ICAR-NBSS&LUP Sujala MWS Publ. 9

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

MATKI-3 (4D5C2C2d) MICROWATERSHED

Aland 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

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.

Citation: Rajendra Hegde, Ramesh Kumar, S.C., K.V. Niranjana, S. Srinivas, M.Lalitha, B.A. Dhanorkar, R.S. Reddy and S.K. Singh (2019). “Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Matki-3 (4D5C2C2d Microwatershed, Gulbarga Taluk, Gulbarga District, Karnataka”, ICAR-NBSS&LUP Sujala MWS Publ.9, ICAR – NBSS & LUP, RC, Bangalore. p.87 & 28.

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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 Matki-3 Microwatershed, Aland Taluk, Kalaburgi 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: 10.05.2016

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Matki-3 microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soil map shows the geographic distribution and extent, characterstics, classification and use potentials of the soils in the microwartershed.

The present study covers an area of 686 ha in Matki-3 microwatershed in Aland taluk of Kalaburgi district, Karnataka. The climate is semiarid and categorized as drought prone with an average annual rainfall of 786 mm of which about 595 mm is received during south –west monsoon, 116 mm during north-east and the remaining 74 mm during the rest of the year. An area of about 96 per cent is covered by soils, four per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 7 soil series and 24 soil phases (management units) and 5 land management units.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 1rd week of October.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing major agricultural and horticultural crops were assessed and maps showing degree of suitability along with constraints were generated.*
- *About 94 per cent area is suitable for agriculture and two per cent is not suitable for agriculture but well suited for forestry, pasture, agroforestry, silvi-pasture, recreation, installation of wind mills and as habitat for wildlife.*
- *About 17 per cent of the soils are deep (100-150 cm) to moderately deep (75-100 cm), 41 per cent are moderately shallow to shallow (25-75 cm) and about 39 per cent are very shallow (<25 cm) soils.*
- *About 96 per cent of the area has clayey soils at the surface.*
- *About 35 per cent of the area has non-gravelly soils, 39 per cent gravelly soils (15-35 % gravel) and 22 per cent has very gravelly (35- 60% gravel) to extremely gravelly (60-80%) soils.*
- *About 13 per cent of the area has soils that are very high (>200mm/m) in available water capacity, four per cent medium (100-150 mm/m) and about 79 per cent low (50-100 mm/m) and very low (<50mm/m).*
- *About 86 per cent of the area has nearly level (0-1% slope) to very gently sloping (1-3% slope) lands and about 10 per cent area is gently (3-5% slope) to moderately sloping (5-10% slope) lands.*
- *An area of about 69 per cent has soils that are slightly eroded (e1), 17 per cent moderately eroded (e2) and 10 per cent severely eroded (e3).*
- *An area of about 59 per cent has soils that are moderately alkaline (pH 7.8 to 8.4), 9 per cent neutral (pH 6.5-7.3) and about 28 per cent slightly alkaline (pH 7.3-7.8).*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm-1indicating that the soils are non-saline.*
- *About 64 per cent medium (0.5-0.75%), 31 per cent high (>0.75%) and <1 per cent low (<0.5%) in organic carbon.*

- ❖ Major area of 84 per cent has soils that are low (<23 kg/ha), 7 per cent medium (23-57 kg/ha) and 5 per cent high (>57 kg/ha) in available phosphorus.
- ❖ About 33 per cent medium (145-337 kg/ha) and 63 per cent high (>337 kg/ha) in available potassium.
- ❖ Available sulphur is low (<10 ppm) in about 46 per cent area, medium (10-20 ppm) in 47 per cent and 3 per cent high (>20 ppm).
- ❖ Available boron is low (<0.5 ppm) in about 71 per cent area and 25 per cent medium (0.5-1.0 ppm).
- ❖ About 2 per cent area has soils that are deficient (<4.5 ppm) in available iron and 94 per cent sufficient (>0.6 ppm).
- ❖ Available manganese and copper are sufficient in all the soils.
- ❖ About 63 per cent area has soils that are deficient (<0.6 ppm) in available zinc and 33 per cent sufficient (>0.6 ppm).
- ❖ The land suitability for 18 major crops (agricultural and horticultural) grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, price, and finally the demand and supply position.

Land suitability for various crops in the microwatershed

Crop	Suitability Area in ha (%)			Crop	Suitability Area in ha (%)	
	Highly suitable (S1)	Moderately suitable (S2)			Highly suitable (S1)	Moderately suitable (S2)
Sorghum	115 (17)	61 (9)		Sapota	-	-
Maize	-	-		Jackfruit	-	-
Red gram	-	176 (26)		Jamun	-	84 (13)
Sunflower	115 (17)	-		Musambi	89 (13)	26 (4)
Cotton	115 (17)	61 (9)		Lime	89 (13)	26 (4)
Sugarcane	-	-		Cashew	-	-
Soybean	115(17)	61 (9)		Custard apple	115 (17)	62(9)
Guava	-	-		Amla	91 (17)	62 (9)
Mango	-	-		Tamarind	-	89 (13)

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 5 identified LMUs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops that helps in maintaining the ecological balance in the microwatershed.

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

Chapter 1

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socioeconomic development of its people. Soils provide food, fodder, 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 (>3.5 lakh ha) in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

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

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

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

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

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

The land resource inventory aims to provide site specific database for Matki-3 microwatershed in Aland Taluk, Kalaburgi District, Karnataka state for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. Later, an attempt will be made to uplink this LRI data generated at 1:7920 scale under Sujala-III Project to the proposed Landscape Ecological Units (LEUs) map.

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

GEOGRAPHICAL SETTING

2.1 Location and Extent

The study area of Matki-3 microwatershed (Matki subwatershed) is located in the northeastern part of Karnataka in Aland Taluk, Kalaburgi District, Karnataka State (Fig.2.1). It comprises of part of Matki village. It lies between 17^0 36' and 17^0 38' North latitude and between 77^0 28' and 77^0 31' east longitude and covers an area of 686 ha. It is about 15 km south of Kalaburgi and is surrounded by Hubli on the south, Nirgudi village on the northwest, Tirth on the east and Padsavli on the west.

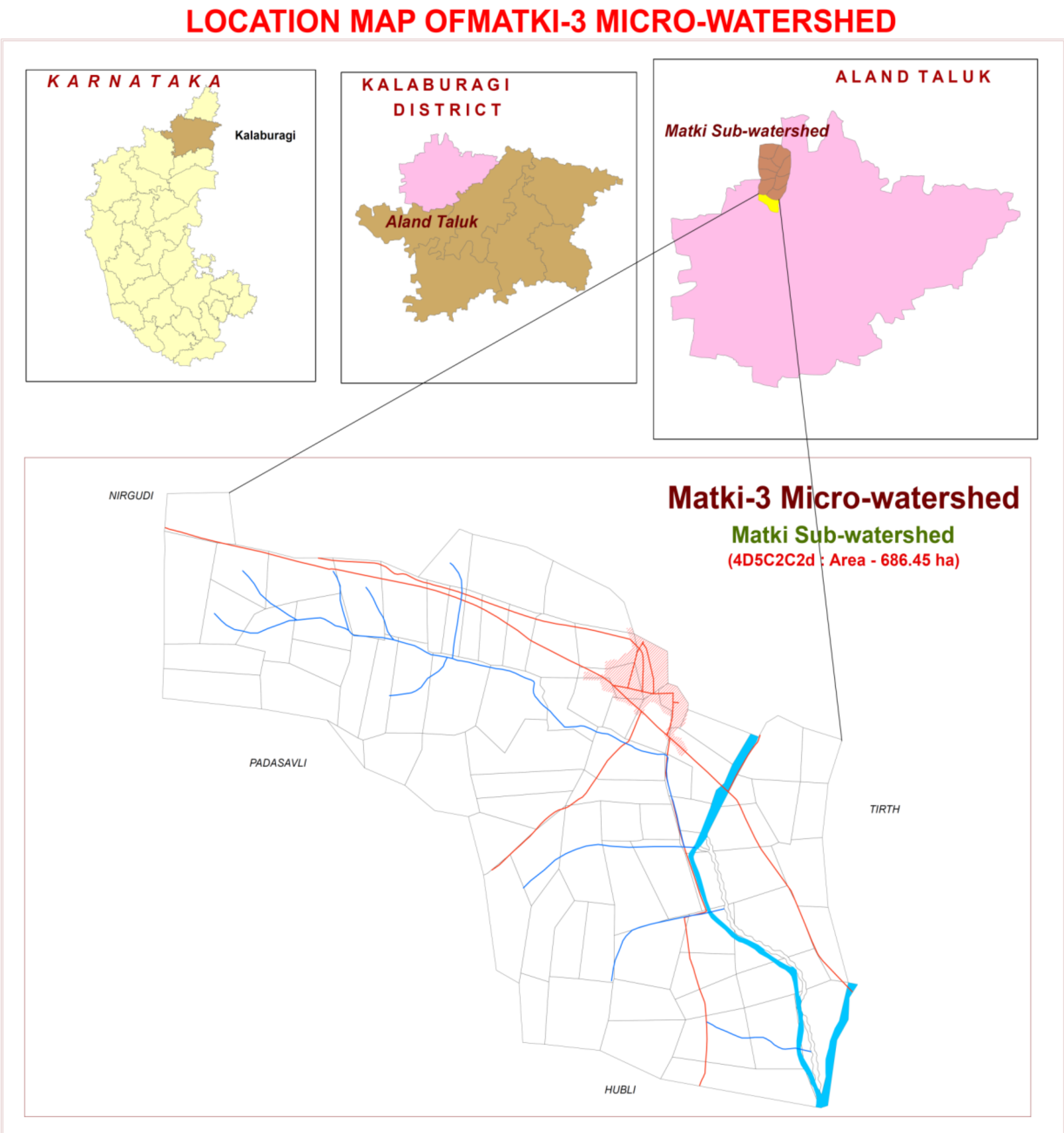


Fig.2.1 Location map of Matki-3 microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Basalt (Fig.2.2) or Deccan Trap. The Deccan Traps cover the whole of Bidar, parts of Kalaburgi, Bijapur and Belgaum districts. Eight lava flows have been identified in Karnataka horizontally overlying the older formations. The thickness of the individual flows averages about five metres. It is relatively uniform in petrographic character. The most common type is augite basalt. Dominant colour is grayish green and texture ranges from cryptocrystalline to glassy. The rock is often vesicular and scoriaceous filled up with secondary minerals like coloured agate, quartz, calcite and a large variety of zeolites. The Deccan Traps form an excellent building material and also used as road-metal and railway ballast.

Fig. 2.2 Basalt rock formation

2.3 Physiography

Physiographically, the area has been identified as Basalt landscape based on geology. Based on slope and its relief features, the area has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands. The elevation ranges from 488 to 543 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 village. If the available rain water is properly harnessed by constructing new tanks and recharge structures at appropriate places in the village, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is parallel to sub parallel and dendritic.

2.5 Climate

The Kalaburgi district lies in the northern plains of Karnataka and falls under semiarid tract of the state and is categorized as drought prone with average annual rainfall of 785 mm (Table 2.1). Of the total rainfall, maximum of 595 mm is recived during the south–west monsoon period from June to September, the north-east monsoon from October to early December contributes about 116 mm, and the remaining 75 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, temperature shoots 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 evapotranspiration (PET) is 150 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 August and September. Generally, the length of crop growing period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET at Aland Taluk, Kalaburgi District

Sl.No.	Months	Rainfall	PET	1/2 PET
1	January	7.50	126.80	63.40
2	February	3.40	143.90	71.95
3	March	11.30	189.90	94.95
4	April	19.40	209.80	104.90
5	May	32.70	232.20	116.10
6	June	111.00	186.40	93.20
7	July	139.20	152.80	76.40
8	August	172.40	147.60	73.80
9	September	172.30	131.70	65.85
10	October	91.30	145.50	72.75
11	November	19.30	129.80	64.90
12	December	5.80	114.80	57.40
Total		785.6	149.70	

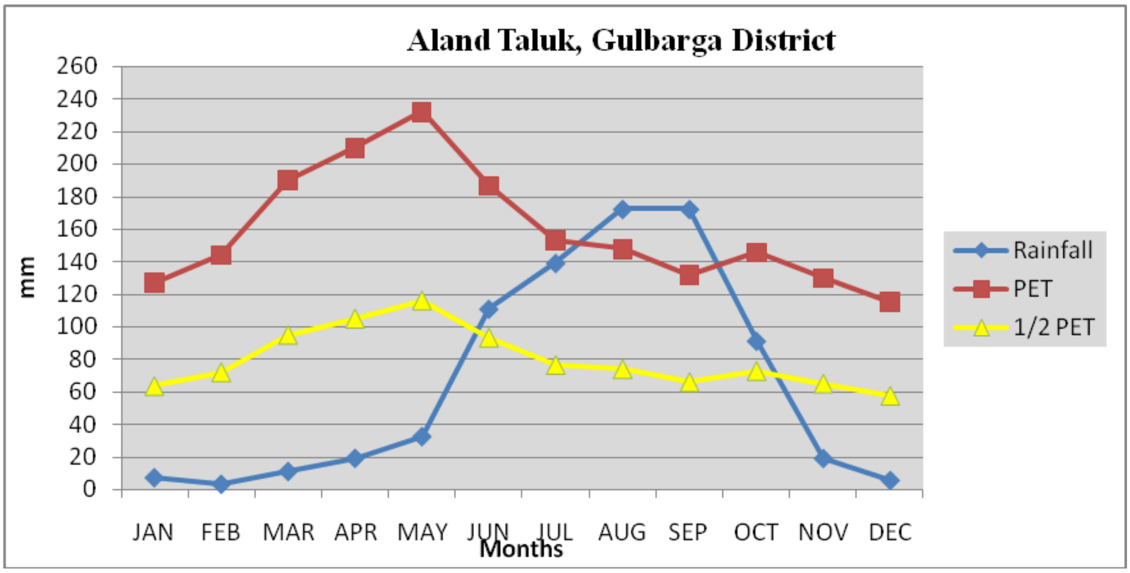


Fig 2.3 Rainfall distribution in Aland Taluk, Kalaburgi District

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 are under thin to moderately thick forest vegetation. Still, there are some remnants of the past forest cover which can be seen in patches in some ridges and hillocks in the microwatershed (Fig. 2.4).

Fig. 2.4 Natural vegetation (Scrub) of Matki-3 Microwatershed

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.

2.7 Land Utilization

About 89 per cent area (Table 2.2) in Aland taluk is cultivated at present. An area of about 2 per cent is permanently under pasture, 3 per cent under current fallows and 2 per cent each under non agricultural land and 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 sorghum, maize, cotton, sugarcane, safflower, groundnut, red gram and sapota. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is 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 Matki-3 microwatershed is presented in Fig.2.5.

Table 2.2 Land Utilization in Aland Taluk

Sl. No.	**Agricultural land use**	**Area (ha)**	**Per cent**
1.	Total geographical area	173417	
2.	Total cultivated area	153806	88.69
3.	Area sown more than once	7910	
4.	Trees and grooves	59	0.034
5.	Forest	2854	1.64
6.	Cultivable wasteland	974	0.56
7.	Permanent Pasture land	3469	2.00
8.	Barren land	3142	1.81
9.	Non- Agriculture land	3465	1.99
10.	Currently Fallow lands	5648	3.25

Simultaneously, enumeration of wells (bore wells and open wells) in the microwatershed was made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells and other water bodies in the Matki-3 microwatershed is given in Figure 2.6.

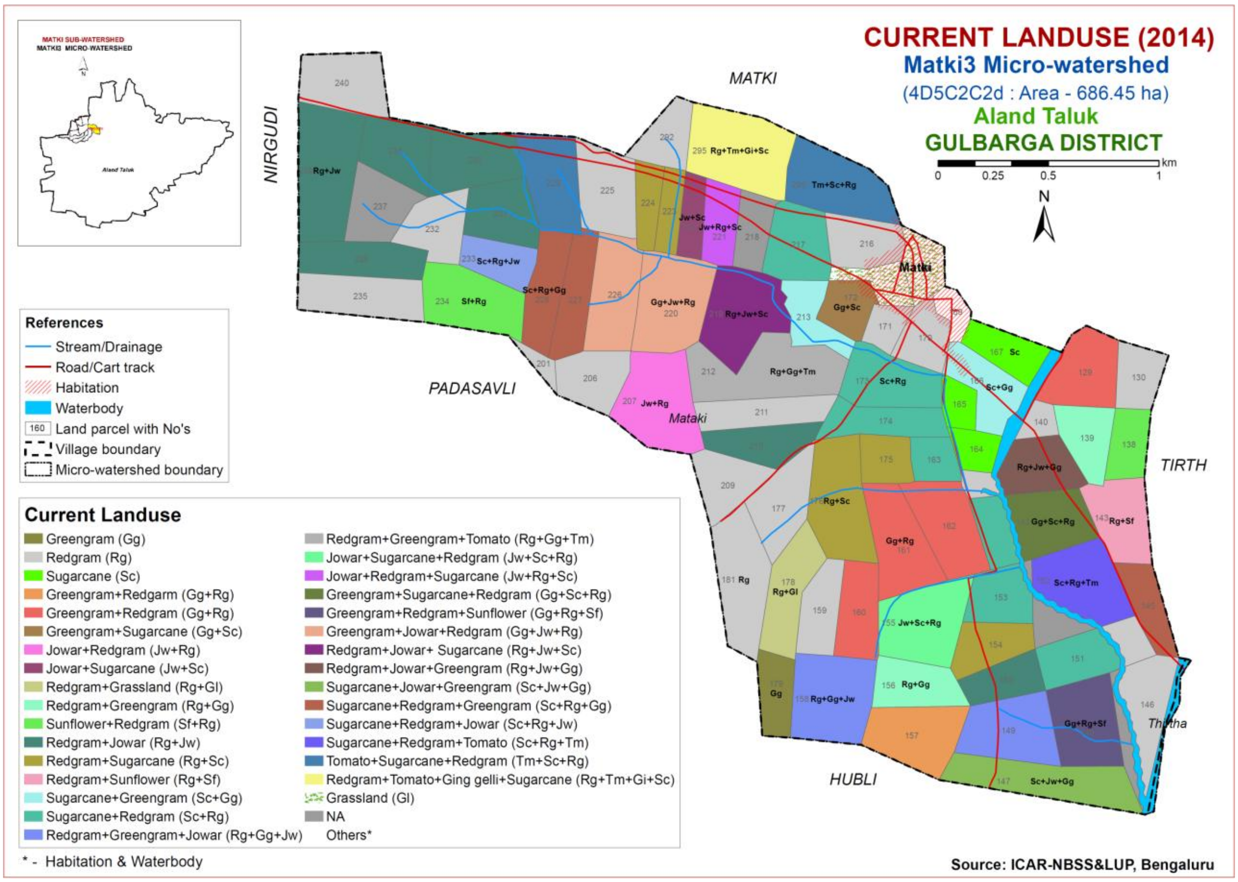


Fig.2.5 Current Land Use – Matki-3 Microwatershed

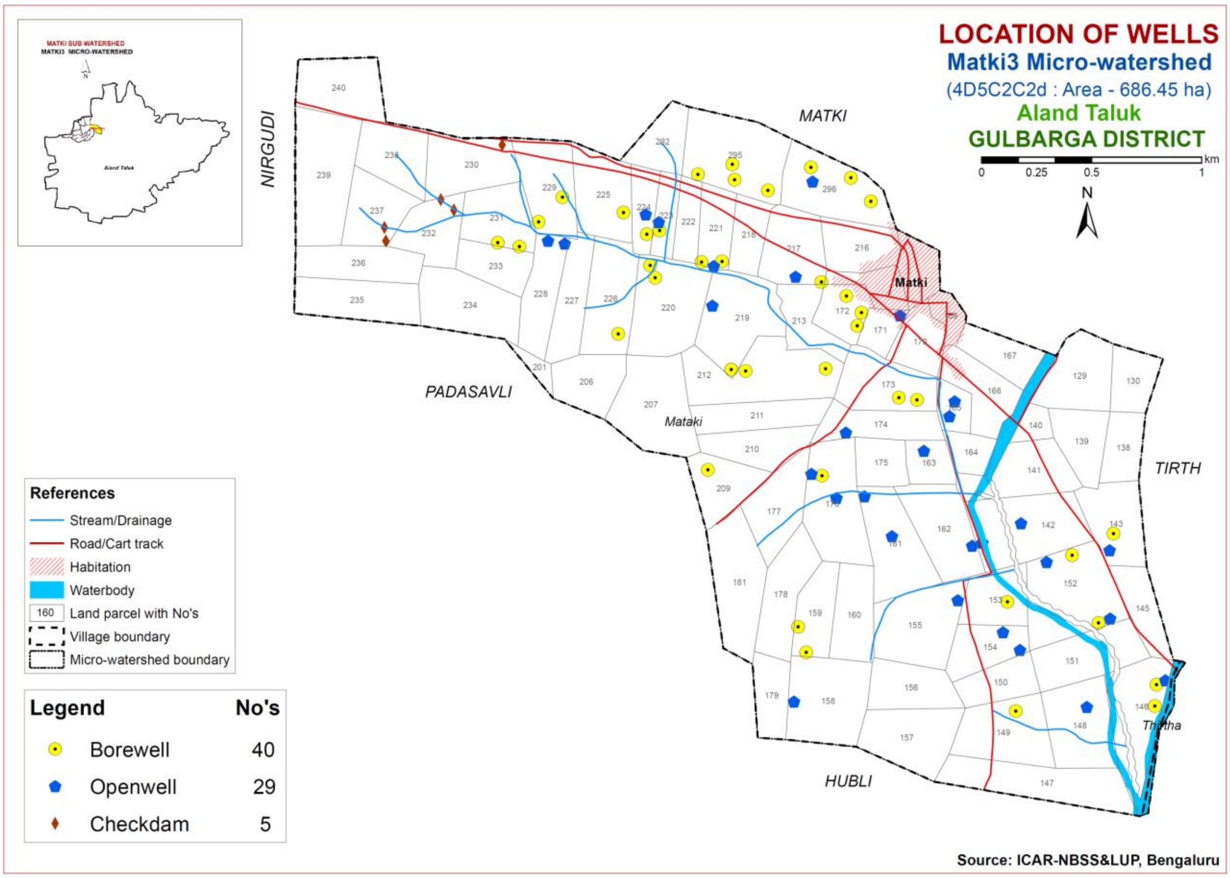


Fig.2.6 Location of Wells – Matki-3 Microwatershed

Chapter 3

SURVEY METHODOLOGY

The purpose of land resource inventory is to delineate similar areas (soil series and phases), which respond or expected to respond similarly to a given level of management. This was achieved in Matki-3 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site (slope of the land, erosion, drainage, occurrence of rock fragments etc.) followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units and showing their area extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in 686 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 helps to identify the parcel boundaries and other permanent features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were used for initial traversing, identification of geology and landforms, drainage features, present land use and also for selection of transects in the microwatershed.

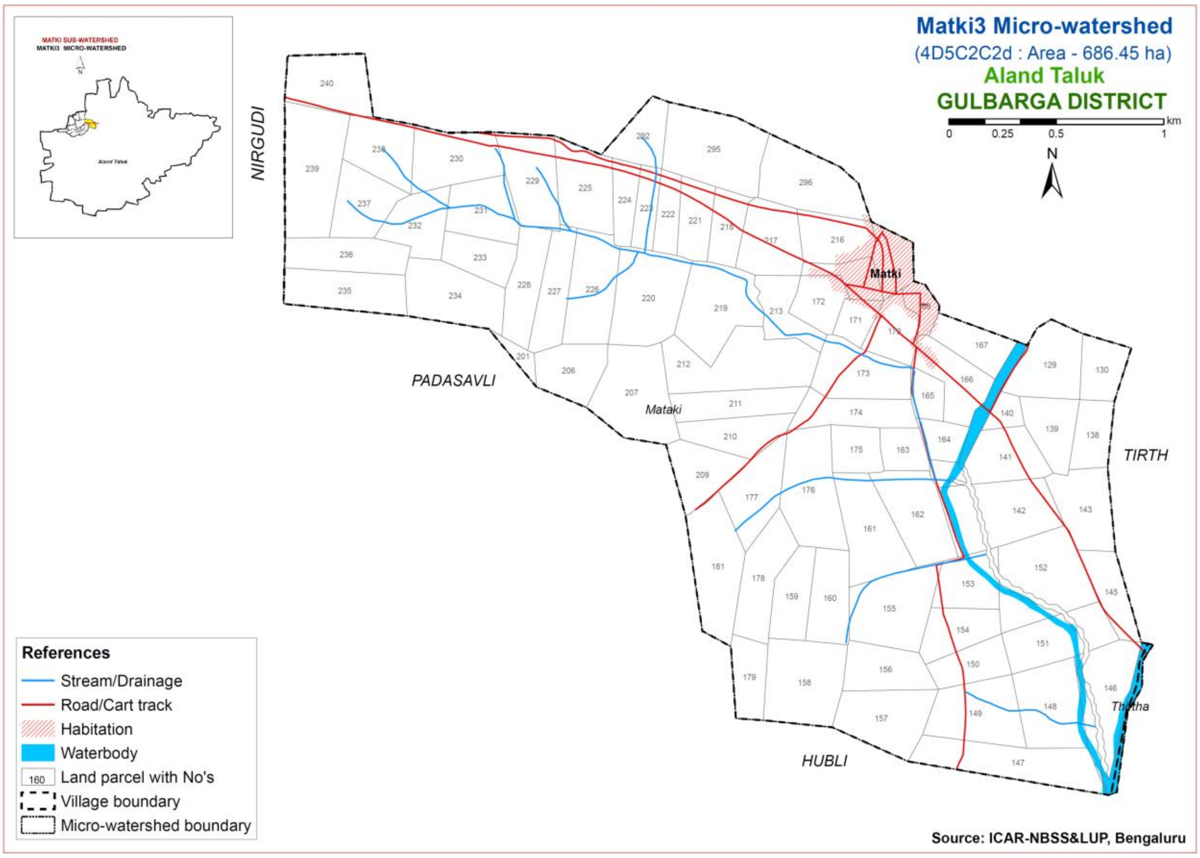


Fig 3.1 Scanned and Digitized Cadastral map of Matki-3 Microwatershed

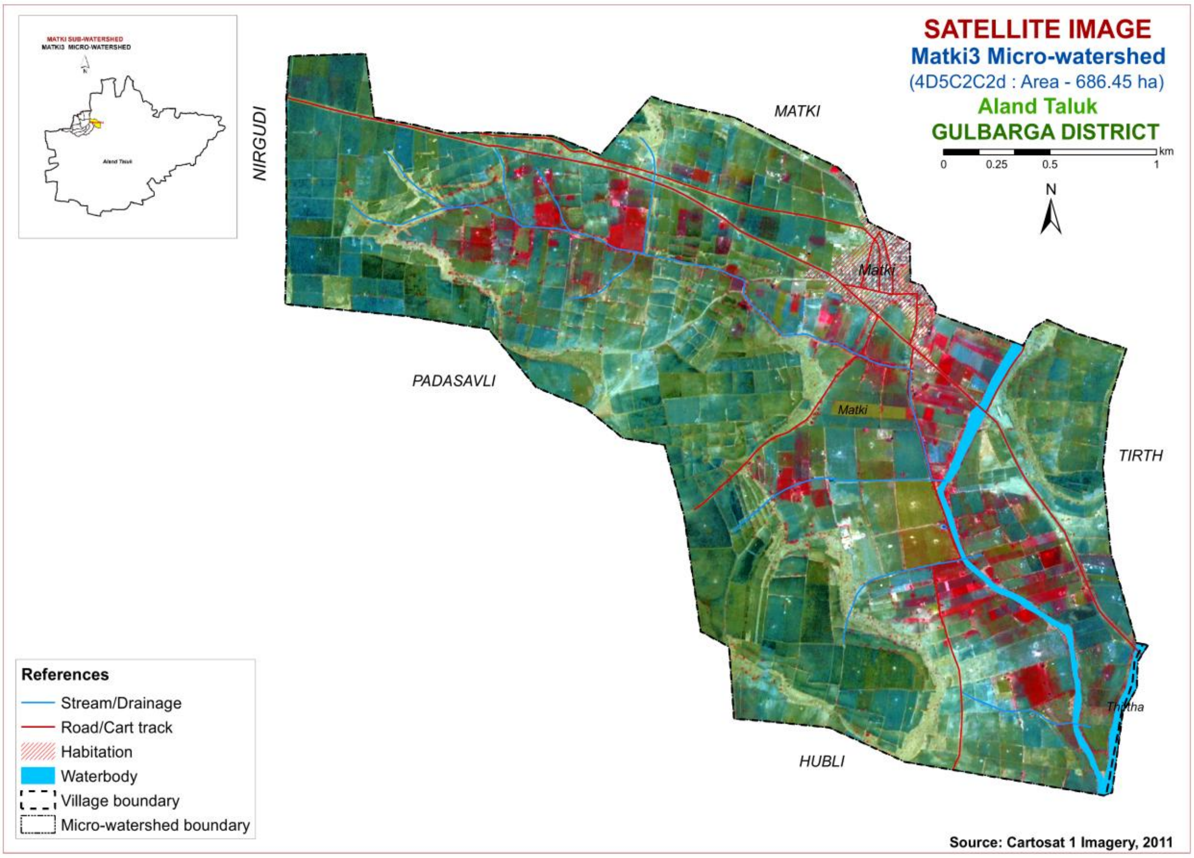


Fig.3.2 Satellite Image of Matki-3 Microwatershed

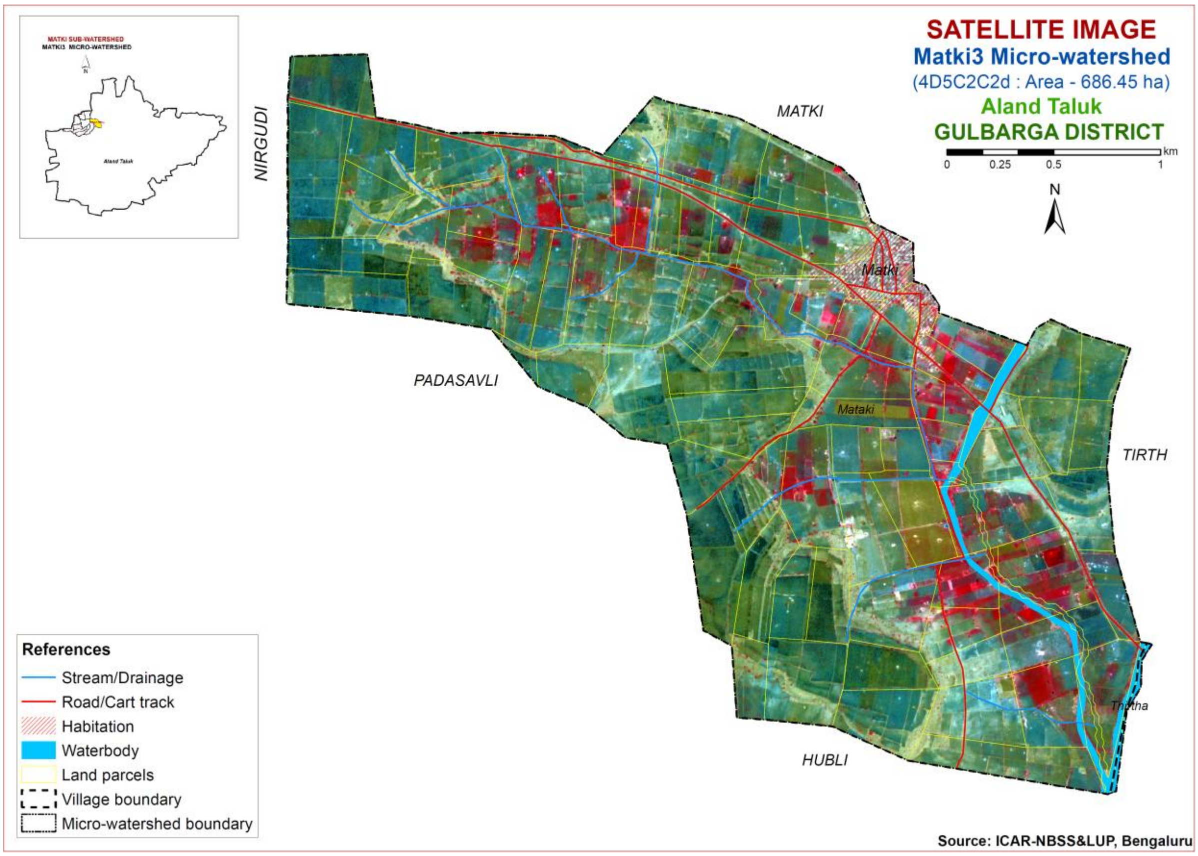


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Matki-3 Microwatershed

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 were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

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

Based on the soil-site characteristics, the soils were grouped into different soil series (soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management). Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 7 soil series were identified in the Matki-3 microwatershed.

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

SOILS OF BASALT LANDSCAPE							
Sl. no	**Soil Series**	**Depth (cm)**	**Colour**	**Text-ure**	**Gravel (%)**	**Horizon sequence**	**Calcar-eousness**
1	Margutti (MGT)	<25	10YR3/3,4/3,5/4 7.5YR4/3	c	15-35	Ap-R/cr	-
2	Novinihala (NHA)	25-50	10YR3/2,3/1,4/2 7.5YR3/4	c	<15	Ap-Bw-cr/R	-
3	Bhimanahalli (BHI)	25-50	10YR3/2,3/3,3/1 7.5YR3/2,4/2	c	15-35	Ap-Bw-cr/R	-
4	Kalamundargi (KGI)	25-50	10YR4/3,4/2 7.5YR3/3,3/4, 4/3	c	15-35	Ap-Bw-cr/R	-
5	Gutti (GTT)	50-75	10YR3/2, 3/1 7.5YR3/3, 4/3	c	15-35	Ap-Bw-Bss-cr	-
6	Kamalapur (KMP)	75-100	10YR3/2, 3/1	c	<15	Ap-Bw-Bss-cr	-
7	Rajanala (RNL)	100-150	10YR3/, 3/2,4/2, 4/3	c	35-60	Ap-Bw-Bss	-

3.3 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected from farmer's fields (107 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory. (Katyal and Rattan, 2003) By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated for the microwatershed.

3.4 Finalization of Soil Maps

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 map (Fig.3.4) in the form of symbols. During the survey about 29 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. All the profile locations are indicated on the village cadastral map in the form of a triangle. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map. The soil map shows the geographic distribution of 24 mapping units representing 7 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 24 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 they have to be treated accordingly.

The 24 soil phases identified and mapped in the microwatershed were regrouped into 5 Land Management Units (LMU's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land 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 Matki-3 microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

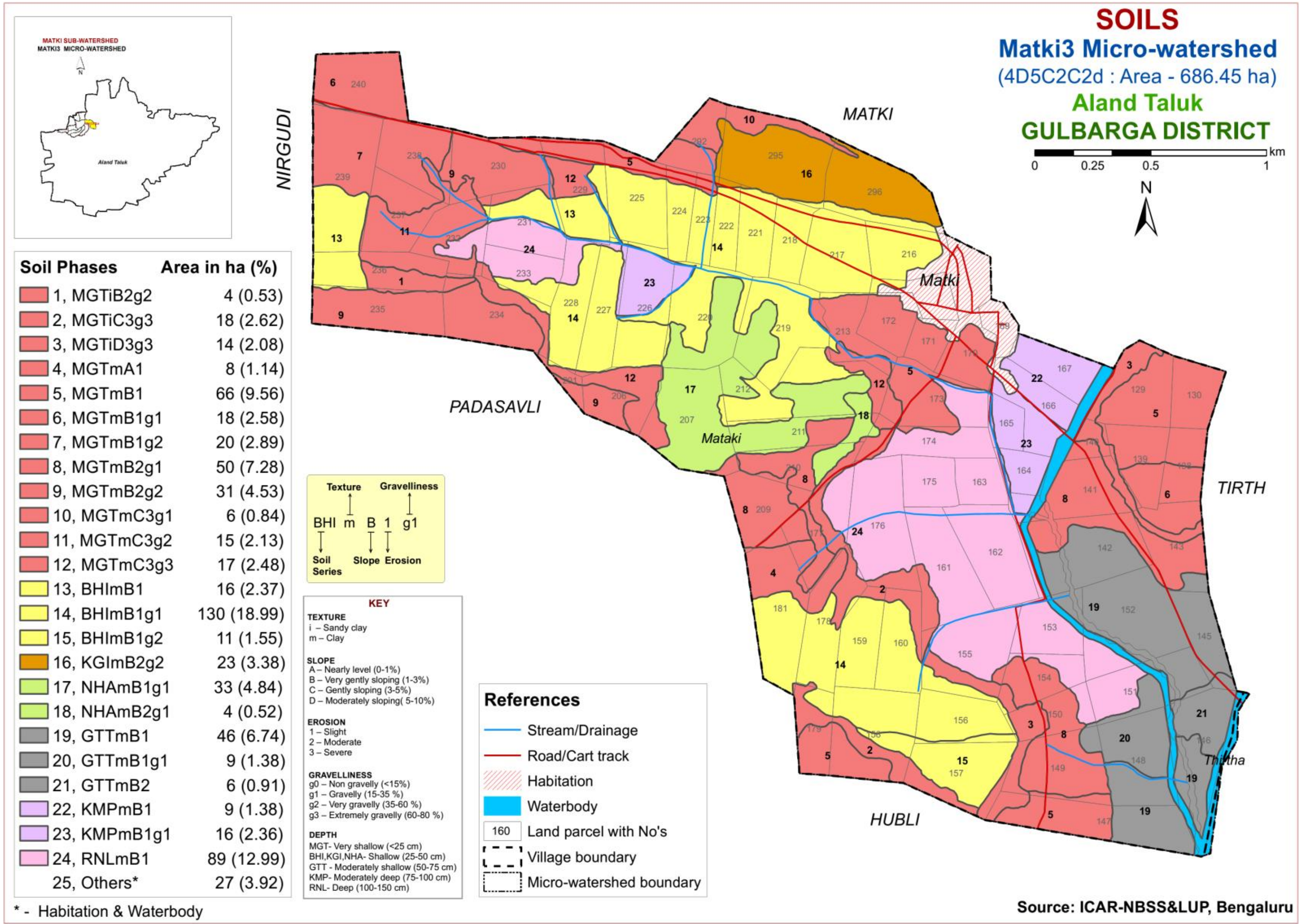


Fig 3.4 Soil phase or management units map of Matki-3 Microwatershed

Table 3.2 Soil Legend

Map unit No.	Soil series	Soil phase	Mapping Unit Description	Area in ha (%)
Soils of Basalt Landscape				
	MGT	Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clayey soils occurring on very gently sloping to moderately sloping uplands under cultivation		**265.47 (38.67)**
1		MGTiB2g2	Sandy clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)	3.67 (0.53)
2		MGTiC3g3	Sandy clay surface, 3-5% slope, severe erosion, extremely gravelly (60-80%)	18.00 (2.62)
3		MGTiD3g3	Sandy clay surface, 5-10% slope, severe erosion, extremely gravelly (60-80%)	14.24 (2.08)
4		MGTmA1	Clay surface, 0-1% slope, slight erosion	7.84 (1.14)
5		MGTmB1	Clay surface, 1-3% slope, slight erosion	65.65 (9.56)
6		MGTmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	17.70 (2.58)
7		MGTmB1g2	Clay surface, 1-3% slope, slight erosion, very gravelly (35-60%)	19.84 (2.89)
8		MGTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	49.98 (7.28)
9		MGTmB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)	31.11 (4.53)
10		MGTmC3g1	Clay surface, 3-5% slope, severe erosion, gravelly (15-35%)	5.78 (0.84)
11		MGTmC3g2	Clay surface, 3-5% slope, severe erosion, very gravelly (35-60%)	14.59 (2.13)
12		MGTmC3g3	Clay surface, 3-5% slope, severe erosion, extremely gravelly (60-80%)	17.04 (2.48)
	BHI	Bhimanahalli soils are shallow (25-50 cm), well drained, have very dark gray to brown clay soils occurring on very gently sloping uplands under cultivation		**157.28 (22.91)**
13		BHImB1	Clay surface, 1-3% slope, slight erosion	16.30 (2.37)
14		BHImB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	130.34 (18.99)
15		BHImB1g2	Clay surface, 1-3% slope, slight erosion, very gravelly (35-60%)	10.64 (1.55)

	KGI	Kalamundargi soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown gravelly clay soils occurring on very gently sloping uplands under cultivation		**23.17 (3.38)**
16		KGImB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)	23.17 (3.38)
	NHA	Novinihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clayey soils occurring on very gently sloping uplands under cultivation		**36.75 (5.36)**
17		NHAmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	33.20 (4.84)
18		NHAmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	3.55 (0.52)
	GTT	Gutti soils are moderately shallow (50-75 cm), moderately well drained, have very dark gray to brown clayey soils occurring on very gently sloping uplands under cultivation		**62.00 (9.03)**
19		GTTmB1	Clay surface, 1-3% slope, slight erosion	46.25 (6.74)
20		GTTmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	9.48 (1.38)
21		GTTmB2	Clay surface, 1-3% slope, moderate erosion	6.27 (0.91)
	KMP	Kamalapur soils are moderately deep (75-100 cm), moderately well drained, have very dark gray to very dark grayish brown cracking clay soils occurring on very gently sloping uplands under cultivation		**25.68 (3.74)**
22		KMPmB1	Clay surface, 1-3% slope, slight erosion	9.46 (1.38)
23		KMPmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)	16.23 (2.36)
	RNL	Rajanala soils are deep (100-150 cm), moderately well drained, have very dark gray to brown cracking clay soils occurring on very gently sloping uplands under cultivation		**89.18 (12.99)**
24		RNLmB1	Clay surface, 1-3% slope, slight erosion	89.18 (12.99)
25		Habitation		26.92 (3.92)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Matki-3 microwatershed is provided in this chapter. The microwatershed area has been identified as Basalt landscape. In all, 7 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 Basalt landscape, it is by parent material and climate. A brief description of each of the 7 soil series identified followed by 24 soil phases (management units) mapped under each series are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, erosion, gravelliness, AWC, LCC etc, with respect to each of the soil phase identified is given village/survey number wise for the microwatershed in Appendix-I.

4.1 Soils of Basalt Landscape

In this landscape, 7 soil series are identified and mapped. Of these, Margutti (MGT) soil series occupies maximum area of about 265 ha (39%). The brief description of each series along with the soil phases identified and mapped is given below.

4.1.1 Margutti (MGT) Series: Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clay soils. They have developed from basalt and occur on very gently sloping to moderately sloping uplands.

The total depth of the soil ranges from 10 to 23 cm. The thickness of A horizon ranges from 7 to 18 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. The texture is clay with 15 to 35 per cent gravel. The available water capacity is very low (<50 mm/m).

Twelve phases were identified:

MGTiB2g2	Sandy clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)
MGTiC3g3	Sandy clay surface, 3-5% slope, moderate erosion, extremely gravelly (60-80%)
MGTiD3g3	Sandy clay surface, 5-10% slope, moderate erosion, extremely gravelly (60-80%)
MGTmA1	Clay surface, 0-1% slope, slight erosion
MGTmB1	Clay surface, 1-3% slope, slight erosion
MGTmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)

MGTmB1g2	Clay surface, 1-3% slope, slight erosion, very gravelly (35-60%)
MGTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)
MGTmB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)
MGTmC3g1	Clay surface, 3-5% slope, severe erosion, gravelly (15-35%)
MGTmC3g2	Clay surface, 3-5% slope, severe erosion, very gravelly (35-60%)
MGTmC3g3	Clay surface, 3-5% slope, severe erosion, extremely gravelly (60-80%)

Landscape and Soil Profile Characteristics of Margutti (MGT) Series

4.1.2 Novanihala (NHA) Series: Novinihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 27 to 48 cm. The thickness of A horizon ranges from 12 to 20 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from sandy clay to clay with 10 to 20 per cent gravel. The thickness of B horizon ranges from 22 to 37 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with gravel content of 10-15 per cent. The available water capacity is low (51-100 mm/m).

Two phases were identified:

NHAmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)
NHAmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)

Landscape and Soil profile Characteristics of Novanihala (NHA) Series

4.1.3 Bhimanahalli (BHI) Series: Bhimanahalli soils are shallow (25-50 cm), well drained, have very dark gray to brown clay soils. They have developed from basalt and occur on very gently sloping to gently sloping uplands.

The thickness of the solum ranges from 29 to 48 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 4 and chroma 2 to 4. The texture varies from sandy clay to clay with 15 to 25 per cent gravel. The thickness of B horizon ranges from 23 to 33 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 1 to 3. Its texture is clay with gravel content of 15 to 35 per cent. The available water capacity is very low (<50 mm/m).

Three phases were identified:

BHImB1	Clay surface, 1-3% slope, slight erosion
BHImB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)
BHImB1g2	Clay surface, 1-3% slope, slight erosion, very gravelly (35-60%)

Landscape and Soil profile Characteristics of Bhimanahalli (BHI) Series

4.1.4 Kalamundargi (KGI) Series: Kalamundargi soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown gravelly clay soils. Tthey have developed from basalt and occur on very gently sloping uplands uplands.

The thickness of the solum ranges from 26 to 48 cm. The thickness of A horizon ranges from 10 to 19 cm. Its colour is in 7.5 YR and 10 YR hue with value 3 to 4 and chroma 2 to 4. The texture is clay with 15 to 25 per cent gravel. The thickness of B horizon ranges from 26 to 37 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with gravel content of 35 to 60 per cent. The available water capacity is very low (<50 mm/m).

Only one phase was identified :

KGImB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)

4.1.5 Gutti (GTT) Series: Gutti soils are moderately shallow (50-75 cm), moderately well drained, have very dark gray to brown clayey soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 24 to 74 cm. The thickness of A horizon ranges from 7 to 23 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 3. The texture is clay with 10 to 15 per cent gravel. The thickness of B horizon ranges from 28 to 65 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2to 3. Its texture is clay with gravel content of 15 to 35 per cent. The available water capacity is low (51-100 mm/m).

Three phases identified are briefly described below:

GTTmB1	Clay surface, 1-3% slope, slight erosion
GTTmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)
GTTmB2	Clay surface, 1-3% slope, moderate erosion

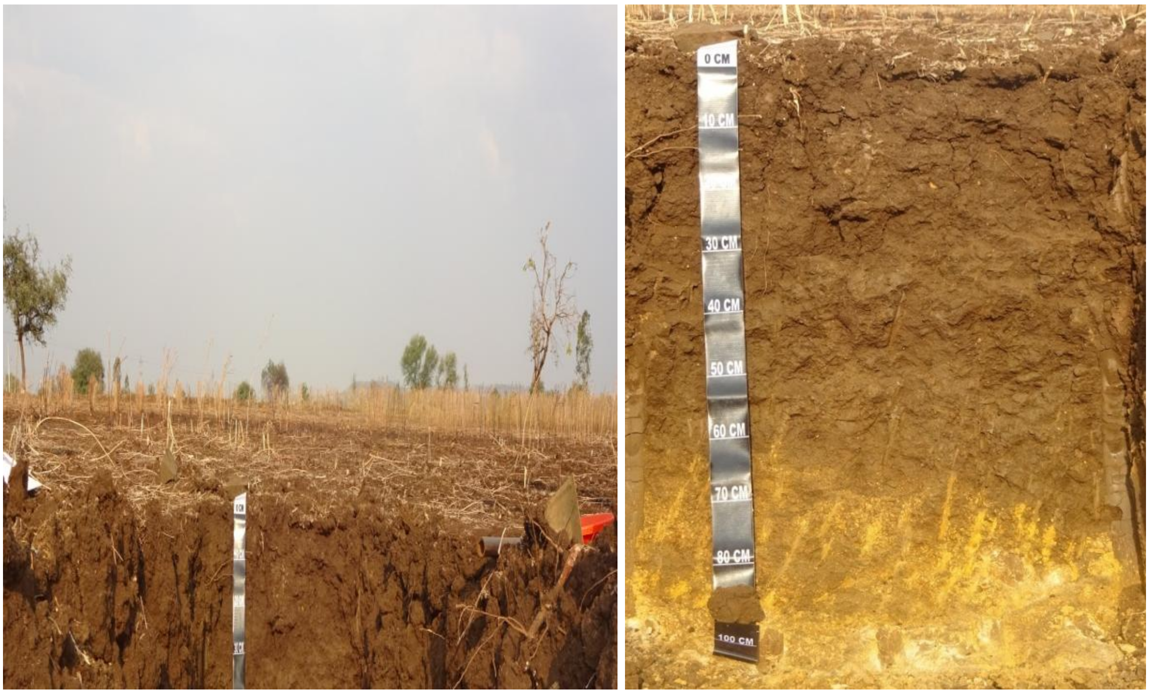
Landscape and Soil Profile Characteristics of Gutti (GTT) Series

4.1.6 Kamalapur (KMP) Series: Kamalapur soils are moderately deep (75-100 cm), moderately well drained, have very dark gray to very dark grayish brown cracking clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 75 to 95 cm. The thickness of A horizon ranges from 10 to 30 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 1 to 4. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 45 to 84 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 4. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is medium (101-150 mm/m).

Two phases identified are briefly described below:

KMPmB1	Clay surface, 1-3% slope, slight erosion
KMPmB1g1	Clay surface, 1-3% slope, slight erosion, gravelly (15-35%)



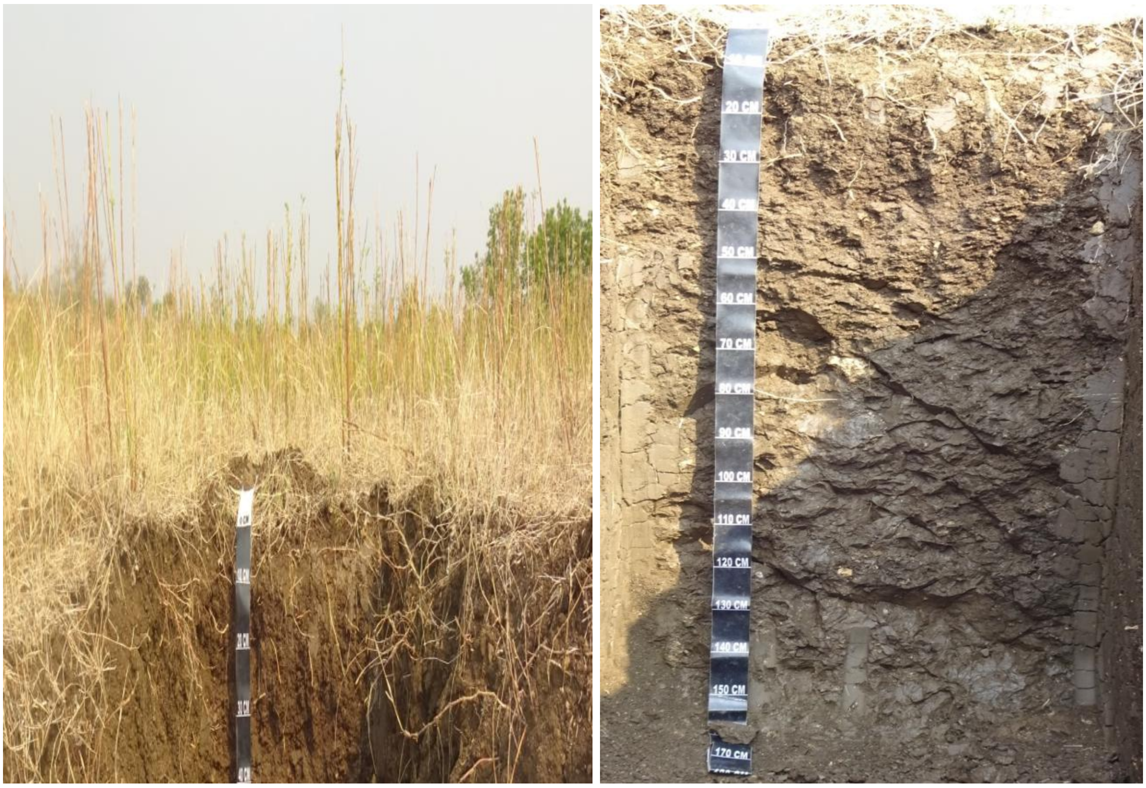
Landscape and Soil Profile Characteristics of Kamalapur (KMP) Series

4.1.7 Rajanala (RNL) Series: Rajanala soils are deep (100-150 cm), moderately well drained, have very dark gray to brown cracking clay soils. They have developed from basalt and occur on very gently to gently sloping uplands.

The thickness of the solum ranges from 125 to 140 cm. The thickness of A horizon ranges from 14 to 23 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 2. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 85 to 130 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 3. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m).

Only one phase was identified:

RNLmB1	Clay surface, 1-3% slope, slight erosion



Landscape and Soil Profile Characteristics of Rajanala (RNL) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

The most important soil and site characteristics that affect the land use and conservation needs of an area are land capability, soil depth, soil texture, coarse fragments, available water capacity, soil slope, soil erosion, soil reaction etc. These are interpreted from the data base gathered 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: Soil depth, soil texture, coarse fragments, soil reaction, available water capacity, calcareousness, salinity/alkali *etc*.

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

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

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

Class I: They are very good lands that have no limitations 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 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 only.

The 24 soil map units identified in the Matki-3 microwatershed are grouped under 4 land capability classes and 7 land capability subclasses. About 94 per cent area in the microwatershed is suitable for agriculture (Fig. 5.1) and 2 per cent not suitable for agriculture but well suited for grazing or forestry, recreation and wildlife.

Good cultivable lands (Class II) cover about 26 per cent area and are distributed in the eastern part of the micowatershed with minor problems of soil and erosion.

Moderately good cultivable lands (Class III) cover maximum area of about 32 per cent and are distributed in the northern and southern part of the microwatershed with moderate problems of erosion and soil.

The fairly good cultivable lands (class IV) cover maximum area of about 36 per cent. They have severe limitations of erosion and soil and are distributed in the northwestern and southwestern part of the microwatershed.

The class VI lands cover about 2 per cent and are distributed in the southern and southeastern part of the microwatershed. They are well suited for pasture, forestry, wild life and recreation. They have very severe limitations of erosion and soil.

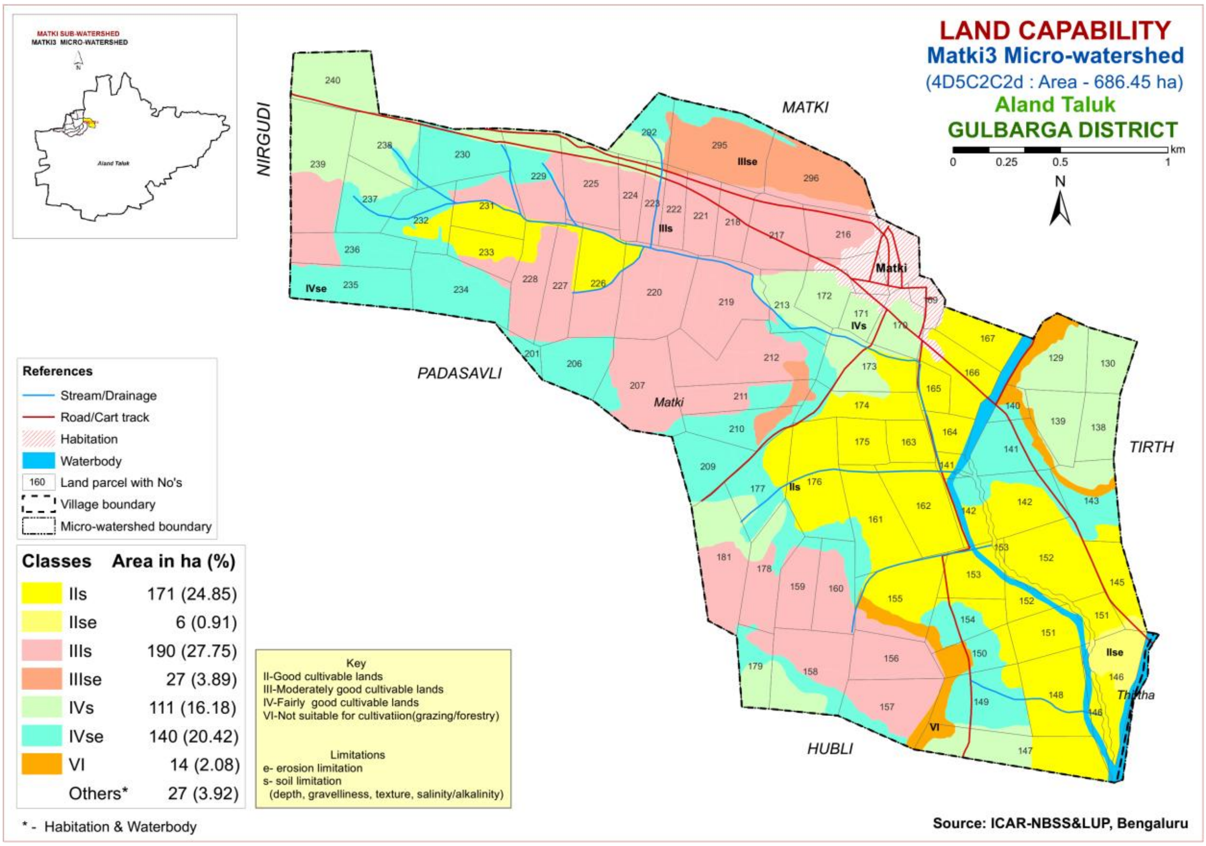


Fig. 5.1 Land Capability map of Matki-3 Microwatershed

5.2 Soil Depth

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

Deep soils (100-150 cm) occur in small area of about 89 ha (13%) and are distributed in the central and northwestern part of the micro watershed. Moderately deep soils (75-100 cm) occur in about 26 ha (4%) area and are distributed in the northwestern and eastern part of the microwatershed. Moderately shallow (50-75 cm) soils occupy about 62 ha (9%) and are distributed in the southeastern part of the microwatershed.

Maximum area of about 265 ha (39%) is under very shallow (<25 cm) and are distributed in all parts of the microwatershed. Shallow soils (25-50 cm) occupy an area of about 217 ha (32%) in the southwestern and northwestern part of the microwatershed.

The most productive lands 89 ha (13%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep soils (100-150 cm depth) occurring in the northwestern and central part of the microwatershed.

The most problem lands with an area of about 482 ha (71%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occur in all parts of the microwatershed. They are not suitable for growing agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal.

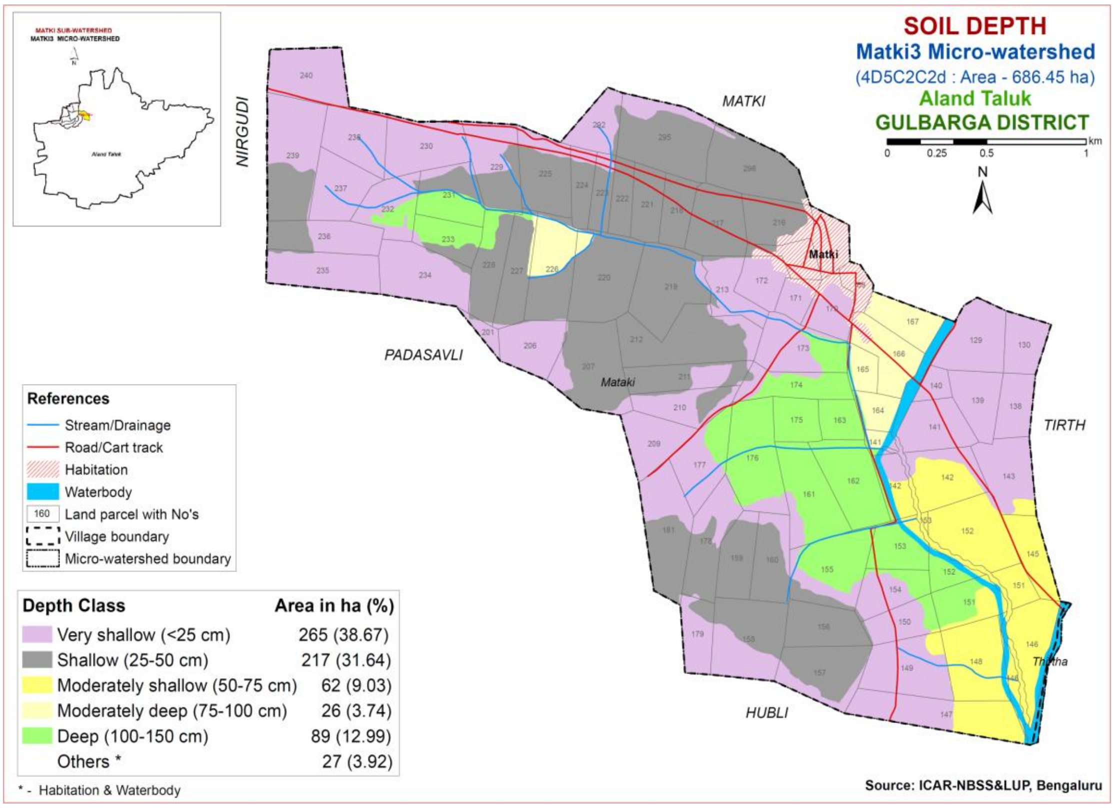


Fig. 5.2 Soil Depth map of Matki-3 Microwatershed

5.3 Surface Soil Texture

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

Maximum area of 660 ha (96%) has soils that are clayey and are distributed all over the microwatershed (Fig. 5.3).

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

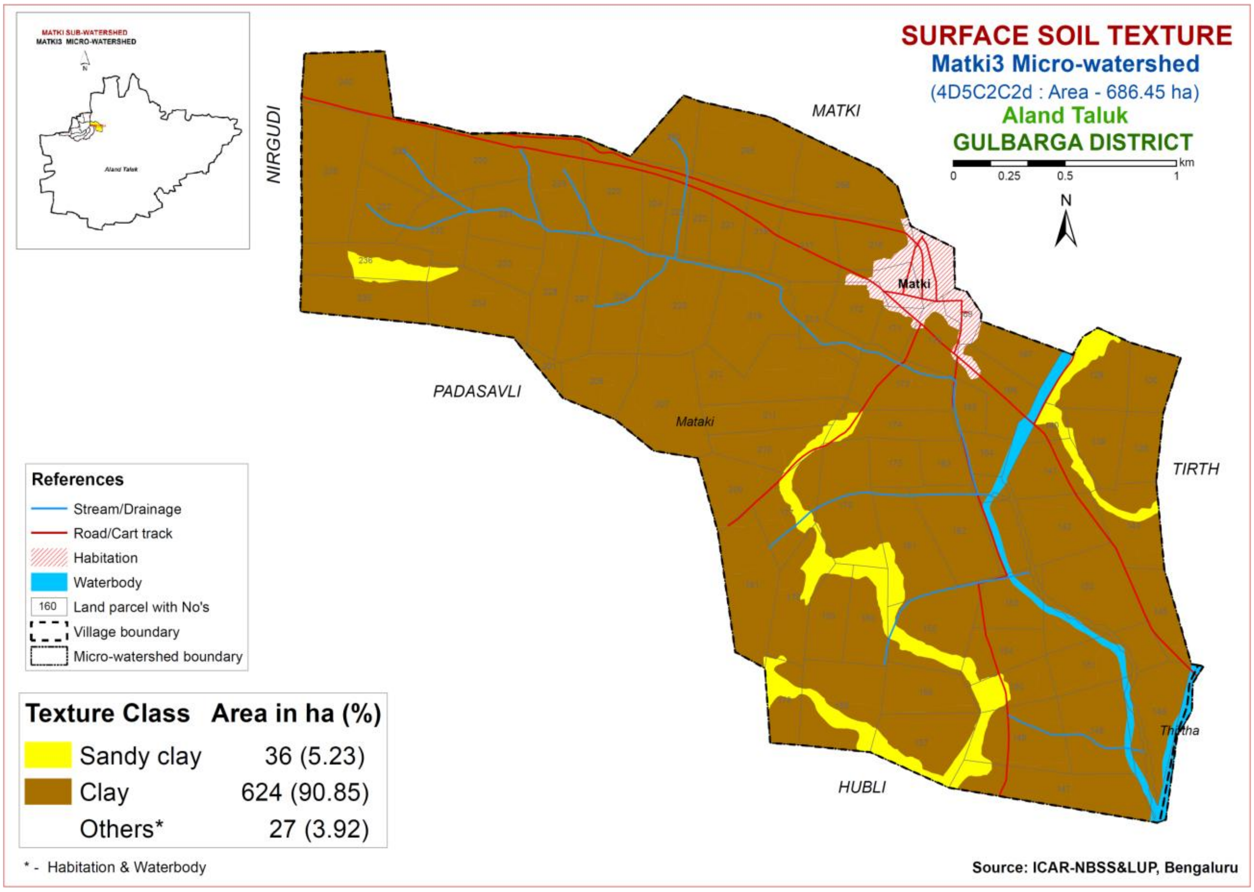


Fig. 5.3 Surface Soil Texture map of Matki-3 Microwatershed

5.4 Soil Gravelliness

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

Maximum area has soils that are gravelly (15-35%) covering about 266 ha (39%) and are distributed in the northern and southern part of the microwatershed (Fig.5.4).

About 241 ha (35%) of area in the micro watershed has soils that are nongravelly (<15%) and are distributed in the southern and southeastern part of the microwatershed followed by soils that are very gravelly (35-60%) covering about 103 ha (15%) that are distributed in the northwestern and small area in southern part of the microwatershed. About 49 ha (7%) area has soils that are extremely gravelly (60-80%) and are distributed in the central and southern part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 35 per cent. They are nongravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops.

The problem soils that are very gravelly (35-60%) and extremely gravelly (60-80%) are found to be 22 per cent where only short duration crops can be grown.

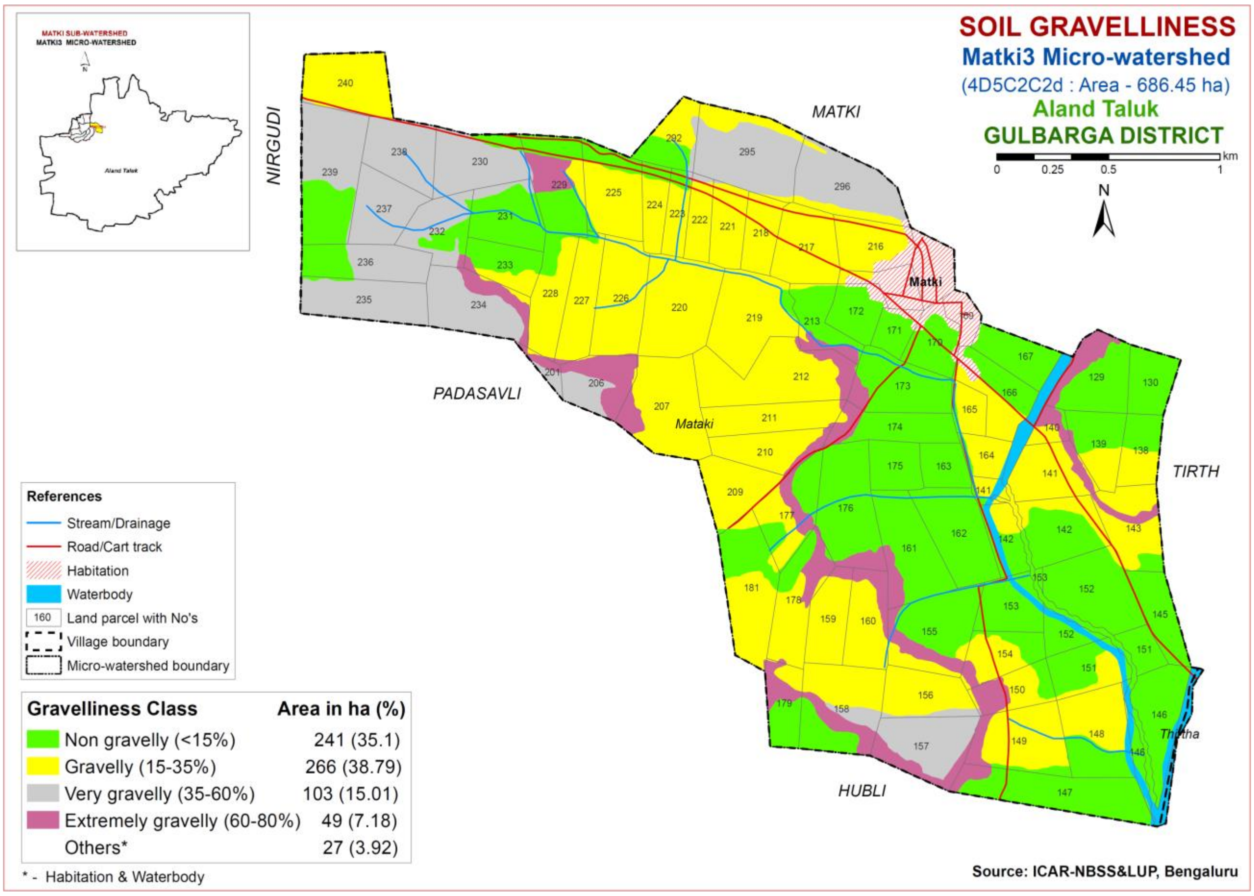


Fig. 5.4 Soil Gravelliness map of Makti-3 Microwatershed

5.5 Available Water Capacity

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

Major area of about 446 ha (65%) has soils that are very low (<50 mm/m) in available water capacity and are distributed in all parts of the microwatershed. An area of about 99 ha (14%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the southern and central part of the microwatershed. Small area in the microwatershed has soils that are medium (101-150 mm/m) in available water capacity. They occur in about 26 ha (4%) and are distributed in the eastern part of the microwatershed followed by soils that are very high (>200 mm/m) in AWC covering about 89 ha (13%) in the microwatershed and are distributed in the northwestern and central part of the microwatershed.

An area of about 115 ha (17%) has soils that have very high potential (>200 mm/m) and medium (101-150 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.

About 446 ha (65%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses.

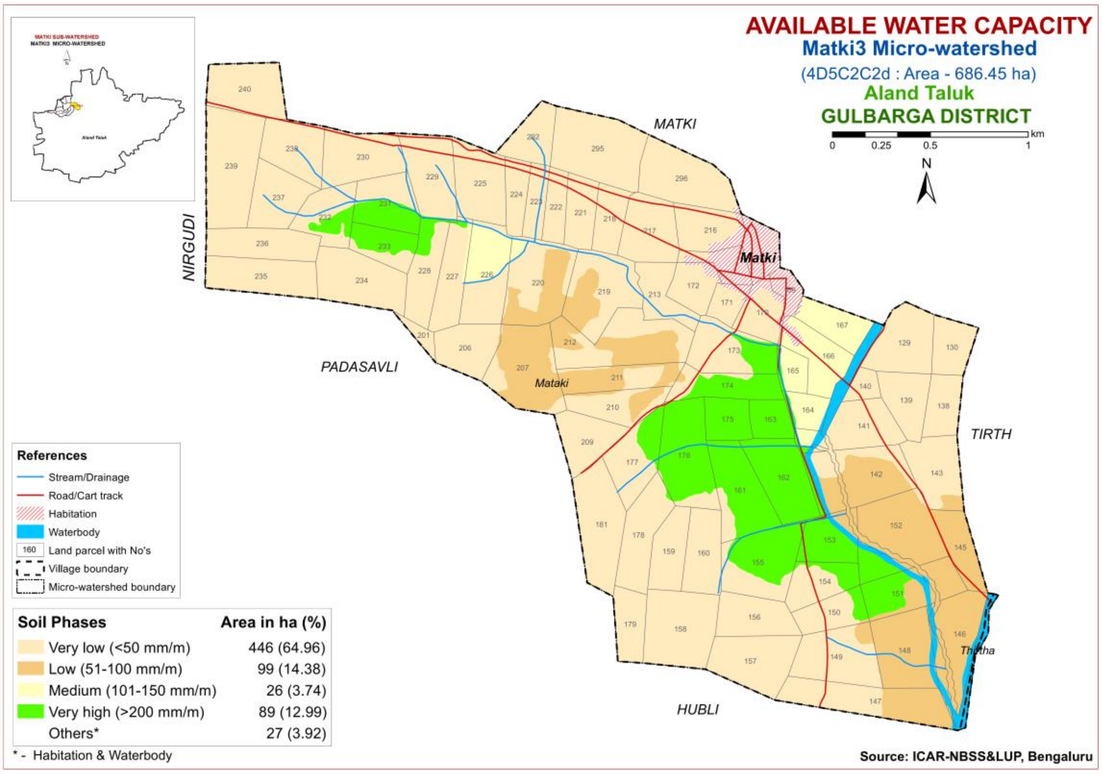


Fig. 5.5 Soil Available Water Capacity map of Matki-3 Microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3% slope) slope class. It covers a small area of about 582 ha (85%) and is distributed in all parts of the microwatershed and an area of about 55 ha (8 %) in the microwatershed falls under gently sloping (3-5%) slope class and is distributed in the northwestern, central and southern part of the microwatershed.

Moderately sloping (5-10% slope) slope class cover a very minor area of about 14 ha (2%) and is distributed in the southeastern part of the microwatershed. Nearly level lands (0-1%) slope class cover a very minor area of about 8 ha (1%) and are distributed in the southwestern part of the microwatershed.

An area of about 582 ha (85%) in the microwatershed has soils that have high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

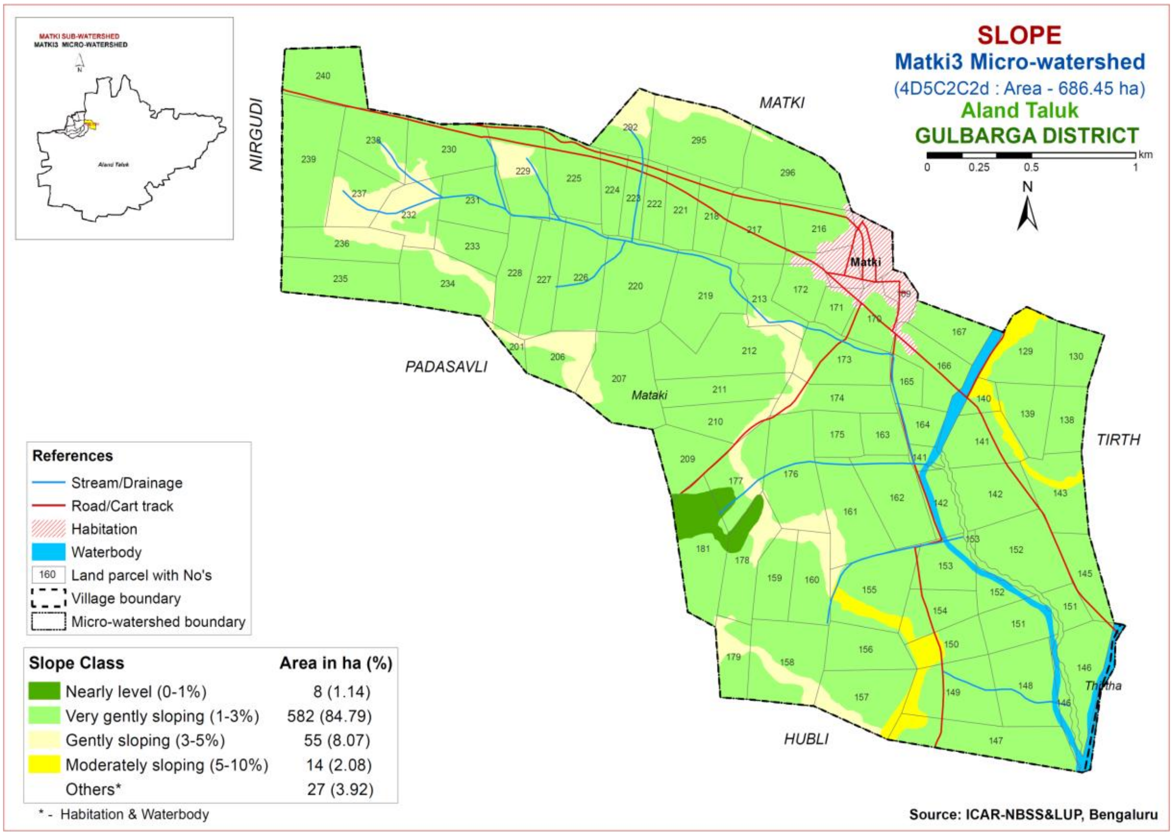


Fig. 5.6 Soil Slope map of Matki-3 Microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) covers about 472 ha (69%) and are distributed in all parts of the microwatershed.

Soils that are moderately eroded (e2 class) cover about 118 ha (17%) in the microwatershed and are distributed in the northwestern and southern part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 70 ha (10%) and are distributed in northwestern, central and southern part of the microwatershed.

Top priority is to be given to these 70 ha areas for taking up soil and water conservation and other land development measures followed by moderately eroded lands (17%).

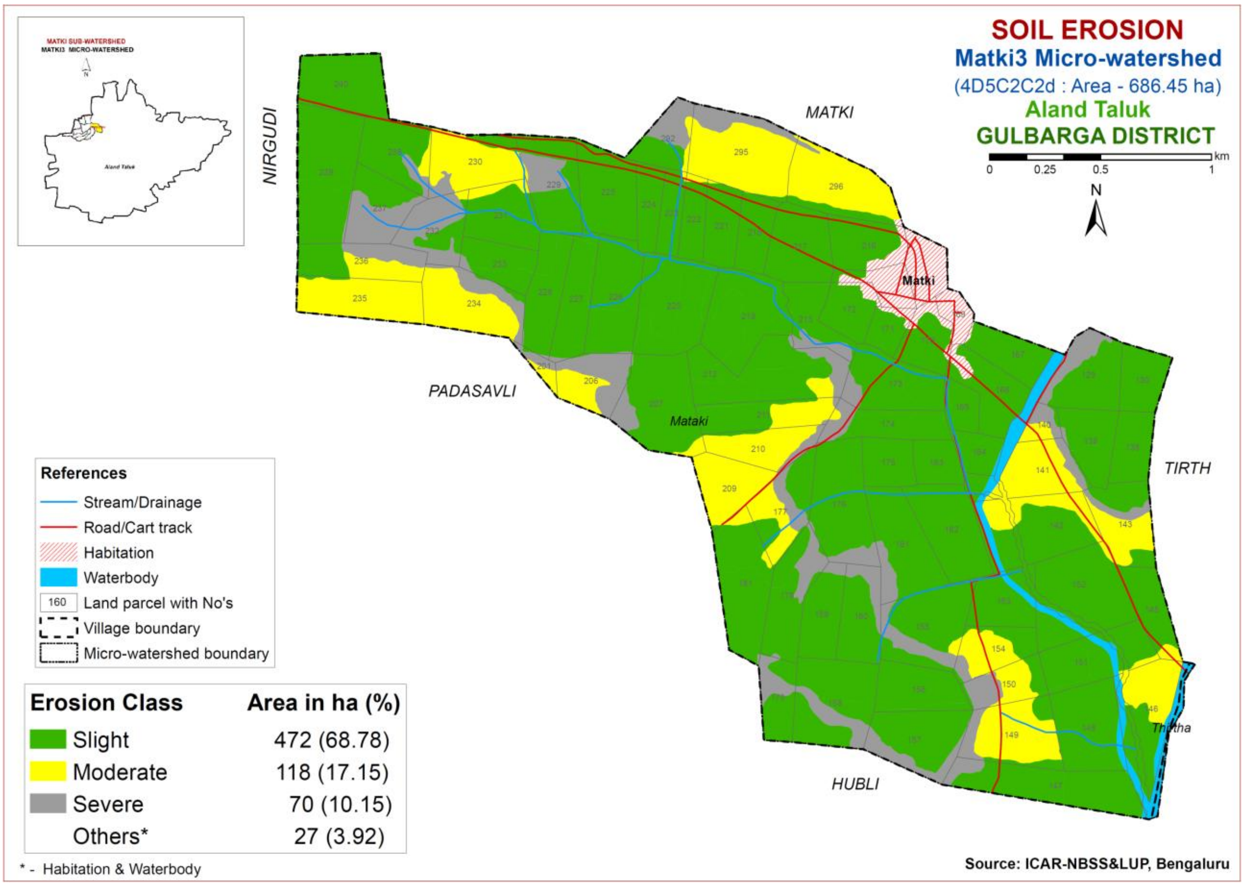


Fig. 5.7 Soil Erosion map of Matki-3 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2014 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil fertility analysis of the Matki-3 microwatershed for soil reaction (pH) showed that about 192 ha (28%) area is slightly alkaline (pH 7.3-7.8) and is distributed in the northwestern and southwestern part of the microwatershed. Maximum area of about 403 ha (59%) area is moderately alkaline (pH 7.8-8.4) and is distributed in northeastern and southeastern part of the microwatershed. About 64 ha (9%) area is neutral (pH 6.5-7.3) and is distributed in the northwestern part of the microwatershed.

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content of the soils in the microwatershed is medium (0.5-0.75%) in 441 ha (64%) area that are distributed in all parts of the microwatershed (Fig.6.3). High (>0.75%) organic carbon content accounts for 216 ha (31%) area and is distributed in the central, southern and northwestern part of the microwatershed. Low (<0.5%) organic carbon content accounts for very minor area of 3 ha (<1%) in the microwatershed and is distributed in the northern part of the microwatershed.

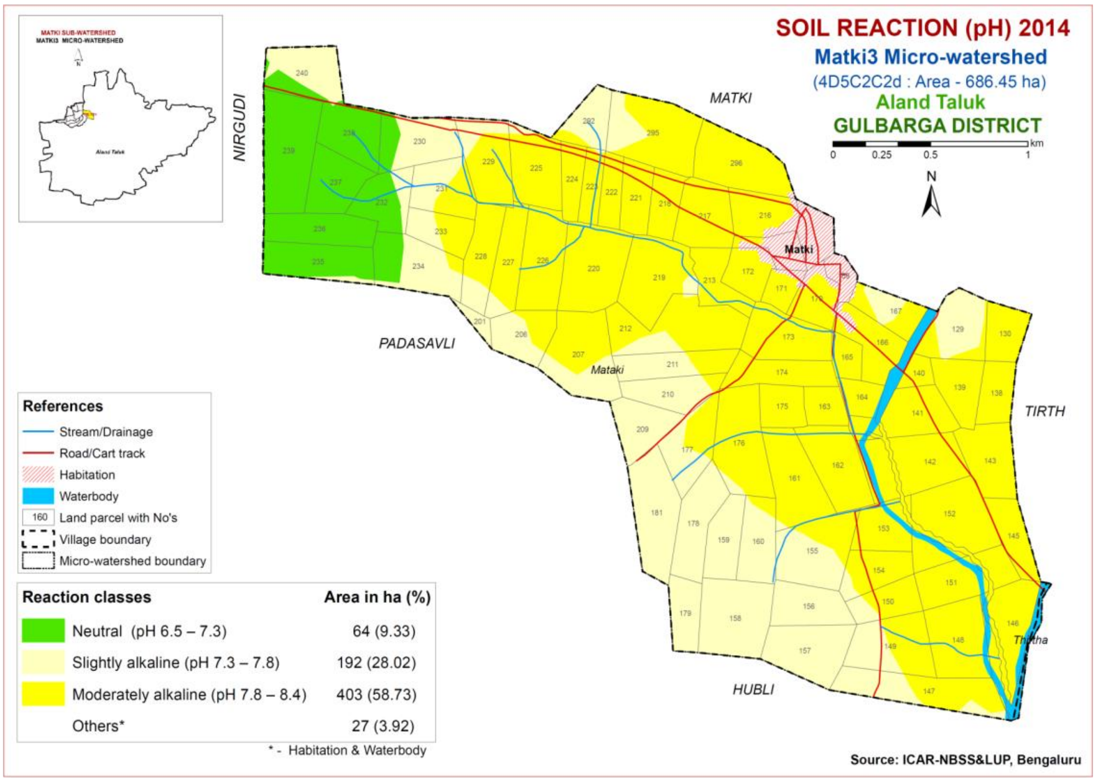


Fig.6.1 Soil Reaction (pH) map of Matki-3 Microwatershed

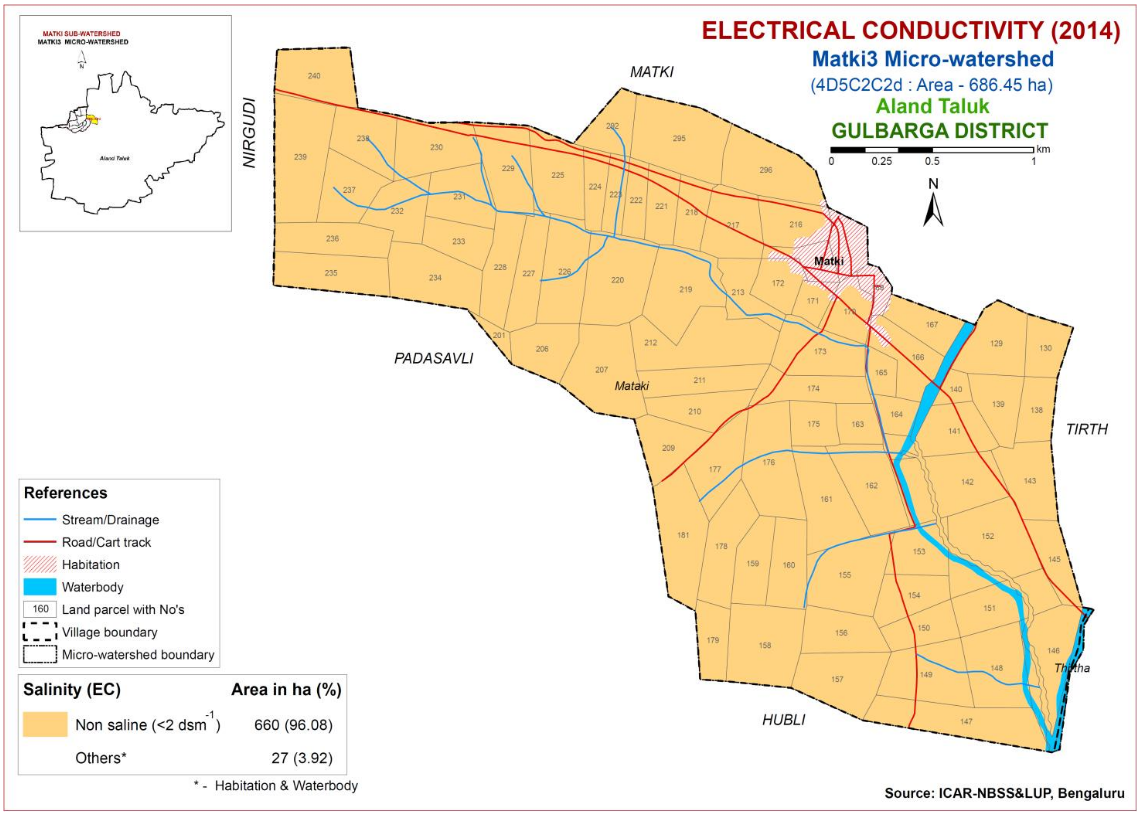


Fig.6.2 Electrical Conductivity (EC) map of Matki-3 Microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in major area 578 ha (84%) and is distributed in all parts of the microwatershed (Fig.6.4). There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. About 46 ha (7%) area in the microwatershed is medium (23-57 kg/ha) and is distributed in the northern part of the microwatershed. A small area of about 36 ha (5%) is high (>57 kg/ha) and is distributed in the northern part of the microwatershed.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in 229 ha (33%) area distributed in the central, northern and southern part of the microwatershed (Fig.6.5); high available potassium (>337 kg/ ha) content accounts for major area of 430 ha (63%) and is distributed in the northern and southeastern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in 316 ha (46%) area and is distributed in the central and eastern part of the microwatershed. Maximum area of about 320 ha (47%) is medium (10-20 ppm) in available sulphur and is distributed in the northern and southern part of the microwatershed (Fig.6.6). Available sulphur is high (>20 ppm) in small area of 23 ha (3%) and is distributed in the northern part of the microwatershed.

6.7 Available Boron

Available boron content is low (<0.5 ppm) in major area of about 487 ha (71%) and is distributed in all parts of the microwatershed. About 173 ha (25%) has soils that are medium (0.5-1.0 ppm) in available boron (Fig 6.7) and is distributed in the northern and southern part of the microwatershed.

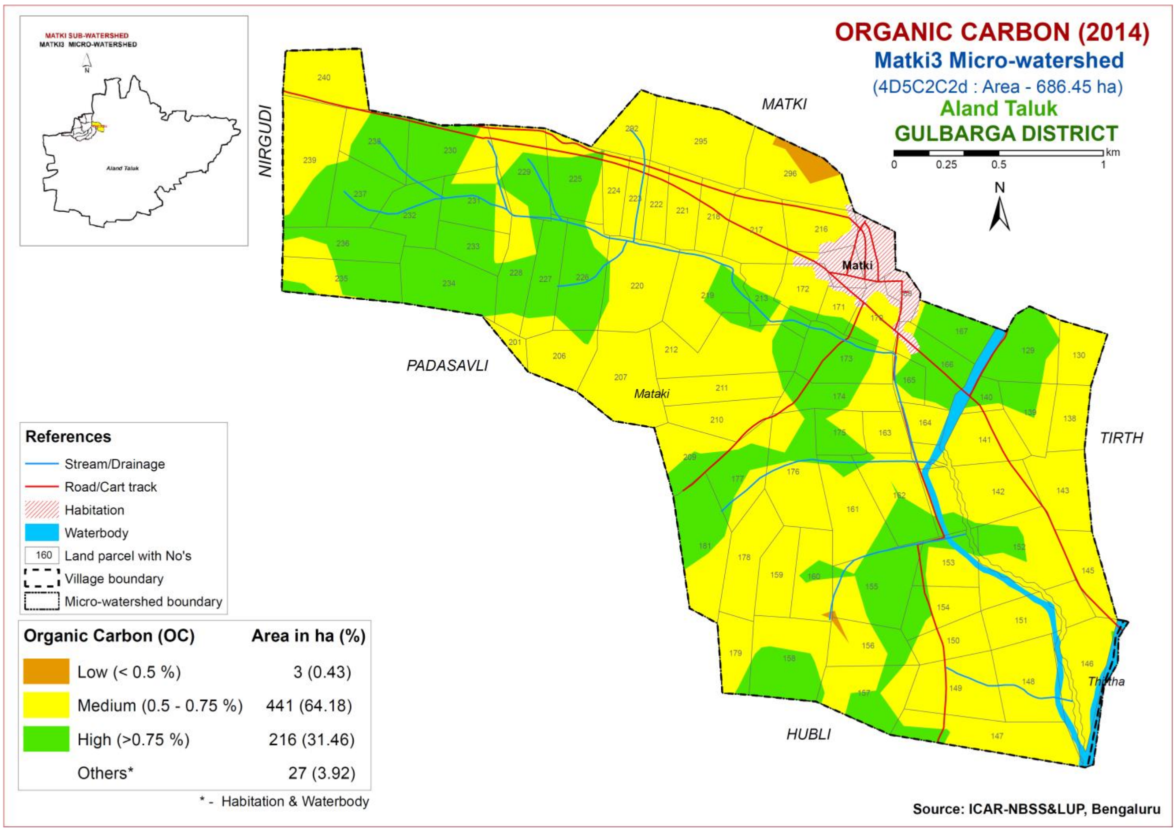


Fig.6.3 Soil Organic Carbon map of Matki-3 Microwatershed

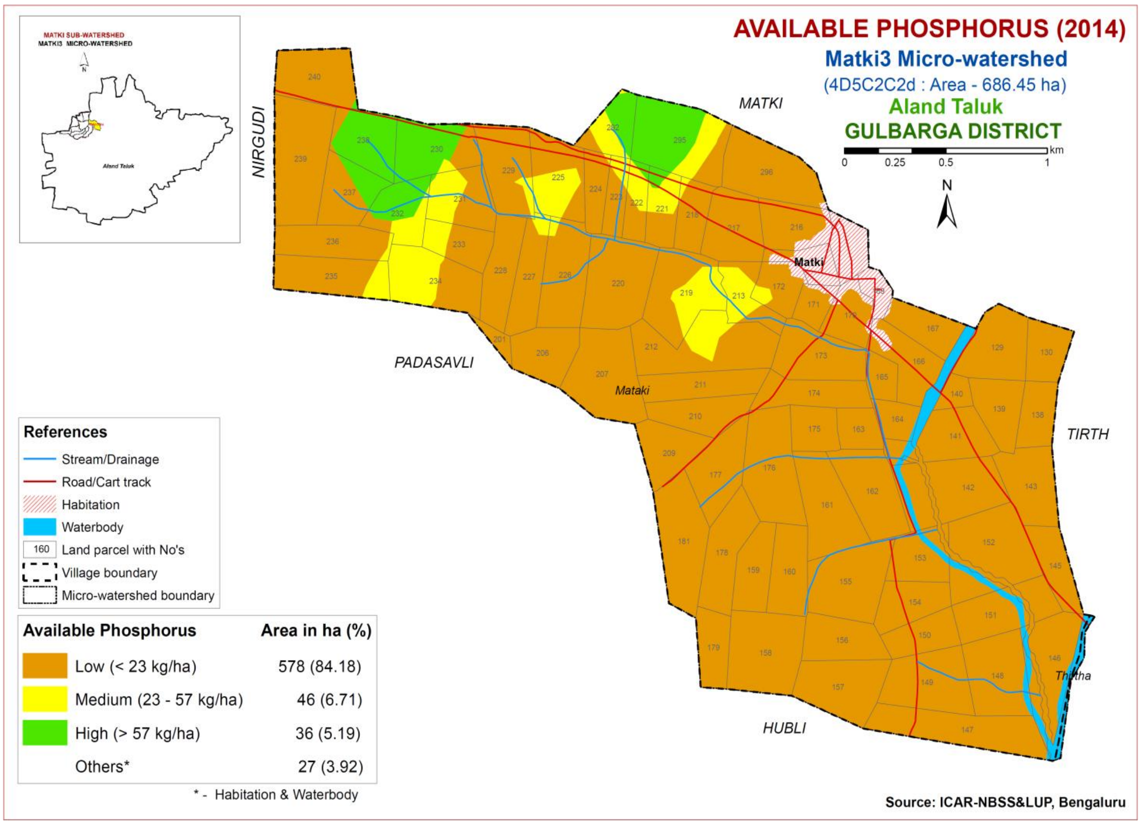


Fig.6.4 Soil available Phosphorus map of Matki-3 Microwatershed

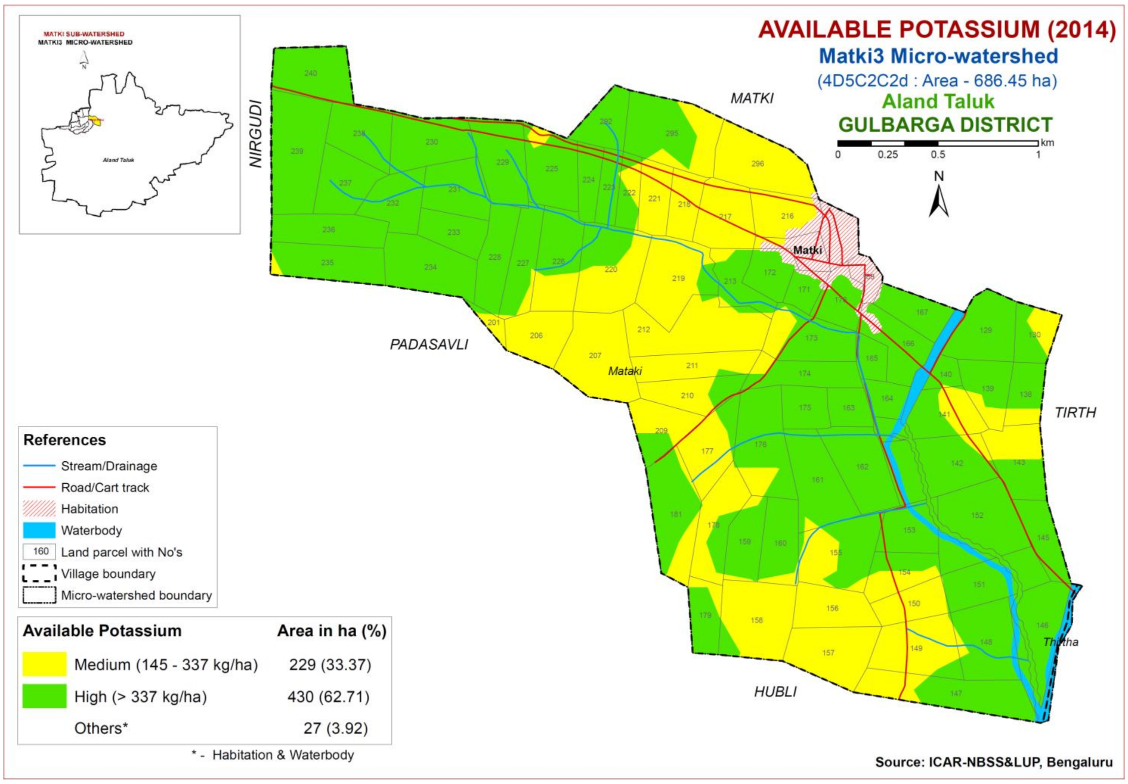


Fig.6.5 Soil available Potassium map of Matki-3 Microwatershed

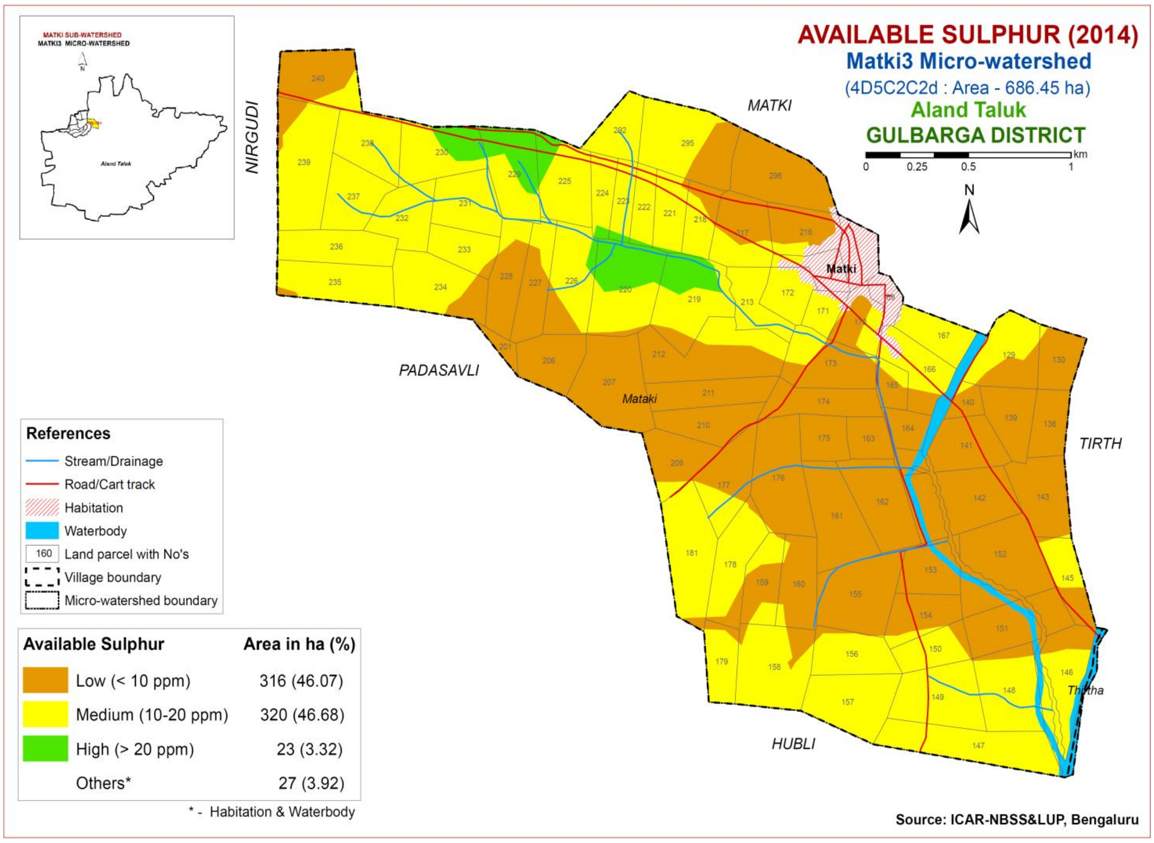


Fig.6.6 Soil available Sulphur map of Matki-3 Microwatershed

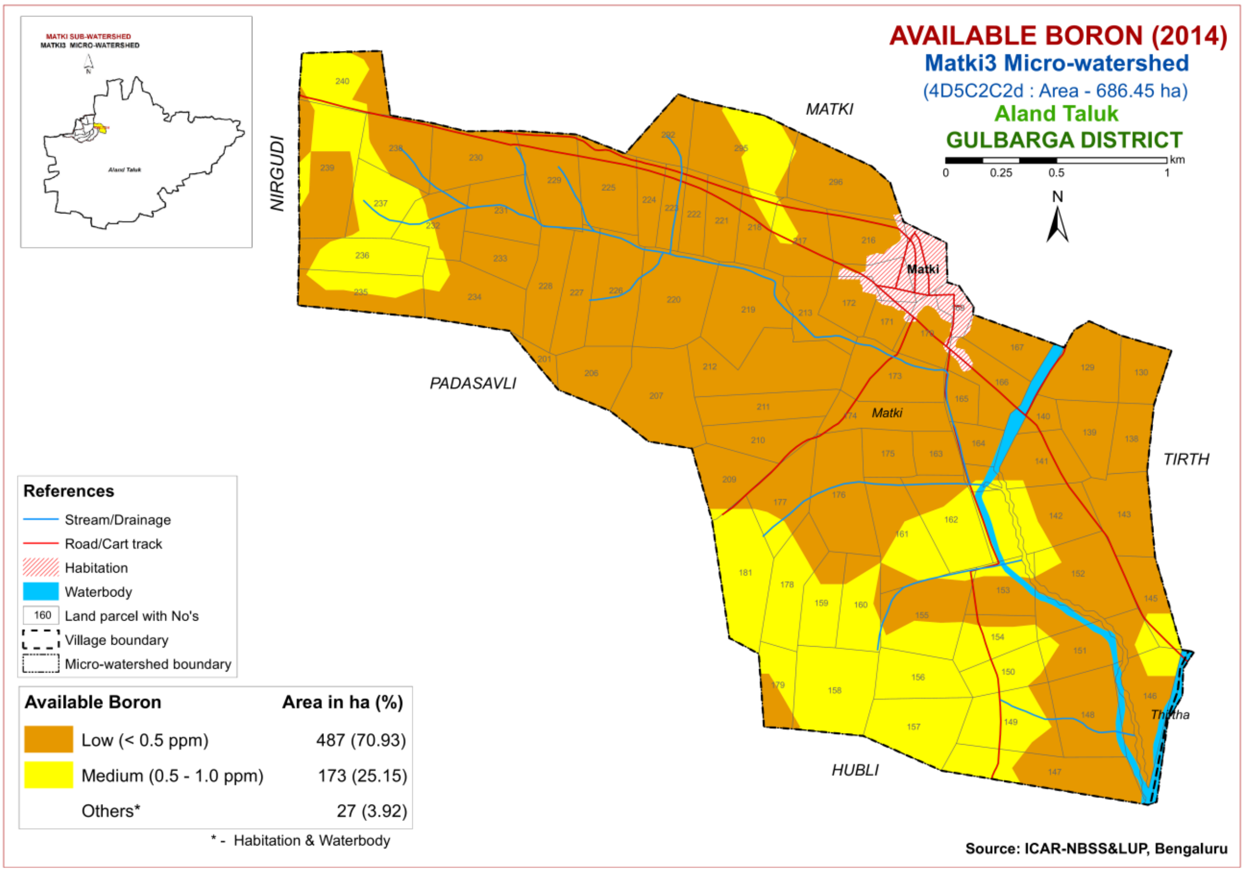


Fig.6.7 Soil available Boron map of Matki-3 Microwatershed

6.8 Available Iron

Available iron content is deficient (<4.5 ppm) in a small area of 14 ha (2%) and is distributed in the northern part of the microwatershed. It is sufficient in 645 ha (94%) (Fig 6.8) and are distributed in all parts of the microwatershed.

6.9 Available Manganese

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

6.10 Available Copper

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

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in major area of about 435 ha (63%) and is distributed in all parts of the microwatershed. It is sufficient (>0.6 ppm) in 224 ha (33%) area (Fig 6.11) and is distributed in the northwestern, southern and eastern part of the microwatershed.

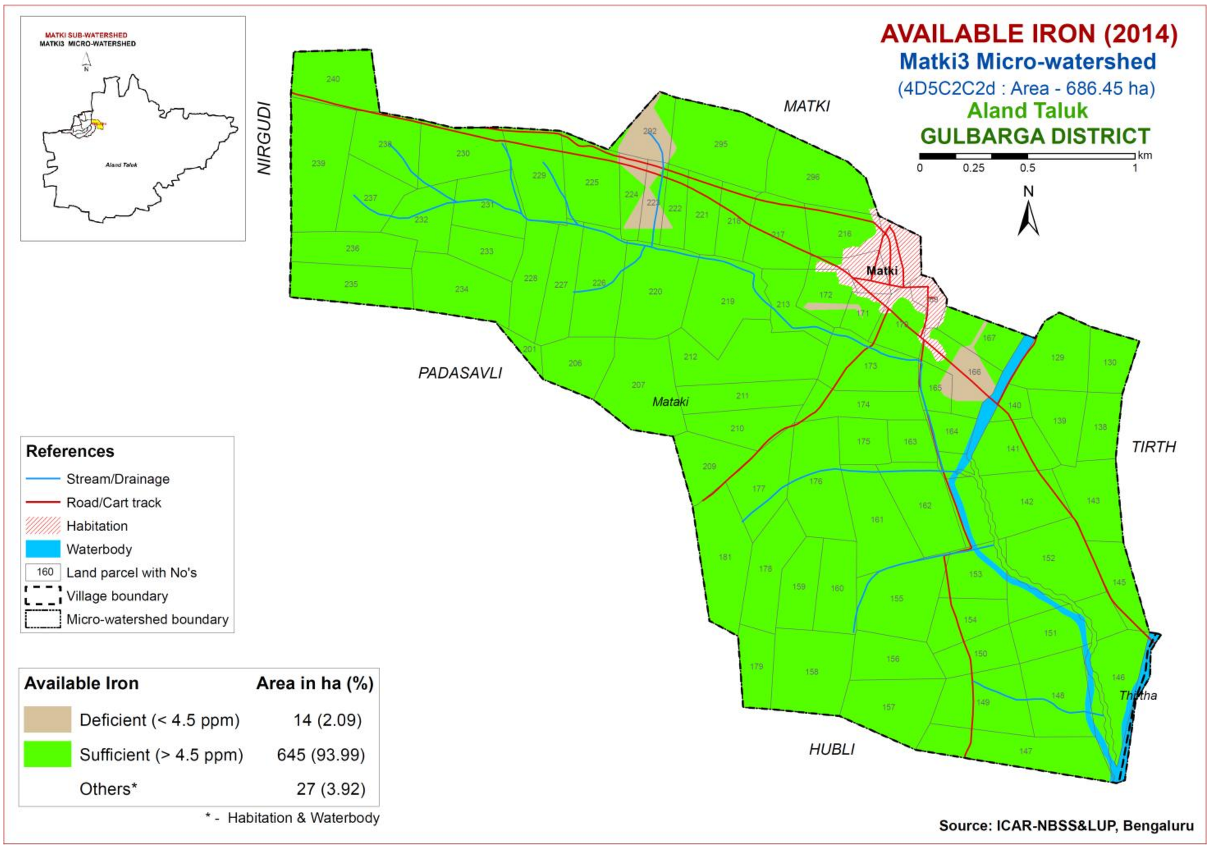


Fig.6.8 Soil available Iron map of Matki-3 Microwatershed

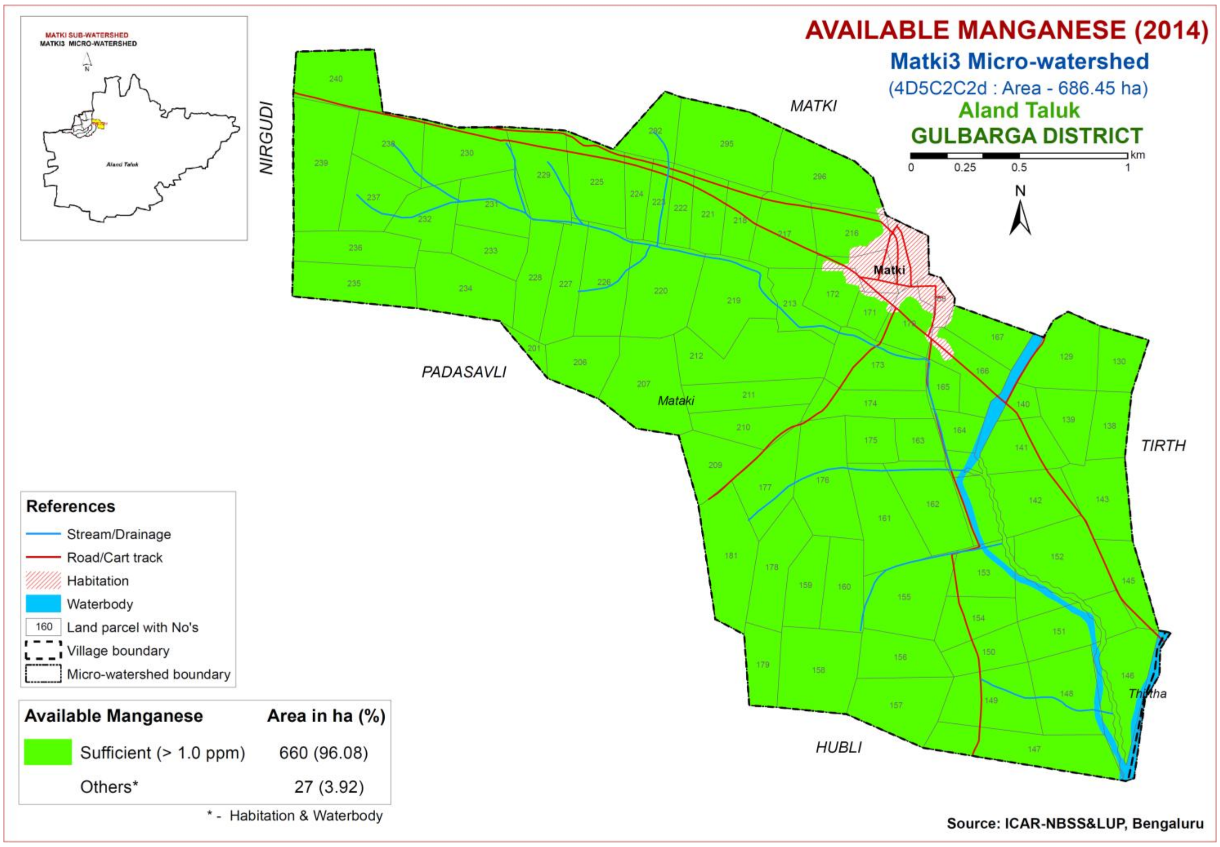


Fig.6.9 Soil available Manganese map of Matki-3 Microwatershed

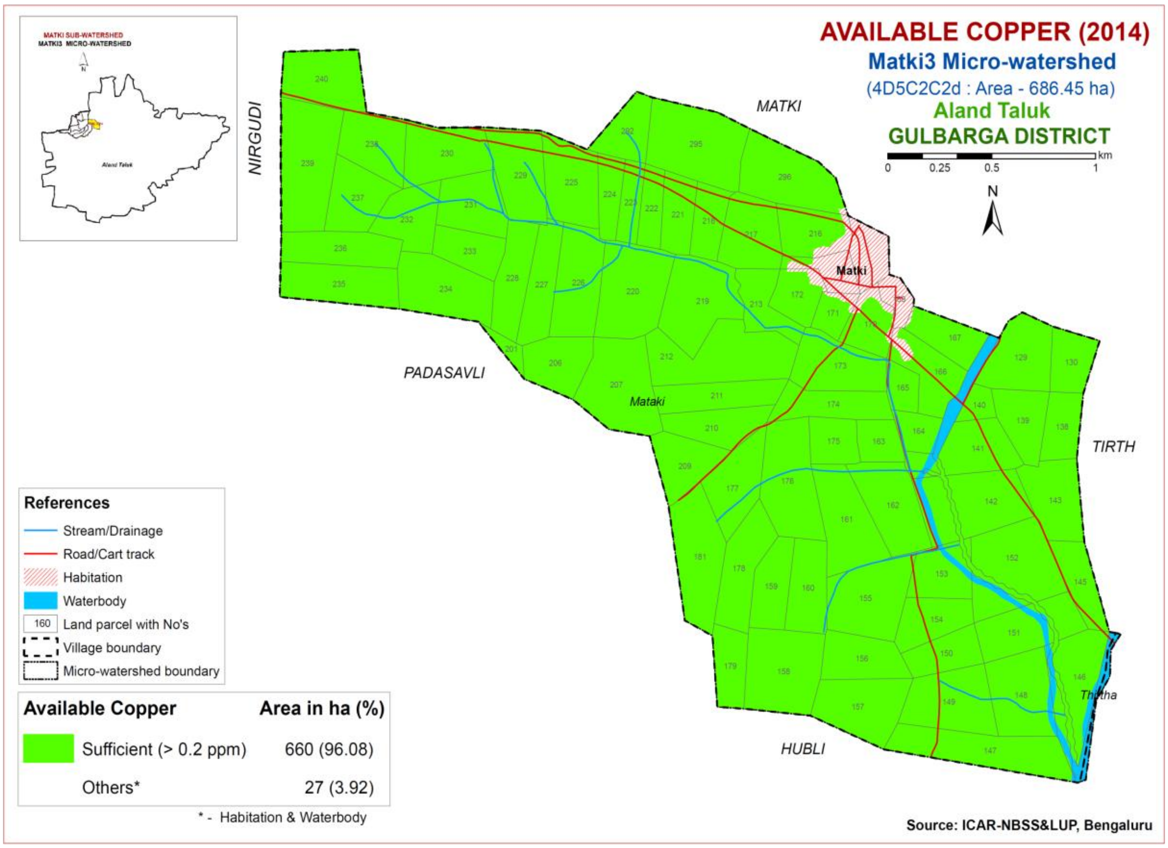


Fig.6.10 Soil available Copper map of Matki-3 Microwatershed

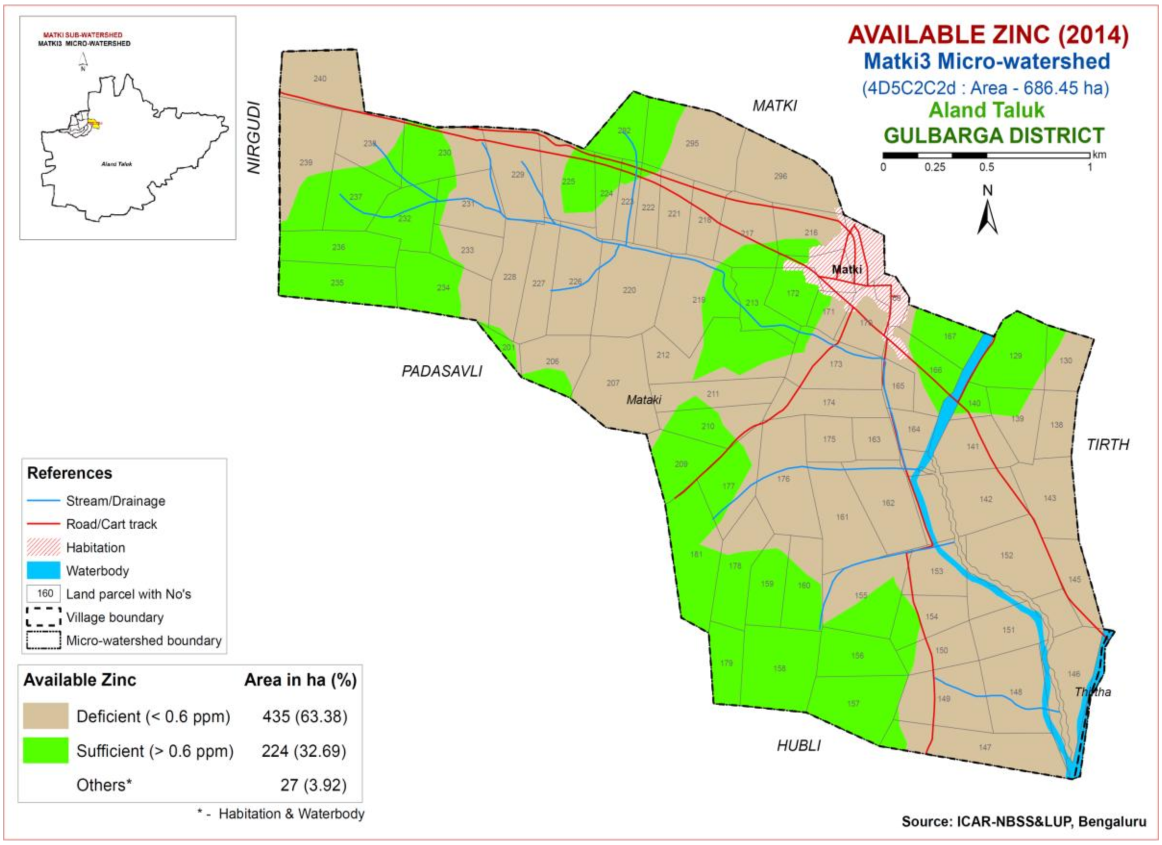


Fig.6.11 Soil available Zinc map of Matki-3 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Matki-3 microwatershed were assessed for their suitability for growing food, fibre, fodder and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S- Suitable and order N- Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1- Highly Suitable, Class S2- Moderately Suitable and Class S3- Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2- Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability and 'w' for drainage. 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 18 major annual and perennial crops were prepared. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 11.02 lakh ha in 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 land suitability map for growing sorghum was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure. 7.1.

An area of about 115 ha (17%) in the microwatershed has soils that are highly suitable (class S1) for growing sorghum crop. They are distributed mainly in the central and small areas in northwestern part of the microwatershed.

Table 7.1 Soil-Site Characteristics of Matki-3 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p^+) kg^{-1}]	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Subsurface (%)								
MGTiB2g2	786	150	WD	<25	sc	c	35-60	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTiC3g3	786	150	WD	<25	sc	c	60-80	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGTiD3g3	786	150	WD	<25	sc	c	60-80	15-35	<50	5-10	Slight	6.8	0.3	0.2	46	100
MGTmA1	786	150	WD	<25	c	c	-	15-35	<50	<1	Slight	6.8	0.3	0.2	46	100
MGTmB1	786	150	WD	<25	c	c	-	15-35	<50	1-3	Slight	6.8	0.3	0.2	46	100
MGTmB1g1	786	150	WD	<25	c	c	15-35	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTmB1g2	786	150	WD	<25	c	c	35-60	15-35	<50	1-3	Slight	6.8	0.3	0.2	46	100
MGTmB2g1	786	150	WD	<25	c	c	15-35	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTmB2g2	786	150	WD	<25	c	c	35-60	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTmC3g1	786	150	WD	<25	c	c	15-35	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGTmC3g2	786	150	WD	<25	c	c	35-60	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGTmC3g3	786	150	WD	<25	c	c	60-80	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
BHImB1	786	150	WD	25-50	c	c	-	15-35	<50	1-3	Slight	7.0	0.1	0.2	28	100

To be continued

BHImB1g1	786	150	WD	25-50	c	c	15-35	15-35	<50	1-3	Slight	7.0	0.1	0.2	28	100
BHImB1g2	786	150	WD	25-50	c	c	35-60	15-35	<50	1-3	Slight	7.0	0.1	0.2	28	100
KGImB2g2	786	150	WD	25-50	c	c	35-60	35-60	<50	1-3	Moderate	7.0	0.1	0.2	28	100
NHAmB1g1	786	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Slight	7.2	0.1	0.3.	40	100
NHAmB2g1	786	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Moderate	7.2	0.1	0.3	40	100
GTTmB1	786	150	MWD	50-75	c	c	-	15-35	51-100	1-3	Slight	6.5	0.1	0.6	38	91
GTTmB1g1	786	150	MWD	50-75	c	c	15-35	15-35	51-100	1-3	Slight	6.5	0.1	0.6	38	91
KMPmB1	786	150	MWD	75-100	c	c	-	<15	101-150	1-3	Slight	6.7	0.2	0.2	43	100
KMPmB1g1	786	150	MWD	75-100	c	c	15-35	<15	101-150	1-3	Slight	6.7	0.2	0.2	43	100
RNLmB1	786	150	MWD	100-150	c	c	-	<15	>200	1-3	Slight	8.4	0.2	0.2	60	100

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

A small area of about 61 ha (9%) is moderately suitable (class S2) for growing sorghum and are distributed in the southeastern part the microwatershed. They have minor limitations of erosion, gravelliness and rooting depth. Major area of about 217 ha (32%) area is not suitable for growing sorghum in the microwatershed and occur in the western, central, northern, northwestern, southeastern and southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. About 265 ha (39%) area is not suitable for sorghum and are distributed in the northwestern, central and southeastern 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

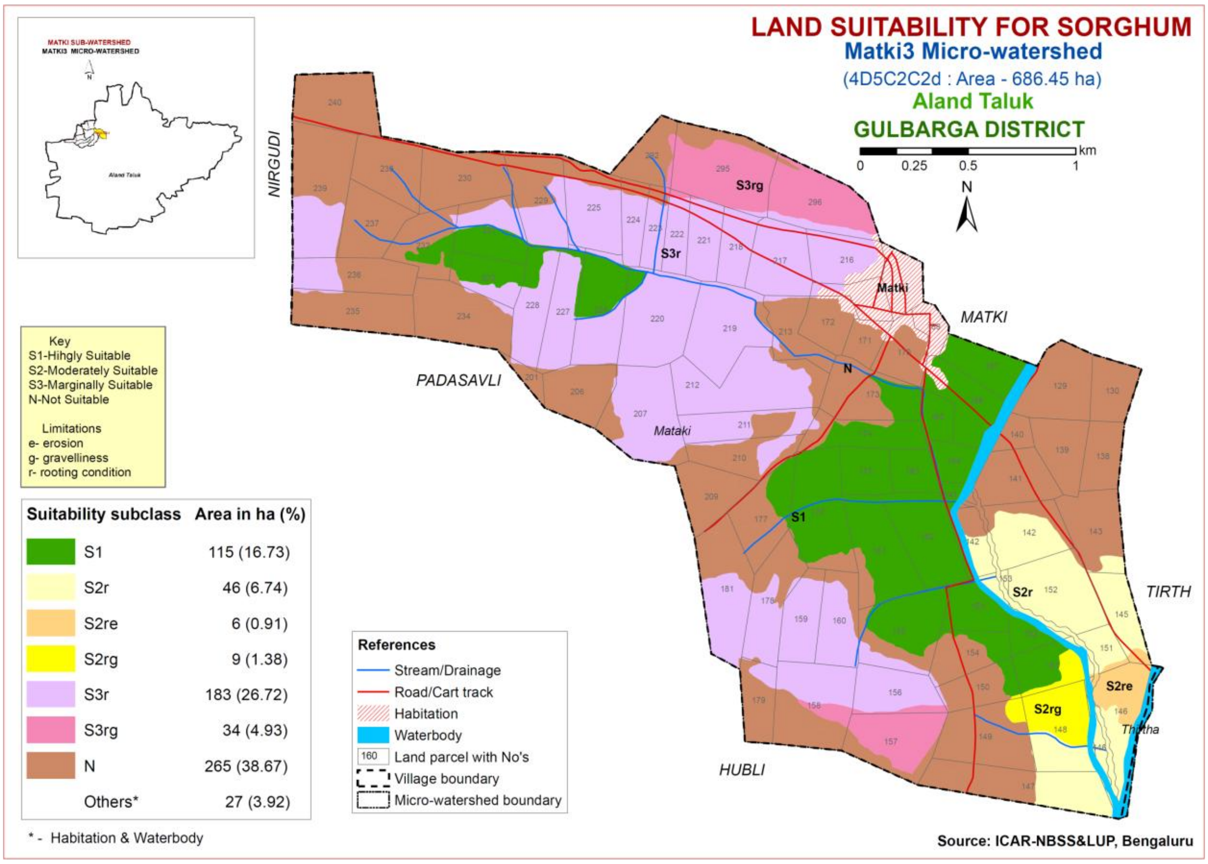


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

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

In Matki-3 microwatershed there are no lands that are highly (class S1) or moderately (class S2) suitable lands for growing maize. The marginally suitable (class S3) lands cover about 394 ha (58%) area in the microwatershed and occur in major part of the microwatershed. They have moderate limitations of texture and rooting depth. About 265 ha (39%) area is not suitable for growing maize and occur in the southern, eastern and northwestern part of the microwatershed.

Table 7.3 Crop suitability criteria for Maize

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

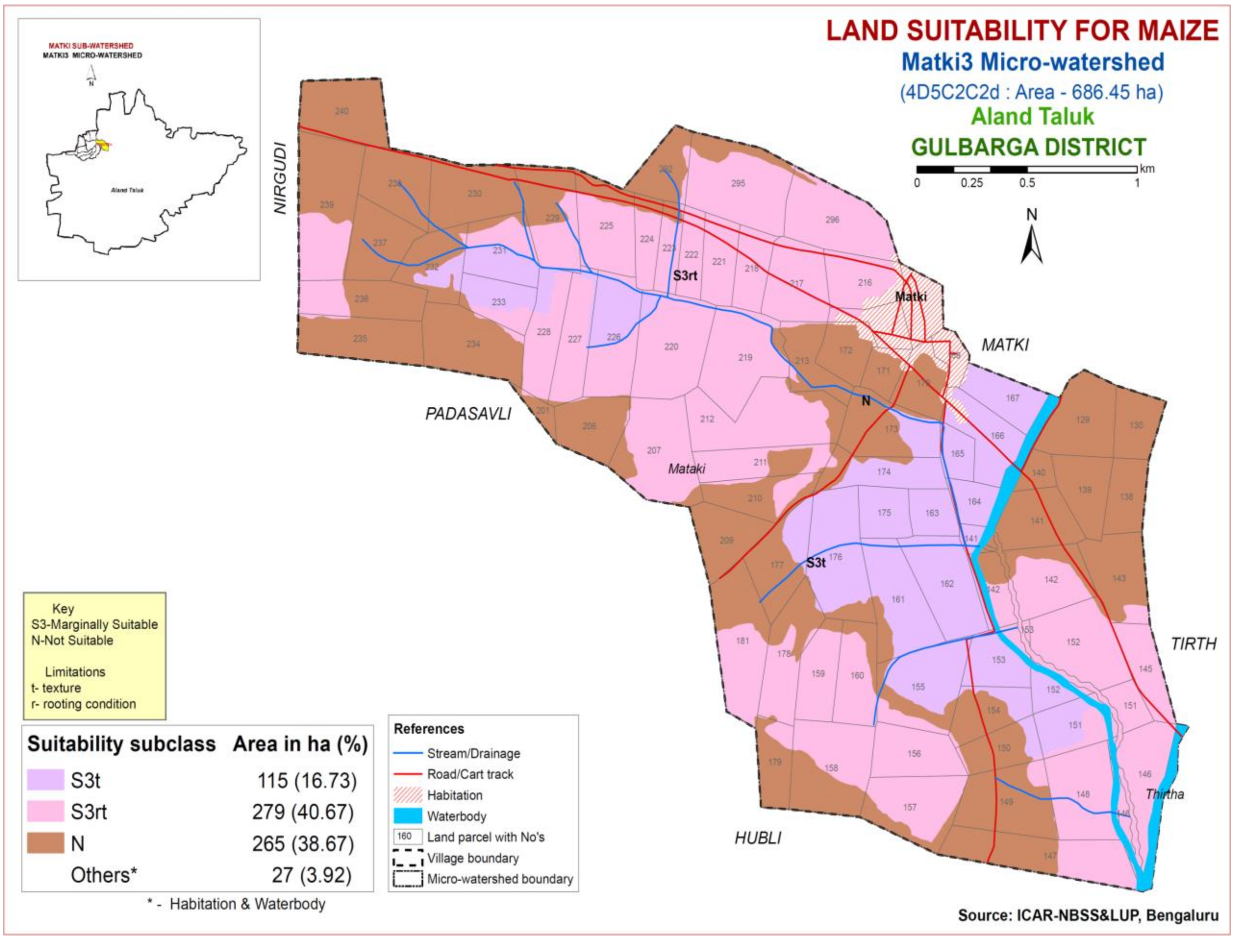


Fig. 7.2 Land Suitability map of Maize

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

Red gram is one of the major pulse crop grown in an area of 8.23 lakh ha 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 land suitability map for growing red gram was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

An area of about 176 ha (26%) is moderately suitable (class S2) for red gram and is distributed dominantly in the southeastern part of the microwatershed. They have minor limitations of rooting depth, erosion, gravelliness and texture. Marginally suitable lands (class S3) for growing red gram occupy about 217 ha (32%) and mainly occur in northwestern and southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 265 ha (39%) is not suitable for growing red gram and occur in northwestern, southeastern and central 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	

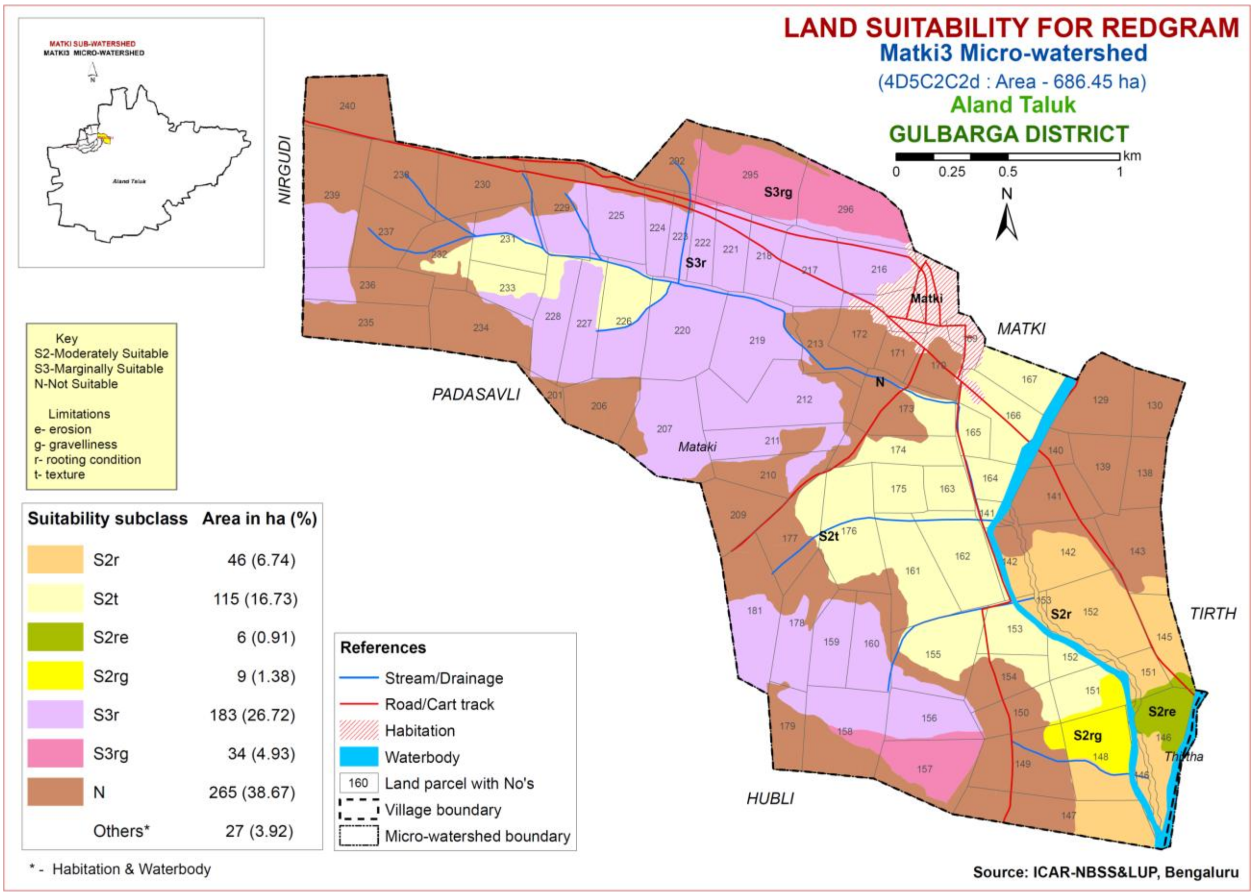


Fig. 7.3 Land Suitability map of Red gram

7.4 Land Suitability for Sunflower (*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 4.1 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.5) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sunflower was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

Highly suitable (class S1) lands are found to occur in an area of 115 ha (17%) and are distributed in the central and small area in northern part of the microwatershed. The marginally suitable (class S3) lands cover about 62 ha (9%) area in the microwatershed and mainly occur in the southeastern part of the microwatershed. They have moderate limitations of rooting depth. Major area of about 483 ha (70%) area is not suitable for growing sunflower and occur in all parts of the microwatershed.

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 suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	>90	80-90	70-80	<70
Soil drainage	class	Well drained	mod. Well drained	imperfectly drained	Poorly drained
Soil reaction	pH	6.5-8.0	8.1-8.5 5.5-6.4	8.6-9.0; 4.5-5.4	>9.0 <4.5
Surface soil texture	Class	l, cl, sil, sc	Scl, sic, c,	c (>60%), sl	ls, s
Soil depth	Cm	>100	75-100	50-75	<50
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

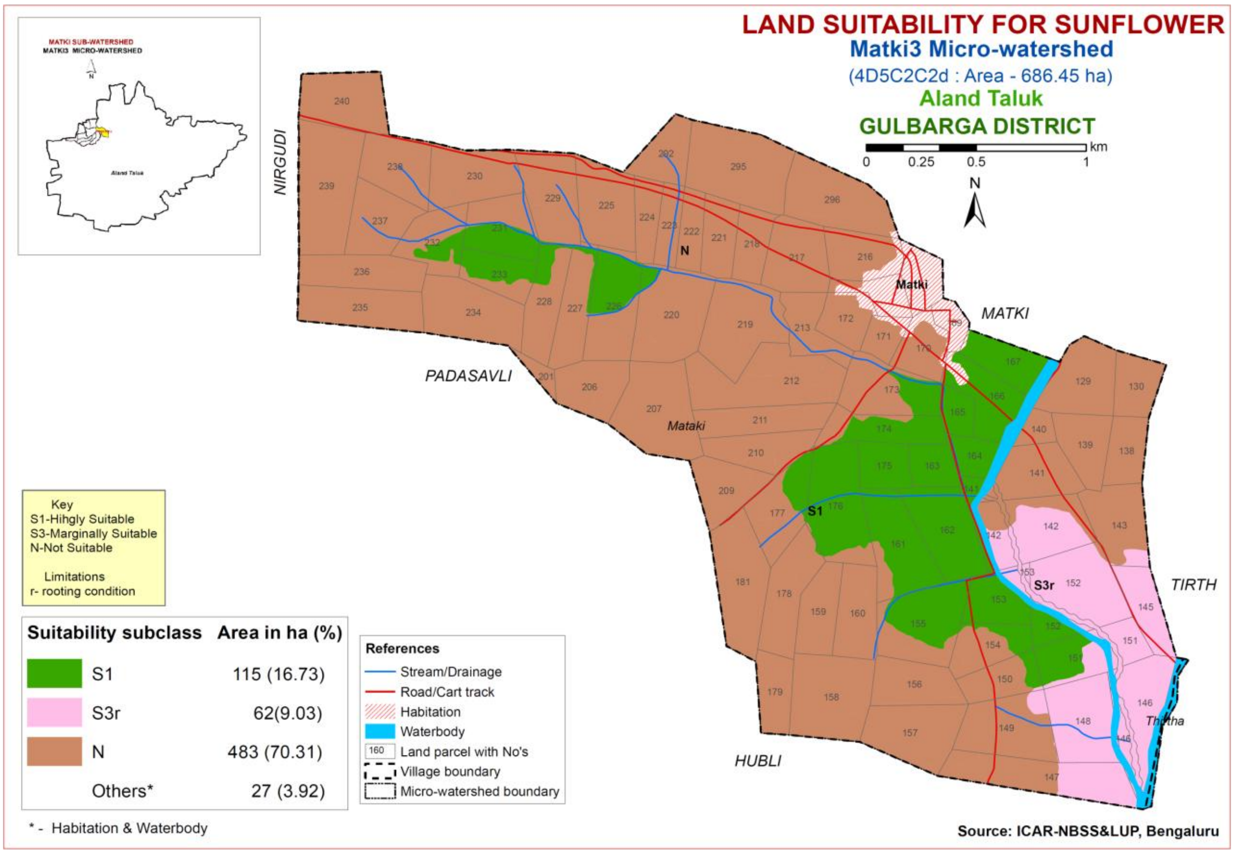


Fig. 7.4 Land Suitability map of Sunflower

7.5 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 6.6 lakh ha area in Raichur, Dharwad, Belgaum, 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 and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

Highly suitable (class S1) lands are found to occur in an area of 115 ha (17%) and are distributed in the northern and eastern part of the microwatershed. Moderately suitable (class S2) lands are found to occur in a small area of about 61 ha (9%). The soils have minor limitations of erosion, gravelliness and rooting depth. They are dominantly distributed in the southeastern part of the microwatershed. The marginally suitable (class S3) lands cover about 217 ha (32%) area and mainly occur in the northwestern and southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. Major area of about 265 ha (39%) area is not suitable for growing cotton and distributed in the northern, central and southeastern part of the microwatershed.

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

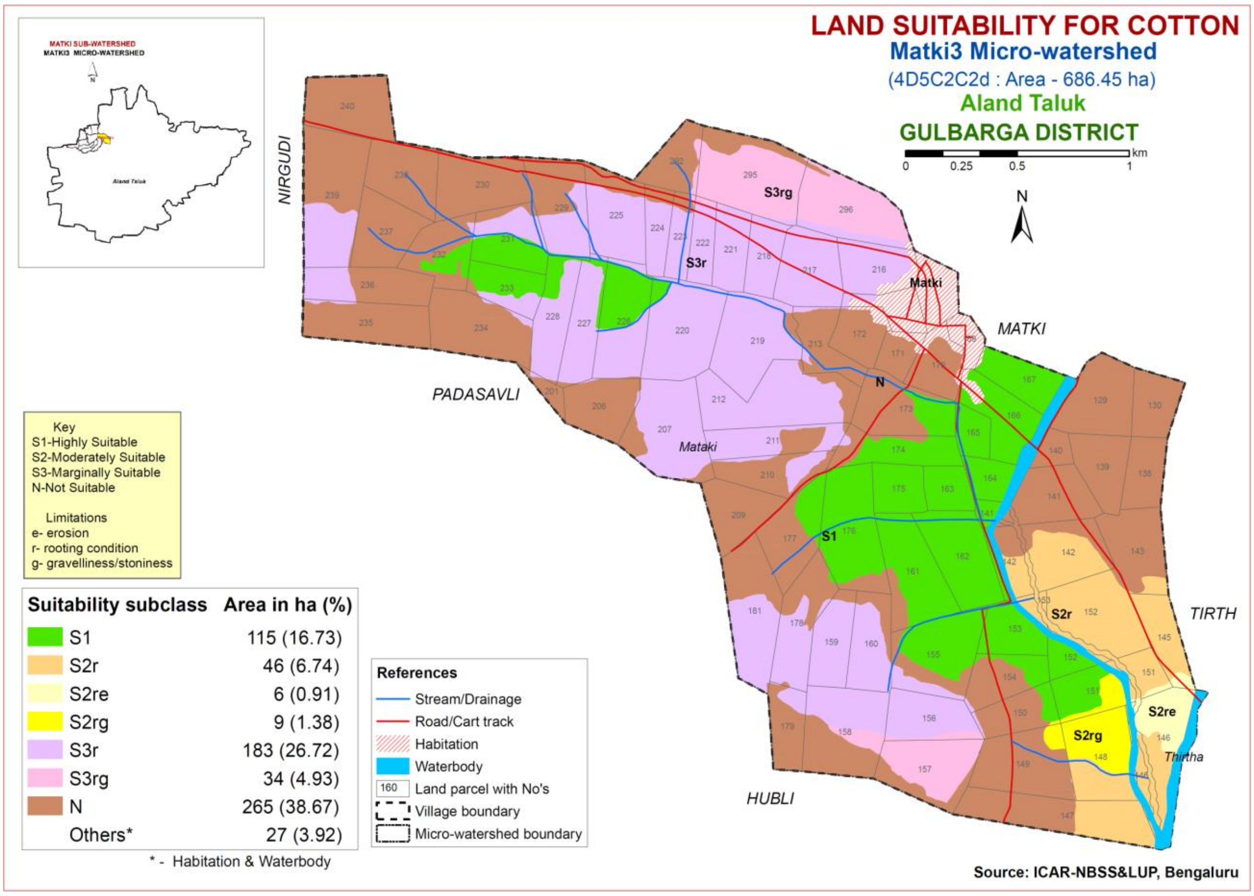


Fig. 7.5 Land Suitability map of Cotton

7.6 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.7 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar Mysore and Mandya districts. 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 and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

The marginally suitable (class S3) lands cover about 117 ha (26%) area and mainly occur in the southeastern and small area in the northern part of the microwatershed. They have moderate limitations of texture. Major area of about 483 ha (70%) is not suitable for growing sugarcane and occur in all parts of the microwatershed.

Table 7.7 Crop suitability criteria for Sugarcane

Land use 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

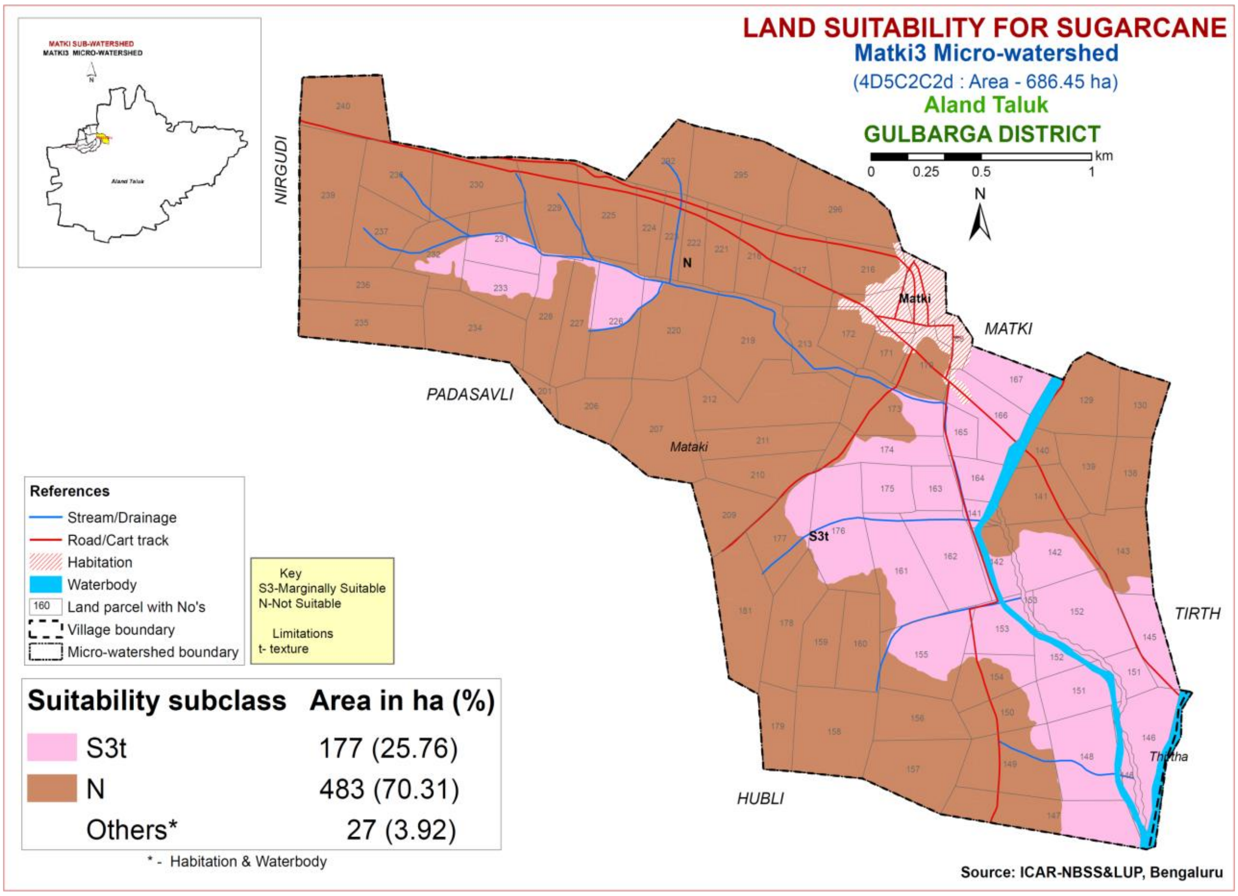


Fig. 7.6 Land Suitability map of Sugarcane

7.7 Land Suitability for Soybean (*Glycine max*)

Soybean is the most important pulse crop grown in about 1.68 lakh ha area in almost all the districts of the state. The crop requirements for growing soybean were matched with the soil-site characteristics and a land suitability map for growing soybean was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

Highly suitable (class S1) lands are found to occur in an area of 115 ha (17%) and are distributed in the central and small area in northwestern part of the microwatershed. Moderately suitable (class S2) lands are found to occur an area of about 61 ha (9%). The soils have minor limitations of erosion, gravelliness and rooting depth. They are dominantly distributed in southeastern part of the microwatershed.

The marginally suitable (class S3) lands cover about 217 ha (32%) area and mainly occur in the northern and southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. Major area of about 265 ha (39%) is not suitable for growing soybean and occur in the northwestern, central and southeastern part of the microwatershed.

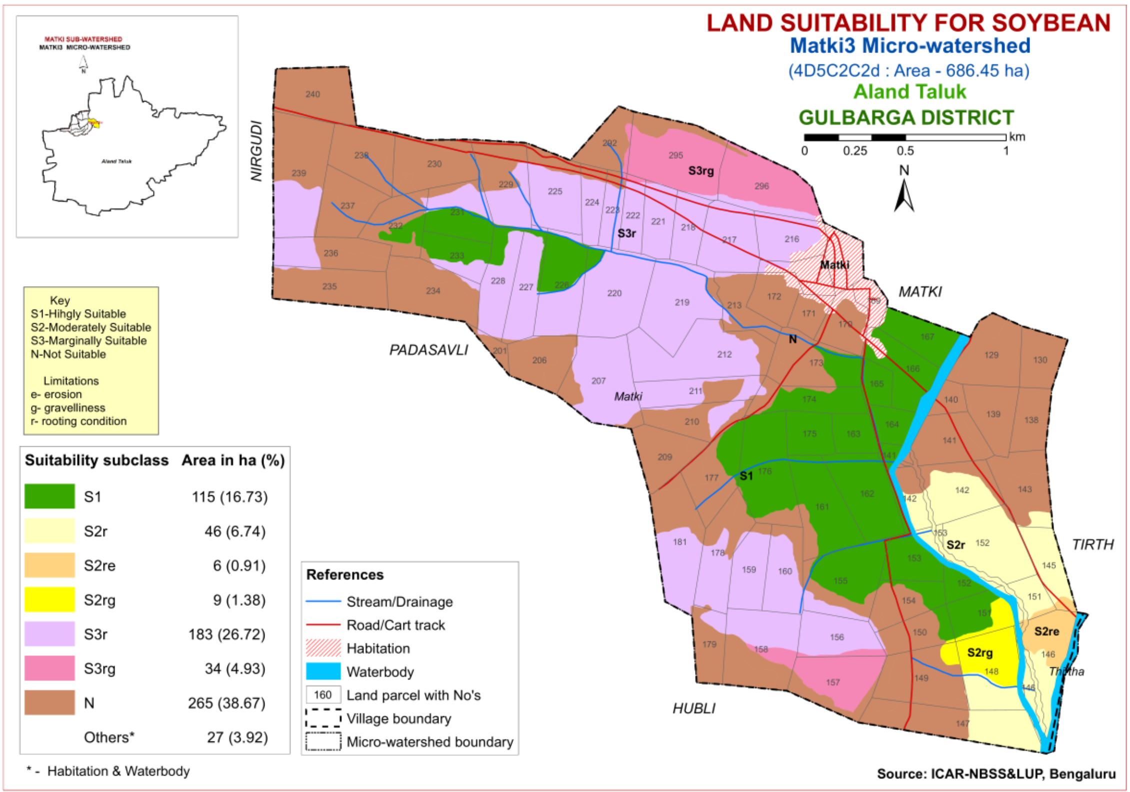


Fig. 7.7 Land Suitability for Soybean

7.8 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in the State in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing guava (Table 7.8) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing guava was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

In Matki-3 microwatershed there are no highly (class S1) and moderately (Class S2) suitable lands available for growing guava. The marginally suitable (class S3) lands cover about 177 ha (26%) area in the microwatershed and mainly occur in the southeastern and small area in the northwestern part of the microwatershed. They have moderate limitations of texture and rooting depth. Major area of about 483 ha (70%) area is not suitable for growing guava and occur in all parts of the microwatershed.

Table 7.8 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

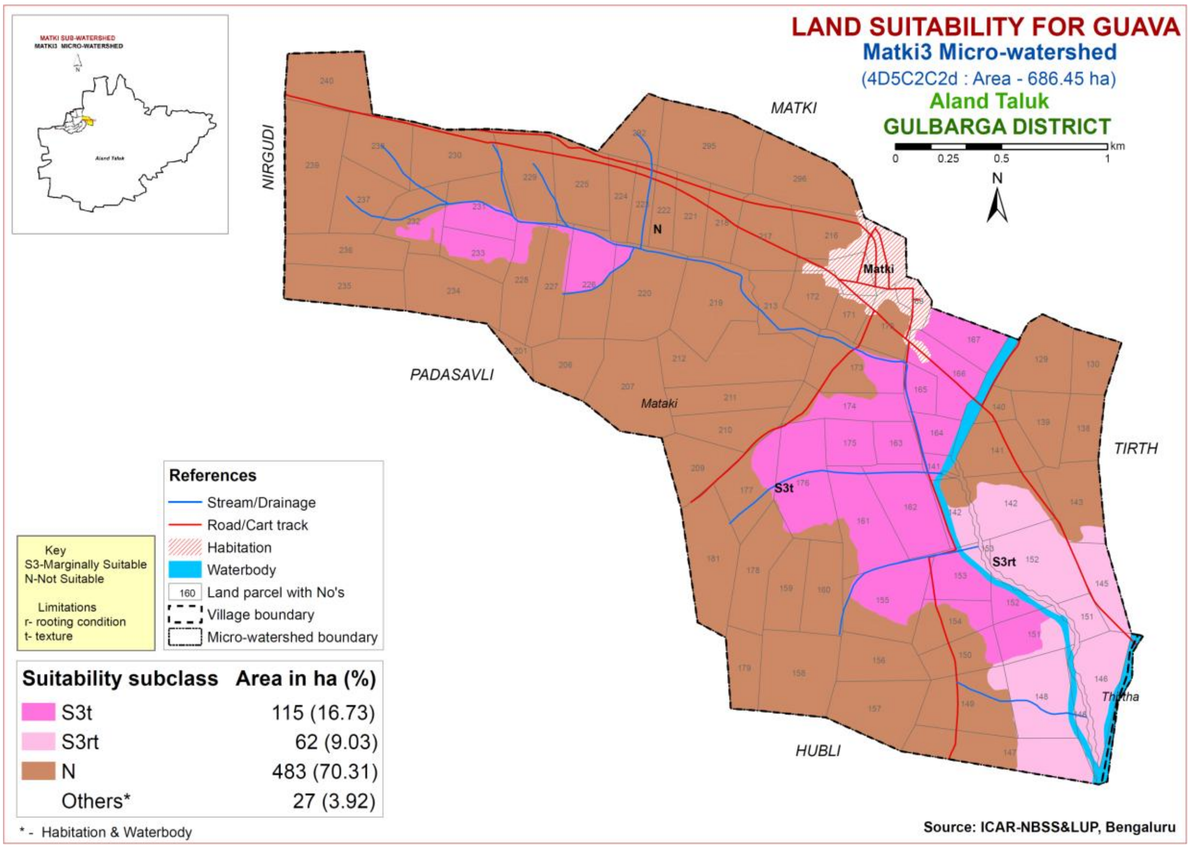


Fig 7.8 Land Suitability for Guava

7.9 Land Suitability for Mango (*Mangifera indica*)

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

In Matki-3 microwatershed there are no highly (class S1) and moderately (Class S2) suitable lands available for growing mango. The marginally suitable (class S3) lands cover about 115 ha (17%) area in the microwatershed and mainly occur in the central and small area in northwestern part of the microwatershed. They have moderate limitations of texture. Major area of about 545 ha (79%) is not suitable for growing mango and occur in all parts of the microwatershed.

Table 7.9 Crop suitability criteria for Mango

Crop requirement			Rating			
soil-site characteristics		unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temp in growing season	^{0}C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^{0}C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	class	Well drained	Mod. To imperfectly drained	Poor drained	Very poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	Sc, l, sil, cl	Sl, sc, sic, l, c	C (<60%)	C (>60%),
	pH	1:2.5	5.5-7.5	7.6-8.55.0-5.4	8.6-9.0 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	

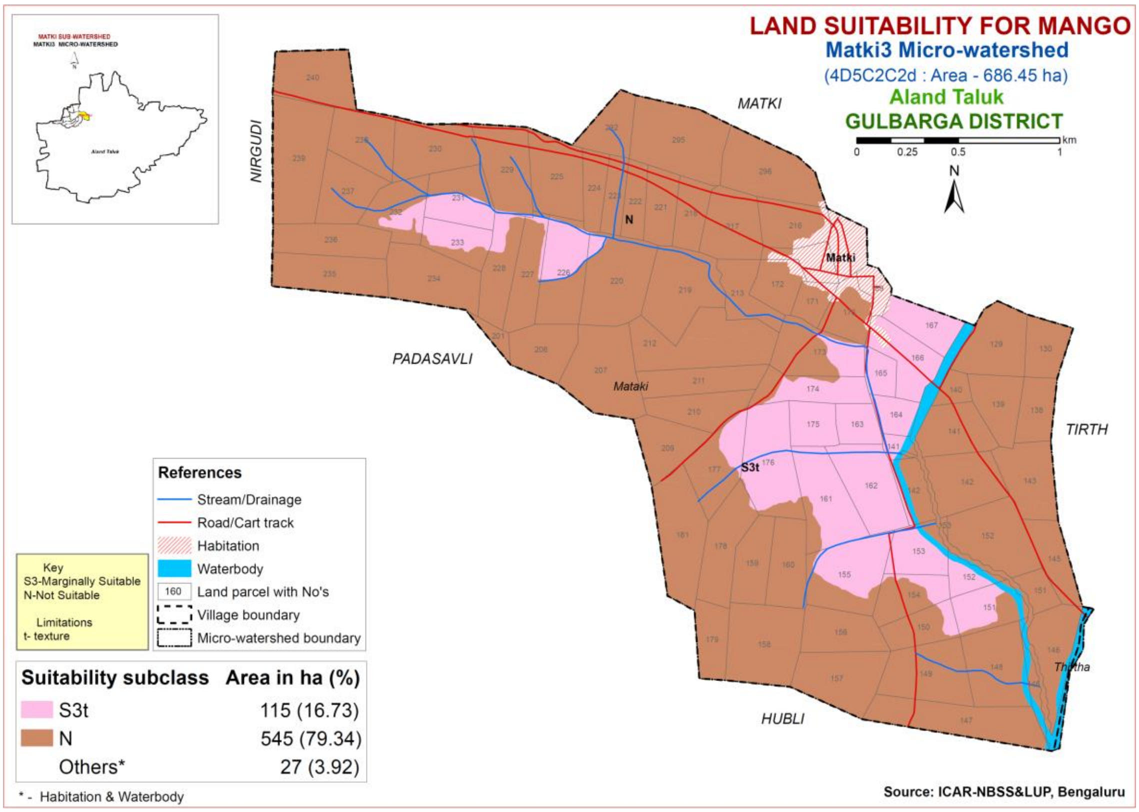


Fig. 7.9 Land Suitability for Mango

7.10 Land Suitability for Sapota (*Manilkara zapota*)

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

In Matki-3 microwatershed there are no highly (class S1) and moderately (Class S2) suitable lands available for growing sapota. The marginally suitable (class S3) lands cover about 177 ha (26%) area in the microwatershed and mainly occur in the southeastern and small area in the northwestern part of the microwatershed. They have moderate limitations of rooting depth and texture. Major area of about 483 ha (70%) is not suitable for growing sapota and occur in all parts of the microwatershed.

Table 7.10 Crop suitability criteria for Sapota

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

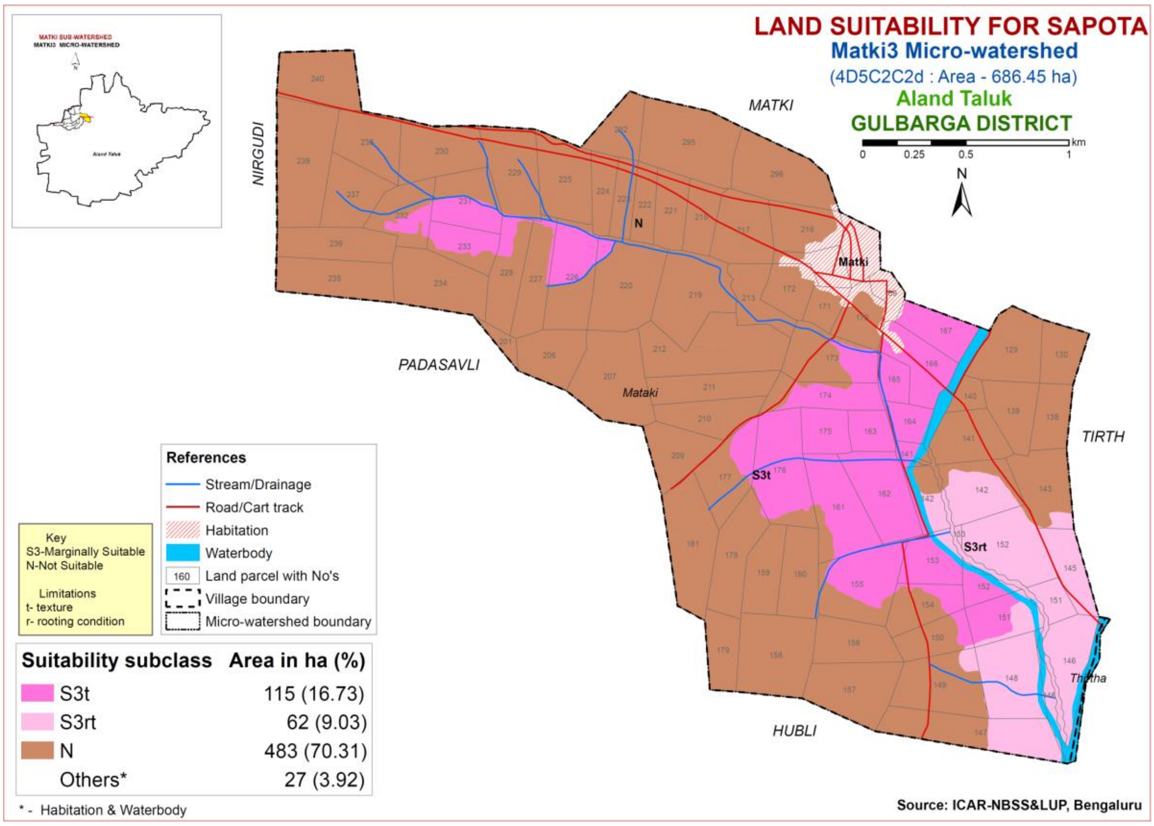


Fig. 7.10 Land Suitability for Sapota

7.11 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing jackfruit were matched with the soil-site characteristics and a land suitability map for growing jackfruit was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.11.

No highly (class S1) and moderately (class S2) suitable lands are available for growing Jackfruit in the microwatershed. The marginally suitable (class S3) lands cover about 177 ha (26%) area in the microwatershed and mainly occur in the central, southern and small area in northwestern part of the microwatershed. They have moderate limitations of rooting depth and texture. Major area of about 483 ha (70%) is not suitable for growing jackfruit and occur in all parts of the microwatershed.

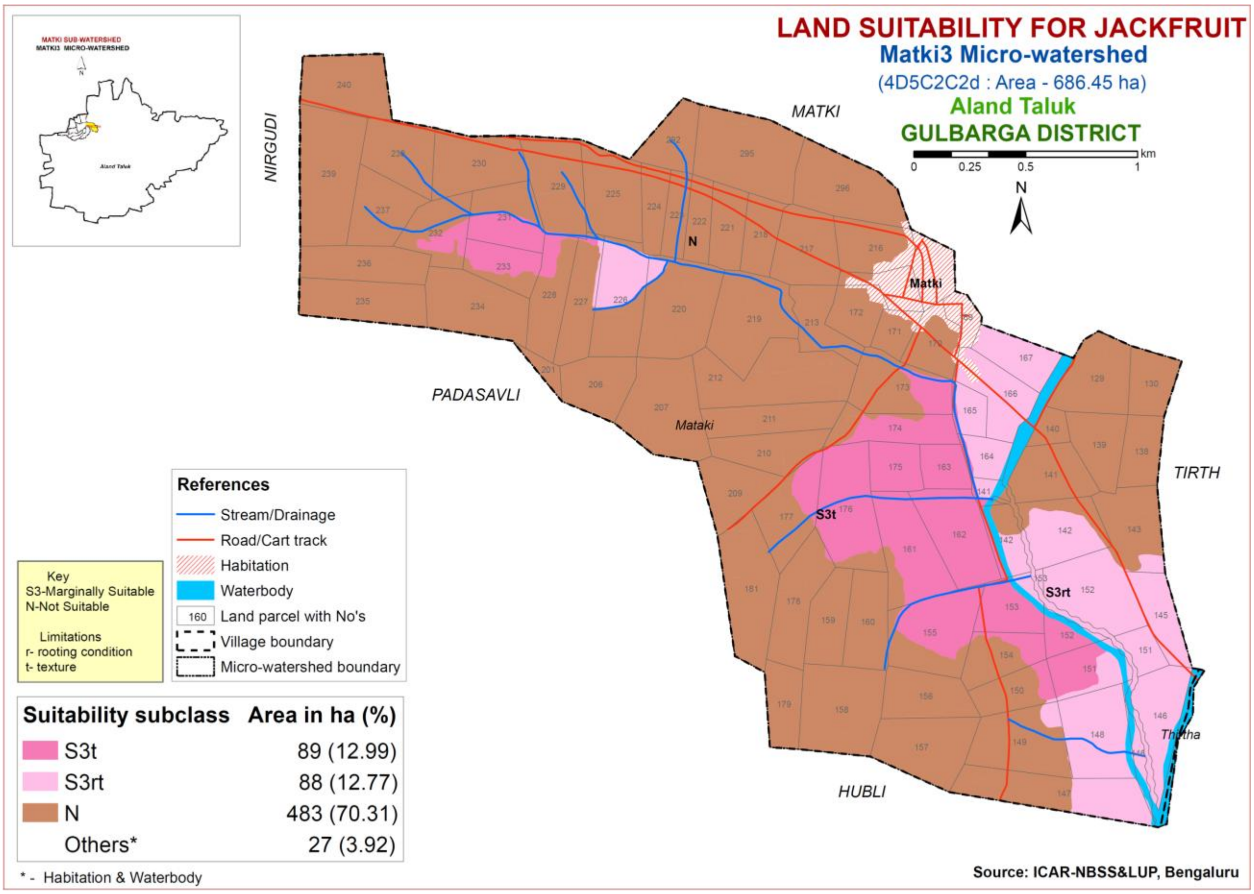


Fig 7.11 Land Suitability for Jackfruit

7.12 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 were matched with the soil-site characteristics and a land suitability map for growing jamun was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.12.

Moderately suitable (class S2) lands are found to occur in an area of about 89 ha (13%). The soils have minor limitations of texture. They are dominantly distributed in the central and small area in northwestern part of the microwatershed.

The marginally suitable (class S3) lands cover about 88 ha (13%) area and mainly occur in the southeastern part of the microwatershed. They have moderate limitations of rooting depth. Major area of about 483 ha (70%) is not suitable for growing jamun and occur in all parts of the microwatershed.

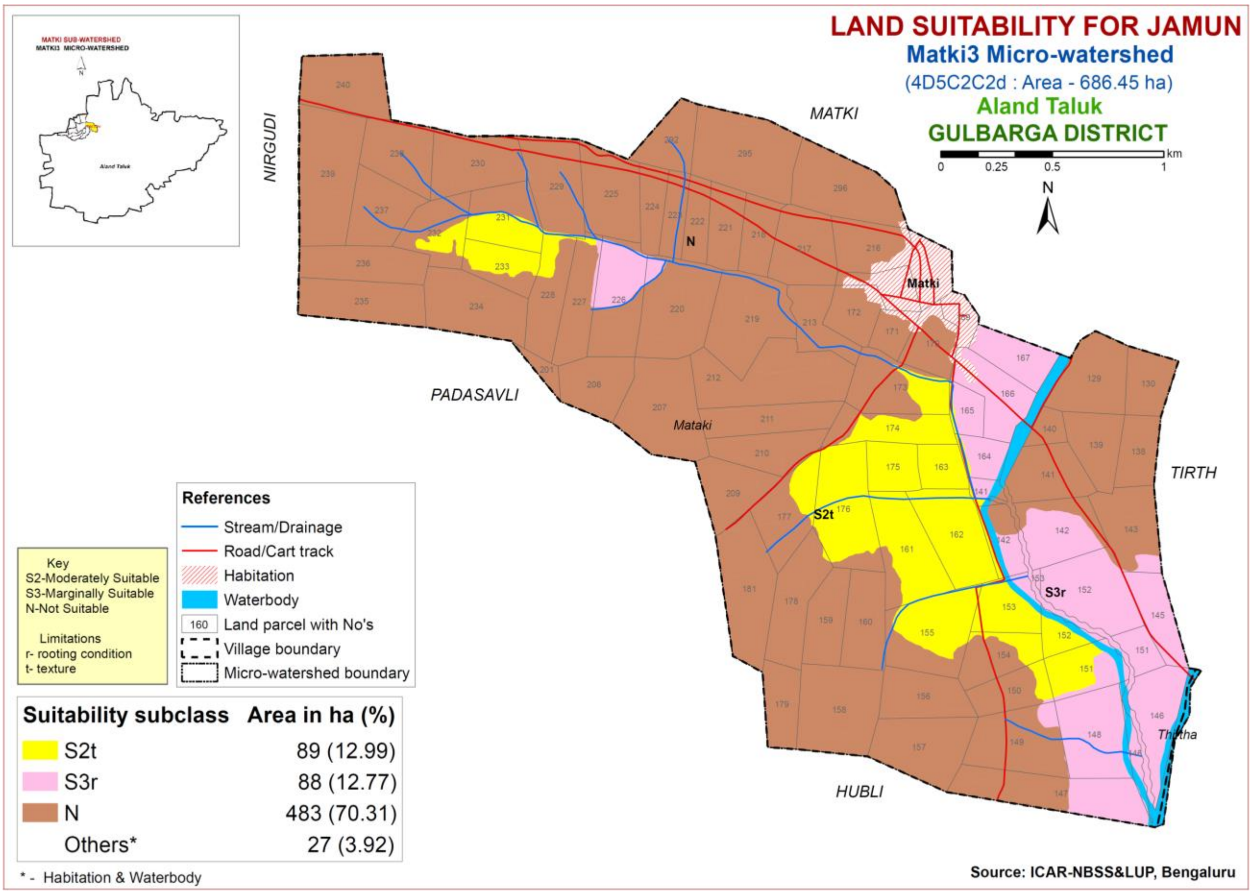


Fig 7.12 Land Suitability for Jamun

7.13 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

Highly suitable (class S1) lands are found to occur in an area of 89 ha (13%) and are distributed in the central and small area in northwestern part of the microwatershed. Moderately suitable (class S2) lands are found to occur in an area of about 26 ha (4%). The soils have minor limitations of rooting depth. They are dominantly distributed in the northeastern and northwestern part of the microwatershed.

The marginally suitable (class S3) lands cover about 62 ha (9%) area and mainly occur in the southern part of the microwatershed. They have moderate limitations of rooting depth. Major area of about 483 ha (70%) is not suitable for growing musambi and occur in all parts of the microwatershed.

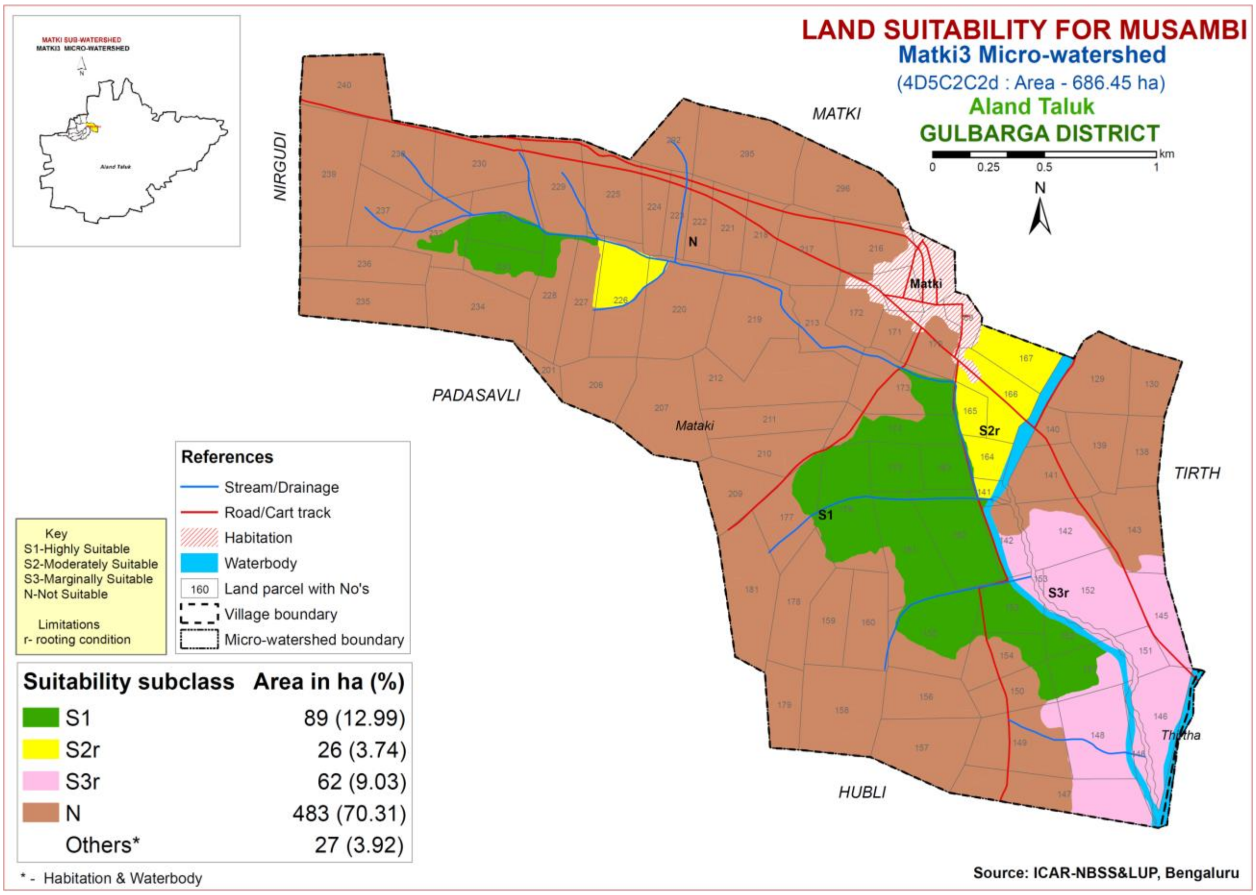


Fig 7.13 Land Suitability for Musambi

7.14 Land Suitability for Lime (*Citrus sp*)

Lime is the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing lime (Table 7.11) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing lime was generated and the area and 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 a small area of about 89 ha (13%) and are distributed in the central part of the microwatershed. Moderately suitable (class S2) lands are found to occur in a very small area of about 26 ha (4%). The soils have minor limitations of rooting depth. They are dominantly distributed in the northeastern part of the microwatershed. The marginally suitable (class S3) lands cover about 62 ha (9%) area and occur in the southern part of the microwatershed. They have moderate limitations of rooting depth. Major area of about 483 ha (70%) is not suitable for growing lime and occur in all parts of the microwatershed.

Table 7.11 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 imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl,cl, s	Sc, sc, c	C (>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4/ 7.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	$CaCO_3$ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting 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	

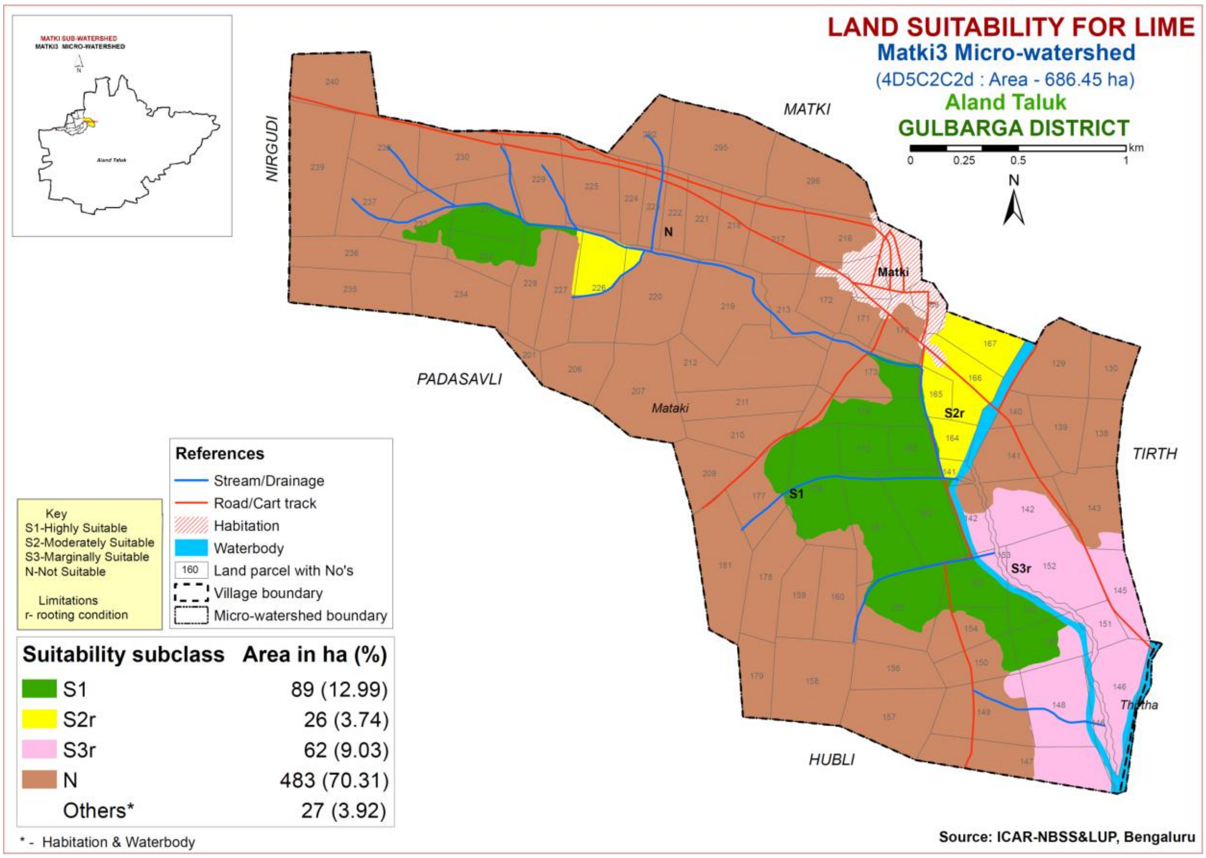


Fig 7.14 Land Suitability for Lime

7.15 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is the most important plantation crop grown in almost all the districts. The crop requirements for growing Cashew were matched with the soil-site characteristics and a land suitability map for growing Cashew was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.15.

The entire area is not suitable for growing cashew in the microwatershed.

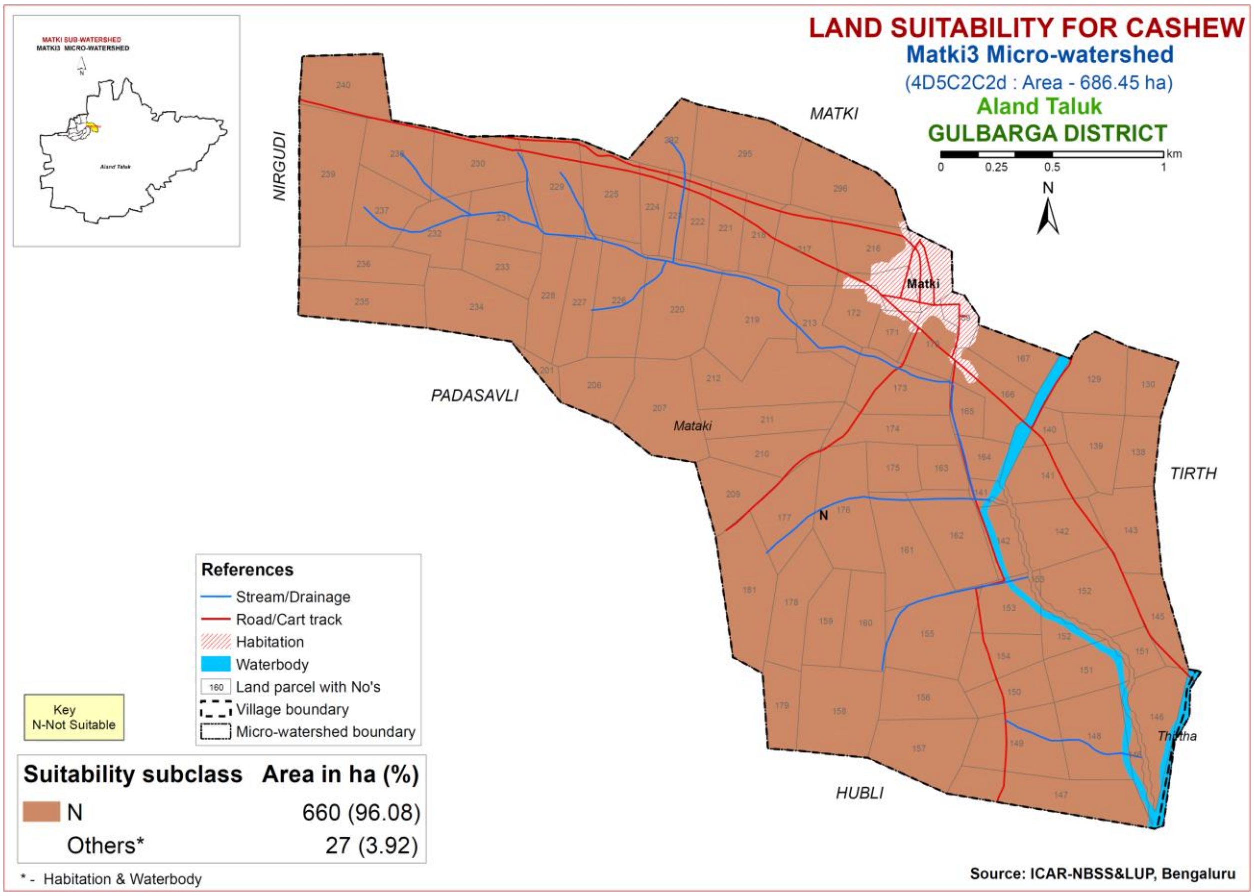


Fig 7.15 Land Suitability for Cashew

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

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

Highly suitable (class S1) lands are found to occur in an area of 115 ha (17%) and distributed in the eastern part of the microwatershed.

Moderately suitable (class S2) lands are found to occur in a small area of about 62 ha (9%). The soils have minor limitations of erosion and rooting depth. They are dominantly distributed in the southern part of the microwatershed. The marginally suitable (class S3) lands cover about 218 ha (32%) area and mainly occur in the northwestern and southern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness.

Major area of about 265 ha (39%) is not suitable for growing Custard apple and occur in the northern, central and southeastern part of the microwatershed.

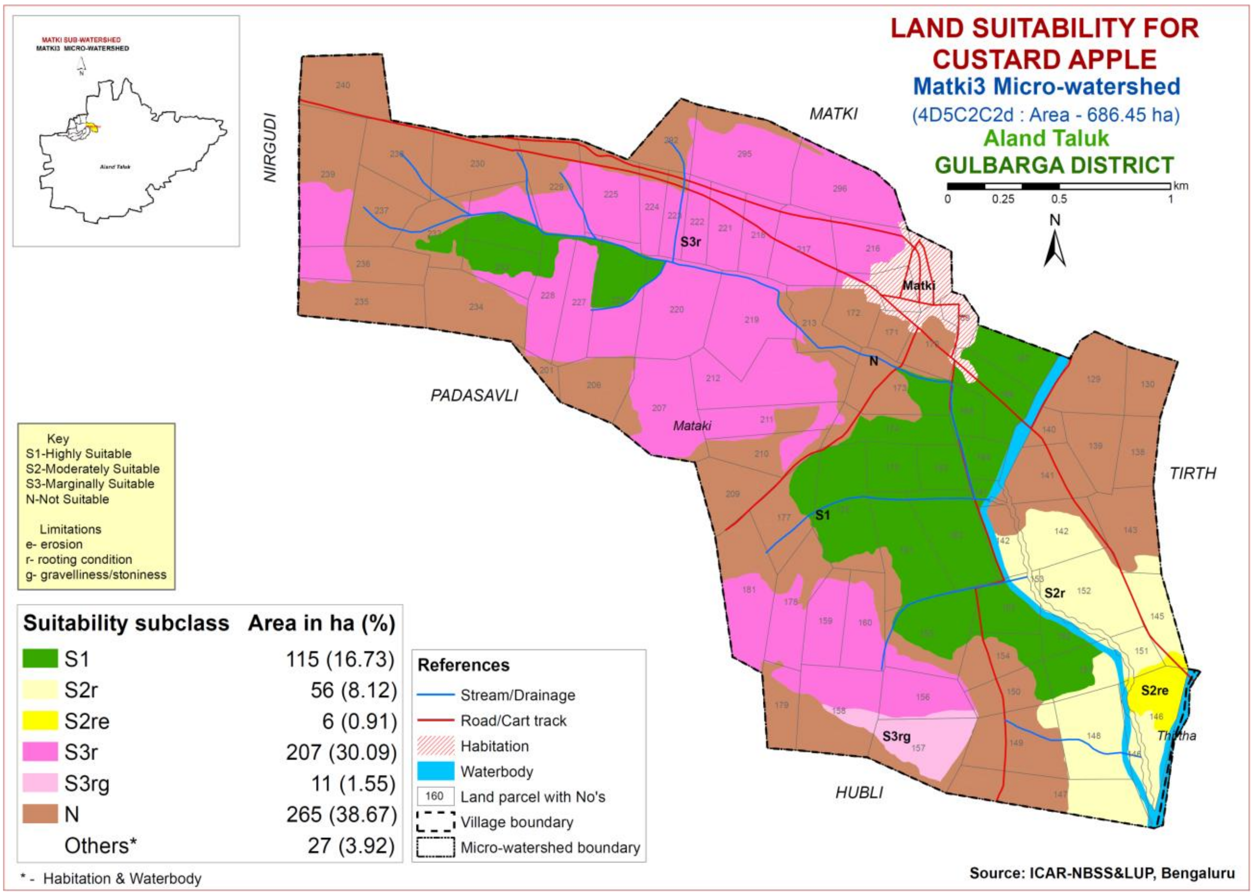


Fig 7.16 Land Suitability for Custard Apple

7.17 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing amla were matched with the soil-site characteristics and a land suitability map for growing amla was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.17.

Highly suitable (class S1) lands are found to occur in an area of 115 ha (17%) and are distributed in the central and a small area in northwestern part of the microwatershed. Moderately suitable (class S2) lands are found to occur in a small area of about 62 ha (9%). The soils have minor limitations of erosion and rooting depth. They are dominantly distributed in the southern part of the microwatershed.

The marginally suitable (class S3) lands cover about 218 ha (32%) area and occur in the southern and northwestern part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. Major area of about 265 ha (37%) is not suitable for growing amla and occur in the northwestern, central and southeastern part of the microwatershed.

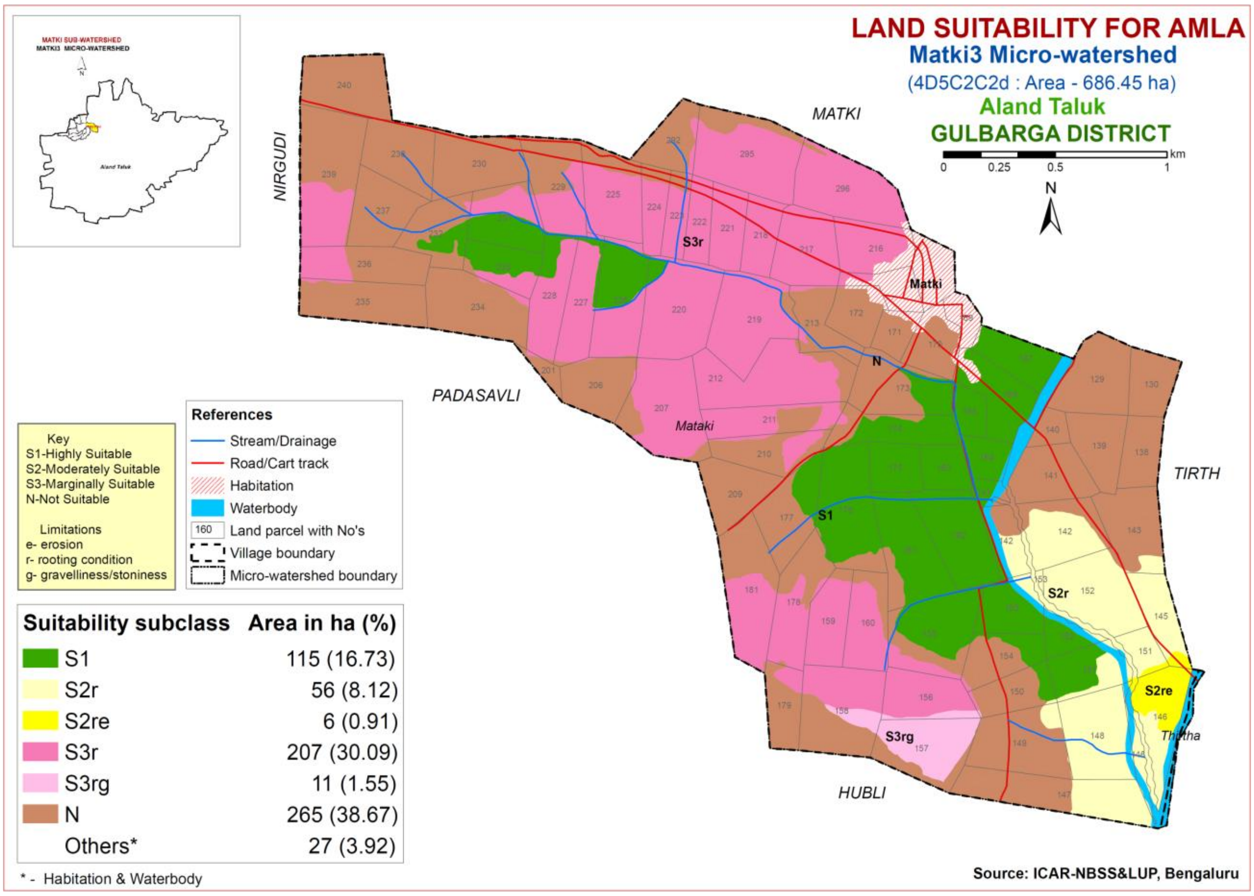


Fig 7.17 Land Suitability for Amla

7.18 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop grown in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

Moderately suitable (class S2) lands are found to occur in an area of about 89 ha (13%). The soils have minor limitations of rooting depth. They are dominantly distributed in the central and small area in northwestern part of the microwatershed and small area of about 26 ha (4%) is in marginally suitable (class S3) lands. They have moderate limitations of rooting depth and are distributed in the northwestern and northeastern part of the microwatershed. Major area of about 545 ha (80%) is not suitable for growing tamarind and occur in all parts of the microwatershed.

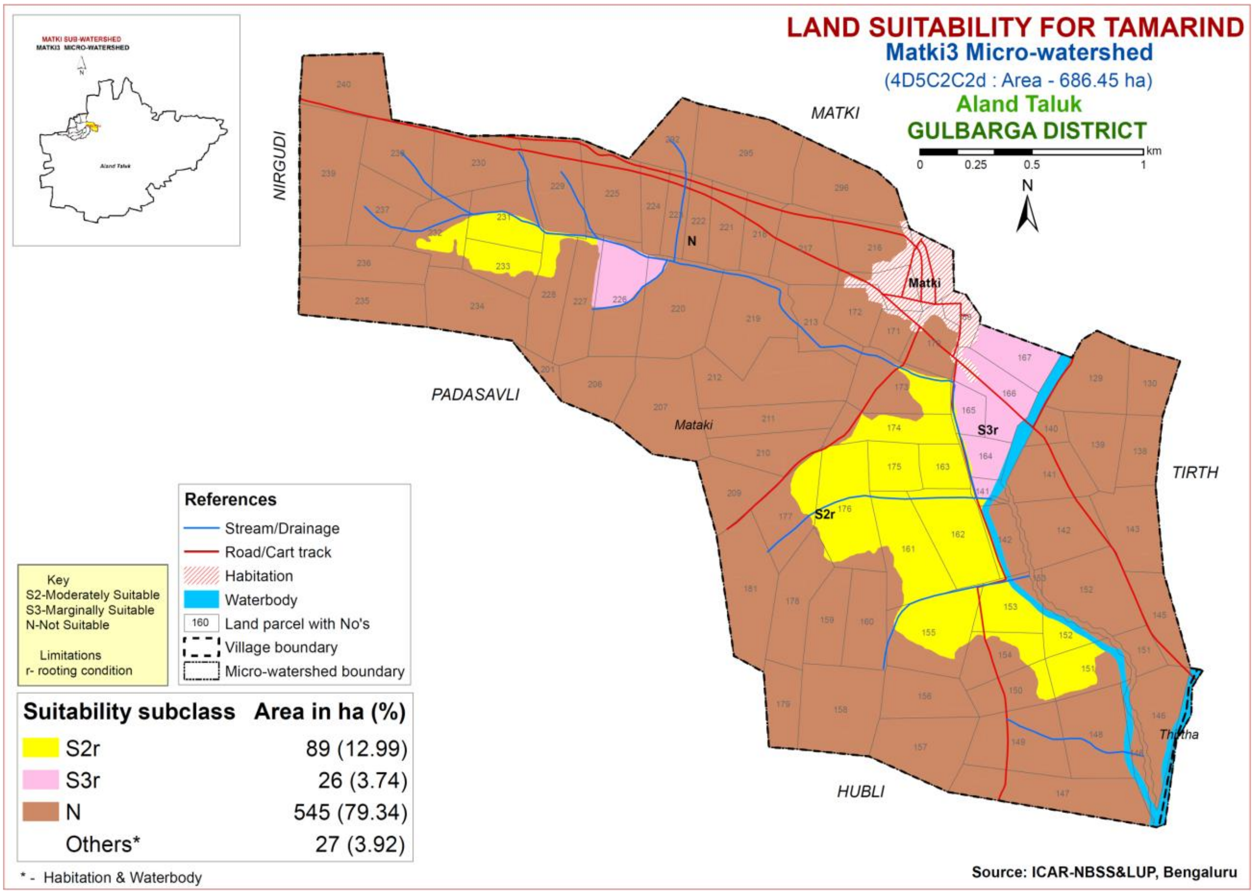


Fig 7.18 Land Suitability for Tamarind

7.19 Land Management Units (LMUs)

The 24 soil map units identified in Matki-3 microwatershed have been regrouped into 5 Land Management Units (LMU's) for the purpose of preparing Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Units map (Fig.7.19) has been prepared. These Land Management Units are expected to behave similarly for a given level of management.

The map units that have been grouped into 5 land management units along with brief description of soil and site characteristics are given below.

LMUs	Soil map units	Soil and site characteristics
1	MGTiC3g3, MGTiD3g3, MGTmC3g1, MGTmC3g2 MGTmC3g3	Very shallow, black soils with slopes of 3-10%, gravelly to extremely gravelly (15-80%) and severe erosion
2	MGTmA1, MGTmB1, MGTmB1g1, MGTmB1g2,MGTmB2g1,MGTiB2g2, MGTmB2g2	Very shallow, black soils with slopes of <1-3%, gravelly to very gravelly (15-60%) and slight to moderate erosion
3	NHAmB1g1, NHAmB2g1, BHImB1, BHImB1g1, BHImB1g2, BHImB2g2	Shallow, black soils with slopes of 1-3 %, gravelly to very gravelly (15-60%) and slight to moderate erosion
4	GTTmB1, GTTmB1g1, GTTmB2, KMPmB1, KMPmB1g1	Moderately shallow, black soils with slopes of 1-3 %, gravelly (15-35%) and slight to moderate erosion
5	RNLmB1	Deep, black soils with slopes of 1-3% and slight erosion

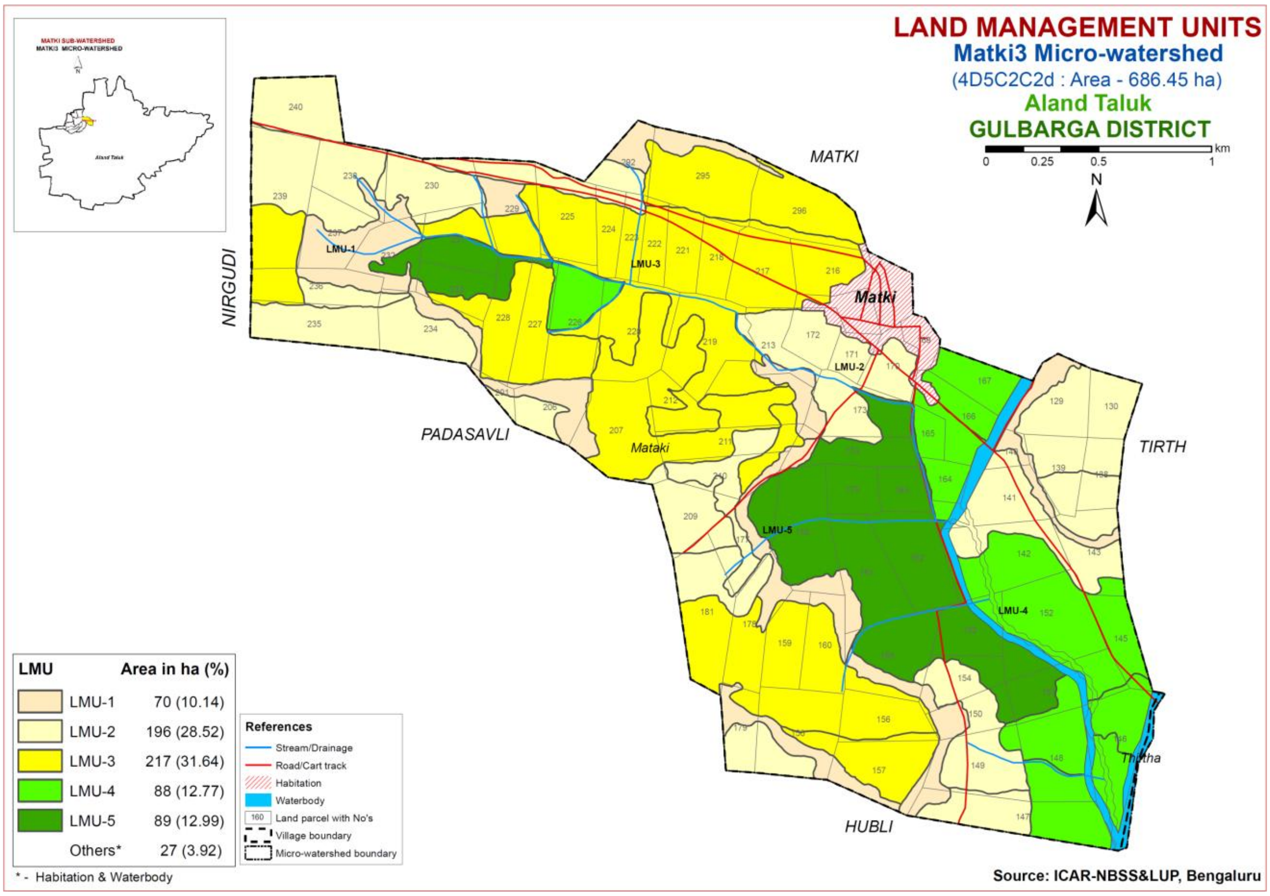


Fig. 7.19 Land Management Units map – Matki-3 microwatershed

7.20 Proposed Crop Plan for Matki-3 Microwatershed

After assessing the land suitability for the 18 crops, the proposed crop plan has been prepared for the 5 identified LMUs by considering only the highly (class S1) and moderately suitable (class S2) lands for each of the eighteen crops. The resultant proposed crop plan is presented below in Table 7.12

Table 7.12 Proposed Crop Plan for Matki-3 Microwatershed

LMUs No	Mapping Units	Survey Number	Field crops	Forestry/Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops With suitable intervention	Suitable Intervention
LMU 1	2,3,10,11,12 (<25 cm)	**Matki:** 140,206,232,237, 292	Horsegram	Neem, Glyricydia Silviculture, Agave, Simaroba	-	-	Cresent bunds
LMU 2	4,5,6,7,8,1,9 (<25 cm)	**Matki:** 129,130,138,139,141,143, 147,149, 150,154,170,171, 172,173,177,179,201,209, 210,213, 230,234,235,238, 239,240	Horsegram	Neem, Glyricydia Silviculture, Agave, Simaroba	-	-	Cresent bunds
LMU 3	17,18,13,14,15 ,16 (25-50 cm)	**Matki**: 156,157,158,159,160,178, 181,207, 211,212,216,217, 218,219,220,221,222,223, 224,225, 226,227,228,229, 236,295,296	Bajra, Linseed, Green gram, Black gram, Chick pea	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla **Vegetables:** Ladies finger, Brinjal, Cowpea, **Flowers:** Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla **Vegetables:** Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers:**Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation like cultivation on raised beds with mulches and drip

LMU 4	19,20,21,22,23 (50-75 cm)	**Matki:**142,145,146,148, 152,164,165,166 ,167	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, **Rabi:** Sorghum, Chickpea, Linseed, Coriander, Safflower	Subabul, 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, Chillies, Bhendi **Flowers:**Marigold, Chrysanthemum	Graded bunds, Strengthening of field bunds
LMU 5	24 (100-150 cm)	**Matki:**151,153,155,161,162,163,174,175,176,231,233	Sorghum, Cotton, Red Gram Black gram, Green gram, Soybean, Sesame, Sunflower, **Rab**i: Sorghum, Chickpea, Linseed, Coriander, Safflower	-	**Vegetables:** Ladies finger, Brinjal,Cowpea, Coriander **Field crops:** Sorghum, Cotton, Red gram, Sunflower, Safflower, **Perennial component:** Guava, Tamarind, Sapota, Lime, Mosambi **Flowers:**Marigold, Chrysanthemum	Banana, Papaya, Lime, Mosambi, Guava, Tamrind **Vegetables:** Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers:**Marigold, Chrysanthemum	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 Matki-3 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of MGT (265 ha), BHI (157 ha), GTT (62 ha), NHA (37 ha), KMP (26 ha), KGI (23 ha), RNL (16 ha).
- As per land capability classification, nearly 94 per cent area falls under arable land category (Class II and IV) and two per cent area belongs to nonarable land category. The major limitations identified in the arable lands were soil and erosion.

- On the basis of soil reaction, about 403 ha (59%) area is moderately alkaline (pH 7.8-8.4) followed by slightly alkaline (pH 7.3-7.8) 192 ha (28%). Thus, about 87 per cent of the soils are alkaline in reaction. About 64 ha (9%) area is neutral (pH 6.5-7.3).

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirullum, Azatobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of $ZnSO_4$ – 12.5 kg/ha (once in three years).
5. Application of Boron – 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 686 ha in the microwatershed, area of about 188 ha is suffering from either moderate or severe erosion. These areas need immediate soil and water conservation and other land husbandry practices for restoring soil health.

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

Inputs for Net Planning and Interventions needed

Net planning in IWMP is focusing on preparation of

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

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

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

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

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

- ❖ **Land Capability Classification:** The land capability map shows the areas suitable and not suitable for agriculture and the major constraints in each of the plot/survey number. Hence, one can decide what kind of enterprise is possible in each of these units. In general, erosion and soil are the major constraints in Matki-3 microwatershed.

- ❖ **Organic Carbon:** In a very small area of about 3 ha (<1%) area, the OC content is low (<0.5%), in about 441 ha (64%) area, the OC content is medium (0.5-0.75%) and in about 215 ha (31%) 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.

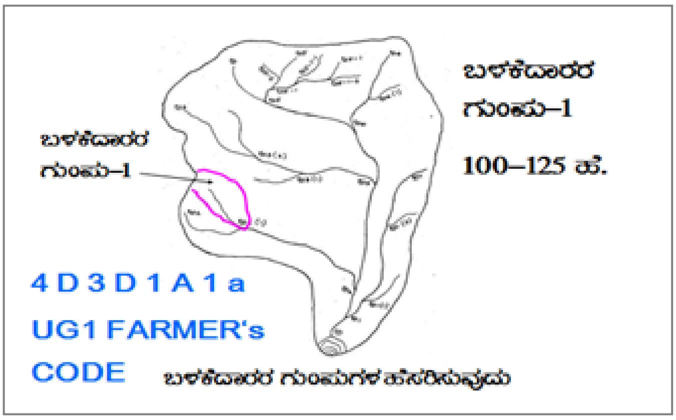
- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 65 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 578 ha (84%), the available phosphorus is low and about 46 ha (6%) area it is medium in available phosphorus, Hence for all the crops, 25% additional P-needs to be applied. About 36 ha (5%) area is high in available phosphorus in the microwatershed.
- **Available Potassium:** Available potassium is medium in 229 ha (33%) area of the microwatershed. Hence, in all these plots, for all crops, an additional 25 % potassium may be applied. It is high in 430 ha (63%) area of the microwatershed.
- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 316 ha (46%) area of the microwatershed and medium in 320 ha (47%).These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for 2-3 years for the deficiency to be corrected. About 23 ha (3 %) is high in available sulphur.
- **Available iron:** It is deficient in a small area of 14 ha (2%) in the microwatershed. To manage iron deficiency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years. It is sufficient in the rest of 645 ha (94 %) in the microwatershed.
- **Available Zinc:** It is deficient in 435 ha (63%) area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied. It is sufficient in 224 ha (33%) area in the microwatershed.
- **Soil alkalinity:** The microwatershed has 595 ha area with soils that are slightly to 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 subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc. are recommended.

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

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Matki-3 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were



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

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

Steps for Survey and Preparation of Treatment Plan

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

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

9.1 Treatment Plan

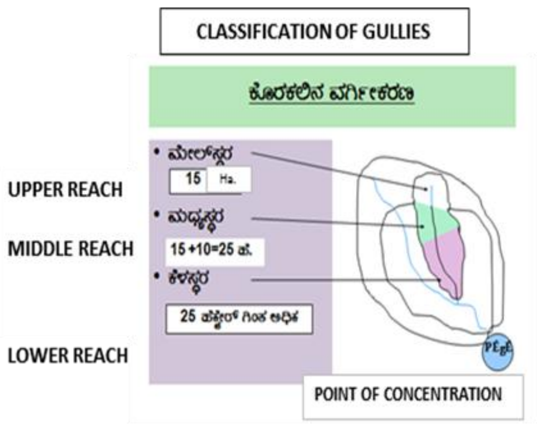
The treatment plan recommended for arable lands is briefly described below.

9.1.1 Arable Land Treatment

A. BUNDING

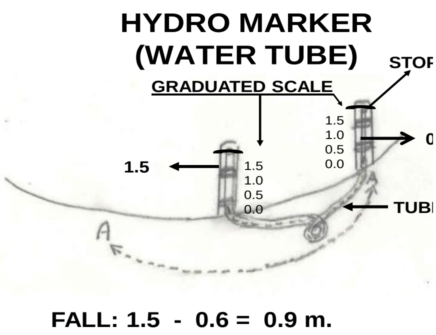
Steps for Survey and Preparation of Treatment Plan	
Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale Drainage lines are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

USER GROUP-1



Measurement of Land Slope

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



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

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

Note: (i) The above intervals are maximum.

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

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

Section of the Bund

Bund section is decided considering the soil texture class and gravelliness class ($bg_{0,}$ loamy sand, <15% gravel). The recommended Sections for different soils are given below.

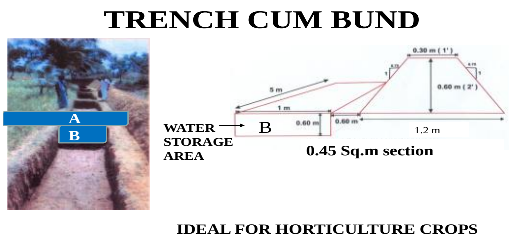
Recommended Bund Section

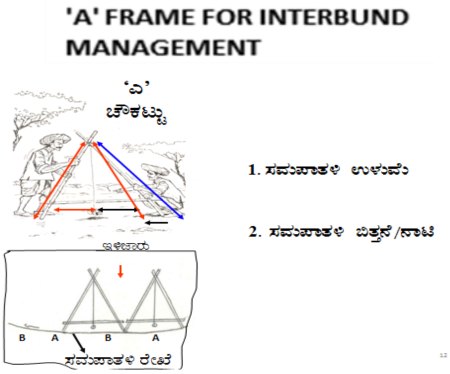
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soil	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below





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

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

B. Waterways

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

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

c) The design details are given in the Manual.

C. Farm Ponds

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

D. Diversion channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation Measures

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

The different kinds of conservation structures recommended are

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been prepared which shows the spatial distribution and extent of area. An area of about 88 ha (13%) requires trench cum bunding and about 89 ha (13%) area needs graded bunds. The maximum area of about 483 ha (70%) requires crescent bund.

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

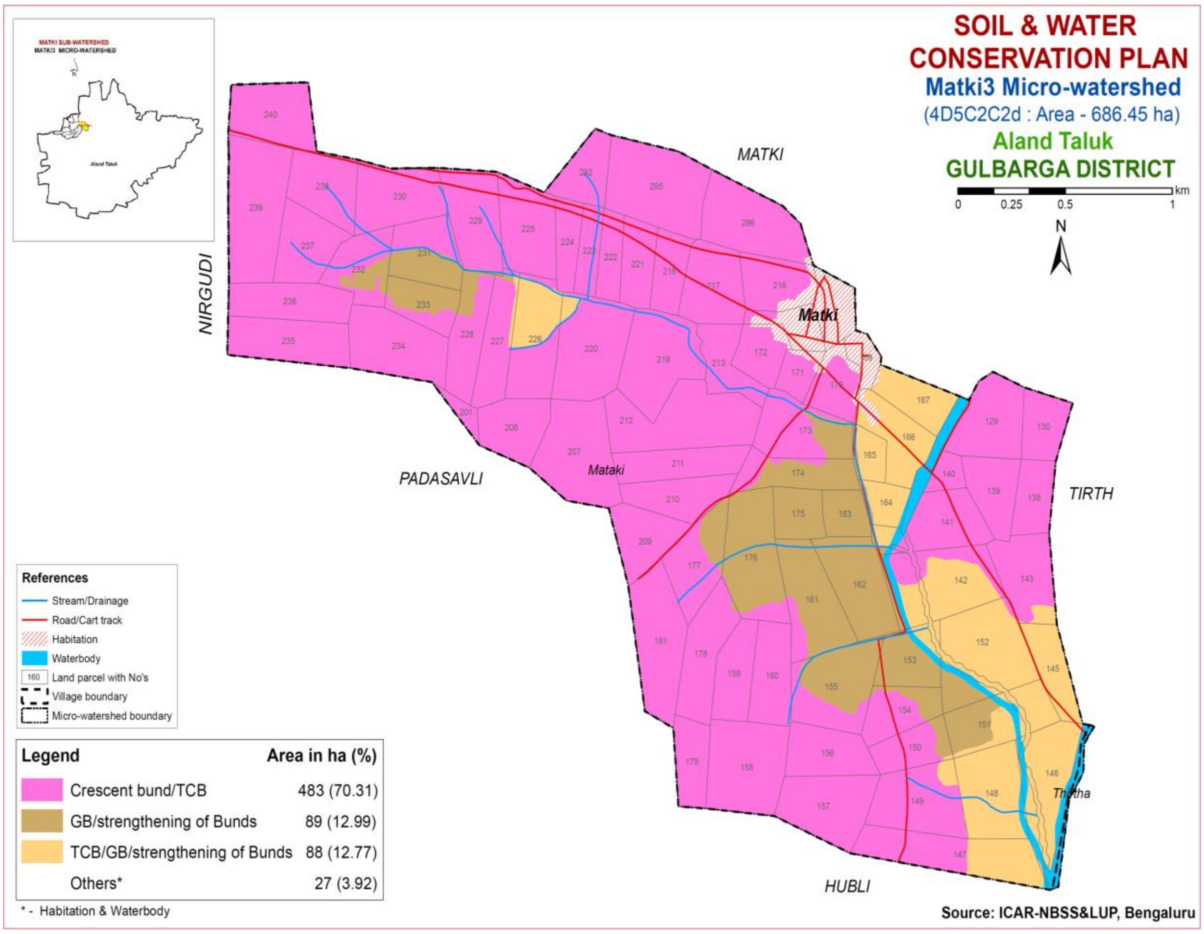


Fig. 9.1 Soil and Water Conservation Plan map of Matki-3 Microwatershed

9.3 Greening of Microwatershed

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

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

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

Dry Deciduous Species			Temp (°C)	Rainfall (mm)
1.	Bevu	*Azadiracta indica*	21–32	400 –1,200
2.	Tapasi	*Holoptelia integrifolia*	20-30	500 - 1000
3.	Seetaphal	*Anona Squamosa*	20-40	400 - 1000
4.	Honge	*Pongamia pinnata*	20 -50	500– 2,500
5.	Kamara	*Hardwikia binata*	25 -35	400 - 1000
6.	Bage	*Albezzia lebbek*	20 - 45	500 - 1000
7.	Ficus	*Ficus bengalensis*	20 - 50	500–2,500
8.	Sisso	*Dalbargia Sissoo*	20 - 50	500 -2000
9.	Ailanthus	*Ailanthus excelsa*	20 - 50	500 - 1000
10.	Hale	*Wrightia tinctoria*	25 - 45	500 - 1000
11.	Uded	*Steriospermum chelanoides*	25 - 45	500 -2000
12.	Dhupa	*Boswella Serrata*	20 - 40	500 - 2000
13.	Nelli	*Emblica Officinalis*	20 - 50	500 -1500
14.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 2000
Moist Deciduous Species			**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 - 1

Matki-3 Microwatershed														
Soil Site and Thematic Information														
Village	Sur-vey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	129	9.65	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+ Redgram (Gg+Rg)	Not Available	IVs	Crescent bund/TCB
Mataki	130	5.5	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Mataki	138	5.37	MGTmB1g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sunflower+ Redgram (Sf+Rg)	Not Available	IVs	Crescent bund/TCB
Mataki	139	6.69	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Greengram (Rg+Gg)	Not Available	IVs	Crescent bund/TCB
Mataki	140	2.24	MGTiD3g3	LMU-1	Very shallow (<25 cm)	Sandy clay	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram (Rg)	Not Available	V	Crescent bund/TCB
Mataki	141	9.5	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Jowar+Green gram (Rg+Jw+Gg)	Not Available	IVse	Crescent bund/TCB
Mataki	142	13.95	GTTmB1	LMU-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+ Sugarcane+ Redgram (Gg+Sc+Rg)	Openwell, Openwell	IIs	TCB/GB/ strengthening of Bunds
Mataki	143	9.06	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Sunflower (Rg+Sf)	Borewell, Openwell	IVse	Crescent bund/TCB
Mataki	145	5.93	GTTmB1	LMU-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Redgram+ Greengram (Sc+Rg+Gg)	Not Available	IIs	TCB/GB/ strengthening of Bunds
Mataki	146	10.38	GTTmB2	LMU-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Borewell, Borewell, Openwell	IIse	TCB/GB/ strengthening of Bunds

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	147	13.29	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Jowar+Green gram (Sc+Jw+Gg)	Not Available	IVs	Crescent bund/TCB
Mataki	148	11.17	GTTmB1g1	LMU-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+ Redgram+Sun flower (Gg+Rg+Sf)	Openwell	IIs	TCB/GB/ strengthening of Bunds
Mataki	149	11.33	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Greengram+ Jowar (Rg+Gg+Jw)	Borewell	IVse	Crescent bund/TCB
Mataki	150	5.84	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Mataki	151	9.65	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Redgram (Sc+Rg)	Not Available	IIs	GB/strengthening of Bunds
Mataki	152	14.68	GTTmB1	LMU-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Redgram+ Tomato (Sc+Rg+Tm)	Borewell, Openwell, Openwell, Borewell	IIs	TCB/GB/ strengthening of Bunds
Mataki	153	6.88	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+ Redgram (Sc+Rg)	Borewell	IIs	GB/strengthening of Bunds
Mataki	154	6.68	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Sugarcane (Rg+Sc)	Openwell, Openwell	IVse	Crescent bund/TCB
Mataki	155	12.59	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+ Sugarcane+ Redgram (Jw+Sc+Rg)	Openwell	IIs	GB/strengthening of Bunds
Mataki	156	7.75	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Greengram (Rg+Gg)	Not Available	IIIs	Crescent bund/TCB

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	157	10.94	BHImB1g2	LMU-3	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+ Redgarm (Gg+Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	158	13.58	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Greengram+Jowar (Rg+Gg+Jw)	Openwell	IIIs	Crescent bund/TCB
Mataki	159	6.78	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Borewell, Borewell	IIIs	Crescent bund/TCB
Mataki	160	7.74	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Redgram (Gg+Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	161	11.57	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Redgram (Gg+Rg)	Openwell, Openwell	IIs	GB/strengthening of Bunds
Mataki	162	10.7	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Redgram (Gg+Rg)	Openwell	IIs	GB/strengthening of Bunds
Mataki	163	4.04	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram (Sc+Rg)	Openwell	IIs	GB/strengthening of Bunds
Mataki	164	3.52	KMPmB1g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Not Available	IIs	TCB/GB/strengthening of Bunds
Mataki	165	3.14	KMPmB1g1	LMU-4	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Openwell, Openwell	IIs	TCB/GB/strengthening of Bunds
Mataki	166	7.93	KMPmB1	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Greengram (Sc+Gg)	Not Available	IIs	TCB/GB/strengthening of Bunds
Mataki	167	5.9	KMPmB1	LMU-4	Moderately deep (75-100 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane (Sc)	Not Available	IIs	TCB/GB/strengthening of Bunds
Mataki	169	2.56	Habitation	Others	Others	Others	Others	Others	Others	Others	Others	Not Available	Others	Others

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	170	5.69	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Mataki	171	3.24	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Openwell	IVs	Crescent bund/TCB
Mataki	172	5.24	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Sugarcane (Gg+Sc)	Borewell, Borewell, Borewell	IVs	Crescent bund/TCB
Mataki	173	9.93	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram (Sc+Rg)	Borewell, Borewell	IVs	Crescent bund/TCB
Mataki	174	7.49	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram (Sc+Rg)	Openwell	IIs	GB/strengthening of Bunds
Mataki	175	4.96	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Not Available	IIs	GB/strengthening of Bunds
Mataki	176	13.32	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Openwell, Borewell, Openwell	IIs	GB/strengthening of Bunds
Mataki	177	8.94	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Mataki	178	9.58	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Grassland (Rg+Gl)	Not Available	IIIs	Crescent bund/TCB
Mataki	179	5.59	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram (Gg)	Not Available	IVs	Crescent bund/TCB
Mataki	181	12.71	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	201	1.55	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Mataki	206	7.43	MGTmC3g3	LMU-1	Very shallow (<25 cm)	Clay	Extremely gravelly (60-80%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Mataki	207	13.88	NHAmB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Redgram (Jw+Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	209	7.09	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Borewell	IVse	Crescent bund/TCB

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	210	7.18	MGTmB2g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Not Available	IVse	Crescent bund/TCB
Mataki	211	7.66	NHAmB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	212	15.8	NHAmB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Greengram+Tomato (Rg+Gg+Tm)	Borewell, Borewell	IIIs	Crescent bund/TCB
Mataki	213	5.98	MGTmB1	LMU-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Greengram (Sc+Gg)	Not Available	IVs	Crescent bund/TCB
Mataki	214_GRASS_FIELD	4.01	Habitation	Others	Others	Others	Others	Others	Others	Others	Grassland (Gl)	Not Available	Others	Others
Mataki	215Grassfield	4.79	Habitation	Others	Others	Others	Others	Others	Others	Others	Grassland (Gl)	Not Available	Others	Others
Mataki	216	7.23	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IIIs	Crescent bund/TCB
Mataki	217	9.03	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram (Sc+Rg)	Borewell, Openwell	IIIs	Crescent bund/TCB
Mataki	218	5.08	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIIs	Crescent bund/TCB
Mataki	219	12.73	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar+ Sugarcane (Rg+Jw+Sc)	Borewell, Borewell, Openwell	IIIs	Crescent bund/TCB
Mataki	220	13.53	NHAmB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Jowar+Redgram (Gg+Jw+Rg)	Borewell, Borewell	IIIs	Crescent bund/TCB
Mataki	221	5.5	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Redgram+Sugarcane (Jw+Rg+Sc)	Openwell, Borewell, Borewell	IIIs	Crescent bund/TCB
Mataki	222	3.96	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Jowar+Sugarcane (Jw+Sc)	Not Available	IIIs	Crescent bund/TCB
Mataki	223	3.78	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Borewell, Openwell	IIIs	Crescent bund/TCB

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	224	4.19	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Sugarcane (Rg+Sc)	Borewell, Openwell	IIIs	Crescent bund/TCB
Mataki	225	9.78	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Borewell	IIIs	Crescent bund/TCB
Mataki	226	10.92	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Greengram+Jowar+Redgram (Gg+Jw+Rg)	Borewell	IIIs	Crescent bund/TCB
Mataki	227	7.55	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram+Greengram (Sc+Rg+Gg)	Not Available	IIIs	Crescent bund/TCB
Mataki	228	7.91	BHImB1g1	LMU-3	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram+Greengram (Sc+Rg+Gg)	Openwell, Openwell	IIIs	Crescent bund/TCB
Mataki	229	10	BHImB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Tomato+Sugarcane+Redgram (Tm+Sc+Rg)	Borewell, Borewell	IIIs	Crescent bund/TCB
Mataki	230	10.02	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar (Rg+Jw)	Checkdam	IVse	Crescent bund/TCB
Mataki	231	8.35	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar (Rg+Jw)	Borewell, Borewell	IIs	GB/strengthening of Bunds
Mataki	232	7.57	MGTmC3g2	LMU-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram (Rg)	Checkdam Checkdam	IVse	Crescent bund/TCB
Mataki	233	5.86	RNLmB1	LMU-5	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sugarcane+Redgram+Jowar (Sc+Rg+Jw)	Not Available	IIs	GB/strengthening of Bunds
Mataki	234	11.57	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Sunflower+Redgram (Sf+Rg)	Not Available	IVse	Crescent bund/TCB
Mataki	235	10.05	MGTmB2g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB

Village	Survey No.	Total Area (ha)	Soil Phase	Land Manage-ment Unit	Soil Depth	Surface Soil Texture	Soil Grave-lliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capa-bility	Conserva-tion Plan
Mataki	236	8.61	BHImB1	LMU-3	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Jowar (Rg+Jw)	Not Available	IIIs	Crescent bund/TCB
Mataki	237	8.02	MGTmC3g2	LMU-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	NA	Checkdam, Checkdam	IVse	Crescent bund/TCB
Mataki	238	8.52	MGTmB1g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Jowar (Rg+Jw)	Not Available	IVs	Crescent bund/TCB
Mataki	239	15.37	MGTmB1g2	LMU-2	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Jowar (Rg+Jw)	Not Available	IVs	Crescent bund/TCB
Mataki	240	9.84	MGTmB1g1	LMU-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	Crescent bund/TCB
Mataki	292	5.85	MGTmC3g1	LMU-1	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Mataki	295	15.13	KGImB2g2	LMU-3	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Tomato+ Gingelli+ Sugarcane (Rg+Tm+Gi +Sc)	Borewell, Borewell, Borewell, Borewell	IIIse	Crescent bund/TCB
Mataki	296	12.21	KGImB2g2	LMU-3	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Tomato+ Sugarcane+ Redgram (Tm+Sc+Rg)	Borewell, Openwell, Borewell, Borewell	IIIse	Crescent bund/TCB
Mataki	STREAM	8.53	Waterbody	Others	Others	Others	Others	Others	Others	Others	Others	Not Available	Other s	Others
Thirtha	River Amarja	1.16	Waterbody	Others	Others	Others	Others	Others	Others	Others	Others	Others	Other s	Others

Appendix - II

Soil Fertility Information

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Mataki	129	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	130	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	138	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	139	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	140	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)
Mataki	141	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	142	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	143	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	145	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	146	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	147	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	148	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	149	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	150	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	151	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	152	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	153	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Mataki	155	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	156	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	157	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	158	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	159	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	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)
Mataki	160	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	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)
Mataki	161	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	162	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	163	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	164	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	165	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	166	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Dwficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	167	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	169	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	170	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	171	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	172	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)
Mataki	173	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	174	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	175	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Mataki	177	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	178	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5 - 1.0 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	179	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	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)
Mataki	181	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	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)
Mataki	201	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	206	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	207	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	209	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	210	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	211	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	212	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	213	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	214 grass field	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	215 grass field	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	216	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	217	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	218	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	219	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	220	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	221	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Mataki	223	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Dwficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	224	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	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)
Mataki	225	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	226	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	227	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	228	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>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)	Deficient (< 0.6 ppm)
Mataki	229	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	230	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	High (> 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)
Mataki	231	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	232	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	High (>0.75 %)	High (> 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)
Mataki	233	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	234	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	High (>0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	235	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	High (>0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)
Mataki	236	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	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)
Mataki	237	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	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)
Mataki	238	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	High (>0.75 %)	High (> 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)
Mataki	239	Neutral (pH 6.5 – 7.3)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	240	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	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)	Deficient (< 0.6 ppm)
Mataki	292	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	High (> 57 kg/ha)	High (> 337 kg/ha)	Medium (10-20 ppm)	Low (< 0.5 ppm)	Dwficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Sufficient (> 0.6 ppm)

Village	Survey No.	Soil Reaction (pH)	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Mataki	296	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2dS/m)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	Medium (145 - 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Mataki	STREAM	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Thirtha	River Amarja	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Appendix – III
Soil Suitability information

Village	Survey No.	Sorgh-um	Maize	Redgram	Sun-flower	Cotto-n	Sugar-cane	Soybe-an	Guav-a	Ma-ngo	Sapota	Jack-fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tam-arind
Mataki	129	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	130	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	138	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	139	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	140	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	141	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	142	S2r	S3rt	S2r	S3r	S2r	S3t	S2r	S3rt	N	S3rt	S3rt	S3r	S3r	S3r	N	S2r	S2r	N
Mataki	143	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	145	S2r	S3rt	S2r	S3r	S2r	S3t	S2r	S3rt	N	S3rt	S3rt	S3r	S3r	S3r	N	S2r	S2r	N
Mataki	146	S2re	S3rt	S2re	S3r	S2re	S3t	S2re	S3rt	N	S3rt	S3rt	S3r	S3r	S3r	N	S2re	S2re	N
Mataki	147	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	148	S2rg	S3rt	S2rg	S3r	S2rg	S3t	S2rg	S3rt	N	S3rt	S3rt	S3r	S3r	S3r	N	S2r	S2r	N
Mataki	149	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	150	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	151	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	152	S2r	S3rt	S2r	S3r	S2r	S3t	S2r	S3rt	N	S3rt	S3rt	S3r	S3r	S3r	N	S2r	S2r	N
Mataki	153	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	154	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	155	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	156	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	157	S3rg	S3rt	S3rg	N	S3rg	N	S3rg	N	N	N	N	N	N	N	N	S3rg	S3rg	N
Mataki	158	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	159	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	160	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	161	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	162	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	163	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	164	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3rt	S3r	S2r	S2r	N	S1	S1	S3r

Village	Survey No.	Sorghum	Maize	Redgram	Sun-flower	Cotton	Sugar-cane	Soybean	Guava	Mango	Sapota	Jack-fruit	Jamun	Mus-ambi	Lime	Cashew	Custard Apple	Amla	Tamarind
Mataki	166	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3rt	S3r	S2r	S2r	N	S1	S1	S3r
Mataki	167	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3rt	S3r	S2r	S2r	N	S1	S1	S3r
Mataki	169	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	170	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	171	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	172	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	173	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	174	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	175	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	176	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	177	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	178	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	179	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	181	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	201	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	206	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	207	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	209	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	210	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	211	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	212	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	213	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	214_GRASS_FIELD	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	215_GRASS_FIELD	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Mataki	216	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	217	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	218	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	219	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	220	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N

Village	Survey No.	Sorgh -um	Maize	Redgr am	Sun-flower	Cotto-n	Sugar -cane	Soybe -an	Guav-a	Ma-ngo	Sapota	Jack -fruit	Jamun	Mus-ambi	Lime	Cas-hew	Custard Apple	Amla	Tam-arind
Mataki	222	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	223	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	224	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	225	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	226	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	227	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	228	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	229	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	230	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	231	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	232	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	233	S1	S3t	S2t	S1	S1	S3t	S1	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2r
Mataki	234	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	235	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	236	S3r	S3rt	S3r	N	S3r	N	S3r	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	237	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	238	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	239	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	240	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	292	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Mataki	295	S3rg	S3rt	S3rg	N	S3rg	N	S3rg	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	296	S3rg	S3rt	S3rg	N	S3rg	N	S3rg	N	N	N	N	N	N	N	N	S3r	S3r	N
Mataki	STREAM	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Thirtha	River Amarja	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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Chapter 1

EXECUTIVE SUMMARY

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

Methodology: *Matki-3 micro-watershed (Matki sub-watershed, Aland taluk, Gulbarga district) is located in between $17^0 36'$–$17^0 38'$ North latitudes and $77^0 28'$–$77^0 31'$ East longitudes, covering an area of about 686.45 ha, bounded by Nirgudi, Padasavali, Tirth and Hubli villages with length of growing period (LGP) 120-150 days.We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for Matki-3 micro-watershed (Matki sub-watershed, Aland taluk, Gulbarga district) are presented here.*

Social Indicators

- *Male and female ratio is 57.8 to 42.2 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 58 per cent to the total population.*
- *Literacy population is around 86.7 per cent.*
- *Social groups belong to other backward caste (OBC) among all households.*
- *Fire wood and liquefied petroleum gas is the source of energy for a cooking is 50 per cent each.*
- *About 30 per cent of households have a yashaswini health card.*
- *Majority of farm households (50 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system having all the farm households.*
- *Swach bharath program providing closed toilet facilities around 90 per cent of sample households.*
- *Institutional participation is only 2.2 per cent of sample households.*
- *Women participation in decisions making for agriculture production of among all the households was found.*

Economic Indicators

- *The average land holding is 1.9 ha indicates that majority of farm households are belong to small and medium farmers. The dry land is total cultivated area among the sample farmers.*

- *Agriculture is the main occupation among 75.6 per cent and agriculture is the main and agriculture labour is subsidiary occupation for 11.1 per cent of sample households.*
- *The average value of domestic assets is around Rs. 173331 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs.131074 per household, about 50 per cent of sample farmers having plough and bullock cart.*
- *The average value of livestock is around Rs.38541 per household; about 33.3 per cent of household are having livestock.*
- *The average per capita food consumption is around 987.5 grams (2415 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 20 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs.60347 per household. About 70 per cent of farm households are below poverty line.*
- *The per capita average monthly expenditure is around Rs.2131.*

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.1072 per ha/year. The total cost of annual soil nutrients is around Rs.704338 per year for the total area of 686.45 ha.*
- *The average value of ecosystem service for food grain production is around Rs 12936/ ha/year. Per hectare food grain production services is maximum in red gram (Rs.26289) and sunflower is negative return.*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. Per hectare value of water used and value of water was maximum in red gram (Rs. 544) and sunflower (Rs. 337).*

Economic Land Evaluation

- *The major cropping pattern is red gram (95.2 %) and sugarcane (4.8 %).*
- *In matki 3 Microwatershed, major soil are Margutti (MGT) series is having Very shallow soil depth cover around 33.5 % of area. On this soil farmers are presently growing redgram (63.2 %) and sunflower (36.8 %). Bhimanahalli (BHI) is also having shallow soil depth cover 22.91 % of area, the crop is red gram. Gutti (GTT) soil series having moderately shallow soil depth cover around 9.03 % of areas, the major crop is red gram.*

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for red gram ranges between Rs.30178/ha in BHI soil (with BCR of 1.88) and Rs.26194/ha in MGT soil (with BCR of 2.30).*
- *In sunflower the cost of cultivation in MGT soil is Rs 20559/ha (with of 0.98).*
- *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 (16.2 %) and sunflower (67.4%).*

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

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

Matki-3 micro-watershed (Matki sub-watershed, Aland taluk, Gulbarga district) is located in between 17036'–17038' North latitudes and 77028'–77031' East longitudes, covering an area of about 686.45 ha, bounded by Nirgudi, Padasavali, Tirth and Hubli villages.

Sampling Procedure:

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

Sources of data and analysis:

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

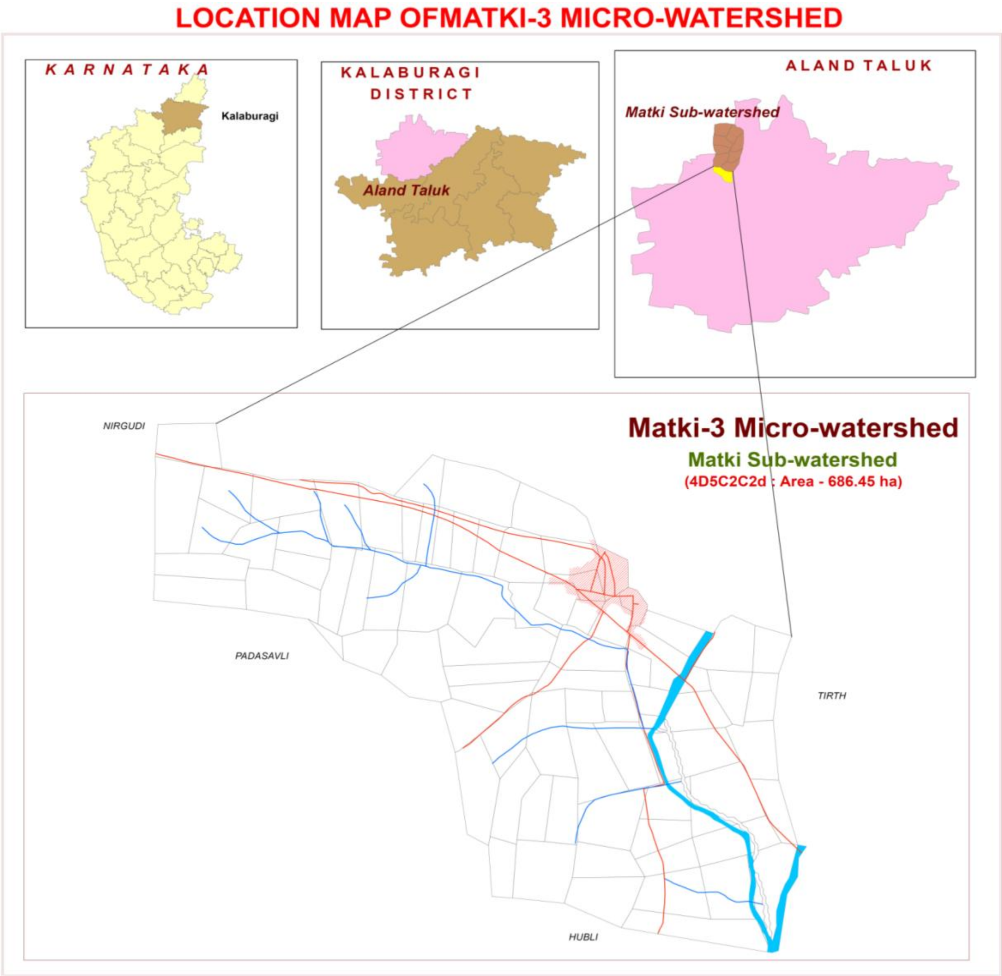

Figure 1: Location of study area

Steps followed in socio-economic assessment

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

Figure 2: ALPES FRAMEWORK

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

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

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

Net returns = Gross returns-Operational cost.

Benefit Cost Ratio = Net returns/Total cost.

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

Economic Valuation of Soil escosystem services:

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

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

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

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 45, out of which 57.8 per cent were males and 42.2 per cent females. Average family size of the households is 4.5. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 18 to 30 years (33.3 %) followed by 30 to 50 years (24.4 %) and more than 50 years (20 %). 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 13.3 per cent of respondents were illiterate and 86.7 per cent literate (Table 1).

Table 1: Human population among sample households in Matki 3 Micro-watershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	45
Male	% to total Population	57.8
Female	% to total Population	42.2
Average family size	Number	4.5
Age group		
0 to 18 years	% to total Population	22.2
18 to 30 years	% to total Population	33.3
30 to 50 years	% to total Population	24.4
>50 years	% to total Population	20.0
Average age	Age in years	31.8
Education Status		
Illiterates	% to total Population	13.3
Literates	% to total Population	86.7
Primary School (<5 class)	% to total Population	22.2
Middle School (6- 8 class)	% to total Population	22.2
High School (9- 10 class)	% to total Population	28.9
Others	% to total Population	13.3

The ethnic groups among the sample farm households found to be 100 per cent belonging to other backward castes (OBC). (Table 2 and Figure 3) About 50 per cent of sample households are using liquefied petroleum gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 30 per cent are sample households having health cards. Majority of households (50 %) are having MNREGA job cards for employment generation. Among all farm households are having ration cards for taking food grains from public distribution system. About 90 per cent of farm households are having toilet facilities.

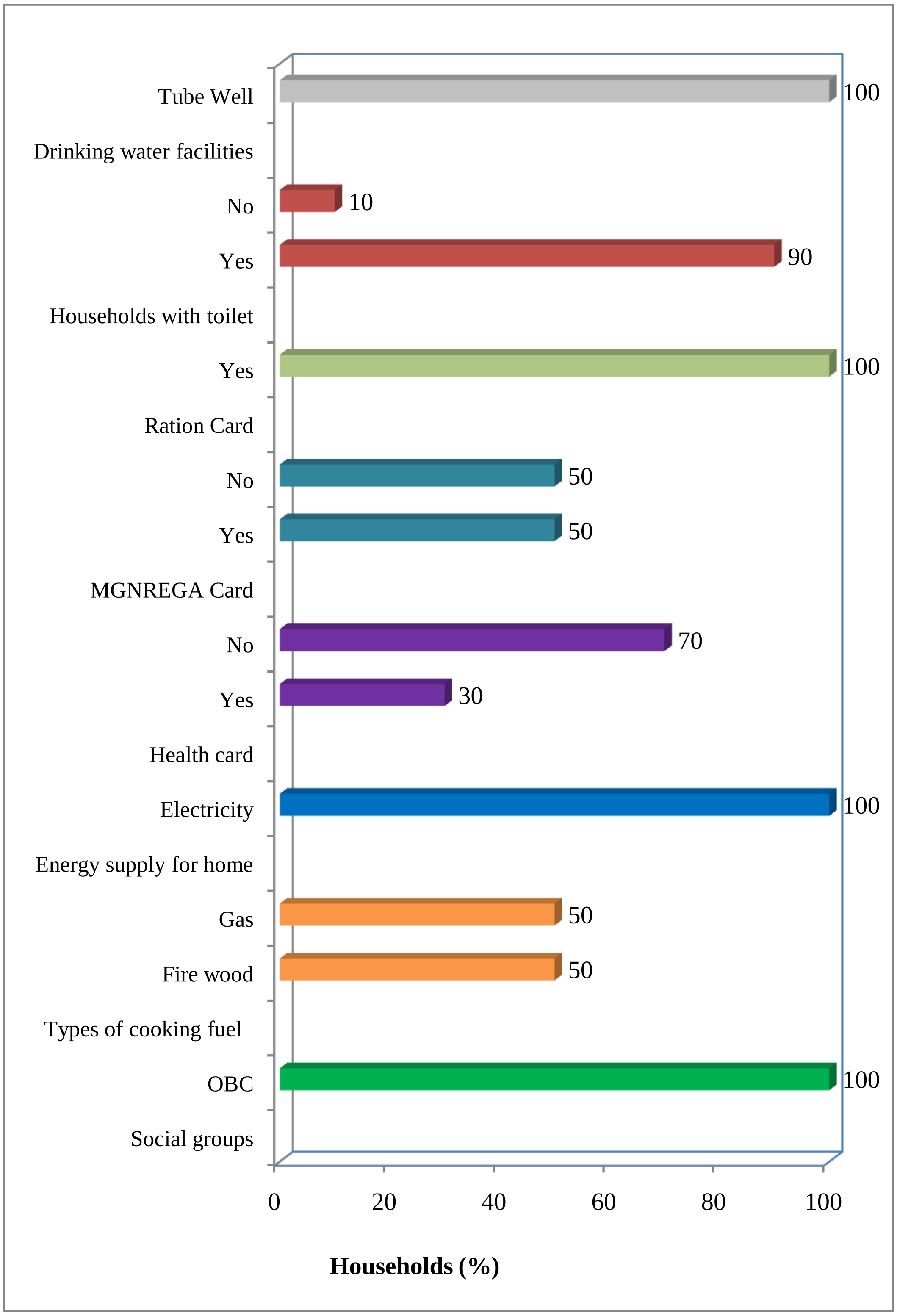

Figure 3: Basic needs of sample households in Matki 3 Micro-watershed

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.

Table 2: Basic needs of sample households in Matki 3 Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	100.0
Types of fuel use for cooking		
Fire wood	% of Households	50.0
Gas	% of Households	50.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	30.0
No	% of Households	70.0
MGNREGA Card		
Yes	% of Households	50.0
No	% of Households	50.0
Ration Card		
Yes	% of Households	100.0
Households with toilet		
Yes	% of Households	90.0
No	% of Households	10.0
Drinking water facilities		
Tube Well	% of Households	100.00

About 2.2 percent of farmers are participating in community based organizations (Table 3). Among them majority were participating in village panchayat.

Table 3: Institutional participation among the sample population in Matki 3 Micro-watershed

Particulars	Units	Value
No. of people participating	% to total	2.2
Village Panchayath	% of total	2.2
No. of people not participating	% to total	97.8

Table 4: Occupational pattern in sample population in Matki 3 Micro-watershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	75.6
	Agriculture Labour	11.1
	Self employed	6.7
Dairy farming		2.2
Others		4.4
Total		100
Family labour availability		**Man days/month**
Male		42.5
Female		30.0
Total		72.50

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 75.6 per cent of farmers followed by subsidiary occupations like agricultural labour (11.1 %), self employment(6.7%) and main occupation dairy farming and other activities around 2.2 % and 4.4 percent respectively.

The important assets especially with reference to domestic assets were analyzed and are given in Table 5 and Figure 4. The important domestic assets possessed by all categories of farmers are television (100 %) followed by mobile phones (90 %), mixer/grinder (70 %), motorcycle (70 %) and four wheeler (10 %). The average value of domestic assets is around Rs.173331 per household.

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

Particulars	% of households	Average value in Rs
Four wheeler	10.0	800000
Mixer/grinder	70.0	2329
Mobile Phone	90.0	6222
Motorcycle	70.0	50857
Television	100.0	7250
Average Value	173331	

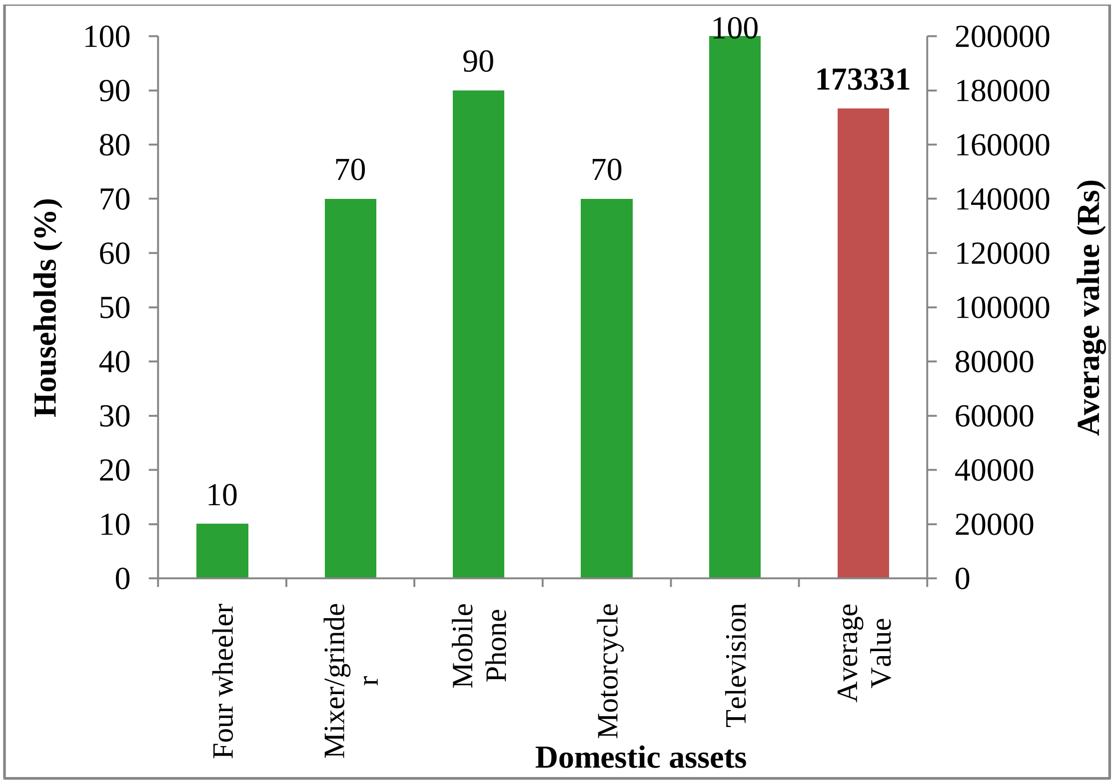

Figure 4: Domestic assets among the sample households in Matki 3 Microwatershed

The most popularly owned farm equipments were bullock cart, harvester, plough, sprayer, tractor, and weeder. Plough and weeder were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned bullock cart (50 %), plough (50 %), weeder (40 %), sprayer (20 %)

and tractor (20 %). The average value of farm assets is around Rs.131074per households (Table 6 and Figure 5).

Table 6: Farm assets among samples households in Matki 3 Micro-watershed

Particulars	% of households	Average value in Rs
Bullock cart	50.0	27200
Harvester	10.0	200000
Plough	50.0	4360
Sprayer	20.0	4550
Tractor	20.0	550000
Weeder	40.0	338
Average Value	131074	

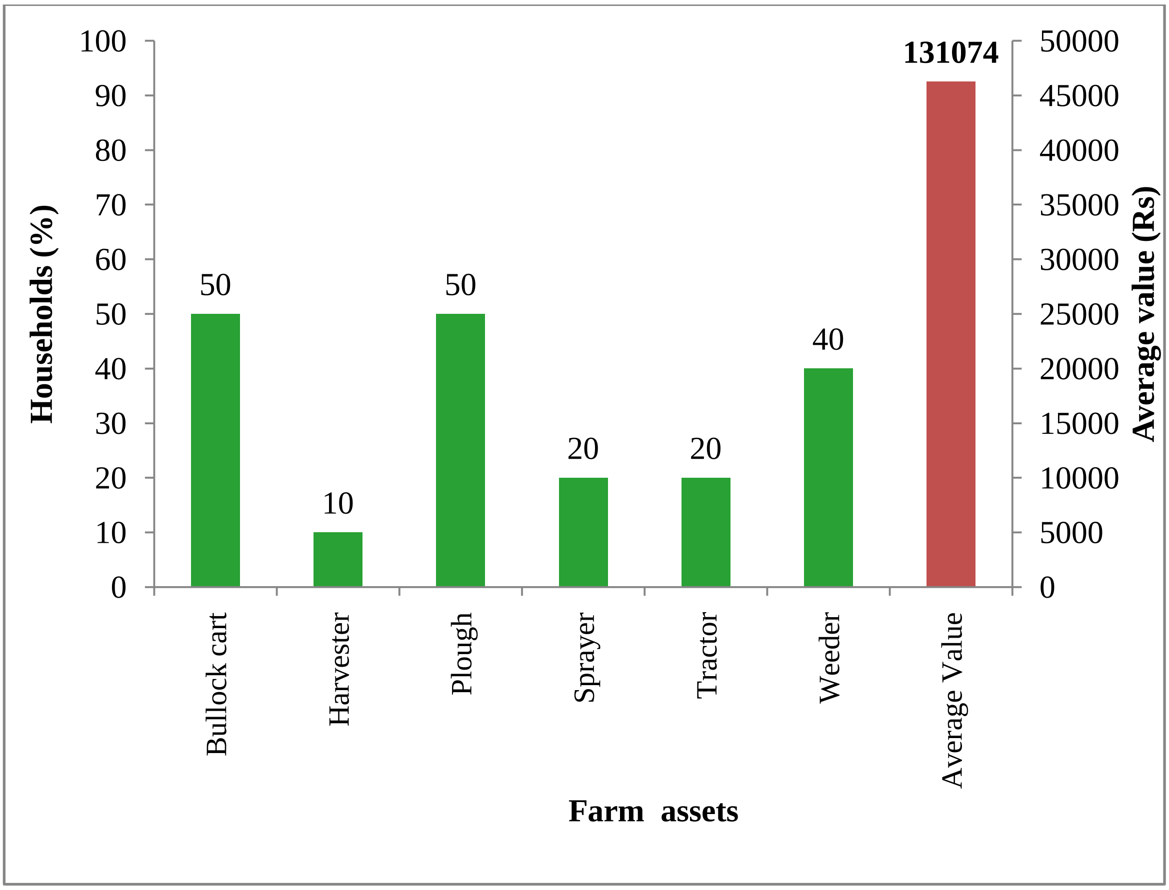

Figure 5: Farm assets among samples households in Matki 3 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population local mulching cows were around 61.5 per cent bullocks (30.8 %) and sheep's 7.7 per cent. The average livestock value was Rs 38541 per household.

Table 7: Livestock assets among sample households in Matki 3 micro-watershed

Particulars	% of livestock population	Average value in Rs
Local Milching Cow	61.5	36375
Bullocks	30.8	69250
Sheep's	7.7	10000
Average value	38541	

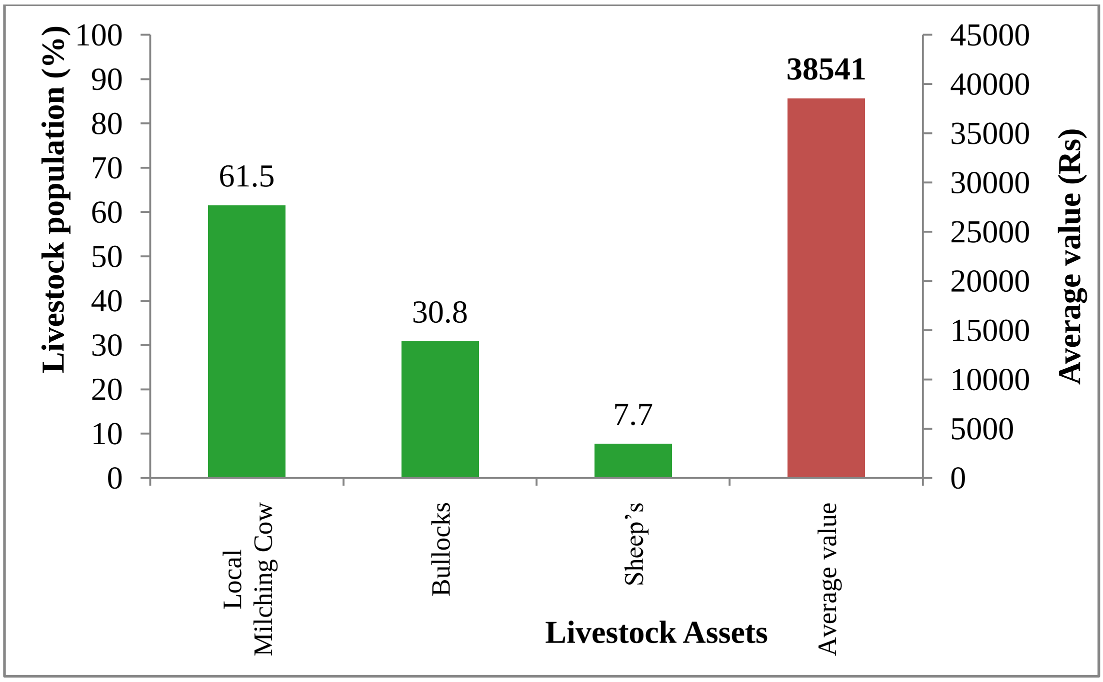

Figure 6: Livestock assets among sample households in Matki 3 microwatershed

Average milk produced in sample households is 963 litters/ annum in Table 8. The number of livestock having households was 87 per cent and total number of livestock was 22.

Table 8: Milk produced of sample households in Matki 3 Microwatershed

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Local Milching Cow	693
Average Milk Produced	**693**
Livestock having households (%)	87
Livestock population (Numbers)	22

Table 9: Women empowerment of sample households in Matki 3 Microwatershed

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

A woman participation in decision making is in this Microwatershed is presented in Table 9. All the women taking decision in her family and agriculture related activities

20 per cent of women participation in local organisation activates, among all women earning for her family requirement.

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

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	463.3	1575.4
Pulses	43	59.9	205.3
Milk	200	201.5	131.0
Vegetables	143	101.7	24.4
Cooking Oil	31	56.6	322.9
Egg	0.5	85.9	128.8
Meat	14.2	18.5	27.8
Total	**827.7**	**987.5**	**2415.6**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		40	20.0
% Above NIN		60	80.0

Note: * day/person

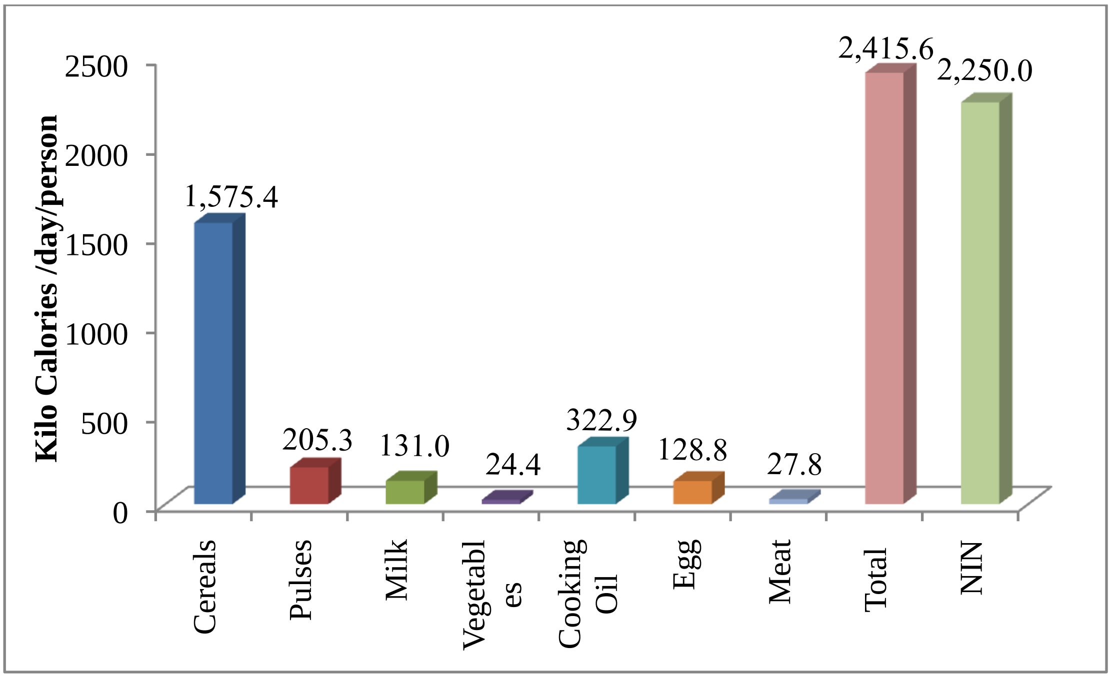

Figure 7: Per capita daily consumption of food among the sample households in Matki 3 Micro-watershed

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 2415.59.kcal per person. The other important food items consumed was pulses 1575.36 kcal followed by cooking oil 322.86 kcal, milk 130.98 kcal, vegetables 24.42 kcal, egg 128.81 kcal and meat 27.82 kcal. In the sampled households, farmers were consuming more (2415.59 kcal) than NIN- recommended food requirement (2250 kcal).

Annual income of the sample HHs: The average annual household income is around Rs 60348. Major source of income to the farmers in the study area is from crop production (Rs 48150) followed by livestock (Rs. 12198). The monthly per capita income is Rs. 1118, which is more than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

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

Particulars	Income *
Nonfarm income (Rs)	0 (0)
Livestock income (Rs)	12198 (80)
Crop Production (Rs)	48150 (100)
Total Annual Income (Rs)	***60348***
Average monthly per capita income (Rs)	1118
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	30.0
% of households above poverty line	70.0

* Figure in the parenthesis indicates % of Households

The average annual expenditure of farm households indicated that farmers in the study area spend highest on food (Rs. 54060) 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.2131 and about 30 per cent of farm households are below poverty line and 70 per of farm households are above poverty line (Table 12 and Figure 8).

Table 12: Average annual expenditure of sample HHs in Matki 3 Micro-watershed

Particulars	Value in Rupees	Per cent
Food	54060	47.0
Education	6000	5.2
Clothing	13800	12.0
Social functions	31000	26.9
Health	10200	8.9
Total Expenditure (Rs/year)	115060	100.0
Monthly per capita expenditure (Rs)	2131	

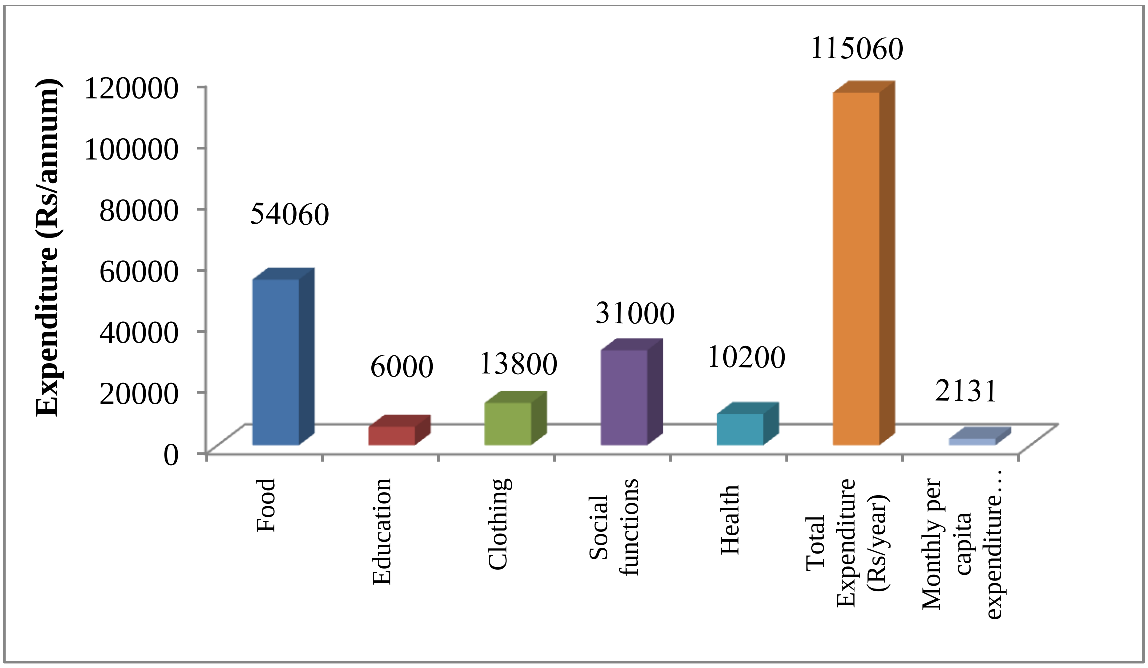

Figure 8: Average annual expenditure of sample HHs in Matki 3 Micro-watershed

Land holding: Total area cultivated by them is 19.5 ha (Table 13). The average land holding of sample HHs is 1.9 ha. Large number of sample HHs (50%) belong to small size group with an average holding size of 1.6 ha and medium farmers (50%) with an average holding size of 2.2 ha.

Table 13: Distribution of land holding among the sample households in Matki 3 micro-watershed

Particulars	**Units**	**Values**
Small farmers		
Total land	ha	8.1
Sample size	Per cent	50.0
Average land holding	ha	1.6
Medium farmers		
Total land	ha	11.4
Sample size	Per cent	50
Average land holding	ha	2.2
Total sample households		
Total land	ha	19.5
Sample size	Per cent	100
Average land holding	ha	1.9

Table 14: Land use among samples households in Matki 3 Microwatershed

Particulars	**Per cent**	**Area in ha**
Dry Land	100.0	19.6
Irrigated land	0.0	0.0
Fallow Land	0.0	0.0
Total land holding	100.0	19.6
Average land holding	1.96	

Land use: The total land holding in the Matki 3 microwatershed is 19.6 ha is rain fed (Table 14). The average land holding per household is worked out to be 1.96 ha.

In the microwatershed, the prevalent present land uses under perennial plants are neem tree (70.7 %) followed by mango tree (8.5 %), banyan tree (6.1 %), people tree (Arali) (1.2 %), tamarind (4.9%) and teak (4.9%) (Table 15).

Table 15: Number of trees/plants covered in sample farm households in Matki 3 Micro-watershed

Particulars	Number of Plants/trees	Per cent
Banyan tree(Alada)	5	6.1
Coconut	2	2.4
Jelly	1	1.2
Mango	7	8.5
Neem trees	58	70.7
People tree(Arali)	1	1.2
Tamarind	4	4.9
Teak	4	4.9
Grand Total	82	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 red gram (95.2 %) and sugarcane (4.8) which is during the kharif season (Table 16).

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

(% to grand total)

Crops	Kharif	Grand Total
Red gram	95.2	95.18
Sugarcane	4.8	4.8
Grand Total	100.0	100.0

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 Matki 3 micro-watershed, 7 soil series are identified and mapped (Table 17). The distribution of major soil series are Margutti covering an area around 243.77 ha (35.5 %) followed by Bhimanahalli 157.2 ha (22.9%), Kalamundargi 23.17 ha (3.3%), Novinahala 36.75 ha (5.36 %), Gutti 62 ha (9.3%), Kamalapur 25.82 ha (3.7%), Rajnala 89.1 ha (12.9%), and Other 26.9 ha (3.9 %).

Table 17: Distribution of soil series in Matki 3 Micro-watershed

Sl. No	Map unit	Description	Area in ha (%)
1	MGT iB2g2	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; sandy clay surface on 1-3 % slope, moderately eroded, moderately gravelly, 35-60 per cent gravels.	3.67 (0.53)
	MGTiC 3g3	Very shallow, black gravelly clay soils developed from weathered basalt on gently sloping uplands; sandy clay surface on 3-5 % slope, severely eroded, highly gravelly, more than 60 per cent gravels.	18.00 (2.62)
	MGTiD 3g3	Very shallow, black gravelly clay soils developed from weathered basalt on moderately sloping uplands; sandy clay surface on 5-10 % slope, severely eroded, highly gravelly, more than 60 per cent gravels.	14.24 (2.08)
	MGTm A1	Very shallow, black gravelly clay soils developed from weathered basalt on nearly level uplands; clay surface on 0-1% slope, slightly eroded	7.84 (1.14)
	MGTm B1	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded	65.65 (9.56)
	MGTm B1g1	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded, slightly gravelly, 15-35 per cent gravels.	17.70 (2.58)
	MGTm B1g2	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded, moderately gravelly, 35-60 per cent gravels.	19.84 (2.89)
	MGTm B2g1	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, moderately eroded, slightly gravelly, 15-35 per cent gravels.	49.98 (7.28)
	MGTm B2g2	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, moderately eroded, slightly gravelly, 35-60 per cent gravels.	31.11 (4.53)
	MGTm C3g1	Very shallow, black gravelly clay soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, severely eroded, slightly gravelly, 15-35 per cent gravels.	5.78 (0.84)
	MGTm C3g2	Very shallow, black gravelly clay soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, severely eroded, moderately gravelly, 35-60 per cent gravels.	14.59 (2.13)
	MGTm C3g3	Very shallow, black gravelly clay soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, severely eroded, highly gravelly, more than 60 per cent gravels.	17.04 (2.48)
2	BHI mB1	Shallow, black clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	16.30 (2.37)
	BHI mB1g1	Shallow, black clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded, slightly gravelly, 15-35 per cent gravels.	130.34 (18.99)
	BHI	Shallow, black clay soils developed from weathered basalt on very	10.64

	mB1g2	gently sloping uplands; clay surface on 1-3% slope, slightly eroded, moderately gravelly, 35-60 per cent gravels.	(1.55)
3	KGI mB2g2	Shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded, moderately gravelly, 35-60 per cent gravels.	23.17 (3.38)
4	NHA mB1g1	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded, slightly gravelly, 15-35 per cent gravels.	33.20 (4.84)
	NHA mB2g1	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded, moderately gravelly, 15-35 per cent gravels.	3.55 (0.52)
5	GTT mB1	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	46.25 (6.74)
	GTT mB1g1	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded , slightly gravelly, 15-35 per cent gravels.	9.48 (1.38)
	GTT mB2	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded	6.27 (0.91)
6	KMP mB1	Moderately deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	9.46 (1.38)
	KMP mB1g1	Moderately deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded, slightly gravelly, 15-35 per cent gravels.	16.23 (2.36)
7	RNL mB1	Deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded	89.18 (12.99)
Habitation			26.92 (3.92)

Present cropping pattern on different soil series are given in Table 18. Crops grown on Margutti soils are redgram and sunflower. Redgram on Bhimanahalli and Gutti soils are grown.

Table 18: Cropping pattern on major soil series in Matki 3 Microwatershed (Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Grand Total
			Kharif	
MGT	Very Shallow (<25)	Red gram	63.2	63.2
		Sunflower	36.8	36.8
BHI	Shallow (25-50 cm)	Red gram	100	100
GTT	Moderately shallow (50-75 cm)	Red gram	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 19).

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

Soil Series	Small Farmers	Medium Farmers
MGT		Red gram 2.30 & Sunflower 0.98
BHI	Red gram (1.91)	Red gram (1.86)
GTT	Red gram (1.97)	Red gram (1.79)

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

Table 20: Economic land evaluation and bridging yield gap for different crops in Matki 3 microwatershed

Particulars	**MGT (<25 cm)**		**BHI (25-50cm)**	**GTT (50-75 cm)**
	Red gram	**Sunflower**	**Red gram**	**Red gram**
Total cost (Rs/ha)	26194	20559	30178	27160
Gross Return (Rs/ha)	60268	20142	56260	50889
Net returns (Rs/ha)	34074	-417	26081	23730
BCR	2.30	0.98	1.88	1.91
Farmers Practices (FP)				
FYM (t/ha)	1.3	0.0	1.1	1.1
Nitrogen (kg/ha)	20.9	20.9	34.5	35.8
Phosphorus (kg/ha)	53.4	53.4	76.1	72.8
Potash (kg/ha)	0.0	0.0	7.8	12.1
Grain (Qtl/ha)	12.5	5.4	11.7	10.4
Price of Yield (Rs/Qtl)	4880	3800	4850	5000
Soil test based fertilizer Recommendation (STBR)				
FYM (t/ha)	7.4	6.6	7.4	7.4
Nitrogen (kg/ha)	24.7	55.2	18.5	24.7
Phosphorus (kg/ha)	61.8	74.1	61.8	61.8
Potash (kg/ha)	24.7	37.1	18.5	18.5
Grain (Qtl/ha)	12.4	16.5	12.4	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)				
FYM (%)	83.1	100.0	85.3	84.7
Nitrogen (%)	15.4	62.1	-86.2	-45.1
Phosphorus (%)	13.5	27.9	-23.2	-17.8
Potash (%)	100.0	100.0	58.1	34.6
Grain (%)	-1.2	67.4	5.0	16.2
Value of yield and Fertilizer (Rs)				
Additional Cost (Rs/ha)	7066	8648	5716	5786
Additional Benefits (Rs/ha)	-732	42187	2966	9983
Net change Income (Rs/ha)	-7798	33539	-2750	4197

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 20. The total cost of cultivation in study area for redgram ranges between

Rs.30128/ha in BHI soil (with BCR of 1.88) and Rs 26194/ha in MGT soil (with BCR of 2.30) and sunflower cost of cultivation in MGT soil is Rs 20559/ha (with BCR of 0.98).

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 20. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs 33539 in sunflower and a minimum of Rs 4197 in redgram cultivation.

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 21 and Figure 10. The average value of soil nutrient loss is around Rs 1072.05 per ha/year. The total cost of annual soil nutrients is around Rs704338 per year for the total area of 595.6 ha.

Table 21: Estimation of onsite cost of soil erosion in Matki 3 Microwatershed

Particulars	**Quantity (kg)**		**Value (Rs)**	
	Per ha	**Total**	**Per ha**	**Total**
Organic matter	136.67	89791	861.01	565684
Phosphorus	0.08	53	3.53	2316
Potash	1.89	1243	37.83	24852
Iron	0.14	91	6.62	4351
Manganese	0.48	317	132.63	87135
Cupper	0.05	30	25.44	16716
Zinc	0.01	4	0.25	167
Sulpher	0.11	75	4.56	2998
Boron	0.00	3	0.18	119
Total	139.43	91606	1072.05	704338

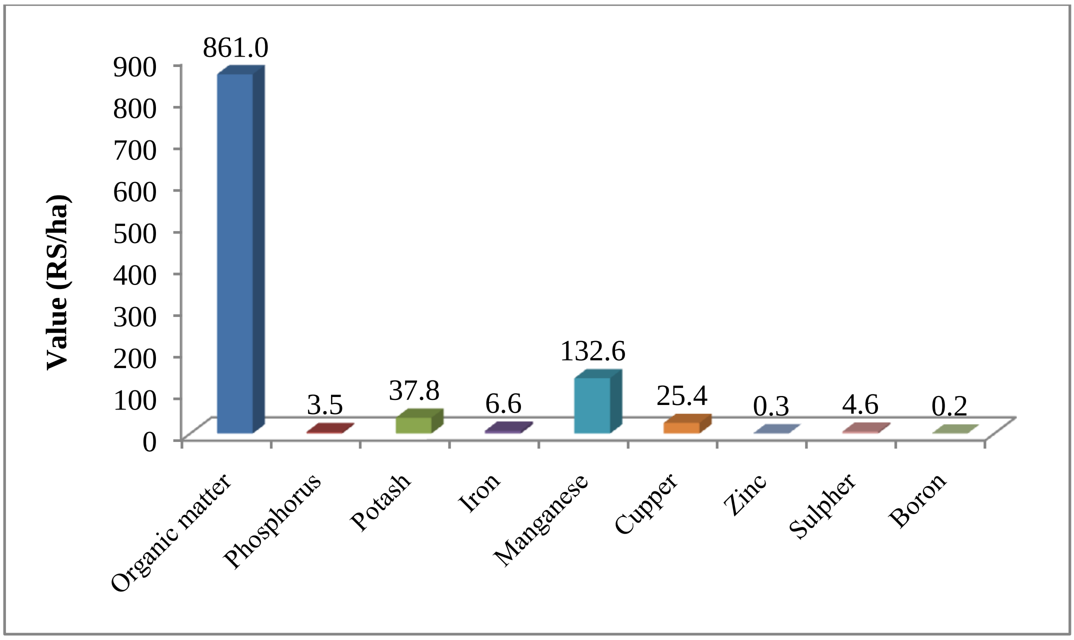

Figure 9: Estimation of onsite cost of soil erosion in Matki 3 Microwatershed

The average value of ecosystem service for food grain production is around Rs 12936ha/year (Table 22 and Figure 11). Per hectare food grain production services is maximum in redgram (Rs. 26289) and sunflower is negative return.

Table 22: Ecosystem services of food grain production in Matki 3 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	Red gram	18.6	11	4898	55163	28874	26289
Oil seeds	Sunflower	0.9	5	3800	20142	20559	-417
Average value		19.5	8	4349	37652.5	24716.5	12936

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. Per hectare value of water used and value of water was maximum (Table 23 and Figure 12) in red gram (Rs.61312) and sunflower (Rs 17841).

Table 23: Ecosystem services of water supply in Matki 3 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Red gram	11.3	6131	61312	544
Sunflower	5.3	1784	17841	337
Average value	16.6	3957.5	39576.5	440.5

The main farming constraints in Matki 3 micro-watershed to be found are less rainfall, non availability fertilizers, high crop pests & diseases, animal pests & diseases, damage of crops by wild animals and non availability of plant protection chemicals.

Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 24).

Table 24: Farming constraints related land resources of sample households in Matki 3 Micro-watershed

Sl .No	Particulars	Per cent
1	Less Rainfall	100.0
2	Lack of good quality seeds	10.0
3	Non availability Fertilizers	20.0
4	Lack of storage	60.0
5	Damage of crops by Wild Animals	10.0
6	Non availability of Plant Protection Chemicals	90.0
7	**Source of loan**	
	Bank	20.0
	Money Leander	70.0
	Village merchants	10.0
8	**Market for selling**	
	Regulated	40.0
	Village market	60.0
9	**Sources of Agri-Technology information**	
	Mobile	20.0
	Newspaper	70.0
	Television	10.0

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