ICAR-NBSS&LUP Sujala MWS Publ.73

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

DUMMADRI-4 (4D5A3O2d) MICROWATERSHED

Jewargi Taluk, Gulbarga District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

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

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

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

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

Nagpur
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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

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

The present study covers an area of 585 ha in Dummadri-4 microwatershed in Jewargi taluk of Gulbarga district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 751 mm, of which about 538 mm is received during south–west monsoon, 138 mm during north-east and the remaining 75 mm during the rest of the year. 96 per cent area is covered by soils and 4 per cent is by habitation and waterbodies. The salient findings from the land resource inventory are summarized briefly below.

- ❖ *The soils belong to 2 soil series and 4 soil phases (management units) and one land use class.*
- ❖ *The length of crop growing period is about 150 days starting from the 1st week of June to 1st week of October.*
- ❖ *From the master soil map, several interpretative and thematic maps like 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 19 major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with the constraints were generated.*
- ❖ *96 per cent area is suitable for agriculture and 4 per cent is not suitable.*
- ❖ *About 89 per cent of the soils are very deep (>150 cm) and 7 per cent is deep (100-150 cm) soils.*
- ❖ *Entire area in the microwatershed has clayey soils at the surface.*
- ❖ *Entire area has non-gravelly (<15%) soils.*
- ❖ *Entire area has soils that are very high (>200mm/m) in available water capacity.*
- ❖ *Entire area has very gently sloping (1-3%) lands.*
- ❖ *An area of about 35 per cent has soils that are slightly eroded (e1), 61 per cent moderately eroded (e2).*
- ❖ *An area of about 72 per cent has soils that are strongly alkaline soils (pH 8.4-9.0) and 24 per cent very strongly alkaline (>9.0).*
- ❖ *The Electrical Conductivity (EC) of the soils are dominantly <2 dS m^{-1} indicating that the soils are non-saline.*

- *About 13 ha (2%) area is low (<0.5%) in organic carbon, medium (0.5-0.75%) in about 430 ha (73%) and high (>0.75%) in 118 ha (20%) in organic carbon.*
- *Major area of 83 per cent has soils that are low (<23 kg/ha), 8 per cent medium (23-57 kg/ha) and 4 per cent high (>57 kg/ha) in available phosphorus.*
- *About 66 per cent high (>337 kg/ha) and 30 per cent medium (145-337 kg/ha) in available potassium.*
- *Available sulphur is medium (10-20 ppm) in 76 per cent and 20 per cent high (>20 ppm) in available sulphur.*
- *Available boron is low (<0.5 ppm) in about 34 per cent area and medium (0.5-1.0 ppm) in about 61 per cent area.*
- *About 91 per cent area is sufficient (>4.5 ppm) and 5 per cent is deficient (<4.5ppm) in available iron.*
- *Available manganese and copper are sufficient in all the soils.*
- *About 85 per cent area has soils that are deficient (<0.6 ppm) in available zinc and 10 per cent sufficient (>0.6 ppm).*
- *The land suitability for 19 major crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.*

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	*562 (96)*	-		*Guava*	-	*562 (96)*
Maize	-	-		*Jackfruit*	-	-
Red gram	-	*562 (96)*		*Jamun*	-	*562 (96)*
Soybean	*562 (96)*	-		*Musambi*	*562 (96)*	-
Bengalgram	*562 (96)*	-		*Lime*	*562 (96)*	-
Sunflower	*562 (96)*	-		*Cashew*	-	-
Cotton	*562 (96)*	-		*Custard apple*	*562 (96)*	-
Sugarcane	-	-		*Amla*	*562 (96)*	-
Mango	-	-		*Tamarind*	-	*562 (96)*
Sapota	-	*562 (96)*				

Apart from the individual crop suitability, a proposed crop plan has been prepared for the one identified LUCs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops that helps in maintaining the productivity and ecological balance in the microwatershed.

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

Chapter 1

INTRODUCTION

Land is a scarce resource and basic unit for any material production. It can support the needs of the growing population, provided they use the land in a rational and judicious manner. But what is happening in many areas of the state is a cause for concern to everyone involved in the management of land resources at the grassroots level. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. The limited land area is under severe stress and strain due to increasing population pressure and competing demands of various land uses. Due to this, every year there is significant diversion of farm lands and water resources for non-agricultural purposes. Apart from this, due to lack of interest in farmers for farming, large tracts of cultivable lands are turning into fallows in many areas and this trend is continuing at an alarming rate.

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

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. The continued neglect and unscientific use of the resources for a long time has led to the situation observed at present in the state. It is a known fact and established beyond doubt by many studies in the past that the cause for all kinds of degradation is the neglect and irrational use of the land resources. Hence, there is an urgent need to generate a detailed site-specific farm level database on various land resources for all the villages/watersheds in a time bound manner that would help to protect the valuable soil and land resources and also to stabilize the farm production.

Therefore, the land resource inventory required for farm level planning is the one which investigates not only the surface but also consider the other parameters which are critical for productivity *viz.*, soil, climate, water, minerals and rocks, topography, geology, hydrology, vegetation, crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed.

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

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

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

Chapter 2

GEOGRAPHICAL SETTING

2.1 Location and Extent

The Dummadri-4 microwatershed (Dummadri sub-watershed) is located in the northern part of Karnataka in Jewargi Taluk, Kalaburagi District, Karnataka State (Fig. 2.1). It comprises parts of Dummadri, Kachapura, Vadagera and Sumbada villages. It lies between 16^0 45' and 16^0 48' North latitudes and 76^0 30' and 76^0 34' East longitudes and covers an area of 585 ha. It is about 80 km south of Kalaburagi and is surrounded by Dummadri, Kachapura and Sumbada villages on the north and Vadegera village on the west, south and southeastern part of the microwatershed.

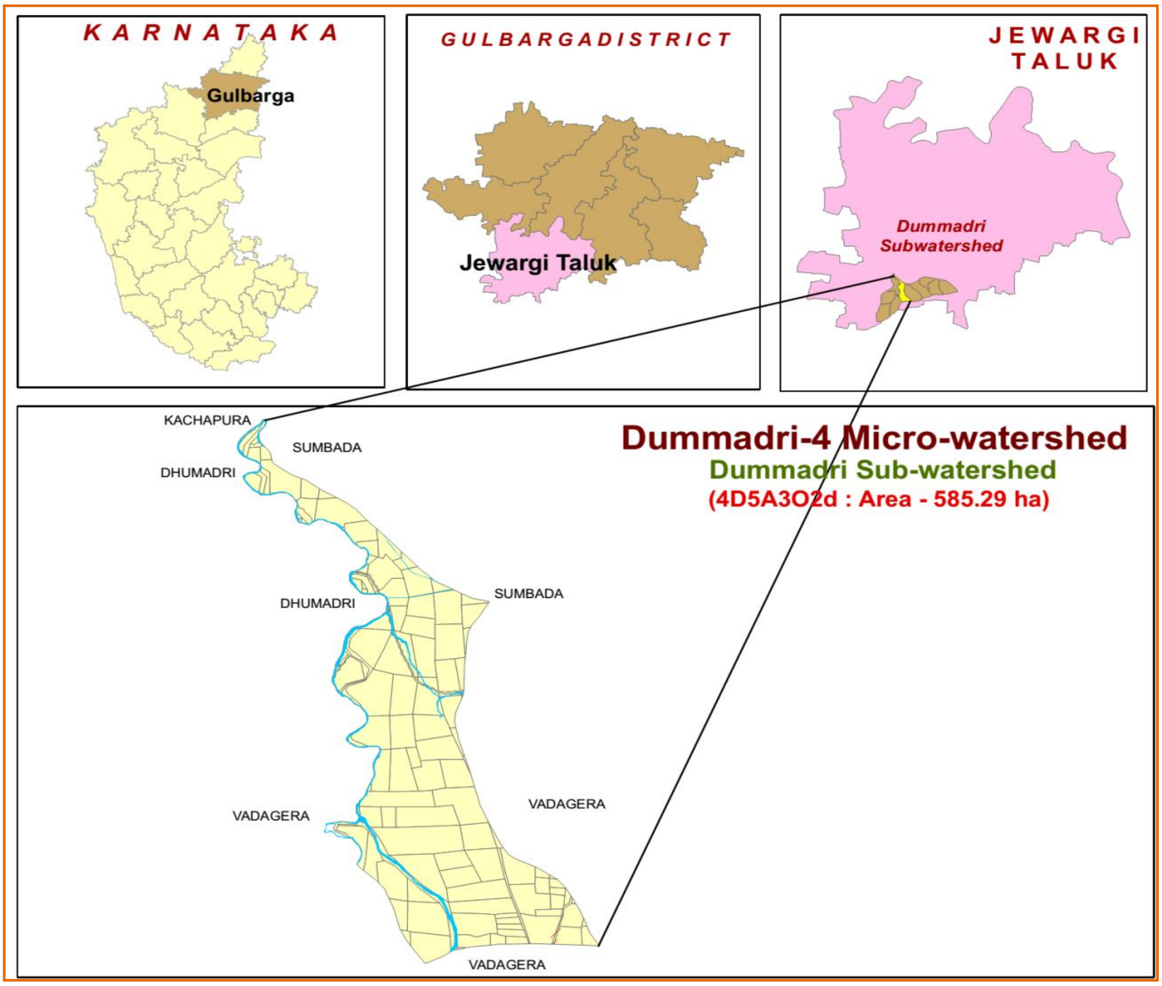

Fig. 2.1 Location map of Dummadri-4 Microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Shales (Fig. 2.2). Shales are gray in color and composed of clay to fine silt-size quartz, sericite, opaques and in some cases, chlorite. Alternate silt-rich and sericite-rich laminations are common within the Manoli Argillite. The silt-rich laminations contain angular to very well rounded quartz grains (polymodal source) with some sub-rounded to subangular clasts of feldspar (predominantly microcline). Fissile and friable but become compact and slabby towards the top and grade into calcareous shales.

Fig. 2.2 Shales rock

2.3 Physiography

Physiographically, the area has been identified as Shales landscape based on geology. Based on slope and its relief features, the area has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands. The elevation ranges from 422 to 458 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

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

2.5 Climate

The district falls under semiarid tract and is categorized as drought-prone with average annual rainfall of 751 mm (Table 2.1). Of the total rainfall, a maximum of 538 mm is received during south-west monsoon period from June to September, north-east monsoon from October to early December contributes about 138 mm and the remaining 75 mm is received during the rest of the year. The winter season is from December to

February. During April and May, the temperatures reach up to 42° C and in December and January, the temperatures will go down to 16° C. Rainfall distribution is shown in Figure 2.3. The average Potential Evapo-transpiration (PET) is 159 mm and varies from a low of 115 mm in December to 232 mm in the month of May. The PET is always higher than precipitation in all the months except in September. Generally, the Length of crop Growing Period (LGP) is 150 days and starts from 1st week of June to 1st week of October.

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

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

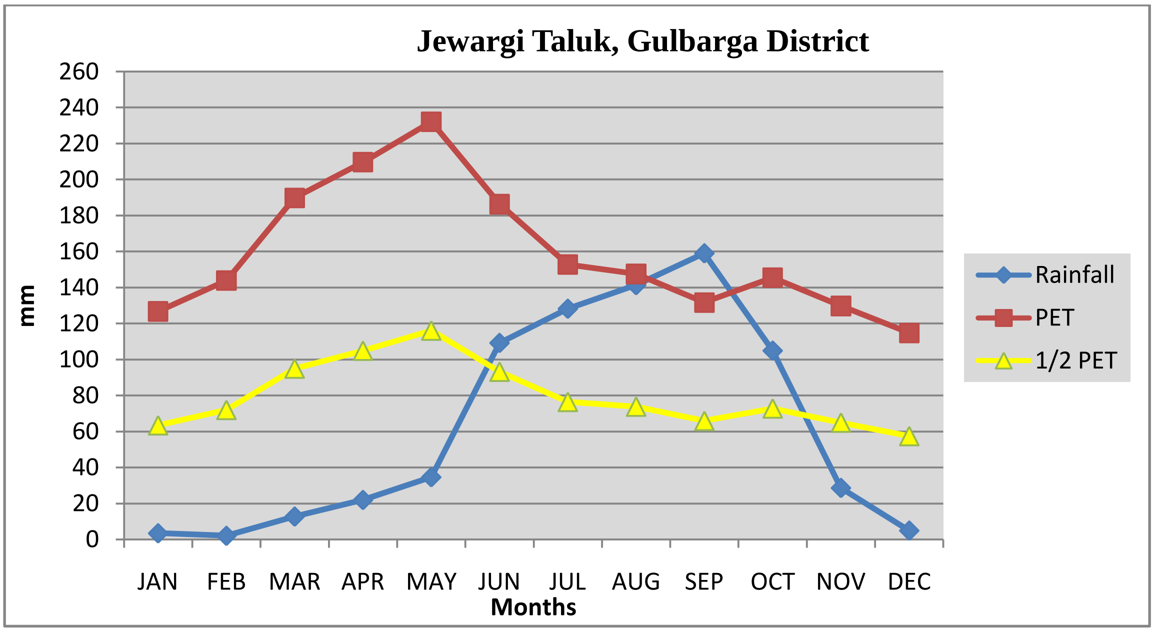

Fig 2.3 Rainfall distribution in Jewargi Taluk, Kalaburagi District

2.6 Natural Vegetation

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

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

Fig.2.4. Natural vegetation of Dummadri-4 Microwatershed

2.7 Land Utilization

About 84 per cent area (Table 2.2) in Jewargi taluk is cultivated at present. An area of about 4 per cent is permanently under pasture, one per cent each under non agricultural land and currently barren. Forests occupy an area of about less than one per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are Sorghum, Maize, Soybean, Cotton, Redgram and Sapota. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is generated. The current land use map generated shows the arable and non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Dummadri-4 microwatershed is presented in Figure 2.5.

Table 2.2 Land Utilization in Jewargi Taluk

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

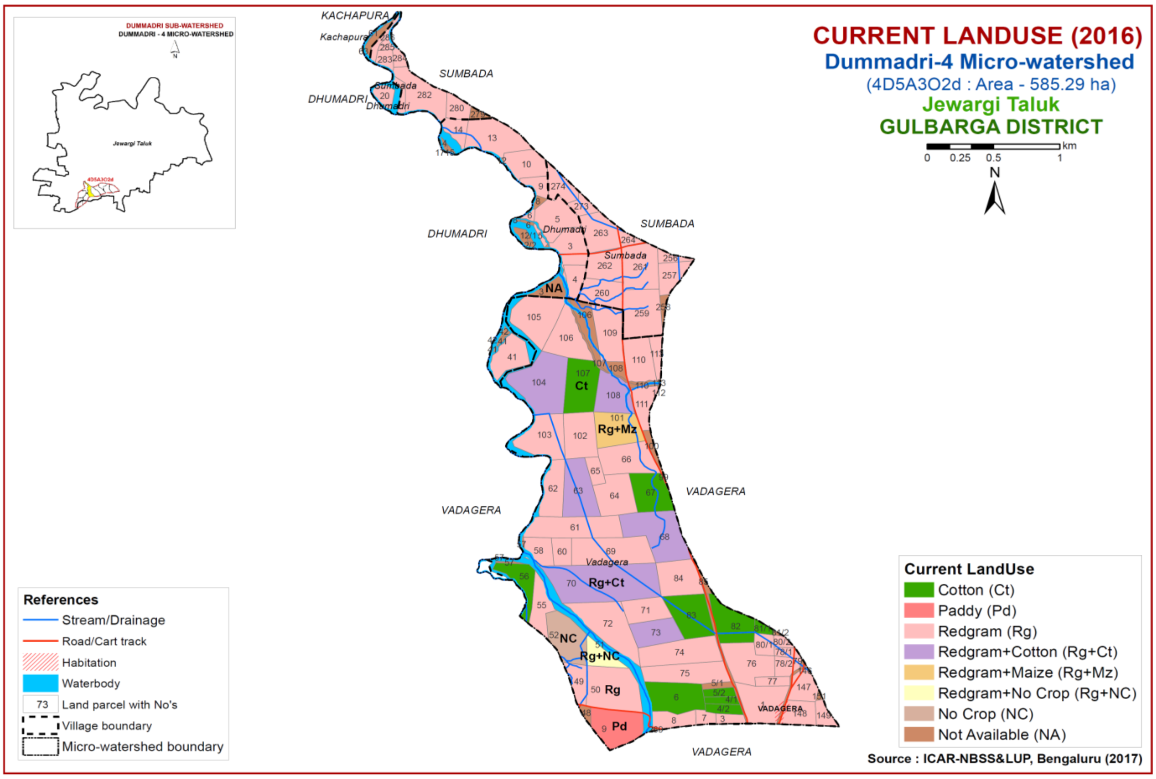

Fig.2.5 Current Land Use – Dummadri-4 Microwatershed

Chapter 3

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Dummadri-4 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.), and site characteristics (slope of the land, erosion, drainage, occurrence of rock fragments etc.) and followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units, and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in an area of 585 ha. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

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

3.2 Image Interpretation for Physiography

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

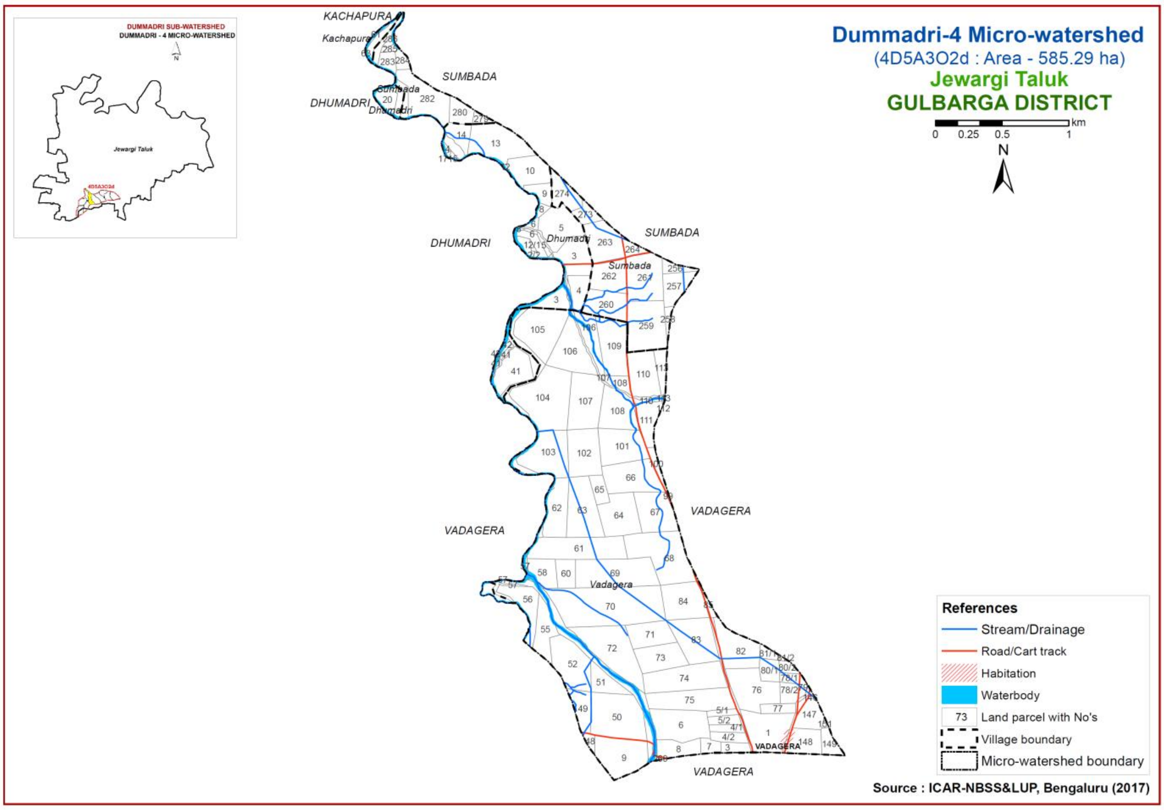

Fig 3.1 Scanned and Digitized Cadastral map of Dummadri-4 Microwatershed

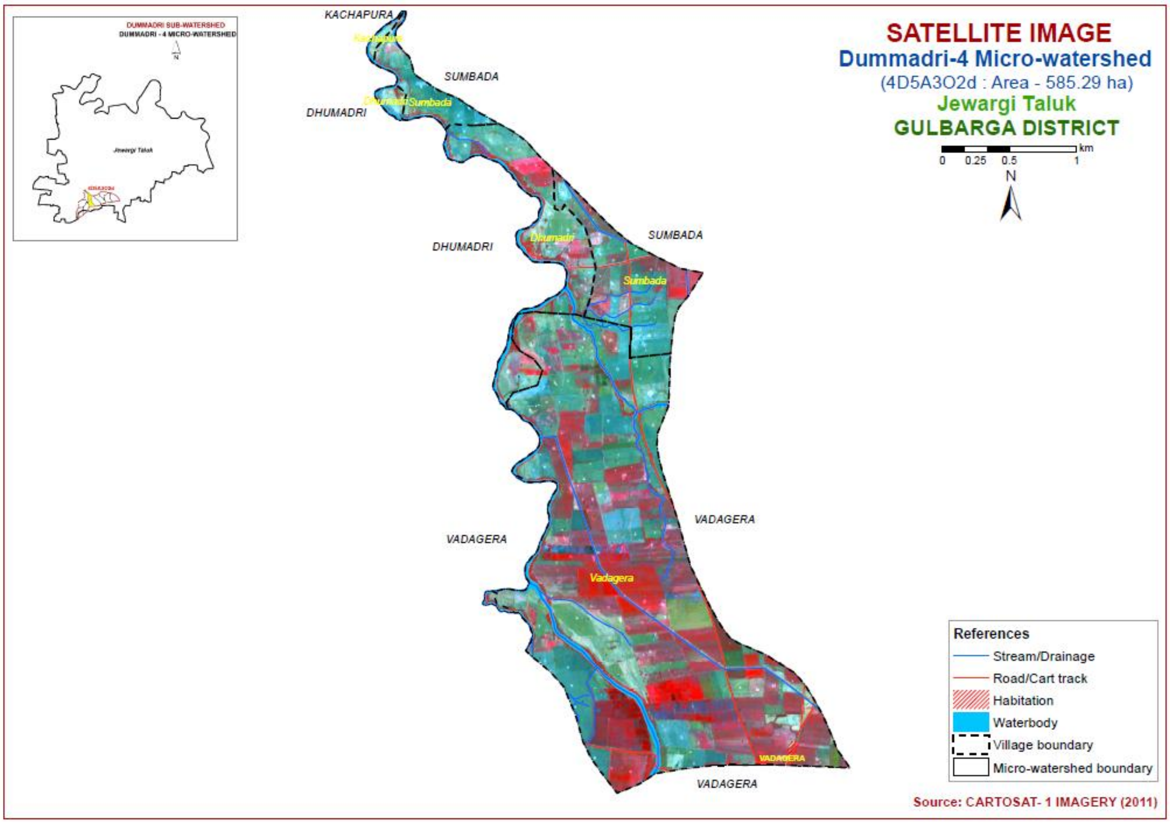

Fig.3.2 Satellite Image of Dummadri-4 Microwatershed

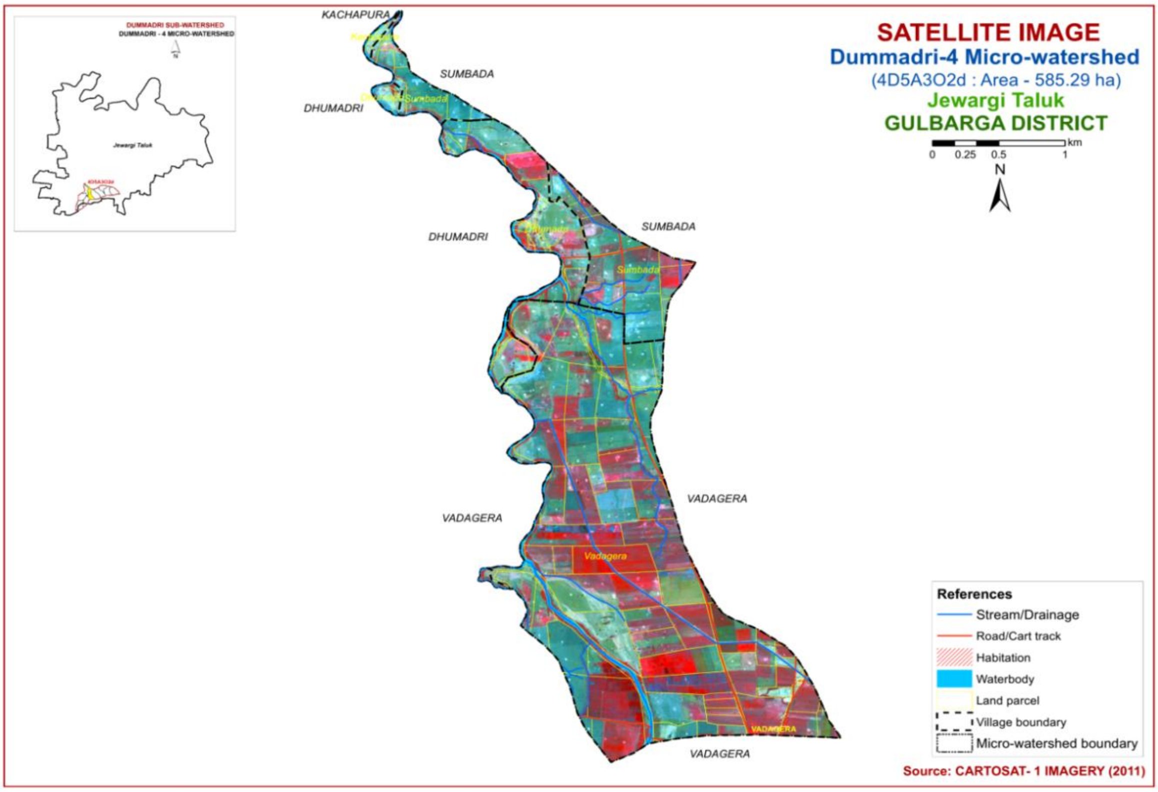

Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Dummadri-4 Microwatershed

3.3 Field Investigation

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, nallas, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Preliminary traverse of the microwatershed was carried out with the help of cadastral map, imagery and toposheets. While traversing, landforms and physiographic units identified were checked and preliminary soil legend was prepared by studying soils at few selected places. Then, intensive traversing of each physiographic unit like hills, ridges and uplands was carried out. Based on the variability observed on the surface, transects (Fig. 3.4) were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

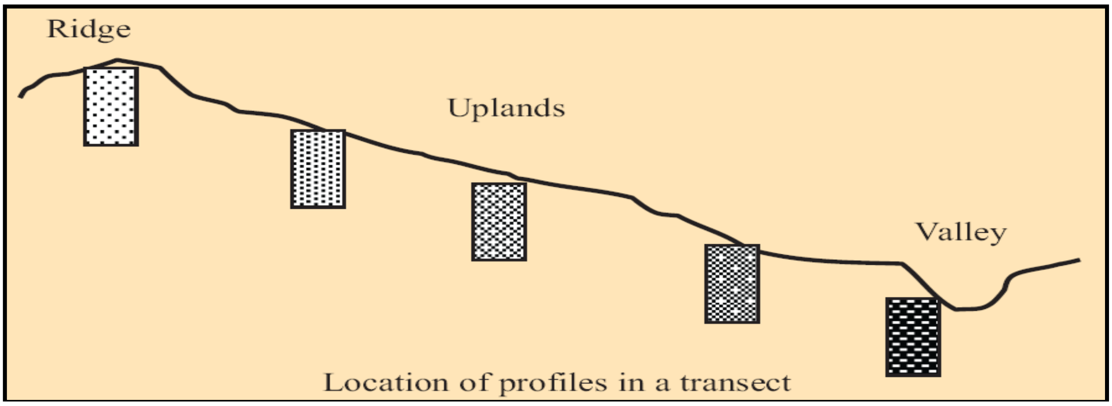

Fig: 3.4. Location of profiles in a transect

In the selected transect, soil profiles (Fig. 3.4) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, profiles (vertical cut showing the soil layers from surface to the rock) were opened up to 200 cm or to the depth limited by rock or hard substratum and studied in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all the profile sites on a standard proforma as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff, 2012). Apart from the transect study, profiles were also studied at random, almost like in a grid pattern, outside the transect areas.

Based on the soil characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management. Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, 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, 2 soil series were identified in the Dummadri-4 microwatershed.

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

Soils of Shales Landscape							
Sl No.	**Series**	**Depth (cm)**	**Colour (moist)**	**Texture**	**Gravel (%)**	**Effer vesence**	**Horizon sequence**
1.	Balbatti (BBT)	100-150	10YR3/2, 3/3 4/4,3/1,2/2,2/1	c	<15	e-es	Ap-BA-Bss
2.	Yedrami (YDM)	>150	10YR3/2,3/3,3/1 4/4,4/6,4/3, 2/2, 2/1	c	<15	e-es	Ap-BA-Bss

3.4 Soil Mapping

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

The 4 soil mapping units are shown on the map (Fig.3.5) in the form of symbols. During the survey about 13 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. All the profile locations are indicated on the village cadastral map in the form of a triangle. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.

The soil map shows the geographic distribution of 4 mapping units representing 2 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 4 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and have to be treated accordingly.

The 4 soil phases identified and mapped in the microwatershed were grouped into 1 Land Use class (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 class (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 Dummadri-4 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.

3.5 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (95 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated by using kriging method for the microwatershed.

Table 3.2 Soil map unit description of Dummadri-4 Microwatershed

Soil map unit no.	Soil Series	Soil phase	Mapping Unit Description	Area in ha (%)
	BBT		Balbatti soils are deep (100-150 cm), moderately well drained, have very very dark gray to dark reddish brown calcareous cracking clay soils occuring on very gently sloping uplands	**44 (7.47)**
1		BBTmB1	Clay surface, 1-3% slope, slight erosion	13 (2.19)
2		BBTmB2	Clay surface, 1-3% slope, moderate erosion	31 (5.28)
	YDM		Yedrami soils are deep (>150 cm), moderately well drained, have very very dark gray to dark reddish brown calcareous cracking clay soils occuring on nearly level to very gently sloping uplands	**519 (88.61)**
3		YDMmB1	Clay surface, 1-3% slope, slight erosion	195 (33.25)
4		YDMmB2	Clay surface, 1-3% slope, moderate erosion	324 (55.36)
5		Others	Habitation & waterbody	23 (3.93)

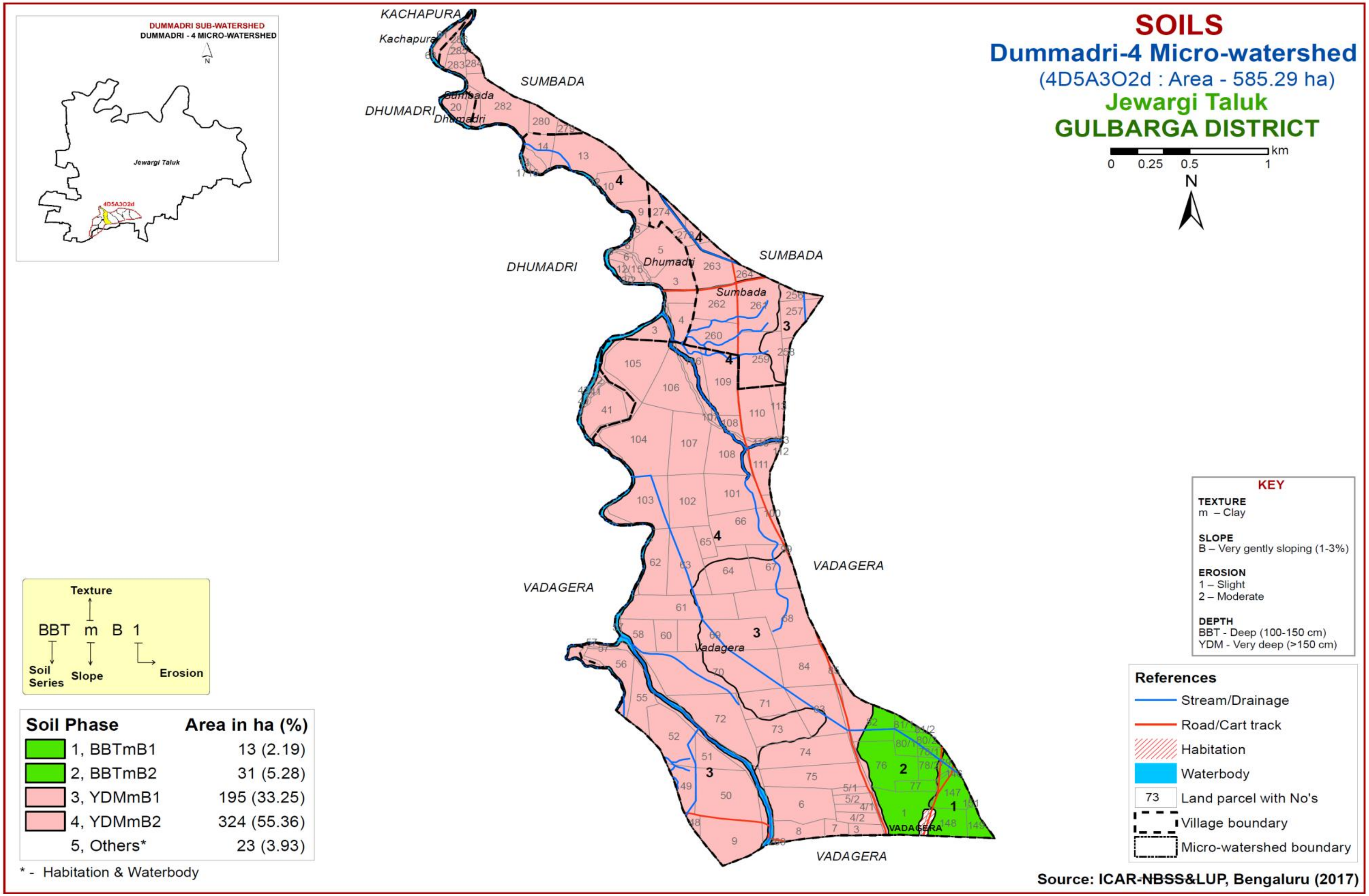

Fig 3.5 Soil Phase or Management Units - Dummadri-4 Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Dummadri-4 microwatershed is provided in this chapter. The microwatershed area has been identified as shales landscape based on geology. In all, 2 soil series are identified. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. Soil formation in the shales landscape is dominantly influenced by the parent material, climate and relief.

A brief description of each of the 2 soil series identified followed by 4 soil phases (management units) mapped under each series (Fig. 3.5) are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of the Shale landscape

In this landscape, 2 soil series are identified and mapped. Brief description of each series and their phases identified are given below. Of these, Yedrami (YDM) occupies major area 519 ha (88%) and Balbatti (BBT) series 44 ha (7%) area in the microwatershed

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4.1.1 Balbatti Series (BBT): Balbatti soils are deep (100-150 cm), moderately well drained, have very very dark gray to dark reddish brown calcareous cracking clay soils. They have developed from shale and occur on very gently sloping uplands.

The thickness of the solum ranges from 102 to 148 cm. The thickness of A horizon ranges from 14 to 23 cm. Its colour is in 10 YR hue with value 3 and chroma 2. The texture is clay. The thickness of B horizon ranges from 85 to 130 cm. Its colour is in 10 YR hue with value 2 to 4 and chroma 1 to 4. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m). Two phases were identified and mapped.

Landscape and Soil Profile characteristics of Balbatti (BBT) Series

4.1.2 Yedrami (YDM) Series: Yedrami soils are very deep (>150 cm), moderately well drained, have very very dark gray to dark reddish brown calcareous cracking clay soils. They have developed from shale and occur on nearly level to very gently sloping uplands.

The thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 12 to 25 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 2. The texture is clay. The thickness of B horizon ranges from 130 to 160 cm. Its colour is in 10 YR hue with value 2 to 4 and chroma 1 to 6. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m). Two phases were identified and mapped.

Landscape and Soil Profile characteristics of Yedrami (YDM) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

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

5.1 Land Capability Classification

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

Soil Characterisation: Depth, texture, gravelliness, calcareousness.

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

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

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

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

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

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

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

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

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

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

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

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

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

The 4 soil map units identified in the Dummadri-4 microwatershed are grouped under two land capability class and two subclasses. An entire area in the microwatershed is suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover an entire area of about 96 per cent area and are distributed in all parts of the microwatershed with minor problems of soil and erosion.

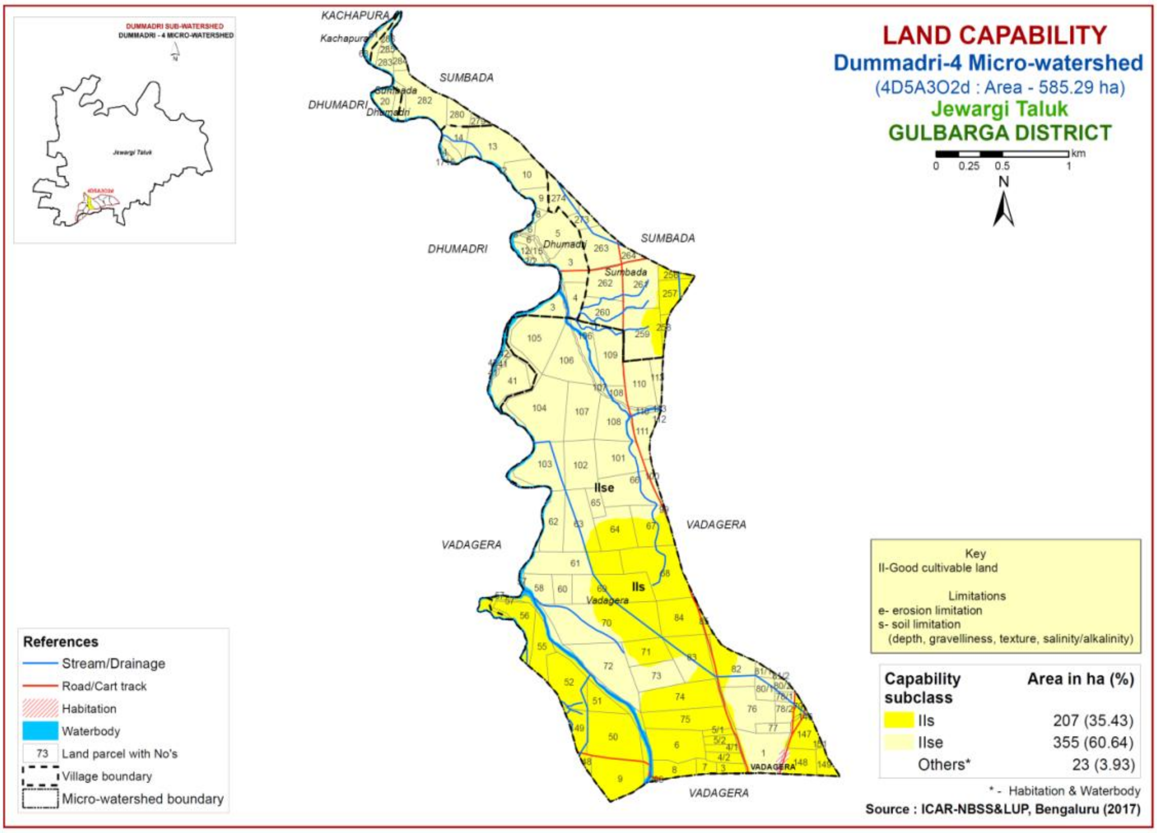


Fig. 5.1 Land Capability map of Dummadri-4 Microwatershed

5.2 Soil Depth

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

Deep soils cover an area of about 44 ha (7%) area and are distributed in the southeastern part of the microwatershed. Very deep (>150 cm) soils cover major area of 519 ha (89%) and are distributed in the northwestern, western, southern, southwestern and southeastern part of the microwatershed. The most productive lands 563 ha (95%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are very deep (>150 cm) and deep (100-150 cm) occurring in all parts of the microwatershed.

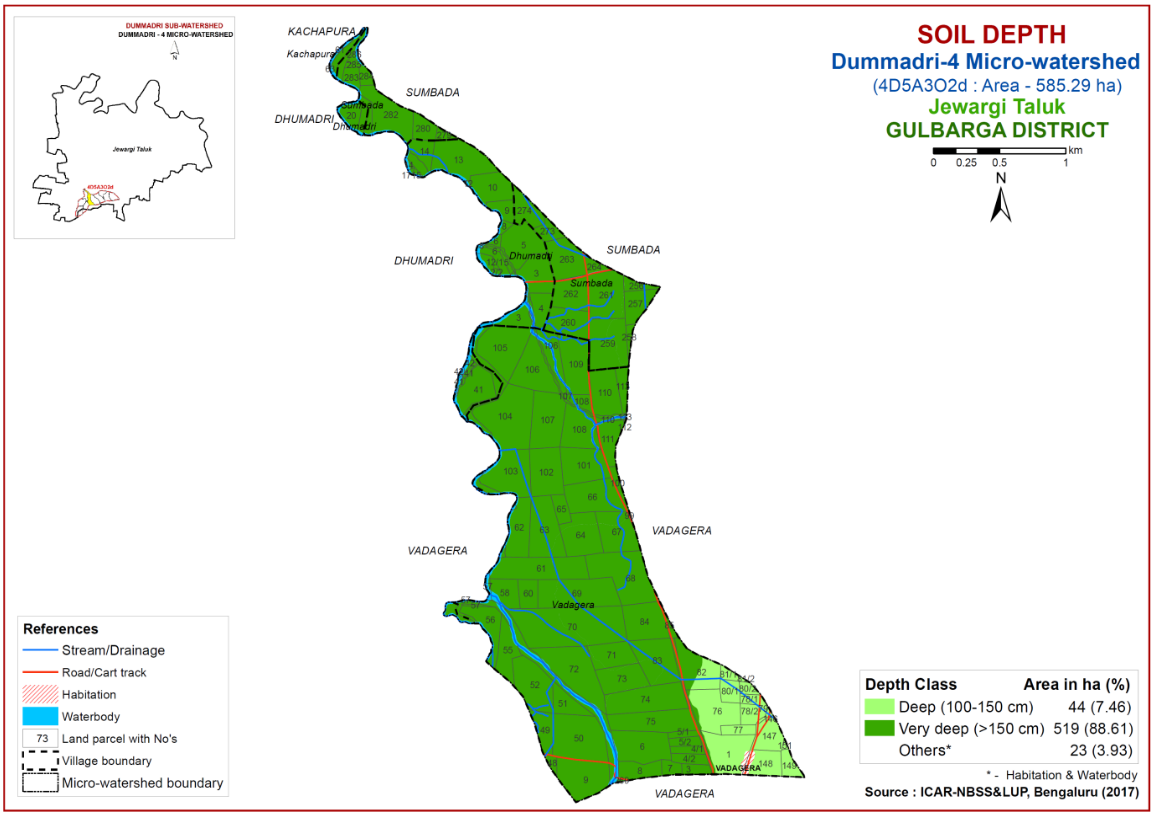


Fig. 5.2 Soil Depth map of Dummadri-4 Microwatershed

5.3 Surface Soil Texture

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

The most productive lands (96%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but have problems of drainage, infiltration, workability and other physical problems.

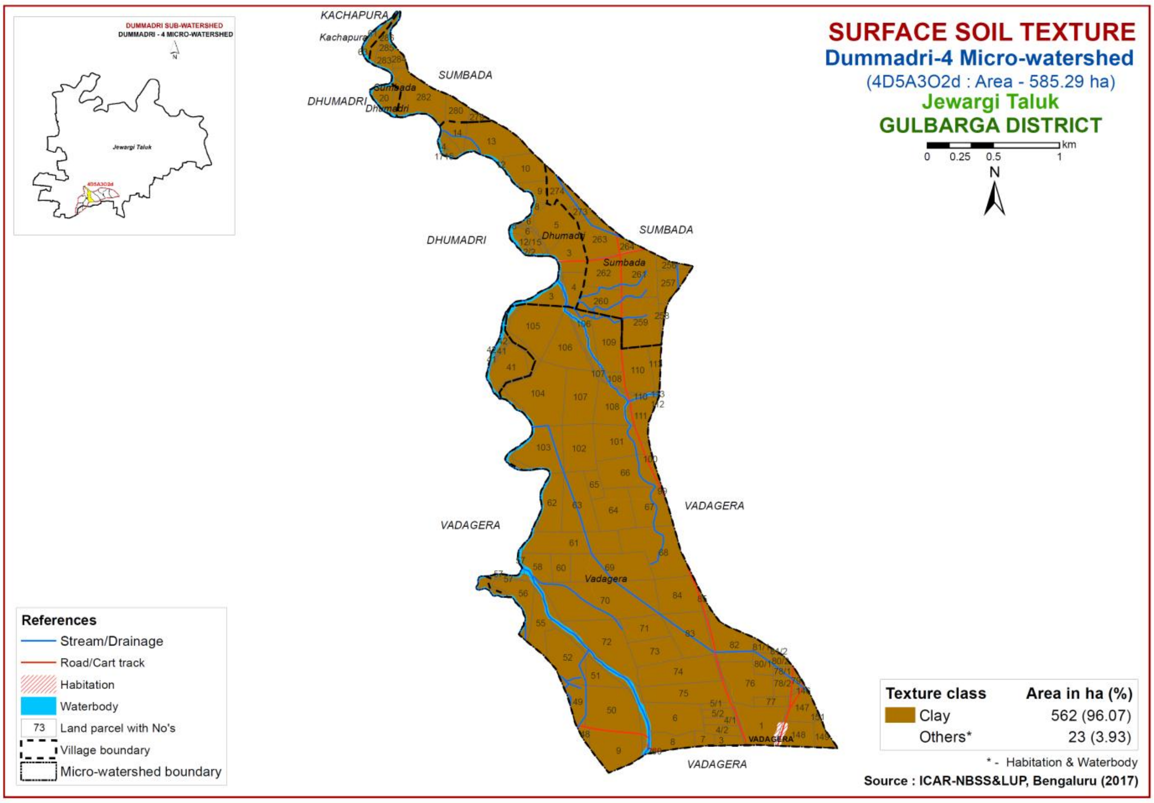


Fig. 5.3 Surface Soil Texture map of Dummadri-4 Microwatershed

5.4 Soil Gravelliness

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

The entire area in the microwatershed is non gravelly (Fig. 5.4). The most productive lands with respect to soil gravelliness are found to be 96 per cent. They are nongravelly (<15% gravel) and have high potential for growing both annual and perennial crops.

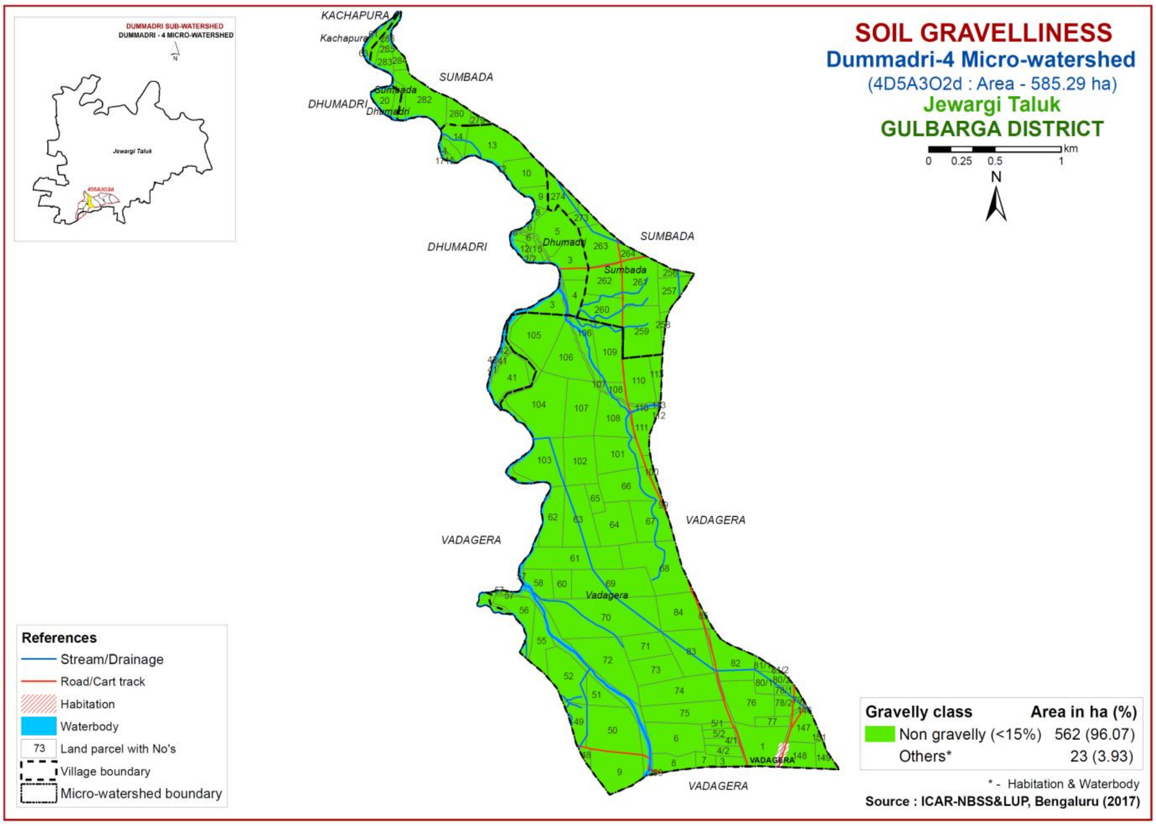


Fig. 5.4 Soil Gravelliness map of Dummadri-4 Microwatershed

5.5 Available Water Capacity

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

Entire area of about 562 ha (96%) is very high (>200 mm/m) in available water capacity and are distributed in all parts of the microwateshed. All these areas have soils that have high potential (>200 mm/m) with regard to available water capacity where all climatically adapted long duration crops can be grown successfully.

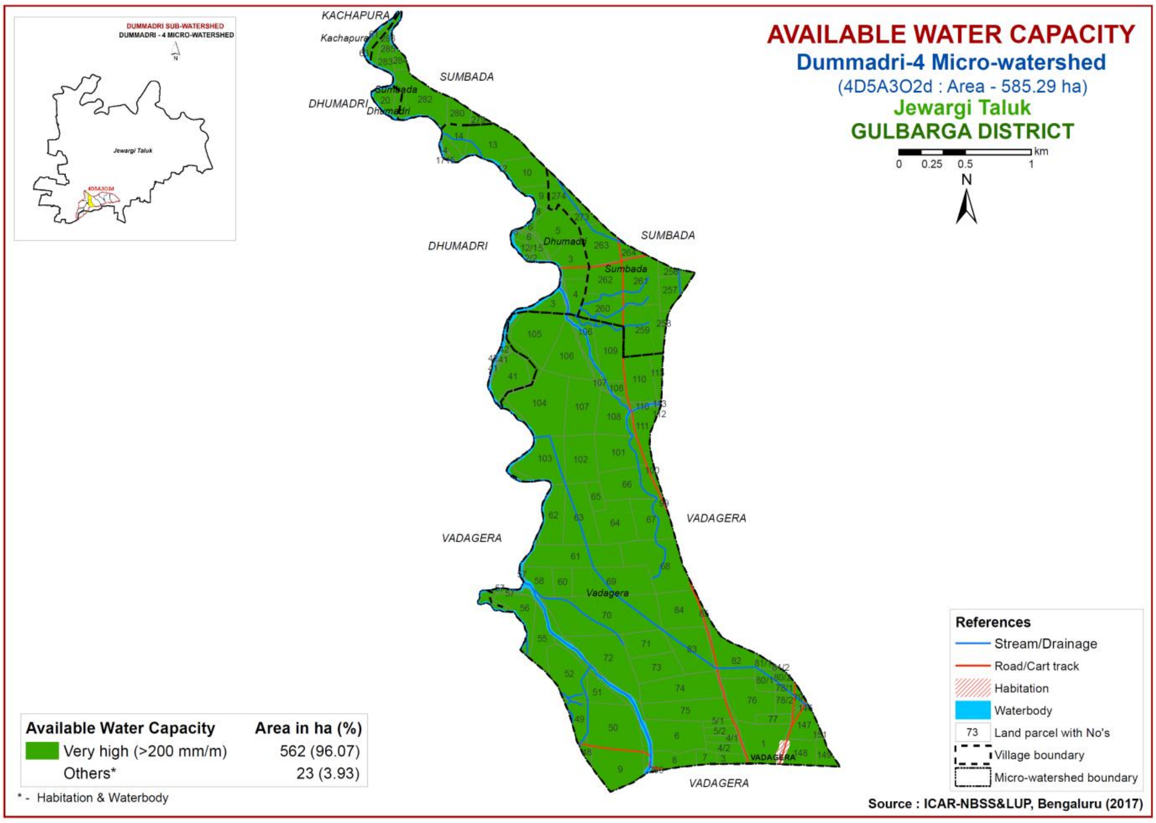


Fig. 5.5 Soil Available Water Capacity map of Dummadri-4 Microwatershed

5.6 Soil Slope

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

Entire area in the microwatershed is under very gently sloping (1-3%) lands. The most productive lands with respect to soil slopes cover entire area where all climatically adapted annual and perennial crops can be grown without much soil and water conservation, and other land development measures.

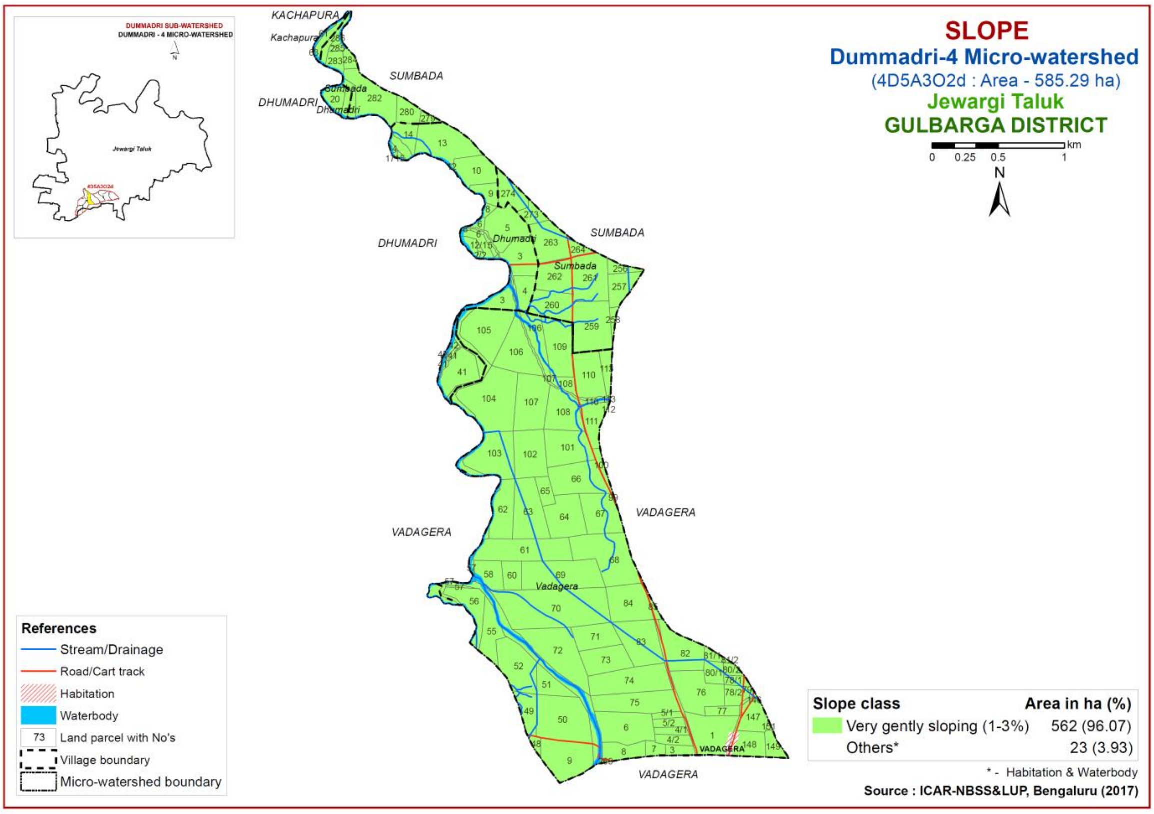


Fig. 5.6 Soil Slope map of Dummadri-4 Microwatershed

5.7 Soil Erosion

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

Soils that are moderately eroded (e2 class) cover a maximum area of about 355 ha (60%) in the microwatershed. They are distributed in the southwestern, western, northwestern and small patches in the southeastern and central part of the microwatershed. Slightly eroded (e1 class) soils cover an area of about 207 ha (35%) and are distributed in the southern, southwestern, southeastern and small patch in northeastern part of the microwatershed.

An area of about 355 ha (61%) in the microwatershed is problematic because of moderate erosion. These areas need soil and water conservation and other land development measures for restoring the soil health.

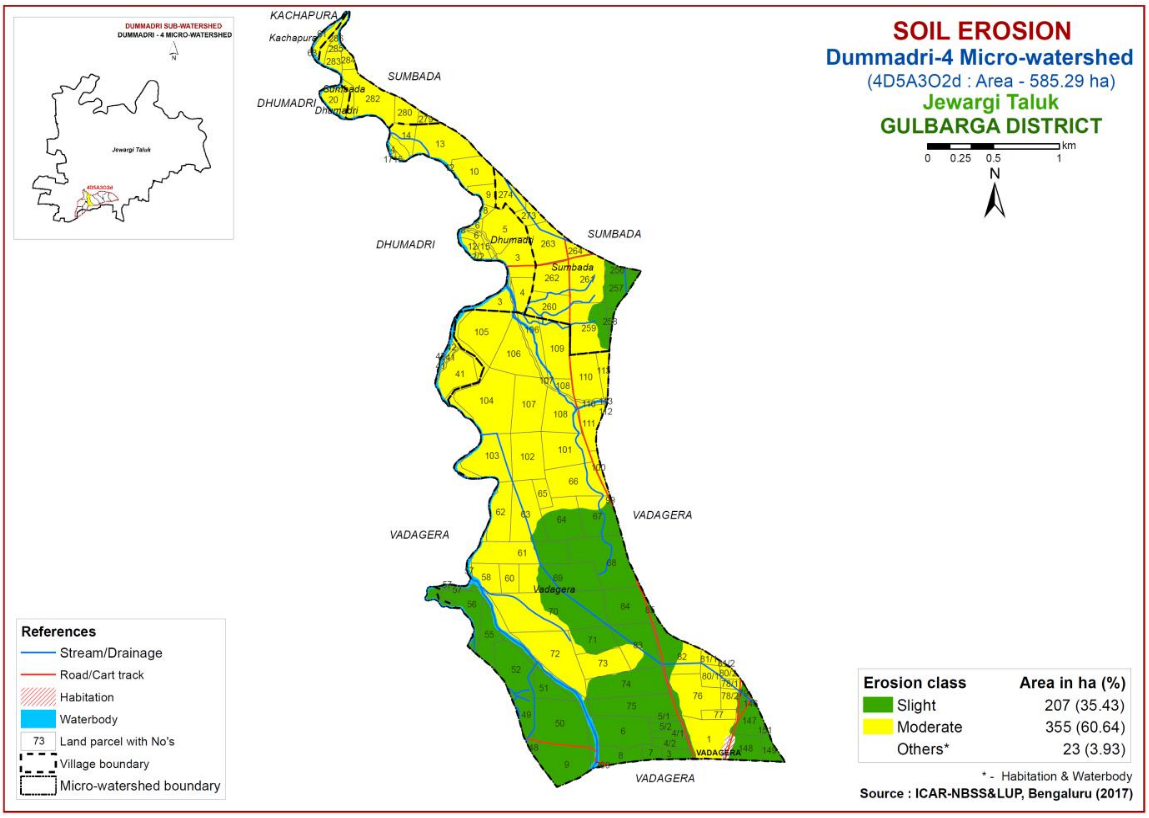


Fig. 5.7 Soil Erosion map of Dummadri-4 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status as the area is characterised by low rainfall anf high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected (89 samples) from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2016 were analysed for pH, EC, organic carbon, available phosphorus and potassium, and for micronutrients like zinc, boron, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil analysis of the Dummadri-4microwatershed for soil reaction (pH) showed that maximum area of about 421 ha (72%) is strongly alkaline (pH 8.4-9.0) and occur in all parts of the microwatershed. Very strongly alkaline (pH >9.0) covers an area of 141 ha (24%) and occurs in northwestern part of the microwatershed (Fig. 6.1).

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content (an index of available Nitrogen) in the soils of the microwatershed is high (>0.75%) in an area of about 118 ha (20%) and are distributed in small areas in the southern, southwestern and southeastern part of the microwatershed. Major area of 430 ha (73%) is under medium (0.5-0.75%) in organic carbon content and are distributed in the northwestern, southwestern, eastern and central part of the microwatershed. Organic carbon content is low (<0.5%) in a small area of 13 ha (2%) and are distributed in the northwestern part of the microwatershed (Fig. 6.3).

6.4 Available Phosphorus

Available phosphorus content is low (<23 kg/ha) in maximum area of about 488 ha (83%) and is distributed in all parts of the microwatershed. An area of about 49 ha

(8%) is medium (23-57 kg/ha) in available phosphorus and high (>57 kg/ha) in about 24 ha (4%) area and occur in the southwestern part of the microwatershed (Fig 6.4).

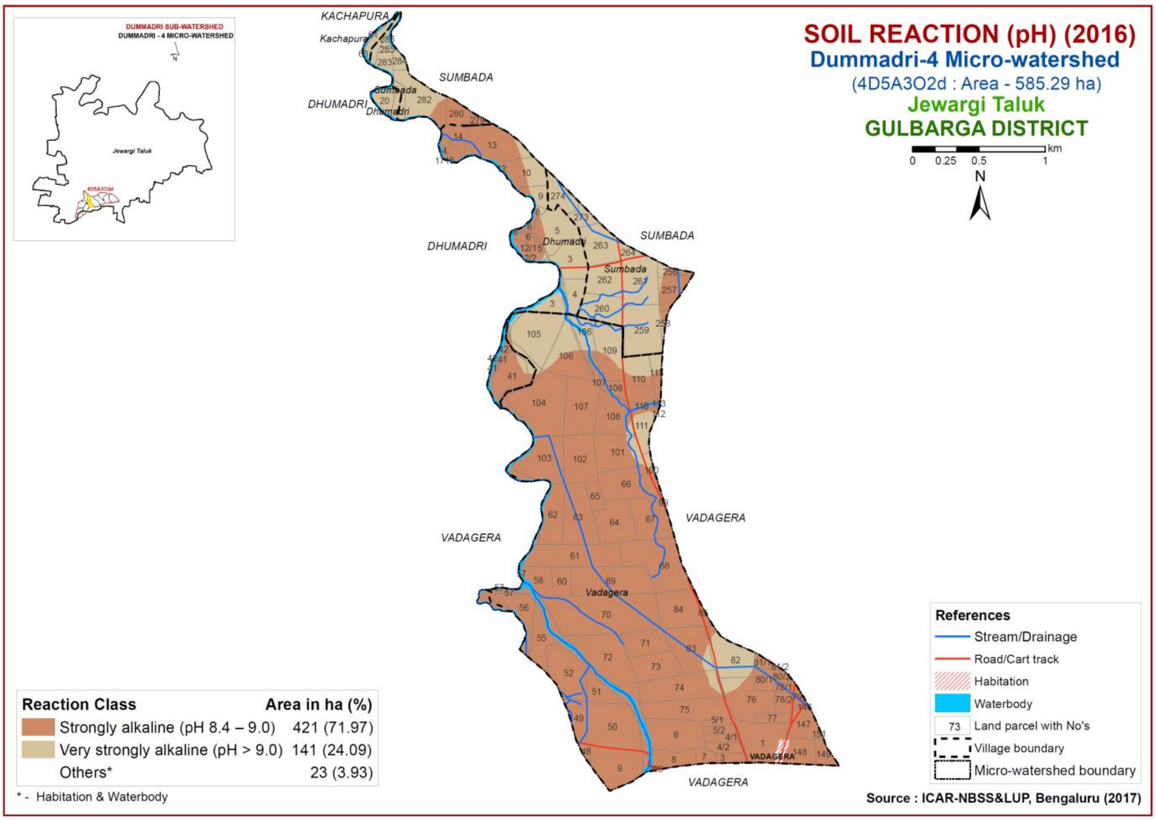


Fig.6.1 Soil Reaction (pH) map of Dummadri-4 Microwatershed

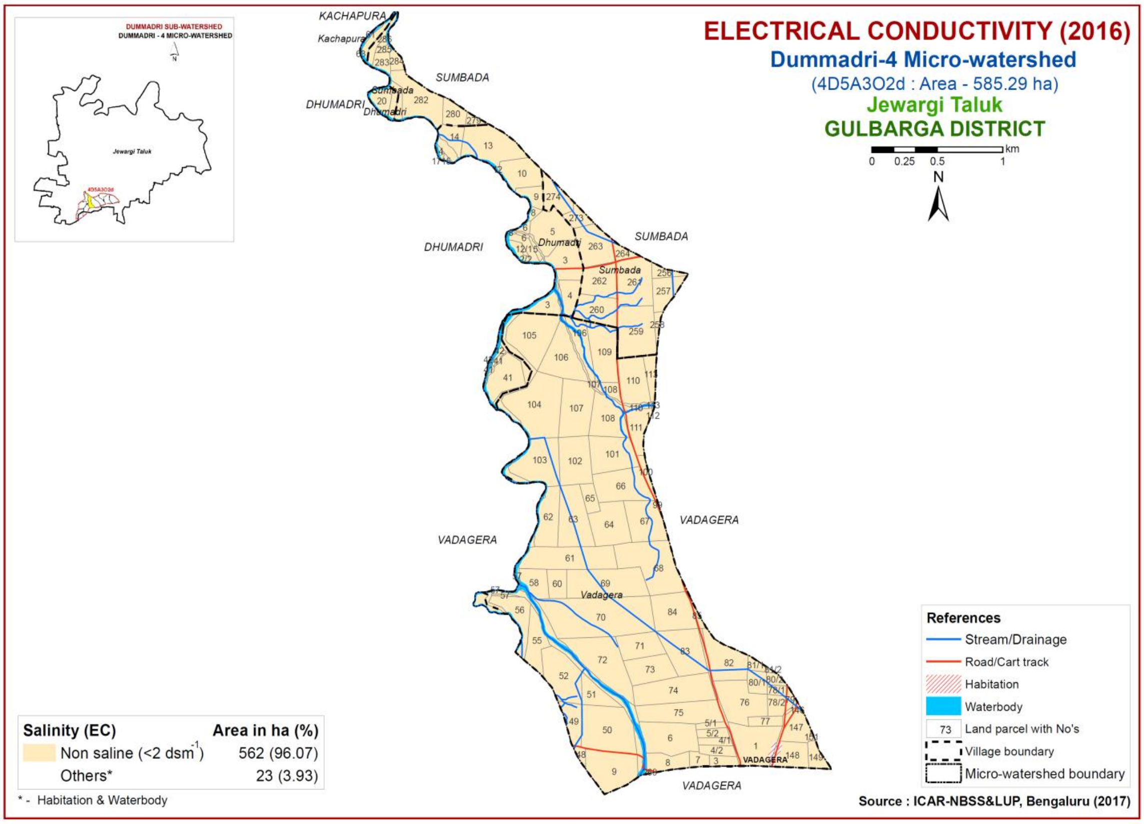


Fig.6.2 Electrical Conductivity (EC) map of Dummadri-4 Microwatershed

6.5 Available Potassium

It is high in available potassium (>337 kg/ ha) in maximum area of 389 ha (66%) and is distributed in all parts of the microwatershed and medium (145-337 kg/ha) in about 172 ha (29%) area and occurs in the western, southern and northwestern part of the microwatershed (Fig. 6.5).

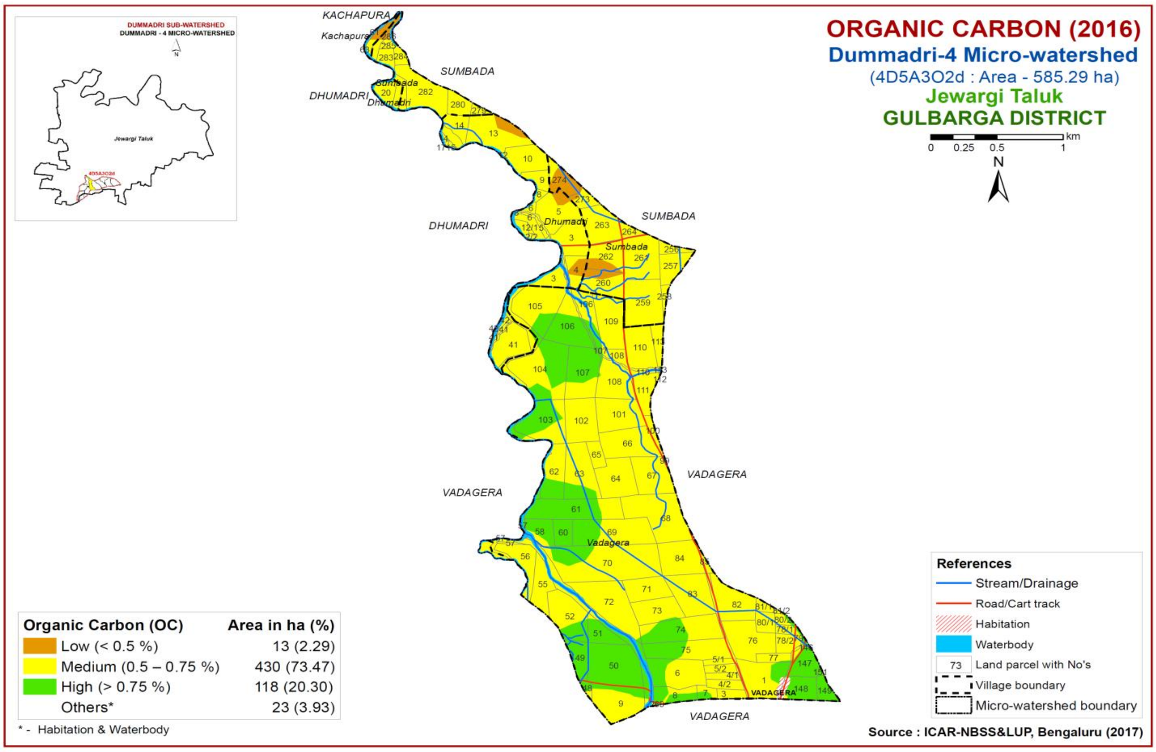


Fig.6.3 Soil Organic Carbon map of Dummadri-4Microwatershed

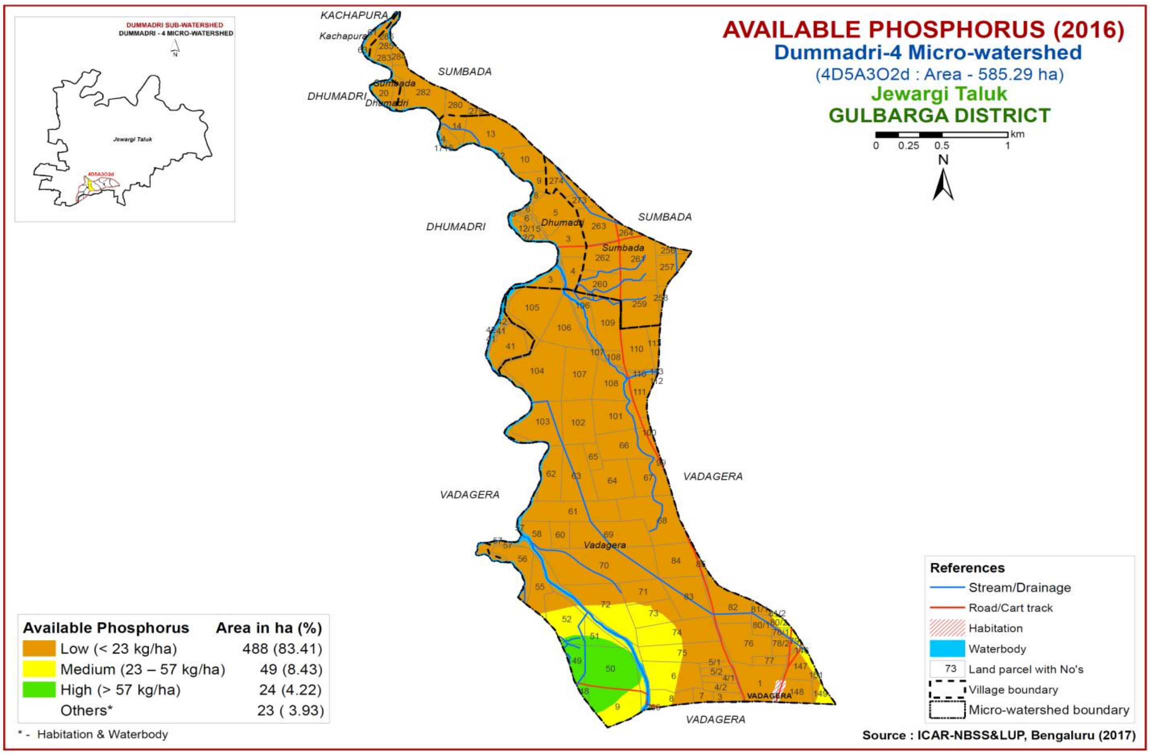


Fig.6.4 Soil Available Phosphorus map of Dummadri-4 Microwatershed

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) in an area of about 443 ha (76%) and is distributed in the major part of the microwatershed. An area of about 118 ha (20%) is high (>20 ppm) in available sulphur and is distributed in the southern 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 359 ha (61%) in the microwatershed and is distributed in major part of the microwatershed. An area of about 202 ha (34%) is low (<0.5 ppm) in available boron and is distributed in the southern, southeastern, central and northwesterntern part of the microwatershed (Fig. 6.7).

6.8 Available Iron

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

6.9 Available Manganese

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

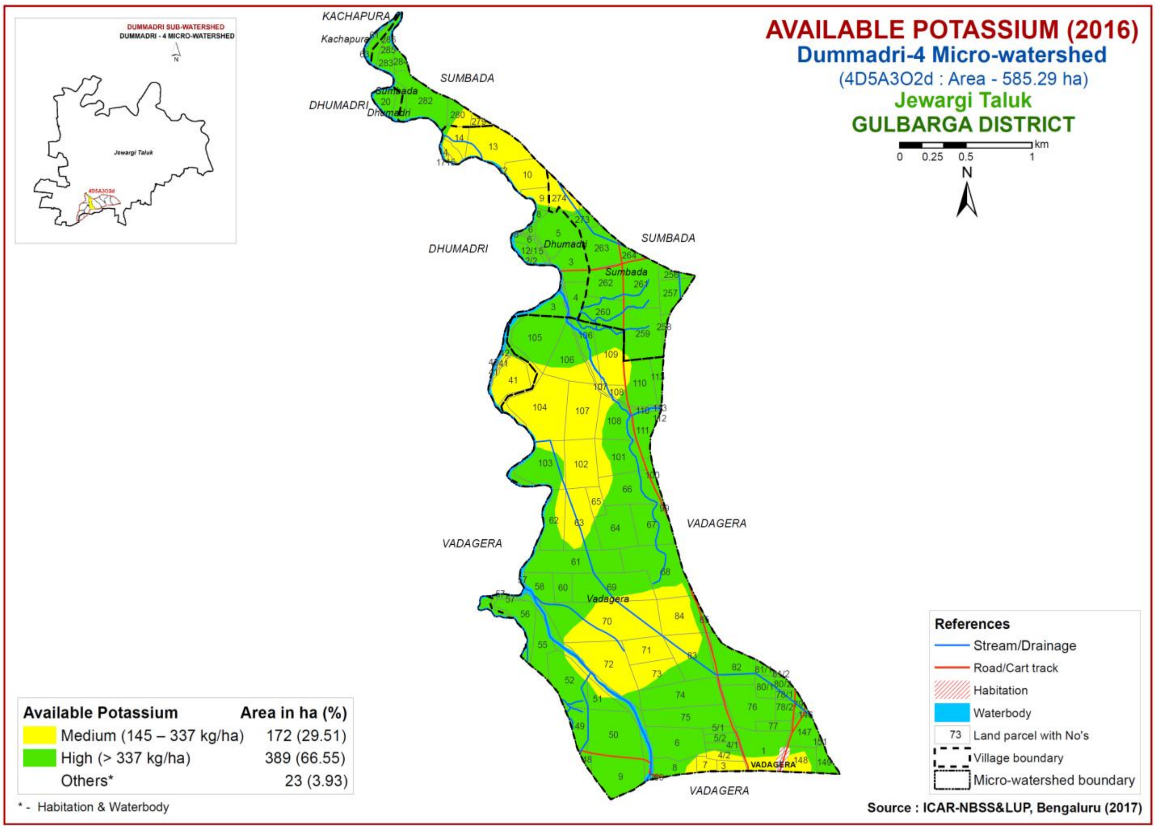


Fig.6.5 Soil Available Potassium map of Dummadri-4 Microwatershed

6.10 Available Copper

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

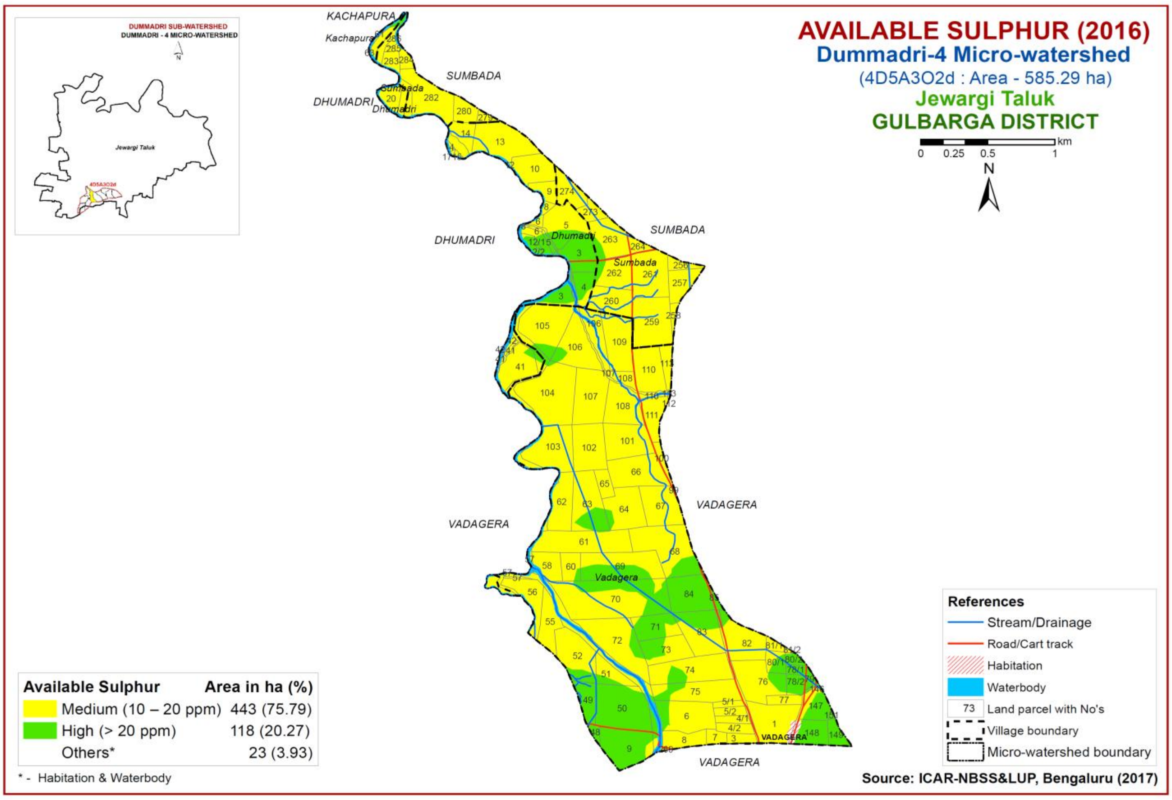


Fig.6.6 Soil Available Sulphur map of Dummadri-4 Microwatershed

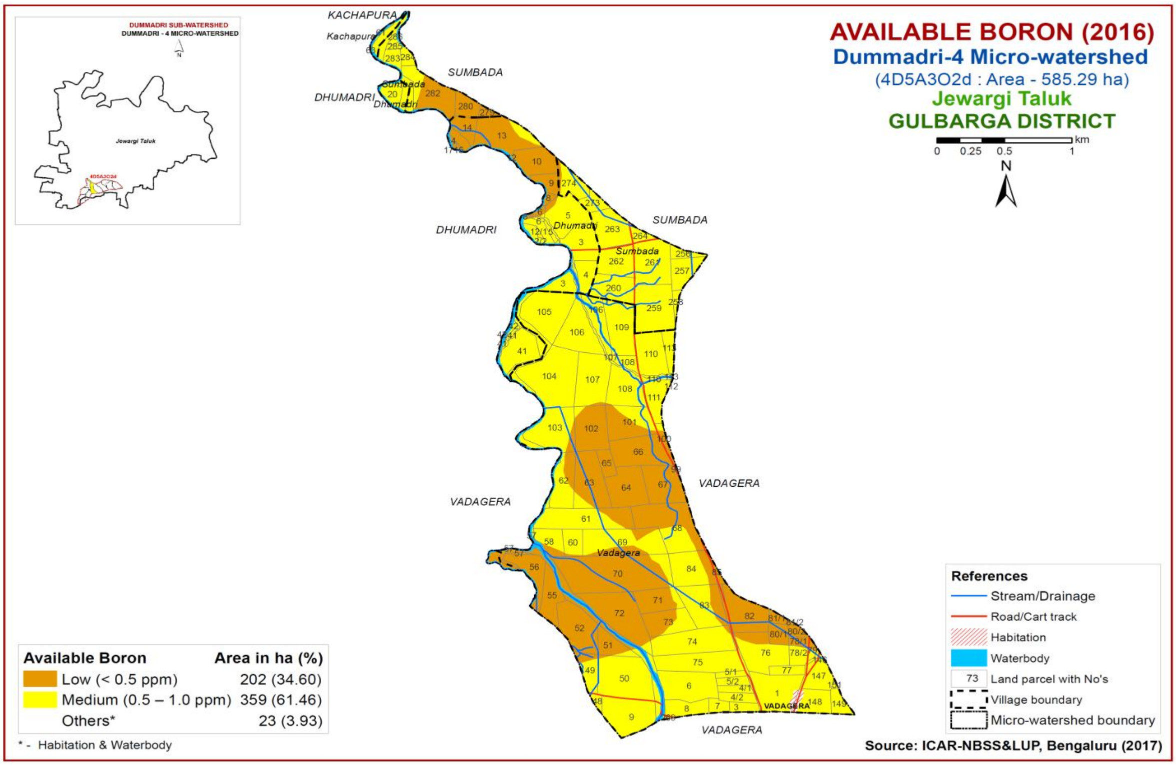


Fig.6.7 Soil Available Boron map of Dummadri-4 Microwatershed

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in 500 ha (85%) and about 62 ha (10%) is sufficient (>0.6 ppm) in available zinc (Fig 6.11).

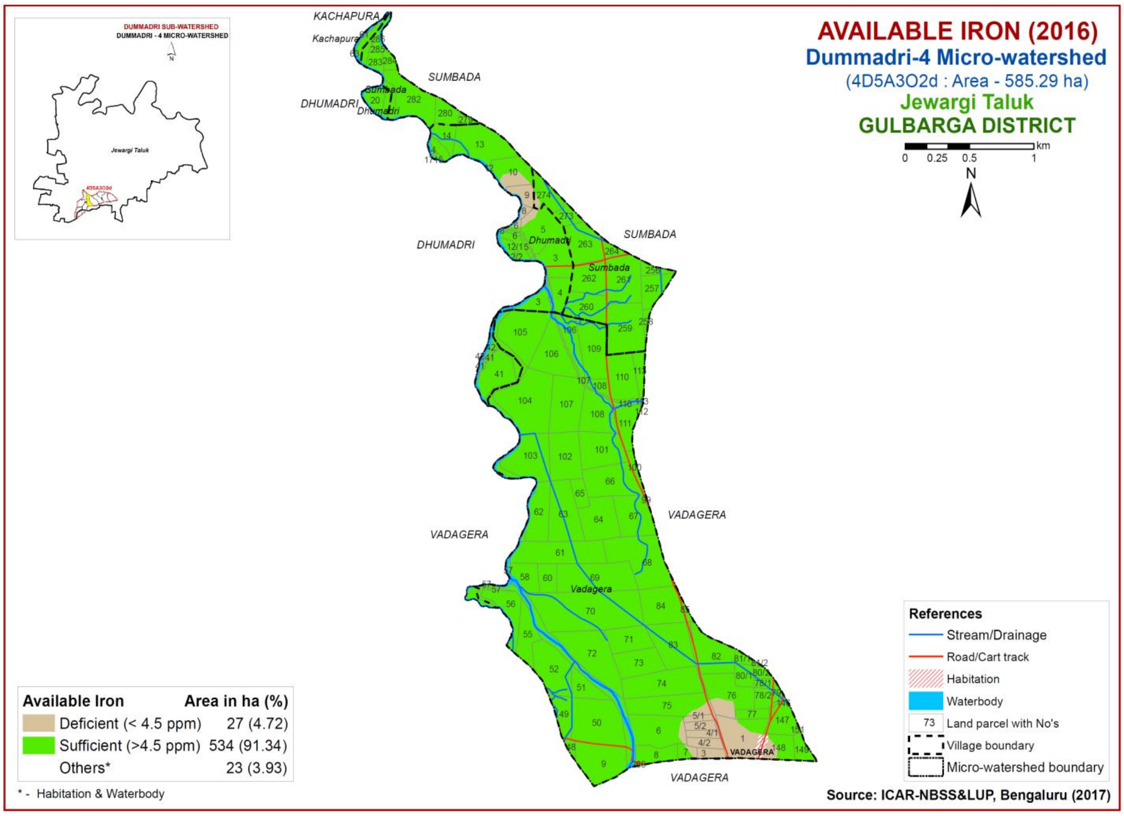


Fig.6.8 Soil Available Iron map of Dummadri-4 Microwatershed

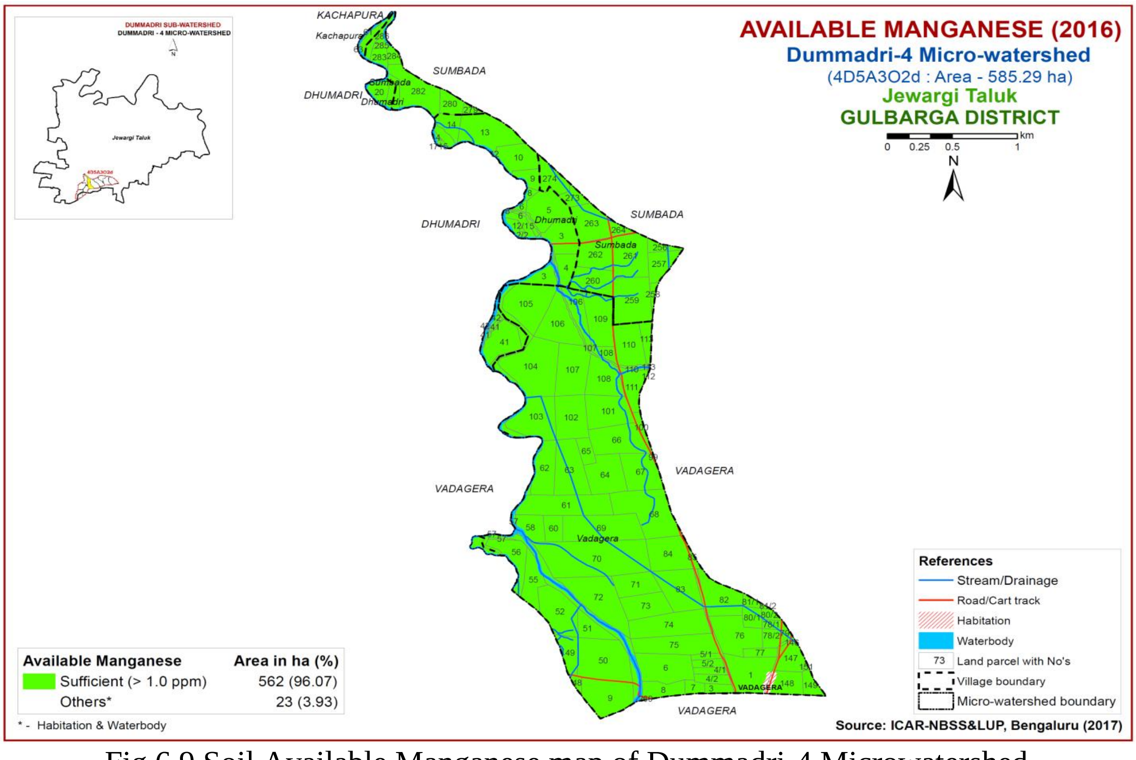


Fig.6.9 Soil Available Manganese map of Dummadri-4 Microwatershed

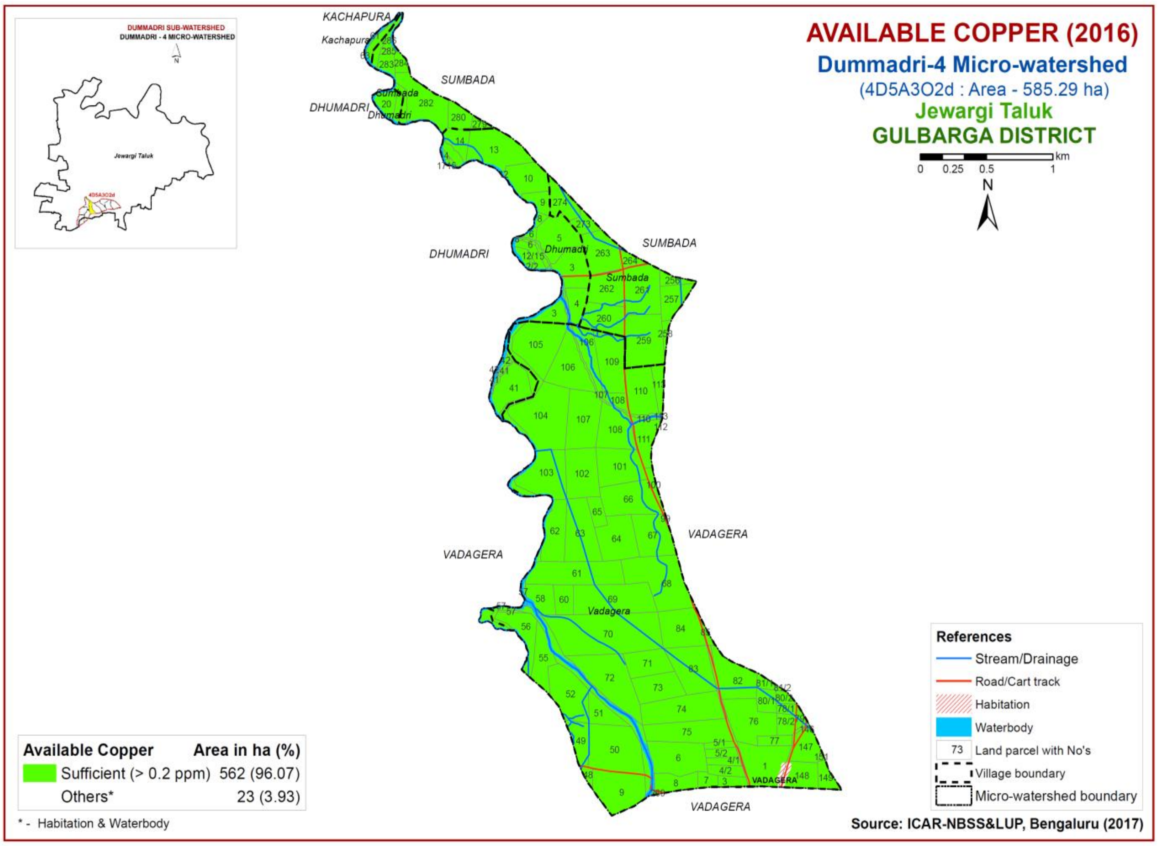


Fig.6.10 Soil Available Copper map of Dummadri-4 Microwatershed

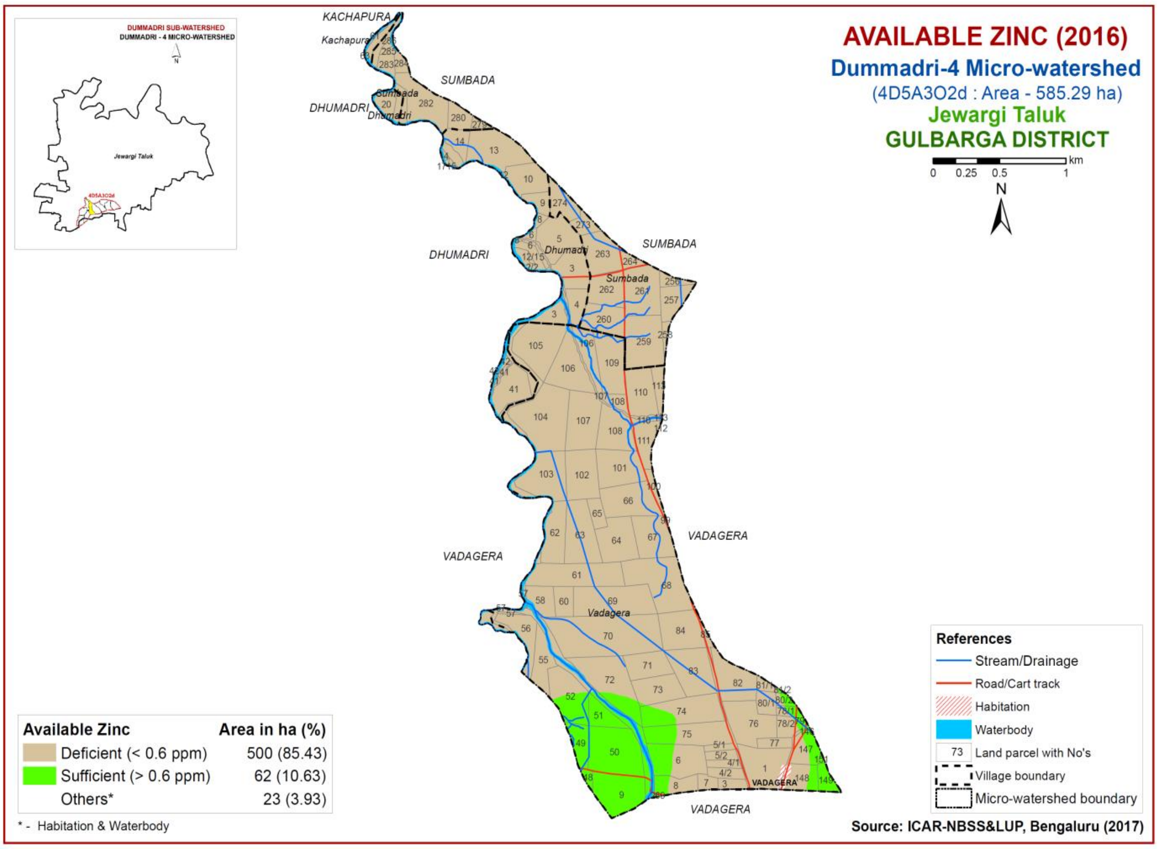


Fig.6.11 Soil Available Zinc map of Dummadri-4 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Dummadri-4 microwatershed were assessed for their suitability for growing food, fodder, fibre and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S-Suitable and Order N-Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1- Highly Suitable, Class S2- Moderately Suitable and Class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the Class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability and 'w' for drainage and 'z' for calcareousness. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable 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 19 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Chamarajnagar districts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing sorghum was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure. 7.1. Entire area of about 562 ha (96%) is highly suitable (Class S1) for growing sorghum and are distributed in all part of the microwatershed.

Table 7.1 Soil-Site Characteristics of Dummadri-4 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC (dS m^{-1})	ESP	CEC [Cmol $(p^{+})kg^{-1}$]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Sub surface (%)								
BBTmB1	751	150	MWD	100-150	c	c	-	<15	>200	1-3	Slight	8.55	0.20	2.09	43.74	100
BBTmB2	751	150	MWD	100-150	c	c	-	<15	>200	1-3	moderate	8.55	0.20	2.09	43.74	100
YDMmB1	751	150	MWD	>150	c	c	-	<15	>200	1-3	Slight	8.76	0.20	2.32	26.57	100
YDMmB2	751	150	MWD	>150	c	c	-	<15	>200	1-3	moderate	8.76	0.20	2.32	26.57	100

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

Table 7.2 Crop suitability criteria for Sorghum

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

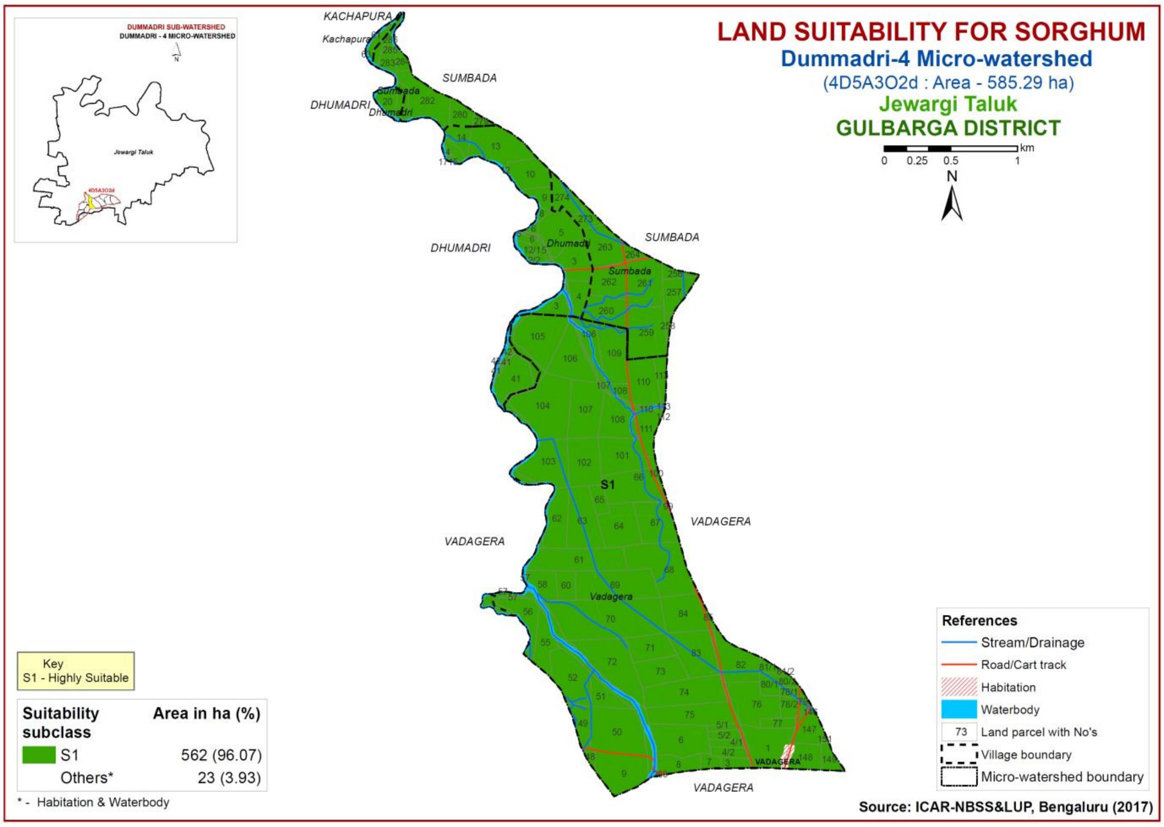


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.37 lakh ha in almost all the districts of the State. The crop requirements for growing maize (Table 7.3) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing maize was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.2. An entire area of about 562 ha (96 %) is marginally suitable (Class S3) for growing maize and are distributed in all parts of the microwatershed. They have moderate limitation of texture.

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)	dS m^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity (ESP)	%	<10	10-15	>15	

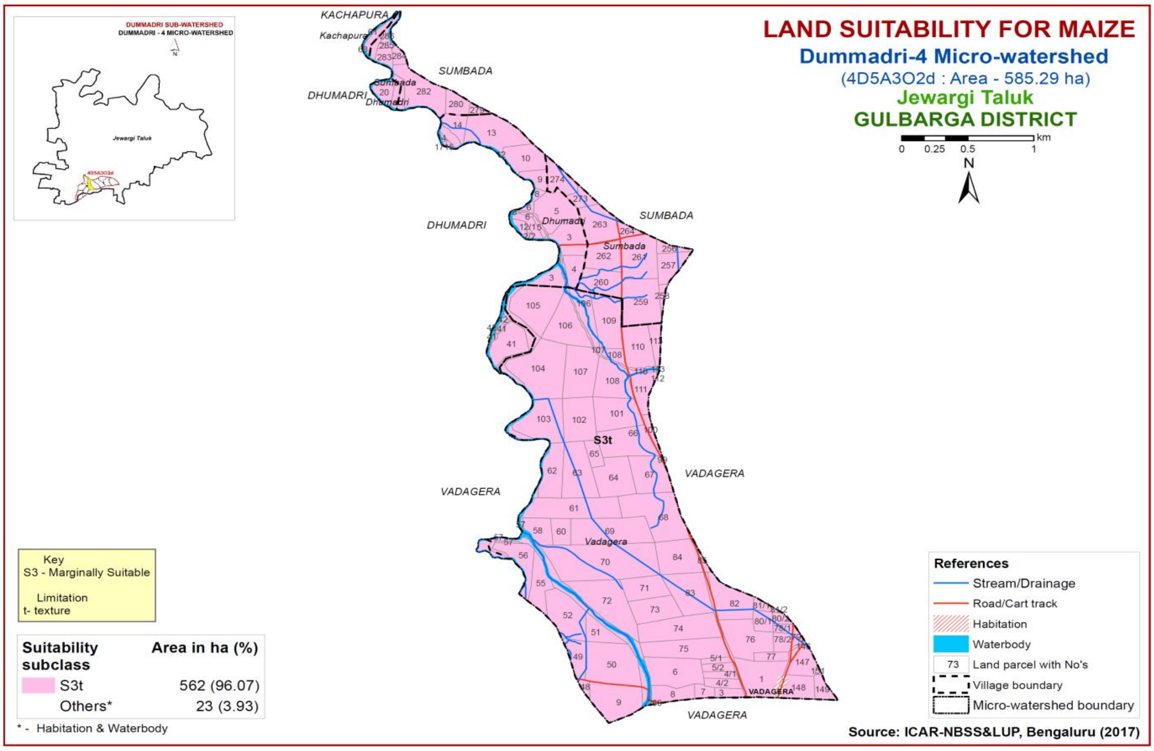


Fig. 7.2 Land Suitability map of Maize

7.3 Land Suitability for Redgram (*Cajanus cajan*)

Redgram is the most important pulse crop grown in an area of 7.28 lakh ha in almost all the districts of the State. The crop requirements for growing redgram (Table

7.4) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing redgram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

The entire area of 562 ha (96%) is moderately suitable (Class S2) for growing redgram and occur in all parts of the microwatershed. They have minor limitation of texture.

Table 7.4 Land suitability criteria for Red gram

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

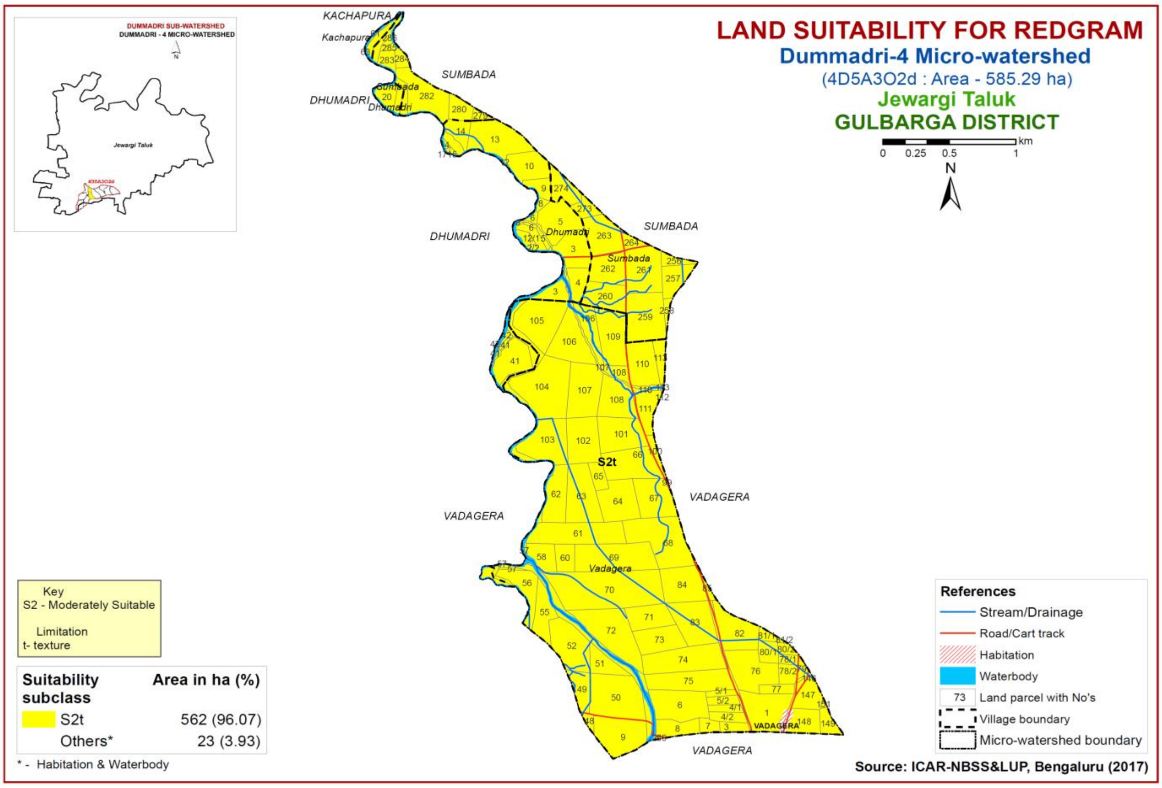


Fig. 7.3 Land Suitability map of Redgram

7.4 Land Suitability for Soybean (*Glycine max*)

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

Highly suitable (class S1) lands are found to occur in an entire area of 562 ha (96%) and are distributed in all parts of the microwatershed.

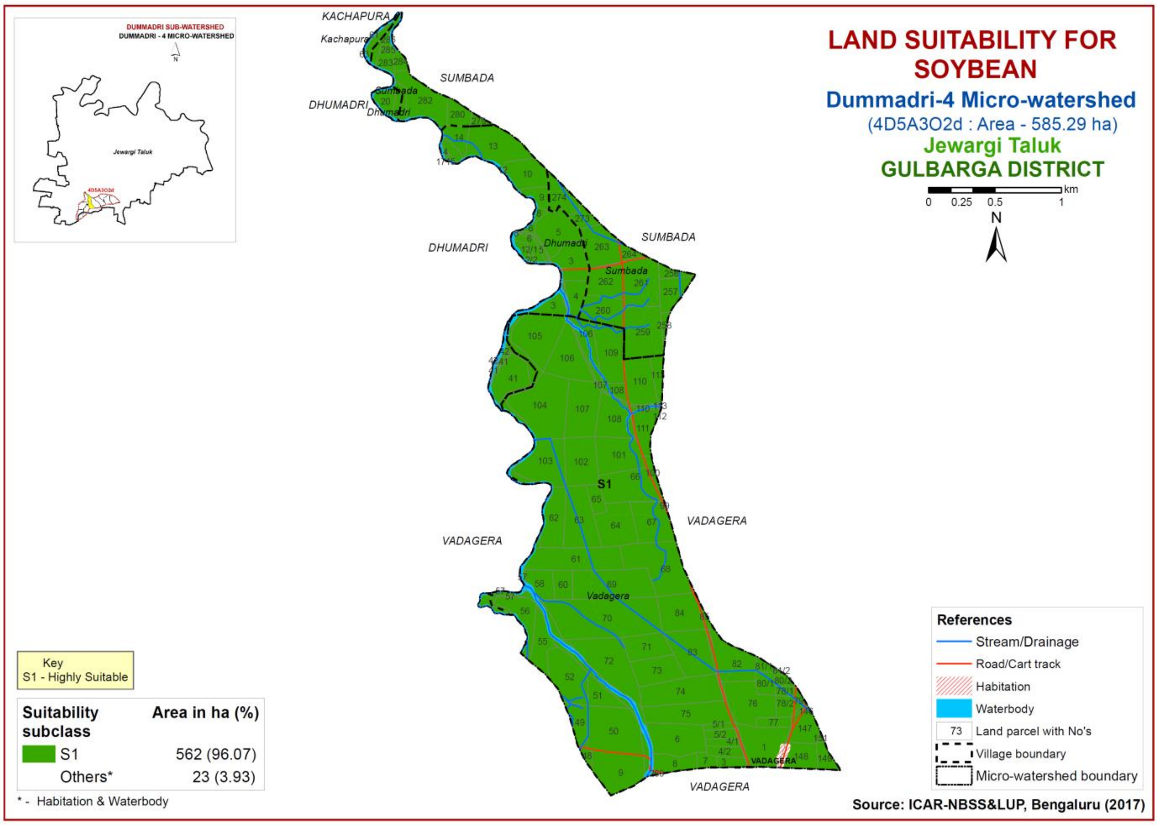


Fig. 7.4 Land Suitability map of Soybean

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

Bengal gram is one of the major pulse crop grown in an area of 9.37 lakh ha in northern Karnataka in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing Bengal gram (Table 7.5) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing Bengal gram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.5.

An entire area of about 562 ha (96%) in the microwatershed has soils that are highly suitable (Class S1) for growing Bengal gram. They have minor or no limitations for growing Bengal gram and are distributed in all parts of the microwatershed.

Table 7.5 Crop suitability criteria for Bengal gram

Crop requirement		Rating			
Soil–site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
Slope	%	<3	3-5	5-10	>10
LGP	Days	>100	90-100	70-90	<70
Soil drainage	class	Well drained	Mod. to well drained; Imperfectly drained	Poorly drained; excessively drained	Very Poorly drained
Soil reaction	pH	6.0-7.5	5.5-5.77.6-8.0	8.1-9.0;4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	Sl, c>60%	S, fragmental
Soil depth	Cm	>75	51-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dS m^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

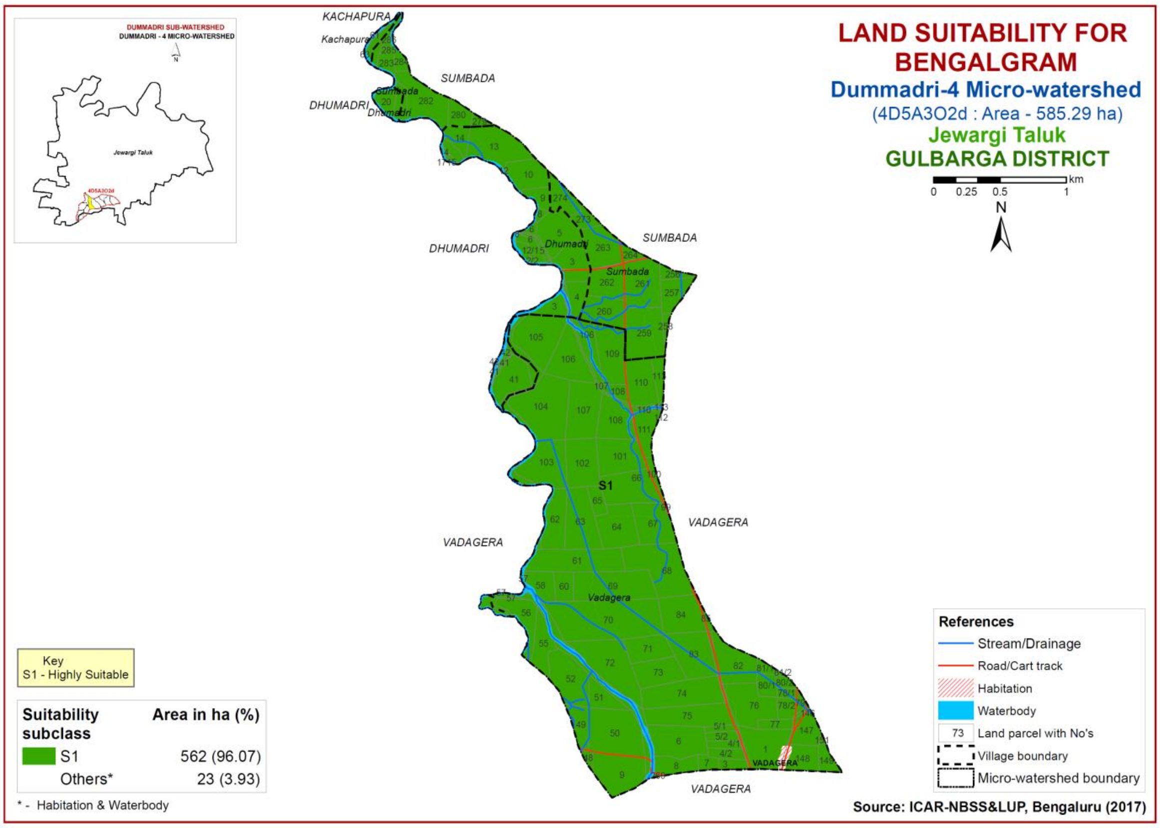


Fig. 7.5 Land Suitability map of Bengalgram

7.6 Land Suitability for Sunflower (*Helianthus annus*)

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

An entire area of about 562 ha (96%) is highly suitable (Class S1) for growing sunflower and are distributed in all parts of the microwatershed. They have minor or no limitations for growing Sunflower.

Table 7.6 Crop suitability criteria for Sunflower

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

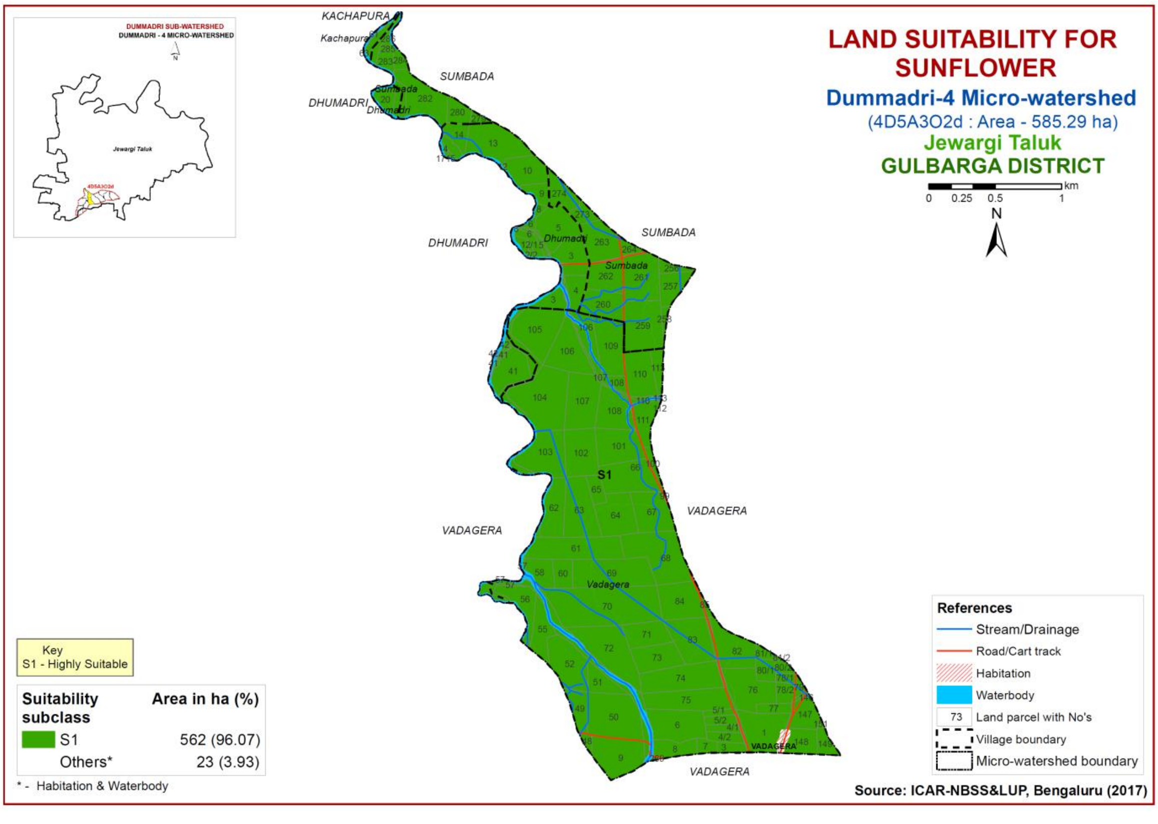


Fig. 7.6 Land Suitability map of Sunflower

7.7 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 8.75 lakh ha area in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.7) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cotton was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

Table 7.7 Crop suitability criteria for Cotton

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

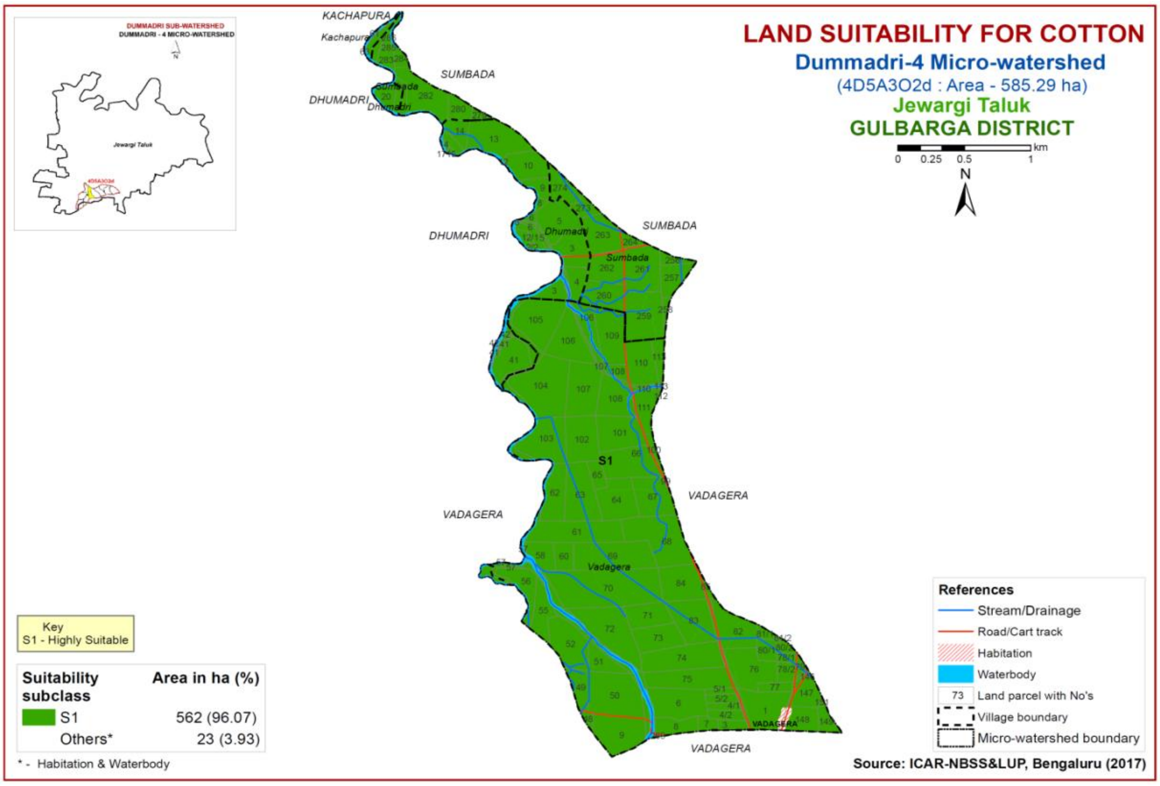


Fig. 7.7 Land Suitability map of Cotton

Entire area of about 562 ha (96%) has soils that are highly suitable (Class S1) for cotton and are distributed in all parts of the microwatershed. They have minor or no limitations for growing cotton.

7.8 Land Suitability for Sugarcane (*Saccharum officinarum*)

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

Table 7.8 Crop suitability criteria for Sugarcane

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

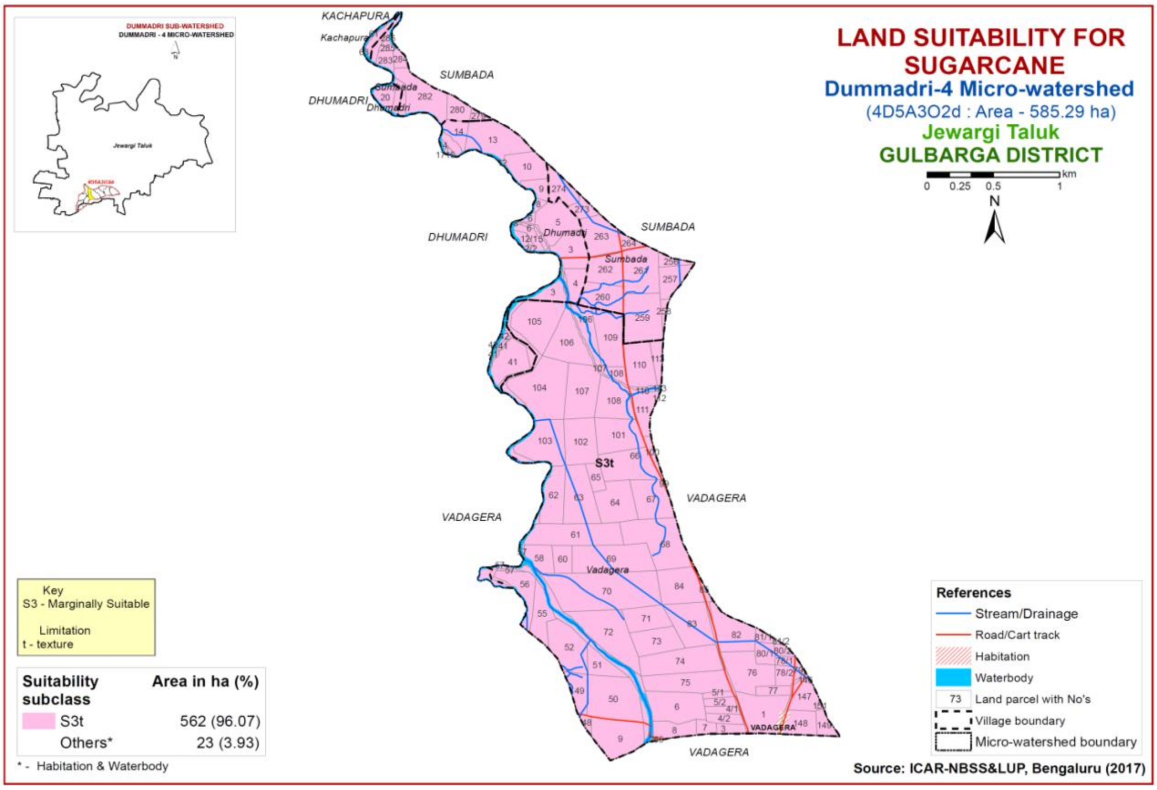


Fig. 7.8 Land Suitability map of Sugarcane

The marginally suitable (Class S3) lands cover an entire area of about 562 ha (96%) and occur in all parts of the microwatershed. They have moderate limitation of texture.

7.9 Land suitability for Mango (*Mangifera indica*)

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

The marginally suitable (Class S3) lands cover an area of about 562 ha (93%) and are distributed in all parts of the microwatershed. They have moderate limitation of texture.

Table 7.9 Crop suitability criteria for Mango

Crop requirement			Rating			
Soil-site characteristics		Unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Climate	Temp. 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^{-1}	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

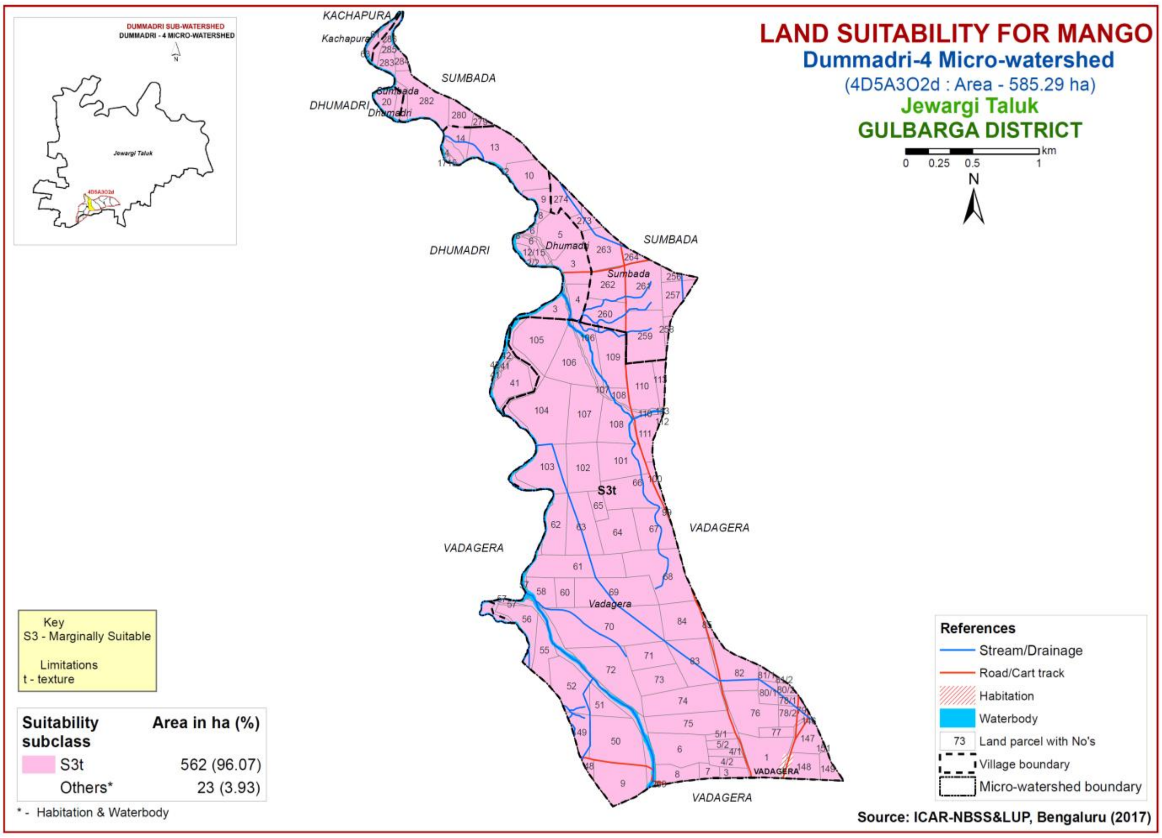


Fig. 7.9 Land Suitability map of Mango

7.10 Land suitability for Sapota (*Manilkara zapota*)

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

An entire area of about 562 ha (96%) is moderately suitable (Class S2) and are distributed in all parts and they have minor limitation of texture.

Table 7.10 Crop suitability criteria for Sapota

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

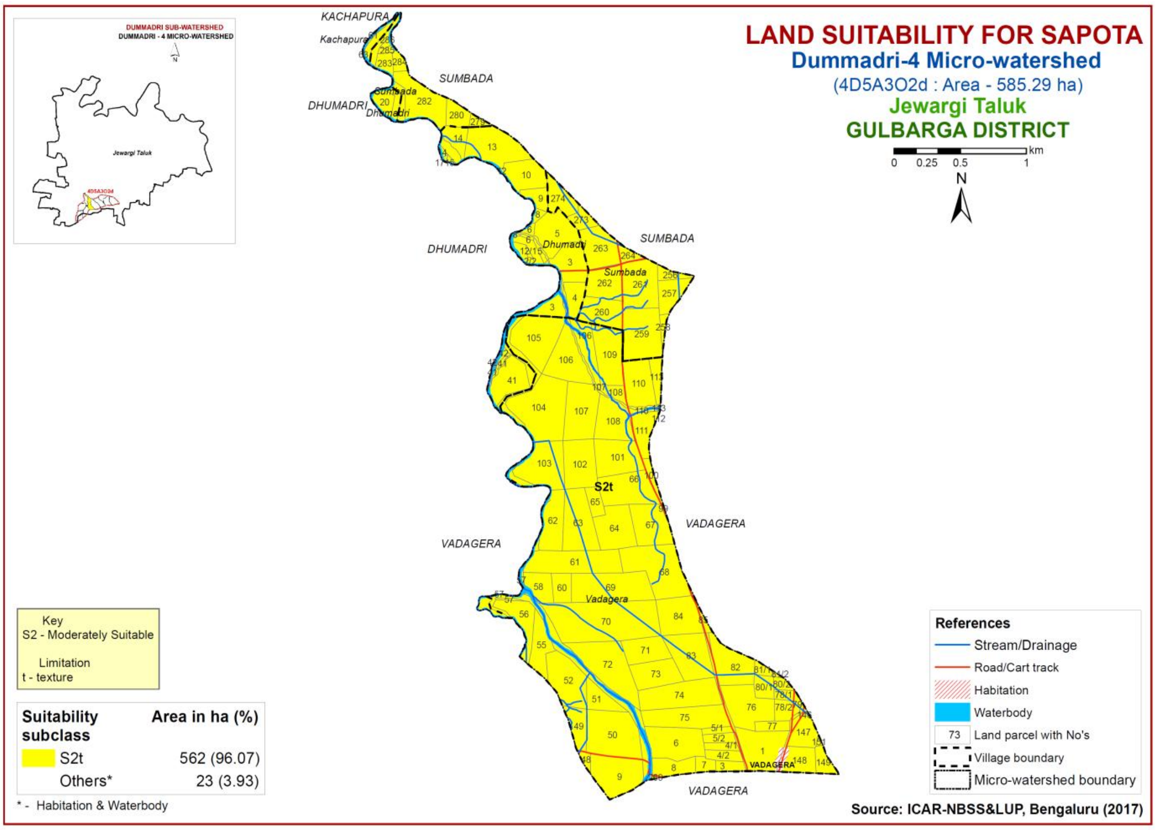


Fig. 7.10 Land Suitability map of Sapota

7.11 Land suitability for Guava (*Psidium guajava*)

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

An entire area of about 562 ha (96%) is moderately suitable (Class S2) and are distributed in all parts and have minor limitation of texture.

Table 7.11 Crop suitability criteria for Guava

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

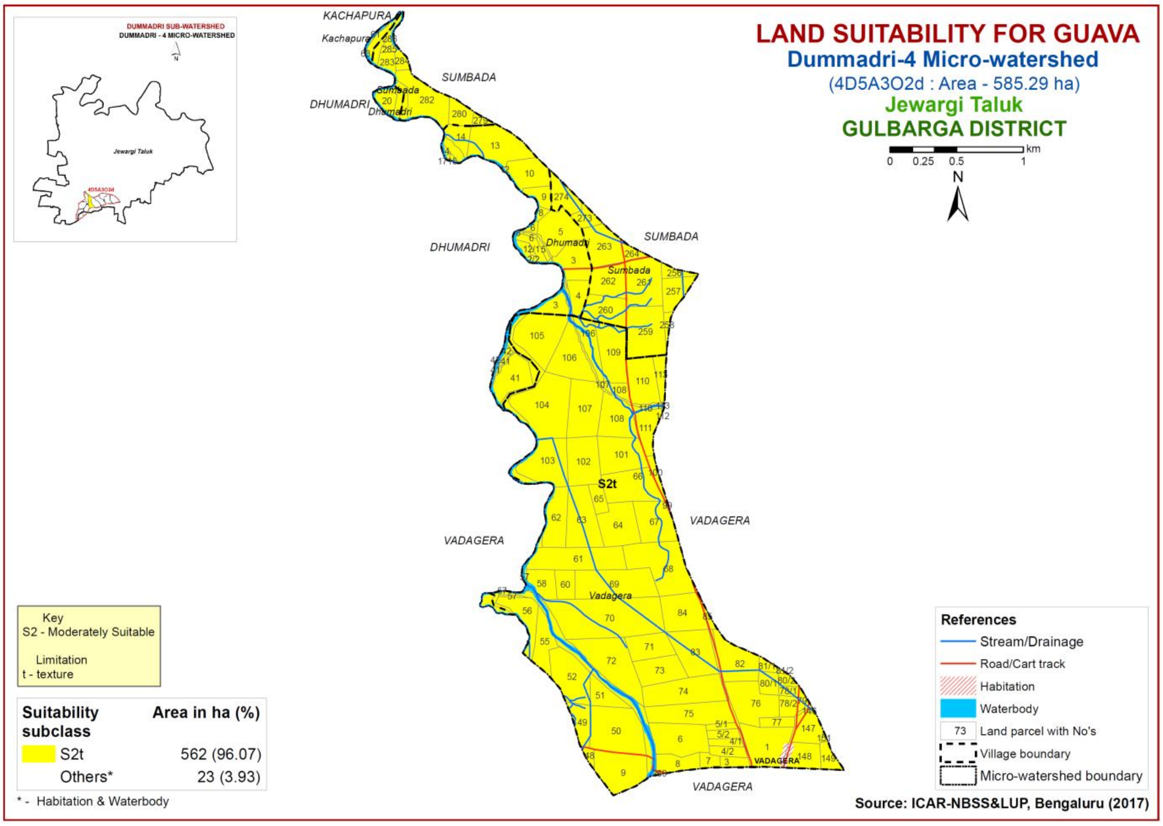


Fig. 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

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

Marginally suitable (Class S3) lands for growing jackfruit occupy an entire area of about 562 ha (96%) and are distributed in all parts of the microwatershed. They have moderate limitation of texture.

Table 7.12 Crop suitability criteria for Jackfruit

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

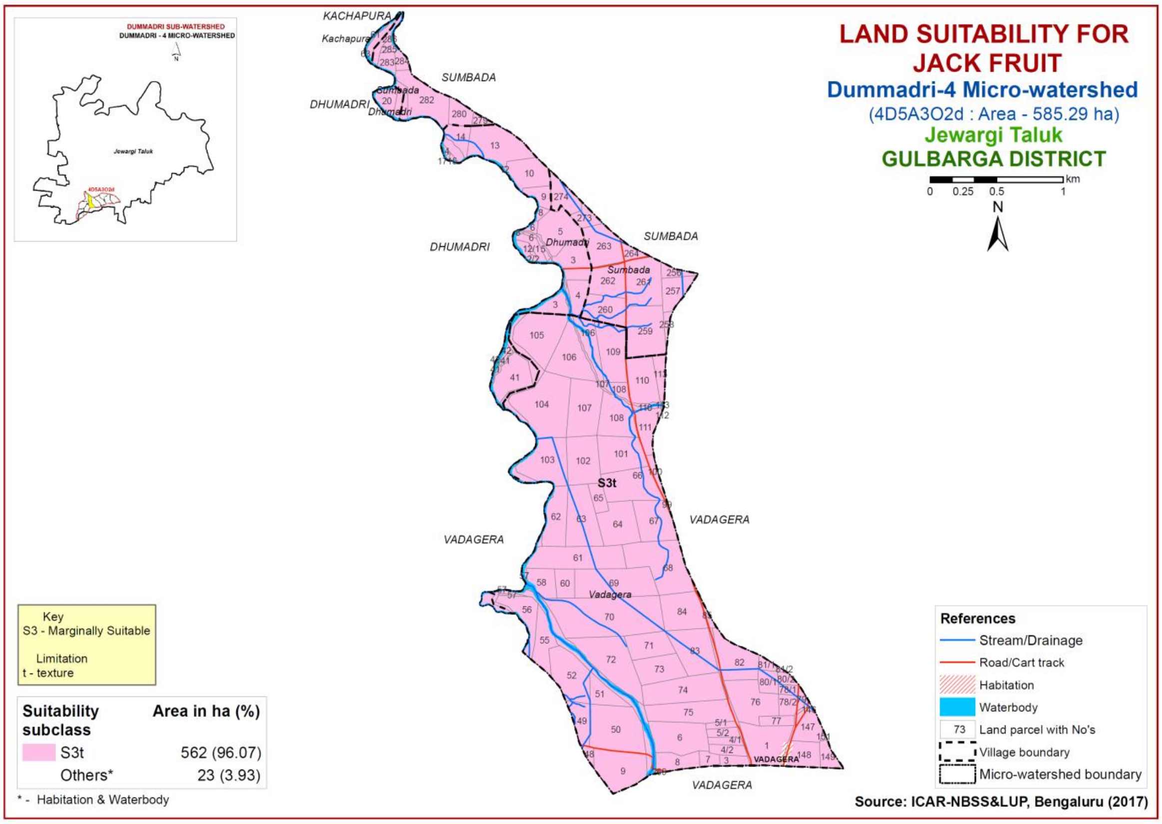


Fig. 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

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

An entire area of 562 ha (96%) is moderately suitable (Class S2) for growing jamun and are distributed in all parts of the microwatershed. They have minor limitation of texture.

Table 7.13 Crop suitability criteria for Jamun

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

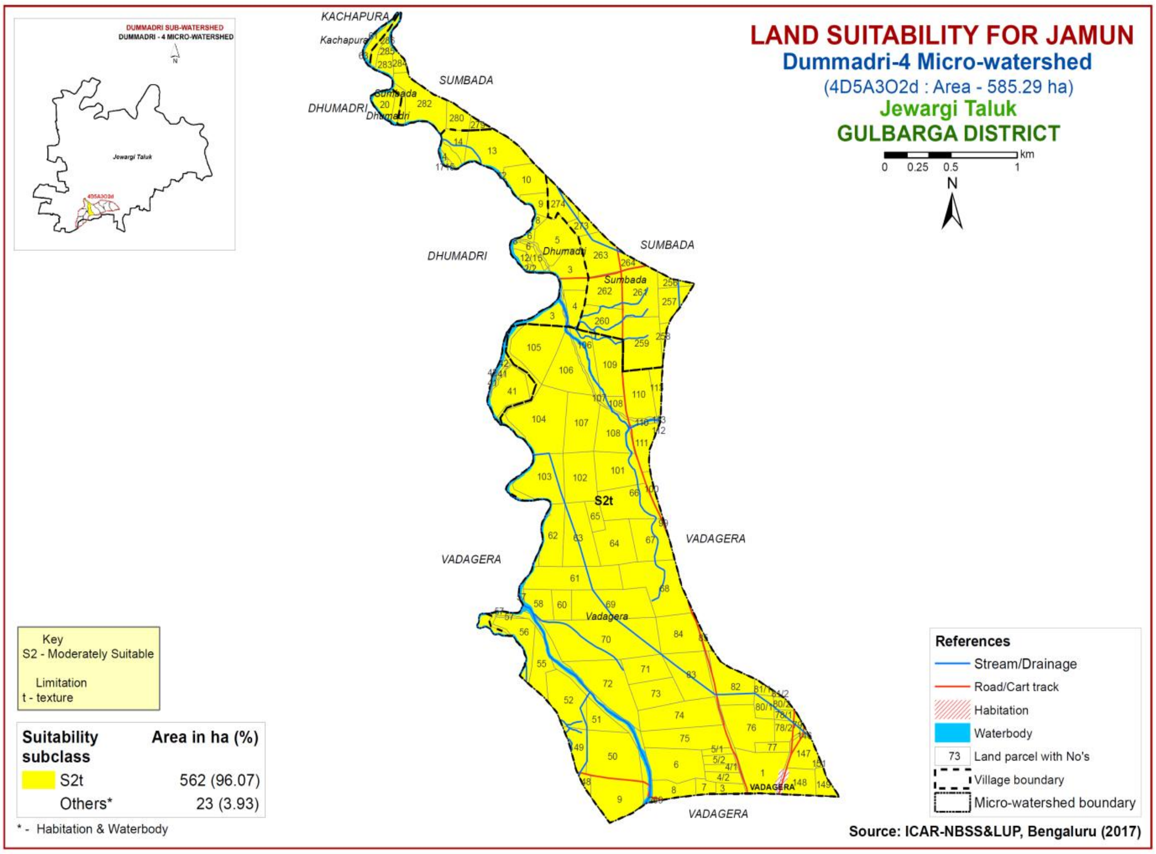


Fig. 7.13 Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing musambi (Table 14) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing musambi was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.14.

An entire area of about 562 ha (96%) has soils that are highly suitable (Class S1) for growing musambi and are distributed in all parts of the microwatershed.

Table 7.14 Crop suitability criteria for Musambi

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

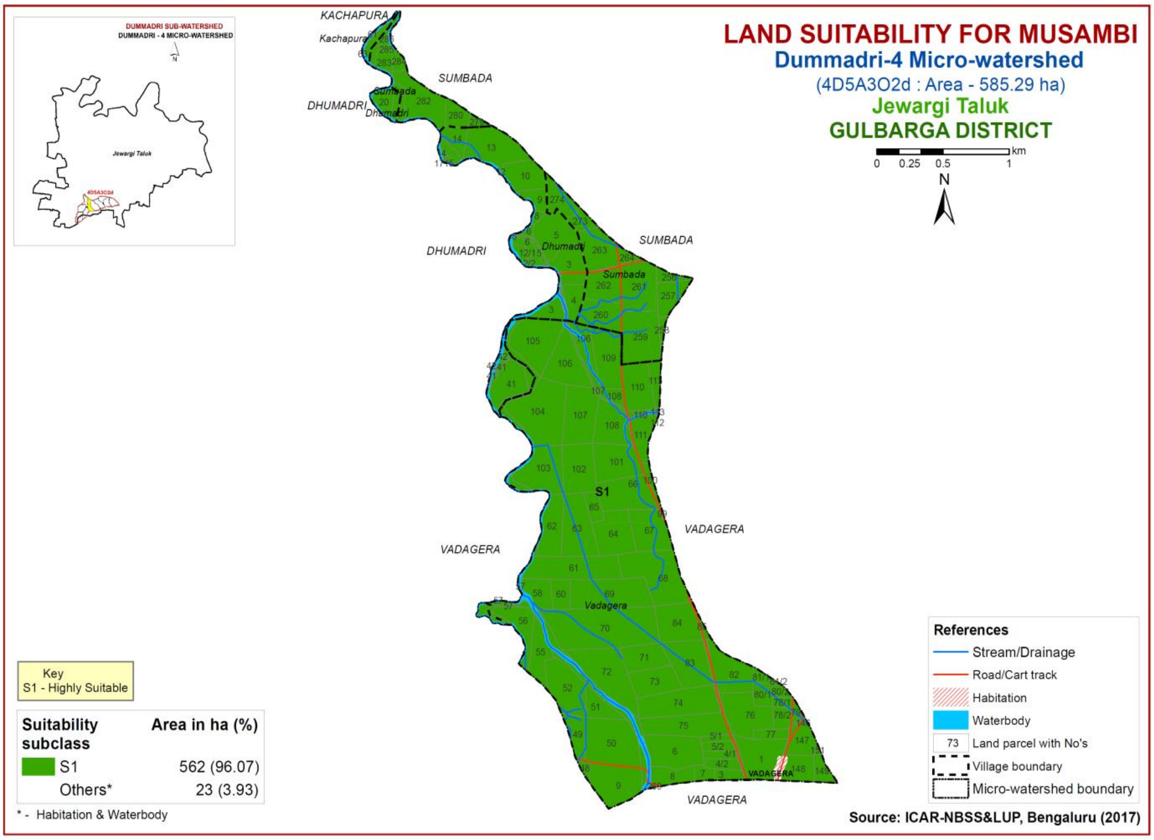


Fig. 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in an area of 0.11 lakh ha in almost all the districts of the State. The crop requirements for growing lime (Table 7.15) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.15.

An entire area of about 562 ha (96%) has soils that are highly suitable (Class S1) for growing lime and are distributed in all parts of the microwatershed.

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	^0C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	Class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C (>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.47.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non 34 calcareous	Upto 5	5-10	>10
Rooting conditions	Soil depth	Cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS m^{-1}	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

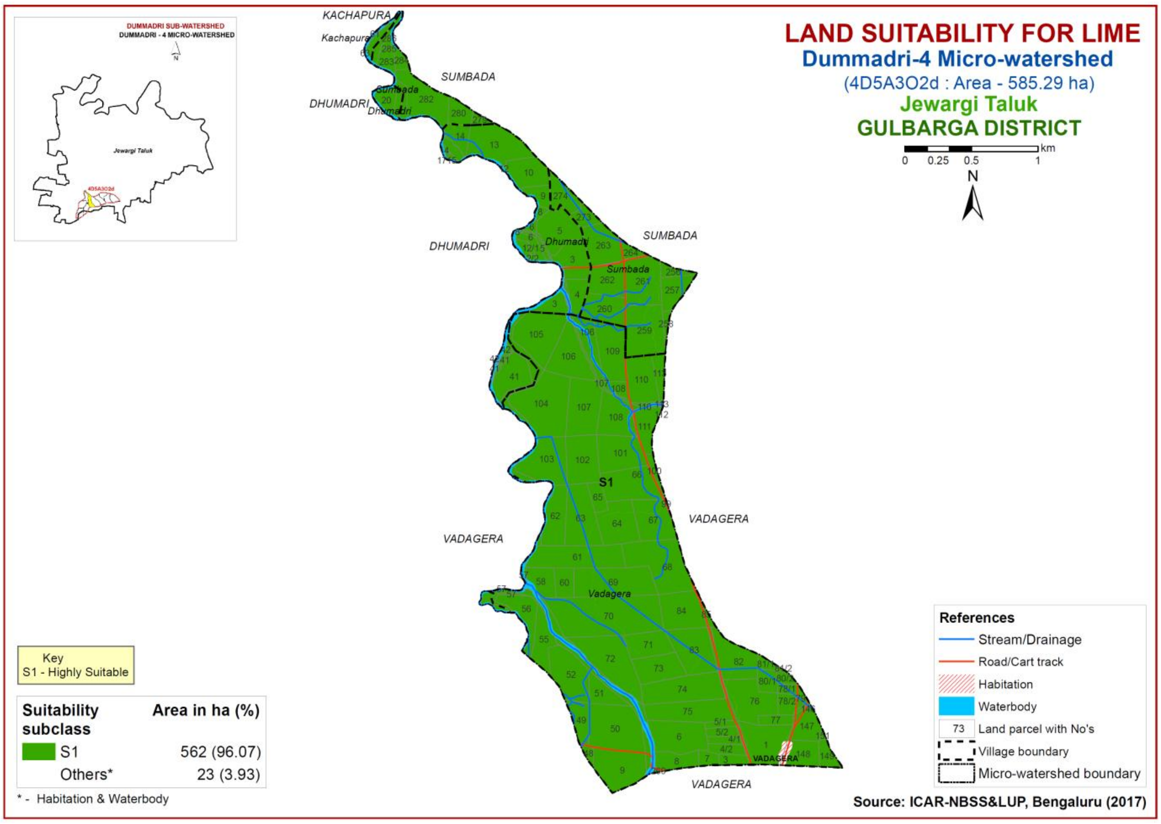


Fig. 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale)*

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

Table 7.16 Crop suitability criteria for cashew

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

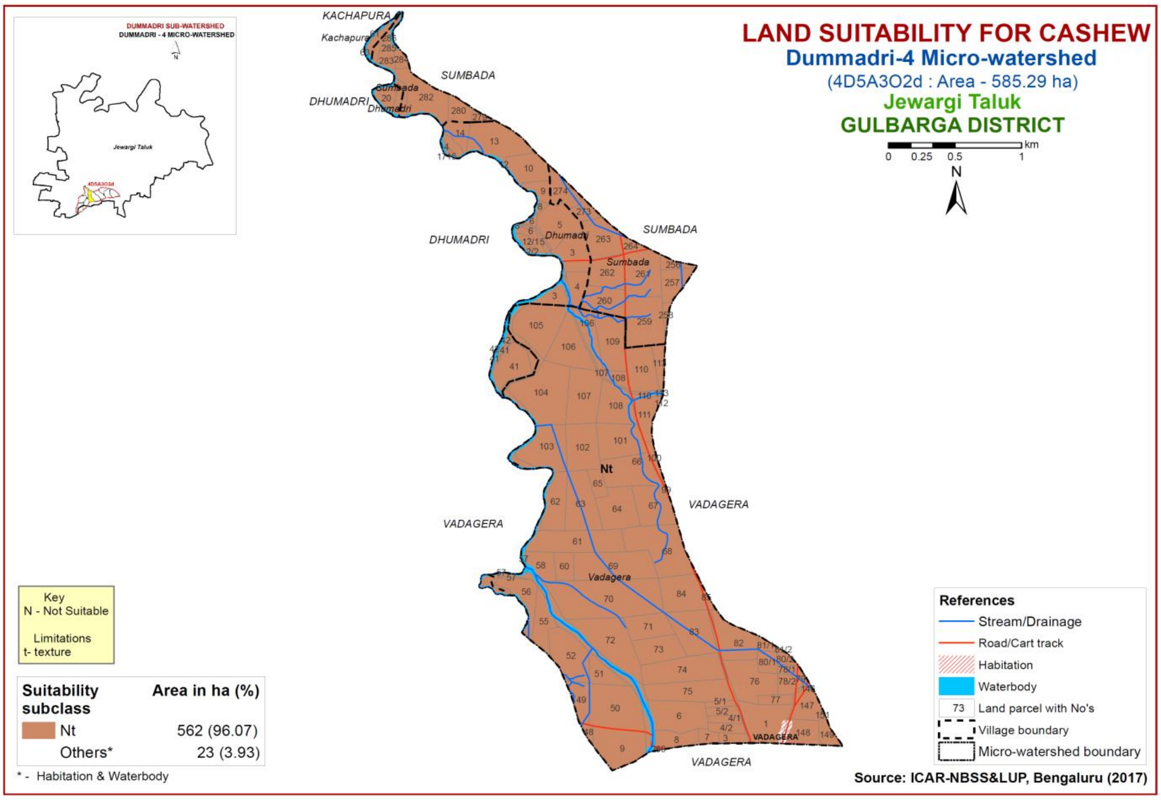


Fig. 7.16 Land Suitability map of Cashew

Entire area about 562 (96%) is not suitable (Class N) for growing cashew in the microwatershed. They have very severe limitations of texture, gravelliness, slope and rooting depth.

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

Custard apple is one of the most important fruit crop grown in almost all the districts of the State. The crop requirements for growing custard apple (Table 17) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing custard apple was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.17.

Entire area of about 562 ha (96%) has soils that are highly suitable (Class S1) for growing custard apple and are distributed in all parts of the microwatershed.

Table 7.17 Crop suitability criteria for Custard Apple

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

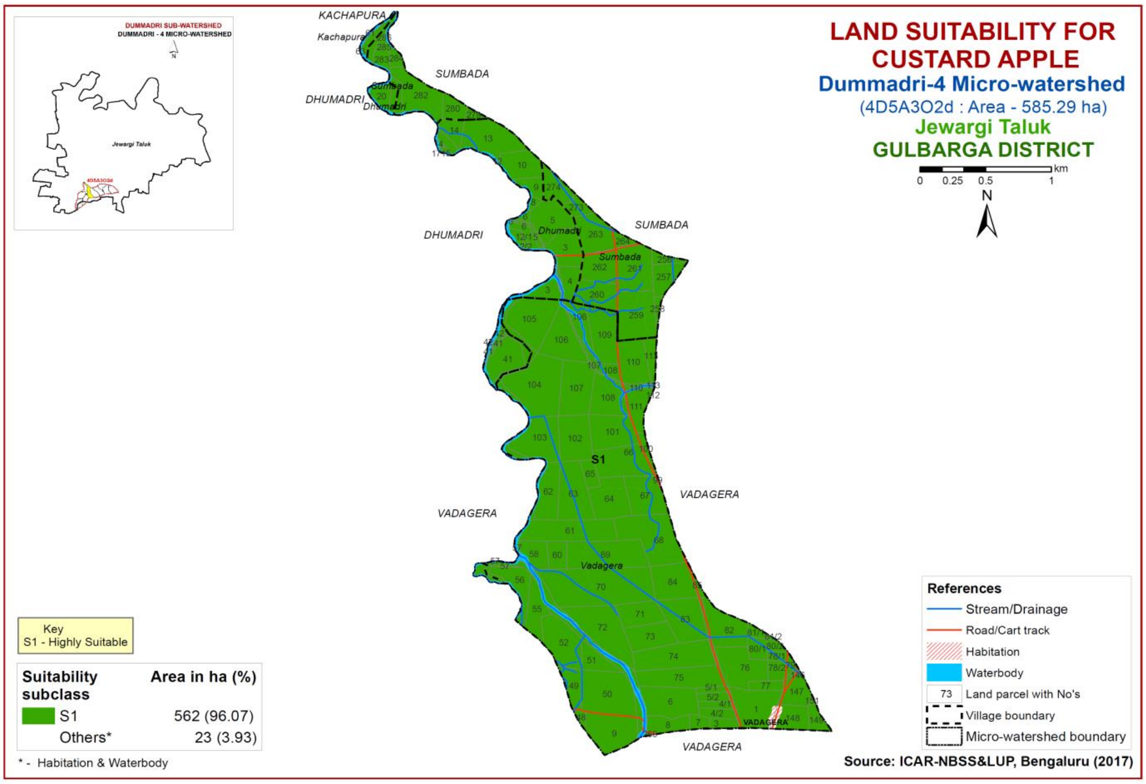


Fig. 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

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

Entire area of about 562 ha (96%) has soils that are highly suitable (Class S1) for growing amla and are distributed in all parts of the microwatershed.

Table 7.18 **Land suitability criteria for Amla**

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

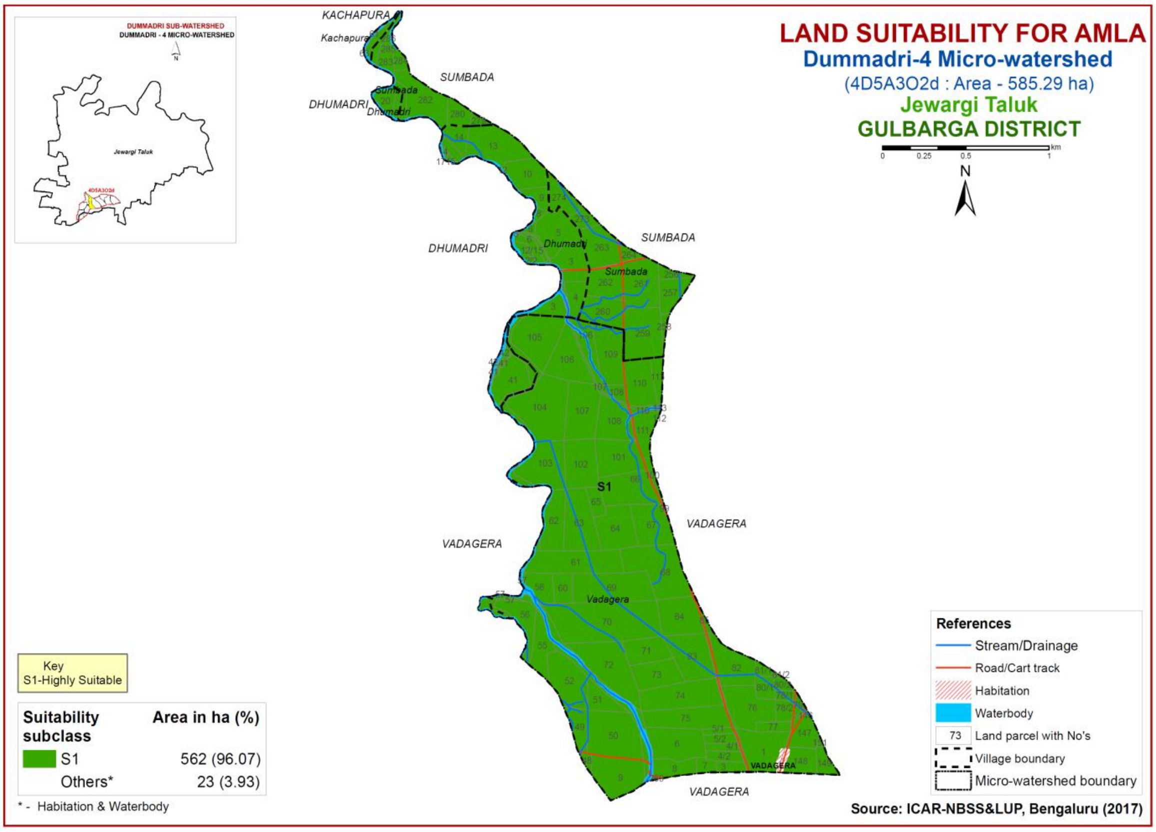


Fig. 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

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

Entire area of about 562 ha (96%) has soils that are moderately suitable (Class S2) with minor limitation of texture and are distributed in all parts of the microwatershed.

Table 7.19 Land suitability criteria for Tamarind

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

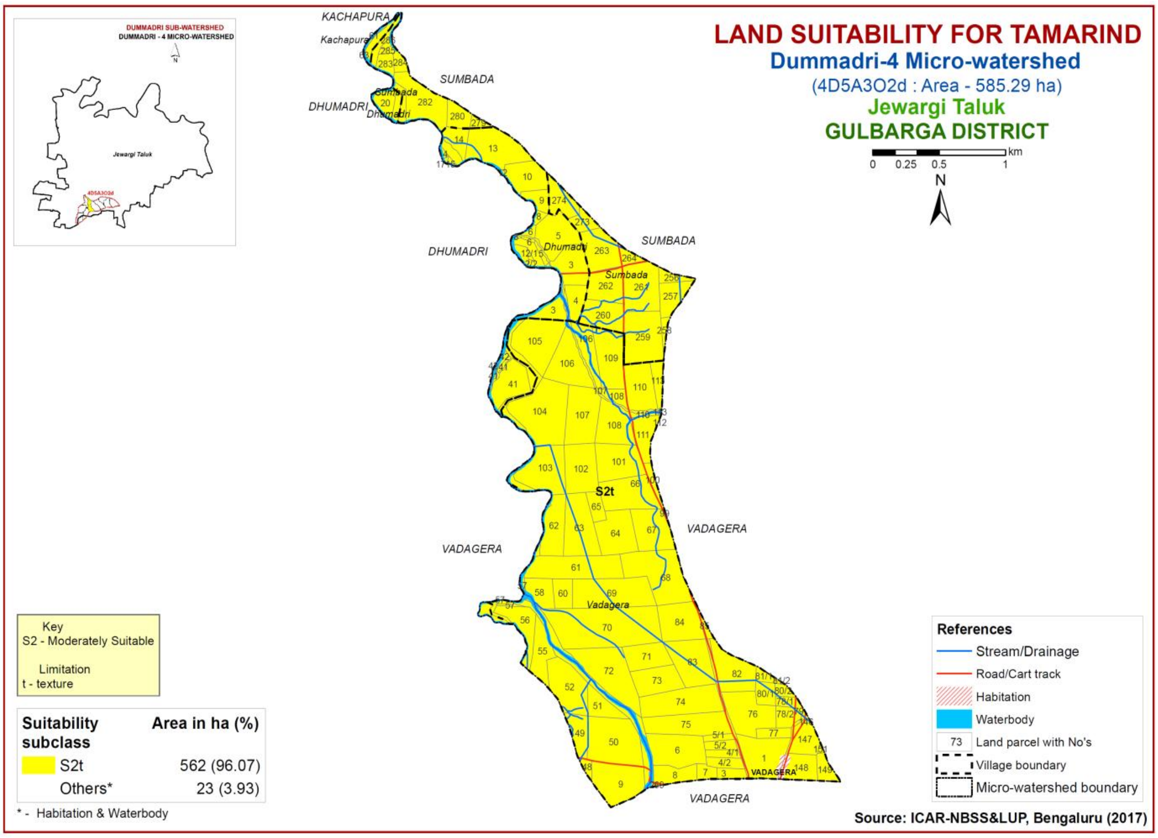


Fig. 7.19 Land Suitability map of Tamarind

7.20 Land Unit Classes (LUC's)

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

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

LUCs	Soil map units	Soil and site characteristics
1	1BBTmB1 2 BBTmB2 3 YDMmB1 4 YDMmB2	Deep to very deep black soils (100->150 cm), 1-3 % slopes, slight to moderate erosion.

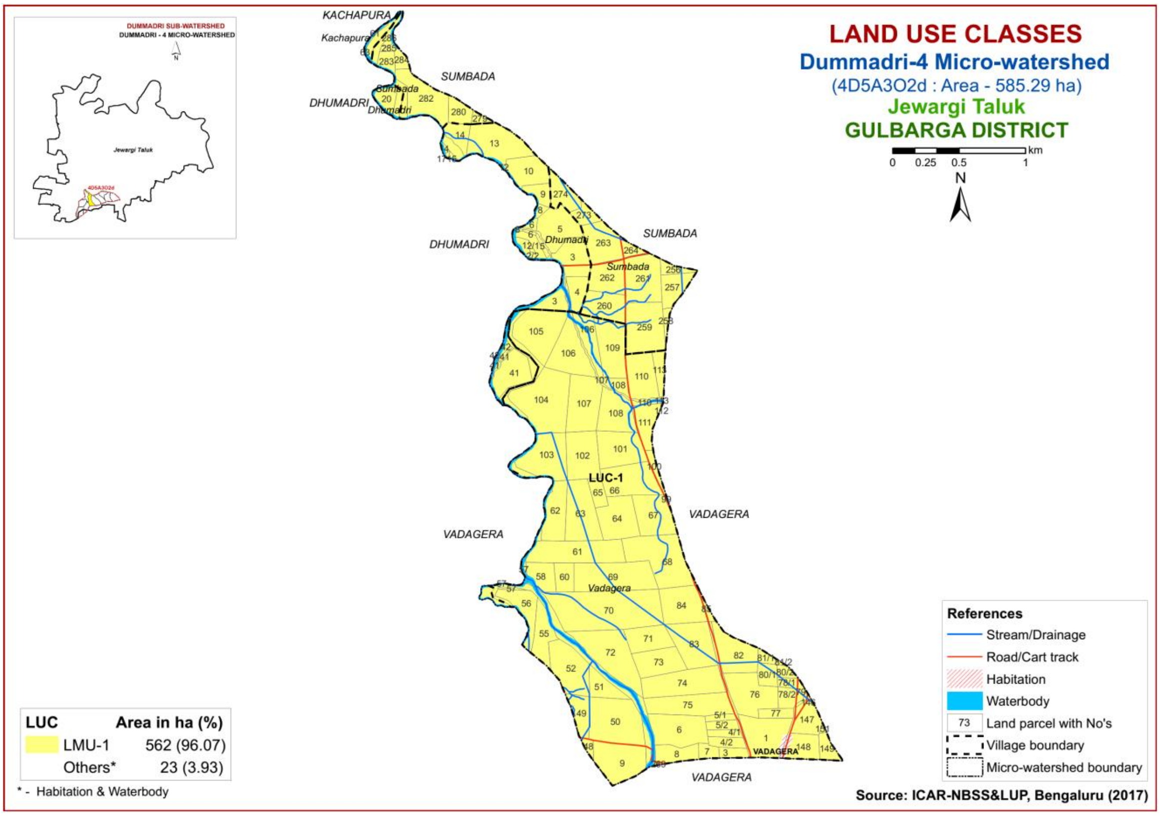


Fig. 7.20 Land Use Classes Map-Dummadri-4 Microwatershed

7.21 Proposed Crop Plan for Dummadri-4 Microwatershed

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

Table 7.20 Proposed Crop Plan for Dummadri-4 Microwatershed

LUC	Mapping unit	Survey No's	Soil Characters	Crops proposed				Suitable Intervention
				Field crops	Forestry Crop/ Grasses	Horticulture crops (Rain-fed Condition)	Horticulture crops With suitable intervention	
LUC-1 562ha (96%)	1 BBTmB1 2 BBTmB2 3 YDMmB1 4 YDMmB2	**Dhumadri:** 1,2/1,2/2,3,4,5,6,8,9,10,13,14, 15,17,20,41 **Kachapura:** 61,63 **Sumbada:** 256,257,258,259,260, 261,262,263,264,273, 274,279,280,282,283, 284,285,286 **Vadagera:** 1,3,4/1,4/2,5/1,5/2,6,7,8,9,48,49 ,50,51,52,55,56,58,60,61,62,63, 64, 65,66,67,68,69,70,71,72,73,74, 75,76,77,78/1,78/2,79,80/1,80/2 ,81/1,81/2,82,83,84,85,99,100,1 01,102,103,104,105,106,107,10 8,109,110,111,112,113,146,147 ,148,149,151, 269	Deep to very deep black soil (100- >150 cm), 1-3 % slope, slight to moderate erosion.	Sorghum, Cotton, Red Gram Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower, **Rabi:** Sorghum, Chickpea, Coriander	-	**Vegetables:** Ladies finger, Brinjal, Cowpea, Coriander **Field crops:** Sorghum, Cotton, Red Gram, Sunflower, Safflower, **Perennial components**: Guava, Tamarind, Sapota, Lime, Musambi **Flowers:** Marigold, Chrysanthemum	Banana, Papaya, Lime, Musambi, Guava, Tamarind **Vegetables**: Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers**: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip, Graded bunds, Strengthening of field bunds

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 Dummadri-4 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of (YDM) 519 ha and (BBT) 44 ha.
- As per land capability classification, 96 % area in the microwatershed falls under arable land category (Class II). The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, 72% area is strongly alkaline (pH 8.4 - 9.0) and 24% area is very strongly alkalime (>9.0) in the microwatershed.

Soil Health Management

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

Alkaline soils

(strongly alkaline to very strongly alkaline soils)

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

Neutral soils

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

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

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total 585 ha area in the microwatershed, about 355 ha is suffering from moderate erosion and 207 ha slight erosion. The moderately eroded areas need immediate soil and water conservation and, other land development and land husbandry practices for restoring soil health.

Dissemination of information and communication of benefits

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

Inputs for Net Planning and Interventions needed

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

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

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

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

❖ **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.

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

❖ **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Dummadri-4 microwatershed.

❖ **Organic Carbon:** The OC content (an index of available Nitrogen) is medium (0.5-0.75%) in maximum area of about 430 ha (73%), low (<0.5%) in about 13 ha (2%) and high (>0.5%) in 118 ha (20%). 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 443 ha out of 585 ha area where OC is medium (0.5-0.75%) and low (<0.5%). For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.
- ❖ **Available Phosphorus**: In 488 ha (83%) area, the available phosphorus is low (<23 kg/ha), medium (23-57 kg/ha) in about 49 ha (8%) area. Hence for all the crops, 25% additional P-needs to be applied.
- ❖ **Available Potassium:** Available potassium is high (>337 kg/ha) in an area of 389 ha (66%) and medium (145-337 kg/ha) in an area of about 172 ha (29%) in the microwatershed.
- ❖ **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is medium in an area of about 443 ha (76%) and high (>20 ppm) in about 118 ha (20%). The areas which are medium in available sulphur need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- ❖ **Available Iron:** It is deficient in a small area of 27 ha (4%) in the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years.
- ❖ **Available Zinc:** It is deficient (<0.6 ppm) in maximum area 500 ha (85%) of the microwatershed and sufficient (>0.6 ppm) in 62 ha (10%) of the microwatershed. Application of zinc sulphate @25kg/ha is recommended.
- ❖ **Soil alkalinity:** The microwatershed has 562 ha (96%) area with soils that are strongly to very strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc, are recommended.

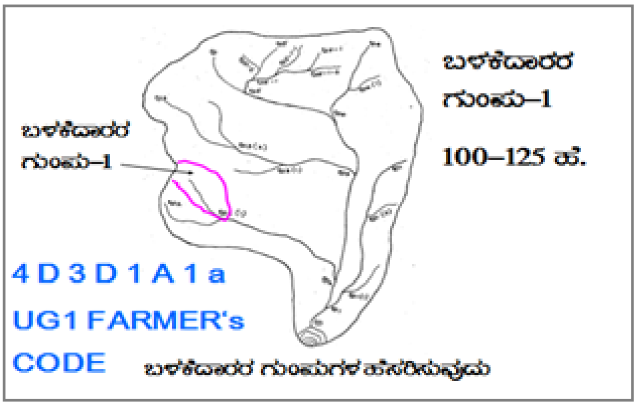
Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and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

Chapter 9

SOIL AND WATER CONSERVATION TREATMENT PLAN

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

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



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

Steps for Survey and Preparation of Treatment Plan

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

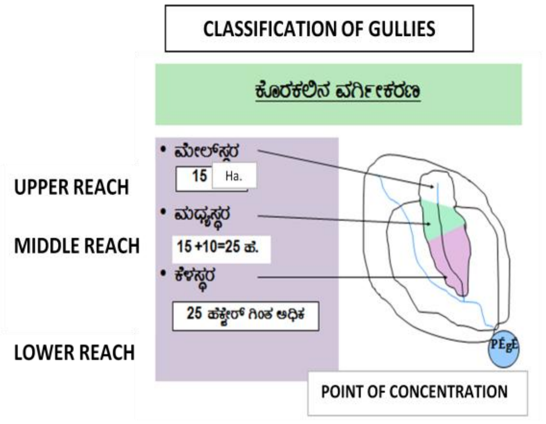
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

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

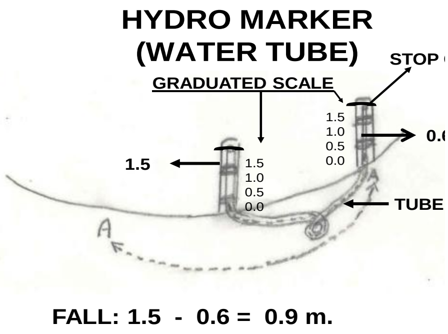
9.1.1 Arable Land Treatment

A. BUNDING

<table>
<tr><td colspan="2">Steps for Survey and Preparation of Treatment Plan</td><td rowspan="6">USER GROUP-1
</td></tr>
<tr><td colspan="2">• Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale
• Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale
• Drainage lines are demarcated into</td></tr>
<tr><td>Small gullies</td><td>(up to 5 ha catchment)</td></tr>
<tr><td>Medium gullies</td><td>(5-15 ha catchment)</td></tr>
<tr><td>Ravines</td><td>(15-25 ha catchment) and</td></tr>
<tr><td>Halla/Nala</td><td>(more than 25ha catchment)</td></tr>
</table>

Measurement of Land Slope

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



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

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

Note: i) The above intervals are maximum.

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

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

Section of the Bund

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

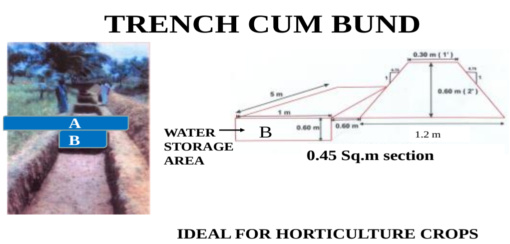
Recommended Bund Section

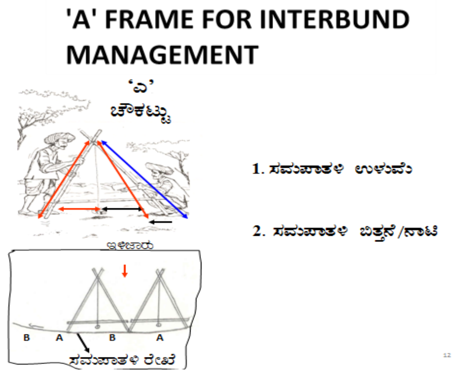
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soils	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below





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

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

B. Waterways

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

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

c) The design details are given in the Manual.

C. Farm Ponds

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

D. Diversion channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been generated which shows the spatial distribution and extent of area. A maximum area of about 562 ha (96%) needs graded bunds or strengthening of existing field bund. The conservation plan generated may be presented to all the stakeholders including the farmers and after considering their suggestions, the conservation plan for the microwatershed may be finalised in a participatory approach.

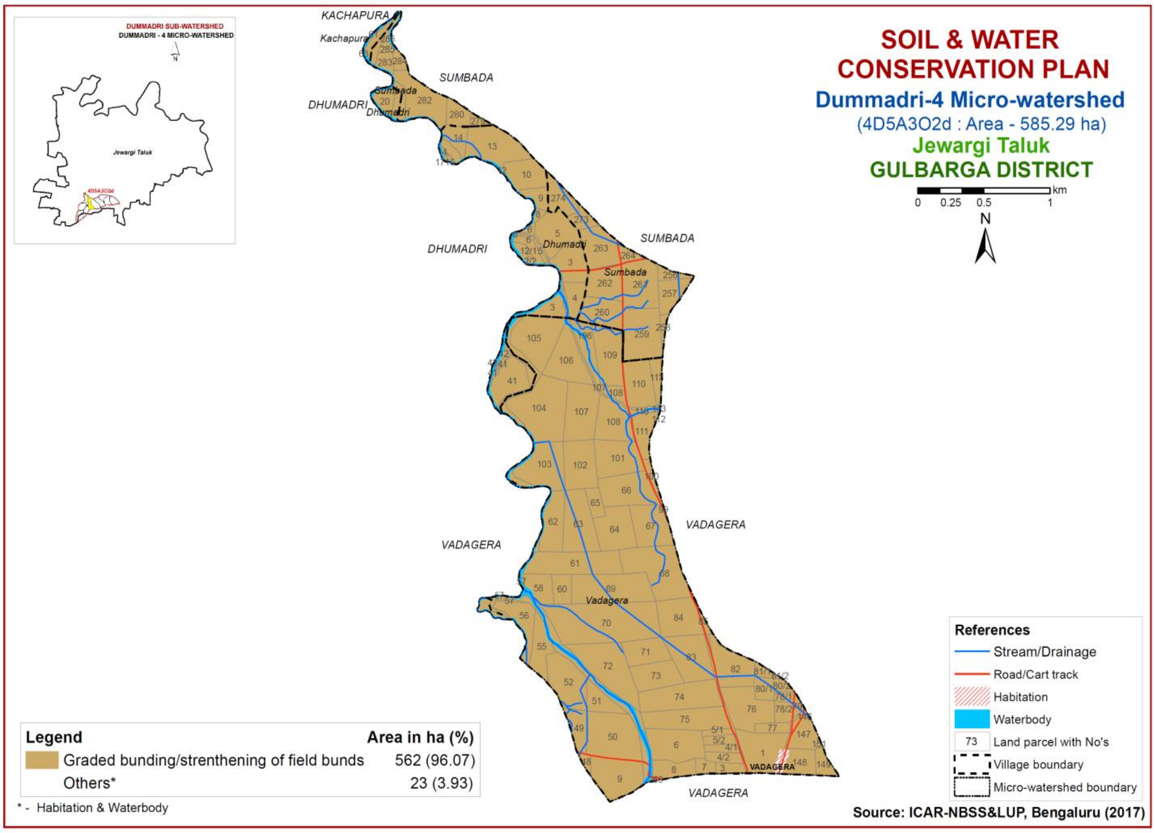


Fig. 9.1 Soil and Water Conservation Plan of Dummadri-4 Microwatershed

9.3 Greening of Microwatershed

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

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

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

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

References

1. FAO (1976) Framework for Land Evaluation, Food and Agriculture Organization, Rome.72 pp.
2. FAO (1983) Guidelines for Land Evaluation for Rainfed Agriculture, FAO, Rome, 237 pp.
3. IARI (1971) Soil Survey Manual, All India Soil and Land Use Survey Organization, IARI, New Delhi, 121 pp.
4. Katyal, J.C. and Rattan, R.K. (2003) Secondary and Micronutrients; Reaserch Gap and future needs. Fert. News 48 (4); 9-20.
5. Naidu, L.G.K., Ramamurthy, V., Challa, O., Hegde, R. and Krishnan, P. (2006) Manual Soil Site Suitability Criteria for Major Crops, NBSS Publ. No. 129, NBSS &LUP, Nagpur, 118 pp.
6. Natarajan, A. and Sarkar, Dipak (2010) Field Guide for Soil Survey, National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur, India.
7. Natarajan, A., Rajendra Hegde, Raj, J.N. and Shivananda Murthy, H.G. (2015) Implementation Manual for Sujala-III Project, Watershed Development Department, Bengaluru, Karnataka.
8. Sarma, V.A.K., Krishnan, P. and Budihal, S.L. (1987) Laboratory Manual, Tech. Bull. 23, NBSS &LUP, Nagpur.
9. Sehgal, J.L. (1990) Soil Resource Mapping of Different States of India; Why and How?, National Bureau of Soil Survey and Land Use Planning, Nagpur, 49 pp.
10. Shivaprasad, C.R., Reddy, R.S., Sehgal, J. and Velayuthum, M. (1998) Soils of Karntaka for Optimising Land Use, NBSS Publ. No. 47b, NBSS & LUP, Nagpur, India.
11. Soil Survey Staff (2006) Keys to Soil Taxonomy, Tenth edition, U.S. Department of Agriculture/ NRCS, Washington DC, U.S.A.
12. Soil Survey Staff (2012) Soil Survey Manual, Handbook No. 18, USDA, Washington DC, USA.

Appendix I

Dummadri-4 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
Dhumadri	1	1.2	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	1/2	0.2	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	2/1	0.28	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	3	10.3	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	4	3.31	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	5	8.1	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	6	0.84	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	8	0.86	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	9	2.45	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	10	6.08	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	12	0.15	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Dhumadri	13	10.31	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	14	3.36	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	15	0.25	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	17	0.13	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds

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
Dhumadri	20	2.55	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	40	0	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Dhumadri	41	7.22	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Dhumadri	42	0.65	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Kachapura	61	0.51	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Kachapura	63	0.02	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Sumbada	256	1.61	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Sumbada	257	4.35	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Sumbada	258	0.89	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Sumbada	259	10.84	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	260	6.47	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	261	9.45	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	262	6.29	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	263	7.25	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	264	1.63	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	273	2.24	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	274	4.36	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds

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
Sumbada	279	0.97	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	280	2.98	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	282	9.15	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	283	1.85	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	284	1.32	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	285	0.54	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Sumbada	286	0.46	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	1	9.39	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	3	1.66	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	4/1	1.43	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	4/2	2.08	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	5/1	1.06	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	5/2	1.63	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	6	9.56	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	7	1.59	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	8	3.99	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds

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
Vadagera	9	9.81	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Paddy (Pd)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	48	0.85	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	49	3.91	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	50	13.15	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	51	3.79	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+No Crop (Rg+NC)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	52	9.29	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	No Crop (NC)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	55	5.38	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	56	5.72	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	57	0.86	Waterbody	Others	Others	Others	Others	Others	Others	Others	Not Available (NA)	Not Available	Others	Others
Vadagera	58	4.36	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	60	3.12	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	61	11.92	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	62	7.1	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	63	10.2	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	64	8.52	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	65	2.27	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds

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
Vadagera	66	9.53	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	67	8.1	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	68	13.95	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	69	12.88	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	70	23.43	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	71	5.9	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	72	13.03	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	73	6.73	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	74	11.08	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	75	9.54	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	76	9.44	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	77	1.92	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	78/1	1.12	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	78/2	2.1	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	79	0.8	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	80/1	2.48	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds

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
Vadagera	80/2	1.1	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	81/1	1.08	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	81/2	0.16	BBTmB2	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	82	8.14	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	83	9.56	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Cotton (Ct)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	84	8.47	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	85	0.85	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	99	0.25	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	100	1.19	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	101	8.72	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Maize (Rg+Mz)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	102	8.66	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	103	10.25	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	104	15.44	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	105	11.02	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	106	13.58	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	107	10.03	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Cotton (Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds

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
Vadagera	108	9.35	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	109	8.9	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	110	7.93	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	111	4.64	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	112	0.04	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	113	2.42	YDMmB2	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	Graded bunding/strenthening of field bunds
Vadagera	146	0.13	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	147	4.46	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	148	4.67	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	149	2.26	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	151	0.23	BBTmB1	LUC -1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds
Vadagera	269	0.1	YDMmB1	LUC -1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IIs	Graded bunding/strenthening of field bunds

Appendix II

Dummadri-4 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
Dhumadri	1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	1/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	2/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	3	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	4	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	5	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	6	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	8	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	9	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	10	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	12	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Dhumadri	13	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	14	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	15	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	17	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	20	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	40	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Dhumadri	41	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Dhumadri	42	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kachapura	61	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kachapura	63	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sumbada	256	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	257	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	258	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	259	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sumbada	260	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	261	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	262	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	263	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	264	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	273	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	274	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Low (< 0.5 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	279	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	280	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	282	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	283	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	284	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	285	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sumbada	286	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	3	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)
Vadagera	4/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	4/2	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)
Vadagera	5/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	5/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	6	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	7	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	8	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	9	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Vadagera	48	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	High (> 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	49	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	High (> 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	50	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	High (> 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	51	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	52	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	55	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	56	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	57	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Vadagera	58	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	60	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	61	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	62	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	63	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	64	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	65	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	66	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	67	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	68	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	69	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	70	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	71	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	72	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	73	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	74	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	75	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Vadagera	76	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	77	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	78/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	78/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	79	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	80/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	80/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	81/1	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	81/2	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	82	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	83	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	84	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	85	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	99	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	100	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	101	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	102	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Low (< 0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	103	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	104	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	105	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	106	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	107	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	108	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	109	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Surve y No.	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Vadagera	110	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	111	Very strongly alkaline (pH > 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	112	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	113	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	146	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	147	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	148	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	Medium (145 – 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Vadagera	149	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	151	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Vadagera	269	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 – 0.75 %)	Medium (23 – 57 kg/ha)	High (> 337 kg/ha)	Medium (10 – 20 ppm)	Medium (0.5 – 1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)

Appendix III

Dummadri-4 Microwatershed

Soil Suitability Information

Village	Survey No.	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean	Bengal gram
Dhumadri	1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	1/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	2/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	3	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	4	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	5	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	6	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	8	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	9	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	10	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	12	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Dhumadri	13	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	14	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	15	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	17	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	20	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	40	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Dhumadri	41	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Dhumadri	42	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kachapura	61	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kachapura	63	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sumbada	256	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	257	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	258	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	259	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	260	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	261	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	262	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	263	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	264	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	273	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	274	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	279	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	280	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	282	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	283	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	284	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	285	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Sumbada	286	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	3	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	4/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	4/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1

Village	Survey No.	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean	Bengal gram
Vadagera	5/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	5/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	6	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	7	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	8	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	9	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	48	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	49	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	50	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	51	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	52	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	55	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	56	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	57	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Vadagera	58	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	60	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	61	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	62	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	63	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	64	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	65	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	66	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	67	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	68	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	69	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	70	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	71	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	72	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	73	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	74	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	75	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	76	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	77	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	78/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	78/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	79	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	80/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	80/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	81/1	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	81/2	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	82	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	83	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	84	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	85	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	99	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	100	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	101	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1

Village	Survey No.	Mango	Maize	Sapota	Sorghum	Guava	Cotton	Tamarind	Lime	Sunflower	Redgram	Amla	Jackfruit	Custard apple	Cashew	Jamun	Musambi	Sugarcane	Soyabean	Bengal gram
Vadagera	102	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	103	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	104	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	105	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	106	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	107	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	108	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	109	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	110	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	111	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	112	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	113	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	146	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	147	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	148	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	149	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	151	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1
Vadagera	269	S3t	S3t	S2t	S1	S2t	S1	S2t	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1	S1

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: *Dummadri-4 micro-watershed (Dummadri sub-watershed, Jewargi taluk, Gulbarga district) is located in between $16^{0}45'$ – $16^{0}48'$ North latitudes and $76^{0}30'$ – $76^{0}34'$ East longitudes, covering an area of about 585.29 ha, bounded by Dummadri, Kachapura, Vadagera and Sumbada villages with length of growing period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for Dummadri-4 micro-watershed (Dummadri sub-watershed, Jewargi taluk, Gulbarga district) are presented here.*

Social Indicators;

- *Male and female ratio is 61.5 to 38.5 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 56.4 per cent to the total population.*
- *Literacy population is around 69.2 per cent.*
- *Social groups belong to general caste is around 70.0 per cent.*
- *Fire wood is the source of energy for a cooking among all the households.*
- *About 20.0 per cent of households have a yashaswini health card.*
- *About 10.0 per cent of farm households are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 90.0 per cent.*
- *Swach bharath program providing closed toilet facilities around 10.0 per cent of sample households.*
- *Women participation in decisions making are around 30 per cent of households were found.*

Economic Indicators;

- *The average land holding is 1.98 ha indicates that majority of farm households are belong to marginal and small farmers. The dry land is total cultivated area among all the sample farmers.*

- *Agriculture is the main occupation among 27.6 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 65.5 per cent of sample households.*
- *The average value of domestic assets is around Rs. 19429 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 7929 per household, about 50 per cent of sample farmers having bullock cart.*
- *The average value of livestock is around Rs. 57222 per household; about 50 per cent of household are having livestock in sample households.*
- *The average per capita food consumption is around 869 grams (1871.3 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Among all sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 55082 per household. About 70.0 per cent of farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs. 2707.*

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. 894 per ha/year. The total cost of annual soil nutrients is around Rs. 502518 per year for the total area of 563 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 20104/ ha/year. Per hectare food grain production services is maximum in cotton (Rs. 29367) followed by redgram (Rs. 20481) and paddy (Rs. 10464).*
- *The average value of ecosystem service for fodder production is around Rs 1366/ ha/year is paddy.*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in red gram (Rs. 59056), cotton (Rs. 48673) and paddy (Rs. 29483).*

Economic Land Evaluation;

- *The major cropping pattern is paddy (55.0 %) followed by cotton (24.9 %) and red gram (20.1 %)*
- *In Dummadri micro-watershed, major soil are Yedrami (YDM) series having very deep soil depth cover around 88.6 % of area; the main crop are cotton (24.6 %), paddy (55.4 %) and redgram (20.0 %).*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for paddy in YDM soil is Rs.27719/ha (with BCR of 1.41).*

- *In cotton the cost of cultivation in YDM soil is Rs.20164/ha (with BCR of 2.52) and red gram the cost of cultivation in YDM soil is Rs 17487/ha (with BCR of 2.19).*
- *The land management practices reported by the farmers are crop rotation, tillage practices, fertilizer application and use of farm yard manure (FYM). Due to higher wages farmer are following labour saving strategies is not prating soil and water conservation measures. Less ownership of livestock limiting application of FYM.*
- *It was observed soil quality influences on the type and intensity of land use. More fertilizer applications in deeper soil to maximize returns.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in paddy (69.9%), cotton (29.3%) and redgram (11.1 %).*

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

Dummadri-4 micro-watershed located in north-eastern dry zone of Karnataka (Figure 1**):** The total geographic area of this zone is about 1.76 M ha covering 8 taluks of Gulbarga district and 3 taluks of Raichur. Net cultivated area in the zone is about 1.31 M ha of which about 0.09 M ha are irrigated. The mean elevation of the zone is 300-450 m MSL. The main soil type is deep to very deep soils with small pockets of shallow to medium black soils. The zone is cropped predominantly during rabi due to insufficient rainfall (465-785 mm). The principal crops of the zone are jowar, bajra, oilseeds, pulses, cotton and sugarcane. It represents Agro Ecological Sub Region (AESR) 6.2 having LGP 120-150 days.

Dummadri-4 micro-watershed (Dummadri sub-watershed, Jewargi taluk, Gulbarga district) is located in between $16^0$45' – $16^0$48' North latitudes and $76^0$30' – $76^0$34' East longitudes, covering an area of about 585.29 ha, bounded by Dummadri, Kachapura, Vadagera and Sumbada villages.

Sampling Procedure:

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

Sources of data and analysis:

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

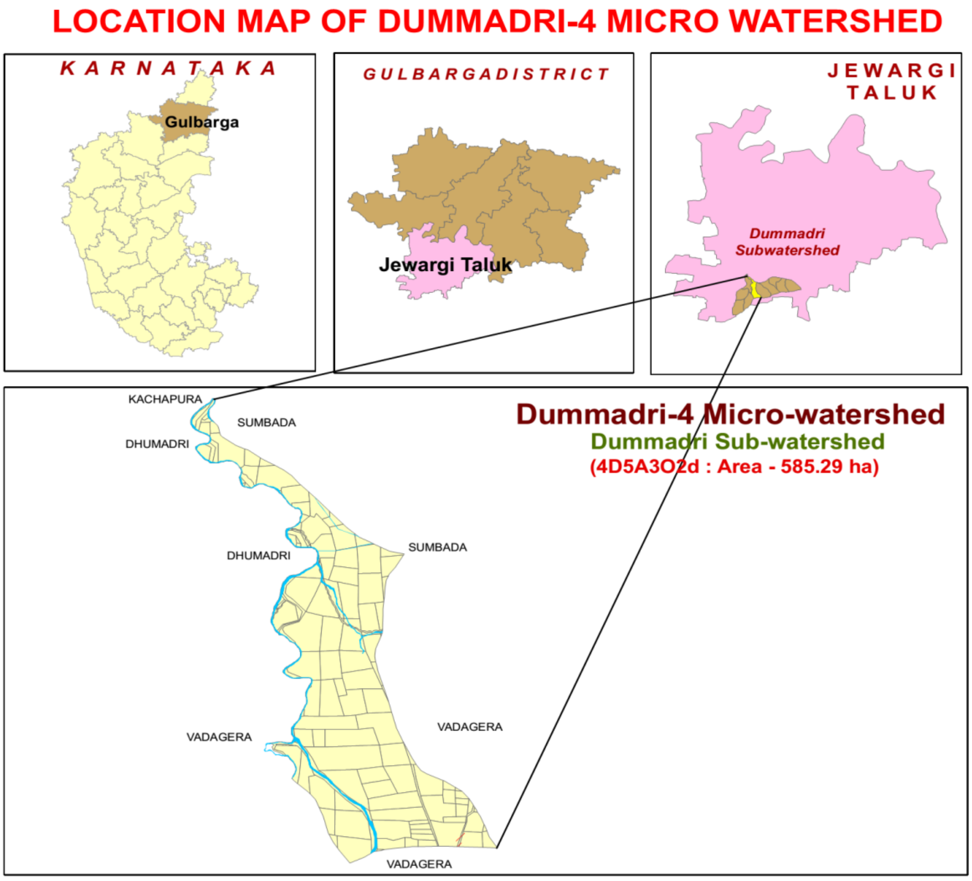

Figure 1: Location of study area

Steps followed in socio-economic assessment

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

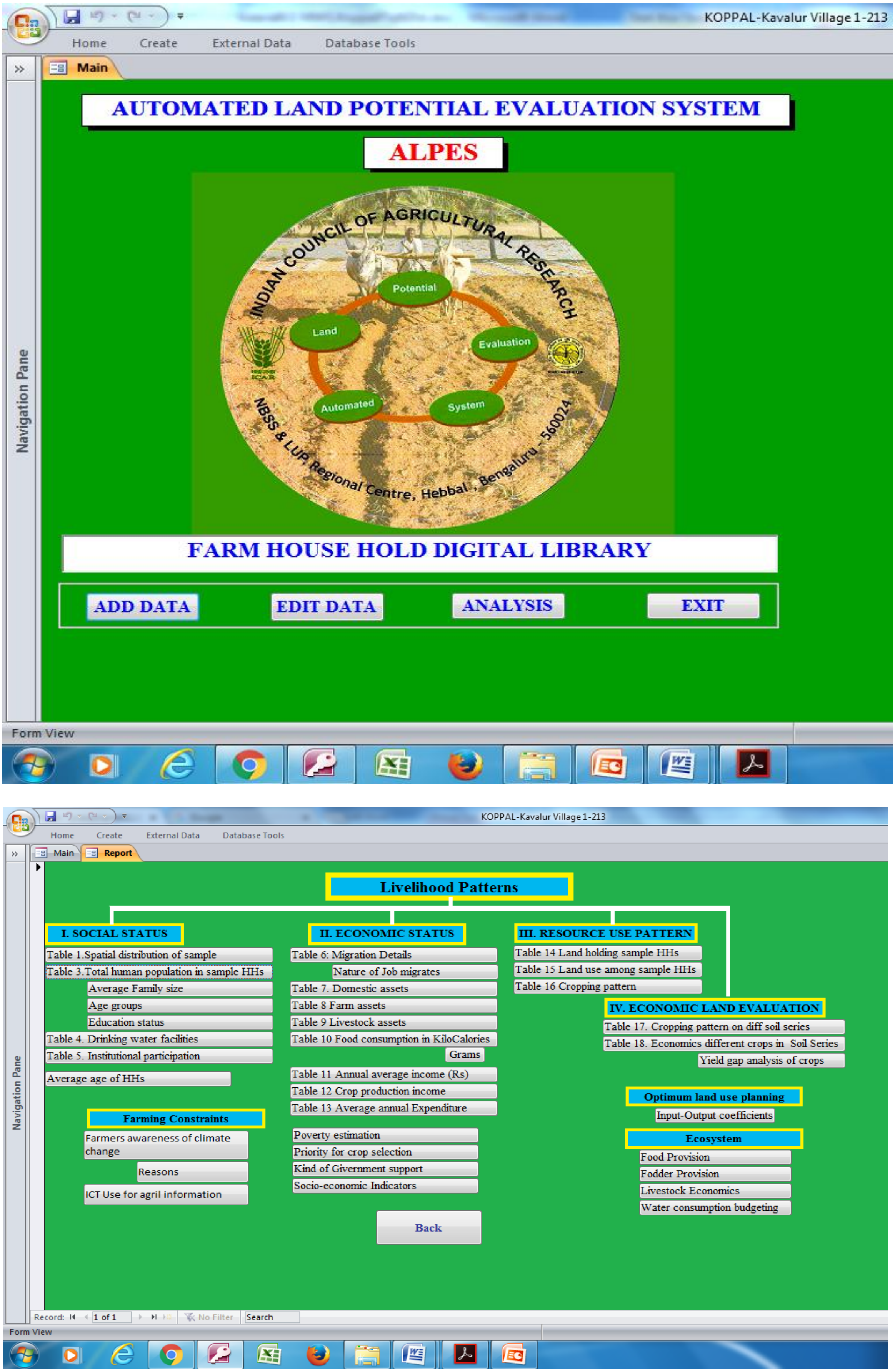

Figure 2: ALPES FRAMEWORK

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

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

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

Economic Valuation of Soil ecosystem services:

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

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

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

Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 39, out of which 61.5 per cent were males and 38.5 per cent females. Average family size of the households is 3.9. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 30 to 50 years (33.3 %) followed by 0 to 18 years (28.2 %),18 to 30 years (23.1 %) and more than 50 years (15.4 %).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 30.8 per cent of respondents were illiterate and 69.2 per cent literate (Table 1).

Table 1: Human population among sample households in Dummadri - 4 Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	39
Male	% to total Population	61.5
Female	% to total Population	38.5
Average family size	Number	3.9
Age group		
0 to 18 years	% to total Population	28.2
18 to 30 years	% to total Population	23.1
30 to 50 years	% to total Population	33.3
>50 years	% to total Population	15.4
Average age	Age in years	32.8
Education Status		
Illiterates	% to total Population	30.8
Literates	% to total Population	69.2
Primary School (<5 class)	% to total Population	17.9
Middle School (6- 8 class)	% to total Population	12.8
High School (9- 10 class)	% to total Population	12.8
Others	% to total Population	25.6

The ethnic groups among the sample farm households found to be 70.0 per cent belonging to general castes and 30.0 per cent belonging to other backward castes (OBC)

(Table 2 and Figure 3). All the sample households are using fire wood as source of fuel for cooking. All the sample farmers are having electricity connection. About 20.0 per cent are sample households having health cards. Majority (10.0 %) are having MNREGA job cards for employment generation. About 90.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 10.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Dummadri - 4 Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	30.0
General	% of Households	70.0
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	20.0
No	% of Households	80.0
MGNREGA Card		
Yes	% of Households	10.0
No	% of Households	90.0
Ration Card		
Yes	% of Households	90.0
No	% of Households	10.0
Households with toilet		
Yes	% of Households	10.0
No	% of Households	90.0
Drinking water facilities		
Tube Well	% of Households	90.00
Dug well	% of Households	10.00

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well source for water supply for domestic purpose (90.0 %) and dug well (10.0).

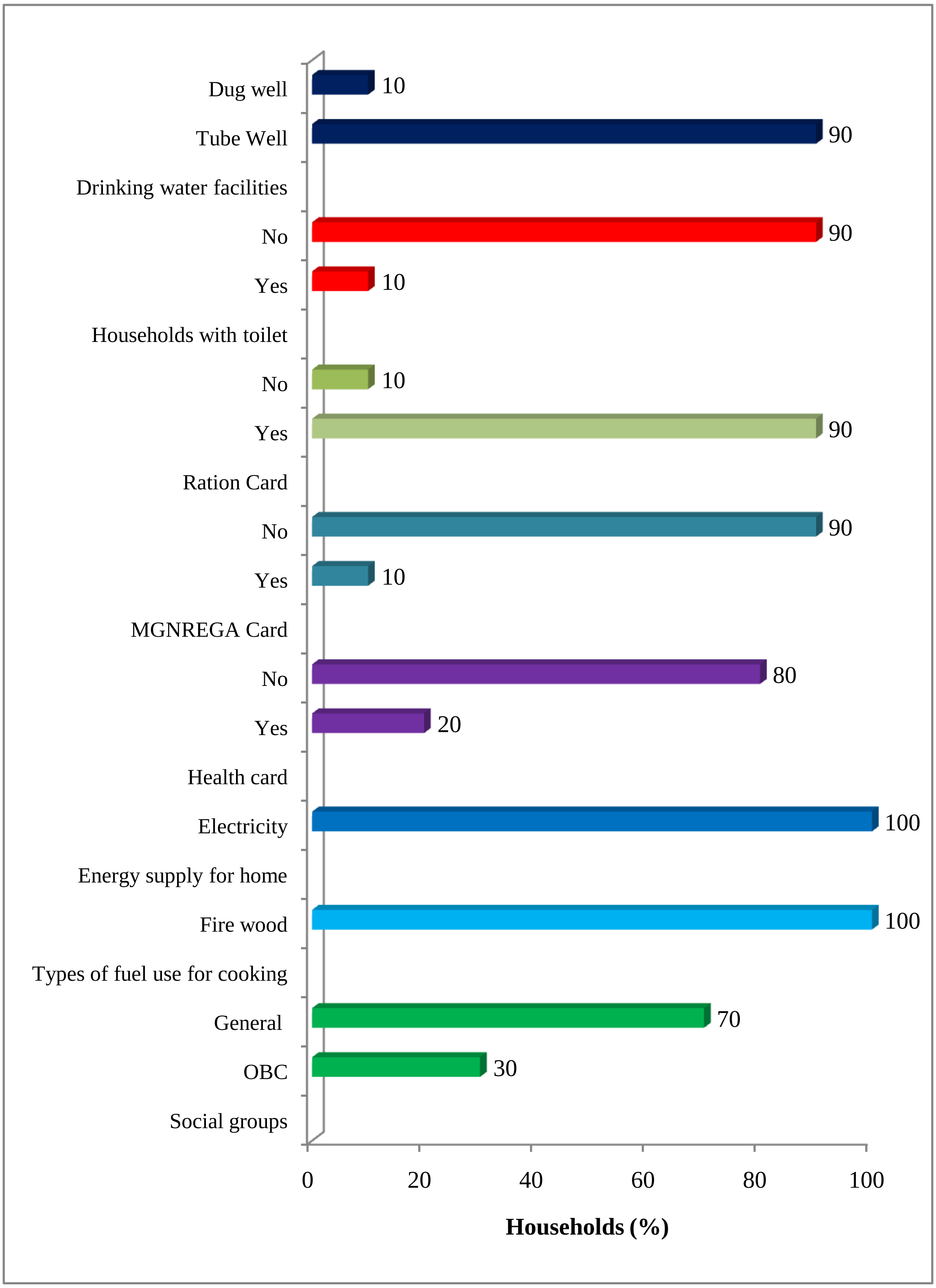

Figure 3: Basic needs of sample households in Dummadri - 4 Microwatershed

The occupational pattern (Table3) among sample households shows that agriculture is the main occupation around 27.6 per cent of farmers followed by subsidiary occupations like non agricultural labour (65.5 %) and private services is 3.4 per cent. Around 3.5 per cent of the population are household trade and business.

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

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	27.6
	Agriculture labour	65.5
	Private service	3.4
Trade and business		3.5
Family labour availability		**Man days/month**
Male		30.00
Female		22.2
Total		52.2

The important assets especially with reference to domestic assets were analyzed and are given in Table 4 and Figure 4. The important domestic assets possessed by all categories of farmers are television (100 %) followed by mixer/grinder (100 %), mobile phones (90 %), motorcycle (60 %) and refrigerator (20 %). The average value of domestic assets is around Rs 19429 per household.

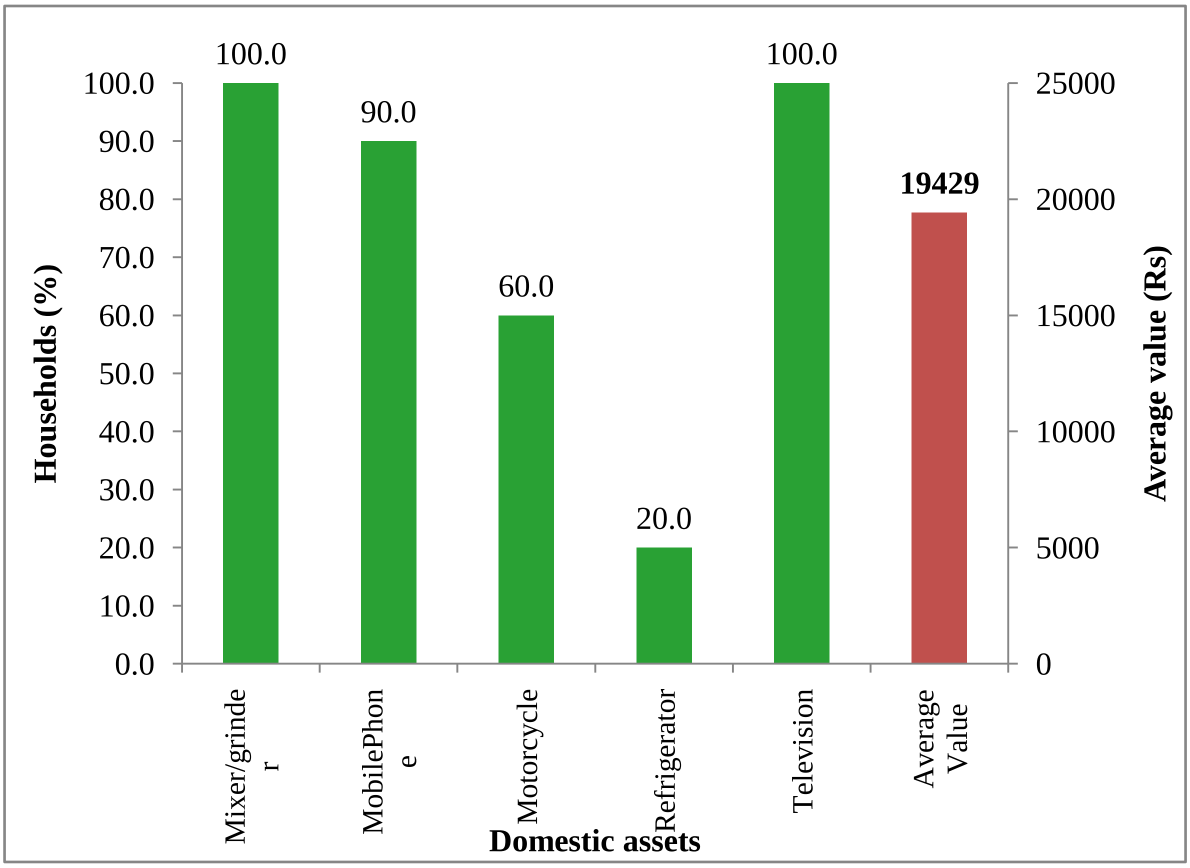

Figure 4: Domestic assets among the sample households in Dummadri - 4 Micro-watershed

Table 4: Domestic assets among the sample households in Dummadri - 4 Microwatershed

Particulars	% of households	Average value in Rs
Mixer/grinder	100.0	2050
Mobile Phone	90.0	4944
Motorcycle	60.0	62000
Refrigerator	20.0	20000
Television	100.0	8150
Average Value	19429	

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned bullock cart (50 %), weeder (40 %), plough (40 %) and sprayer (30 %) was found highest among the sample farmers. The average value of farm assets is around Rs 7929 per households (Table 5 and Figure 5).

Table 5: Farm assets among samples households in Dummadri - 4 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	50.0	23250
Plough	40.0	2133
Sprayer	30.0	4333
Weeder	40.0	2000
Average Value	7929	

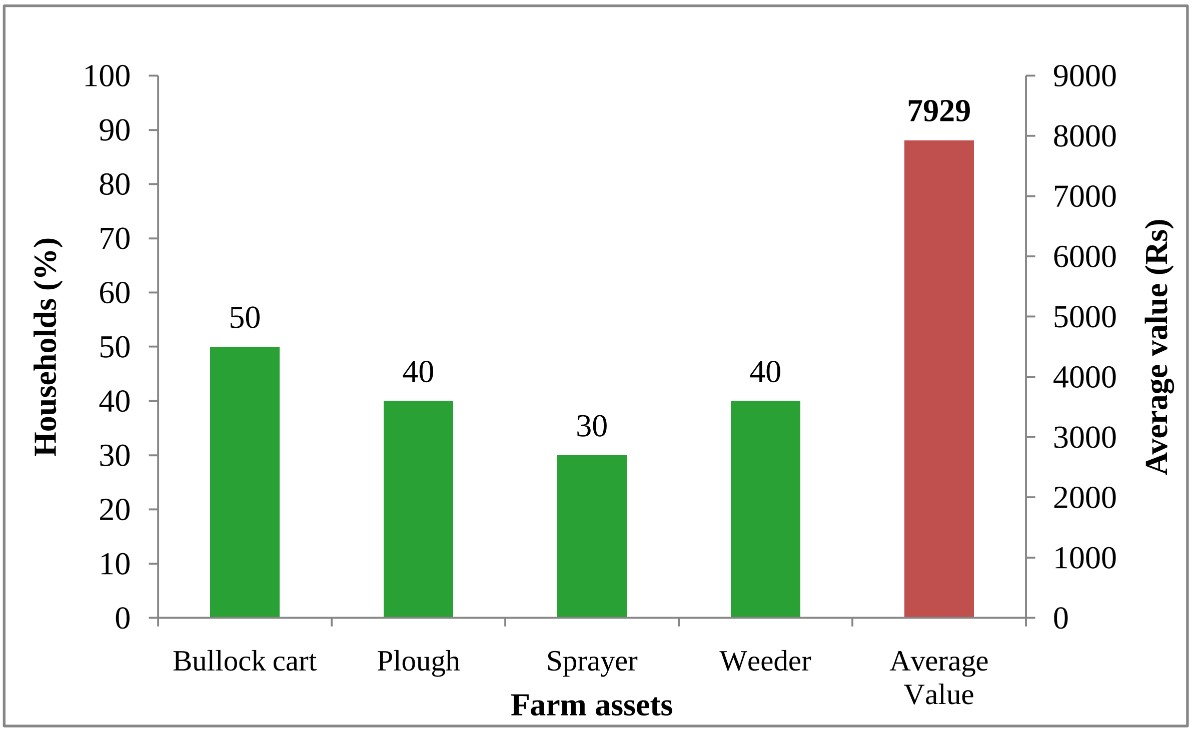

Figure5: Farm assets among samples households in Dummadri - 4 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 6 and Figure 6). The highest livestock population is local milching cow were around 41.7 per cent and bullocks followed by local dry cow (50 %), dry buffalos (33.3%) and bullocks (16.7 %). The average livestock value was Rs 57222 per household.

Table 6: Livestock assets among sample households in Dummadri - 4 Microwatershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	50.0	26667
Dry Buffalos	33.3	45000
Bullocks	16.7	100000
Average value	57222	

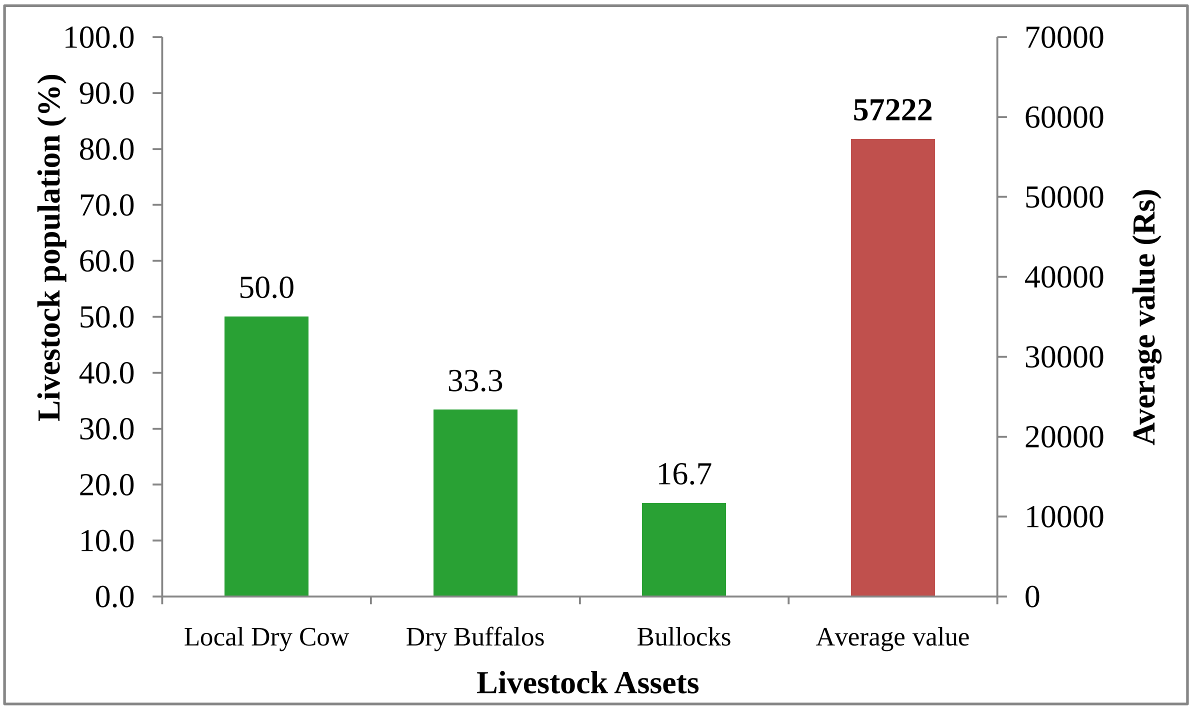

Figure 6: Livestock assets among sample households in Dummadri - 4 Microwatershed

Average farm households of fodder crops are paddy are the main crops for domestic food and fodder for animals. About 2083 kg /ha of average fodder is available per season for the livestock feeding (Table 7).

Table 7: Milk produced and fodder availability of sample households in Dummadri - 4 Microwatershed

Particulars	
Fodder produces	**Fodder yield (kg/ha.)**
Paddy	2083
Average fodder availability	2083
Livestock having households (%)	50
Livestock population (Numbers)	12

A woman participation in decision making is in this Microwatershed is presented in Table 8. Among all the households' women taking decision in her family and agriculture related activities and among all sample HHs women earning for her family requirement.

Table 8: Women empowerment of sample households in Dummadri - 4 Microwatershed

% to Grand Total

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

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 9 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1167.9 kcal per person. The other important food items consumed was pulses 204.1 kcal followed by cooking oil 232.1 kcal, milk 103.8 kcal, vegetables 44.7 kcal, egg 100.0 kcal and meat 18.7 kcal. In the sampled households, farmers were consuming less (1871.3 kcal) than NIN- recommended food requirement (2250 kcal).

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

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	343.5	1167.9
Pulses	43	59.5	204.1
Milk	200	159.7	103.8
Vegetables	143	186.1	44.6
Cooking Oil	31	40.7	232.1
Egg	0.5	66.7	100.0
Meat	14.2	12.5	18.7
Total	**827.7**	**868.7**	**1871.3**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% of households below NIN		80.0	30.0
% of households above NIN		20.0	70.0

Note: * day/person

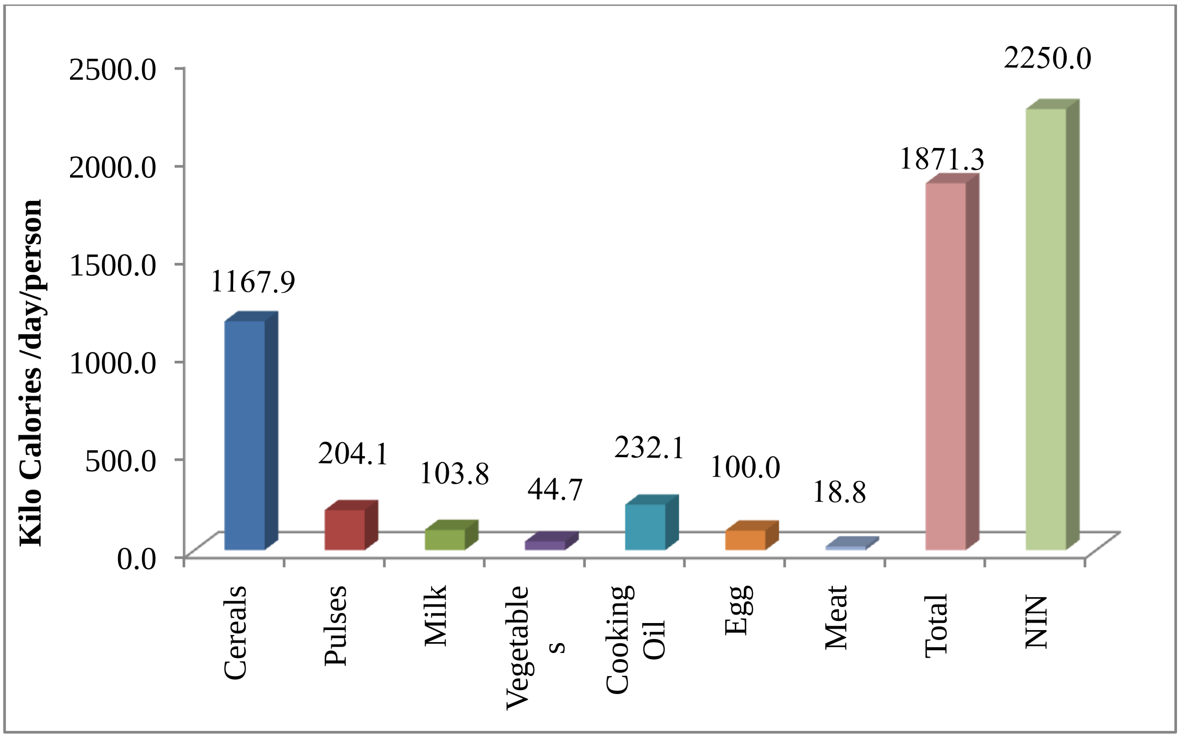

Figure 7: Per capita daily consumption of food among the sample households in Dummadri- 4 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 55082. Major source of income to the farmers in the study area is from crop production (Rs 55082). The monthly per capita income is Rs. 1177 which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 10).

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

Particulars	Income *
Nonfarm income (Rs)	0 (0)
Livestock income (Rs)	0 (0)
Crop Production (Rs)	55082 (100)
Total Annual Income (Rs)	***55082***
Average monthly per capita income (Rs)	1177
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	30.0
% of households above poverty line	70.0

* 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. 40109) followed by education, clothing, social function and health. Now a day's education is most important among all of us. In today's competitive world, education is a necessity for man after food, clothing, and shelter. It is the only fundamental way by which a desired change in the society can happen. The average per capita monthly expenditure is around Rs 2707 and about 30 per cent of farm households are below poverty line and 70 per cent of farm households are above poverty line (Table 11 and Figure 8).

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

Particulars	Value in Rupees	Per cent
Food	40109	31.7
Education	5100	4.0
Clothing	6500	5.1
Social functions	54000	42.6
Health	21000	16.6
Total Expenditure (Rs/year)	126709	100.0
Monthly per capita expenditure (Rs)	2707	

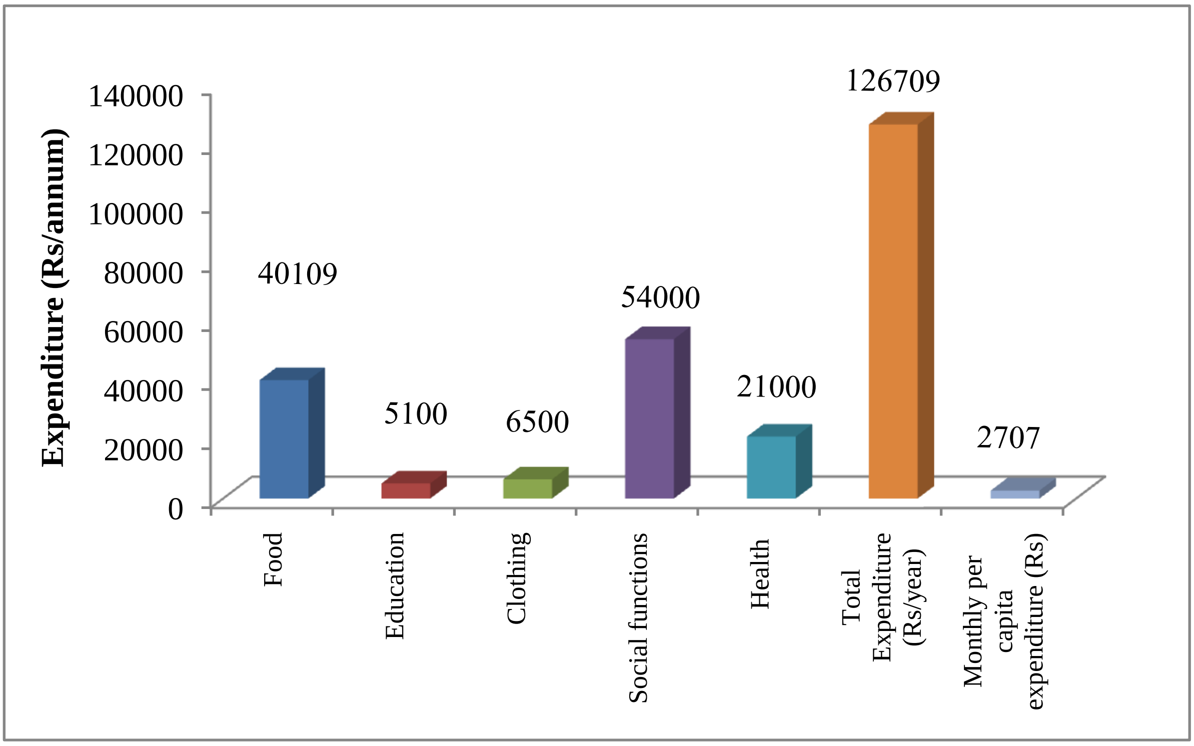

Figure 8: Average annual expenditure of sample HHs in Dummadri - 4 Microwatershed

Land holding: Total area cultivated by them is 35.0 ha. The average land holding of sample HHs is 3.5 ha. Large number of sample HHs (60 %) belong to medium size group with an average holding size of 2.9 ha followed by small farmer (30 %) with a average land holding size of 1.4 ha and large farmer (10 %) with a average land holding size of 13.1 ha (Table 12).

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

Particulars	**Units**	**Values**
Small farmers		
Total land	ha	4.2
Sample size	Per cent	30.0
Average land holding	ha	1.4
Medium farmers		
Total land	ha	17.7
Sample size	Per cent	60.0
Average land holding	ha	2.9
Large farmers		
Total land	ha	13.1
Sample size	Per cent	10.0
Average land holding	ha	13.1
Total sample households		
Total land	ha	35.0
Sample size	Per cent	100
Average land holding	ha	3.5

Land use: The total land holding in the Dummadri - 4 micro-watershed is 35.0 ha (Table 13). Of which 35.0 ha is rain fed land. The average land holding per household is worked out to be 3.5 ha.

Table 13: Land use among samples households in Dummadri - 4 Microwatershed

Particulars	**Per cent**	**Area in ha**
Irrigated land	0.0	0.0
Rainfed Land	100.0	35.0
Fallow Land	0.0	0.0
Total land holding	100.0	35.00
Average land holding	3.50	

In the micro-watershed, the prevalent present land uses under perennial plants (Table 14) are neem trees (81.2 %) followed by banyan tree (Alada) (2 %) and tamarind (1 %).

Table 14: Number of trees/plants covered in sample farm households in Dummadri - 4 Microwatershed

Particulars	Number of Plants/trees	Per cent
Banyan tree(Alada)	2	12.5
Neem trees	13	81.2
Tamarind	1	6.3
Grand Total	28	100.0

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

The present dominant crops grown in dry lands in the study area were by paddy (55.0 %) followed by cotton (24.9 %) and redgram (20.1 %) which are taken during Kharif season respectively. The cropping intensity was 100 per cent (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Chikasavanur-2 Microwatershed

% to Grand Total

Crops	Kharif	Grand Total
Cotton	24.9	24.9
Paddy	55.0	55.0
Redgram	20.1	20.1
Grand Total	100.0	100.0

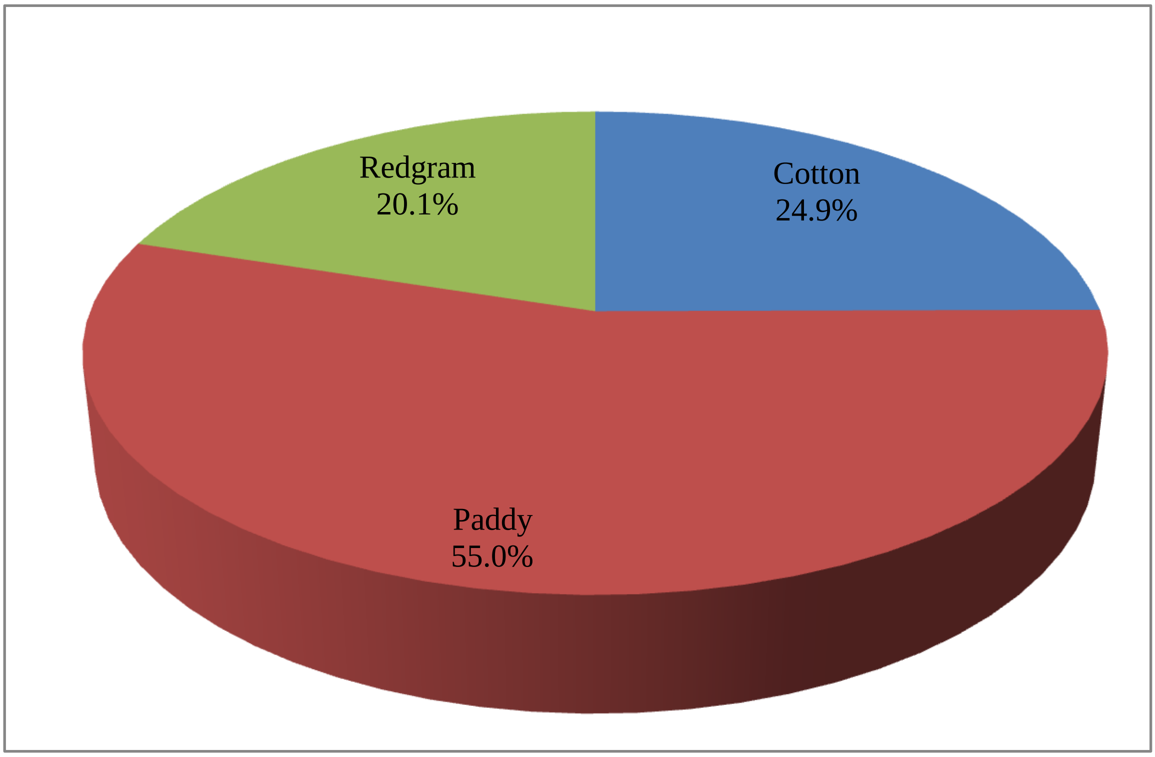

Figure 9: Present cropping pattern in Dummadri - 4 Microwatershed

Economic land evaluation

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

In Dummadri -4 micro-watershed, 2 soil series are identified and mapped (Table 16). The distribution of major soil series are Yedrami (YDM) covering an area around 519 ha (88.61 %) and Balbatti (BBT) 44 ha (7.47 %).

Table 16: Distribution of soil series in Dummadri - 4 Microwatershed

Sl.No	Soil series	Description	Area in ha (%)
1	BBT	Balbatti soils are deep (100-150 cm), moderately well drained. They have very dark gray to dark reddish brown soils and occur on very gently sloping uplands	44 (7.47)
2	YDM	Yedrami soils are deep (100-150 cm), moderately well drained. They have very dark gray to dark reddish brown soils and occur on nearly level to very gently sloping uplands	519 (88.61)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Yedrami (CRS) soils are paddy, cotton and redgram.

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

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Grand Total
			Kharif	
YDM	Very deep (>150 cm)	Cotton	24.6	24.6
		Paddy	55.4	55.4
		Redgram	20.0	20.0

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

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

Soil Series	Small Farmers	Medium Farmers	Large Farmers
YDM	Cotton (2.53)	Cotton (2.49) Paddy (1.52) Redgram(2.19)	Paddy (1.20)

The productivity of different crops grown in Dummadri - 4 micro-watersheds under potential yield of the crops is given in Table19.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 19. The total cost of cultivation in study area for paddy in YDM soil is Rs.27719/ha (with BCR of 1.41), cotton cost of cultivation in YDM soil is Rs.20164/ha (with BCR of 2.52) and redgram cost of cultivation in YDM soil is Rs.17487/ha (with BCR of 2.19).

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

Particulars	**YDM (>150 cm)**		
	Cotton	**Paddy**	**Redgram**
Total cost (Rs/ha)	20164	27719	17487
Gross Return (Rs/ha)	49310	40688	37968
Net returns (Rs/ha)	29147	12969	20481
BCR	2.52	1.41	2.19
Farmers Practices (FP)			
FYM (t/ha)	2.3	1.5	1.8
Nitrogen (kg/ha)	42.8	115.8	53.0
Phosphorus (kg/ha)	56.5	129.4	63.9
Potash (kg/ha)	0.0	4.4	0.0
Grain (Qtl/ha)	12.2	17.8	11.0
Price of Yield (Rs/Qtl)	4100	2167	3500
Soil test based fertilizer Recommendation (STBR)			
FYM (t/ha)	12.4	9.9	7.4
Nitrogen (kg/ha)	126.0	90.6	21.6
Phosphorus (kg/ha)	85.2	53.5	61.8
Potash (kg/ha)	63.0	41.2	18.5
Grain (Qtl/ha)	17.3	59.3	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)			
FYM (%)	81.1	84.8	75.3
Nitrogen (%)	66.0	-27.8	-145.1
Phosphorus (%)	33.8	-141.7	-3.5
Potash (%)	100.0	89.4	100.0
Grain (%)	29.3	69.9	11.1
Value of yield and Fertilizer (Rs)			
Additional Cost (Rs/ha)	13535	5477	5476
Additional Benefits (Rs/ha)	20757	89794	4796
Net change Income (Rs/ha)	7222	84316	-680

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 19. 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 84316 in paddy and a minimum of Rs 7222 in cotton cultivation

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 20 and Figure 10. The average value of soil nutrient loss is around Rs 894 per ha/year. The total cost of annual soil nutrients is around Rs 502518 per year for the total area of 563 ha.

Table 20: Estimation of onsite cost of soil erosion in Dummadri - 4 Microwatershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	129.72	72904	817.25	459295
Phosphorous	0.07	41	3.20	1800
Potash	1.84	1036	36.88	20724
Iron	0.06	35	2.98	1674
Manganese	0.06	32	15.74	8844
Cupper	0.02	9	9.14	5138
Zinc	0.00	2	0.14	80
Sulpher	0.21	120	8.58	4820
Boron	0.01	4	0.25	143
Total	132.00	74183	894.16	502518

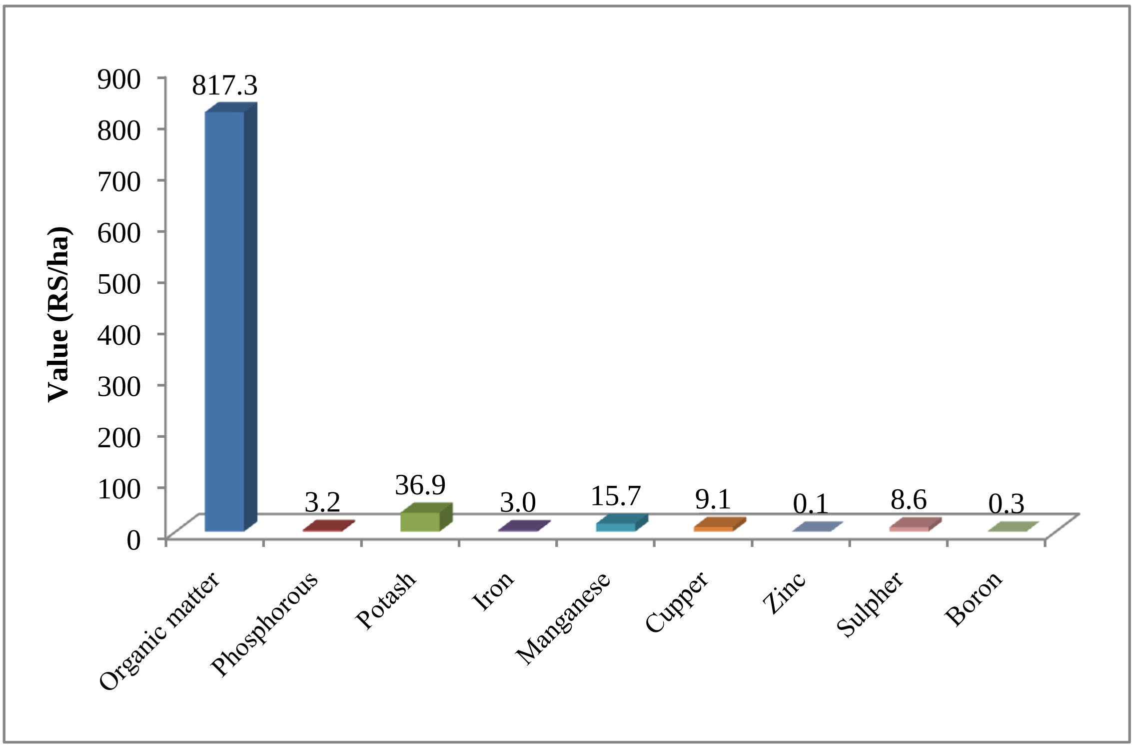

Figure 10: Estimation of onsite cost of soil erosion in Dummadri - 4 Microwatershed

The average value of ecosystem service for food grain production is around Rs 20104/ ha/year (Table 21 and Figure 11). Per hectare food grain production services is maximum in cotton (Rs 29367) followed by redgram (Rs 20481) and paddy (Rs 10464).

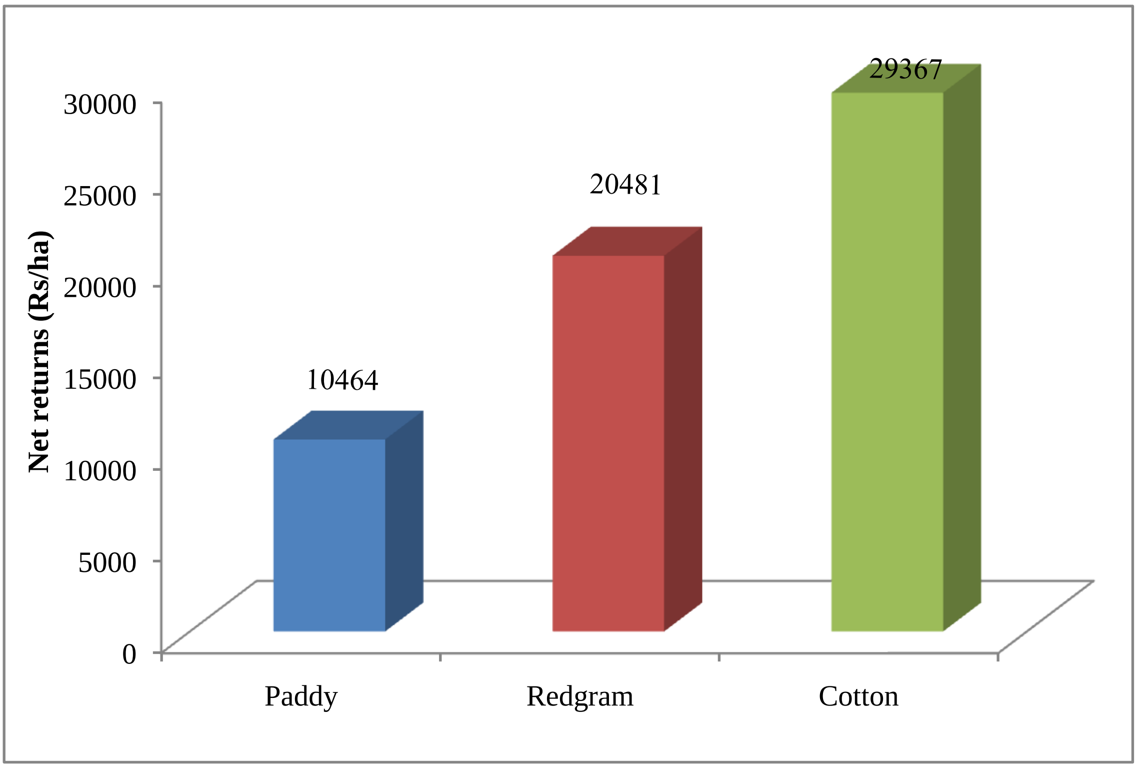

Figure 11: Ecosystem services of food grain production in Dummadri - 4 Microwatershed

Table 21: Ecosystem services of food grain production in Dummadri - 4 Microwatershed

Production items	**Crops**	**Area in ha**	**Yield (Qtl/ha)**	**Price (Rs/Qtl)**	**Gross Returns (Rs/ha)**	**Cost of Cultivation (Rs/ha)**	**Net Returns (Rs/ha)**
Cereals	Paddy	19.3	18	2167	38183	27719	10464
Pulses	Redgram	7.0	11	3500	37968	17487	20481
Commercial Crops	Cotton	8.6	12	4100	49530	20164	29367
Average value		34.9	14	3256	41894	21790	20104

The average value of ecosystem service for fodder production is around Rs 1366/ ha/year (Table 22). Per hectare fodder production services is maximum in paddy crop (Rs 1366).

Table 22: Ecosystem services of fodder production in Dummadri – 4 Microwatershed

Production	**Crops**	**Area in ha**	**Yield (Qtl/ha)**	**Price (Rs/Qtl)**	**Net Returns (Rs/ha)**
Cereals	Paddy	19.3	0.7	2000	1366

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 23 and Figure 12) in red gram (Rs. 59056), cotton (Rs. 48673) and paddy (Rs. 29483).

Table 23: Ecosystem services of water supply in Dummadri - 4 Microwatershed

Crops	**Yield (Qtl/ha)**	**Virtual water (cubic meter) per ha**	**Value of Water (Rs/ha)**	**Water consumption (Cubic meters/Qtl)**
Cotton	12.1	4867	48673	403
Paddy	17.6	2948	29483	167
Redgram	10.8	5906	59056	544
Average value	40.5	4574	45737	371

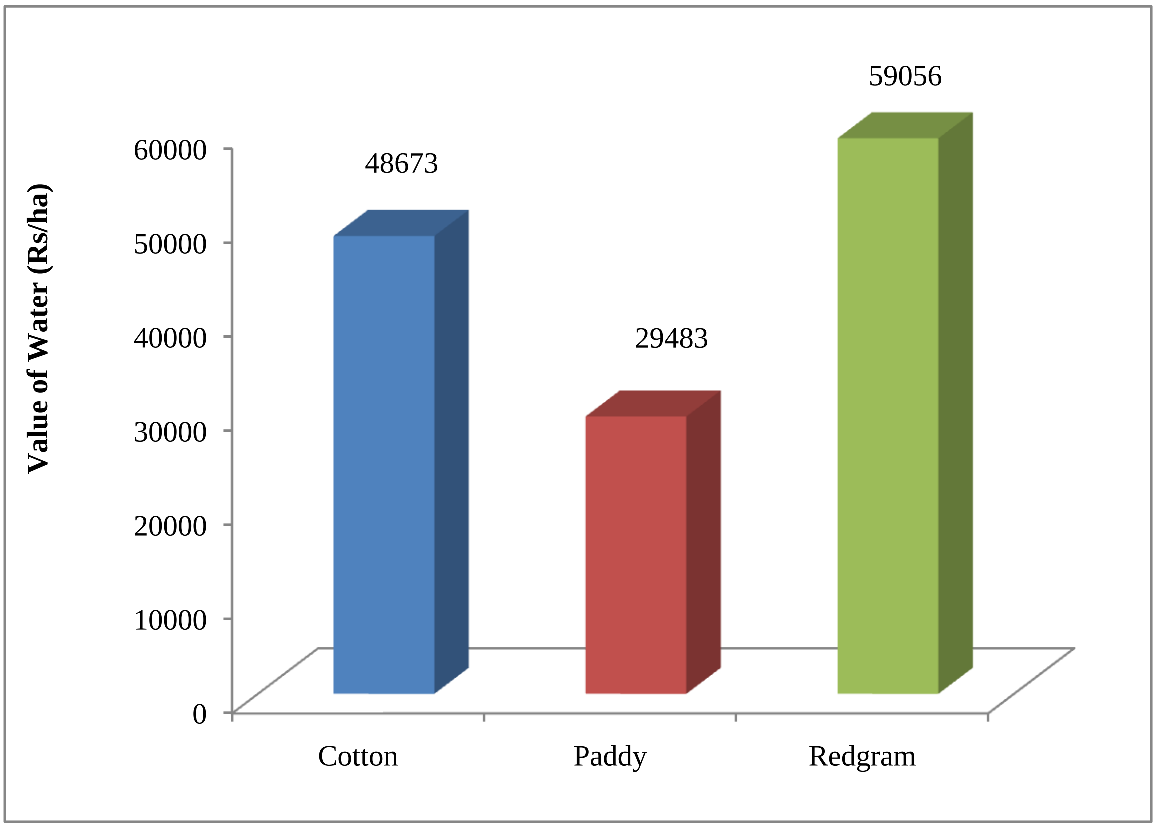

Figure 12: Ecosystem services of water supply in Dummadri - 4 Microwatershed

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

Sl.No	Particulars	Per cent
1	Less Rainfall	80.0
2	Lack of good quality seeds	20.0
4	High Crop Pests & Diseases	10.0
6	Lack of transportation	50.0
7	Lack of storage	40.0
8	Damage of crops by Wild Animals	30.0
9	Non availability of Plant Protection Chemicals	100.0
10	**Source of loan**	
	Bank	80.0
	Village merchants	20.0
11	**Market for selling**	
	Regulated	20.0
	Village market	80.0
12	**Sources of Agri-Technology information**	
	Newspaper	10.0
	Television	90.0

The main farming constraints in Dummadri - 4 micro-watershed to be found are less rainfall, lack of good quality seeds, high crop pests & diseases, lack of transportation, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on bank of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 24).

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.