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

DEVIHAL-2 (4D4A3G1b) MICRO WATERSHED

Shirahatti Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

ICAR - NBSS & LUP

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

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

The natural resources (land, water and vegetation) of the state need adequate and constant care and management, backed by site-specific technological interventions and investments particularly by the government. Detailed database pertaining to the nature of

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

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on "Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of for Devihal-2 microwatershed in Shirahatti Taluk, Gadag District, Karnataka" for integrated development was taken up in collaboration with the State Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

Nagpur
Date: 02.01.2018

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Devihal-2 microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit 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 471 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 75 per cent is covered by soils and 25 per cent by rocklands, waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 10 soil series and 22 soil phases (management units) and 6 land use classes.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 1st 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 the degree of suitability along with constraints were generated.*
- *About 71 per cent area is suitable for agriculture, 4 per cent is not suitable for agriculture and about 25 per cent is covered by rocky lands.*
- *About 55 per cent of the soils are moderately shallow (50-75 cm) to shallow (25-50 cm) and about 6 per cent are moderately deep (75-100 cm) to deep (100-150 cm) soils.*
- *About 63 per cent of the area has loamy soils at the surface and 11 per cent of the area has clayey soils at the surface.*
- *About 4 per cent of the area has non-gravelly soils, 51 per cent gravelly soils (15-35 % gravel) and 19 per cent very gravelly (35- 60% gravel) soils.*
- *About 70 per cent low (51-100 mm/m) to very low (<50mm/m) and 4 per cent is medium (101-150 mm/m) in available water capacity.*
- *About 70 per cent is very gently (1-3%) slope lands and 4 per cent is gently sloping (3-5%).*
- *An area of about 15 per cent has soils that are slightly eroded (e1), 56 per cent moderately eroded (e2) and 3 per cent is severely eroded.*
- *An area of about 17 per cent has soils that are moderately alkaline (pH 7.8 to 8.4), 8 per cent is slightly alkaline (pH 7.3-7.8) and 12 per cent strongly alkaline (pH 8.4 to >9.0). An area of about 18 per cent is neutral (pH 6.5-7.3), 14 per cent is slightly acid (pH 6.0-6.5) and 4 per cent moderately acid (pH 5.5-6.5).*

- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1} indicating that the soils are non-saline.*
- *About 12 per cent of the soils are medium (0.5-0.75%) in organic carbon, low (<0.5%) in about 61 per cent and <1 per cent of the soils are high (>0.75%).*
- *An area of about 74 per cent is low (<23 kg/ha) in available phosphorus and medium in very negligible area.*
- *About 70 per cent medium (145-337 kg/ha), low (<145 kg/ha) in 3 per cent and < 1 per cent high (>337 kg/ha) in available potassium.*
- *Available sulphur is medium (10-20 ppm) in about 66 per cent area and 7 per cent is high (>20 ppm).*
- *Available boron is low (0.5 ppm) in about 15 per cent, medium (0.5-1.0 ppm) in 46 per cent and high (>1.0 ppm) in 13 per cent.*
- *Available iron is deficient in about 48 per cent and sufficient in 26 per cent.*
- *Available manganese is sufficient in the entire microwatershed area.*
- *Available copper is sufficient in the entire microwatershed area.*
- *Available zinc is sufficient (>0.6 ppm) in 7 per cent and deficient (<0.6 ppm) in 67 per cent area of the microwatershed.*
- *The land suitability for 23 major crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.*

Land suitability for various crops in the microwatershed

Crop	*Suitability Area in ha (%)*		*Crop*	*Suitability Area in ha (%)*	
	Highly suitable (S1)	*Moderately suitable (S2)*		*Highly suitable (S1)*	*Moderately suitable (S2)*
Sorghum	*14(3)*	*154(33)*	*Sapota*	*5(1)*	*22(5)*
Maize	*14(3)*	*154(33)*	*Jackfruit*	-	*20(4)*
Cotton	*20(4)*	*178(38)*	*Jamun*	-	*20(4)*
Sunflower	*20(4)*	*178(38)*	*Musambi*	-	*20(4))*
Onion	*23(5)*	*175(37)*	*Lime*	-	*20(4)*
Groundnut	*23(5)*	*180(38)*	*Cashew*	-	*28(6)*
Chilli	*28(6)*	*170(36)*	*Custard apple*	*20(4)*	*187(40)*
Sugarcane	*20(4)*	*8(2)*	*Amla*	*20(4)*	*187(40)*
Pomegranate	*20(4)*	*8(2)*	*Tamarind*	-	*20(4)*
Tomato	*28(6)*	*195 (41)*	*Marigold*	*28(6)*	*170(36)*
Guava	*14(3)*	*13 (3)*	*Chrysanthemum*	*28(6)*	*170(36)*
Mango	-	*20(4)*			

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 6 identified LUCs 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 field bundsand also in the hillocks, mounds and ridges that would help in supplementing the income, provide fodder and fuel and generate lot of biomass. This would help in maintaining ecological balance and also help in mitigating the climate change.*

Chapter 1

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socio-economic development of its people. Soils provide food, fodder, fibre and fuel for meeting the basic human and animal needs. With the ever increasing growth in human and animal population, the demand on soil for more food and fodder production is on the increase. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agroclimatic setting, and use and management. There is therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. Soil erosion alone has degraded about 35 lakh ha. Almost all the uncultivated areas are facing various degrees of degradation, particularly soil erosion. Salinity and alkalinity has emerged as a major problem in >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 land and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and uses potential, which is very important for developing an effective land use and cropping systems for augmenting agricultural production on a sustainable basis.

The soil and land resource inventories made so far in Karnataka had limited utility because the surveys were of different types, scales and intensities carried out at different times with specific objectives. Hence, there is an urgent need to generate detailed site-

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

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

The land resource inventory aims to provide site specific database for Devihal-2 microwatershed in Shirahatti Taluk, Gadag District, Karnataka State for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological units (LEUs) map.

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

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Devihal-2 Microwatershed (Nilogal subwatershed) is located in the central part of northern Karnataka in Shirahatti Taluk, Gadag District, Karnataka State (Fig.2.1). It comprises parts of Madki Khanapur, Nadigatti, Rantur, Chabbi and Devihal villages. It lies between 15^0 06' and 15^0 8' North latitudes and 75^0 35' and 75^0 37' East longitudes and covers an area of 471 ha. It is about 60 km south of Gadag and is surrounded by Chabbi village on the north, Madki Khanapur village on the southwest and Nadigatti village on the northwest and Devihal village on the southeastern part.

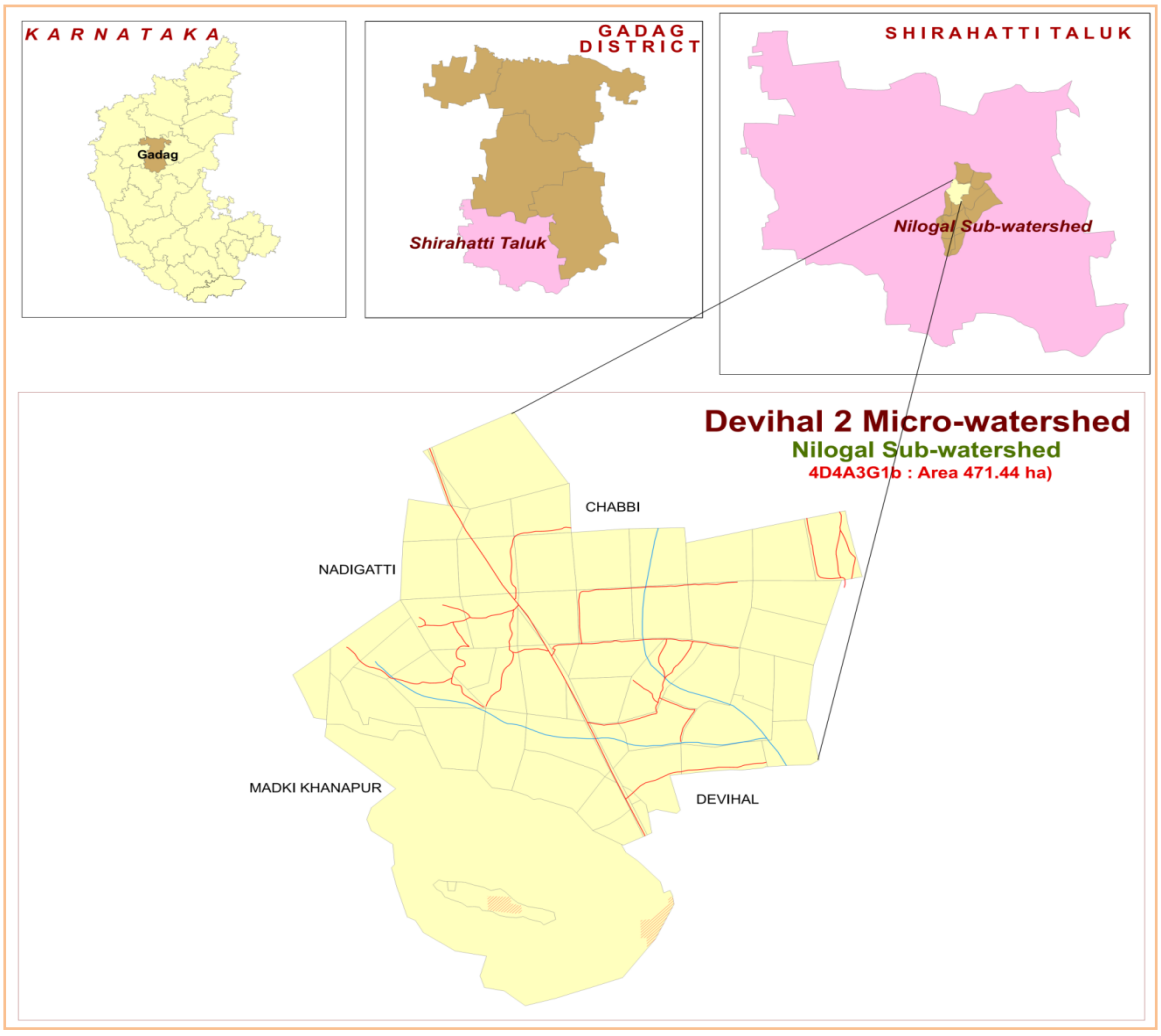


Fig.2.1 Location map of Devihal-2 Microwatershed

2.2 Geology

Major rock formations observed in the microwatershed are of Archaean age and comprise of (Figs.2.2) granite and granite gneiss. They are essentially pink to gray granite gneisses. The rocks are coarse to medium grained. They consist primarily of quartz,

feldspar, biotite and hornblende. The gray granite gneisses are highly weathered, fractured and fissured up to a depth of about 10 m. Dolerite dykes and quartz veins are common with variable width and found to occur in Chiksavanur-3 village.

Fig.2.2 Granite and granite gneiss rocks

2.3 Physiography

Physiographically, the area has been identified as granite gneiss landscape based on geology. The microwatershed area has been further divided into mounds/ridges, summits, side slopes and very gently sloping uplands based on slope and its relief features. The elevation ranges from 569 to 617 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 villages. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing tanks and recharge structures at appropriate places in the villages, then the drinking and irrigation needs of the area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

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

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET 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	

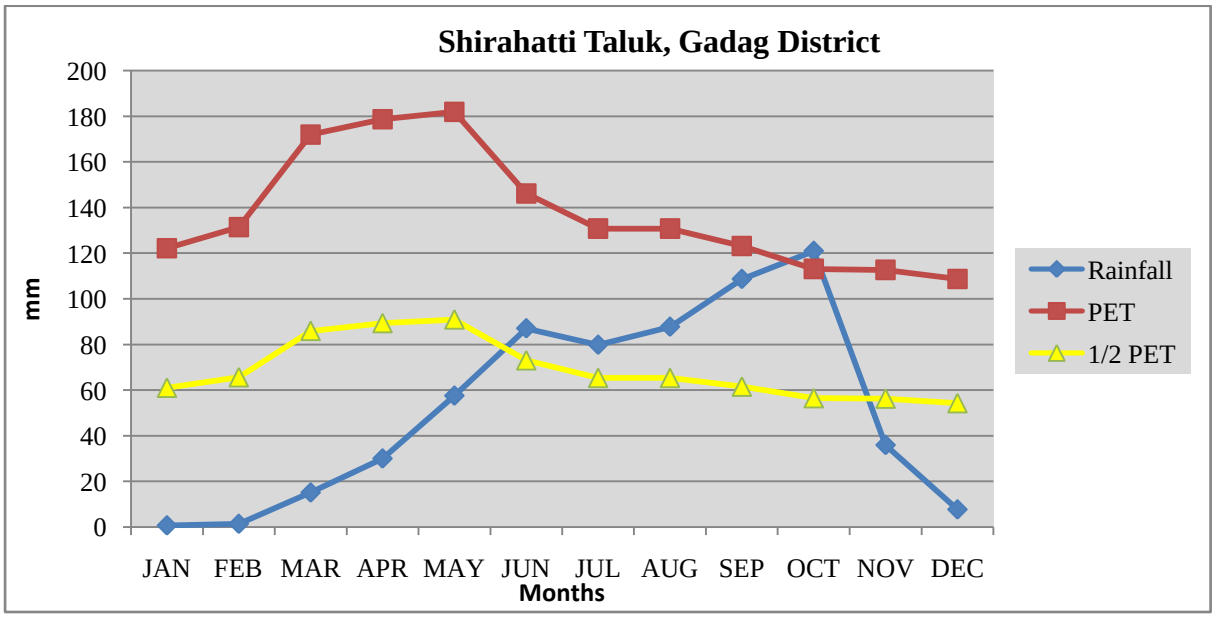


Fig. 2.3 Rainfall distribution in Shirahatti Taluk, Gadag District

2.6 Natural Vegetation

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

Apart from the continuing deforestation, the presence of large population of goats, sheep and other cattle in the 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

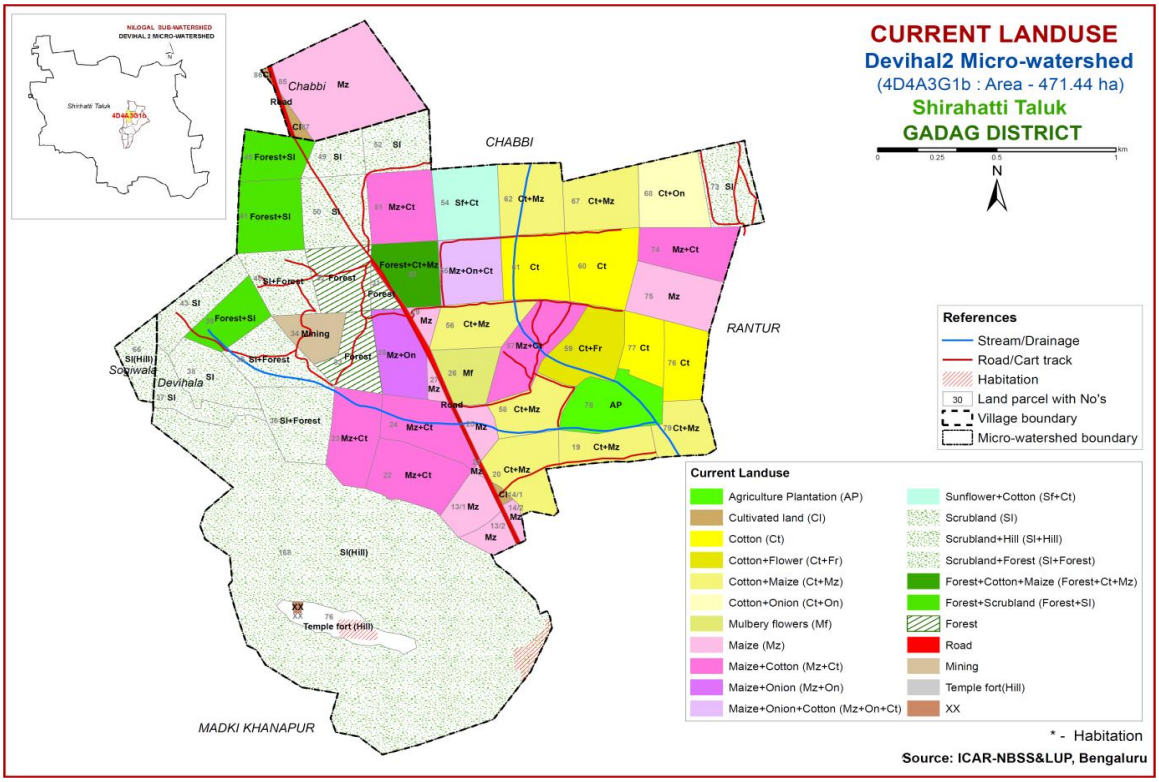


Fig.2.4 Current Land Use – Devihal-2 Microwatershed

About 77 per cent area (Table 2.2) in 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 (Figs 2.6a &b) in the area are sorghum, maize, cotton, safflower, sunflower, red gram, horse gram, onion, mulberry, sugarcane, bengal gram, pomogranate 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 Devihal-2 Microwatershed is presented in Fig.2.4.

Simultaneously, enumeration of existing wells (bore wells and open wells) and other soil and water conservation structures in the microwatershed is made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells, soil conservation structures and other water bodies in Devihal-2 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	Currently Barren	18302	16.7
7	Total geographical area	109751	

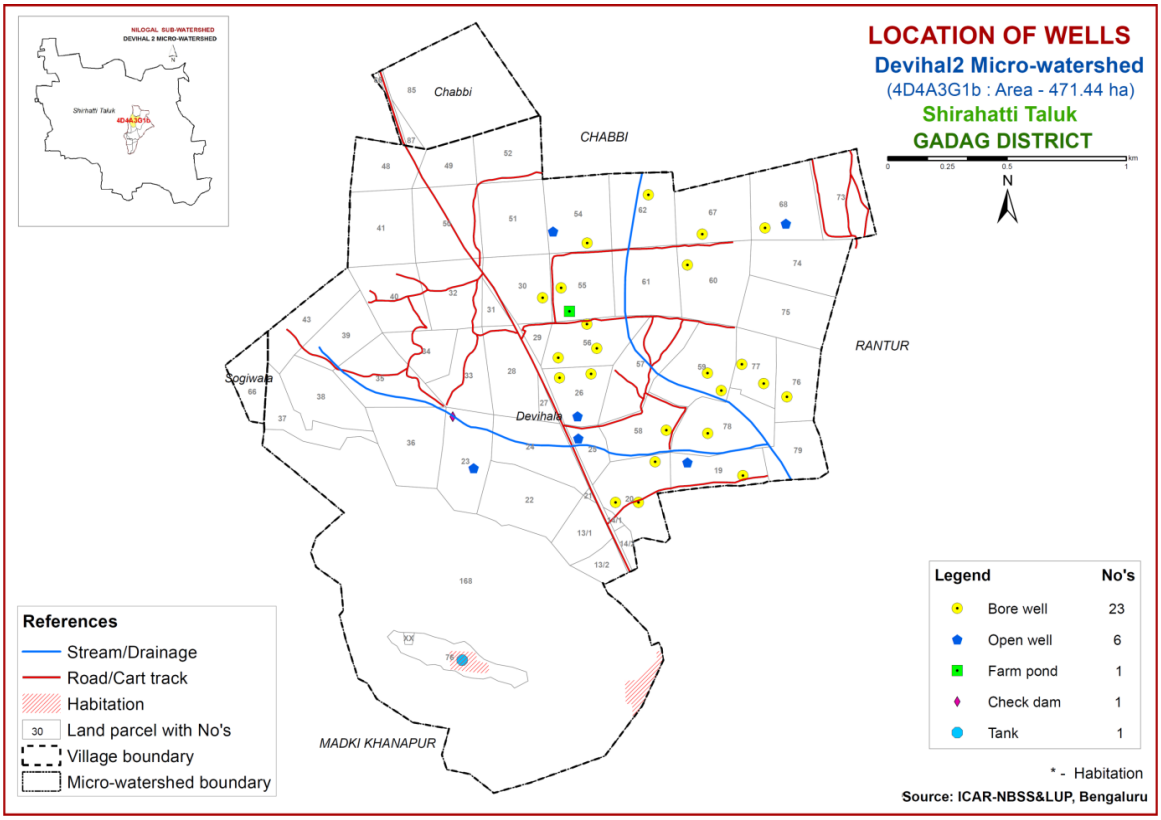


Fig.2.5 Location of Wells and Conservation Structures- Devihal-2 Microwatershed

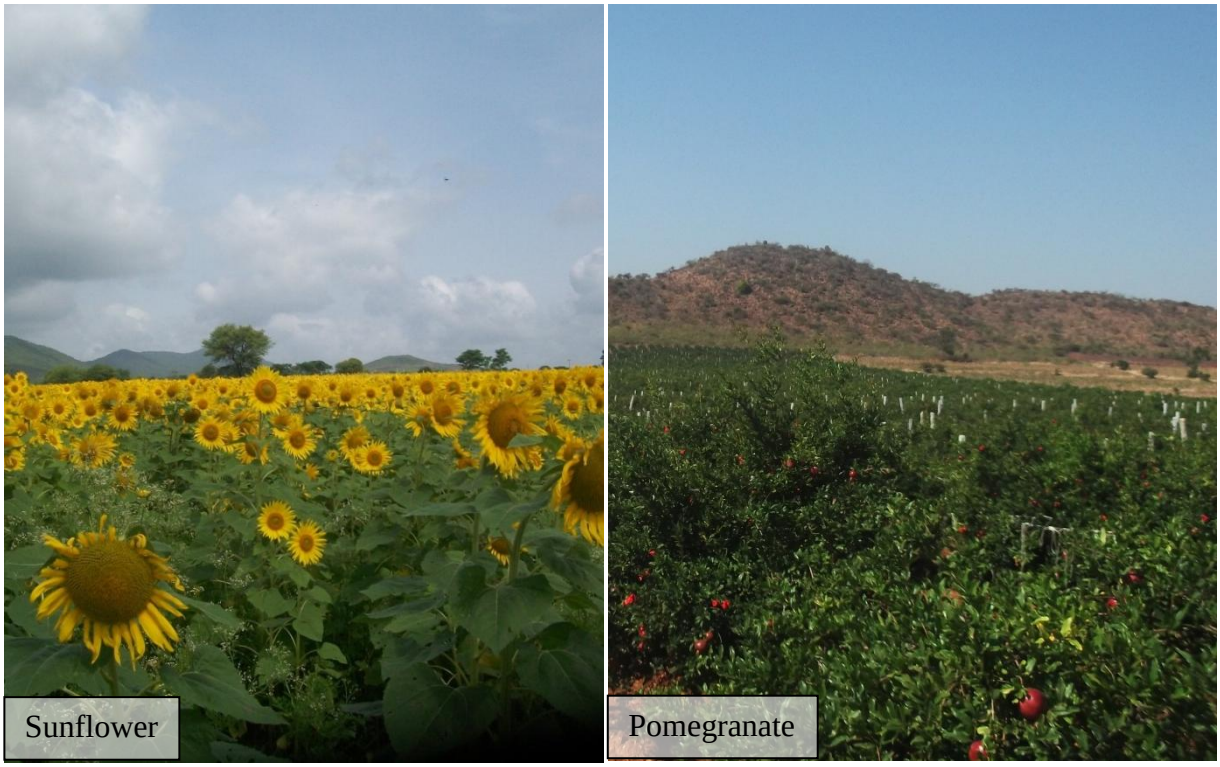


Fig. 2.6a Different crops and cropping systems in Devihal-2 Microwatershed

Fig. 2.6b Different crops and cropping systems in Devihal-2 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 Devihal-2 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, 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 soil survey at 1:7920 scale was carried out in 471 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 geology, landscapes, landforms and other surface features. The imagery helped in the identification and delineation of boundaries between hills, uplands and lowlands, water bodies, forest and vegetated areas, roads, habitations and other cultural features of the area (Fig.3.2).The cadastral map was overlaid on the satellite imagery (Fig.3.3) that helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were used for initial traversing, identification of geology, landscapes, landforms, drainage features and present land use and also for selection of transects in the microwatershed.

3.2 Image Interpretation for Physiography

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

Image Interpretation Legend for Physiography

G- Granite gneiss landscape

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

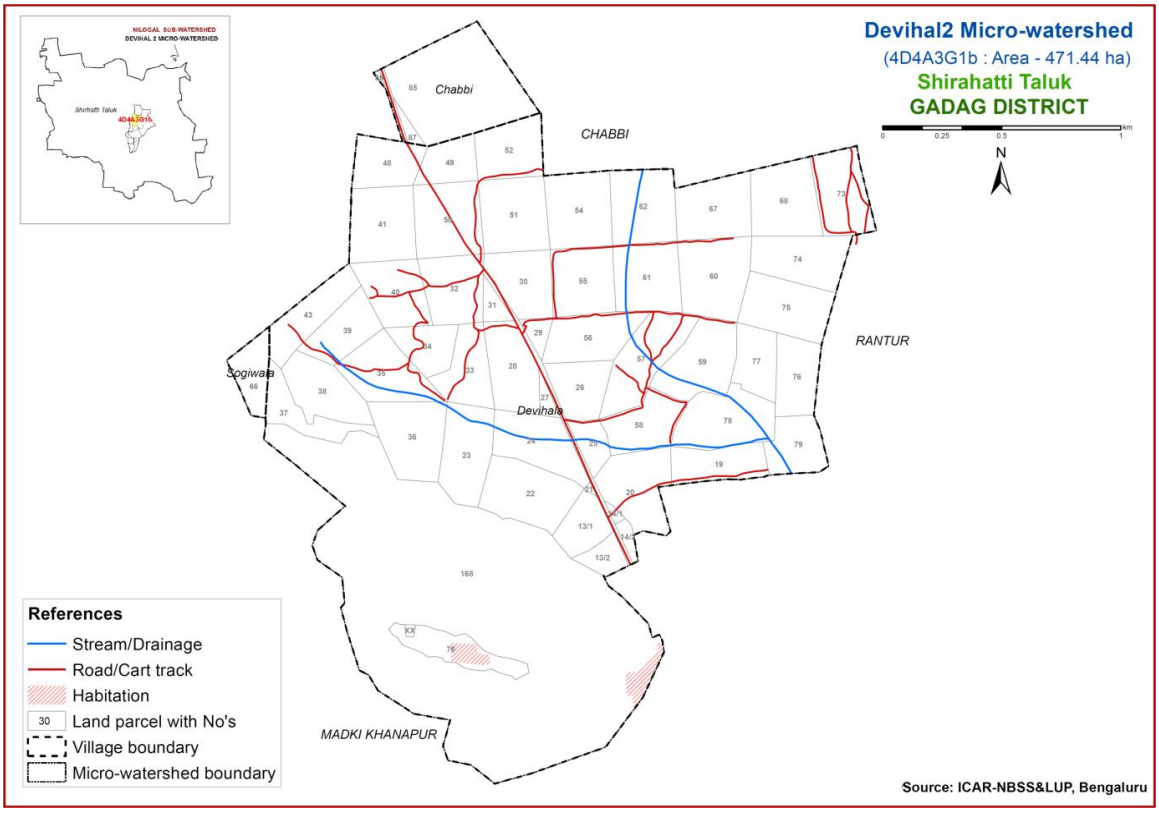


Fig 3.1 Scanned and Digitized Cadastral map of Devihal-2 Microwatershed

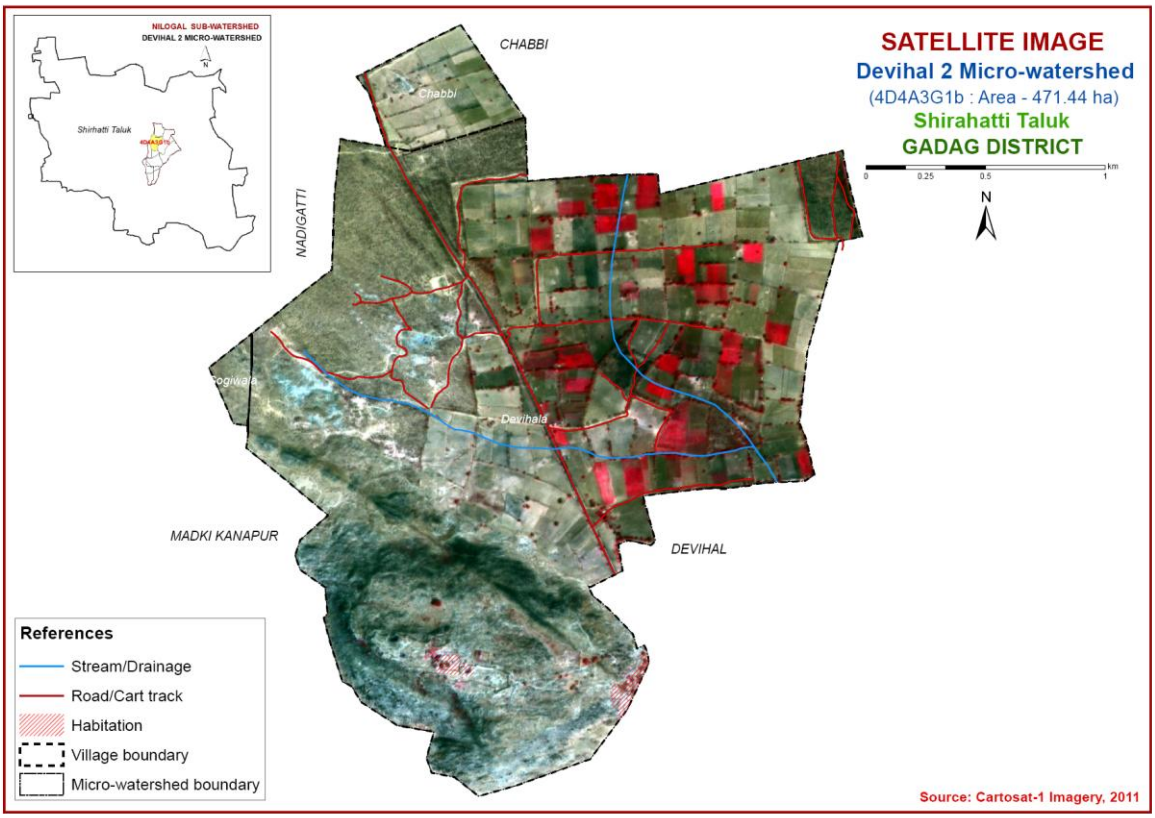


Fig.3.2 Satellite Image of Devihal-2 Microwatershed

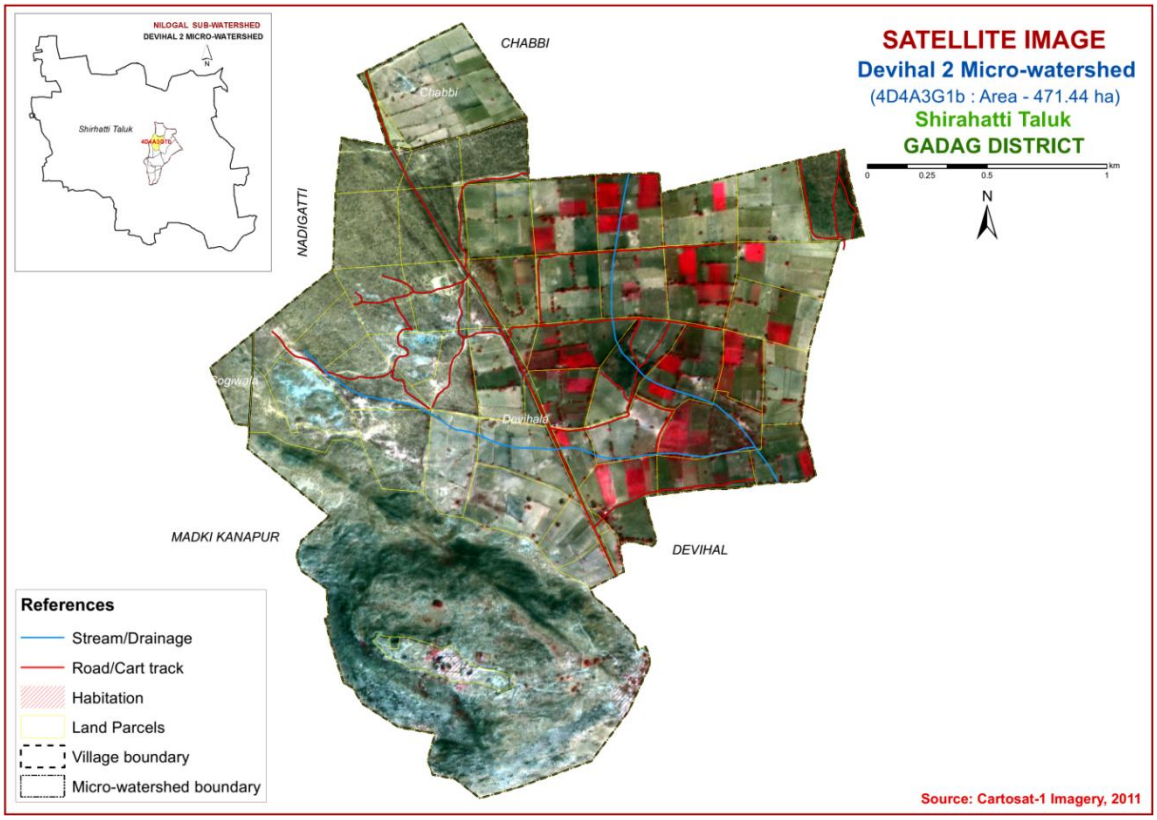


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Devihal-2 Microwatershed

3.3 Field Investigation

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

Based on the soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 10 soil series were identified in the Devihal-2 Microwatershed.

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

Soils of Granite Gneiss Landscape							
Sl. No	**Soil Series**	**Depth (cm)**	**Colour (moist)**	**Texture**	**Gravel (%)**	**Horizon & horizon sequence**	**Calcareousness**
1	Chikkamegheri (CKM)	75-100	2.5YR2.5/3, 3/4,3/6	sc	-	Ap-Bt-Cr	-
2	Chikkasavanur (CSR)	25-50	7.5YR3/2,3/ 3,3/4	scl	<15	Ap-Bw-Cr	-
3	Devihal (DVH)	<25	2.5YR2.5/4 5YR3/4 ,4/6	cl	<15	Ap-Cr	-
4	Kaggalipura (KGP)	25-50	2.5YR2.5/4	scl-sc	15-35	Ap-Bt-Cr	-
5	Kumchahalli (KMH)	100-150	2.5YR3/4, 3/6	scl-sc	<15	Ap-Bt-Cr	-
6	Kanchanahalli (KNH)	25-50	2.5YR3/4	sc	<15	Ap—Bt-Cr	-
7	Lakkur (LKR)	50-75	2.5YR3/4, 3/6	scl-sc	40-60	Ap-Bt-Bc-Cr	
8	Mukhadahalli (MKH)	50-75	5YR3/3,3/4, 4/3, 5/4,6/6 2.5YR3/4	scl	>35	Ap-Bt-Cr	-
9	Thammadahalli (TDH)	50-75	2.5YR2.5/4, 3/6	sc-c	-	Ap-Bt-Cr	-
10	Vaddarahalli (VDH)	100-150	7.5YR3/2,3/ 3,3/4	sc-c	-	Ap-Bt-Cr	-

3.4 Laboratory Characterization

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

3.5 Finalization of Soil Map

The area under each soil series was further separated and mapped as 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 soil map (Fig.3.4) in the form of symbols. During the survey about 18 soil profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.

The soil map shows the geographic distribution of 22 mapping units representing 10 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 22 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 22 soil phases identified and mapped in the microwatershed were regrouped into 6 Land Use Classes (LUC's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Use Classes (LUC's) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LUC's. For Devihal-2 Microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUC's. The land use classes are expected to behave similarly for a given level of management.

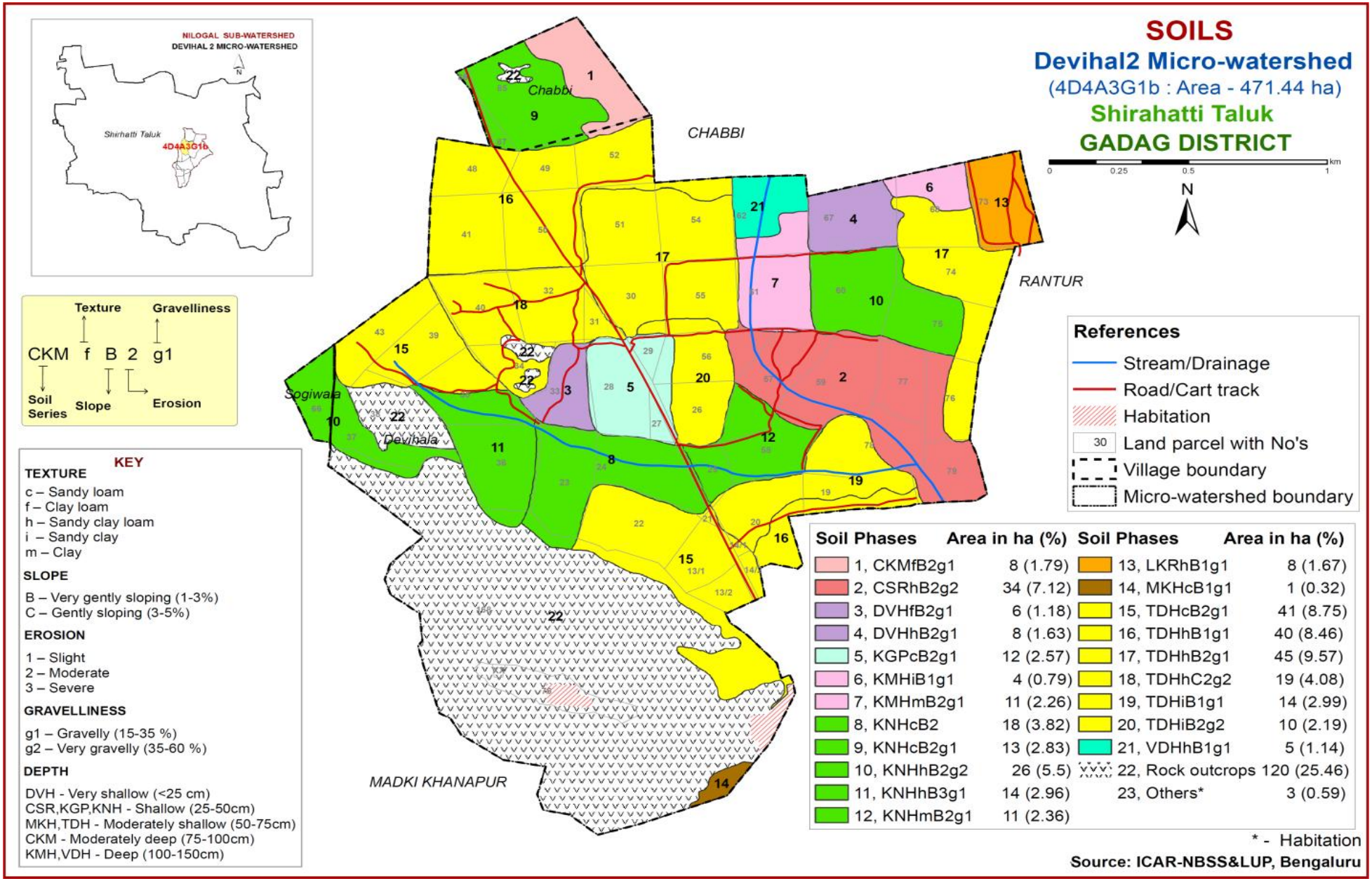


Fig 3.4 Soil Phase or Management Units- Devihal-2 Microwatershed

Table 3.2 Soil map unit description of Devihal-2 Microwatershed

Sl. No.	Soil Series	Soil Phases	Mapping Unit description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	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 to very gently sloping uplands under cultivation		**8.45 (1.79)**
1		CKMfB2g1	Clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	8.45 (1.79)
	CSR	Chikkasavanur soils are shallow (25-50 cm), well drained, have dark brown to light yellowish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation		**33.59 (7.12)**
2		CSRhB2g2	Sandy clay loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	33.59 (7.12)
	DVH	Devihal soils are very shallow (< 25 cm), well drained, have dark reddish brown to yellowish red clay loam soils occurring on very gently sloping uplands under cultivation		**13.26 (2.81)**
3		DVHfB2g1	Clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	5.56 (1.18)
4		DVHhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	7.70 (1.63)
	KGP	Kaggalipura soils are shallow (25-50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		**12.10 (2.57)**
5		KGPcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	12.10 (2.57)
	KMH	Kumchahalli soils are deep (100-150cm), well drained, have dark reddish brown to dark red sandy clay loam to sandy clay soils occurring on nearly level to very gently sloping uplands under cultivation		**14.35 (3.05)**
6		KMHiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	3.71 (0.79)
7		KMHmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	10.64 (2.26)
	KNH	Kanchanahalli soils are shallow (25 -50 cm), well drained, have dark reddish brown sandy clay soils occurring on very gently sloping uplands under cultivation		**82.33 (17.47)**
8		KNHcB2	Sandy loam surface, slope 1-3%, moderate erosion	17.99 (3.82)
9		KNHcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	13.34 (2.83)
10		KNHhB2g2	Sandy clay loam surface, slope 1-3%,	25.92

			moderate erosion, very gravelly (35-60%)	(5.50)
11		KNHhB3g1	Sandy clay loam surface, slope 1-3%, severe erosion, gravelly (15-35%)	13.93 (2.96)
12		KNHmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	11.15 (2.36)
	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on nearly level to gently and moderately sloping uplands under cultivation		**7.87 (1.67)**
13		LKRhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	7.87 (1.67)
	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation		**1.50 (0.32)**
14		MKHcB1g1	Sandy loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	1.50 (0.32)
	TDH	Thammadahalli soils are moderately shallow (50-75 cm), well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils occurring on nearly level to gently sloping uplands under cultivation		**169.85 (36.04)**
15		TDHcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	41.23 (8.75)
16		TDHhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	39.86 (8.46)
17		TDHhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	45.12 (9.57)
18		TDHhC2g2	Sandy clay loam surface, slope 3-5%, moderate erosion, very gravelly (35-60%)	19.22 (4.08)
19		TDHiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	14.09 (2.99)
20		TDHiB2g2	Sandy clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	10.33 (2.19)
	VDH	Vaddarahalli soils are deep (100-150 cm), well drained, have dark reddish brown to dark brown clayey soils occurring on nearly level to very gently sloping uplands under cultivation		**5.38 (1.14)**
21		VDHhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	5.38 (1.14)
22		Rock outcrops	Rock lands, both massive and bouldery	120.01 (25.46)
23		Habitation		2.77 (0.59)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Devihal-2 Microwatershed is provided in this chapter. The microwatershed area has been identified as granite gneiss landscape based on geology. In all, 10 soil series are identified. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. The soil formation is dominantly influenced by the parent material, climate and relief.

A brief description of each of the 10 soil series identified followed by 21 number of 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 characteristic that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Granite Gneiss Landscape

In this landscape, 10 soil series are identified and mapped. Of these, Thammadahalli (TDH) soil series occupies maximum area of about 170 ha (36%) and Kanchanahalli (KNH) 82 ha (17%) area. The brief description of each soil series and number of phases identified in the microwatershed are given below.

4.1.1 Chikkamegheri (CKM) Series: Chikkamegheri soils are moderately deep (75-100 cm), well drained, have dark brown to dark reddish brown red sandy clay soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands. The Chikkamegheri series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Rhodic Paleustalfs.

The thickness of the solum ranges from 76 to 100 cm. The thickness of A horizon ranges from 11 to 24 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2 to 4 and chroma 3 to 6. The texture varies from sandy clay loam to sandy clay with 10 to 15 per cent gravel. The thickness of B horizon ranges from 65 to 86 cm. Its colour is in 2.5 YR hue with value 2.5 to 3 and chroma 3 to 6. Its texture is dominantly sandy clay. The available water capacity is medium (100-150 mm/m).Only one phase was identified and mapped.

Landscape and soil profile characteristics of Chikkamegheri (CKM) Series

4.1.2 Chikkasavanur (CSR) Series: Chikkasavanur soils are shallow (25-50 cm), well drained, have dark brown to light yellowish brown sandy clay to clay soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Chikkasavanur series has been tentatively classified as a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 32 to 49 cm. The thickness of A horizon ranges from 12 to 23 cm. Its colour is in 7.5 YR and 10 YR hue with value 2.5 to 4 and chroma 3 to 6. The texture varies from sandy loam to clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 16 to 32 cm. Its colour is in 7.5 YR and 5 YR hue with value 3 and chroma 2 to 4. Its texture is sandy clay loam with gravel content of < 15 per cent. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Chikkasavanur (CSR) Series

4.1.3 Devihal (DVH) Series: Devihal soils are very shallow (< 25 cm), well drained, have dark reddish brown to yellowish red clay loam soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Devihal series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Ustorthents.

The thickness of the soil ranges from 11 to 25 cm. The thickness of A horizon ranges from 7 to 19 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2.5 to 6 and chroma 3 to 6. The texture varies from sandy clay loam to clay loam with 10 to 20 per cent gravel. The available water capacity is very low (<50 mm/m). Two phases were identified and mapped.

Landscape and soil profile characteristics of Devihal (DVH) Series

4.1.4 Kaggalipura (KGP) Series: Kaggalipura soils are shallow (25-50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Kaggalipura series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 26 to 49 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 7.5 YR, 5YR and 2.5 YR hue with value 2.5 to 4 and chroma 2 to 6. The texture varies from sandy clay loam to sandy clay with 10 to 25 per cent gravel. The thickness of B horizon ranges from 28 to 36 cm. Its colour is in 2.5 YR hue with value 2.5 and chroma 4. Its texture is sandy clay with gravel content of 15 to 35 per cent. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

Landscape and soil profile characteristics of Kaggalipura (KGP) Series

4.1.5 Kumchahalli (KMH) Series: Kumchahalli soils are deep (100-150cm), well drained, have dark reddish brown to dark red sandy clay loam to sandy clay soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands. The Kumchahalli series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Rhodustalfs.

The thickness of the solum ranges from 102 to 150 cm. The thickness of A horizon ranges from 11 to 23 cm. Its colour is in 5 YR and 2.5 YR hue with value 2.5 to 3 and chroma 3 to 6. The texture is dominantly sandy clay. The thickness of B horizon ranges from 95 to 132 cm. Its colour is in 2.5 YR hue with value 3 and chroma 4 to 6. Its texture is dominantly sandy clay. The available water capacity is high (150-200 mm/m). Two phases were identified and mapped.

Landscape and soil profile characteristics of Kumchahalli (KMH) Series

4.1.6 Kanchanahalli (KNH) Series: Kanchanahalli soils are shallow (25 -50 cm), well drained, have dark reddish brown sandy clay soils. They have developed from granite gneiss and occur on very gently sloping uplands. The Kanchanahalli series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Rhodustalfs.

Landscape and soil profile characteristics of Kanchanahalli (KNH) Series

The thickness of the solum ranges from 28 to 48 cm. The thickness of A horizon ranges from 12 to 18 cm. Its colour is in 5YR and 2.5 YR hue with value 3 and chroma 4 to 6. The texture varies from sandy clay loam to sandy clay with 10 to 15 per cent gravel. The thickness of B horizon ranges from 16 to 38 cm. Its colour is in 2.5 YR hue with value 3 to 4 and chroma 4 to 6. Its texture is sandy clay with gravel content of < 15 per cent. The available water capacity is low (50-100 mm/m). Five phases were identified and mapped.

4.1.7 Lakkur (LKR) Series: Lakkur soils are moderately shallow (50-75cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils. They have developed from granite gneiss and occur on nearly level to very gently and gently sloping uplands.TheLakkur series has been tentatively classified as a member of the clayey-skeletal, mixed, isohyperthermic family of Typic Rhodustalfs.

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

Landscape and soil profile characteristics of Lakkur (LKR) Series

4.1.8 Mukhadahalli (MKH) Series: Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils.

They are developed from weathered granite gneiss and occur on very gently to gently sloping uplands. The Mukhadahalli series has been tentatively classified as a member of the loamy-skeletal, mixed, isohyperthermic family of Typic Haplustalfs.

Landscape and soil profile characteristics of Mukhadahalli (MKH) Series

The thickness of the solum ranges from 51 to 72 cm. The thickness of A horizon ranges from 12 to 17 cm. Its colour is in 5 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from loamy sand to sandy loam with 20 to 45 per cent gravel. The thickness of B horizon ranges from 40 to 58 cm. Its colour is in 2.5 YR and 5 YR hue with value and chroma 3 to 6. Texture is sandy clay loam to sandy clay with 35 to 50 per cent gravel. The available water capacity is low (50-100 mm/m). Only one phase was identified and mapped.

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

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

Landscape and soil profile characteristics of Thammadahalli (TDH) Series

4.10 Vaddarahalli (VDH) Series: Vaddarahalli soils are deep (100-150 cm), well drained, have dark reddish brown to dark brown clayey soils. They have developed from granite gneiss and occur on nearly level to very gently sloping uplands. The Vaddarahalli series has been tentatively classified as a member of the fine, mixed, isohyperthermic family of Typic Haplustalfs.

The thickness of the solum ranges from 106 to 148 cm. The thickness of A horizon ranges from 13 to 23 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 and chroma 3 to 4. The texture varies from sandy loam to clay. The thickness of B horizon ranges from 95 to 132 cm. Its colour is in 7.5 YR and 5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is sandy clay to clay. The available water capacity is high (150-200 mm/m). Only one phase was identified and mapped.


Landscape and soil profile characteristics of Vaddarahalli (VDH) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

The most important soil and site characteristics that affect the land use and conservation needs of an area are land capability, soil depth, soil texture, coarse fragments, available water capacity, soil slope, soil erosion, soil reaction etc. These are interpreted from the data base generated through land resource inventory and several thematic maps are generated. These would help in identifying the areas suitable for growing crops and, soil and water conservation measures and structures needed thus helping to maintain good soil-health for sustained crop production. The various thematic maps generated are described below.

5.1 Land Capability Classification

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

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

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

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

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

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

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

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

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

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

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

Class VIII: Soil and other miscellaneous areas (rock lands) that have very severe limitations that nearly preclude their use for any crop production, but suitable for wildlife, recreation and installation of wind mills.

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

The land capability subclasses have been further subdivided into land capability units based on the kinds of limitations present in each subclass. Ten land capability units are used in grouping the soil map units. They are stony or rocky (0), erosion hazard (slope, erosion) (1), coarse texture (sand, loamy sand, sandy loam) (2), fine texture (cracking clay, silty clay) (3), slowly permeable subsoil (4), coarse underlying material (5), salinity/alkali (6), stagnation, overflow, high ground water table (7), soil depth (8) and fertility problems (9). The capability units thus identified have similar soil and land characteristics that respond similarly to a given level of management. The soils of the microwatershed have been classified upto land capability subclass level.

The 22 soil map units identified in the Devihal-2 microwatershed are grouped under 5 land capability Classes and 7 land capability subclasses. An area of (71 %) in the microwatershed is suitable for agriculture and 29% is not suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover major area of about 198 ha (42%) and are distributed in the northern, northwestern, central, southeastern and eastern part of the micowatershed with minor problems of soil and erosion. Moderately good cultivable lands (Class III) cover an area of about 42 ha (9%) and are distributed in the eastern part of the microwatershed with moderate problems of soil and erosion. The fairly good cultivable lands (Class IV) cover an area of about 94 ha (20%) and occur in the western, northern, central and northeastern part of the microwatershed. They have severe limitations of erosion and soil. The class VI lands cover about 14 ha (3%)bthat have severe limitations that make them not suitable for agriculture, but well suited for forestery, pasure etc. Soil and other miscellaneous areas (Class VIII) cover about 120 ha (25%) that have very severe limitations that preclude them for any crop productivity, but well suited for wildlife, recreation and installation of wind mills.

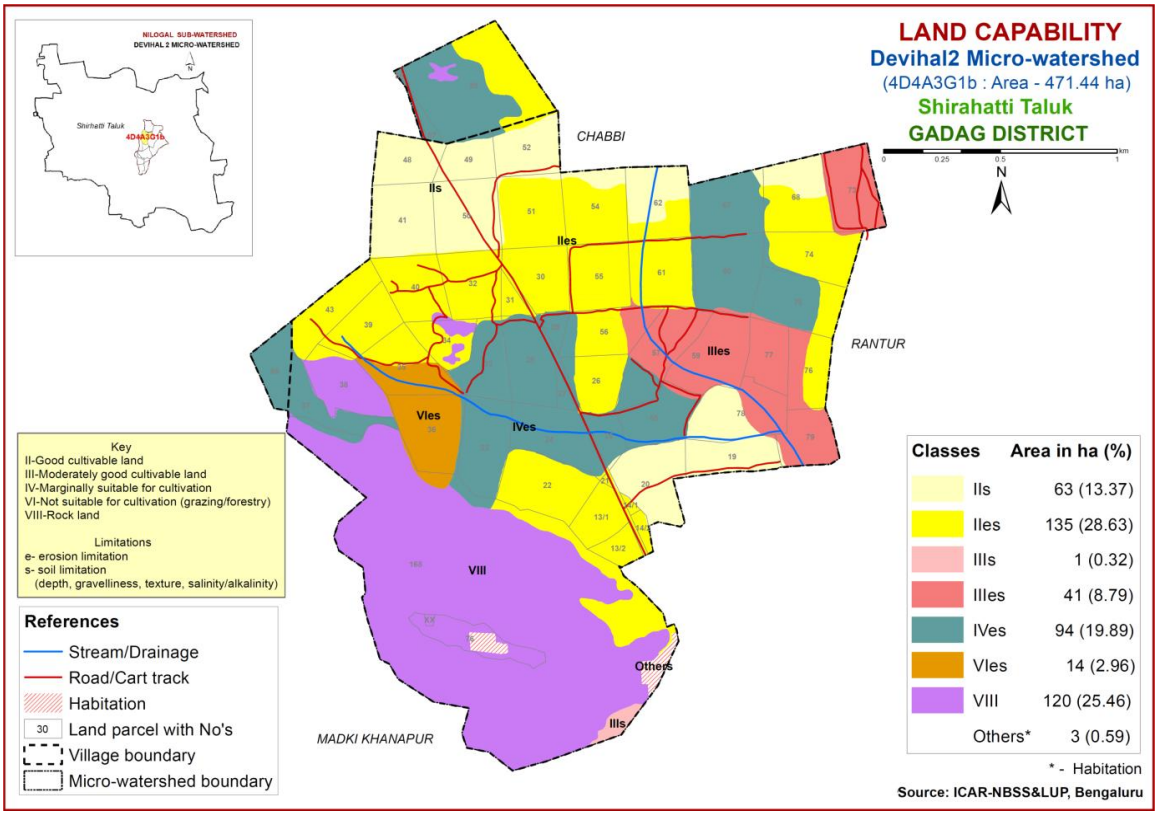


Fig. 5.1 Land Capability map of Devihal-2 Microwatershed

5.2 Soil Depth

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

Moderately shallow soils (50-75 cm) occupy maximum area of about 179 ha (38%) in the northwestern, central, southeastern and eastern part of the microwatershed. Shallow (25-50 cm) soils occupy an area of about 128 ha (27%) and are distributed in the western, central, northern and eastern part of the microwatershed. Moderately deep (75-100 cm) soils occupy a small area of about 8 ha (2%) and are distributed in the northern part of the microwatershed. Deep (100-150 cm) soils cover about 20 ha (4%) and occur in the northeastern part of the microwatershed. Very shallow (<25 cm) soils occupy an area of about 13 ha (3%) and occur in the central and northeastern part of the microwatershed.

The most problem lands with an area of about 141 ha (30%) having shallow (25-50 cm) to very shallow (<25 cm) rooting depth occur in major part of the microwatershed. They are not suitable for growing all agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal. The most productive soils cover 6 per cent that are moderately deep to deep (75-150 cm) and have potential for growing both annual and perennial crops.

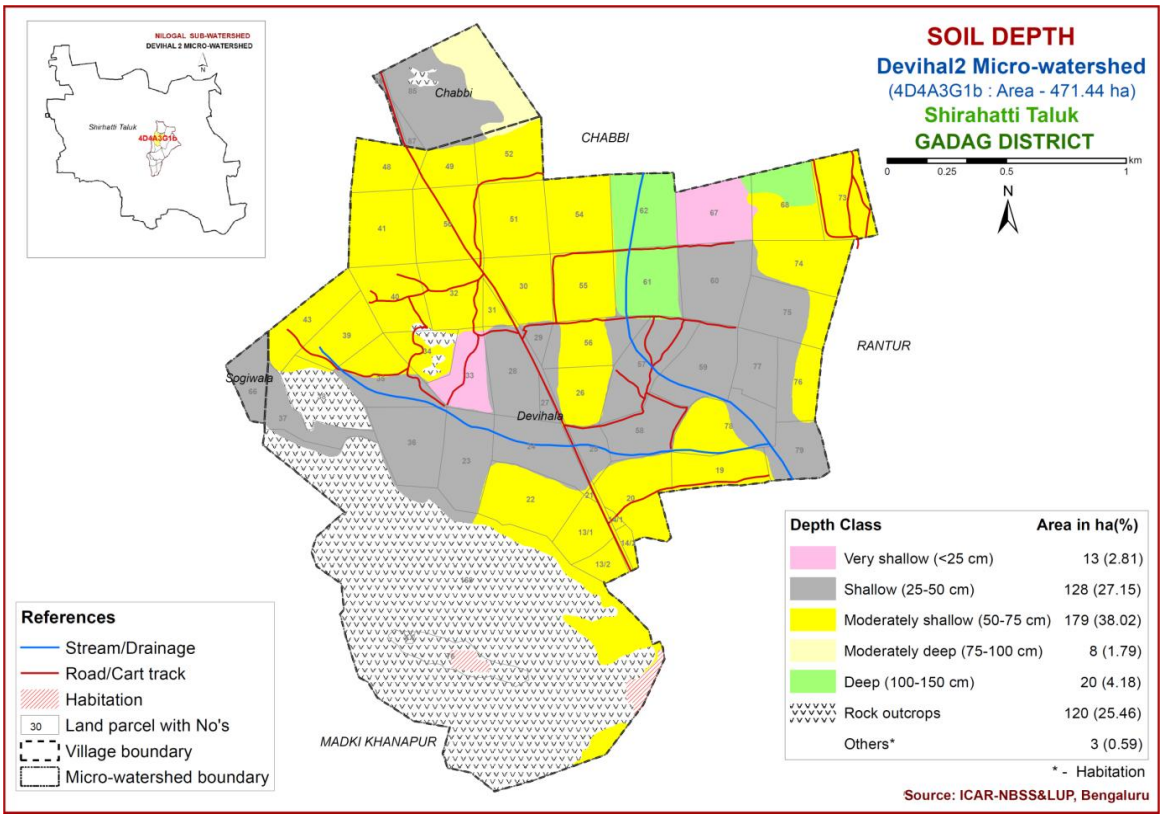


Fig. 5.2 Soil Depth map of Devihal-2 Microwatershed

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 for understanding the soil-water retention and availability, nutrient holding capacity, infiltration, workability, drainage, physical and chemical behaviour, microbial activity and crop suitability.

Maximum area of about 299 ha (63%) has soils that are loamy at the surface and are distributed in the northern, central and eastern part of the microwatershed. Clayey soils occupy an area of about 50 ha (11%) and occur in the central and southeastern part of the microwatershed (Fig. 5.3).

The most productive lands (74%) with respect to surface soil texture are the loamy and clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but clayey soils have problems of drainage, infiltration, workability and other physical problems.

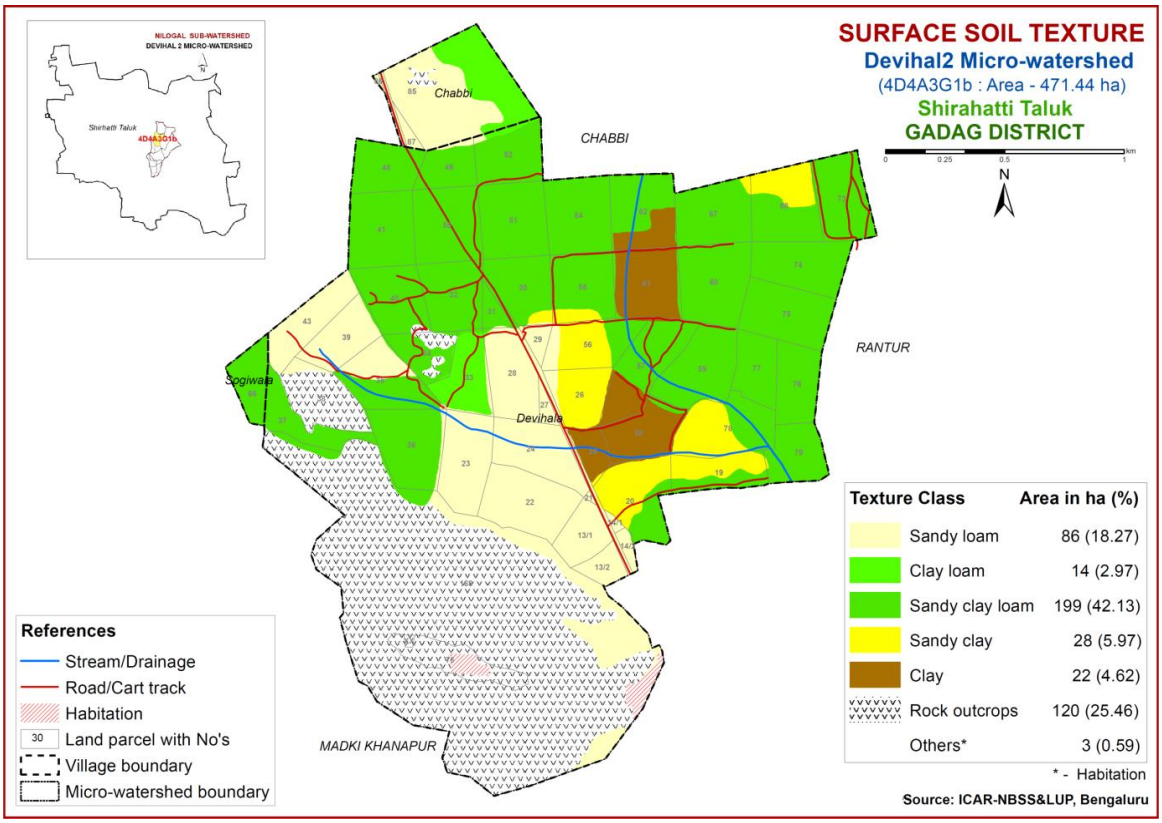


Fig. 5.3 Surface Soil Texture map of Devihal-2 Microwatershed

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.

About 89 ha (19%) area in the microwatershed has soils that are very gravelly (35-60%) and are distributed in the western, central and eastern part of the microwatershed (Fig. 5.4). Maximum area of 242 ha (51%) is covered by gravelly (15-35%) soils and are distributed in the western, central, northern and eastern part of the microwatershed. The soils that are non-gravelly (<15%) cover an area of about 18 ha (4%) and are distributed in the central parts of the microwatershed.

The most productive lands with respect to gravelliness are found to be 18 ha (4%). The problematic soils (19%) that are very gravelly (35-60%) where only short duration crops can be grown.

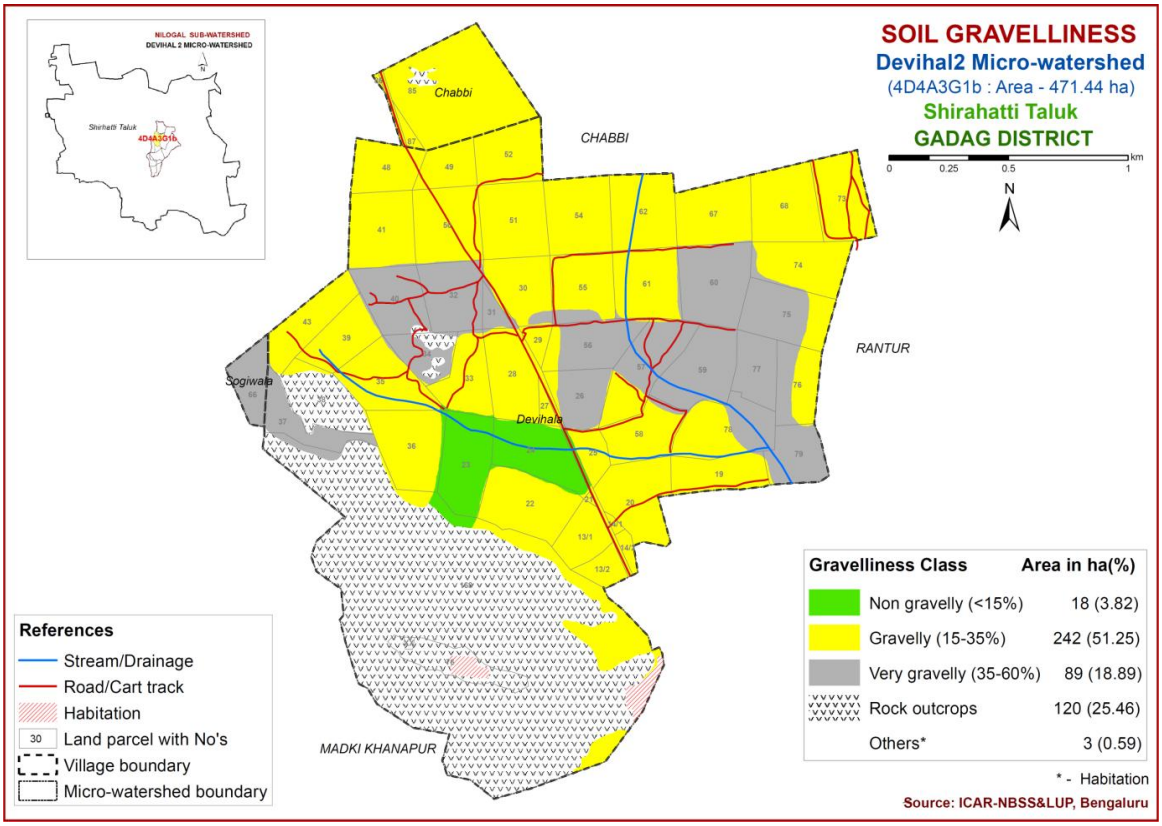


Fig. 5.4 Soil Gravelliness map of Devihal-2 Microwatershed

5.5 Available Water Capacity

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

An area of about 151 ha (32%) in the microwatershed has soils that are very low (<50mm/m) in available water capacity and are distributed in the northern, western, central and eastern part of the microwatershed. Major area of about 178 ha (38%) is low (51-100 mm/m) in available water capacity and are distributed in the northwestern, central, southeastern and eastern part of the microwateshed. An area of about 20 ha (4%) is medium (101-150 mm/m) in available water capacity and are distributed in small patches in the northeastern part of the micerowatershed.

An area of about 70 per cent 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. About 25 per cent of the area is covered by rock outcrops.

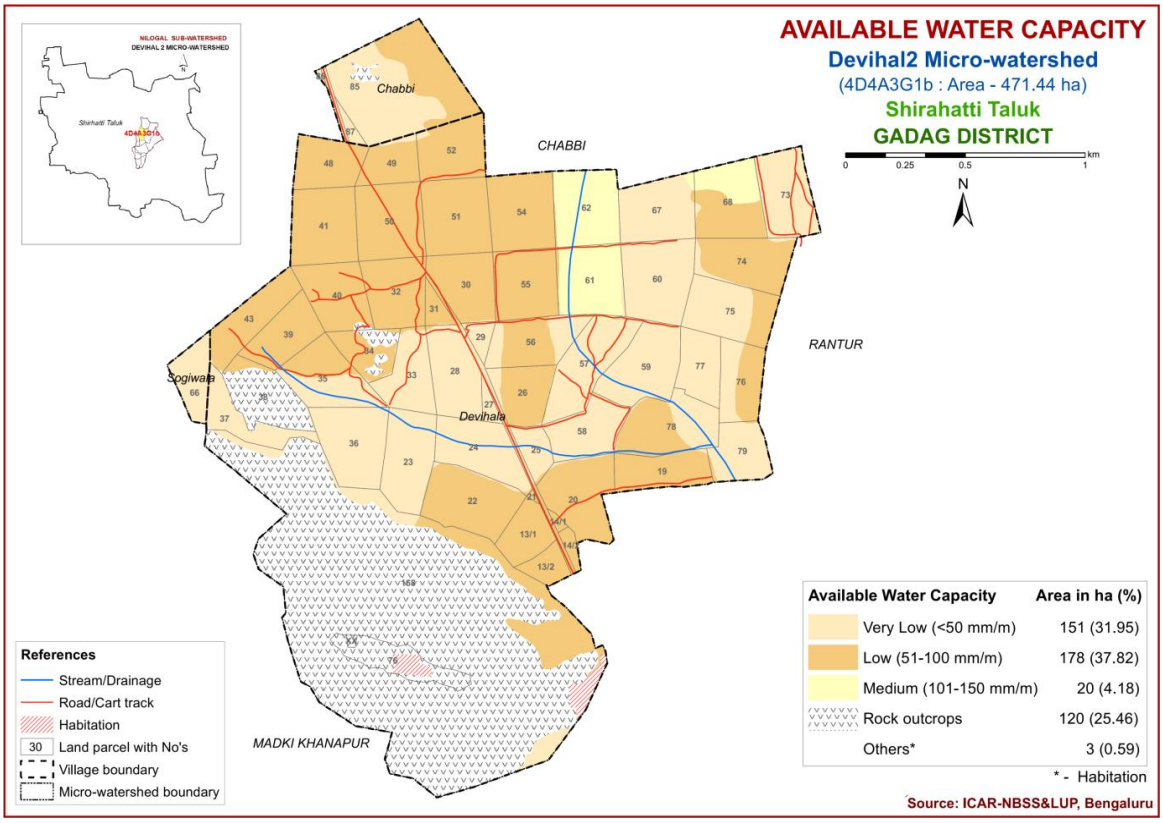


Fig. 5.5 Soil Available Water Capacity map of Devihal-2 Microwatershed

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).

An area of about 329 ha (70%) falls under very gently sloping (1-3% slope) lands and is distributed in all parts of the microwatershed. Gently sloping (3-5%) lands occupy an area of 19 ha (4%) and occur in the northwestern part of the microwatershed.

In these very gently sloping areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

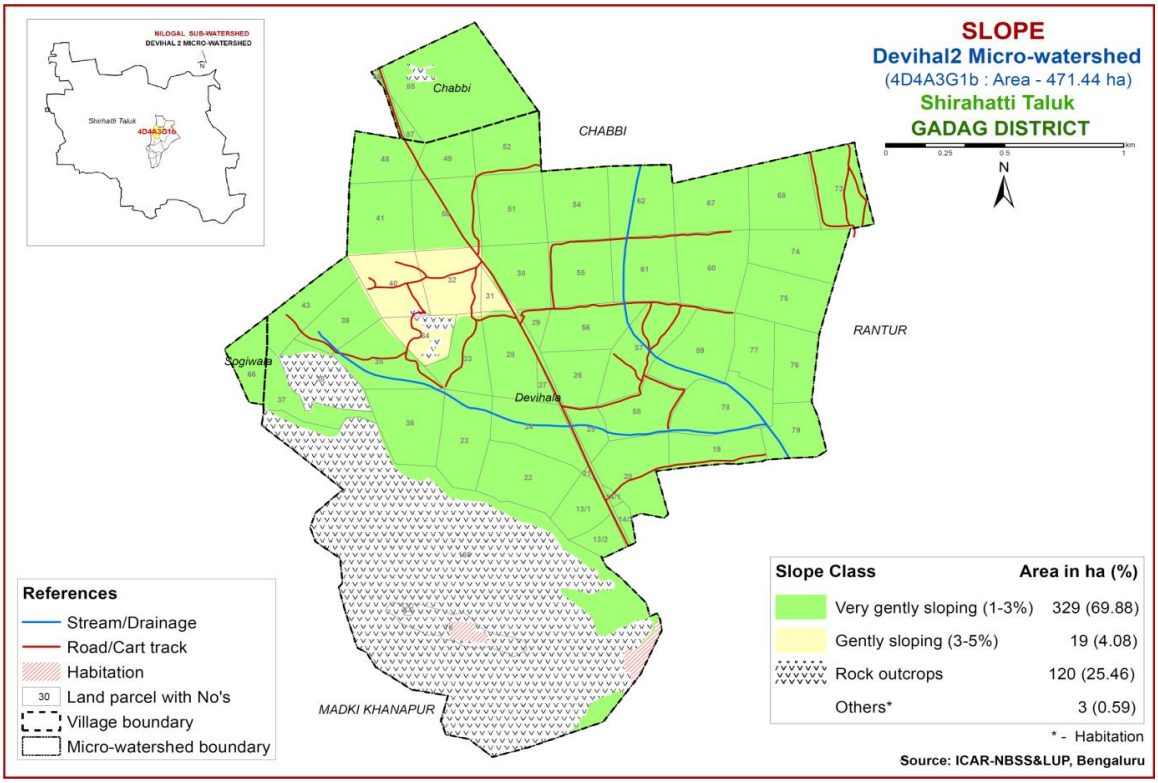


Fig. 5.6 Soil Slope map of Devihal-2 Microwatershed

5.7 Soil Erosion

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

Soils that are moderately eroded (e2 class) cover maximum area of about 262 ha (56%) in the microwatershed. They are distributed in the northern, western, central and eastern part of the microwatershed. Slightly eroded (e1 class) soils cover an area of about 72 ha (15%) and are distributed in the nothwestern, northeastern and southeastern part of the microwatershed. Severely eroded (e3 class) soils cover a very small area of about 14 ha (3%) and occur in the central part of the microwatershed.

The problem lands with respect to erosion are severely eroded and moderately eroded areas. These need appropriate soil and water conservation and, other land development measures to restore soil-health.

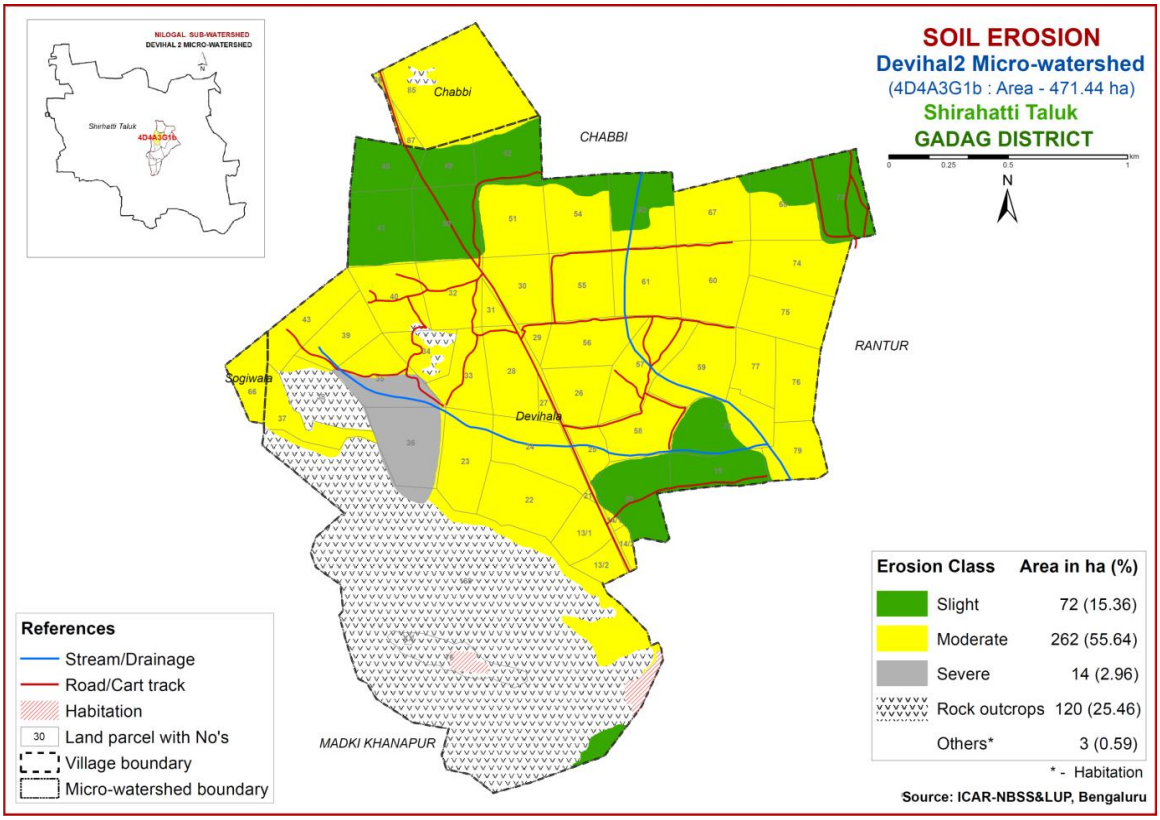


Fig. 5.7 Soil Erosion map of Devihal-2 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status as the area is characterised by low rainfall and high temperature. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m grid 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, boron, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil analysis of the Devihal-2 microwatershed for soil reaction (pH) showed that an area of about 81 ha (17%) is moderately alkaline (pH 7.8-8.4) and is distributed in the northern, central and eastern part of the microwatershed. An area of about 59 ha (12%) is under strongly alkaline (pH 8.4-9.0) and occur in the eastern part of the microwatershed. Slightly alkaline (pH 7.3-7.8) soils occupy an area of about 39 ha (8%) and are distributed in the western, central and southeastern part of the microwatershed. An area of about 85 ha (18%) is neutral (6.5-7.3) and are distributed in the northern, northeastern, central and western part of the microwatershed (Fig.6.1). An area of about 67 ha (14%) is slightly acid and is distributed in the northwestern and southeastern part of the microwatershed and a very small area of about 18 ha (4%) is moderately acid (pH 5.5-6.0) and occur in the northwestern 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 as such the soils are nonsaline.

6.3 Organic Carbon

The soil organic carbon (an index of available Nitrogen) content of the soils of the microwatershed is medium (0.5-0.75%) covering an area of about 58 ha (12%) and is distributed in the western and eastern part of the microwatershed. Maximum area of 288

ha (61%) is low (<0.5%) in organic carbon content and occur in major part of the microwatershed (Fig.6.3).

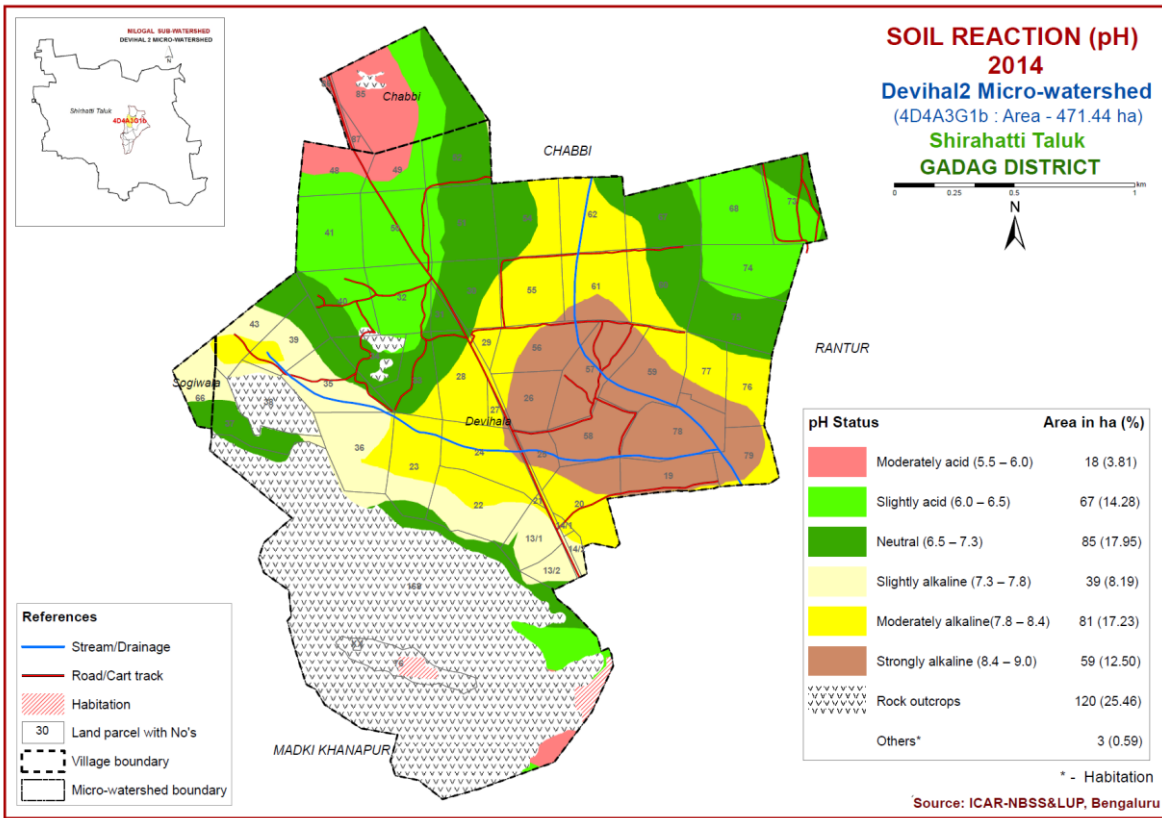


Fig.6.1 Soil Reaction (pH) map of Devihal-2 Microwatershed

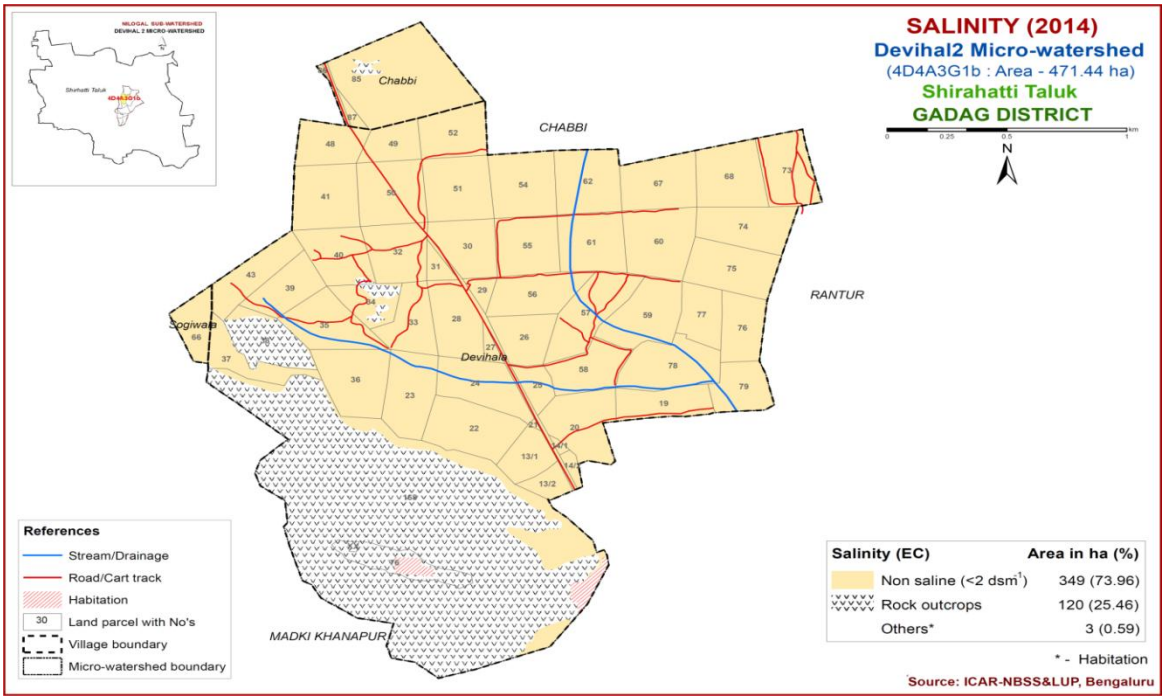


Fig.6.2 Electrical Conductivity (EC) map of Devihal-2 Microwatershed

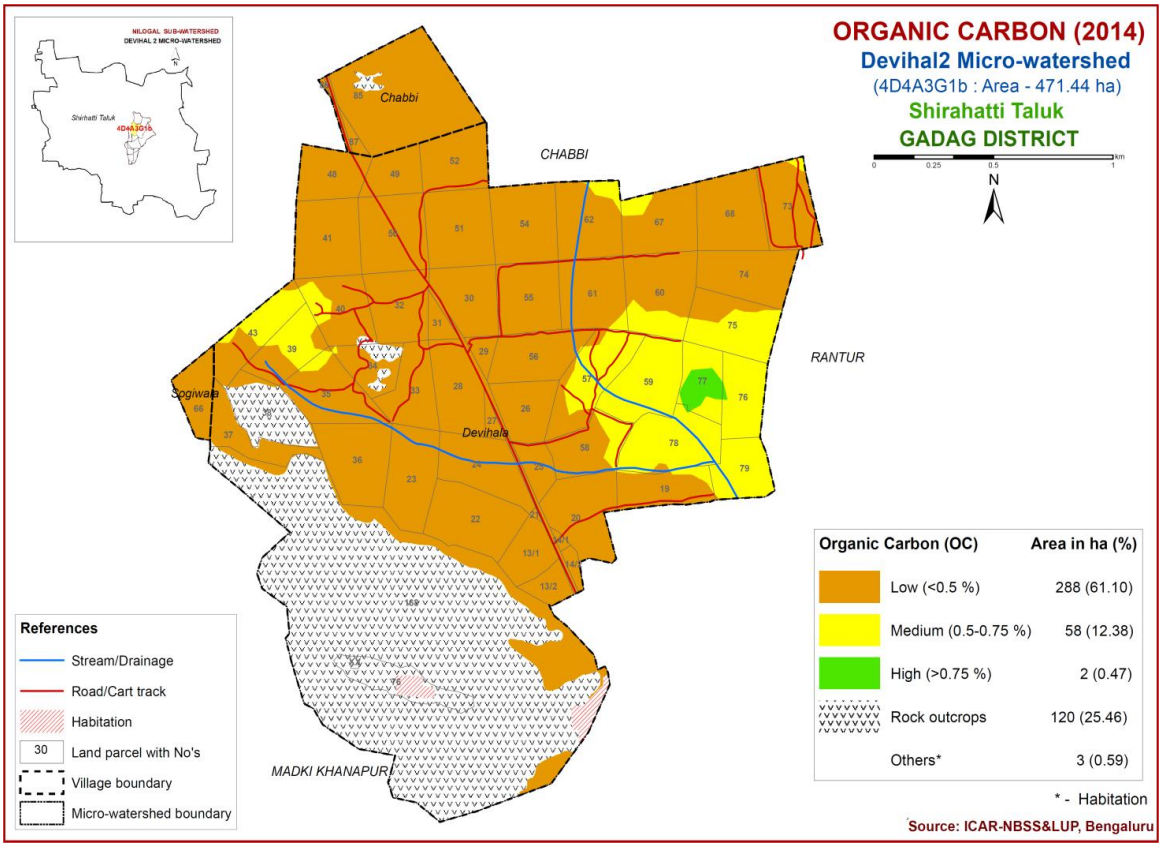


Fig.6.3 Soil Organic Carbon map of Devihal-2 Microwatershed

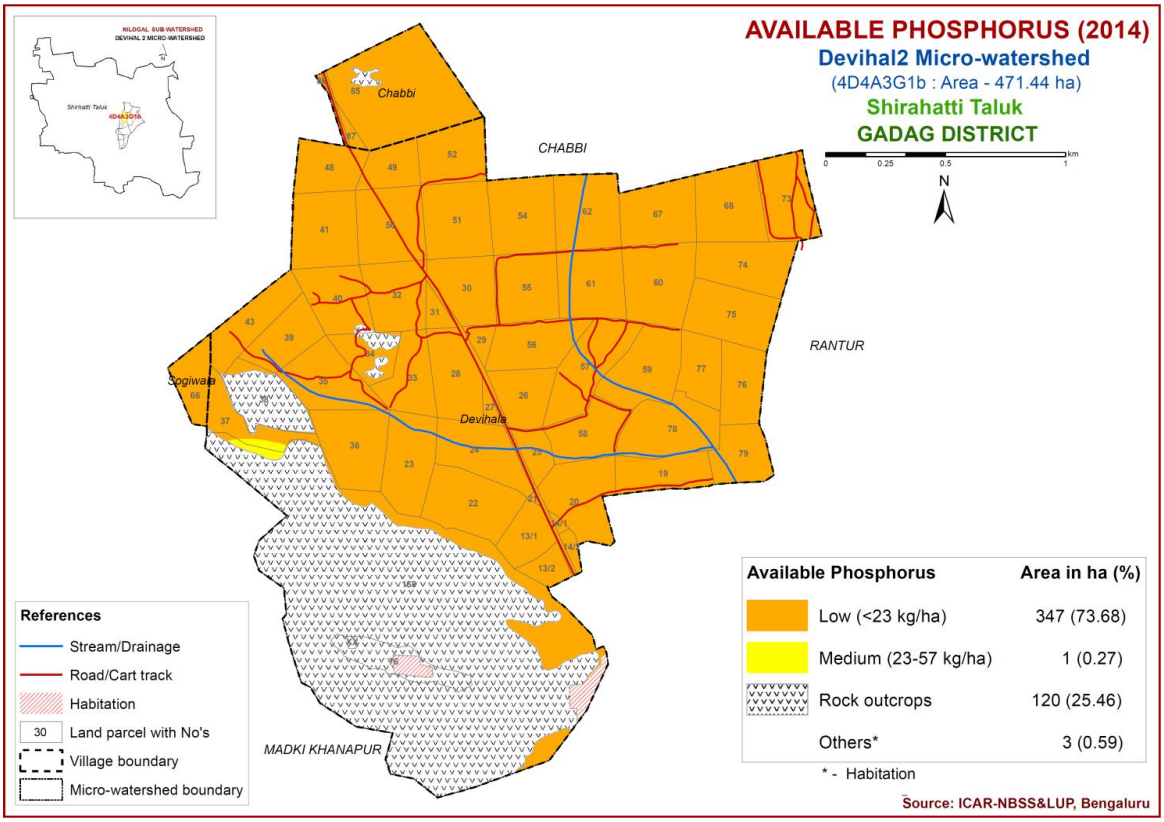


Fig.6.4 Soil Available Phosphorus map of Devihal-2 Microwatershed

6.4 Available Phosphorus

Available phosphorus content of the soils is low (<23 kg/ha) in an area of about 347 ha (74%) and are distributed in major area of the microwatershed (Fig 6.4).

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in maximum area of about 332 ha (70%) and is distributed in major part of the microwatershed (Fig.6.5). Low available potassium (<145 kg/ ha) content accounts for 15 ha (3%) and are distributed in small patches in the western, central and northeastern part of the microwatershed.

6.6 Available Sulphur

Maximum area of about 314 ha (66%) is medium (10-20 ppm) in available sulphur and is distributed in major part of the microwatershed. An area of about 35 ha (7%) is high (>10 ppm) and occur in small patches in the northeastern and central part of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in maximum area of 218 ha (46%) in the microwatershed and are distributed in the northwestern, western, central and northeastern part of the microwatershed. An area of about 69 ha (15%) is low (<0.5 ppm) in available boron and occur in the northern, western and northeastern part of the microwatershed (Fig.6.7). Available boron content is high (>1.0 ppm) in an area of about 62 ha (13%) and is distributed in the western, central and eastern part of the microwatershed.

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in an area of 121 ha (26%) and are distributed in the western, central, eastern and northern parts of the microwatershed. Maximum area of about 227 ha (48%) area is deficient (<4.5 ppm) in available iron content and are distributed in the northwestern, central and eastern part of the microwatershed (Fig 6.8).

6.9 Available Manganese

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

6.10 Available Copper

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

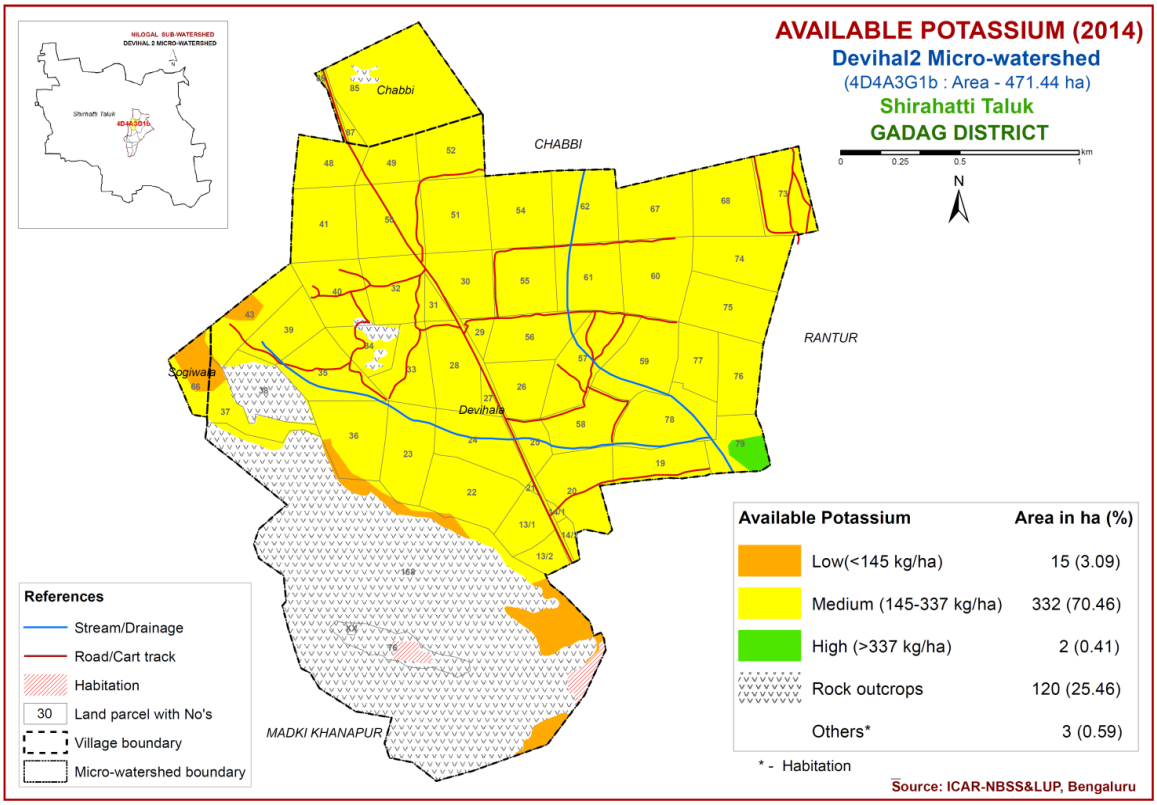


Fig.6.5 Soil Available Potassium map of Devihal-2 Microwatershed

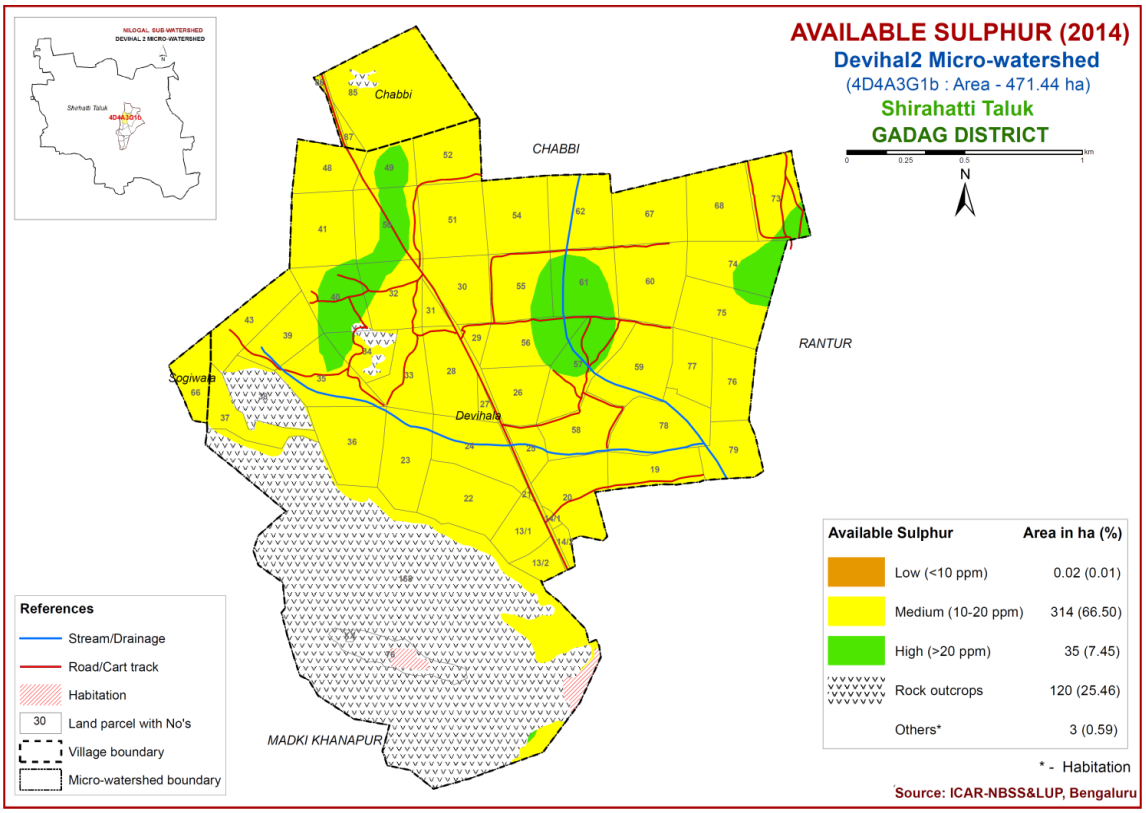


Fig.6.6 Soil Available Sulphur map of Devihal-2 Microwatershed

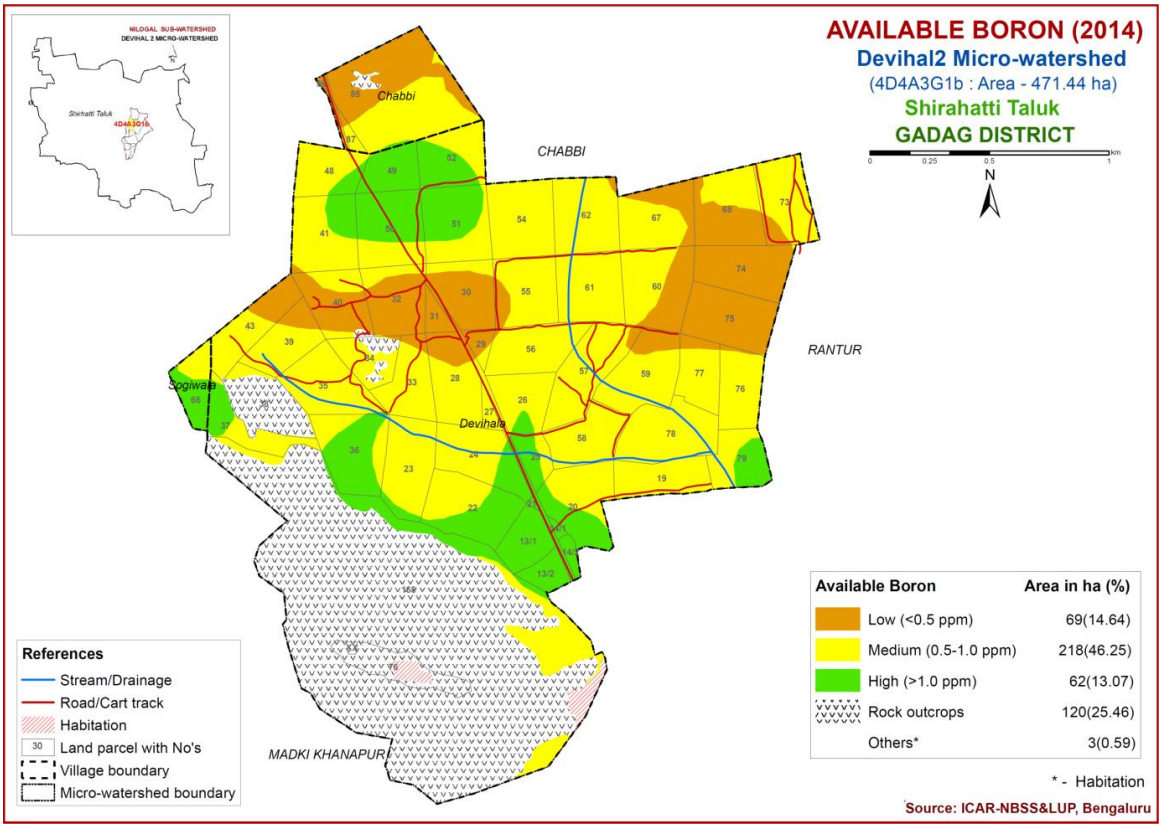


Fig.6.7 Soil Available Boron map of Devihal-2 Microwatershed

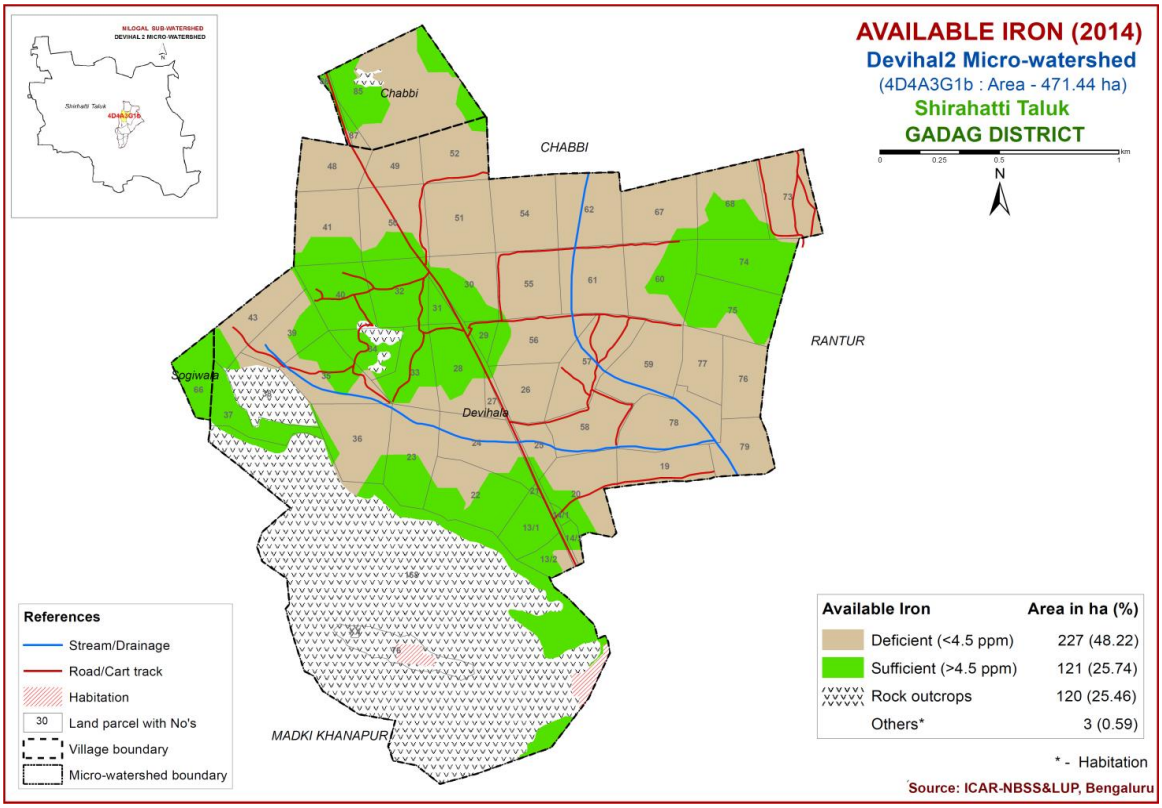


Fig.6.8 Soil Available Iron map of Devihal-2 Microwatershed

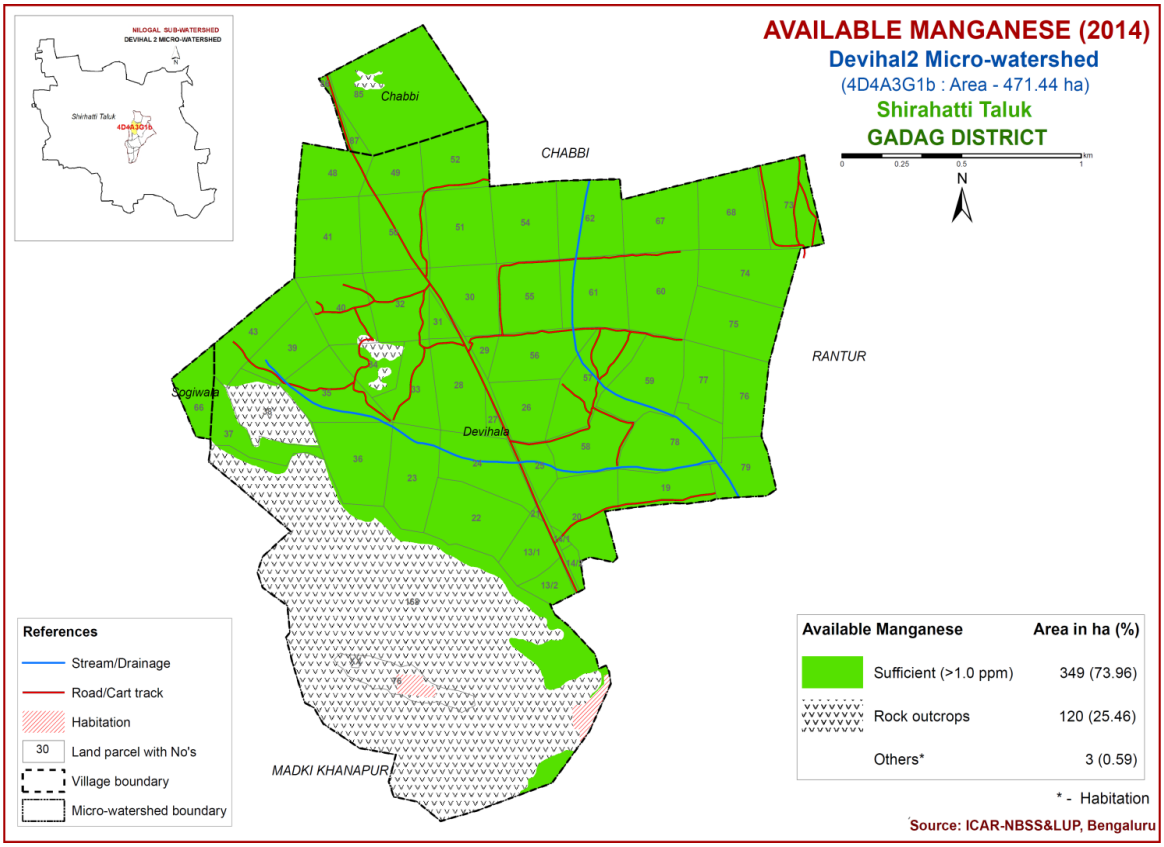


Fig.6.9 Soil Available Manganese map of Devihal-2 Microwatershed

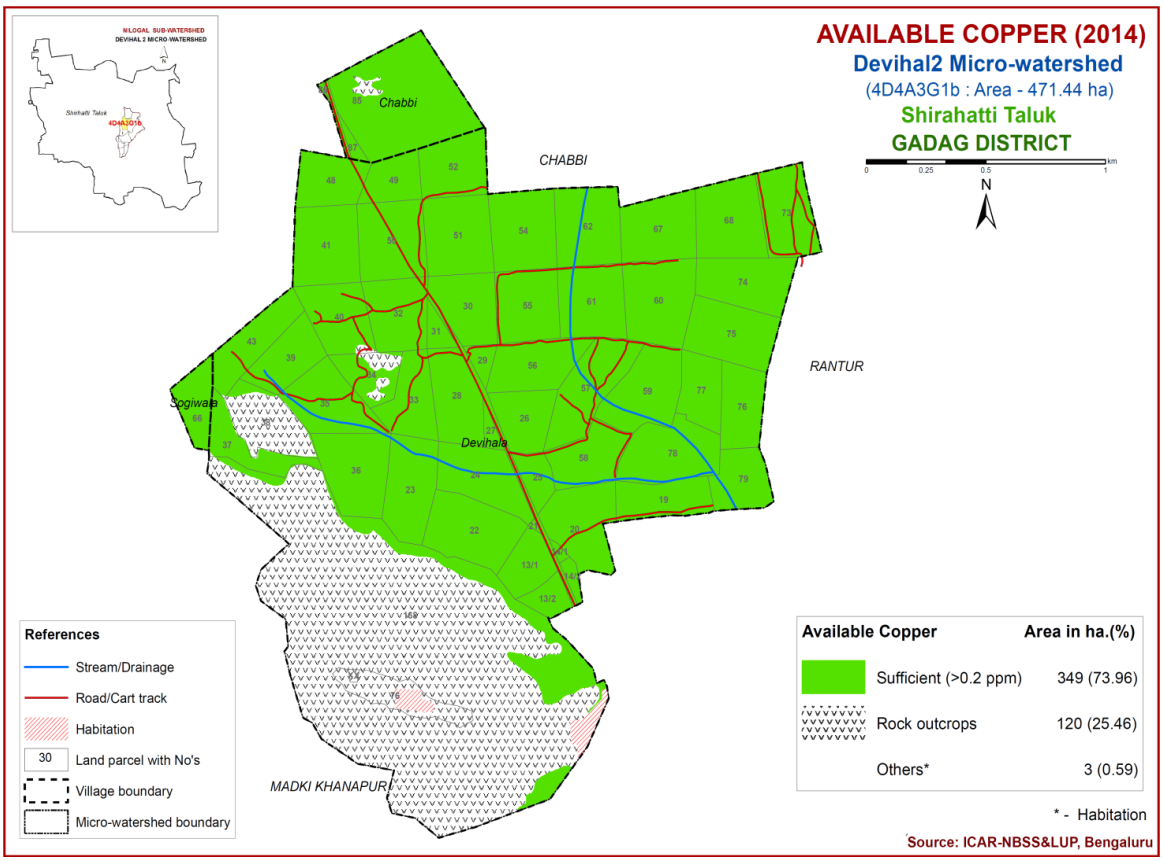


Fig.6.10 Soil Available Copper map of Devihal-2 Microwatershed

6.11 Available Zinc

Available zinc content is sufficient (>0.6 ppm) in an area of 31 ha (7%) and are distributed in the northern, central and eastern part of the microwatershed. Maximum area of about 317 ha (67%) is deficient (<0.6 ppm) in available zinc content and occur in all parts of the microwatershed (Fig 6.11).

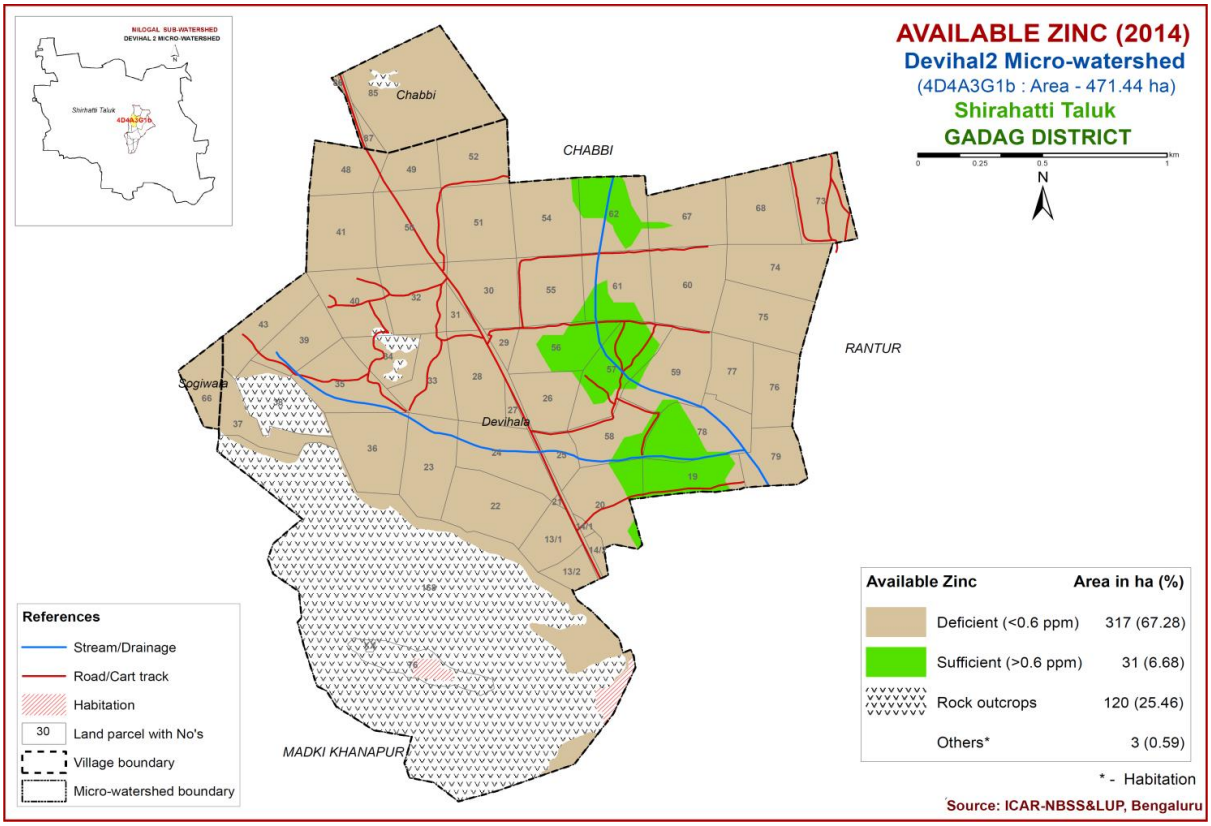


Fig.6.11 Soil Available Zinc map of Devihal-2 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Devihal-1 Microwatershed were assessed for their suitability for growing food, fodder, fibre and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S- Suitable and Order N- Not suitable. The orders have classes, subclasses and units. Order-S has three classes, class S1- Highly Suitable, class S2- Moderately Suitable and class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability, 'z' for calcareousness and 'w' for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 23 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and aChamarajnagar districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing sorghum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure. 7.1.

Highly suitable (Class S1) lands occupy small area of about 14 ha (3%) for growing sorghum and occur in the northern part of the microwatershed. An area of about 154 ha (33%) is moderately suitable (Class S2) for growing sorghum and are distributed in the northeastern, central and southeastern part the microwatershed.

Table 7.1 Soil-Site Characteristics of Devihal-2 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage Class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol $(p^+)kg^{-1}$]	BS (%)
					Surface	Sub-surface	Surface (%)	Sub surface (%)								
CKMfB2g1	633	150	WD	75-100	sc	sc	15-35	-	100-150	1-3	moderate					
CSRhB2g2	633	150	WD	25-50	scl	scl	35-60	<15	50-100	1-3	moderate					
DVHfB2g1	633	150	WD	<25	cl	scl	15-35	<15	<50	1-3	moderate					
DVHhB2g1	633	150	WD	<25	cl	cl	15-35	<15	<50	1-3	moderate					
KGPcB2g1	633	150	WD	25-50	scl-sc	scl-sc	15-35	15-35	50-100	1-3	moderate					
KMHiB1g1	633	150	WD	100-150	scl-sc	scl-sc	15-35	<15	150-200	1-3	slight					
KMHmB2g1	633	150	WD	100-150	scl-sc	scl-sc	15-35	<15	150-200	1-3	moderate					
KNHcB2	633	150	WD	25-50	sc	sc	-	<15	50-100	1-3	moderate					
KNHcB2g1	633	150	WD	25-50	sc	sc	15-35	<15	50-100	1-3	moderate					
KNHhB2g2	633	150	WD	25-50	sc	sc	35-60	<15	50-100	1-3	moderate					
KNHhB3g1	633	150	WD	25-50	sc	sc	15-35	<15	50-100	1-3	severe					
KNHmB2g1	633	150	WD	25-50	sc	sc	15-35	<15	50-100	1-3	moderate					
LKRhB1g1	633	150	WD	50-75	scl-sc	scl-sc	15-35	15-35	50-100	1-3	slight					
MKHcB1g1	633	150	WD	50-75	scl	scl	15-35	>35	50-100	1-3	slight					
TDHcB2g1	633	150	WD	50-75	sc-c	sc-c	15-35	-	100-150	1-3	moderate					
TDHhB1g1	633	150	WD	50-75	sc-c	sc-c	15-35	-	100-150	1-3	moderate					
TDHhB2g1	633	150	WD	50-75	sc-c	sc-c	15-35	-	100-150	1-3	moderate					
TDHhC2g2	633	150	WD	50-75	sc-c	sc-c	35-60	-	100-150	3-5	moderate					
TDHiB1g1	633	150	WD	50-75	sc-c	sc-c	15-35	-	100-150	1-3	slight					
TDHiB2g2	633	150	WD	50-75	sc-c	sc-c	35-60	-	100-150	1-3	moderate					
VDHhB1g1	633	150	MWD	100-150	sc-c	sc-c	15-35	-	150-200	1-3	slight					

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

They have minor limitations of gravelliness and rooting depth. Marginally suitable (Class S3) for growing sorghum occupy major area of about 167 ha (35%) and occur in the western, central and eastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 13 ha (3%) is not suitable (Class N) for growing sorghum with severe limitation of rooting depth. They are distributed in small patches in the central and northeastern part of the microwatershed.

Table 7.2 Crop suitability criteria for Sorghum

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

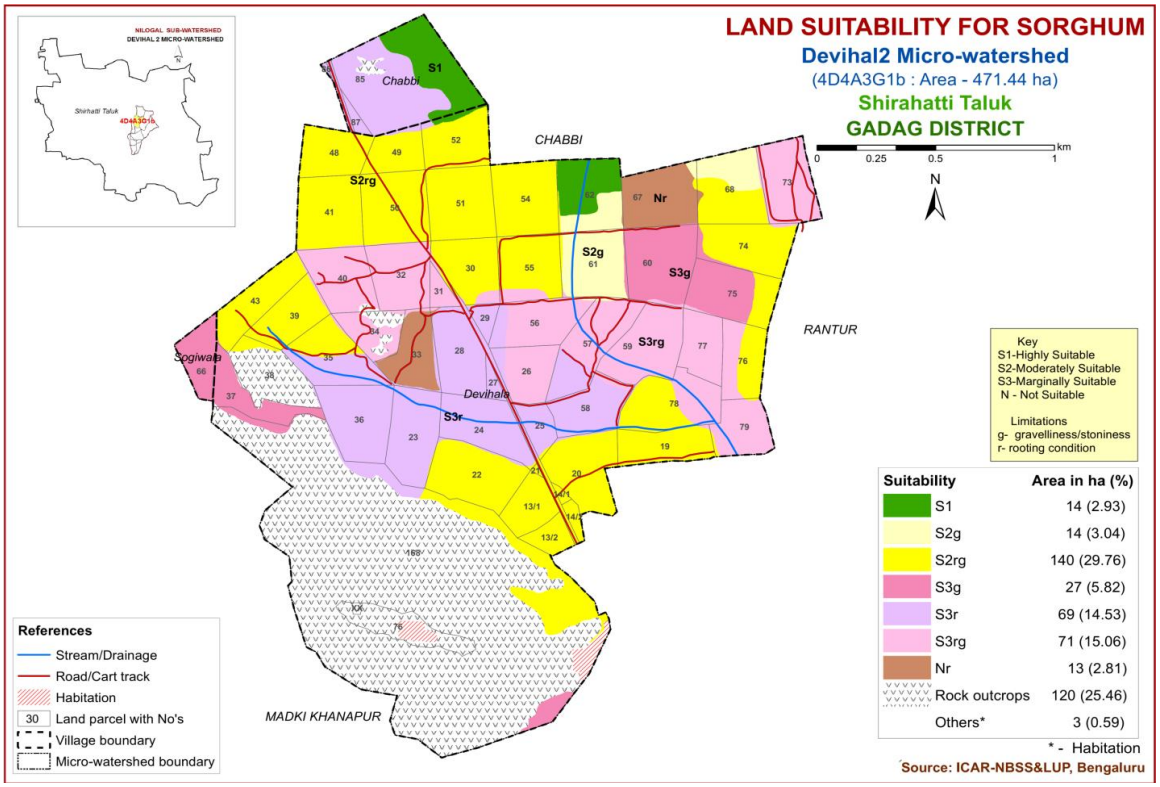


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.37 lakh ha in almost all the districts of the State. The crop requirements for growing maize (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing maize was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2.

A very small area of about 14 ha (3%) is highly suitable (Class S1) for growing maize and occur in the northern part of the microwatershed. Moderately suitable (Class S2) lands occupy an area of about 154 ha (33%) and are distributed in the western, central and southeastern part the microwatershed. They have minor limitations of gravelliness and rooting depth. Marginally suitable (Class S3) for growing sorghum occupy major area of about 167 ha (35%) and occur in the western, central and eastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 13 ha (3%) is not suitable for growing maize with severe limitation of rooting depth. They are distributed in the central and northeastern part of the microwatershed.

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	

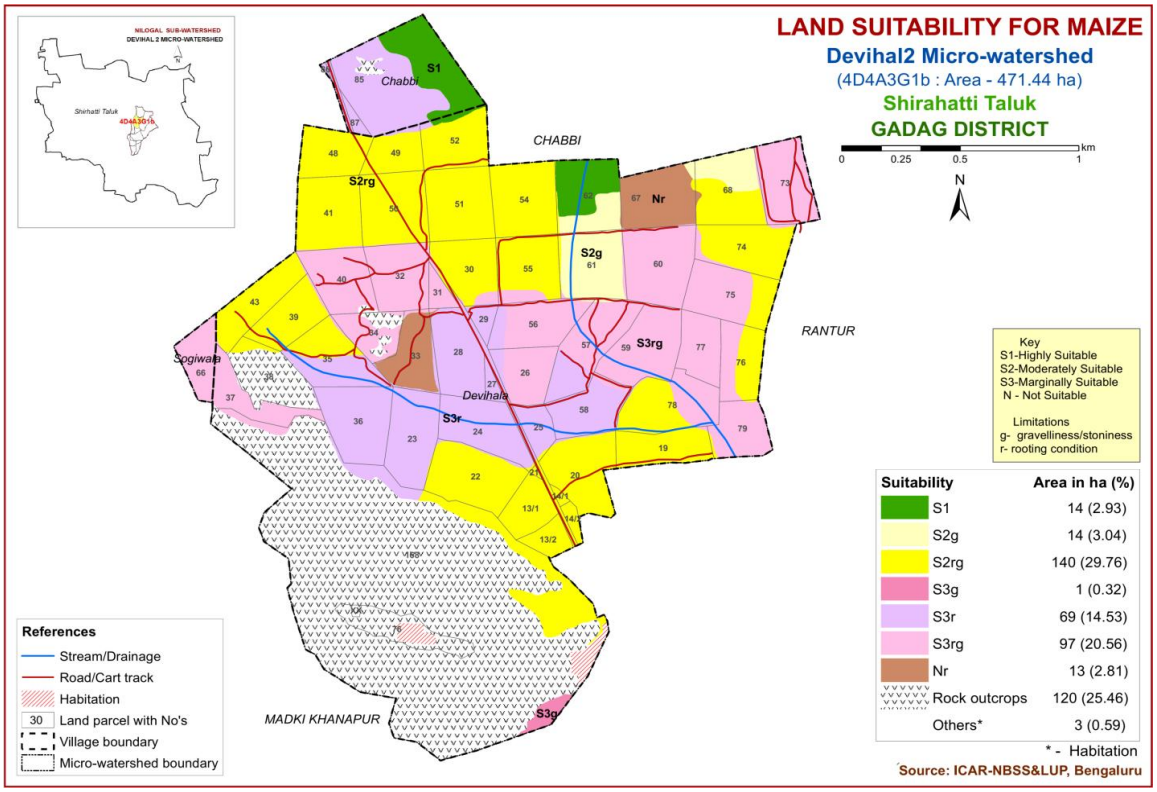


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for 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 7.4) 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 7.3.

Highly suitable (Class S1) lands occupy a small area of about 20 ha (4%) for growing cotton and occur in the northern part of the microwatershed. Major area of about 178 ha (38%) has soils that are moderately suitable (Class S2) with minor limitations of gravelliness and rooting depth. They are distributed in the northwestern, central, eastern and southeastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 138 ha (29%) and occur in the central and eastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 13 ha (3%) is not suitable (Class N) and occur in small patches in the central and northern part of the microwatershed with severe limitation of rooting depth.

Table 7.4 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

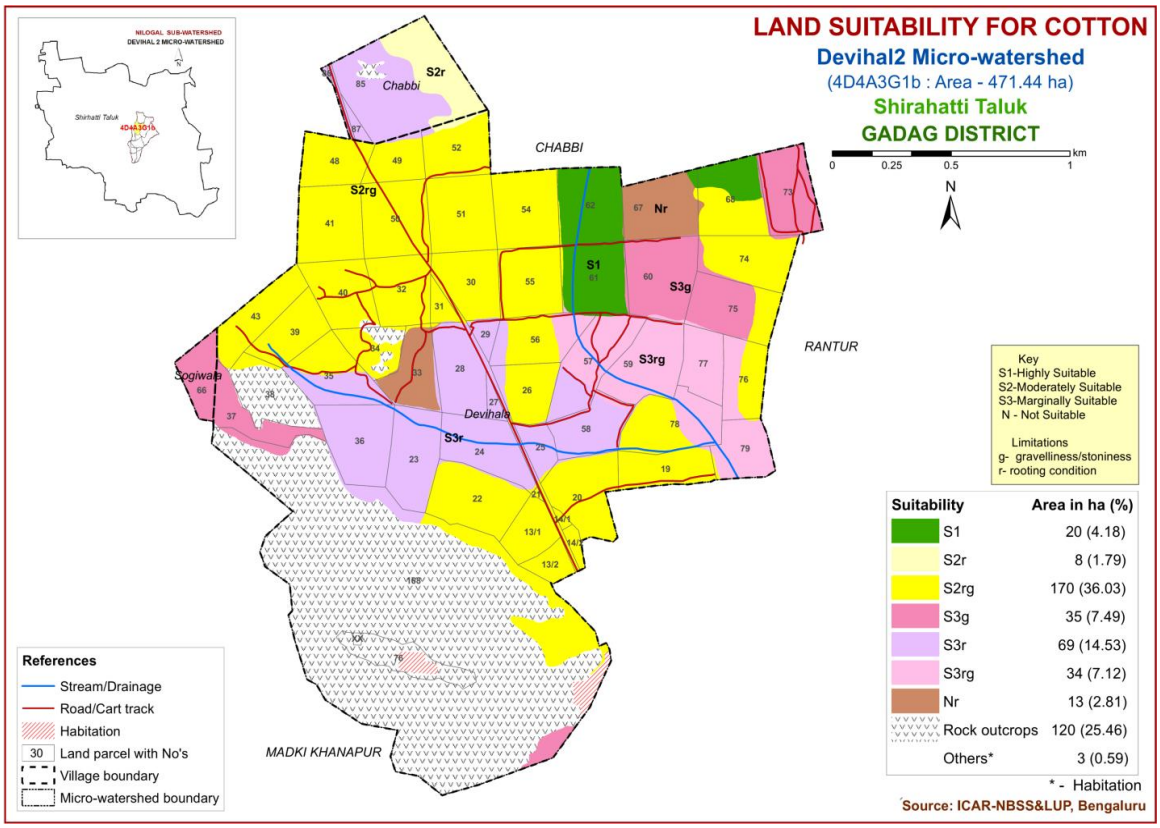


Fig. 7.3 Land Suitability map of Cotton

7.4 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 3.56 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for

growing sunflower was generated (Fig. 7.4). The area extent and their geographical distribution of different suitability subclasses in the microwatersheds is given in Table 7.5.

Table 7.5 Land 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	8.1-8.5 5.5-6.4	8.6-9.0; 4.5-5.4	>9.0 <4.5
Sub Surface soil texture	Class	l, cl, sil, sc	cl, 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	

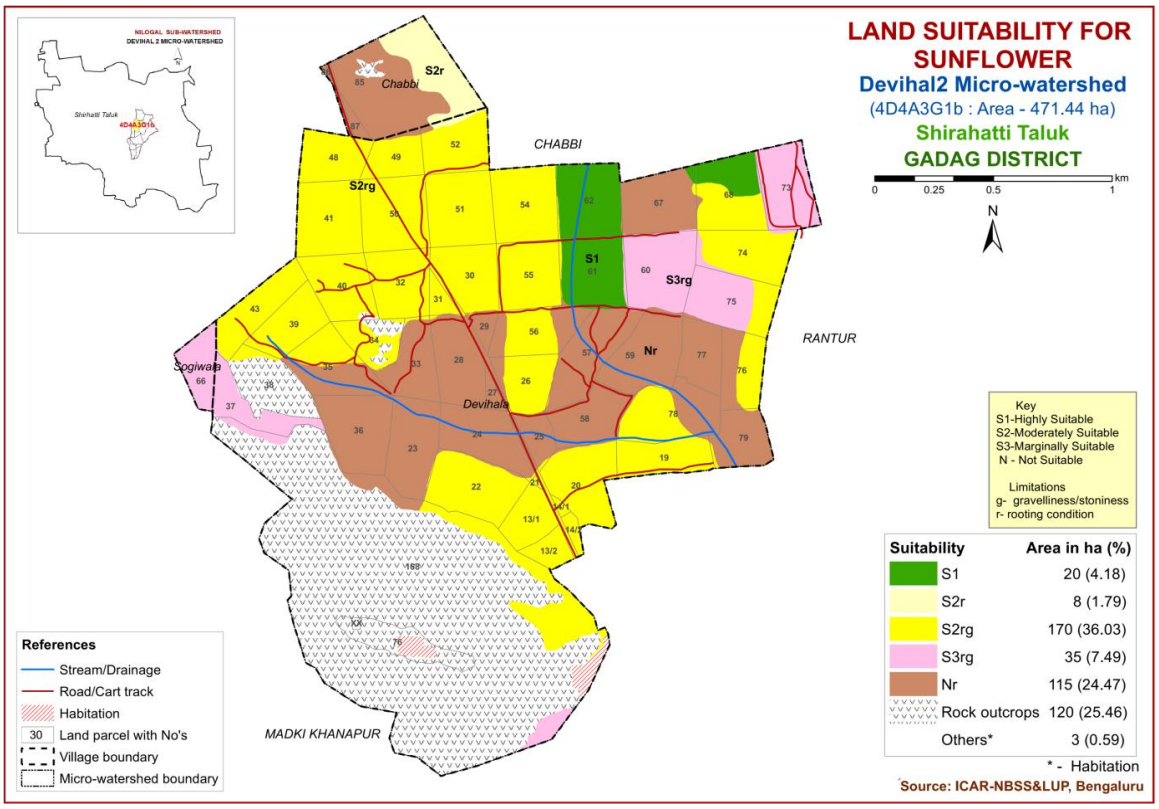


Fig. 7.4 Land Suitability map of Sunflower

Highly suitable (Class S1) lands occupy an area of about 20 ha (4%) for growing sunflower and occur in the northern part of the microwatershed. Moderately suitable (Class S2) lands occupy major area of about 178 ha (38%) and are distributed in the northern, northwestern, southeastern and eastern part of the microwatershed with minor limitations of rooting depth and gravelliness. An area of about 35 ha (7%) is marginally suitable (Class S3) lands and are distributed in the northeastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 115 ha (24%) is not suitable (Class N) and occur in the central, northern and eastern part of the microwatershed with severe limitation of rooting depth.

7.5 Land Suitability for Onion (*Allium cepa*)

Onion is the most important vegetable crop grown in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing onion (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing onion was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

Table 7.6 Land suitability criteria for Onion

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

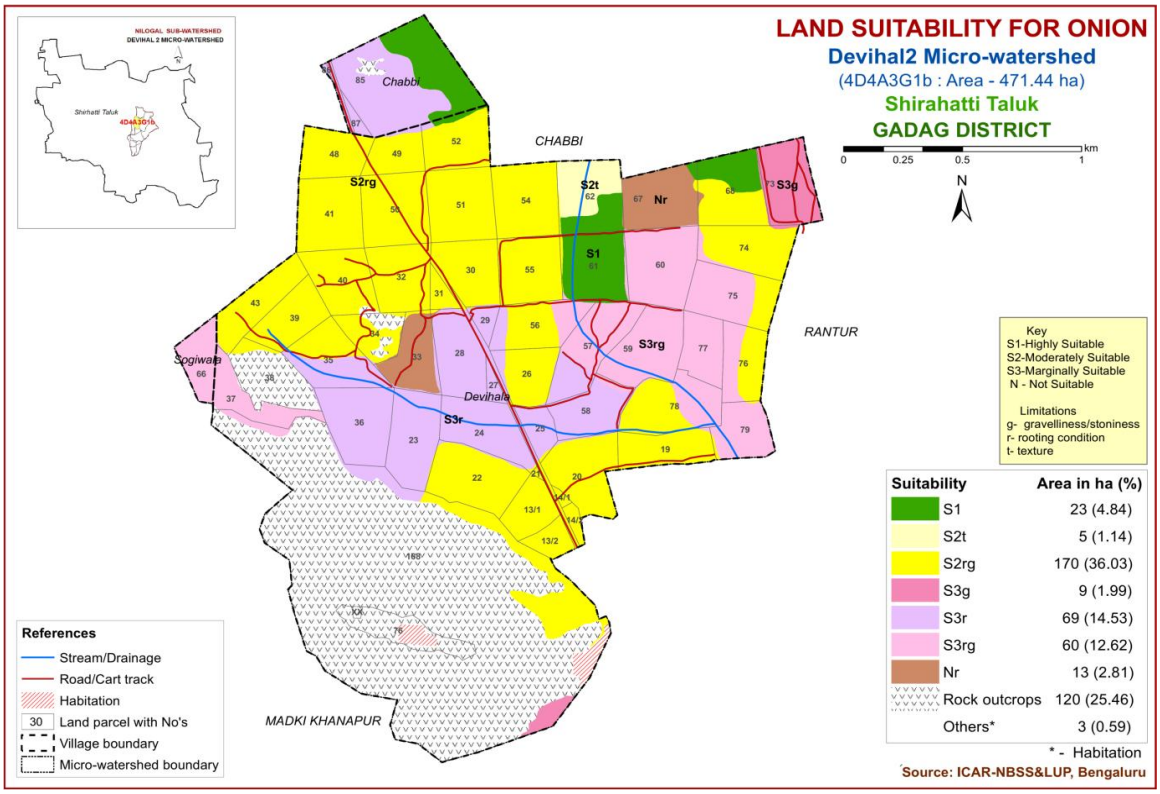


Fig. 7.5 Land Suitability map of Onion

Highly suitable (class S1) lands occupy an area of about 23 ha (5%) for growing onion and occur in the central and northtern part of the microwatershed. Moderately suitable (Class S2) lands occupy major area of about 175 ha (37%) with minor limitations of topography, gravelliness and rooting depth. They are distributed in the northwestern, eastern, southeastern and central part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 138 ha (29%) and occur in the northern, western, central and eastern part of the microwatershed. They have moderate limitations of rooting depth and gravellineess. A very small area of about 13 ha (3%) is not suitable (Class N) and occur in the central and northern part of the microwatershed. They have severe limitation of rooting depth.

7.6 Land Suitability for Groundnut (*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.54 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.7) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing groundnut was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.6.

Table 7.7 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	

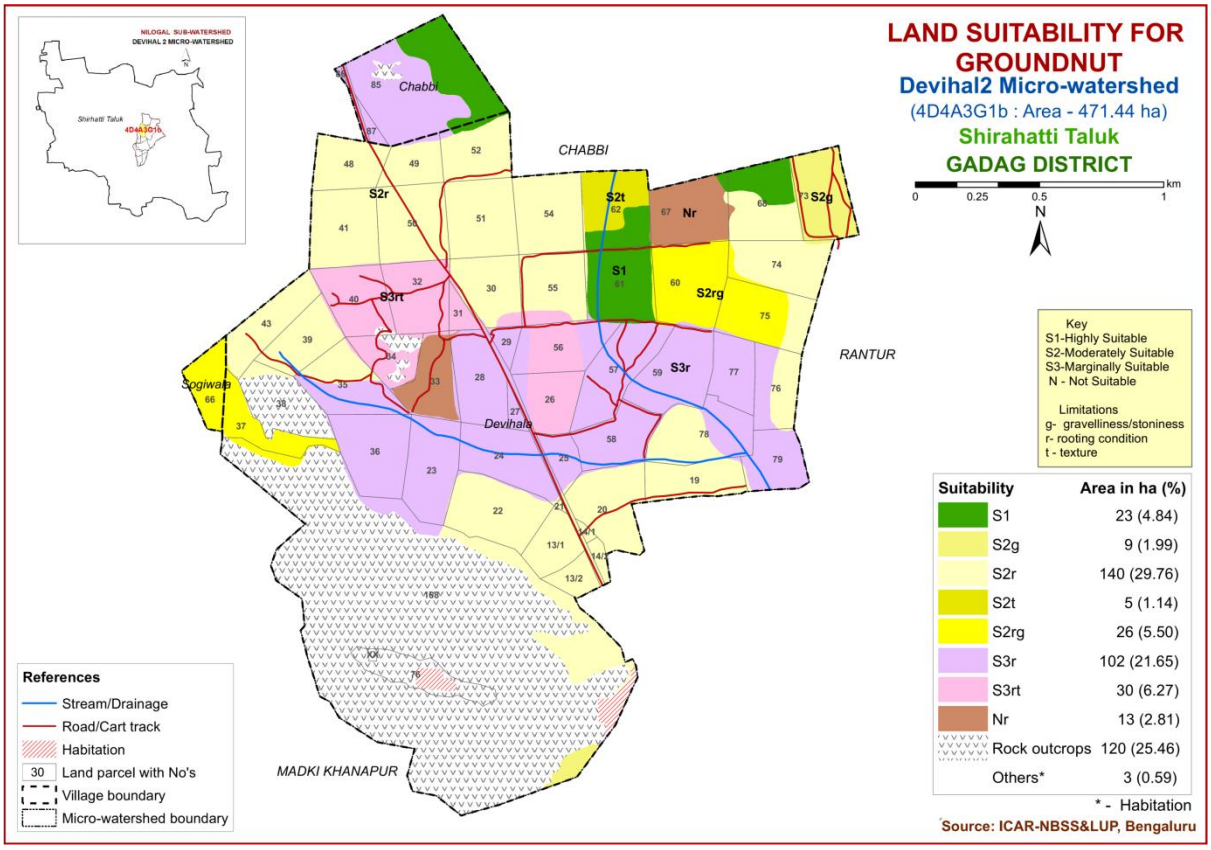


Fig. 7.6 Land Suitability map of Groundnut

An area of about 23 ha (5%) is highly suitable (Class S1) for growing groundnut. They are distributed in the northern part of the microwatershed. Moderately suitable lands (Class S2) cover major area of about 180 ha (38%) and are distribuited in the western,

central, eastern and southeastern parts of the microwatershed. They have minor limitations of rooting depth, texture and gravelliness. Marginally suitable (Class S3) lands for growing groundnut occupy an area of about 132 ha (28%) and are distributed in the northern, central and eastern part of the microwatershed. They have moderate limitations of rooting depth and texture. A very small area of about 13 ha (3%) is not suitable (Class N) and occur in the central and northeastern part of the microwatershed. They have severe limitation of rooting depth.

7.7 Land Suitability for Chilli (*Capsicum annuum L*)

Chilli is one of the major fruit and spice crop grown in an area of 0.42 lakh ha in Karnataka State. The crop requirements for growing chilli (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 chilli was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.7.

Highly suitable (Class S1) lands ccupy a small area of about 28 ha (6%) for growing chilli and occur in the northern part of the microwatershed. Moderately suitable (Class S2) lands cover major area of about 170 ha (36%) and are distributed in the northwestern, central, northeastern and southeastern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. Marginally suitable (Class S3) for growing chilli occupy an area of about 138 ha (29%) and are distributed in the western, central and northeastern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. A very small area of about 13 ha (3%) is not suitable (Class N) and occur in the central and northern part of the microwatershed with severe limitation of rooting depth.

Table 7.8 Crop suitability criteria for Chilli

Crop requirement		**Rating**			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Mean temperature in growing season	^{0}C	20-30	30-35 13-15	35-40 10-12	>40 <10
Slope	%	<3	3-5	5-10	>10
LGP	Days	>150	120-150	90-120	<90
Soil drainage	Class	Well drained	Moderately drained	Imp./ poor drained/excessively	Very poorly drained
Soil reaction	pH	6.5-7.8 6.0-7.0	7.8-8.4	8.4-9.0 5.0-5.9	>9.0
Surface soil texture	Class	scl, cl, sil	sl, sc, sic,c(m/k)	C(ss), ls, s	
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	

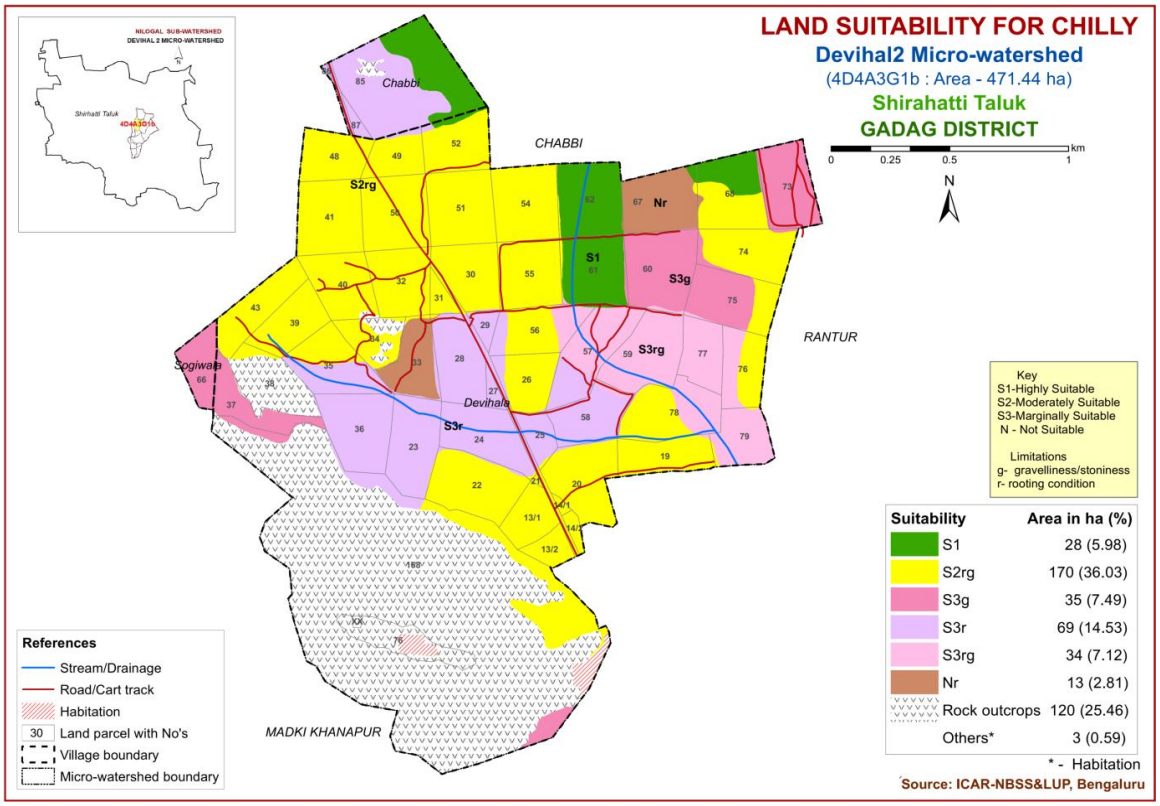


Fig. 7.7 Land Suitability map of chilli

7.8 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.7 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, Chamarajanagar and Mandya districts. The crop requirements for growing sugarcane (Table 7.9) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sugarcane was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

Highly suitable (Class S1) lands occupy small area of about 20 ha (4%) for growing sugarcane and occur in the northeastern part of the microwatershed. Moderately suitable (Class S2) lands occupy a very small area of about 8 ha (2%) and occur in the northern part of the microwatershed. They have minor limitation of rooting depth. Marginally suitable (Class S3) lands cover major area of about 205 ha (43%) and occur in the western, central, eastern and southeastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 115 ha (24%) is not suitable (Class N) for growing sugarcane and occur in the central, eastern and small patches in the northern part of the microwatershed and they have severe limitation of rooting depth.

Table 7.9 Land suitability criteria for Sugarcane

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

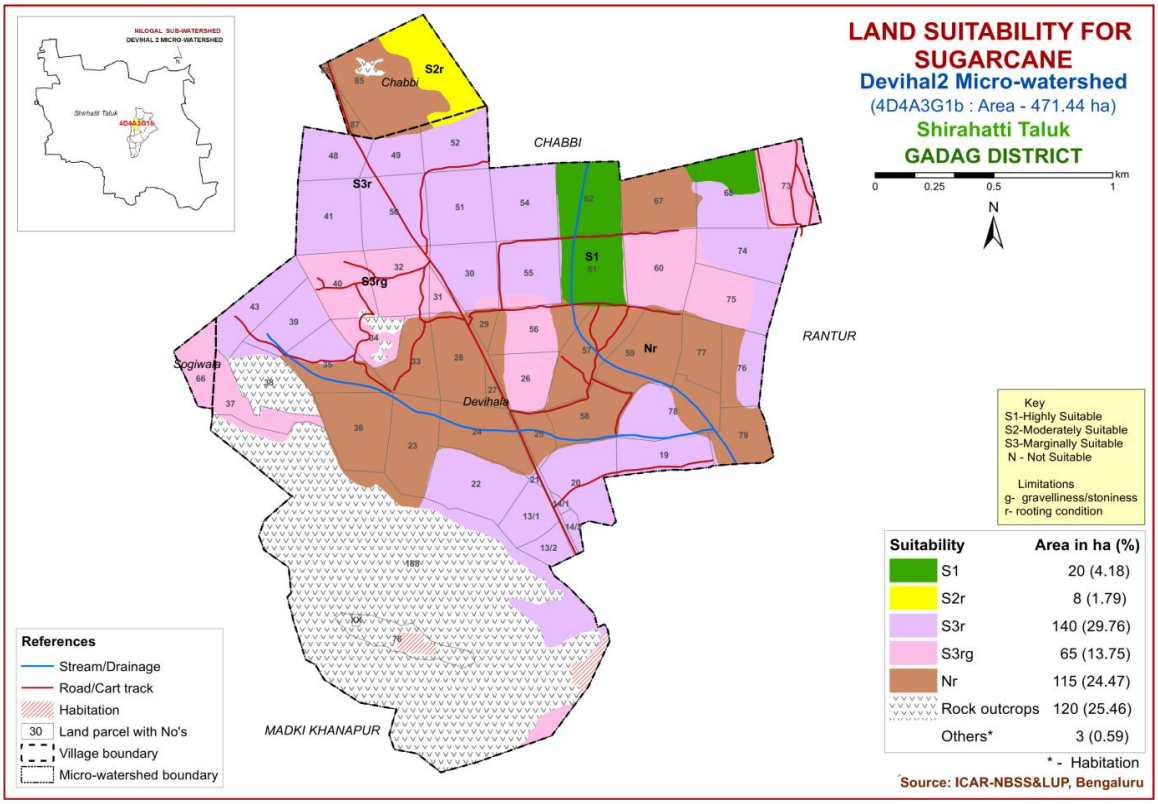


Fig. 7.8 Land Suitability map of Sugarcane

7.9 Land Suitability for Pomegranate (*Punica granatum*)

Pomegranate is one of the commercially grown fruit crop in Karnataka in an area of 0.18 lakh ha mainly in Bijapur, Bagalkot, Koppal, Gadag and Chitradurga districts. The crop requirements for growing pomegranate (Table 7.10) were matched with the soil-

site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing pomegranate was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.9.

Highly suitable (Class S1) lands occupy a very small area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. A very small area of about 8 ha (2%) is moderately suitable (Class S2) for growing pomegranate and occur in the northern part of the microwatershed with minor limitation of rooting depth. Marginally suitable (Class S3) for growing pomegranate occupy major area of about 205 ha (43%) and are distributed in the western, central, southeastern and eastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 115 ha (24%) is not suitable (Class N) for growing pomegranate and occur in the central, eastern and northern part of the microwatershed. They have severe limitation of rooting depth.

Table 7.10 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	

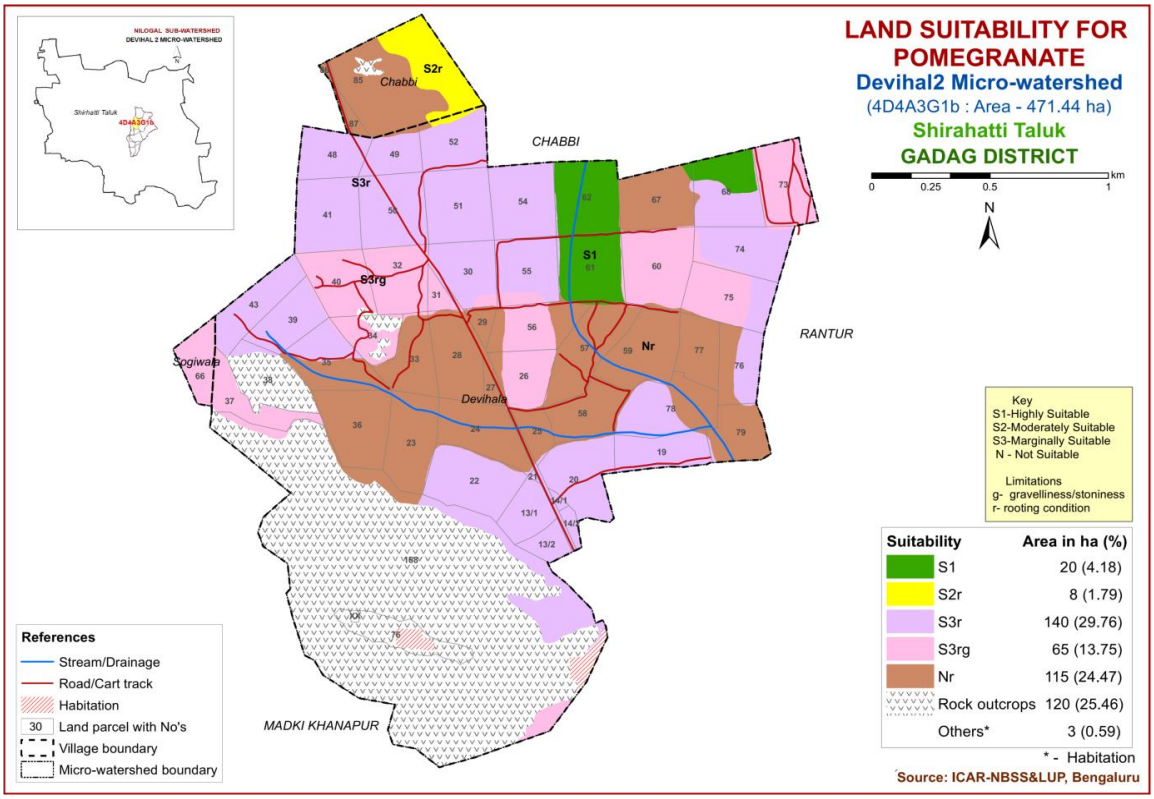


Fig. 7.9 Land Suitability map of Pomegranate

7.10 Land suitability for Tomato (*Solanum lycopersicum*)

Tomato is the most important fruit crop grown in an area of 0.65 lakh ha in almost all the districts of the State. The crop requirements (Table 7.11) for growing tomato were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing tomato was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.10.

An area of about 28 ha (6%) in the microwatershed is highly suitable (Class S1) for growing tomato and are distributed in the northern part of the microwatershed. Moderately suitable (Class S2) lands occupy major area of about 195 ha (41%) and occur in the western, central, southeastern and eastern part of the microwatershed. They have minor limitations of gravelliness and rooting depth. The marginally suitable (Class S3) lands cover an area of about 112 ha (24%) and are distributed in the central, eastern and southeastern part of the microwatershed with moderate limitations of rooting depth and gravelliness. A very small area of about 13 ha (3%) is not suitable (Class N) and occur in the central and northeastern part of the microwatershed with severe limitation of rooting depth.

Table 7.11 Crop suitability criteria for Tomato

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
climate	Temperature in growing season	^{0}c	25-28	29-32 20-24	15-19 33-36	<15 >36
Soil moisture	Growing period	Days	>150	120-150	90-120	
Soil aeration	Soil drainage	Class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient availability	Texture	Class	l, sl, cl, scl	Sic, sicl, sc, c(m/k)	C (ss)	ls, s
	pH	1:2.5	6.0-7.0	5.0-5.9 7.1-8.5	<5; >8.5	
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strongly calcareous	
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	ds/m	Non saline	slight	strongly	
	Sodicity (ESP)	%	<10	10-15	>15	-
Erosion	Slope	%	1-3	3-5	5-10	>10

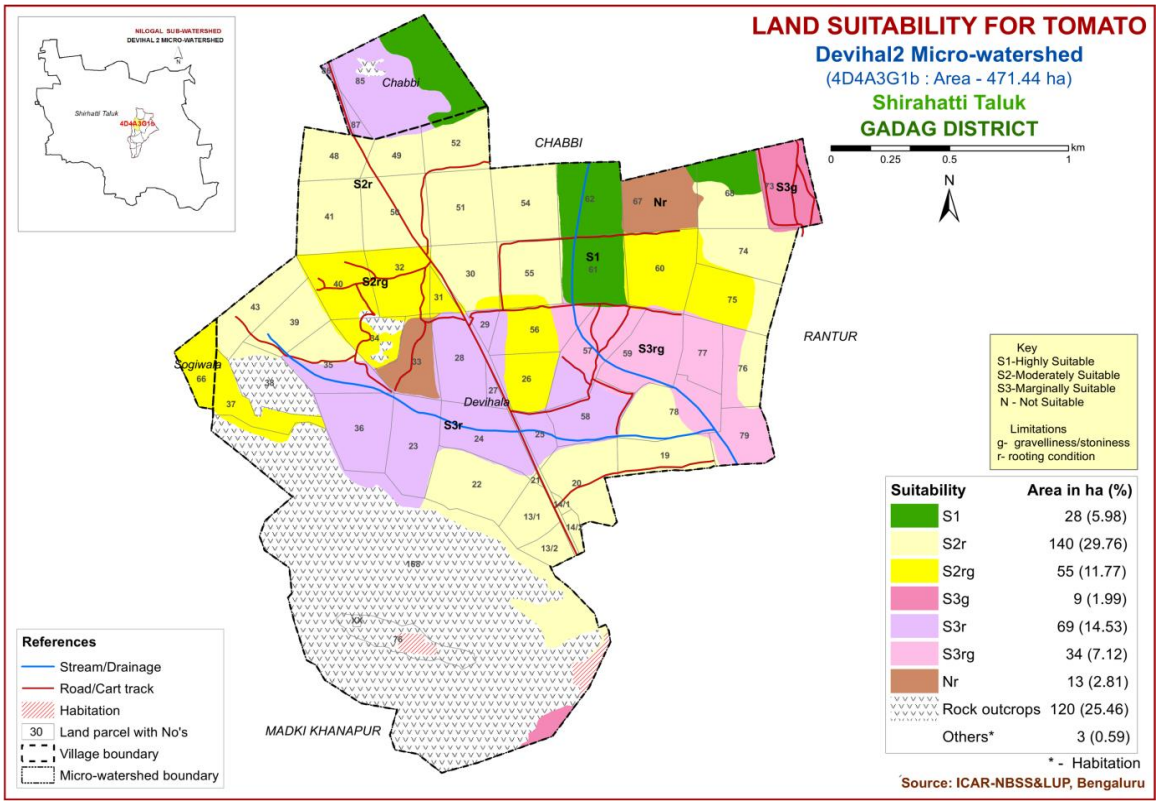


Fig. 7.10 Land Suitability map of Tomato

7.11 Land suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in an area of 6558 ha in almost all the districts of the State. The crop requirements (Table 7.12) for growing guava were matched with the soil-site characteristics (7.1) and a land suitability map for growing guava was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.11.

An area of about 14 ha (3%) is highly suitable (Class S1) for growing guava in the microwatershed and occur in the northeastern part of the microwatershed. Moderately suitable (Class S2) lands occupy a very small area of about 13 ha (3%) and occur in the northern part of the microwatershed with minor limitations of rooting depth and texture. The marginally suitable (Class S3) lands cover maximum area of about 205 ha (43%) and are distributed in the western, central, southeastern and eastern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 115 ha (24%) is not suitable (Class N) for growing guava and are distributed in the central, eastern and northern part of the microwatershed with severe limitation of 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

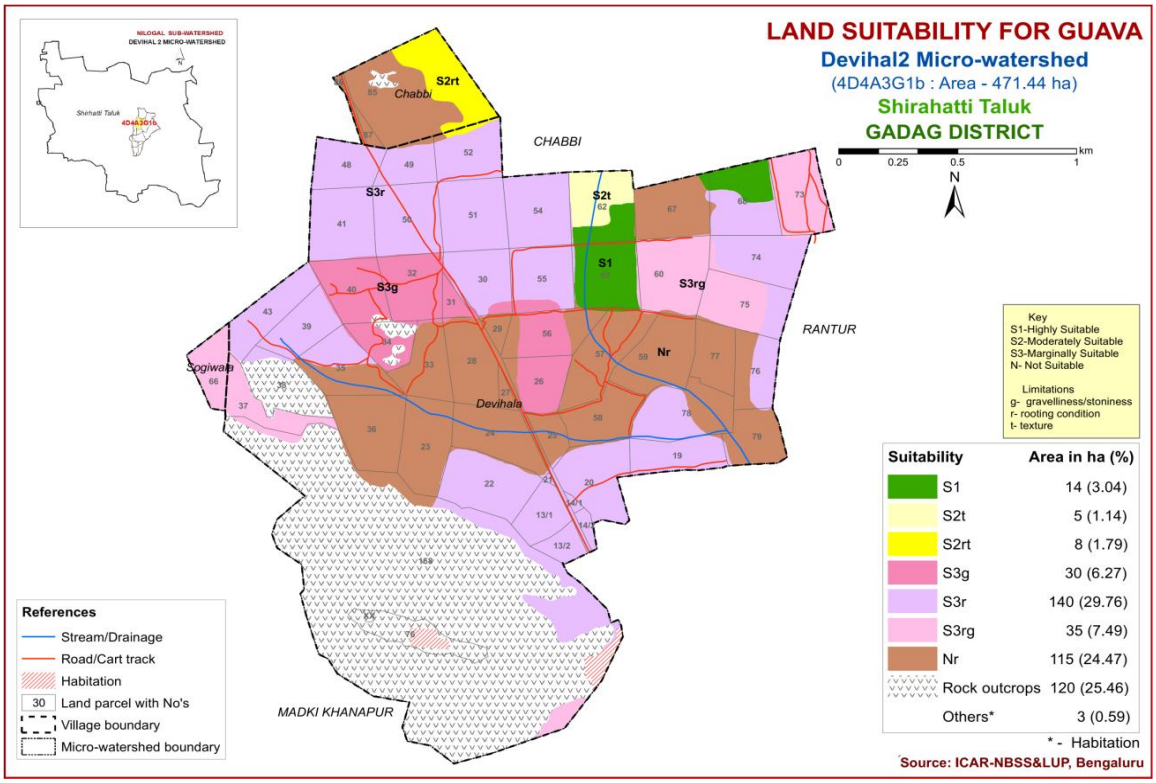


Fig. 7.11 Land Suitability map of Guava

7.12 Land suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in about 1.73 lakh ha in almost all the districts of the State. The crop requirements (Table 7.13) for growing mango were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.12.

There are no highly suitable (Class S1) lands for growing mango. An area of about 20 ha (4%) is moderately suitable (Class S2) for growing mango and occur in the northeastern part of the microwatershed. They have minor limitation of rooting depth. Marginally suitable (Class S3) lands for growing mango occupy a very small area of about 8 ha (2%) and are distributed in the northern part of the microwatershed. They have moderate limitations of rooting depth. Major area of about 320 ha (68%) is not suitable (Class N) for growing mango and occur in major part of the microwatershed.

Table 7.13 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	

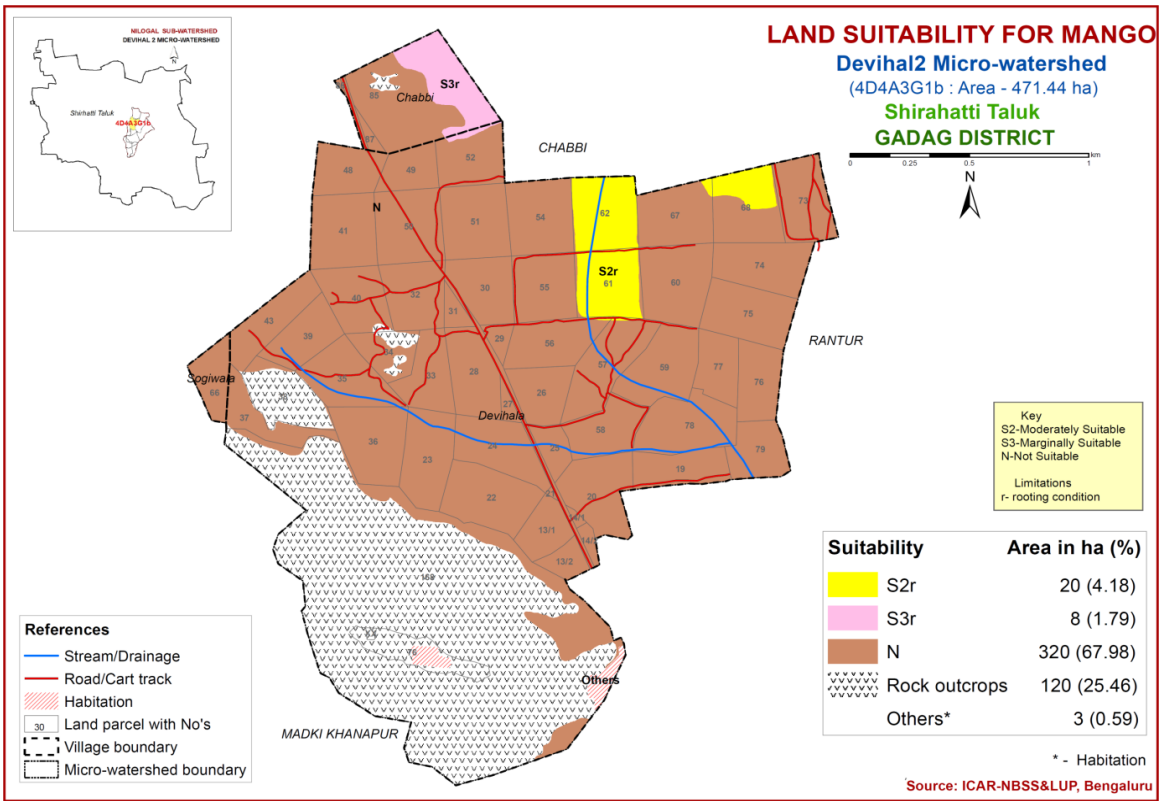


Fig. 7.12 Land Suitability map of Mango

7.13 Land suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 29373 ha in almost all the districts of the State. The crop requirements (Table 7.14) for growing sapota were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sapota was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

Highly suitable (Class S1) lands for growing sapota occupy a very small area of about 5 ha (1%) and are distributed in the northeastern part of the microwatershed. An area of about 22 ha (5%) is moderately suitable (Class S2) and occur in the northern part of the microwatershed. They have minor limitations of texture and gravelliness. The marginally suitable (Class S3) lands cover major area of about 205 ha (43%) and are distributed in all parts of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 115 ha (24%) is not suitable for growing sapota and are distributed in the eastern, central and northern part of the microwatershed with severe limitation of rooting depth.

Table 7.14 Crop suitability criteria for Sapota

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

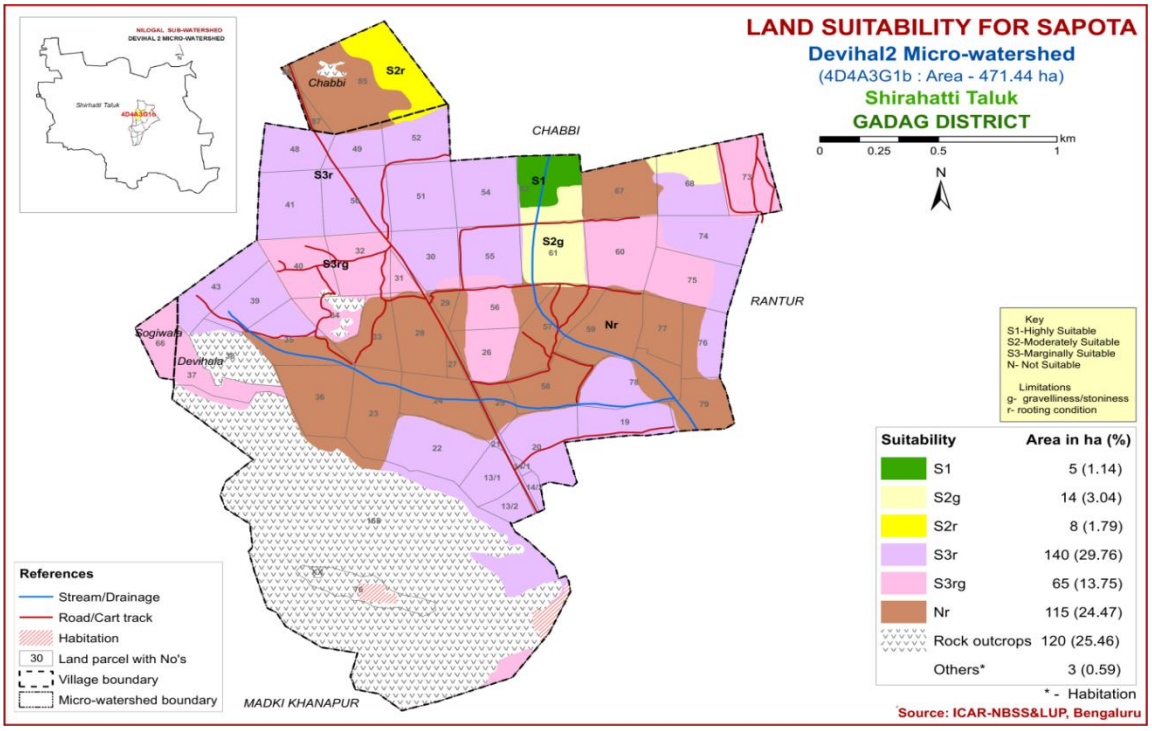


Fig. 7.13 Land Suitability map of Sapota

7.14 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 5368 ha in all the districts of the state. The crop requirements for growing jackfruit were matched with the soil-site characteristics and a land suitability map for growing jackfruit was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

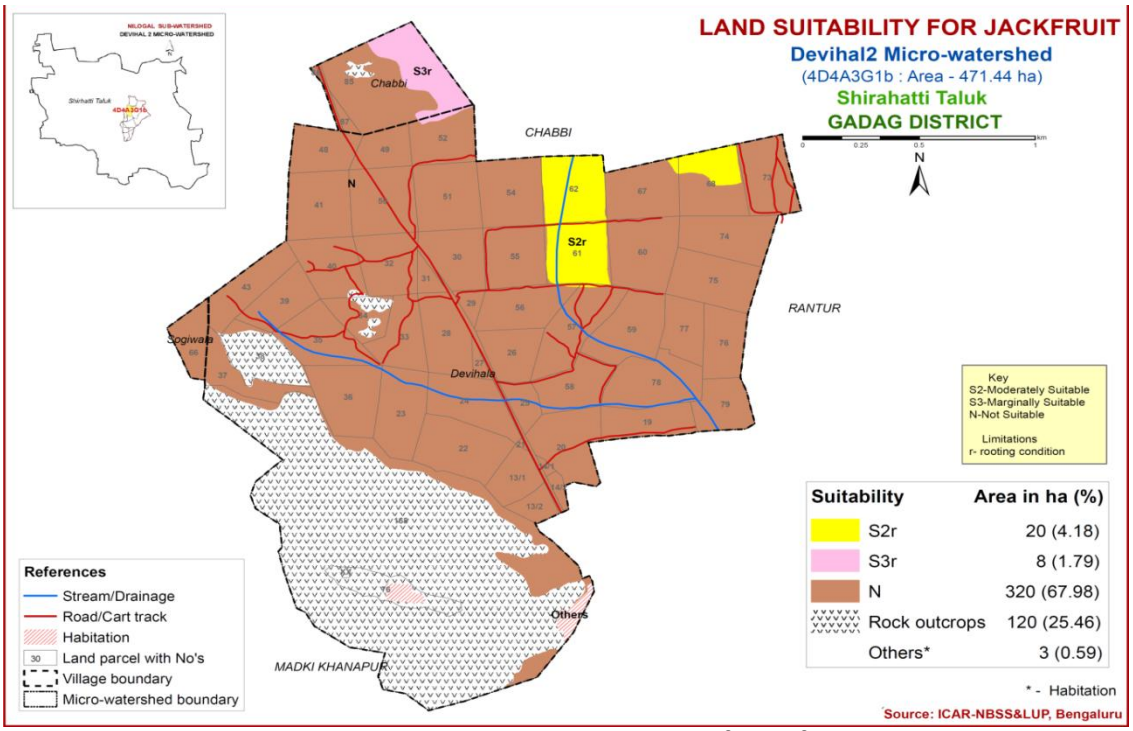


Fig. 7.14 Land Suitability map of Jackfruit

There are no highly suitable (Class S1) lands for growing jackfruit. Moderately suitable (S2) lands occupy a very small area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. They have minor limitation of rooting depth. Marginally suitable (Class S3) for growing jackfruit occupy a very small area of about 8 ha (2%) and are distributed in the northern part of the microwatershed. They have moderate limitation of rooting depth. Major area of about 320 ha (68%) is not suitable (Class N) for growing jackfruit and occur in major part of the microwatershed.

7.15 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. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.15.

Moderately suitable (S2) lands occupy a very small area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. They have minor limitation of rooting depth. Major area of about 187 ha (40%) is marginally suitable (Class S3) and are distributed in the northern, central, eastern and southeastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 141 ha (30%) is not suitable (Class N) for growing jamun and are distributed in the western, northern and central part of the microwatershed.

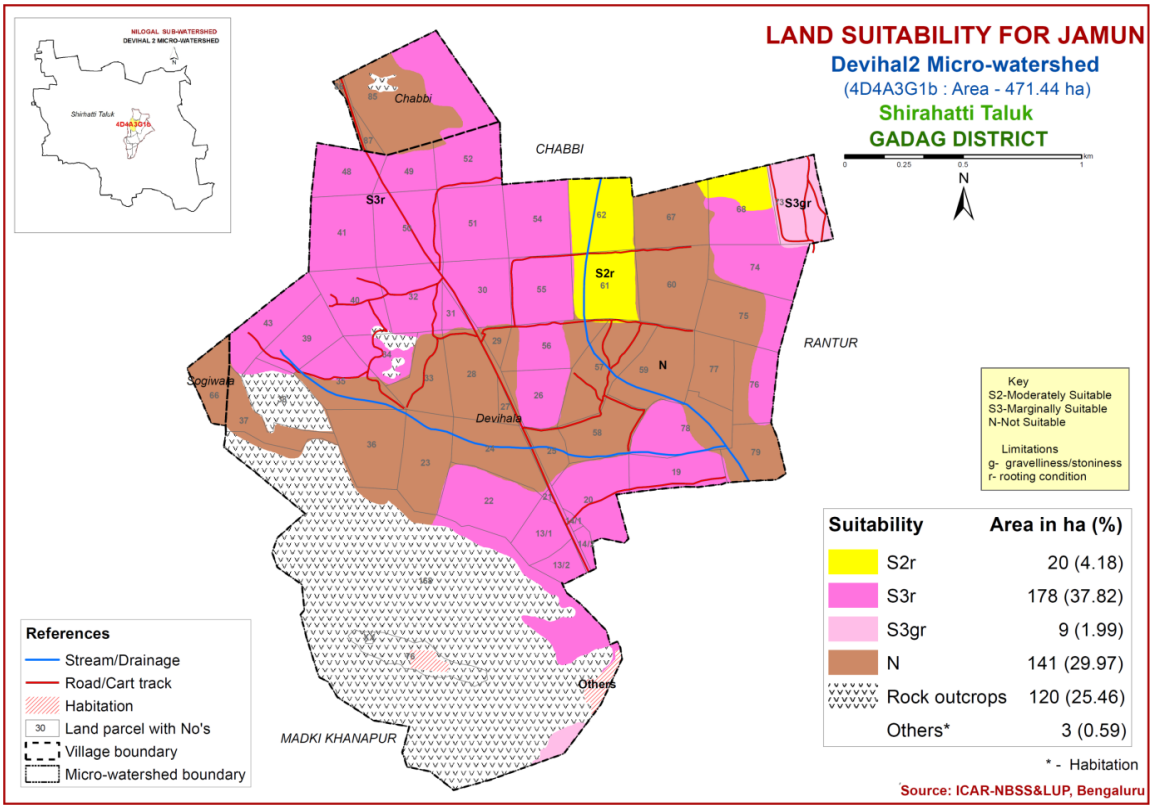


Fig. 7.15 Land Suitability map of Jamun

7.16 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

There are no highly suitable (Class S1) lands for growing musambi. Moderately suitable (Class S2) lands occupy an area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. They have minor limitation of rooting depth. A very small area of about 8 ha (2%) is marginally suitable (Class S3) for growing musambi and are distributed in the northern part of the microwatershed. They have moderate limitation of rooting depth. Major area of about 320 ha (68%) is not suitable (Class N) for growing musambi and are distributed in the major part of the microwatershed.

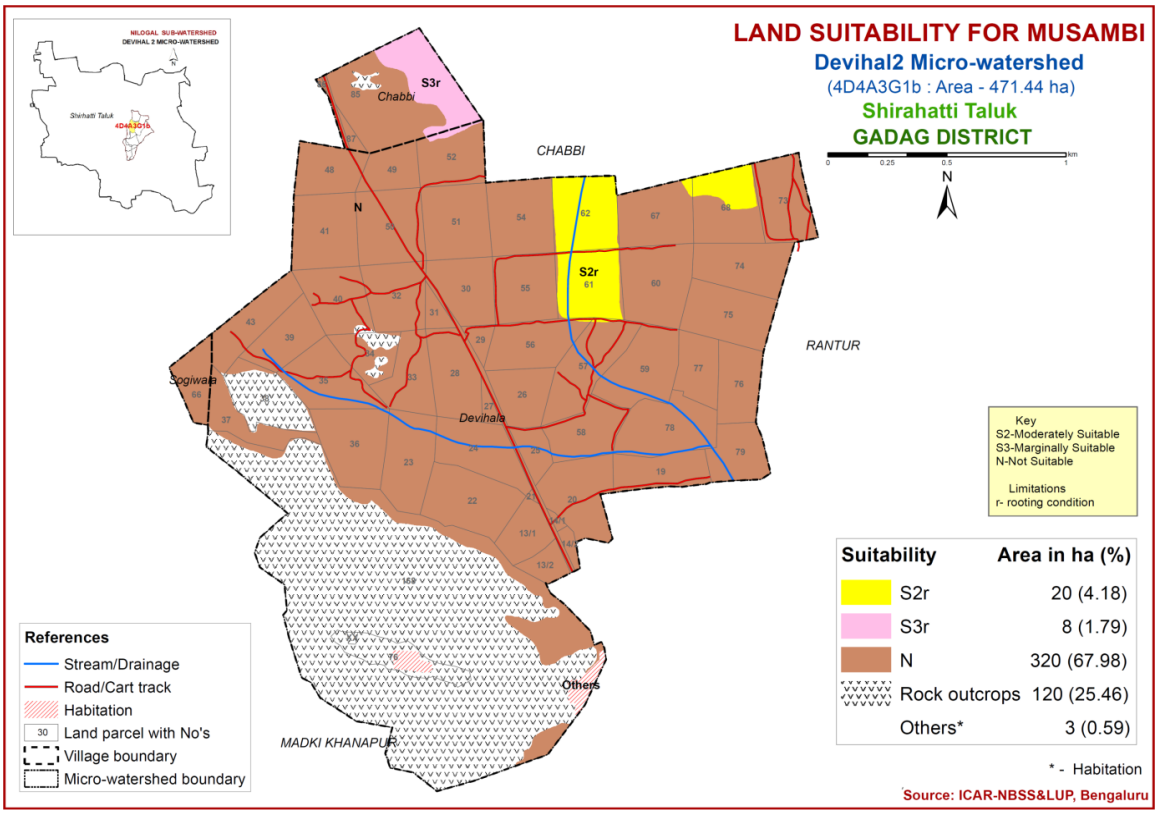


Fig. 7.16 Land Suitability map of Musambi

7.17 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 11752 ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.15) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.17.

Table 7.15 Crop suitability criteria for Lime

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
Climate	Temperature in growing season	^{0}C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. 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	

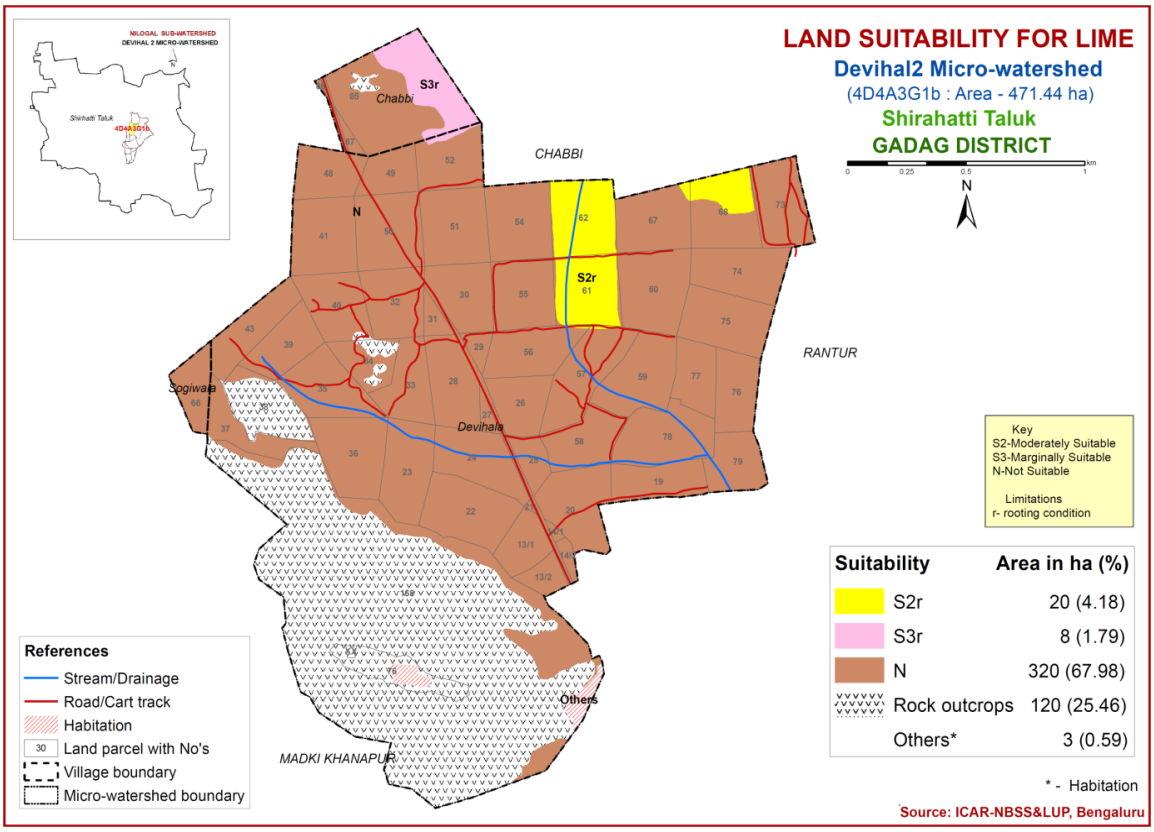


Fig. 7.17 Land Suitability map of Lime

There are no highly suitable lands for growing lime. Moderately suitable (S2) lands occupy an area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. They have minor limitation of rooting depth. A very small area of about 8 ha (2%) is marginally suitable (Class S3) for growing lime and are distributed in the northern part of the microwatershed. They have moderate limitation of rooting depth. Major area of about 320 ha (68%) is not suitable (Class N) for growing lime and are distributed in major part of the microwatershed.

7.18 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important fruit and nut crop grown in an area of 7052 ha in almost all the districts of the State. The crop requirements for growing cashew were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cashew was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

Moderately suitable (S2) lands occupy an area of about 28 ha (6%) and are distributed in the northern part of the microwatershed. They have minor limitation of rooting depth. Major area of about 179 ha (38%) is marginally suitable (Class S3) for growing cashew and are distributed in the western, central, eastern and southeastern part of the microwatershed with moderate limitation of rooting depth. An area of about 141 ha (30%) is not suitable (Class N) for growing cashew and are distributed in the central, western and northern part of the microwatershed.

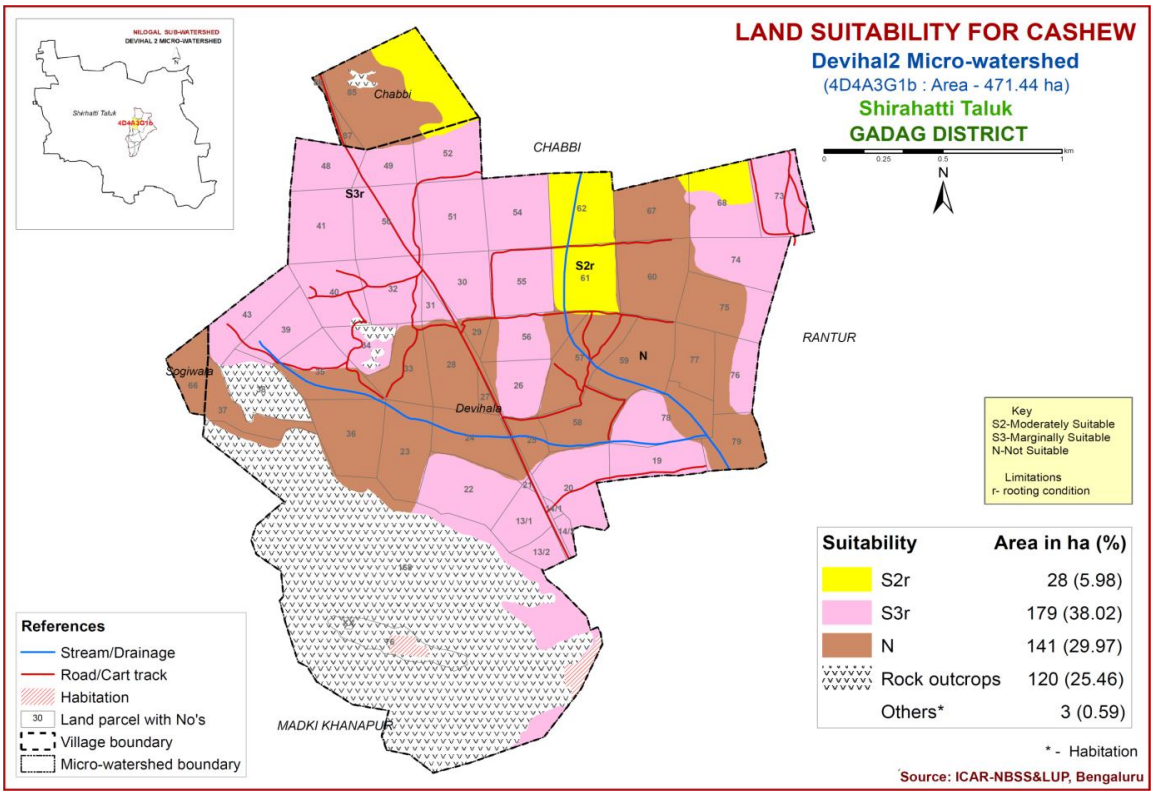


Fig. 7.18 Land Suitability map of Cashew

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

Custard apple is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing custard apple were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

An area of 20 ha (4%) is highly suitable (Class S1) land for growing custard apple and are distributed in the notheastern part of the microwatershed. Maximum area of about 187 ha (40%) is moderately suitable (Class S2) and occur in the southwestern, central, northern and eastern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. An area of about 128 ha (27%) is marginally suitable (Class S3) for growing custard apple and are distributed in the northern, western, central parts of the microwatershed with moderate limitation of rooting depth. A very small area of about 13 ha (3%) is not suitable (Class N) for growing custard apple and occur in the northeastern and central part of the microwatershed.

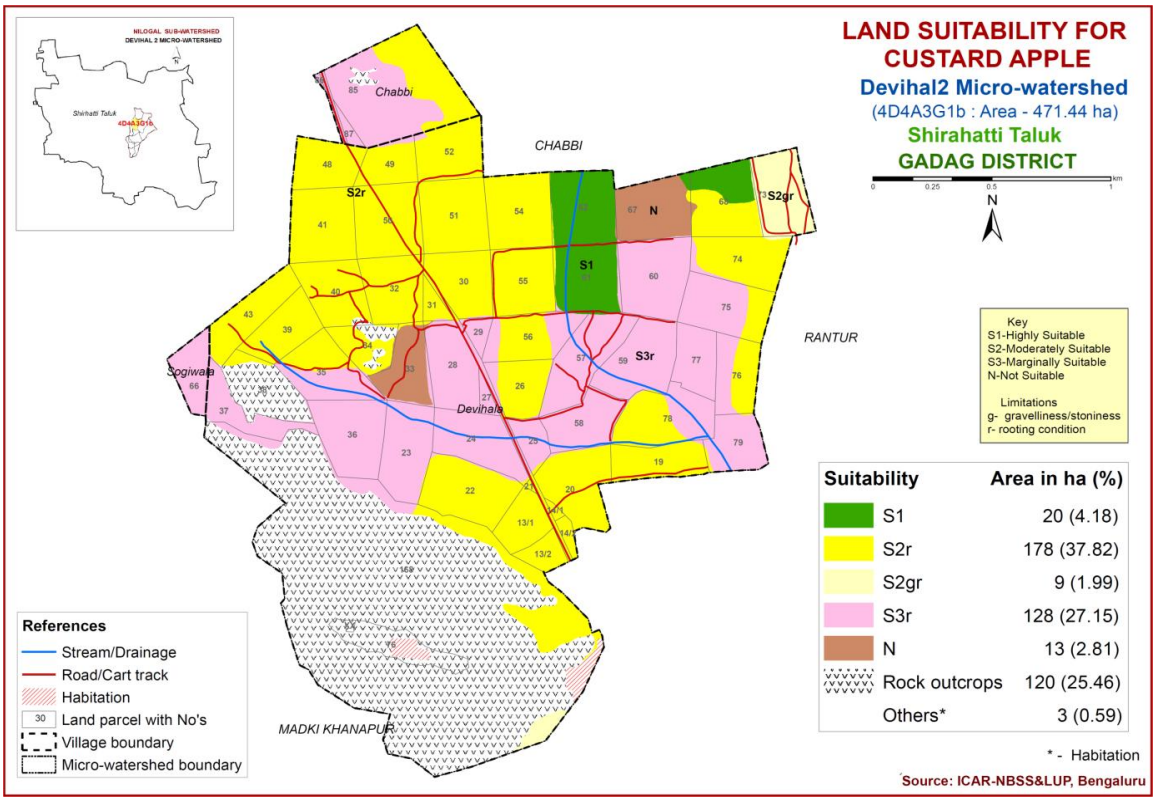


Fig. 7.19 Land Suitability map of Custard Apple

7.20 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the most important medicinal plant grown in 151 ha in 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. The area

extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.20.

Highly suitable (Class S1) lands occupy an area of about 20 ha (5%) and are distributed in the northeastern part of the microwatershed. Maximum area of about 187 ha (40%) is moderately suitable (Class S2) and occurs in the southwestern, central, northern and eastern part of the microwatershed. They have minor limitations of rooting depth and gravelliness. An area of about 128 ha (27%) is marginally suitable (Class S3) for growing amla and are distributed in the northern, western, central part of the microwatershed with moderate limitation of rooting depth. A very small area of about 13 ha (3%) is not suitable (Class N) and occur in the northeastern and central part of the microwatershed.

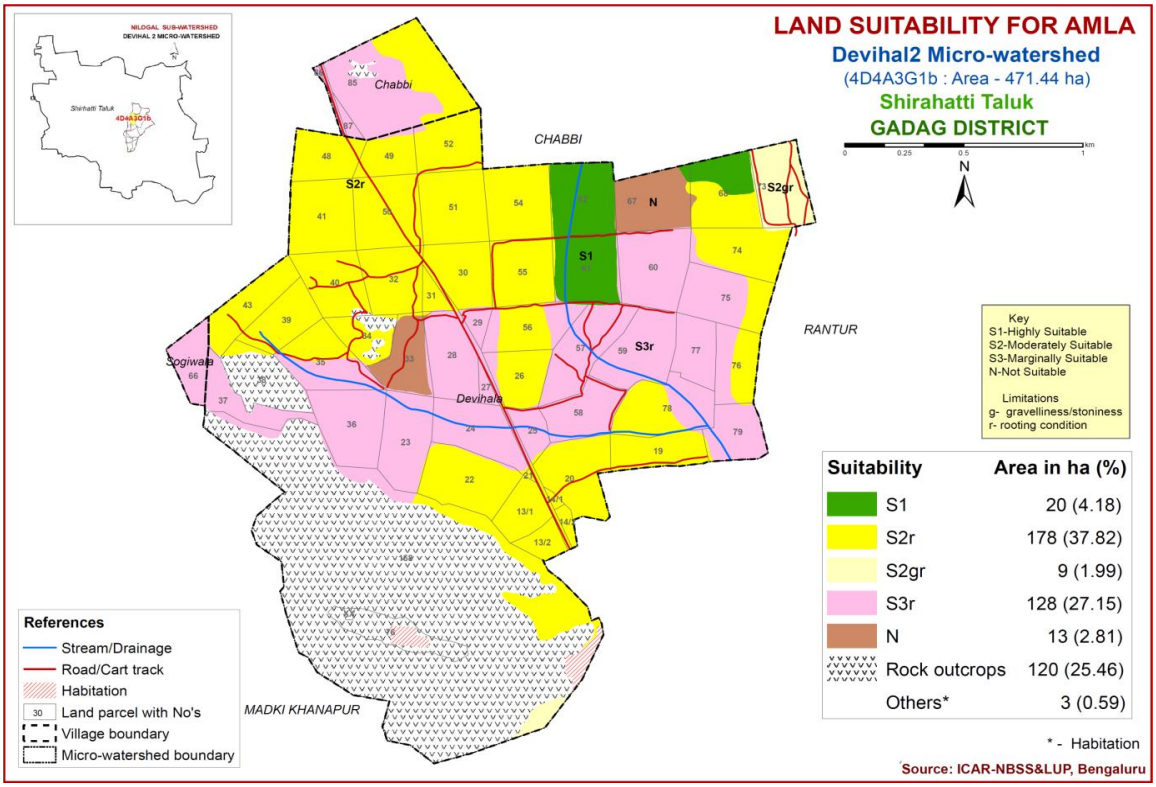


Fig. 7.20 Land Suitability map of Amla

7.21 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in 14897 ha in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Fig. 7.21.

Moderately suitable (S2) lands occupy a very small area of about 20 ha (4%) and are distributed in the northeastern part of the microwatershed. They have minor limitation of rooting depth. Major area of about 178 ha (38%) is occupied by marginally suitable (Class S3) lands and are distributed in the northwestern, central and eastern part of the

microwatershed with moderate limitation of rooting depth. An area of about 151 ha (32%) is not suitable (Class N) for growing tamarind and are distributed in the western, central, northern and eastern part of the microwatershed.

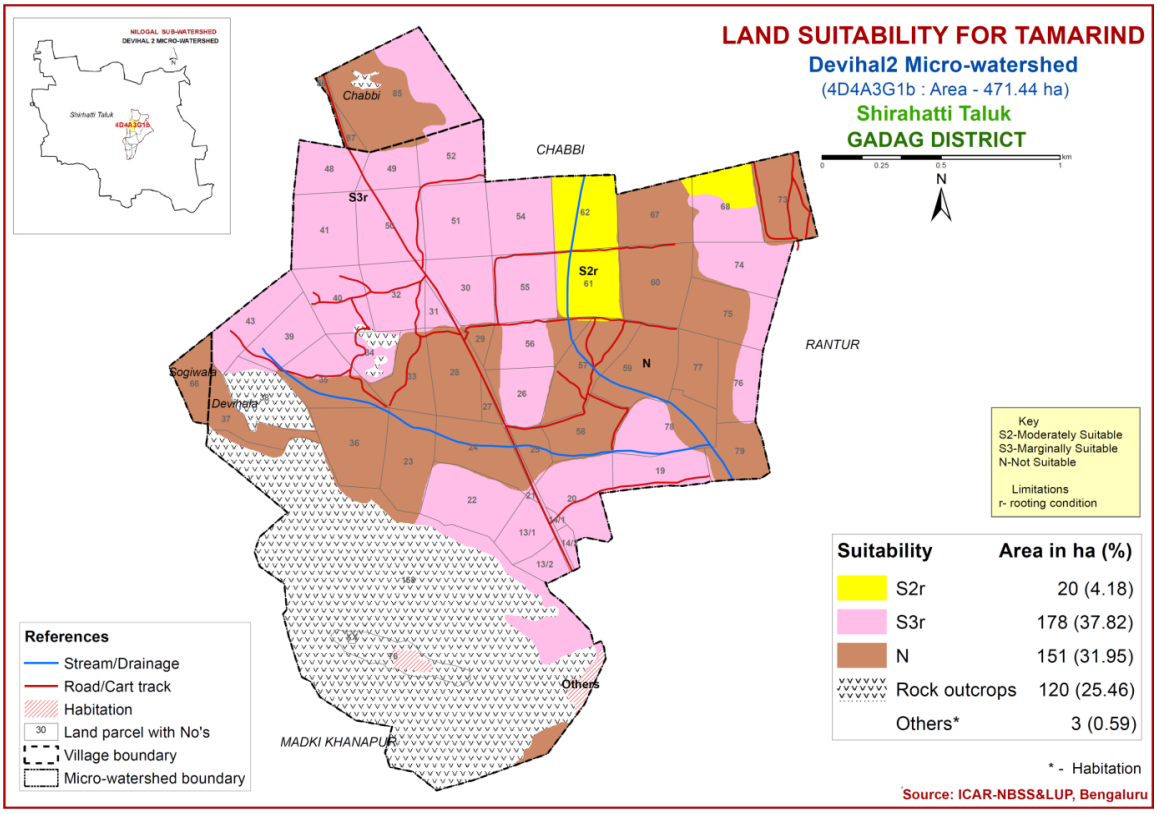


Fig. 7.21 Land Suitability map of Tamarind

7.22 Land Suitability for Marigold (*Tagetes erecta*)

Marigold is the most important flower crop grown in an area of 9108 ha in almost all the districts of the state. The crop requirements for growing marigold were matched with the soil-site characteristics and a land suitability map for growing marigold was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.22.

An area of about 28 ha (6%) is highly suitable (Class S1) for growing marigold. They are distributed in the northern part of the microwatershed. Major area of about 170 ha (36%) and are moderately suitable (Class S2) with minor limitations of gravelliness and rooting depth and are distributed in the central, eastern and southeastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 137 ha (29%) and occur in the northern, western, eastern and central part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. A very small area of about 13 ha (3 %) is not suitable for growing marigold and occur in the central and northeastern part of the microwatershed with severe limitation of rooting depth.

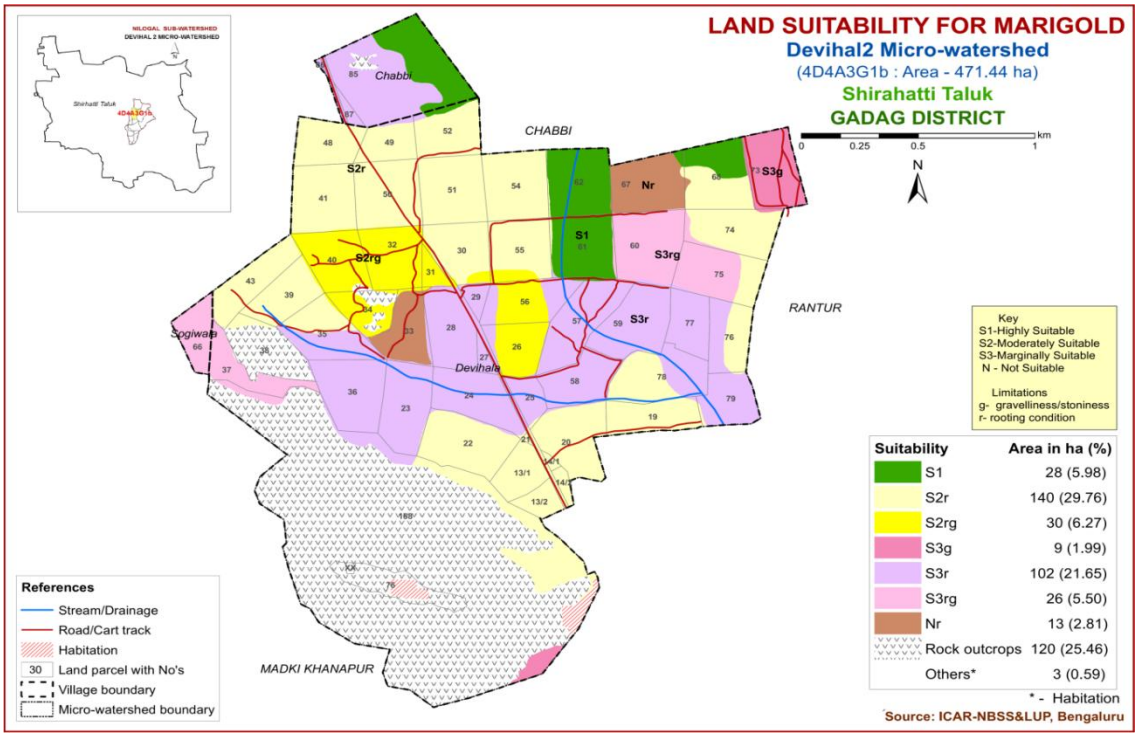


Fig. 7.22 Land Suitability map of Marigold

7.23 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 7.23.

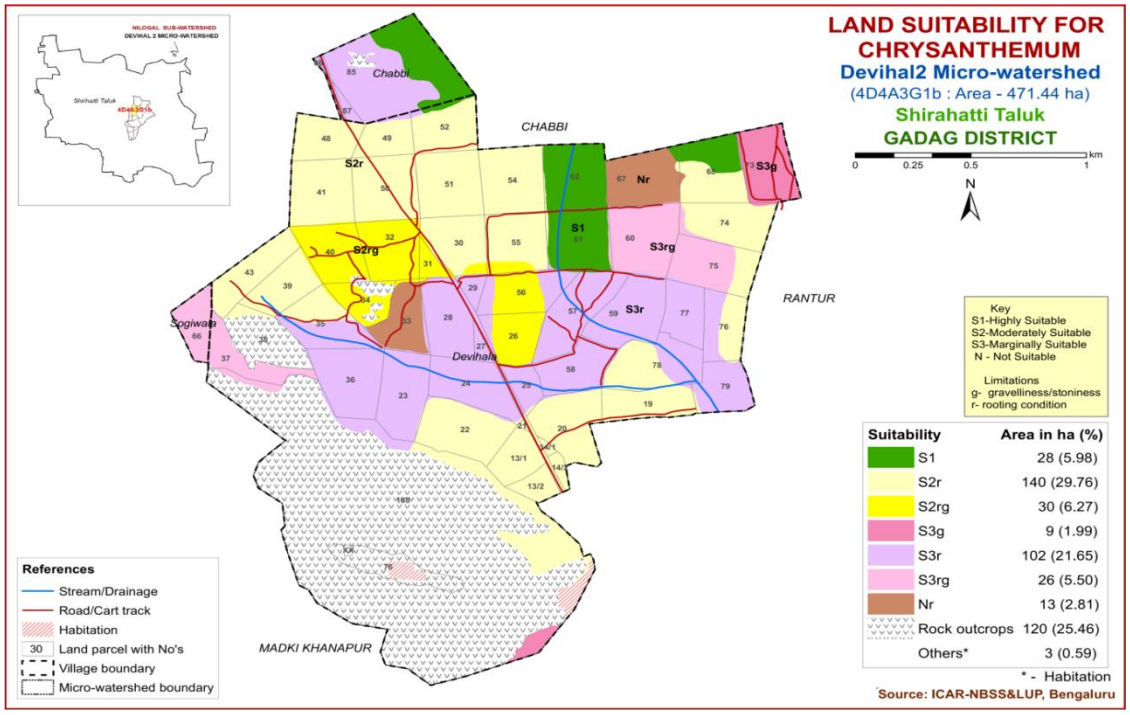


Fig. 7.23 Land Suitability map of Chrysanthemum

Highly suitable (Class S1) lands occupy an area of about 28 ha (6%) for growing chrysanthemum and occur in the northern and northeastern part of the microwatershed. Major area of about 170 ha (36%) are moderately suitable (Class S2) with minor limitations of gravelliness and rooting depth and are distributed in the central, eastern and southeastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 137 ha (29%) and occur in the northern, western, eastern and central part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. A very small area of about 13 ha (3 %) is not suitable for growing chrysanthemum and occur in the central and northeastern part of the microwatershed with severe limitation of rooting depth.

7.22 Land Use Classes (LUC's)

The 22 soil map units identified in Devihal-2 Microwatershed have been regrouped into 6 Land Use Classes (LMU's) for the purpose of preparing a Proposed Crop Plan. Land use classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a land use classes map (Fig.7.24) has been generated. These land use classes are expected to behave similarly for a given level of management.

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

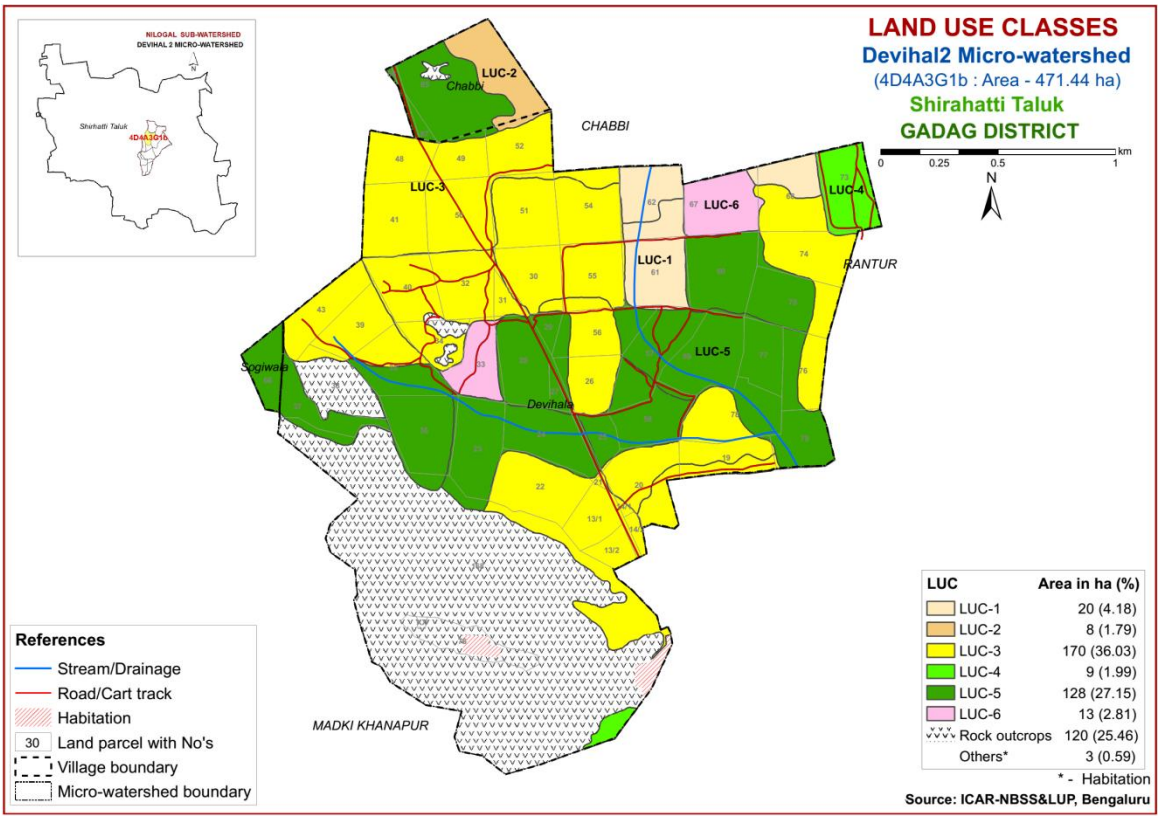


Fig. 7.24 Land Use Classes Map- Devihal-2 Microwatershed

LUC's	Soil map units	Soil and site characteristics
1	KMHiB1g1 KMHmB2g1 VDHhB1g1	Deep (100-150), red sandy clay loam to clayey soils with slopes of 1-3%, gravelly (15-35%) and slight to moderate erosion
2	CKMfB2g1	Moderately deep (75-100 cm), sandy clay soils with slopes of 1-3%, gravelly (15-35%) and moderate erosion
3	TDHcB2g1 TDHhB1g1 TDHhB2g1 TDHhC2g2 TDHiB1g1 TDHiB2g2	Moderately shallow (50-75 cm), sandy loam to clay loam soils with slopes of 1-5%, gravelly to very gravelly (15-60%) and slight to moderate erosion
4	LKRhB1g1 MKHcB1g1	Moderately shallow (50-75), sandy clay loam to sandy clay soils with slopes of 1-3%, gravelly (15-35%) and slight erosion
5	CSRhB2g2 KGPcB2g1 KNHcB2 KNHcB2g1 KNHhB2g2 KNHhB3g1 KNHmB2g1	Shallow (25 -50 cm), sandy clay loam to clay soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and moderate erosion
6	DVHfB2g1 DVHhB2g1	Very shallow (< 25 cm), sandy clay loam to sandy clay soils with slopes of 1-3%, gravelly (15-35%) and moderate erosion

7.23 Proposed Crop Plan for Devihal-2 Microwatershed

After assessing the land suitability for the 23 crops, the proposed crop plan has been prepared for the 6 identified LUC's by considering only the highly suitable (Class S1) and moderately suitable (Class S2) lands for each of the 23 crops. The resultant proposed crop plan is presented below in Table 7.16.

Table 7.16 Proposed Crop Plan for Devihal-2 Microwatershed

LUC No.	Mapping Units	Survey Number	Field Crops/ Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Suitable Interventions
LUC 1 Deep	6, 7, 21 (100-150 cm)	Devihala: 61,62	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, ucurbits **Flower Crops:** Marigold, Gaillardia	Mango, Sapota, Guava, Lime, Banana, Papaya, Jamun **Mixed Orchard:**Mango+Guava +Drumsticks+ Curry leaf Sapota+Guava+Drumsticks+ Curryleaf **Vegetables**: Tomoto, Capsicum, Green Chillies, French Bean, Bhendi, Crucifers, Cucurbits **Flower Crops:**Tuberose,Aster, Chrysanthemum, Rose, Jasmine, Spider Lilly	Dripirrigation, Mulching, other suitable conservation practices
LUC 2 Moderately deep	1 (75-100 cm)	Chabbi: 85	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	Mango, Sapota, Guava, Lime, Banana, Papaya, Jamun **Mixed Orchard:** Mango + Guava+ Drumsticks+ Curry leaf Sapota+Guava+Drumsticks+ Curryleaf **Vegetables**: Tomoto, Capsicum, Green Chillies, French Bean,	-do-

				Bean, Bhendi, Vegetable Cowpea, Cucurbits **Flower Crops:** Marigold, Gaillardia	Bhendi, Crucifers, Cucurbits **Flower Crops:** Tuberose,Aster,Chrysanthemum , Rose, Jasmine, Spider Lilly	
LUC 3	15, 16, 17, 18, 19, 20 (50-75 cm) Moderately shallow	Devihala: 13/1,13/2, 14/1,14/2,19,20,21,22,26,30,31,32,34,39,40,41, 43,48,49,50,51,52,54,55,56,68,74,78	Ragi, Sorghum, Maize, Bajra, Horsegram, Castor	Bear, Fig, Aonla, Bael, Wood Apple	Custurd Apple, Bear, Fig, Aonla, Pommelo	-do-
LUC 4	13, 14 (50-75 cm) Moderately shallow	Devihala: 73	Ragi, Bajra, Horsegram, Groundnut	Bear, Custurd Apple **Vegetables:** Cluster Bean, Ridge Guard, Ash Gouard	Fig, Aonla, Pomelo	-do-
LUC 5	2, 5, 8, 9, 10, 11, 12 (25-50 cm) Shallow	Chabbi: 85,86,87 Devihala: 23,24,25,27, 28,29,35,36, 37,57,58,59, 60,75,77,79 Sogiwala: 66	Groundnut, Horsegram, Greengram **Silviculture:** Simaruba, Acacia auriculiformis, Glyricidia, Subabul, Agave, Cassia sp.	**Vegetables:** Chillies, Tomato	-	-do-
LUC 6	3, 4 (<25 cm) Very shallow	Devihala: 33,67	Anjan Grass, Marvel Grass, Styloxantheshamata	-	-	-do-

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

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

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

The most important characterististics of a healthy soil are

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

Characteristics of Devihal-2 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of TDH (170 ha), CSR (34 ha), KNH (82 ha), KMH (14 ha), DVH (13 ha), KGP (12 ha), CKM (8 ha), LKR (8 ha), VDH (5 ha) and MKH (1 ha).
- As per land capability Classification, an area of 7 per cent in the microwatershed falls under arable land category (Class II, III and IV). The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, an area of about 39 ha (8%) is under slightly alkaline (pH 7.3-7.8), about 81 ha (17%) is moderately alkaline (pH 7.8-8.4) and about 59 ha

(12%) is strongly alkaline (pH 8.4-9.0). A small area of about 18 ha (4%) is moderately acid (pH 5.5-6.0), 67 ha (14%) is slightly acid (pH 6.0-6.5) and about 85 ha (18%) has soils that are neutral (pH 6.5 -7.3).

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

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

Acid soils

(Slightly acid to strongly acid soils)

1. Application of lime in the form of calcium carbonate or lime stone ($CaCO_3$)
2. 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.
3. Use of rock phosphate (30-50 % of CaO, which helps in improving soil pH).
4. Application of basic fertilizers (Sodium nitrate, basic slag etc, reduces acidity in acid soils)

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

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total 471 ha area in the microwatershed, an area of 262 ha is suffering from moderate and small area of 14 ha under severe erosion. These areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Disseminate information and communicate benefits

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

Inputs for Net Planning (Saturation Plan) and Interventions needed

Net planning in IWMP is focusing on preparation of

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

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

- **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops, either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.

- **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato

etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.

- **Gravelliness:** More gravel content is favorable for run-off harvesting but poor in soil moisture storage and nutrient availability. It is a significant parameter that decides the kind of crop to be raised.

- **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Devihal-2 Microwatershed.

- **Organic Carbon:** The OC content (an index of available Nitrogen) is medium (0.5-0.75%) in about 58 ha (12%) area, low (<0.5%) in maximum area of 288 ha (61%) and high (>0.5%) in about 2 ha (<1%). The areas that are low and medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 288 ha area where OC is less than 0.5% and 58 ha area is medium (0.5-0.75%) in OC. 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**: Available phosphorus is low in major area of about 347 ha (74%) area. Hence for all the crops, 25% additional P-needs to be applied.
- **Available Potassium:** Available potassium is medium in 332 ha (70%) area of the microwatershed and an area of about 15 ha (3%) is low <145 kg/ha) in available potassium. For all these areas for all crops, additional 25 % potassium may be applied. A very small area of about 2 ha (<1%) is high (>0.75%).
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. Available sulphur is medium (10-20 ppm) in maximum area of about 314 ha (66%) in 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. High in an area of about 35 ha (7%) in the microwatershed.

- **Available Boron:** Available boron is medium in an area of 218 ha (46%), low in 69 ha (15%) and 62 ha (13%0 is high in the microwatershed.
- **Available iron:** It is deficient in a maximum area of 227 ha (48%) in the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years. It is sufficient in the rest of 121 ha (26 %) area in the microwatershed.
- **Available Zinc:** It is deficient (<0.6 ppm) in 317 ha (67%) area and sufficient (>0.6 ppm) in 31 ha (7%) in the microwatershed. Application of zinc sulphate @25 kg/ha is to be followed.
- **Soil acidity:** The microwatershed has 85 ha area with soils that are acidic. These areas need application of lime ($CaCO_3$) and wherever acidity is in excess, rock phosphate and basic slag can be recommended. Management practices like soil management, water management *etc.* increase the efficiency of nitrogen and potassic fertilizers and growing of acid tolerant crops like Rice, Potato, Tomato, Barley, Wheat *etc*., are recommended.
- **Soil alkalinity:** The microwatershed has 140 ha (30%) area with soils that are moderately to strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc, are recommended.

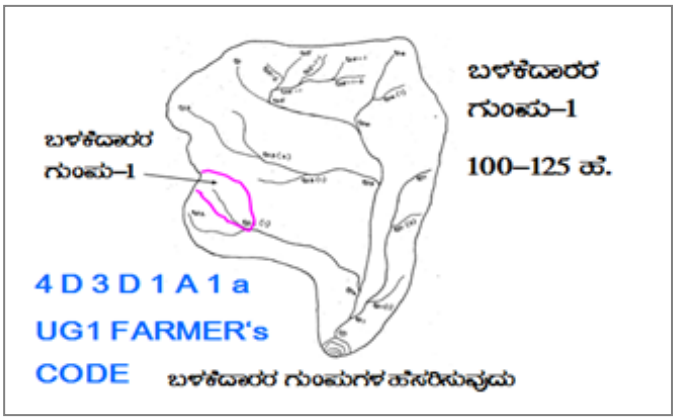
Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and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

Chapter 9

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Devihal-2 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 and land cover
- Crop suitability
- Rainfall
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features- Network of waterways, pothissa boundaries, cut up/ minor terraces etc.
- Cadastral map (1:7920 scale)
- Satellite imagery (1:7920 scale)



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

Steps for Survey and Preparation of Treatment Plan

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

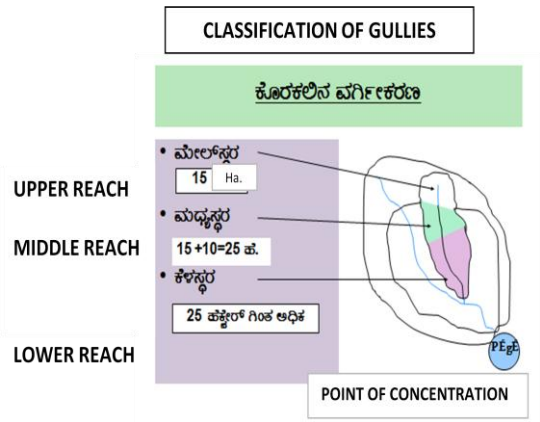
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

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

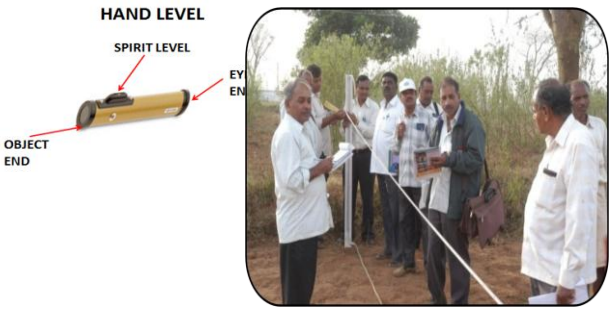
9.1.1 Arable Land Treatment

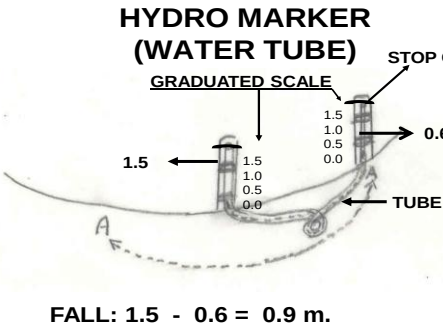
A. BUNDING

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

Measurement of Land Slope

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





FALL: 1.5 - 0.6 = 0.9 m.

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

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

Note: i) The above intervals are maximum.

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

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

Section of the Bund

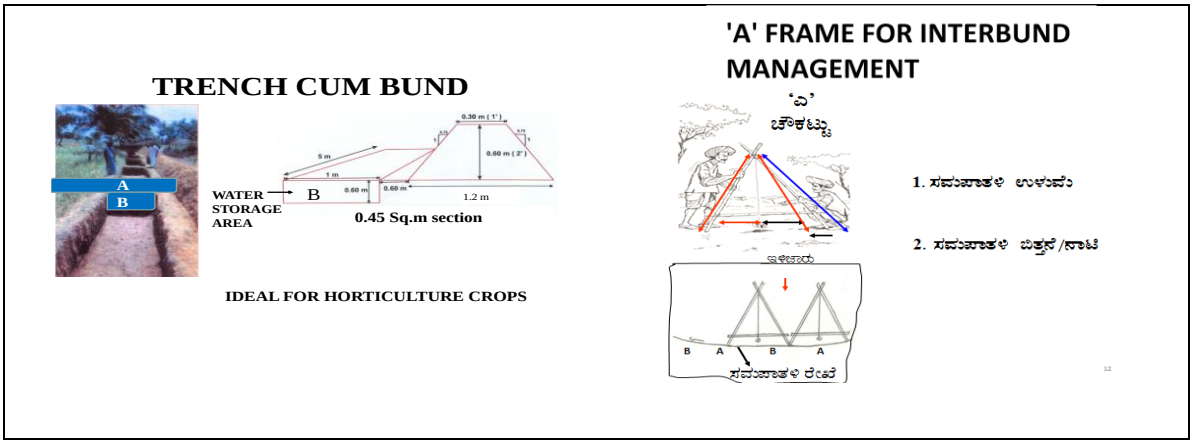
Bund section is decided considering the soil texture class and gravelliness class (bg_0 - loamy sand, <15% gravel). The recommended Sections for different soils are given below.

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 soils	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3	2.1	0.6	1.5:1	0.72	Very shallow black soils	
0.45	2	0.75	01:01	0.92		
0.45	2.4	0.75	1.3:1	1.07	Shallow black soils	
0.6	3.1	0.7	1.78:1	1.29	Medium black soils	
0.5	3	0.85	1.47:1	1.49		

Formation of Trench cum Bund

Dimensions of the Borrow Pits/ Trenches to be excavated (machinery are decided considering the Bund Section). Details of Borrow Pit dimensions are given below



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

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

B. Waterways

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

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

c) The design details are given in the Manual.

C. Farm Ponds

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

D. Diversion channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been prepared which shows the spatial distribution and extent of area. An area of about 349 ha (74%) requires trench cum bunding. 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.

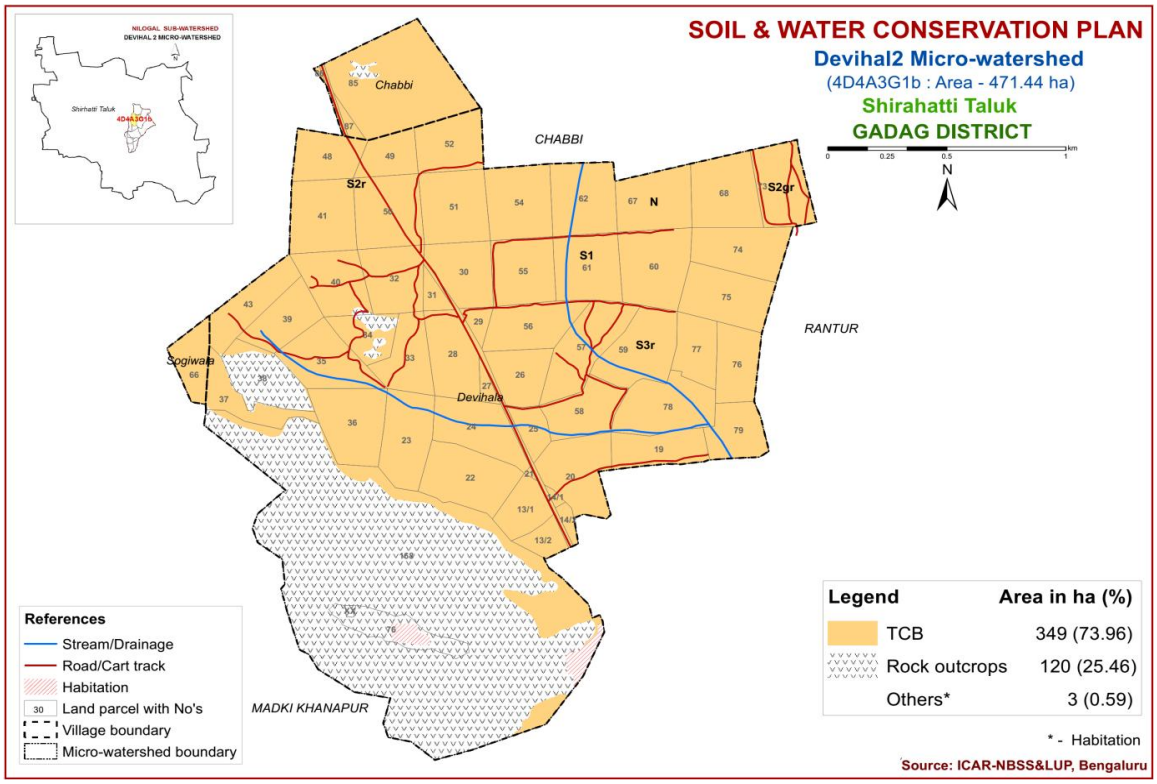


Fig. 9.1 Soil and Water Conservation Plan map of Devihal-2 Microwatershed

9.3 Greening of Microwatershed

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

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

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

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

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Appendix I

Devihal-2 Microwatershed

Soil Phase Information

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Devihala	13/1	4.17	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	TCB
Devihala	13/2	2.24	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	TCB
Devihala	14/1	0.32	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cultivated land (Cl)	Not Available	IIes	TCB
Devihala	14/2	0.84	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	TCB
Devihala	19	5.75	TDHiB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Maize (Ct+Mz)	Borewell,Openwell	IIs	TCB
Devihala	20	8.39	TDHiB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Maize (Ct+Mz)	3 Borewell	IIs	TCB
Devihala	21	0.13	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IIes	TCB
Devihala	22	9.09	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IIes	TCB
Devihala	23	8.07	KNHcB2	LUC-5	Shallow (25-50 cm)	Sandy loam	Non gravelly (<15%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Openwell,Checkdam	IVes	TCB
Devihala	24	7.69	KNHcB2	LUC-5	Shallow (25-50 cm)	Sandy loam	Non gravelly (<15%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IVes	TCB
Devihala	25	2.6	KNHmB2g1	LUC-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Openwell	IVes	TCB
Devihala	26	5.33	TDHiB2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Mulberry flower (Mf)	Openwell,2 Borewell	IIes	TCB
Devihala	27	0.87	KGPcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IVes	TCB
Devihala	28	7.13	KGPcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Onion (Mz+On)	Not Available	IVes	TCB
Devihala	29	1.32	KGPcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IVes	TCB
Devihala	30	6.57	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Forest+Cotton +Maize (F+Ct+Mz)	Borewell	IIes	TCB
Devihala	31	1.36	TDHhC2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Moderate	Forest (F)	Not Available	IIes	TCB
Devihala	32	7.06	TDHhC2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Moderate	Forest (F)	Not Available	IIes	TCB
Devihala	33	6.03	DVHfB2g1	LUC-6	Very shallow (<25 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Forest (F)	Not Available	IVes	TCB
Devihala	34	4.47	TDHhC2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Moderate	Mining	Not Available	IIes	TCB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Devihala	35	7.85	KNHhB3g1	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Scrub land+Forest (Sl+F)	Not Available	VIes	TCB
Devihala	36	8.69	KNHhB3g1	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Scrub land+Forest (Sl+F)	Not Available	VIes	TCB
Devihala	37	4.84	KNHhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IVes	TCB
Devihala	38	7.15	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Scrub land (Sl)	Not Available	VIII	Rock outcrops
Devihala	39	5.71	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Forest+Scrub land (F+Sl)	Not Available	IIes	TCB
Devihala	40	6.97	TDHhC2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Very gravelly (35-60%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Moderate	Scrub land+Forest (Sl+F)	Not Available	IIes	TCB
Devihala	41	8.48	TDHhB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Forest+Scrub land (F+Sl)	Not Available	IIs	TCB
Devihala	43	6.27	TDHcB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IIes	TCB
Devihala	48	5.6	TDHhB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Forest+Scrub land (F+Sl)	Not Available	IIs	TCB
Devihala	49	4.18	TDHhB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	Not Available	IIs	TCB
Devihala	50	8.68	TDHhB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	Not Available	IIs	TCB
Devihala	51	8.61	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IIes	TCB
Devihala	52	6.58	TDHhB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	Not Available	IIs	TCB
Devihala	54	8.53	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Sunflower+Cotton (Sf+Ct)	Borewell,Openwell	IIes	TCB
Devihala	55	7.47	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Onion+Cotton (Mz+On+Cotton)	Farm pond,Borewell	IIes	TCB
Devihala	56	7.14	TDHiB2g2	LUC-3	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	3 Borewell	IIes	TCB
Devihala	57	8.71	CSRhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IIIes	TCB
Devihala	58	6.23	KNHmB2g1	LUC-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Borewell	IVes	TCB
Devihala	59	8.48	CSRhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Flower (Ct+Fr)	2 Borewell	IIIes	TCB

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Devihala	60	9.41	KNHhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Borewell	IVes	TCB
Devihala	61	7.95	KMHmB2g1	LUC-1	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIes	TCB
Devihala	62	8.4	VDHhB1g1	LUC-1	Deep (100-150 cm)	Sandy clay loam	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Cotton+Maize (Ct+Mz)	Borewell	IIs	TCB
Devihala	67	7.92	DVHhB2g1	LUC-6	Very shallow (<25 cm)	Sandy clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Borewell	IVes	TCB
Devihala	68	8.55	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Onion (Ct+On)	Borewell,Openwell	IIes	TCB
Devihala	73	7.54	LKRhB1g1	LUC-4	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Scrub land (Sl)	Not Available	IIIes	TCB
Devihala	74	7.78	TDHhB2g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Maize+Cotton (Mz+Ct)	Not Available	IIes	TCB
Devihala	75	8.33	KNHhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IVes	TCB
Devihala	76	11.12	Rockout crop	Rockoutcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Temple fort (Hill)	Tank,Borewell	VIII	Rock outcrops
Devihala	77	4.88	CSRhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	2 Borewell	IIIes	TCB
Devihala	78	8.91	TDHiB1g1	LUC-3	Moderately shallow (50-75 cm)	Sandy clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Agricultural Plantation (AP)	Borewell	IIs	TCB
Devihala	79	5.39	CSRhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton+Maize (Ct+Mz)	Not Available	IIIes	TCB
Devihala	168	121.45	Rockout crop	Rockoutcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Scrub land (Sl)	Not Available	VIII	Rock outcrops
Chabbi	85	20	KNHcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Maize (Mz)	Not Available	IVes	TCB
Chabbi	86	0.12	KNHcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cultivated land (Cl)	Not Available	IVes	TCB
Chabbi	87	0.69	KNHcB2g1	LUC-5	Shallow (25-50 cm)	Sandy loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Cultivated land (Cl)	Not Available	IVes	TCB
Sogiwala	66	4.07	KNHhB2g2	LUC-5	Shallow (25-50 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (Sl)	Not Available	IVes	TCB

Appendix II

Devihal-2 Microwatershed

Soil Fertility Information

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Devihala	13/1	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	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)
Devihala	13/2	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	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)
Devihala	14/1	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	14/2	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	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)
Devihala	19	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Devihala	20	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	21	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	22	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	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)
Devihala	23	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	24	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	25	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	26	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	27	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	28	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	29	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	30	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	31	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	32	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	33	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	34	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	35	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	36	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Devihala	37	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	38	Rock outcrops	Rockout crops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Devihala	39	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	40	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	41	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	43	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	48	Moderately acid (pH 5.5-6.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	49	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	50	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	51	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	52	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	54	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	55	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	56	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Devihala	57	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Devihala	58	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	59	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	60	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	61	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	High (>20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	62	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Devihala	67	Neutral (pH 6.5-7.3)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	68	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	73	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	74	Slightly acid (pH 6.0-6.5)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Devihala	75	Neutral (pH 6.5-7.3)	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)
Devihala	76	Rock outcrops	Rockout crops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Devihala	77	Moderately alkaline (pH 7.8-8.4)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	78	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	79	Strongly alkaline (pH 8.4-9.0)	Non Saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Devihala	168	Rock outcrops	Rockout crops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Chabbi	85	Moderately acid (pH 5.5-6.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Chabbi	86	Moderately acid (pH 5.5-6.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Chabbi	87	Moderately acid (pH 5.5-6.0)	Non Saline (<2 dsm)	Low (<0.5 %)	Low (<23 kg/ha)	Medium (145-337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Sogiwala	66	Slightly alkaline (pH 7.3-7.8)	Non Saline (<2 dsm)	Low (<0.5 %)	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)

Appendix III

Devihal-2 Microwatershed

Soil Suitability Information

Village	Survey No.	Sorgham	Maize	Groundnut	Sunflower	Cotton	Chilly	Tomato	Mango	Sapota	Guava	Pomegranate	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Marigold	Chrysanthemum	Sugarcane	Onion	Citrus	Bhendi
Devihala	13/1	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	13/2	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	14/1	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	14/2	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	19	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	20	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	21	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	22	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	23	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	24	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	25	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	26	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	27	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	28	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	29	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	30	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	31	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	32	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	33	Nr	Nr	Nr	Nr	Nr	Nr	Nr	N	Nr	Nr	Nr	N	N	N	N	N	N	N	N	Nr	Nr	Nr	Nr	Nr	Nr
Devihala	34	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	35	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	36	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	37	S3g	S3rg	S2rg	S3rg	S3g	S3g	S2rg	N	S3rg	S3rg	S3rg	N	N	N	N	N	S3r	S3r	N	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg
Devihala	38	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops
Devihala	39	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	40	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	41	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	43	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	48	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	49	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	50	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	51	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	52	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r

Village	Survey No.	Sorgham	Maize	Groundnut	Sunflower	Cotton	Chilly	Tomato	Mango	Sapota	Guava	Pomegranate	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Marigold	Chrysanthemum	Sugarcane	Onion	Citrus	Bhendi
Devihala	54	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	55	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	56	S3rg	S3rg	S3rt	S2rg	S2rg	S2rg	S2rg	N	S3rg	S3g	S3rg	N	S3r	N	N	S3r	S2r	S2r	S3r	S2rg	S2rg	S3rg	S2rg	S3rg	S2rg
Devihala	57	S3rg	S3rg	S3r	Nr	S3rg	S3rg	S3rg	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3rg	Nr	S3rg
Devihala	58	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Devihala	59	S3rg	S3rg	S3r	Nr	S3rg	S3rg	S3rg	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3rg	Nr	S3rg
Devihala	60	S3g	S3rg	S2rg	S3rg	S3g	S3g	S2rg	N	S3rg	S3rg	S3rg	N	N	N	N	N	S3r	S3r	N	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg
Devihala	61	S2g	S2g	S1	S1	S1	S1	S1	S2r	S2g	S1	S1	S2r	S2r	S2r	S2r	S2r	S1	S1	S2r	S1	S1	S1	S1	S2r	S1
Devihala	62	S1	S1	S2t	S1	S1	S1	S1	S2r	S1	S2t	S1	S2r	S2r	S2r	S2r	S2r	S1	S1	S2r	S1	S1	S1	S2t	S1	S2t
Devihala	67	Nr	Nr	Nr	Nr	Nr	Nr	Nr	N	Nr	Nr	Nr	N	N	N	N	N	N	N	N	Nr	Nr	Nr	Nr	Nr	Nr
Devihala	68	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	73	S3rg	S3rg	S2g	S3rg	S3g	S3g	S3g	N	S3rg	S3rg	S3rg	N	S3gr	N	N	S3r	S2gr	S2gr	N	S3g	S3g	S3rg	S3g	S3rg	S3g
Devihala	74	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	75	S3g	S3rg	S2rg	S3rg	S3g	S3g	S2rg	N	S3rg	S3rg	S3rg	N	N	N	N	N	S3r	S3r	N	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg
Devihala	76	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops
Devihala	77	S3rg	S3rg	S3r	Nr	S3rg	S3rg	S3rg	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3rg	Nr	S3rg
Devihala	78	S2rg	S2rg	S2r	S2rg	S2rg	S2rg	S2r	N	S3r	S3r	S3r	N	S3r	N	N	S3r	S2r	S2r	S3r	S2r	S2r	S3r	S2rg	S3r	S2r
Devihala	79	S3rg	S3rg	S3r	Nr	S3rg	S3rg	S3rg	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3rg	Nr	S3rg
Devihala	168	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops	R.crops
Chabbi	85	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Chabbi	86	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Chabbi	87	S3r	S3r	S3r	Nr	S3r	S3r	S3r	N	Nr	Nr	Nr	N	N	N	N	N	S3r	S3r	N	S3r	S3r	Nr	S3r	Nr	S3r
Sogiwala	66	S3g	S3rg	S2rg	S3rg	S3g	S3g	S2rg	N	S3rg	S3rg	S3rg	N	N	N	N	N	S3r	S3r	N	S3rg	S3rg	S3rg	S3rg	S3rg	S3rg

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

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

Methodology: *Devihal-2 micro-watershed (Nilogal sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^0 6'$ – $15^0 8'$ North latitudes and $75^0 35'$ – $75^0 37'$ East longitudes, covering an area of about 471 ha, bounded by Chabbi village on north, Madki Khanapur and Nadigatti villages on the west, Devihal village on the east with an 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 Devihal-2 Microwatershed (Nilogal sub-watershed, Shirahatti taluk, Gadag district) are presented here.*

Social Indicators;

- *Male and female ratio is 51.0 to 49.0 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 57 per cent to the total population.*
- *Literacy population is around 75 per cent.*
- *Fire wood is the source of energy for a cooking among all sample households.*
- *About 30 per cent of households have a Bhima and Yashaswini health card.*
- *Majority of farm households (80 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 90 per cent.*
- *Swach bharath program providing closed toilet facilities around 70 per cent of sample households.*
- *Institutional participation is only 8 per cent of sample households.*
- *Rural migration to unban centre for employment is prevalent among 10 per cent of farm households.*
- *Women participation in decisions making are around 80 per cent of households.*

Economic Indicators;

- *The average land holding is 1.12 ha indicates that majority of farm households are belong to marginal and small farmers. The dry land of 89 % and irrigated land 11 % of total cultivated land area among the sample farmers.*
- *Agriculture is the main occupation among 53 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 42 per cent of sample households.*
- *The average value of domestic assets is around Rs. 13159 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 7435 per household, about 30 per cent of sample farmers owen plough and sprayer (20 %).*
- *The average value of livestock is around Rs. 24479 per household; about 67 per cent of household are having livestock.*
- *The average per capita food consumption is around 934.88 grams (2030 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 50 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs.18189 per household. Among all sample farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs.1201.*

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. 694 per ha/year. The total cost of annual soil nutrients is around Rs. 241483 per year for the total area of 471.44 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 5639 ha/year. Per hectare food grain production services is maximum in maize (Rs. 8704) followed by sunflower (Rs. 8554), horse gram (Rs. 4959) and groundnut (Rs. 339).*
- *The average value of ecosystem service for fodder production is around Rs. 2628/ ha/year. Per hectare fodder production services is maximum in maize (Rs. 3120) followed by groundnut (Rs. 2408) and horse gram (Rs. 2355).*
- *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 sunflower (Rs. 35658) followed by horse gram (Rs. 32967), maize (Rs. 30378) and groundnut (Rs. 22333).*

Economic Land Evaluation;

- *The major cropping pattern is maize (53.8 %) followed by groundnut (18.9 %) sunflower (17.2) and horse gram (9.9 %).*
- *In Devihal 2 major soil series are Thammadahalli soil are having moderately shallow soil depth covered around 36.04 per cent of area. On this soil farmers are presently growing maize. Kanchanahalli soil series are having shallow soil depth covered around 17.4 per cent of area. On this soil farmers are presently growing groundnut (40 %), horse gram (20 %) and sunflower (40 %). Chikkasavanur soil series are shallow soil depth covered around 7.1 per cent of area. On this soil farmers are presently growing groundnut (17.2 %) and maize (82.8 %). Kaggalipura series are having shallow soil depth covered around 12.1 per cent of area. On this soil farmers are presently growing horse gram, Devihal soil series are having very shallow soil depth cover around 5.4 per cent of area presently growing maize (50 %) and sunflower (50 %). Vaddarahalli series are having deep soil depth cover around 1.1 per cent of area; crops are maize (57.1 %) and sunflower (42.9 %).*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for groundnut ranges between Rs. 38930/ha in CSR soil (with BCR of 1.12) and Rs.24612/ha in KNH soil (with BCR of 1.05).*
- *In maize the cost of cultivation range between Rs. 59727/ha in DVH soil (with of 1.21) and Rs. 23088/ha in CSR soil (with BCR of 1.62).*
- *In horse gram the cost of cultivation ranges between Rs. 31783/ha in KGP soil (with BCR of 1.22) and Rs. 15065/ha in KNH soil (with BCR of 1.05).*
- *In sunflower the cost of cultivation range between is Rs. 34268/ha in DVH soil (with BCR of 0.96) and Rs. 19716 in KNH soil (with BCR of 1.91).*
- *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 on deeper soil to maximize returns.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*

- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in groundnut maize (76.2 to 58.3 %), sunflower (43.8 to 29.1 %), groundnut (56.6 to 49.4 %), and maize (84.4 to 52.7%).*

Chapter 2

INTRODUCTION

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

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

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

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

Objectives of the study

1. To characterize socio-economic status of farm households
2. To evaluate the economic viability of land use and land related constraints
3. To estimate the ecosystem service provided by the watershed and
4. To suggest alternatives for sustainable agriculture production.

Chapter 3

METHODOLOGY

Study area

Devihal-2 micro-watershed is located in Northern Transition Zone of Karnataka (Figure 1).Extends over all area of 1.13 M ha of which 0.86 M ha is under cultivation. Nearly 0.052 M ha in the zone enjoys irrigation facilities. Elevation ranges between 450-900 m MSL with most parts situated between 800 and 900 m. Shallow to black soils and red loams are distributed in equal proportion. The average annual rainfall ranges from 620 to 1300 mm of which more than 60 per cent is received during the southwest monsoon (*kharif*). Sorghum, rice, groundnut, maize, chilli, pulses, sugarcane, tobacco and cotton are the major crops of the zone. It's represented Agro Ecological Sub Region (AESR) 6.4 having LGP 150-180 days.

Devihal-2 micro-watershed (Nilogal sub-watershed, Shirahatti taluk, Gadag district) is located in between $15^0$6' – $15^0$8' North latitudes and $75^0$35' – $75^0$37' East longitudes, covering an area of about 471 ha, bounded by Chabbi village on north, Madki Khanapur and Nadigatti villages on the west, Devihal village on the east.

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).

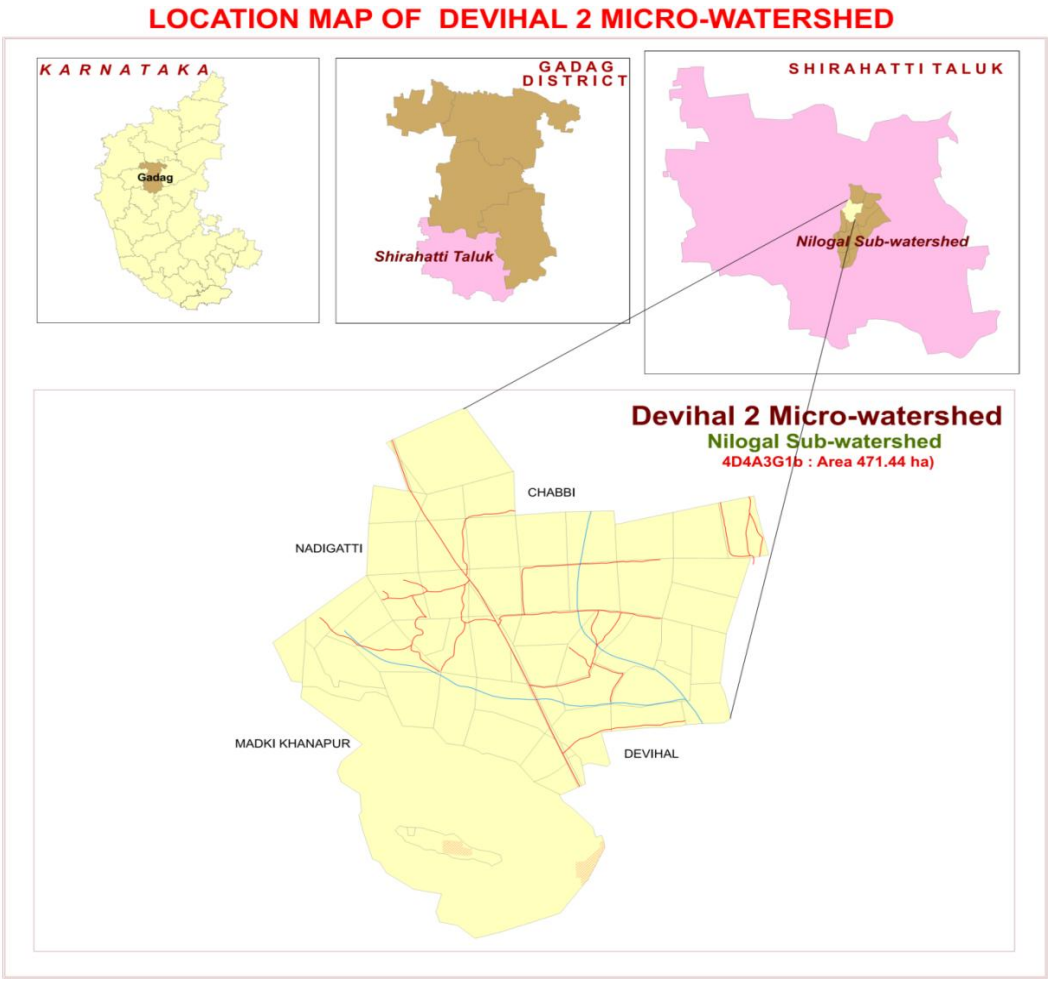


Figure 1: Location of study area

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 .

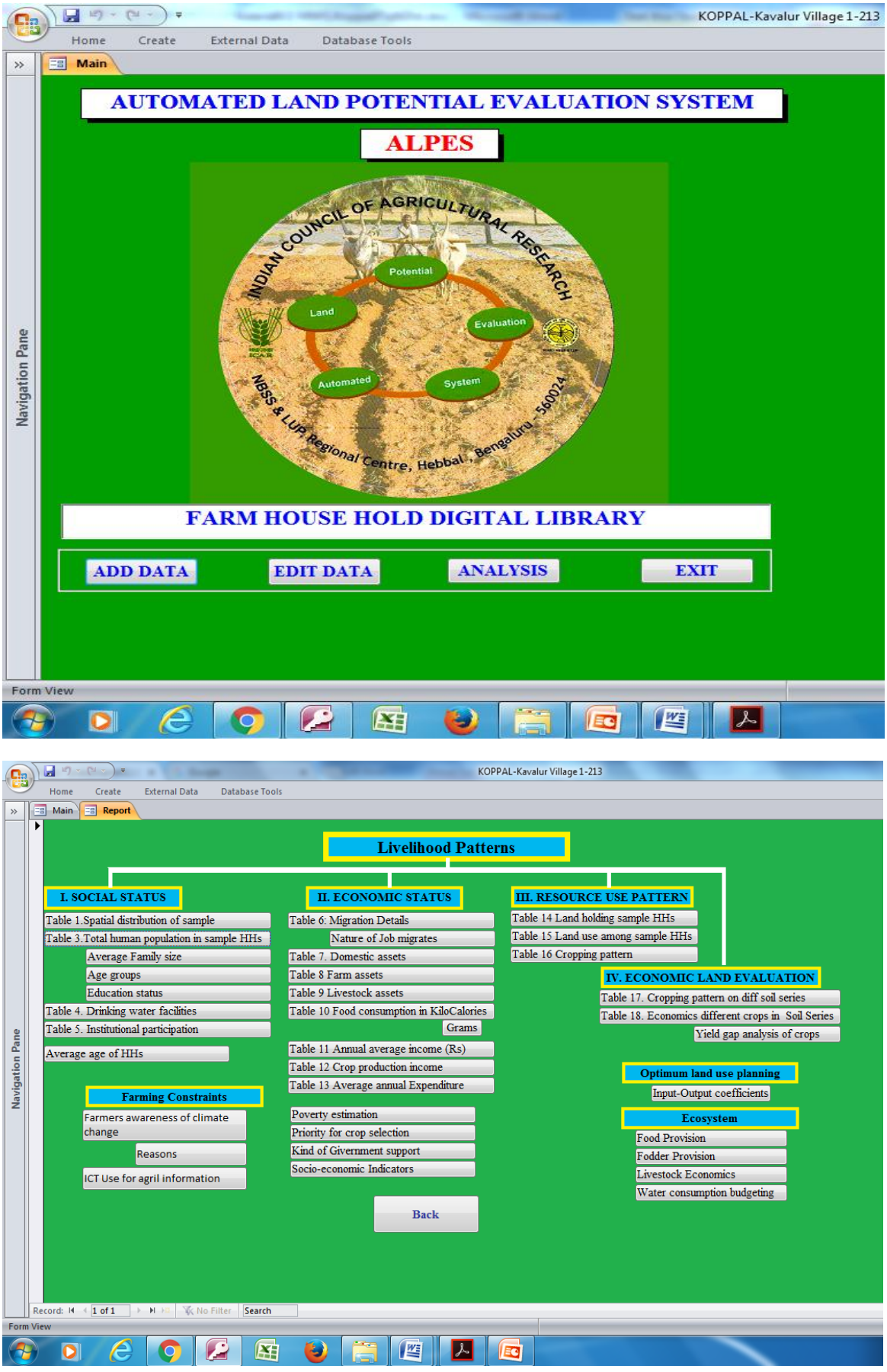


Figure 2: ALPES FRAMEWORK

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.

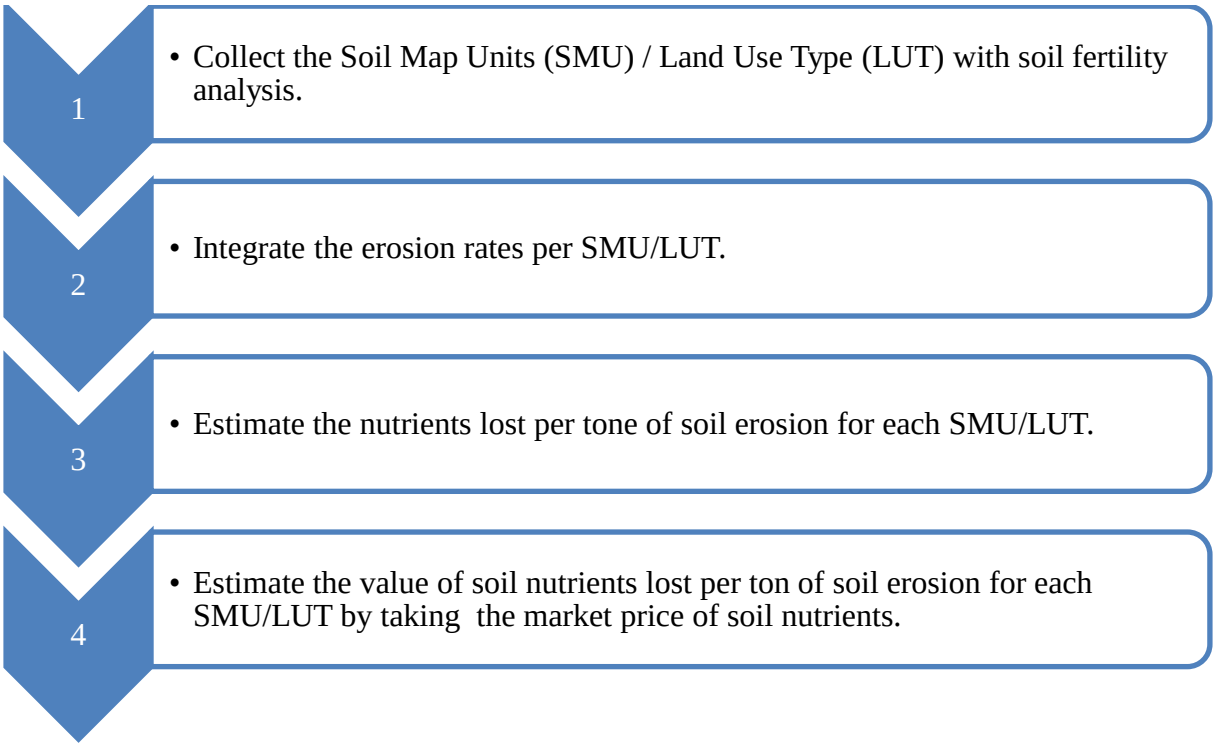
Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.
Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)
Net returns = Gross returns-Operational cost.
Benefit Cost Ratio = Net returns/Total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



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 53 out of which 51 per cent were males and 49 per cent females. Average family size of the households is 5.3. 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 (36 %) followed by18 to 30 (21 %) years, 50 years (18 %) and more than 0 to18 years (25 %). 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 25 per cent of respondents were illiterate and 75 per cent literate (Table 1).

Table 1: Human population among sample households in Devihal 2 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	53.0
Male	% to total Population	51.0
Female	% to total Population	49.0
Average family size	Number	5.3
Age group		
0 to 18 years	% to total Population	25.0
18 to 30 years	% to total Population	21.0
30 to 50 years	% to total Population	36.0
>50 years	% to total Population	18.0
Average age	Age in years	33.2
Education Status		
Illiterates	% to total Population	25.0
Literates	% to total Population	75.0
Primary School (<5 class)	% to total Population	34.0
Middle School (6- 8 class)	% to total Population	17.0
High School (9- 10 class)	% to total Population	13.0
Others	% to total Population	11.0

The ethnic groups among the all sample farm households to be found belonging to other backward castes (OBC) (Table 2 and Figure 3). Among all sample households are using fire wood as source of fuel for cooking all sample farmers are having electricity connection. About 40 per cent are sample households having health cards. Majority (30

%) are having MNREGA job cards for employment generation. About 90 per cent of farm households are having ration cards for taking food grains from public distribution system. About 70 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Devihal 2 Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	100.0
Types of fuel use for cooking		
Fire wood	% of Households	100.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	30.0
No	% of Households	70.0
MGNREGA Card		
Yes	% of Households	80.0
No	% of Households	20.0
Ration Card		
Yes	% of Households	90.0
No	% of Households	10.0
Households with toilet		
Yes	% of Households	70.0
No	% of Households	30.0
Drinking water facilities		
Tube well	% of Households	90.0
Tank	% 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 source for water supply for domestic purpose (90 %).

Only 8.0 per cent of the farmers are participating in community based organizations (Table 3). Among them majority were participating in village panchayat (4.0 %) followed by marketing co-operative societies (2.0 %) and dairy co-operative societies (2.0 %).

Table 3: Institutional participation among the sample population in Devihal 2 Microwatershed

Particulars	Units	Value
No. Of people participating	% to total	8.0
Village panchayath	% to total	4.0
Co-operative Societies - Marketing	% to total	2.0
Co-operative Societies-Dairy	% to total	2.0
No. Of people not participating	% to total	92.0

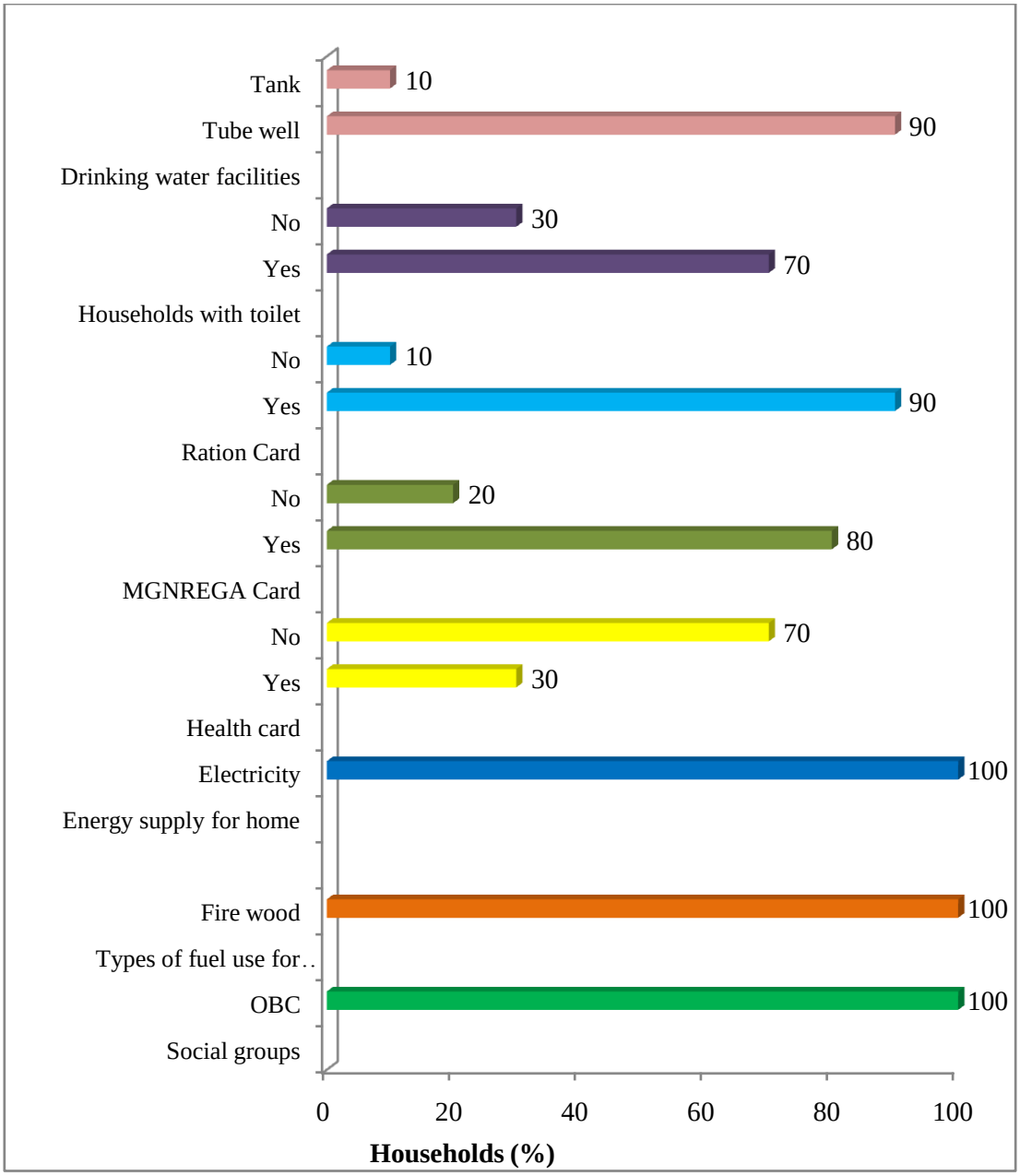


Figure 3: Basic needs of sample households in Devihal 2 Microwatershed

The data on migration in Devihal 2 Micro-watershed is given in Table 4. It indicated that around 10 per cent of samples households were migrated. The average distance travelled for seeking employment is 40 km.

Table 4: Migration details among the sample households in Devihal 2 micro-watershed

Particulars	**Value**
% of households showing migration	10.0
% of persons migrating	3.7
No. of months migrated in a year	6.0
Average Distance of migration(Km)	40
Nature of job (%)	
Job/wage/work	100

The occupational pattern (Table 5) among sample households shows that agriculture is the main occupation for 53 per cent of farmers followed by subsidiary occupations like agricultural labour (42 %), trade and private service (5 %).

Table 5: Occupational pattern in sample population in Devihal 2 Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	53.0
	Agriculture Labour	42.0
	Private service	5.0
Grand Total		100.0
Family labour availability		**Man days/month**
Male		38.0
Female		28.0
Total		66.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 6 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (100 %) followed by television (90 %), mixer/grinder (20 %), motorcycle (60 %) and bicycle (10 %). The average value of domestic assets is Rs.13159 per household.

Table 6: Domestic assets among the sample households in Devihal 2 Microwatershed

Particulars	% of households	Average value in Rs
Bicycle	10.0	3000
Mixer/grinder	20.0	3000
Mobile Phone	100.0	2350
Motorcycle	60.0	50167
Television	90.0	7278
Average value	13159	

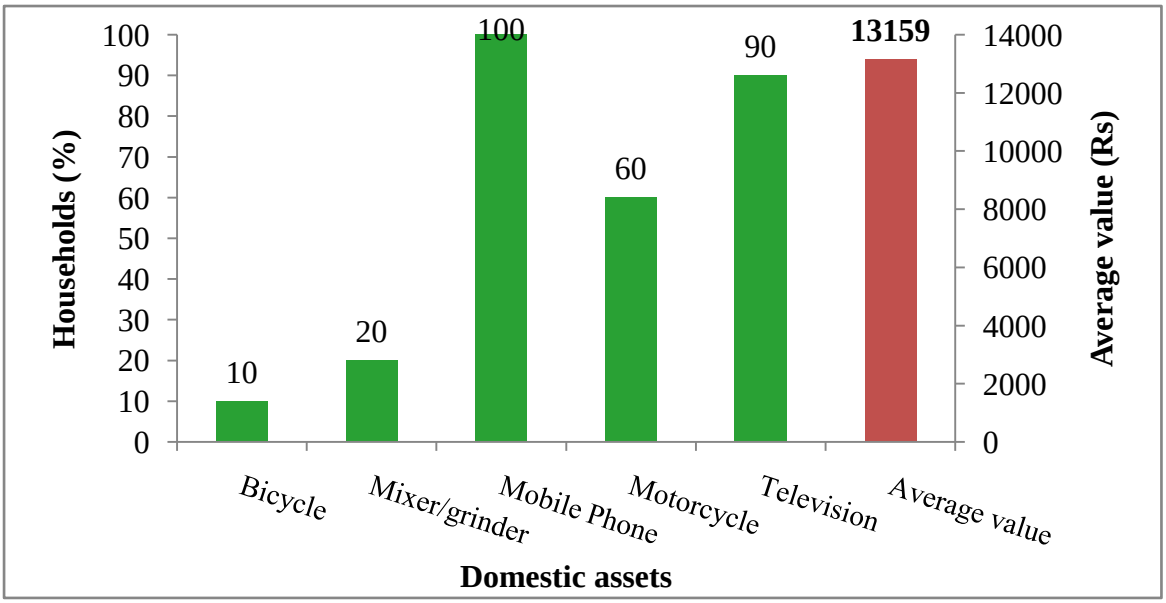


Figure 4: Domestic assets among the sample households in Devihal 2 Microwatershed

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 (50 %), plough (30 %), bullock cart (30 %), sprayer (20 %) and seed cum fertiliser drill (10 %) was found highest among the sample farmers. The average value of farm assets is around Rs. 7435 per households (Table 7 and Figure 5).

Table 7: Farm assets among samples households in Devihal 2 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	30.0	23333
Plough	30.0	3500
Sprayer	20.0	5000
Seed cum fertiliser drill	10.0	5000
Weeder	50.0	340
Average value	7435	

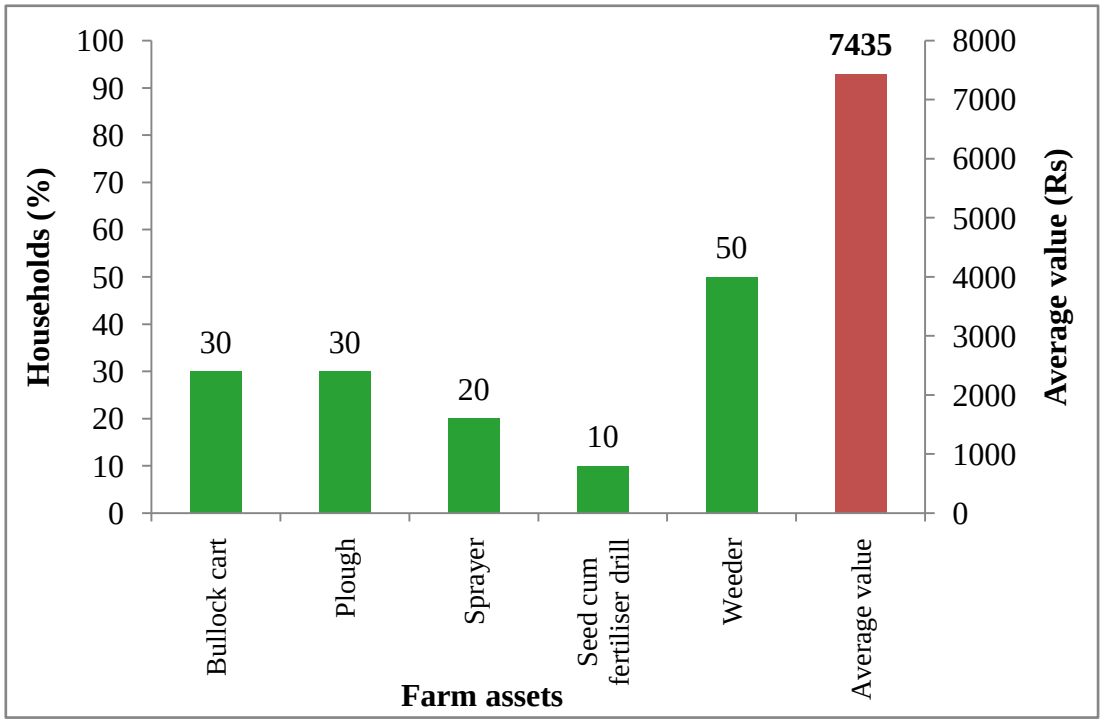


Figure5: Farm assets among samples households in Devihal 2 Microwatershed

Table 8: Livestock assets among sample households in Devihal 2 micro-watershed

Particulars	% of livestock population	Average value in Rs
Local Milching Cow	10.0	15000
Local Dry Cow	10.0	8000
Dry Buffalos	10.0	17000
Milching Buffalos	40.0	19063
Bullocks	33.0	63333
Average value	24479	

Livestock is an integral component of the conventional farming systems (Table 8 and Figure 6). The highest livestock population is milching buffalos were around 40 per cent followed by bullocks (33 %), milching cow (10 %), local dry cow (10 %) and dry buffalos (10 %). The average livestock value was Rs 24479 per households.

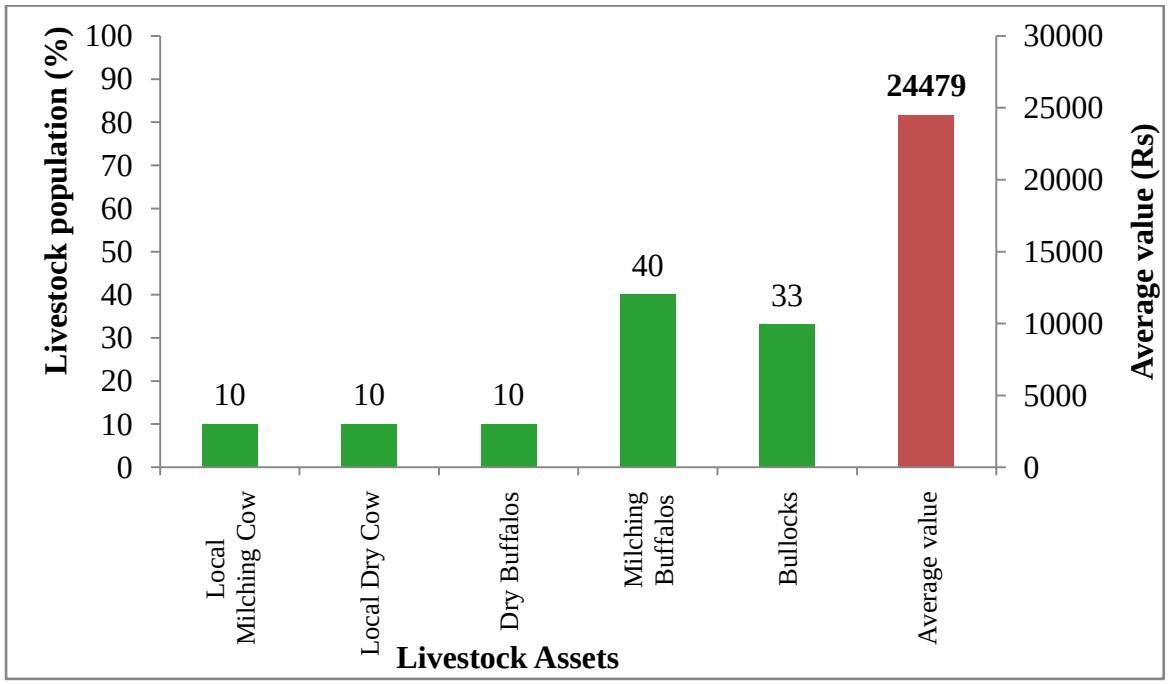


Figure 6: Livestock assets among sample households in Devihal 2 micro-watershed

Average milk produced in sample households is 552 litters/ annum. Among the farm households; maize, groundnut, and horse gram are the main crops for domestic food and fodder for animals. About 1638 kg /ha of average fodder is available per season for the livestock feeding (Table 9).

Table 9: Milk produced and fodder availability of sample households in Devihal 2 Microwatershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	180
Milching Buffalos	645
Average Milk produced	552
Fodder produces	**Fodder yield (kg/ha.)**
Maize	2067
Groundnut	938
Horsegram	833
Average fodder availability	1638
Livestock having households (%)	67
Livestock population (Numbers)	21

A woman participation in decision making is in this micro-watershed is presented in Table 10. About 90 per cent women earning for her family requirement, 80 per cent of women taking decision in her family and agriculture related activities and 20 per cent of women participation in local organization activities.

Table 10: Women empowerment of sample households in Devihal 2 Microwatershed

% to Grand Total

Particulars	**Yes**	**No**
Women participation in local organization activities	20.0	80.0
Women elected as panchayat member	0.0	100.0
Women earning for her family requirement	90.0	10.0
Women taking decision in her family and agriculture related activities	80.0	20.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 11 and Figure 7. More quantity of cereals are consumed by sample farmers which accounted for 1220 kcal per person. The other important food items consumed was pulses 226 kcal followed by cooking oil 201 kcal, milk 113 kcal, vegetables 34 kcal, Egg 201 kcal and Meat 35 kcal. In the sampled households, farmers were consuming less (2030 kcal) than NIN- recommended food requirement (2250 kcal).

Table 11: Per capita daily consumption of food among the sample households in Devihal 2 Microwatershed

Particulars	**NIN recommendation (gram/ per day/ person)**	**Present level of consumption (gram/ per day/ person)**	**Kilo Calories /day/person**
Cereals	396	359.20	1220.0
Pulses	43	65.20	226.0
Milk	200	175.0	113.0
Vegetables	143	143.21	34.0
Cooking Oil	31	35.34	201.0
Egg	0.48	133.73	201.0
Meat	14.2	23.20	35.0
Total	**827.7**	**934.88**	**2030**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		50	60
% Above NIN		50	40

Note: * day/person

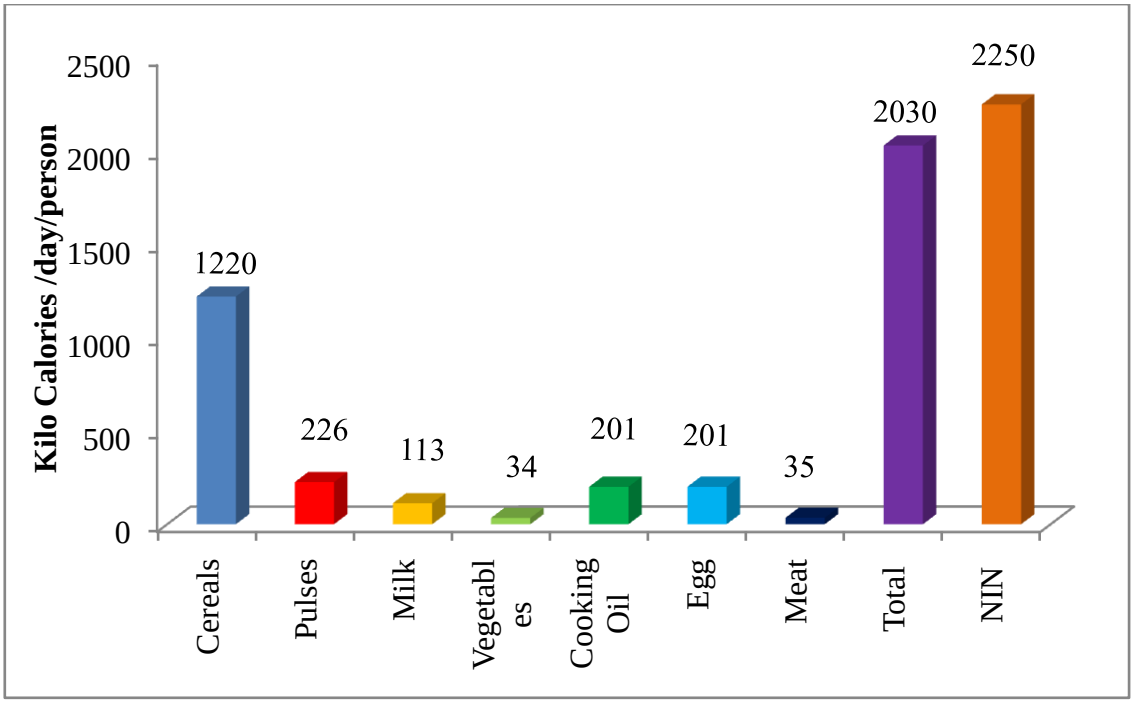


Figure 7: Per capita daily consumption of food among the sample households in Devihal 2 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs18189. Major source of income to the farmers in the study area is from crop production (Rs 11695) followed by livestock (Rs. 3663). The monthly per capita income is Rs.286, 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 12).

Table 12: Annual average income of HHs from various sources in Devihal 2 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	2832(10)
Livestock income (Rs)	3663 (40)
Crop Production (Rs)	11695 (100)
Total Annual Income (Rs)	***18189***
Average monthly per capita income (Rs)	286
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. 52398) 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. 1201 and among all farm households are below poverty line (Table 13 and Figure 8).

Table 13: Average annual expenditure of sample HHs in Devihal 2 Microwatershed

Particulars	Value in Rupees	Per cent
Food	52398	68.6
Education	3700	4.8
Clothing	6700	8.8
Social functions	8500	11.1
Health	5100	6.7
Total Expenditure (Rs/year)	76398	100.0
Monthly per capita expenditure (Rs)	1201	

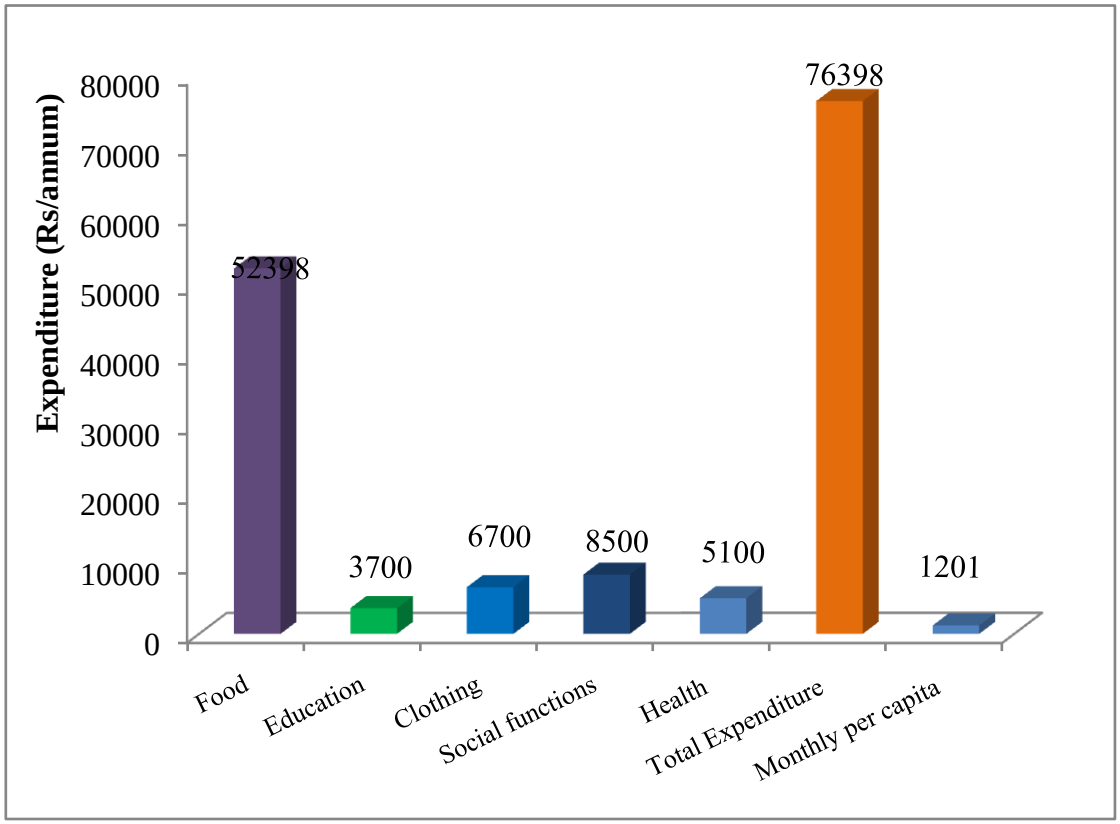


Figure 8: Average annual expenditure of sample HHs in Devihal 2 Microwatershed

Land holding: The total area cultivated by them is 11.23 ha. The average land holding of sample HHs is 1.12 ha, Large number of households belong to small size (90%) group with an average land holding size of 0.98 ha followed by the medium size (10 %) groups with an average land holding is 2.44 ha (Table 14).

Table 14: Distribution of land holding among the sample households in Gopalapur micro-watershed

Particulars	Units	Values
Small farmers		
Total land	ha	8.79
Sample size	Per cent	90
Average land holding	ha	0.98
Medium farmers		
Total land	ha	2.44
Sample size	Per cent	10
Average land holding	ha	2.44
Total sample households		
Total land	ha	11.23
Sample size	Per cent	100
Average land holding	ha	1.12

Land use: The total land holding in the Devihal 2 micro-watershed is 11.23 ha (Table 15). Of which 9.98 ha is rain fed land and 1.25 ha is irrigated land. The average land holding per household is worked out to be 1.12 ha.

Table 15: Land use among samples households in Devihal 2 Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	11.0	1.3
Rainfed Land	89.0	10.0
Fallow Land	00.	0.0
Total land holding	100	11.2
Average land holding	1.12	

In the micro-watershed, the prevalent present land uses under perennial plants are neem trees (27 %) followed by banyan tree coconut (5 %), Lime (1 %) and guava (1 %) (Table 16).

Table 16: Number of trees/plants covered in sample farm households in Devihal 2 Microwatershed

Particulars	Number of Plants/trees	Per cent
Neem trees	27	79
Cconut	5	15
Lime	1	3
Guava	1	3
Grand Total	34	100

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 the study area were by maize (53.8 %) followed by groundnut (18.9 %) sunflower (17.2), and horse gram (6.3 %) which are taken during Kharif and horse gram (3.6 %). during Rabi season respectively. The cropping intensity was 103.8 per cent (Table 17 and Figure 9).

Table 17: Present cropping pattern and cropping intensity in Devihal 2 Microwatershed

% to Grand Total

Crops	**Kharif**	**Rabi**	**Grand Total**
Groundnut	18.9	0.0	18.9
Horsegram	6.3	3.6	9.9
Maize	53.8	0.0	53.8
Sunflower	17.2	0.0	17.2
Grand Total	*96.3*	*3.6*	*100.0*
Cropping intensity (%)	103.8		

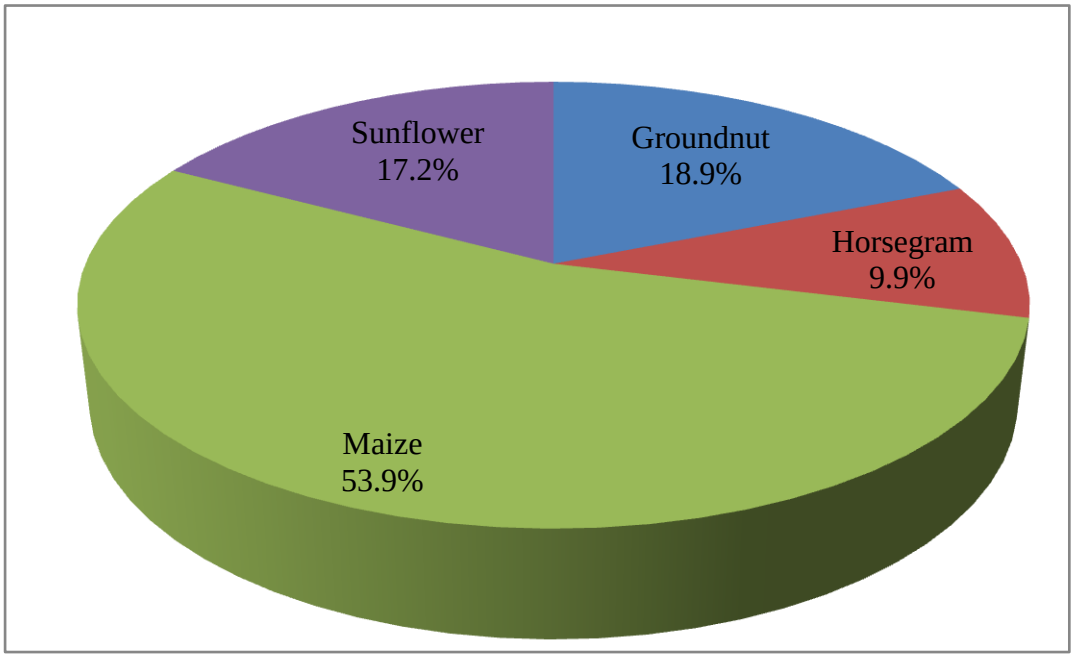


Figure 9: Present cropping pattern in Devihal 2 Microwatershed

Economic land evaluation

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

In Devihal 2 micro-watershed, 13 soil series are identified and mapped (Table 18). The distribution of major soil series are Thammadahalli covering an area around 169.9 ha

(36.0%) followed by Kanchanahalli 82.3 ha (17.5%), Chikkasavanur 33.6 ha (7.1%), Kumchahalli 14.4 ha (3.1 %), Devihal 13.3 ha (2.8 %), Kaggalipura 12.1 ha (2.6 %), Chikkamegheri 8.8 ha (1.8 %), Lakkur 7.9 ha (1.7%), Vaddarahalli 5.4 ha (1.1 %) and Mukhadahalli 1.5 ha (0.3 %).

Table 18: Distribution of soil series in Devihal 2 Microwatershed

Soil No	Soil Series	Mapping unit description	Area in ha (%)
1	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 to very gently sloping uplands under cultivation	8.8 (1.8)
2	CSR	Chikkasavanur soils are shallow (25 -50 cm), well drained, have dark brown to light yellowish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation	33.6 (7.1)
3	DVH	Devihal soils are very shallow (< 25 cm), well drained, have dark reddish brown to yellowish red clay loam soils occurring on very gently sloping uplands under cultivation	13.3 (2.8)
4	KGP	Kaggalipura soils are shallow (25-50 cm), well drained, have brown to dark reddish brown sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation	12.1 (2.6)
5	KMH	Kumchahalli soils are deep (100-150cm), well drained, have dark reddish brown to dark red sandy clay loam to sandy clay soils occurring on nearly level to very gently sloping uplands under cultivation	14.4 (3.1)
6	KNH	Kanchanahalli soils are shallow (25 -50 cm), well drained, have dark reddish brown sandy clay soils occurring on very gently sloping uplands under cultivation	82.3 (17.5)
7	LKR	Lakkur soils are moderately shallow (50-75 cm), well drained, have reddish brown to dark red gravelly sandy clay loam to sandy clay red soils occurring on nearly level to gently and moderately sloping uplands under cultivation	7.9 (1.7)
8	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well drained, have dark brown to reddish brown gravelly sandy clay loam soils occurring on very gently to gently sloping uplands under cultivation	1.5 (0.3)
9	TDH	Thammadahalli soils are moderately shallow (50-75 cm), well drained, have brown to very dark brown and dark reddish brown sandy loam to clay loam soils occurring on nearly level to gently sloping uplands under cultivation	169.9 (36.0)
10	VDH	Vaddarahalli soils are deep (100-150 cm), well drained, have dark reddish brown to dark brown clayey soils occurring on nearly level to very gently sloping uplands under cultivation	5.4 (1.1)

Present cropping pattern on different soil series are given in Table 19. Crops grown on Chikkasavanur soils are groundnut and maize, groundnut horse gram and sunflower on Kanchanahalli soils, horse gram on Kaggalipura, maize and sunflower on Devihal soils, maize on Thammadahalli soils and Maize, sunflower on Vaddarahalli soils.

Table 19: Cropping pattern on major soil series in Devihal 2 micro-watershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Irrigated	Grand Total
			Kharif	Rabi	Kharif	
DVH	Very shallow (<25 cm)	Maize	50.0	0.0	0.0	50.0
		Sunflower	50.0	0.0	0.0	50.0
CSR	Shallow (25-50 cm)	Groundnut	0.0	0.0	17.2	17.2
		Maize	65.5	0.0	17.2	82.8
KGP	Shallow (25-50 cm)	Horsegram	0.0	100.0	0.0	100.0
KNH	Shallow (25-50 cm)	Groundnut	40.0	0.0	0.0	40.0
		Horsegram	20.0	0.0	0.0	20.0
		Sunflower	40.0	0.0	0.0	40.0
TDH	Moderately shallow (50-75 cm)	Maize	100.0	0.0	0.0	100.0
VDH	Deep (100-150 cm)	Maize	0.0	0.0	57.1	57.1
		Sunflower	0.0	0.0	42.9	42.9

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 20).

Table 20: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Devihal 2 Microwatershed.

Soil Series	Small farmers	Medium Farmers
CSR	Groundnut (1.12), Maize(1.82)	Maize(1.14)
KGP	Horsegram (1.22)	
KNH	Sunflower(1.91)	Groundnut (1.05), Horsegram(1.55),
DVH	Maize(1.21), Sunflower(0.96)	
TDH	Maize (1.64)	
VDH	Maize (1.0)	Sunflower(1.33)

The productivity of different crops grown in Devihal 2 micro-watershed under potential yield of the crops is given in Table 21.

The productivity of different crops grown in Devihal 2 micro-watershed under potential yield of the crops is given in Table 21. The total cost of cultivation and benefit cost ratio (BCR) in study area for groundnut ranges between Rs.38930/ha in CSR soil (with BCR of 1.12) and Rs.24612/ha in KNH soil (with BCR of 1.05), maize the cost of cultivation range between Rs59727/ha in DVH soil (with of 1.21) and Rs.23088/ha in CSR soil (with BCR of 1.62), horse gram the cost of cultivation ranges between Rs.31783/ha in KGP soil (with BCR of 1.22) and Rs. 15065/ha in KNH soil (with BCR of 1.05), sunflower cost of cultivation range between is Rs.34268/ha in DVH soil (with BCR of 0.96) and Rs 19716 in KNH soil (with BCR of 1.91).

Table 21: Economic land evaluation and bridging yield gap for different crops in Devihal 2 micro-watershed

Particulars	DVH (<25 cm)		KGP (25-50 cm)	KNH (25-50 cm)			CSR (25-50 cm)		TDH (50-75 cm)	VDH (100-150 cm)	
	Maize	Sun flower	Horse gram	Ground nut	Horse gram	Sun flower	Ground nut	Maize	Maize	Maize	Sun flower
Total cost (Rs/ha)	59727	34268	31783	24612	15065	19716	38930	23088	23645	29534	26077
Gross Return (Rs/ha)	72124	32900	38753	25935	23342	37569	43472	38223	38043	29640	34580
Net returns (Rs/ha)	12397	-1367	6970	1323	8277	17853	4542	15135	14399	106	8503
BCR	1.21	0.96	1.22	1.05	1.55	1.91	1.12	1.62	1.64	1.00	1.33
Farmers Practices (FP)											
FYM (t/ha)	5.0	2.5	4.3	1.3	0.0	1.3	1.3	1.9	3.0	1.3	0.0
Nitrogen (kg/ha)	101.9	101.9	69.0	91.9	91.9	40.0	122.5	97.5	71.5	161.6	161.6
Phosphorus (kg/ha)	96.9	96.9	49.6	89.7	89.7	28.8	123.8	87.9	51.4	130.9	130.9
Potash (kg/ha)	10.6	10.6	0.0	10.6	10.6	37.5	21.3	10.6	0.0	15.9	15.9
Grain (Qtl/ha)	35.0	9.3	12.9	7.5	8.8	11.3	8.8	28.3	22.7	20.0	11.7
Price of Yield (Rs/Qtl)	2000	3600	2800	3200	2500	3380	4800	1463	1490	1400	3000
Soil test based fertilizer Recommendation (STBR)											
FYM (t/ha)	8.6	6.6	0.0	8.6	0.0	6.6	8.6	8.6	8.6	8.6	6.6
Nitrogen (kg/ha)	154.4	69.0	30.9	30.9	30.9	69.0	24.7	123.5	154.4	154.4	69.0
Phosphorus (kg/ha)	77.2	74.1	46.3	77.2	46.3	74.1	77.2	77.2	77.2	77.2	74.1
Potash (kg/ha)	32.1	37.1	24.7	30.9	24.7	37.1	30.9	32.1	32.1	32.1	37.1
Grain (Qtl/ha)	84.0	16.5	9.9	17.3	9.9	16.5	17.3	84.0	84.0	84.0	16.5
% of Adoption/yield gap (STBR-FP) / (STBR)											
FYM (%)	42.2	62.0	0.0	85.5	0.0	81.0	85.5	78.3	65.5	85.5	100.0
Nitrogen (%)	34.0	-47.7	-123.4	-197.6	-197.6	42.0	-396.0	21.1	53.7	-4.7	-134.3
Phosphorus (%)	-25.5	-30.7	-7.0	-16.2	-93.7	61.2	-60.3	-13.9	33.4	-69.6	-76.7
Potash (%)	66.9	71.3	100.0	65.6	57.0	-1.2	31.2	66.9	0.0	50.4	57.0
Grain (%)	58.3	43.8	-30.9	56.6	11.4	31.7	49.4	66.3	72.9	76.2	29.1
Value of yield and Fertilizer (Rs)											
Additional Cost (Rs/ha)	3838	3218	-4417	6518	-2359	7671	4365	7040	8437	5267	3397
Additional Benefits (Rs/ha)	97960	25980	-8543	31328	2825	17632	40992	81437	91276	89572	14400
Net change Income (Rs/ha)	94122	22762	-4126	24810	5184	9962	36627	74397	82839	84305	11003

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 21. 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 94122 in maize and a minimum of Rs 5184 in horse gram cultivation.

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 22 and Figure 10. The average value of soil nutrient loss is around Rs 694 per ha/year. The total cost of annual soil nutrients is around Rs 241483 per year for the total area of 471.44 ha.

Table 22: Estimation of onsite cost of soil erosion in Devihal 2 micro-watershed

Particulars	Quantity(kg		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	94.13	32757	593.01	206366
Phosphorus	0.05	19	2.42	842
Potash	1.37	477	27.41	9538
Iron	0.07	25	3.45	1201
Manganese	0.19	67	52.64	18317
Cupper	0.01	3	4.94	1720
Zinc	0.00	1	0.17	58
Sulphur	0.24	82	9.46	3292
Boron	0.01	4	0.43	148
Total	76.16	33435	694	241483

The average value of ecosystem service for food grain production is around Rs. 5639/ ha/year (Table 23 and Figure 11). Per hectare food grain production services is maximum in maize (Rs 8704) followed by sunflower (Rs. 8554), horse gram (Rs. 4959) and groundnut (Rs 339).

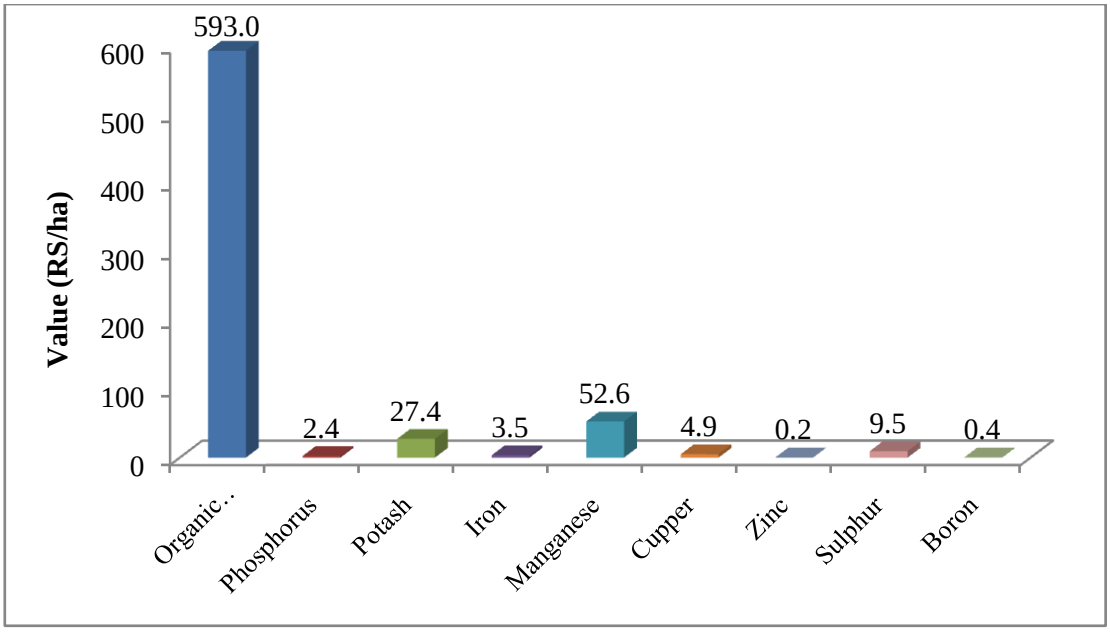


Figure 10: Estimation of onsite cost of soil erosion in Devihal 2 micro-watershed

Table 23: Ecosystem services of food grain production in Devihal 2 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Cereals	Maize	6.9	25	1533	38106	29402	8704
Pulses	Horsegram	1.3	11	2650	28383	23424	4959
Oil seeds	Groundnut	2.4	8	4000	32110	31771	339
	Sunflower	2.6	11	3327	35241	26687	8554
Average value		13.2	1375	2878	33460	27821	5639

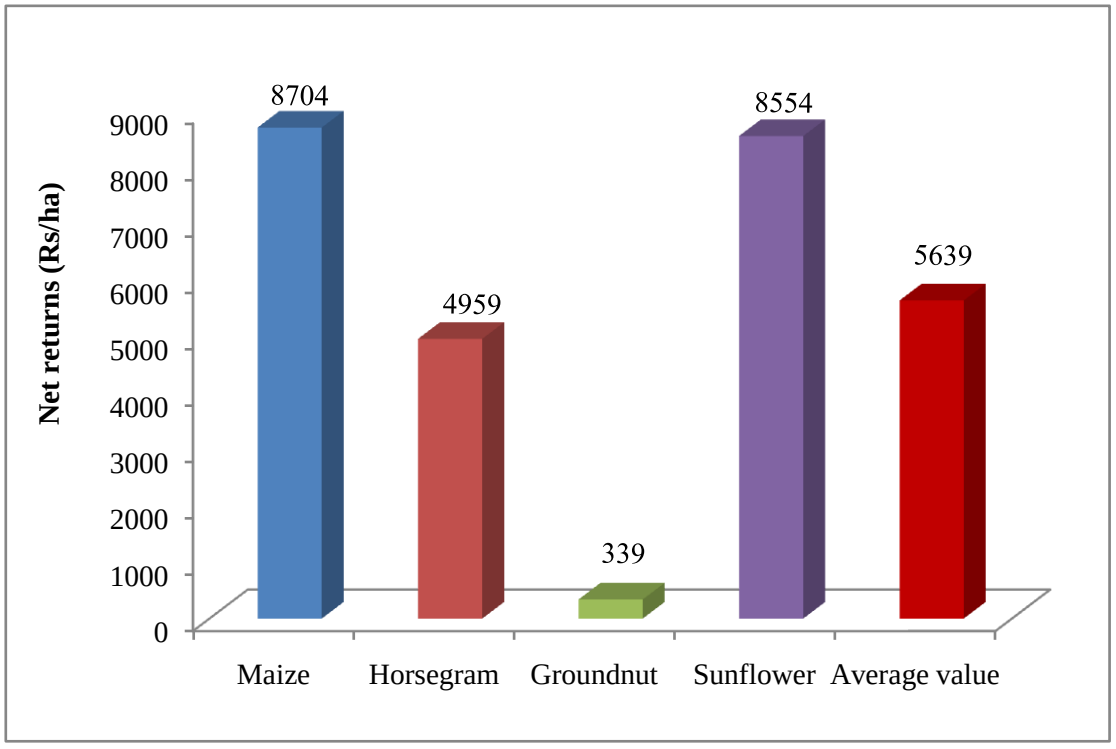


Figure 11: Ecosystem services of food grain production in Devihal 2 Microwatershed

The average value of ecosystem service for fodder production is around Rs 2628/ ha/year (Table 24). Per hectare fodder production services is maximum in maize (Rs 3120) followed by groundnut (Rs 2408) and horse gram (Rs 2355).

Table 24: Ecosystem services of fodder production in Devihal 2 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	6.9	3.8	829	3120
Pulses	Horsegram	1.3	1.7	1400	2355
Oil seeds	Groundnut	2.4	1.9	1300	2408
Average value		10.6	2.4	1176	2628

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 25 and Figure 12) in sunflower (Rs. 35658) followed by horse gram (Rs. 32967), maize (Rs. 30378) and groundnut (Rs. 22333).

Table 25: Ecosystem services of water supply in Devihal 2 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Groundnut	8.0	2233	22333	278
Horsegram	10.7	3297	32967	308
Maize	24.9	3038	30378	122
Sunflower	10.6	3566	35658	337
Grand Total	54.2	3033	30334	261

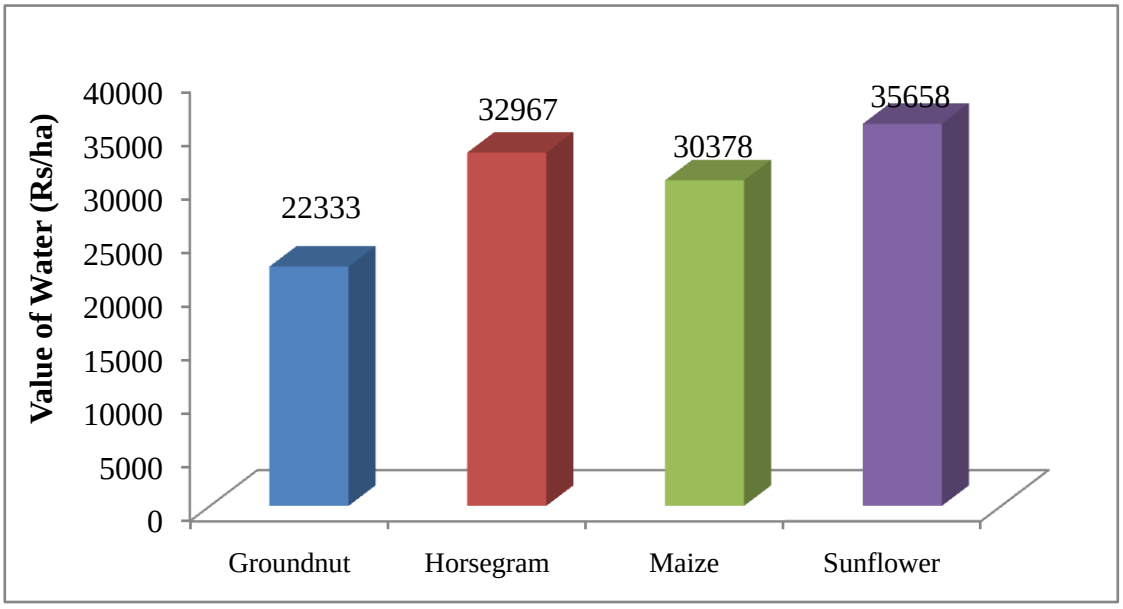


Figure 12: Ecosystem services of water supply in Devihal 2 Microwatershed

The main farming constraints in Devihal 2 micro-watershed to be found are less rainfall, lack of good quality seeds, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 26).

Table 26: Farming constraints related land resources of sample households in Devihal 2 Microwatershed

Sl. No	Particulars	Per cent
1	Less Rainfall	90.0
2	Lack of good quality seeds	10.0
3	Lack of transportation	20.0
5	Lack of storage	10.0
6	Damage of crops by Wild Animals	50.0
7	Non availability of Plant Protection Chemicals	90.0
8	**Source of loan**	
	Village merchants	20.0
	Bank	30.0
	Money Leander	50.0
9	**Market for selling**	
	Regulated	20.0
	Village market	80.0
10	**Sources of Agri-Technology information**	
	Mobile	10.0
	Newspaper	70.0
	Television	20.0

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