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

MADKAL (4D5B4E2c) MICROWATERSHED

Sedam Taluk, Gulbarga District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

ICAR - NBSS & LUP

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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PREFACE

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

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

Nagpur
Date: 30.08.2018

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PART-A

LAND RESOURCE INVENTORY

Contents

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

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

The present study covers an area of 466 ha in Sedam taluk of Gulbarga district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 839 mm, of which about 639 mm is received during south-west monsoon, 109 mm during north-east and the remaining 91 mm during the rest of the year. An area of 366 ha (79%) in the microwatershed is covered by soils, about 80 ha (17%) is covered by stone quarry and about 19 ha (4%) by others (habitation and water bodies). The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 6 soil series and 14 soil phases (management units) and 5 land use class.*
- *The length of crop growing period is about 120-150 days starting from 2nd week of June to 3rd 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 was assessed and maps showing the degree of suitability along with constraints were generated.*
- *About 79 percent of area in the microwatershed is suitable for agriculture.*
- *About 35 per cent area of the microwatershed has soils that are moderately deep (75-100 cm) to very deep (>150 cm) and 44 per cent soils are very shallow (<25 cm) to moderately shallow (50-75 cm).*
- *Entire area in the microwatershed has clayey soils at the surface.*
- *About 54 per cent area is non gravelly (<15%), 22 per cent is gravelly (15-35%) and 3 per cent area of the microwatershed is very gravelly (35-60%).*
- *About 27 per cent area of the microwatershed is very high (>200 mm/m) in available water capacity, 20 per cent area is medium (101-150 mm/m) and 33 per cent area is very low (<50 mm/m) in available water capacity.*
- *About 76 per cent area of the microwatershed has nearly level (0-1% slope) to very gently sloping (1-3% slope) lands and 3 per cent area is moderately sloping (5-10% slope) lands.*

- *An area of about 28 per cent has soils that are slightly eroded (e1) and 51 per cent area is moderately (e2) to severely eroded (e3).*
- *An area of about 79 per cent soil are moderately alkaline (pH 7.8-8.4) in soil reaction.*
- *The Electrical Conductivity (EC) of the soils in 34 per cent area is dominantly <2 dsm^{-1}indicating that the soils are non-saline and low (2-4 dSm^{-1}) in 45 per cent area of the microwatershed.*
- *About 45 per cent of the soils are medium (0.5-0.75%) and 34 per cent is high (>0.75) in organic carbon.*
- *About 10 per cent of the area is low (<23 kg/ha) in available phosphorus and an area of 69 per cent medium (23-57 kg/ha) in available phosphorus.*
- *About 20 per cent of the soils are medium (145-337 kg/ha) and 59 per cent is high (>337 kg/ha) in available potassium.*
- *Available sulphur is medium (10 -20 ppm) in an area of about 38 per cent and low (<10 ppm) in an area of about 41 per cent area of the microwatershed.*
- *Available boron is low (0.5 ppm) in an area of about 32 per cent and medium (0.5-1.0 ppm) in 47 per cent.*
- *Available iron is sufficient (>4.5 ppm) in 73 per cent area and deficient (<4.5 ppm) in 5 per cent area of the microwatershed.*
- *Available manganese and copper are sufficient in all the soils of the microwatershed.*
- *Available zinc is deficient (<0.6 ppm) in 47 per cent and sufficient (>0.6 ppm) in 31 per cent of the soils in the microwatershed.*
- *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	*162(35)*	*54(12)*	*Sapota*	-	-
Maize	-	-	*Jackfruit*	-	-
Redgram	-	*216(46)*	*Jamun*	-	*161(35)*
Sunflower	*162(35)*	*54(12)*	*Musambi*	*127(27)*	*34(7)*
Cotton	*162(35)*	*54(12)*	*Lime*	*127(27)*	*34(7)*
Sugarcane	-	-	*Cashew*	-	-
Soybean	*162(35)*	*54(12)*	*Custard apple*	*162(35)*	*54(12)*
Bengal gram	*216(46)*	*137(29)*	*Amla*	*162(35)*	*54(12)*
Guava	-	-	*Tamarind*	-	*161(35)*
Mango	-	-			

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

- *Maintaining soil-health is vital to crop production and conserve soil and land resource base for maintaining ecological balance and to mitigate climate change. For this, several ameliorative measures have been suggested to these problematic soils like saline/alkali, highly eroded, sandy soils etc.,*
- *Soil and water conservation treatment plan has been prepared that would help in identifying the sites to be treated and also the type of structures required.*
- *As part of the greening programme, several tree species have been suggested to be planted in marginal and submarginal lands, field bunds and also in the hillocks, mounds and ridges. This would help in not only supplementing the farm income but also provide fodder and fuel, generate lot of biomass which would help in maintaining an ecological balance and also contribute to mitigating the climate change.*

Chapter 1

INTRODUCTION

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

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

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

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

The land resource inventory aims to provide site specific database for Madkal microwatershed in Sedam Taluk, Gulbarga 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. 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 study area of Madkal microwatershed (Adki subwatershed) is located in the northern part of Karnataka in Sedam Taluk, Gulbarga District, Karnataka State (Fig.2.1). It lies between $17^0$08' and $17^0$10' North latitudes and $77^0$20' and $77^0$22' East longitudes and comprises of Madhakal and Sedam villages covering an area of 466 ha. It is surrounded by Kurkunta on the northwest, Madkal on the east, Sedam on the south and Telangana State on the northeastern side. The Madkal microwatershed is about 16 km from Sedam town.

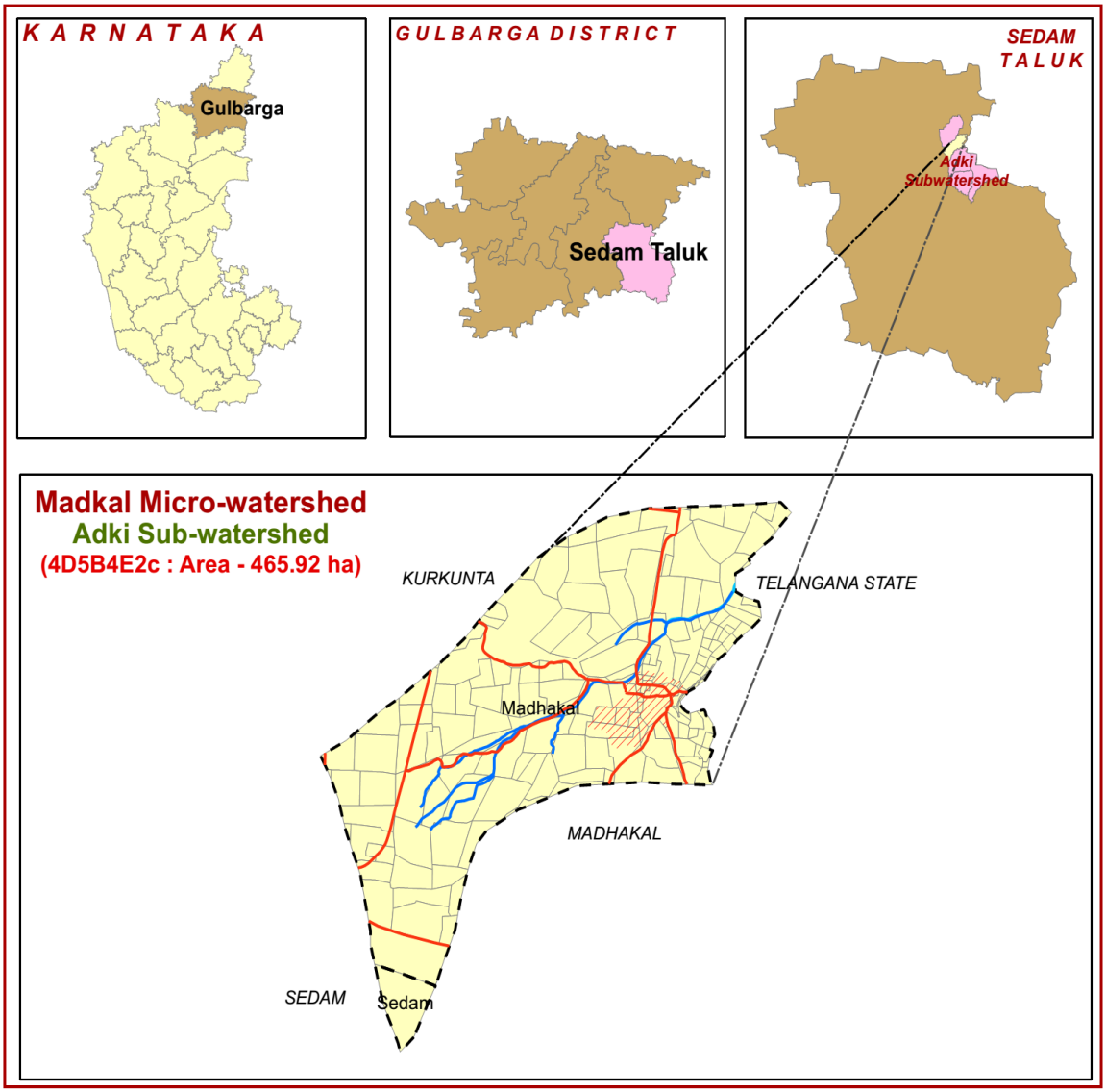


Fig.2.1 Location map of Madkal Microwatershed

2.2 Geology

Major rock formation observed in the microwatershed belongs to Bhima Group of rocks exposed on either side of the Bhima river flowing through Gulbarga district. The Bhima Group is mainly made up of limestone (Fig 2.2). It has two subgroups, the lower being dominantly clastic made up of sandstone and shale while the upper sequence is mainly of limestone and shale. Limestone is the most characteristic and economically important rock type. It is fine grained, dense, waxy-lustred and breaking with conchoidal fracture. Five types of limestone are recognized. They are

1. Flaggy dark gray argillaceous limestone
2. Massive dark gray to bluish gray limestone
3. Variegated silicified limestone with various coloured chert bands
4. Slabby to blocky blue gray limestone and
5. Flaggy impure limestone.

The slabby varieties are extensively quarried and make an excellent material for paving and take very good polish. The blocky limestone is of cement grade and forms the main raw material for cement factories.

Fig. 2.2 Limestone rock formation

2.3 Physiography

Physiographically, the area has been identified as limestone landscape based on geology. It has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands based on slope and its relief features. The elevation ranges from 425-471 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 downstream 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 subparallel and dendritic.

2.5 Climate

The Gulbarga district lies in the northern plains of Karnataka and falls under semiarid tract of the state and is categorized as drought-prone area. The average annual rainfall of Sedam taluk is 839 mm (Table 2.1). Of the total rainfall, maximum of 639 mm is received during the south–west monsoon period from June to September, the north-east monsoon from October to early December contributes about 109 mm, and the remaining 91 mm during the rest of the year. December is the coldest month with mean daily maximum and minimum temperatures being 29.5^0C and 15^0 to 10^0C respectively. During peak summer, temperatures shoot up to 45^0C. Relative humidity varies from 26 per cent in summer to 62 per cent in winter. 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 July, August and September. Generally, the Length of crop Growing Period (LGP) is 120-150 days and starts from 2nd week of June to 3rd week of October.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET at Sedam Taluk, Gulbarga District

Sl. No.	Months	Rainfall	PET	1/2 PET
1	January	5.0	126.8	63.4
2	February	4.6	143.9	71.95
3	March	18.4	189.9	94.95
4	April	25.7	209.8	104.9
5	May	33.3	232.2	116.1
6	June	105.5	186.4	93.2
7	July	177.1	152.8	76.4
8	August	174.7	147.6	73.8
9	September	181.4	131.7	65.85
10	October	91.7	145.5	72.75
11	November	17.6	129.8	64.9
12	December	4.0	114.8	57.4
Total		**839.0**		

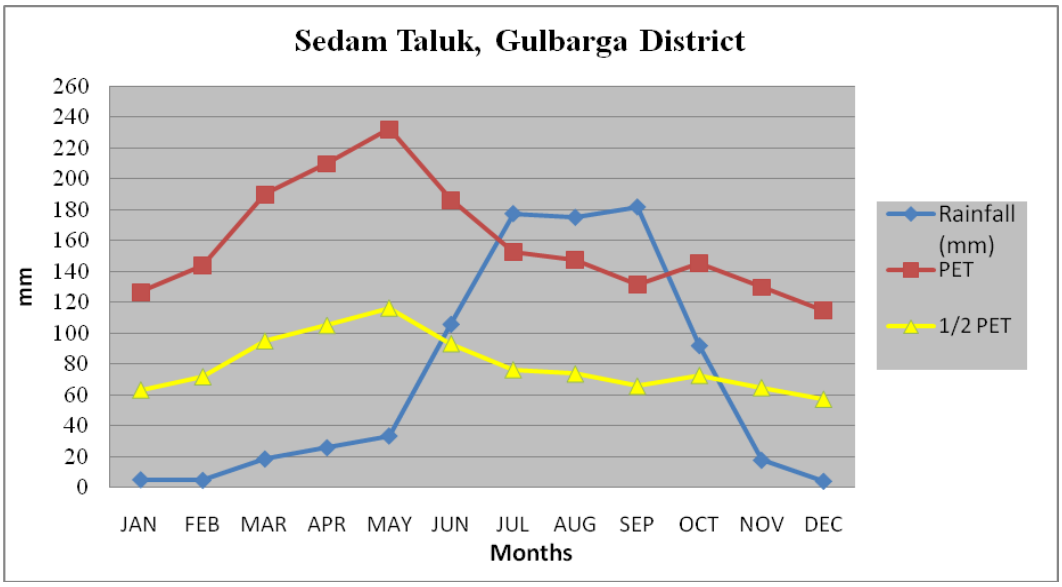


Fig 2.3 Rainfall distribution in Sedam Taluk, Gulbarga District

2.6 Natural Vegetation

The natural vegetation is sparse comprising few tree species, shrubs and herbs. The mounds, ridges and boulders occupy very sizeable area which is 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 Madkal Microwatershed

2.7 Land Utilization

About 84 per cent area (Table 2.2) in Sedam taluk is cultivated at present. An area of about 3 per cent is permanently under pasture, 3 per cent is under nonagricultural land and 7 per cent is under currently barren. Forests occupy an area of about 2 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 paddy, sorghum, maize, cotton, green gram, bengal gram and red gram (Fig 2.5). While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is prepared. The current land use map prepared shows the arable and non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Madkal microwatershed is presented in Fig.2.6. Simultaneously, enumeration of wells (bore wells and open wells) and conservation structures in the microwatershed was made and their location in different survey numbers is marked on the cadastral map. The map showing the location of wells and conservation structures of Madkal microwatershed is presented in Fig.2.7.

Table 2.2 Land Utilization in Sedam Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	102445	-
2.	Total cultivated area	85345	84.01
3.	Area sown more than once	19885	-
4.	Cropping intensity	-	123.3
5.	Trees and grooves	50	0.05
6.	Forest	2181	2.13
7.	Cultivable wasteland	360	0.35
8.	Permanent Pasture land	3066	2.99
9.	Barren land	6823	6.66
10.	Non- Agriculture land	3295	3.21

Fig 2.5 Different crops and cropping systems in Madkal microwatershed

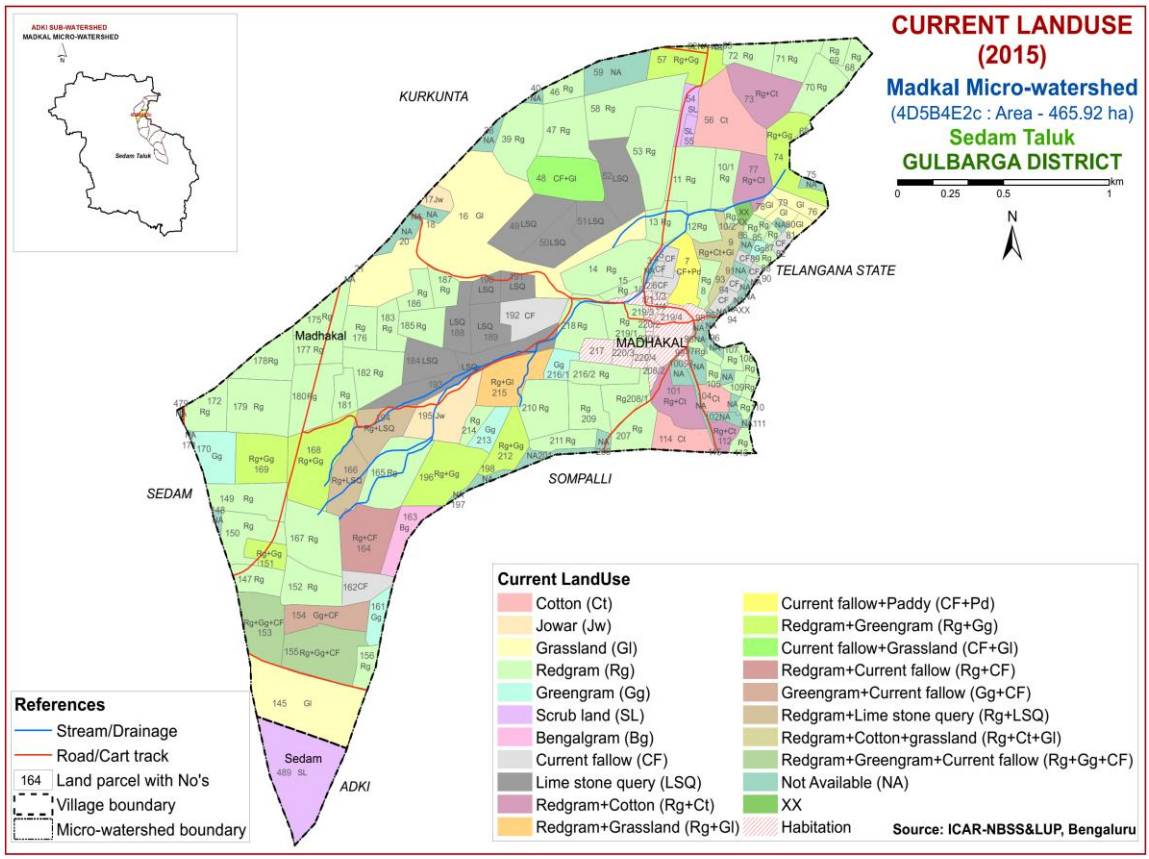


Fig.2.6 Current Land Use map of Madkal Microwatershed

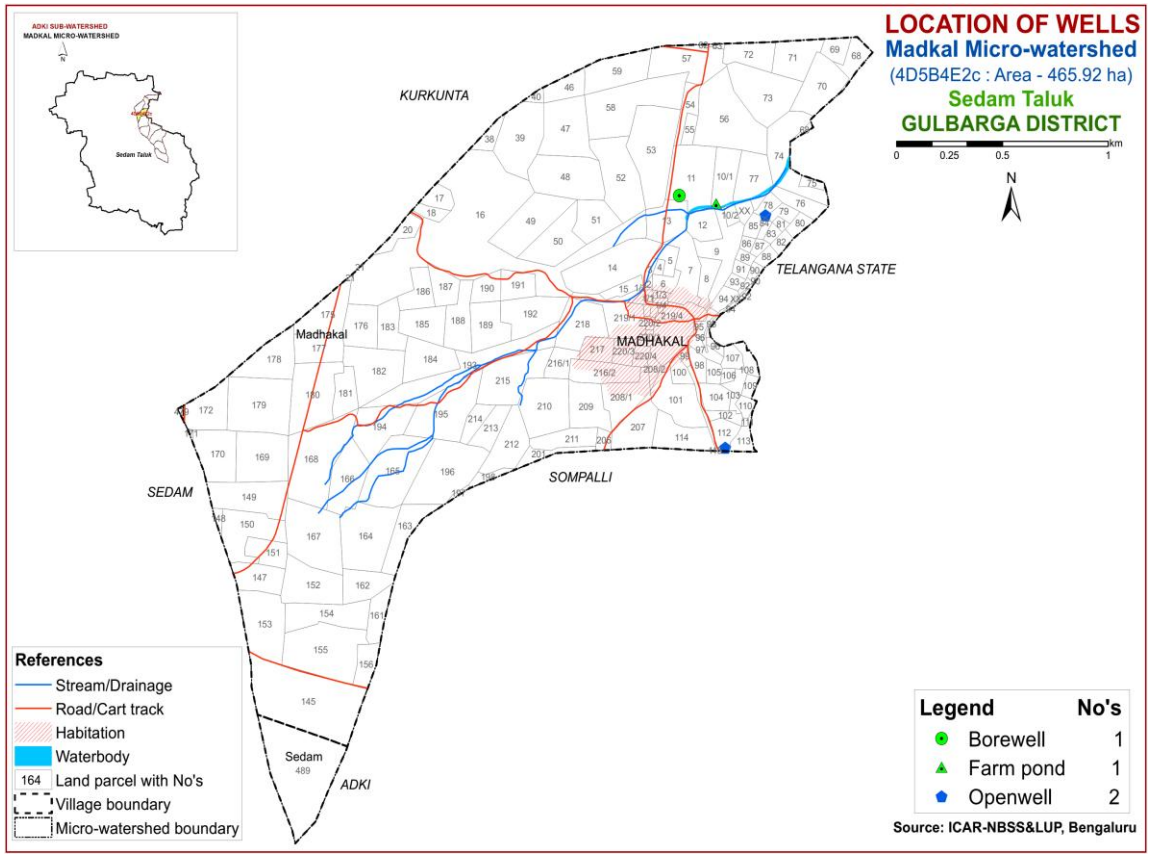


Fig.2.7 Location of wells and conservation structures of Madkal Microwatershed

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 Madkal microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site (slope of the land, erosion, drainage, occurrence of rock fragments etc.) followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units. Their area extent and geographic distribution is shown on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in 466 ha area. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.,* 2015) which is briefly described below.

3.1 Base Maps

The detailed survey of the land resources occurring in the microwatershed was carried out by using digitized cadastral map as a base. The cadastral map shows field boundaries with their survey numbers, location of tanks, streams and other permanent features of the area (Fig. 3.1). Apart from the cadastral map, remote sensing data products from Cartosat-1 and LISS-IV merged at the scale of 1:7920 were used in conjunction with the cadastral map to identify the rock types, 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 helped to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were used for initial traversing, identification of geology and landforms, drainage features, present land use and also for selection of transects in the microwatershed.

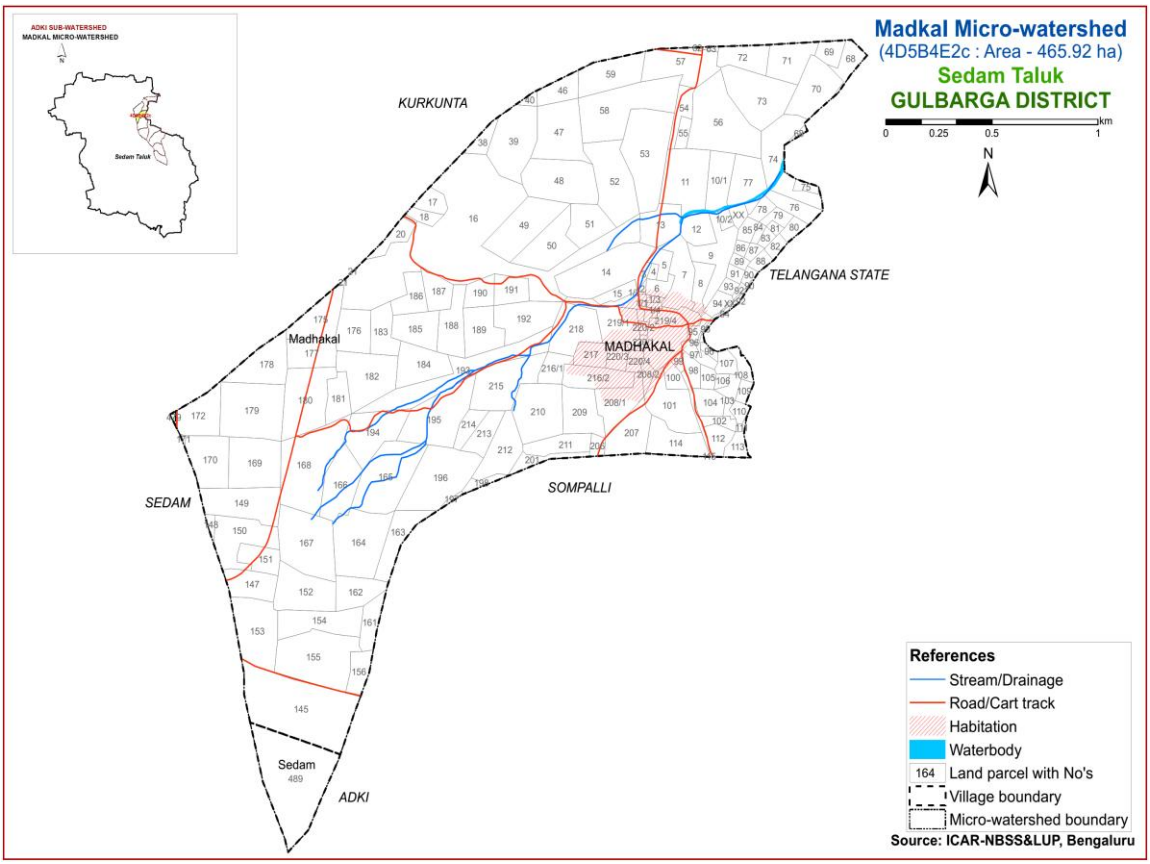


Fig 3.1 Scanned and Digitized Cadastral map of Madkal Microwatershed

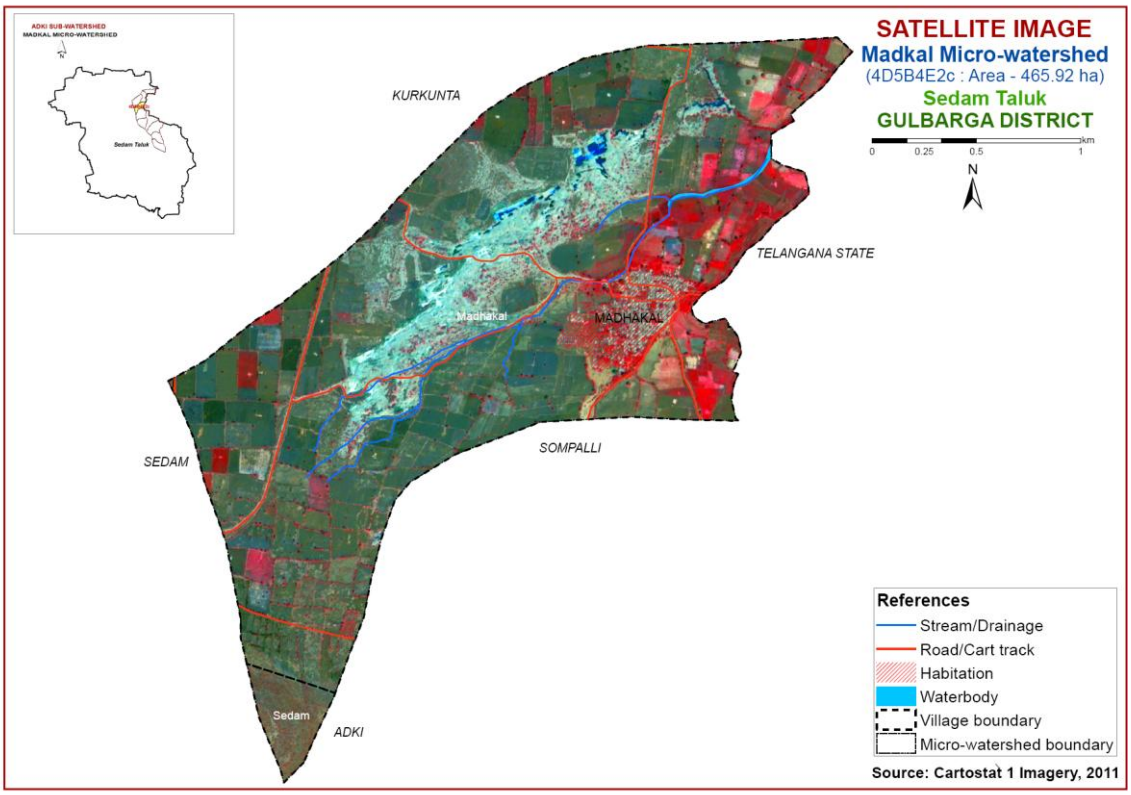


Fig.3.2 Satellite Image of Madkal Microwatershed

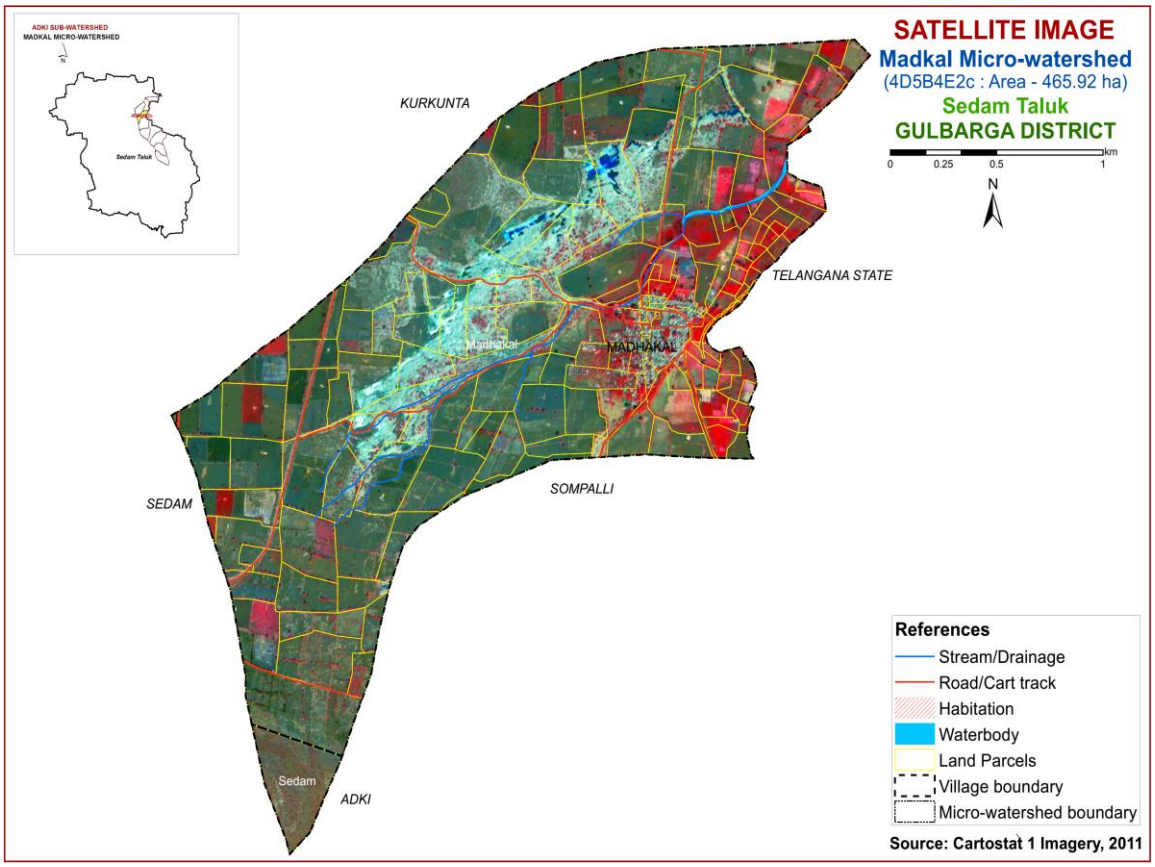


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Madkal Microwatershed

3.2 Field Investigation

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

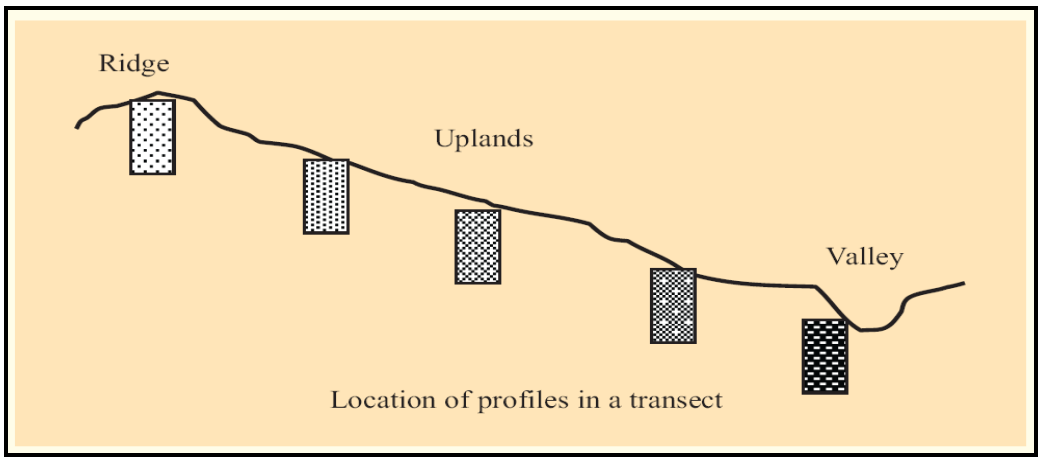


Fig: 3.4. Location of profiles in a transect

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

Based on the soil-site characteristics, the soils were grouped into different soil series (soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management). Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying soil series are given in Table 3.1. Based on the above characteristics, 6 soil series were identified in the Madkal microwatershed.

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

SOILS OF LIMESTONE LANDSCAPE							
Sl. No.	**Soil Series**	**Depth (cm)**	**Colour (moist)**	**Texture**	**Gravel (%)**	**Horizon sequence**	**Calcar-eousness**
1	Gundagunthi (GGN)	<25	10YR3/2, 3/3	c	15-35	Ap-Bw-cr	-
2	Adki (ADK)	25-50	10YR3/2, 3/3	c	<15	Ap-Bw	e
3	Tonsanhalli (TNH)	50-75	10 YR3/2,3/1	c	15-35	Ap-Bw-cr/R	-
4	Mathimuda (MTM)	75-100	10YR 3/2,4/3,3/1	c	<15	Ap-Bw-cr	e-es
5	Dargah (DRG)	100-150	10YR 3/2,4/3,3/1,2/2,2/1	c	<15	Ap-BA-Bss-cr	e-es
6	Dhondothi (DDT)	>150	10YR 3/2,3/1,4/3 4/2,2/2,2/1	c	<15	Ap-BA-Bss-cr	e-es

3.3 Soil Mapping

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

The soil mapping units are shown on the soil map (Fig.3.5) in the form of symbols. During the survey about 9 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map. The soil map shows the geographic distribution of 14 mapping units representing 6 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 14 soil phases identified and 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 are to be treated accordingly.

The 14 soil phases identified and mapped in the microwatershed were grouped into 5 Land Management Units (LMUs) 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 Management Units (LMUs) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LMUs. For Madkal microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The Land Management Units are expected to behave similarly for a given level of management.

3.4 Laboratory Characterization

Soil samples for each series 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 (56 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 for 11 elements including pH and EC were generated using Kriging method for the microwatershed.

Table 3.2 Soil map unit description of Madkal Microwatershed

Soil No	Soil Series	Soil phase	Mapping Unit Description	Area in ha (%)
Soils of Limestone Landscape				
	GGN	Gundagunthi soils are very shallow (0-25cm), well drained, have very dark grayish brown to dark brown gravelly clay soils. They have developed from limestone and occur on vey gently to moderately sloping uplands under cultivation.		**14 (3.07)**
1		GGNmD3g2	Clay surface, 5-10% slopes, severe erosion, very gravelly (35-60 %)	14(3.07)
	ADK	Adki soils are shallow (25-50cm), moderately well drained, have very dark grayish brown to dark brown calcareous cracking clay soils. They have developed from limestone and occur on very gently to gently sloping uplands under cultivation.		**137 (29.46)**
2		ADKmA1	Clay surface, 0-1% slopes, slight erosion	21(4.51)
3		ADKmB1	Clay surface, 1-3% slopes, slight erosion	3(0.67)
4		ADKmB2	Clay surface, 1-3% slopes, moderate erosion	55(11.76)
5		ADKmB2g1	Clay surface, 1-3% slopes, moderate erosion, gravelly (15-35 %)	58(12.52)
	TNH	Tonsanhalli soils are moderately shallow (50-75 cm), moderately well drained, have very dark grayish brown to dark brown gravelly cracking clay soils occurring on nearly level to very gently sloping uplands under cultivation.		**54 (11.53)**
6		TNHmA1	Clay surface, 0-1% slopes, slight erosion	37(7.89)
7		TNHmB1	Clay surface, 1-3% slopes, slight erosion	17(3.64)
	MTM	Mathimuda soils are moderately deep (75-100 cm), moderately well drained, have very dark gray to dark brown calcareous cracking clay soils occurring on very gently to gently sloping uplands under cultivation		**35 (7.39)**
8		MTMmB2	Clay surface, 1-3% slopes, moderate erosion	26(5.49)
9		MTMmB2g1	Clay surface, 1-3% slopes, moderate erosion, gravelly (15-35 %)	9(1.90)
	DRG	Dargah soils are deep (100-150 cm), moderately well drained, have very dark brown to dark brown calcareous cracking clay soils occurring on very gently sloping uplands under cultivation		**106 (22.6)**
10		DRGmA1	Clay surface, 0-1% slopes, slight erosion	26(5.49)
11		DRGmB1	Clay surface, 1-3% slopes, slight erosion	5(1.13)
12		DRGmB2	Clay surface, 1-3% slopes, moderate erosion	40(8.48)
13		DRGmB2g1	Clay surface, 1-3% slopes, moderate erosion, gravelly (15-35 %)	35(7.50)
	DDT	Dhondothi soils are very deep (>150 cm), moderately well drained, have very dark brown to dark brown calcareous cracking clay soils occurring on very gently to gently sloping uplands under cultivation		**22 (4.65)**
14		DDTmA1	Clay surface, 0-1% slopes, slight erosion	22(4.65)

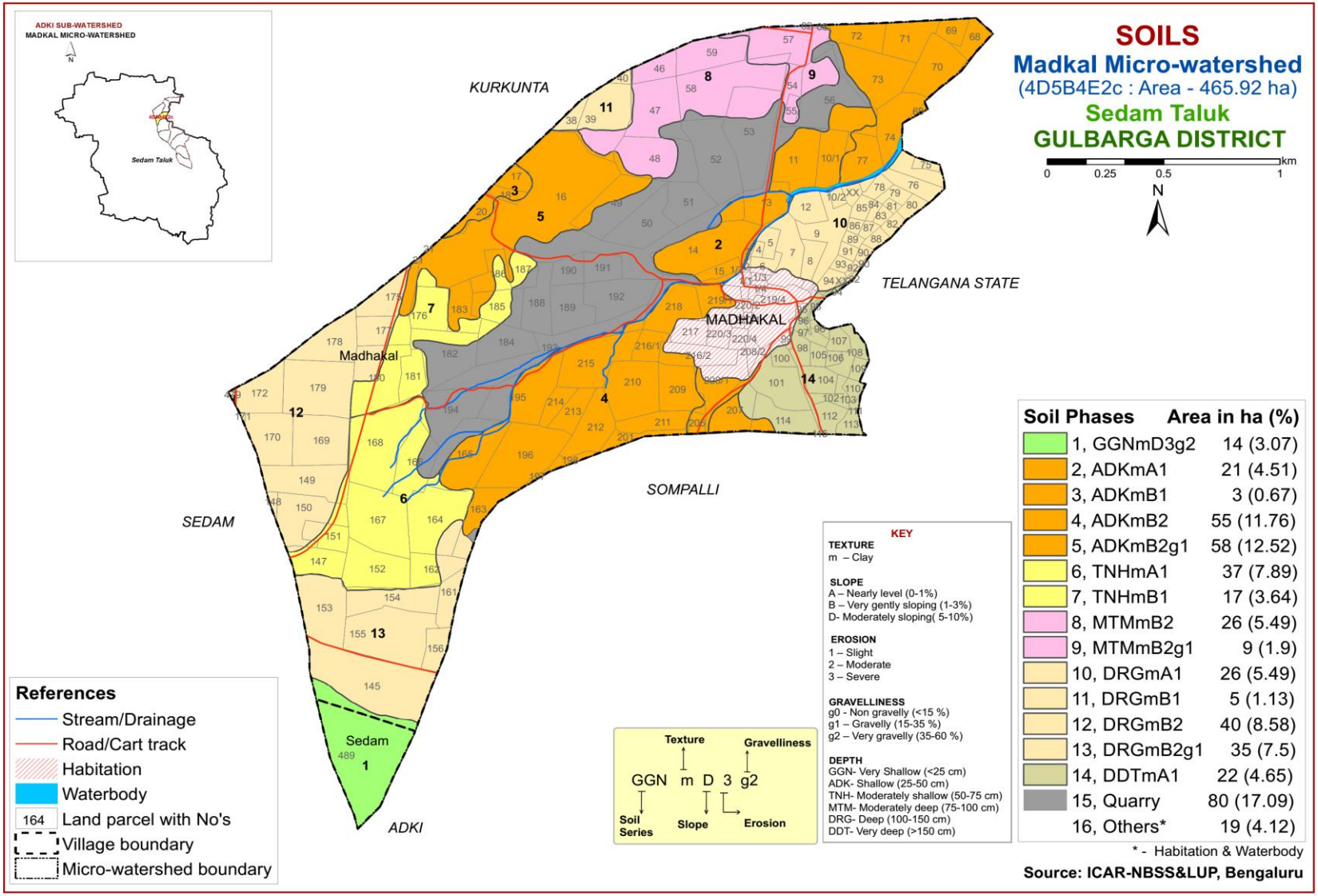


Fig 3.5 Soil phase or management units map of Madkal Microwatershed

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Madkal microwatershed is provided in this chapter. The microwatershed area has been identified as limestone landscape. In all, 6 soil series were identified in this landscape. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In the limestone landscape, it is by parent material, relief and climate. A brief description of each of the 6 soil series identified and phases mapped under each series are furnished below. The physical and chemical characteristics of soil series identified in Madkal microwatershed are given in Table 4.1. 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 Limestone Landscape

In this landscape, 6 soil series are identified and mapped. Among these, Adki (ADK) soil series occupies maximum area of about 137 ha (29%) followed by Dargah (DRG) about 106 ha (23%). The brief description of each soil series is given below.

4.1.1 Dhondothi Series (DDT): Dhondothi soils are very deep (>150 cm), moderately well drained, have very dark brown to dark brown, calcareous cracking clay soils. They have developed from limestone/alluvium and occur on very gently to gently sloping uplands under cultivation. The Dhondothi series has been classified as a member of the very fine, smectitic, isohyperthermic (calcareous) family of Typic Haplusterts.

The thickness of the solum is >150 cm. The thickness of A horizon ranges from 9 to 20 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. The texture is dominantly clay. The thickness of B horizon is more than 150 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 4. Its texture is clay and are calcareous. The available water capacity is very high (>200 mm/m). Only one phase was identified and mapped.

Landscape and Soil Profile characteristics of Dhondothi series (DDT)

4.1.2 Dargah Series (DRG): Dargah soils are deep (100-150 cm), moderately well drained, very dark grayish brown to dark brown, calcareous cracking clay black soils. They have developed from limestone/alluvium and occur on nearly level to gently sloping uplands under cultivation. The Dargah series has been classified as a member of the very fine, smectitic, isohyperthermic (calcareous) family of Typic Haplusterts.

The thickness of the solum ranges from 101-148 cm. The thickness of A horizon ranges from 8 to 20 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. The texture is clay. The thickness of B horizon ranges from 100 to 140 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 4. Its texture is clay and are calcareous. The available water capacity is very high (>200 mm/m). Four phases were identified and mapped.

Landscape and Soil Profile characteristics of Dargah series (DRG)

4.1.3 Gundagunthi Series (GGN): Gundagunthi soils are very shallow (0-25cm), well drained, have very dark grayish brown to dark brown gravelly clay soils. They have developed from limestone and occur on vey gently to moderately sloping uplands under cultivation. The Gundagunthi series has been classified as a member of the clayey, mixed, isohyperthermic family of (paralithic) Haplustepts.

The thickness of the solum is 9-25 cm. The thickness of A horizon ranges from 6 to 12 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 4. The texture is clay with 15 to 35 per cent gravel. The thickness of B horizon ranges from 11 to 18 cm. Its colour is 10 YR hue with value 4 to 6 and chroma 2 to 4. The texture is clay. The available water capacity is very low (<50 mm/m). Only one phase was identified and mapped.

Landscape and Soil Profile characteristics of Gundagunthi series (GGN)

4.1.4 Adki Series (ADK): Adki soils are shallow (25-50cm), moderately well drained, have very dark grayish brown to dark brown, calcareous cracking clay soils. They have developed from limestone and occur on very gently to gently sloping uplands under cultivation. The Adki series has been classified as a member of the clayey, mixed, isohyperthermic (calcareous) family of (paralithic) Haplustepts.

The thickness of the solum ranges from 25 to 50 cm. The thickness of A horizon ranges from 10 to 17 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. The texture is dominantly clay. The thickness of B horizon ranges from 30 to 39 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. Its texture is clay. The available water capacity is low (51-100 mm/m). Four phases were identified and mapped.

Landscape and Soil Profile characteristics of Adki series (ADK)

4.1.5 Tonsanhalli Series (TNH): Tonsanhalli soils are moderately shallow (50-75 cm), moderately well drained, have very dark grayish brown to dark brown, gravelly cracking clay soils. They have developed from limestone and occur on nearly level to very gently sloping uplands under cultivation. The Tonsanhalli series has been classified as a member of the very fine, montmorillonitic, isohyperthermic (calcareous) family of Typic Haplustepts.

The thickness of the solum ranges from 50 to 75 cm. The thickness of A horizon ranges from 10 to 12 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. The texture is dominantly clay. The thickness of B horizon ranges from 43 to 50 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 4. Its texture is clay with gravel content of 10 to 25 per cent. The available water capacity is low (51-100 mm/m). Two phases were identified and mapped.

Landscape and Soil Profile characteristics of Tonsanhalli series (TNH)

4.1.6 Mathimuda Series (MTM): Mathimuda soils are moderately deep (75-100 cm), moderately well drained, have very dark grayish brown to dark brown, calcareous cracking clay soils. They have developed from limestone and occur on nearly level to very gently sloping uplands under cultivation. The Mathimuda series has been classified as a member of the very fine, montmorillonitic (calcareous), isohyperthermic family of Typic Haplustepts.

The thickness of the solum ranges from 75-100 cm. The thickness of A horizon ranges from 10 to 20 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 3. The texture is clay. The thickness of B horizon ranges from 68 to 80 cm. Its colour is in 10 YR hue with value 3 and chroma 2 to 4. Its texture is clay and are calcareous. The available water capacity is low (51-100 mm/m). Two phases were identified and mapped.

Landscape and Soil Profile characteristics of Mathimuda series (MTM)

Table: 4.1 Physical and Chemical characteristics of soil series identified in Madkal microwatershed

Series Name: Dhondhothi (DDT), **Pedon:** T_2/P3
Location: $17^0$22'62.0"N, $77^0$09'64.2"E, (4D5B3L2a), Dhondothi village, Chitapur taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Very fine, smectitic, isohyperthermic (calcareous) Typic Haplusterts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-10	Ap	6.19	32.00	61.81	0.43	0.22	0.33	1.85	3.37	<5	c	-	-
10-37	A1	6.95	29.99	63.06	0.76	0.65	0.33	1.74	3.47	<5	c	-	-
37-72	Bss1	9.74	29.27	60.98	1.30	1.08	1.41	2.92	3.03	<5	c	-	-
72-120	Bss2	10.85	26.15	63.00	2.74	1.91	1.42	2.28	5.01	<5	c	-	-
120-175	Bss3	11.96	23.02	65.01	4.17	2.74	1.43	1.65	1.98	<5	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-10	8.27	-	-	0.13	0.47	4.02	-	-	1.00	0.31	-	65.89	1.07	100	0.47
10-37	8.39	-	-	0.19	0.63	3.48	-	-	0.68	1.02	-	65.55	1.04	100	1.56
37-72	8.98	-	-	0.24	0.35	4.08	-	-	0.60	2.53	-	63.73	1.04	100	3.97
72-120	8.87	-	-	1.26	0.27	12.30	-	-	0.69	3.83	-	47.54	0.75	100	8.07
120-175	8.16	-	-	6.07	0.11	9.84	-	-	0.87	1.82	-	57.68	0.89	100	3.15

Contd...

Series Name: Dargah (DRG), **Pedon:** R_3-1
Location: $17^0$24'18.4"N, $77^0$09'12.2"E, (4D5B3L2e), Gundgurthi village, Chitapur taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Very fine, smectitic, isohyperthermic (calcareous) Typic Haplusterts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-10	Ap	5.37	32.91	61.72	1.64	0.66	0.55	0.99	1.53	-	c	-	-
10-30	A1	5.24	30.73	64.03	1.86	0.55	0.44	0.76	1.64	-	c	-	-
30-50	A2	4.94	29.42	65.64	1.87	0.55	0.22	0.88	1.43	-	c	-	-
50-71	Bss1	4.60	26.20	69.20	1.75	0.44	0.33	0.77	1.31	-	c	-	-
71--90	Bss2	4.38	28.86	66.76	1.53	0.55	0.33	0.77	1.20	-	c	-	-
90-130	Bss3	7.68	28.02	64.31	3.40	1.10	0.66	1.10	1.43	-	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-10	8.12	-	-	0.15	0.58	3.96	-	-	1.12	0.20	-	73.0	1.2	100	0.27
10-30	8.22	-	-	0.16	0.62	4.02	-	-	0.85	0.44	-	72.6	1.1	100	0.61
30-50	8.35	-	-	0.14	0.51	4.98	-	-	0.81	0.44	-	75.2	1.1	100	0.58
50-71	8.33	-	-	0.13	0.47	4.20	-	-	0.66	0.20	-	74.0	1.1	100	0.27
71--90	8.43	-	-	0.14	0.55	4.56	-	-	0.65	0.12	-	74.4	1.1	100	0.16
90-130	8.42	-	-	0.15	0.51	6.84	-	-	0.79	0.29	-	70.3	1.1	100	0.42

Contd...

Series Name: Gundagurthi (GGN), **Pedon:** T_1/P1
Location: $17^0$07'90.8"N, 77^0 23'59.8"E, (4D5B4E2b), Konthanpalli village, Sedam taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Clayey, mixed, isohyperthermic, (paralithic) Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-18	Ap	30.89	17.47	51.64	9.86	5.04	3.40	6.24	6.35	20	c	-	-
18-23	Bw	15.09	25.55	59.35	2.22	1.44	1.22	3.55	6.66	20	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-18	7.61	-	-	0.152	0.152	2.46	-	-	0.27	0.13	-	51.84	1.00	100.00	0.26
18-23	7.67	-	-	0.298	0.298	3.17	-	-	0.44	0.29	-	57.672	0.97	100.00	0.50

Contd...

Series Name: Adki (ADK), **Pedon:** T_1/P2
Location: $17^0$06'03.0"N, 77^0 20'54.8"E, (4D5B4H2d), Nagasanpalli village, Sedam taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Clayey, mixed, isohyperthermic (calcareous), (paralithic) Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-17	Ap	17.39	37.78	44.84	4.64	2.95	2.11	3.79	3.90	-	c	-	-
17-47	Bw	16.95	33.69	49.36	5.69	3.97	2.04	2.58	2.68	-	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-17	8.46	-	-	0.122	0.67	18.91	-	-	0.87	0.01	-	45.468	1.01	100.00	0.02
17-47	8.55	-	-	0.1	0.63	22.67	-	-	0.46	0.01	-	44.388	0.90	100.00	0.02

Contd...

Series Name: Tonsanhalli (TNH), **Pedon:** T_4/P2
Location: $17^0$21'51.8"N, $77^0$09'43.2"E, (4D5B3L2a), Dhondothi village, Chitapur taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Very fine, montmorillonitic, isohyperthermic (calcareous), Typic Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-14	Ap	10.00	22.39	67.61	2.53	1.54	1.21	2.53	2.20	<5	c	-	-
14-45	A1	10.61	23.96	65.43	3.39	1.64	1.31	2.30	1.97	<5	c	-	-
45-73	A2	13.46	19.23	67.31	7.00	1.97	1.31	1.20	1.97	20	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-14	8.47	-	-	0.18	0.43	6.60	-	-	0.83	2.67	-	67.26	0.99	100	3.98
14-45	8.42	-	-	0.17	0.51	6.72	-	-	0.84	1.18	-	67.03	1.02	100	1.76
45-73	8.46	-	-	0.15	0.47	10.56	-	-	0.64	4.77	-	60.42	0.90	100	7.89

Contd...

Series Name: Mathimada (MTM), **Pedon:** T_2/P2
Location: $17^0$25'0.6"N, $77^0$10'18.4"E, (4D5B3L2c), Gundgurthi village, Chitapur taluk and Kalaburagi district
Analysis at: NBSS&LUP, Regional Centre, Bangalore. **Classification:** Very fine, montmorillonitic (calcareous), isohyperthermic, Typic Haplustepts

Depth (cm)	Horizon	Size class and particle diameter (mm)								Coarse fragments w/w (%)	Texture Class (USDA)	% Moisture	
		Total			Sand								
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)			1/3 Bar	15 Bar
0-18	Ap	7.69	23.72	68.59	1.45	1.00	1.11	2.01	2.12	-	c	-	-
18-40	Bw1	6.76	19.93	73.31	1.33	0.89	0.89	1.66	2.00	-	c	-	-
40-55	Bw2	6.98	19.80	73.23	2.44	0.89	0.89	1.11	1.66	-	c	-	-
55-80	BC	37.01	19.68	43.31	15.72	8.30	5.46	4.48	3.06	-	c	-	-

Depth (cm)	pH (1:2.5)			E.C. (1:2.5)	O.C.	$CaCO_3$	Exchangeable bases					CEC	CEC/ Clay	Base saturation	ESP
							Ca	Mg	K	Na	Total				
	Water	$CaCl_2$	M KCl	dS m^{-1}	%	%	cmol kg^{-1}							%	%
0-18	8.34	-	-	0.15	0.71	5.10	-	-	1.44	0.06	-	74.44	1.09	100	0.08
18-40	8.28	-	-	0.17	0.75	3.78	-	-	1.13	0.10	-	69.88	0.95	100	0.15
40-55	8.43	-	-	0.15	0.71	5.76	-	-	1.23	0.18	-	80.37	1.10	100	0.23
55-80	8.63	-	-	0.14	0.39	12.42	-	-	0.52	0.15	-	53.58	1.24	100	0.28

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 characteristics: 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 14 soil map units identified in the Madkal microwatershed are grouped under 3 land capability classes and 4 land capability subclasses. The soils of the entire microwatershed are suitable for agriculture (Fig. 5.1).

Good cultivable lands (Class II) cover an area of about 127 ha (27%) and are distributed in the southern, western and eastern part of the microwatershed with minor limitation of soil. Moderately good cultivable lands (Class III) cover a small area of 34 ha (7%) and are distributed in the northern part of the microwatershed with moderate limitations of soil and erosion. Fairly good lands (Class IV) occur in 205 ha (44%) and are distributed in the major part of the microwatershed with severe limitations of soil and erosion.

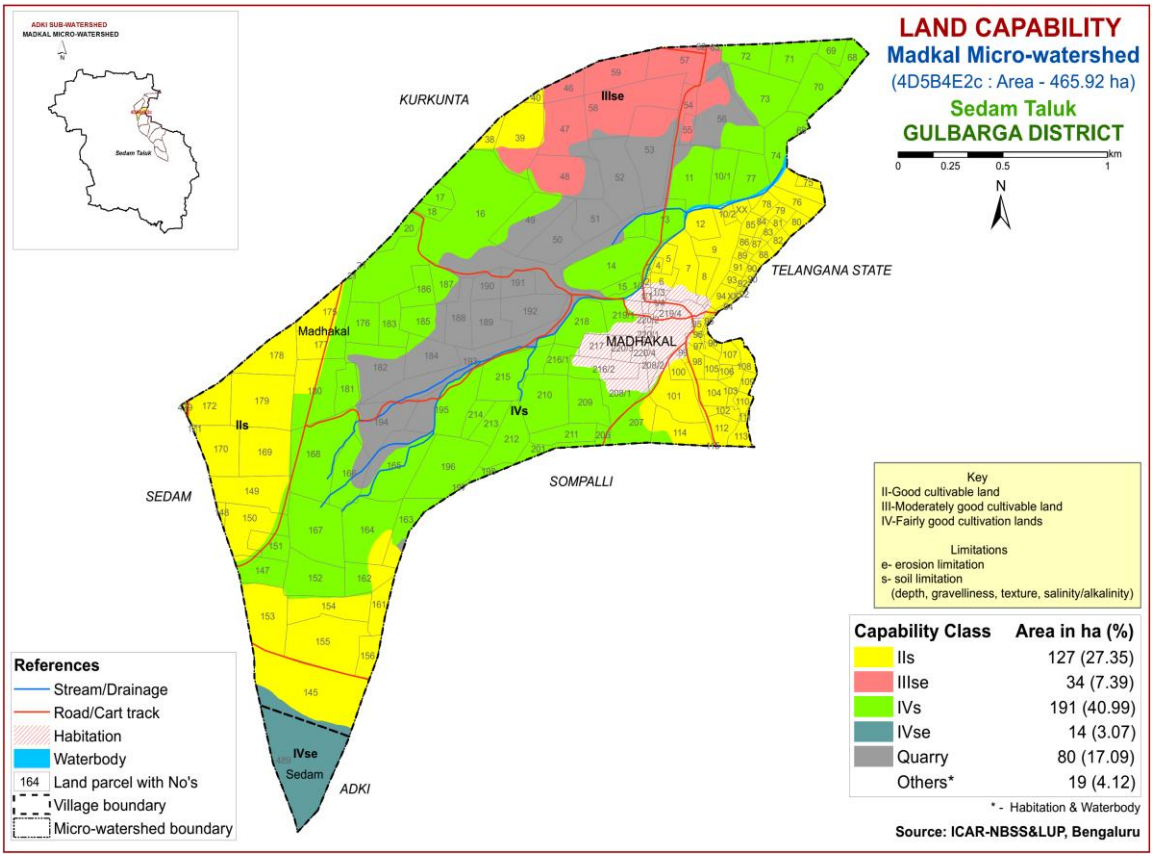


Fig. 5.1 Land Capability map of Madkal Microwatershed

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.

Very deep soils (>150 cm) occur in 22 ha (5%) and are distributed in the eastern part of the microwatershed. Deep soils (100-150 cm) occur in about 106 ha (23%) and are distributed in the southern, western, eastern and northern part of the microwatershed. Moderately deep (75-100 cm) soils occur in 34 ha (7%) and are distributed in the northern part of the microwatershed. Moderately shallow (50-75 cm) soils occur in 54 ha (12%) and are distributed in the central part of the microwatershed. Shallow (25-50 cm) soils occupy maximum area of 137 ha (29%) and are distributed in the major part of the microwatershed and very shallow (<25 cm) soils occur in a very small area of 14 ha (3%) and are distributed in the southern part of the microwatershed.

The most productive lands of about 128 ha (27%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep (100-150 cm) to very deep soils (>150 cm) occurring in the major part of the microwatershed. The problematic soils covering about 151 ha (33%) are shallow and very shallow soils, where short duration crops can be grown.

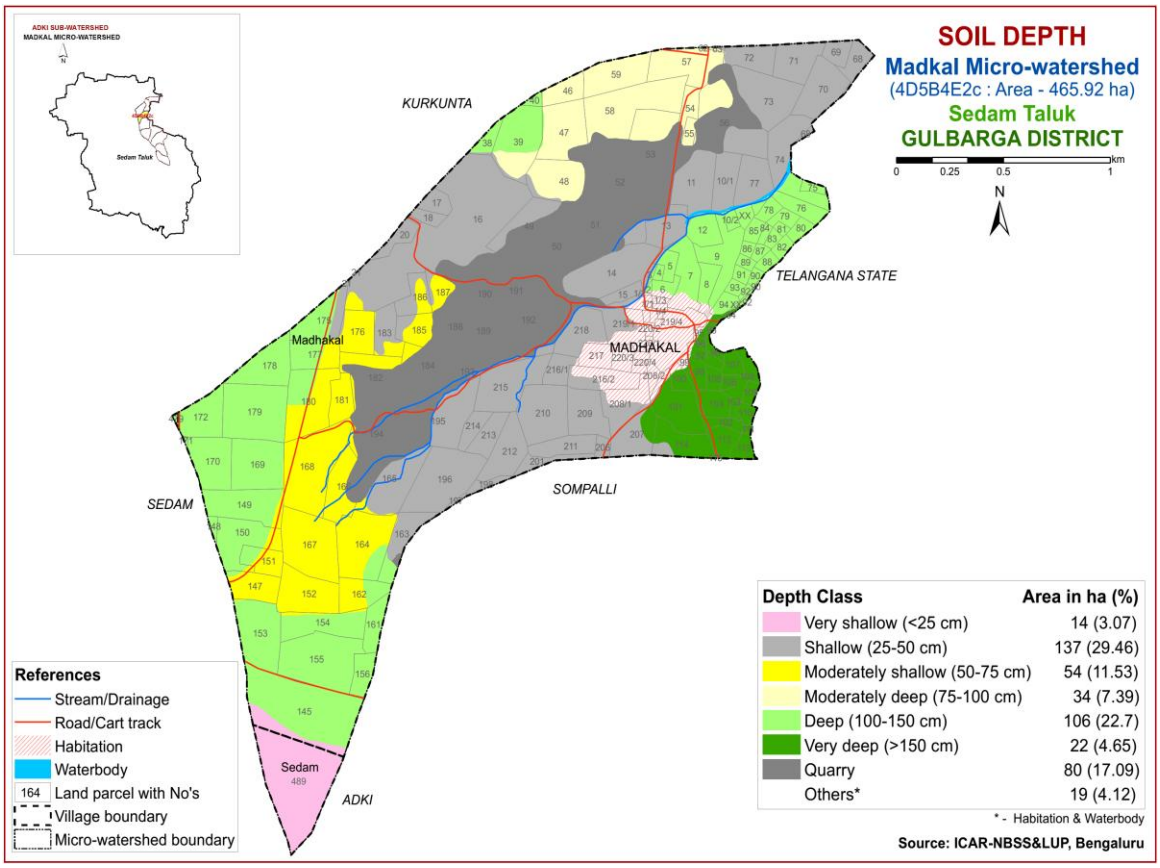


Fig. 5.2 Soil Depth map of Madkal Microwatershed

5.3 Surface Soil Texture

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

An entire area of 367 ha (79%) in the microwatershed have soils that are clayey at the surface and are distributed in all parts of the microwatershed. They are the most productive lands with respect to surface soil texture that have high potential for soil-water

retention and availability, and nutrient retention and availability, but have more problems of drainage, infiltration, workability and other physical problems.

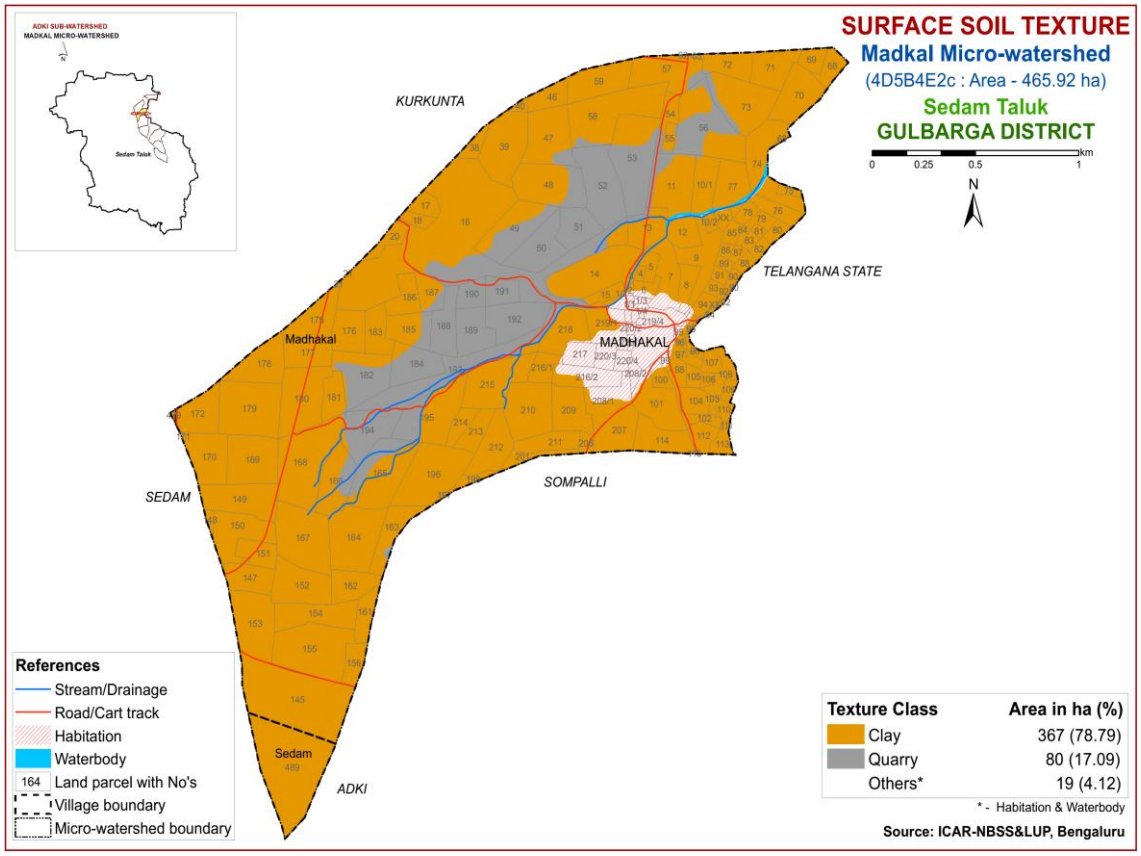


Fig. 5.3 Surface Soil Texture map of Madkal Microwatershed

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 geographical distribution in the microwatershed is shown in Figure 5.4.

An area of about 251 ha (54%) is non gravelly (<15%) and distributed in the major part of the microwatershed. About 102 ha (22%) area is gravelly (15-35%) and is distributed in the central, southern, northeastern and northern part of the microwatershed. Very gravelly (35-60%) soils occur in a small area of about 14 ha (3%) and are distributed in the southern part of the microwatershed.

An area of 116 ha (25%) is gravelly (15-60%) and is distributed in the major part of the microwatershed. These areas are problematic with respect to gravelliness. They are gravelly with more than 15 to 60 per cent gravel and have limitation for growing many

crops that require good seed bed for proper germination. The most productive lands covering about 251 ha (54%) are non gravelly, where all climatically adapted crops can be grown.

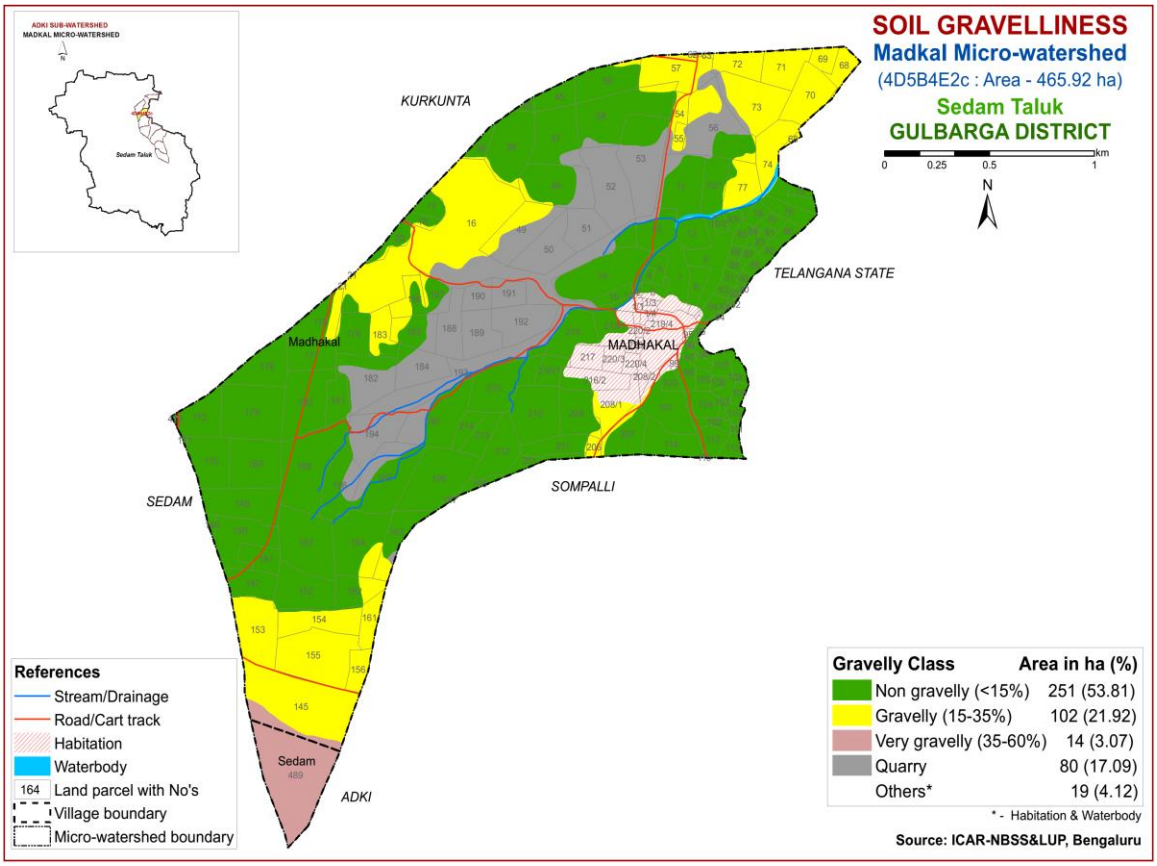


Fig. 5.4 Soil Gravelliness map of Madkal Microwatershed

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 geographical distribution in the microwatershed is shown in Figure 5.5.

An area of 127 ha (27%) in the microwatershed has soils that are very high (>200 mm/m) in available water capacity and are distributed in the southern, western, northern and eastern part of the microwatershed. About 88 ha (19%) area is medium (101-150 mm/m) and distributed in the central and northern part of the microwatershed. An area of 152 ha (34%) is very low (<50 mm/m) and distributed in the major part of the microwatershed.

An area of about 127 ha (37%) has very high potential (>200 mm/m) with regard to available water capacity. In these areas, if the rainfall is normal and well distributed, all climatically adapted long duration annual and perennial crops can be grown.

An area of 152 ha (34%) has soils that are problematic with regard to AWC. Here only short duration crops can be grown and the probability of crop failure is high. These areas are best for other alternative uses.

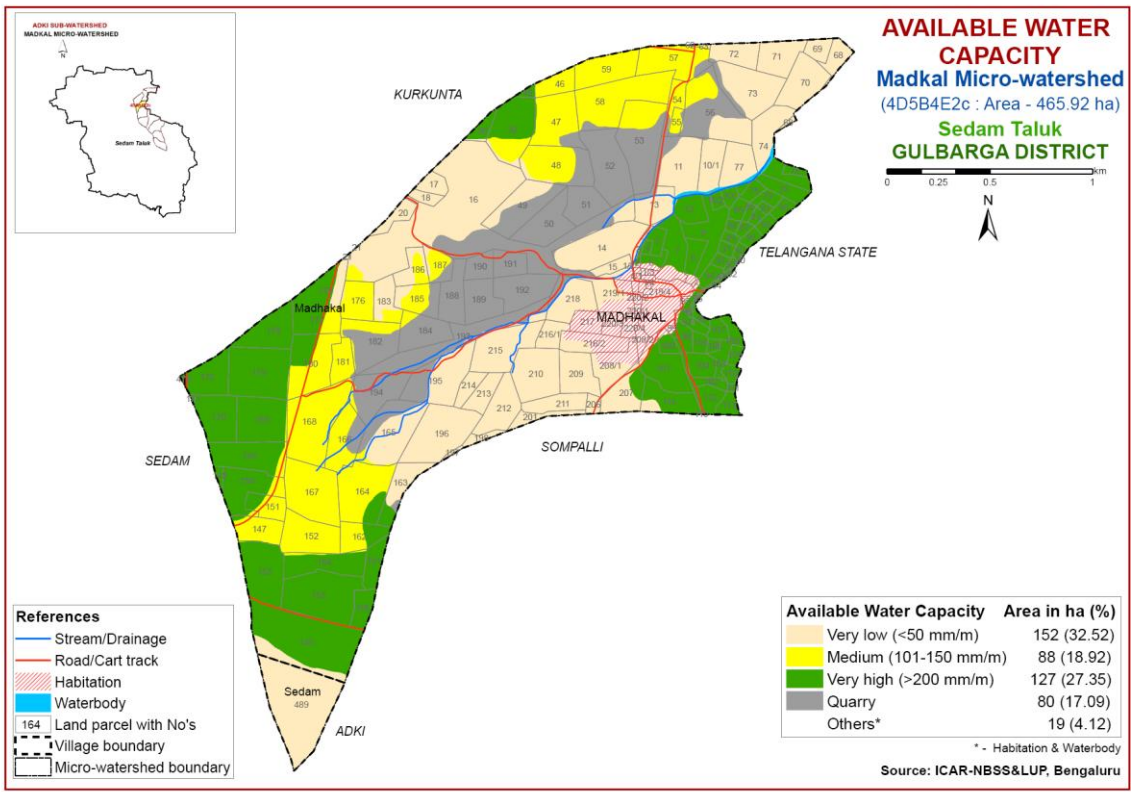


Fig. 5.5 Soil Available Water Capacity map of Madkal Microwatershed

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 three slope classes and a slope map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.6.

An area of about 105 ha (23 %) falls under nearly level (0-1% slope) lands and are distributed in the central and eastern part of the microwatershed. Major area of the microwatershed falls under very gently sloping (1-3% slope) class. It covers a maximum area of about 248 ha (53%) and is distributed in the major part of the microwatershed. Small area of about 14 ha (3%) falls under moderately sloping (5-10% slope) class and are distributed in the southern part of the microwatershed.

Maximum area of about 353 ha (76%) in the microwatershed has high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

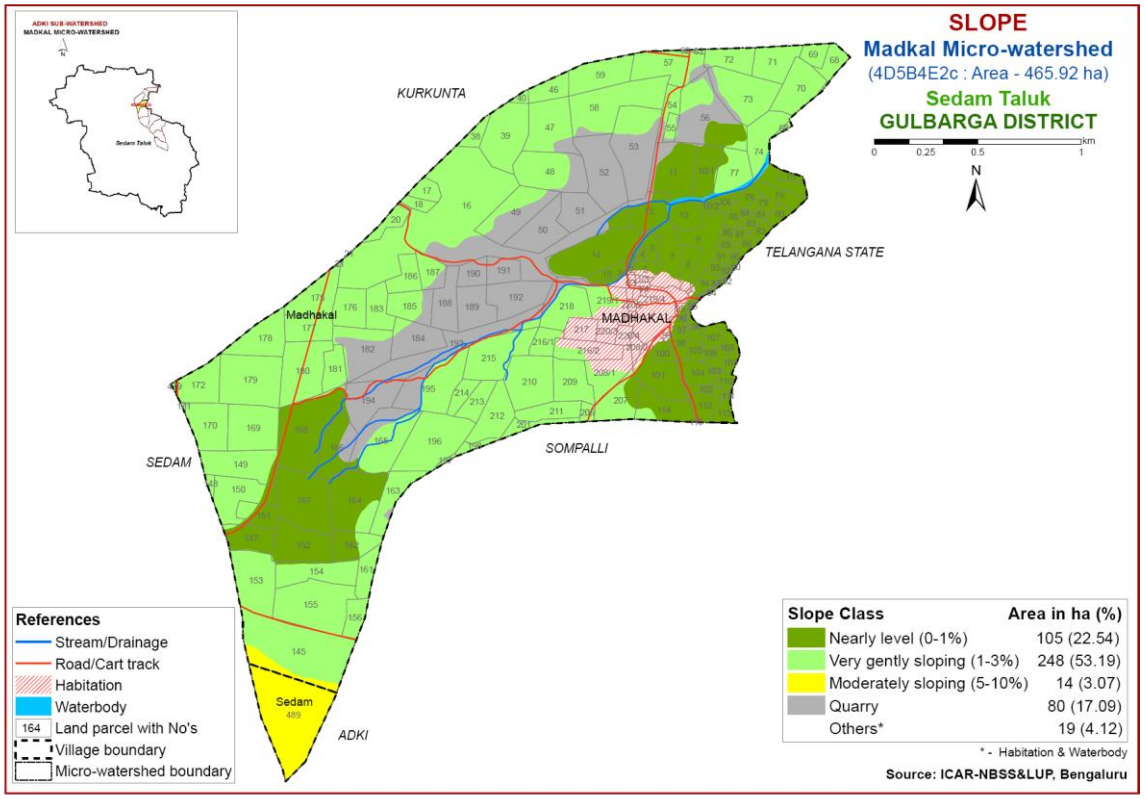


Fig. 5.6 Soil Slope map of Madkal Microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover an area of 130 ha (28%) and are distributed in the major part of microwatershed. Soils that are moderately eroded (e2 class) cover maximum area of about 222 ha (48%) and are distributed in the major part of the microwatershed. Soils that are severely eroded (e3 class) cover small area of 14 ha (3%) and are distributed in the southern part of the microwatershed.

In moderately and severely eroded areas, the soil and water conservation and other land development measures should be carried out in order to control the soil erosion.

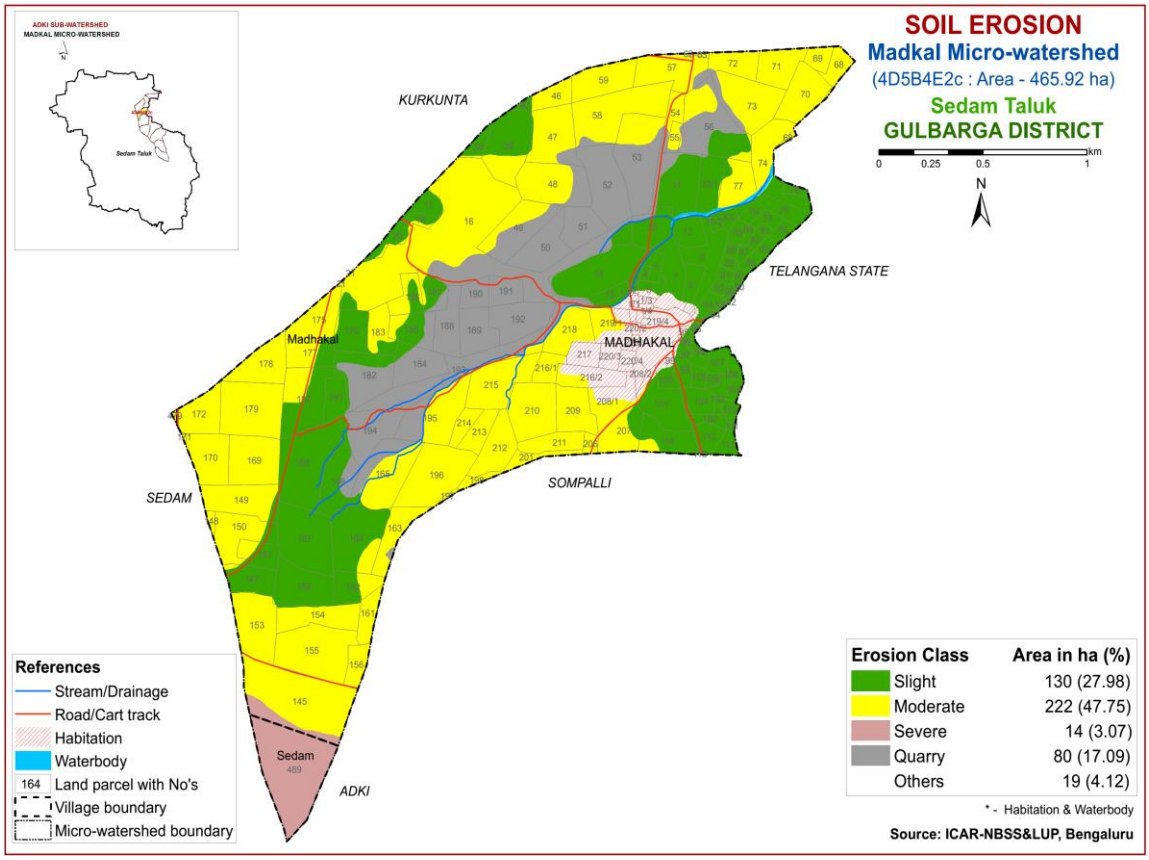


Fig. 5.7 Soil Erosion map of Madkal Microwatershed

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 these soils are characterized by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, 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 fertility analysis of the Madkal microwatershed for soil reaction (pH) showed that maximum area of about 367 ha (79%) is moderately alkaline (pH 7.8-8.4) in reaction and is distributed in all parts of the microwatershed.

6.2 Electrical Conductivity (EC)

The Electrical Conductivity of the soils of the microwatershed are non saline (<2 dSm^{-1}) in an area of about 157 ha (34%) and are distributed in the major part of the microwatershed (Fig 6.2). About 210 ha (45%) area of soils are low (2 - 4 dSm^{-1}) and are distributed in the major part of the microwatershed.

6.3 Organic Carbon

The soil organic carbon content (an index of available Nitrogen) of the soils in the microwatershed is high (>0.75%) in an area of about 158 ha (34%) that are distributed in the southern part of the microwatershed (Fig.6.3). Medium (0.5-0.75%) organic carbon content accounts for major area of about 209 ha (45%) and are distributed in the major part of the microwatershed.

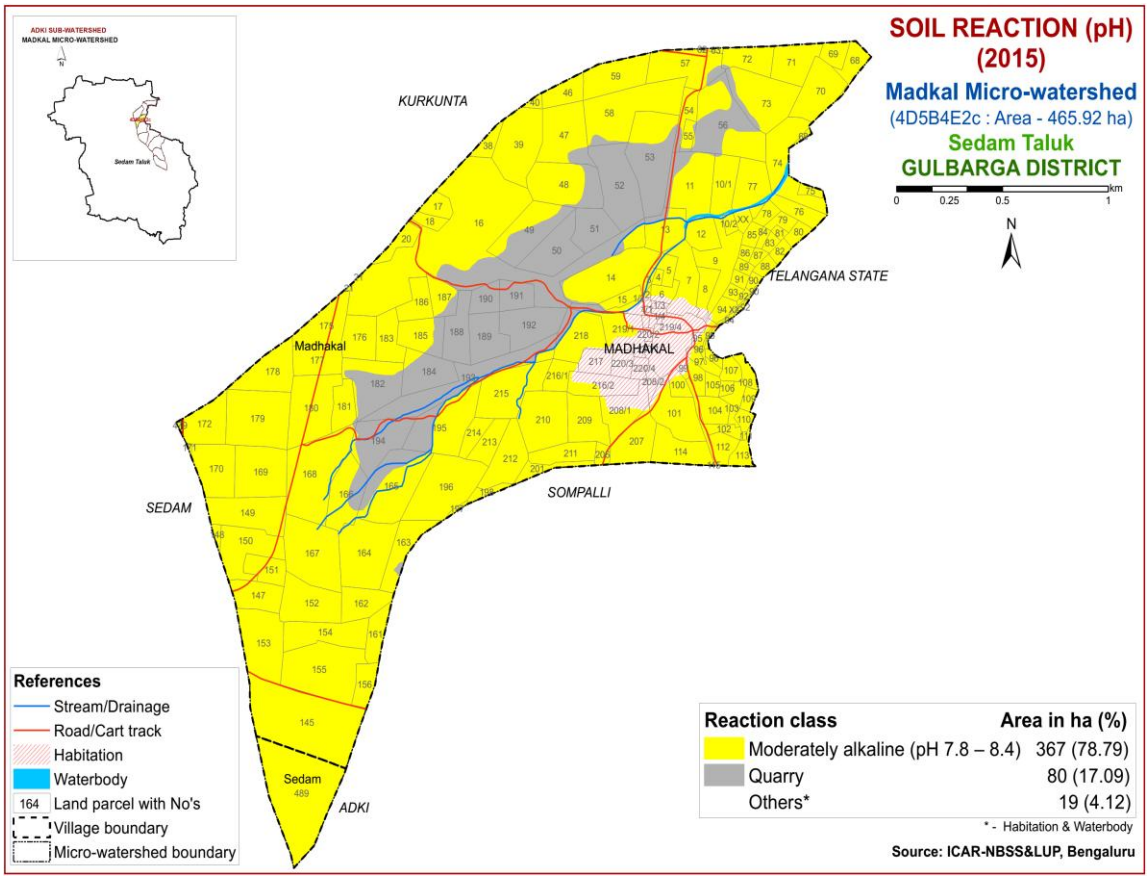


Fig.6.1 Soil Reaction (pH) map of Madkal Microwatershed

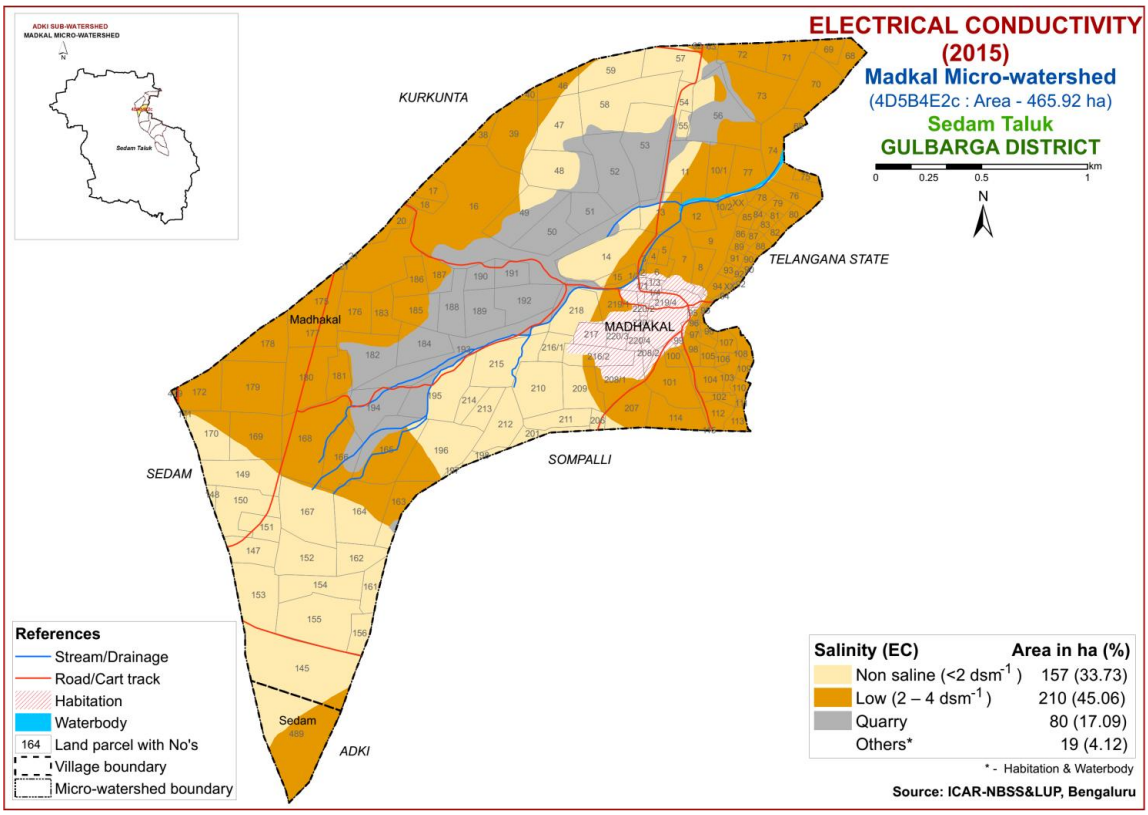


Fig.6.2 Electrical Conductivity (EC) map of Madkal Microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in an area of about 45 ha (10%) and is distributed in the northwestern part of the microwatershed (Fig.6.4). Maximum of 323 ha (69%) area in the microwatershed is medium (23-57 kg/ha) and is distributed in the major part of the microwatershed. There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in an area of about 93 ha (20%) and is distributed in the central and southwestern part of the microwatershed (Fig.6.5). High available potassium (>337 kg/ha) is maximum in area of about 274 ha (59%) and distributed in the major part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in an area of about 190 ha (41%) and is distributed in the major part of the microwatershed (Fig.6.6). Available sulphur is medium (10-20 ppm) in an area of 177 ha (38%) and are distributed in all parts of the microwatershed.

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in maximum area of about 220 ha (47%) and is distributed in the major part of the microwatershed (Fig 6.7). An area of about 147 ha (32%) is low (<0.5 ppm) in available boron and are distributed in all parts of the microwatershed.

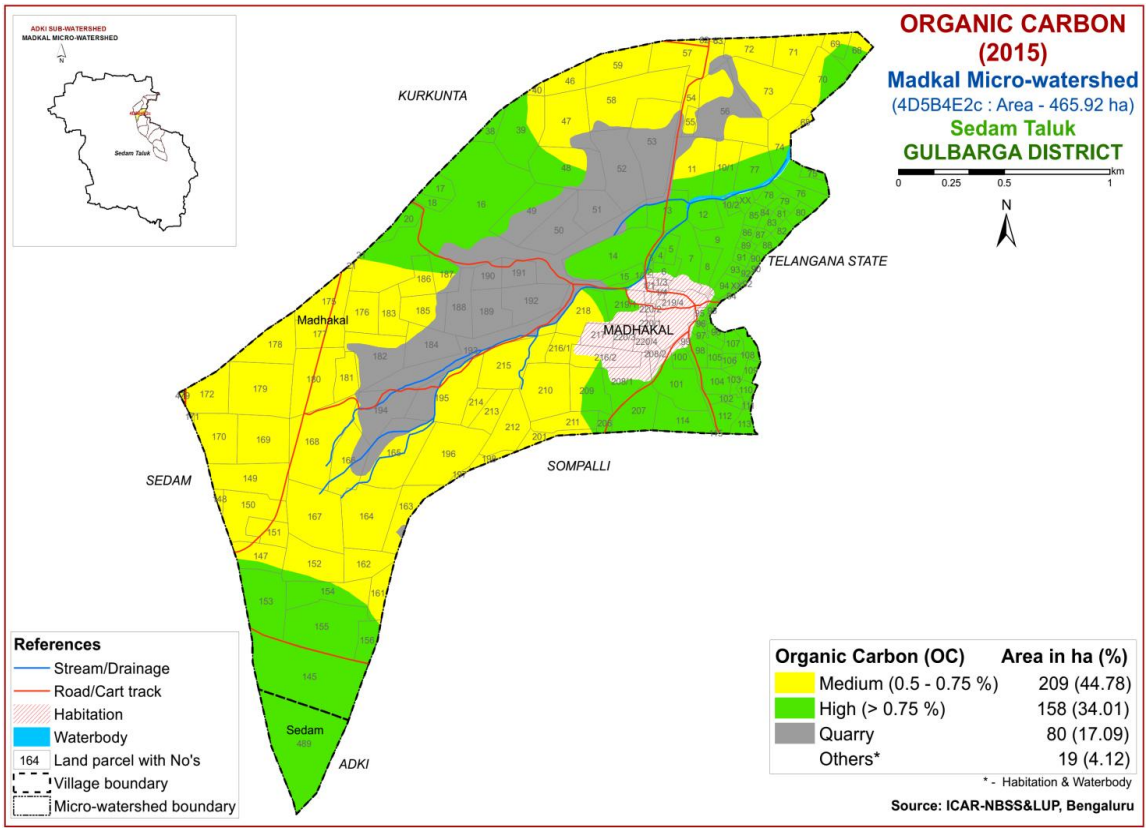


Fig.6.3 Soil Organic Carbon map of Madkal Microwatershed

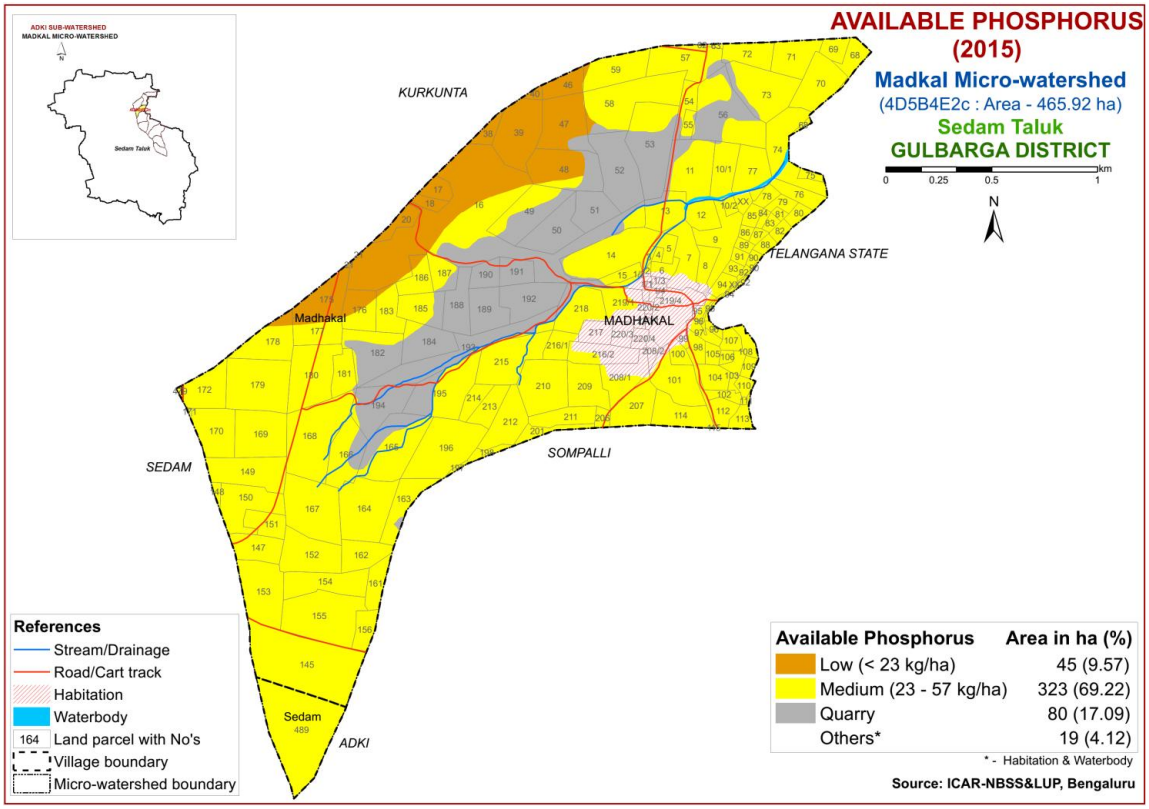


Fig.6.4 Soil available Phosphorus map of Madkal Microwatershed

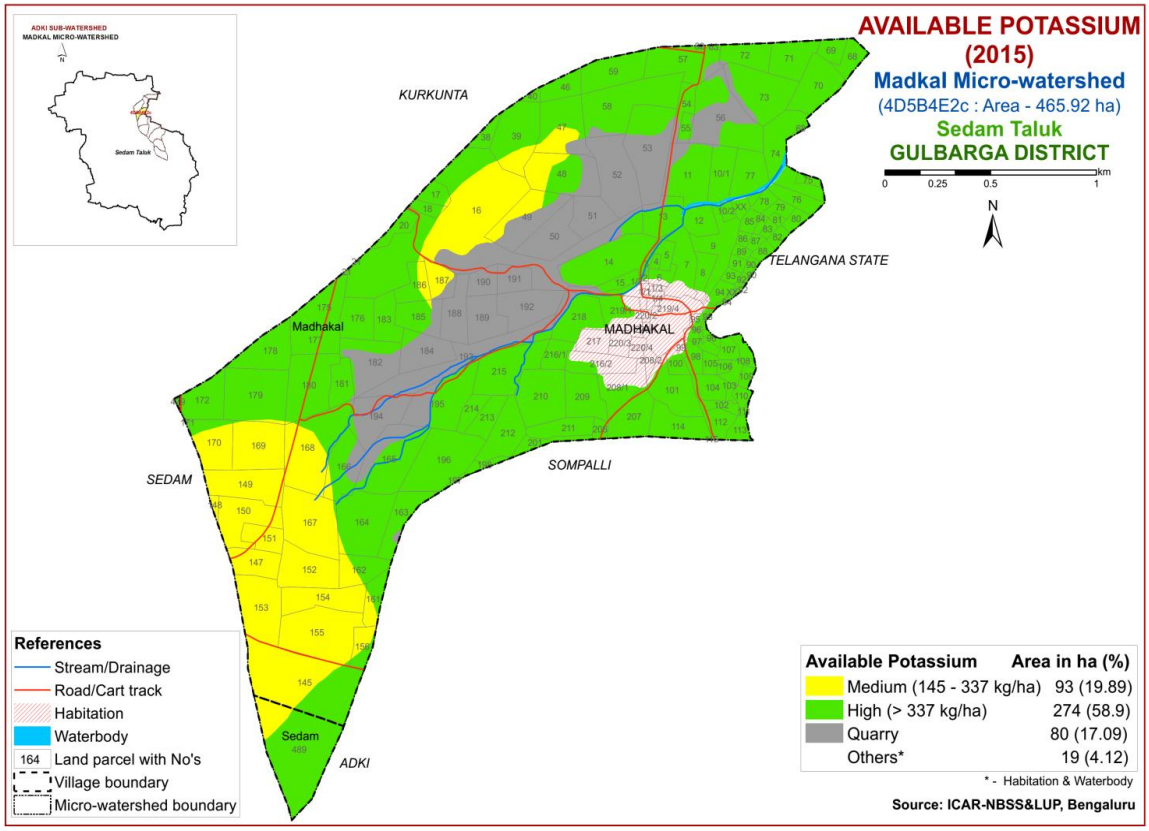


Fig.6.5 Soil available Potassium map of Madkal Microwatershed

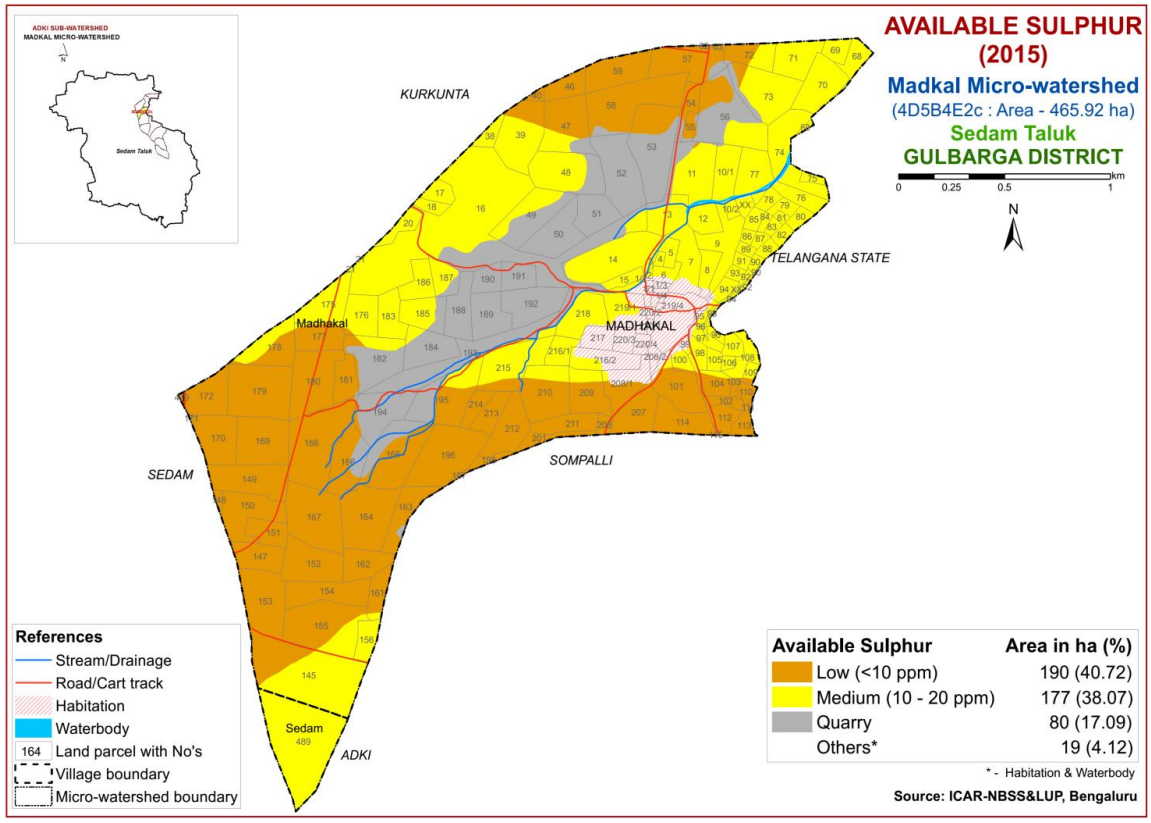


Fig.6.6 Soil available Sulphur map of Madkal Microwatershed

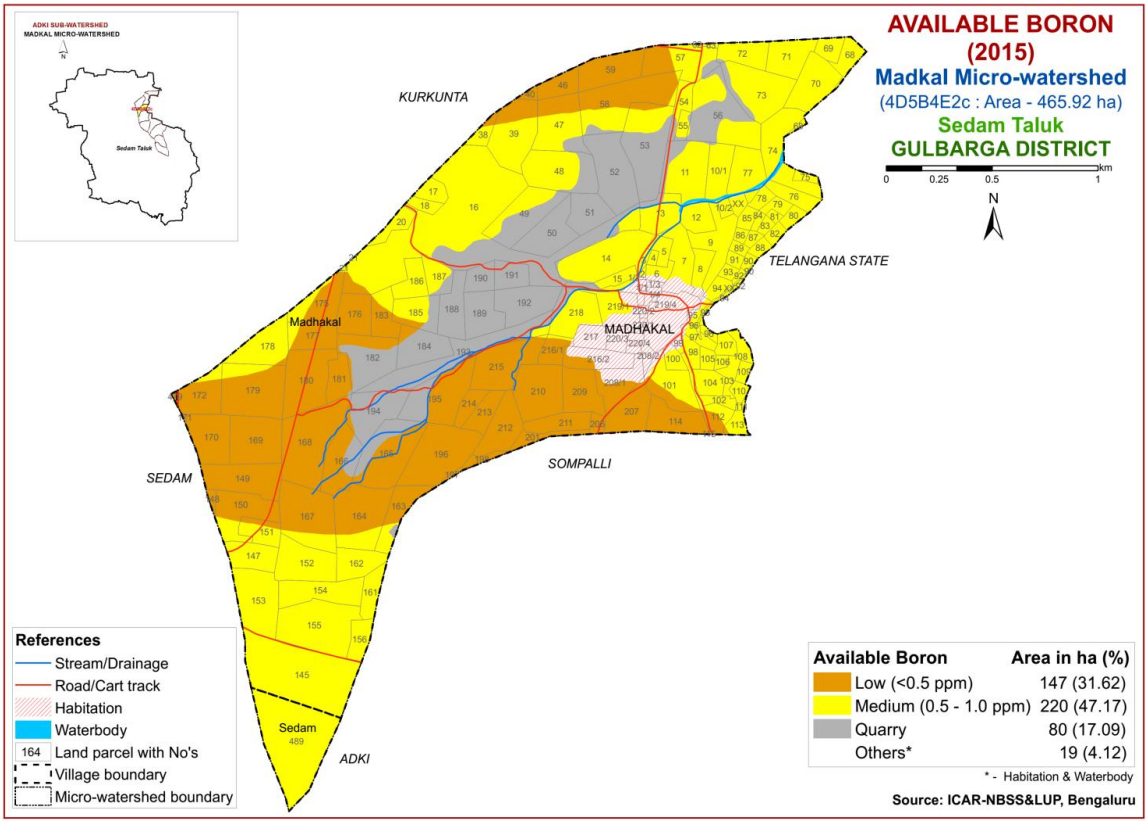


Fig.6.7 Soil available Boron map of Madkal Microwatershed

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in maximum area of 342 ha (73%) and distributed in the major part of the microwatershed. Deficient (<4.5 ppm) in small area of 25 ha (5%) and is distributed in the southern part of the microwatershed (Fig 6.8).

6.9 Available Manganese

Available manganese content is sufficient (>1.0 ppm) in all the soils of the microwatershed (Fig 6.9).

6.10 Available Copper

Available copper content is sufficient (>0.2 ppm) in all the soils of the microwatershed (Fig 6.10).

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in maximum area of about 221 ha (47%) and is distributed in the major part of the microwatershed (Fig 6.11). It is sufficient (>0.6 ppm) in an area of about 146 ha (31%) and is distributed in the southern, western, northwestern and northern part of the microwatershed.

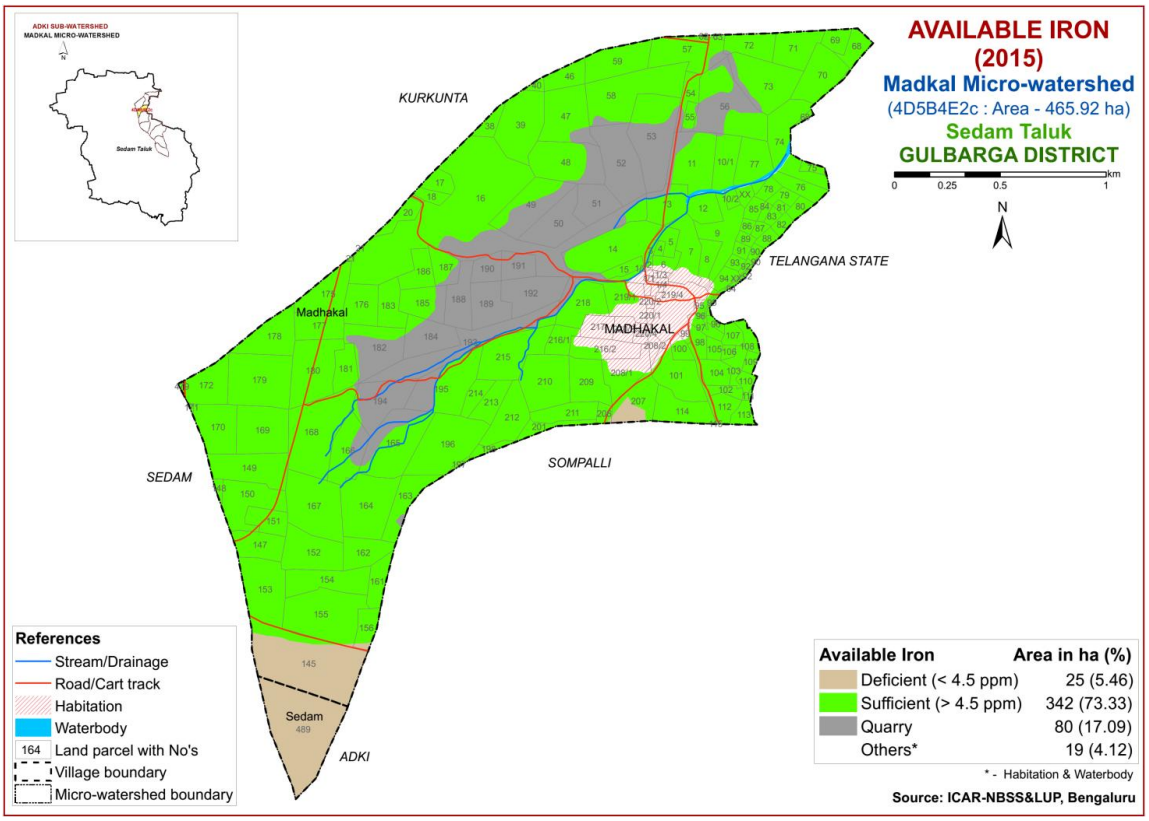


Fig.6.8 Soil available Iron map of Madkal Microwatershed

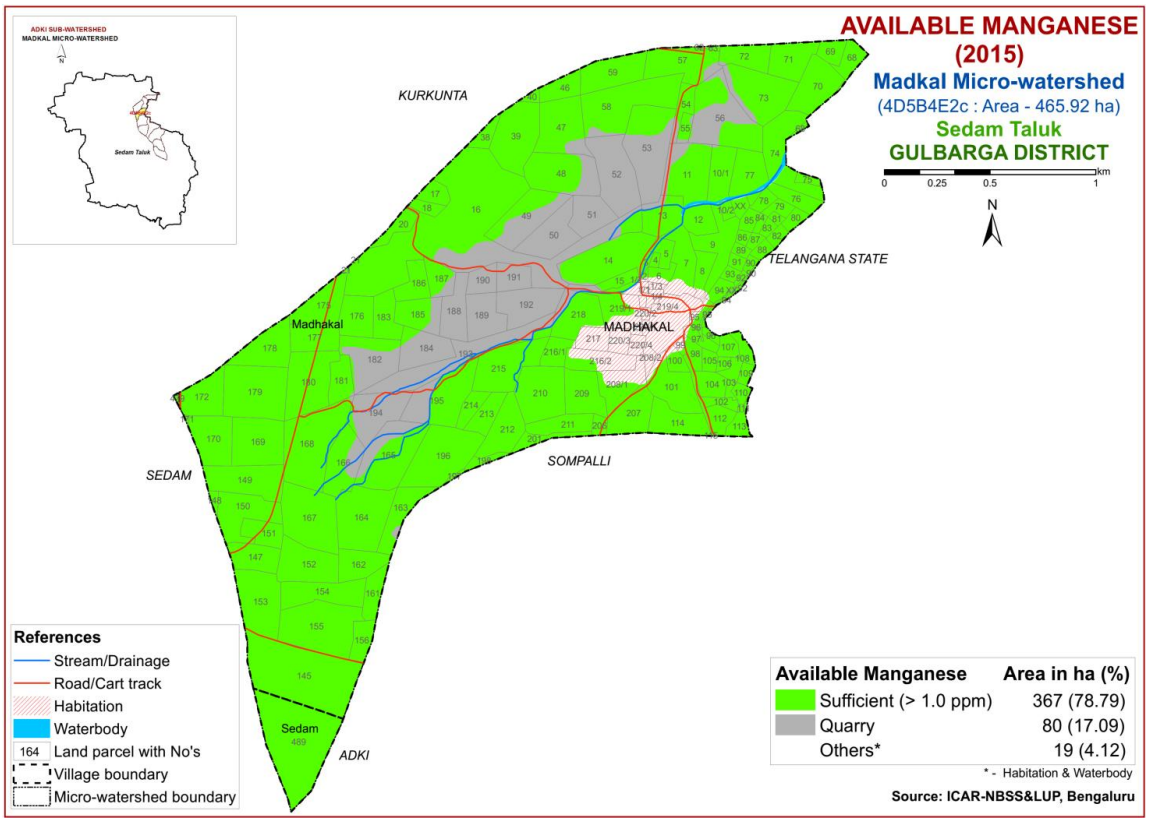


Fig.6.9 Soil available Manganese map of Madkal Microwatershed

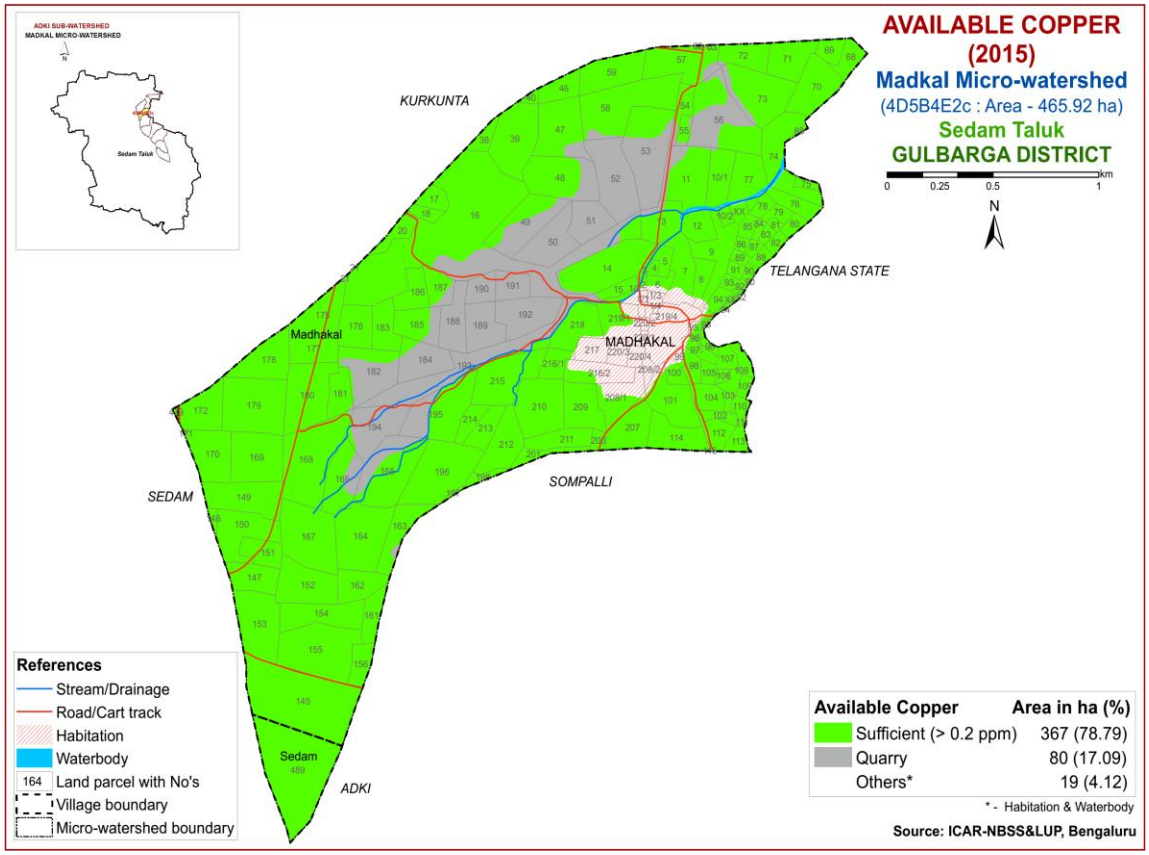


Fig.6.10 Soil available Copper map of Madkal Microwatershed

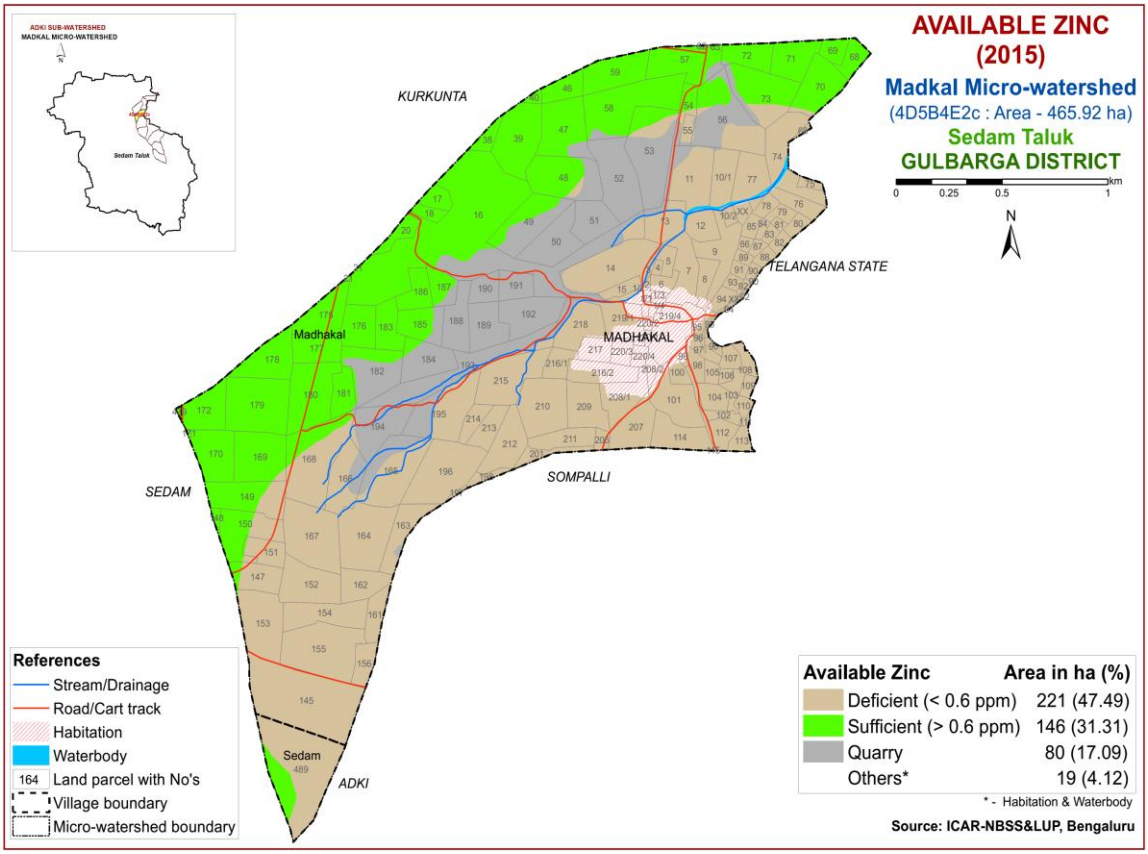


Fig.6.11 Soil available Zinc map of Madkal Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

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

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 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 crop grown in Karnataka in an area of 10.47 lakh ha in northern Karnataka in Bijapur, Kalaburgi, Raichur, Bidar, Belgaum, Dharwad and Bellary 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.

Maximum area of about 162 ha (35%) in the microwatershed is highly suitable (Class S1) for growing sorghum crop. They have minor or no limitations for growing sorghum and are distributed in the eastern, northern, northwestern and southern part of the microwatershed. Moderately suitable (Class S2) lands occur in an area of about 54 ha (12%) and are distributed in the central part of the microwatershed with minor limitation

Table 7.1 Soil-Site Characteristics of Madkal Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC (dSm^{-1})	ESP (%)	CEC [Cmol (p^{+}) kg^{-1}]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Sub-surface (%)								
GGNmD3g2	839	150	WD	<25	c	c	35-60	15-35	<50	5-10	severe	8.76	0.12	0.02	45.47	100
GGNmD3g3	839	150	WD	<25	c	c	60-80	15-35	<50	5-10	severe	8.76	0.12	0.02	45.47	100
ADKmC2g2	839	150	MWD	25-50	c	c	35-60	<15	51-100	3-5	moderate	7.61	0.15	0.25	21.84	100
TNHmB2	839	150	MWD	50-75	c	c	<15	15-35	51-100	1-3	moderate	8.47	0.18	3.96	67.26	100
TNHmB2g1	839	150	MWD	50-75	c	c	15-35	15-35	51-100	1-3	moderate	8.47	0.18	3.96	67.26	100
MTMiB2g1	839	150	MWD	75-100	sc	c	15-35	<15	51-100	1-3	moderate	8.34	0.15	0.08	74.44	100
DRGiB2	839	150	MWD	100-150	sc	c	<15	<15	>200	1-3	moderate	8.12	0.15	0.27	73.0	100
DRGiB2g1	839	150	MWD	100-150	sc	c	15-35	<15	>200	1-3	moderate	8.12	0.15	0.27	73.0	100
DRGmA1	839	150	MWD	100-150	c	c	<15	<15	>200	0-1	slight	8.12	0.15	0.27	73.0	100
DRGmB1	839	150	MWD	100-150	c	c	<15	<15	>200	1-3	slight	8.12	0.15	0.27	73.0	100
DRGmB1g1	839	150	MWD	100-150	c	c	15-35	<15	>200	1-3	slight	8.12	0.15	0.27	73.0	100
DRGmB2	839	150	MWD	100-150	c	c	<15	<15	>200	1-3	moderate	8.12	0.15	0.27	73.0	100
DRGmB2g1	839	150	MWD	100-150	c	c	15-35	<15	>200	1-3	moderate	8.12	0.15	0.27	73.0	100
DDTiB2	839	150	MWD	>150	sc	c	<15	<15	>200	1-3	moderate	8.27	0.13	0.47	68.85	100
DDTmA1	839	150	MWD	>150	c	c	<15	<15	>200	0-1	slight	8.27	0.13	0.47	68.85	100
DDTmB2	839	150	MWD	>150	c	c	<15	<15	>200	1-3	moderately	8.27	0.13	0.47	68.85	100
DDTmB3g1	839	150	MWD	>150	c	c	15-35	<15	>200	1-3	severe	8.27	0.13	0.47	68.85	100

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

of rooting depth. Marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) with moderate limitation of rooting depth and are distributed in the central, northern and northwestern part of the microwatershed. Not suitable (Class N) lands occur in small area of about 14 ha (3%) with severe limitations of rooting depth and topography and are distributed in the southern part of the microwatershed.

Table 7.2 Crop suitability criteria for Sorghum

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

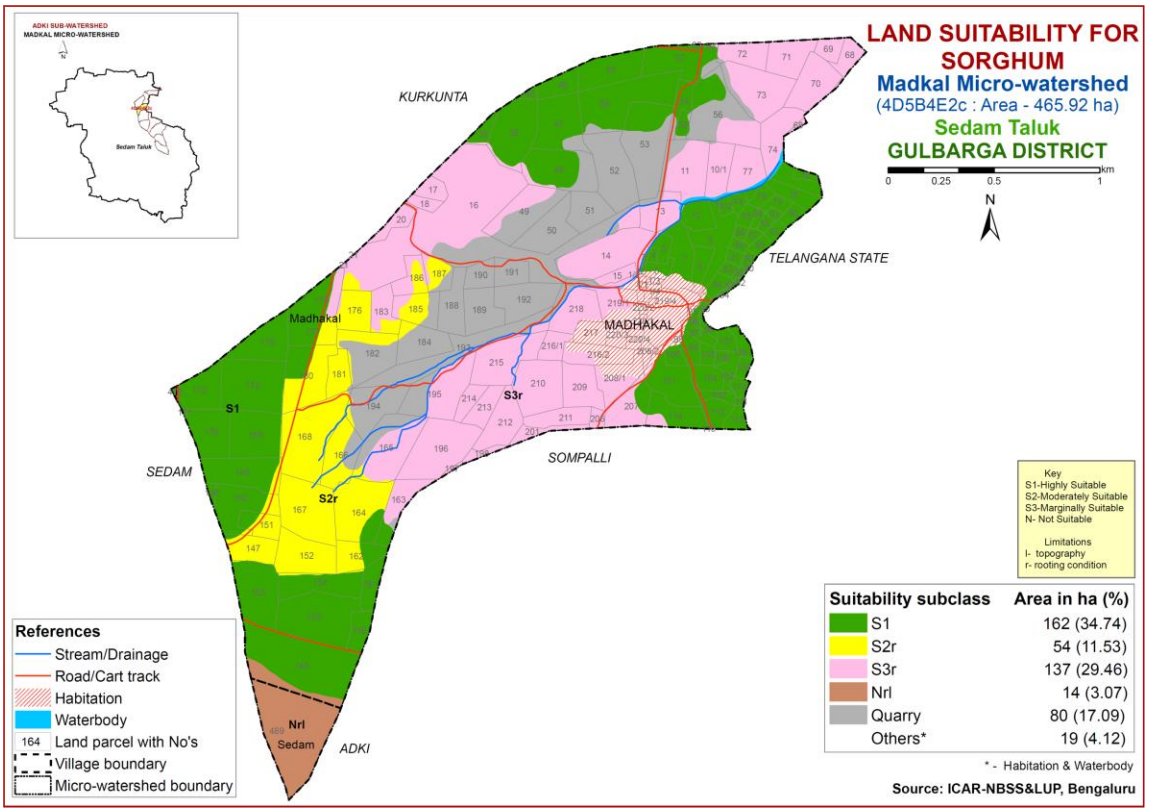


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

Maize is the most important food crop grown in an area of 13.37 lakh ha in all the district 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.

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	>8
LGP	Days	>100	100-80	60-80	
Soil drainage	class	Well drained	Mod. to imperfectly	Poorly/excessively	V.poorly
Soil reaction	pH	5.5-7.5	7.6-8.5	8.6-9.0	
Surface soil texture	Class	l, cl, scl, sil	sl, sicl, sic	c(s-s), ls	s,fragmental
Soil depth	cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-50	>50
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	2.0-4.0	
Sodicity (ESP)	%	<10	10-15	>15	

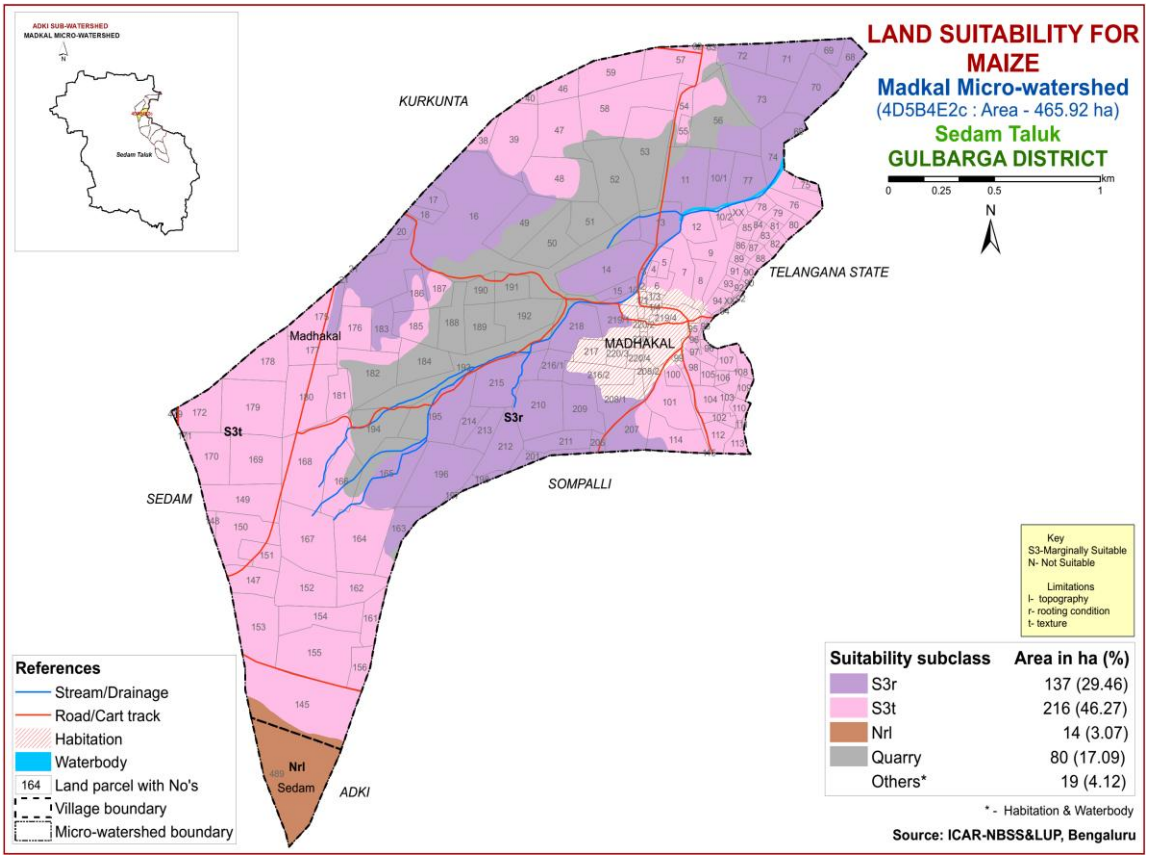


Fig. 7.2 Land Suitability map of Maize

In Madkal microwatershed, there are no lands that are highly (Class S1) and moderately (Class S2) suitable for growing maize. The marginally suitable (Class S3) lands cover a maximum area of about 353 ha (76%) and occur in the major part of the microwatershed. They have moderate limitations of texture and rooting depth. Not Suitable (Class N) lands occur in an area of about 14 ha (3%) and are distributed in the southern part of the microwatershed with severe limitations of rooting depth and topography.

7.3 Land Suitability for Red gram/Pigeonpea (*Cajanus cajan*)

Red gram is one of the major pulse crop grown in an area of 7.28 lakh ha mainly in northern Karnataka in Bijapur, Kalaburgi, Raichur, Bidar, Belgaum, Dharwad and Bellary districts. The crop requirements for growing red gram (Table 7.4) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and a land suitability map for growing red gram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

In Madkal microwatershed, there are no lands that are highly (Class S1) suitable for growing redgram. About 216 ha (46%) is moderately suitable (Class S2) for red gram and distributed in the major part of the microwatershed. They have minor limitations of texture and rooting depth. Marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) with moderate limitation of rooting depth and are distributed in the central, northwestern and northern part of the microwatershed. Not suitable (Class N) lands occur in an area of about 14 ha (3%) with severe limitations of rooting depth and topography and are distributed in the southern part of the microwatershed.

Table 7.4 Crop 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. to 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
Surface soil texture	Class	l, scl, sil, cl, sl	sicl, sic, c(m)	ls	S,fragmental
Soil depth	Cm	>100	85-100	40-85	<40
Gravel content	% vol.	<20	20-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

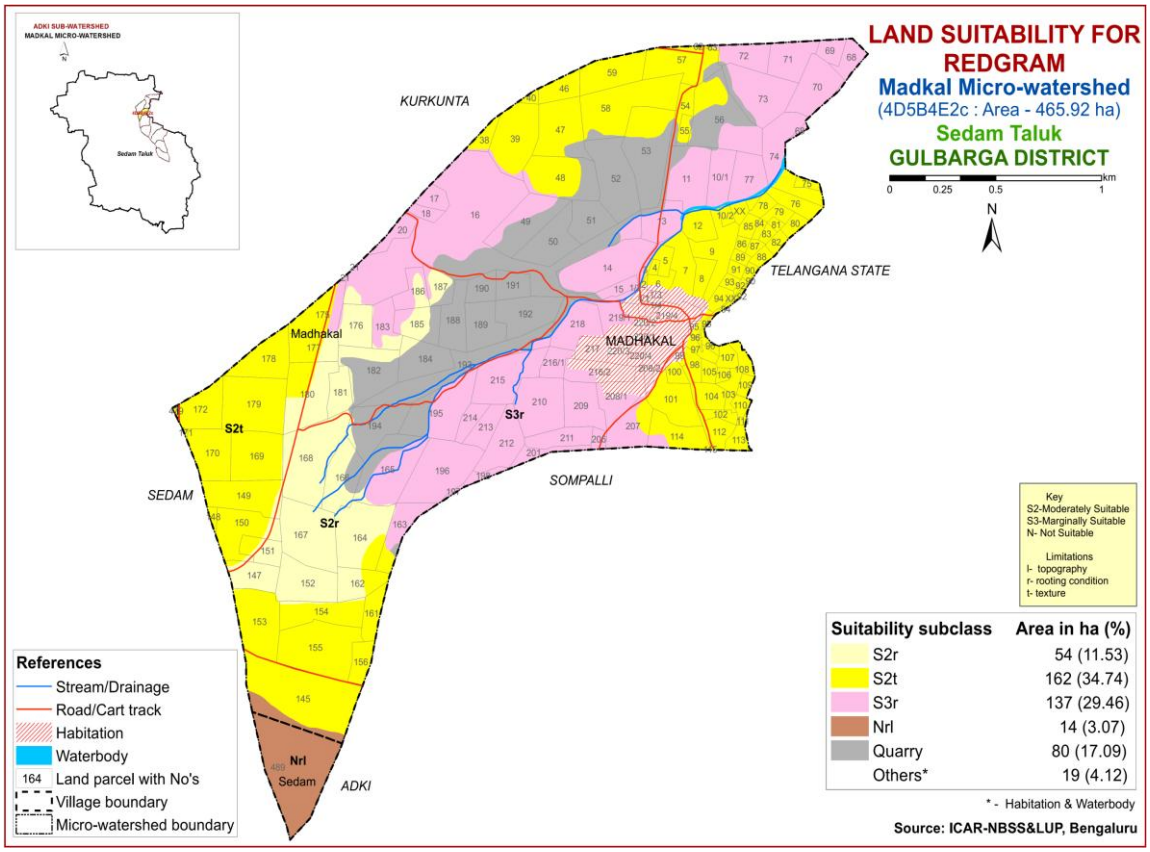


Fig. 7.3 Land Suitability map of Red gram

7.4 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is one of the most important oilseed crop grown in an area of 3.56 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

Table 7.5 Crop suitability criteria for Sunflower

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

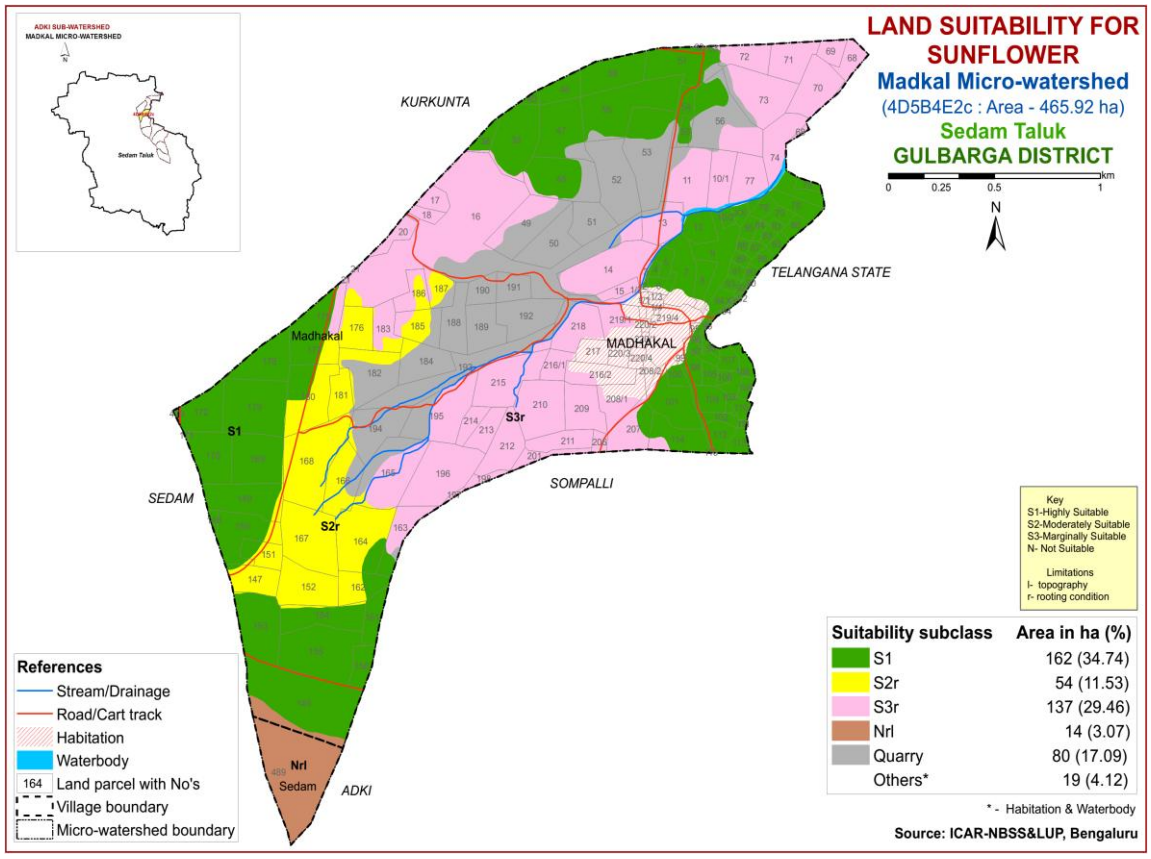


Fig. 7.4 Land Suitability map of Sunflower

In Madkal microwatershed, the highly (Class S1) suitable lands for growing sunflower occur in a maximum area of about 162 ha (35%) with minor or no limitations for growing sunflower. An area of about 54 ha (12%) is moderately suitable (Class S2) for growing sunflower and is distributed in the central part of the microwatershed. They have minor limitation of rooting depth. Marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) with moderate limitation of rooting depth and are distributed in the central, northwestern and northern part of the microwatershed. Not suitable (Class N) lands occur in an area of about 14 ha (3%) with severe limitations of rooting depth and topography and are distributed in the southern part of the microwatershed.

7.5 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, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.6) 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 7.5.

In Madkal microwatershed, the highly (Class S1) suitable lands for growing cotton occur in an area of about 162 ha (35%) with minor or no limitations for growing cotton and are distributed in the major part of the microwatershed. An area of about 54 ha (12%) is moderately suitable (Class S2) for cotton with minor limitation of rooting depth

and are distributed in the central part of the microwatershed. The marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) with moderate limitation of rooting depth and are distributed in the central, northwestern and northern part of the microwatershed. Not suitable (Class N) lands occur in a small area of about 14 ha (3%) and are distributed in the southern part of the microwatershed. They have severe limitations of rooting depth and topography.

Table 7.6 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 mod.well	imperfectly drained	Poor some whatexcessive	Stagnant/excessive
Soil reaction	pH	6.5-7.5	7.6-8.0	8.1-9.0	>9.0 >6.5
Surface soil texture	Class	sic, c	sicl, cl	si,sil,sc,scl,l	sl, s,ls
Soil depth	Cm	100-150	60-100	30-60	<30
Gravel content	% vol.	<5	5-10	10-15	15-35
$CaCO_3$ in root zone	%	<3	3-5	5-10	10-20
Salinity (EC)	dSm^{-1}	2-4	4.0-8.0	8.0-12	>12
Sodicity (ESP)	%	5-10	10-20	20-30	>30

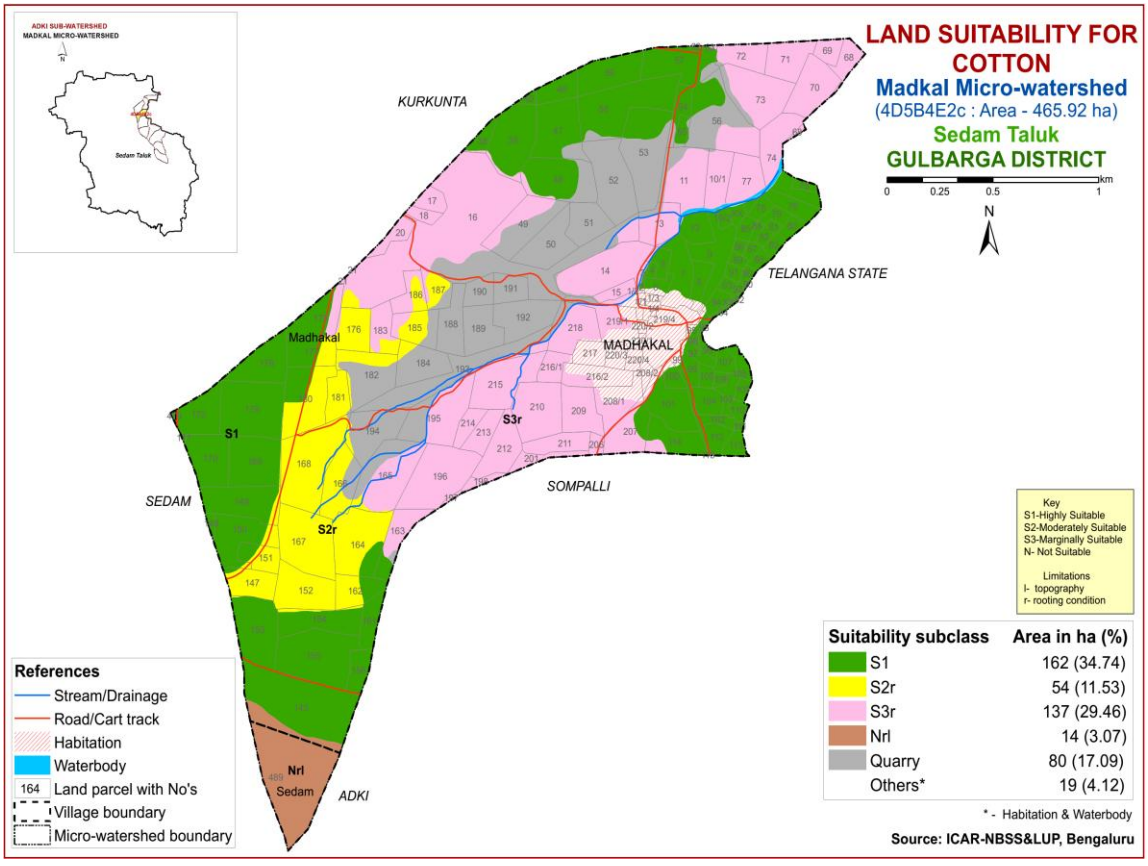


Fig. 7.5 Land Suitability map of Cotton

7.6 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 under irrigated conditions. The crop requirements for growing sugarcane (Table 7.7) 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 7.6.

Table 7.7 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)	dSm^{-1}	<2.0	2.0-4.0	4.0-9.0	>9
Sodicity (ESP)	%	<10	10-15	15-25	>25

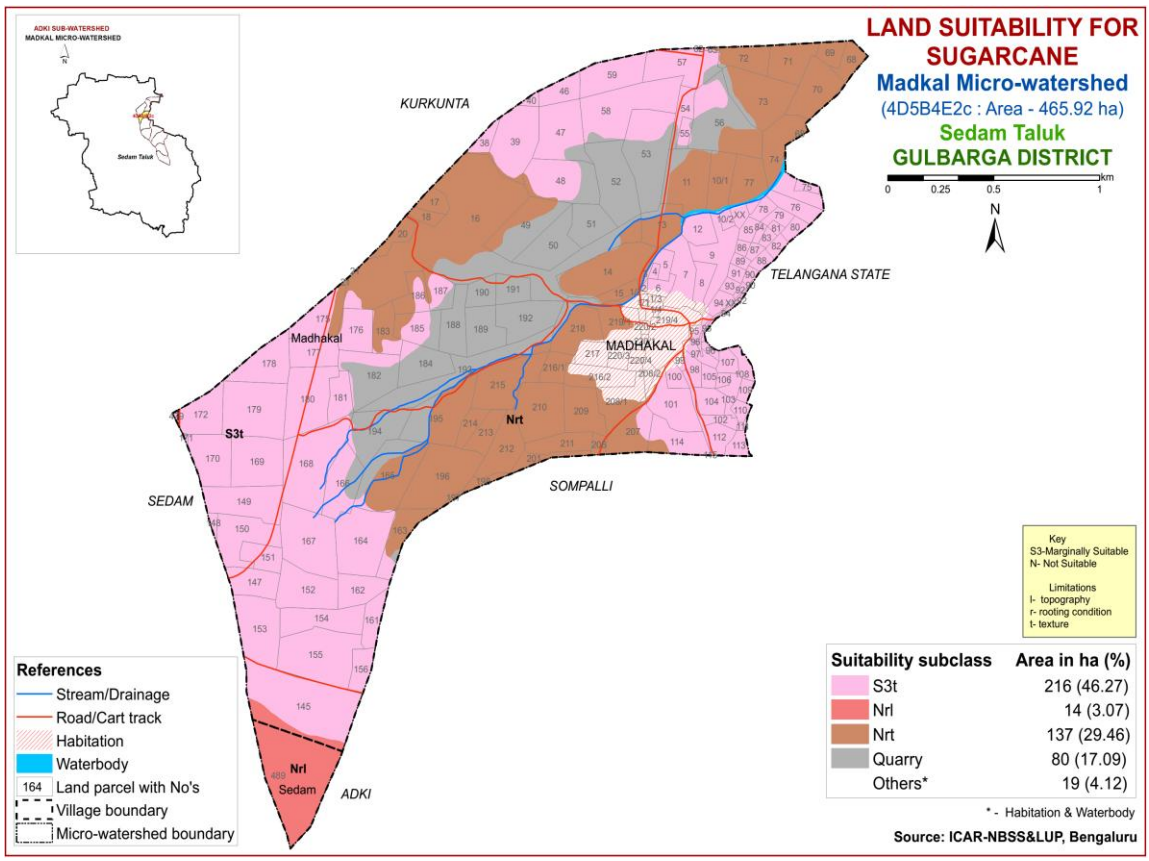


Fig. 7.6 Land Suitability map of Sugarcane

Highly (Class S1) and moderately suitable (Class S2) lands are not available for growing sugarcane in Madkal microwatershed. The marginally suitable (Class S3) lands cover a maximum area of about 216 ha (46%) and are distributed in the major part of the microwatershed. They have moderate limitation of texture. Not suitable (Class N) lands occur in an area of about 151 ha (33%) and are distributed in the southern, central, northwestern and northern part of the microwatershed. They have severe limitations of rooting depth, topography and texture.

7.7 Land Suitability for Soybean (*Glycine max*)

Soybean is one of 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 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 7.7.

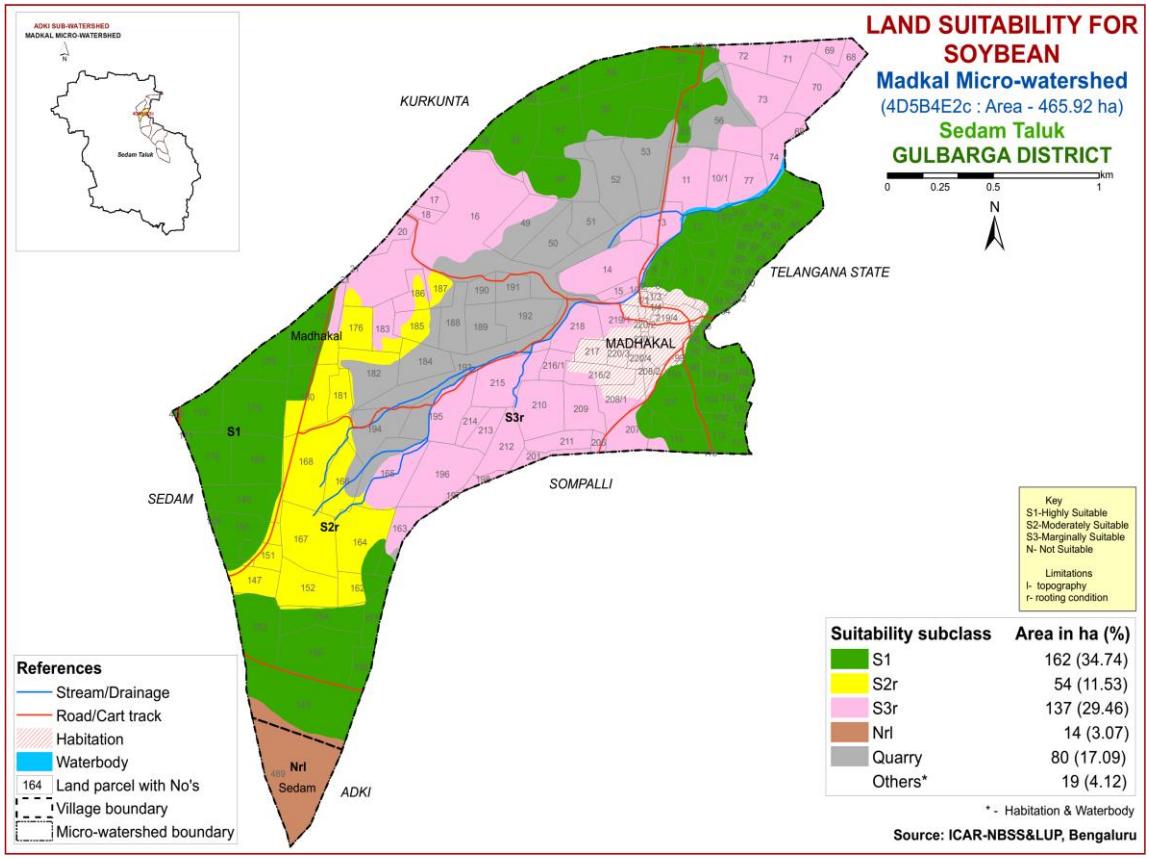


Fig. 7.7 Land Suitability map of Soybean

Highly suitable (Class S1) lands for growing soybean occur in a maximum area of about 162 ha (35%) and distributed in the major part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 54 ha (12%) in the microwatershed. These soils have minor limitation of rooting depth. They are distributed in the central part of the microwatershed. Marginally suitable (Class S3) lands occur in

137 ha (29%) area with moderate limitation of rooting depth and are distributed in the central, northwestern and northern part of the microwatershed. Not suitable (Class N) lands occur in 14 ha (3%) and are distributed in the southern part of the microwatershed. They have severe limitations of rooting depth and topography.

7.8 Land Suitability for Bengal gram (*Cicer aerativum*)

Bengal gram is one of the most important pulse crop grown in about 9.39 lakh ha area in Bijapur, Raichur, Kalaburgi, Dharwad, Belgaum and Bellary districts. The crop requirements for growing Bengal gram (Table 7.8) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing Bengal gram was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

Highly suitable (Class S1) lands for growing Bengal gram occur in a maximum area of about 216 ha (46%) and are distributed in the major part of the microwatershed. Moderately suitable (Class S2) lands found to occur in an area of 137 ha (29%). The soils have minor limitation of rooting depth for growing Bengal gram and are distributed in the central, northwestern and northern part of the microwatershed. Not suitable (Class N) lands occur in an area of about 14 ha (3%) and are distributed in the southern part of the microwatershed. They have severe limitations of rooting depth and topography.

7.8 Land 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;imp.drained	Poorly drained; exc.drained	Very Poorly drained
Soil reaction	pH	6.0-7.5	5.5-5.7,7.6-8.0	8.1-9.0,4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	sl, c>60%	
Soil depth	Cm	>75	51-75	25-50	<25
Gravel content	% vol.	<15	15-35	>35	
Salinity (ECe)	dsm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

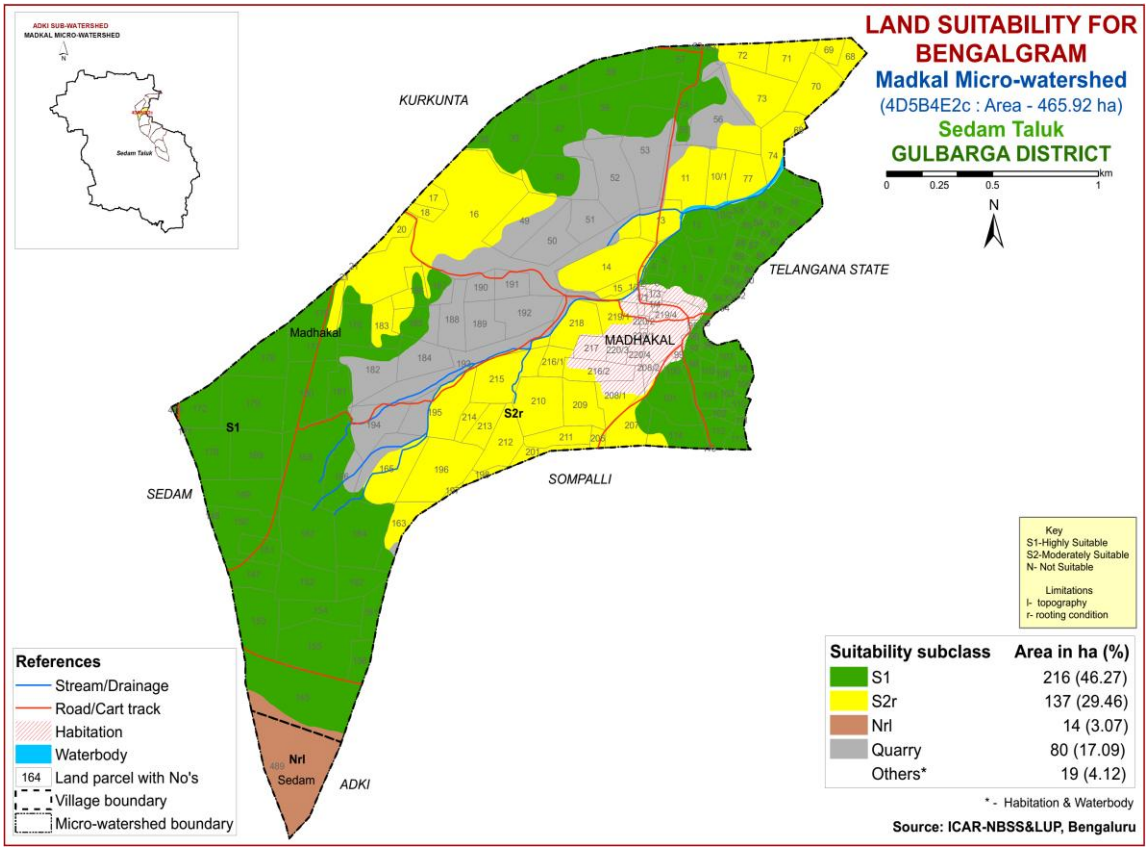


Fig. 7.8 Land Suitability map of Bengal gram

7.9 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in about 6558 ha area in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga, Bangalore and Chamarajnagar districts. The crop requirements for growing guava (Table 7.9) were matched with the soil-site characteristics (Table 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 7.9.

In Madkal microwatershed, there are no highly (Class S1) and moderately suitable (Class S2) lands available for growing guava. The marginally suitable (Class S3) lands found to occur in a maximum area of about 215 ha (46%) and are distributed in the major part of the microwatershed. They have moderate limitations of texture and rooting depth. The not suitable (Class N) lands occur in an area of 151 ha (33%) with severe limitations of texture, topography and rooting depth and are distributed in the central, northwestern, northern and southern part of the microwatershed.

Table 7.9 Crop suitability criteria for Guava

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

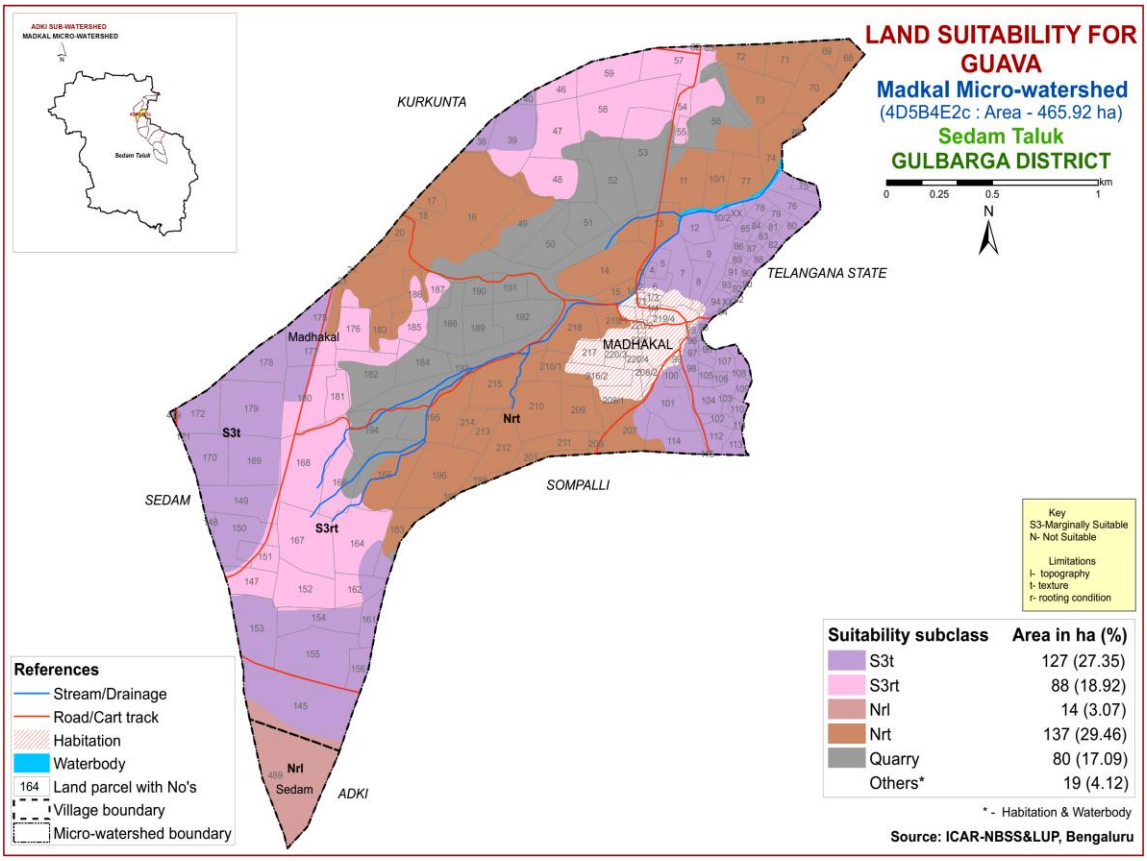


Fig 7.9 Land Suitability map of Guava

7.10 Land Suitability for Mango (*Mangifera indica*)

Mango is one of the most important fruit crop grown in about 1.73 lakh ha area in all the districts of the State. The crop requirements for growing mango (Table 7.10) 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 is given in Figure 7.10.

No highly (Class S1) and moderately suitable (Class S2) lands are available for growing mango in the Madkal microwatershed. The marginally suitable (class S3) lands cover an area of about 161 ha (35%) and occur in southern, western, eastern and northern part of the microwatershed. They have moderate limitation of texture. Not suitable (Class N) lands occur in a maximum area of about 205 ha (44%) with severe limitations of rooting depth and topography and are distributed in the major part of the microwatershed.

Table 7.10 Crop suitability criteria for Mango

Crop requirement			**Rating**			
soil-site characteristics		**Unit**	**Highly suitable(S1)**	**Moderately Suitable(S2)**	**Marginally suitable(S3)**	**Not suitable(N)**
climate	Temp in growing season	^{0}C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^{0}C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	class	Well drained	Mod. To imp.drained	Poor drained	V.poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	sc, l, sil, cl	sl, sc, sic, l,c	c (<60%)	c (>60%),
	pH	1:2.5	5.5-7.5	7.6-8.5,5.0-5.4	8.6-9.0,4.0-4.9	>9.0 <4.0
	OC	%	High	medium	low	
	$CaCO_3$ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	% vol.	Non gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS/m	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

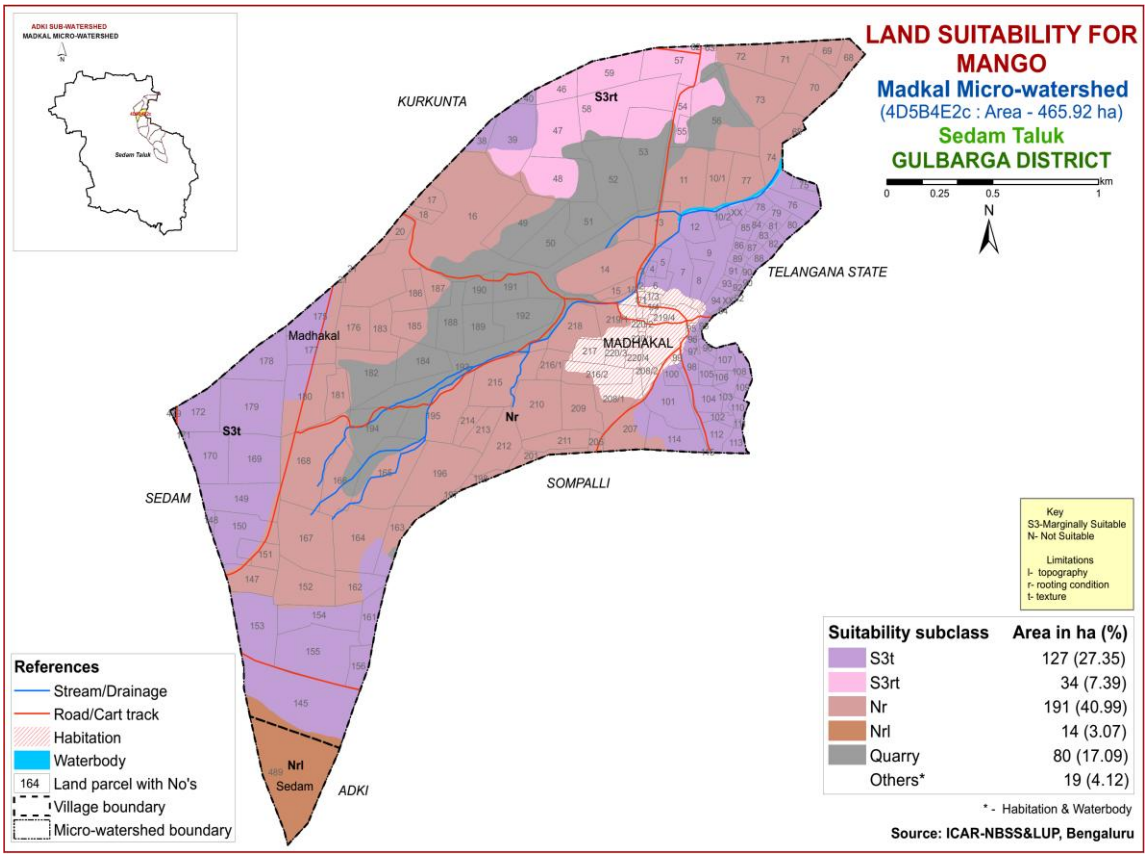


Fig. 7.10 Land Suitability map of Mango

7.11 Land Suitability for Sapota (*Manilkara zapota*)

Sapota is one of the most important fruit crop grown in about 0.29 lakh ha area in almost all the districts of the state. The crop requirements for growing sapota (Table 7.11) 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 7.11.

In Madkal microwatershed, there are no highly (Class S1) and moderately (Class S2) suitable lands available for growing sapota. Marginally suitable lands are found to occur in an area of 215 ha (46%). The soils have moderate limitations of texture and rooting depth and are distributed in the major part of the microwatershed. Not suitable (Class N) lands occur in an area of about 151 ha (33%) with severe limitations of rooting depth and topography and are distributed in the central, northwestern, northern and southern part of the microwatershed.

Table 7.11 Crop suitability criteria for Sapota

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

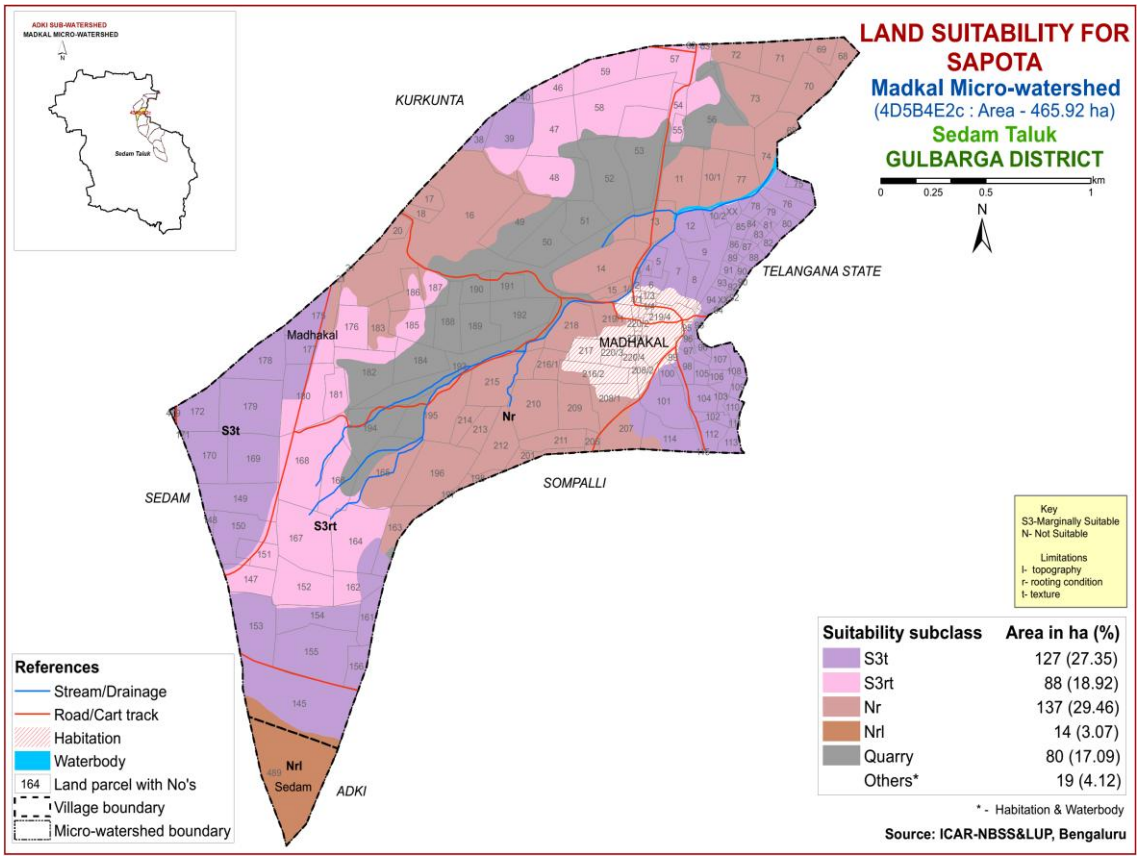


Fig. 7.11 Land Suitability map of Sapota

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is one of the most important fruit crop grown in about 5368 ha area 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.12.

No highly (Class S1) and moderately suitable (Class S2) lands are available for growing jackfruit in the microwatershed. The marginally suitable (Class S3) lands cover an area of 215 ha (46%) and occur in the major part of the microwatershed. They have moderate limitations of texture and rooting depth. The not suitable (Class N) lands occur in an area of about 151 ha (33) with severe limitations of rooting depth, topography and texture and occur in the central, northwestern, northern and southern part of the microwatershed.

7.12 Land suitability criteria for Jackfruit

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

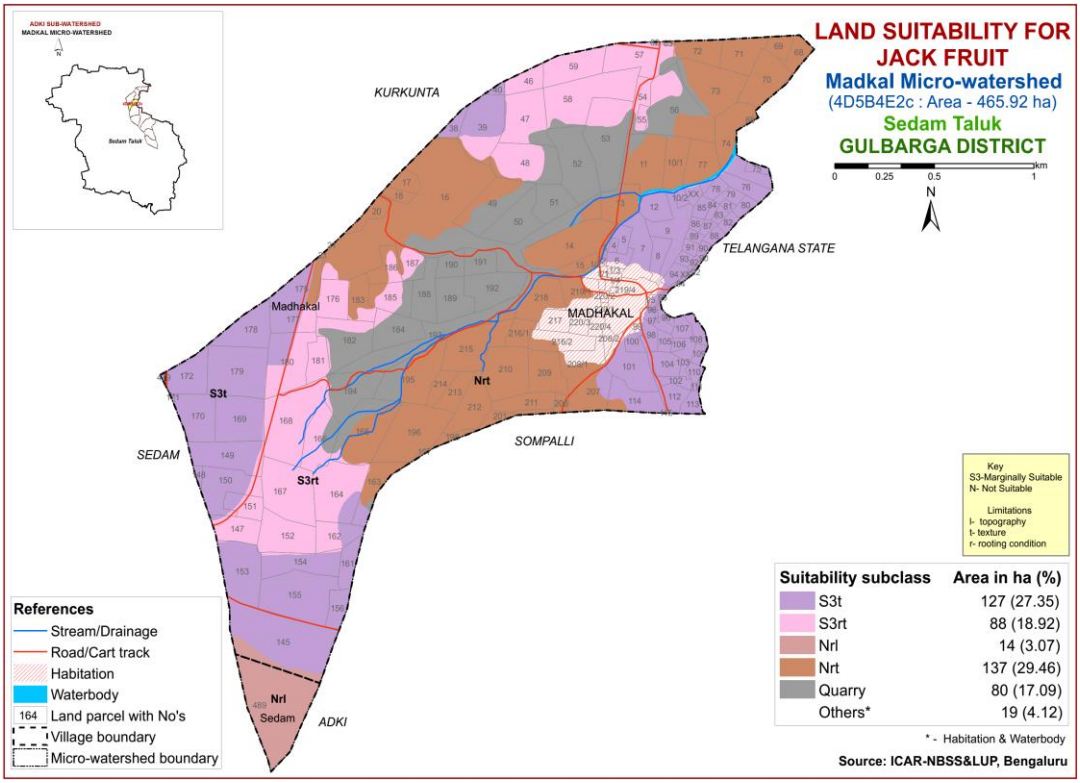


Fig 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is the most 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

7.13 Land suitability criteria for Jamun

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

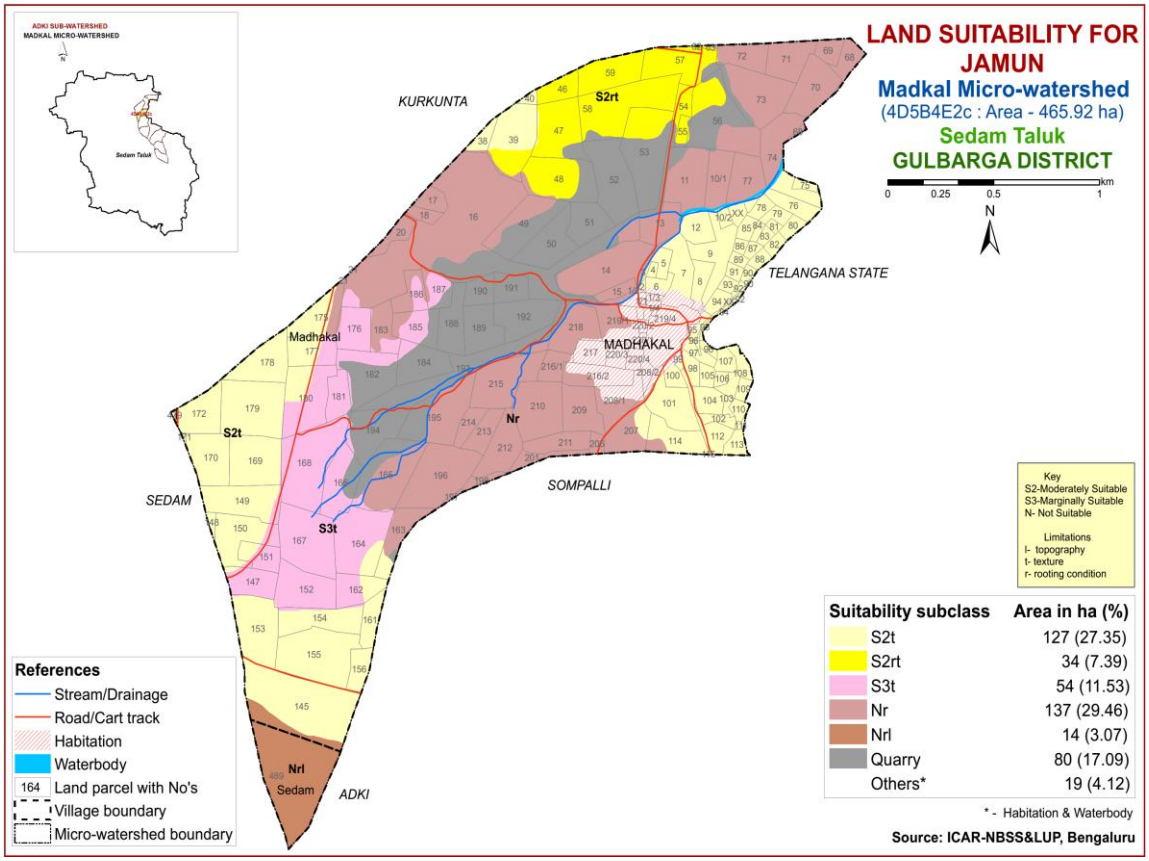


Fig 7.13 Land Suitability map of Jamun

No highly (Class S1) suitable lands are available for growing jamun in the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of

161 ha (35%). The soils have minor limitations of texture and rooting depth. They are distributed in the major part of the microwatershed. Marginally suitable (Class S3) lands occur in 54 ha (12%) and are distributed in the central part of the microwatershed. They have moderate limitation of texture. Not suitable (Class N) lands occur in an area of about 151 ha (33%) and are distributed in the central, northwestern, northern and southern part of the microwatershed. They have severe limitations of rooting depth and topography.

7.14 Land Suitability for Musambi (*Citrus limetta*)

Musambi is one of the most important fruit crop grown in about 5446 ha area in almost all the districts of the state. The crop requirements for growing musambi (Table 7.14) 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

Highly suitable (Class S1) lands are found to occur in an area of 127 ha (27%) and are distributed in the major part of the microwatershed. Moderately suitable (Class S2) lands occur in an area of 34 ha (7%) and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and texture. Marginally suitable (Class S3) lands occur in an area of about 54 ha (12%) and are distributed in the central part of the microwatershed with moderate limitation of rooting depth. The not suitable (Class N) lands occur in an area of about 151 ha (33%) and area distributed in the central, northwestern, northern and southern part of the microwatershed. They have severe limitations of rooting depth and topography.

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	Temp 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 imp.drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl,l,sicl,cl,s	Sc, sc, c	C (>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4,7.6-8.0	4.0-5.4, 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting condition	Soil depth	cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

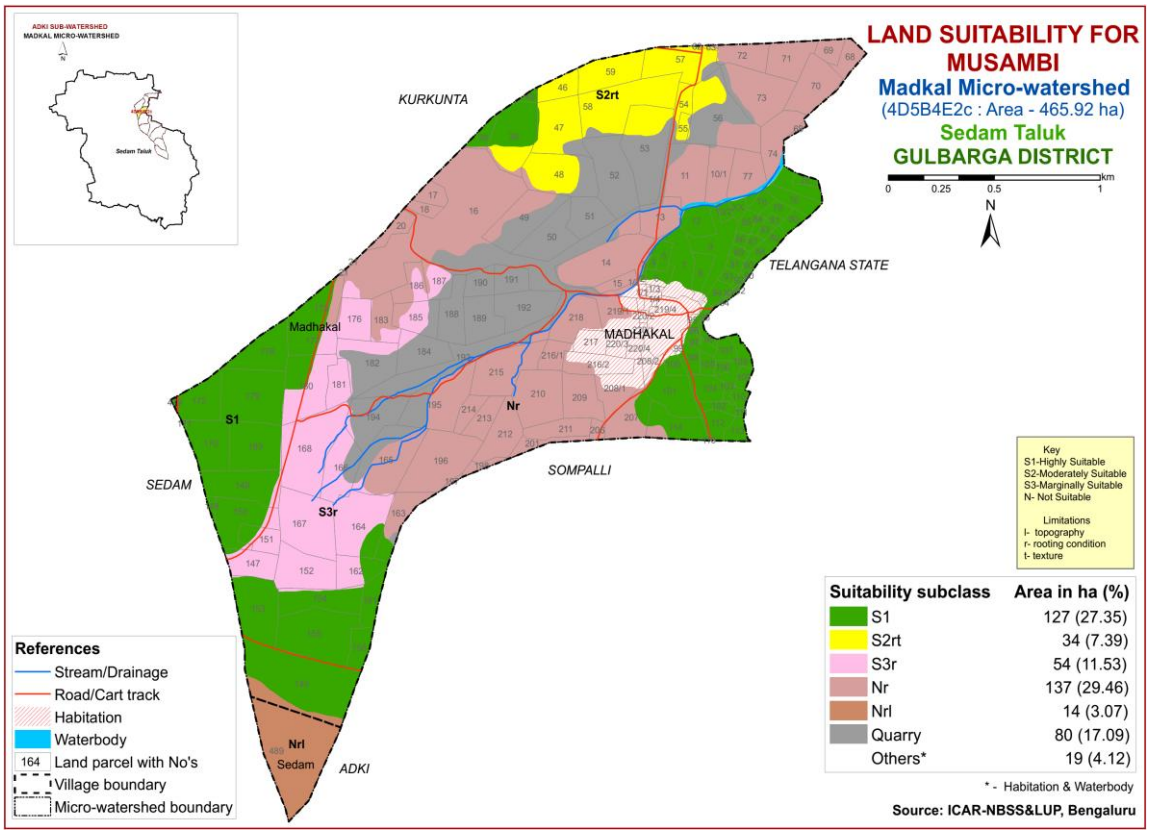


Fig 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is one of the most important fruit crop grown in about 0.11 lakh 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 is given in Figure 7.15.

Highly suitable (Class S1) lands for growing lime occur in an area of 127 ha (27%) and are distributed in the major part of the microwatershed. Moderately suitable (Class S2) lands occur in an area of 34 ha (7%) and are distributed in the northern part of the microwatershed with minor limitations of rooting depth and texture. Marginally suitable (Class S3) lands occur in an area of about 54 ha (12%) and are distributed in the central part of the microwatershed with moderate limitation of rooting depth. The not suitable (Class N) lands occur in an area of about 151 ha (33%) and area distributed in the central, northwestern, northern and southern part of the microwatershed. They have severe limitations of rooting depth and topography.

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	Temp 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 imp.drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl,l,sicl,cl,s	Sc, sc, c	C (>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4, 7.6-8.0	4.0-5.4, 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting condition	Soil depth	cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

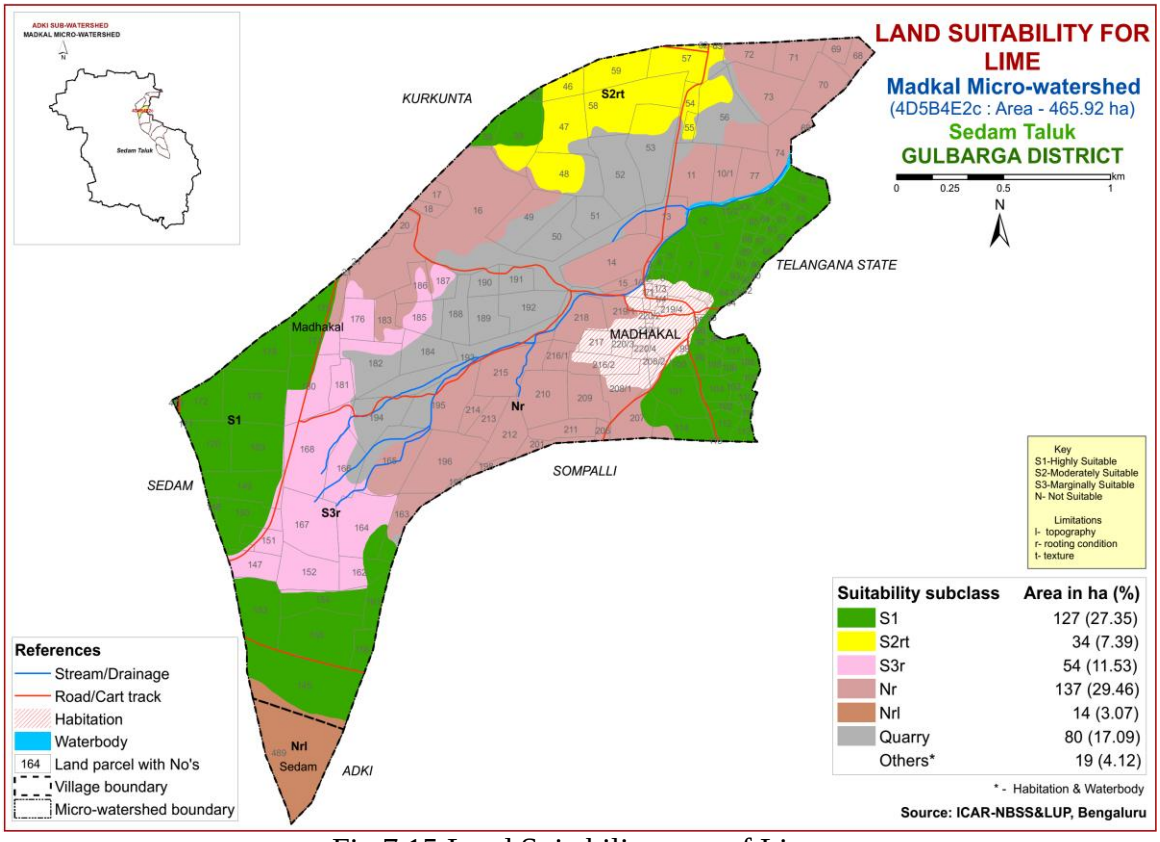


Fig 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is one of the most important plantation crop grown in about 0.70 lakh ha area in almost all the districts. 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 is given in Figure 7.16.

There are no suitable lands available for growing cashew in the entire area of the microwatershed.

7.16 Land 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

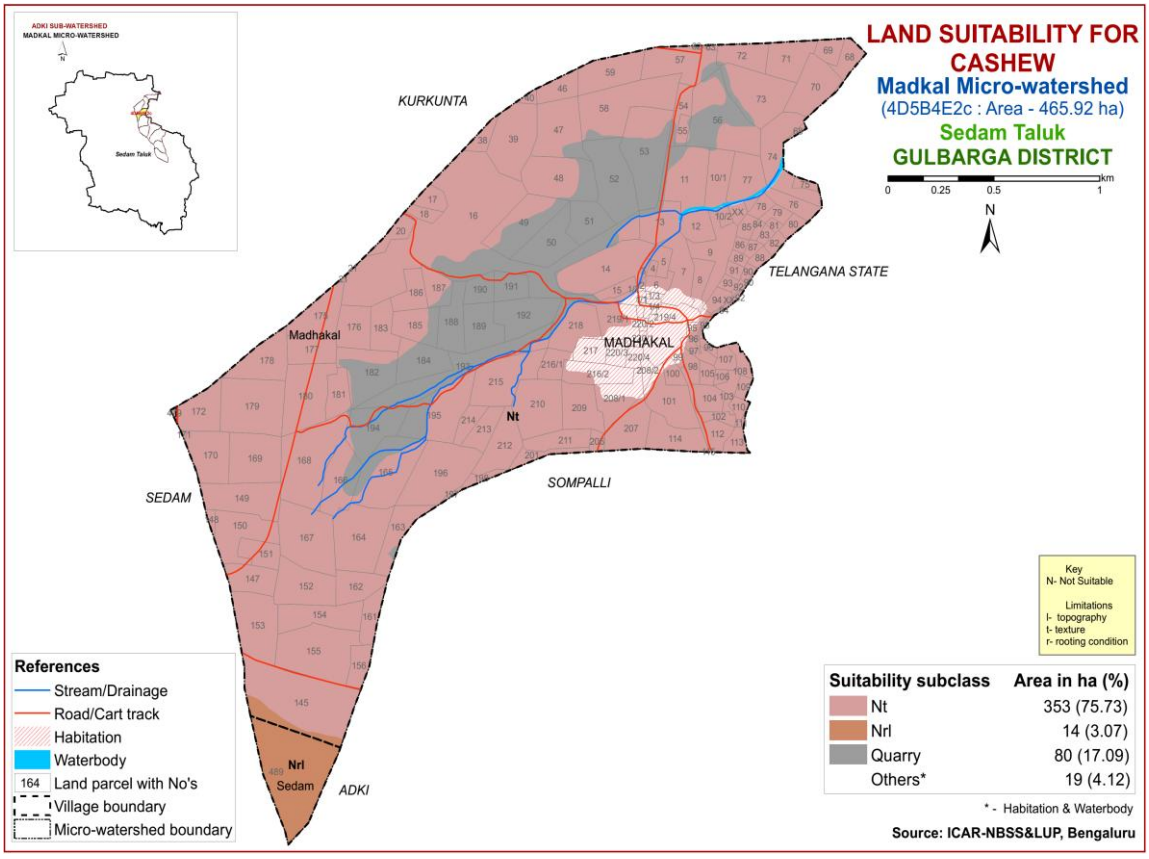


Fig 7.16 Land Suitability map of Cashew

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

Custard apple is the most important fruit crop grown in about 1426 ha area in almost all the districts of the state. The crop requirements for growing custard apple (Table 7.17) 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 is given in Figure 7.17.

7.17 Land suitability criteria for Custard apple

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

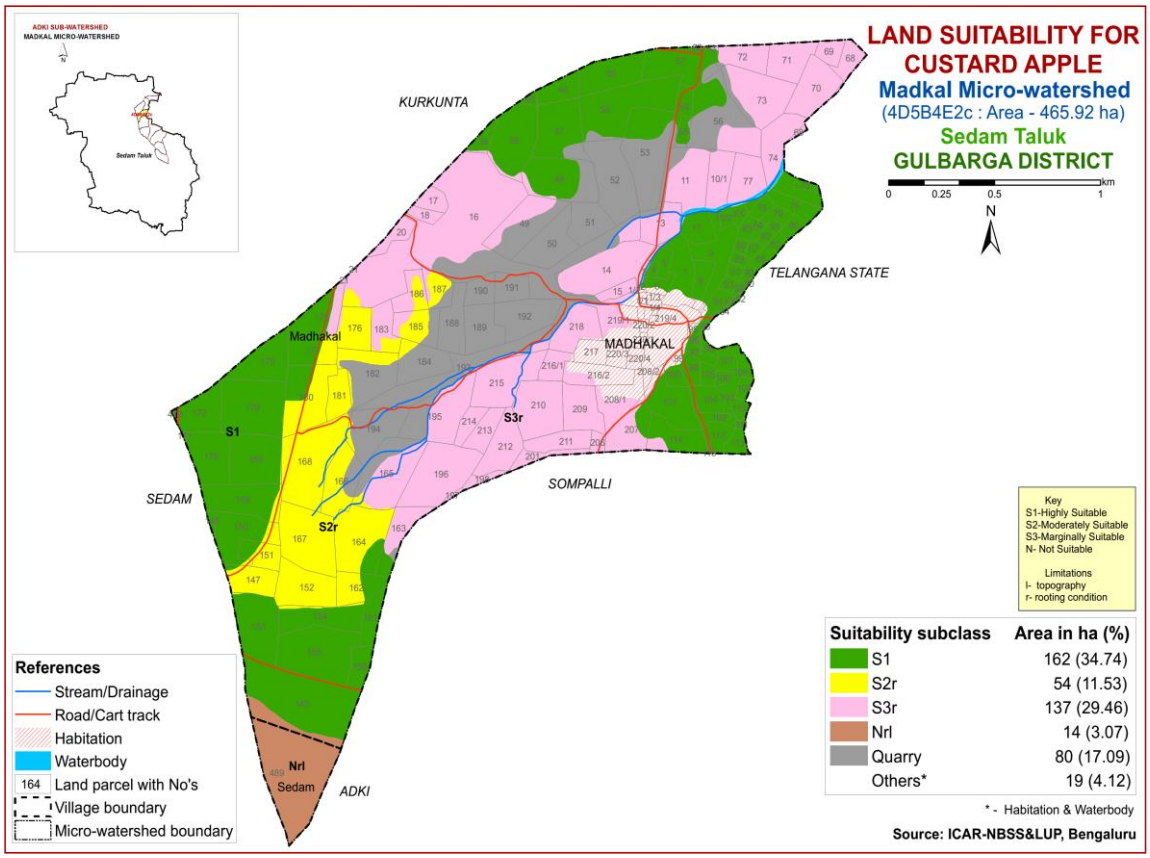


Fig 7.17 Land Suitability map of Custard Apple

Highly suitable (Class S1) lands are found to occur in a maximum area of 162 ha (35%) and are distributed in the major part of the microwatershed. They have minor or no limitations for growing custard apple. Moderately suitable (Class S2) lands occur in 54 ha (12%) and are distributed in the central part of the microwatershed with minor limitation of rooting depth. Marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) and are distributed in the central, northwestern and northern part of the microwatershed. They have moderate limitation of rooting depth. Not suitable (Class N) lands occur in an area of 14 ha (3%) and are distributed in the southern part of the microwatershed. They have severe limitations of rooting depth and topography.

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is one of the most important fruit and medicinal crop grown in about 151 ha area in almost all the districts of the state. The crop requirements for growing amla (Table 7.18) 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 geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

Highly suitable (Class S1) lands are found to occur in a maximum area of 162 ha (35%). They have minor or no limitations for growing amla and are distributed in the major part of the microwatershed. Moderately suitable (Class S2) lands occur in 54 ha (12%) and are distributed in the central part of the microwatershed with minor limitation of rooting depth. Marginally suitable (Class S3) lands occur in an area of about 137 ha (29%) and are distributed in the central, northwestern and northern part of the microwatershed. They have moderate limitation of rooting depth. Not suitable (Class N) lands occur in an area of 14 ha (3%) and are distributed in the southern part of the microwatershed. They have severe limitations of rooting depth and topography.

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

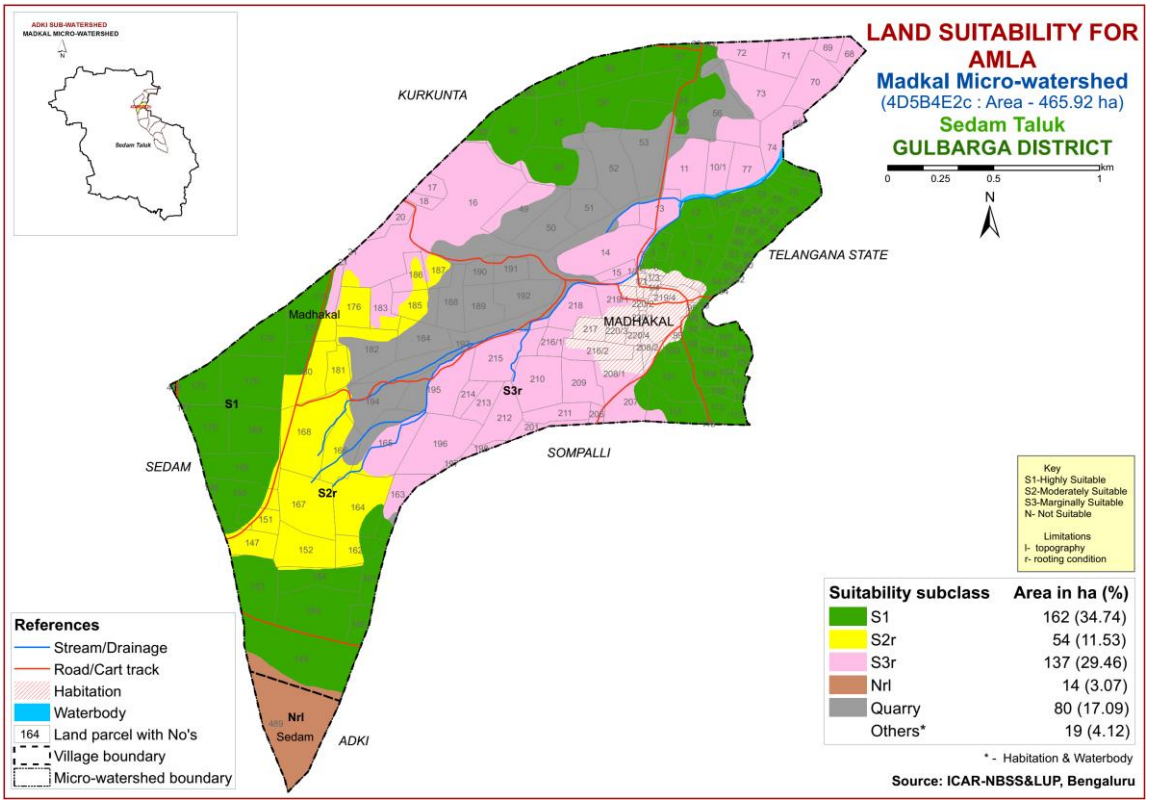


Fig 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is one of the most important spice crop raised in about 0.14 lakh ha area in 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 geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

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

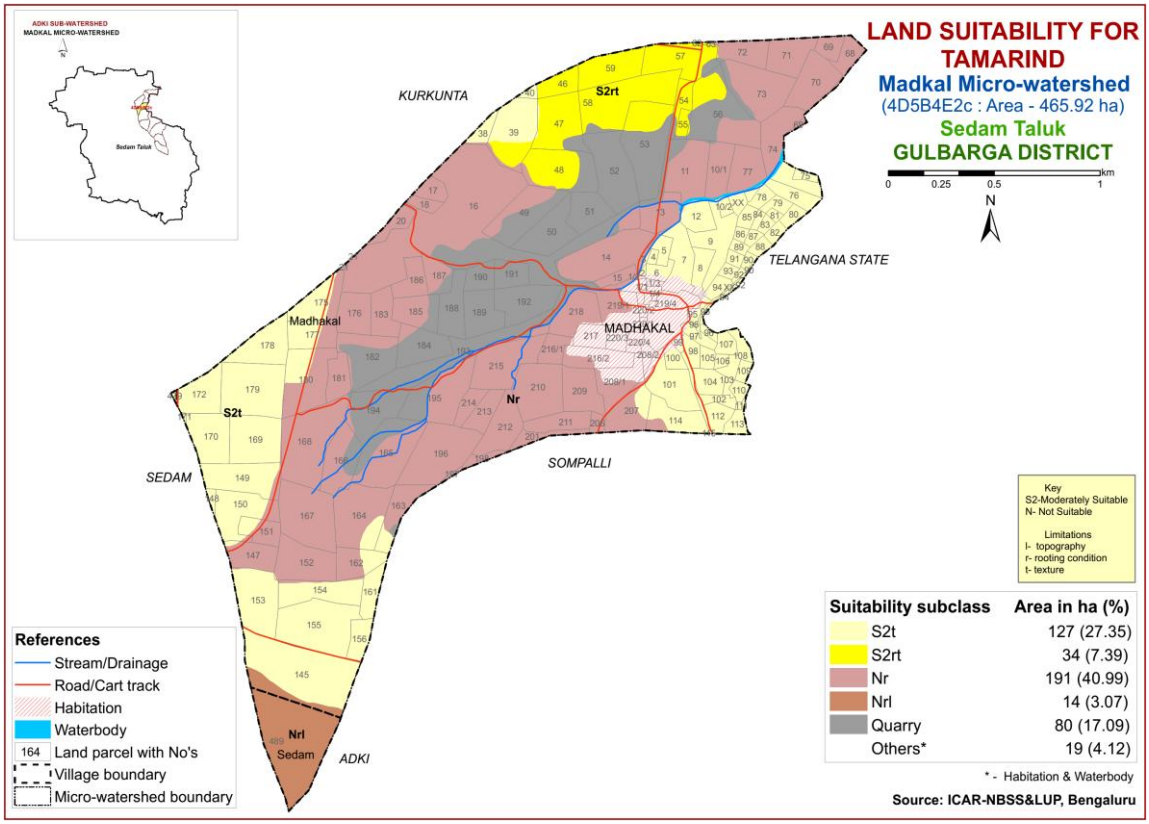


Fig 7.19 Land Suitability map of Tamarind

No highly (Class S1) suitable lands are available for growing tamarind in the Madkal microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of 161 ha (35%). The soils have moderate limitations of texture and rooting depth. They are distributed in the central, western, northern and eastern part of the microwatershed. Not suitable (Class N) lands occur in a maximum area of 205 ha (44%) and are distributed in the major part of the microwatershed. They have severe limitations of rooting depth and topography.

7.20 Land Management Unit (LMU)

The 14 soil map units identified in Madkal microwatershed have been grouped into 5 Land Management Unit (LMU) for the purpose of preparing a Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Unit map (Fig.7.20) has been generated. These Land Management Unit are expected to behave similarly for a given level of management.

The 14 map units that have been grouped into 5 Land Management Unit along with brief description of soil and site characteristics are given below.

LMUs	Soil map units	Soil and site characteristics
LMU-1	1 GGNmD3g2	Very shallow black soils (<25 cm), 5-10 % slopes, very gravelly (35-60%), severe erosion
LMU-2	2 ADKmA1 3 ADKmB1 4 ADKmB2 5 ADKmB2g1	Shallow black soils (25-50 cm), 0-3 % slopes, non gravelly to gravelly (<15-35%), slight to moderate erosion,
LMU-3	6 TNHmA1 7 TNHmB1	Moderately shallow black soils (50-75 cm), 0-3 % slopes, slight erosion.
LMU-4	8 MTMmB2 9 MTMmB2g1	Moderately deep black soils (75-100 cm), 1-3 % slopes, non gravelly to gravelly (<15-35%), moderate erosion.
LMU-5	10 DRGmA1 11 DRGmB1 12 DRGmB2 13 DRGmB2g1 14 DDTmA1	Deep to very deep black soils (100-150 & >150 cm), 0-3 % slopes, non gravelly to gravelly (<15-35%), slight to moderate erosion

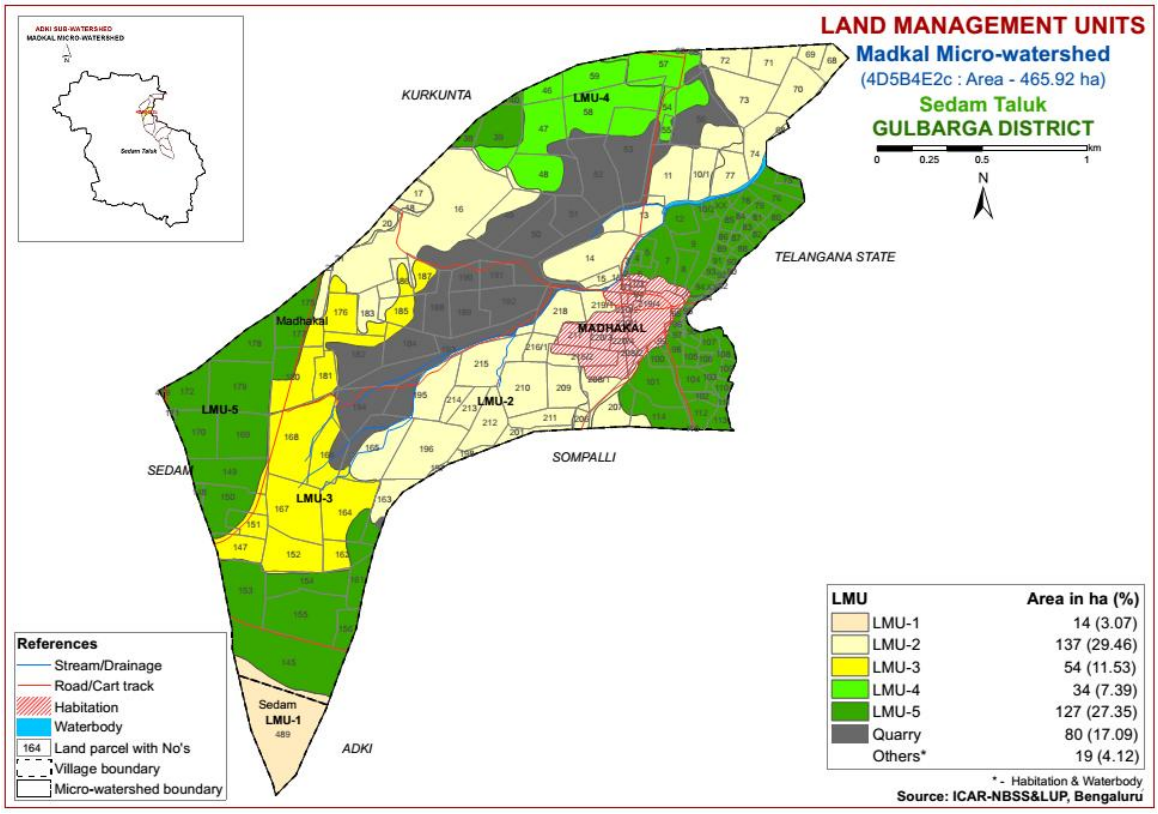


Fig. 7.20 Land Management Unit map of Madkal Microwatershed

7.21 Proposed Crop Plan for Madkal Microwatershed

After assessing the land suitability for the 19 crops, a proposed crop plan has been prepared for the 5 identified LMUs 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 Madkal Microwatershed

LMU	Mapping unit	Survey No	Soil Characteristics	Crops proposed				Suitable Intervention
				Field crops	Forestry Crop/ Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops with suitable intervention	
LMU-1	1GGNmD3g2	**Sedam:** 489	Very shallow black soils (<25 cm), 5-10 % slopes, very gravelly (35-60%), severe erosion	-	Neem, Glyricydia, Silviculture, Agave, Simaroba	-	-	Crescent bund
LMU-2	2ADKmA1 3ADKmB1 4ADKmB2 5ADKmB2g1	**Madhakal:**3,10/1,11,13,14,15,16,17,18,20,21,68,69,70,71,72,73,74,77,163,165,183,186,195,196,197,198,201,206,207,208/1,209,210,211,212,213,214, 215, 216/1,218	Shallow black soils (25-50 cm), 0-3 % slopes, non gravelly to gravelly (<15-35%), slight to moderate erosion,	Bajra, Linseed, Green gram, Black gram, Chick pea	Neem, Teak	Custard apple, Charoli, Ber, Amla	Custard apple, Charoli, Ber, Amla	Crescent bunds
LMU-3	6TNHmA1 7TNHmB1	**Madhakal:** 147,151,152,162,164,166,167, 168,176,180,181,185, 187	Moderately shallow black soils (50-75 cm), 0-3 % slopes, slight erosion.	Sorghum, Black gram, Green gram, Soybean, Sesame, Safflower **Rabi:** Sorghum, Chickpea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla **Vegetables:** Ladies finger, Brinjal, Cowpea, **Flowers:** Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Lime, Citrus **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

LMU-4	8MTMmB2 9MTMmB2g1	**Madhakal:** 46,47,48,54,55,57,58,59,62,63	Moderately deep black soils (75-100 cm), 1-3 % slopes, non gravelly to gravelly (<15-35%), moderate erosion.	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower **Rabi:** Sorghum, Chickpea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla **Vegetables:** Ladies finger, Brinjal, Cowpea, **Flowers:** Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus **Vegetables:** Onion, Tomato, Brinjal, Bhendi, Chillies, **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
LMU-5	10DRGmA1 11DRGmB1 12DRGmB2 13DRGmB2g1 14DDTmA1	**Madhakal:**2,4,5,6,7,8,9,10/2, 12,38,39,40,75,76,78,79,80,81 ,82,83,84,85,86,87,88,89,90, 91,92,93,94,95,96,97,98,100, 101,102,103,104,105,106,107, 108,109,110,111,112,113,114, 145,148,149,150,153,154,155, 156,161,169,170,171,172,175, 177, 178,179 **Sedam:** 479	Deep to very deep black soils (100-150 & >150 cm), 0-3 % slopes, non gravelly to gravelly (<15-35%), slight to moderate erosion	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sunflower, Safflower, Sesame, **Rabi:** Sorghum, wheat, Chickpea **Mixed cropping:** Red gram-cotton Pulses + sorghum	-	**Vegetables:** Ladies finger, Brinjal, Cowpea, coriander **Field crops:** Sorghum, Cotton, Red Gram, Sunflower, Safflower, **Perennial component:** 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 characteristics of a healthy soil are

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

Characteristics of Madkal Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of ADK (137 ha), DRG (106 ha), TNH (54 ha), MTM (35 ha), DDT (22 ha) and GGN (14 ha)
- As per land capability classification, entire area comes under arable land category (Class II, III & IV) and the major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, entire area of the microwatershed is moderately alkaline (pH 7.8-8.4) in reaction.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% 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 area of 466 ha in the microwatershed, an area of 236 ha is suffering from moderate and severe soil erosion. These areas need immediate soil and water conservation and other land development measures for restoring soil health.

Dissemination of information and communication of benefits

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

Inputs for Net Planning (Saturation Plan) and Interventions needed

Net planning in IWMP is focusing on preparation of

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

   In this connection, how various outputs of Sujala-III are of use in addressing these objectives of Net Planning are briefly presented 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 may 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 Madkal microwatershed.
- **Organic Carbon:** In about 209 ha (45%) area, the OC content is medium (0.5-0.75%) and in about 158 ha (34%) area it is high (>0.75%). 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 cost 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 209 ha area where OC is

less than 0.5-0.75%. For example, for rainfed maize, recommended level is 50 kg N per ha and an additional 12 kg /ha needs to be applied for all the crops grown in these plots.

- **Available Phosphorus**: In 45 ha (10%) area, the available phosphorus is low and about 232 ha (69%) area it is medium in available phosphorus in the microwatershed. Hence for all the crops, 25% additional P-needs to be applied where available P is low and medium.
- **Available Potassium:** Available potassium is medium in 93 ha (20%) area of the microwatershed, Hence, in these areas, for all crops, additional 25 % potassium may be applied. The available potassium is high in maximum area of 274 ha (59%).
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in an area of 190 ha (41%) of the microwatershed and medium in 177 ha (38%).These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- **Available Iron:** It is sufficient in an area of 342 ha (73%) and deficient in 25 ha (5%) area of the microwatershed. To manage iron deficiency, application of iron sulphate @ 25 kg/ha for 2-3 years.
- **Available Boron:** Available Boron is medium in an area of 220 ha (47%), low in 147 ha (32%). These areas need to be applied with sodium borate @10 kg/ha as soil application or 0.2% borax as foliar application to correct the boron deficiency.
- **Available Zinc:** It is deficient in 221 ha (47%) area of the microwatershed. Application of zinc sulphate @25kg/ha is to be followed. It is sufficient in 146 ha (31%) area in the microwatershed.

Soil alkalinity: An area of about 367 ha (79%) in the microwatershed has soils that are moderately 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, Acacia, Neem, Ber etc., are recommended.

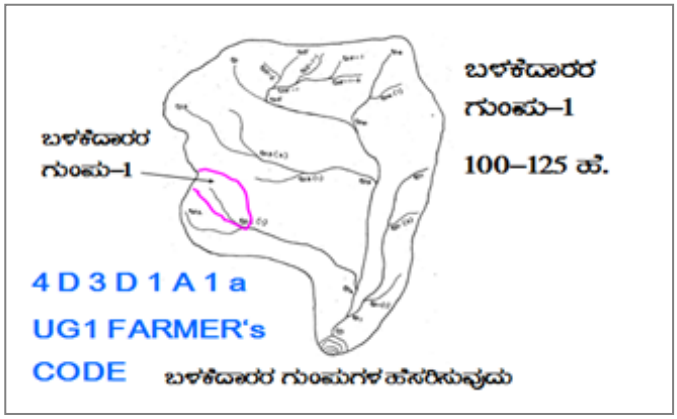
Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content, rooting depth and 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 Madkal microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were

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



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

Steps for Survey and Preparation of Treatment Plan

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

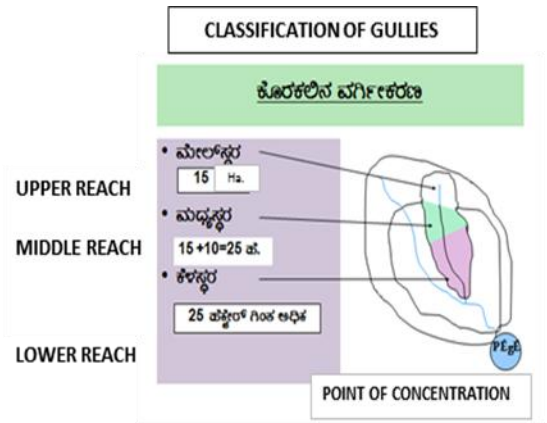
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

The treatment plan recommended for arable lands is briefly described below

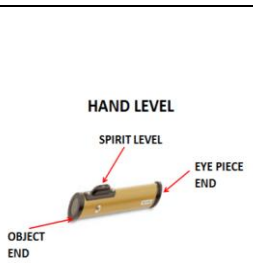
9.1.1 Arable Land Treatment

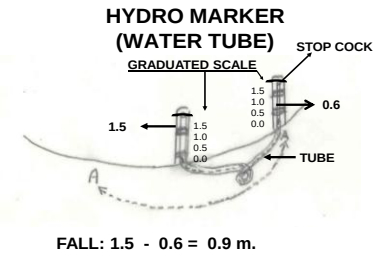
A. BUNDING

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

Measurement of Land Slope

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





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.

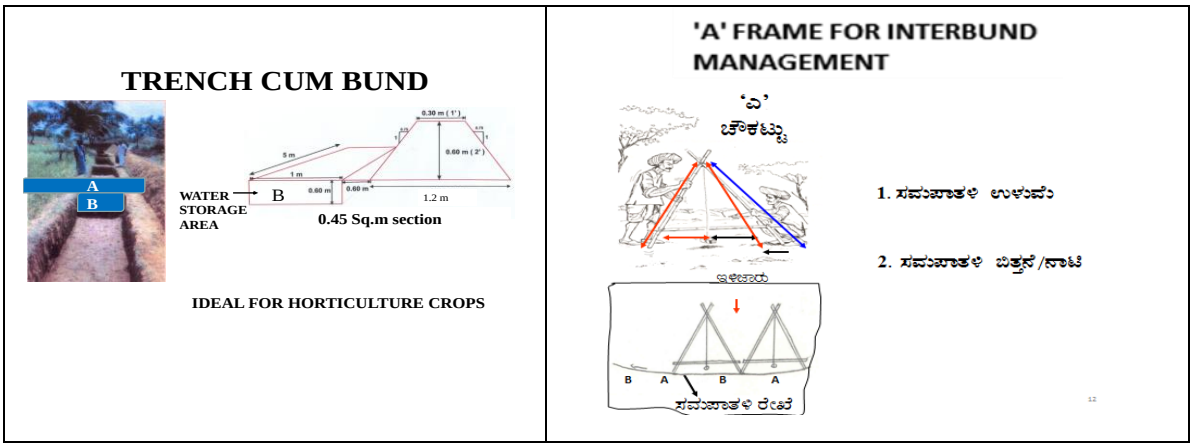
Recommended Bund Section

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 clayey black soils	
0.45	2	0.75	01:01	0.92		
0.45	2.4	0.75	1.3:1	1.07	Shallow clayey black soils	
0.6	3.1	0.7	1.78:1	1.29	Medium clayey black soils	
0.5	3	0.85	1.47:1	1.49		

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below:



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

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

B. Water Ways

- Existing waterways are marked on the cadastral map (1:7920 scale) and their dimensions are recorded.
- Considering the contour plan of the MWS, additional waterways/ modernization of the existing ones can be thought of.
- The design details are given in the Manual.

C. Farm Ponds

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

D. Diversion Channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been prepared which shows the spatial distribution and extent of area. An area of about 14 ha (3%) needs crescent bunds. About 137 ha (29%) area needs crescent bund/TCB. An area of 54 ha (12%) needs trench cum bund (TCB) and maximum area of 162 ha (35%) needs TCB/GB/ strengthening of field bunds.

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

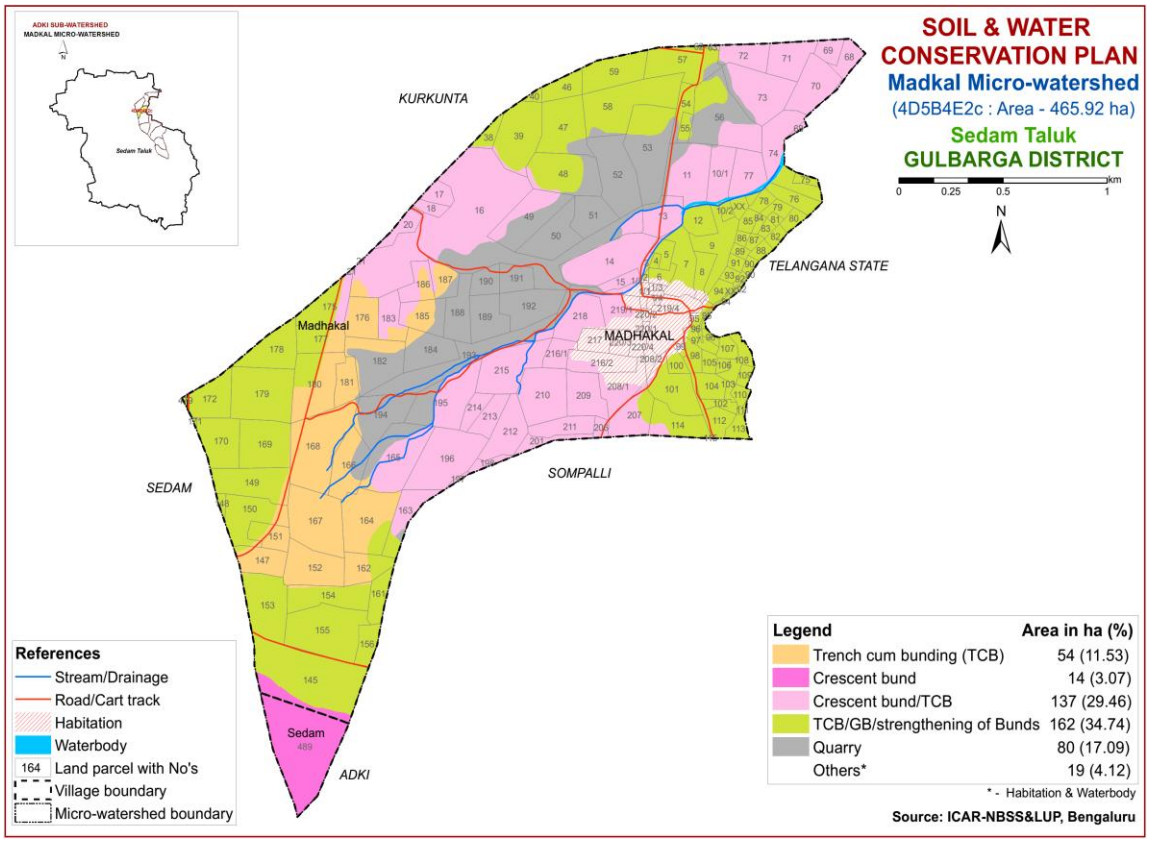


Fig. 9.1 Soil and Water Conservation Plan map of Madkal Microwatershed

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 and field bunds 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 Nerale (*Sizyzium cumini*) and Bamboo. Dry areas are to be planted with species like Honge, Bevu, Seetaphal *etc*.

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

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Appendix I

Madkal Microwatershed

Soil Phase Information

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	1/1	0.11	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	1/2	0.11	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	1/3	0.23	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	1/4	0.16	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	2	0.16	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Habitation	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	3	0.36	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	4	0.28	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	5	1.05	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	6	0.9	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	7	3.38	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow+Paddy (CF+Pd)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	8	1.48	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	9	3.78	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton+grassland (Rg+Ct+Gl)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	10/1	2.85	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	1 Farm pond	IVs	Crescent bund/TCB
Madhakal	10/2	0.48	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	11	5.61	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	1 Borewell	IVs	Crescent bund/TCB
Madhakal	12	1.98	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	13	3.02	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	14	6.68	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	15	1	ADKmA1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	16	31.17	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Grassland (Gl)	Not Available	IVs	Crescent bund/TCB
Madhakal	17	1.23	ADKmB1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Jowar (Jw)	Not Available	IVs	Crescent bund/TCB
Madhakal	18	0.81	ADKmB1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	20	1.37	ADKmB1	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Not Available (NA)	Not Available	IVs	Crescent bund/TCB

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	21	0.05	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	38	1.04	DRGmB1	LMU-5	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	TCB/GB/strengthening of Bunds
Madhakal	39	5.79	DRGmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	40	0.37	DRGmB1	LMU-5	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	TCB/GB/strengthening of Bunds
Madhakal	46	1.88	MTMmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	47	5.49	MTMmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	48	6.12	MTMmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Current fallow+Grassland (CF+Gl)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	49	5.34	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	50	4.18	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	51	3.01	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	52	6.06	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	53	7.73	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Redgram (Rg)	Not Available	Quarry	Quarry
Madhakal	54	1.53	MTMmB2g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (SL)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	55	0.75	MTMmB2g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub land (SL)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	56	8.11	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Cotton (Ct)	Not Available	Quarry	Quarry
Madhakal	57	4.85	MTMmB2g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram (Rg+Gg)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	58	7.99	MTMmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	59	4.09	MTMmB2	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	62	0.03	MTMmB2g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	63	0.13	MTMmB2g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIIse	TCB/GB/strengthening of Bunds
Madhakal	68	1.74	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	69	1.2	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	70	4.13	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	71	3.2	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	72	2.5	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	73	6	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IVs	Crescent bund/TCB
Madhakal	74	5.17	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram (Rg+Gg)	Not Available	IVs	Crescent bund/TCB
Madhakal	75	0.46	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	76	1.66	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Grassland (Gl)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	77	3.45	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Cotton (Rg+Ct)	Not Available	IVs	Crescent bund/TCB
Madhakal	78	0.76	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Grassland (Gl)	1 Openwell	IIs	TCB/GB/strengthening of Bunds
Madhakal	79	0.77	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Grassland (Gl)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	80	0.77	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Grassland (Gl)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	81	0.29	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	82	0.62	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	83	0.42	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	84	0.33	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	85	0.75	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	86	0.38	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	87	0.43	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Greengram (Gg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	88	0.61	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	89	0.43	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	90	0.4	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	91	0.49	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	92	0.28	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	93	0.47	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	94	0.95	DRGmA1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	95	0.73	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	96	0.38	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	97	0.86	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	98	0.91	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	99	0.35	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	100	0.94	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	101	4.18	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton (Rg+Ct)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	102	0.75	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	103	0.32	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	104	1.53	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Cotton (Ct)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	105	0.69	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	106	0.39	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	107	0.9	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	108	1.56	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	109	0.57	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	110	0.59	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	111	0.2	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	112	1.36	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Cotton (Rg+Ct)	1 Openwell	IIs	TCB/GB/strengthening of Bunds
Madhakal	113	0.95	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	114	3.3	DDTmA1	LMU-5	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Cotton (Ct)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	145	13.17	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Grassland (Gl)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	147	2.82	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	148	0.34	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	149	5.04	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	150	4.63	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	151	2.02	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Greengram (Rg+Gg)	Not Available	IVs	TCB
Madhakal	152	4.68	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	153	5.59	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram+Current fallow (Rg+Gg+CF)	Not Available	IIs	TCB/GB/strengthening of Bunds

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	154	4.25	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram+Current fallow (Gg+CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	155	7.79	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram+Current fallow (Rg+Gg+CF)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	156	1.73	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	161	1.85	DRGmB2g1	LMU-5	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram (Gg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	162	2.73	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Current fallow (CF)	Not Available	IVs	TCB
Madhakal	163	3.12	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IVs	Crescent bund/TCB
Madhakal	164	6.69	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Current fallow (Rg+CF)	Not Available	IVs	TCB
Madhakal	165	7.07	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	166	4.25	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Lime stone query (Rg+LSQ)	Not Available	IVs	TCB
Madhakal	167	6.91	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	168	8.48	TNHmA1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Redgram+Greengram (Rg+Gg)	Not Available	IVs	TCB
Madhakal	169	5.34	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram (Rg+Gg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	170	4.12	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram (Gg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	171	0.08	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	172	3.47	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	175	3.61	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	176	2.94	TNHmB1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	177	2.96	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	178	4.07	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	179	7.17	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Madhakal	180	6	TNHmB1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	181	2.09	TNHmB1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	182	5.28	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Redgram (Rg)	Not Available	Quarry	Quarry
Madhakal	183	2.46	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	184	3.69	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	185	3.07	TNHmB1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	186	2.16	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	187	1.95	TNHmB1	LMU-3	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Madhakal	188	3.13	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	189	3.36	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	190	1.66	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	191	1.94	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	192	4.25	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Current fallow (CF)	Not Available	Quarry	Quarry
Madhakal	193	7.21	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Lime stone query (LSQ)	Not Available	Quarry	Quarry
Madhakal	194	4.64	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Redgram+Lime stone query (Rg+LSQ)	Not Available	Quarry	Quarry
Madhakal	195	6.33	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IVs	Crescent bund/TCB
Madhakal	196	7.12	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram (Rg+Gg)	Not Available	IVs	Crescent bund/TCB
Madhakal	197	0.18	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	198	0.66	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	201	1.23	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	206	0.63	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IVs	Crescent bund/TCB
Madhakal	207	3.42	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	208/1	3.26	ADKmB2g1	LMU-2	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	1 Temple	IVs	Crescent bund/TCB
Madhakal	208/2	0.61	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	209	3.53	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	210	5.39	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	211	2.35	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	1 Temple	IVs	Crescent bund/TCB
Madhakal	212	3.73	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Greengram (Rg+Gg)	Not Available	IVs	Crescent bund/TCB
Madhakal	213	1.93	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram (Gg)	Not Available	IVs	Crescent bund/TCB
Madhakal	214	1.34	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB

Village	SY.No	Area (ha)	Soil Phase	LMU	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Madhakal	215	5.5	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Grassland (Rg+Gl)	Not Available	IVs	Crescent bund/TCB
Madhakal	216/1	1.58	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Greengram (Gg)	Not Available	IVs	Crescent bund/TCB
Madhakal	216/2	2.97	Habitation	Others	Others	Others	Others	Others	Others	Others	Redgram (Rg)	Not Available	Others	Others
Madhakal	217	1.59	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	218	4.05	ADKmB2	LMU-2	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Madhakal	219/1	3.69	Habitation	Others	Others	Others	Others	Others	Others	Others	Redgram (Rg)	Not Available	Others	Others
Madhakal	219/2	0.17	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	219/3	0.17	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	219/4	0.07	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	220/1	0.23	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	220/2	0.26	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	220/3	1.13	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Madhakal	220/4	0.66	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Sedam	479	0.1	DRGmB2	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Not Available (NA)	Not Available	IIs	TCB/GB/strengthening of Bunds
Sedam	489	12.24	GGNmD3g2	LMU-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Scrub land (SL)	Not Available	IVse	Crescent bund

Appendix II

Madkal Microwaterhed

Soil Fertility Information

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	1/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	2	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	3	Moderately alkaline (pH 7.8 – 8. 4)	Low (2 – 4 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)
Madhakal	4	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	5	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	6	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	7	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	8	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	9	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	10/1	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	10/2	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	11	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	12	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	13	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	14	Moderately alkaline (pH 7.8 – 8.4)	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)
Madhakal	15	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	16_GRASS FIELD	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	17	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	18	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	20	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	21	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	38	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	39	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	40	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	46	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	47	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	48	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	49	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	50	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	51	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	52	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	53	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	54	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	55	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	56	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	57	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	58	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	59	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	62	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	63	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	68	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	69	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	70	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	71	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	72	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	73	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	74	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	75	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	76	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	77	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	78	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	79	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	80	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	81	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	82	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	83	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	84	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	85	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	86	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	87	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	88	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	89	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	90	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	91	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	92	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	93	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	94	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	95	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	96	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	97	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	98	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	99	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	100	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	101	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	102	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	103	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	104	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	105	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	106	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	107	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	108	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	109	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	110	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	111	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	112	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	113	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	114	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	145_GRASSFIELD	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 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)
Madhakal	147	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	148	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	149	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	150	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	151	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	152	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	153	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	154	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	155	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	156	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	161	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	162	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	163	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	164	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	165	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	166	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	167	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	168	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	169	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	170	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	171	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	172	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	175	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)	Sufficient (> 0.6 ppm)
Madhakal	176	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	177	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	178	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	179	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	180	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	181	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	182	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	183	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	184	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	185	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)
Madhakal	186	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 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)

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	187	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Madhakal	188	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	189	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	190	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	191	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	192	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	193	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	194	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	195	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	196	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	197	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	198	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	201	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	206	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	207	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	208/1	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	208/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	209	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	210	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	211	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	212	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	213	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	214	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Madhakal	215	Moderately alkaline (pH 7.8 – 8.4)	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)	Deficient (< 0.6 ppm)
Madhakal	216/1	Moderately alkaline (pH 7.8 – 8.4)	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)	Deficient (< 0.6 ppm)
Madhakal	216/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	217	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Village	SY.No	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Madhakal	218	Moderately alkaline (pH 7.8 – 8.4)	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)
Madhakal	219/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sedam	479	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Sedam	489	Moderately alkaline (pH 7.8 – 8.4)	Low (2 – 4 dsm)	High (> 0.75 %)	Medium (23 - 57 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)

Appendix III

Madkal Microwaterhed

Soil Suitability Information

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tama rind	Lime	Bengal gram	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	1/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	1/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	2	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	3	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	4	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	5	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	6	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	7	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	8	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	9	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	10/1	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	10/2	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	11	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	12	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	13	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	14	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	15	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	16	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	17	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	18	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	20	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	21	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	38	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	39	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	40	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	46	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	47	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	48	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	49	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	50	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	51	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	52	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	53	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	54	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	55	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	56	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	57	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	58	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	59	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	62	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	63	S3rt	S3t	S3rt	S1	S3rt	S1	S2rt	S2rt	S1	S1	S2t	S1	S3rt	S1	Nt	S2rt	S2rt	S3t	S1
Madhakal	68	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	69	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	70	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	71	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	72	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	73	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	74	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	75	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	76	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	77	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	78	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	79	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	80	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	81	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	82	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	83	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tama rind	Lime	Bengalgr am	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	84	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	85	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	86	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	87	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	88	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	89	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	90	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	91	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	92	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	93	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	94	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	95	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	96	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	97	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	98	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	99	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	100	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	101	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	102	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	103	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	104	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	105	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	106	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	107	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	108	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	109	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	110	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	111	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	112	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	113	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	114	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	145_GRASSFIELD	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	147	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	148	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	149	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	150	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	151	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	152	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	153	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	154	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	155	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	156	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	161	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	162	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	163	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	164	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	165	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	166	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	167	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	168	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	169	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	170	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	171	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	172	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	175	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	176	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	177	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	178	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	179	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Madhakal	180	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	181	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tama rind	Lime	Bengalgr am	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	182	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	183	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	184	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	185	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	186	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	187	Nr	S3t	S3rt	S2r	S3rt	S2r	Nr	S3r	S1	S2r	S2r	S2r	S3rt	S2r	Nt	S3t	S3r	S3t	S2r
Madhakal	188	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	189	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	190	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	191	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	192	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	193	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	194	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry	Quarry
Madhakal	195	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	196	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	197	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	198	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	201	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	206	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	207	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	208/1	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	208/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	209	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	210	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	211	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	212	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	213	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	214	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	215	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	216/1	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	216/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Village	SY.No	Mango	Maize	Sapota	Sorgham	Guava	Cotton	Tamarind	Lime	Bengalgram	Sun flower	Redgram	Amla	Jackfruit	Custard-apple	Cashew	Jamun	Musambi	Sugar cane	Soyabean
Madhakal	217	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	218	Nr	S3r	Nr	S3r	Nrt	S3r	Nr	Nr	S2r	S3r	S3r	S3r	Nrt	S3r	Nt	Nr	Nr	Nrt	S3r
Madhakal	219/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	219/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/3	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Madhakal	220/4	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Sedam	479	S3t	S3t	S3t	S1	S3t	S1	S2t	S1	S1	S1	S2t	S1	S3t	S1	Nt	S2t	S1	S3t	S1
Sedam	489	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl	Nrl

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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: *Madkal micro-watershed (Adki sub-watershed, Sedam taluk, Gulbarga district) is located in between $17^0$8'–$17^0$10' North latitudes and $77^0$20'–$77^0$22' East longitudes, covering an area of about 465.92 ha, bounded by Khurgunta, Madhakal, Sedam villages and Telangana state 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 eco system services were quantified.*

Results: *The socio-economic outputs for The Madkal Microwatershed (Adki sub-watershed, Sedam taluk, Gulbarga district) are presented here.*

Social Indicators;

- *Male and female ratio is 54.8 to 45.2 Per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is 60.0 around per cent to the total population.*
- *Literacy population is around 62 per cent.*
- *Social groups belong to other backward caste (OBC) is around 77.7 per cent.*
- *Firewood is the source of energy for a cooking among 66.6 per cent.*
- *About 11.0 per cent of households have a yashaswini health card.*
- *Farm households are having MGNREGA card only 22 per cent for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 89 per cent.*
- *Swach bharath program providing closed toilet facilities around 56 per cent of sample households.*
- *Women participation in decisions making is among all the households were found.*

Economic Indicators;

- *The average land holding is 1.97 ha indicates that majority of farm households are belong to small and medium farmers. The dry land is total cultivated land area among all the sample farmers.*

- *Agriculture is the main occupation among 91.0 per cent and agriculture is the main and govt service is a subsidiary occupation is around 2.3 per cent among the sample households.*
- *The average value of domestic assets is around Rs. 17343 per household. Mobile and television are popular mass media communication.*
- *The average farm assets value is around Rs. 8066 per household, about 33 per cent of sample farmers having plough and bullock cart.*
- *The average livestock value is around Rs. 38791 per household; about 57.1 per cent of household are having livestock.*
- *The average per capita food consumption is around 913 grams (2098 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 60 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 36655 per household. About 77.7 per cent of farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs.1658.*

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. 685 per ha/year. The total cost of annual soil nutrients is around Rs. 329794 per year for the total area of 603 ha.*
- *The average value of ecosystem service for food grain production is around Rs 19077/ ha/year in red gram.*
- *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. 52882).*

Economic Land Evaluation;

- *The major cropping pattern is red gram (100 %).*
- *In Madkal micro-watershed, major soil series are Dargah soils series are deep soil depth covers around 21.7 % of area major crops are red gram. Adki soils are shallow soils depth covers around 15.6 % of area. on this soil farmers are presently growing red gram. Mathumuda series having soils are moderately deep covers around 10.6 % of area and Dhandothi soils are very deep covers around 4.6 % of area. major crops are redgram.*
- *The total cost of cultivation and benefit cost ratio (BCR) in study area for Red gram ranges between Rs. 28153/ha in MTM soil (with BCR of 1.93) and Rs. 20449/ha in DDT soil (with BCR of 1.81).*

- *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 red gram (19.0 to 24.1 %).*

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

Madkal micro-watershed located in southern 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 Region (AER) – 3 having LGP 120-150 days.

Madkal micro-watershed (Adki sub-watershed, Sedam taluk, Gulbarga district) is located in between $17^0$8'–$17^0$10' North latitudes and $77^0$20'–$77^0$22' East longitudes, covering an area of about 465.92 ha, bounded by Khurgunta, Madhakal, Sedam villages and Telangana state.

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 1).

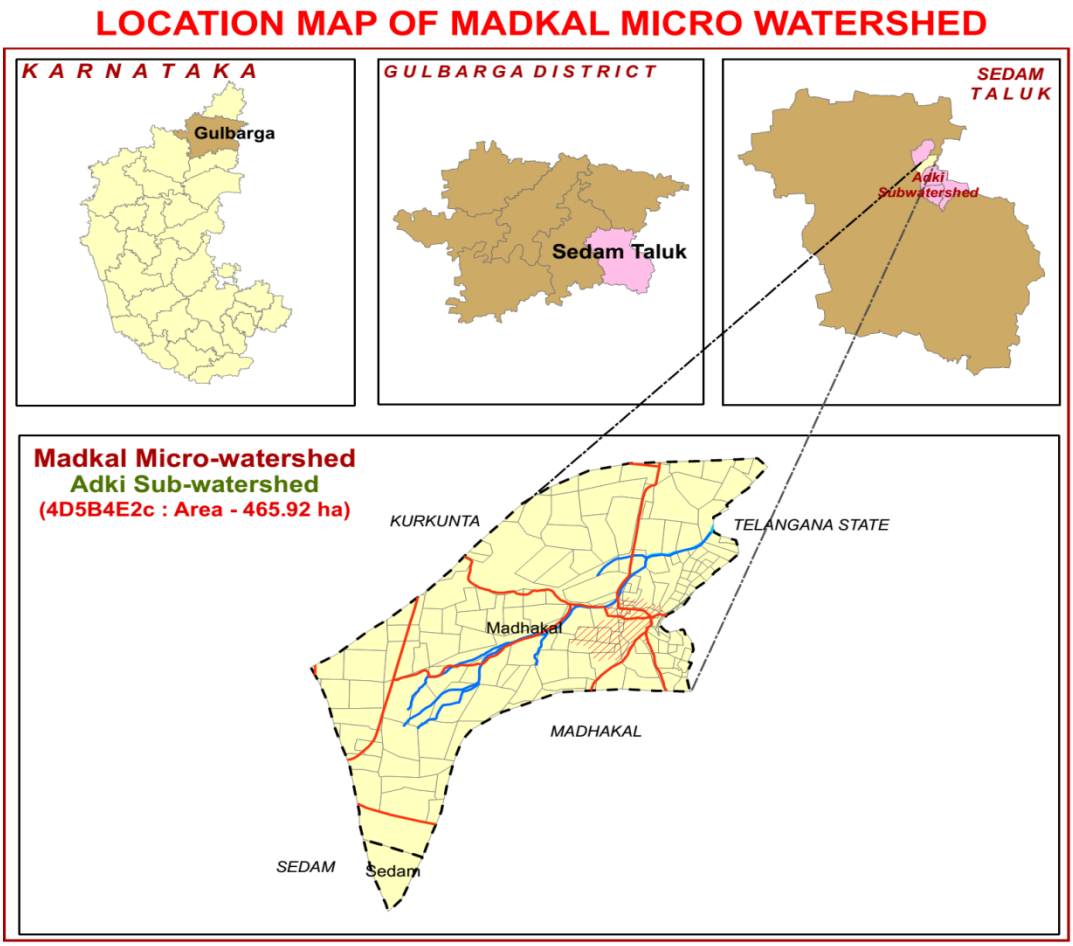


Figure 1: Location of study area

Steps followed in socio-economic assessment

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

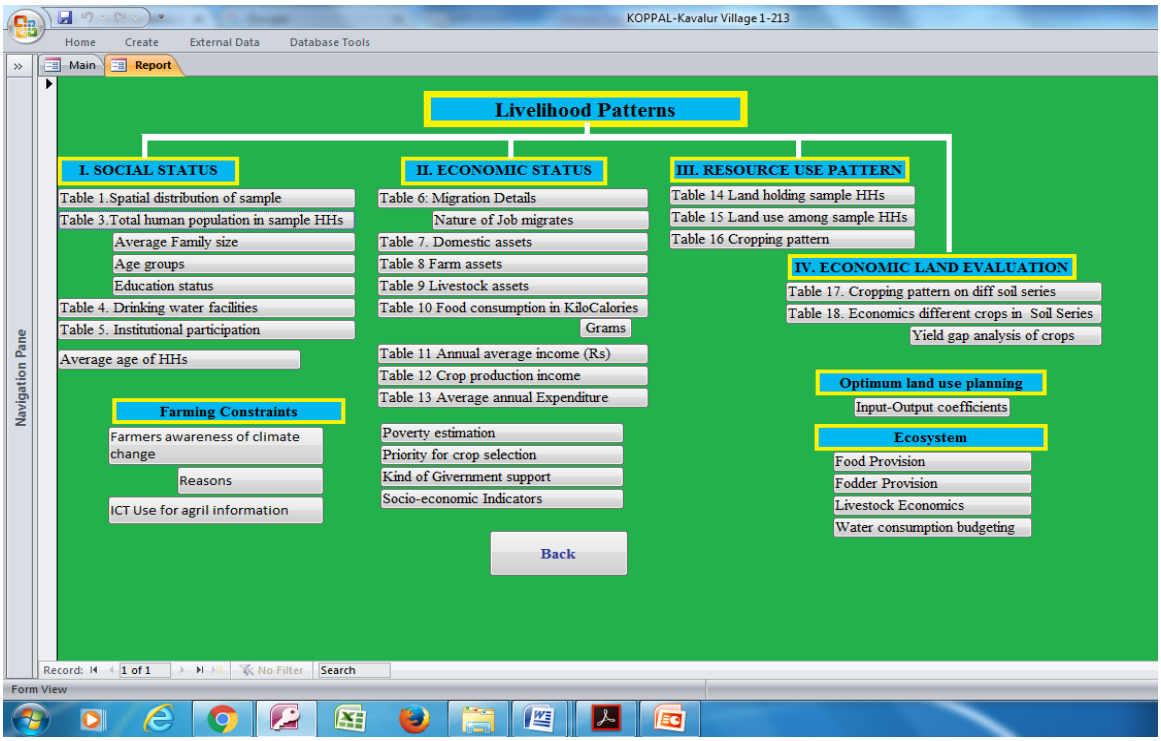


Figure 2: ALPES FRAMEWORK

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

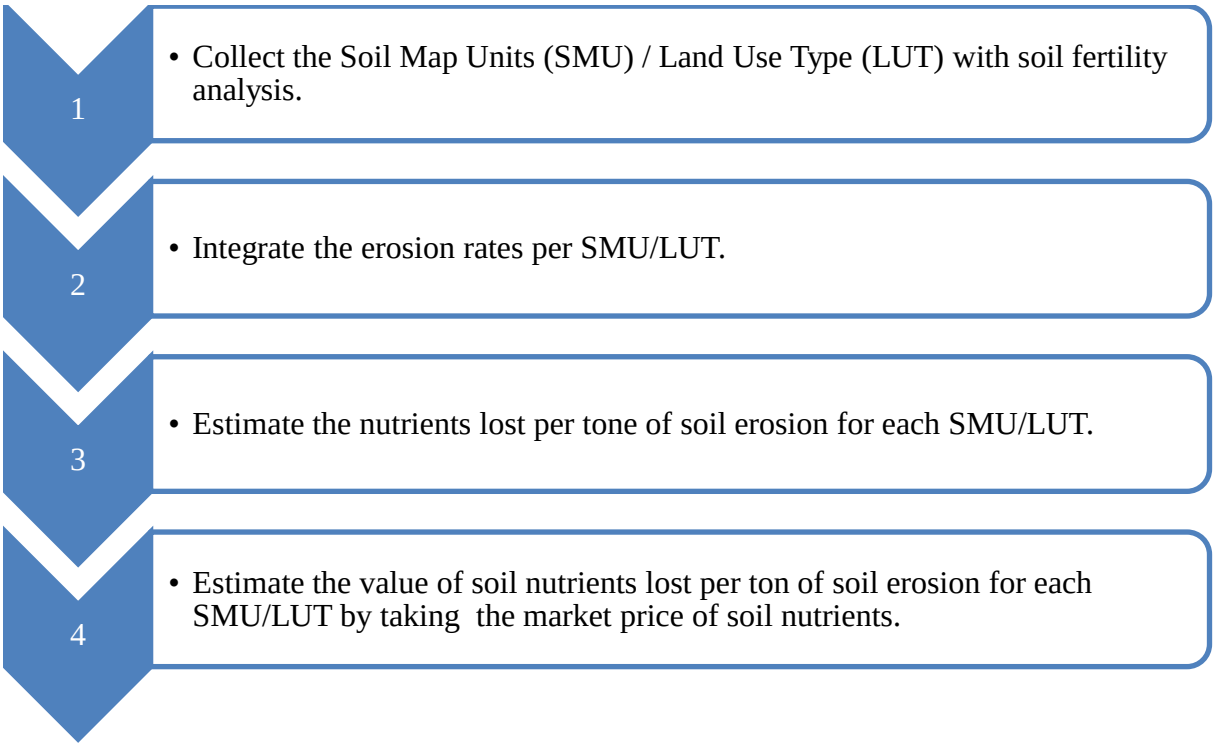
Operational Cost = cost of seeds, fertilizers, pesticides. Cost of human and bullock labour, cost of machinery, cost of irrigation water + interest on working capital.
Gross returns = Yield (Quintals/hectare)*Price (Rs/Quintal)
Net returns = Gross returns-Operational cost.
Benefit Cost Ratio = Net returns/Total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

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

Economic Valuation of Soil ecosystem services:

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

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



Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The Total number of population in watershed area was 50, out of which 54.8 per cent were males and 45.2 per cent females. Average family size of the households is 5.5 Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 18 to 30 years (28.0 %) followed by 0 to18 years (16.0 %), 30 to 50 years (32.0 %) and more than 50 years (24.0 %). 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 38.0 per cent of respondents were illiterate and 62.0 per cent literate (Table 1).

Table 1: Human population among sample households in Madkal Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	50
Male	% to total Population	54.8
Female	% to total Population	45.2
Average family size	Number	5.5
Age group		
0 to 18 years	% to total Population	16.0
18 to 30 years	% to total Population	28.0
30 to 50 years	% to total Population	32.0
>50 years	% to total Population	24.0
Average age	Age in years	33.6
Education Status		
Illiterates	% to total Population	38.0
Literates	% to total Population	62.0
Primary School (<5 class)	% to total Population	16.0
Middle School (6- 8 class)	% to total Population	10.0
High School (9- 10 class)	% to total Population	22.0
Others	% to total Population	14.0

The ethnic groups among the sample farm households found to be 77.7 per cent belonging to other backward castes (OBC) followed by 22.2 per cent of general caste (Table 2 and Figure 3). About 66.6 per cent of sample households are using firewood and 33.3 percent uses in liquefied petroleum gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 11 per cent are sample households having health cards. Majority (22 %) are having MNREGA job cards for employment generation. About 89.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 44 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Madkal Microwatershed

Particulars	**Units**	**Value**
Social groups		
OBC	% of Households	77.7
General	% of Households	22.2
Types of fuel use for cooking		
Firewood	% of Households	66.6
Gas	% of Households	33.3
Energy supply for home		
Electricity	% of Households	100
Number of households having Health card		
Yes	% of Households	11
No	% of Households	89
MGNREGA Card		
Yes	% of Households	22
No	% of Households	78
Ration Card		
Yes	% of Households	89
No	% of Households	11
Households with toilet		
Yes	% of Households	44
No	% of Households	56
Drinking water facilities		
Tube well	% of Households	100

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having Tube well source for water supply for domestic purpose (100 %).

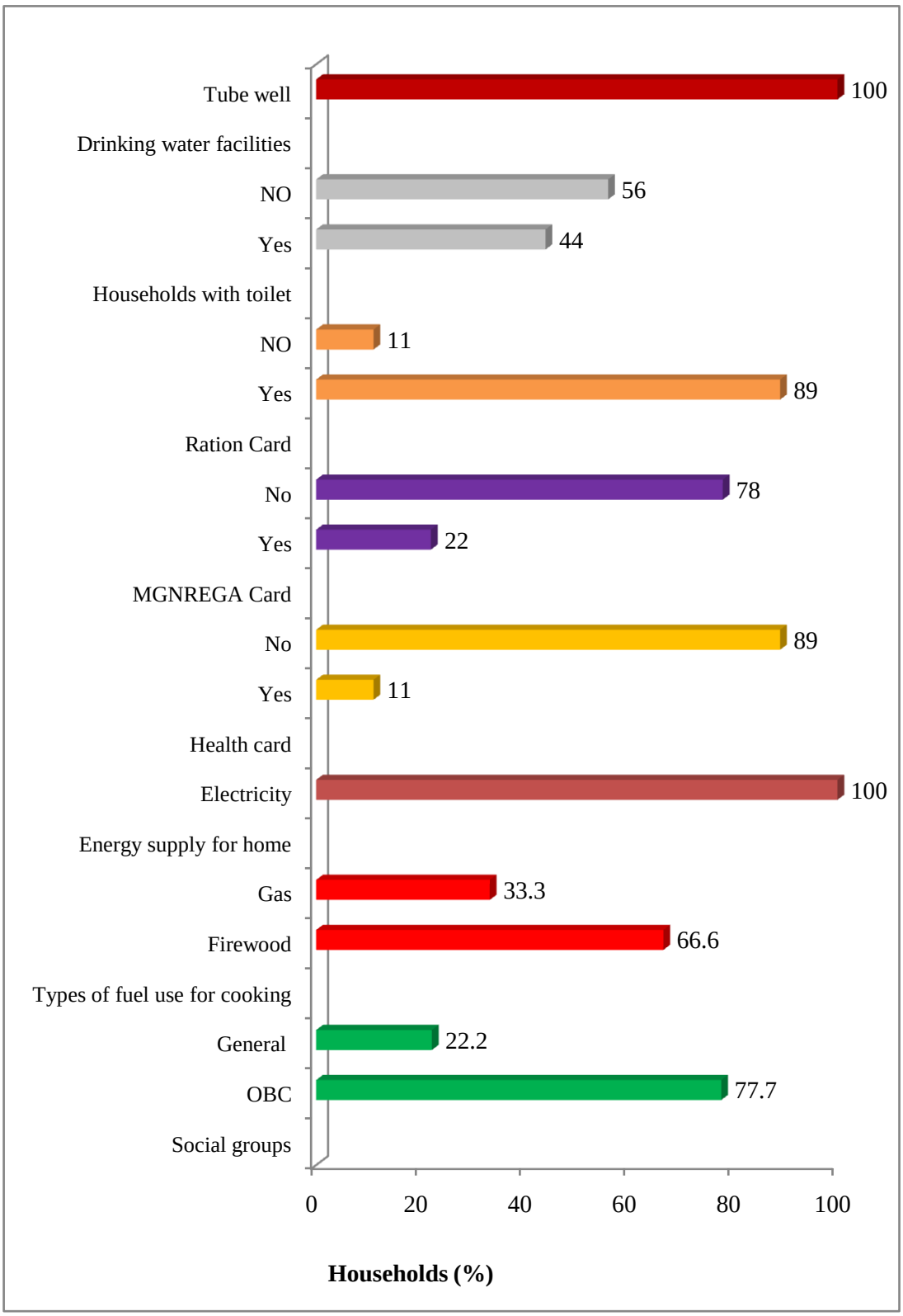


Figure 3: Basic needs of sample households in Madkal Microwatershed

Only 2.0 per cent of the farmers are participating in community based organizations (Table 3). Among them majority were participating in co-operatives societies-marketing (2.0 %).

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

Particulars	Units	Value
No. Of people participating	% to total	2.0
Co-operative Societies - Marketing	% to total	2.0
No. Of people not participating	% to total	98.0

The occupational pattern (Table 3) among sample households shows that agriculture is the main occupation around 30 per cent and agriculture is main agriculture labour (60%) private service (4.0 %) and poultry (2.0 %) subsidiary occupation in sample households.

Table 4: Occupational pattern in sample population in Madkal Microwatershed

Occupation		**% to total**
Main	**Subsidiary**	
Agriculture	Agriculture	30
	Agriculture labour	60
	Private service	4.0
	Poultry	2.0
Govt service		4.0
Grand Total		100.0
Family labour availability		**Man days/month**
Male		38.8
Female		25.7
Total		64.6

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 (88.8 %) followed by mobile phone (55.5 %), motor cycle (33.3 %) and bicycle (11.1 %).The average value of domestic assets is around Rs 17343 per households.

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

Particulars	% of households	Average value in Rs
Bicycle	11.1	4000
Mobile Phone	55.5	6000
Motor cycle	33.3	50000
Television	88.8	9375
Average value	17343	

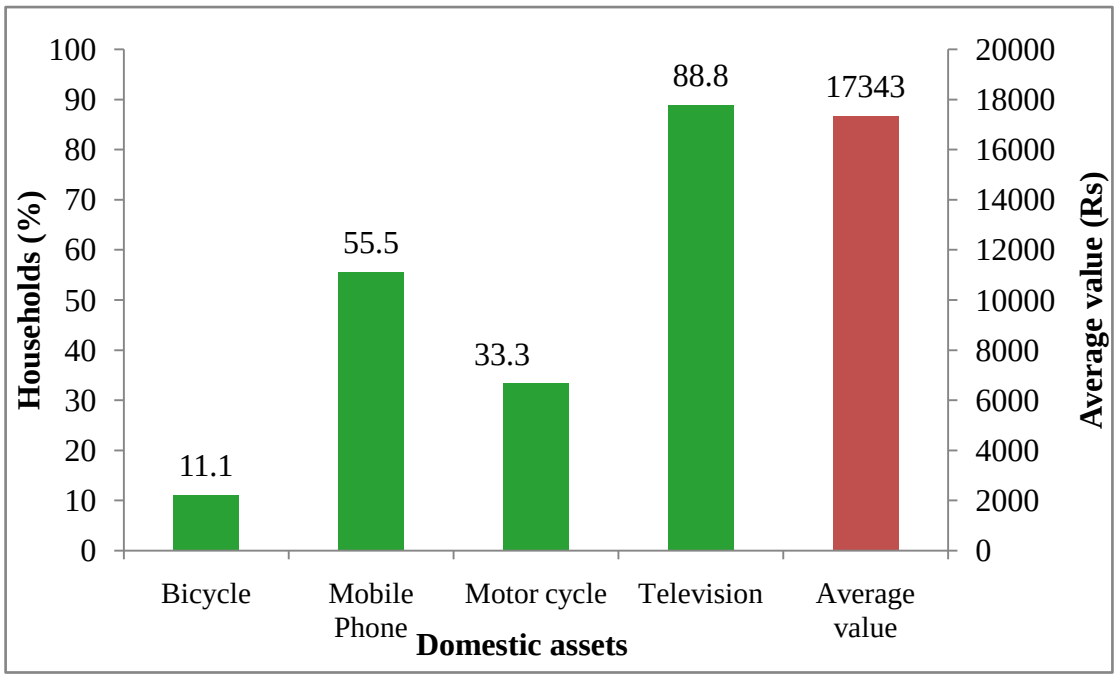


Figure 4: Domestic assets among the sample households in Madkal Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned plough (33.3 %), bullock cart (33.3 %), and sprayer (11.1 %). The average value of farm assets is around Rs 8066 per households (Table 5 and Figure 4).

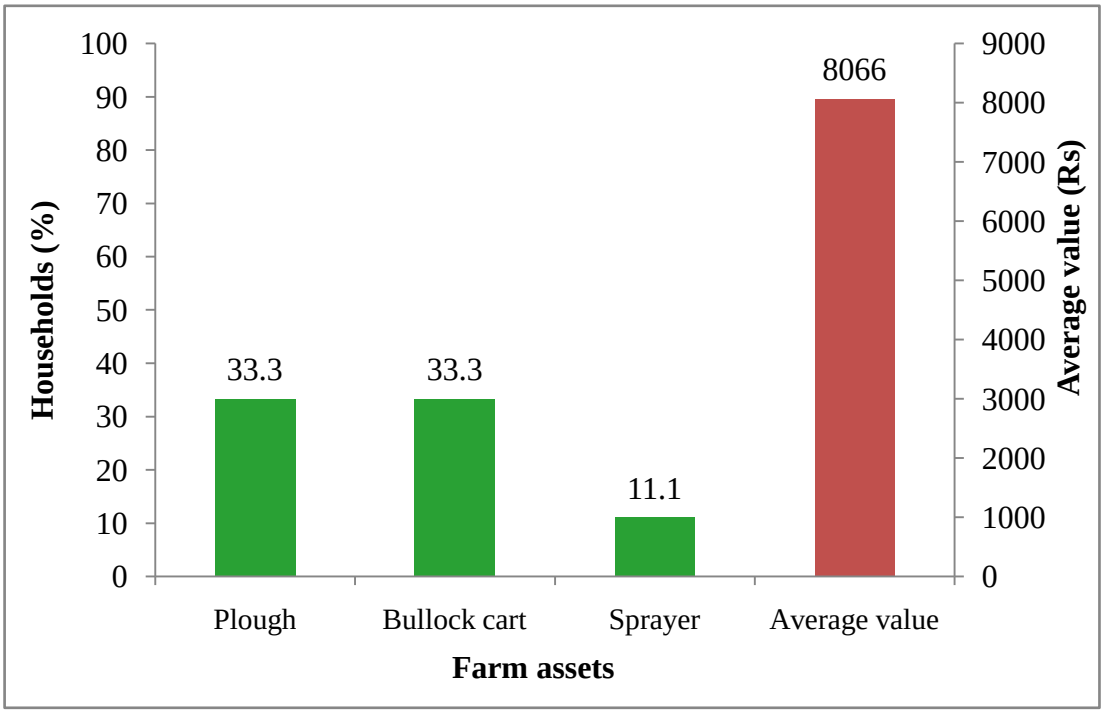


Figure5: Farm assets among samples households in Madkal Microwatershed

Table 6: Farm assets among samples households in Madkal Microwatershed

Particulars	% of households	Average value in Rs
Plough	33.3	2533
Bullock cart	33.3	16666
Sprayer	11.1	5000
Average value	8066	

Livestock is an integral component of the conventional farming systems (Table 7). The highest livestock population is local mulching cow were around 25.0 per cent. The average livestock value was Rs 38791 per household.

Table 7: Livestock assets among sample households in Madkal Microwatershed

Particulars	% of livestock population	Average value in Rs
Local dry cow	25.0	35000
Local milching cow	25.0	50000
Milching buffalos	12.5	20000
Bullocks	37.5	50166
Average value	38791	

Average milk produced in sample households is 1080 litters/ annum among the farm households. The average livestock value was Rs 33666 per livestock. Livestock having population are 57.1 percent and 24 livestock population numbers in the livestock (Table 8).

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

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Milching Buffalos	1080
Livestock having households (%)	57.1
Livestock population (Numbers)	24

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 9 and Figure 6. More quantity of cereals are consumed by sample farmers which accounted for 1324 kcal per person. The other important food items consumed was pulses 173 kcal followed by milk 89 kcal, vegetables 25 kcal, cooking oil 189 kcal, egg 259 kcal and meat 35 kcal. In the sampled households, farmers were consuming less (2098 kcal) than NIN- recommended food requirement (2250 kcal).

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

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396.0	389	1324
Pulses	43.0	50	173
Milk	200.0	138	89
Vegetables	143.0	105	25
Cooking Oil	31.0	33	189
Egg	0.5	173	259
Meat	14.2	23	35
Total	**827.7**	**913**	**2098**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		60	70
% Above NIN		40	30

Note: * day/person

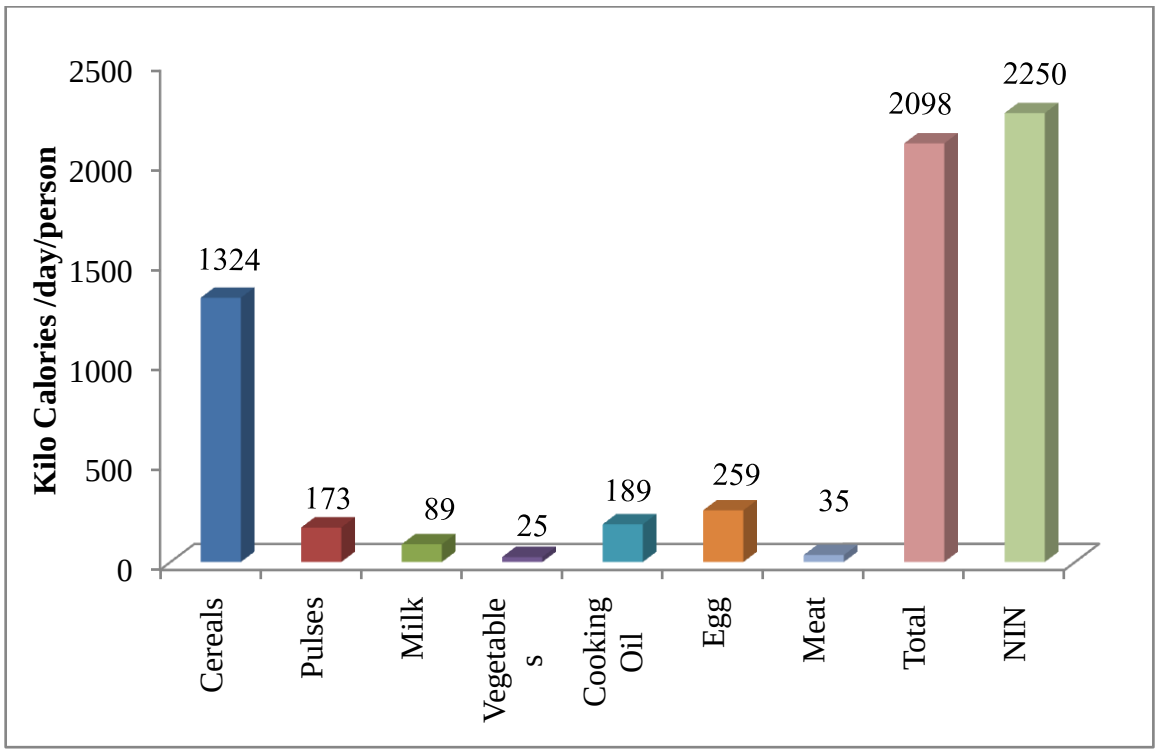


Figure 6: Per capita daily consumption of food among the sample households in Madkal Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 36655. Major source of income to the farmers in the study area is from crop production (Rs 48361), followed by livestock (Rs.-7010) The monthly per capita income is Rs.549,

which is above 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 Madkal Microwatershed

Particulars	**Income ***
Nonfarm income	0.0
Livestock income (Rs)	-7010 (22.2)
Crop Production (Rs)	43665(100)
Total Annual Income (Rs)	**36655**
Average monthly per capita income (Rs)	549
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	77.7
% of households above poverty line	22.3

* 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. 53820) 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 1658 and about 77.7 per cent of farm households are below poverty line (Table 11 and Figure 7).

Table 11: Average annual expenditure of sample HHs in Madkal Microwatershed

Particulars	**Value in Rupees**	**Per cent**
Food	53820	48.6
Education	888	0.8
Clothing	8277	7.4
Social functions	30388	27.4
Health	17222	15.5
Total Expenditure (Rs/year)	110597	100
Monthly per capita expenditure (Rs)	1658	

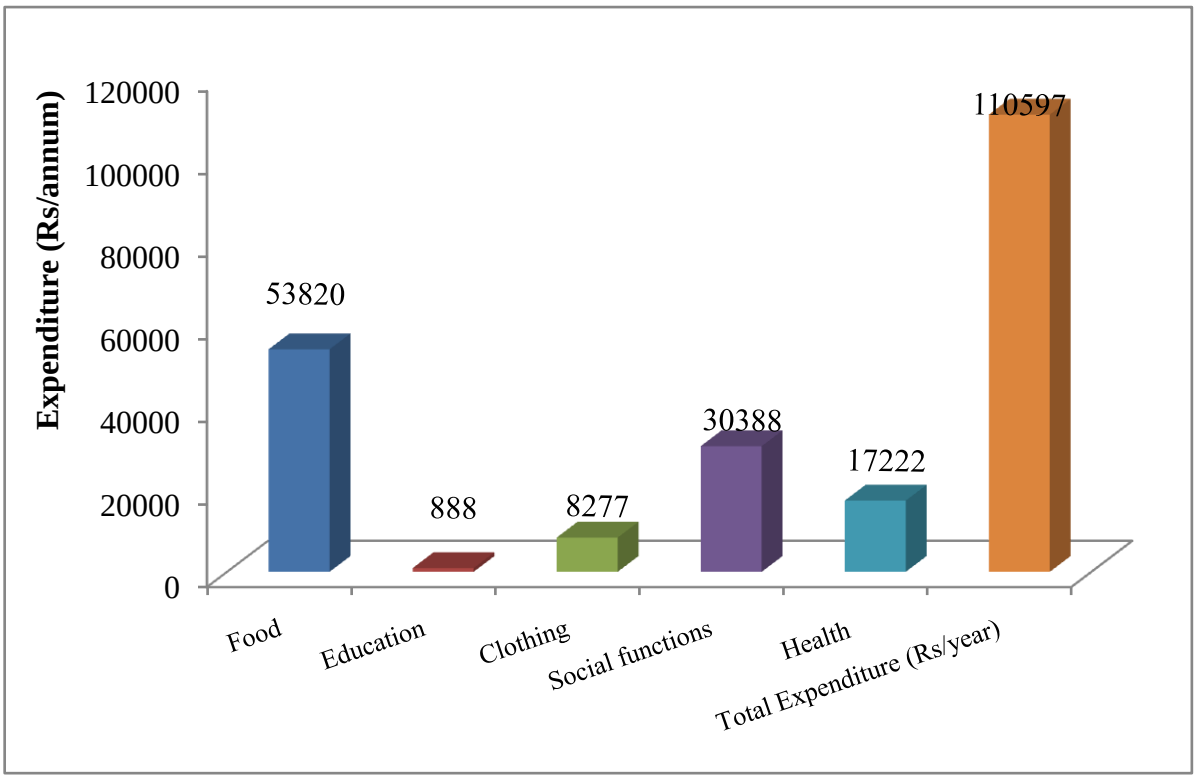


Figure 7: Average annual expenditure of sample HHs in Madkal Microwatershed

Table 12: Distribution of land holding among the sample households in Madkal Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	5.2
Sample size	Per cent	66.6
Average land holding	ha	0.87
Medium farmers		
Total land	ha	7.09
Sample size	Per cent	22.2
Average land holding	ha	3.54
Large farmers		
Total land	ha	5.42
Sample size	Per cent	11.1
Average land holding	ha	5.42
Total sample households		
Total land	ha	17.7
Sample size	Per cent	100
Average land holding	ha	1.97

Land holding: Total sample households total area cultivated by them is 17.7 ha. The average land holding of sample HHs is 1.97 ha. The large number of HHs (66.6 %) is belong to small size groups with an average land holding size of 0.87 ha followed by medium farmers (22.2 %) with an average land holding is 3.54 ha and large number (11.1 %) with an average land holding is 5.42 ha (Table 12).

Land use: The total land holding in the Madkal micro-watershed is 17.7 ha (Table 13) of rainfed land .The average land holding per household is worked out to be 1.97 ha.

Table 13: Land use among samples households in Madkal Microwatershed

Particulars	Per cent	Area in ha
Rainfed Land	17.7	17.7
Irrigated land	0.0	0.0
Fallow Land	0.0	0.0
Total land holding	100	17.7
Average land holding	1.97	

In the micro-watershed, the prevalent present land uses under perennial plants are banyan tree (20.0 %), neem tress (77.14 %) and tamarid (2.86) (Table 14).

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

Particulars	Number of Plants/trees	Per cent
Banyan tree	7	20.0
Neem tress	27	77.14
Tamarid	1	2.86
Grand Total	35	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 redgram (100 %), which are taken during kharif (Table 15 and Figure 9).

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

% to Grand Total

Crops	Kharif	Grand Total
Redgram	100	100

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 Madkal micro-watershed, 3 soil series are identified and mapped (Table 16). The distribution of major soil series are Dargah covering an area around 106 ha (21.7 %) followed by Adki 78 ha (15.6 %),Tonsanhalli 54 ha (10.6 %), Mathumuda 35 ha (6.2 %), Dhandothi 22 (4.65 %) and Gundagunthi 14 (3.07 %).

Table 16: Distribution of soil series in Madkal Microwatershed

Sl. No	Soil series	Description	Area in ha(%)
1	Gundagunthi (GGN)	Very shallow, clayey soils developed from weathered lime stone on moderately sloping uplands, clay surface on 5-10% slope, severely eroded	14 (3.07)
2	Adki (ADK)	Shallow, black clayey soils developed from weathered lime stone on very gently sloping uplands, clay surface on 1-3% slope, moderately eroded	78 (15.6)
3	Tonsanhalli (TNH)	Moderately shallow, black clayey soils developed from weathered lime stone on very gently sloping uplands, clay surface on 1-3% slope, moderately eroded	54 (10.6)
4	Mathumuda (MTM)	Moderately deep, black clayey soils developed from weathered lime stone on very gently sloping uplands, clay surface on 1-3% slope, moderately eroded	35 (6.2)
5	Dargah (DRG)	Deep, black clayey soils developed from weathered basalt on very gently sloping uplands, clay surface on 1-3% slope, slightly eroded	106 (21.7)
6	Dhandothi (DDT)	Very deep, black clayey soils developed from weathered lime stone on very gently sloping uplands, clay surface on 1-3% slope, moderately eroded	22 (4.65)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Dhoandothi, Mathumuda and Dargah and Adki soils are Redgram.

Table 17: Cropping pattern on major soil series in Madkal Microwatershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Grand Total
			Kharif	
ADK	Shallow(25-50 cm)	Redgram	100	100
MTM	Moderately deep(75-100 cm)	Redgram	100	100
DRG	Deep (100-150 cm)	Redgram	100	100
DDT	Very deep (>150 cm)	Redgram	100	100

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

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

Soil Series	**Small farmers**	**Medium farmers**	**Large farmer**
ADK	Redgram (1.16).	Redgram (4.65).	Redgram (1.71).
DDT	Redgram (1.81)		
DRG		Redgram (1.86)	
MTM	Redgram (1.93).		

The productivity of different crops grown in Madkal Microwatershed under potential yield of the crops is given in Table 19.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 19. The total cost of cultivation in study area for Red gram ranges between Rs. 28153/ha in MTM soil (with BCR of 1.93) and Rs.20449/ha in DDT soil (with BCR of 1.81).

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 8429 in red gram and a minimum of Rs 5036 in red gram cultivation.

Table 19: Economic land evaluation and bridging yield gap for different crops in Madkal Microwatershed

Particulars	ADK (25-50 cm)	MTM (75-100 cm)	DRG (100-150 cm)	DDT (>150 cm)
	Redgram	Redgram	Redgram	Redgram
Total cost (Rs/ha)	24641	28153	26614	20449
Gross Return (Rs/ha)	39164	54340	49400	37050
Net returns (Rs/ha)	14523	26187	22786	16601
BCR	1.97	1.93	1.86	1.81
Farmers Practices (FP)				
FYM (t/ha)	2.4	3.2	3.3	1.6
Nitrogen (kg/ha)	53.2	37.9	40.0	14.1
Phosphorus (kg/ha)	53.6	47.9	102.2	35.9
Potash (kg/ha)	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	9.3	10.0	12.5	9.4
Price of Yield (Rs/Qtl)	4400	5500	4000	4000
Soil test based fertilizer Recommendation (STBR)				
FYM (t/ha)	7.4	7.4	7.4	7.4
Nitrogen (kg/ha)	24.7	21.6	18.5	18.5
Phosphorus (kg/ha)	49.4	55.6	49.4	49.4
Potash (kg/ha)	18.5	18.5	18.5	18.5
Grain (Qtl/ha)	12.4	12.4	12.4	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)				
FYM (%)	68.1	56.4	55.0	78.9
Nitrogen (%)	-115.2	-75.4	-115.9	24.1
Phosphorus (%)	-8.5	13.8	-106.9	27.3
Potash (%)	100.0	100.0	100.0	100.0
Grain (%)	24.5	19.0	-1.2	24.1
Value of yield and Fertilizer (Rs)				
Additional Cost (Rs/ha)	4893	4693	1865	6864
Additional Benefits (Rs/ha)	13322	12925	-600	11900
Net change Income (Rs/ha)	8429	8232	-2465	5036

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 8. The average value of soil nutrient loss is around Rs 1281 per ha/year. The total cost of annual soil nutrients is around Rs 468884 per year for the total area of 465 ha.

Table 20: Estimation of onsite cost of soil erosion in Madkal Microwatershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	189.06	69196	1191	435936
Phosphorous	0.19	70	8.4	3096
Potash	1.85	678	37.0	13552
Iron	0.06	23	2.9	1093
Manganese	0.11	39	29.1	10659
Cupper	0.01	5	6.9	2527
Zinc	0.01	2	0.2	77
Sulphurs	0.13	46	5.0	1843
Boron	0.01	3	0.2	101
Total	191.4	70061	1281	468884

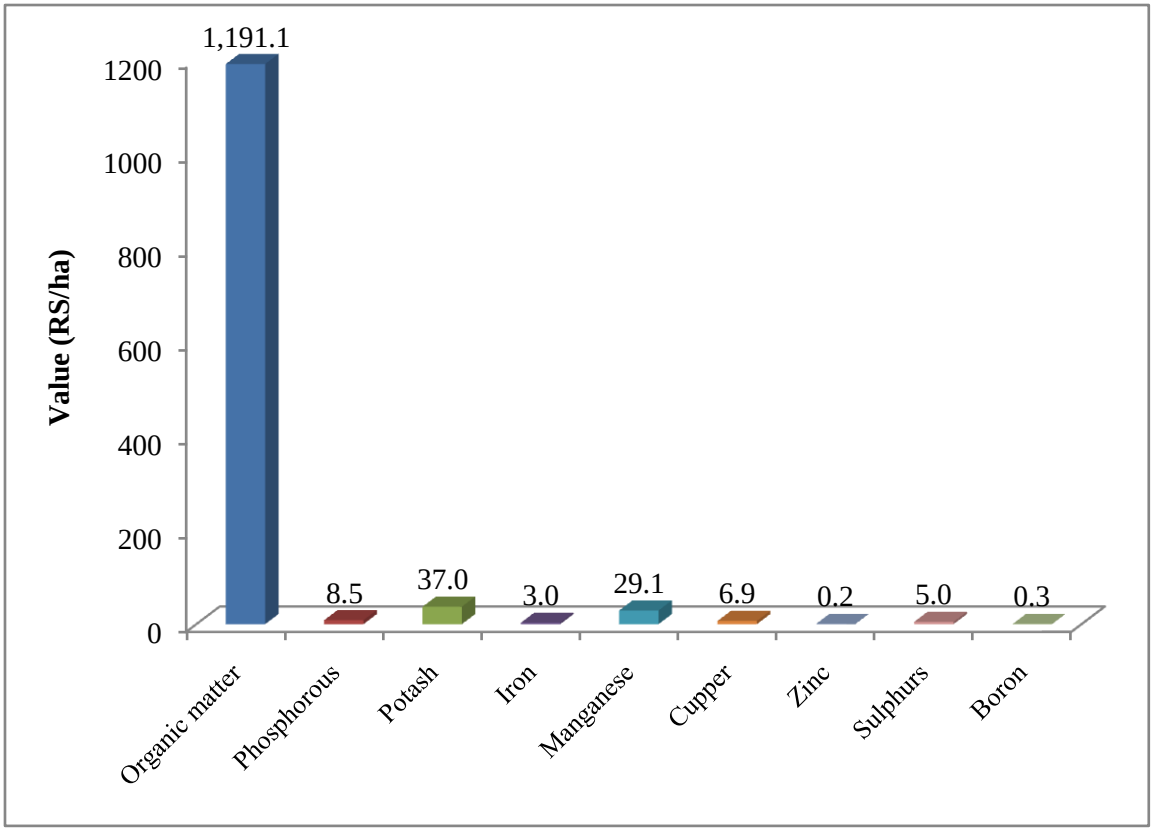


Figure 8: Estimation of onsite cost of soil erosion in Madkal Microwatershed

The average value of ecosystem service for food grain production is around Rs 19077/ ha/year (Table 21 and Figure 11) is red gram.

Table 21: Ecosystem services of food grain production in Madkal 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)
Pulses	Redgram	17.4	10	4556	44252	25175	19077

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 in redgram (Rs.52882). (Table 22 and Figure 12)

Table 22: Ecosystem services of water supply in Madkal Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Redgram	9.7	5288	52882	544

The main farming constraints in Madkal micro-watershed to be found are less rainfall, Non availability fertilizers, Lack of good quality seeds, Damage of crops pests & Diseases High crop pests & diseases. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 23).

Table 23: Farming constraints related land resources of sample households in Madkal Microwatershed

Sl. No	Particulars	Per cent
1	Less Rainfall	100
3	Non availability fertilizers	60
4	Lack of good quality seeds	80
5	Damage of crops pests & Diseases	100
6	High crop pests & diseases	50
7	**Source of loan**	
	Money Leander	100
8	**Market for selling**	
	Village market	100
9	**Sources of Agri-Technology information**	
	Newspaper	100

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