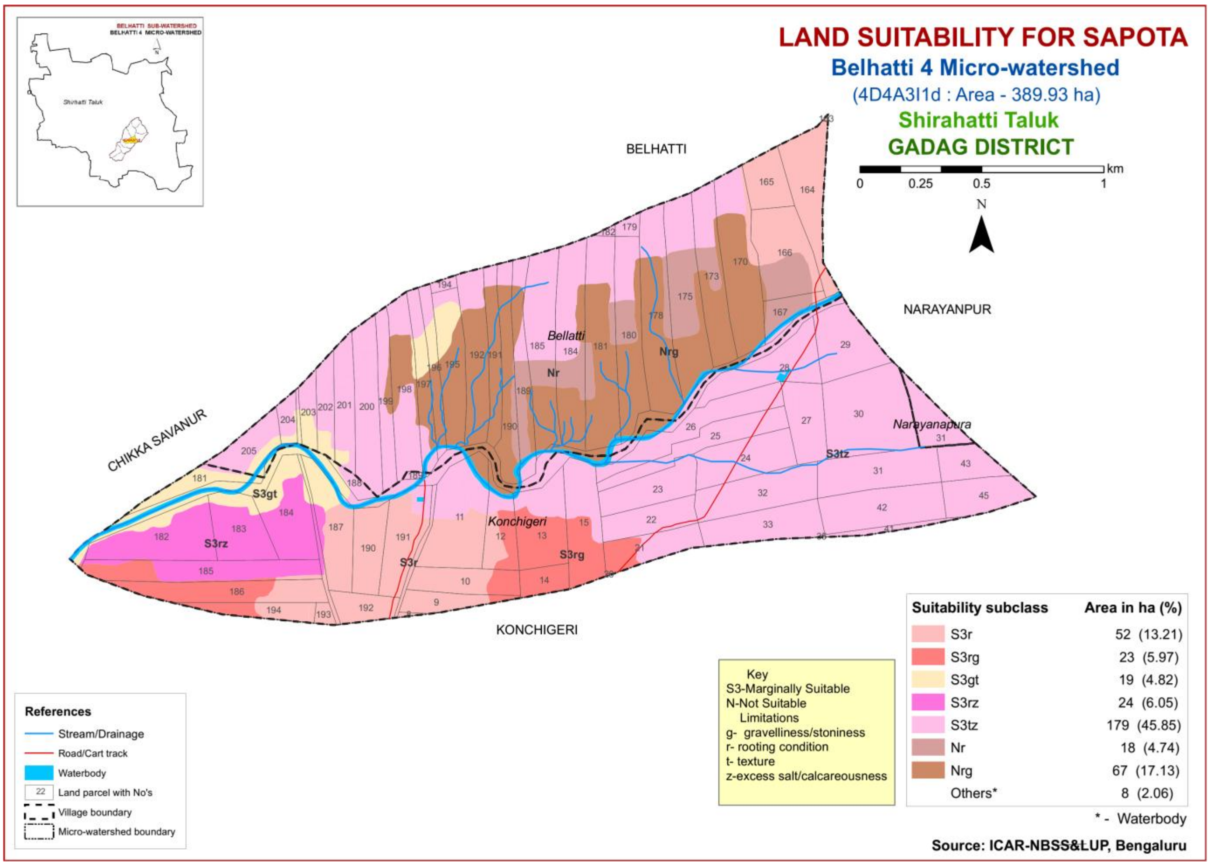


Fig. 7.10 Land Suitability map of Sapota

7.11 Land suitability for Guava (*Psidium guajava*)

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

Maximum area of about 196 ha (50%) in the microwatershed is moderately suitable (class S2) for growing guava and are distributed in the central, northern and eastern part of the microwatershed. They have moderate limitations of texture, calcareousness and rooting depth.

The marginally suitable (class S3) lands cover about 101 ha (26%) area and occur in the western and southern part of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

An area of about 85 ha (22%) is not suitable for growing guava in the microwatershed and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.12 Crop suitability criteria for Guava

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

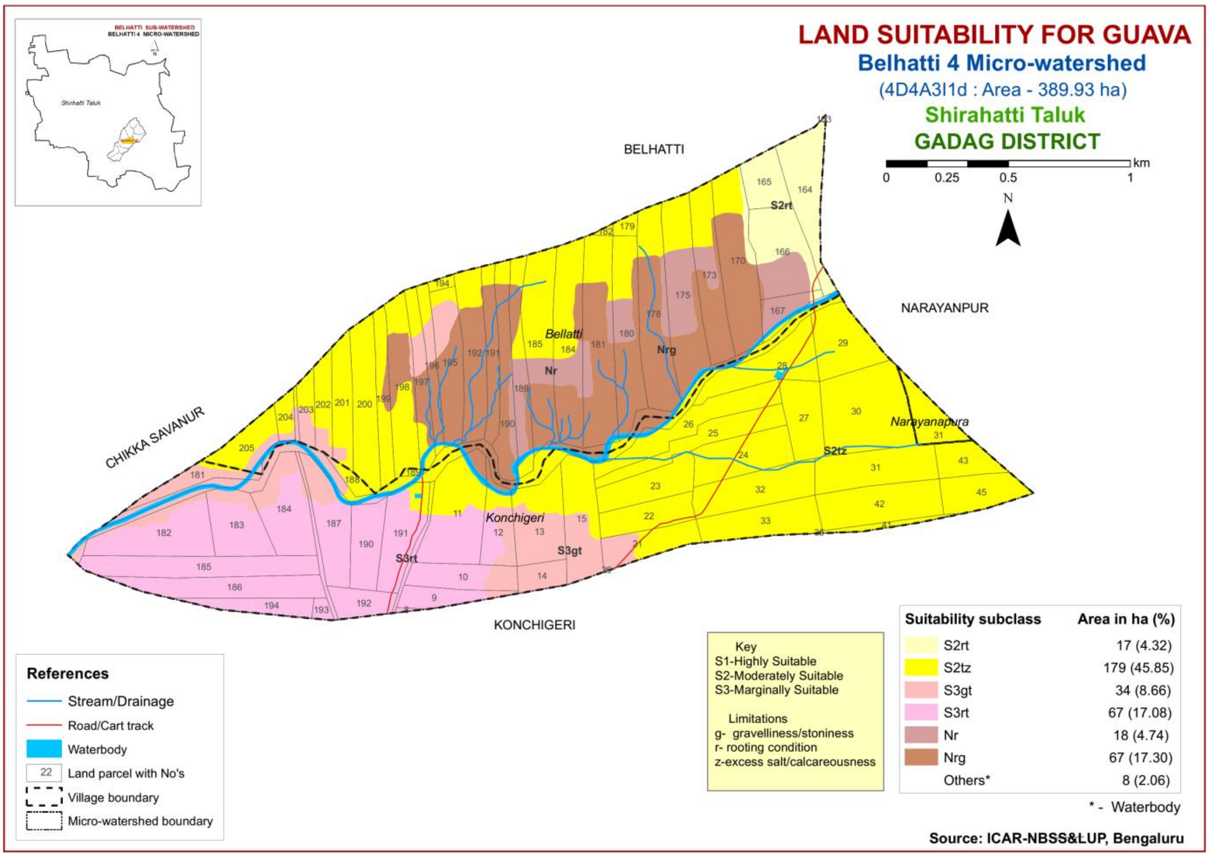


Fig. 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing jackfruit were matched with the soil-site characteristics and a land suitability map for growing jackfruit was generated (Fig. 7.12).

A small area of about 15 ha (4%) is moderately suitable (class S2) for growing jackfrit and is distributed in the southern part of the microwatershed. They have moderate limitations of rooting depth.

The marginally suitable (class S3) lands cover a maximum area of about 282 ha (72%) and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture, rooting depth and calcareousness.

An area of about 85 ha (22%) is not suitable for growing jackfruit and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

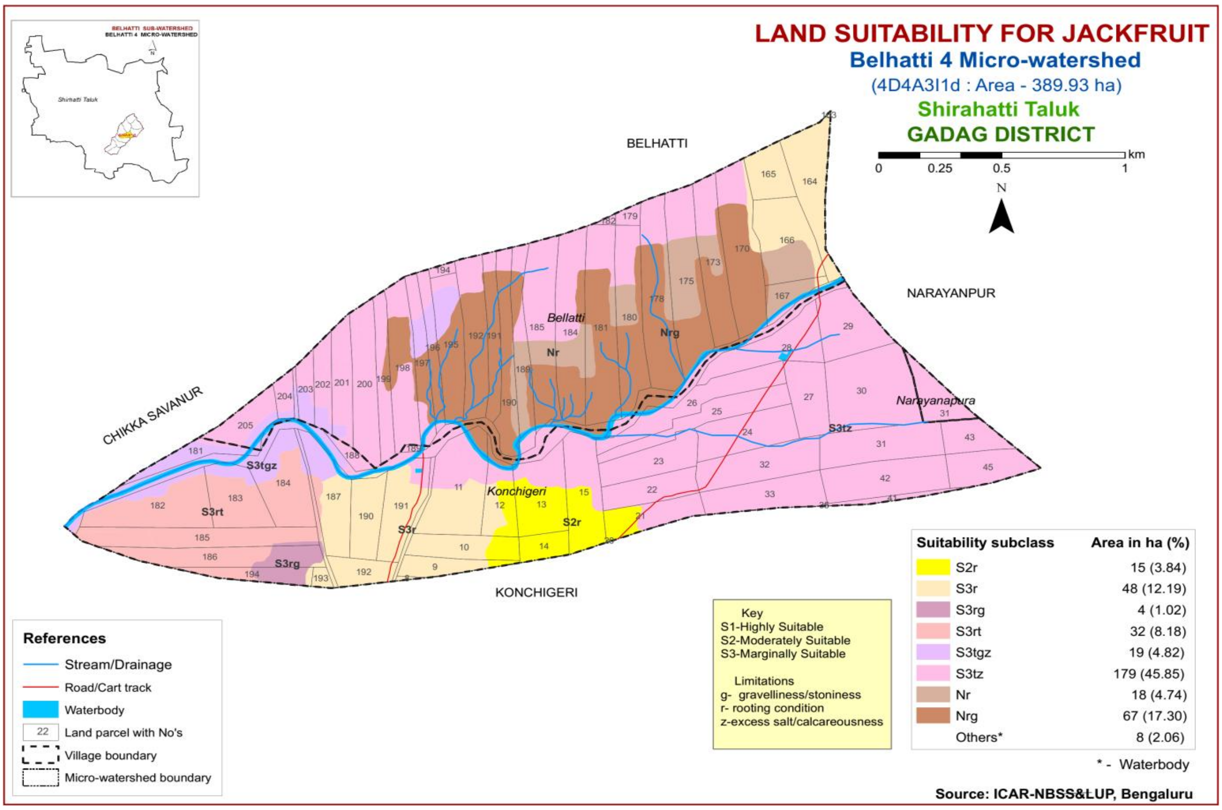


Fig. 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

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

The major area of about 213 ha (55%) has soils that are moderately suitable (class S2) with moderate limitations of texture, gravelliness, calcareousness and rooting depth. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover an area of about 84 ha (21%) and occur in western, southern and northwestern part of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

An area of about 85 ha (22%) is not suitable for growing jamun in the microwatershed and occur in central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

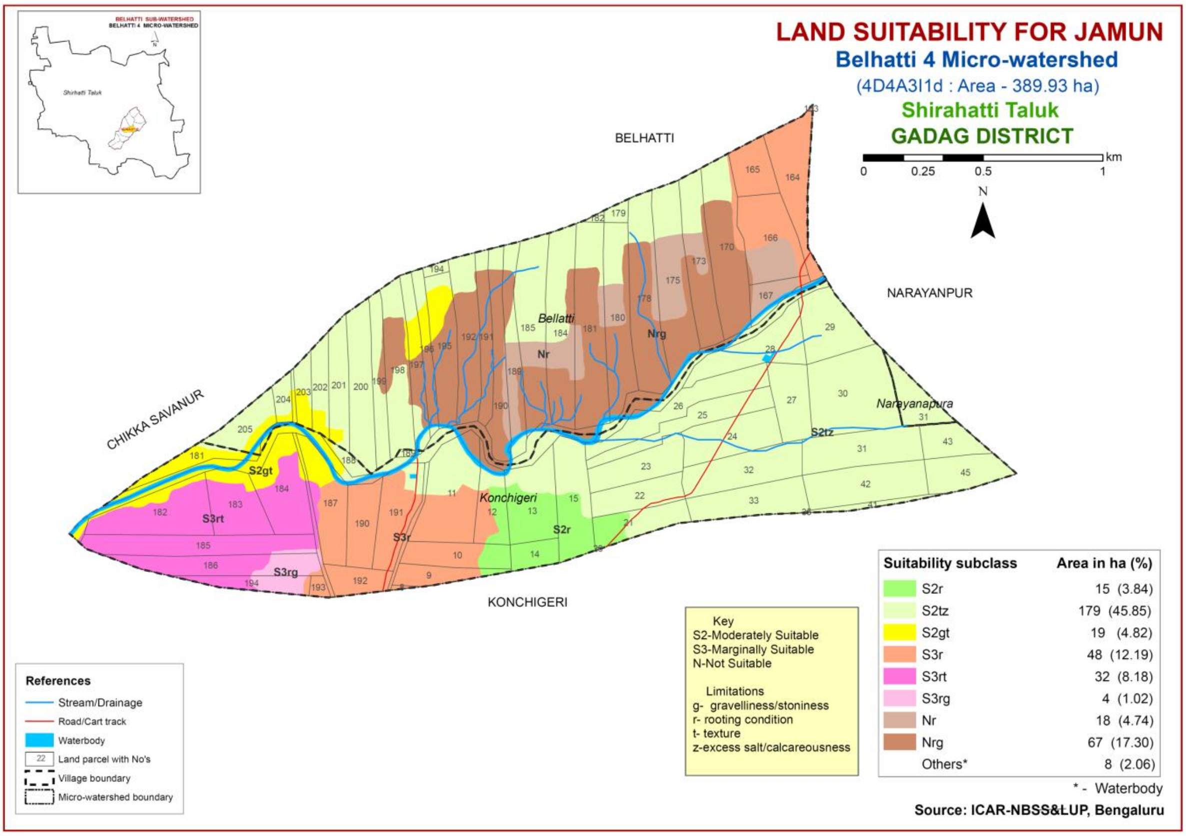


Fig. 7.13 Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

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

The major area of about 179 ha (46%) has soils that are moderately suitable (class S2) with moderate limitations of calcareousness. They are distributed in the northern and eastern part of the microwatershed.

The marginally suitable (class S3) lands cover about 118 ha (30%) and occur in the western, southern and northeastern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth.

An area of about 85 ha (22%) is not suitable for growing musambi and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

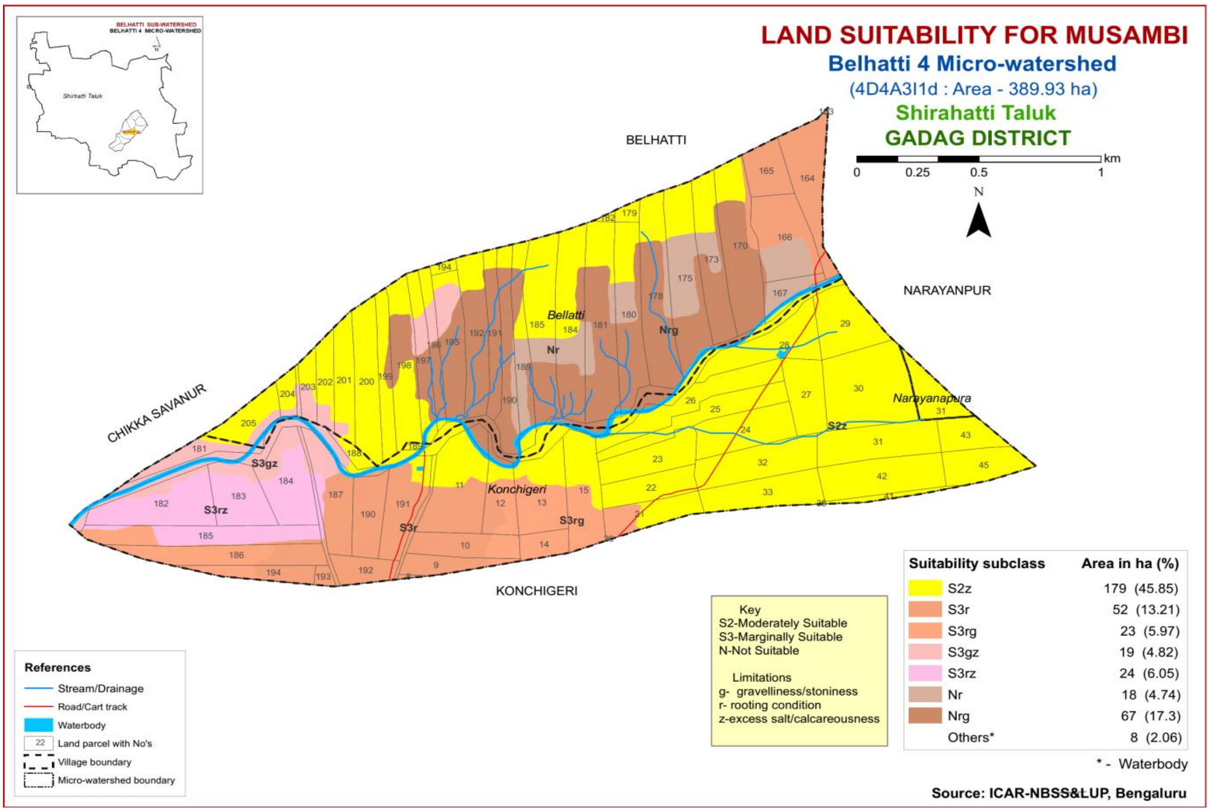


Fig. 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 1.1 lakh ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.13) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated (Fig. 7.15).

A small area of about 15 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing lime. They are distributed mainly in the southern part of the microwatershed. They have minor or no limitations for growing lime.

Major area of about 189 ha (48%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 93 ha (24%) and occur in the western and southern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth.

An area of about 85 ha (22%) is not suitable for growing lime and occur in the central part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.13 Crop suitability criteria for Lime

Land use 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	5.5-6.4 7.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

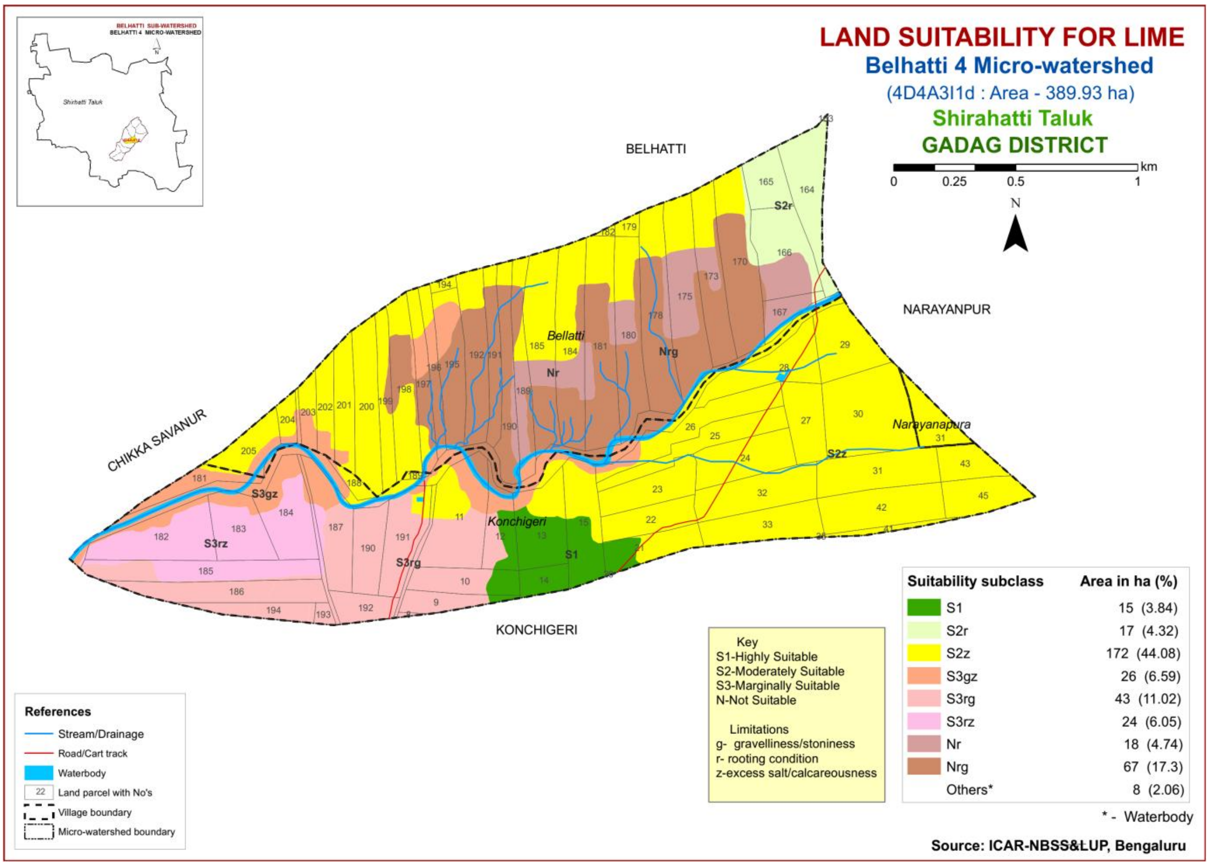


Fig. 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale)*

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

A small area of about 36 ha (9%) has soils that are moderately suitable (class S2) with moderate limitations of texture, rooting depth and calcareousness. They are distributed in the northeastern and southern part of the microwatershed.

The marginally suitable (class S3) lands also cover a small area about 31 ha (8%) and occur in the southern part of the microwatershed. They have severe limitations of gravelliness and rooting depth. A major area of about 314 ha (81%) is not suitable for growing cashew and occur in all parts of the microwatershed. They have very severe limitations of gravelliness, texture, calcareousness and rooting depth.

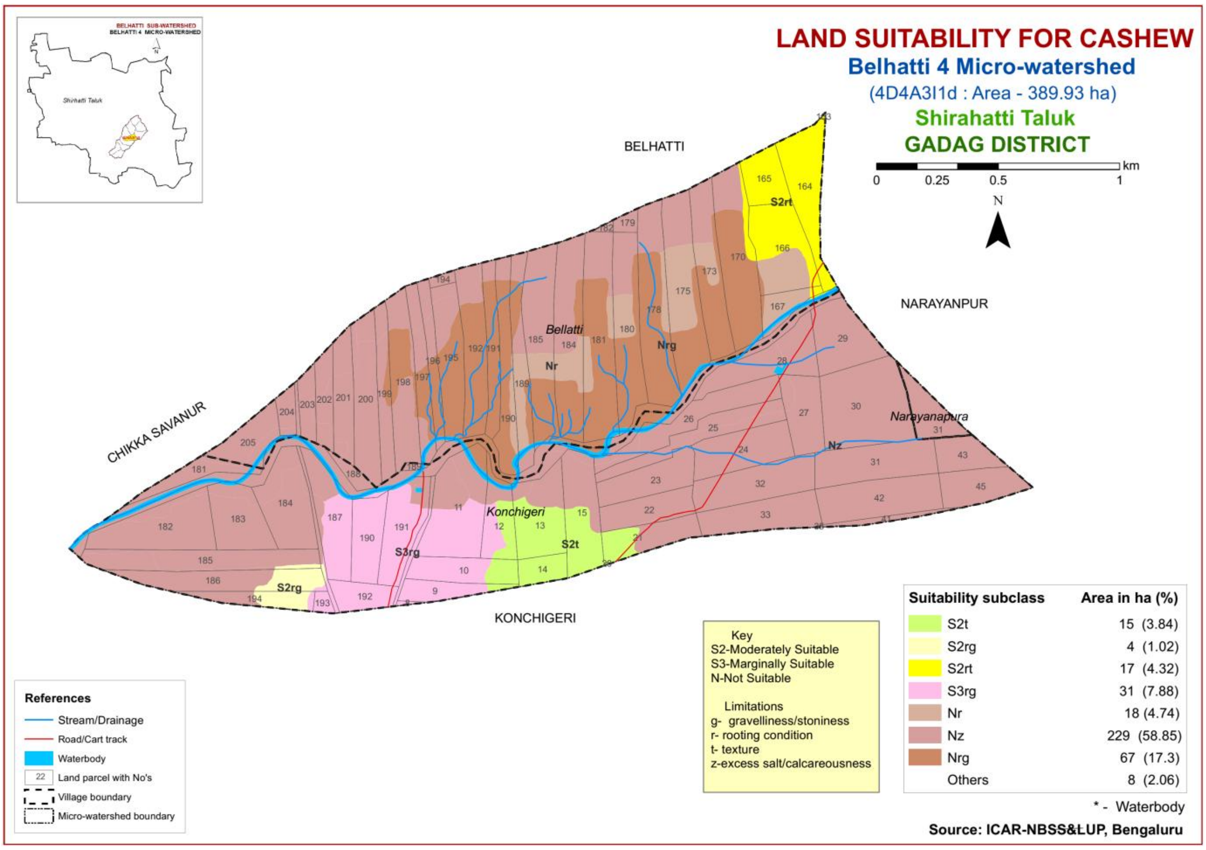


Fig. 7.16 Land Suitability map of Cashew

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

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

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing custard apple. They are distributed mainly in the northeastern part of the microwatershed. They have minor or no limitations for growing custard apple.

Major area of about 225 ha (58%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth, gravelliness and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 140 ha (36%) area and occur in the central and southwestern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth.

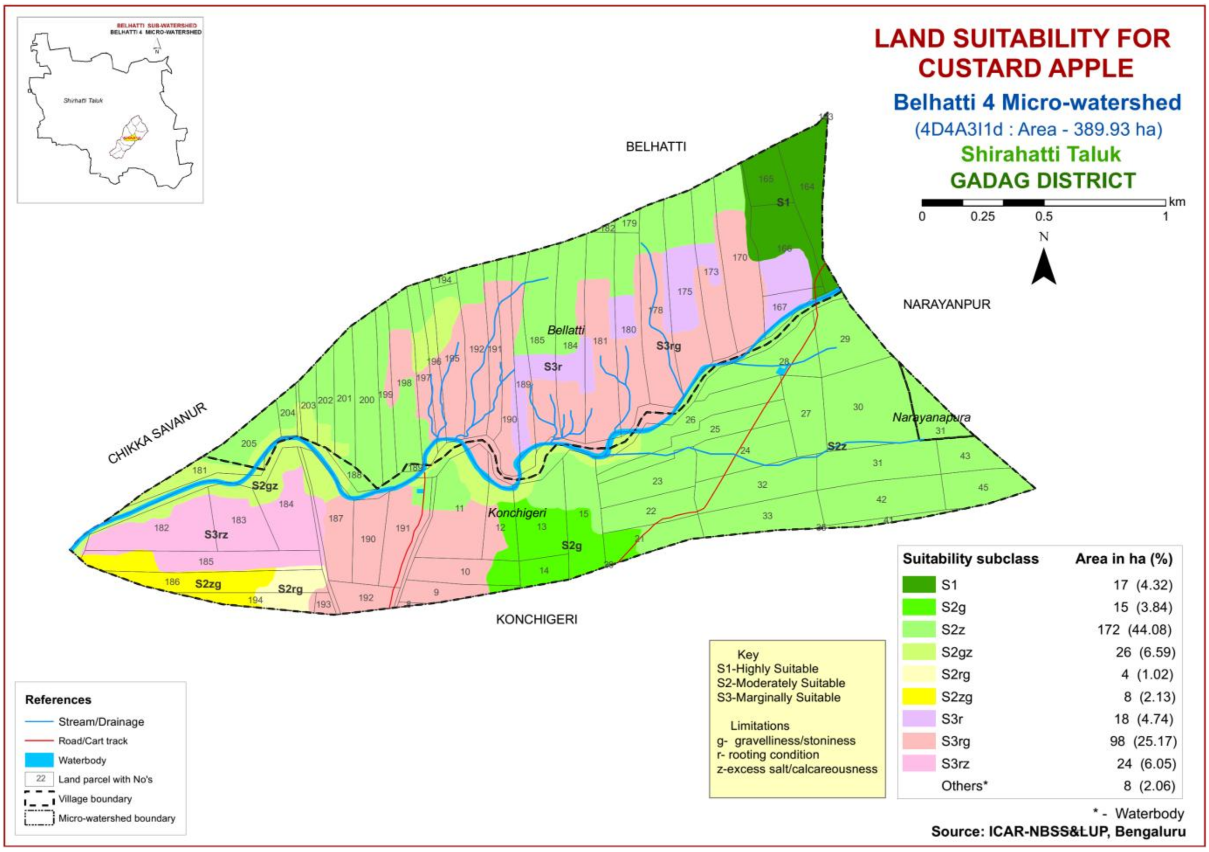


Fig. 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

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

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing amla. They are distributed mainly in the northeastern part of the microwatershed. They have minor or no limitations for growing amla.

Maximum area of about 217 ha (56%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth, gravelliness and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 146 ha (38%) area in the microwatershed and occur in the central and southern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth.

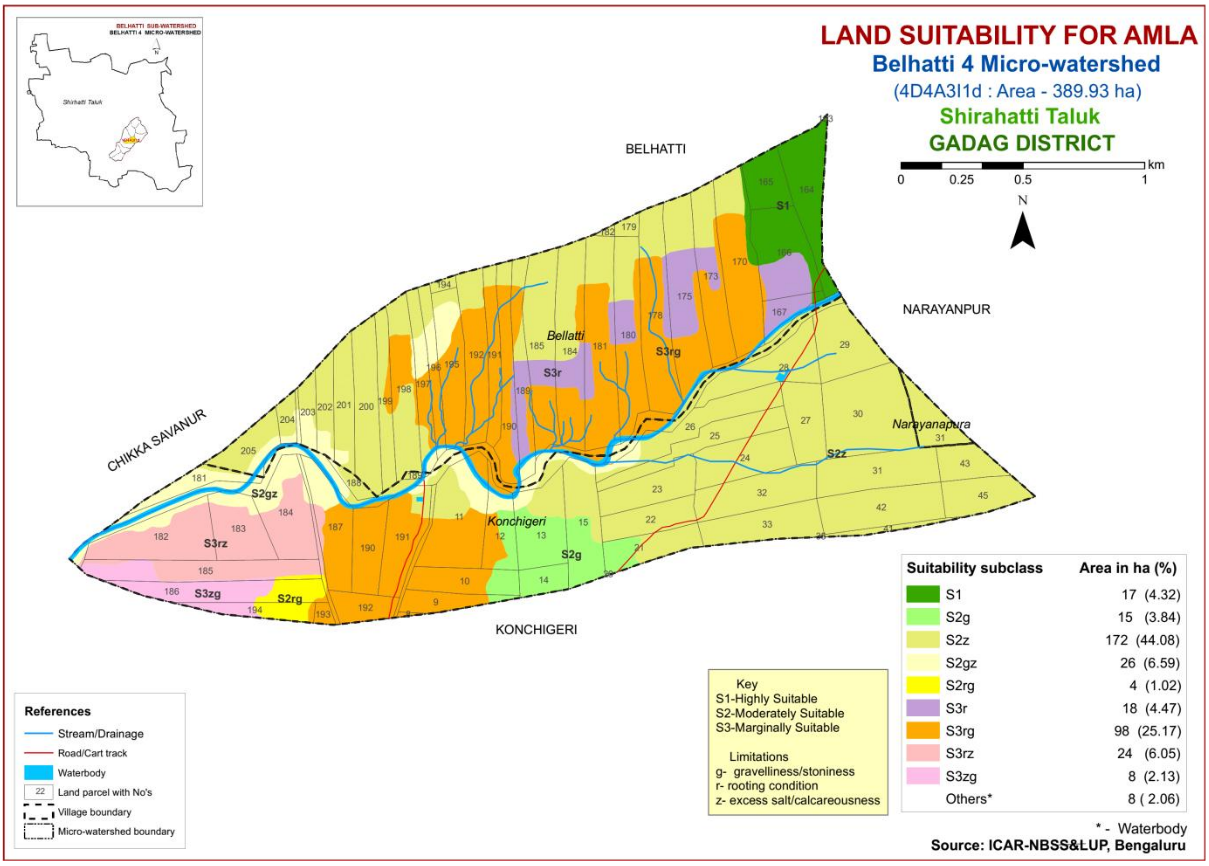


Fig. 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in almost all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.19.

A small area of about 15 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing tamarind. They are distributed mainly in the southern part of the microwatershed. They have minor or no limitations for growing tamarind.

Major area of about 198 ha (51%) has soils that are moderately suitable (class S2) with moderate limitations of texture, gravelliness and calcareousness. They are distributed in the southeastern and northern part of the microwatershed.

The marginally suitable (class S3) lands cover a small area of about 17 ha (4%) and occur in the northeastern part of the microwatershed. They have severe limitations of rooting depth.

About 152 ha (39%) is not suitable for growing tamarind and occur in the southwestern and central part of the microwatershed. They have very severe limitations of rooting depth, texture and gravelliness.

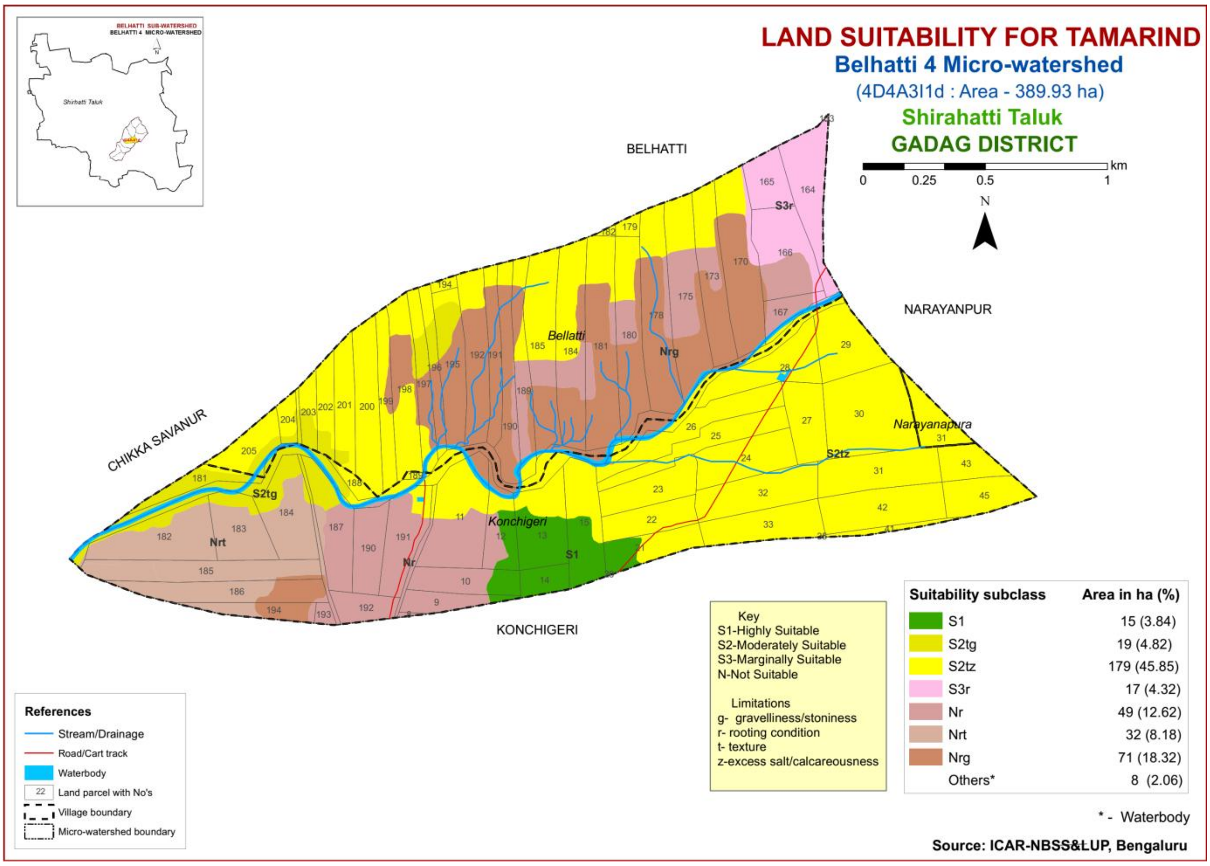


Fig. 7.19 Land Suitability map of Tamarind

7.20 Land Suitability for Marigold (*Tagetes erecta*)

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

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing marigold crop. They are distributed mainly in the northeastern part of the microwatershed. They have minor or no limitations for growing marigold. Major area of about 248 ha (63%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, texture, rooting depth and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 86 ha (22%) area in the microwatershed and occur in the central and southwestern part of the microwatershed. They have severe limitations of calcareousness and texture.

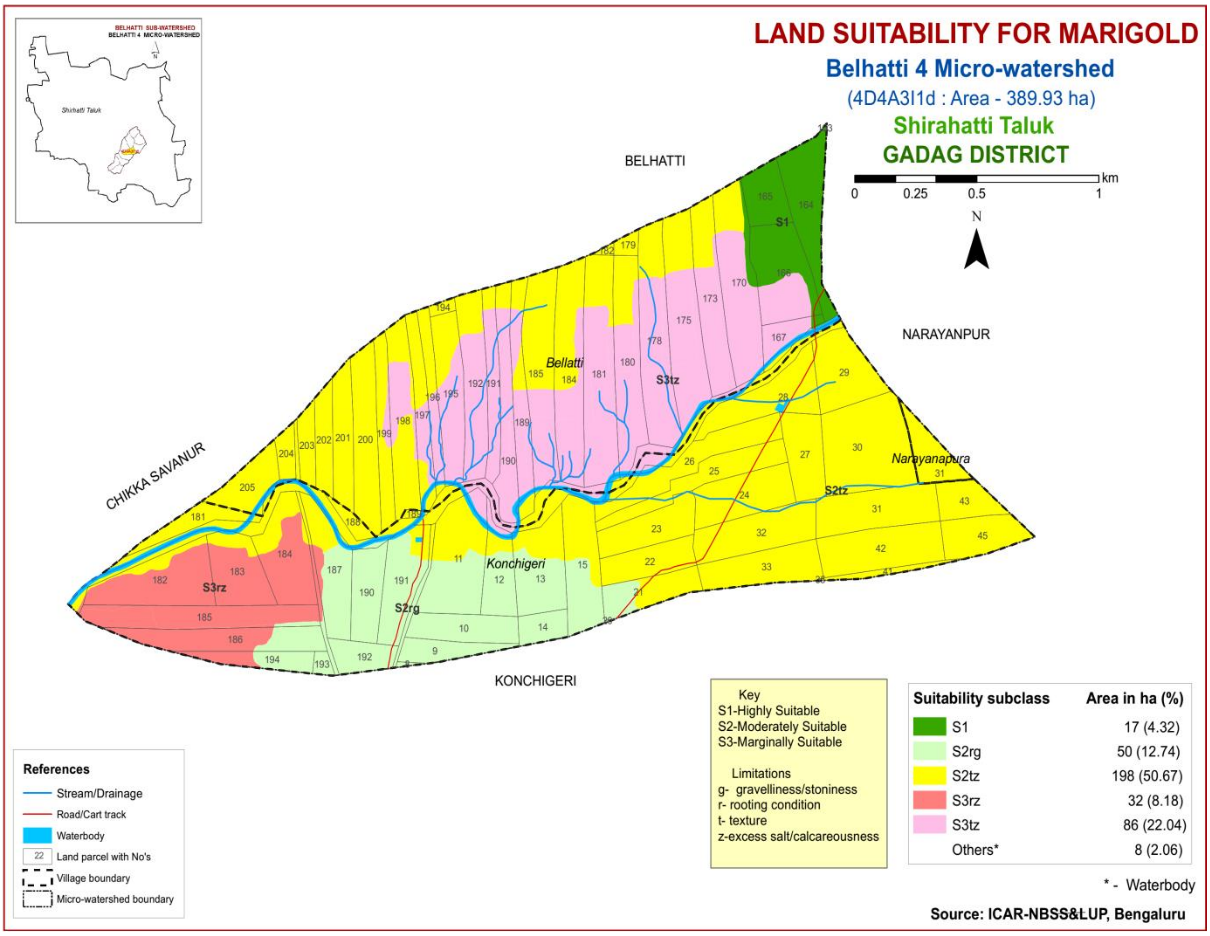


Fig. 7.20 Land Suitability map of Marigold

7.21 Land Suitability for Chrysanthemum

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

A small area of about 17 ha (4%) in the microwatershed has soils that are highly suitable (class S1) for growing chrysanthemum crop. They are distributed mainly in the northeastern part of the microwatershed. They have minor or no limitations for growing chrysanthemum. Major area of about 248 ha (63%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, texture, rooting depth and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 86 ha (22%) area in the microwatershed and occur in the central and southwestern part of the microwatershed. They have severe limitations of calcareousness and texture.

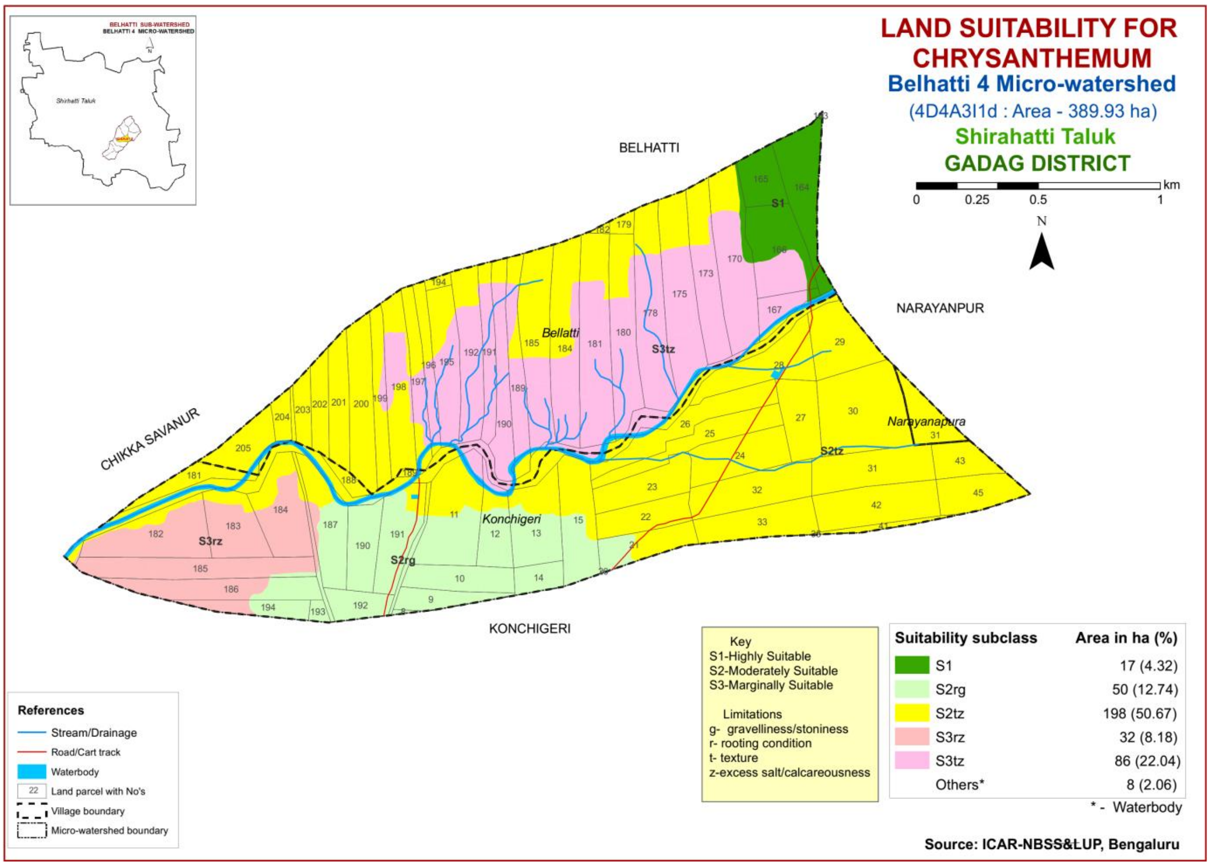


Fig. 7.21 Land Suitability map of Chrysanthemum

7.22 Land Management Units (LMUs)

The 17 soil map units identified in Belhatti-4 microwatershed have been regrouped into 7 Land Management Units (LMU's) for the purpose of preparing Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Units map (Fig.7.22) has been prepared. These Land Management Units are expected to behave similarly for a given level of management.

The map units that have been grouped into 7 land management units along with brief description of soil and site characteristics are given below.

LMUs	Soil Map units	Soil and Site characteristics
1	BGPmB1	Very deep, clay soils with slopes of 1-3%, and slight erosion
2	BPRiB1g2	Deep, clay soils with slopes of 1-3%, gravelly to very gravelly (35-60%) and slight erosion
3	LGDiB2g1, LGDmA1, LGDmA2, LGDmB1, LGDmB1g1, LGDmB2g1, LGDmB2g2	Deep, clay soils with slopes of <1-3%, gravelly to very gravelly (15-60%) and slight to moderate erosion
4	CKMhA1g1	Moderately deep, sandy clay soils with slopes of 0-1%, gravelly (15-35%) and slight erosion

5	KGHiB2g2, MKHhB1g1	Moderately shallow, sandy clay loam soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and slight to moderate erosion
6	RNKmB2g1, RNKmB2g2	Moderately shallow, sandy clay to clay soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and moderate erosion
7	MTLiB1g1, MTLmB2g1, MTLmB3g2	Shallow, sandy clay to clay soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and slight to severe erosion

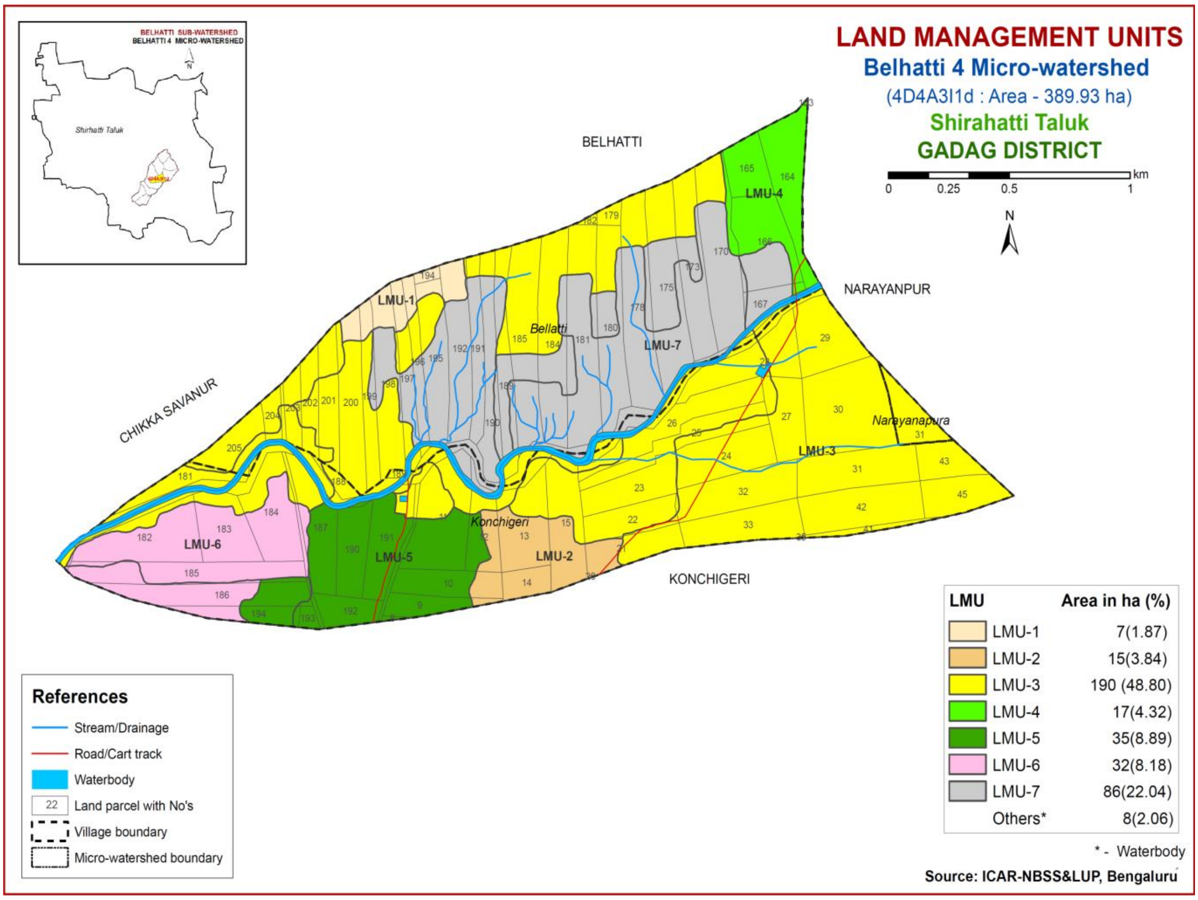


Fig. 7.22 Land Management Units map- Belhatti-4 microwatershed

7.23 Proposed Crop Plan for Belhatti-4 microwatershed

After assessing the land suitability for the 21 crops, the proposed crop plan has been prepared for the 7 identified LMUs by considering only the highly (class S1) and moderately suitable (class S2) lands for each of the 21 crops. The resultant proposed crop plan is presented below in Table 7.14

Table 7.14 Proposed Crop Plan for Belhatt-4 microwatershed

LMU No	Mapping Units	Survey Number	Field Crops/ Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Recommended Interventions
LMU1	17 (>150 cm)	Belhatti: 194	Redgram, Sorghum, Bajra, Cotton, Safflower, Bengalgram **Multiple/ crop rotation:** Redgram+ Fodder, Sorghum,Pulses-Sorghum	**Vegetables**: Green Chillies, Bhendi, Drumstick, Onion **Flower crops:** Marigold, Gaillardia, Aster **Fruit crops:** Banana, lime, pomegranate	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate **Vegetables***:*Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, conservation practices (Crescent Bunding with Catch Pit etc)
LMU 2	9 (100-150 cm)	Konchigeri:12,13, 14,15,20	Ragi, Maize, Groundnut, Sorghum, Sunflower, Bajra, Sesamum, Castor	**Perennial Component:** Mango, Tamarind, Aonla, **Intercrops:** Groundnut, HebbalAvare, Clusterbean, Coriander **Vegetables:** Tomato, Green Chillies, French Bean, Bhendi, Cowpea, Cucurbits **Flower Crops:** Marigold, Gaillardia	Mango, Sapota, Guava, Lime, Banana, Papaya, Jamun **Mixed Orcharding:** Mango+ Guava+ Drumsticks+Curryleaf, Sapota +Guava +Drumsticks +Curry leaf **Vegetables**:Tomoto, Capsicum, Green Chillies, French Bean, Bhendi, Crucifers, Cucurbits **Flower Crops:**Tuberose, Aster, Chrysanthemum, Rose, Jasmine, Spider Lilly	Drip irrigation, Mulching, suitable conservation practises

LMU 3	10, 11, 12, 13, 14, 15,16 (100-150 cm)	Belhatti:179,182, 184,185,198,199, 200,201,202,203, 204,205 Konchigeri:21,22, 23,24,25,26,27,28 ,29,30,31,32,33,3 5,41,42,43,45,181 ,188,189 Narayanapura: 31	Sorghum, Redgram, Cotton, Sunflower, Safflower, Linseed, Coriander, Bajra, Bengal gram **Multiple Crop rotation:** Redgram+ Fodder jowar, Pulses+ Sorghum	**Vegetables:** Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, other suitable conservation practises
LMU 4	8 (75-100 cm)	Belhatti:163,164, 165,166	Ragi, Maize, Groundnut, Sorghum, Sunflower, Bajra, Sesamum, Castor	**Perennial Component:** Mango, Tamarind, Aonla, Pomelo **Intercrops:** Groundnut, Hebbal Avare, Clusterbean, Coriander **Vegetables:** Tomato, Green Chillies, French Bean, Bhendi, Vegetable Cowpea, Cucurbits **Flower Crops:** Marigold, Gaillardia	Mango,Sapota,Guava,Lime,Banana, Papaya, Jamun **Mixed Orcharding:** Mango+Guava+Drumsticks+ Curry leaf, Sapota+ Guava+ Drumsticks+ Curry leaf **Vegetables:** Tomoto, Capsicum, Green Chillies, FrenchBean, Bhendi, Crucifers, Cucurbits **Flower Crops:** Tuberose, Aster, Chrysanthemum, Rose, Jasmine, Spider Lilly	Drip irrigation, Mulching, suitable conservation practises
LMU 5	4, 5 (50-75 cm)	Konchigeri:8,9,10 ,11,187,190,191,1 92,193,194	Ragi, Sorghum, Maize, Bajra, Horsegram, Castor	Bear, Fig, Aonla, Bael, Wood Apple	Custurd Apple, Bear, Fig, Aonla, Pommelo	-do-

LMU 6	6, 7 (50-75 cm)	Konchigeri:182,183,184,185,186	Sorghum, Cotton, Bajra, Bengal gram, Safflower, Redgram	**Vegetables:** Chillies, Tomato, Bhendi, Cabbage, Drumstick, Onion, Ridge Gouard, Ashguard	Bear, Fig, Aonla, Pomelo	Drip irrigation, Mulching, suitable conservation practises
LMU 7	1,2,3 (25-50 cm)	Belhatti:167,170, 173,175,178,180, 181,189,190,191, 192,195,196,197	Bengalgram, Cowpea, Greengram	**Vegetables:**Chillies, Tomato	Bear, Fig, Aonla, Pomelo	-do-

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

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

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

The most important characterististics of a healthy soil are

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

Characteristics of Belhatti-4 microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of LGD (135 ha), MTL (86 ha), RNK (32 ha), MKH (31 ha), CKM (17 ha), BPR (15 ha), BGP (7 ha) and KGH (4 ha). As per land capability classification, nearly 98 per cent area comes under arable land category (Class II, III and IV) and two per cent area belongs to nonarable land category. The major limitations identified in the arable lands were soil erosion and soil characteristics.
- On the basis of soil reaction, very strongly alkaline (pH >9.0) soils occupy about 139 ha (36%) followed by strongly alkaline (pH 8.4-9.0) 155 ha (40%); about 56 ha (14%) is moderately alkaline (pH 7.8-8.4) and 32 ha (8%) area is neutral (pH 6.5-7.3) to slightly

alkaline (pH 7.3-7.8). Thus, major soils in the microwatershed are alkaline in reaction and need appropriate ameliorative measures to restore soil health.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% of 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.

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

Inputs for Net Planning and Interventions needed

Net planning in IWMP is focusing on preparation of

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

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

- **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, 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 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, rooting depth and gravelliness are the major constraints in Belhatti-4 microwatershed.

- **Organic Carbon:** In about 227 ha (58%) area, the OC content is medium (0.5-0.75%) and in about 155 ha (40%) area it is low (<0.5%). The areas that are low in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in areas where OC is less than 0.5-0.75%. For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.

- **Available Phosphorus**: In 353 ha (91%) area, the available phosphorus is low. Hence for all the crops, 25% additional P-needs to be applied.

- **Available Potassium:** Available potassium is medium in 166 ha (43%) area of the microwatershed. Hence, in all these plots, for all crops, an additional 25 % potassium can be applied.

- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 12 ha (3%) area of the microwatershed. These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.

- **Available iron:** It is deficient in 22 ha (6%) area of the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years.

- **Available Zinc:** It is deficient in major area of 360 ha (92%) in the microwatershed. Application of zinc sulphate @25kg/ha is to be applied.

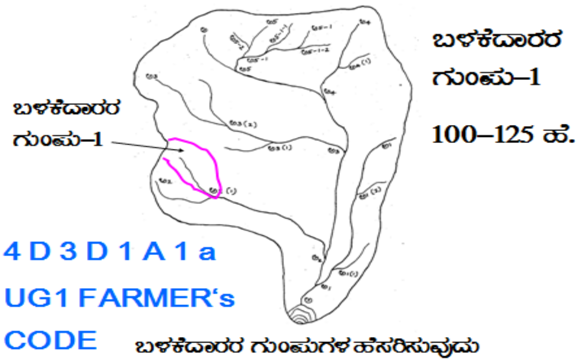
- **Soil alkalinity:** The major soils in the microwatershed are moderately to very strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like proper drainage or subsurface drainage, treating repeatedly with good quality water to drain out the excess salts, growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc. are recommended.

Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and salinity/alkalinity are the major constraints in various plots. With suitable management interventions, the productivity can be enhanced. In order to increase water holding capacity of light textured soils, growing of green manure crops and application of organic manure is recommended.

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Belhatti-4 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using the soil phase map as a base. The various thematic maps (1:7920 scale) generated were

- Soil depth
- Surface soil texture
- Available water capacity
- Soil slope
- Soil gravelliness
- Land capability
- Present land use & land cover
- Crop suitability maps
- Rainfall map
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features- Network of water ways, 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

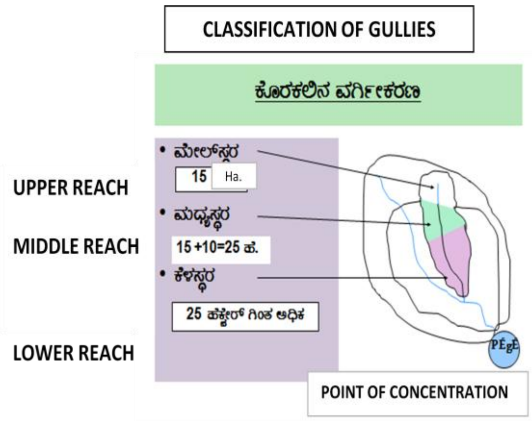
The treatment plan recommended for arable lands is briefly described below

9.1.1 Arable Land Treatment

A. BUNDING

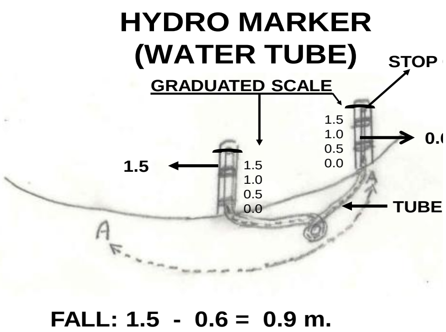
Steps for Survey and Preparation of Treatment Plan	
Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale Drainage lines are 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 hydrometer.



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

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

Note: (i) The above intervals are maximum.

(ii) Considering the slope class and erosion status (A1….) the intervals have to be decided.

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

Section of the Bund

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

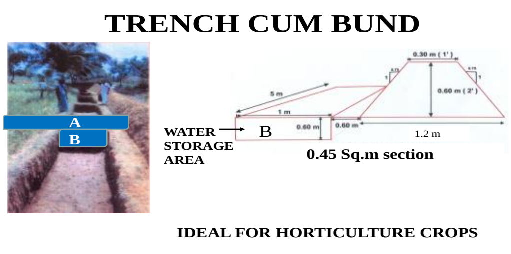
Recommended Bund Section

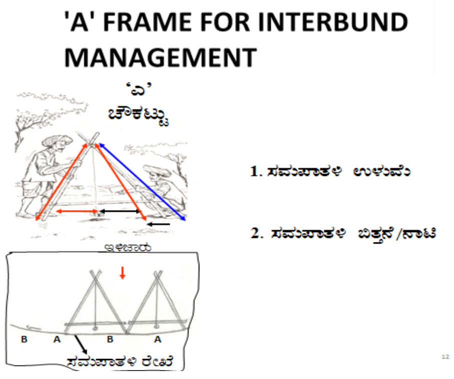
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soil	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below





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

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

B. Water ways

a) Existing waterways are marked on the cadastral map (1:7920 scale) and their dimensions are recorded.

b) Considering the contour plan of the MWS, additional waterways/ modernization of the existing ones can be thought of.

c) The design details are given in the Manual.

C. Farm ponds

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

D. Diversion channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of drainge lines (gullies/ nalas/ hallas) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.
b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.
c) Considering the Catchment, Nala bed and bank conditions, suitable structures are decided.
d) Number of storage structures (Check dam/ Nala bund/ Percolation tank) will be decided considering the commitments and available runoff in water budgeting and quality of water in the wells and site suitability.
e) Detailed Levelling Survey using Dumpy Level / Total Station has to be carried out to arrive at the site-specific designs as shown in the Manual.
f) The location of ground water recharge structures are decided by examining the lineaments and fracture zones from geological maps.
g) Rainfall intensity data of the nearest Rain gauge station is considered for Hydrologic Designs.
h) Silt load to the Storage/Recharge structures is reduced by providing vegetative, boulder and earthen checks in the natural water course. Location and design details are given in the Manual.

9.2 Recommended Soil and Water Conservation measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been prepared which shows the spatial distribution and extent of area. Major area of about 309 ha (80%) needs graded bunds and minor area of about 35 ha (9%) requires trench cum bunding. About 38 ha (10%) area requires bunding/ strengthening of existing bunds.

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

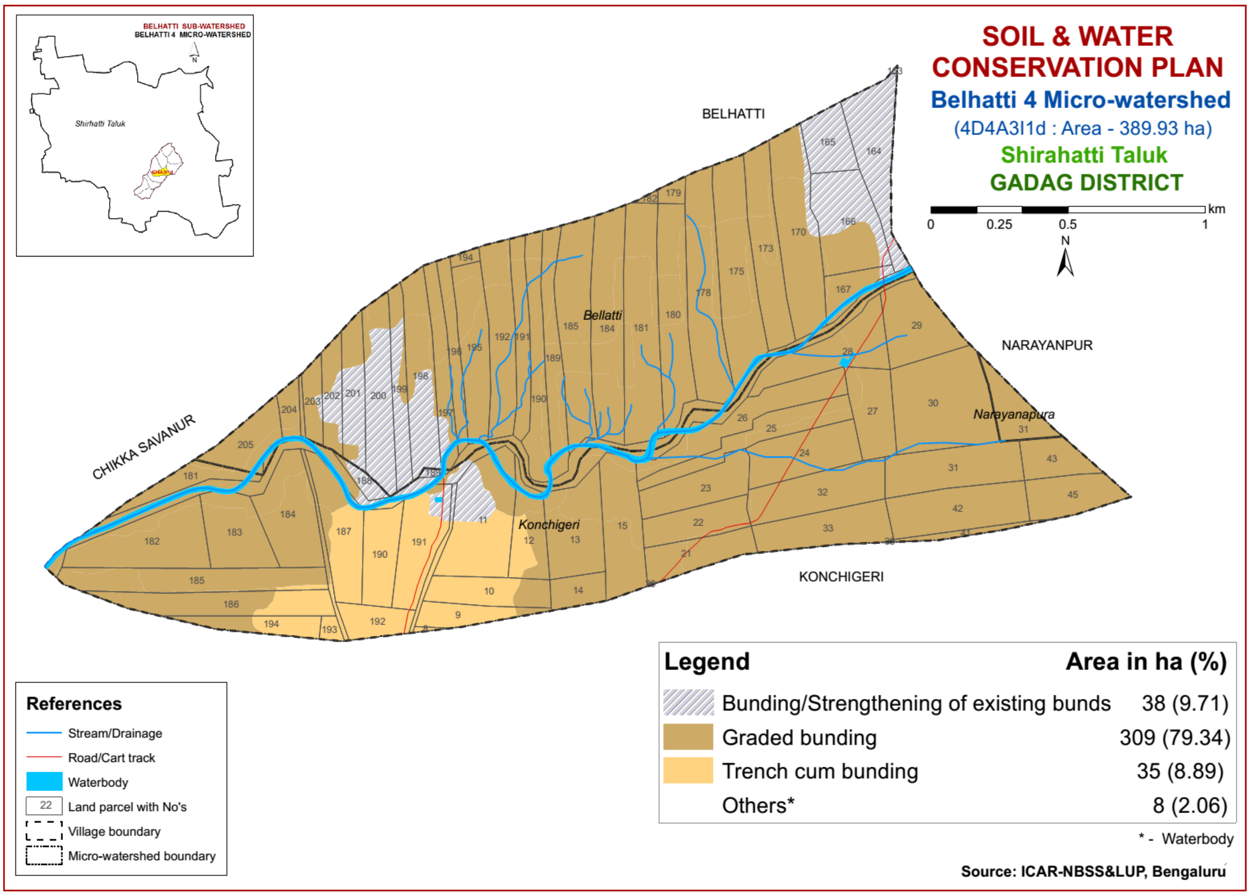


Fig. 9.1 Soil and Water Conservation Plan map of Belhatti-4 watershed

9.3 Greening of microwatershed

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

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

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; water logged 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				
15.	Teak	*Tectona grandis*	20 - 50	500-5000
16.	Nandi	*Legarstroemia lanceolata*	20 - 40	500 - 4000
17.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 3000
18.	Mathi	*Terminalia alata*	20 -50	500 - 2000
19.	Shivane	*Gmelina arboria*	20 -50	500 -2000
20.	Kindal	*T.Paniculata*	20 - 40	500 - 1500
21.	Beete	*Dalbargia latifolia*	20 - 40	500 - 1500
22.	Tare	*T. belerica*	20 - 40	500 - 2000
23.	Bamboo	*Bambusa arundinasia*	20 - 40	500 - 2500
24.	Bamboo	*Dendrocalamus strictus*	20 – 40	500 – 2500
25.	Muthuga	*Butea monosperma*	20 - 40	400 - 1500
26.	Hippe	*Madhuca latifolia*	20 - 40	500 - 2000
27.	Sandal	*Santalum album*	20 - 50	400 - 1000
28.	Nelli	*Emblica officinalis*	20 - 40	500 - 2000
29.	Nerale	*Sizyzium cumini*	20 - 40	500 - 2000
30.	Dhaman	*Grevia tilifolia*	20 - 40	500 - 2000
31.	Kaval	*Careya arborea*	20 - 40	500 - 2000
32.	Harada	*Terminalia chebula*	20 - 40	500 - 2000

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Appendix I

Soil Phase Information

VILLAGE	Survey No.	Total Area (ha)	Soils	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Bellatti	163	0.03	CKMhA1g1	LMU-4	Moderately deep (75-100 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIes	Bunding/Strengthening of existing bunds
Bellatti	164	7.07	CKMhA1g1	LMU-4	Moderately deep (75-100 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Nearly level (0-1%)	Slight	Greengram+Mango +Sugarcane (Gg+Mn+Sc)	Not Available	IIes	Bunding/Strengthening of existing bunds
Bellatti	165	3.69	CKMhA1g1	LMU-4	Moderately deep (75-100 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Nearly level (0-1%)	Slight	Maize+Fallow Land (Mz+FL)	Not Available	IIes	Bunding/Strengthening of existing bunds
Bellatti	166	8.12	CKMhA1g1	LMU-4	Moderately deep (75-100 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Nearly level (0-1%)	Slight	Maize+Chilli+Sugarcane (Mz+Ch+Sc)	Openwell	IIes	Bunding/Strengthening of existing bunds
Bellatti	167	2.48	MTLiB1g1	LMU-7	Shallow (25-50 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	NA	Check dam	IIIs	Graded bunding
Bellatti	170	10.08	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Fallow Land (FL)	Not Available	IVes	Graded bunding
Bellatti	173	7.26	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Cotton+Fallow Land (Mz+Ct+FL)	Not Available	IVes	Graded bunding
Bellatti	175	10.02	MTLmB2g1	LMU-7	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Onoin+Fallow Land (Mz+On+FL)	Not Available	IIIes	Graded bunding
Bellatti	178	9.81	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Onion (Mz+On)	Not Available	IVes	Graded bunding
Bellatti	179	0.75	LGDmB1	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIe	Graded bunding
Bellatti	180	8.44	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Sugarcane (Mz+Sc)	Not Available	IVes	Graded bunding
Bellatti	181	11	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize (Mz)	Farm pond	IVes	Graded bunding
Bellatti	182	0.23	LGDmB1	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIe	Graded bunding
Bellatti	184	9.57	LGDmB1	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIe	Graded bunding
Bellatti	185	9.24	LGDmB1	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Onion (Mz+On)	Not Available	IIe	Graded bunding

VILLAGE	Survey No.	Total Area (ha)	Soils	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Bellatti	189	5.32	MTLmB2g1	LMU-7	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Fallow Land (Mz+FL)	Not Available	IIIes	Graded bunding
Bellatti	190	5.52	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Fallow Land (Mz+FL)	Not Available	IVes	Graded bunding
Bellatti	191	3.84	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Jowar+Fallow Land (Mz+Jw+FL)	Openwell	IVes	Graded bunding
Bellatti	192	6.9	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Jowar+Fallow Land (Jw+FL)	Openwell	IVes	Graded bunding
Bellatti	194	0.49	BGPmB1	LMU-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIe	Graded bunding
Bellatti	195	6.46	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Jowar+Groundnut+Fallow Land (Mz+Jw+Gn+FL)	Not Available	IVes	Graded bunding
Bellatti	196	3	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Cotton+Jowar+Fallow Land (Ct+Jw+FL)	Not Available	IVes	Graded bunding
Bellatti	197	4.19	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Cotton+Fallow land (Ct+FL)	Not Available	IVes	Graded bunding
Bellatti	198	7.17	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Moderate	Jowar+Cotton+Greengram+Fallow Land (Jw+Ct+Gg+FL)	Not Available	IIIe	Bunding/Strengthening of existing bunds
Bellatti	199	3.94	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Moderate	Maize+Cotton+Fallow Land (Mz+Ct+FL)	Not Available	IIIe	Bunding/Strengthening of existing bunds
Bellatti	200	6.81	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Moderate	Cotton+Jowar+Fallow Land (Ct+Jw+FL)	Not Available	IIIe	Bunding/Strengthening of existing bunds
Bellatti	201	4.31	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Moderate	Maize+Greengram (Mz+Gg)	Not Available	IIIe	Bunding/Strengthening of existing bunds
Bellatti	202	2.83	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram (Mz+Gg)	Not Available	IIes	Graded bunding
Bellatti	203	1.96	LGDmB2g2	LMU-3	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIes	Graded bunding
Bellatti	204	1.39	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Bellatti	205	4	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding

VILLAGE	Survey No.	Total Area (ha)	Soils	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capabi -lity	Conservation Plan
Bellatti	STREAM	5.23	MTLmB3g2	LMU-7	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Waterbody	Not Available	IVes	Graded bunding
Konchigeri	8	0.15	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIIs	Trench cum bunding
Konchigeri	9	2.85	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIIs	Trench cum bunding
Konchigeri	10	4.54	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+ Cotton (Mz+Gn+Ct)	Not Available	IIIs	Trench cum bunding
Konchigeri	11	9.71	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+ Cotton (Mz+Gn+Ct)	Not Available	IIIs	Trench cum bunding
Konchigeri	12	4.26	BPRiB1g2	LMU-2	Deep (100-150 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut+ Current Fallow Land (Mz+Gn+CFL)	Not Available	IIIes	Graded bunding
Konchigeri	13	6.92	BPRiB1g2	LMU-2	Deep (100-150 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram+ Groundnut (Mz+Gg+Gn)	Not Available	IIIes	Graded bunding
Konchigeri	14	2.18	BPRiB1g2	LMU-2	Deep (100-150 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Groundnut (Gn)	Not Available	IIIes	Graded bunding
Konchigeri	15	7.01	BPRiB1g2	LMU-2	Deep (100-150 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIIes	Graded bunding
Konchigeri	20	0.02	BPRiB1g2	LMU-2	Deep (100-150 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIIes	Graded bunding
Konchigeri	21	4.4	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Konchigeri	22	4.35	LGDmB2g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Horsegram (Mz+Hg)	Not Available	IIIe	Graded bunding
Konchigeri	23	5.13	LGDmB2g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Greengram (Mz+Ct+Gg)	Not Available	IIIe	Graded bunding
Konchigeri	24	6.43	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	25	5.59	LGDmB2g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIe	Graded bunding
Konchigeri	26	6.79	LGDmB2g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIIe	Graded bunding
Konchigeri	27	4.8	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding

VILLAGE	Survey No.	Total Area (ha)	Soils	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capabi-lity	Conservation Plan
Konchigeri	28	6.68	LGDmB2g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Sugarcane+Onion (Mz+Ct+Sc+On)	Borewell	IIIe	Graded bunding
Konchigeri	29	6.23	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Oinion (On)	Not Available	IIes	Graded bunding
Konchigeri	30	11.81	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton (Mz+Ct)	Not Available	IIes	Graded bunding
Konchigeri	31	7.31	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	32	7.14	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	33	6.19	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram (Mz+Gg)	Not Available	IIes	Graded bunding
Konchigeri	35	0.03	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	41	0.99	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIes	Graded bunding
Konchigeri	42	7.7	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	43	3.2	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram (Mz+Gg)	Not Available	IIes	Graded bunding
Konchigeri	45	4.53	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding
Konchigeri	181	2.76	LGDmB2g2	LMU-3	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIes	Graded bunding
Konchigeri	182	8.61	RNKmB2g1	LMU-6	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Greengram (Mz+Gg)	Not Available	IIIe	Graded bunding
Konchigeri	183	5.86	RNKmB2g1	LMU-6	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Onion (Mz+On)	Not Available	IIIe	Graded bunding
Konchigeri	184	7.19	RNKmB2g1	LMU-6	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Onion+Cotton (Mz+On+Ct)	Borewell	IIIe	Graded bunding
Konchigeri	185	8.08	RNKmB2g1	LMU-6	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Sugarcane+Cotton (Sc+Ct)	Not Available	IIIe	Graded bunding
Konchigeri	186	6.89	RNKmB2g2	LMU-6	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIIes	Graded bunding
Konchigeri	187	6.31	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Groundnut+Cotton (Gn+Ct)	Not Available	IIIs	Trench cum bunding

VILLAGE	Survey No.	Total Area (ha)	Soils	Land Manage -ment Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU code	WELLS	Land Capabili ty	Conserva tion Plan
Konchigeri	188	1.01	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Modera te	Fallow Land (FL)	Not Available	IIIe	Bunding/ Strength ening of existing bunds
Konchigeri	189	0.26	LGDmA2	LMU-3	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Modera te	Fallow Land (FL)	Not Available	IIIe	Bunding/ Strength ening of existing bunds
Konchigeri	190	4.45	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Groundnut (Mz+Gn)	Not Available	IIIs	Trench cum bunding
Konchigeri	191	6.1	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Openwell	IIIs	Trench cum bunding
Konchigeri	192	2.8	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Greengram (Jw+Gg)	Openwell	IIIs	Trench cum bunding
Konchigeri	193	0.63	MKHhB1g1	LMU-5	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram (Gg)	Not Available	IIIs	Trench cum bunding
Konchigeri	194	2.97	KGHiB2g2	LMU-5	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Modera te	Maize (Mz)	Not Available	IIIes	Trench cum bunding
Konchigeri	STRE AM	12.19	LGDmB2g2	LMU-3	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Modera te	Waterbody	Not Available	IIIes	Graded bunding
Narayanap ura	31	3.53	LGDmB1g1	LMU-3	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize (Mz)	Not Available	IIes	Graded bunding

Appendix II

Soil Fertility Information

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Bellatti	**163**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**164**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**165**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**166**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**167**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Sufficient (> 0.6 ppm)**
Bellatti	**170**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**173**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**175**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**178**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**179**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**180**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**181**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**182**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**184**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**185**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**189**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**190**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**191**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**192**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**194**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Bellatti	**195**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Low (< 0.5 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**High (> 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Bellatti	196	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	197	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	198	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	199	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	200	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	201	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	202	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	203	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	204	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	205	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Bellatti	STREAM	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	8	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)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	9	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)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	10	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)
Konchigeri	11	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	12	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	13	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	14	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	15	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	20	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Low (<10 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	21	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	22	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchigeri	23	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	24	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	25	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	26	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	27	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	28	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Konchigeri	29	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	30	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	31	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	32	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	33	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	35	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	41	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	42	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	43	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	45	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	181	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	182	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	183	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	184	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	185	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Konchigeri	186	Strongly alkaline (pH 8.4 – 9.0)	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)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

VILLAGE	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchigeri	**187**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**188**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**189**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**190**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**191**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**192**	**Slightly alkaline (pH 7.3 – 7.8)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Medium (23 – 57 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**193**	**Slightly alkaline (pH 7.3 – 7.8)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Medium (23 – 57 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Low (<10 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**194**	**Moderately alkaline (pH 7.8 – 8.4)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Medium (23 – 57 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Low (<10 ppm)**	**Low (< 0.5 ppm)**	**Deficient (< 4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Konchigeri	**STREAM**	**Strongly alkaline (pH 8.4 – 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**Medium (145 – 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**
Narayanapura	**31**	**Very strongly alkaline (pH > 9.0)**	**Non saline (<2 dsm)**	**Medium (0.5 – 0.75 %)**	**Low (< 23 kg/ha)**	**High (> 337 kg/ha)**	**Medium (10 – 20 ppm)**	**Low (< 0.5 ppm)**	**Sufficient (>4.5 ppm)**	**Sufficient (> 1.0 ppm)**	**Sufficient (> 0.2 ppm)**	**Deficient (< 0.6 ppm)**

Appendix III

Soil Suitability Information

VILLAGE	Survey No.	Sorghum	Mai ze	Beng al gram	Gro und-nut	Sun-flower	Cotto n	Tom -ato	Onion	Chill y	Guava	Ma ngo	Sapo ta	Jack fruit	Jamun	Musa mbi	Lim e	Cash ew	Custa rd apple	Amla	Ta mar ind	Pome g-ranat e	Ban ana	Mari-gold	Chrys an-them um
Bellatti	163	S1	S1	S2rt	S2t	S2r	S2r	S1	S1	S1	S2rt	S3r	S3r	S3r	S3r	S3r	S2r	S2rt	S1	S1	S3r	S2r	S2r	S1	S1
Bellatti	164	S1	S1	S2rt	S2t	S2r	S2r	S1	S1	S1	S2rt	S3r	S3r	S3r	S3r	S3r	S2r	S2rt	S1	S1	S3r	S2r	S2r	S1	S1
Bellatti	165	S1	S1	S2rt	S2t	S2r	S2r	S1	S1	S1	S2rt	S3r	S3r	S3r	S3r	S3r	S2r	S2rt	S1	S1	S3r	S2r	S2r	S1	S1
Bellatti	166	S1	S1	S2rt	S2t	S2r	S2r	S1	S1	S1	S2rt	S3r	S3r	S3r	S3r	S3r	S2r	S2rt	S1	S1	S3r	S2r	S2r	S1	S1
Bellatti	167	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3tz	S3tz	S3z	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3r	S3r	Nr	Ntz	Ntz	S3tz	S3tz
Bellatti	170	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	173	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	175	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3tz	S3tz	S3z	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3r	S3r	Nr	Ntz	Ntz	S3tz	S3tz
Bellatti	178	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	179	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	180	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	181	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	182	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	184	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	185	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	189	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3tz	S3tz	S3z	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3r	S3r	Nr	Ntz	Ntz	S3tz	S3tz
Bellatti	190	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	191	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	192	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	194	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3zg	S3zg	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz

VILLAGE	Survey No.	Sorgh-um	Maize	Bengal gram	Groundnut	Sun-flower	Cotton	Tom-ato	Onion	Chilly	Guava	Mango	Sapota	Jack fruit	Jamun	Musambi	Lime	Cashew	Custard apple	Amla	Tamarind	Pomeg-ranate	Banana	Mari-gold	Chrysan-themum
Bellatti	195	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	196	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	197	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Bellatti	198	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	199	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	200	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	201	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	202	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	203	S2zg	S3tz	S2zg	S3tz	S2zg	S2zg	S3tz	S3tz	S2zg	S3gt	S3gt	S3gt	S3tgz	S2gt	S3gz	S3gz	Nz	S2gz	S2gz	S2tg	S2tz	S2tz	S2tz	S2tz
Bellatti	204	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	205	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Bellatti	STREAM	S3rz	S3zt	S3rz	S3zt	Nrz	S3rz	S3zg	S3zg	S3zg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	S3rg	S3rg	Nrg	Ntz	Ntz	S3tz	S3tz
Konchigeri	8	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	9	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	10	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	11	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	12	S2rg	S2rg	S2rg	S2rg	S2g	S2rg	S2g	S2g	S2g	S3gt	S2rg	S3rg	S2r	S2r	S3rg	S1	S2t	S2g	S2g	S1	S2rg	S2rg	S2rg	S2rg
Konchigeri	13	S2rg	S2rg	S2rg	S2rg	S2g	S2rg	S2g	S2g	S2g	S3gt	S2rg	S3rg	S2r	S2r	S3rg	S1	S2t	S2g	S2g	S1	S2rg	S2rg	S2rg	S2rg
Konchigeri	14	S2rg	S2rg	S2rg	S2rg	S2g	S2rg	S2g	S2g	S2g	S3gt	S2rg	S3rg	S2r	S2r	S3rg	S1	S2t	S2g	S2g	S1	S2rg	S2rg	S2rg	S2rg
Konchigeri	15	S2rg	S2rg	S2rg	S2rg	S2g	S2rg	S2g	S2g	S2g	S3gt	S2rg	S3rg	S2r	S2r	S3rg	S1	S2t	S2g	S2g	S1	S2rg	S2rg	S2rg	S2rg
Konchigeri	20	S2rg	S2rg	S2rg	S2rg	S2g	S2rg	S2g	S2g	S2g	S3gt	S2rg	S3rg	S2r	S2r	S3rg	S1	S2t	S2g	S2g	S1	S2rg	S2rg	S2rg	S2rg

VILLAGE	Survey No.	Sorgh -um	Mai ze	Beng al gram	Gro und- nut	Sun- flower	Cotto n	Tom -ato	Onion	Chil ly	Guava	Man go	Sap ota	Jack fruit	Jamun	Musa mbi	Lim e	Cash ew	Custa rd apple	Amla	Tam arin d	Pome g- ranat e	Ban ana	Mari- gold	Chry san- them um
Konchigeri	**21**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**22**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**23**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**24**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**25**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**26**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**27**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**28**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**29**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**30**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**31**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**32**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**33**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**35**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**41**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**42**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**43**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**45**	**S2rz**	**S3tz**	**S2rz**	**S3tz**	**S2rz**	**S2rz**	**S3tz**	**S3tz**	**S2z**	**S2tz**	**S3tz**	**S3tz**	**S3tz**	**S2tz**	**S2z**	**S2z**	**Nz**	**S2z**	**S2z**	**S2tz**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**181**	**S2zg**	**S3tz**	**S2zg**	**S3tz**	**S2zg**	**S2zg**	**S3tz**	**S3tz**	**S2zg**	**S3gt**	**S3gt**	**S3gt**	**S3tg z**	**S2gt**	**S3gz**	**S3gz**	**Nz**	**S2gz**	**S2gz**	**S2tg**	**S2tz**	**S2tz**	**S2tz**	**S2tz**
Konchigeri	**182**	**S3rz**	**S3tz**	**S3rz**	**S3tz**	**S3rz**	**S2rz**	**S3tz**	**S3tz**	**S2zg**	**S3rt**	**Nrz**	**S3rz**	**S3rt**	**S3rt**	**S3rz**	**S3rz**	**Nz**	**S3rz**	**S3rz**	**Nrt**	**S3rz**	**S3rz**	**S3rz**	**S3rz**
Konchigeri	**183**	**S3rz**	**S3tz**	**S3rz**	**S3tz**	**S3rz**	**S2rz**	**S3tz**	**S3tz**	**S2zg**	**S3rt**	**Nrz**	**S3rz**	**S3rt**	**S3rt**	**S3rz**	**S3rz**	**Nz**	**S3rz**	**S3rz**	**Nrt**	**S3rz**	**S3rz**	**S3rz**	**S3rz**
Konchigeri	**184**	**S3rz**	**S3tz**	**S3rz**	**S3tz**	**S3rz**	**S2rz**	**S3tz**	**S3tz**	**S2zg**	**S3rt**	**Nrz**	**S3rz**	**S3rt**	**S3rt**	**S3rz**	**S3rz**	**Nz**	**S3rz**	**S3rz**	**Nrt**	**S3rz**	**S3rz**	**S3rz**	**S3rz**

VILLAGE	Survey No.	Sorgh-um	Maize	Bengal gram	Ground-nut	Sun-flower	Cotton	Tom-ato	Onion	Chilly	Guava	Mango	Sapota	Jack fruit	Jamun	Musambi	Lime	Cashew	Custard apple	Amla	Tamarind	Pomeg-ranate	Banana	Mari-gold	Chrysan-themum
Konchigeri	185	S3rz	S3tz	S3rz	S3tz	S3rz	S2rz	S3tz	S3tz	S2zg	S3rt	Nrz	S3rz	S3rt	S3rt	S3rz	S3rz	Nz	S3rz	S3rz	Nrt	S3rz	S3rz	S3rz	S3rz
Konchigeri	186	S3rz	S3tz	S3rz	S3tz	S3rz	S2rz	S3zg	S3zg	S2zg	S3rt	Nrz	S3rg	S3rt	S3rt	S3rg	S3rg	Nz	S2zg	S3zg	Nrt	S3rz	S3rz	S3rz	S3rz
Konchigeri	187	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	188	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	189	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz
Konchigeri	190	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	191	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	192	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	193	S2rg	S2rg	S2rg	S2rg	S3rg	S2rg	S2g	S2g	S2g	S3rt	Nr	S3r	S3r	S3r	S3r	S3rg	S3rg	S3rg	S3rg	Nr	S3rg	S3rg	S2rg	S2rg
Konchigeri	194	S2rg	S2rg	S2rt	S2rg	S3rg	S2r	S2g	S2g	S2g	S3rt	Nrg	S3r	S3rg	S3rg	S3r	S3rg	S2rg	S2rg	S2rg	Nrg	S3r	S3r	S2rg	S2rg
Konchigeri	STREAM	S2zg	S3tz	S2zg	S3tz	S2zg	S2zg	S3tz	S3tz	S2zg	S3gt	S3gt	S3gt	S3tgz	S2gt	S3gz	S3gz	Nz	S2gz	S2gz	S2tg	S2tz	S2tz	S2tz	S2tz
Narayanapura	31	S2rz	S3tz	S2rz	S3tz	S2rz	S2rz	S3tz	S3tz	S2z	S2tz	S3tz	S3tz	S3tz	S2tz	S2z	S2z	Nz	S2z	S2z	S2tz	S2tz	S2tz	S2tz	S2tz

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**:** Belhatti-4 micro-watershed (Belhatti 4 sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^0 2'$ – $15^0 4'$ North latitudes and $75^0 37'$ – $75^0 39'$ East longitudes, covering an area of about 390 ha, bounded by Belhatti, Konchigeri, Chikasavanur and Narayanpur villages with length of growing period (LGP) 150-180 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for the Belhatti-4 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) are presented here.*

Social Indicators;

- *Male and female ratio is 60.8 to 39.2 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 74.5 per cent to the total population.*
- *Literacy population is around 80.4 per cent.*
- *Social groups belong to other backward caste (OBC) is around 80 per cent.*
- *Fire wood is the source of energy for a cooking among 70.0 per cent.*
- *About 40 per cent of households have a yashaswini health card.*
- *Majority of farm households (50 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 60 per cent.*
- *Swach bharath program providing closed toilet facilities around 80 per cent of sample households.*
- *Rural migration to urban centre for employment is prevalent among 10.0 per cent of farm households.*

Economic Indicators;

- *The average land holding is 2.0 ha indicates that majority of farm households are belong to small and medium farmers. The dry land of 20.1 per cent and irrigated land of 6 per cent of total cultivated land area among the sample farmers.*

- *Agriculture is the main occupation among 19.9 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 60.9 per cent of sample households.*
- *The average value of domestic assets is around Rs.12575 per household. Mobile and television are mass popular media mass communication.*
- *The average value of farm assets is around Rs.75292 per household, about 40 per cent of sample farmers bullock cart and plough (30 %).*
- *The average value of livestock is around Rs. 3600 per household; about 61.5 per cent of household are having livestock.*
- *The average per capita food consumption is around 828.0 grams (1796.0 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 50 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs.13601 per household. Among all sample farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs.1219.*

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. 866 per ha/year. The total cost of annual soil nutrients is around Rs. 329879 per year for the total area of 389.9 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 5059/ha/year. Per hectare food grain production services is maximum in cotton (Rs. 10175) followed by maize (Rs. 8882), horse gram (Rs. 3533), groundnut (Rs 2122) and sorghum (Rs. 582).*
- *The average value of ecosystem service for fodder production is around Rs. 954/ ha/year. Per hectare fodder production services is maximum in horse gram (Rs. 1317) followed by sorghum (Rs. 988), maize (Rs. 970), cotton (Rs. 823) and groundnut (Rs. 542).*
- *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 cotton (Rs. 39806) followed by sorghum (Rs. 27604), horse gram (Rs. 25342), maize (Rs. 25036), and groundnut (Rs. 21960).*

Economic Land Evaluation;

- *The major cropping pattern is maize (58.9 %) followed by Groundnut (22.8 %), cotton (6.1 %), horse gram (6.1 %) and sorghum (6.1%).*

- *In Belhatti 4 micro-watershed, major soil of alluvial landscape of KLK series is having very shallow soil deep on this soil farmers are presently growing maize and sorghum. BMD soil series are also having shallow soil depth the crops are groundnut (56.2 %) and maize (43.8 %). KPR soil series are having deep soil depth, crops are cotton (50.0 %) and sorghum (50.0 %). BGP and NGT soil series very deep soil depth, crops are maize and groundnut.*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for maize ranges between Rs. 23883/ha in KLP soil (with BCR of 1.33) and Rs.13204/ha in NBP soil (with BCR of 1.50).*
- *In groundnut range between Rs. 34464/ha in NGT soil (with BCR of 1.15) and Rs.21051/ha in BLD soil (with BCR of 1.26).*
- *In sunflower the cost of cultivation ranges between Rs. 39247/ha in DRL soil (with BCR of 1.1) and Rs. 17619/ha in NSP soil (with BCR of 2.36).*
- *In hors gram the cost of cultivation Rs. 26605/ha in NBP soil (with BCR of 1.50).*
- *In cotton the cost of cultivation is Rs.30226/ha in KPR soil (with BCR of 1.08).*
- *In bengal gram the cost of cultivation rage between is Rs. 26508/ha in DRL soil (with BCR of 1.68) and Rs.18518/ha in NSP soil (with BCR of 1.68).*
- *In sorghum the cost of cultivation Rs. 17531/ha in KPR soil (with BCR of 1.08).*
- *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 Groundnut (56.6 to 72.8 %), maize (80.9 to 61 %), (8.6 to 11.3 %), cotton (56.6 %), horse gram (42.2 %) and sorghum (15.7 %).*

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

Belhatti-4 micro-watershed is located in Northern Transition Zone of Karnataka (Figure 1). Extends over all area of 1.13 M ha of which 0.86 M ha is under cultivation. Nearly 0.052 M ha in the zone enjoys irrigation facilities. Elevation ranges between 450-900 m MSL with most parts situated between 800 and 900 m. Shallow to black soils and red loams are distributed in equal proportion. The average annual rainfall ranges from 620 to 1300 mm of which more than 60 per cent is received during the southwest monsoon (*kharif*). Sorghum, rice, groundnut, maize, chilli, pulses, sugarcane, tobacco and cotton are the major crops of the zone. It's represents Agro Ecological Sub Region (AESR) 6.4 having LGP 150-180 days.

Belhatti-4 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^{0}2'$ – $15^{0}4'$ North latitudes and $75^{0}37'$ – $75^{0}39'$ East longitudes, covering an area of about 390 ha, bounded by Belhatti, Konchigeri, Chikasavanur and Narayanpur villages.

Sampling Procedure:

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

Sources of data and analysis:

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

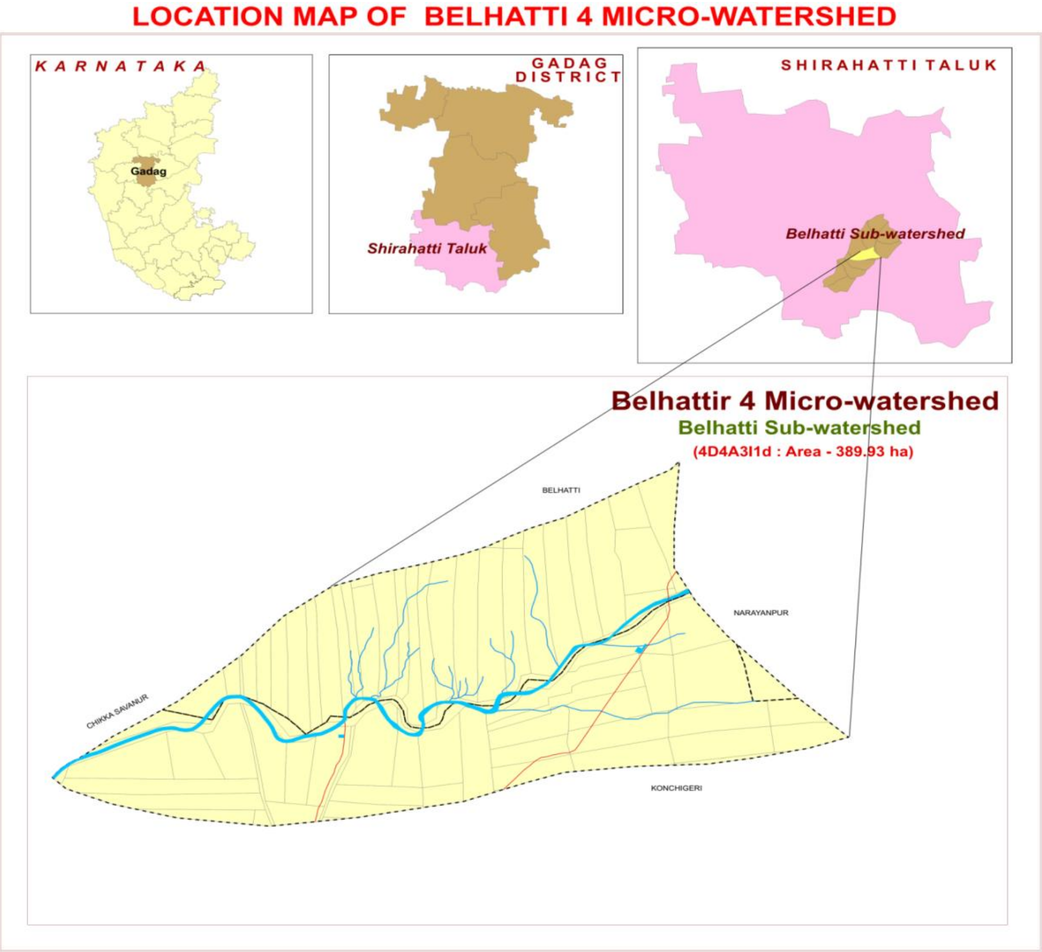

Figure 1: Location of study area

Steps followed in socio-economic assessment

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

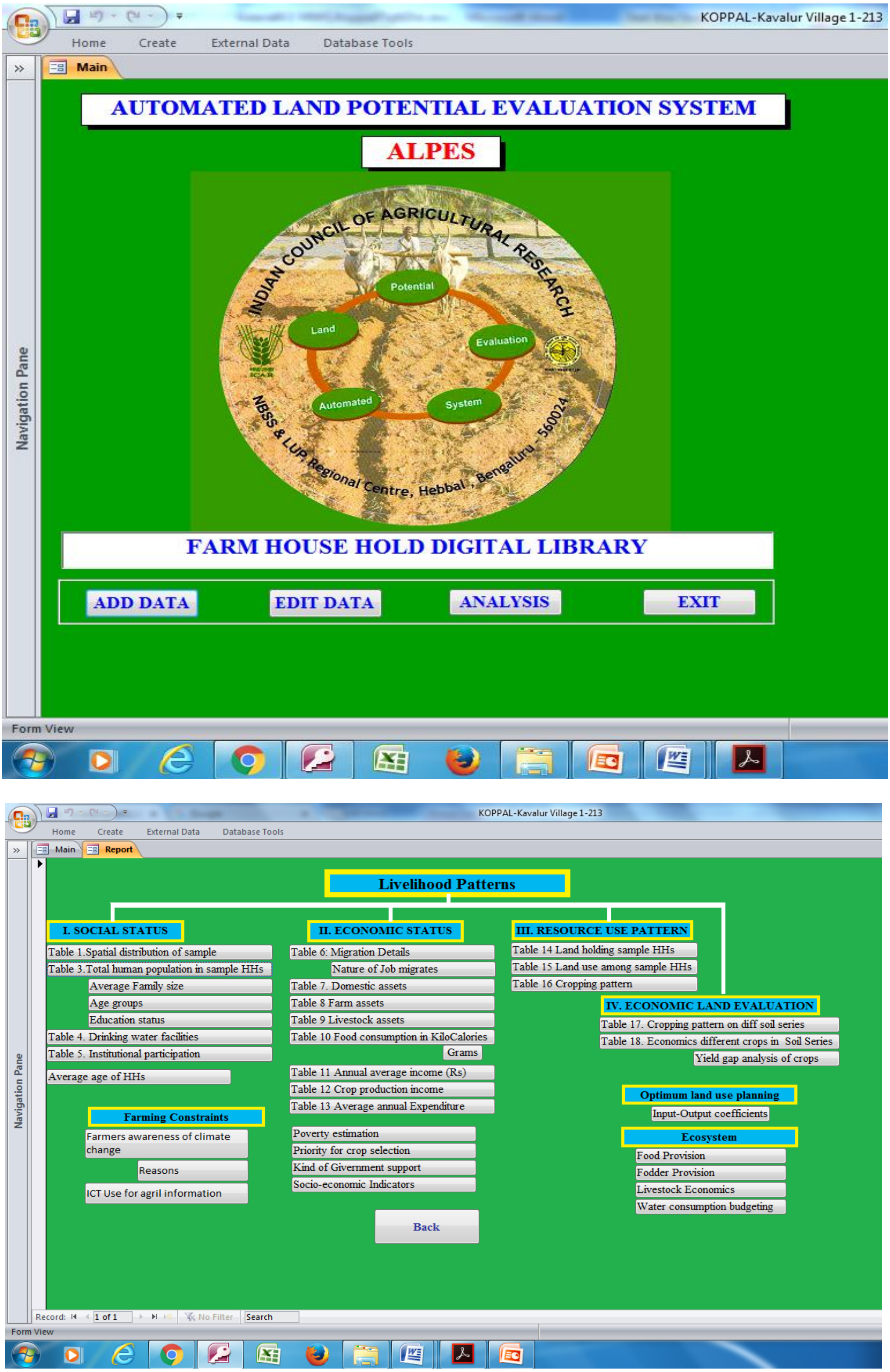

Figure 2: ALPES FRAMEWORK

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

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

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

Net returns = Gross returns-Operational cost.

Benefit Cost Ratio = Net returns/Total cost.

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

Economic Valuation of Soil ecosystem services:

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

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

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

Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The Total number of population in watershed area was 51, out of which 60.8 per cent were males and 39.9 per cent females. Average family size of the households is 5.1. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 18 to 30 years (33.3 %) followed by 0 to18 years (3.9 %), 30 to 50 years (41.2 %) and more than 50 years (21.6 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 80.4 per cent of respondents were illiterate and 19.6 per cent literate (Table 1).

Table 1: Human population among sample households in Belhatti 4 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	501
Male	% to total Population	60.8
Female	% to total Population	39.2
Average family size	Number	5.10
Age group		
0 to 18 years	% to total Population	3.9
18 to 30 years	% to total Population	33.3
30 to 50 years	% to total Population	41.2
>50 years	% to total Population	21.6
Average age	Age in years	38.2
Education Status		
Illiterates	% to total Population	19.6
Literates	% to total Population	80.4
Primary School (<5 class)	% to total Population	11.7
Middle School (6- 8 class)	% to total Population	11.7
High School (9- 10 class)	% to total Population	23.5
Others	% to total Population	33.3

The ethnic groups among the sample farm households found to be 70 per cent belonging to other backward castes (OBC) followed by 20 per cent belonging to scheduled castes (SC) and 10 per cent scheduled tribe (ST) (Table 2 and Figure 3). About 70.0 per cent of sample households are using fire wood as source of fuel for cooking. All the sample farmers are having electricity connection. About 40 per cent are sample households having health cards. Majority (50.0 %) are having MNREGA job cards for employment generation. About 60.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 80.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Belhatti 4 Microwatershed

Particulars	**Units**	**Value**
Social groups		
SC	% of Households	20
ST	% of Households	10
OBC	% of Households	70
Types of fuel use for cooking		
Fire wood	% of Households	70
Gas	% of Households	30
Energy supply for home		
Electricity	% of Households	100
Number of households having Health card		
Yes	% of Households	40
No	% of Households	60
MGNREGA Card		
Yes	% of Households	50
No	% of Households	50
Ration Card		
Yes	% of Households	60
No	% of Households	40
Households with toilet		
Yes	% of Households	80
No	% of Households	20
Drinking water facilities		
Tube well	% of Households	100

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

The data on migration in Belhatti 4 Micro-watershed is given in Table 3. It indicated that around 6.0 per cent of samples households were migrated. The average distance travelled for seeking employment is 175 km.

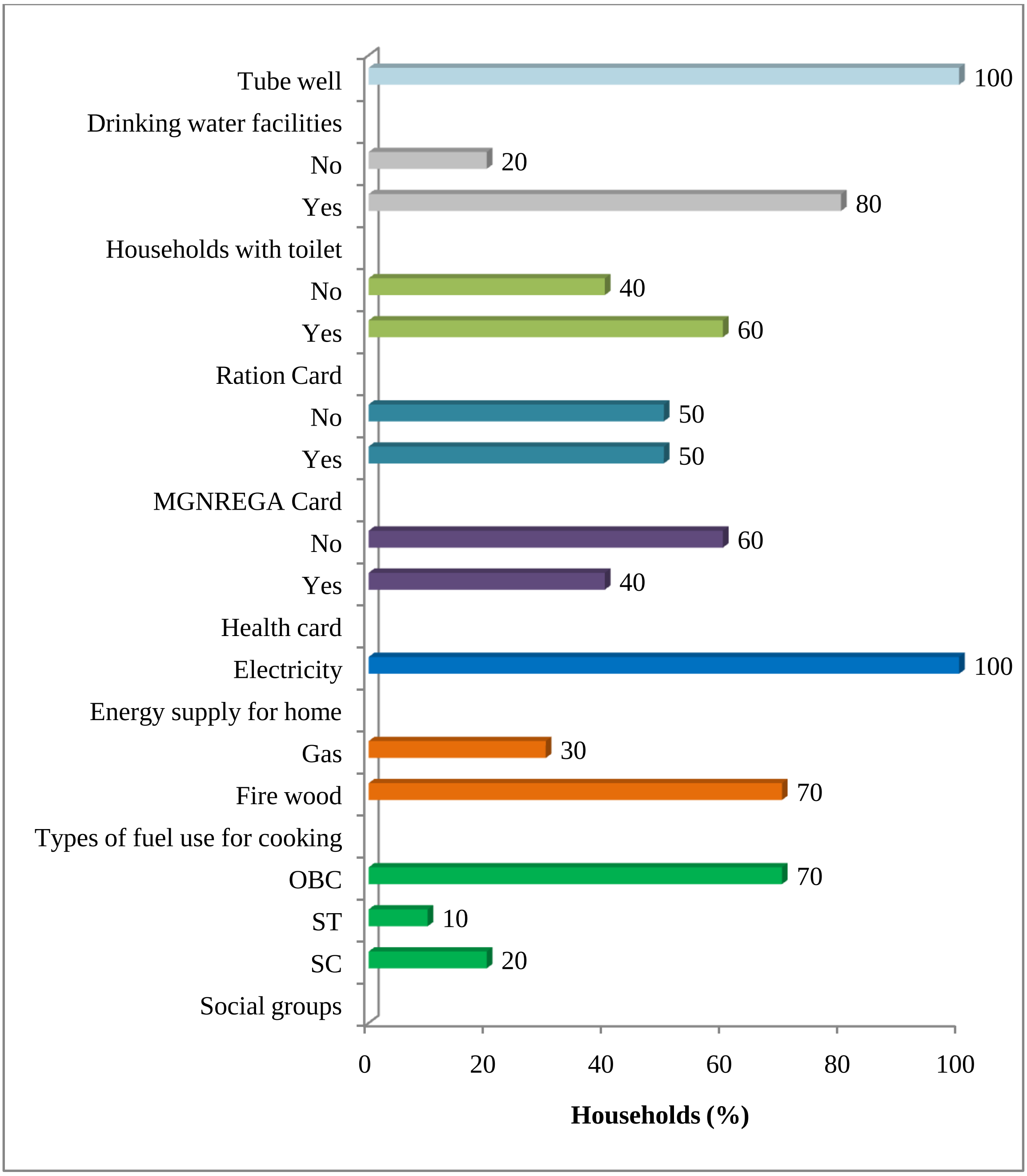

Figure 3: Basic needs of sample households in Belhatti 4 Microwatershed

Table 3: Migration details among the sample households in Belhatti 4 micro-watershed

Particulars	**Value**
% of households showing migration	10.0
% of persons migrating	4.0
No. of months migrated in a year	6.0
Average Distance of migration(Km)	175
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture Labour is the main occupation around (19.2 per cent of farmers followed by subsidiary occupations like Agricultural labour (2.1 %) and trade and business is (2.1) per cent. The Government services and private services is a main occupation of 2.1 per cent and 15.2 per cent of sample population.

Table 4: Occupational pattern in sample population in Belhatti 4 Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	19.9
	Agriculture Labour	60.9
	Trade and business	2.1
Govt. service		2.1
Private service		15.2
Family labour availability		**Man days/month**
Male		42.5
Female		24.4
Total		33.4

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 (100 %) followed by television (100 %), motorcycle (80%) mixer/grinder (60 %), and bicycle (10 %), The average value of domestic assets is around Rs 12575 per households.

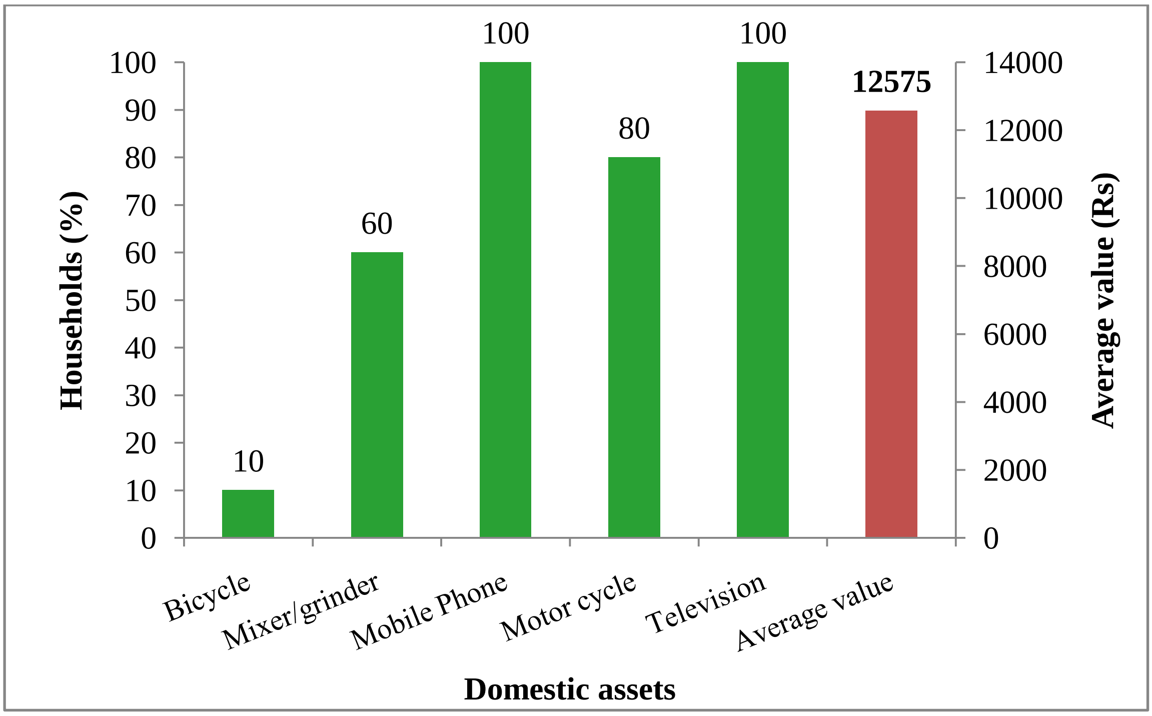

Figure 4: Domestic assets among the sample households in Belhatti 4 Micro watershed

Table 5: Domestic assets among the sample households in Belhatti 4 Microwatershed

Particulars	% of households	Average value in Rs
Bicycle	10	2500
Mixer/grinder	60	3500
Mobile Phone	100	3800
Motor cycle	80	46875
Television	100	6200
Average value	12575	

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned, bullock cart (40 %), plough (30 %), power tiller (20 %), tractor (20 %), and weeder (10 %) was found highest among the sample farmers. The average value of farm assets is around Rs 75292 per households (Table 6 and Figure 5).

Table 6: Farm assets among samples households in Belhatti 4 Microwatershed

Particulars	% of households	Average value in Rs
Weeder	10	400
Tractor	20	400000
Sprayer	10	5000
Power tiller	20	25000
Plough	30	5100
Bullock cart	40	16250
Average Value	75292	

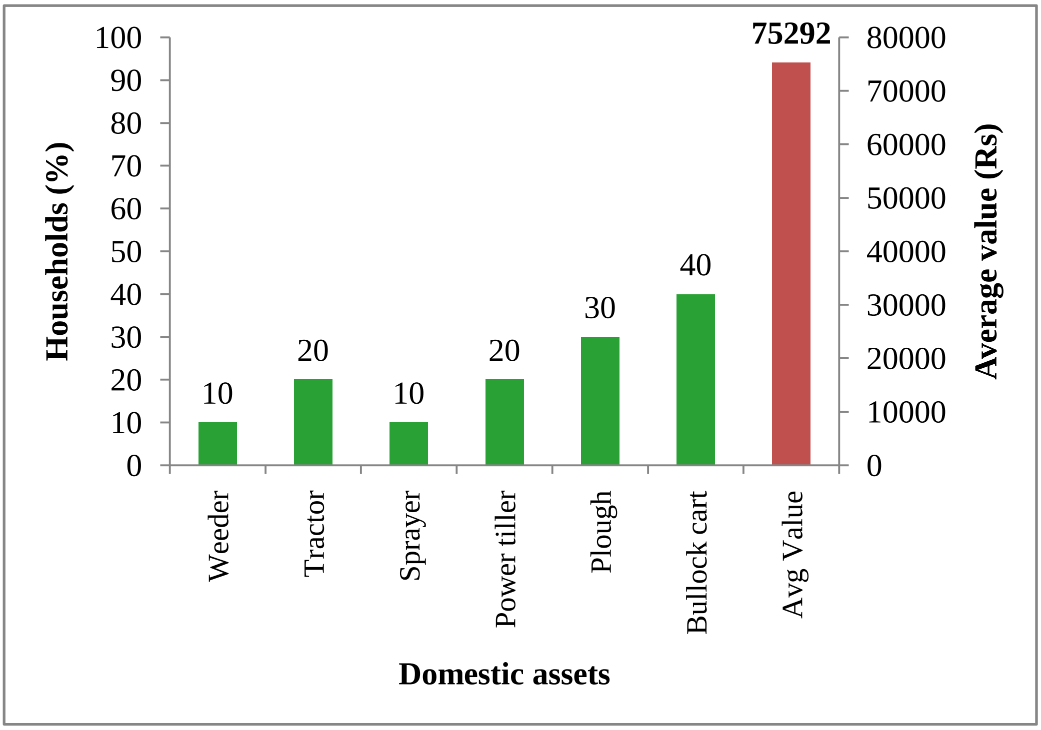

Figure 5: Farm assets among samples households in Belhatti 4 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population is bullocks were around (37.5 %) followed by Local milching cow (25.0 %) and miliching bullocks (12.5 %). The average livestock value was Rs 30375 per household.

Table 7: Livestock assets among sample households in Belhatti 4 micro-watershed

Particulars	% of livestock population	Average value in Rs
Local dry cow	25	9000
Local Milching cow	25	17500
Miliching Buffalos	12.5	25000
Bullocks	37.5	70000
Average value	30375	

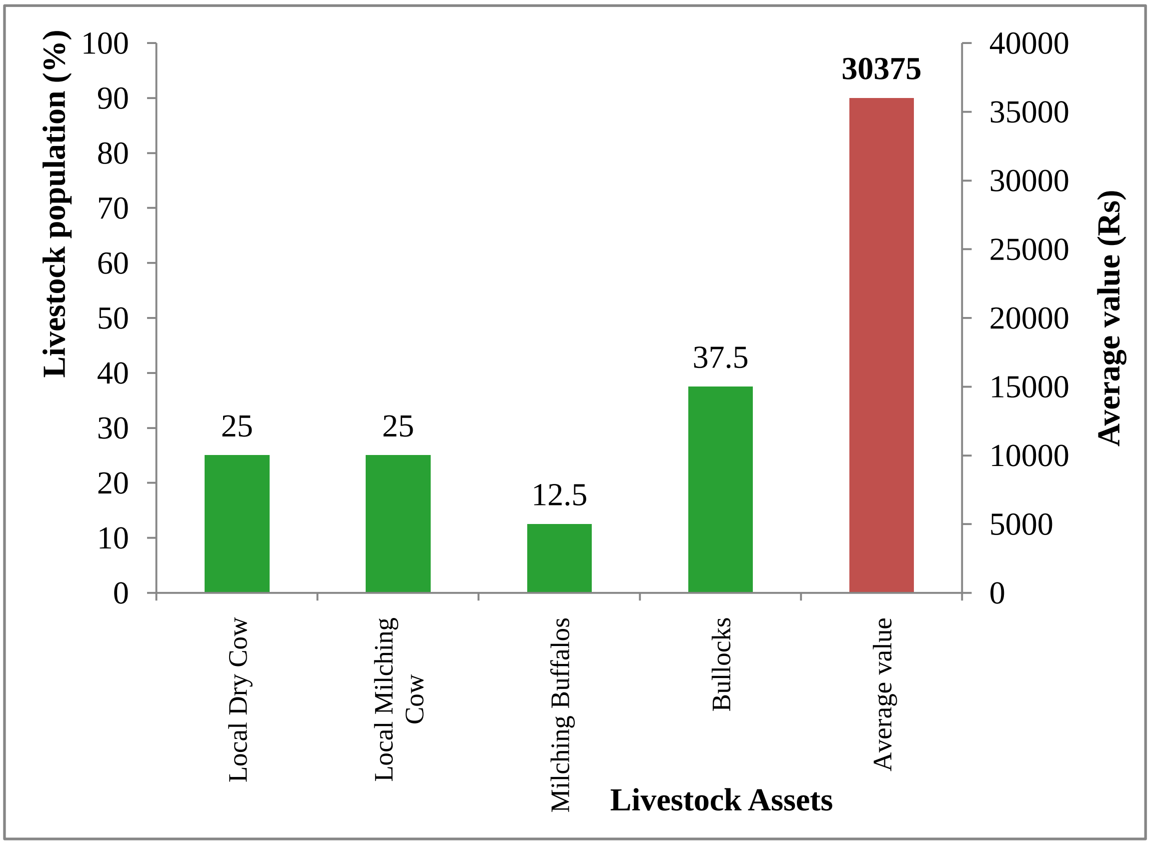

Figure 6: Livestock assets among sample households in Belhatti 4 micro-watershed

Average milk produced in sample households of 458 litters/annum. Among the farm households, horse gram, maize, groundnut and sorghum are the main crops for domestic food and fodder for animals. About 1204 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 Belhatti 4 Microwatershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	375
Milching Buffalos	540
Average Milk produced	458
Fodder produces	**Fodder yield (kg/ha.)**
Maize	1402
Sorghum	833
Groundnut	915
Horsegram	1666
Average fodder availability	1204
Livestock having households (%)	61.5
Livestock population (Numbers)	14

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 9 and Figure 7. More quantity of cereals are consumed by sample farmers which accounted for 1099.2 kcal per person. The other important food items consumed was pulses 203.9 kcal followed by cooking oil 180.1 kcal, milk 134.6 kcal, vegetables 39.4 kcal, egg 118.8 kcal and meat 20.0 kcal in the sampled households, farmers were consuming less (1796.0 kcal) than NIN- recommended food requirement (2250.0 kcal).

Table 9: Per capita daily consumption of food among the sample households in Belhatti 4 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396.0	323.3	1099.2
Pulses	43.0	59.4	203.9
Milk	200.0	207.1	134.6
Vegetables	143.0	164.0	39.4
Cooking Oil	31.0	31.6	180.1
Egg	0.5	79.1	118.8
Meat	14.2	13.3	20.00
Total	**827.7**	**878.0**	**1796.0**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		50.0	80.0
% Above NIN		50.0	20.0

Note: * day/person

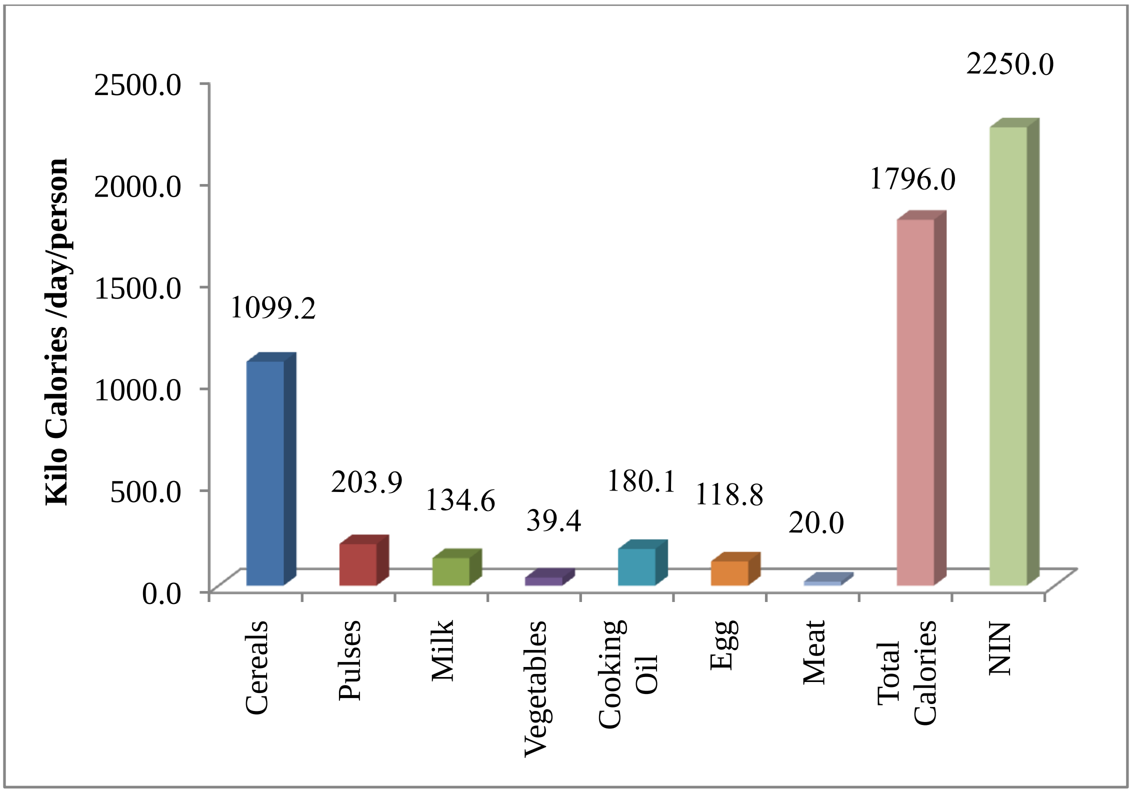

Figure 7: Per capita daily consumption of food among the sample households in Belhatti 4 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 13601. Major source of income to the farmers in the study area is from crop production (Rs 11935) followed by livestock (Rs. 11935). The income from Non farm income was very low at Rs 2832. The monthly per capita income is Rs.2832, which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 10).

Table 10: Annual average income of HHs from various sources in Belhatti 4 Microwatershed

Particulars	Income *
Nonfarm income	2832 (10)
Livestock income (Rs)	-1166(30)
Crop Production (Rs)	11935(100)
Total Annual Income (Rs)	13601
Average monthly per capita income (Rs)	2832
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	100
% of households above poverty line	0.0

* 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. 49566) followed by education, clothing, social function and health. Now a day's education is most important among all of us. In today's competitive world, education is a necessity for man after food, clothing, and shelter. It is the only fundamental way by which a desired change in the society can happen. The average per capita monthly expenditure is around Rs 1219 and among all sample farm households are below poverty line (Table 11 and Figure 8).

Table 11: Average annual expenditure of sample HHs in Belhatti 4 Microwatershed

Particulars	**Value in Rupees**	**Per cent**
Food	49566	66.4
Education	5000	6.7
Clothing	5600	7.5
Social functions	4950	6.6
Health	9500	12.7
Total Expenditure (Rs/year)	74616	100
Monthly per capita expenditure (Rs)	1219	

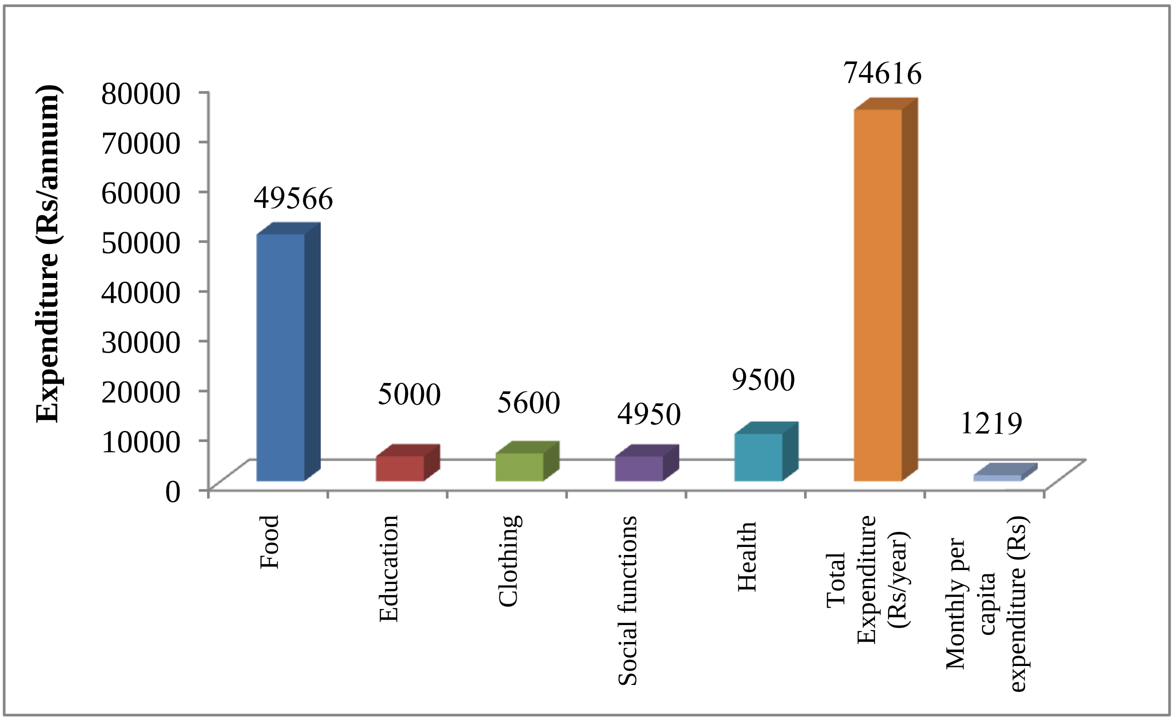

Figure 8: Average annual expenditure of sample HHs in Belhatti 4 Microwatershed

Land holding: The total area cultivated by them is 8.1 ha. The average land holding of sample HHs is 2.0 ha. Large number of sample HHs (60 %) belong to small size group with an average holding size of 1.1 ha followed by medium farmers (30 %) with an average holding size of 2.8 ha and a large farmer (10 %) with a average land holding size of 5.3 ha (Table 12).

Table 12: Distribution of land holding among the sample households in Belhatti 4 micro-watershed

Particulars	Units	Values
Small farmers		
Total land	ha	2.6
Sample size	Per cent	60.0
Average land holding	ha	1.1
Medium farmers		
Total land	ha	3.4
Sample size	Per cent	30.0
Average land holding	ha	2.8
Large farmers		
Total land	ha	2.2
Sample size	Per cent	10.0
Average land holding	ha	5.3
Total sample households		
Total land	ha	8.1
Sample size	Per cent	100.0
Average land holding	ha	2.0

Land use: The total land holding in the Belhatti 4 micro-watershed is 20 ha is rain fed land (Table 13). The average land holding per household is worked out to be 2.0 ha.

Table 13: Land use among samples households in Belhatti 4 Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	0.0	0.0
Rainfed Land	20.1	100.0
Fallow Land	0.0	0.0
Total land holding	20.0	100.0
Average land holding	2.0	

In the micro-watershed, the prevalent present land uses under perennial plants are neem (59.0 %) followed by banyan (Alada) (18.1 %) and coconut (22.2 %), (Table 14).

Table 16: Number of trees/plants covered in sample farm households in Belhatti 4 Microwatershed

Particulars	Number of Plants/trees	Per cent
Banayan (Alada)	4	18.1
coconut	5	22.2
Neem	13	59.0
Grand Total	22	100.0

The land use decisions are usually based on experience of farmers, tradition, expected profit, personal preferences, resources and social requirements.

The present dominant crops grown in dry lands in the study area were by maize (58.9 %), followed by groundnut (22.8 %), cotton (6.1 %), horse gram (6.1 %) during Kharif season and sorghum (6.1%) during Rabi season respectively. The cropping intensity was 106 per cent (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Belhatti 4 Microwatershed

% to Grand Total

Crops	Kharif	Rabi	Grand Total
Cotton	6.5	0.0	6.1
Groundnut	22.8	0.0	22.8
Horsegram	6.1	0.0	6.1
Maize	58.9	0.0	58.9
Sorghum	0.0	6.1	6.1
Total	93.9	6.1	100
Cropping intensity (%)	106		

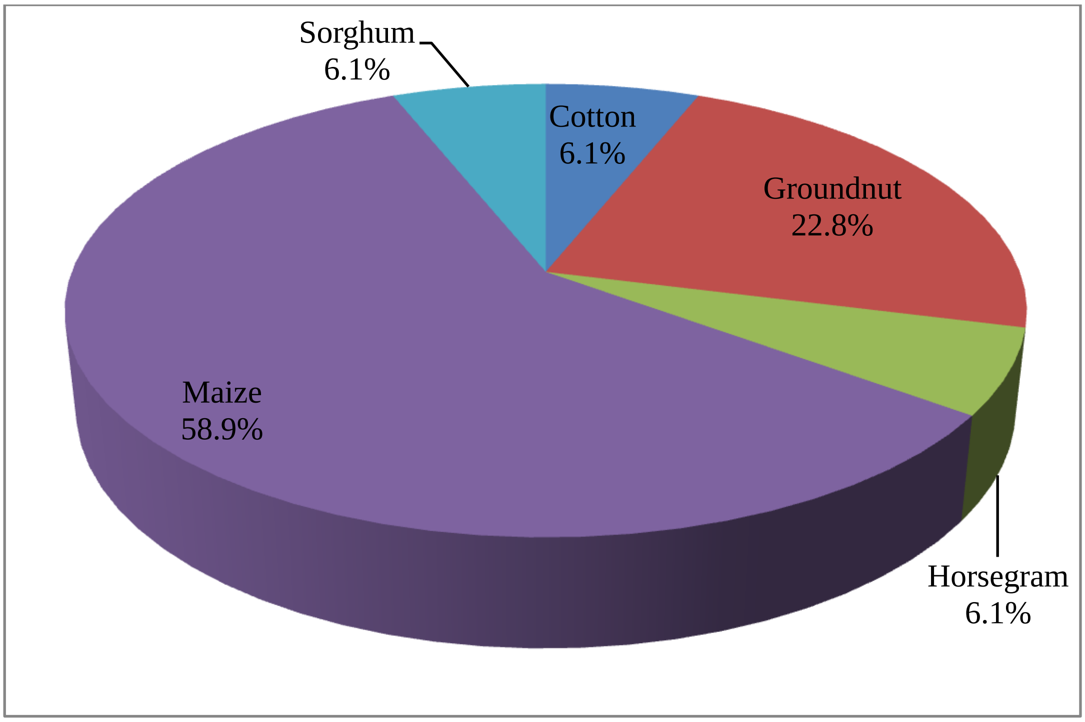

Figure 9: Present cropping pattern in Belhatti 4 Microwatershed

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 Belhatti 4 micro-watershed, 8 soil series are identified and mapped (Table 16). The distribution of major soil series are Muttal covering an area around 85.9 ha (22.0 %) followed by Kutegouanahundi 3.9 ha (1.0 %), Mukkadahalli 30.7 ha (7.8 %), Ravanki 31.9 ha (8.1 %), Chikkamrgeheri 16.8 ha (4.3 %), Balapura 14.9 ha (3.8 %), Lakshmangudda 135.4 ha (48.7 %) and Budagumapa 7.2 ha (1.8 %).

Table 16: Distribution of soil series in Belhatti 4 Micro watershed

Soil No	Soil Series	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE			
1	MTL	Muttal soils are shallow (25-50 cm), well drained, have dark brown to very dark greyish brown calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation	85.95 (22.04)
2	KGH	Kutegoudanahundi soils are moderately shallow (50-75 cm), well drained, have brown to dark brown loamy sand to sandy loam soils occurring on very gently sloping uplands under cultivation	3.97 (1.01)
3	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under cultivation	30.71 (7.87)
4	RNK	Ravanki soils are moderately shallow (50-75 cm), well drained, black calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation	31.90 (8.18)
5	CKM	Chikkamegheri soils are moderately deep (75-100 cm), well drained, have dark brown to dark reddish brown sandy clay soils occurring on nearly level uplands under cultivation	16.83 (4.31)
6	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently sloping uplands under cultivation	14.98 (3.84)
7	LGD	Lakshmangudda soils are deep (100-150 cm), well drained, have light olive brown to very dark gray calcareous clay soils occurring on nearly level to very gently sloping uplands under cultivation	135.42 (48.76)
8	BGP	Budagumpa soils are very deep (>150 cm), well drained, black calcareous gravelly clay soils occurring on very gently sloping uplands under cultivation	7.29 (1.86)
9		Water body	8.03 (2.05)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Buagumapa soils are maize. Groundnut and maize on Beramabadi soils is grown. Maize is grown on (KLK) soils. Cotton and sorghum on (KPR) soils are growing. Groundnut, horse gram and maize on (NBP) soils are growing. Groundnut on (NGT) soils can grow.

Table 17: Cropping pattern on major soil series in Belhatti 4 micro-watershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Grand Total
			Kharif	Rabi	
KLK	Very shallow (<25 cm)	Maize	100	0	100
BLD	Shallow (25-50 cm)	Groundnut	56.2	0	56.2
		Maize	43.8	0.0	43.8
NBP	Shallow (25-50 cm)	Groundnut	19.1	0.0	19.1
		Horsegram	11.5	0.0	11.5
		Maize	69.4	0.0	69.4
KPR	Deep (100-150 cm)	Cotton	50	0	50
		Sorghum	0	50	50
NGT	Very deep (>150 cm)	Groundnut	0	100	0
BGP	Very deep (>150 cm)	Maize	100	0	100

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

Table 18: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Belhatti 4 Microwatershed.

Soil series	Small Farmer	Medium Farmer	Large Farmer
KLK	Maize (1.38)		
NBP		Groundnut (1.13), Horsegram (1.19), Maize (2.0)	Maize (1.12)
BLD	Maize (1.08)	Groundnut (1.32)	
KPR	Cotton (1.37), Sorghum (1.09)		
BGP	Maize (2.34)		
NGT	Ground nut (0.96)		

The productivity of different crops grown in Belhatti 4 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 Tables 19. The total cost of cultivation in study area for maize ranges between Rs.23883/ha in KLP soil (with BCR of 1.33) and Rs.13204/ha in NBP soil (with BCR of 1.50), groundnut range between Rs 34464/ha in NGT soil (with BCR of 1.15) and Rs.21051/ha in BLD soil (with BCR of 1.26), horse gram cost of cultivation Rs. 26605/ha in NBP soil (with BCR of 1.50), cotton cost of cultivation is Rs.30226/ha in KPR soil (with BCR of 1.08), sorghum cost of cultivation Rs. 17531/ha in KPR soil (with BCR of 1.08) .

Table 19: Economic land evaluation and bridging yield gap for different crops in Belhatti 4 micro-watershed

Particulars	KLK (<25 cm)	BLD (25-50 cm)		NBP (25-50 cm)			KPR (100-150 cm)		NGT (>150 cm)	BGP (>150 cm)
	Maize	Groundnut	Maize	Groundnut	Horse gram	Maize	Cotton	Sorghum	Groundnut	Maize
Total cost (Rs/ha)	23883	21051	21558	23971	26605	13204	30226	17531	34464	22390
Gross Return (Rs/ha)	31371	26429	21850	26725	28817	20463	39520	18937	39653	49616
Net returns (Rs/ha)	7488	5378	292	2754	2211	7259	9294	1405	5189	27226
BCR	1.33	1.26	1.01	1.11	1.08	1.50	1.31	1.08	1.15	2.22
Farmers Practices (FP)										
FYM (t/ha)	2.2	1.9	2.4	1.9	1.7	0.0	1.5	2.5	1.0	2.2
Nitrogen (kg/ha)	69.9	45.6	76.9	82.3	90.8	90.8	70.0	70.0	52.3	71.7
Phosphorus (kg/ha)	50.2	43.1	55.3	67.2	74.2	74.2	61.6	61.6	44.9	51.6
Potash (kg/ha)	0.0	37.5	0.0	5.6	7.1	7.1	15.6	15.6	0.0	0.0
Grain (Qtl/ha)	32.8	7.5	16.0	22.9	10.0	9.2	7.5	8.3	14.9	9.0
Price of Yield (Rs/Qtl)	1500	3500	1300	1350	4000	2000	3500	3500	1300	3500
Soil test based fertilizer Recommendation (STBR)										
FYM (t/ha)	8.6	8.6	8.6	8.6	12.4	7.4	8.6	0.0	8.6	8.6
Nitrogen (kg/ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphorus (kg/ha)	77.2	61.8	61.8	77.2	92.6	71.0	77.2	46.3	61.8	61.8
Potash (kg/ha)	32.1	38.6	40.1	40.1	92.6	49.4	38.6	30.9	40.1	38.6
Grain (Qtl/ha)	84.0	17.3	84.0	84.0	17.3	28.4	17.3	9.9	84.0	17.3
% of Adoption/yield gap (STBR-FP) / (STBR)										
FYM (%)	74.7	78.3	72.2	78.1	86.5	100.0	82.6	0.0	88.7	74.1
Nitrogen (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phosphorus (%)	34.9	30.2	10.5	13.0	19.9	-4.4	20.2	-33.0	27.3	16.5
Potash (%)	100.0	2.8	100.0	86.1	92.4	85.7	59.6	49.5	0.0	100.0
Grain (%)	61.0	56.6	80.9	72.8	42.2	67.7	56.6	15.7	82.2	48.1
Value of yield and Fertilizer (Rs)										
Additional Cost (Rs/ha)	7452	7064	6405	6891	12116	7028	7452	-3706	8588	6762
Additional Benefits (Rs/ha)	76843	34265	88341	82486	29160	38477	34265	5413	89748	29125
Net change Income (Rs/ha)	69391	27201	81936	75595	17044	31449	26813	9119	81160	22363

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 21 and 21a. 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 81160 in Groundnut and a minimum of Rs 9119 in sorghum 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 865 per ha/year. The total cost of annual soil nutrients is around Rs 3298979 per year for the total area of 389.93 ha.

Table 20: Estimation of onsite cost of soil erosion in Belhatti 4 micro-watershed

Particulars	**Quantity(kg)**		**Value (Rs)**	
	Per ha	**Total**	**Per ha**	**Total**
Organic matter	124.27	47348	782.93	298295
Phosphorus	0.06	23	2.61	994
Potash	2.66	1012	53.15	20249
Iron	0.07	27	3.44	1312
Manganese	0.00	2	1.25	475
Cupper	0.01	5	7.50	2856
Zinc	0.09	35	3.72	1419
Sulphur	0.28	105	11.01	4197
Boron	0.01	2	0.22	84
Total	123.25	48560	865.83	329879

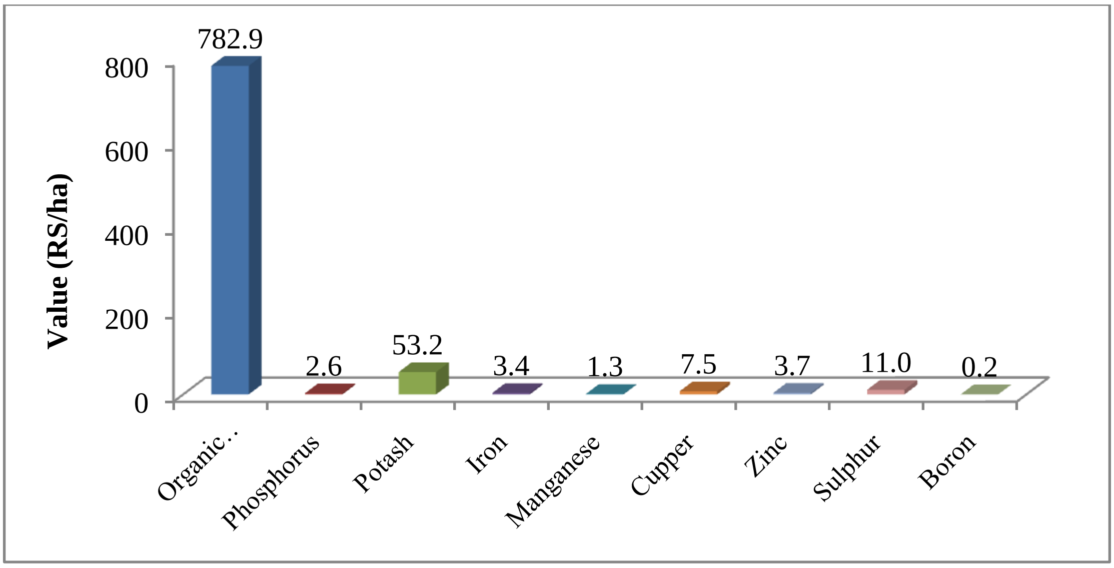

Figure 10: Estimation of onsite cost of soil erosion in Belhatti 4 micro-watershed

The average value of ecosystem service for food production is around Rs 5059/ ha/year (Table 21 and Figure 11). Per ha food production services is maximum in cotton (Rs 10175) followed by maize (Rs 8882), horse gram (Rs 3533), groundnut (Rs 2122), and sorghum (582).

Table 21: Ecosystem services of food production in Belhatti 4 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	Maize	11.7	20.5	1350	27659	18777	8882
	Sorghum	1.2	9.1	2000	18113	17531	582
Pulses	Horsegram	1.2	8.2	3500	28817	25284	3533
Oil seeds	Groundnut	4.5	7.9	3500	27628	25506	2122
Commercial Crops	Cotton	1.2	9.9	4000	39520	29345	10175
Average value		19.8	11.1	2870	28347	23289	5059

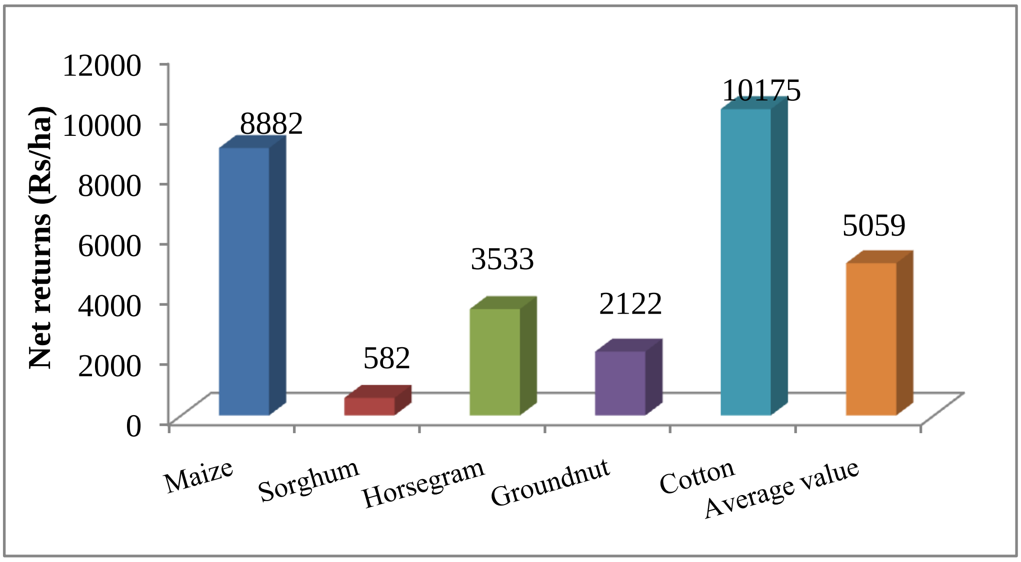

Figure 11: Ecosystem services of food production in Belhatti 4 Microwatershed

The average value of ecosystem service for fodder production is around Rs 954/ ha/year (Table 22). Per hectare fodder production services is maximum in horse gram (Rs 1317) followed by maize (Rs 970), sorghum (Rs 988), cotton (Rs 823) groundnut (Rs 542).

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	Maize	11.74	1.1	900	970
	Sorghum	1.21	1.6	600	988
Pulses	Horsegram	1.21	1.6	800	1317
Oil seeds	Groundnut	4.55	0.7	733	542
Grand Total		18.72	1.3	758	954

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 cotton (Rs 39806) followed by sorghum (Rs 27604), horse gram (Rs 25342), maize (Rs 25036) and groundnut (Rs 21960).

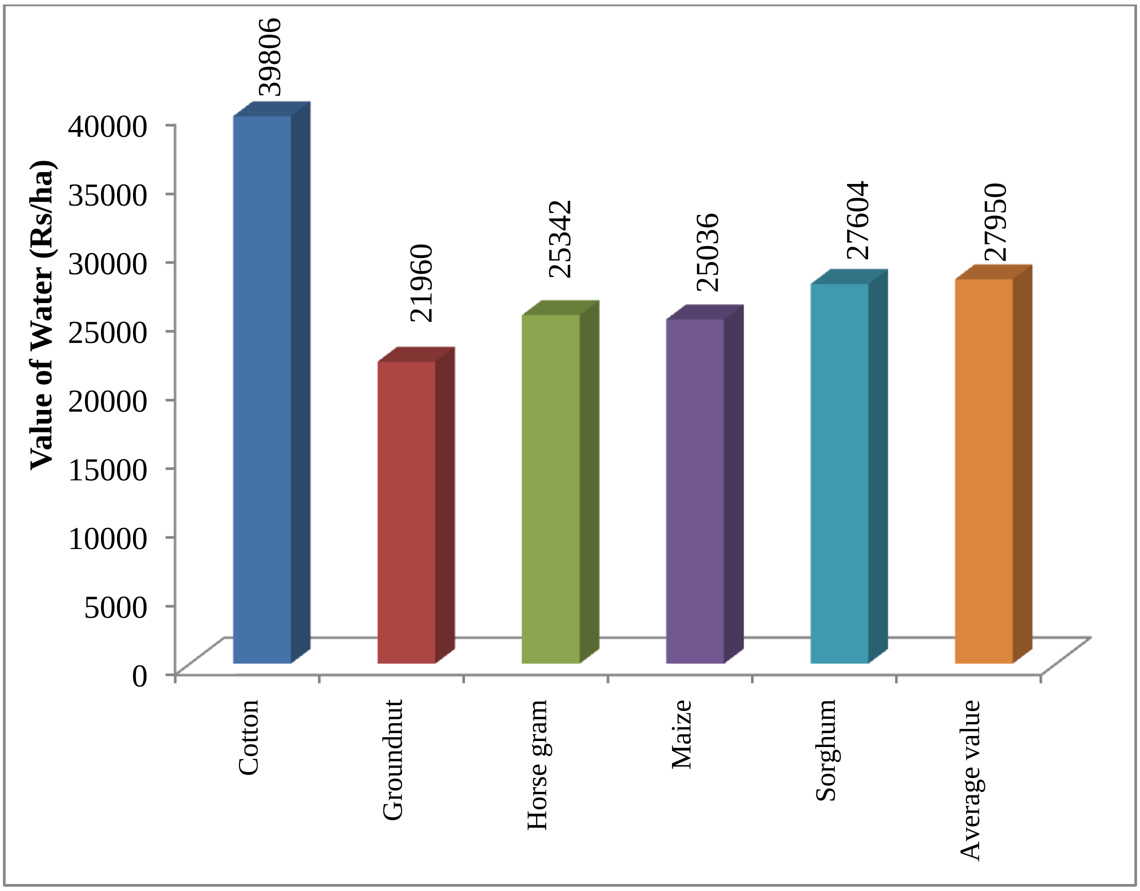

Figure 12: Ecosystem services of water supply in Belhatti 4 Microwatershed

Table 23: Ecosystem services of water supply in Belhatti 4 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Cotton	9.9	3981	39806	402
Groundnut	7.9	2196	21960	278
Horse gram	8.2	2534	25342	307
Maize	20.5	2504	25036	122
Sorghum	9.1	2760	27604	304
Average value	11.1	2795	27950	283

The main farming constraints in Devihal-1 micro-watershed to be found are less rainfall, lack of good quality seeds, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 24).

Table 24: Farming constraints related land resources of sample households in Belhatti 4 Microwatershed

Sl. No	Particulars	Per cent
1	Less Rainfall	100
2	Non availability Fertilizers	30
3	High Crop Pests & Diseases	60
4	Lack of transportation	30
5	Lack of storage	20
6	Damage of crops by Wild Animals	100
7	Non availability of Plant Protection Chemicals	100
8	**Source of loan**	
	Money Leander	60
	Village merchants	40
9	**Market for selling**	
	Village market	100
10	**Sources of Agri-Technology information**	
	Newspaper	100

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