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

BELHATTI-3 (4D4A3I1c) MICROWATERSHED

Shirahatti Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

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

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

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on “Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Belhatti-3 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**

Date: Director, ICAR -NBSS&LUP, Nagpur

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Belhatti-3 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 6land management units.*
- *The length of crop growing period is about 150days 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 eroded (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 stronglyto 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 of the soils are 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 29per 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*	*-*	*-*
Maize	*5 (1)*	*-*		*Jamun*	*-*	*97 (24)*
Bengalgram	*185 (46)*	*161 (40)*		*Musambi*	*141 (35)*	*144 (36)*
Groundnut	*-*	*5 (1)*		*Lime*	*141 (35)*	*144 (36)*
Sunflower	*88 (22)*	*180 (45)*		*Cashew*	*-*	*5 (1)*
Cotton	*90 (22)*	*268 (65)*		*Custard Apple*	*171 (43)*	*165 (41)*
Banana	*-*	*5 (1)*		*Amla*	*114 (28)*	*247 (62)*
Pomegranate	*5 (1)*	*312 (78)*		*Tamarind*	*-*	*141 (35)*
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 landuse. 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-3 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.

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Belhatti-3 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 $15^{0}3'$ to $15^{0}4'$ North latitudes and $75^{0}38'$ to $75^{0}40'$ East longitudesand covers an area of 400 ha. It is about 60 km south of Gadag and is surrounded by Belhatti village on the northwest, Konchigeri in thesouthwest, Hosur on the southeast and Suganhalli on the northeast.

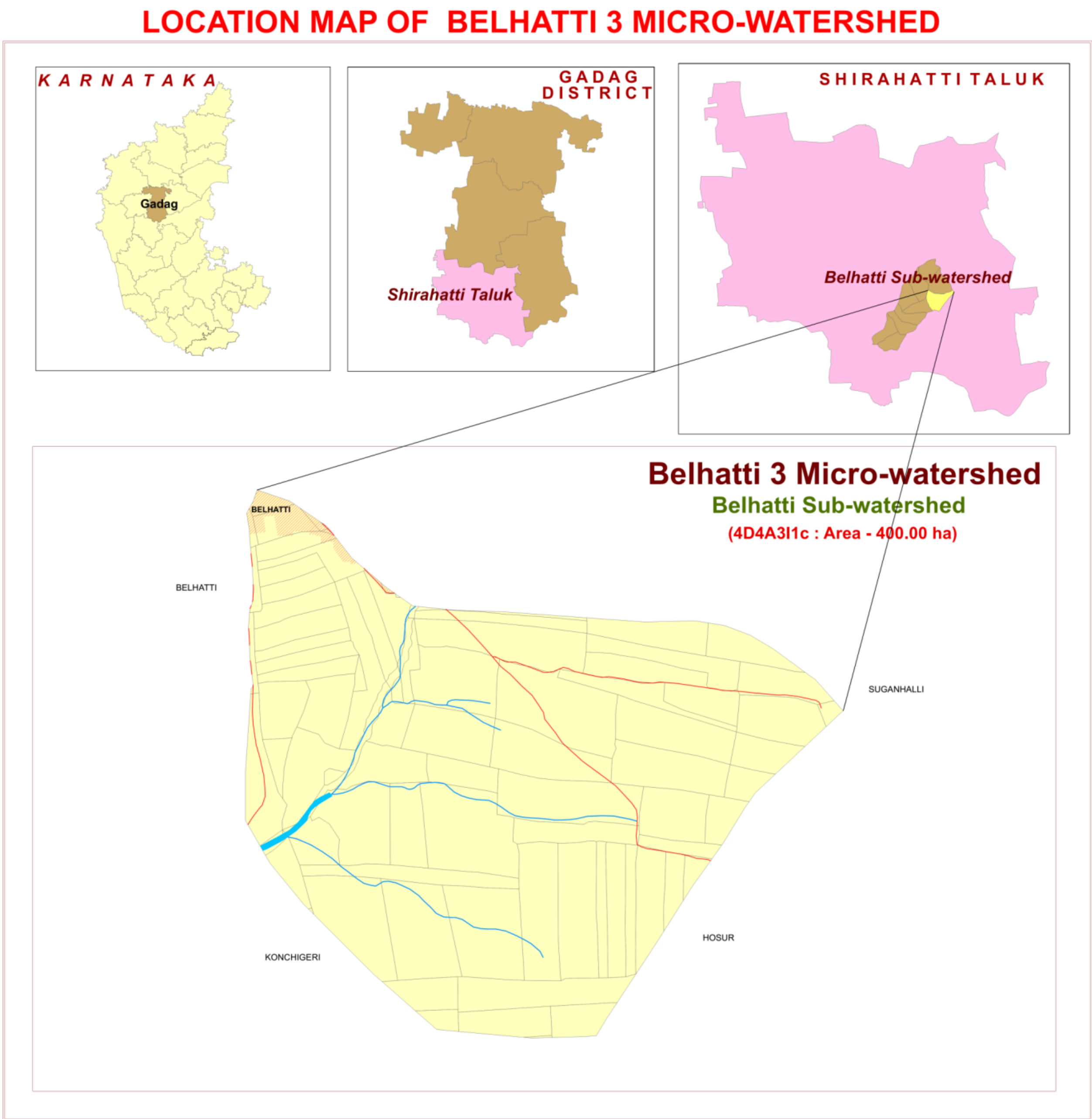


Fig.2.1 Location map of Belhatti-3 microwatershed

2.2 Geology

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

Fig.2.2aGranite gneiss

Fig.2.2bGadag Schist

Fig.2.2cBanded Ferrugenous Quartzite

2.3 Physiography

Physiographically, the area has been broadly divided into two landscapes based on geology. They are Granite gneiss and Schist. 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 584 to 603 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 village, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract of the state and is categorized as drought prone with average annual rainfall of 633 mm (Table 2.1). 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 evapo transpiration (PET) is 137 mm and varies from a low of 109 mm in December to 182 mm in the month of May. Generally, the length of crop growing period (LGP) is 150 days and starts from 3rd week of June to third week of November.

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

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

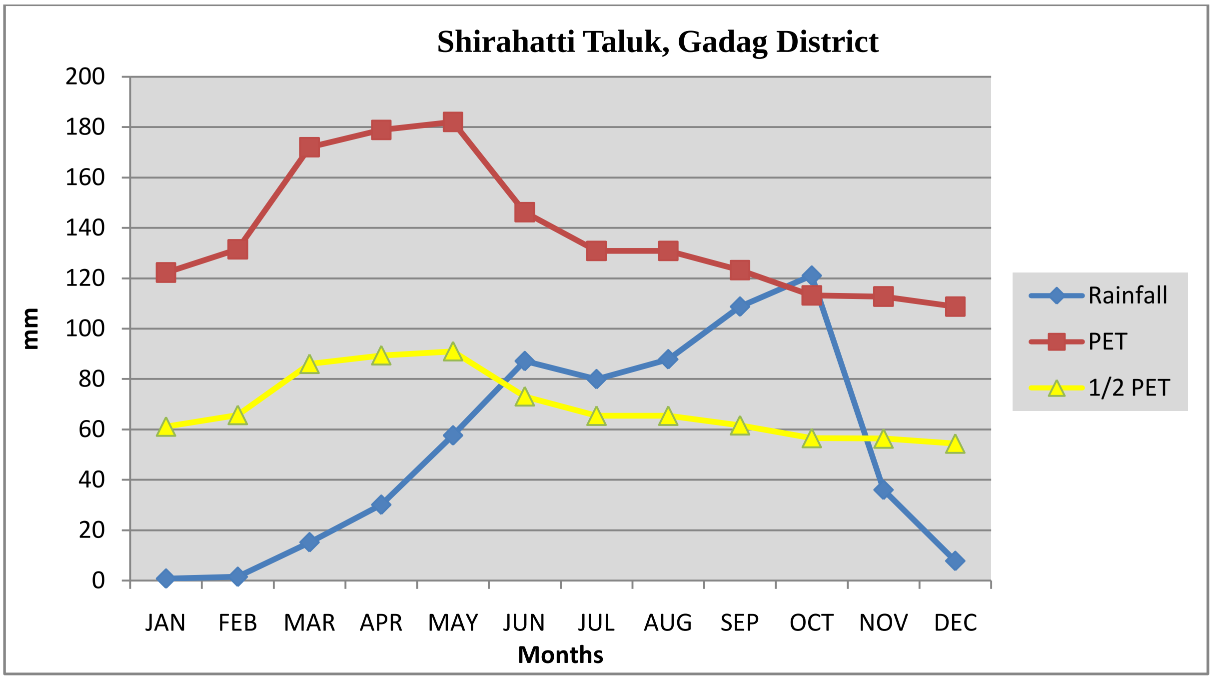


Fig. 2.3 Rainfall distribution in Shirahatti Taluk, Gadag District

2.6 Natural Vegetation

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

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

2.7 Land Utilization

About 77 per cent area (Table 2.2) in the Shirahatti taluk is cultivated at present and about 14 per cent of the area is sown more than once. An area of about 17 per cent is currently barren. Forests occupy a small area of about 1.6 per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are sorghum, maize, cotton, safflower, sunflower, red gram, horse gram, onion, mulberry, sugarcane, bengal gram and groundnut. 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-3 microwatershed is presented in Fig.2.4.

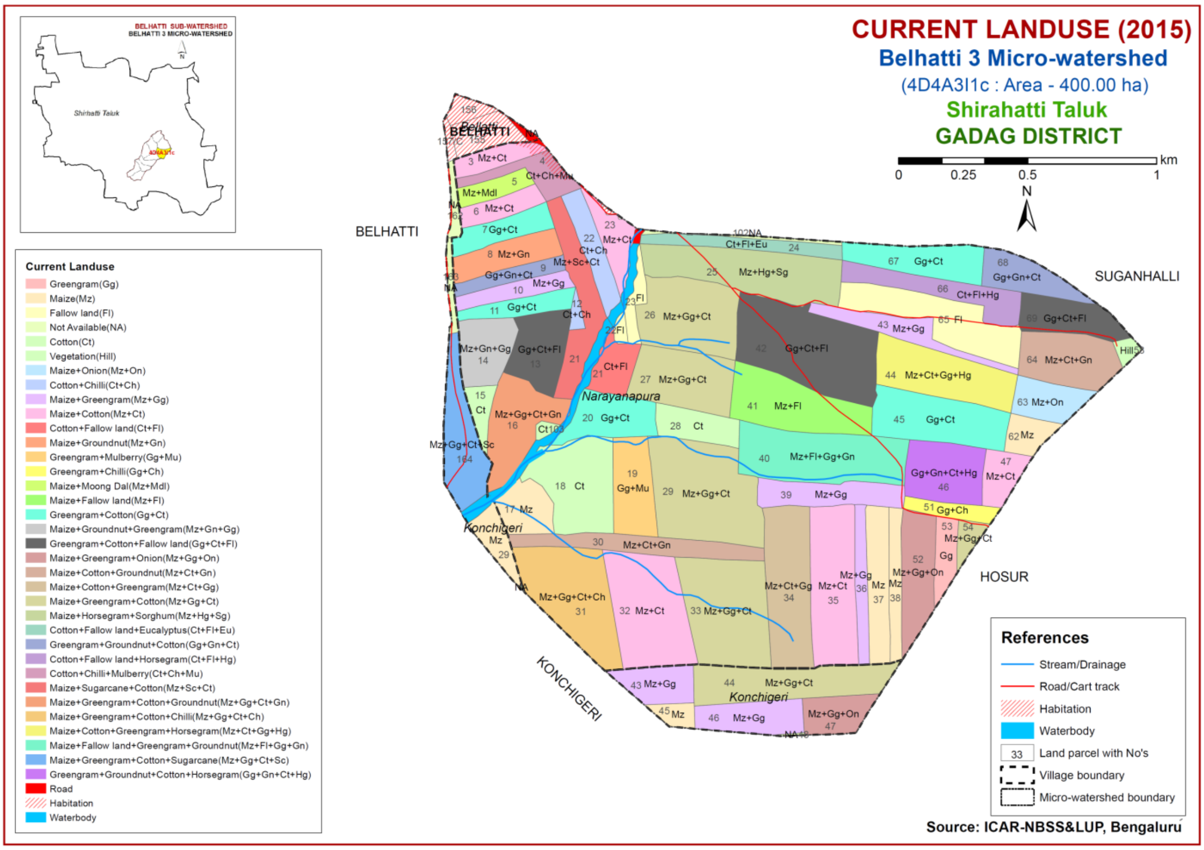


Fig.2.4 Current Land Use – Belhatti-3 microwatershed

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-3 microwatershed 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	

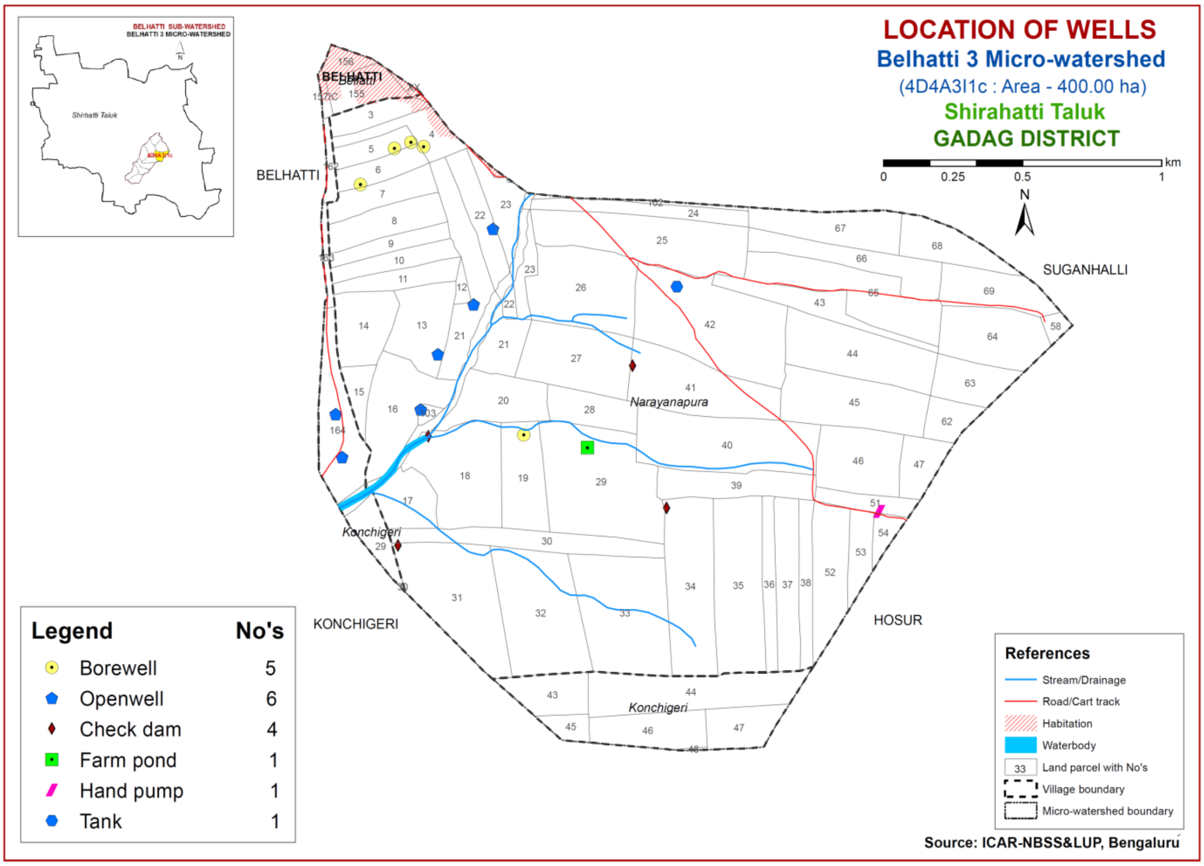
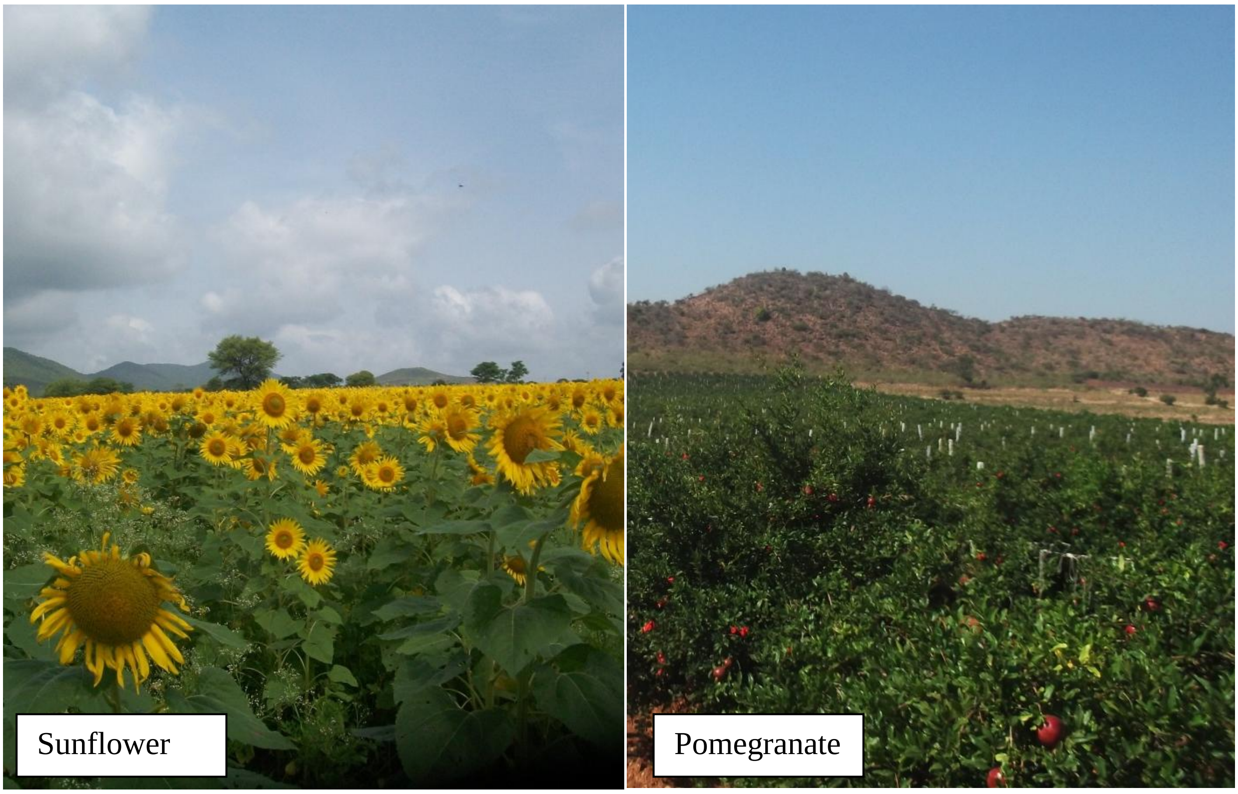


Fig.2.5Location of Wells- Belhatti-3microwatershed



Different crops and cropping systems in Belhatti-3 microwatershed

Different crops and cropping systems in Belhatti-3 microwatershed

Chapter 3

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Belhatti-3 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site (slope of the land, erosion, drainage, occurrence of rock fragments etc.) and followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in 400 ha area. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map as a base. The cadastral map shows field boundaries with their survey numbers, location of tanks, streams and other permanent features of the area (Fig. 3.1). Apart from the cadastral map, remote sensing data products from Cartosat-1 and LISS IV merged at the scale of 1:7920 were used in conjunction with the cadastral map to identify the 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 divided into two landscapes, *viz.,*granite gneiss and schist. They were divided into land forms 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)

S-Schist landscape

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

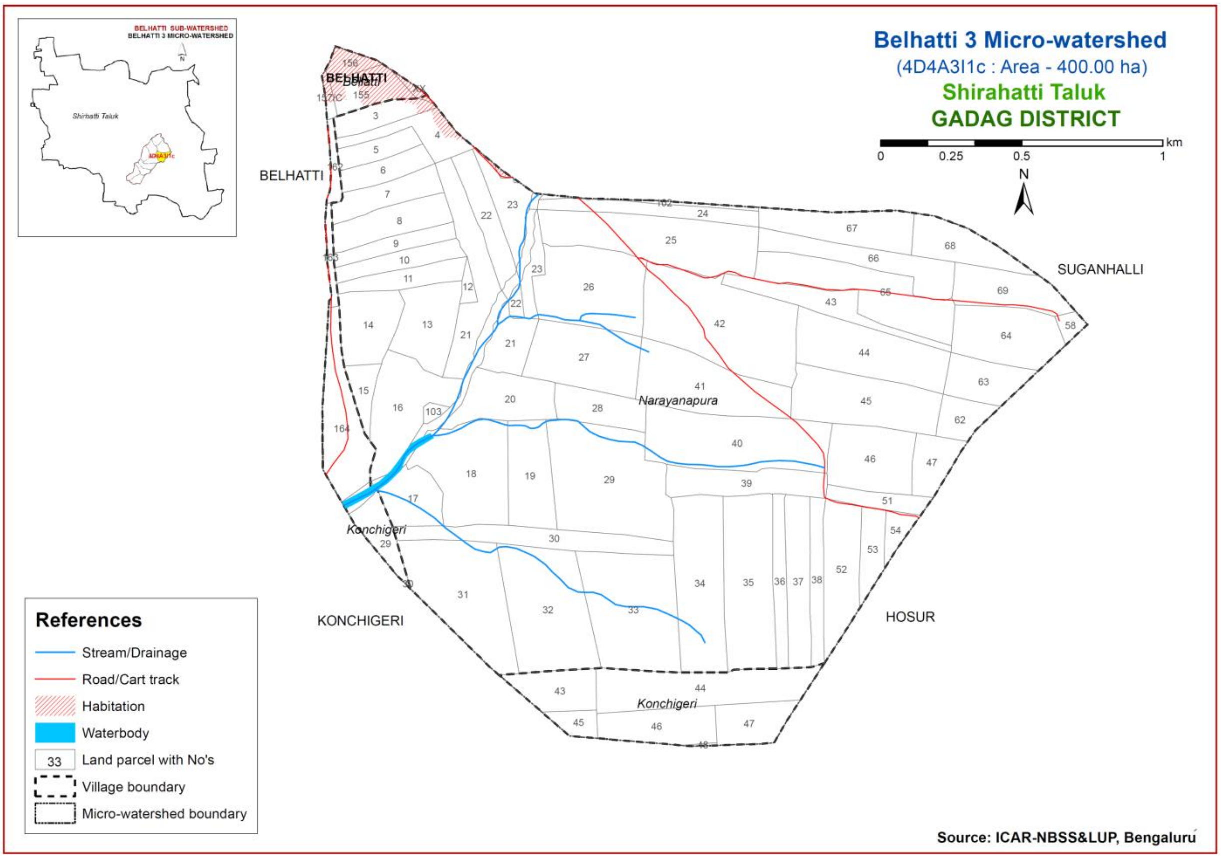


Fig 3.1 Scanned and Digitized Cadastral map of Belhatti-3 microwatershed

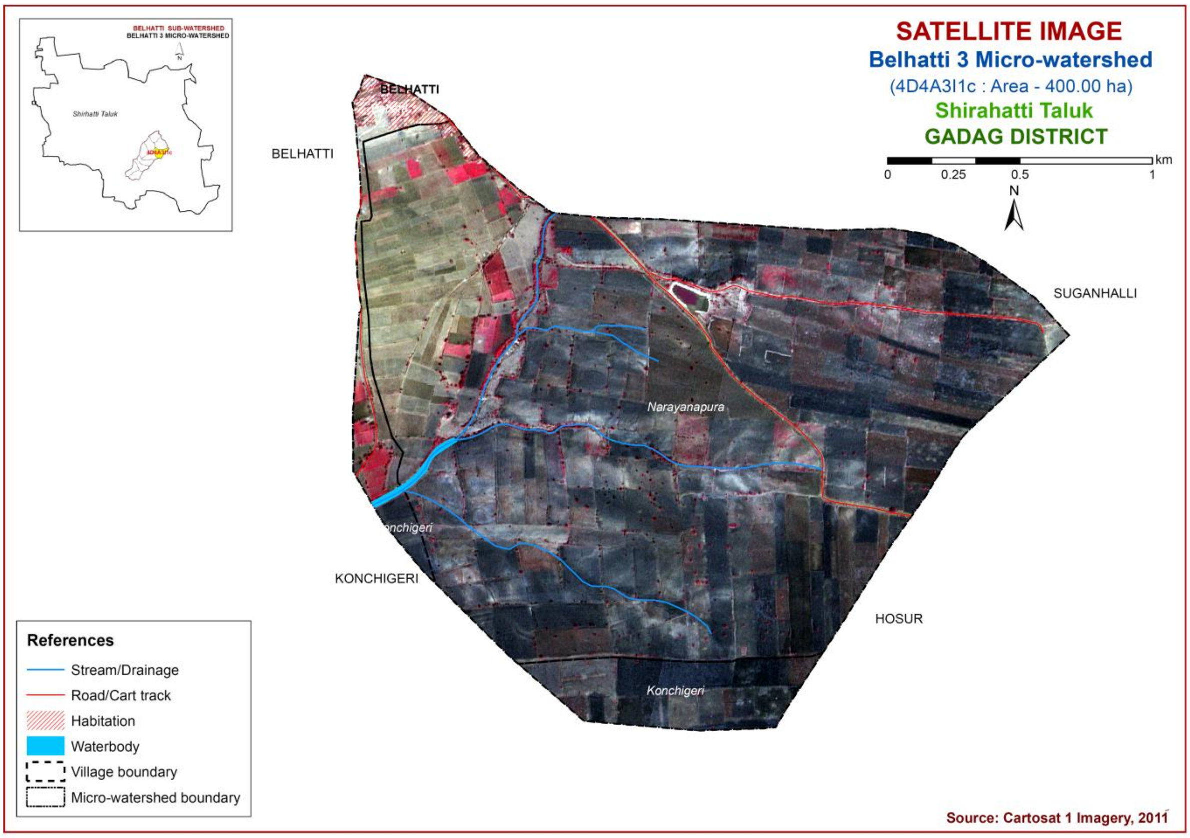


Fig.3.2 Satellite Image of Belhatti-3 microwatershed

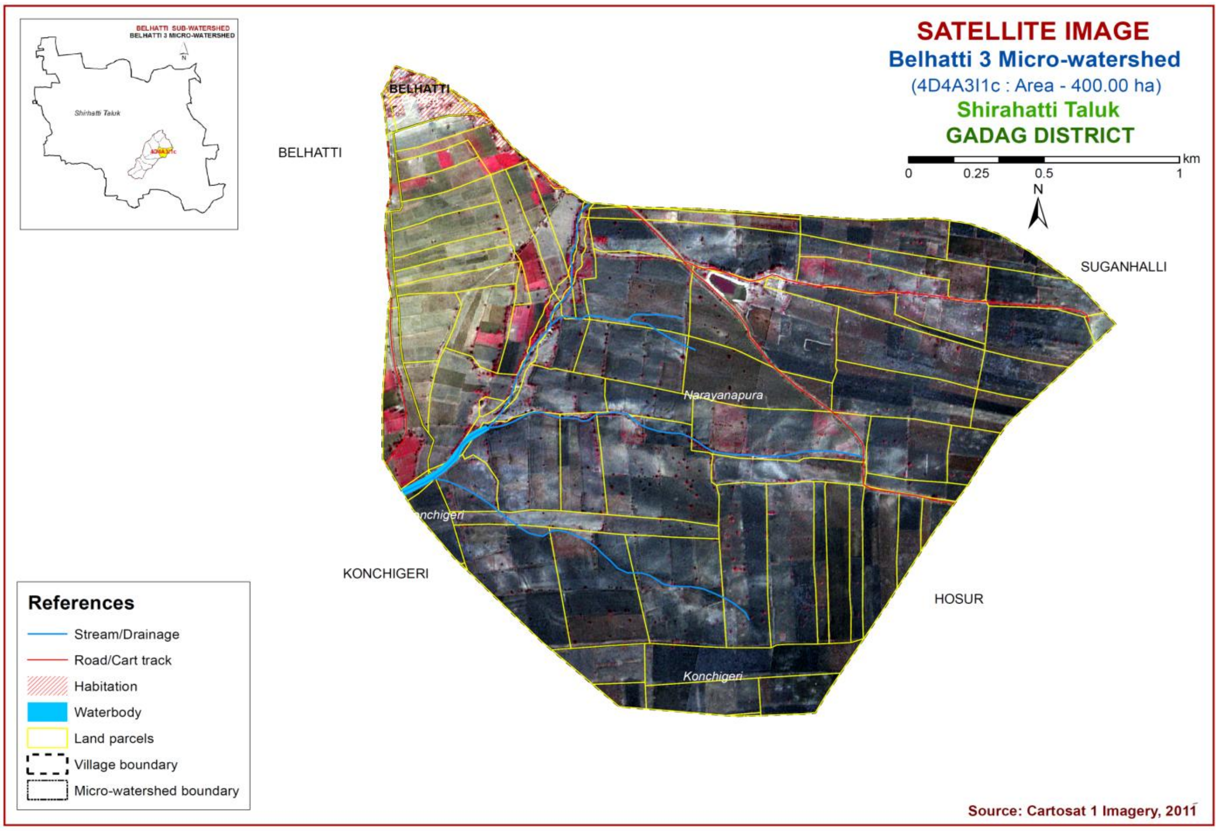


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Belhatti-3 microwatershed

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 11soil series were identified in the Belhatti-3 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**	**Texture**	**Gravel (%)**	**Horizon sequence**	**Calcareo-usness**
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	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
3	Chikkamegheri (Ckm)	75-100	2.5YR2.5/3,3/4, 3/6	sc	-	Ap-Bt-Cr	
4	Jedigere (Jdg)	100-150	5YR4/6,3/4, 7YR3/4, 4/6	sc-c	<15	Ap-Bt-Cr	-
5	Lakshmangudda (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
6	Budagumpa (Bgp)	.>150	7.5YR3/2,5/1 10YR4/1,4/4	c	10-20	Ap-Bw	es
Soils of Schist Landscape							
7	Dindur (Ddr)	<25	2.5YR 2.5/3,2.5/4,3/3, 3/4, 3/6	cl, c	>35	Ap -Cr	-
8	Attikatti Tanda (Att)	50-75	10YR2/2,3/1,4/2, 5/47.5YR2.5/1,3/2	c	-	Ap-Bw-Crk	-
9	Jelligeri (Jlg)	75-100	10YR2/1,2/2,3/1 7.5YR2.5/2,3/1, 3/2,3/3	c	-	Ap-Bw-Cr	-
10	Varvi (Vrv)	75-100	10YR2/1, 3/1, 3/2, 2.5Y 2.5/1, 4/2, 7.5YR3/1, 3/2, 3/3	c	<15	Ap-Bss-Crk	e-es
11	Mahalingapur Tanda (Mpt)	100-150	10YR2/2,3/1,3/2, 3/3,4/2 7.5YR2.5/3, 3/2	c	-	Ap-Bw-Crk	-

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 (61 samples) for fertility status (major and micronutrients) at 250m 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 12 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 20 mapping units representing 11 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 20 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 20 soil phases identified and mapped in the microwatershed were regrouped into 6 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-3 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

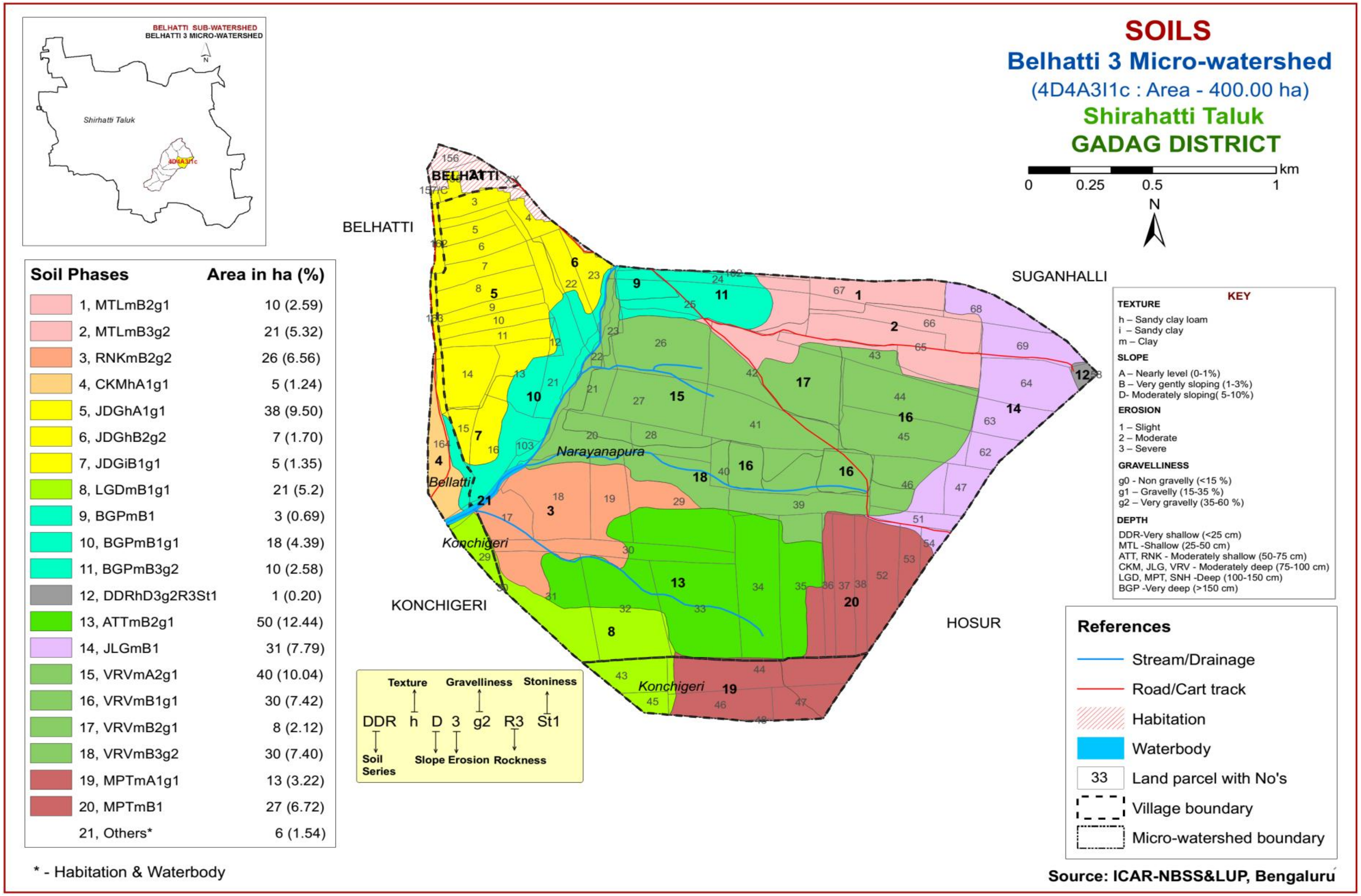


Fig 3.4 Soil Phase or management units- Belhatti-3 microwatershed

Table 3.2 Soil map unit description of Belhatt-3 microwatershed

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 grayish browncalcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**31.66 (7.91)**
1		MTLmB2g1	Clay surface, slope 1-3 %, moderate erosion, gravelly (15-35%)	10.36 (2.59)
2		MTLmB3g2	Clay surface, slope 1-3 %, severe erosion, very gravelly (35-60%)	21.30 (5.32)
	RNK	Ravanaki soils are moderately shallow (50-75 cm), well drained, black calcareoussandy clay to clay soils occurring on very gently sloping uplands under cultivation		**26.23 (6.56)**
3		RNKmB2g2	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60%)	26.23 (6.56)
	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		**4.96 (1.24)**
4		CKMhA1g1	Sandy clay loam surface, slope 0-1 %, slight erosion, gravelly (15-35%)	4.96 (1.24)
	JDG	Jedigere soils are deep (100-150 cm) well drained, have yellowish red to strong brown soils occurring on nearly level to very gently sloping uplands under cultivation		**50.22 (12.55)**
5		JDGhA1g1	Sandy clay loam surface, slope 0-1 %, slight erosion, gravelly (15-35%)	38.02 (9.50)
6		JDGhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60%)	6.80 (1.70)
7		JDGiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)	5.40 (1.35)
	LGD	Lakshmangudda soils are deep (100 - 150 cm), well drained, have light olive brown to very dark gray calcareous clay soils occurring on very gently sloping uplands under cultivation		**20.81 (5.20)**
8		LGDmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	20.81 (5.20)

	BGP	Budagumpa soils are very deep (>150 cm), well drained, black calcareoussandy clay to clay soils occurring on very gently sloping uplands under cultivation		**30.60 (7.66)**
9		BGPmB1	Clay surface, slope 1-3 %, slight erosion	2.75 (0.69)
10		BGPmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	17.55 (4.39)
11		BGPmB3g2	Clay surface, slope 1-3 %, severe erosion, very gravelly (35-60 %)	10.30 (2.58)
SOILS OF SCHIST LANDSCAPE				
	DDR	Dindur soils are very shallow (<25 cm), well drained, have dark reddish brown to dark red gravelly clay loam to gravelly clay soils occurring on moderately sloping uplands under cultivation		**0.79 (0.20)**
12		DDRhD3g2R3St1	Sandy clay loam surface, slope 5-10%, severe erosion, very gravelly (35-60 %), very rocky (25-50 %), stony (0.01-0.1%)	0.79 (0.20)
	ATT	Attikatti soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation		**49.75 (12.44)**
13		ATTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35 %)	49.75 (12.44)
	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands under cultivation		**31.16 (7.79)**
14		JLGmB1	Clay surface, slope 1-3 %, slight erosion	31.16 (7.79)
	VRV	Varavi soils are moderately deep (75-100 cm), moderately well drained, very dark brown, cracking clay calcareous soils occurring on nearly level to very gently sloping uplands under cultivation		**107.91 (26.98)**
15		VRVmA2g1	Clay surface, slope 0-1 %, moderate erosion, gravelly (15-35 %)	40.18 (10.04)
16		VRVmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)	29.68 (7.42)
17		VRVmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35 %)	8.46 (2.12)
18		VRVmB3g2	Clay surface, slope 1-3%, severe erosion, very gravelly (35-60 %)	29.59 (7.40)

	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark grayish brown cracking clay soils occurring on nearly level to very gently sloping uplands under cultivation		**39.73 (9.94)**
19		MPTmA1g1	Clay surface, slope 0-1 %, slight erosion, gravelly (15-35%)	12.87 (3.22)
20		MPTmB1	Clay surface, slope 1-3 %, slight erosion	26.86 (6.72)
21		Habitation		5.17 (1.29)
22		Waterbody		1.00 (0.25)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Belhatti-3 microwatershed is provided in this chapter. The microwatershed area has been broadly divided into two landscapes based on geology, *viz*.1. Granite gneiss and 2.Schist.In all, 11 soil series are identified in the two landscape. Of these, 6 soil series are identified in the granite gneiss landscape and5 series in schist 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. In the schist landscape, it is by parent material, climate and relief. Maximum area of about 164 ha (41%) has soils that are developed from granite gneiss followed by about 229 ha (57%) under schist.

A brief description of each of the 11 soil series identified followed by 20 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.

4.1Soils of Granite gneiss Landscape

In this landscape, 6 soil series are identified and mapped. Of these, Jedigere (JDG) soil series occupies maximum area of about 50 ha (13%). 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).

Two phases identified are briefly described below:

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 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).

Only one phase was identified:

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

Landscape and Soil Profile Characteristics of Ravanaki (RNK) Series

4.1.3 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 85 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

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

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

Three phases were identified:

JDGhA1g1	Sandy clay loam surface, slope 0-1 %, slight erosion, gravelly (15-35%)
JDGhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60%)
JDGiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)

4.1.5 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).

Only one phase was identified:

LGDmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)

Landscape and Soil Profile Characteristics of Lakshmangudda (LGD) Series

4.1.6 Budagumpa (BGP) Series: Budagumpa soils are very deep (>150 cm), 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 112 to 160 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 5 and chroma 1 to 4. Its texture is clay with gravel content of 10 to 20 per cent. These soils are calcareous that increase with depth. The available water capacity is very high (>200 mm/m).

Three phases were identified:

BGPmB1	Clay surface, slope 1-3 %, slight erosion
BGPmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)
BGPmB3g2	Clay surface, slope 1-3 %, severe erosion, very gravelly (35-60 %)

Landscape and Soil Profile Characteristics of Budagumpa (BGP) Series

4.2 Soils of Schist Landscape

In this landscape, 4 soil series are identified and mapped. Of these, Varavi (VRV) soil series occupies maximum area of about 108 ha (27%). The brief description of each series along with the soil phases mapped is given below.

4.2.1 Dindur (DDR) Series: Dindur soils are very shallow (<25 cm), well drained, have dark reddish brown to dark red gravelly clay loam to gravelly clay soils. They are developed from schist and occur on moderately sloping uplands.

The thickness of the soil ranges from 11 to 25 cm. Thickness of A horizon ranges from 7 to 19 cm. Its colour is in hue 2.5 YR with value 2.5 to 3 and chroma 3 to 6. The texture is dominantly clay. The available water capacity is very low (<25 mm/m).

Only one phase was identified:

DDRhD3g2R3St1	Sandy clay loam surface, slope 5-10%, severe erosion, very gravelly (35-60 %), very rocky (25-50 %), stony (0.01-0.1%)

Landscape and Soil Profile Characteristics of Dindur (DDR) Series

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

The thickness of the soil ranges from 51-73 cm. Thickness of A horizon ranges from 12 to 18 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1to 3. The texture is dominantly clay. The available water capacity is medium (101-150 mm/m).

Only one phase was identified:

ATTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35 %)

Landscape and Soil Profile Characteristics of Attikatti Tanda (ATT) Series

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

The thickness of the solum ranges from 78 to 98 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 63 to 78 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is medium (101-150 mm/m).

Only one phase was identified:

JLGmB1	Clay surface, slope 1-3 %, slight erosion

Landscape and Soil Profile Characteristics of Jelligeri (JLG) Series

4.2.4 Varavi (VRV) Series: Varavi soils are moderately deep (75-100 cm), moderately well drained, dark gray to very dark grayish brown and black cracking clay calcareous soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 76 to 98 cm. Thickness of A horizon ranges from 18 to 25 cm. Its colour is in hue 7.5 YR with value 3 and chroma 2. The texture is clay. The thickness of B horizon ranges from 58 to 73 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 2 to 3. Its texture is dominantly clay. The available water capacity is medium (101-150 mm/m).

Four phases were identified:

VRVmA2g1	Clay surface, slope 0-1 %, moderate erosion, gravelly (15-35 %)
VRVmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)
VRVmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35 %)
VRVmB3g2	Clay surface, slope 1-3%, severe erosion, very gravelly (35-60 %)

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

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

Two phases were identified:

MPTmA1g1	Clay surface, slope 0-1 %, slight erosion, gravelly (15-35%)
MPTmB1	Clay surface, slope 1-3 %, slight erosion

Landscape and Soil Profile Characteristics of Mahalingapur Tanda (MPT)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 conservations 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 20 soil map units identified in the Belhatti-3 microwatershed are grouped under 3 land capability classes and 5 land capability subclasses (Fig. 5.1). About 98 per cent area in the microwatershed is suitable for agriculture and about 2 per cent not suitable for agriculture but well suited to pasture, forestry, silvi-pastoral system, agri-horti-silvi-pastoral system, mining, quarrying, location of wind mills and as habitat for wildlife and recreation.

Of the lands suitable for agriculture, about 48 per cent are good cultivable lands (Class II) with minor limitations of soil characteristics and soil erosion and are distributed in all parts of the microwatershed.

Moderately good cultivable lands (Class III) cover an area of about 35per cent and are distributed in the central and northern part of the microwatershed with moderate problems of erosion and soil.

The fairly good lands (class IV) cover about 15 per cent area. They have very severe limitations of erosion and soil and are distributed in the northern and central part of the microwatershed.

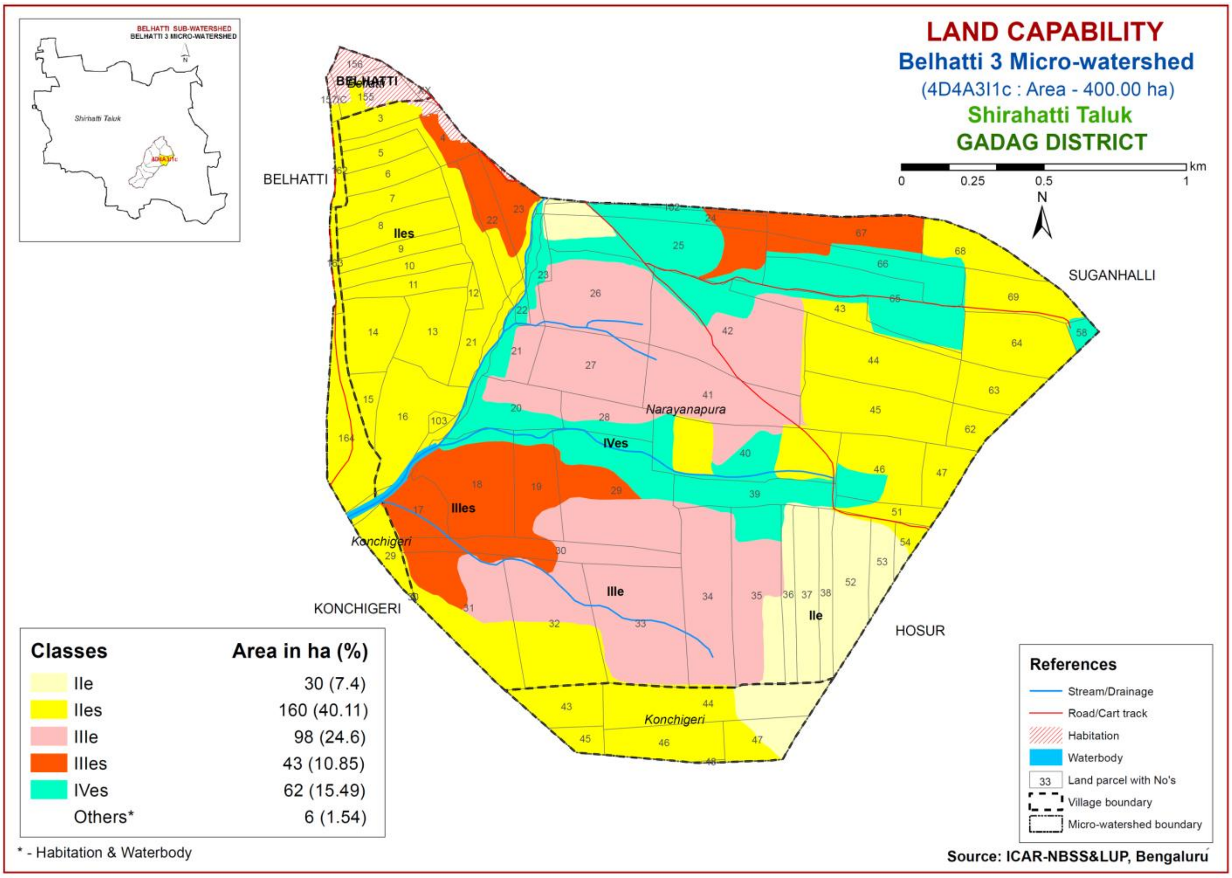


Fig. 5.1 Land Capability map of Belhatti-3 microwatershed

5.2 Soil Depth

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

Moderately deep (75-100 cm) soils occupy maximum area of about 144 ha (36%) in the central, eastern and northeastern part of the microwatershed. Deep soils (100-150 cm) occur in about 111 ha (28%) and are distributed in the southeastern, southern and northwestern part of the microwatershed. Moderately shallow (50-75 cm) soils occupy about 76 ha (19%) and are distributed in the southern and central part of the microwatershed. Very deep soils (>150 cm) occur in about 31 ha (8%) and are distributed in the northern and northwestern part of the microwatershed. Shallow soils (25-50 cm) occupy about 32 ha (8%) in the northeastern part of the microwatershed. A small area of about one ha is under very shallow (<25 cm) and is distributed in the northeastern part of the microwatershed.

The most productive lands (35%) 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 southeastern, southern and central part of the microwatershed.

The most problematic lands (8%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occur in the northeastern 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.

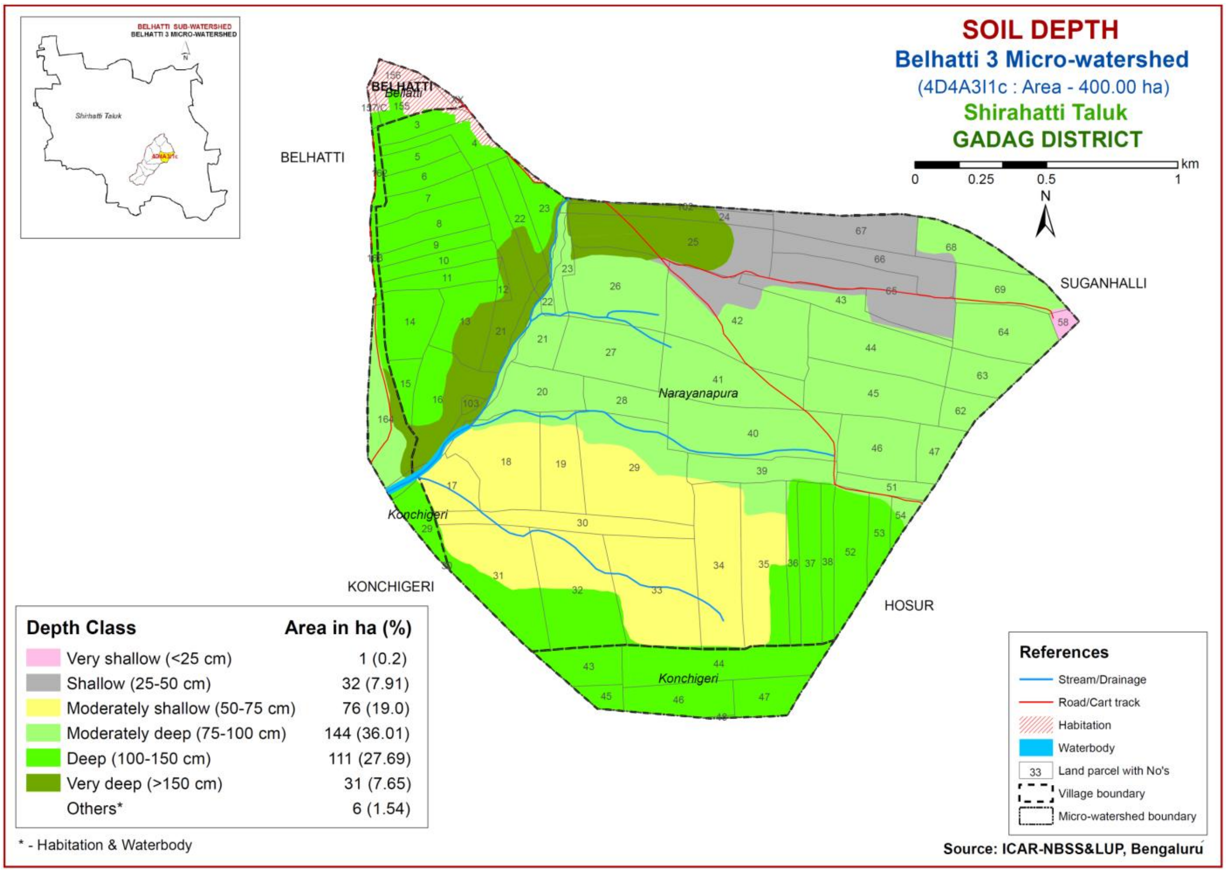


Fig. 5.2Soil Depth map of Belhatti-3 microwatershed

5.3 Surface Soil Texture

Texture is an expression to indicate the coarseness or fineness of the soil as determined by the relative proportion of primary particles of sand, silt and clay. It has a direct bearing on the structure, porosity, adhesion and consistence. The surface layer of a soil to a depth of about 25 cm is the layer that is most used by crops and plants. The surface soil textural class provides a guide to understanding soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behaviour, microbial activity and crop suitability.

Maximum area of 343 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 (51 ha, 13%). They are distributed in the western and northwestern 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.

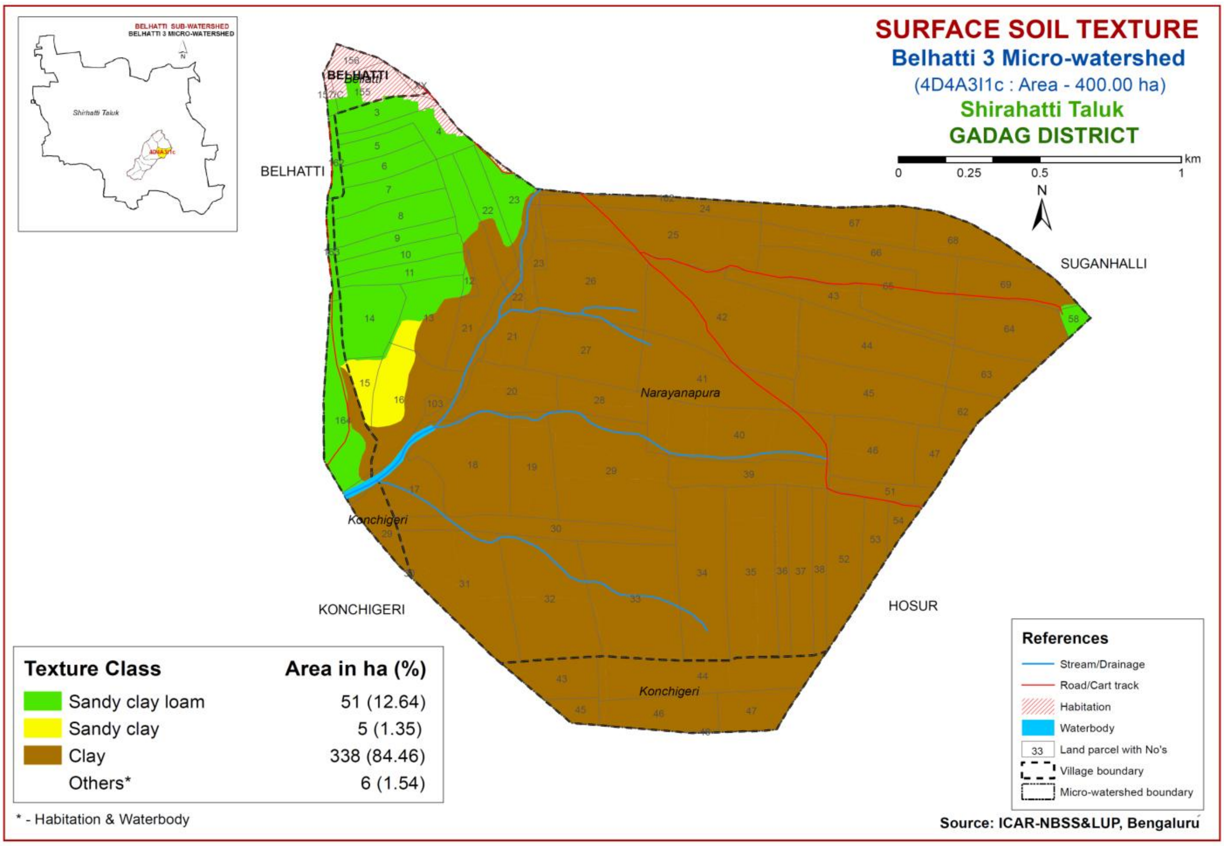


Fig. 5.3 Surface Soil Texture map of Belhatii-3 microwatershed

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization.

Maximum area in the microwatershed has soils that are gravelly (15-35%) covering about 238 ha (60%) and are distributed in all parts of the microwatershed (Fig. 5.4) followed by soils that are very gravelly (35-60%) covering about 95 ha (24%) and are distributed in the northeastern and eastern part of the microwatershed. The soils that are non-gravelly (<15%) covering about 61 ha (15%) are distributed in the southwestern, 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 (24%) that are very gravelly (35-60%) where only short duration crops can be grown.

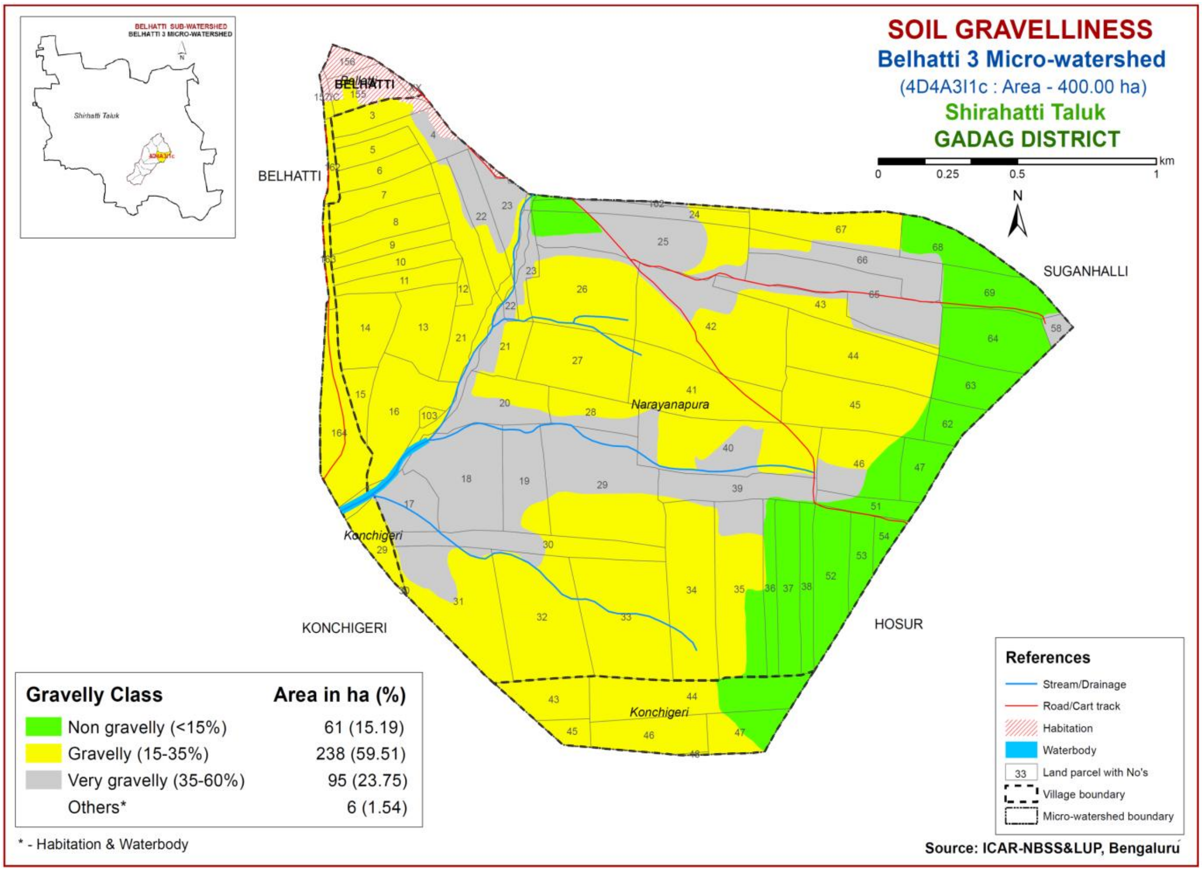


Fig. 5.4 Soil Gravelliness map of Belhatti-3microwatershed

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 in the microwatershed has soils that are medium (101-150mm/m) in available water capacity. They occur in about 189 ha (47%) and are distributed dominantly in the central and western part of the microwatershed. An area of about 141 ha (35%) in the microwatershed has soils that have very high (>200 mm/m) available water capacity and are distributed in the southern, southeastern and northeastern part of the microwatershed.

An area of about 63 ha (16%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the western and north eastern part of the microwatershed. An area of about 1 ha (<1%) has soils that are very low (< 50 mm/m) in available water capacity in microwatershed.

An area of about 141 ha (35%) has soils that have high potential (>200 mm/m) with regard to available water capacity where all climatically adapted long duration crops can be grown successfully.

About 64 ha (16%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses.

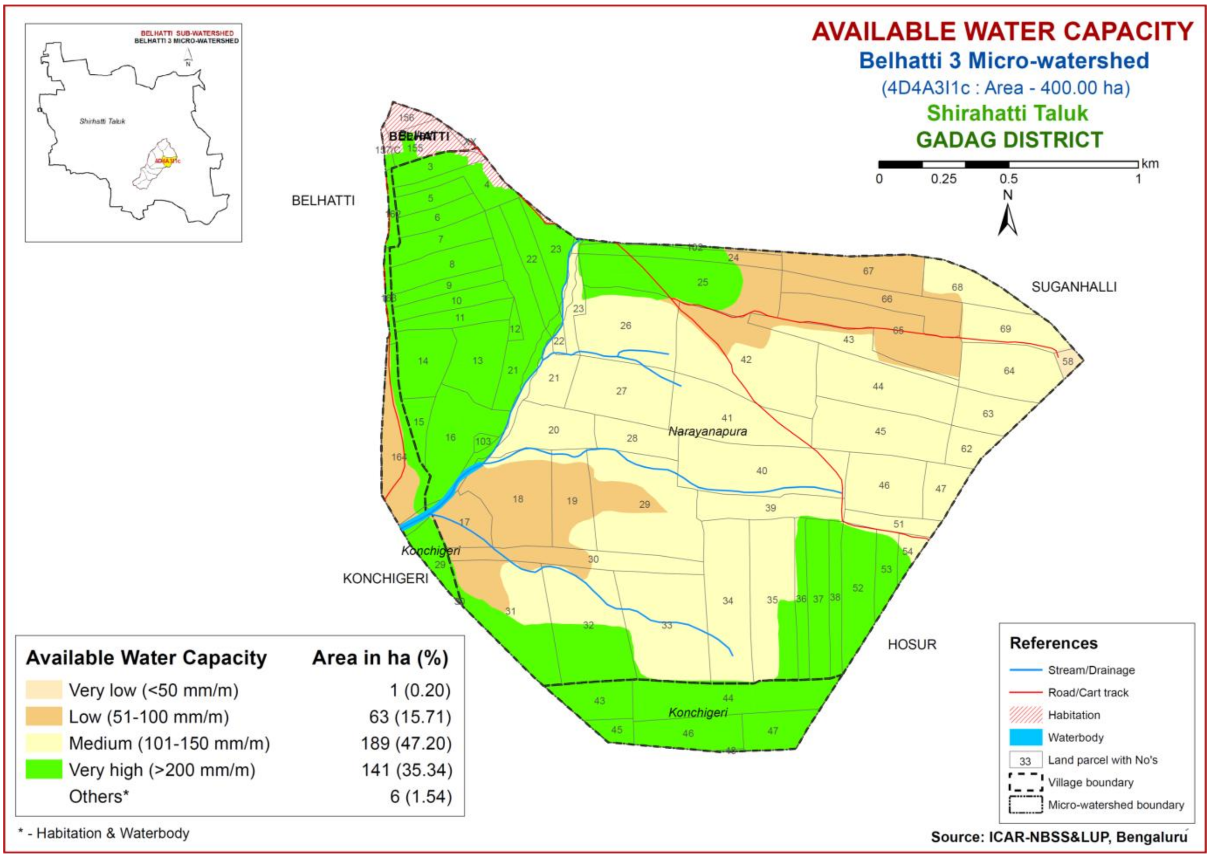


Fig. 5.5 Soil Available Water Capacity map of Belhatti-3 microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3% slope) slope class. It covers an area of about 297 ha (74%) and is distributed in all parts of the microwatershed and followed by nearly level (0-1% slope) slope class. It covers an area of about 96 ha (24%) and is distributed in northeastern and northern part of the microwatershed.

About one ha (<1%) area falls under moderately sloping (5-10% slope) lands microwatershed. An area of about 393 ha (98%) 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.

About one ha (<1%) area has problem with respect to slopes. They require proper soil and water conservation measures for sustained production.

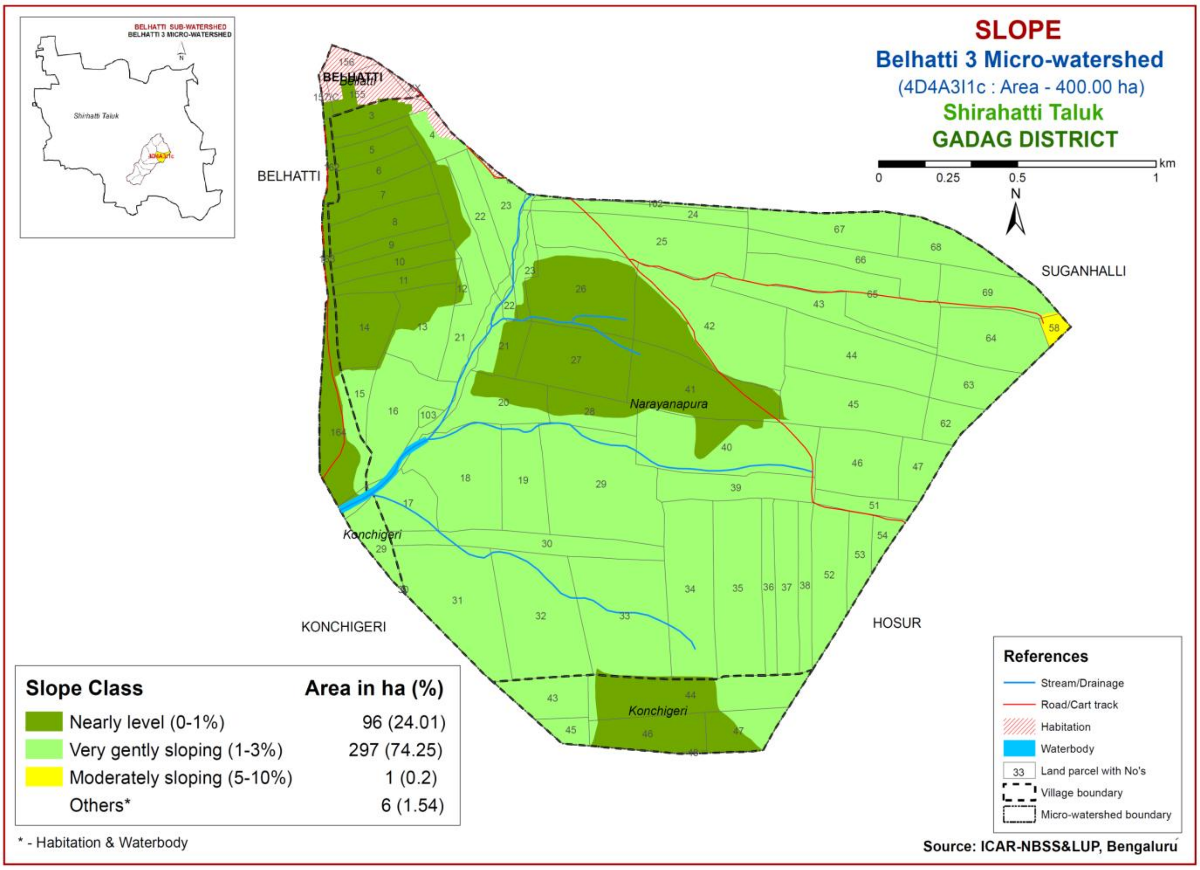


Fig. 5.6 Soil Slope map of Belhatti-3 microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover an area of about 190 ha (48%) in the microwatershed. They are distributed in all parts of the microwatershed. Moderately eroded (e2 class) soils cover an area of about 142 ha (35%) and are distributed in central and northern part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 62 ha (15%) and are distributed in the central and northern part of the microwatershed.

An area of about 190 ha (48%) is relatively stable terrain which needs minimum soil and water conservation measures.

An area of about62 ha (15%) 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 142 ha (35%) where the soils are moderately eroded.

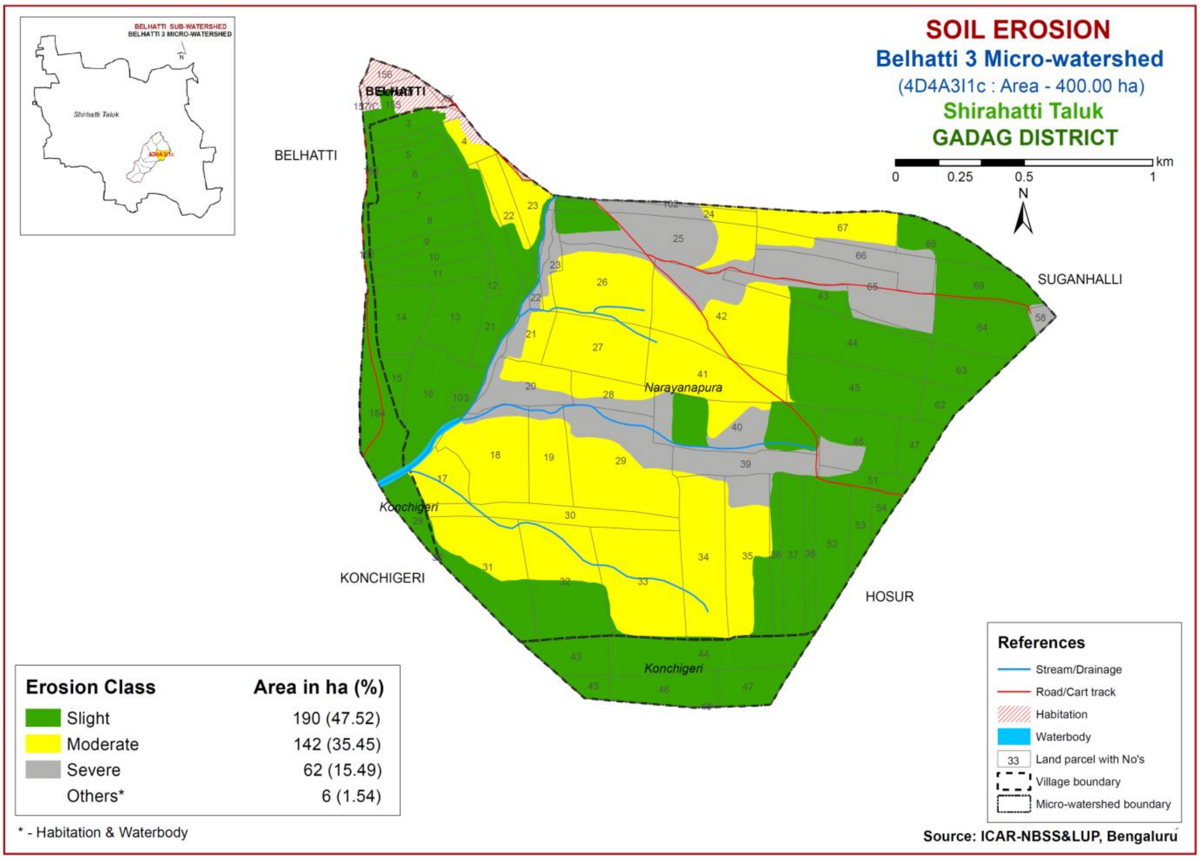


Fig. 5.7 Soil Erosion map of Belhatti-3 microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2014 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 analysis of the Belhatti-3 microwatershed for soil reaction (pH) showed that about 49 ha (12%) area is moderately alkaline (pH 7.8-8.4) and is distributed in the northwestern part of the microwatershed. About 167 ha (42%) area (Fig.6.1) is under strongly alkaline (pH 8.4-9.0) and is distributed in all parts of the microwatershed followed by major area of about 177 ha (44%) is under very strongly alkaline (pH >9.0) and distributed in central, northern and southwestern 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 of the entire microwatershed area is medium (0.5-0.75%) covering about390 ha (97%) and a small area is high (>0.75%) in organic carbon content that accounts for 4 ha (1%) area in the microwatershed and is distributed in the northeastern part of the microwatershed (Fig.6.3).

6.4 Available Phosphorus

The soil analysis revealed that available phosphorus is low (<23 kg/ha) in 382 ha (95%) area (Fig.6.4) and is distributed in all parts of the microwatershed. There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. About 12 ha (3%) area in the microwatershed is medium (23-57 kg/ha) and is distributed in the northwestern part of the microwatershed.

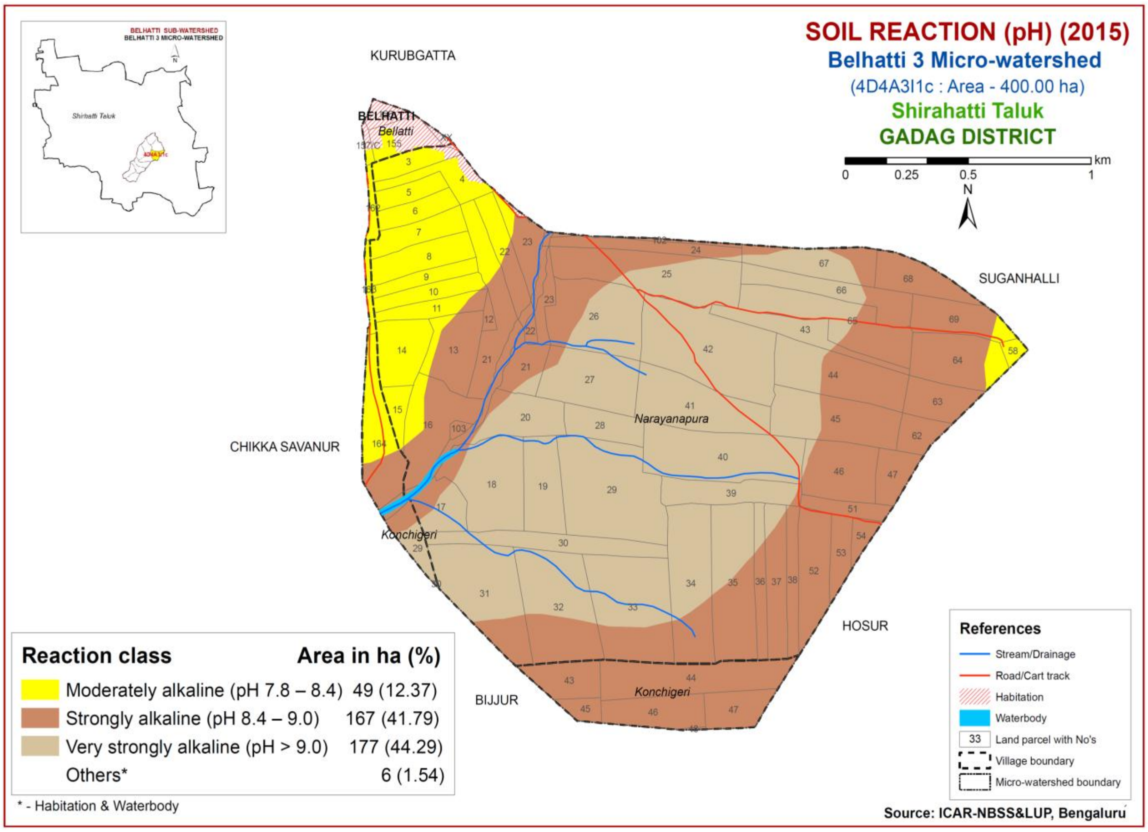


Fig.6.1 Soil Reaction (pH) map of Belhatti-3 microwatershed

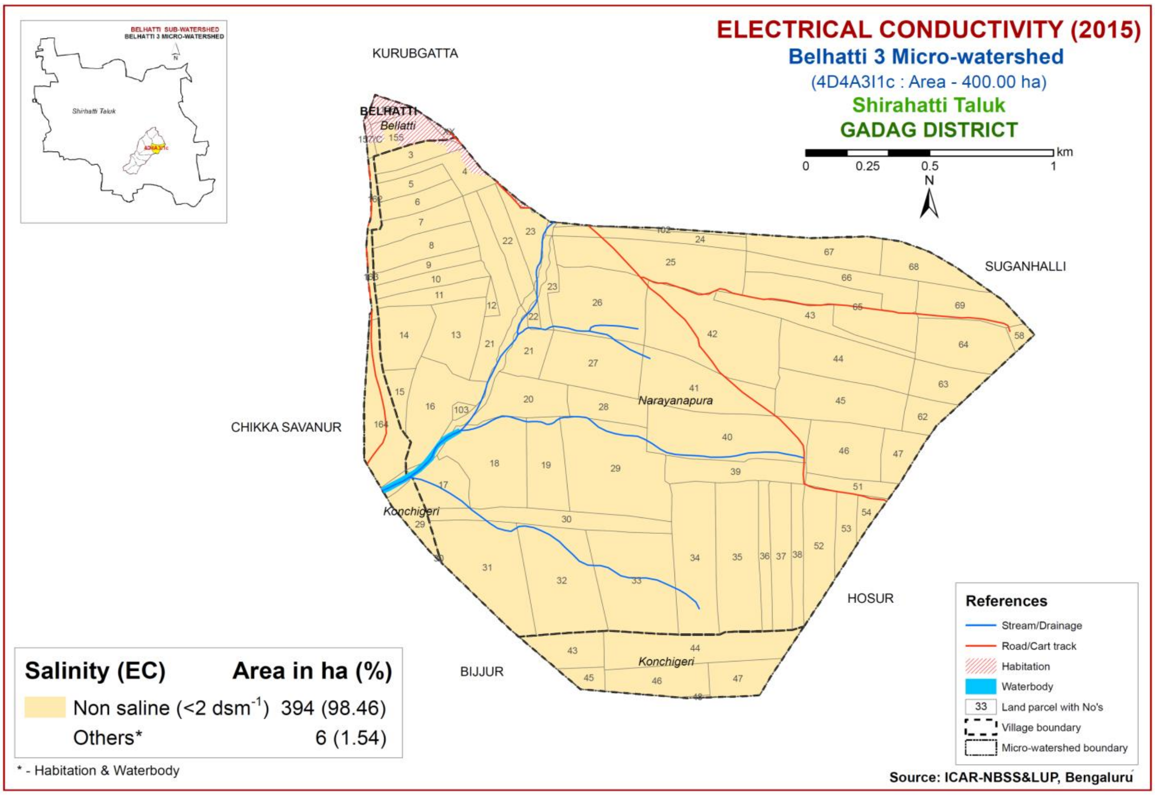


Fig.6.2 Electrical Conductivity (EC) map of Belhatti-3 microwatershed

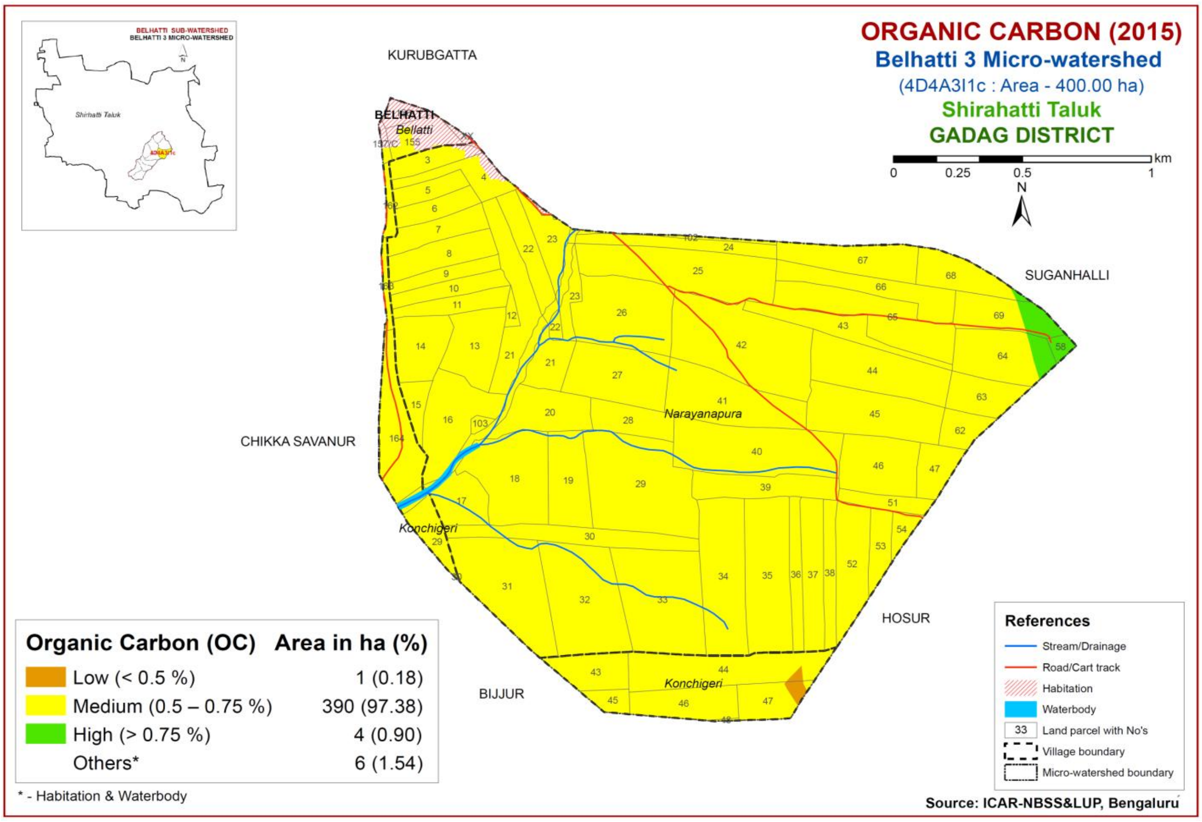


Fig.6.3 Soil Organic Carbon map of Belhatti-3 microwatershed

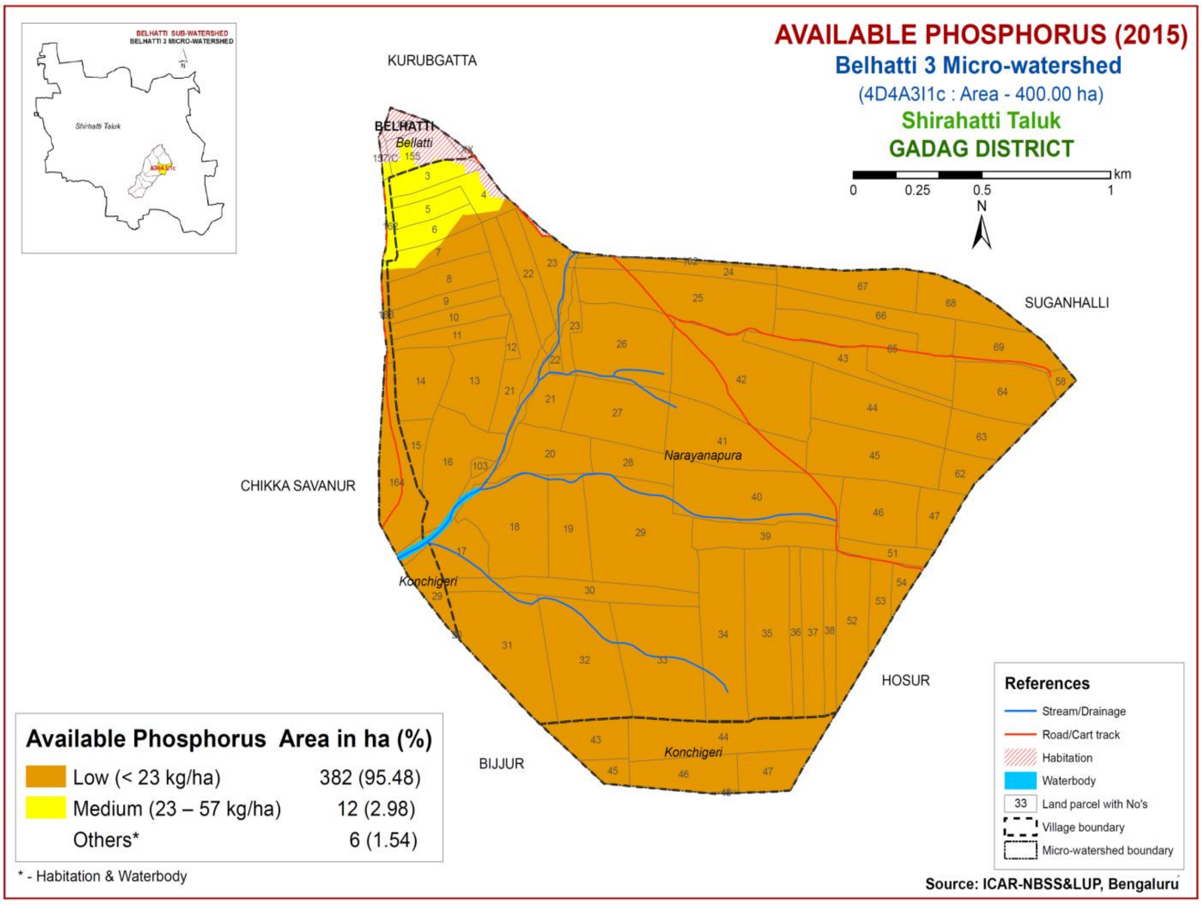


Fig.6.4 Soil available Phosphorus map of Belhatti-3 microwatershed

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in 346 ha (49%) area distributed in all parts of the microwatershed (Fig.6.5); high available potassium (>337 kg/ha) content accounts for 43 ha (11%) and is distributed in the southwestern, southern and northeastern part of the microwatershed. The available potassium content is low (<145 kg/ha) in small area of 5 ha (1%) and is distributed in the eastern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in 84 ha (21%) area in the microwatershed and is distributed in northeastern and northern part of the microwatershed. An area of about 297 ha (74%) 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 small area of 13 ha (3%) and is distributed in the western part of the microwatershed.

6.7 Available Boron

Available boron content is low (<0.5 ppm) in 233 ha (58%) area and is distributed in thesouthwestern, northwestern, northern and northeastern part of the microwatershed. About108 ha (27%) has soils that are medium (0.5-1.0 ppm) in available boron (Fig 6.7) and is distributed in southeastern part of the microwatershed. An area of53 ha (13%) is high (>1.0 ppm) in available boron and is distributed in the southeastern part of the microwatershed.

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in the entire microwatershed area (Fig 6.9).

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 276 ha (69%) and is distributed in all parts of the microwatershed. It is sufficient (>0.6 ppm) in 118 ha (29%) area (Fig 6.11) and is distributed in the northern and northeastern part of the microwatershed.

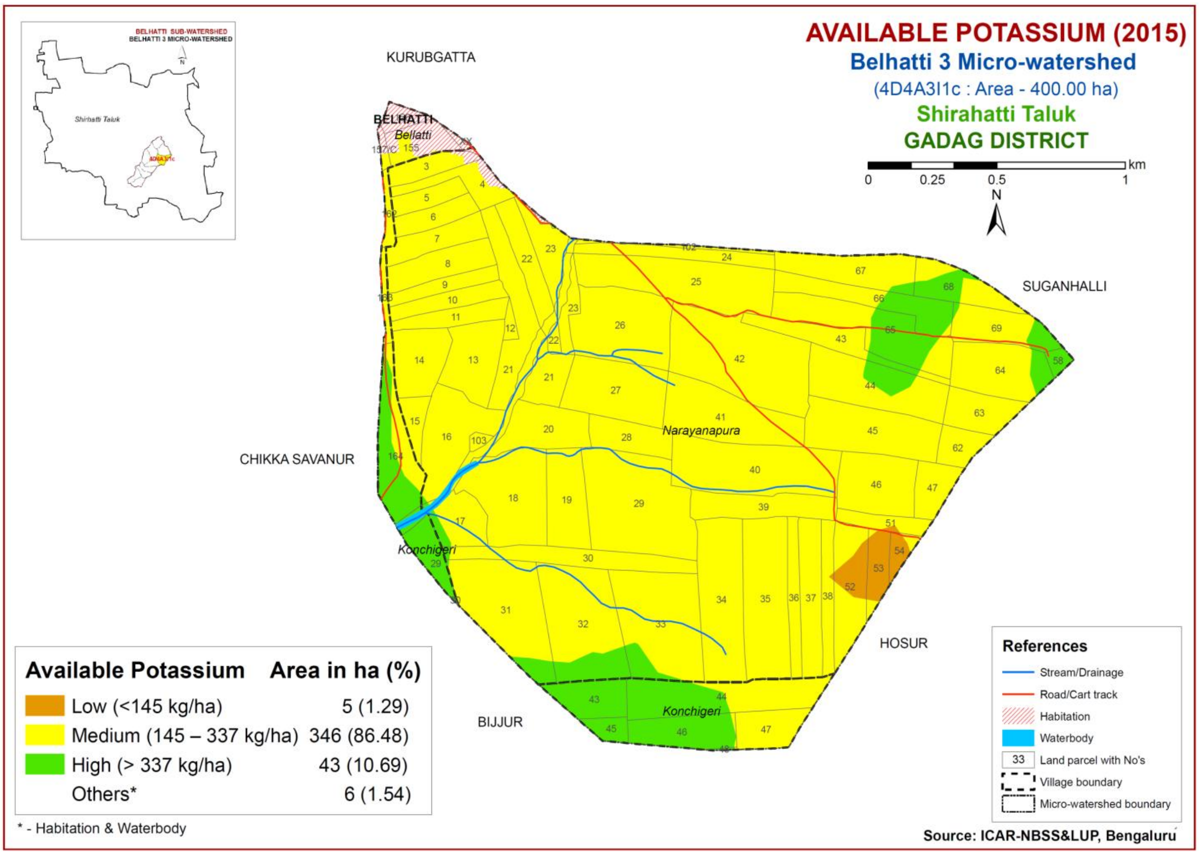


Fig.6.5 Soil available Potassium map of Belhatti-3 microwatershed

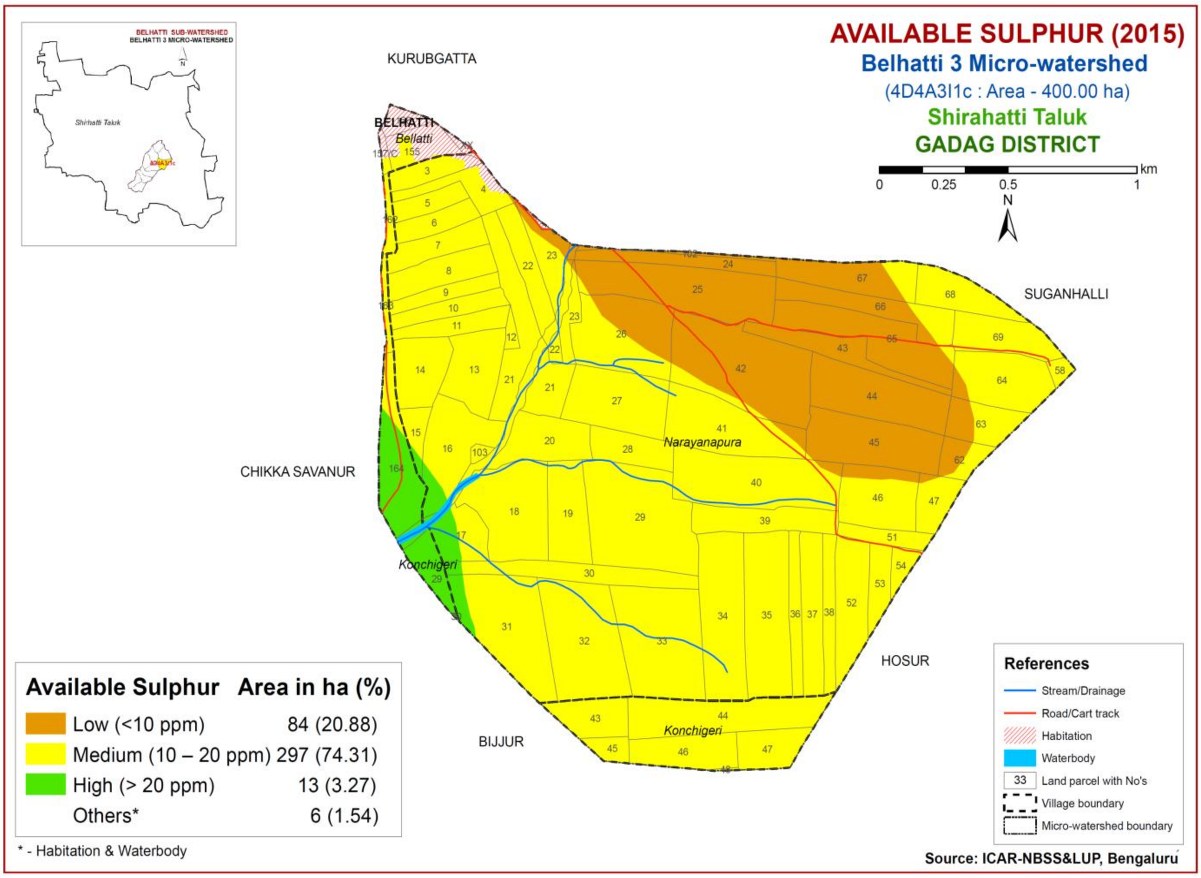


Fig.6.6 Soil available Sulphur map of Belhatti-3 microwatershed

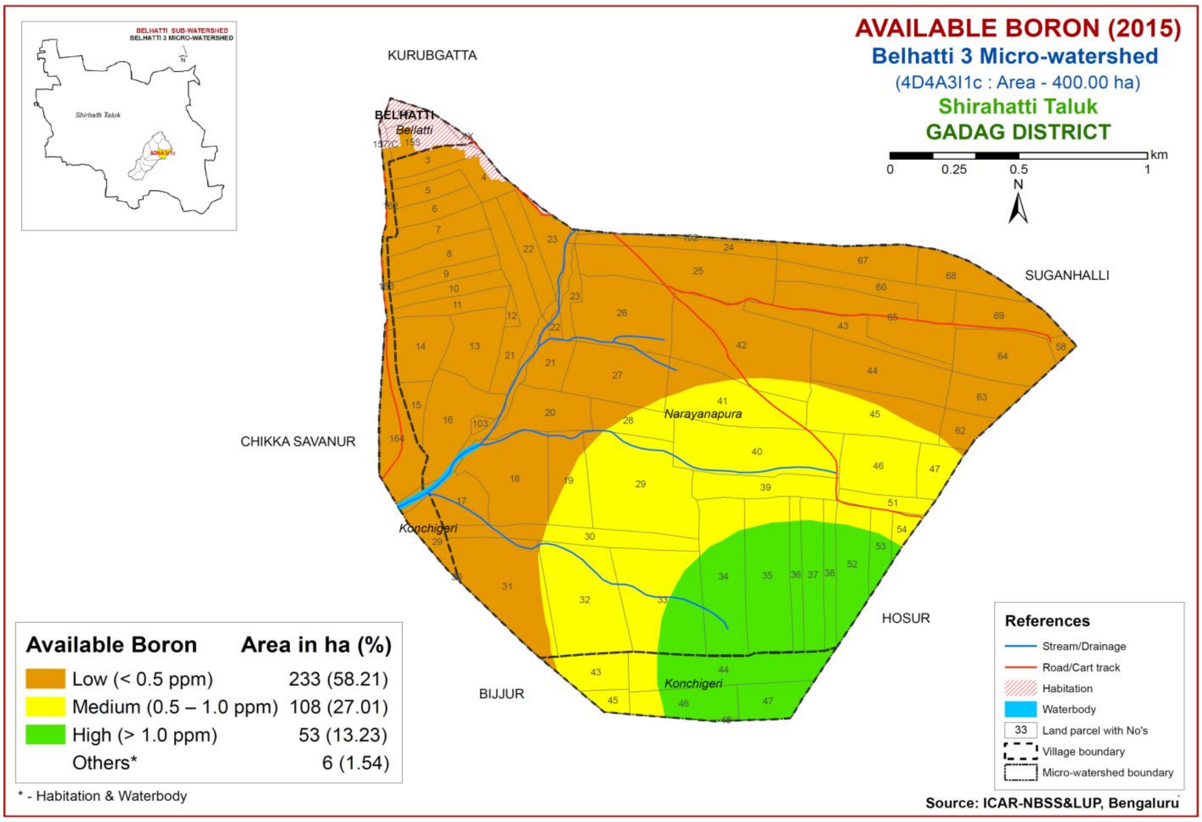


Fig.6.7 Soil available Boron map of Belhatti-3 microwatershed

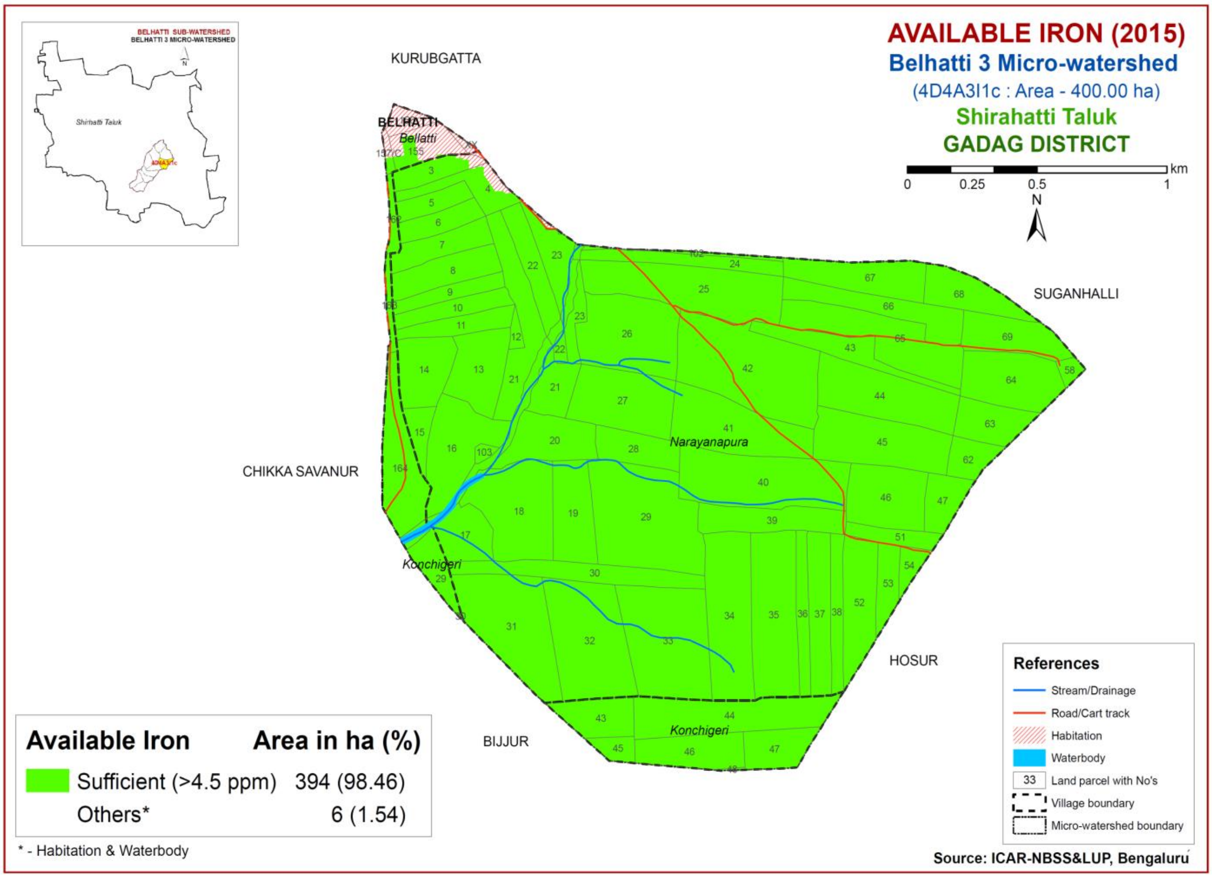


Fig.6.8 Soil available Iron map of Belhatti-3 microwatershed

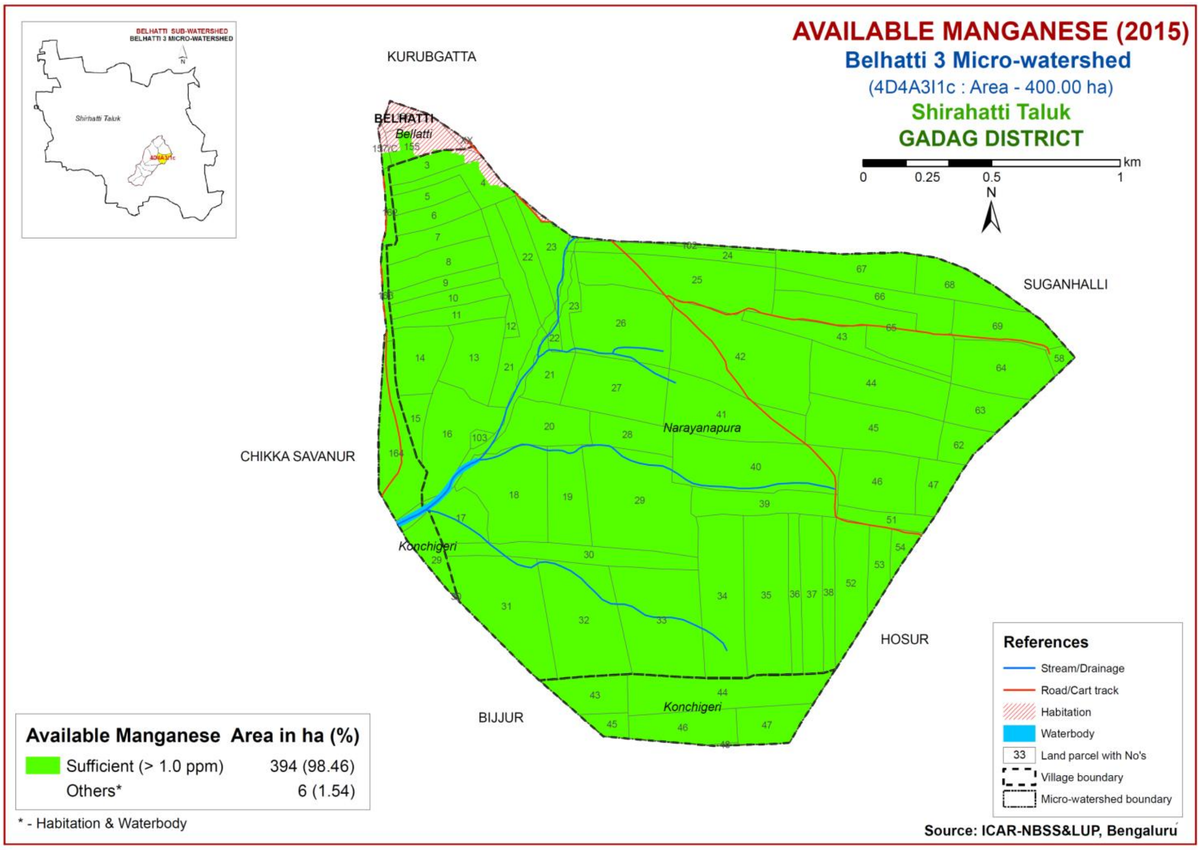


Fig.6.9 Soil available Manganese map of Belhatti-3 microwatershed

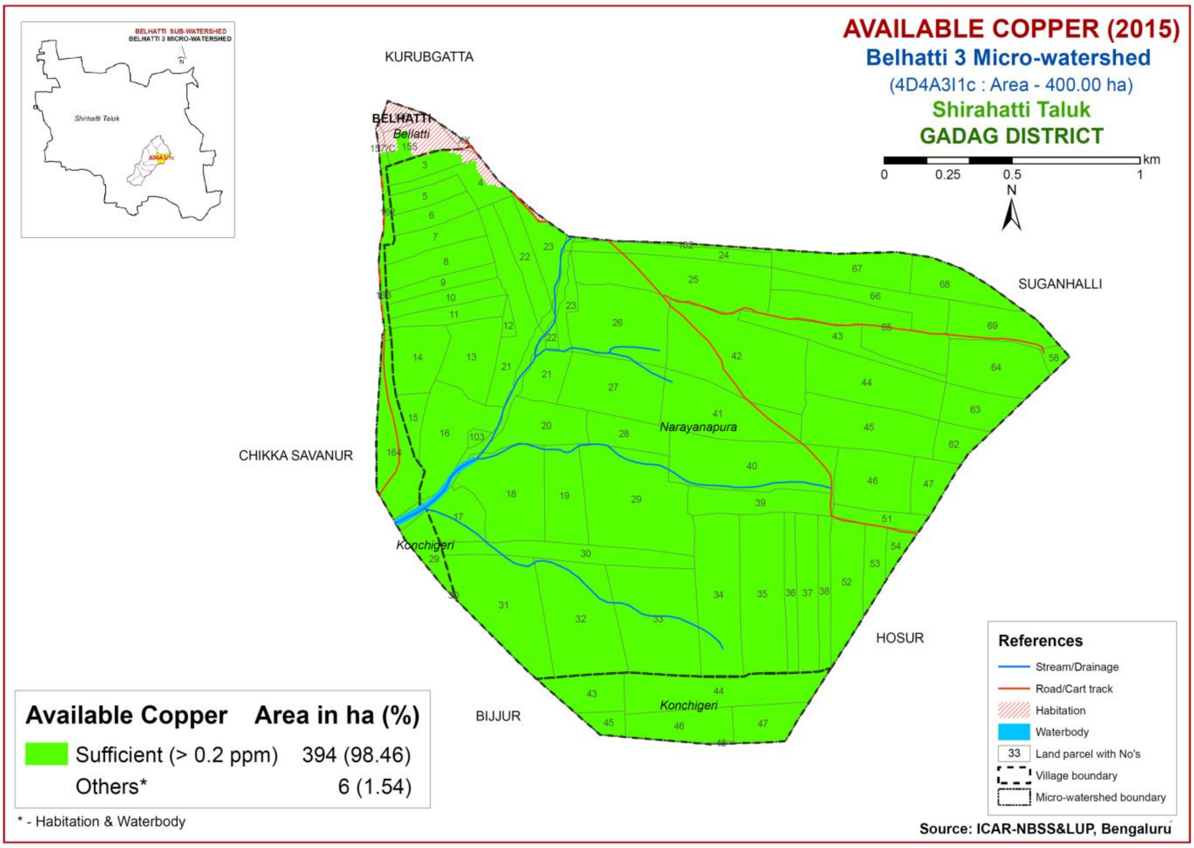


Fig.6.10 Soil available Copper map of Belhatti-3 microwatershed

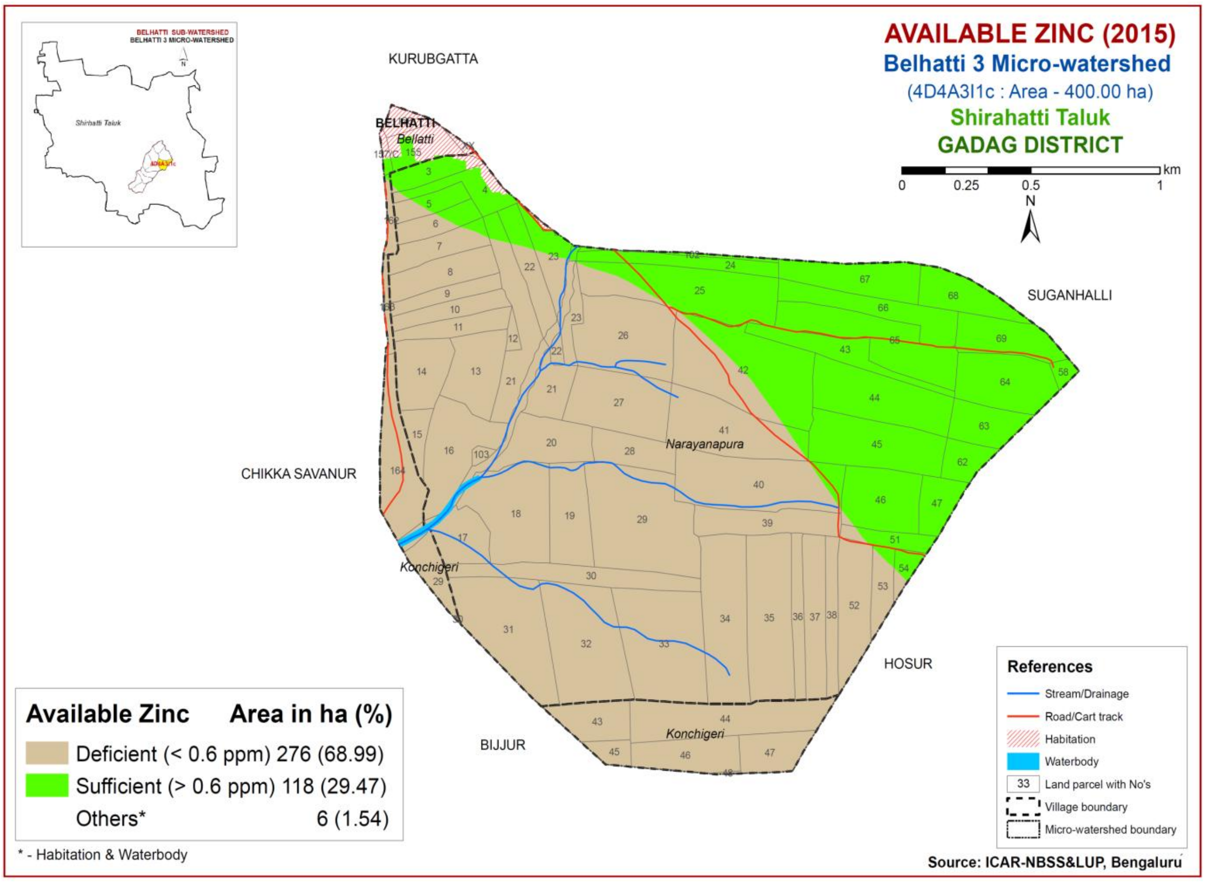


Fig.6.11Soil available Zinc map of Belhatti-3 microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Belhatti-3 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 perennialcrops 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 districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing sorghum was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure. 7.1.

An area of about 114 ha (28%) in the microwatershed has soils that are highly suitable (class S1) for growing sorghum crop. They are distributed mainly in the eastern and northwestern part of the microwatershed. Major area of about232 ha (58%) is moderately suitable (class S2) for growing sorghum and are distributed in central, northern and southwestern part the microwatershed.

Table 7.1 Soil-Site Characteristics of Belhatti-3 microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p^+)kg^{-1}]	BS (%)
					Surf-ace	Sub-sur-face	Surface (%)	Subsurface (%)								
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					
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					
JDGhA1g1	633	150	MWD	100-150	scl	c	15-35	-	>200	0-1	slight					
JDGhB2g2	633	150	MWD	100-150	scl	c	35-60	-	>200	1-3	moderate					
JDGiB1g1	633	150	MWD	100-150	sc	c	15-35	-	>200	1-3	slight					
LGDmB1g1	633	150	MWD	100-150	c	sc-c	15-35	<15	>200	1-3	slight					
BGPmB1	633	150	MWD	>150	c	c	-	10-20	>200	1-3	slight					
BGPmB1g1	633	150	MWD	>150	c	c	15-35	10-20	>200	1-3	slight					
BGPmB3g2	633	150	MWD	>150	c	c	35-60	10-20	>200	1-3	severe					
DDRhD3g2R3St1	633	150	WD	<25	scl	cl, c	35-60	>35	<25	5-10	severe					
ATTmB2g1	633	150	WD	50-75	c	c	15-35	-	101-150	1-3	moderate					
JLGmB1	633	150	MWD	75-100	c	c	-	-	101-150	1-3	slight					
VRVmA2g1	633	150	MWD	75-100	c	c	15-35	<15	101-150	0-1	moderate					
VRVmB1g1	633	150	MWD	75-100	c	c	15-35	<15	101-150	1-3	slight					
VRVmB2g1	633	150	MWD	75-100	c	c	15-35	<15	101-150	1-3	moderate					
VRVmB3g2	633	150	MWD	75-100	c	c	35-60	<15	101-150	1-3	severe					
MPTmA1g1	633	150	MWD	100-150	c	c	15-35	-	>200	0-1	slight					
MPTmB1	633	150	MWD	100-150	c	c	-	-	>200	1-3	slight					

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

They have major limitations of gravelliness, calcareousness and rooting depth. Marginally suitable lands (class S3) for growing sorghum occupy about 47 ha (12%) and mainly occur in northwestern and northeastern part of the microwatershed. They have severe limitations of rooting depth, calcareousness and gravelliness. A small area of about one ha (<1%) is not suitable for growing sorghum in the microwatershed and occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.2 Crop suitability criteria for Sorghum

Crop requirement		Rating			
Soil –site characteristics	unit	Highly suitable(S1)	Moderately suitable(S2)	Marginally suitable(S3)	Not suitable (N)
Slope	%	2-3	3-8	8-15	>15
LGP	Days	120-150	120-90	<90	
Soil drainage	class	Well to mod.Well drained	imperfect	Poorly/excessively	V.poorly
Soil reaction	pH	6.0-8.0	5.5-5.98.1-8.5	<5.58.6-9.0	>9.0
Surface soil texture	Class	C, cl, sicl, sc	l, sil, sic	Sl, ls	S, fragmental skeletal
Soil depth	Cm	100-75	50-75	30-50	<30
Gravel content	% vol.	5-15	15-30	30-60	>60
Salinity (EC)	dSm^{-1}	2-4	4-8	8-10	>10
Sodicity (ESP)	%	5-8	8-10	10-15	>15

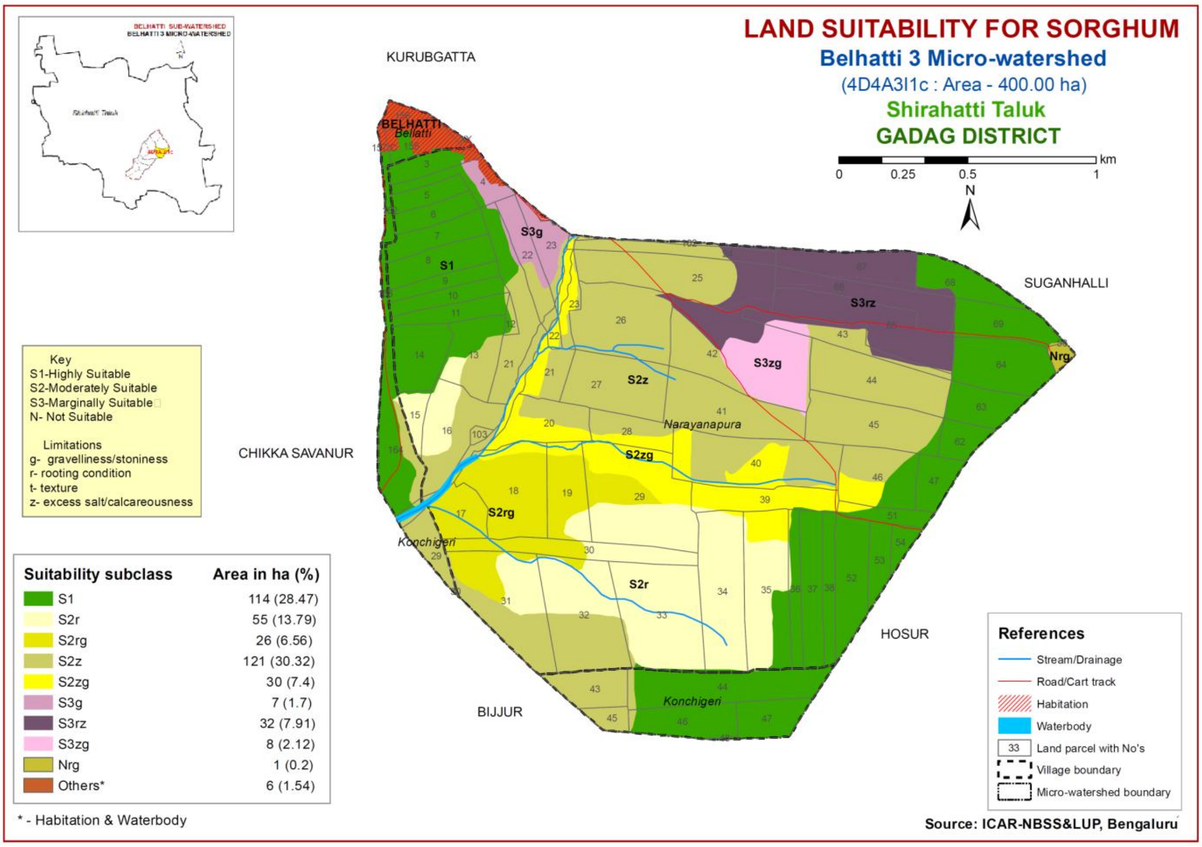


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

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

A small area of about five ha (1%) in the microwatershed has soils that are highly suitable (class S1) for growing maize crop. They are distributed mainly in the western part of the microwatershed. The marginally suitable (class S3) lands cover about 389 ha (97%) area in the microwatershed and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture, calcareousness and rooting depth. About one ha (<1%) area is not suitable for growing maize and occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.3 Crop suitability criteria for Maize

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

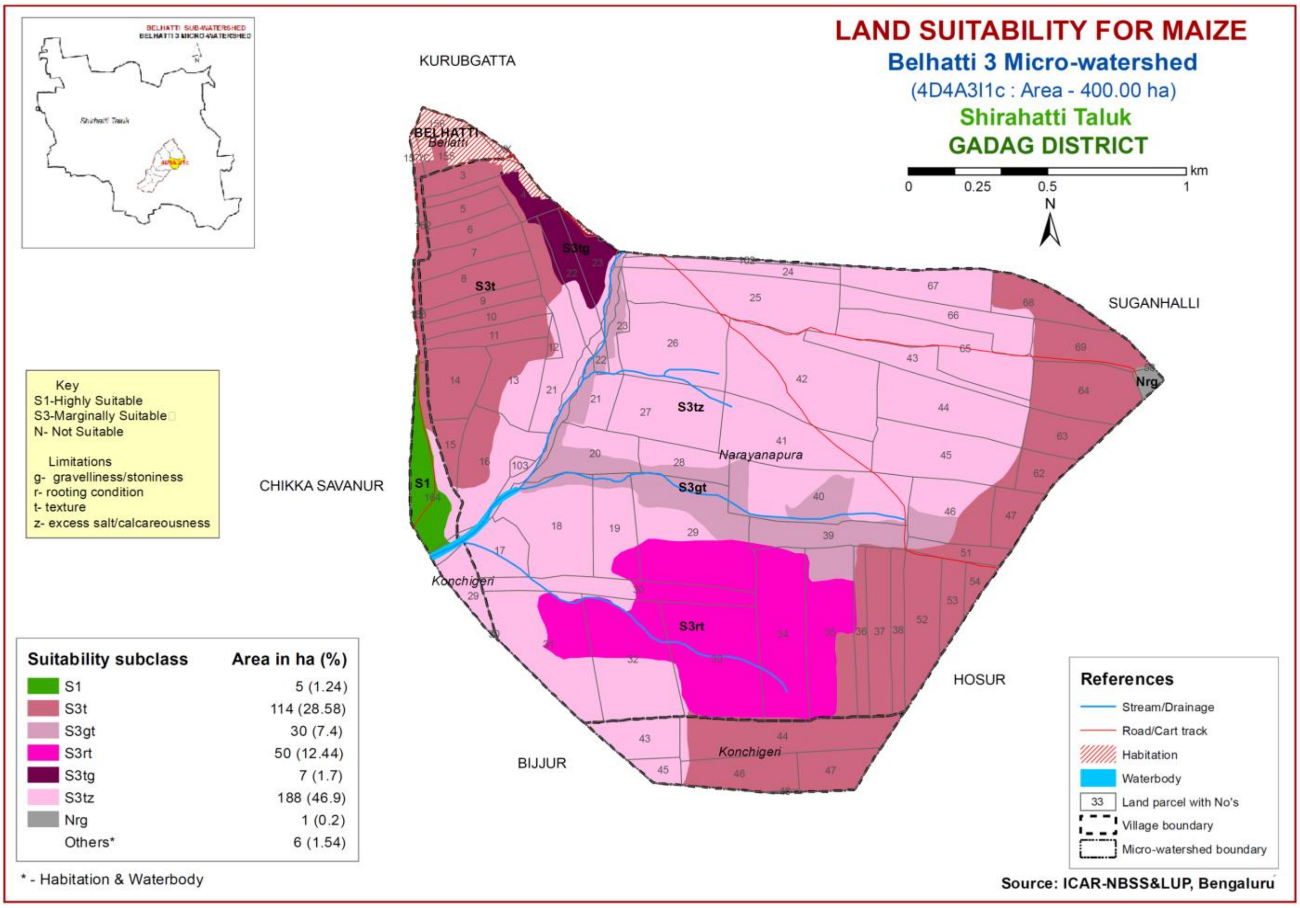


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for 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 districts. 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 prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.3.

An area of about 185 ha (46%) in the microwatershed has soils that are highly suitable (class S1) for growing Bengal gram crop. They are distributed mainly in the northwestern, southern and eastern part of the microwatershed. About 161 ha (40%) is moderately suitable (class S2) for Bengal gram and they are distributed in the northern, central and western part of the microwatershed. They have major limitations of texture, calcareousness and rooting depth. Marginally suitable lands (class S3) for growing Bengal gram occupy about 47 ha (12%) and mainly occur in the northern and central part of the microwatershed. They have severe limitations of calcareousness and rooting depth. A very small area of about one ha (<1%) is not suitable for growing Bengal gram in the microwatershed and occurin the northeastern part of the microwatershed. They have very severe limitations of gravelliness 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	5.5-5.77.6-8.0	8.1-9.0;4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	Sl, c>60%	S, fragmental
Soil depth	Cm	>75	51-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

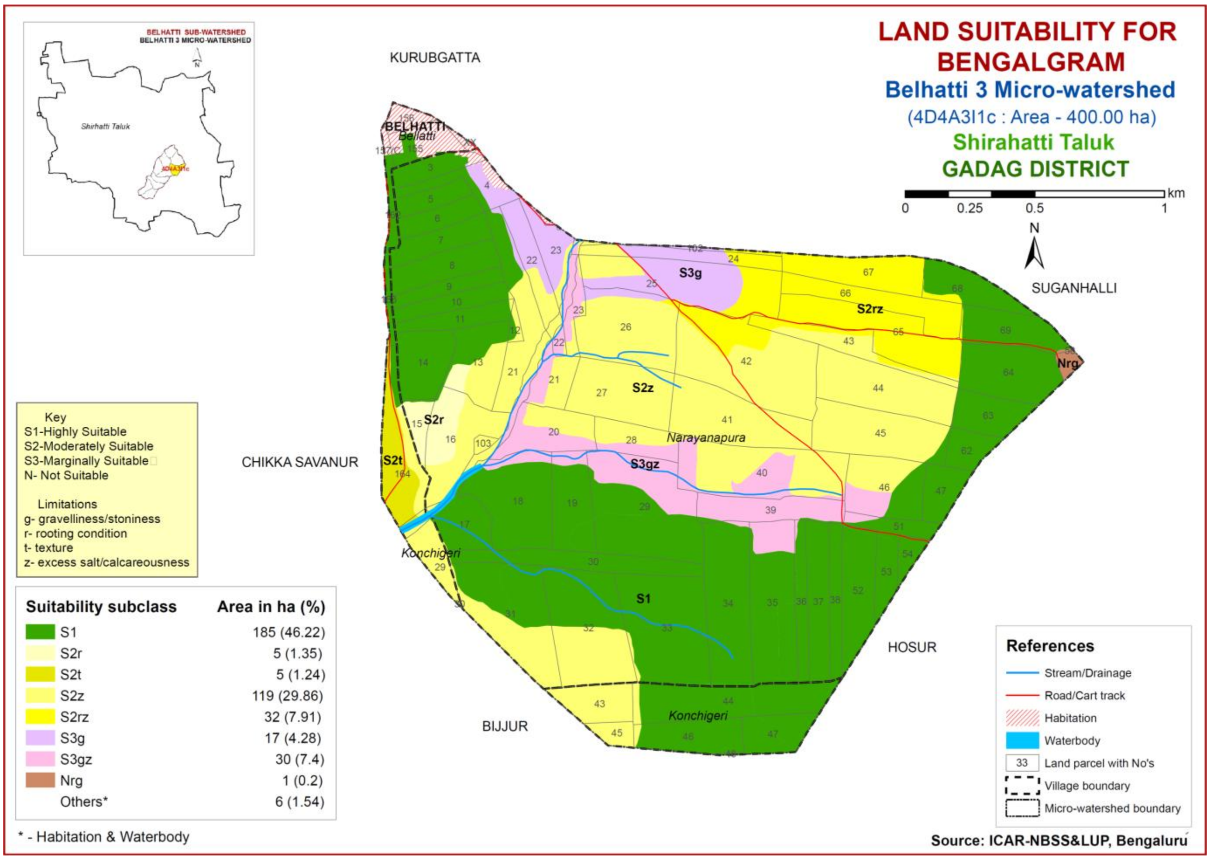


Fig. 7.3 Land Suitability map of Bengal gram

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 prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.4.

About five ha (1%) area is moderately suitable (class S2) for groundnut and these areas are distributed in the western part of the microwatershed. They have moderate limitations of texture. Marginally suitable lands (class S3) for growing groundnut occupy major area of about 388 ha (97%) and are distributed in all parts of the microwatershed. They have severe limitations of calcareousness, gravelliness and texture. A small area of about one ha (<1%) is not suitable for growing groundnut in the microwatershed and occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.5 Crop suitability criteria for Groundnut

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

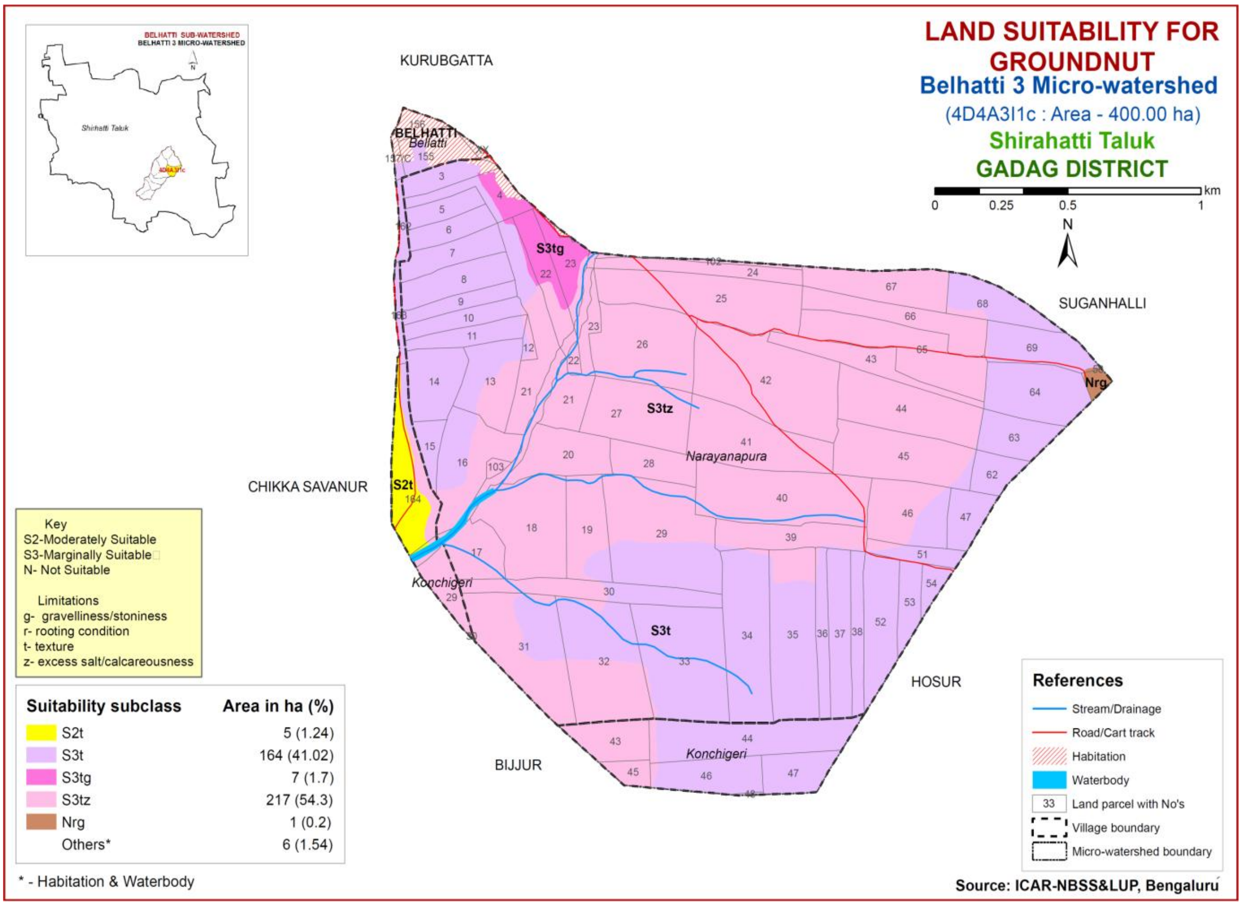


Fig. 7.4 Land Suitability map of Groundnut

7.5 Land Suitability for Sunflower (*Helianthus annus*)

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

An area of about 88 ha (22%) in the microwatershed has soils that are highly suitable (class S1) for growing sunflower crop. They are distributed mainly in the northwestern and southeastern part of the microwatershed. Moderately suitable (class S2) lands are found to occur in major area of about 180 ha (45%). They have moderate limitations of gravelliness, calcareousness and rooting depth. They are dominantly distributed in all parts of the microwatershed. The marginally suitable (class S3) lands cover about 93 ha (23%) area in the microwatershed and mainly occur in the northern and southern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth. About 33 ha (8%) area isnot suitable for growing sunflower and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness, 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 rained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.55.5-6.4	8.6-9.0;4.5-5.4	>9.0<4.5
Surface soil texture	Class	l, cl, sil, sc	Scl, sic, c,	c (>60%), sl	ls, s
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

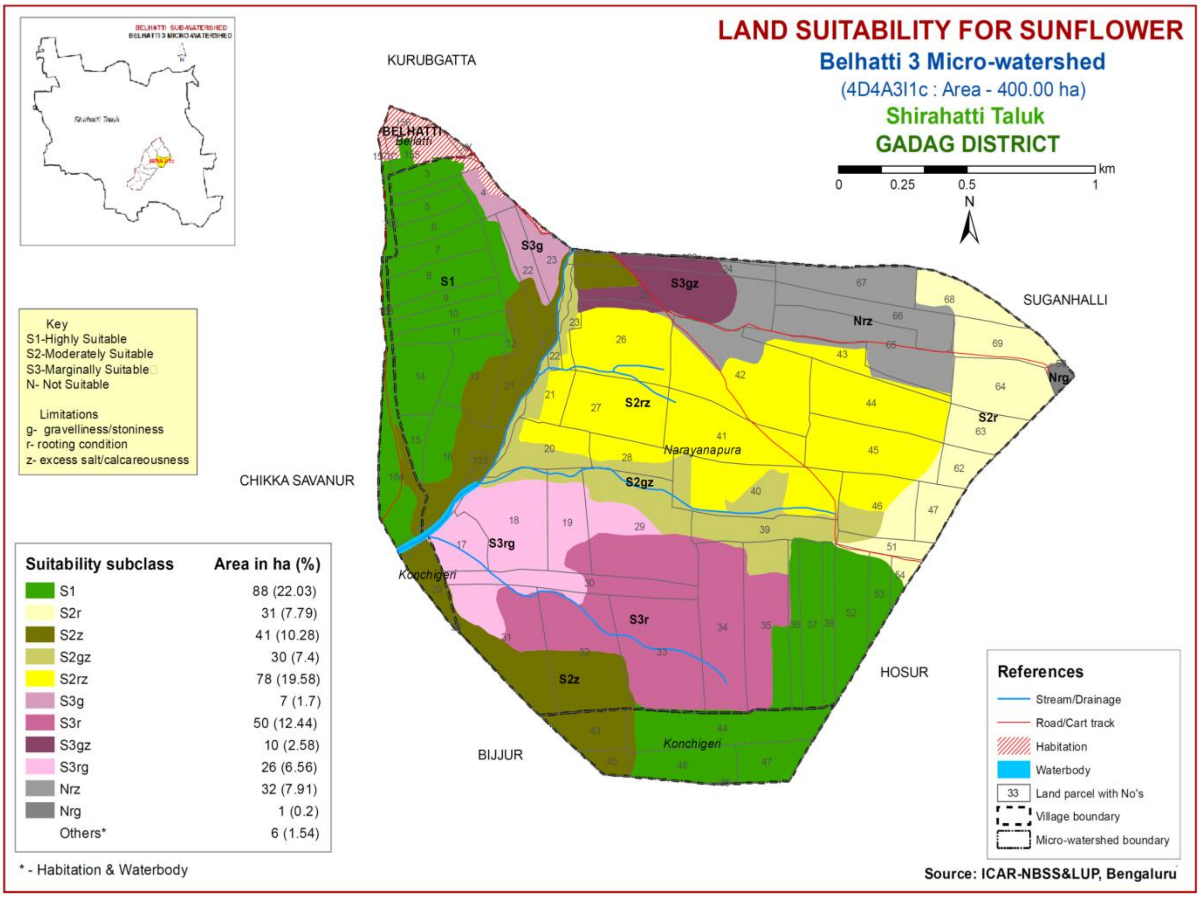


Fig. 7.5 Land Suitability map of Sunflower

7.6 Land Suitability for Cotton (*Gossypium hirsutum*)

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

About 90 ha (22%) areas in the microwatershed is highly suitable (class S1) for growing cotton and are distributed in the southeastern and northwestern part of the microwatershed. Major area of about 268 ha (65%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, calcareousness and rooting depth. They are distributed in the central, northeastern and southern part of the microwatershed. The marginally suitable (class S3) lands cover about 42 ha (10%) area in the microwatershed and occur in the northern part of the microwatershed. They have severe limitations of gravelliness, calcareousness and rooting depth. A small area of one ha (<1%) is not suitable for growing cotton and mainly occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.7 Crop suitability criteria for Cotton

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

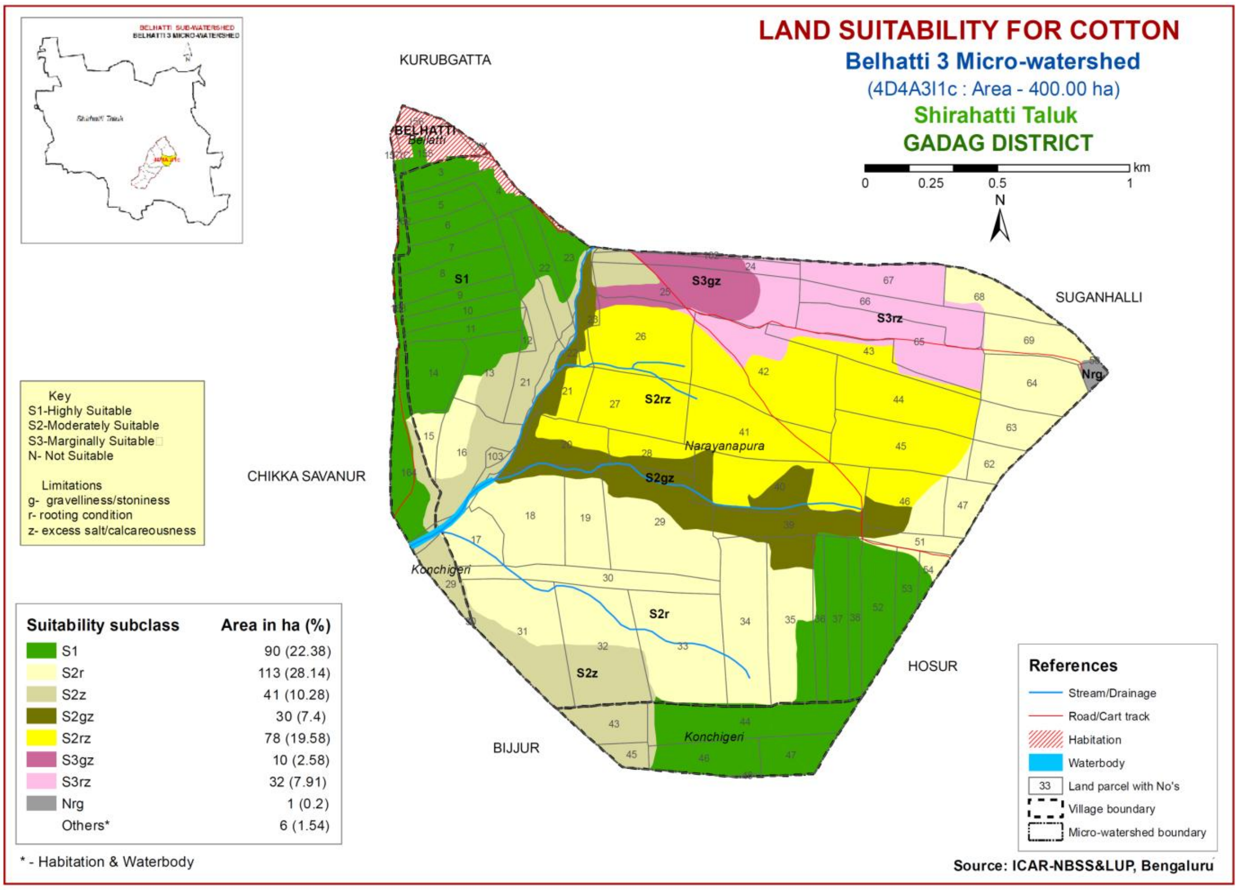


Fig. 7.6 Land Suitability map of Cotton

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 prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.7.

Avery small area of about five ha (1%) is moderately suitable (class S2) for growing banana and they are distributed in the western part of the microwatershed. They have major limitations of rooting depth. Marginally suitable (class S3) lands for growing banana occupy major area of about 356 ha (89%) and are distributed in all parts of the microwatershed. They have severe limitations of rooting depth, texture, calcareousness and gravelliness. An area of about 33 ha (8%) is not suitable for growing banana in the microwatershed and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness, calcareousness and rooting depth.

Table 7.8 Crop suitability criteria for Banana

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

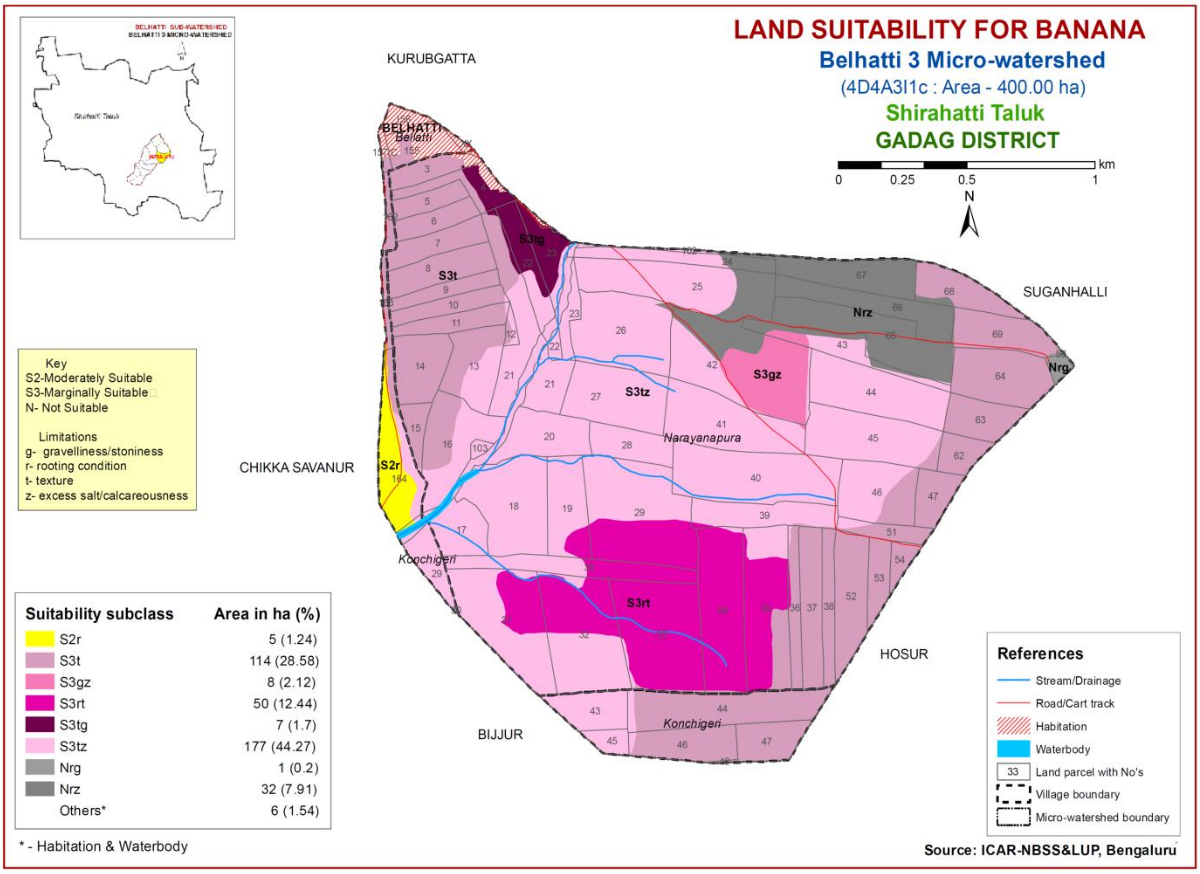


Fig. 7.7 Land Suitability map of Banana

7.8 Land Suitability for Pomegranate (*Punica granatum*)

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

A small area of about five ha (1%) in the microwatershed is highly suitable (class S1) for growing pomegranate and are distributed in the western part of the microwatershed. Major area of about 312 ha (78%) is moderately suitable (class S2) for pomegranate and 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 45 ha (11%) mainly in the southwestern and northern part of the microwatershed. They have severe limitations of texture, calcareousness and gravelliness. An area of about 33 ha (8%) is not suitable for growing pomegranate in the microwatershed and mainly occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness, calcareousness and rooting depth.

Table 7.9 Crop suitability criteria for Pomegranate

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

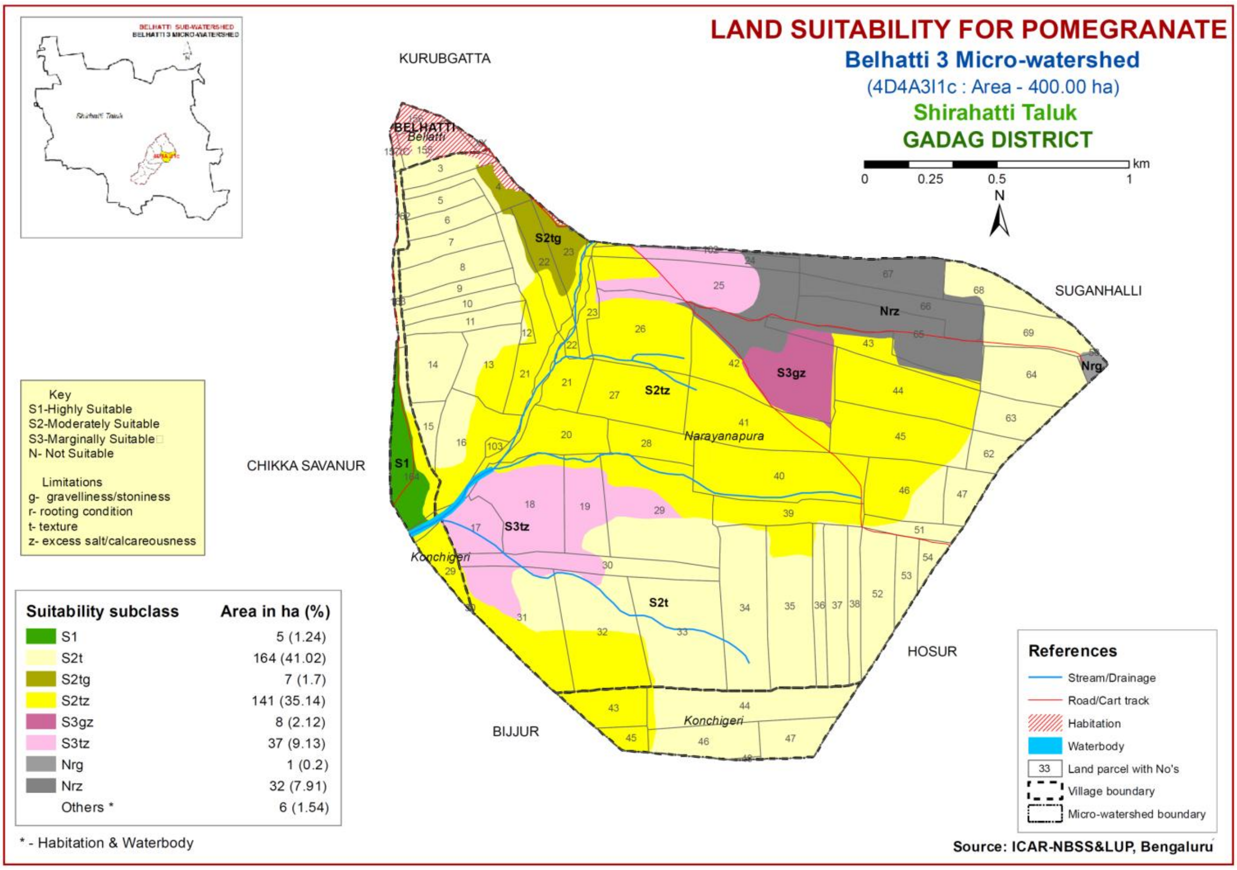


Fig. 7.8 Land Suitability map of Pomegranate

7.9 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in 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).

A small area of about 13 ha (3%) in the microwatershed is highly suitable (class S1) for growing mango and are distributed in the southern part of the microwatershed. They have minor or no limitations for growing mango. The marginally suitable (class S3) lands cover maximum area of about 273 ha (68%) and are distributed in all parts of the microwatershed. They have severe limitations of texture, rooting depth and calcareousness.

An area of about 109 ha (27%) is not suitable for growing mango in the microwatershed and occur in the northeastern, central and southern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.10 Crop suitability criteria for Mango

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

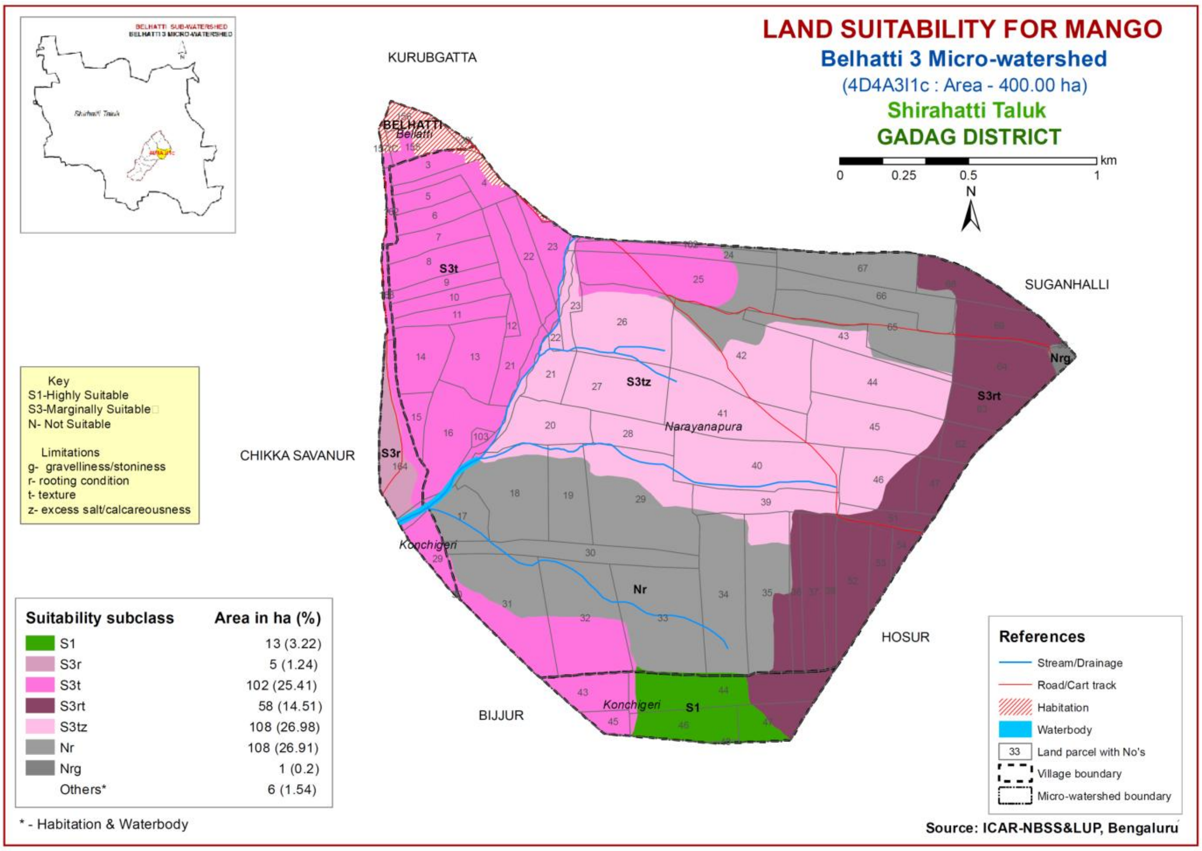


Fig. 7.9 Land Suitability map of Mango

7.10 Land suitability for Sapota (*Manilkara zapota*)

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

Moderately suitable (class S2) lands found to occur in about 144 ha (36%) that have moderate limitations of texture, calcareousness and rooting depth. They are distributed in central and eastern part of the microwatershed.

The marginally suitable (class S3) lands cover about 217 ha (54%) area in the micowatershed and are distributed in all parts of the microwatershed. They have severe limitations of gravelliness, texture and rooting depth.

An area of about 33 ha (8%) is not suitable for growing sapota in the microwatershed and occur in the northeastern and northern 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

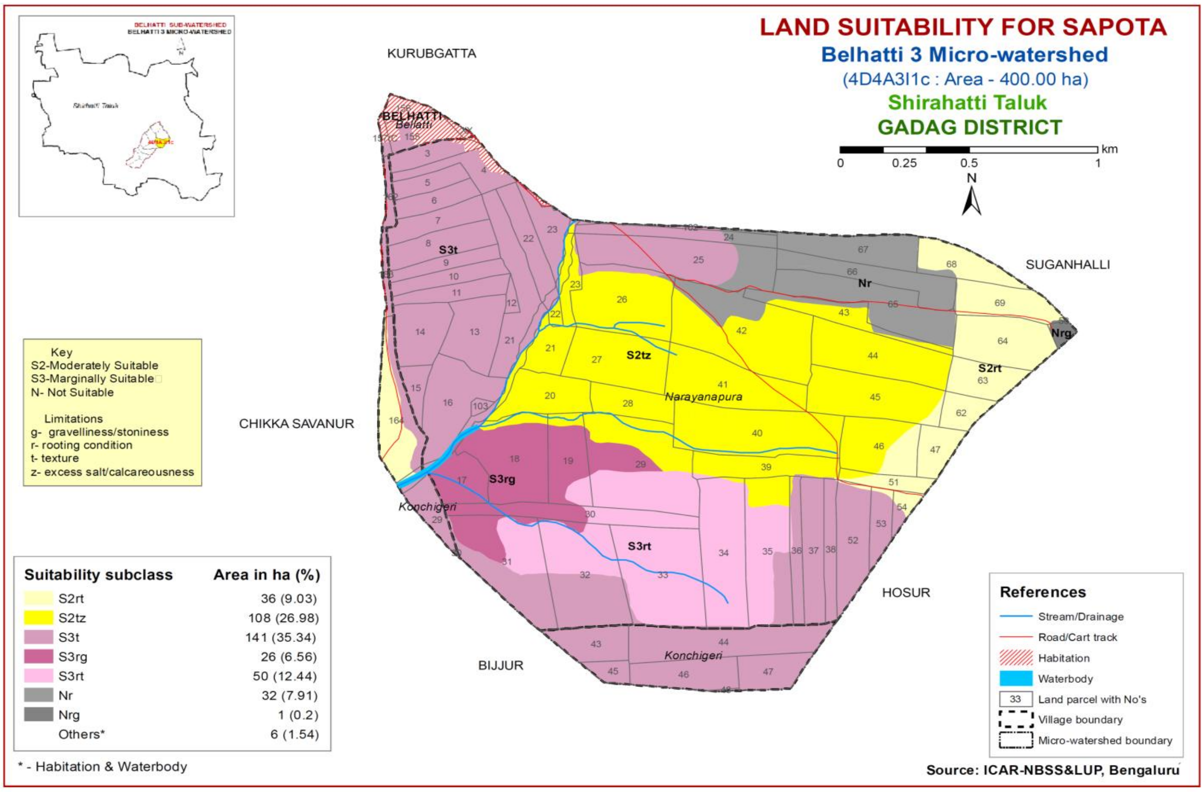


Fig. 7.10Land Suitability map of Sapota

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).

About 113 ha (28%) areas in the microwatershed is moderately suitable (class S2) for growing guava and are distributed in the central and western part of the microwatershed. They have moderate limitations of texture, calcareousness and rooting depth.

The marginally suitable (class S3) lands cover about 249 ha (62%) area in the microwatershed and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture, rooting depth and calcareousness.

A small area of about 33 ha (8%) is not suitable for growing guava in the microwatershed and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

Table 7.12 Crop suitability criteria for Guava

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

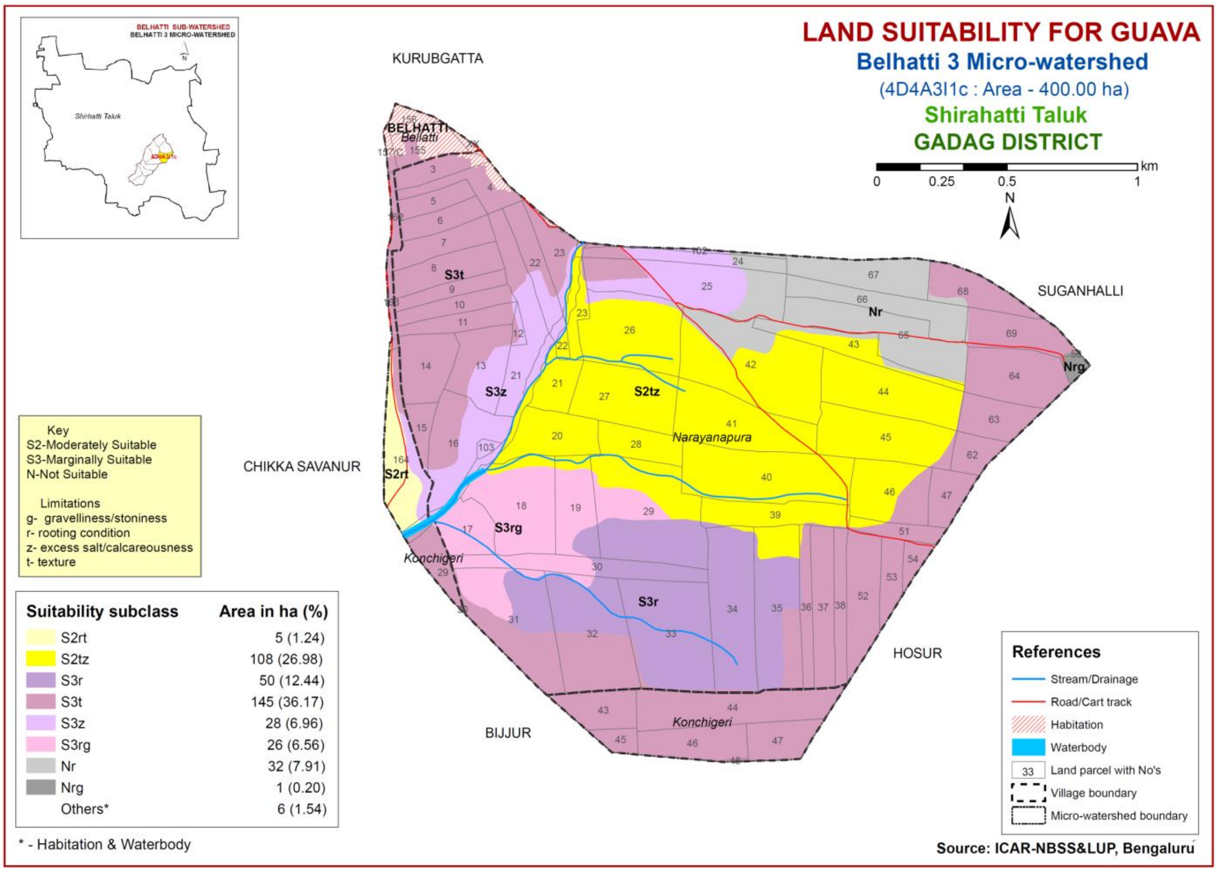


Fig. 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

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

The marginally suitable (class S3) lands cover a maximum area of about 361 ha (90%) and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture, rooting depth and calcareousness.

A small area of about 33 ha (8%) is not suitable for growing jackfruit in the microwatershed and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

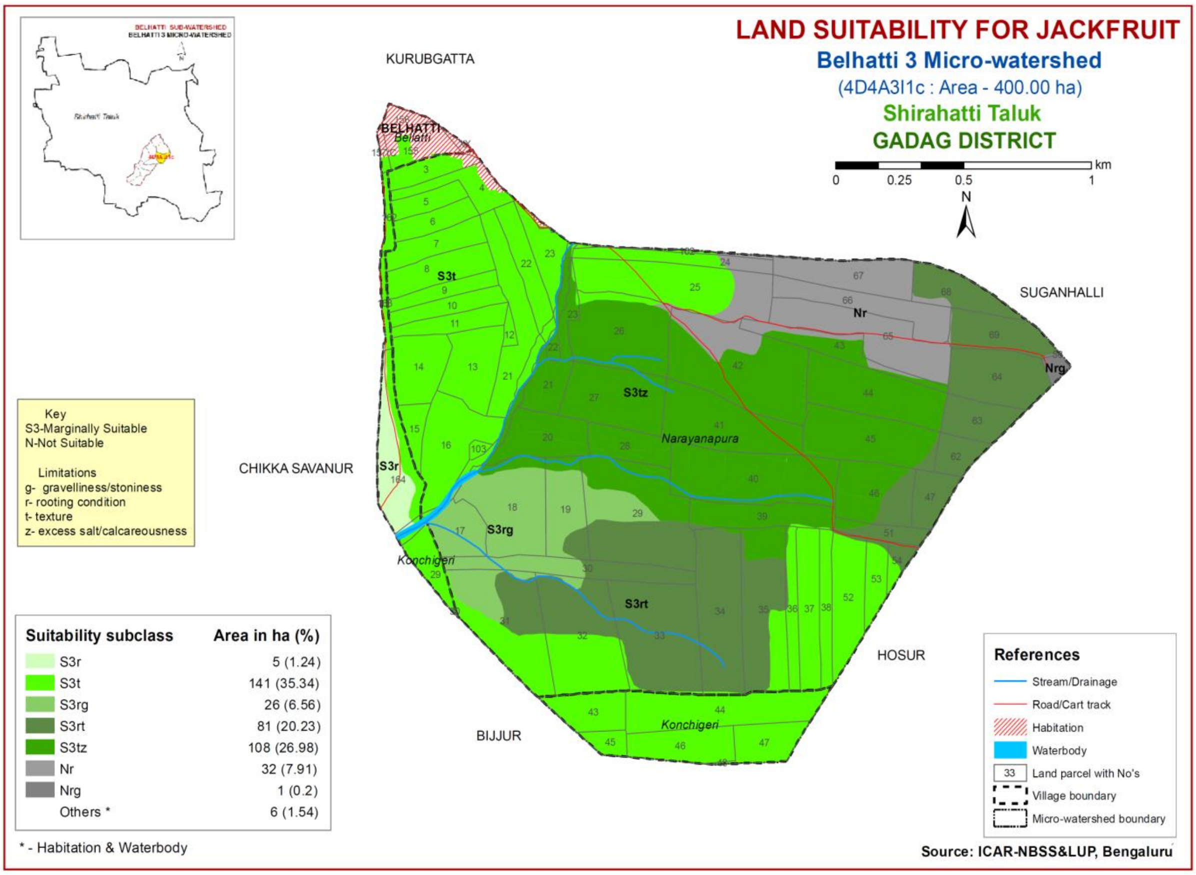


Fig. 7.12 Land Suitability map of Jackfruit

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).

An area of about 97 ha (24%) has soils that are moderately suitable (class S2) with moderate limitations of texture. They are distributed in the western and southern part of the microwatershed.

The marginally suitable (class S3) lands cover a maximum area of about 265 ha (66%) and occur in all parts of the microwatershed. They have severe limitations of gravelliness, texture, rooting depth and calcareousness.

A small area of about 33 ha (8%) is not suitable for growing jamun in the microwatershed and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

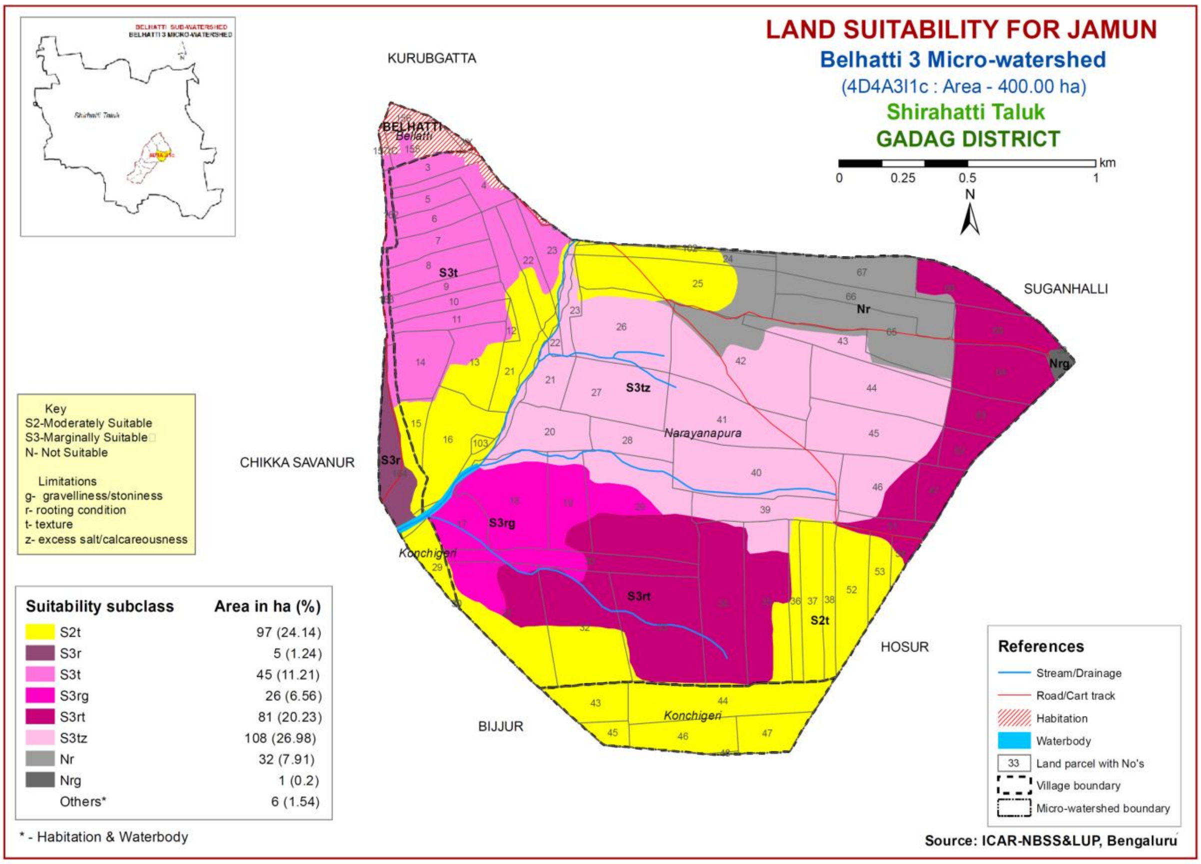


Fig. 7.13Land Suitability map of Jamun

7.14Land Suitability for Musambi (*Citrus limetta*)

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

An area of about 141 ha (35%) in the microwatershed has soils that are highly suitable (class S1) for growing musambi crop. They are distributed mainly in the northwestern and southern part of the microwatershed. They have minor or no limitations for growing musambi. About 144 ha (36%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth and calcareousness. They are distributed inthe central and eastern part of the microwatershed.

The marginally suitable (class S3) lands cover about 76 ha (19%) and occur in the central part of the microwatershed. They have severe limitations of gravelliness and rooting depth.

A small area of about 33 ha (8%) is not suitable for growing musambi and occur in the northeastern and northern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

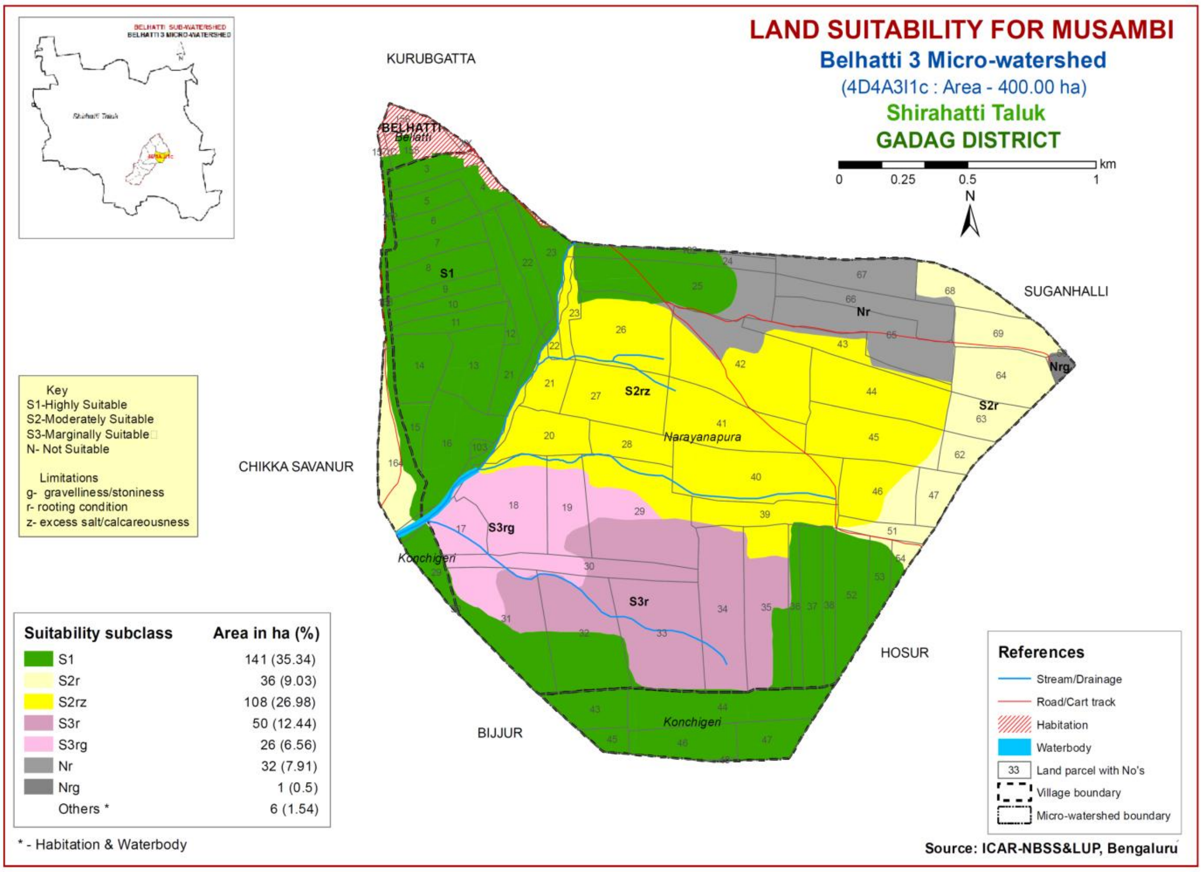


Fig. 7.14 Land Suitability map of Musambi

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).

An area of about 141 ha (35%) in the microwatershed has soils that are highly suitable (class S1) for growing lime. They are distributed mainly in the northwestern and southern part of the microwatershed. They have minor or no limitations for growing lime. About 144 ha (36%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth and calcareousness. They are distributed in the central and eastern part of the microwatershed.

The marginally suitable (class S3) lands cover about 76 ha (19%) and occur in the central part of the microwatershed. They have severe limitations of gravelliness and rooting depth.

A small area of about 33 ha (8%) is not suitable for growing lime and occur in the northeastern and northern 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	^0C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C(>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

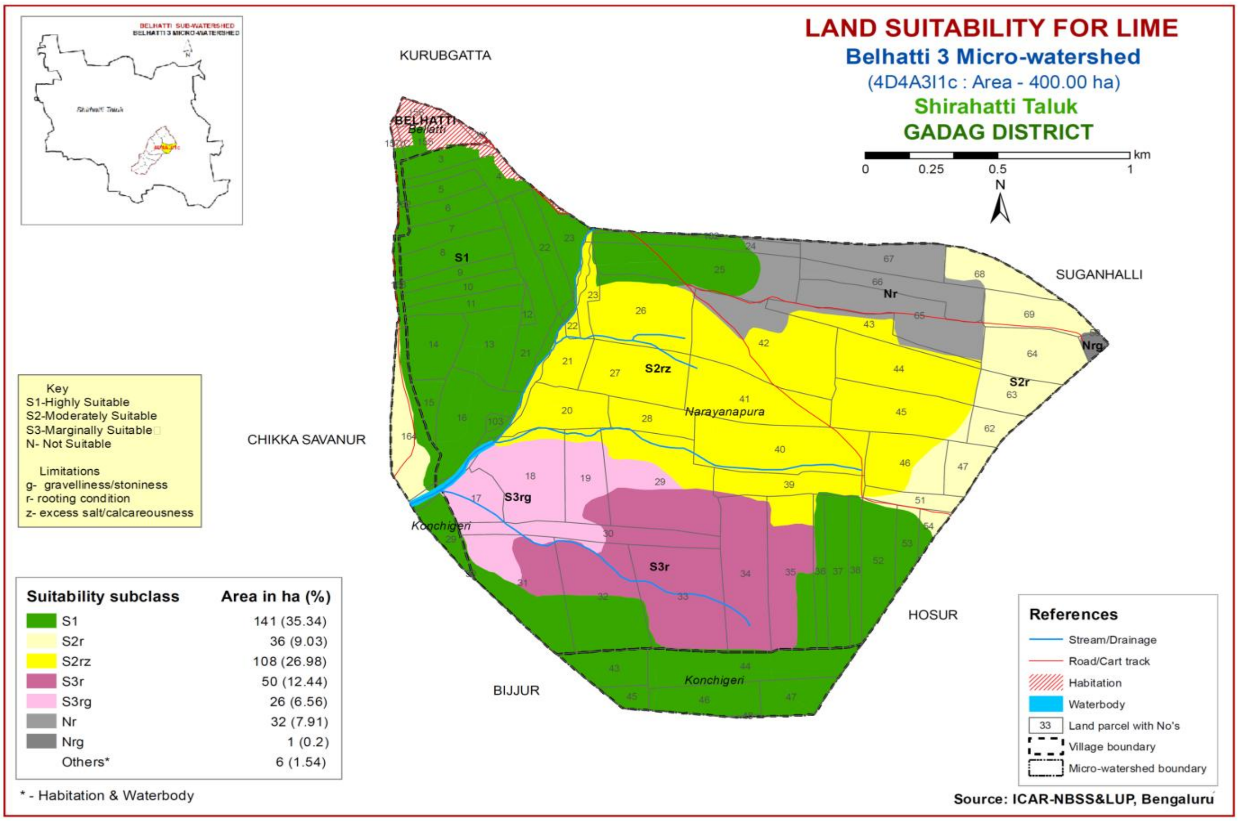


Fig. 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important 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 5 ha (1%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth and texture. They are distributed in the western part of the microwatershed.

The marginally suitable (class S3) lands cover about 128 ha (32%) area and occur in the northern and western part of the microwatershed. They have severe limitations of gravelliness, calcareousness and texture.

A major area of about 261 ha (65%) 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.

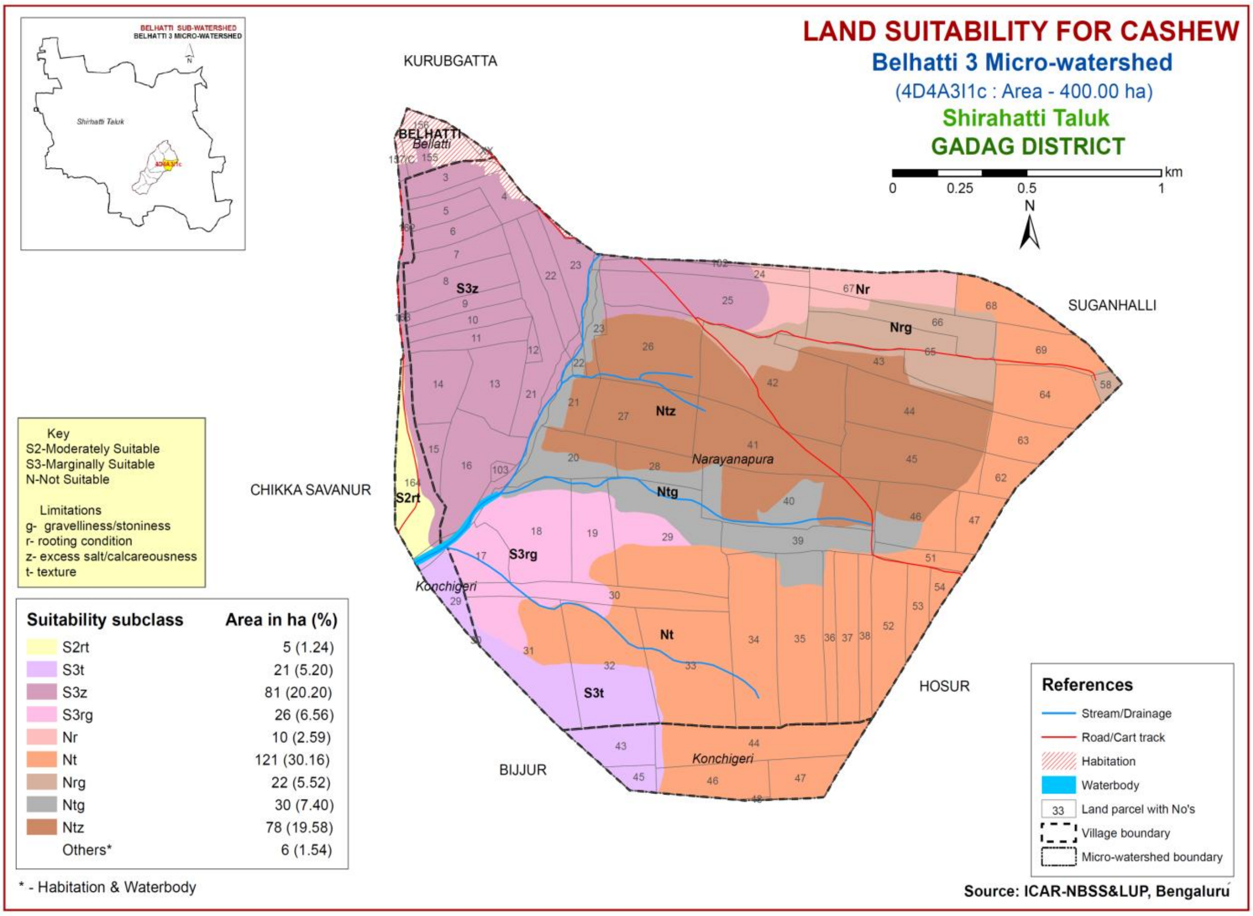


Fig. 7.16 Land Suitability map of Cashew

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

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

An area of about 171 ha (43%) in the microwatershed has soils that are highly suitable (class S1) for growing custard apple. They are distributed mainly in the northwestern, eastern and southern part of the microwatershed. They have minor or no limitations for growing custard apple.

About 165 ha (41%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth, gravelliness and calcareousness. They are distributed in the central part of the microwatershed.

The marginally suitable (class S3) lands cover about 58 ha (14%) area and occur in central and northeastern part of the microwatershed. They have severe limitations of gravelliness and rooting depth.

A small area of about one ha is not suitable for growing custard apple in the microwatershed and occurs in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

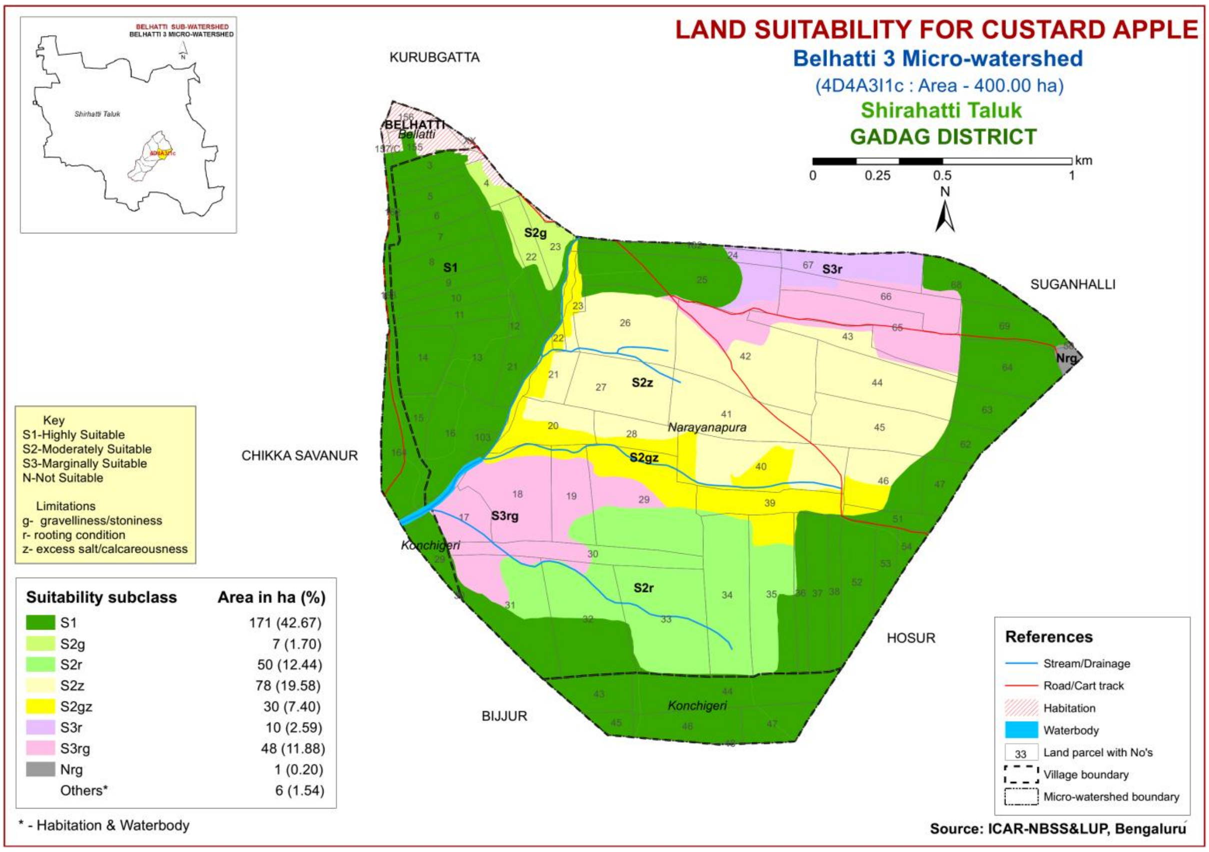


Fig. 7.17 Land Suitability map of Custard Apple

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).

An area of about 114 ha (28%) in the microwatershed has soils that are highly suitable (class S1) for growing amla. They are distributed mainly in the northwestern, eastern and southern part of the microwatershed. They have minor or no limitations for growing amla. Maximum area of about 247 ha (62%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth, gravelliness and calcareousness. They are distributed in the central part of the microwatershed.

The marginally suitable (class S3) lands cover about 31 ha (8%) area in the microwatershed and occur in the northeastern part of the microwatershed. They have severe limitations of gravelliness and rooting depth.

A small area of about one ha is not suitable for growing amla in the microwatershed and occurs in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

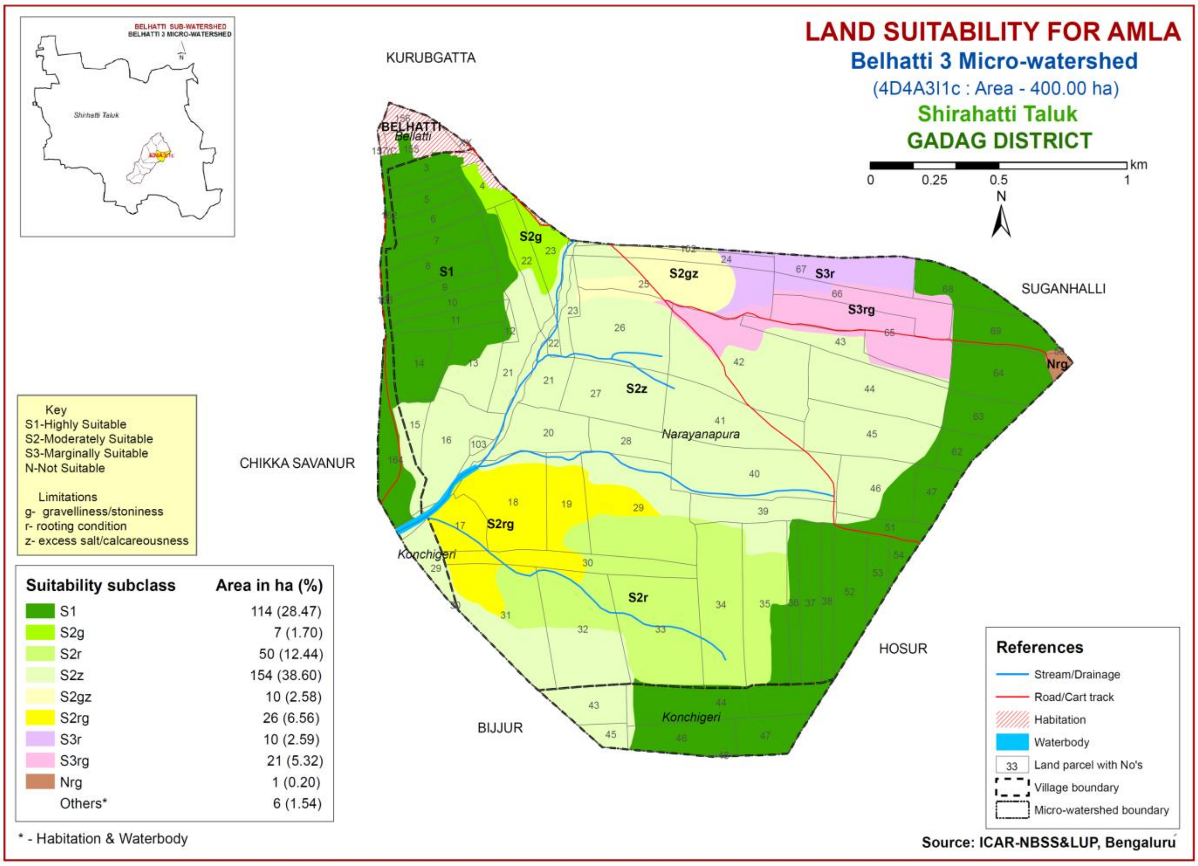


Fig. 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

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

Major area of about 141 ha (35%) has soils that are moderately suitable (class S2) with moderate limitations of texture. They are distributed in the northeastern and southern part of the microwatershed. The marginally suitable (class S3) lands cover about 144 ha (36%) area and occur in the central and northeastern part of the microwatershed. They have severe limitations of calcareousness, rooting depth and texture. About 108 ha (27%) is not suitable for growing tamarind and occur in the northeastern and central part of the microwatershed. They have very severe limitations of rooting depth.

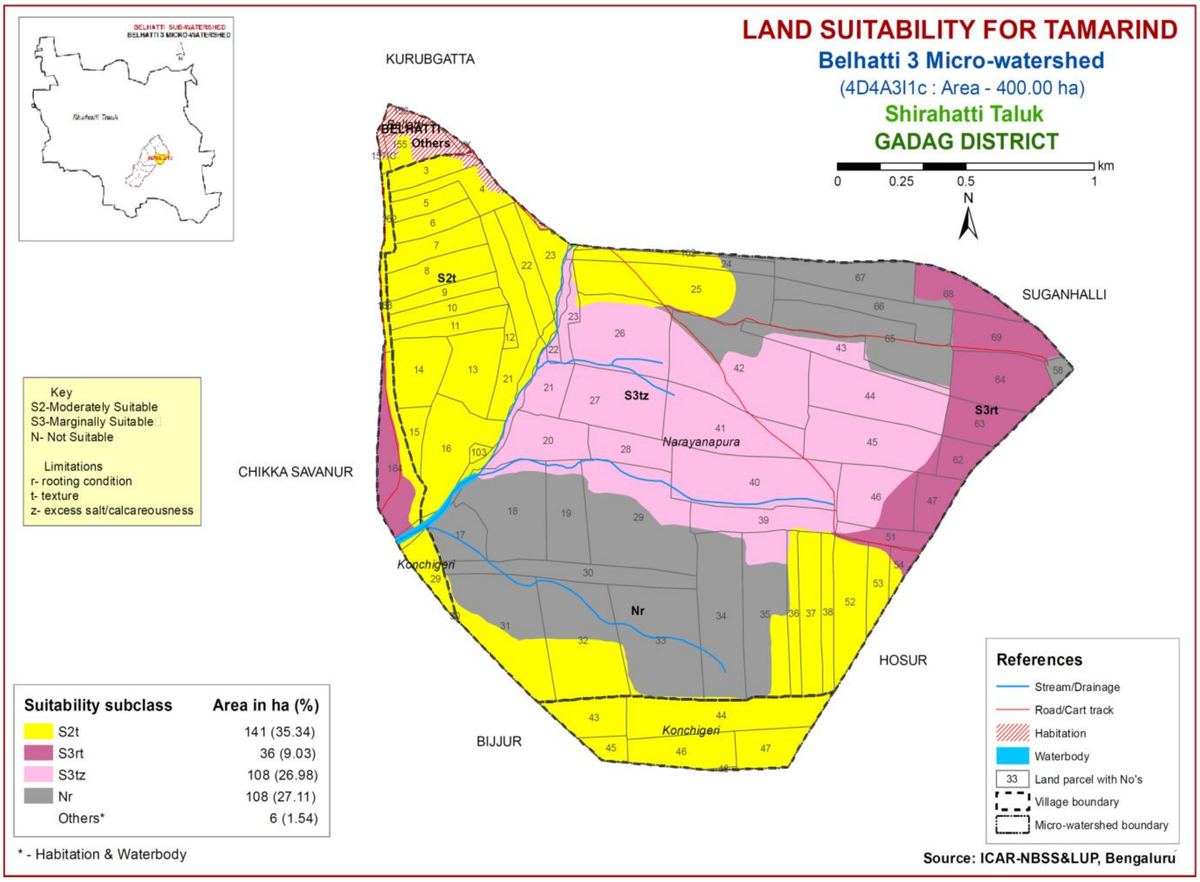


Fig. 7.19 Land Suitability map of Tamarind

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 five ha (1%) in the microwatershed has soils that are highly suitable (class S1) for growing marigold crop. They are distributed mainly in the western part of the microwatershed. They have minor or no limitations for growing marigold. Major area of about 346 ha (87%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, texture and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 42 ha (10%) area in the microwatershed and occur in the northern and northeastern part of the microwatershed. They have severe limitations of calcareousness and texture. A small area of about one ha (<1%) is not suitable for growing marigold in the microwatershed and occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

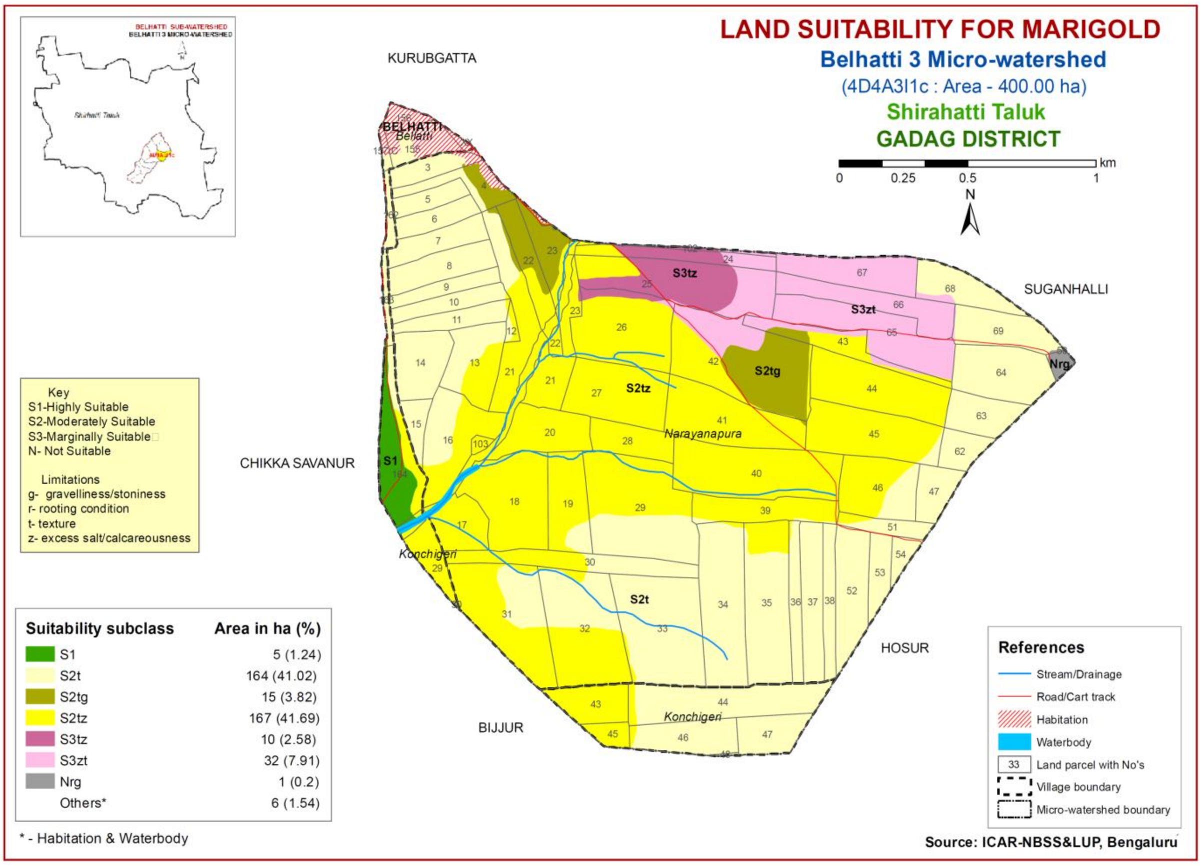


Fig. 7.20 Land Suitability map of Marigold

7.21 Land Suitability for Chrysanthemum (*Chrysanthemum indicum*)

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

A small area of about five ha (1%) in the microwatershed has soils that are highly suitable (class S1) for growing chrysanthemum crop. They are distributed mainly in thewestern part of the microwatershed. They have minor or no limitations for growing chrysanthemum. Major area of about 346 ha (87%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, texture and calcareousness. They are distributed in all parts of the microwatershed.

The marginally suitable (class S3) lands cover about 42 ha (10%) area in the microwatershed and occur in the northern and northeastern part of the microwatershed. They have severe limitations of calcareousness and texture. A very small area of about one ha (<1%) is not suitable for growing chrysanthemum in the microwatershed and occur in the northeastern part of the microwatershed. They have very severe limitations of gravelliness and rooting depth.

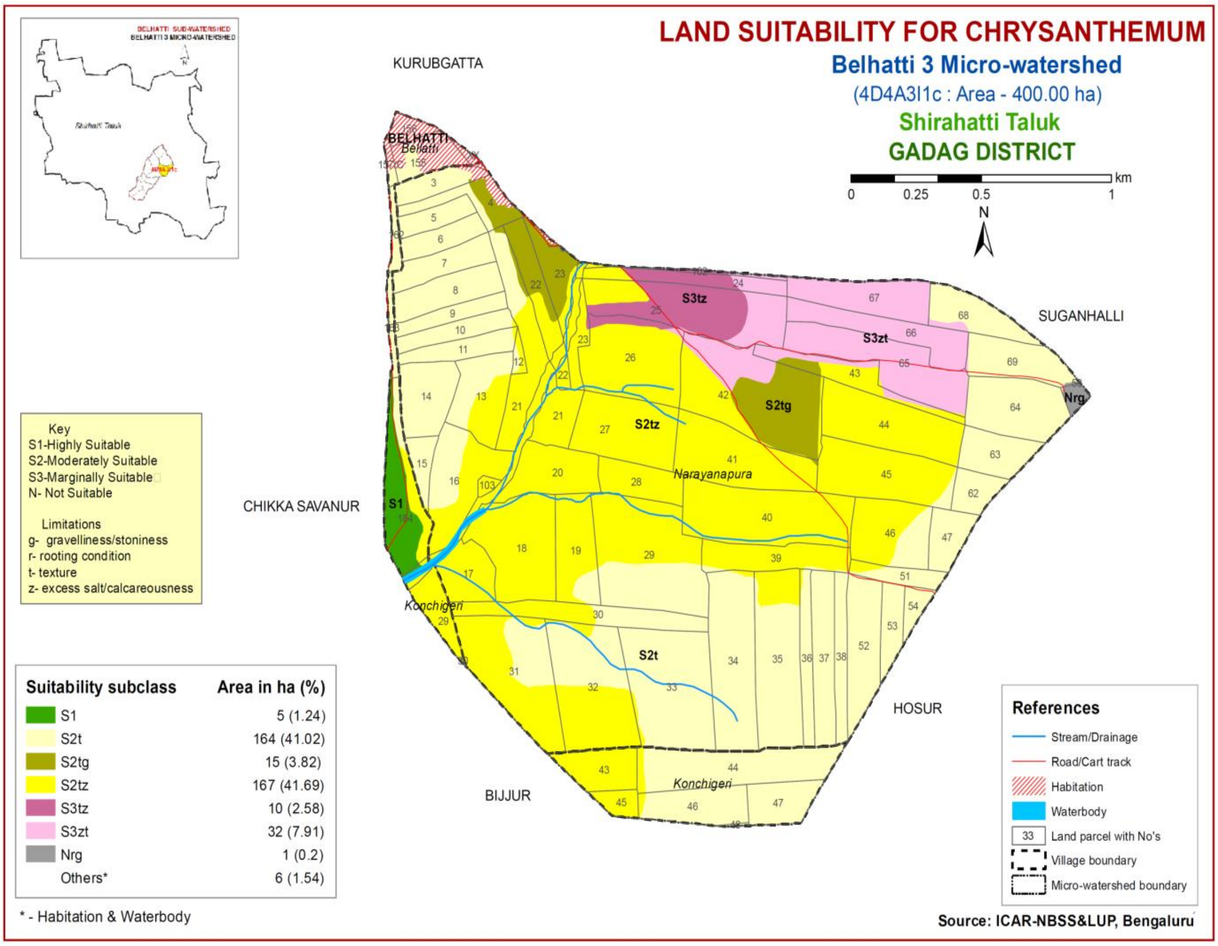


Fig. 7.21 Land Suitability map of Chrysanthemum

7.22 Land Management Units (LMUs)

The 20 soil map units identified in Belhatti-3 microwatershed have been regrouped into 6 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 6 land management units along with brief description of soil and site characteristics are given below.

LMUs	Soil Map units	Soil and Site characteristics
1	BGPmB1, BGPmB1g1, BGPmB3g2	Very deep, clay soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and slight to severe erosion
2	JDGhA1g1, JDGhB2g2, JDGiB1g1, LGDmB1g1MPTmA1g1, MPTmB1	Deep, cracking clay soils with slopes of <1-3%, gravelly (15-60%) and slight to moderate erosion
3	RNKmB2g2, ATTmB2g1, JLGmB1, VRVmA2g1, VRVmB1g1, VRVmB2g1, VRVmB3g2	Moderately shallow to moderately deep, clay soils with slopes of <1-3%, gravelly to very gravelly (<15-60%) and slight to severe erosion
4	CKMhA1g1	Moderately deep, sandy clay soils with slopes of 0-1%, gravelly (15-35%) and slight erosion
5	MTLmB2g1, MTLmB3g2	Shallow, clayey soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and moderate to severe erosion
6	DDRhD3g2R3St1	Very shallow, gravelly clay soils with slopes of 5-10%, very gravelly (35-60%) and severe erosion

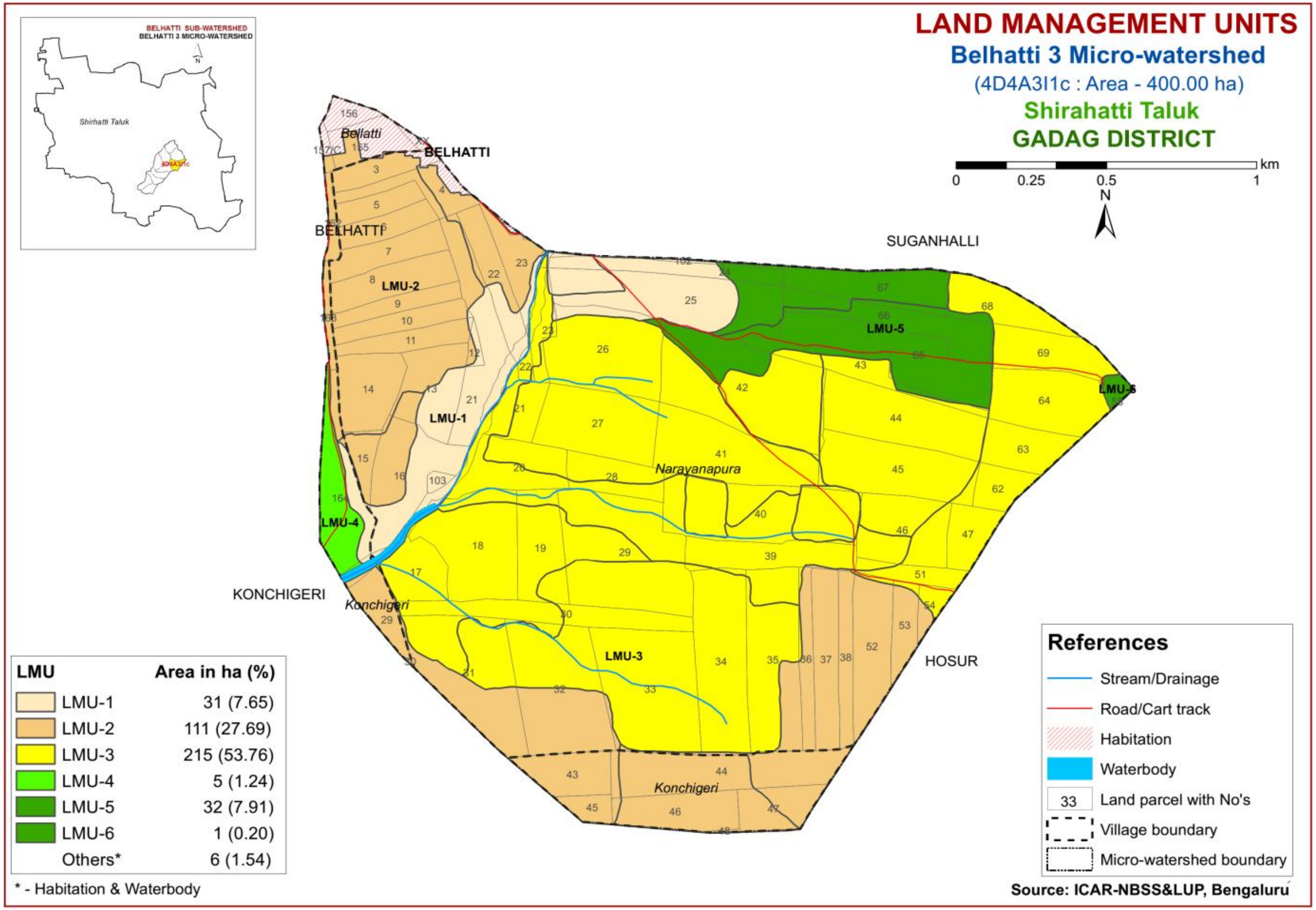


Fig. 7.22 Land Management Units map- Belhatti-3 microwatershed

7.23 Proposed Crop Plan for Belhatti-3 microwatershed

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

Table 7.14Proposed Crop Plan for Belhatt-3 microwatershed

LMUs No	Mapping Units	Survey Number	Field Crops/Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Recommended Interventions
LMU1	9, 10, 11 (>150 cm)	Narayanapura: 12,13,16,21,24,25,102,103	Redgram, Sorghum, Bajra, Cotton, Safflower, Bengal gram **Multiple/crop rotation:** Redgram+Fodder, Sorghum, Pulses-Sorghum	**Vegetables**: Green Chillies, Bhendi, Drumstick, Onion **Flower crops:** Marigold, Gaillardia, Aster **Fruit crops:** Banana, lime, pomegranate	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Musambi, Pomegranate **Vegetables**: Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LMU 2	5, 6, 7, 8, 19 ,20 (100-150 cm)	Belahatti: 162,163 Konchigeri: 29,30,43,44,45, 46,47,48 Narayanapura: 3,4,5,6,7,8,9,10,11,14,15,22, 23, 31,32,36,37,38, 52,53	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, Musambi, Pomegranate **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, suitable conservation practises

LMU 3	3, 13, 14, 15, 16, 17, 18 (50-100 cm)	Narayanapura: 17,18,19,20,26,27,28,29,30,33, 34,35,39,40,41,42,43,44,45,46, 47,51,54,62,63, 64,68, 69	**Sole Crop:** Sorghum, Bajra, Sunflower, Cotton, Safflower **Multiple/Crop rotation:** Redgram+Maize, Redgram+Fodder jowar, Pulses-Sorghum	**Vegetables:**Chillies, Tomato, Bhendi, Onion, Cabbage, Drumstick **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Moosambi, Pomegranate	**Flower Crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial Components:** Tamarind, Custard Apple, Amla, Lime, Musambi, Pomegranate **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, suitable conservation practices
LMU 4	4 (75-100 cm)	Belhatti: 164	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 +Cury 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 practices
LMU 5	1, 2 (25-50 cm)	Narayanapura: 65,66,67	Bengal gram, Cowpea, Green gram	**Vegetables:** Chillies, Tomato	Bear, Fig, Aonla, Pomelo	Drip irrigation, Mulching, suitable conservation practices
LMU 6	12 (<25 cm)	Narayanapura: 58	Anjan Grass, Marvel Grass, Styloxanthes hamata	-	-	Mulching, suitable conservation practices

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-3 microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of VRV (108 ha), ATT (50 ha), JDG (50 ha), MPT (40 ha), MTL (32 ha), JLG (31 ha), BGP (31 ha), LGD (21 ha), RNK (26 ha),CKM (5 ha) and DDR (1 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) soil occupy about 177 ha (44%) followed by strongly alkaline (pH 8.4-9.0) 167 ha (42%) and about 49 ha (12%) is

moderately alkaline (pH 7.8-8.4). Thus, soils of the entire microwatershed are alkaline in reaction.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (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 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-3microwatershed.

- **Organic Carbon:** In about 390 ha (97%) area, the OC content is medium (0.5-0.75%) and in about 4 ha (1%) area it is high (>0.75%). The areas that are medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 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 382 ha area (95%), the available phosphorus is low. Hence for all the crops, 25% additional P-needs to be applied.

- **Available Potassium:** Available potassium is medium in 346ha (86%) area of the microwatershed. Hence, in all these plots, for all crops, additional 25 % potassium can be applied. It is low in 5 ha (1%) area of the microwatershed. For these areas also, 25 % extra K needs to be applied.

- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 84 ha (21%) 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.

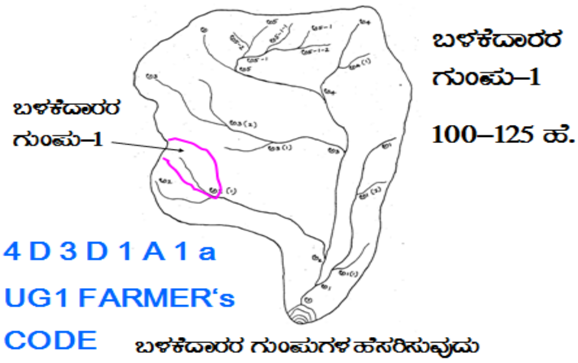
- **Available Zinc:** It is deficient in 276 ha (69%) area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied.

- **Soil alkalinity:** The soils of the entire microwatershed area 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 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-3 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were



- ➢ Soil depth
- ➢ Surface soil texture
- ➢ 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, cutup/ 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

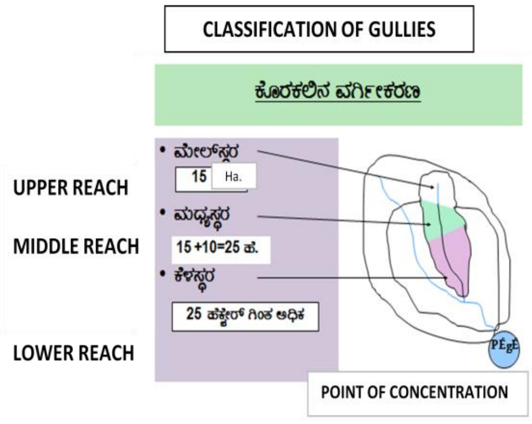
- ➢ Identification of arable and non arable lands
- ➢ Identification of drainage lines and gullies
- ➢ Identification of non treatable areas
- ➢ Identification of priority areas in the arable lands
- ➢ Treatment plan for arable lands
- ➢ Location of water harvesting and recharge structures

9.1Treatment Plan

The treatment plan recommended for arable lands is briefly described below

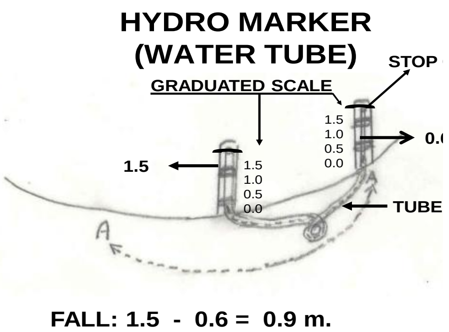
9.1.1 Arable Land Treatment

A. BUNDING

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

</td></tr>
<tr><td colspan="2">Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale
Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cutups/ terraces are marked on the cadastral map to the scale
Drainage lines are demarcated into</td></tr>
<tr><td>Small gullies</td><td>(up to 5 ha catchment)</td></tr>
<tr><td>Medium gullies</td><td>(5-15 ha catchment)</td></tr>
<tr><td>Ravines</td><td>(15-25 ha catchment) and</td></tr>
<tr><td>Halla/Nala</td><td>(more than 25ha catchment)</td></tr>
</table>

Measurement of Land Slope

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



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

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

Note:(i) The above intervals are maximum.

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

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

Section of the Bund

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

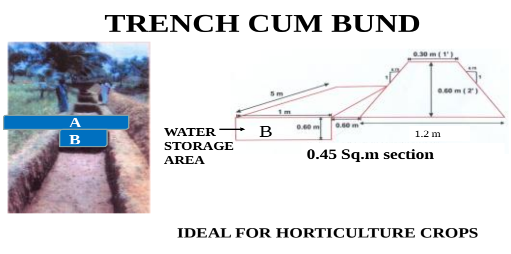
Recommended Bund Section

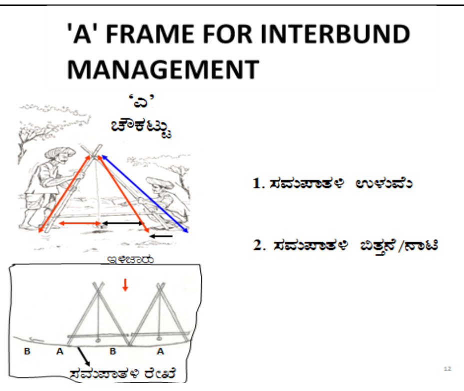
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soil	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below





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

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

B. Water ways

a) Existing waterways are marked on the cadastral map (1:7920scale) 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

Water ways 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.

9.1.3Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of drainage lines (gullies/ nalas/ hallas) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.
b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.
c) Considering the Catchment, Nala bed and bank conditions, suitable structures are decided.
d) Number of storage structures (Check dam/ Nala bund/ Percolation tank) will be decided considering the commitments and available runoff 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 348 ha (87%) area needs graded bunds and minor area of about one ha (<1%) requires trench cum bunding. About 45ha (11%) area requires bunding/ strengthening of existing bunds.

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

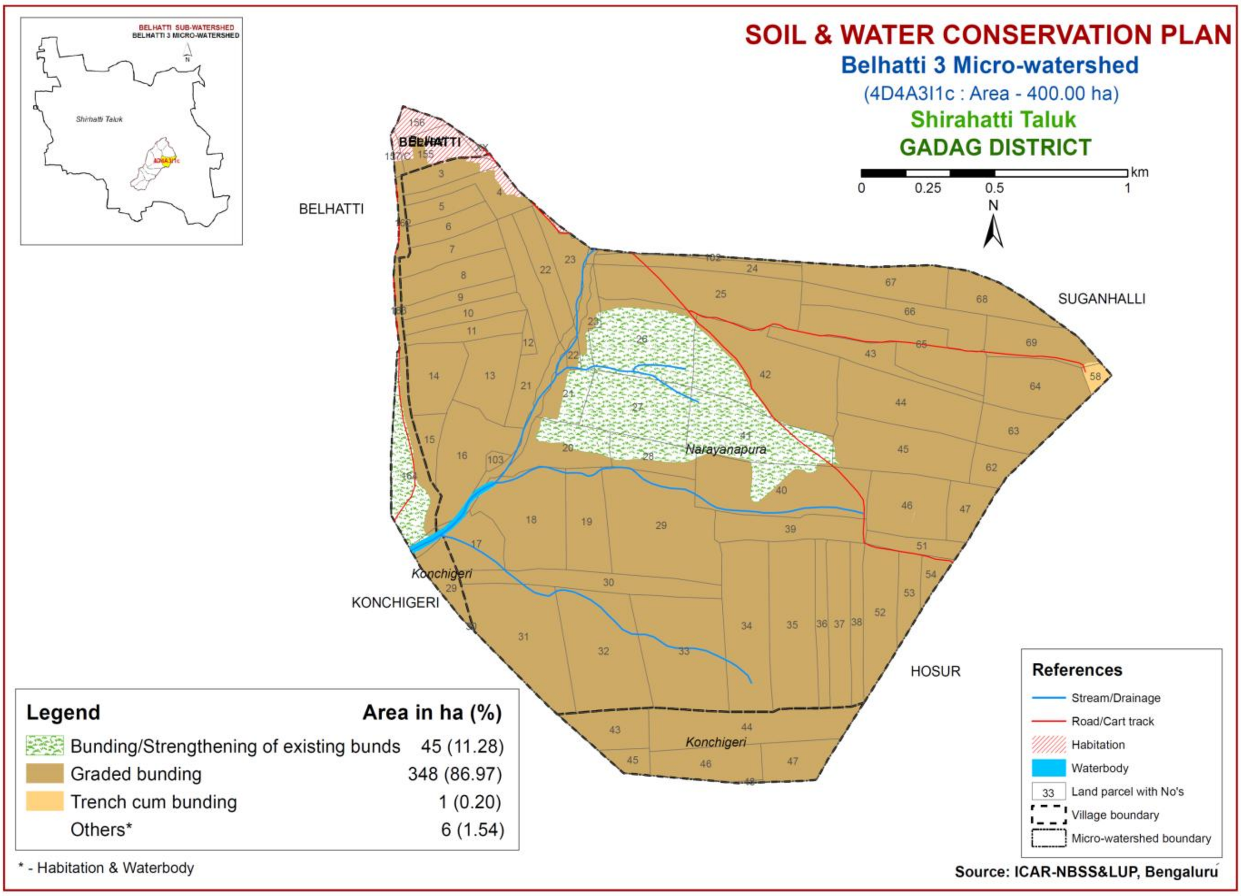


Fig. 9.1 Soil and Water Conservation Plan map of Belhatti-3 watershed

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

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

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

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Appendix - 1

Belhatti - 3 Micro-watershed														
Soil Site and Thematic Information														
Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservation Plan
Belhatti	154/B	0.0	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	No	Others	Others
Belhatti	155	3.14	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	No	Others	Others
Belhatti	156	1.28	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	No	Others	Others
Belhatti	157/C	0.47	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	No	Others	Others
Belhatti	162	0.94	JDGhA1g1	LMU-2	Deep (100-150 cm)	Sandy clay loam	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly level (0-1%)	Slight	NA	No	IIes	Graded bunding
Belhatti	163	0.88	JDGhA1g1	LMU-2	Deep (100-150 cm)	Sandy clay loam	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly level (0-1%)	Slight	NA	No	IIes	Graded bunding
Belhatti	164	7.08	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+Greengram +Cotton+Sugarcane(Mz+Gg+Ct+Sc)	No	IIes	Bunding/ strentheningof existing bunds
Belhatti	Stream	0.29	Waterbody	Others	Others	Others	Others	Others	Others	Others	Waterbody	No	Others	Others
Belhatti	XX	0.0	Habitation	Others	Others	Others	Others	Others	Others	Others	NA	No	Others	Others
Konchi-geri	29	2.6	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	V. gently sloping (1-3%)	Slight	Maize(Mz)	Bore well	IIes	Graded bunding
Konchi-geri	30	0.02	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	V. gently sloping (1-3%)	Slight	NA	No	IIes	Graded bunding
Konchi-geri	43	3.9	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	V. gently sloping (1-3%)	Slight	Maize+Green gram (Mz+Gg)	No	IIes	Graded bunding
Konchi-geri	44	9.76	MPTmA1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly sloping (0-1%)	Slight	Maize+Greengram +Cotton (Mz+Gg+Ct)	No	IIes	Graded bunding
Konchi-geri	45	1.36	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	V. gently sloping (1-3%)	Slight	Maize(Mz)	No	IIes	Graded bunding
Konchi-geri	46	4.93	MPTmA1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly sloping (0-1%)	Slight	Maize+Green gram (Mz+Gg)	Bore well	IIes	Graded bunding

Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservati on Plan
Konchi-geri	47	3.64	MPTmA1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly sloping (0-1%)	Slight	Maize+Greengram +Onion (Mz+Gg+On)	No	IIes	Graded bunding
Konchi-geri	48	.08	MPTmA1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	Nearly sloping (0-1%)	Slight	NA	Open well	IIes	Graded bunding
Konchi-geri	STREAM	0.33	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	V. High (>200 mm/m)	V. gently sloping (1-3%)	Slight	Waterbody	No	IIes	Graded bunding
Narayana-pura	3	2.55	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Cotton(Mz+Ct)	No	IIes	Graded bunding
Narayana-pura	4	3.34	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Cotton+Chilli+Mulberry(Ct+Ch+Mu)	No	IIes	Graded bunding
Narayana-pura	5	2.19	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Moong Dal(Mz+Mdl)	No	IIes	Graded bunding
Narayana-pura	6	2.65	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Cotton(Mz+Ct)	No	IIes	Graded bunding
Narayana-pura	7	3.59	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Greengram+Cotton(Gg+Ct)	No	IIes	Graded bunding
Narayana-pura	8	4.52	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Groundnut (Mz+Gn)	No	IIes	Graded bunding
Narayana-pura	9	2.42	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Greengram+Groundnut+Cotton(Gg+Gn+Ct)	No	IIes	Graded bunding
Narayana-pura	10	2.9	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Greengram (Mz+Gg)	No	IIes	Graded bunding
Narayana-pura	11	2.94	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	Gravelly (15-35%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Greengram+Cotton(Gg+Ct)	No	IIes	Graded bunding
Narayana-pura	12	0.56	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Chilli(Ct+Ch)	No	IIes	Graded bunding
Narayana-pura	13	5.81	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Cotton+Fallow land(Gg+Ct+Fl)	No	IIes	Graded bunding
Narayana-pura	14	5.06	JDGhA1g1	LMU-2	Deep(100-150cm)	Sandy clay loam	V. gravelly (35-60%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Maize+Groundnut+Greengram(Mz+Gn+Gg)	Borewell	IIes	Graded bunding

Village	Survey No.	Total Area (ha)	Soil phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capability	Conservation Plan
Narayana-pura	15	1.72	JDGiB1g1	LMU-2	Deep(100-150cm)	Sandy loam	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton(Ct)	No	IIes	Graded bunding
Narayana-pura	16	7.74	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram+Cotton+Groundnut(Mz+Gg+Ct+Gn)	No	IIes	Graded bunding
Narayana-pura	17	3.84	RNKmB2g2	LMU-3	Moderatelyshallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize(Mz)	No	IIIes	Graded bunding
Narayana-pura	18	10.01	RNKmB2g2	LMU-3	Moderatelyshallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton(Ct)	No	IIIes	Graded bunding
Narayana-pura	19	5.85	RNKmB2g2	LMU-3	Moderatelyshallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram+Mulberry(Gg+Mu)	No	IIIes	Graded bunding
Narayana-pura	20	5.47	VRVmB3g2	LMU-3	Moderately Deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Greengram+Cotton (Gg+Ct)	No	IVes	Graded bunding
Narayana-pura	21	9.74	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Sugarcane+Cotton(Mz+Sc+Ct)	No	IIes	Graded bunding
Narayana-pura	22	4.22	JDGhB2g2	LMU-2	Deep(100-150cm)	Sandy clay loam	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Chilli(Ct+Ch)	No	IIIes	Graded bunding
Narayana-pura	23	4.77	JDGhB2g2	LMU-2	Deep(100-150cm)	Sandy clay loam	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton(Mz+Ct)	No	IIIes	Graded bunding
Narayana-pura	24	3.62	BGPmB3g2	LMU-1	V. Deep (>150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Severe	Cotton+Fallowland+Eucalyptus(Ct+Fl+Eu)	No	IVes	Graded bunding
Narayana-pura	25	12.12	BGPmB3g2	LMU-1	V. Deep (>150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Horsegram+Sorghum(Mz+Hg+Sg)	No	IVes	Graded bunding
Narayana-pura	26	10.36	VRVmA2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Moderate	Maize+Greengram+Cotton(Mz+Gg+Ct)	No	IIIe	Bunding/Strengthening of existing bunds

Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservati on Plan
Narayana-pura	27	8.48	VRVmA2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Moderate	Maize+Greengram+ Cotton(Mz+Gg+Ct)	No	IIIe	BUNDING /Strengthe ning of existing bunds
Narayana-pura	28	3.79	VRVmA2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Moderate	Cotton(Ct)	No	IIIe	BUNDING /Strengthe ning of existing bunds
Narayana-pura	29	15.11	ATTmB2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Greengram+ Cotton(Mz+Gg+Ct)	Borew ell	IIIe	Graded bunding
Narayana-pura	30	6.04	RNKmB2g2	LMU-3	Moderately Deep (75-100 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Gro undnut(Mz+Ct+Gn)	Open well	IIIes	Graded bunding
Narayana-pura	31	12.07	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram+ Cotton+Chilli(Mz+ Gg+Ct+Ch)	Borew ell	IIes	Graded bunding
Narayana-pura	32	12.44	LGDmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton(Mz+ Ct)	Borew ell	IIes	Graded bunding
Narayana-pura	33	13.04	ATTmB2g1	LMU-3	Moderatelysh allow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Greengram+ Cotton(Mz+Gg+Ct)	No	IIIe	Graded bunding
Narayana-pura	34	10.74	ATTmB2g1	LMU-3	Moderatelysh allow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton+Gre engram(Mz+Ct+Gg)	No	IIIe	Graded bunding
Narayana-pura	35	10.81	ATTmB2g1	LMU-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton(Mz+ Ct)	No	IIIe	Graded bunding
Narayana-pura	36	2.78	MPTmB1	LMU-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram(Mz+Gg)	No	IIe	Graded bunding
Narayana-pura	37	5.15	MPTmB1	LMU-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize(Mz)	No	IIe	Graded bunding
Narayana-pura	38	2.84	MPTmB1	LMU-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize(Mz)	No	IIe	Graded bunding

Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservation Plan
Narayana-pura	39	5.26	VRVmB3g2	LMU-3	Moderately Deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Maize+Greengram (Mz+Gg)	No	IVes	Graded bunding
Narayana-pura	40	12.43	VRVmB1g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Fallowland +Greengram+Groundnut(Mz+Fl+Gg +Gn)	No	IIes	Graded bunding
Narayana-pura	41	9.58	VRVmA2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Moderate	Maize+Fallow land(Mz+Fl)	No	IIIe	BUNDING/Strengthening of existing bunds
Narayana-pura	42	15.78	VRVmB2g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram+Cotton+Fallow land(Gg+Ct+Fl)	Borewell	IIIe	Graded bunding
Narayana-pura	43	4.27	VRVmB1g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram (Mz+Gg)	No	IIes	Graded bunding
Narayana-pura	44	9.37	VRVmB1g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Greengram+Horsegram(Mz+Ct+Gg+Hg)	No	IIes	Graded bunding
Narayana-pura	45	9.14	VRVmB1g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Cotton(Gg+Ct)	No	IIes	Graded bunding
Narayana-pura	46	6.8	VRVmB1g1	LMU-3	Moderately Deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Groundnut+Cotton+Horsegram(Gg+Gn+Ct+Hg)	No	IIes	Graded bunding
Narayana-pura	47	2.9	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton(Mz+Ct)	No	IIes	Graded bunding
Narayana-pura	51	2.09	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Chilli(Gg+Ch)	No	IIes	Graded bunding
Narayana-pura	52	6.14	MPTmB1	LMU-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram +Onion(Mz+Gg+On)	No	IIe	Graded bunding

Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservati on Plan
Narayana-pura	53	2.46	MPTmB1	LMU-2	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Greengram(Gg)	No	IIe	Graded bunding
Narayana-pura	54	1.28	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Greengram +Cotton(Mz+Gg+Ct)	No	IIes	Graded bunding
Narayana-pura	58	0.74	DDRhD3g2 R3St1	LMU-6	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Vegetation(Hill)	No	IVes	Trench cum bunding
Narayana-pura	62	2.33	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize(Mz)	No	IIes	Graded bunding
Narayana-pura	63	3.9	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Onion(Mz+On)	No	IIes	Graded bunding
Narayana-pura	64	7.25	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Maize+Cotton+Groundnut(Mz+Ct+Gn)	No	IIes	Graded bunding
Narayana-pura	65	9.62	MTLmB3g2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Fallow land(Fl)	No	IVes	Graded bunding
Narayana-pura	66	5.88	MTLmB3g2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Severe	Cotton+Fallowland +Horsegram(Ct+Fl +Hg)	No	IVes	Graded bunding
Narayana-pura	67	6.09	MTLmB2g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram+Cotton(Gg+Ct)	Open well	IIIes	Graded bunding
Narayana-pura	68	4.55	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Groundnut+Cotton(Gg+Gn+Ct)	No	IIes	Graded bunding
Narayana-pura	69	5.09	JLGmB1	LMU-3	Moderately Deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Cotton+Fallow land(Gg+Ct+Fl)	No	IIes	Graded bunding
Narayana-pura	102	0.68	BGPmB3g2	LMU-1	V. Deep (>150 cm)	Clay	Very gravelly (35-60%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Severe	Not Available(NA)	No	IVes	Graded bunding

Village	Sur-vey No.	Total Area (ha)	Soil phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capabi-lity	Conservati on Plan
Narayana-pura	103	0.42	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton(Ct)	Borew ell	IIes	Graded bunding
Narayana-pura	Sett lem ent	0.12	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	No	Others	Others
Narayana-pura	Stre am	3.34	BGPmB1g1	LMU-1	V. Deep (>150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Waterbody	No	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**
Belhatti	154/B	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	155	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	156	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	157/c	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	162	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23-57kg/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)
Belhatti	163	Moderately 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)	Sufficint (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Belhatti	164	Moderately 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)
Belhatti	STREM	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	XX	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Konchi-geri	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)
Konchi-geri	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)
Konchi-geri	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)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Konchi-geri	44	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Konchi-geri	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)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Konchi-geri	46	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Konchi-geri	47	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Konchi-geri	48	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Konchi-geri	STRE AM	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)
Narayana-pura	3	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)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	4	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)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	5	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)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	6	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)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	7	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)
Narayana-pura	8	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)
Narayana-pura	9	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)
Narayana-pura	10	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)
Narayana-pura	11	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)
Narayana-pura	12	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)
Narayana-pura	13	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)

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
Narayana-pura	14	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)
Narayana-pura	15	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)
Narayana-pura	16	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)
Narayana-pura	17	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	18	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	19	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	20	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	21	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)
Narayana-pura	22	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)
Narayana-pura	23	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)
Narayana-pura	24	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	25	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>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
Narayana-pura	26	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	27	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	28	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	29	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	30	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	31	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	32	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	33	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	34	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	35	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	36	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	37	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Narayana-pura	38	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	39	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	40	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	41	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	42	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	43	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	44	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	45	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	46	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	47	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	51	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	52	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)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Narayana-pura	53	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10–20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Narayana-pura	54	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10–20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	58	Moderately alkaline (pH 7.8–8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	High (>337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	62	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	63	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	64	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	65	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	66	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	67	Very strongly alkaline (pH >9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	68	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	69	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Medium (10–20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	102	Strongly alkaline (pH 8.4–9.0)	Non saline (<2 dsm)	Medium (0.5–0.75 %)	Low (<23 kg/ha)	Medium (145–337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Narayana-pura	103	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)

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
Narayana-pura	Sattle ment	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Narayana-pura	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)

Appendix – III

Soil Suitability Information

Village	Survey No.	Sorghum	Maize	Bengal-gram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard Apple	Amla	Tamarind	Marigold	Chrysanthemum
Belhatti	154/B	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	155	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	156	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	157/c	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	162	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Belhatti	163	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Belhatti	164	S1	S1	S2t	S2t	S1	S1	S2r	S1	S3r	S2rt	S2rt	S3r	S3r	S2r	S2r	S2rt	S1	S1	S3rt	S1	S1
Belhatti	STREAM	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Belhatti	XX	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Konchigeri	29	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Konchigeri	30	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Konchigeri	43	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Konchigeri	44	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S1	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Konchigeri	45	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz

Village	Survey No.	Sorg-hum	Maize	Bengal -gram	Ground-nut	Sun-flower	Cotton	Banana	Pomeg -ranate	Mango	Sapota	Guava	Jack-fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tama -rind	Mari-gold	Chry sant hem um
Konchi-geri	46	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S1	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Konchi-geri	47	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S1	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Konchi-geri	48	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S1	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Konchi-geri	STREA M	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	3	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	4	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	5	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	6	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	7	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	8	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	9	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	10	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	11	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	12	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	13	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	14	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S1	S1	S2t	S2t	S2t
Narayana -pura	15	S2r	S3t	S2r	S3t	S1	S2r	S3t	S2t	S3t	S3t	S3t	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2t	S2t
Narayana -pura	16	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	17	S2rg	S3tz	S1	S3tz	S3rg	S2r	S3tz	S3tz	Nr	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S2rg	Nr	S2tz	S2tz

Village	Survey No.	Sorg-hum	Maize	Bengal -gram	Ground-nut	Sun-flower	Cotton	Banana	Pomeg -ranate	Mango	Sapota	Guava	Jack-fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tama -rind	Mari -gold	Chry sant hem um
Narayana -pura	18	S2rg	S3tz	S1	S3tz	S3rg	S2r	S3tz	S3tz	Nr	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S2rg	Nr	S2tz	S2tz
Narayana -pura	19	S2rg	S3tz	S1	S3tz	S3rg	S2r	S3tz	S3tz	Nr	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S2rg	Nr	S2tz	S2tz
Narayana -pura	20	S2zg	S3gt	S3gz	S3tz	S2gz	S2gz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntg	S2gz	S2z	S3tz	S2tz	S2tz
Narayana -pura	21	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	22	S3g	S3tg	S3g	S3tg	S3g	S1	S3tg	S2tg	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S2g	S2g	S2t	S2tg	S2tg
Narayana -pura	23	S3g	S3tg	S3g	S3tg	S3g	S1	S3tg	S2tg	S3t	S3t	S3t	S3t	S3t	S1	S1	S3z	S2g	S2g	S2t	S2tg	S2tg
Narayana -pura	24	S2z	S3tz	S3g	S3tz	S3gz	S3gz	S3tz	S3tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2gz	S2t	S3tz	S3tz
Narayana -pura	25	S2z	S3tz	S3g	S3tz	S3gz	S3gz	S3tz	S3tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2gz	S2t	S3tz	S3tz
Narayana -pura	26	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	27	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	28	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	29	S2r	S3rt	S1	S3t	S3r	S2r	S3rt	S2t	Nr	S3rt	S3r	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S2t	S2t
Narayana -pura	30	S2rg	S3tz	S1	S3tz	S3rg	S2r	S3tz	S3tz	Nr	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg	S2rg	Nr	S2tz	S2tz
Narayana -pura	31	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	32	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3t	S3t	S2t	S1	S1	S3t	S1	S2z	S2t	S2tz	S2tz
Narayana -pura	33	S2r	S3rt	S1	S3t	S3r	S2r	S3rt	S2t	Nr	S3rt	S3r	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S2t	S2t
Narayana -pura	34	S2r	S3rt	S1	S3t	S3r	S2r	S3rt	S2t	Nr	S3rt	S3r	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S2t	S2t
Narayana -pura	35	S2r	S3rt	S1	S3t	S3r	S2r	S3rt	S2t	Nr	S3rt	S3r	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nr	S2t	S2t

Village	Survey No.	Sorg-hum	Maize	Bengal -gram	Ground-nut	Sun-flower	Cotton	Banana	Pomeg -ranate	Mango	Sapota	Guava	Jack-fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tama-rind	Mari -gold	Chry sant hem um
Narayana -pura	36	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3rt	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Narayana -pura	37	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3rt	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Narayana -pura	38	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3rt	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Narayana -pura	39	S2zg	S3gt	S3gz	S3tz	S2gz	S2gz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntg	S2gz	S2z	S3tz	S2tz	S2tz
Narayana -pura	40	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	41	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	42	S3zg	S3tz	S2z	S3tz	S2rz	S2rz	S3gz	S3gz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tg	S2tg
Narayana -pura	43	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	44	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	45	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	46	S2z	S3tz	S2z	S3tz	S2rz	S2rz	S3tz	S2tz	S3tz	S2tz	S2tz	S3tz	S3tz	S2rz	S2rz	Ntz	S2z	S2z	S3tz	S2tz	S2tz
Narayana -pura	47	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana -pura	51	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana -pura	52	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3rt	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Narayana -pura	53	S1	S3t	S1	S3t	S1	S1	S3t	S2t	S3rt	S3t	S3t	S3t	S2t	S1	S1	Nt	S1	S1	S2t	S2t	S2t
Narayana -pura	54	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana -pura	58	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nrg	Nr	Nrg	Nrg
Narayana -pura	62	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana -pura	63	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t

Village	Survey No.	Sorg-hum	Maize	Bengal-gram	Ground-nut	Sun-flower	Cotton	Banana	Pomeg-ranate	Mango	Sapota	Guava	Jack-fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tama-rind	Mari-gold	Chrysanthemum
Narayana-pura	64	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana-pura	65	S3rz	S3tz	S2rz	S3tz	Nrz	S3rz	Nrz	Nrz	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	S3rg	S3rg	Nr	S3zt	S3zt
Narayana-pura	66	S3rz	S3tz	S2rz	S3tz	Nrz	S3rz	Nrz	Nrz	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nrg	S3rg	S3rg	Nr	S3zt	S3zt
Narayana-pura	67	S3rz	S3tz	S2rz	S3tz	Nrz	S3rz	Nrz	Nrz	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3r	S3r	Nr	S3zt	S3zt
Narayana-pura	68	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana-pura	69	S1	S3t	S1	S3t	S2r	S2r	S3t	S2t	S3rt	S2rt	S3t	S3rt	S3rt	S2r	S2r	Nt	S1	S1	S3rt	S2t	S2t
Narayana-pura	102	S2z	S3tz	S3g	S3tz	S3gz	S3gz	S3tz	S3tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2gz	S2t	S3tz	S3tz
Narayana-pura	103	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz
Narayana-pura	Settlement	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Narayana-pura	Stream	S2z	S3tz	S2z	S3tz	S2z	S2z	S3tz	S2tz	S3t	S3t	S3z	S3t	S2t	S1	S1	S3z	S1	S2z	S2t	S2tz	S2tz

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

CONTENTS

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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-3 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^0$3' – $15^0$4' North latitudes and $75^0$38' – $75^0$40' East longitudes, covering an area of about 400 ha, bounded by Belhatti, Konchigeri, Suganhalli and Hosur 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-3 micro-watershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) are presented here.*

Social Indicators;

- *Male and female ratio is 55.6 to 44.4 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 67.7 per cent to the total population.*
- *Literacy population among all the sample households.*
- *Social groups belong to other backward caste (OBC) is around 40 per cent.*
- *Fire wood is the source of energy for a cooking among 50 per cent.*
- *About 20 per cent of households have a yashaswini health card.*
- *Majority of farm households (20%) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 80 per cent.*
- *Swach bharath program providing closed toilet facilities around 50 per cent of sample households.*
- *Rural migration to unban centre for employment is prevalent is around 10 per cent of farm households.*
- *Women participation in decisions making for agriculture production among all the sample households was found.*

Economic Indicators;

- *The average land holding is 1.41 ha indicates that majority of farm households are belong to marginal and small farmers. The total cultivatable area is dry land condition of the sample households.*

- *Agriculture is the main occupation among 6.25 per cent and agriculture is the main and agriculture labour is subsidiary occupation for 78.13 per cent of sample households.*
- *The average value of domestic assets is around Rs. 16410 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 91967 per household, about 20 per cent of sample farmers having tractor and weeder.*
- *The average value of livestock is around Rs. 35000 per household; about 46 per cent of household are having livestock.*
- *The average per capita food consumption is around 1068 grams (2274.4 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 20 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs.7562 per household. Among all farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs.2458.*

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. 1015 per ha/year. The total cost of annual soil nutrients is around Rs. 399971 per year for the total area of 400 ha.*
- *The average value of ecosystem service for food grain production is around Rs 1464 /ha/year. Per hectare food grain production services is maximum in green gram (Rs. 1979) followed by ground nut (Rs. 948) and maize is negative returns.*
- *The average value of ecosystem service for fodder production is around Rs. 3265/ ha/year. Per hectare fodder production services is maximum in maize (Rs. 6307) followed by ground nut (Rs. 3057) and green gram (Rs. 431).*
- *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 maize (Rs. 38406) followed by green gram (Rs. 33090) and ground nut (Rs. 23812).*

Economic Land Evaluation;

- *The major cropping pattern is maize (66.4 %) followed by green gram (30.6 %) and ground nut (3.0 %).*
- *In Belhatti-3 micro-watershed, major soil is soil of alluvial landscape of Soil of granite and granite gneiss landscape of Muttal (MTL) are also having shallow soil depth cover around 7.9 % of area, the main crops are maize. Ravanaki (RNK) series are also moderately shallow soil depth cover around 6.56 % of*

area the crops are ground nut (72.1 %) and maize (27.9 %). Lakshmanagudda (LGD) series is having deep soil depth cover around 5.2% of area. On this soil farmers are presently growing maize. Budagumpa (BGP) soil series having very deep soil depth cover around 7.7 % of areas, crops are green gram (91.1%) and ground nut (8.9 %). Soils of schist landscape Varavi (VRV) soil series having moderately deep soil depth cover around 27.0 % of area, crops are maize. Jelligere (JLG) soil series are having deep soil depth cover around 7.8 % of area. The major crops grown are maize.

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for maize ranges between Rs.98939/ha in RNK soil (with BCR of 0.96) and Rs.15434/ha in LGD soil (with BCR of 1.14).*
- *In groundnut the cost of cultivation range between Rs 42653/ha in RNK soil (with BCR of 1.11) and Rs.36765/ha in BGP soil (with BCR of 1.08).*
- *In green gram the cost of cultivation in BGP soil is Rs. 14791/ha (with BCR of 1.16).*
- *The land management practices reported by the farmers are crop rotation, tillage practices, fertilizer application and use of farm yard manure (FYM). Due to higher wages farmer are following labour saving strategies is not prating soil and water conservation measures. Less ownership of livestock limiting application of FYM.*
- *It was observed soil quality influences on the type and intensity of land use. More fertilizer applications in deeper soil to maximize returns.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in maize (23.7 to 85.6 %), ground nut (42.7 to 57.1 %) and green gram (43.9 %).*

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-3 Microwatershed 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 450-900m 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 represented Agro Ecological Sub Region (AESR) 6.4 having LGP 150-180 days.

Belhatti-3 Microwatershed (Belhatti sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^0$3' – $15^0$4' North latitudes and $75^0$38' – $75^0$40' East longitudes, covering an area of about 400 ha, bounded by Belhatti, Konchigeri, Suganhalli and Hosur 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).

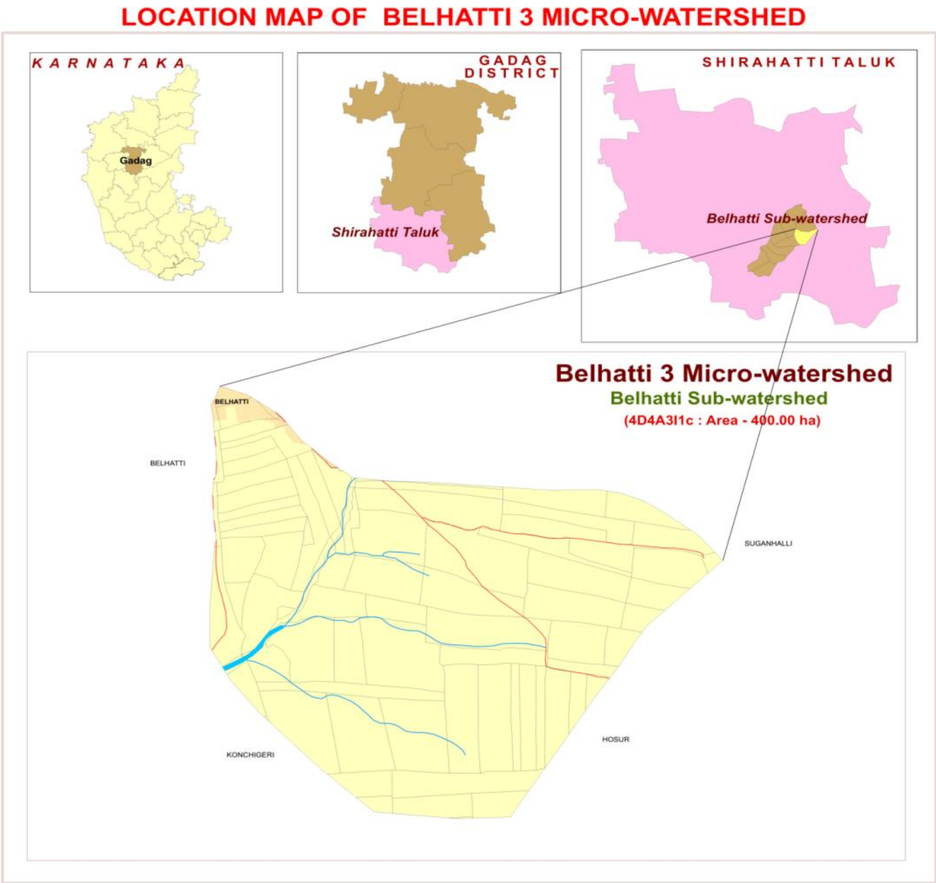

Figure 1: Location of study area

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.

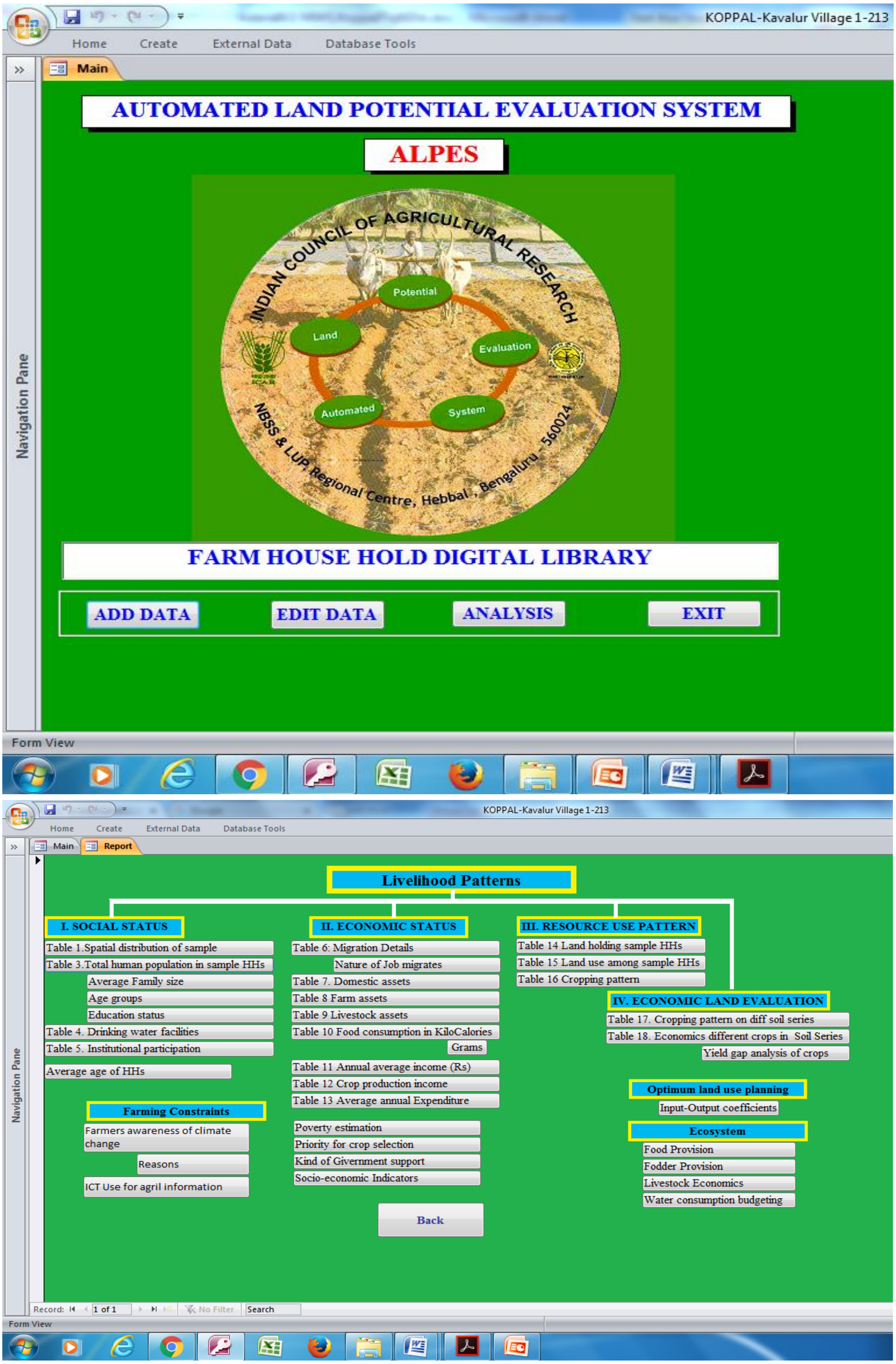

Figure 2: ALPES FRAMEWORK

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 45, out of which 55.6 per cent were males and 44.4 per cent females. Average family size of the households is 4.5. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 30 to 50 years (44.4 %) followed by more than 50 years (24.4 %), 0 to 18 years (17.8 %) and 18 to 50 years (13.3 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 100 per cent of respondents were illiterate (Table 1).

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

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	45
Male	% to total Population	55.6
Female	% to total Population	44.4
Average family size	Number	4.5
Age group		
0 to 18 years	% to total Population	17.8
18 to 30 years	% to total Population	13.3
30 to 50 years	% to total Population	44.4
>50 years	% to total Population	24.4
Average age	Age in years	38.1
Education Status		
Literates	% to total Population	100.0
Primary School (<5 class)	% to total Population	37.8
Middle School (6- 8 class)	% to total Population	15.6
High School (9- 10 class)	% to total Population	24.4
Others	% to total Population	22.2

The ethnic groups among the sample farm households found to be 40 per cent belonging to other backward caste (OBC) followed by 60 per cent belonging to general castes (Table 2 and Figure 3). About 50 per cent of sample households are using fire wood as source of fuel for cooking. All the sample farmers are having electricity connection. About 20 per cent are sample households having health cards. About 20.0

percent households are having MNREGA job cards for employment generation. About 80 per cent of farm households are having ration cards for taking food grains from public distribution system. About 50 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Belhatti-3 Micro watershed

Particulars	Units	Value
Social groups		
OBC	% of Households	40.0
General	% of Households	60.0
Types of fuel use for cooking		
Fire wood	% of Households	50.0
Gas	% of Households	50.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	20.0
No	% of Households	80.0
MGNREGA Card		
Yes	% of Households	20.0
No	% of Households	80.0
Ration Card		
Yes	% of Households	80.0
No	% of Households	20.0
Households with toilet		
Yes	% of Households	50.0
No	% of Households	50.0
Drinking water facilities		
Tube Well	% of Households	40.0
Tank	% of Households	40.0
Lake	% of Households	10.0
Pond	% of Households	10.0

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 (40%) source for water supply for domestic purpose and 40 % was tank.

The data on migration in Belhatti-3 Micro-watershed is given in Table 3. It indicated that around 10 per cent of samples households were migrated. The average distance travelled for seeking employment is 30 km.

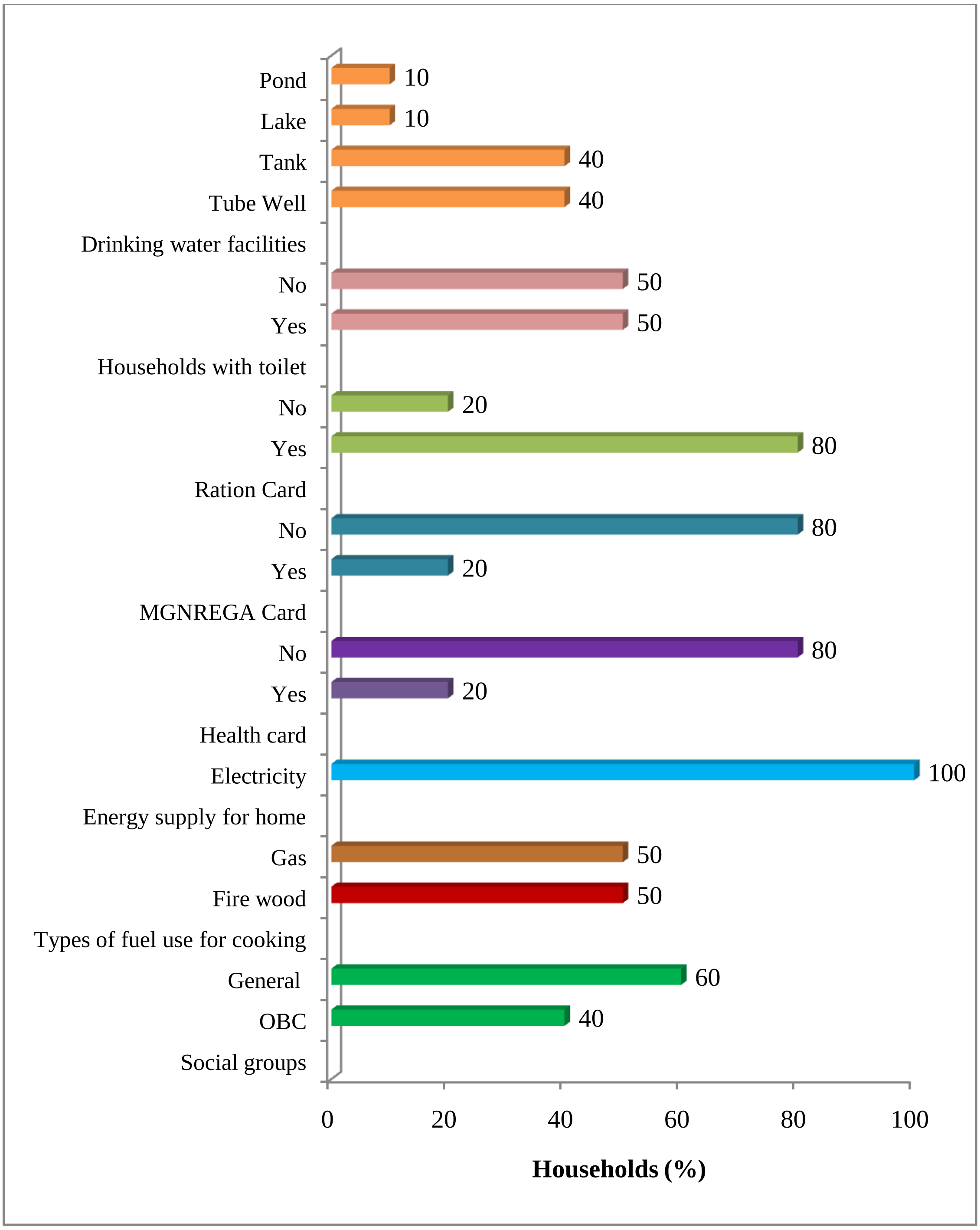

Figure 3: Basic needs of sample households in Belhatti-3 Microwatershed

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

Particulars	**Value**
% of households showing migration	10.0
% of persons migrating	2.2
No. of months migrated in a year	3.0
Average Distance of migration(Km)	30.0
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 6.2 per cent of farmers followed by agriculture is the main and subsidiary occupations like agricultural labour (78.13 %) and non agriculture labour (6.2 %). About 6.2 per cent of the households are govt service and around 3.1 per cent of the population are private service as a main occupation.

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

Occupation		**% to total**
Main	**Subsidiary**	
Agriculture	Agriculture	6.2
	Agriculture Labour	78.1
	Non Agriculture Labour	6.2
Government service		6.2
Private service		3.1
Family labour availability		**Man days/month**
Male		40.0
Female		33.3
Average		36.7

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 (80 %), bicycle (30 %), mixer/grinder (40 %), motorcycle (40 %), four wheeler (10 %). The average value of domestic assets is around Rs 16410 per households.

Table 5: Domestic assets among the sample households in Belhatti-3 Micro watershed

Particulars	% of households	Average value in Rs
Bicycle	30.0	4500
Four wheeler	10.0	20000
Mixer/grinder	40.0	2750
Mobile Phone	90.0	5333
Motorcycle	40.0	56250
Television	80.0	9625
Average Value	16410	

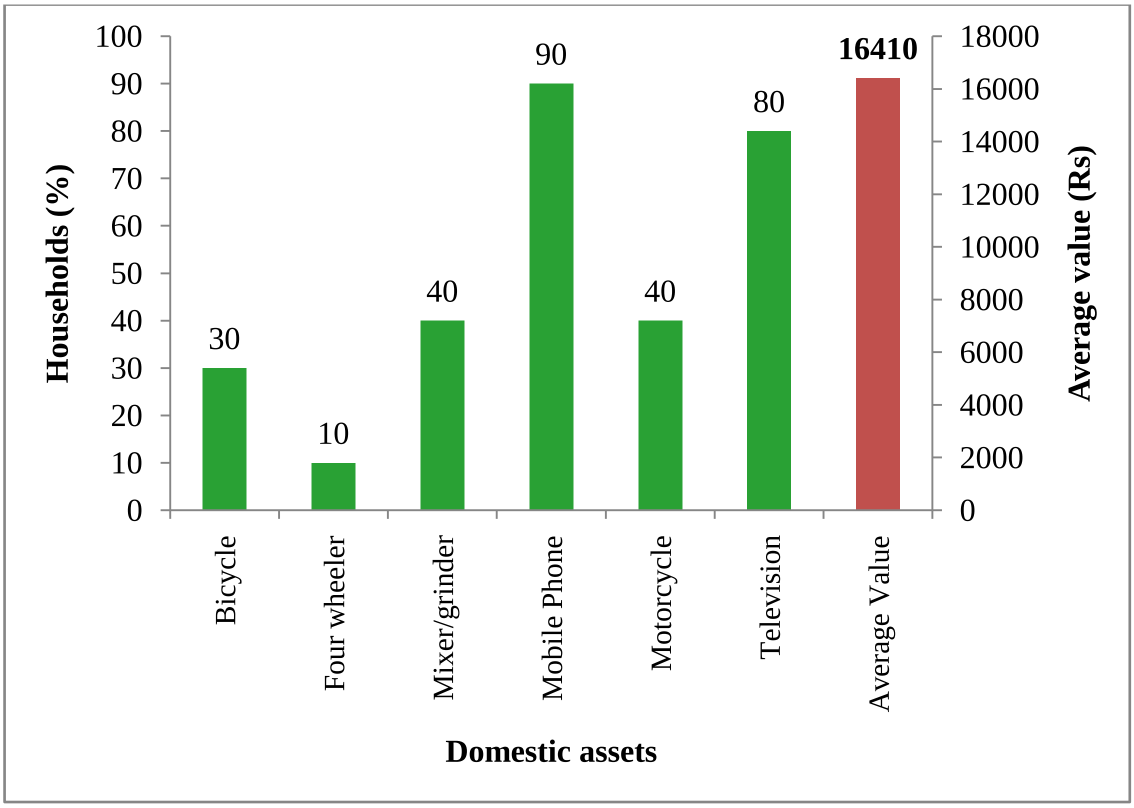

Figure 4: Domestic assets among the sample households in Belhatti-3 Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned weeder (20 %), plough (10 %), bullock cart (20 %), drip/sprinkler (10 %), tractor (10 %) and power tiller (10 %) was found highest among the sample farmers. The average value of farm assets is around Rs 91967 per households (Table 6 and Figure 5).

Table 6: Farm assets among samples households in Belhatti-3 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	20.0	13500
Drip/Sprinkler	10.0	4200
Plough	10.0	3500
Power tiller	10.0	80000
Tractor	20.0	450000
Weeder	20.0	600
Average Value	91967	

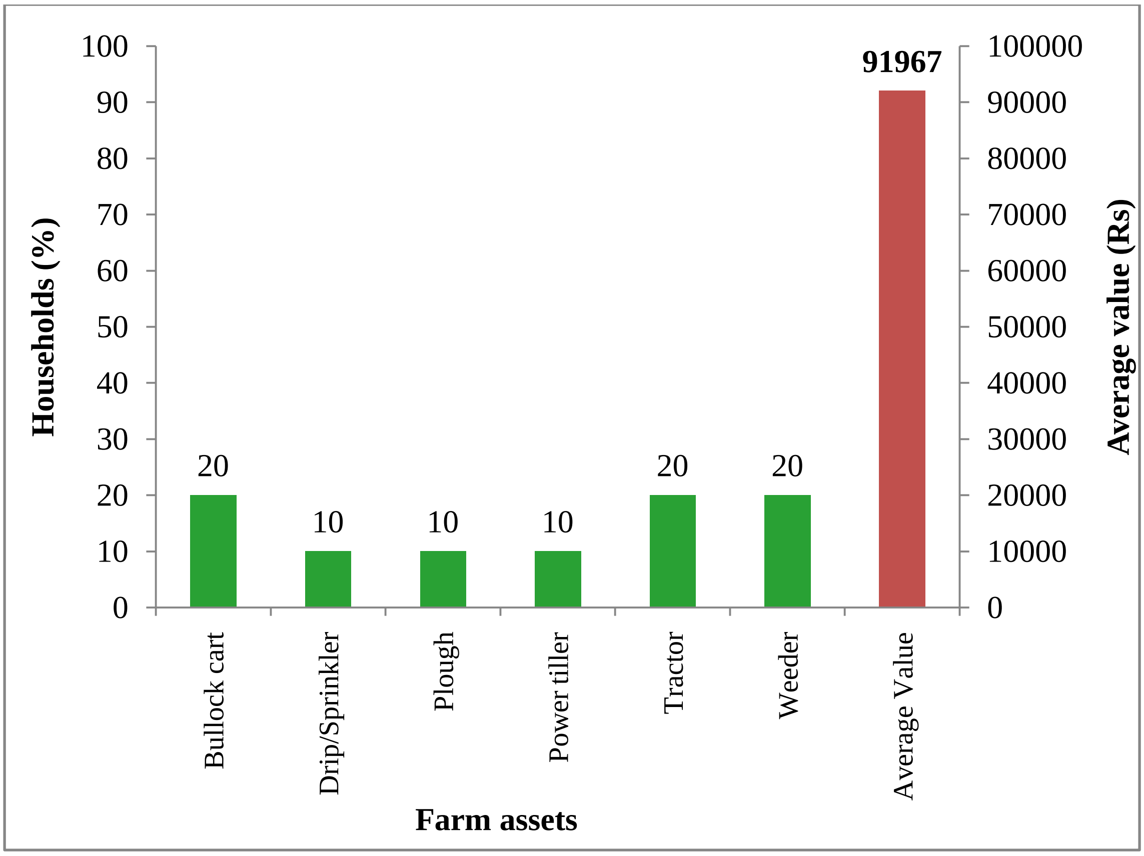

Figure5: Farm assets among samples households in Belhatti-3 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population is bullocks were around 50 per cent followed by local dry cow (16.7 %), dry buffalos (16.7%) and milching buffalos (16.7 %). The average livestock value was Rs 35000 per household.

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

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	16.7	10000
Dry Buffalos	16.7	20000
Milching Buffalos	16.7	50000
Bullocks	50.0	60000
Average value	35000	

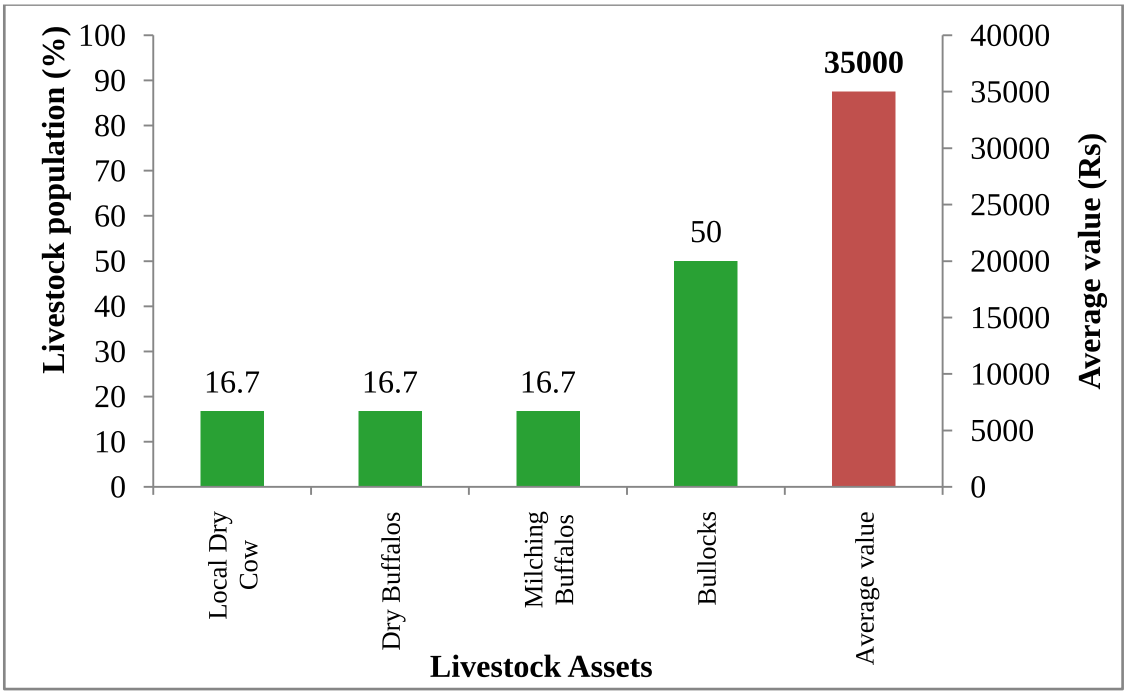

Figure 6: Livestock assets among sample households in Belhatti-3 Micro-watershed

Among the farm households, ground nut and maize are the main crops for domestic food and fodder for animals. About 4549 kg /ha of average fodder is available per season for the livestock feeding (Table 8).

Table 8: Fodder availability of sample households in Belhatti-3 Micro watershed

Particulars	
Fodder produces	**Fodder yield (kg/ha.)**
Maize	6623
Groundnut	2475
Average fodder availability	5931
Livestock having households (%)	46
Livestock population (Numbers)	15

A woman participation in decision making is in this micro-watershed is presented in Table 9. About 70 per cent women earning for her family requirement and 70 per cent of women taking decision in her family and agriculture related activities.

Table 9: Women empowerment of sample households in Belhatti-3 Micro watershed

% to Grand Total

Particulars	**Yes**	**No**
Women participation in local organization activities	0.0	100
Women elected as panchayat member	0.0	100
Women earning for her family requirement	70.0	30.0
Women taking decision in her family and agriculture related activities	70.0	30.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1378.3 kcal per person. The other important food items consumed was pulses 258.43 kcal followed by cooking oil 201.8 kcal, milk 133.5 kcal, vegetables 41.4 kcal, egg 221.1 kcal and meat 39.9 kcal. In the sampled households, farmers were consuming less (2274.4 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample households in Belhatti-3 Micro watershed

Particulars	**NIN recommendation (gram/ per day/ person)**	**Present level of consumption (gram/ per day/ person)**	**Kilo Calories /day/person**
Cereals	396	405.4	1378.
Pulses	43	75.3	258.4
Milk	200	205.4	133.5
Vegetables	143	172.6	41.4
Cooking Oil	31	35.4	201.8
Egg	0.5	147.4	221.1
Meat	14.2	26.6	39.9
Total	**827.7**	**1068.1**	**2274.4**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% of households below NIN		20.0	70.0
% of households above NIN		80.0	30.0

Note: * day/person

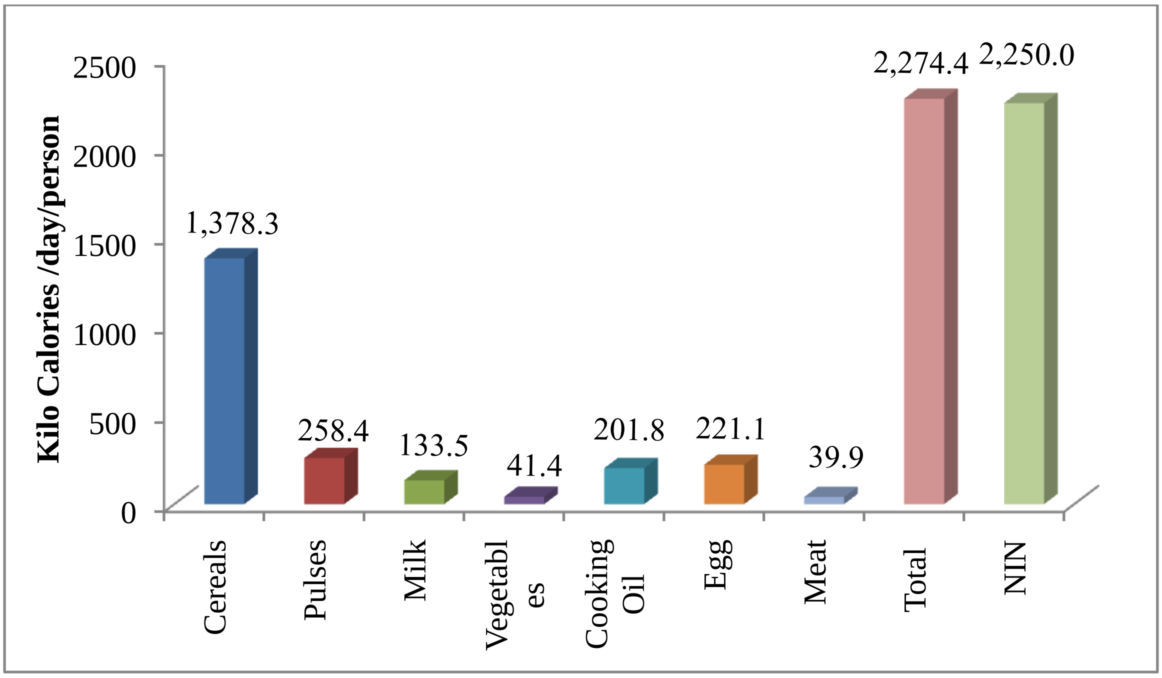

Figure 7: Per capita daily consumption of food among the sample households in Belhatti-3 Microwatershed

Annual income of the sample HHs: The total annual household income is around Rs 7562. Major source of income to the farmers in the study area is from crop production (Rs 6854) followed by income from Non farm income was very low at Rs 708. The monthly per capita income is Rs.140, which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

Table 11: Annual average income of HHs from various sources in Belhatti-3 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	708 (10)
Livestock income (Rs)	0 (0)
Crop Production (Rs)	6854 (100)
Total Annual Income (Rs)	***7562***
Average monthly per capita income (Rs)	140
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	100.0
% 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. 50940) followed by education, clothing, social function and health. Now a days education is most important among all of us. In today's competitive world, education is a necessity for man after food, clothing, and shelter. It is the only fundamental way by which a desired change in the society can happen. The average per capita monthly expenditure is around Rs 2458 and among all farm households are below poverty line (Table 12 and Figure 8).

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

Particulars	Value in Rupees	Per cent
Food	50940	38.4
Education	27500	20.7
Clothing	16000	12.1
Social functions	27500	20.7
Health	10800	8.1
Total Expenditure (Rs/year)	132740	100.0
Monthly per capita expenditure (Rs)	2458	

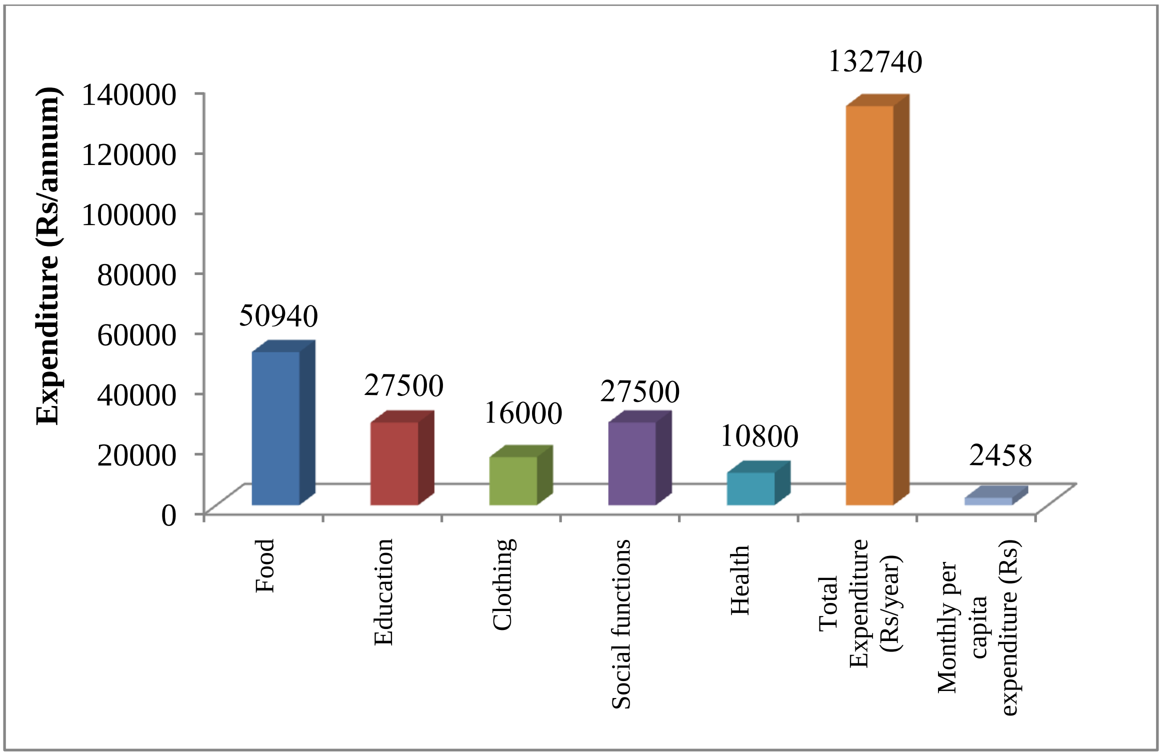

Figure 8: Average annual expenditure of sample HHs in Belhatti-3 Microwatershed

Land holding: Total area cultivated by them is 5.7 ha. The average land holding of sample HHs is 1.4 ha. Large number of sample HHs (70 %) belong to small size group with an average holding size of 0.8 ha followed by medium farmers (20 %) with an average holding size of 2.1 ha and a large farmer (10 %) with a average land holding size of 4.2 ha (Table 13).

Table 13: Distribution of land holding among the sample households in Belhatti-3 Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	5.7
Sample size	Per cent	70.0
Average land holding	ha	0.8
Medium farmers		
Total land	ha	4.2
Sample size	Per cent	20.0
Average land holding	ha	2.1
Large farmers		
Total land	ha	4.2
Sample size	Per cent	10.0
Average land holding	ha	4.2
Total sample households		
Total land	ha	5.7
Sample size	Per cent	100.0
Average land holding	ha	1.4

Land use: The total land holding in the Belhatti-3 Micro-watershed is 1.41 ha is rain fed land (Table 14). The average land holding per household is worked out to be 1.4 ha.

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

Particulars	Per cent	Area in ha
Irrigated Land	0.0	0.0
Rain fed Land	100.0	14.1
Fallow Land	0.0	0.0
Total land holding	100.0	14.1
Average land holding	1.41	

In the micro-watershed, the prevalent present land uses under perennial plants are neem trees (50 %) and banni tree (shami) (50 %) (Table 15).

Table 15: Number of trees/plants covered in sample farm households in Belhatti-3 Microwatershed

Particulars	Number of Plants/trees	Per cent
Banni tree(Shami)	4	50.0
Neem trees	4	50.0
Grand Total	8	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 (66.4 %) followed by green gram (30.6 %) and groundnut (3.0 %) which was a kharif season. The cropping intensity was 100 per cent (Table 16 and Figure 9).

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

% to Grand Total

Crops	Kharif	Grand Total
Green gram	30.6	30.56
Groundnut	3.0	3.0
Maize	66.4	66.4
Grand Total	100.0	100.0

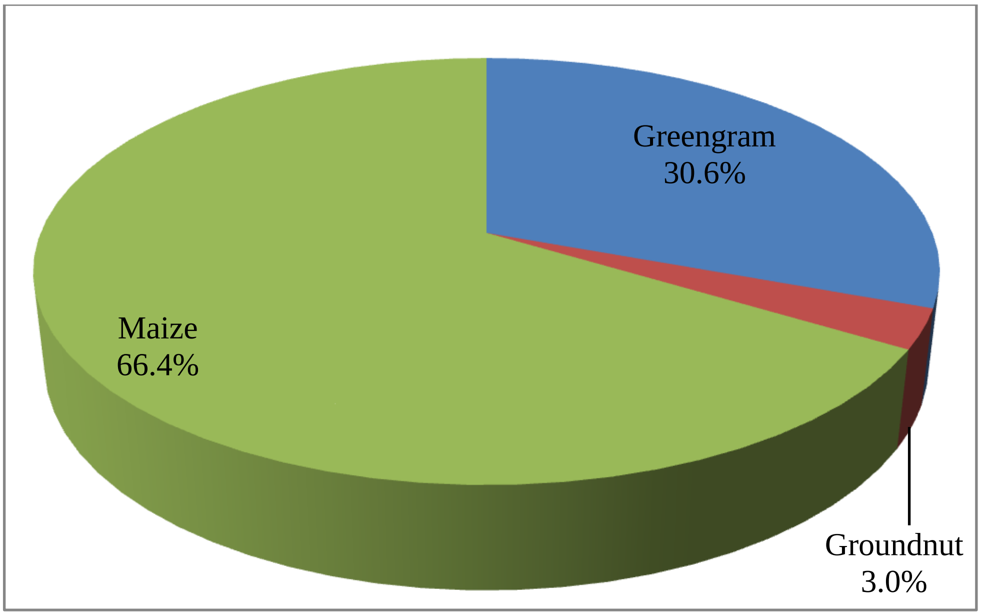

Figure 9: Present cropping pattern in Belhatti-3 Microwatershed

Economic land evaluation

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

In Belhatti-3 Microwatershed, 13 soil series are identified and mapped (Table 17). The distribution of major soil series Varavi are covering an area around 107.1 ha (27.0 %) followed by Shyanadrahalli 50.2 ha (12.5 %), Attikattitanda 49.7 ha (12.4 %), Mahalinga-puratanda 39.73 ha (9.94 %), Muttal 31.66 ha (7.91 %), Jelligere 31.16 ha (7.8%), Budagumpa 30.6 ha (7.6 %), Ravanaki 26.2 ha (6.6 %), Lakshmanagudda 20.8ha (5.2 %), Chikkamegheri 5.0 ha (1.2%) and Dindur 0.8 ha (0.2%).

Table 17: Distribution of soil series in Belhatti-3 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 grayish brown calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation	31.7 (7.9)
2	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	26.2 (6.6)
3	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	5.0 (1.2)
4	SNH	Shyanadrahalli soils are deep (100-150 cm) well drained, have light olive brown to very dark gray soils occurring on nearly level to very gently sloping uplands under cultivation	50.2 (12.5)

5	LGD	Lakshmangudda soils are deep (100 - 150 cm), well drained, have light olive brown to very dark gray calcareous clay soils occurring on very gently sloping uplands under cultivation	20.8 (5.2)
6	BGP	Budagumpa soils are very deep (>150 cm), well drained, black calcareous sandy clay to clay soils occurring on very gently sloping uplands under cultivation	30.6 (7.7)
SOILS OF BANDED FERRUGINOUS QUARTZITE (BFQ) LANDSCAPE			
7	DDR	Dindur soils are very shallow (<25 cm), well drained, have dark reddish brown to dark red gravelly clay loam to gravelly clayey soils occurring on moderately sloping uplands under cultivation	0.8 (0.2)
SOILS OF SCHIST LANDFORM			
8	ATT	Attikattitanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils occurring on very gently sloping uplands under cultivation	49.7 (12.4)
9	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils occurring on very gently sloping uplands under cultivation	31.2 (7.8)
10	VRV	Varavi soils are moderately deep (75-100 cm), moderately well drained, very dark brown, cracking clay soils occurring on nearly level to very gently sloping uplands under cultivation	107.9 (27.0)
11	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark grayish brown cracking clay soils occurring on nearly level to very gently sloping uplands under cultivation	39.7 (9.9)
12		Habitation	5.2 (1.3)
13		Waterbody	1.0(0.2)

Present cropping pattern on different soil series are given in Table 18. Crops grown on Muttal soils are maize. Ground nut and maize are Ravanaki soils are grown. Maize is grown Varavi soils. Maize is Jelligeri soils are grown. Cotton, Maize on Lakshmanagudda soils are grows. Greengram and ground nut on Budagumpa soils are grown.

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

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Irrigated	Grand Total
			Kharif	Kharif	
MTL	Shallow (25-50 cm)	Maize	100.0	0.0	100.0
RNK	Moderately shallow (50-75 cm)	Groundnut	72.1	0.0	72.1
		Maize	27.9	0.0	27.9
VRV	Moderately deep (75-100 cm)	Maize	100.0	100.0	100.0
JLG	Deep (100-150 cm)	Maize	100.0	0.0	100.0
LGD	Deep (100-150 cm)	Maize	100.0	0.0	100.0
BGP	Very deep (>150 cm)	Greengram	91.1	0.0	91.1
		Groundnut	8.9	0.0	8.9

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

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

Soil Series	Small Farmers	Medium Farmers	Large Farmers
MTL	Maize (1.09).		
RNK	Ground nut (1.11), Maize (0.96).		
VRV	Maize (1.43).	Maize (1.28).	
JDG	Maize (1.24)		
LGD		Maize (1.14).	
BGP	Ground nut (1.08).		Green gram (1.16).

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

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 20. The total cost of cultivation in study area for maize ranges between Rs.98939/ha in RNK soil (with BCR of 0.96) and Rs.15434/ha in LGD soil (with BCR of 1.14), Ground nut range between Rs 42653/ha in RNK soil (with of 1.11) and Rs.36765/ha in BGP soil (With BCR of 1.08), Green gram cost of cultivation in BGP soil is Rs. 14791/ha (with BCR of 1.16).

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 20. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs.91625in maize and a minimum of Rs 8390 in greengram cultivation.

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

Particulars	MTL (25-50 cm)	RNK (50-75 cm)		VRV (75-100 cm)	LGD (100-150 cm)	JDG (100-150 cm)	BGP (>150 cm)	
	Maize	Groundnut	Maize	Maize	Maize	Maize	Greengram	Groundnut
Total cost (Rs/ha)	36878	42653	98939	24165	15434	78227	14791	36765
Gross Return (Rs/ha)	40209	47199	95000	31770	17643	67755	17201	39618
Net returns (Rs/ha)	3332	4546	-3939	7604	2209	-10471	2410	2853
BCR	1.09	1.11	0.96	1.38	1.14	1.24	1.16	1.08
Farmers Practices (FP)								
FYM (t/ha)	5.8	2.5	19.2	2.5	1.4	8.3	1.5	2.5
Nitrogen (kg/ha)	124.0	142.2	142.2	73.7	88.3	274.8	93.1	79.2
Phosphorus (kg/ha)	89.1	102.2	102.2	45.9	55.5	197.5	66.9	56.9
Potash (kg/ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	29.1	9.9	64.1	24.0	12.1	38.7	4.8	7.4
Price of Yield (Rs/Qtl)	1200	4500	1400	1267	1400	1375	3500	5000
Soil test based fertilizer Recommendation (STBR)								
FYM (t/ha)	8.6	8.6	8.6	8.6	8.6	8.6	7.4	8.6
Nitrogen (kg/ha)	123.5	24.7	123.5	123.5	123.5	123.5	18.5	24.7
Phosphorus (kg/ha)	77.2	77.2	77.2	77.2	77.2	61.8	46.3	77.2
Potash (kg/ha)	32.1	30.9	32.1	32.1	24.1	32.1	37.1	30.9
Grain (Qtl/ha)	84.0	17.3	84.0	84.0	84.0	84.0	8.6	17.3
% of Adoption/yield gap (STBR-FP) / (STBR)								
FYM (%)	32.7	71.4	-122.4	70.7	83.3	4.2	80.4	71.4
Nitrogen (%)	-0.4	-475.6	-15.1	40.3	28.5	-122.5	-402.6	-220.7
Phosphorus (%)	-15.5	-32.4	-32.4	40.6	28.1	-219.9	-44.5	26.2
Potash (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Grain (%)	65.4	42.7	23.7	71.5	85.6	54.0	43.9	57.1
Value of yield and Fertilizer (Rs)								
Additional Cost (Rs/ha)	2941	4278	-11267	8732	9055	-6781	4894	7024
Additional Benefits (Rs/ha)	65892	33251	27828	76016	100680	62300	13284	49321
Net change Income (Rs/ha)	62952	28973	39096	67284	91625	69081	8390	42297

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 21 and Figure 10. The average value of soil nutrient loss is around Rs 1015 per ha/year. The total cost of annual soil nutrients is around Rs 399971 per year for the total area of 400 ha.

Table 21: Estimation of onsite cost of soil erosion in Belhatti-3 Micro-watershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	147.87	58260	931.57	367040
Phosphorous	0.05	21	2.39	941
Potash	1.88	740	37.58	14805
Iron	0.07	28	3.42	1349
Manganese	0.09	34	24.07	9485
Cupper	0.02	6	8.89	3503
Zinc	0.01	2	0.23	92
Sulpher	0.17	66	6.74	2655
Boron	0.01	2	0.25	100
Total	150.16	59162	1015.15	399971

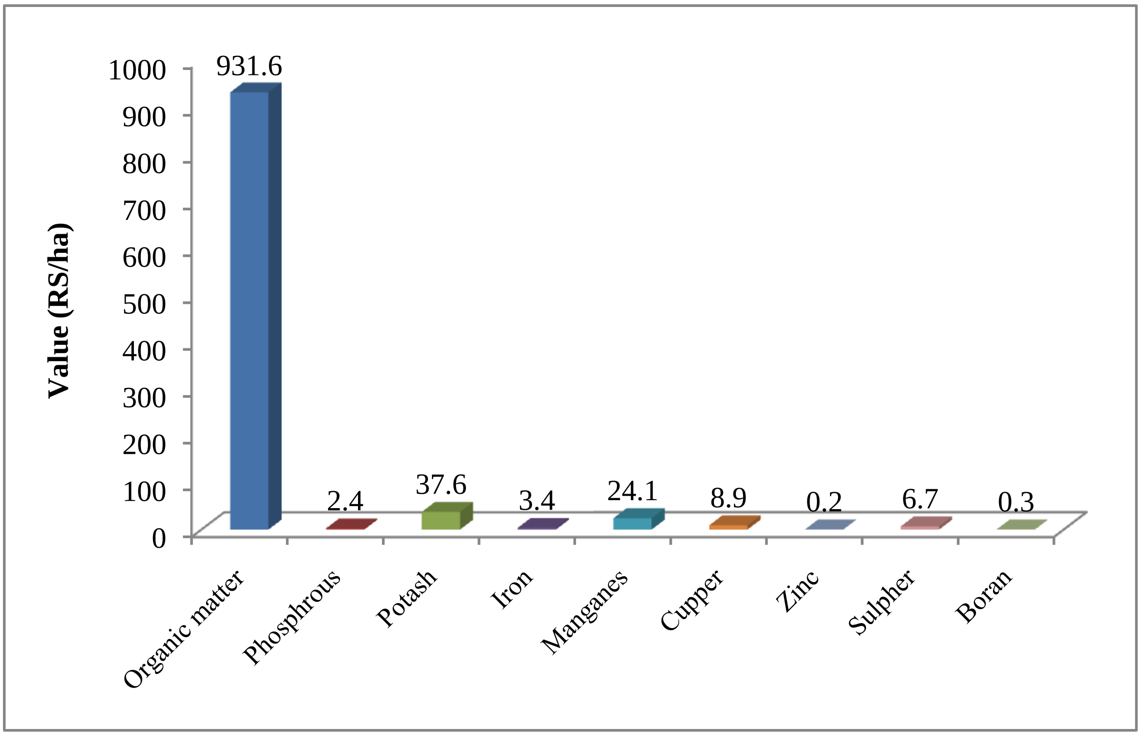

Figure 10: Estimation of onsite cost of soil erosion in Belhatti-3 Microwatershed

The average value of ecosystem service for food grain production is Rs 1464 per ha/year (Table 22). Per hectare food grain production services is maximum in green gram (Rs 1979) followed by groundnut (Rs 948) and maize is negative returns.

Table 22: Ecosystem services of food production in Belhatti-3 Micro watershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Cereals	Maize	9.1	31	1319	41446	47525	-6079
Pulses	Greengram	4.2	5	3500	16770	14791	1979
Oil seeds	Groundnut	0.8	9	4750	40657	39709	948
Average		14.1	15	3190	32958	34008	-1050

The average value of ecosystem service for fodder production is around Rs.3265/ ha/year (Table 23). Per hectare fodder production services is maximum in Maize (Rs 6307) followed by ground nut (Rs.3057) and green gram (Rs 431).

Table 23: Ecosystem services of fodder production in Belhatti-3 Micro watershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	9.1	6.4	988	6307
Pulses	Greengram	4.2	0.7	600	431
Oil seeds	Groundnut	0.8	2.4	1250	3057
Average value		14.1	3.2	946	3265

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 24 and Figure 11) in maize (Rs 38406) followed by green gram (Rs 33090) and groundnut (Rs 23812).

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

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Greengram	4.8	3309	33090	691
Groundnut	8.6	2381	23812	278
Maize	31.4	3841	38406	122
Grand Total	14.9	3177.0	31769	363.7

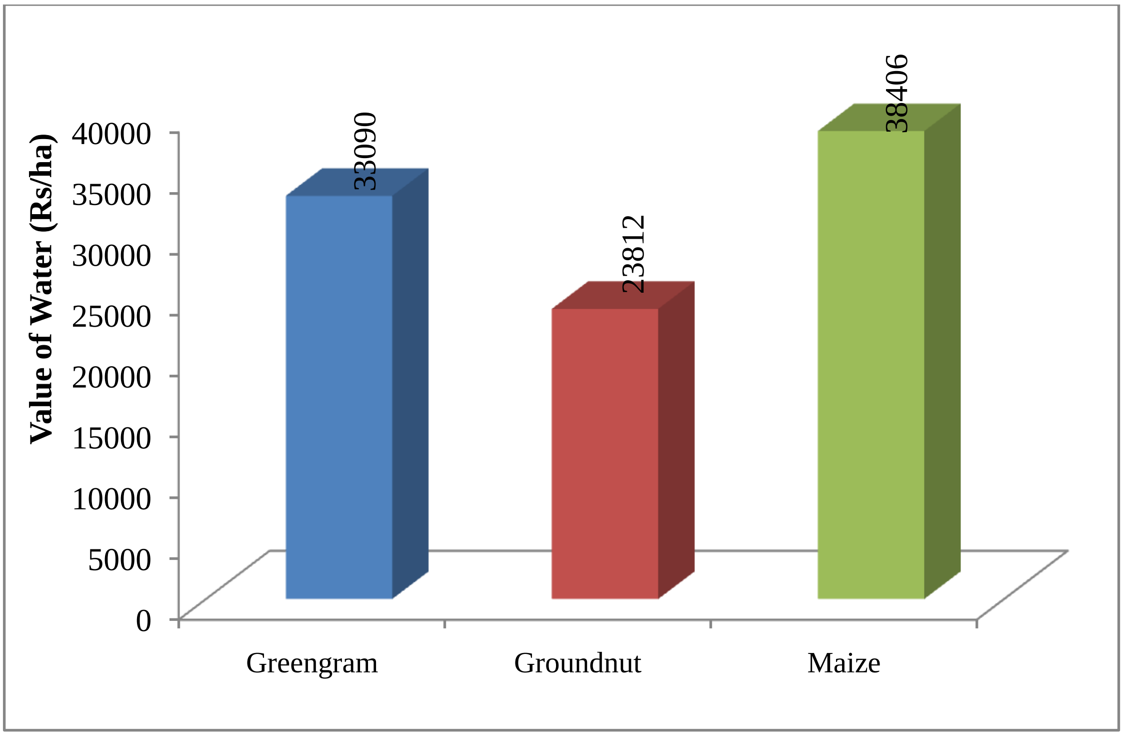

Figure 11: Ecosystem services of water supply in Belhatti-3 Microwatershed

The main farming constraints in Belhatti-3 Microwatershed 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 25).

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

Sl.No.	Particulars	Per cent
1	Less Rainfall	100
2	Lack of good quality seeds	10
3	Non availability Fertilizers	30
4	High Crop Pests & Diseases	20
5	Animal Pests & Diseases	20
6	Lack of transportation	50
7	Lack of storage	60
8	Damage of crops by Wild Animals	80
9	Non availability of Plant Protection Chemicals	70
10	**Source of loan**	
	Money Leander	100
11	**Market for selling**	
	Village market	100
12	**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.