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

KIRINALA-2 (4D5C5C1d) MICROWATERSHED

Afzalpur 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.

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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 Kirinala-2 Microwatershed, Afzalpur 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: 05.01.2018

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PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Kirinala-2 microwatershed was conducted using village cadastral maps and IRS satellite imagery on 1:7920 scale. The false colour composites of IRS imagery were interpreted for physiography and these physiographic delineations were used as base for mapping soils. The soils were studied in several transects and a soil map was prepared with phases of soil series as mapping units. Random checks were made all over the area outside the transects to confirm and validate the soil map unit boundaries. The soil map shows the geographic distribution and extent, characteristics, classification, behaviour and use potentials of the soils in the microwartershed.

The present study covers an area of 750 ha in Kirinala-2 microwatershed in Afzalpur taluk of Kalaburgi district, Karnataka. The climate is semiarid and categorized as drought- prone with an average annual rainfall of 680 mm, of which about 482 mm is received during south –west monsoon, 119 mm during north-east and the remaining 79 mm during the rest of the year. Entire area is covered by soils. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 2 soil series and 6 soil phases (management units) and one land use class.*
- *The length of crop growing period is about 150 days starting from the 3^{rd} week of June to 3^{rd} week of November.*
- *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 18 major agricultural and horticultural crops were assessed and maps showing the degree of suitability along with constraints were generated.*
- *Entire area is suitable for agriculture.*
- *Entire area has deep to very deep (100- >150 cm) soils in the microwatershed.*
- *Entire area has clayey soils at the surface.*
- *Entire area has non-gravelly soils in the microwatershed.*
- *Entire area has soils that are very high (>200mm/m) in available water capacity,*
- *About 40 per cent of the area has very gently sloping (1-3% slope) lands and about 60 per cent area is nearly level (0-1% slope) sloping lands.*
- *An area of about 71 per cent has soils that are slightly eroded (e1) and 29 per cent moderately eroded (e2).*
- *Entire area has strongly alkaline (pH 8.4 -9.0) soils.*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1}indicating that the soils are non-saline.*
- *About 84 per cent area has soils that are medium (0.5-0.75%) and 16 per cent high (>0.75%) in organic carbon.*
- *An area of 42 per cent has soils that are low (<23 kg/ha) and 58 per cent medium (23-57 kg/ha) in available phosphorus.*

- *Entire area has soils that are high (>337 kg/ha) in available potassium.*
- *Available sulphur is low (<10 ppm) in about 28 per cent area, medium (10-20 ppm) in 61 per cent area and high (>20 ppm) in about 11 per cent area.*
- *Available boron is low (<0.5 ppm) in about 27 per cent area and medium (0.5-1.0 ppm) in 73 per cent area.*
- *About 41 per cent area has soils that are deficient (<4.5 ppm) in available iron and 59 per cent area is sufficient (>4.5ppm) in iron.*
- *Available manganese and copper are sufficient in all the soils.*
- *Entire area has soils that are deficient (<0.6 ppm) in available zinc.*
- *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, farm 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	-	*750 (100)*	*Sapota*	-	-
Maize	-	-	*Jackfruit*	-	-
Red gram	-	*750 (100)*	*Jamun*	-	*750 (100)*
Sunflower	-	*750 (100)*	*Musambi*	*532 (71)*	*217 (29)*
Cotton	-	*750 (100)*	*Lime*	*532 (71)*	*217 (29)*
Sugarcane	-	-	*Cashew*	-	-
Soybean	-	*750 (100)*	*Custard apple*	*750 (100)*	-
Guava	-	-	*Amla*	*532 (71)*	*217 (29)*
Mango	-	-	*Tamarind*	-	*75000)*

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 1 identified LUC 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. This would help in supplementing the farm income, provide fodder and fuel*

and generate lot of biomas. This helps in maintaining ecological balance and contribute to mitigating climate change.

Chapter 1

INTRODUCTION

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

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

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

The continued neglect and unscientific use of the resources for a long time has led to the situation observed at present in the state. It is a known fact and established beyond doubt by many studies in the past that the cause for all kinds of degradation is the neglect and irrational use of the land resources. Hence, there is urgent need to generate a detailed site-specific farm level database on various land resources for all the villages/watersheds in a time bound manner that would help to protect the valuable soil and land resources and also to stabilize the farm production.

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

The Land Resource Inventory is basically done for identifying potential and problem areas, developing sustainable land use plans, estimation of surface run off and water harvesting potential, preparation of soil and water conservation plans, land degradation/desertification etc. The Bureau is presently engaged in developing an LRI methodology using high resolution satellite remote sensing data and Digital Elevation Model (DEM) data to prepare Landscape Ecological Units (LEU) map representing agro-ecosystem as a whole. The LEU is preferred over landform as the base 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.

The land resource inventory aims to provide site specific database for Kirinala -2 microwatershed in Afzalpur Taluk, Kalaburagi District, Karnataka state for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery. 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 Kirinala-2 microwatershed (Mannur subwatershed) is located in the northeastern part of Karnataka in Afzalpur Taluk, Kalaburagi District, Karnataka State (Fig.2.1). It comprises parts of Manura and Sirawala villages. It lies between 17^0 19' and 17^0 21' North latitudes and between 76^0 06' and 76^0 08' East longitudes and covers an area of 750 ha. It is about 25 km from Afzalpur town and is surrounded by Chikkamanur on the south, Maharashtra State in the north, Mashyal on the east and Agarkhed on the west.

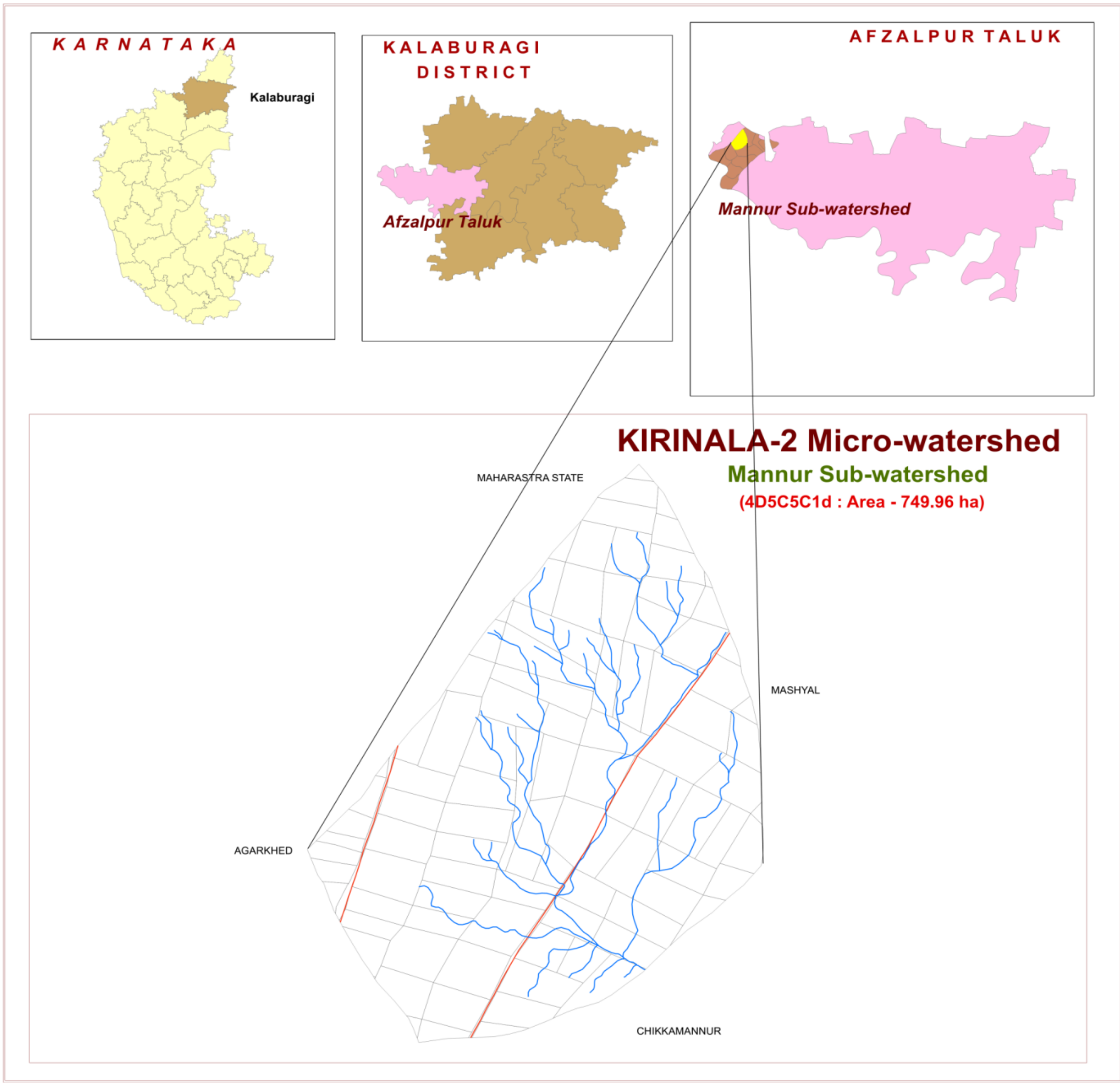


Fig.2.1 Location map of Kirinala-2 microwatershed

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. In all, eight lava flows have been identified in Karnataka horizontally overlying the older formations. The thickness of the individual flows averages about five meters. 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

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 420-444 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

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

2.5 Climate

The 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 680 mm (Table 2.1). Of the total rainfall, maximum of 482 mm is recived during the south–west monsoon period from June to September, the north-east monsoon from October to early December contributes about 119 mm, and the remaining 79 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 159 mm and varies from a low of 115 mm in December to 232 mm in the month of May. The PET is always higher than precipitation in all the months except 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 Afzalpur Taluk, Kalaburgi District

Sl.No.	Months	Rainfall	PET	1/2 PET
1	January	6.70	126.80	63.40
2	February	3.70	143.90	71.95
3	March	8.80	189.90	94.95
4	April	17.50	209.80	104.90
5	May	42.10	232.20	116.10
6	June	90.10	186.40	93.20
7	July	101.90	152.80	76.40
8	August	127.80	147.60	73.80
9	September	162.60	131.70	65.85
10	October	90.90	145.50	72.75
11	November	23.80	129.80	64.90
12	December	4.30	114.80	57.40
Total		680.20	159.27	

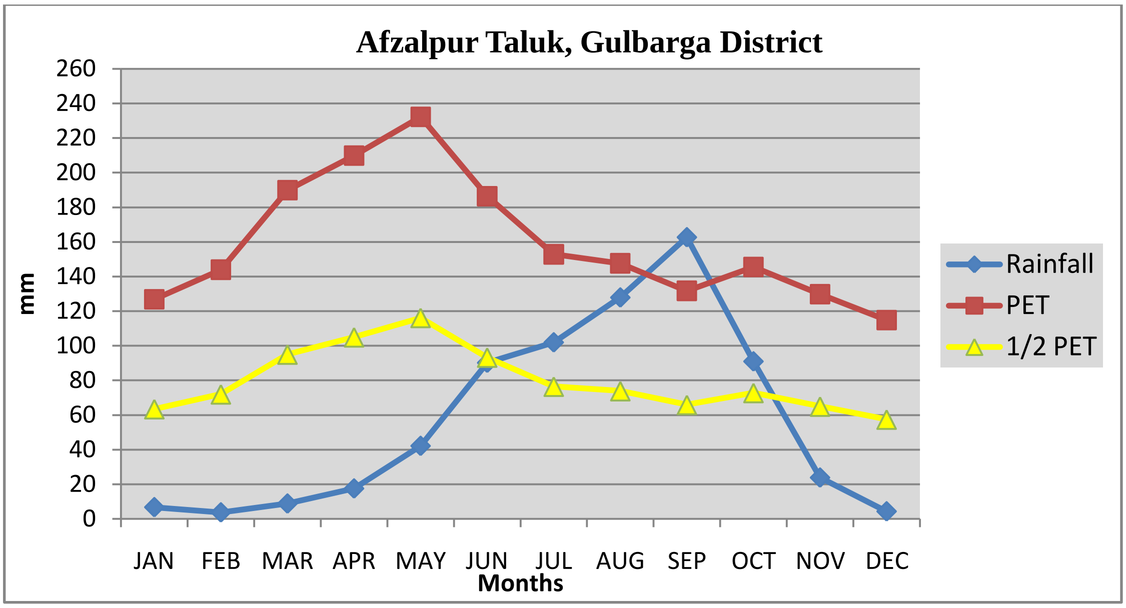


Fig 2.3 Rainfall distribution in Afzalpur Taluk, Kalaburgi District

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).

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

Fig. 2.4 Natural Vegetation (Scrub) of Kirinala-2 Microwatershed

2.7 Land Utilization

About 92 per cent area (Table 2.2) in Afzalpur taluk is cultivated at present. An area of about 1 per cent is permanently under pasture, <1 per cent under current fallows and 6 per cent each under non agricultural land and currently barren. Forests occupy an area of about <1 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, bajra, cotton, sugarcane, safflower, groundnut, sunflower, 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 generated. The current land use map generated shows the arable and non-arable lands, other land uses and different types of crops grown in the area. The current land use map of Kirinala-2 microwatershed is presented in Figure 2.5.

Table 2.2 Land Utilization in Afzalpur Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1.	Total geographical area	130479	
2.	Total cultivated area	119792	91.80
3.	Area sown more than once	19910	-
4.	Cropping intensity	-	1.16
5.	Trees and grooves	10	0.0076
6.	Forest	78	0.059
7.	Cultivable wasteland	458	0.351
8.	Permanent Pasture land	1322	1.01
9.	Barren land	2395	1.83
10.	Non- Agriculture land	5819	4.45
11.	Current fallow	410	0.314

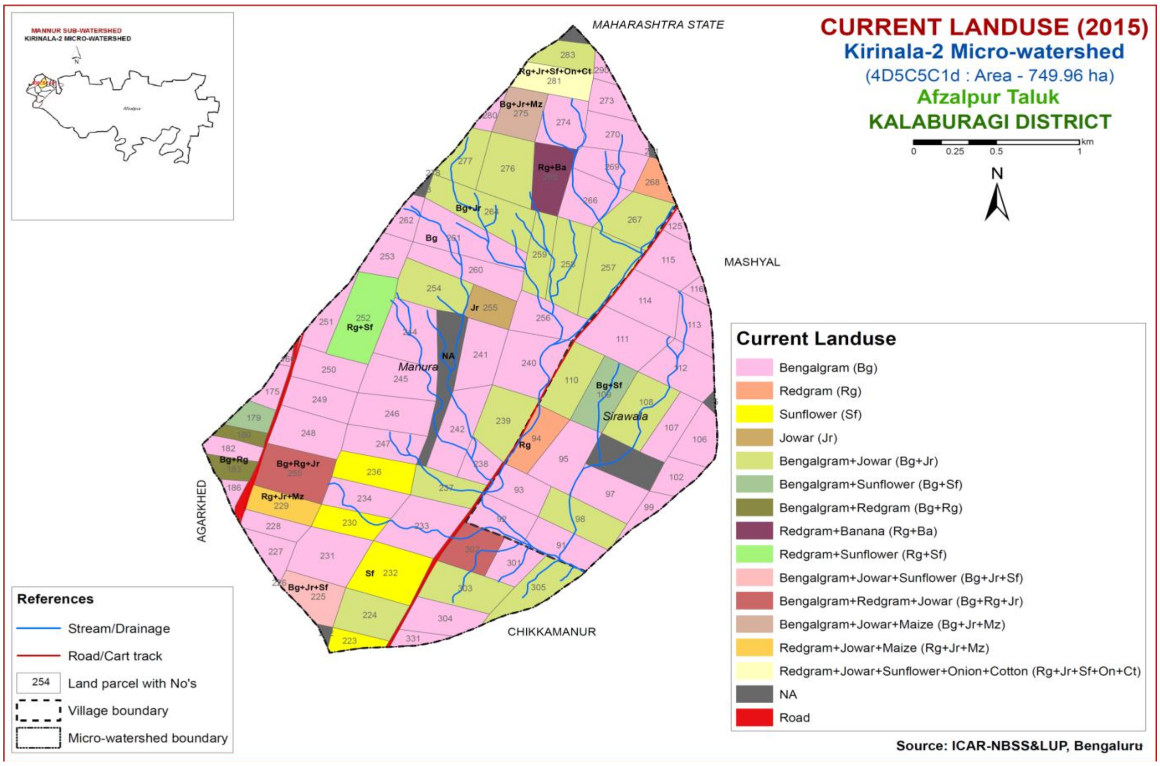


Fig.2.5 Current Land Use – Kirinala-2 Microwatershed

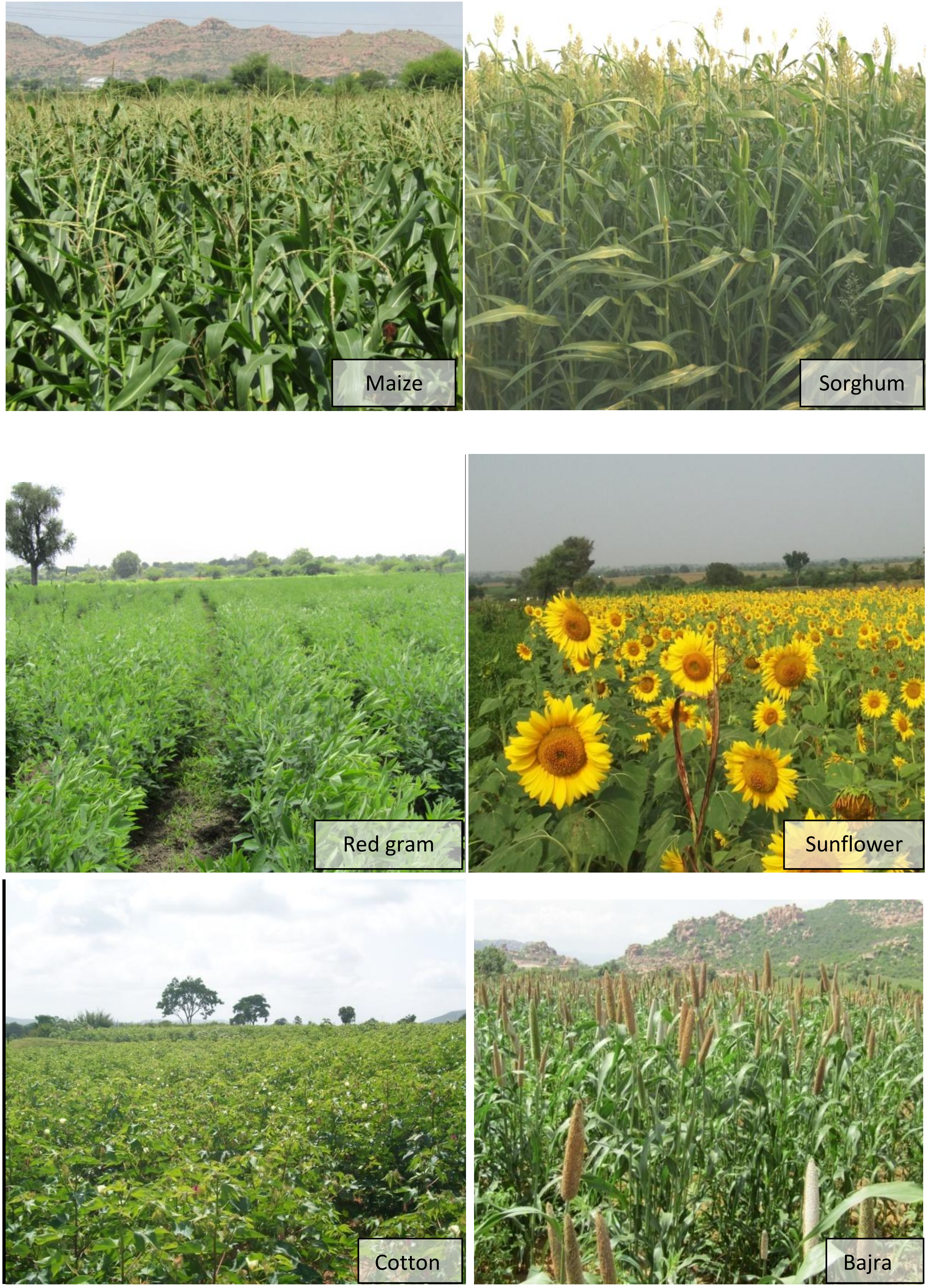


Fig.2.6 Different crops and cropping systems in Kirinala-2 Microwatershed

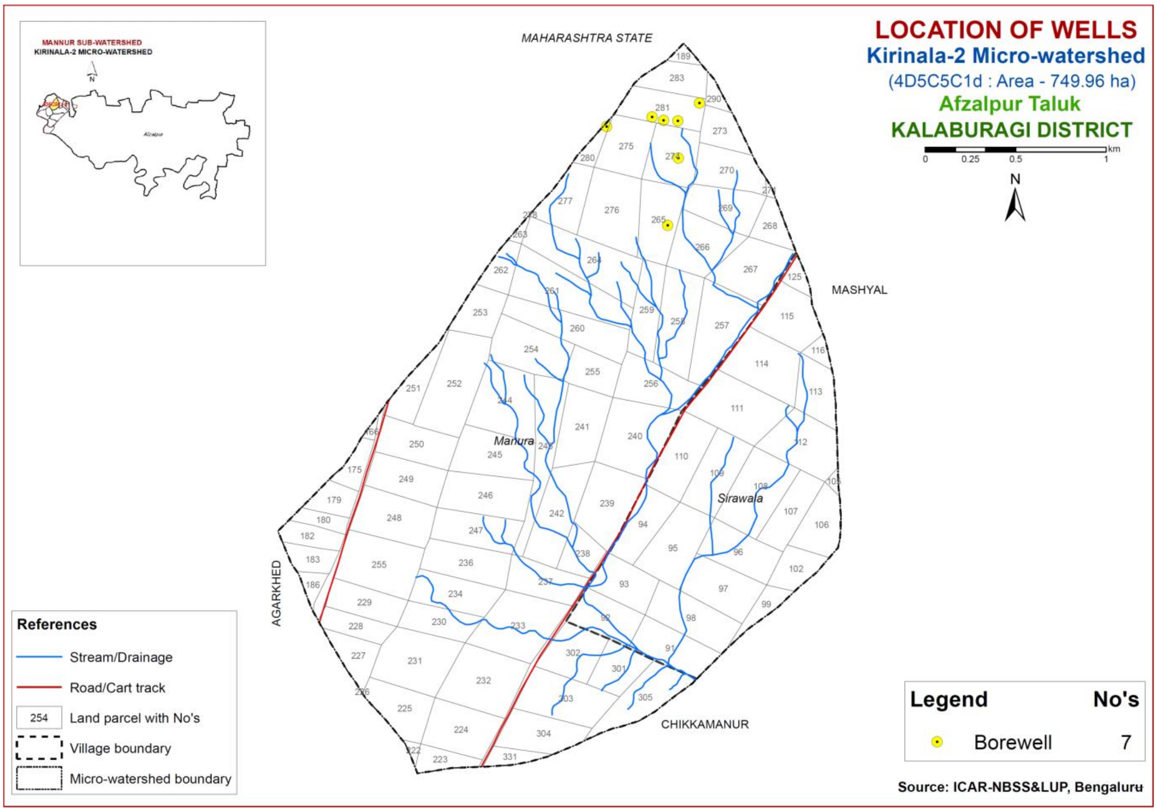


Fig.2.7 Location of Wells – Kirinala-2 Microwatershed

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 Kirinala-2 microwatershed is given Figure 2.7.

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 Kirinala-2 microwatershed by the detailed study of all the soil characteristics (depth, texture, colour, structure, consistence, coarse fragments, porosity, soil reaction, soil horizons etc.) and site (slope 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 750 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.

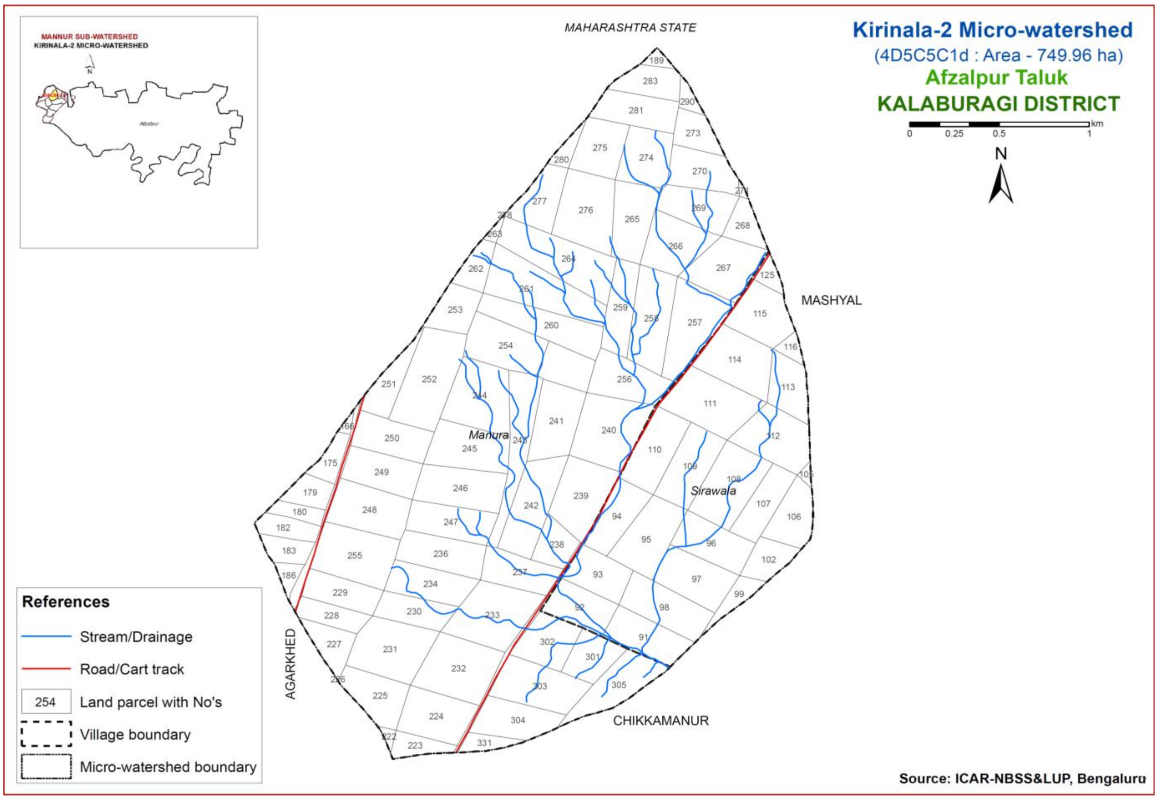


Fig 3.1 Scanned and Digitized Cadastral map of Kirinala-2 Microwatershed

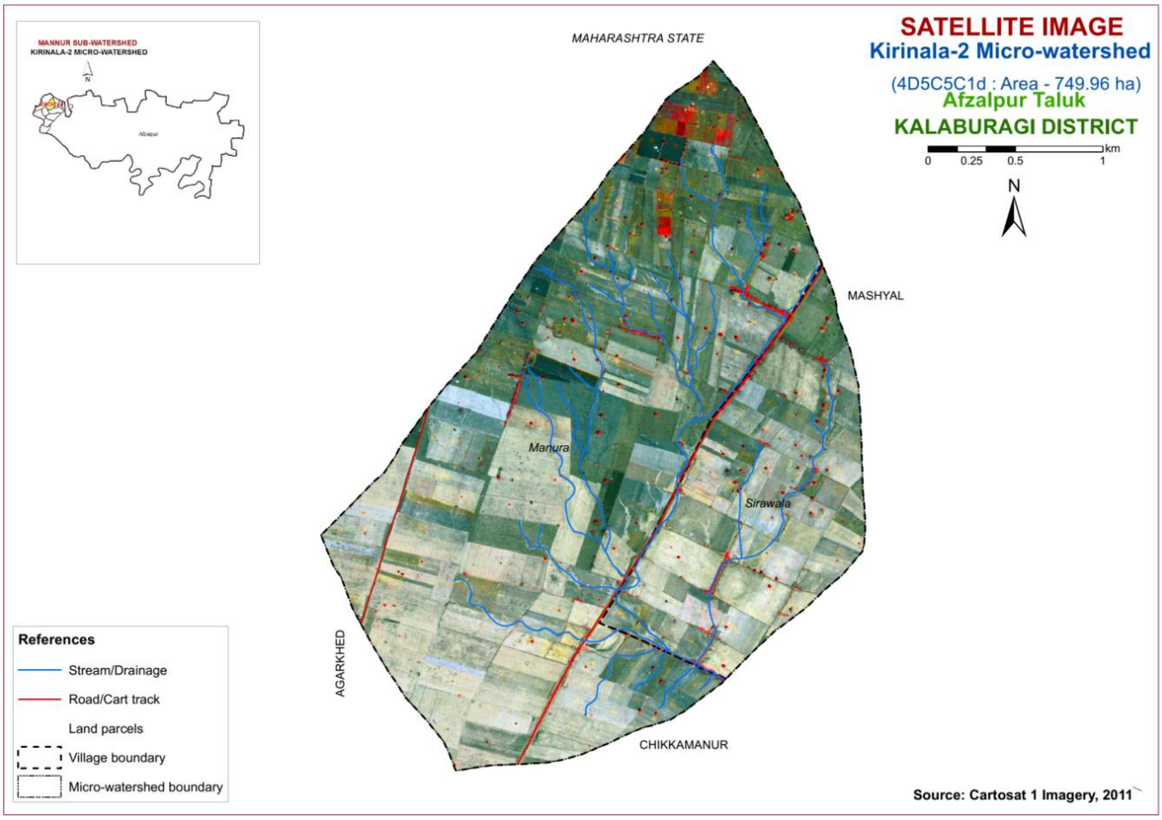


Fig.3.2 Satellite Image of Kirinala-2 Microwatershed

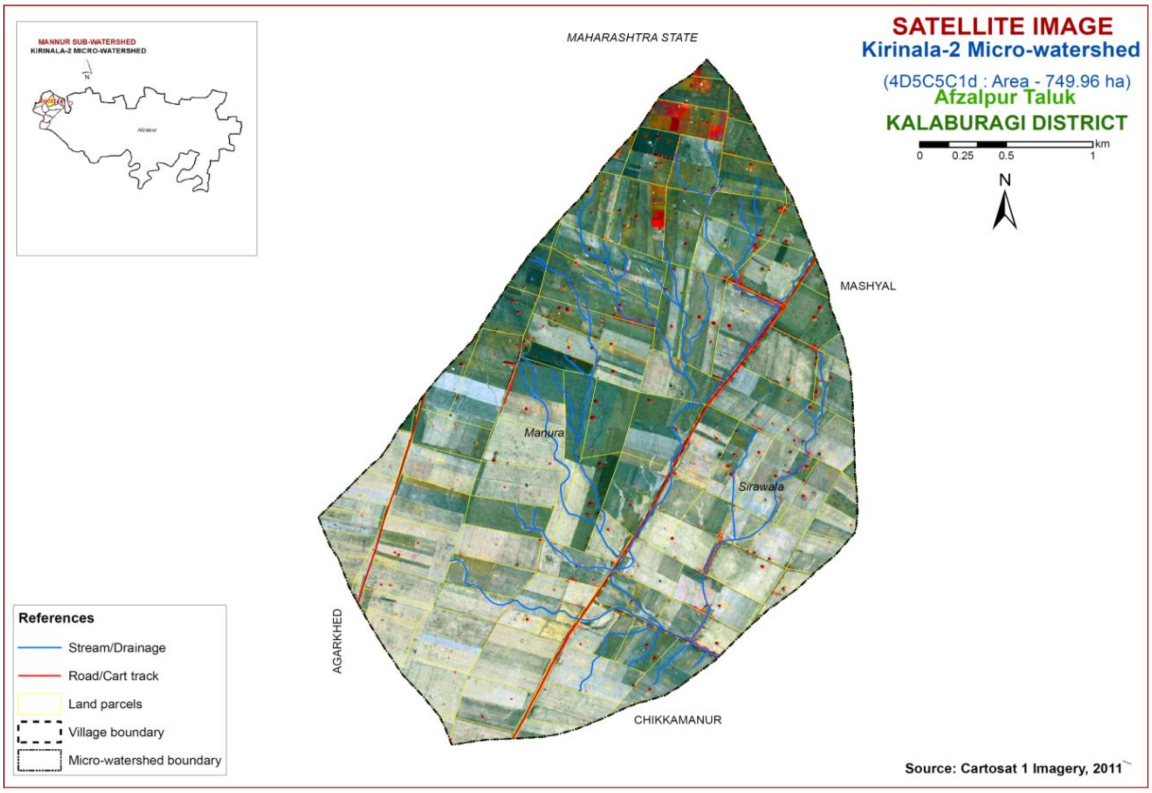


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Kirinala-2 Microwatershed

3.2 Field Investigation

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

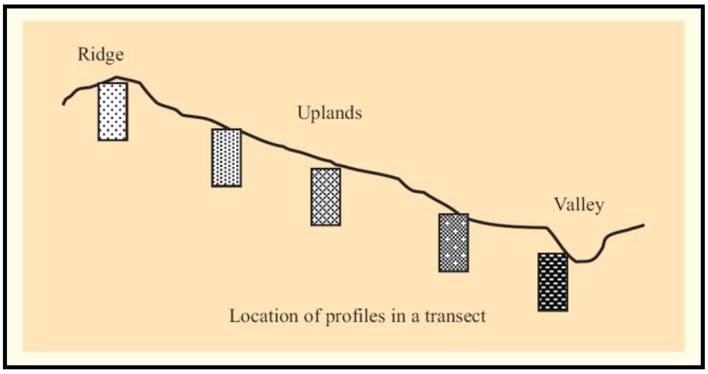


Fig: 3.4. Location of profiles in a transect

In the selected transect, soil profiles (Fig 3.4) were located at closely spaced intervals to take care of any change in the land features like break in slope, erosion, gravel, stones etc. In the selected sites, profiles (vertical cut showing the soil layers from surface to the rock) were opened up to 200 cm or to the depth limited by rock or hard substratum and studied in detail for all their morphological and physical characteristics. The soil and site characteristics were recorded for all 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, 2 soil series were identified in the Kirinala-2 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 (moist)**	**Text ure**	**Gravel (%)**	**Horizon sequence**	**Calcareo usness**
1	Dimal (DIM)	100-150	10YR3/2,3/1	c	<15	Ap-Bw- -Bss-cr	e-es
2	Mannur (MAR)	>150	10YR3/2,3/1, 4/3	c	<15	Ap-Bw-Bss	e-es

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 (121 samples) for fertility status (major and micronutrients) at 250 m grid interval were analyzed in the laboratory. (Katyal and Rattan, 2003) By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated using kriging method for the microwatershed.

3.4 Finalization of Soil Map

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

The soil mapping units are shown on the map (Fig.3.5) in the form of symbols. During the survey about 12 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. 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 6 mapping units representing 2 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2.

The soil phase map (management units) shows the distribution of 6 soil phases identified and mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and have to be treated accordingly.

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

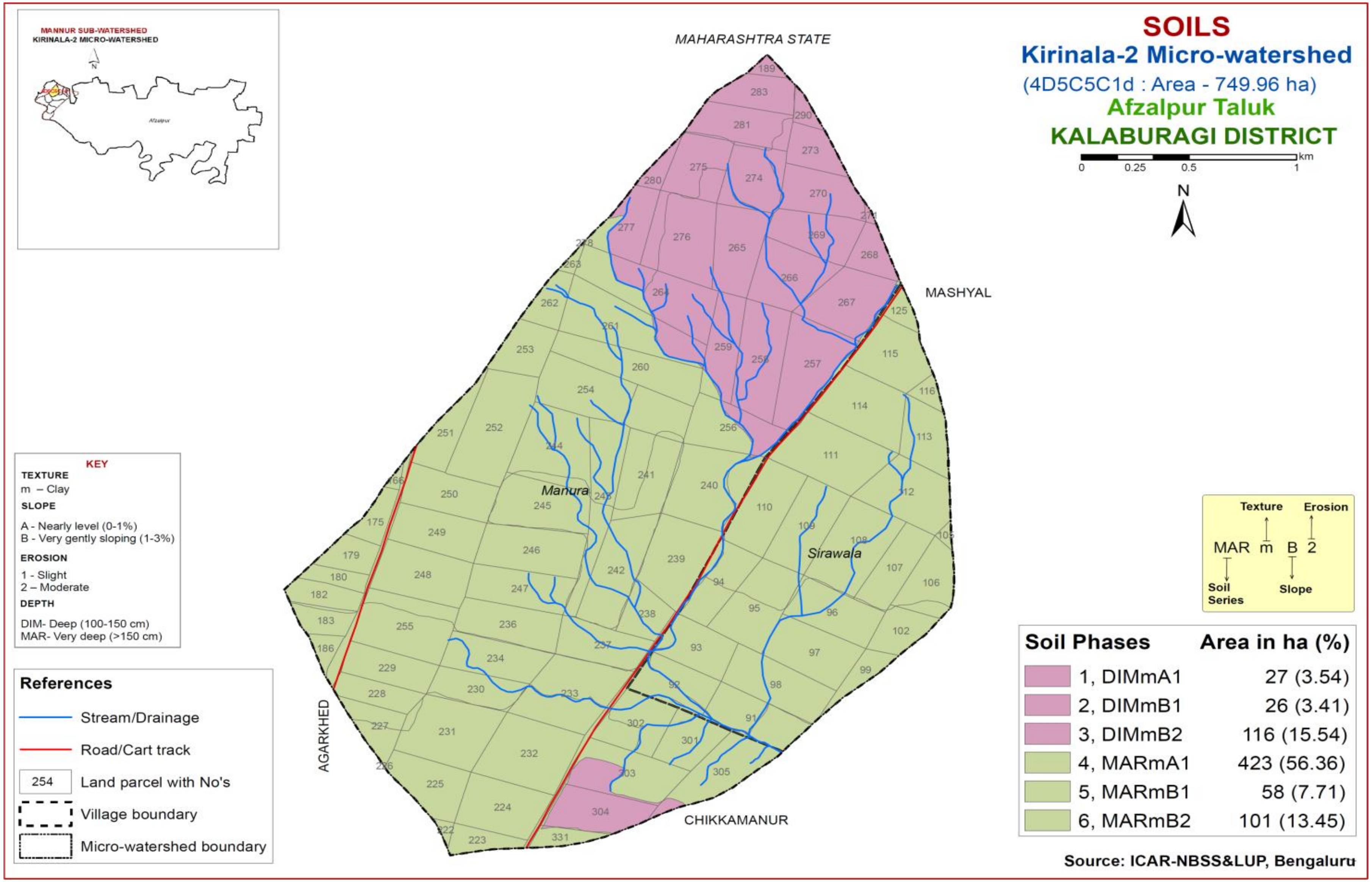


Fig 3.5 Soil phase or management units map of Kirinala-2 Microwatershed

Table 3.2 Soil Legend

Soil map unit no.	Soil series	Soil phase	Mapping Unit Description	Area in ha (%)
Soils of Basalt Landscape				
	DIM	Dimal soils are deep (100-150 cm), moderately well drained, have very dark greyish brown to very dark grey calcareous cracking clay soils occurring on nearly level to very gently sloping uplands		**169 (22)**
1		DIMmA1	Clay surface, slope 0-1%, slight erosion	27 (3.54)
		DIMmB1	Clay surface, slope 1-3%, slight erosion	26 (3.41)
		DIMmB2	Clay surface, slope 1-3%, moderate erosion	116 (15.54)
	MAR	Mannur soils are very deep (>150 cm), moderately well drained, have very dark gray to very dark grayish brown and dark brown calcareous black cracking clay soils occurring on nearly level to very gently sloping uplands		**582 (78)**
2		MARmA1	Clay surface, slope 0-1%, slight erosion	423 (56.36)
		MARmB1	Clay surface, slope 1-3%, slight erosion	58 (7.71)
		MARmB2	Clay surface, slope 1-3%, moderate erosion	101 (13.45)

Chapter 4

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Kirinala-2 microwatershed is provided in this chapter. The microwatershed area has been identified as Basalt landscape. In all, 2 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 2 soil series identified followed by 6 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, 2 soil series are identified and mapped. Of these, Mannur (MAR) soil series occupies maximum area of about 582 (78%) and Dimal (DIM) about 169 ha (22%). The brief description of each series along with the soil phases identified and mapped is given below.

4.1.1 Dimal (DIM) Series: Dimal soils are deep (100-150 cm), moderately well drained. They have very dark grayish brown to very dark gray clayey soils. They have developed from basalt and occur on nearly level to very 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 and chroma 1. The texture is clay with 5 to 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 and chroma 1 to 2. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m). Three phases were identified and mapped.

Landscape and Soil Profile Characteristics of Dimal (DIM) Series

4.1.2. Mannur (MAR) Series: Mannur soils are very deep (>150 cm), moderately well drained, have very dark gray to very dark grayish brown and dark brown calcareous black cracking clay soils occurring on nearly level to very gently sloping uplands.

The thickness of the solum is >150 cm. The thickness of A horizon ranges from 18 to 25 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 2. The texture is clay. The thickness of B horizon ranges from 125 to 175 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). Three phases were identified and mapped.

Landscape and Soil Profile Characteristics of Mannur (MAR) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

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

5.1 Land Capability Classification

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

Soil 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 or very few limitations that restrict their use.

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

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

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

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

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

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

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

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

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

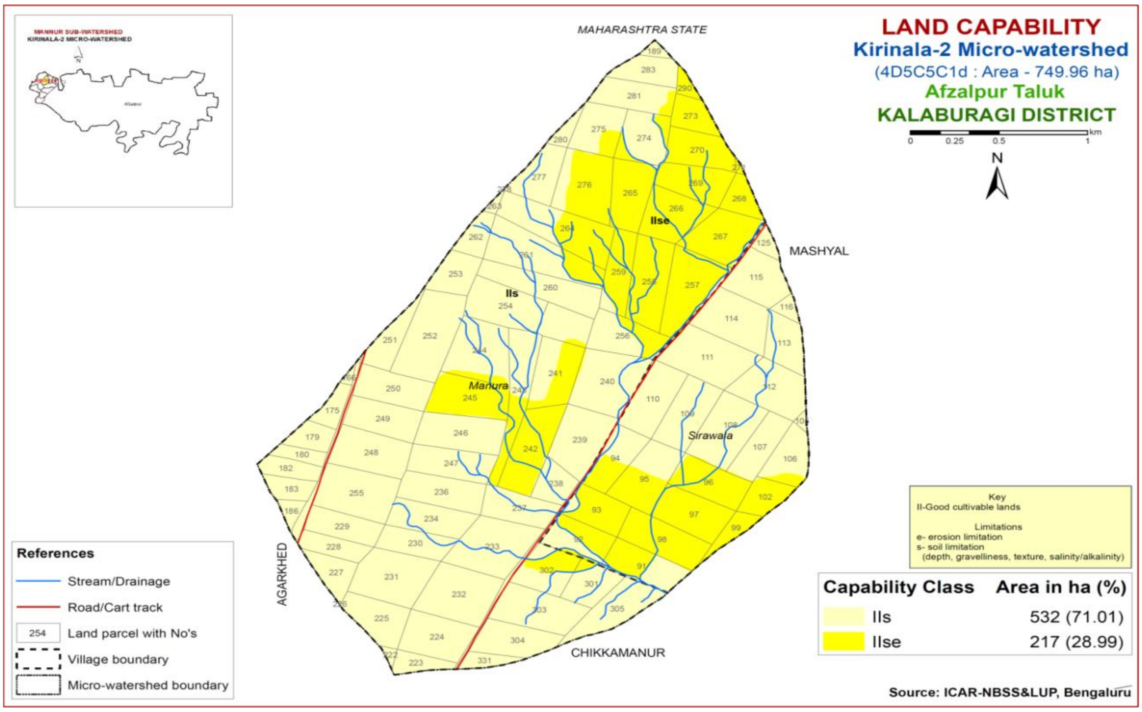


Fig. 5.1 Land Capability map of Kirinala-2 Microwatershed

The 6 soil map units identified in the Kirinala-2 microwatershed are grouped under one land capability class and 2 land capability subclasses. Entire area in the microwatershed is suitable for agriculture (Fig. 5.1).

Entire area in the microwatershed has good cultivable lands (Class II) with minor problems of soil and erosion.

5.2 Soil Depth

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

Very deep soils (>150 cm) occur in a maximum area of about 581 ha (78%) and are distributed in all parts except northern part of the microwatershed. An area of 169 ha (22%) area is under deep soils (100-150 cm) and are distributed in the northern and very minor area in southern part of the microwatershed.

Entire area has most productive lands with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are very deep soils (>150 cm depth) and deep soils (100-150 cm) in the microwatershed.

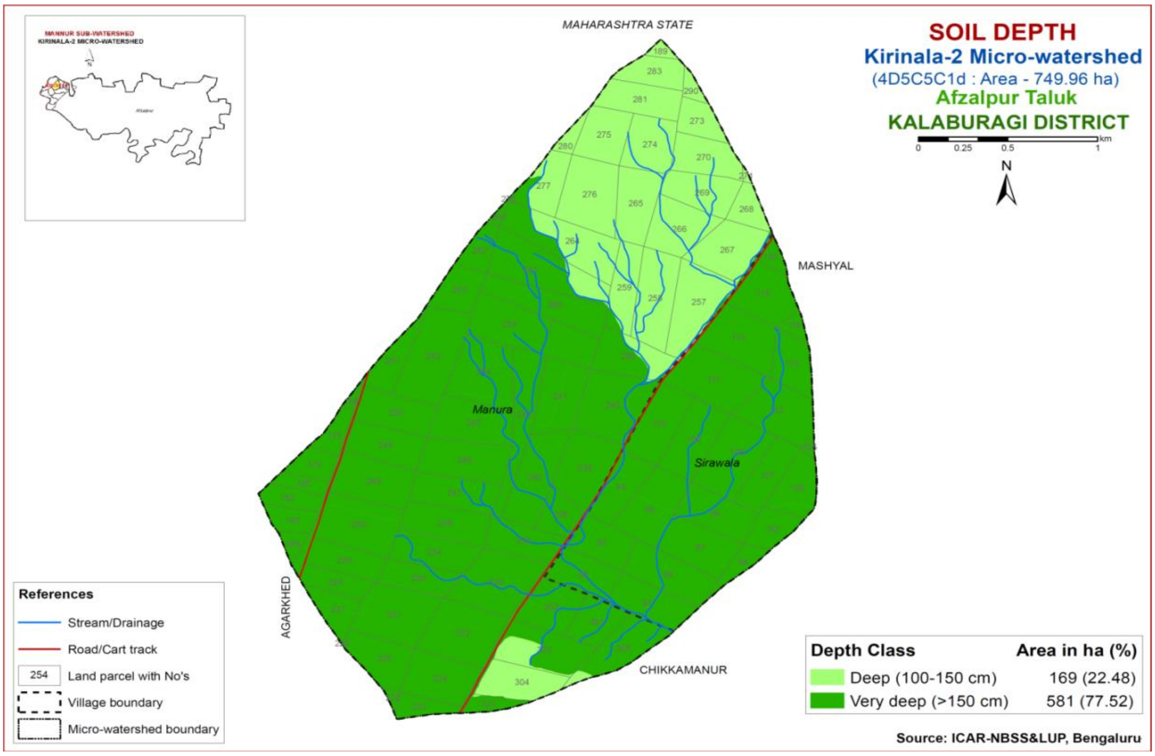


Fig. 5.2 Soil Depth map of Kirinala-2 Microwatershed

5.3 Surface Soil Texture

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

The entire microwatershed is clayey at the surface. They are distributed in all parts of the microwatershed.

The most productive lands 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.

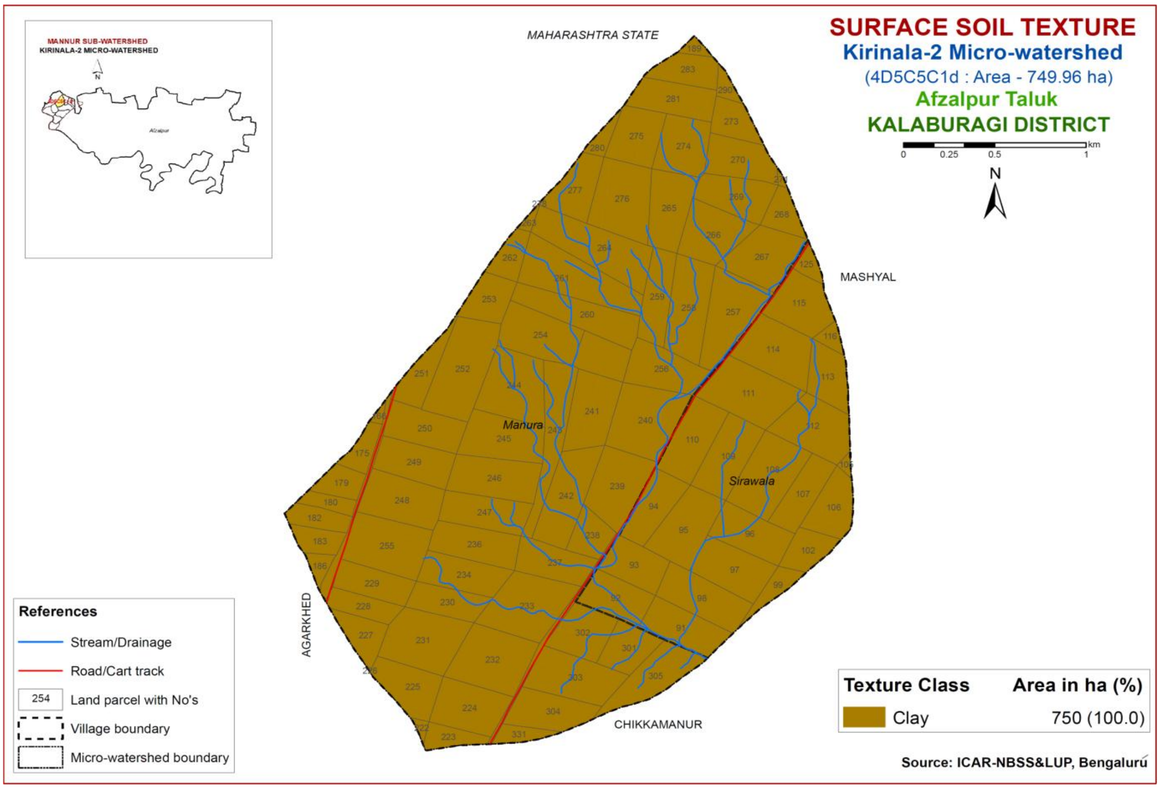


Fig. 5.3 Surface Soil Texture map of Kirinala-2 microwatershed

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization. The gravelliness classes used in LRI were used to classify the soils and using these classes a gravelliness map was generated. The area extent and their geographic distribution in the microwatershed is shown in Figure 5.4. Entire area in the microwatershed is non gravelly (<15%)

The entire area has productive lands with respect to gravelliness .They are nongravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops.

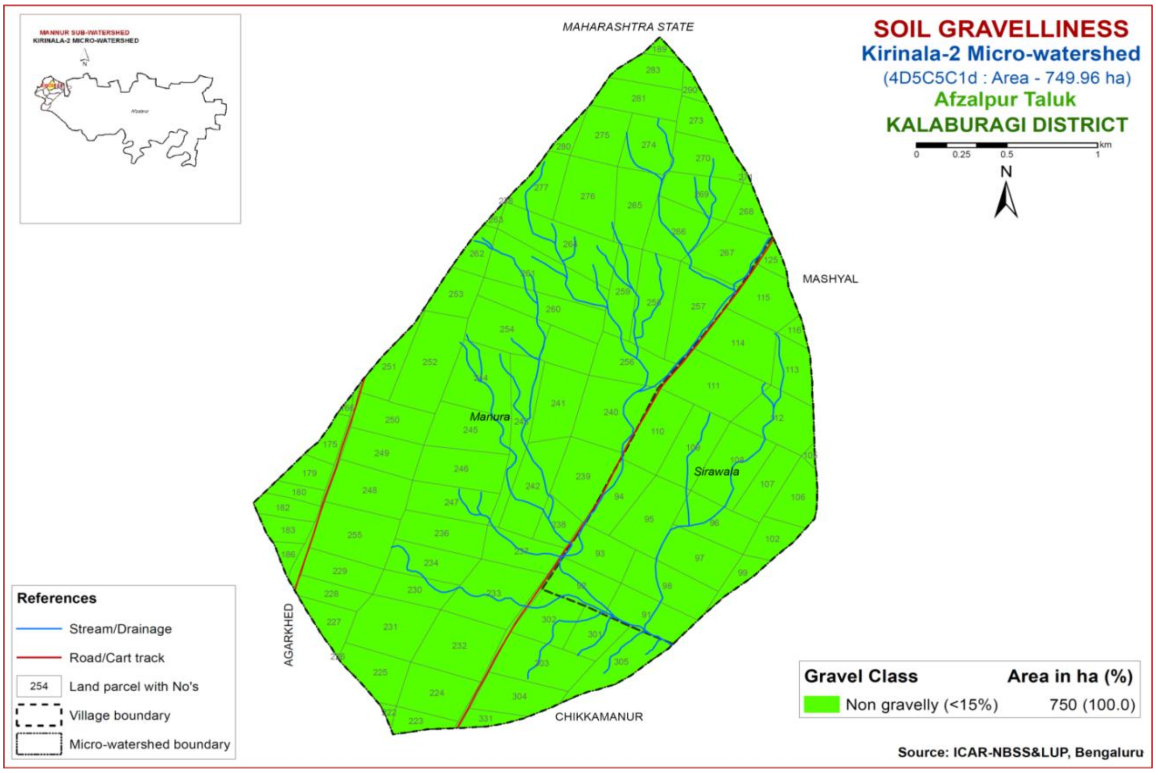


Fig. 5.4 Soil Gravelliness map of Kirinala-2 Microwatershed

5.5 Available Water Capacity

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

Entire area has soils that are very high (>200 mm/m) in AWC in the microwatershed. These soils have very high potential (>200 mm/m) with regard to available water capacity. In these areas, if the rainfall is normal and well distributed, all climatically adapted long duration annual and perennial crops can be grown.

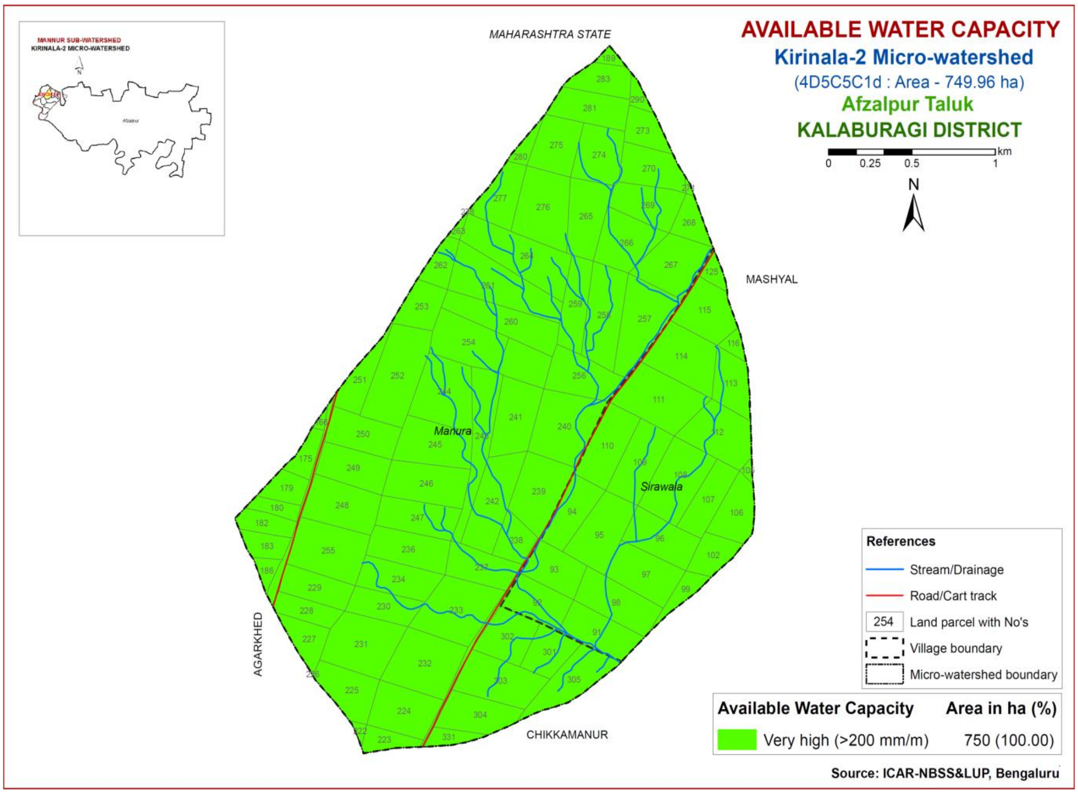


Fig. 5.5 Soil Available Water Capacity map of Kirinala-2 Microwatershed

5.6 Soil Slope

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

An area of about 301 (40%) falls under very gently sloping (1-3% slope) class and is distributed in the northern, central, southwestern and southeastern part of the microwatershed. Major area of about 449 ha (60 %) in the microwatershed falls under nearly level sloping (0-1%) slope class and is distributed in the southern, eastern and western part of the microwatershed.

Entire area in the microwatershed has soils that have high potential in respect of soil slopes where nearly level (0-1% slope) lands about 60% and very gently sloping (1-3% slope) lands about 40% of the area. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures.

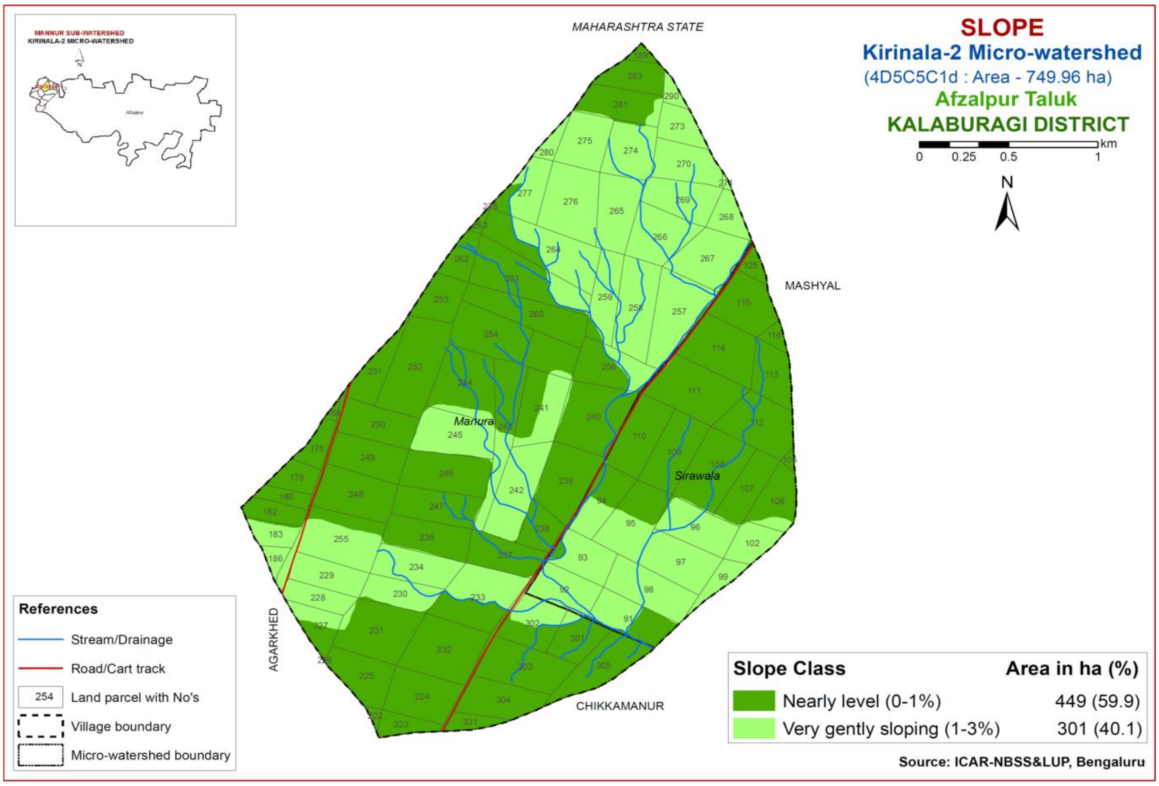


Fig. 5.6 Soil Slope map of Kirinala-2 Microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover major area of about 532 ha (71%) and are distributed in all parts of the microwatershed. Soils that are moderately eroded (e2 class) cover an area of about 217 ha (30%) in the microwatershed and are distributed in the northern, central and southeastern part of the microwatershed.

Soil and water conservation measures are required for the moderately eroded soils covering 217 ha (30%).

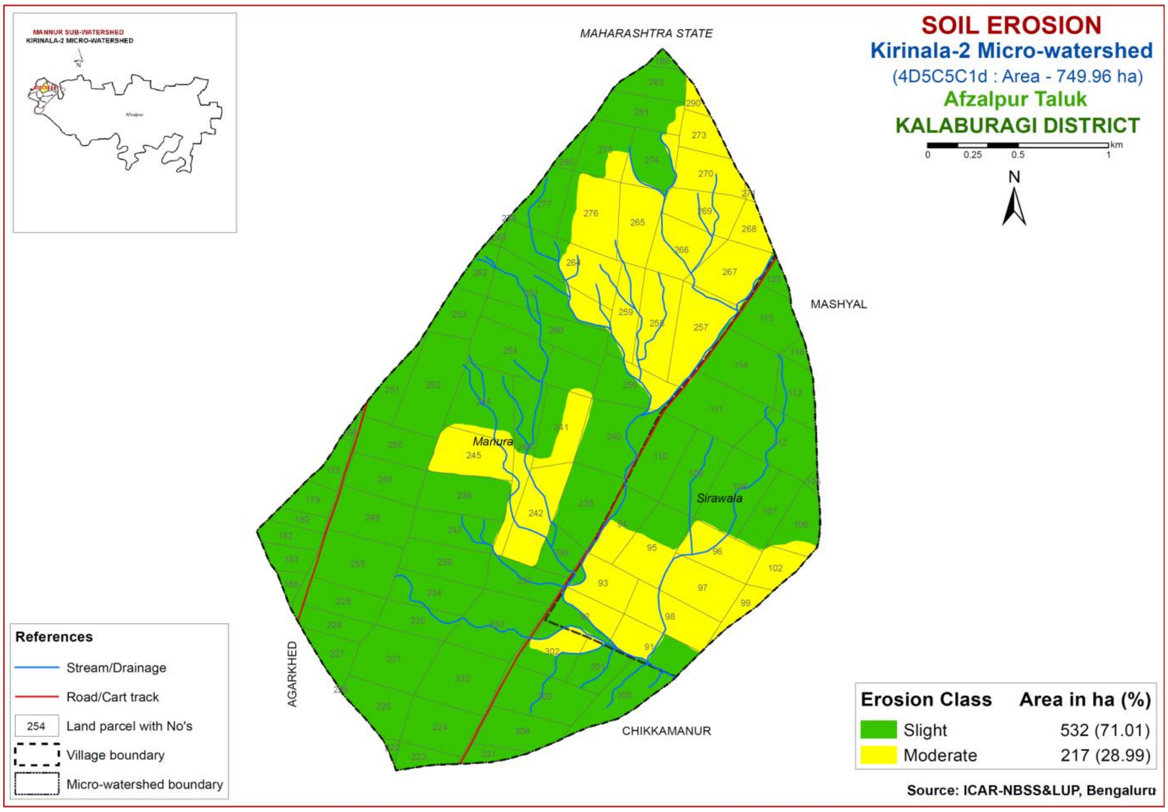


Fig. 5.7 Soil Erosion map of Kirinala-2 Microwatershed

Chapter 6

FERTILITY STATUS

Soil fertility plays an important role in increasing crop yield. The adoption of high yielding varieties that require high amounts of nutrients has resulted in deficiency symptoms in crops and plants due to imbalanced fertilization and poor inherent fertility status as these soils are characterised by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, copper, iron and manganese, and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil fertility analysis of the Kirinala-2 microwatershed for soil reaction (pH) showed that entire area is strongly alkaline (pH 8.4-9.0) (Fig.6.1).

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 (an index of available Nitrogen) of the soils in the microwatershed is medium (0.5-0.75%) in maximum area of about 630 (84%) that are distributed in all parts of the microwatershed (Fig.6.3). High organic carbon (>0.75%) content accounts for 120 ha (16%) area and is distributed in the northeastern, eastern and western part of the microwatershed.

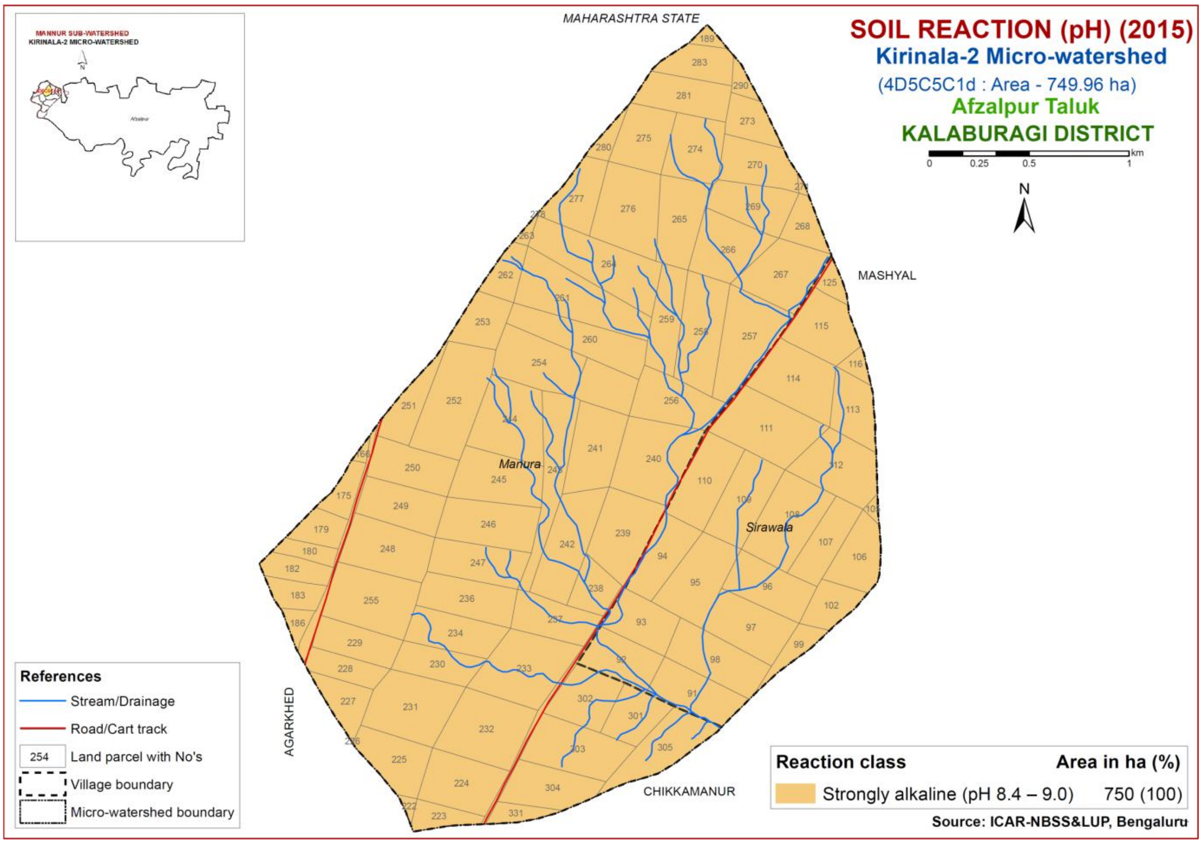


Fig.6.1 Soil Reaction (pH) map of Kirinala-2 Microwatershed

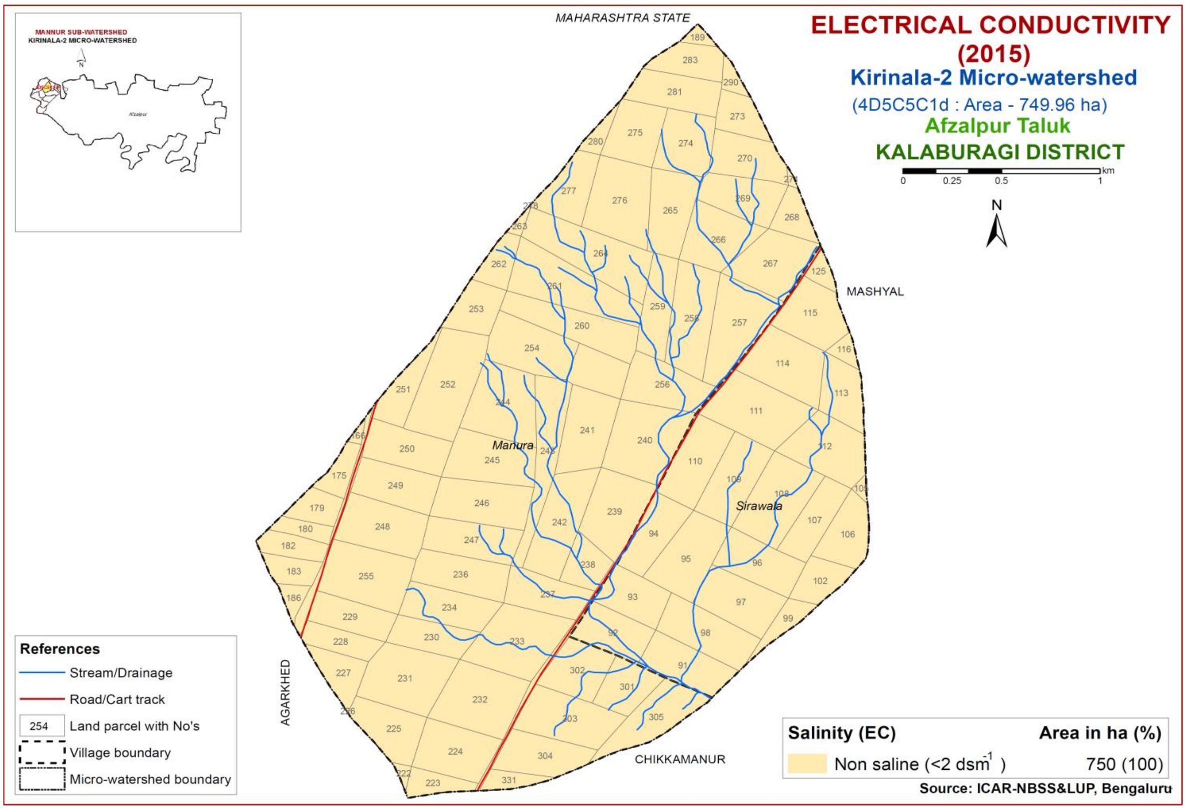


Fig.6.2 Electrical Conductivity (EC) map of Kirinala-2 Microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in an area of about 314 ha (42%) and is distributed in the northern, southern, southeastern and southwestern part 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. Maximum area of about 436 ha (58%) in the microwatershed is medium (23-57 kg/ha) and is distributed in all parts of the microwatershed.

6.5 Available Potassium

Available potassium content is high (>337 kg/ ha) in the entire area of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in an area of about 209 ha (28%) and is distributed in the northern, northeastern and northwestern part of the microwatershed. Major area of about 460 ha (61%) is medium (10-20 ppm) in available sulphur and is distributed in the southern part of the microwatershed and high (>20 ppm) in a small area of about 80 ha (11%) and is distributed in the northeastern part of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is low (<0.5 ppm) in an area of about 204 ha (27%) and is distributed in the northern, northeastern and northwestern part of the microwatershed. Maximum area of about 545 ha (73%) has soils that are medium (0.5-1.0 ppm) in available boron (Fig 6.7) and is distributed in all parts of the microwatershed.

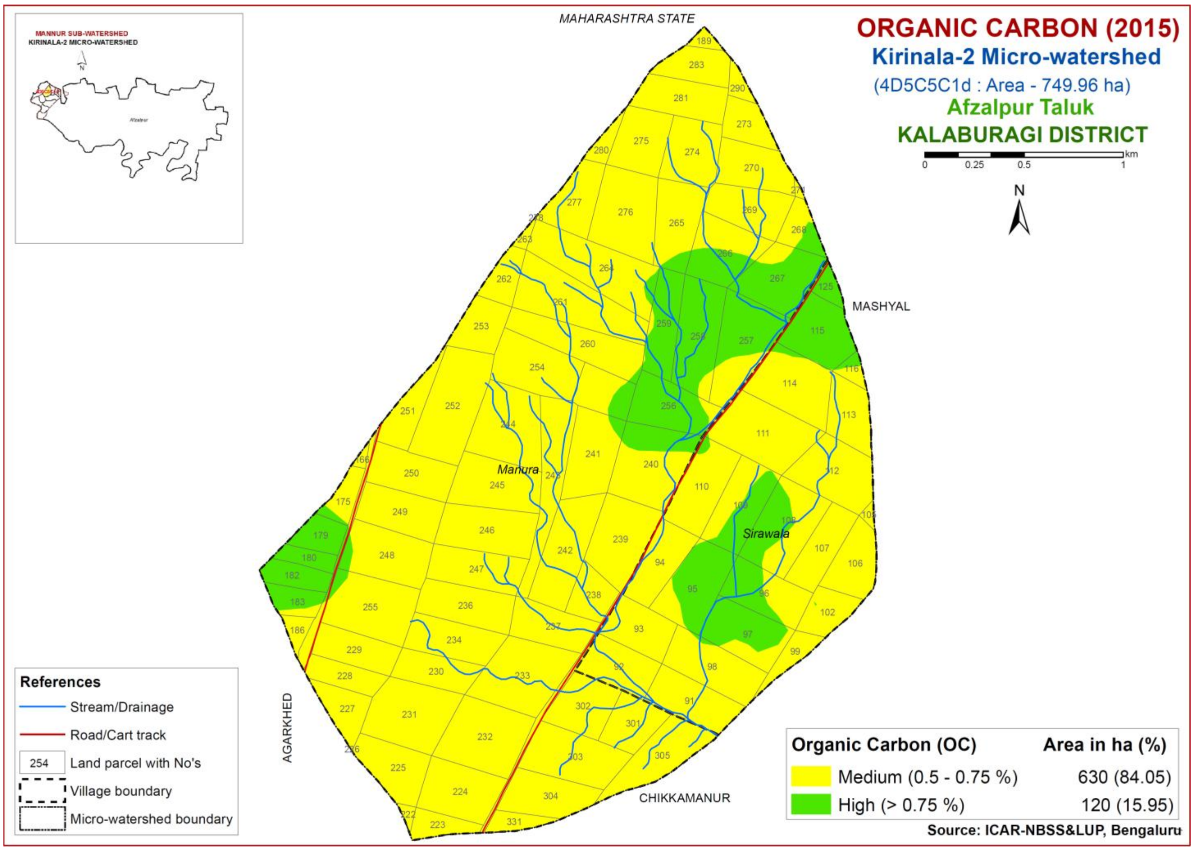


Fig.6.3 Soil Organic Carbon map of Kirinala-2 Microwatershed

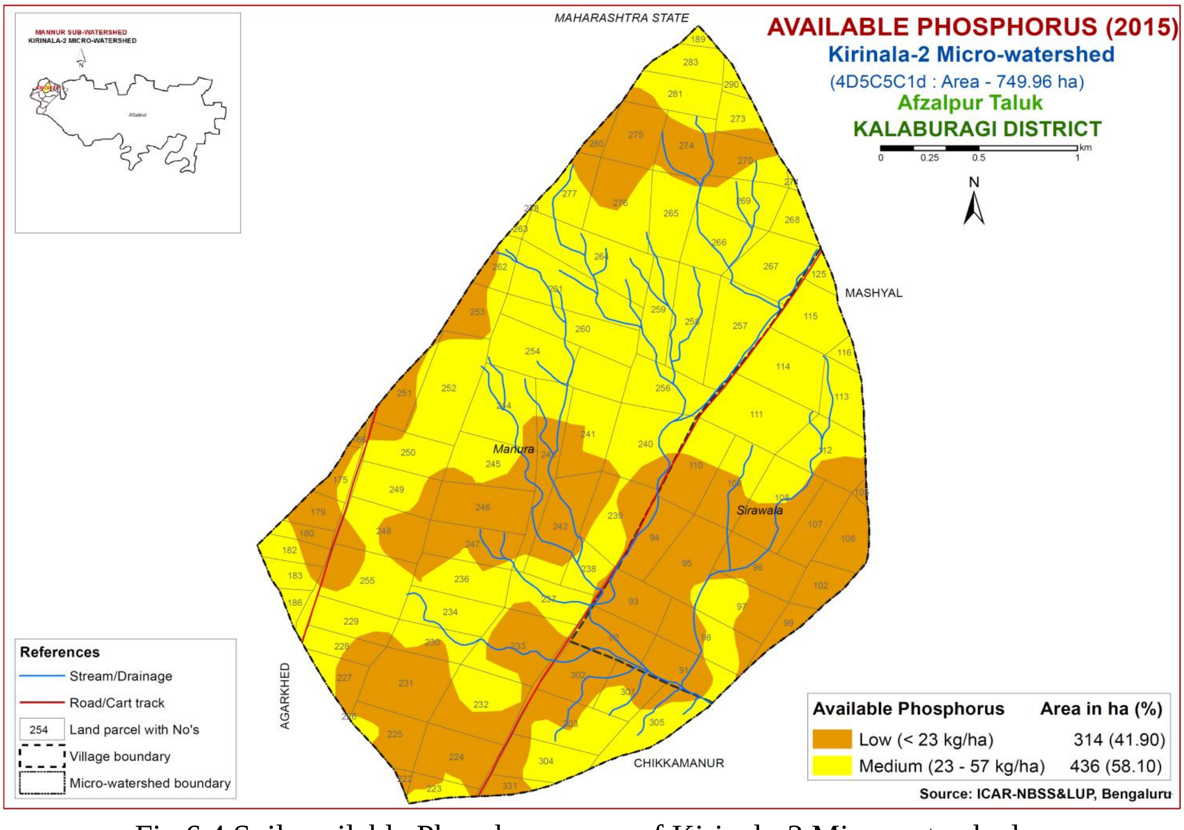


Fig.6.4 Soil available Phosphorus map of Kirinala-2 Microwatershed

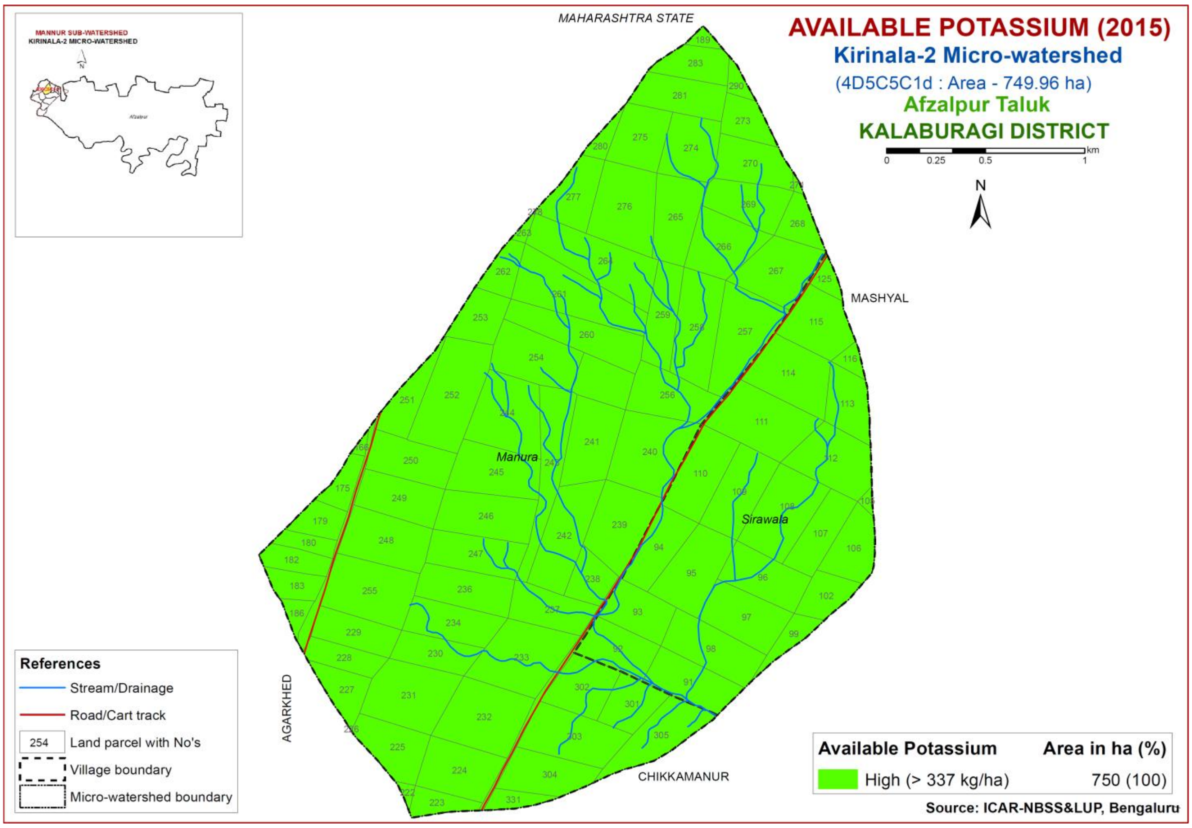


Fig.6.5 Soil available Potassium map of Kirinala-2 Microwatershed

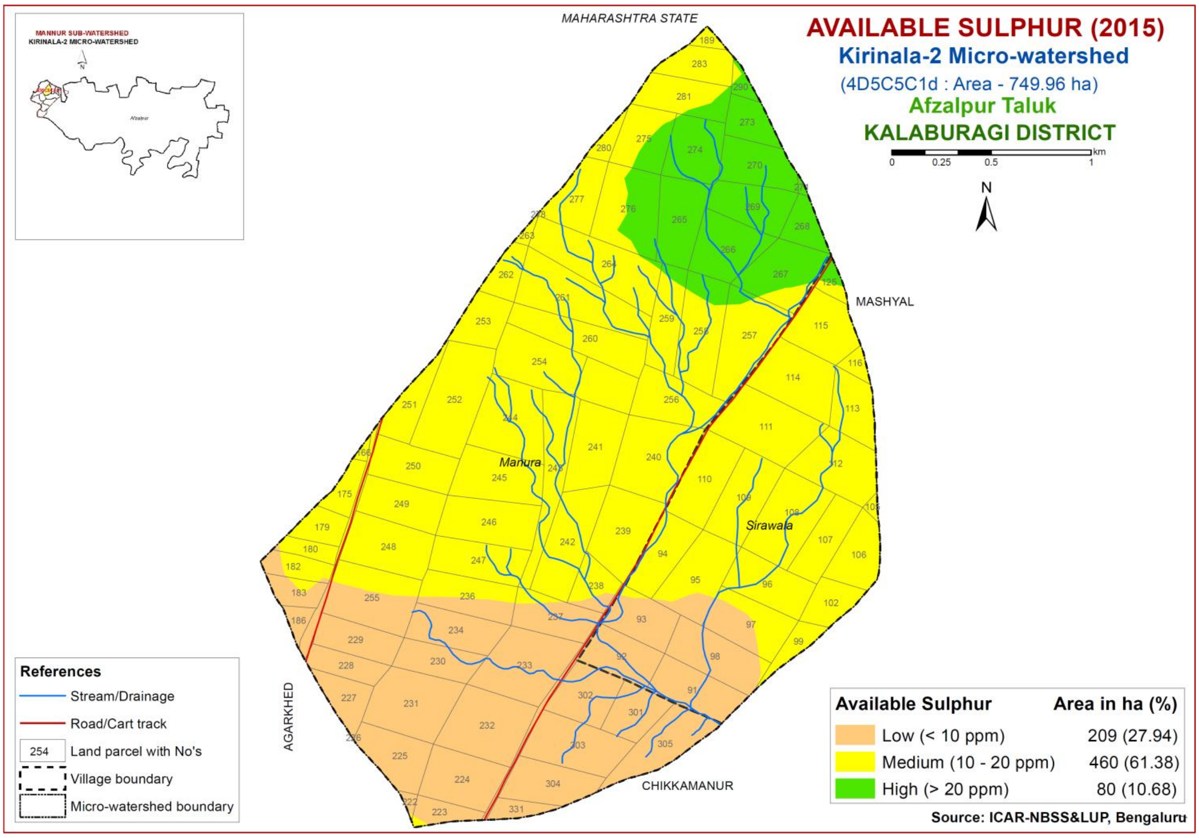


Fig.6.6 Soil available Sulphur map of Kirinala-2 Microwatershed

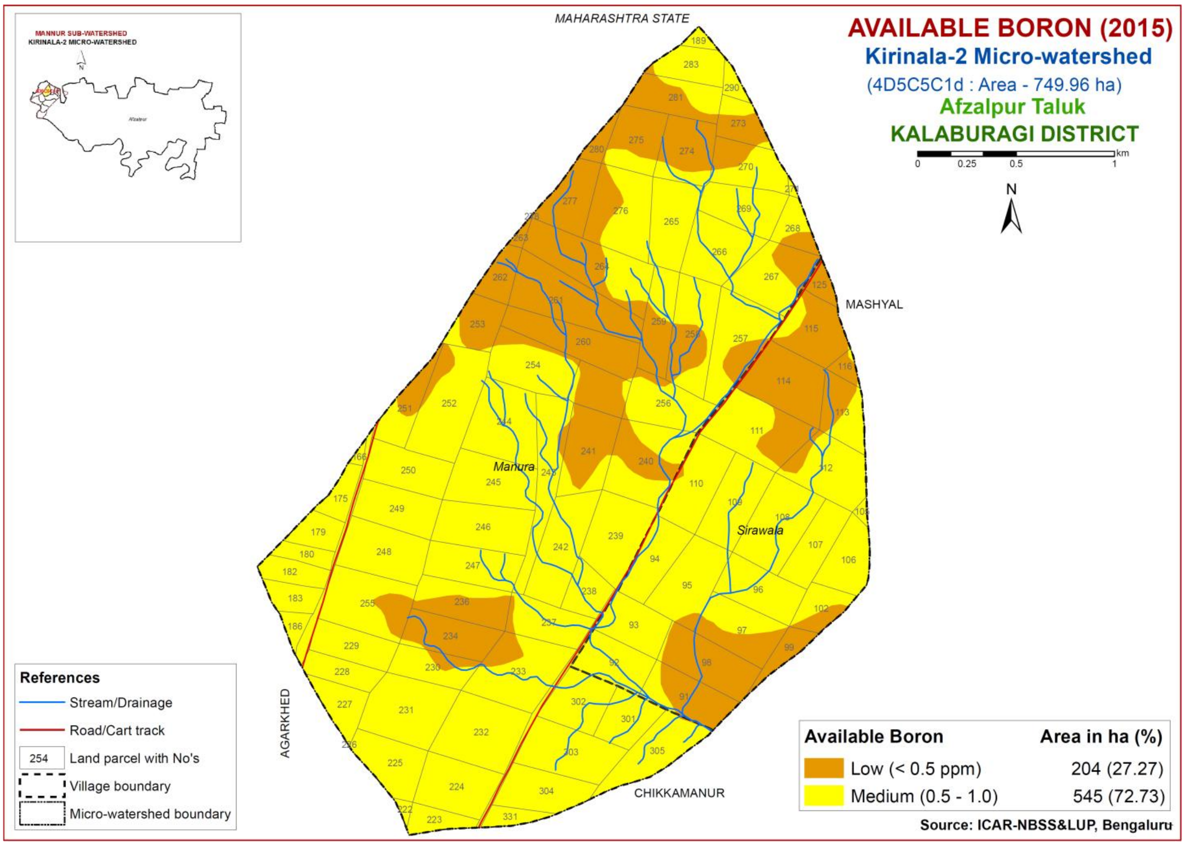


Fig.6.7 Soil available Boron map of Kirinala-2 Microwatershed

6.8 Available Iron

Available iron content is deficient (<4.5 ppm) in an area of 311 ha (41%) and is distributed in the northern, northeastern and northwestern part of the microwatershed. It is sufficient in major area of 439 ha (59%) and are distributed in all parts of the microwatershed (Fig 6.8)

6.9 Available Manganese

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

6.10 Available Copper

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

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in the entire microwatershed area (Fig 6.11).

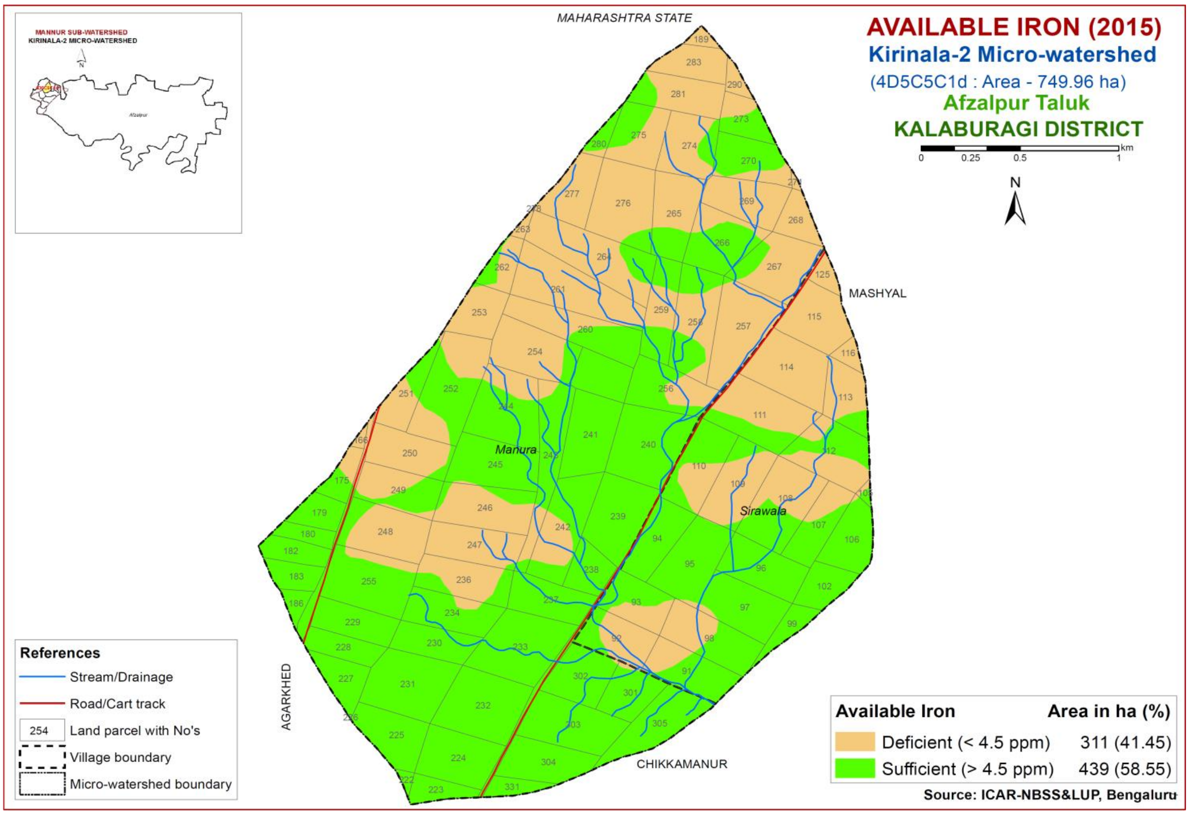


Fig.6.8 Soil available Iron map of Kirinala-2 Microwatershed

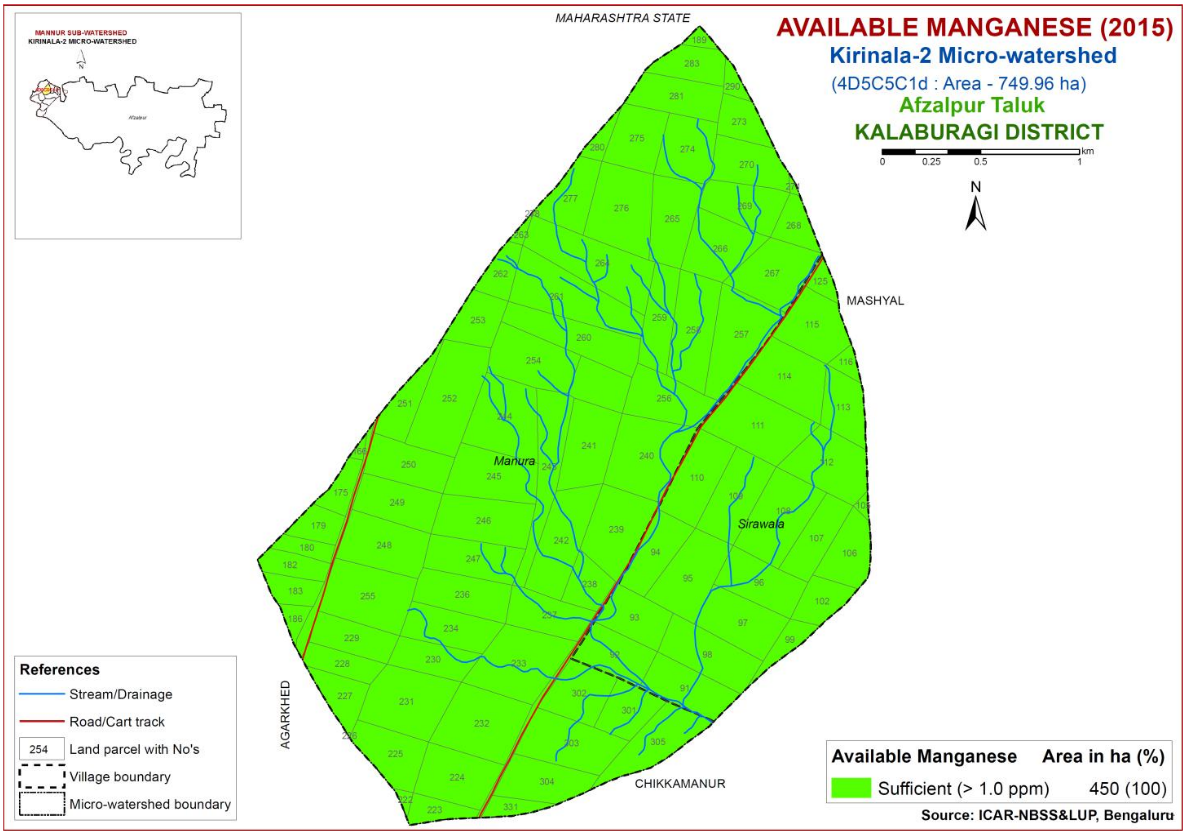


Fig.6.9 Soil available Manganese map of Kirinala-2 Microwatershed

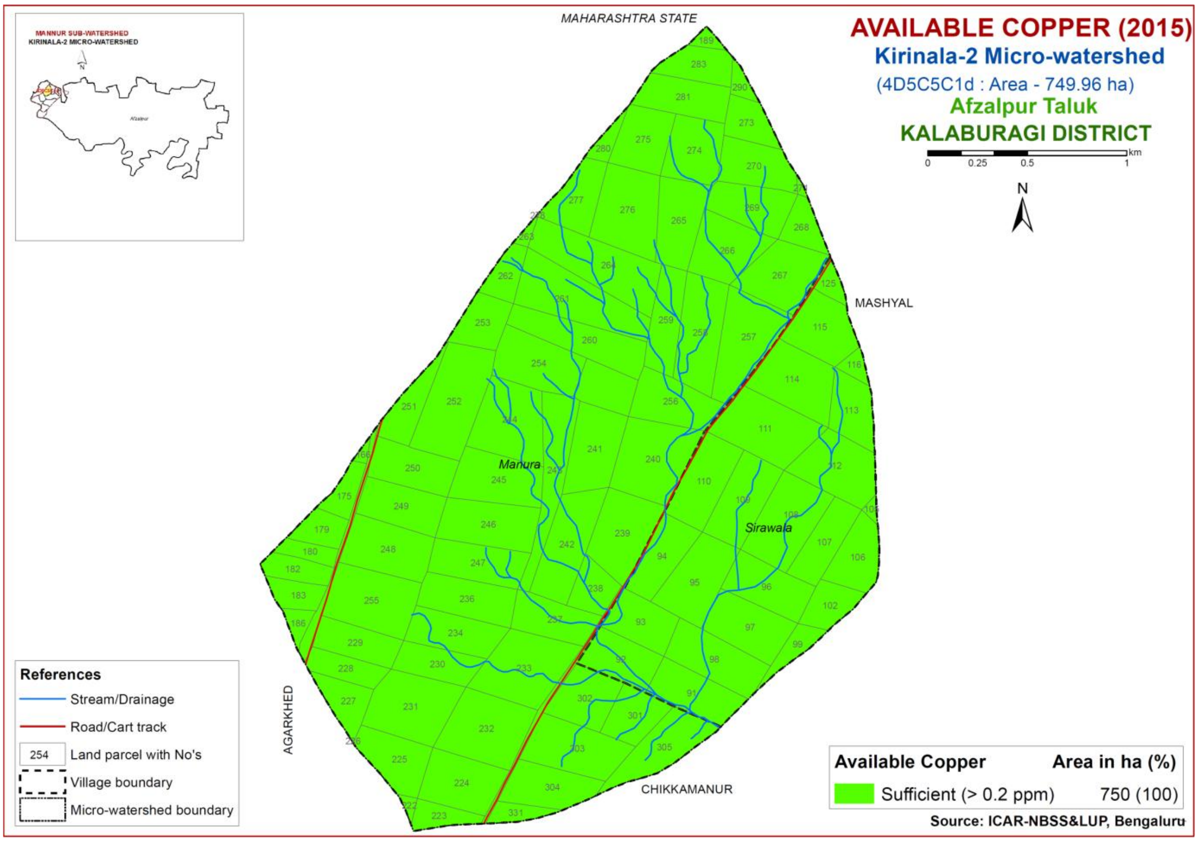


Fig.6.10 Soil available Copper map of Kirinala-2 Microwatershed

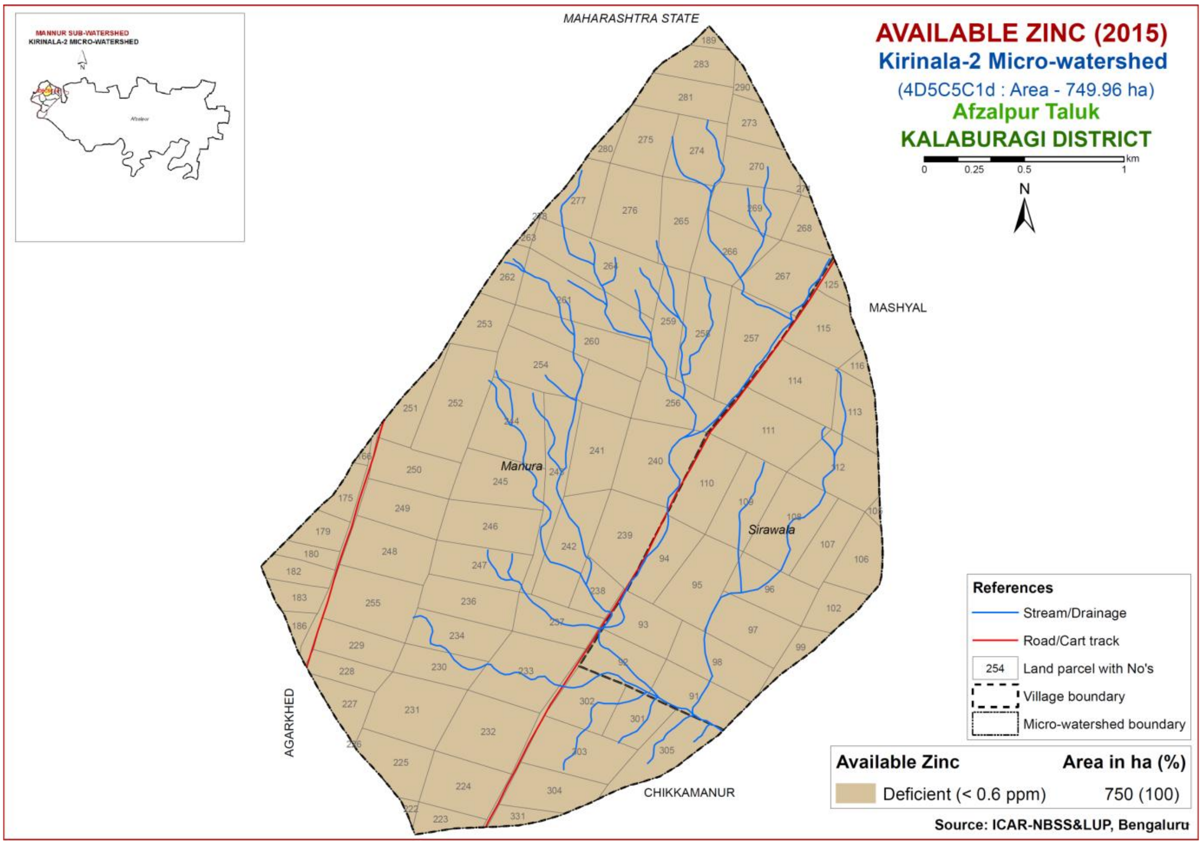


Fig.6.11 Soil available Zinc map of Kirinala-2 Microwatershed

Chapter 7

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Kirinala-2 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, 'z' for calcareousness and 'w' for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 18 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in 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 generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure. 7.1.

There are no highly suitable (Class S1) lands for growing Sorghum in the microwatershed. Entire area has moderately suitable (Class S2) lands for growing Sorghum in the microwatershed. They have minor limitations of erosion and calcareousness.

Table 7.1 Soil-Site Characteristics of Kirinala-2 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 (%)
					Sur-face	Sub surf ace	Surfa ce (%)	Subsur -face (%)								
DIMmA1	680	150	MWD	100-150	c	c	-	<15	>200	0-1	Slight	8.46	2.41	5.69	69	100
DIMmB1	680	150	MWD	100-150	c	c	-	<15	>200	1-3	Slight	8.46	2.41	5.69	69	100
DIMmB2	680	150	MWD	100-150	c	c	-	<15	>200	1-3	Moderate	8.46	2.41	5.69	69	100
MARmA1	680	150	MWD	>150	c	c	-	<15	>200	0-1	Slight	9.33	0.30	16.95	66	100
MARmB1	680	150	MWD	>150	c	c	-	<15	>200	1-3	Slight	9.33	0.30	16.95	66	100
MARmB2	680	150	MWD	>150	c	c	-	<15	>200	1-3	Moderate	9.33	0.30	16.95	66	100

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

Table 7.2 Crop suitability criteria for Sorghum

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

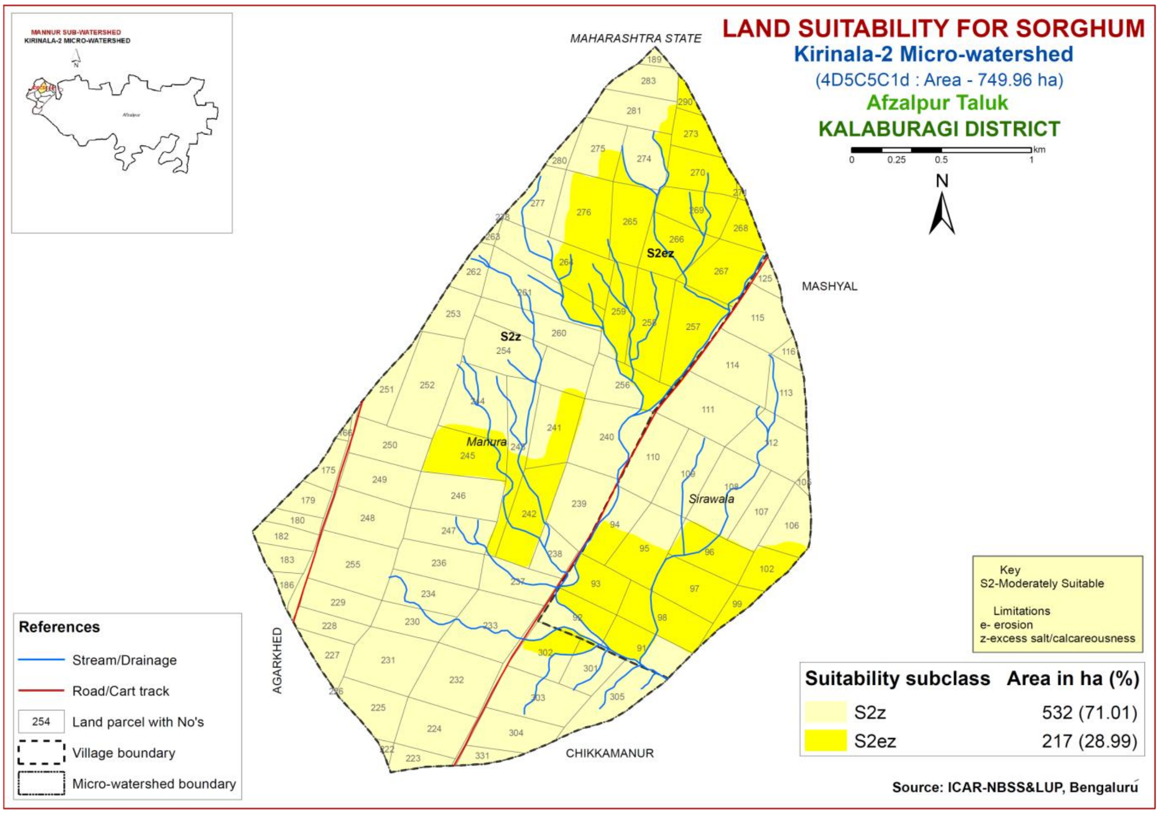


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

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

In Kirinala-2 microwatershed there are no highly (Class S1) and moderately (Class S2) suitable lands available for growing maize. Entire area has marginally suitable lands (Class S3) for growing maize in the microwatershed. They have moderate limitation of texture.

Table 7.3 Crop suitability criteria for Maize

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

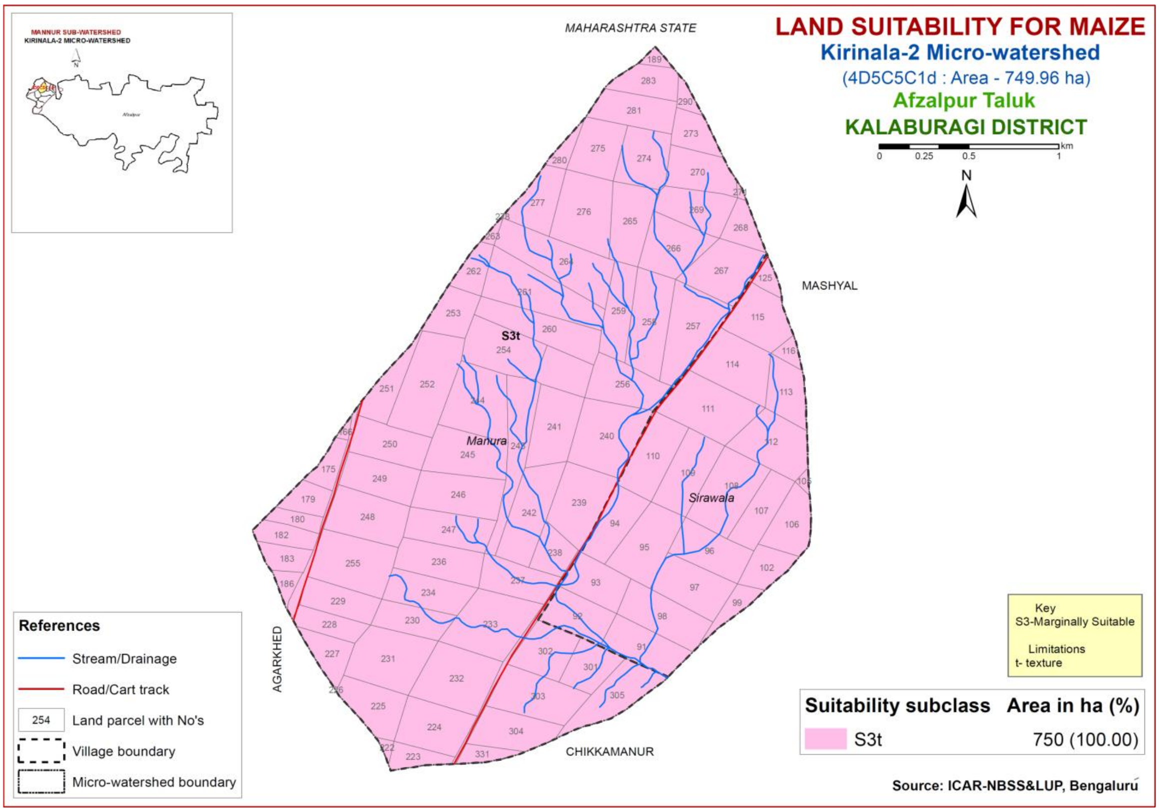


Fig. 7.2 Land Suitability map of Maize

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

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

In Kirinala-2 microwatershed there are no highly (Class S1) suitable lands available for growing Red gram. Entire area is moderately suitable (Class S2) for growing Red gram. They have minor limitations of texture, erosion and calcareousness.

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	

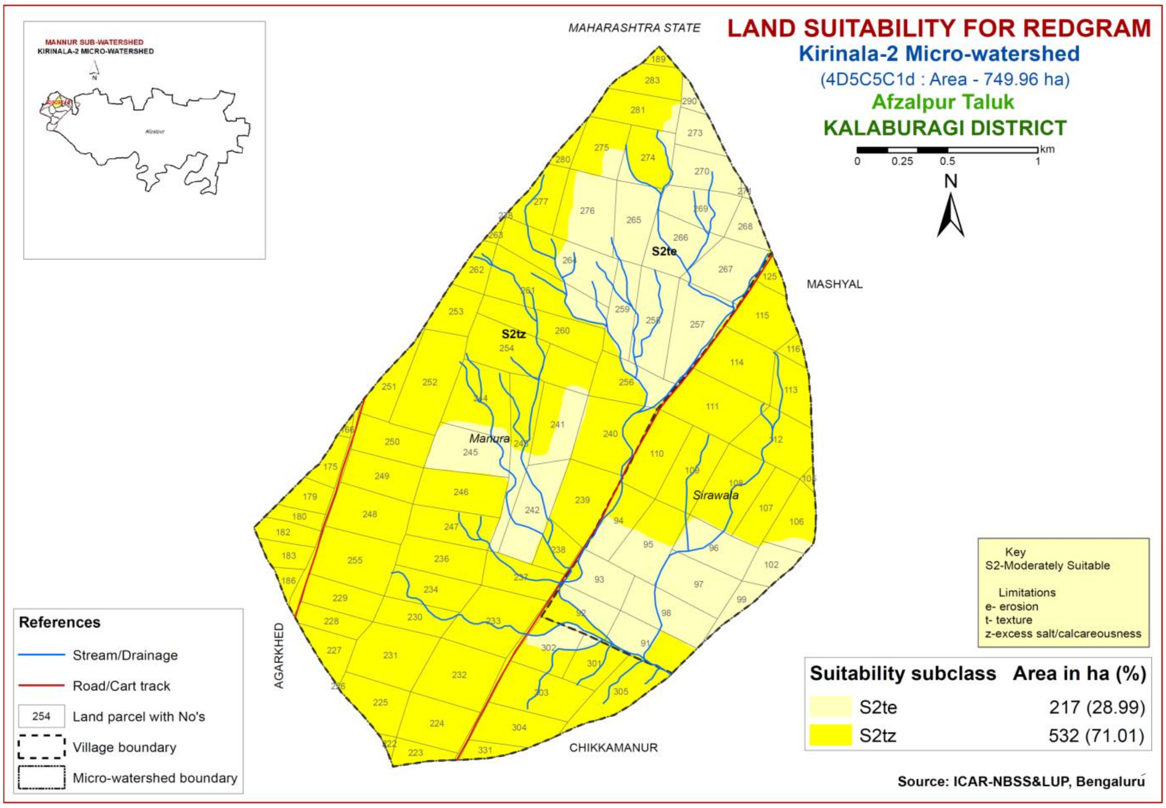


Fig. 7.3 Land Suitability map of Red gram

7.4 Land Suitability for Sunflower (*Helianthus annus*)

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

Table 7.5 Crop suitability criteria for Sunflower

Crop requirement		Rating			
Soil –site characteristics	**Unit**	**Highly suitable (S1)**	**Moderately suitable (S2)**	**Marginally suitable(S3)**	**Not 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	

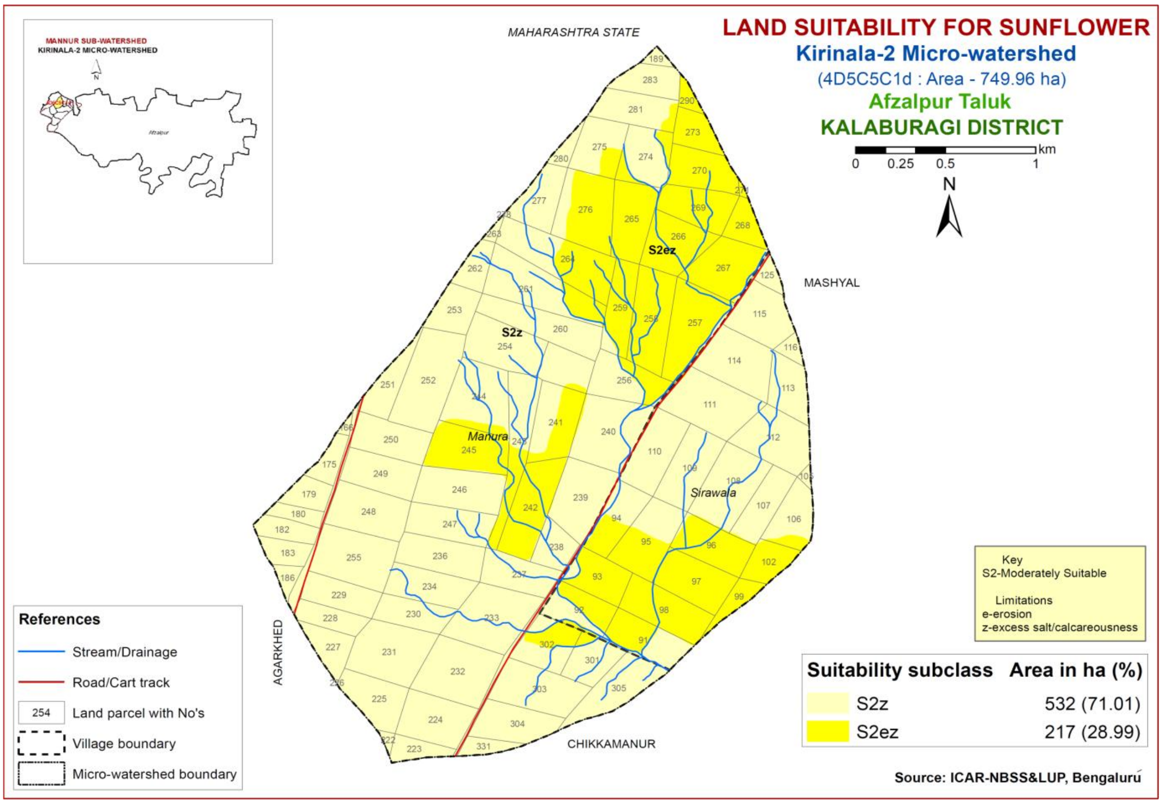


Fig. 7.4 Land Suitability map of Sunflower

In Kirinala-2 microwatershed there are no highly (Class S1) suitable lands available for growing sunflower. Entire area is moderately suitable (Class S2) for growing sunflower. They have minor limitations of erosion and calcareousness.

7.5 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 8.75 lakh ha area in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.6) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing cotton was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.5.

In Kirinala-2 microwatershed there are no highly (Class S1) suitable lands available for growing cotton. Entire area is moderately suitable (Class S2) for growing cotton. They have minor limitations of erosion and calcareousness.

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

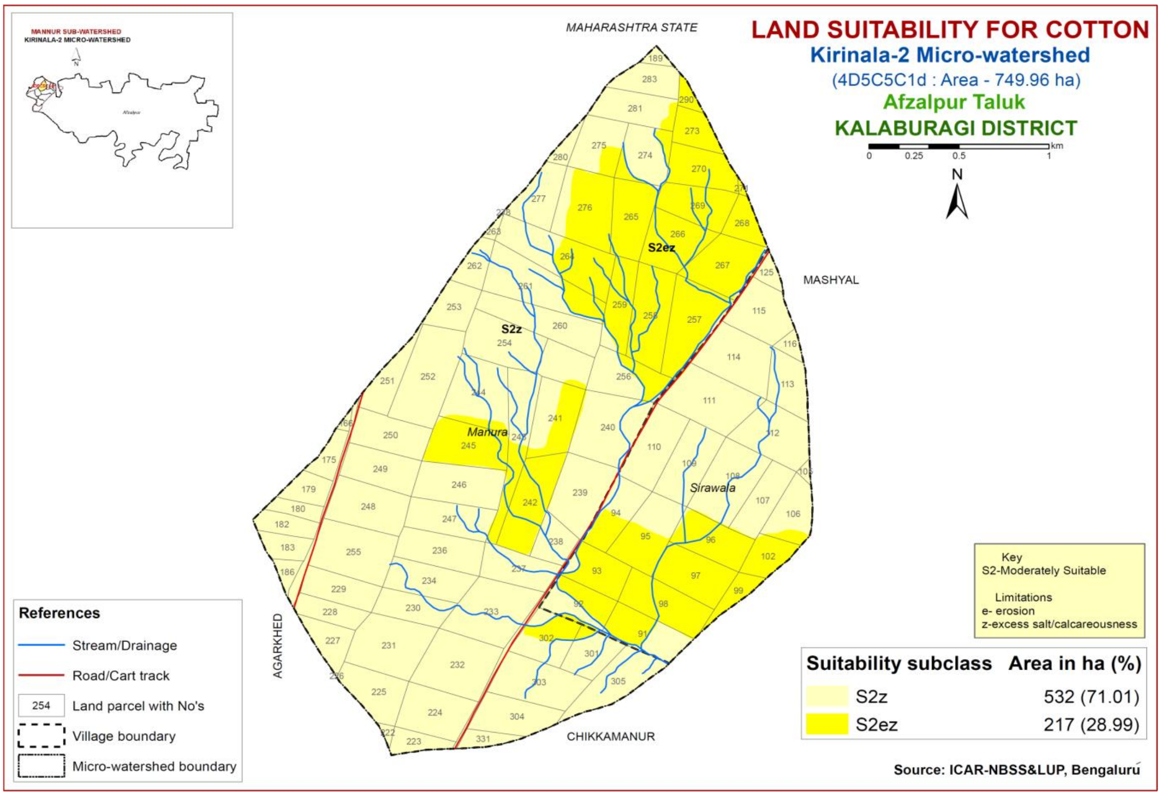


Fig. 7.5 Land Suitability map of Cotton

7.6 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.91 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, chamarajanagar 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. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

Table 7.7 Crop suitability criteria for Sugarcane

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

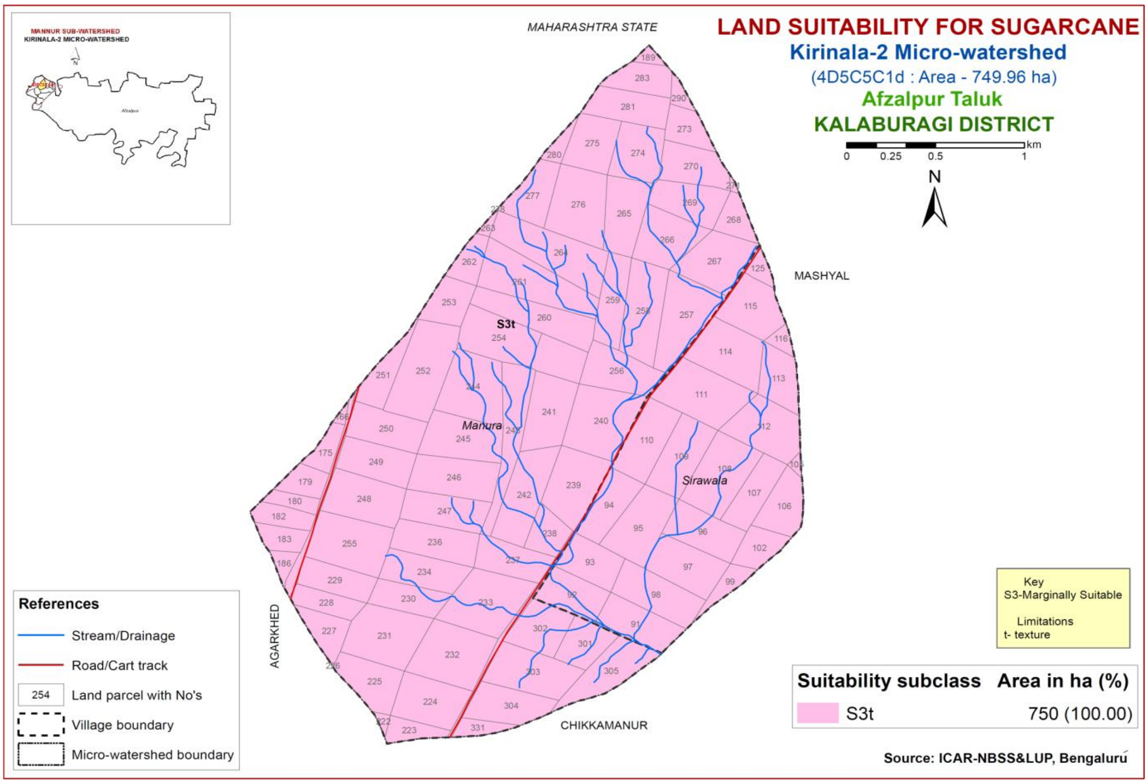


Fig. 7.6 Land Suitability map of Sugarcane

In Kirinala-2 microwatershed there are no highly (Class S1) and moderately (Class S2) suitable lands available for growing sugarcane. Entire area has marginally suitable (Class S3) lands for growing sugarcane in the microwatershed. They have moderate limitations of texture.

7.7 Land Suitability for Soybean (*Glycine max*)

Soybean is the most important pulse and oil seed crop grown in about 2.56 lakh ha area in Bijapur, Raichur, Kalaburgi, Dharwad, Belgaum and Bellary districts. The crop requirements for growing soybean were matched with the soil-site characteristics and a land suitability map for growing soybean was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

There are no highly suitable (Class S1) lands for growing Soybean in the microwatershed. Entire area has soils that are moderately suitable (Class S2) lands for growing Soybean. They have minor limitations of erosion and calcareousness.

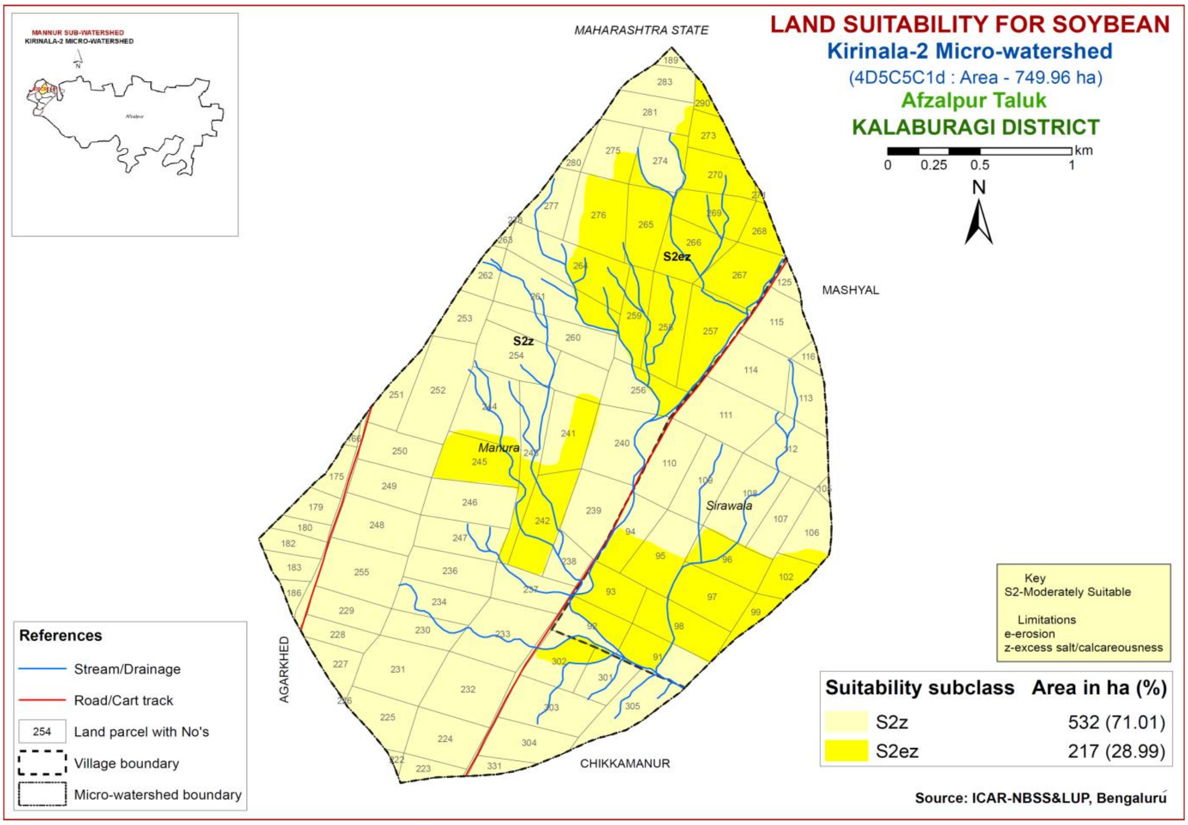


Fig. 7.7 Land Suitability map of Soybean

7.8 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in an area of 6558 ha in the State in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga, Bangalore 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. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

In Kirinala-2 microwatershed there are no highly (Class S1) and moderately (Class S2) suitable lands available for growing guava. The marginally suitable (Class S3) lands cover entire area in the microwatershed. They have moderate limitations of texture.

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

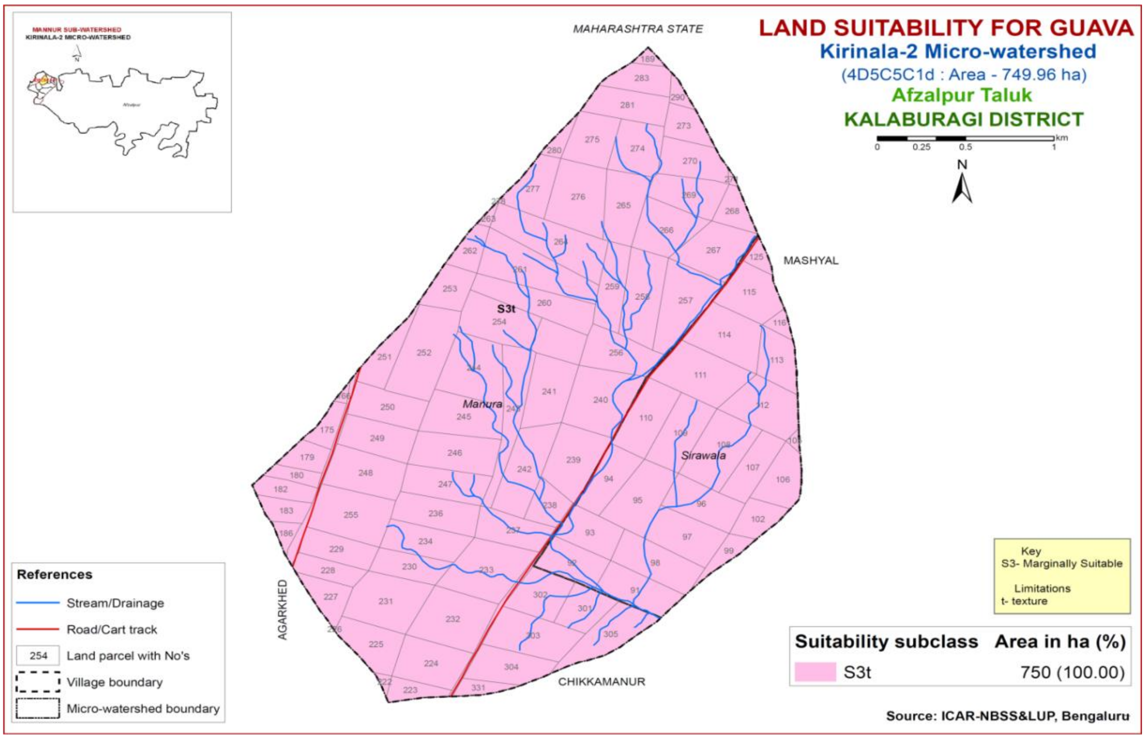


Fig 7.8 Land Suitability map of Guava

7.9 Land Suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in an area of 1.73 lakh ha and distributed 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. The area and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.9.

No highly (Class S1) and moderately (Class S2) suitable lands are available for growing mango in the microwatershed. The marginally suitable (Class S3) lands cover entire area in the microwatershed. They have moderate limitations of texture.

Table 7.9 Crop suitability criteria for Mango

Crop requirement			Rating			
soil-site characteristics		Unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temp in growing season	^0C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	^0C	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	

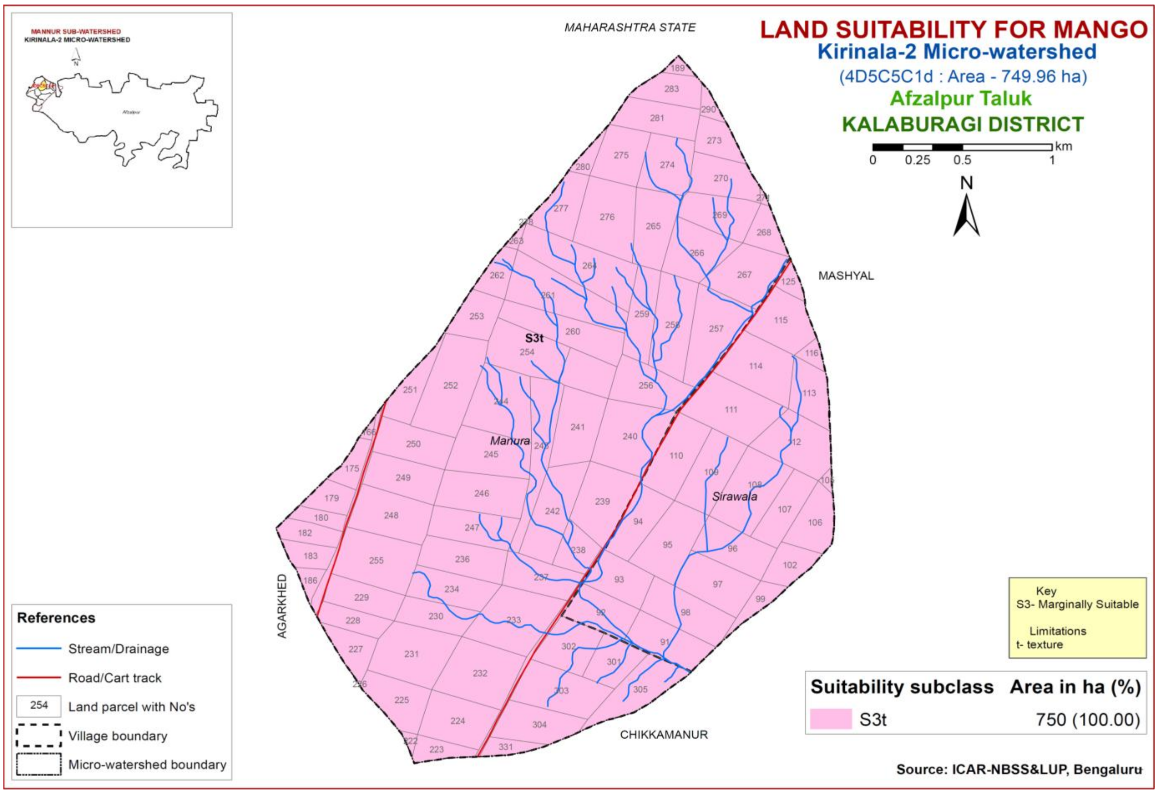


Fig. 7.9 Land Suitability map of Mango

7.10 Land Suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in an area of 0.29 lakh ha and distributed 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.The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.10.

No highly (class S1) and moderately (Class S2) suitable lands are available for growing sapota in the microwatershed. The marginally suitable (Class S3) lands cover entire area in the microwatershed. They have moderate limitations of texture.

Table 7.10 Crop suitability criteria for Sapota

Crop requirement			Rating			
Soil –site characteristics		**Unit**	**Highly suitable (S1)**	**Moderately Suitable (S2)**	**Marginally suitable (S3)**	**Not suitable (N)**
climate	Temperature in growing season	^{0}C	28-32	33-36 24-27	37-42 20-23	>42 <18
Soil moisture	Growing period	Days	>150	120-150	90-120	<120
Soil aeration	Soil drainage	class	Well drained	Moderately well drained	Imperfectly drained	Poorly drained
Nutrient 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

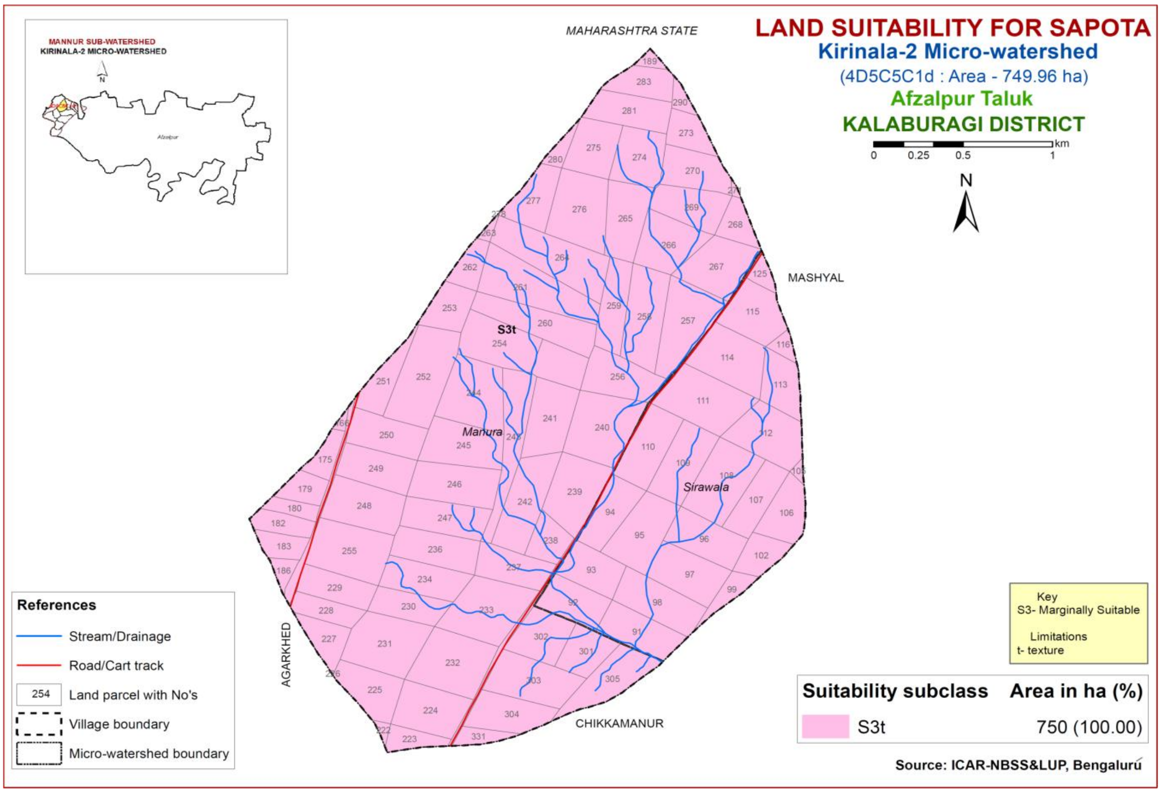


Fig. 7.10 Land Suitability map of Sapota

7.11 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in an area of 5368 ha and distributed 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. The area extent and their 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. entire area in the microwatershed has marginally suitable (Class S3) lands for growing jackfruit. They have moderate limitations of texture.

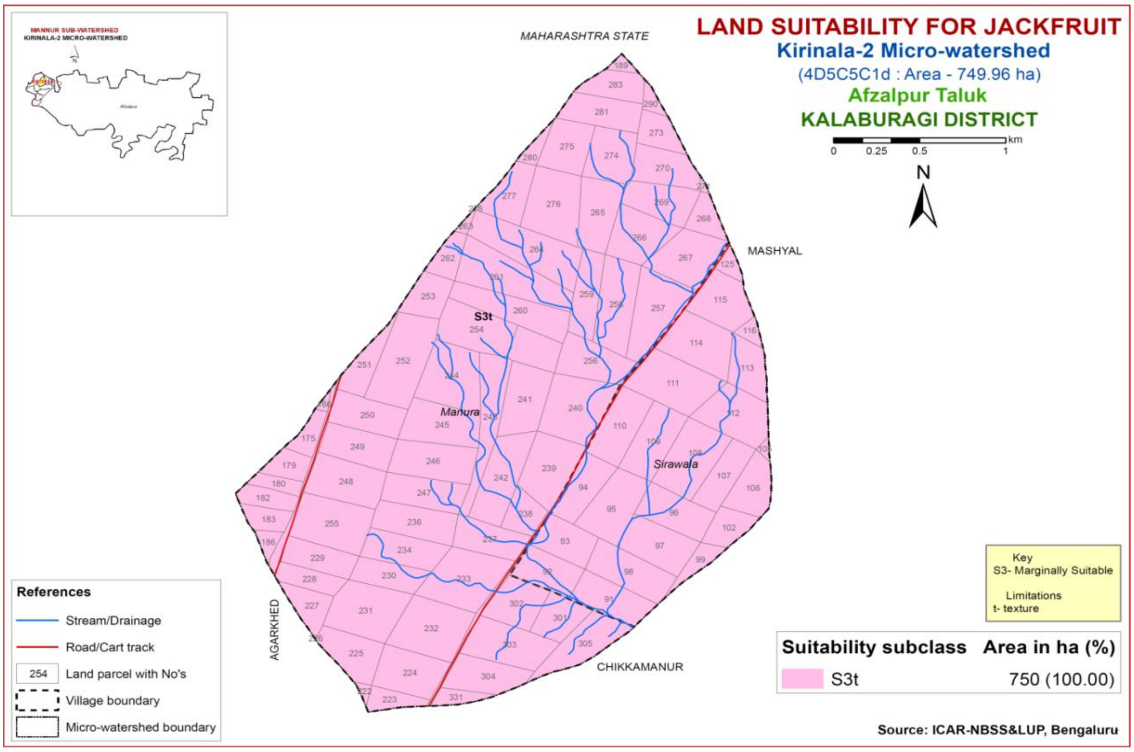


Fig 7.11 Land Suitability map of Jackfruit

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. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.12.

No highly (Class S1) suitable lands are available for growing Jamun in the microwatershed. Moderately suitable (Class S2) lands are found to occur in entire area of the microwatershed. The soils have minor limitations of texture and erosion.

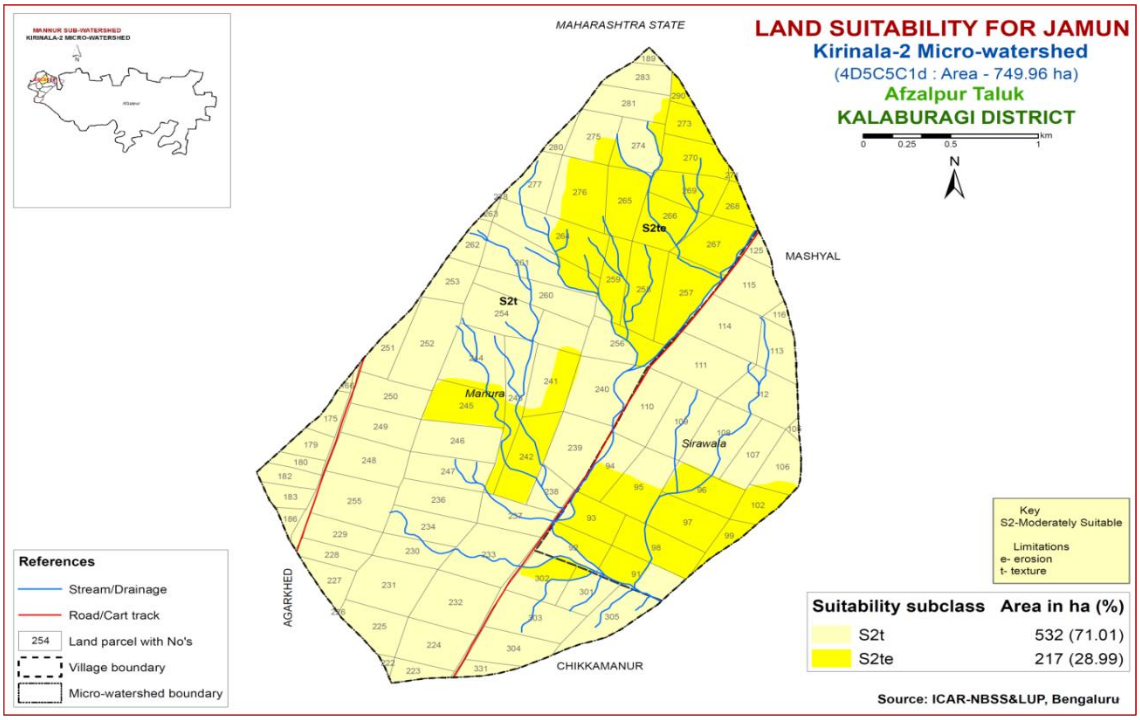


Fig 7.12 Land Suitability map of Jamun

7.13 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha and distributed in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

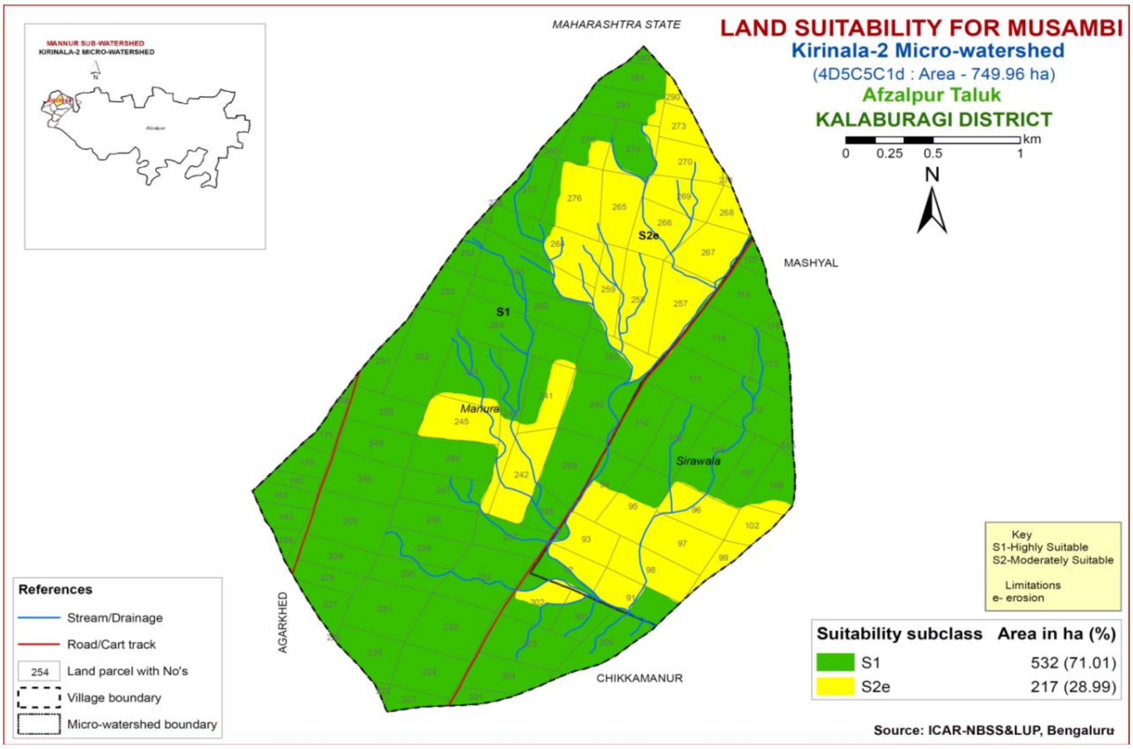


Fig 7.13 Land Suitability map of Musambi

Highly suitable (Class S1) lands are found to occur in major area of about 532 ha (71%) and are distributed in all parts of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 217 ha (29%). The soils have minor limitations of erosion. They are distributed in the northern, central and eastern part of the microwatershed.

7.14 Land Suitability for Lime (*Citrus sp*)

Lime is the most important fruit crop grown in an area of 0.117 lakh ha and distributed 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. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

Highly suitable (Class S1) lands are found to occur in major area of about 532 ha (71%) and are distributed in all parts of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 217 ha (29%). The soils have minor limitations of erosion. They are distributed in the northern, central and eastern part 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	

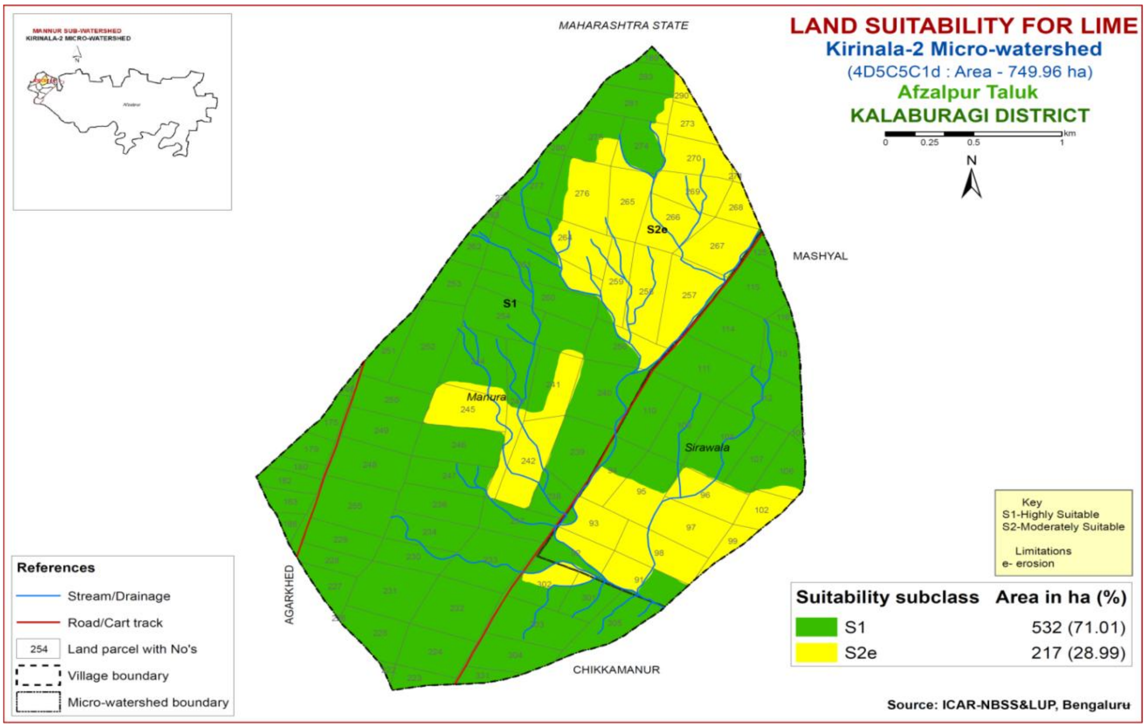


Fig 7.14 Land Suitability map of Lime

7.15 Land Suitability for Cashew (*Anacardium occidentale)*

Cashew is the most important plantation crop grown in an area of 0.70 lakh ha and distributed 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. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.15. The entire area is not suitable (Class N) for growing cashew in the microwatershed.

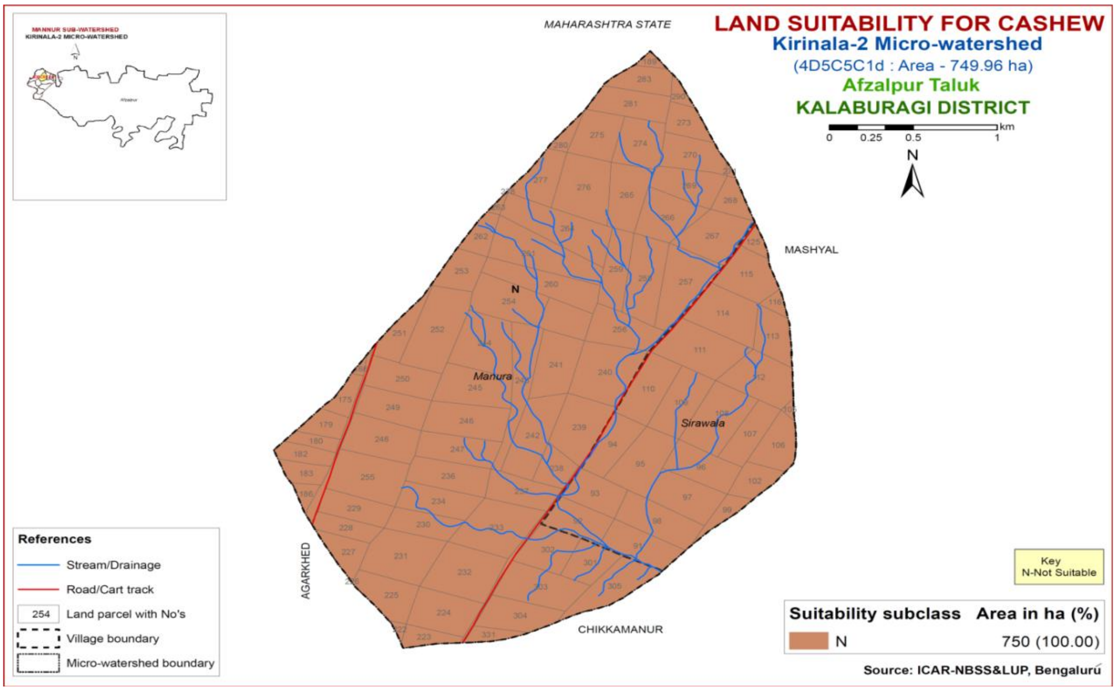


Fig 7.15 Land Suitability map of Cashew

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

Custard apple is the most important fruit crop grown in an area of 1426 ha and distributed 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. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

Entire area has soils that are highly suitable (Class S1) for growing custard apple in the microwatershed.

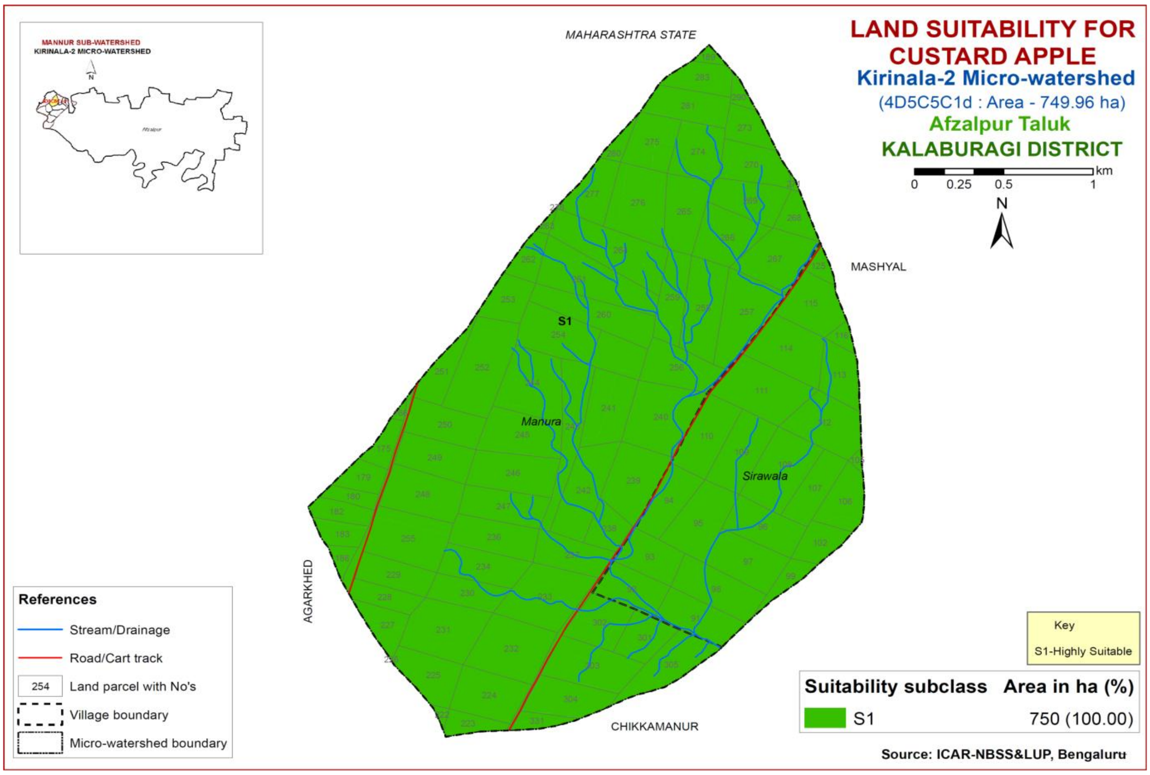


Fig 7.16 Land Suitability map of Custard Apple

7.17 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is the most important fruit and medicinal crop grown in an area of 151 ha and distributed 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. The area extent and their 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 major area of about 532 ha (71%) and are distributed in all parts of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 217 ha (29%). The soils have minor limitations of erosion. They are distributed in the northern, central and eastern part of the microwatershed.

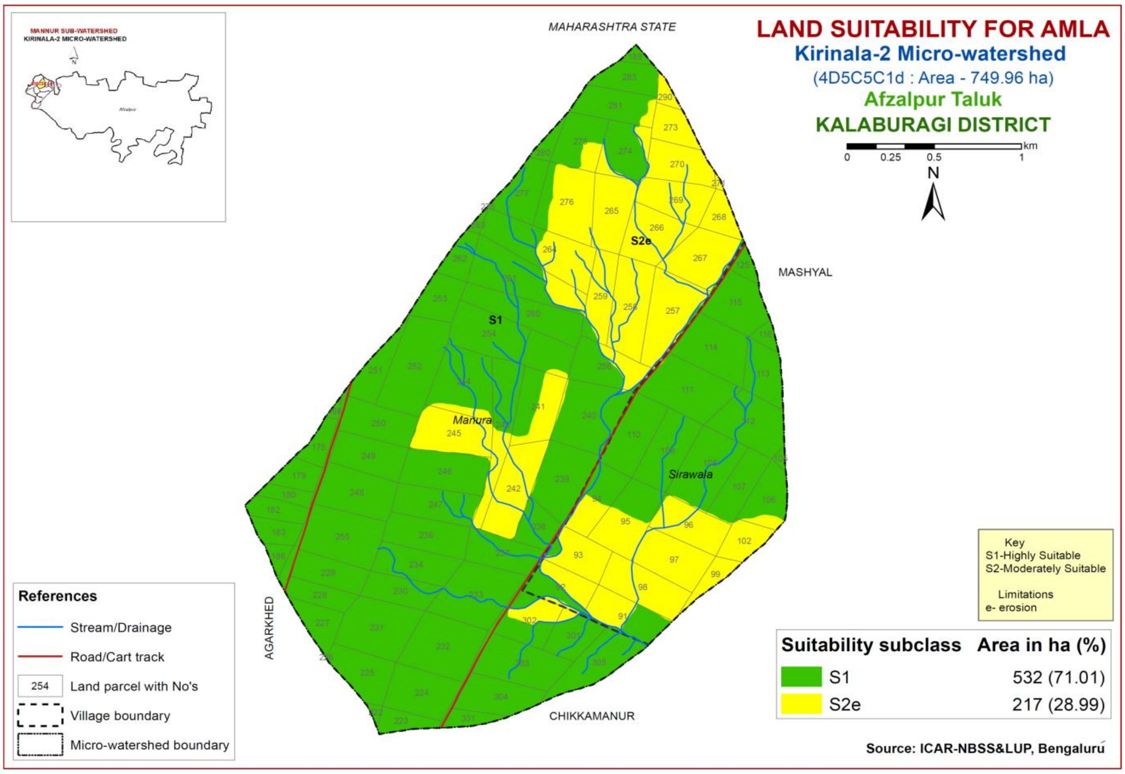


Fig 7.17 Land Suitability map of Amla

7.18 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop raised in an area of 0.14 lakh ha and distributed in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.18.

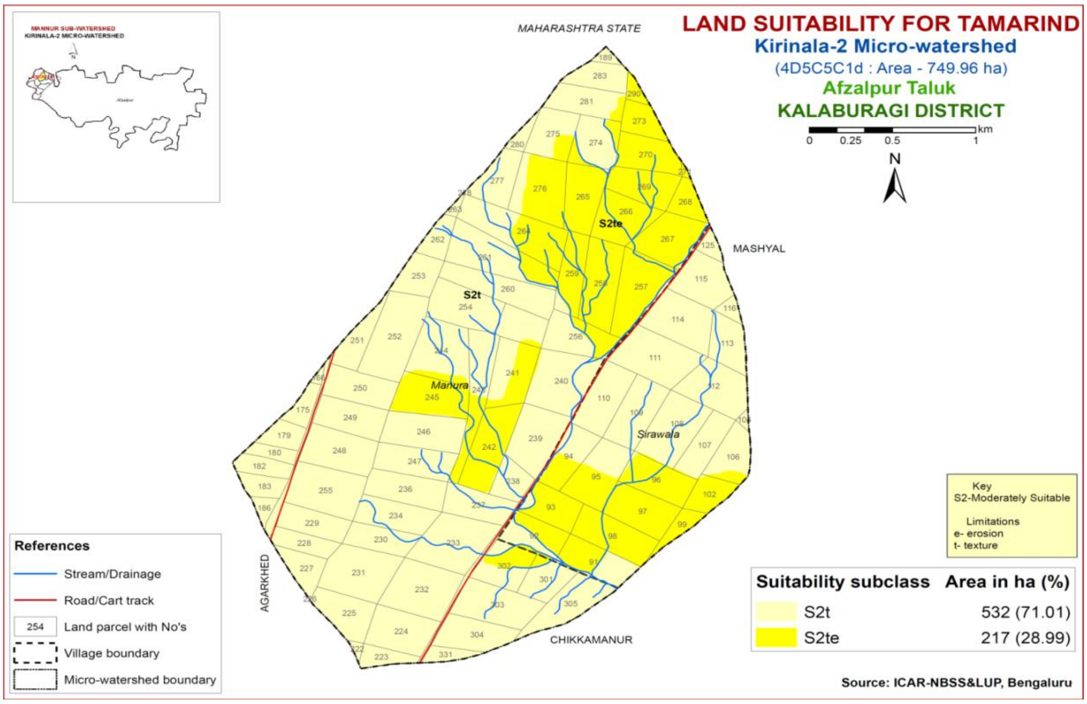


Fig 7.18 Land Suitability map of Tamarind

There are no highly suitable (Class S1) lands for growing tamarind. Entire area has soils that are moderately suitable (Class S2) lands for growing tamarind. The soils have minor limitations of texture and erosion.

7.19 Land Use Classes (LUCs)

The 6 soil map units identified in Kirinala-2 microwatershed have been grouped into one Land Use Class (LUC) for the purpose of preparing a Proposed Crop Plan. Land Use Classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Use Class map (Fig.7.19) has been generated. These Land Use Classes are expected to behave similarly for a given level of management.

The map units that have been grouped under one Land Use Class along with brief description of soil and site characteristics are given below.

LUCs	Soil map units	Soil and site characteristics
1	1 DIMmB1 2 DIMmB1 3 DIMmB2 4 MARmA1 5 MARmB1 6 MARmB	Deep to very deep (100- >150 cm) black soils with slopes of 0-3%, slight to moderate erosion

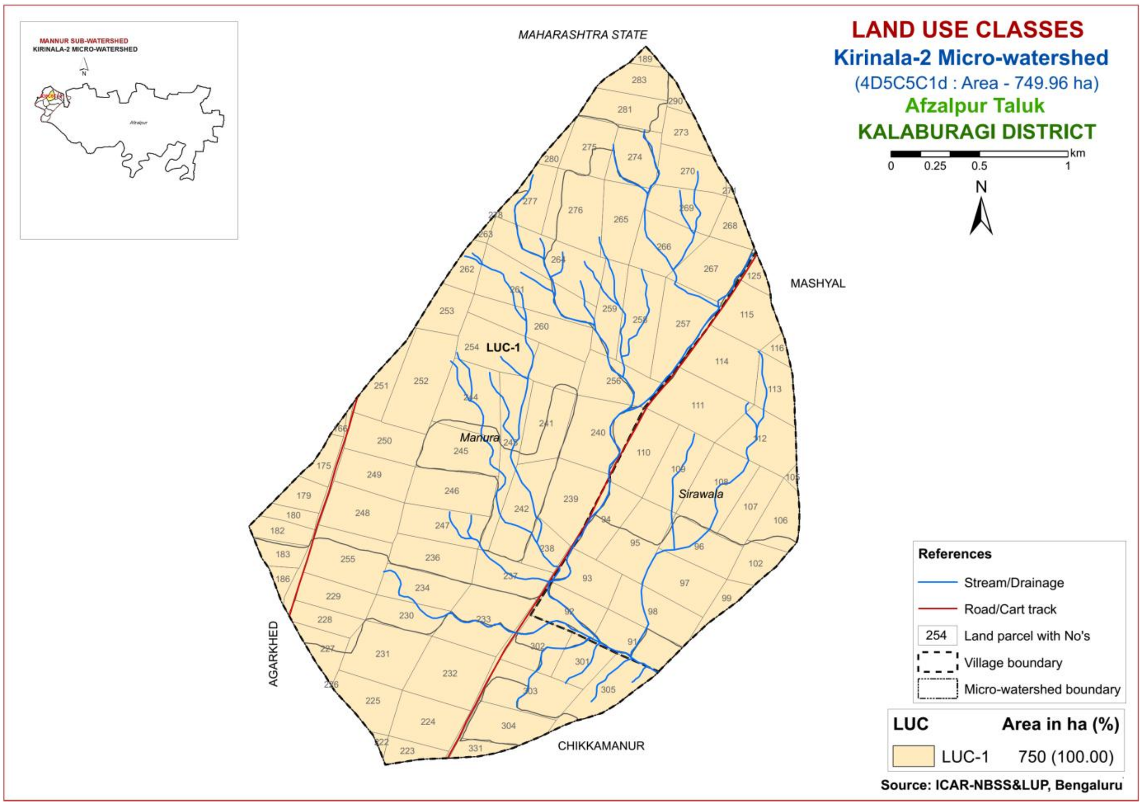


Fig. 7.19 Land Use Class map - Kirinala-2 microwatershed

7.20 Proposed Crop Plan for Kirinala-2 Microwatershed

After assessing the land suitability for the 18 crops, a proposed crop plan has been generated for the one identified LUC by considering only the highly (Class S1) and moderately suitable (Class S2) lands for each of the 18 crops. The resultant proposed crop plan is presented below in Table 7.12.

Table 7.12 Proposed Crop Plan for Kirinala-2 Microwatershed

LUCs	Mapping unit	Survey No	Crops proposed				
			Field crops	Forestry Crop/Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops with suitable intervention	Suitable Intervention
1	1 DIMmB1 2 DIMmB1 3 DIMmB2 4 MARmA1 5 MARmB1 6 MARmB2 (Deep to very deep black clay soils)	Manura: 166,175,179,180,182,183,186,189,222,223,224,225,226,227,228,229,230,231,232,233,234,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,256,257,258,259,260,261,262, 263,264,265,266,267,268,269,270,271,273,274,275,276,277,278,280,281,283,290,301,302,303,304,305, 331 Sirawala: 91,92,93,94,95,96,97,98,99,102,105,106,107,108,109,110,111,112,113, 114, 115,116,125	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sunflower, Coriander, Safflower, Sesame, Linseed **Rabi:** Sorghum, wheat, Chickpea **Mixed cropping:** Red gram-cotton Pulses+sorghum	-	**Field crops:** Sorghum, Cotton, Red Gram, Sunflower, Safflower, **Perennial component:** Guava, Tamarind, Sapota, Lime, Mosambi	Banana, Papaya, Lime, Musambi, Guava, Tamrind **Vegetables:** Onion, Tomato, Brinjal, Chillies, Bhendi **Flowers:** Marigold, Chrysanthemum	Drip irrigation, mulching, and soil and water conservation measures like, Graded bunds, Strengthening of field bunds

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

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

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

The most important characterististics of a healthy soil are

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

Characteristics of Kirinala-2 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of MAR (582 ha) and DIM (169 ha). As per land capability classification, entire area falls under arable land category (Class II). The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, entire area is strongly alkaline (pH 8.4-9.0) in the microwatershed.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to strongly alkaline soils)

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

Neutral soils

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

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

Soil Degradation

Soil erosion is one of the major factor affecting the soil health in the microwatershed. Out of total area of 750 ha in the microwatershed, an area of 217 ha is suffering from moderate 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 the younger farmers.

Inputs for Net Planning (Saturation Plan)and Interventions needed

Net planning in IWMP is focusing on preparation of

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

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

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

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

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

- ❖ **Organic Carbon:** In about 630 ha (84%) area, the OC content is medium (0.5-0.75%) and in about 120 ha (16%) area, it is high (>0.75%). The areas that are medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- **Promoting green manuring:** Growing of green manuring crops costs Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 630 ha area, where OC is medium (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 314 ha (42%) area, the available phosphorus is low and about 436 ha (58%) area it is medium in available phosphorus in the microwatershed. Hence for all the crops, 25% additional P-needs to be applied, where available p is low and medium.

- **Available Potassium:** Available potassium is high (>337 kg/ha) in the entire area of the microwatershed.

- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in an area of 209 ha (28%) in the microwatershed, medium in a major area of 460 ha (61%).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 and high (>20 ppm) in a small area of about 80 ha (11%).

- **Available Boron:** It is low in an area of 204 ha (27%) in the microwatershed, medium in a major area of 545 ha (73%).These areas need to be applied with sodium borate @ 10kg/ha as a soil application or 0.2% borax as foliar spray to correct the deficiency.

- **Available iron:** It is deficient in 131 ha (41%) area of 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 439 ha (59%) area in the microwatershed.

- **Available Zinc:** It is deficient (<0.6 ppm) in the entire area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied.

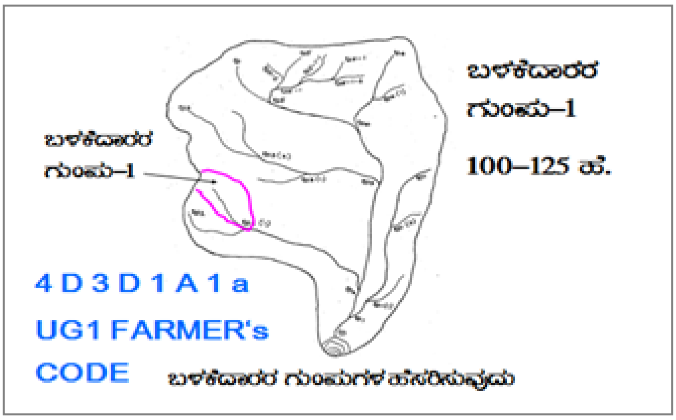
- **Soil alkalinity:** The entire microwatershed has soils that are strongly alkaline (pH 8.4-9.0). These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain 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 the 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 Kirinala-2 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were

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



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

Steps for Survey and Preparation of Treatment Plan

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

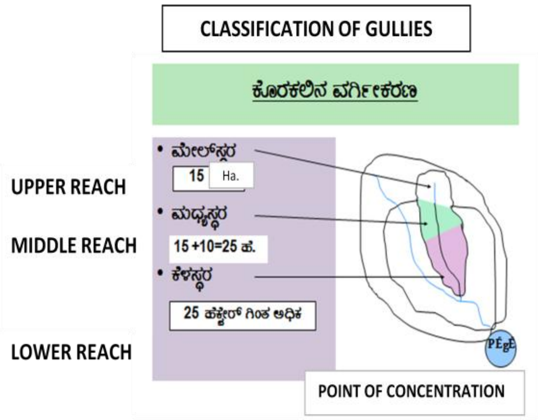
- Naming of user groups and farmers
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge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

9.1 Treatment Plan

The treatment plan recommended for arable lands is briefly described below

9.1.1 Arable Land Treatment

A. BUNDING

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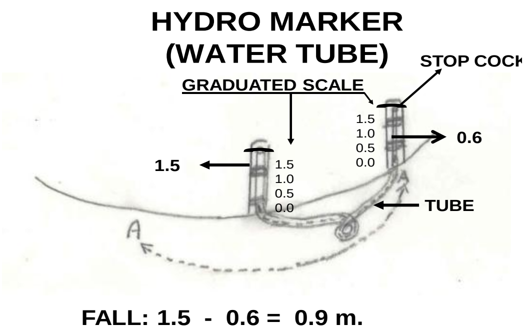
Measurement of Land Slope

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- A= 0-1% slope, 1= slight erosion.) the intervals have to be decided.

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

Section of the Bund

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

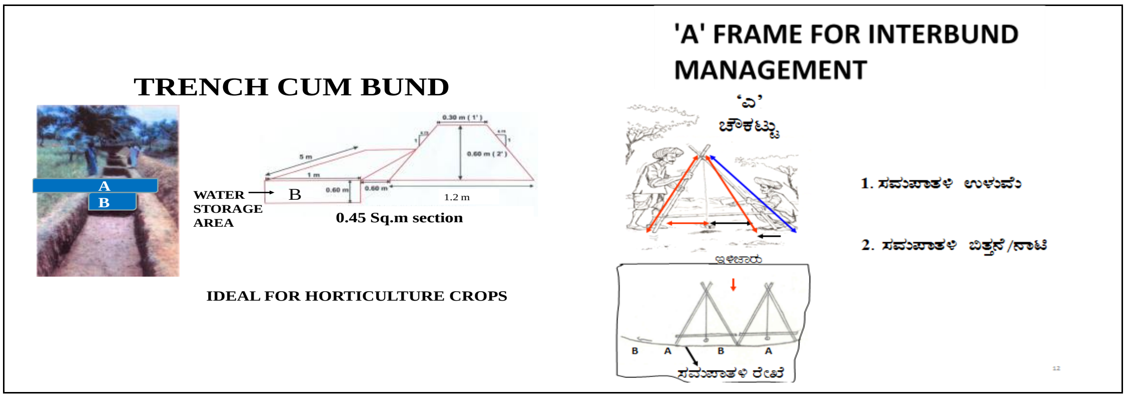
Recommended Bund Section

Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly 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

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

C. Farm Ponds

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

D. Diversion Channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

a) The cadastral map has to be updated as regards the network of drainge lines (gullies/ nalas/ hallas) and existing structures are marked to the scale and storage capacity of the existing water bodies are documented.
b) The drainage line will be demarcated into Upper Reach, Middle Reach and Lower Reach.
c) Considering the Catchment, Nala bed and bank conditions, suitable structures are decided.
d) Number of storage structures (Check dam/ Nala bund/ Percolation tank) will be decided considering the commitments and available runoff from 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 generated which shows the spatial distribution and extent of area. Entire area needs graded bunds/ strengthening of bunds.

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

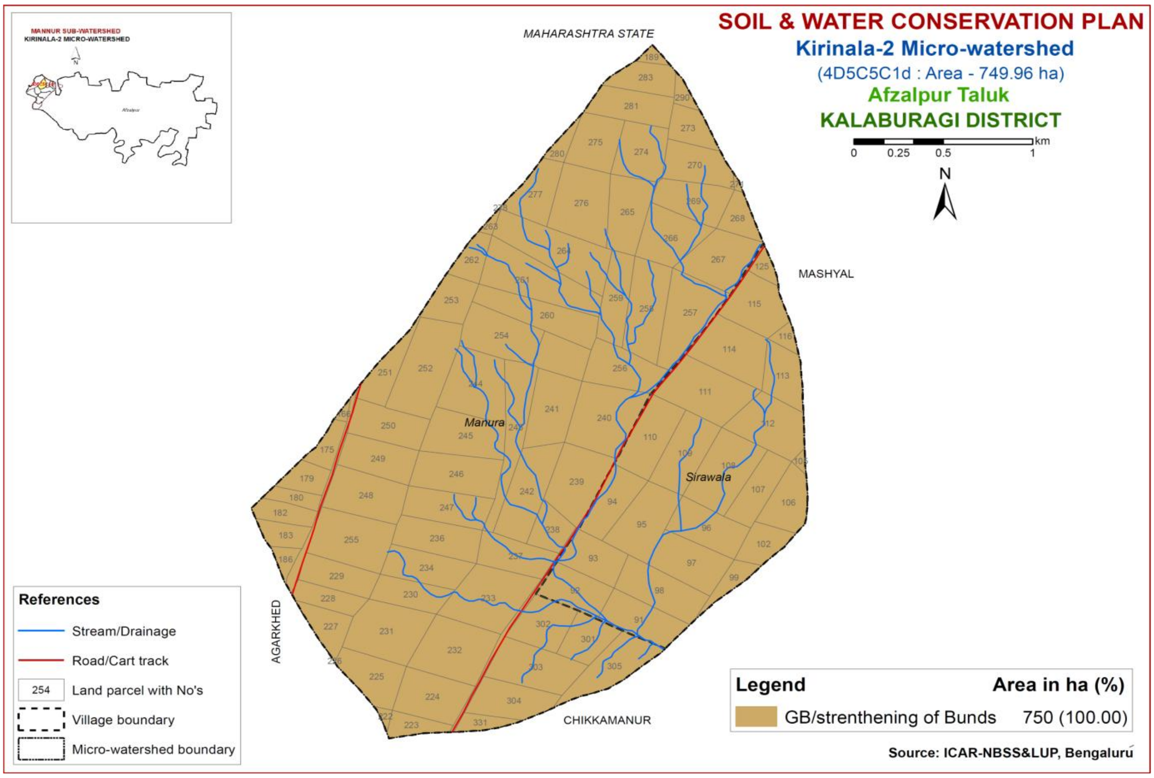


Fig. 9.1 Soil and Water Conservation Plan of Kirinala-2 Microwatershed

9.3 Greening of Microwatershed

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

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

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

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

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Appendix I

Kirnala-2 Microwatershed

Soil Phase Information

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Manura	166	0.53	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	175	3.34	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	179	3.88	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Sunflower (Bg+Sf)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	180	2.55	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Redgram (Bg+Rg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	182	3.94	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	183	3.61	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram+Redgram (Bg+Rg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	186	1.75	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	189	1.08	DIMmA1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds
Manura	222	0.66	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds
Manura	223	3.48	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Sunflower (Sf)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	224	9.87	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	225	8.19	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar+Sunflower (Bg+Jr+Sf)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	226	0.01	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds
Manura	227	5.1	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	228	4.74	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Manura	229	6.81	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+Jowar+Maize (Rg+Jr+Mz)	Not Available	IIs	GB/strenthening of Bunds
Manura	230	6.47	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Sunflower (Sf)	Not Available	IIs	GB/strenthening of Bunds
Manura	231	12.88	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	232	13.22	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Sunflower (Sf)	Not Available	IIs	GB/strenthening of Bunds
Manura	233	13.61	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	234	8.38	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	236	9.03	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Sunflower (Sf)	Not Available	IIs	GB/strenthening of Bunds
Manura	237	7.68	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	238	4.83	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	239	11.36	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	240	13.71	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	241	10.09	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Manura	242	11.82	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Manura	243	10.61	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strenthening of Bunds
Manura	244	12.5	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	245	10.54	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Manura	246	10.66	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	247	8.75	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	248	10.74	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	249	8.49	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	250	8.51	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	251	5.79	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	252	15.13	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Sunflower (Rg+Sf)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	253	5.94	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	254	10.68	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	255	18.57	MARmB1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram+Redgram+Jowar (Bg+Rg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	256	9.21	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	257	12.53	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	258	11.89	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	259	7.76	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	260	10.92	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	261	14.33	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Manura	262	4.01	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	263	0.71	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds
Manura	264	14.6	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	265	9.41	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Banana (Rg+Ba)	1 Borewell	IIse	GB/strentheni ng of Bunds
Manura	266	9.69	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	267	10.42	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	268	3.98	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	269	8.34	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	270	7.93	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	271	0.3	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IIse	GB/strentheni ng of Bunds
Manura	273	4.75	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	274	8.65	DIMmB1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	1 Borewell	IIs	GB/strentheni ng of Bunds
Manura	275	8.11	DIMmB1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram+Jowar+Maize (Bg+Jr+Mz)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	276	12.68	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Manura	277	7.38	DIMmB1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Manura	278	0.01	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Manura	280	1.92	DIMmB1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bengalgram (Bg)	1 Borewell	IIs	GB/strenthening of Bunds
Manura	281	8.15	DIMmA1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram+Jowar+Sunflower+Onion +Cotton (Rg+Jr+Sf+On+Ct)	4 Borewell	IIs	GB/strenthening of Bunds
Manura	283	5.73	DIMmA1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	290	1.52	DIMmB2	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Manura	301	6.41	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	302	8.08	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Redgram+Jowar (Bg+Rg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	303	11.3	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	304	8.54	DIMmA1	LUC-1	Deep (100-150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Manura	305	9.66	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strenthening of Bunds
Manura	331	2.5	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds
Sirawala	91	8.77	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Sirawala	92	7.65	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Sirawala	93	7.4	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Sirawala	94	7.83	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Redgram (Rg)	Not Available	IIs	GB/strenthening of Bunds
Sirawala	95	10.92	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strenthening of Bunds
Sirawala	96	8.93	MARmB2	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IIse	GB/strenthening of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sira wala	97	9.86	MAR mB2	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Sira wala	98	10.29	MAR mB2	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram+Jowar (Bg+Jr)	Not Available	IIse	GB/strentheni ng of Bunds
Sira wala	99	3.16	MAR mB2	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Sira wala	102	4.92	MAR mB2	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IIse	GB/strentheni ng of Bunds
Sira wala	105	0.59	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	NA	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	106	7.27	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	107	7.18	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	108	12.53	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	109	10.01	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Sunflower (Bg+Sf)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	110	10.05	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram+Jowar (Bg+Jr)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	111	13.42	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	112	10.93	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	113	6.74	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	114	11.59	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	115	9.35	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds
Sira wala	116	1.55	MAR mA1	LU C-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strentheni ng of Bunds

Village	Survey Number	Total Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Sirawala	125	2.05	MARmA1	LUC-1	Very deep (>150 cm)	Clay	Non gravelly (<15%)	Very high (>200 mm/m)	Nearly level (0-1%)	Slight	Bengalgram (Bg)	Not Available	IIs	GB/strenthening of Bunds

Appendix II

Kirnala-2 Microwatershed
Soil Fertility Information

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Manura	166	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	175	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	179	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	180	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	182	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	183	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	186	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	189	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	222	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	223	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	224	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	225	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	226	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	227	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	228	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	229	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	230	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	231	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	232	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	233	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	234	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	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 Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Manura	236	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	237	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	238	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	239	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	240	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	241	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	242	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	243	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	244	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	245	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	246	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	247	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	248	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	249	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	250	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	251	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	252	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	253	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	254	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	255	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	256	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	257	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	258	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	259	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Manura	260	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	261	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	262	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	263	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	264	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	265	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	266	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	267	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	268	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	269	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	270	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	271	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	273	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	274	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	275	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	276	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	277	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	278	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	280	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	281	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	283	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	290	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	301	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	302	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Manura	303	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	304	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	305	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Manura	331	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	91	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	92	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	93	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	94	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	95	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	96	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	97	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	98	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Low (< 10 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	99	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	102	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	105	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	106	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	107	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	108	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	109	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	110	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Low (< 23 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Sufficient (> 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	111	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	112	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Medium (0.5 - 1.0)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	113	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	114	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Village	Survey Number	Soil Reaction	Salinity	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Sirawala	115	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	116	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	Medium (0.5 - 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	Medium (10 - 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)
Sirawala	125	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (> 0.75 %)	Medium (23 - 57 kg/ha)	High (> 337 kg/ha)	High (> 20 ppm)	Low (< 0.5 ppm)	Deficient (< 4.5 ppm)	Sufficient (> 1.0 ppm)	Sufficient (> 0.2 ppm)	Deficient (< 0.6 ppm)

Appendix III

Kirnala-2 Microwatershed
Soil Suitability Information

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Redgram	Soyabean
Manura	166	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	175	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	179	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	180	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	182	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	183	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	186	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	189	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	222	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	223	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	224	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	225	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	226	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	227	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	228	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	229	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	230	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	231	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	232	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	233	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	234	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	236	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	237	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	238	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	239	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	240	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Redgram	Soyabean
Manura	241	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	242	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	243	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	244	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	245	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	246	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	247	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	248	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	249	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	250	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	251	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	252	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	253	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	254	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	255	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	256	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	257	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	258	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	259	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	260	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	261	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	262	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	263	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	264	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	265	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	266	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	267	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	268	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	269	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	270	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Redgram	Soyabean
Manura	271	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	273	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	274	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	275	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	276	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	277	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	278	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	280	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	281	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	283	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	290	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Manura	301	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	302	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	303	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	304	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	305	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Manura	331	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	91	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	92	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	93	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	94	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	95	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	96	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	97	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	98	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	99	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	102	S2ez	S3t	S2ez	S2ez	S3t	S3t	S3t	S3t	S2te	S2e	S2e	N	S1	S2e	S2te	S3t	S2te	S2ez
Sirawala	105	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	106	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	107	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard -apple	Amla	Tamarind	Sugarcane	Redgram	Soyabean
Sirawala	108	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	109	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	110	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	111	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	112	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	113	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	114	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	115	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	116	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z
Sirawala	125	S2z	S3t	S2z	S2z	S3t	S3t	S3t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S2tz	S2z

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: *Kirinala-2 Microwatershed (Mannur sub-watershed, Afzalpur taluk, Gulbarga district) is located in between $17^{0}19'$ – $17^{0}21'$ North latitudes and $76^{0}6'$ – $76^{0}8'$ East longitudes, covering an area of about 750 ha, bounded by Mashyal, Chikkamanur, Agarkhed villages and Maharashtra State with length of growing period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified for each watershed.*

Results: *The socio-economic outputs for the Kirinala-2 micro-watershed (Mannur sub-watershed, Afzalpur taluk and Gulbarga district) are presented here.*

Social Indicators;

- *Male and female ratio is 58.8 to 41.2 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 49.1 per cent to the total population.*
- *Literacy population is around 98.0 per cent.*
- *Social groups belong to general category is around 80.0 per cent.*
- *Liquefied petroleum gas (LPG) is the source of energy for a cooking among 70.0 per cent.*
- *About 10.0 per cent of households have a yashaswini health card.*
- *Dependence on ration cards for food grains through public distribution system is around 50.0 per cent.*
- *Swach bharath program providing closed toilet facilities around 30.0 per cent of sample households.*
- *Women participation in decisions making for agriculture production among all sample households was found.*

Economic Indicators;

- *The average land holding is 3.3 ha indicates that majority of farm households are belong to medium and semi-medium farmers. The total cultivated land of dry land of area among the sample farmers.*

- *Agriculture is the main occupation among 29.4 per cent and agriculture is the main agriculture labour is subsidiary occupation for 62.7 per cent of sample households.*
- *The average value of domestic assets is around Rs. 20203 per household. Mobile and television are popular media mass communication.*
- *The average value of farm assets is around Rs. 6500 per household, about 10.0 per cent of sample farmers having plough, sprayer and bullock cart.*
- *The average value of livestock is around Rs. 18988 per household; about 52.8 per cent of household are having livestock.*
- *The average per capita food consumption is around 693.3 grams (1659.6 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 80.0 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 30564 per household. About 80.0 per cent of farm households are below poverty line.*
- *The per capita monthly average expenditure is around Rs.1957.*

Environmental Indicators-Ecosystem Services;

- *The value of ecosystem service helps to support investment to decision on soil and water conservation and in promoting sustainable land use.*
- *The onsite cost of different soil nutrients lost due to soil erosion is around Rs. 685 per ha/year. The total cost of annual soil nutrients is around Rs. 512923 per year for the total area of 749.96 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 15631/ha/year. Per hectare food grain production services is maximum in red gram (Rs. 61493) and bengal gram (Rs. 9047).*
- *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in red gram (Rs. 65889) and bengal gram (Rs. 53949).*

Economic Land Evaluation;

- *The major cropping pattern is bengal gram (93.5 %) and red gram (6.5 %).*
- *In Kirinala 2 Microwatershed, major soils are soil of alluvial landscape of Dimal (DIM) series is having deep soil depth cover around 22.5 % of area. On this soil farmers are presently growing bengal gram (65.4 %) and red gram (34.6 %) and Mannar (MNR) are also having very deep soil depth cover around 77.52 % of area, the crops are bengal gram (94.8 %) and red gram (5.2 %).*

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for bengal gram ranges Rs. 28131/ha in DIM soil (with BCR of 1.34) and Rs.18563/ha in MAR soil (with BCR of 1.52).*
- *In red gram the cost of cultivation range between Rs. 24315/ha in DIM soil (with of 1.71) and Rs.15976/ha in MAR soil (with BCR of 2.71).*
- *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 bengal gram (35.7 to 48.2 %), and red gram (2.8 %).*

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.

METHODOLOGY

Study area

Kirinala-2 micro-watershed is 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 grown are jowar, bajra, oilseeds, pulses, cotton and sugarcane. It's represented Agro Ecological Sub Region (AESR) 6.2 having LGP 120-150 days.

Kirinala-2 micro-watershed (Mannur sub-watershed, Afzalpur taluk, Gulbarga district) is located in between $17^{0}19'$ – $17^{0}21'$ North latitudes and $76^{0}6'$ – $76^{0}8'$ East longitudes, covering an area of about 750 ha, bounded by Mashyal, Chikkamanur, Agarkhed villages and Maharashtra State.

Sampling Procedure:

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

Sources of data and analysis:

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

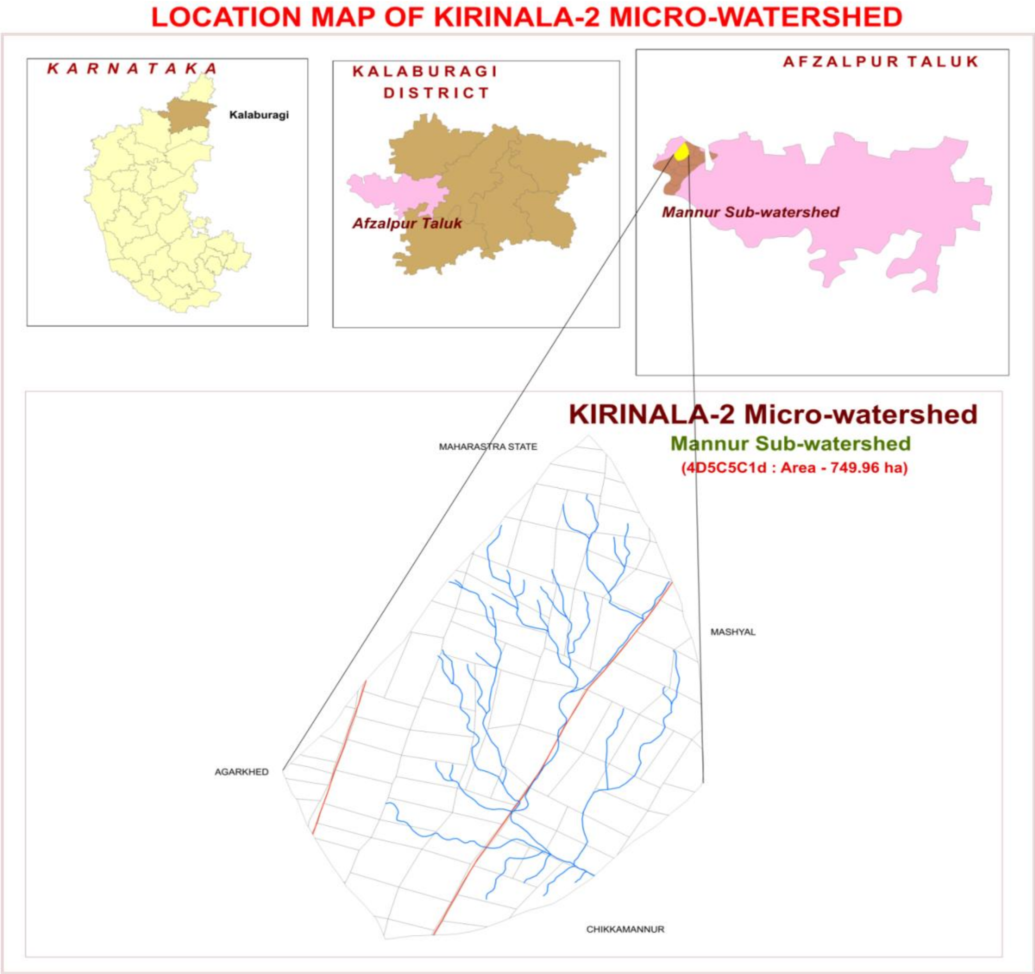

Figure 1: Location of study area

Steps followed in socio-economic assessment

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

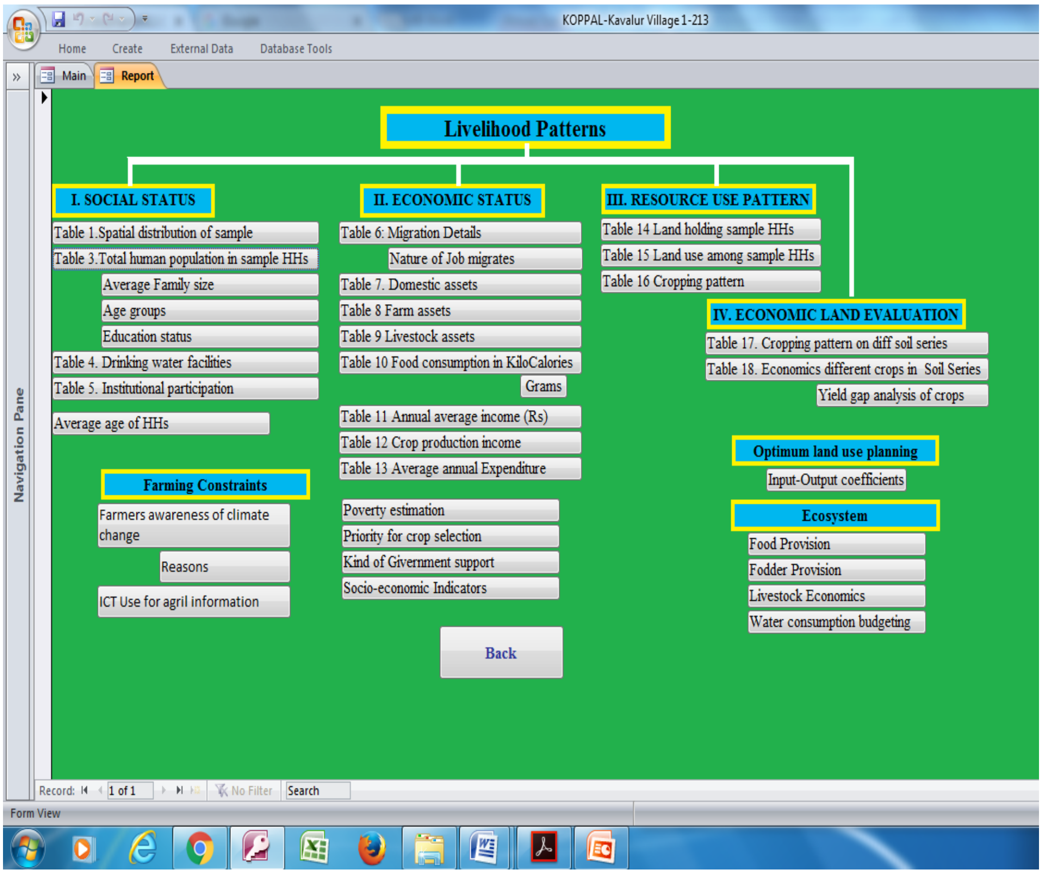

Figure 2: ALPES FRAMEWORK

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

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

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

Economic Valuation of Soil ecosystem services:

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

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

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

Chapter 3

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 51, out of which 58.8 per cent were males and 41.2 per cent females. Average family size of the households is 5.1. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 30 to 50 years (33.3 %) followed by 0 to18 years (27.4 %), more than 50 years (23.5 %) and 18 to 30 years (15.7 %). 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 2.0 per cent of respondents were illiterate and 98.0 per cent literate (Table 1).

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

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	51
Male	% to total Population	58.8
Female	% to total Population	41.2
Average family size	Number	5.1
Age group		
0 to 18 years	% to total Population	27.4
18 to 30 years	% to total Population	15.7
30 to 50 years	% to total Population	33.3
>50 years	% to total Population	23.5
Average age	Age in years	23.5
Education Status		
Illiterates	% to total Population	2.0
Literates	% to total Population	98.0
Primary School (<5 class)	% to total Population	54.8
Middle School (6- 8 class)	% to total Population	11.8
High School (9- 10 class)	% to total Population	5.9
Others	% to total Population	25.5

The ethnic groups among the sample farm households found to be 80.0 per cent belonging to general category and only 20.0 per cent belonging to other backward castes

(OBC) (Table 2 and Figure 3). About 70.0 per cent of sample households are using Gas as source of fuel for cooking. All the sample farmers are having electricity connection. About 10 per cent are sample households having health cards. Only (10 %) are having MNREGA job cards for employment generation. About 50 per cent of farm households are having ration cards for taking food grains from public distribution system. About 30.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Kirinala 2 Micro watershed

Particulars	**Units**	**Value**
Social groups		
OBC	% of Households	20.0
General	% of Households	80.0
Types of fuel use for cooking		
Fire wood	% of Households	30.0
Gas	% of Households	70.0
Energy supply for home		
Electricity	% of Households	100
Number of households having Health card		
Yes	% of Households	10.0
No	% of Households	90.0
Ration Card		
Yes	% of Households	50.0
No	% of Households	50.0
Households with toilet		
Yes	% of Households	30.0
No	% of Households	70.0
Drinking water facilities		
Tube well	% of Households	100

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

The occupational pattern (Table 3) among sample households shows that agriculture is the main occupation around 29.4 per cent of farmers followed by subsidiary occupations like agriculture labour (62.7%), privet service (2.0%) and trade and business is 2.0 per cent each. About 3.9 per cent of the households are government service as main occupation.

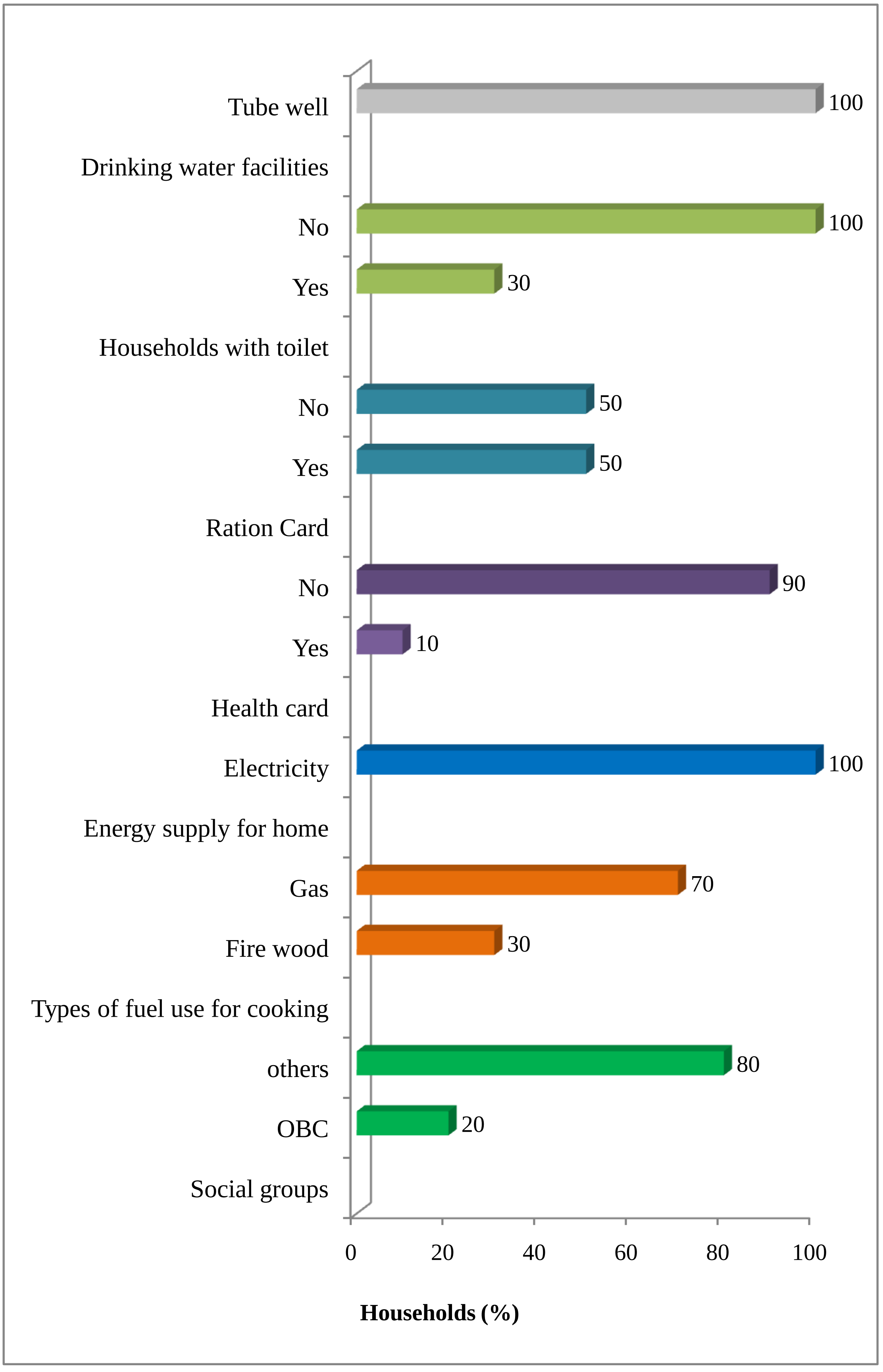

Figure 3: Basic needs of sample households in Kirinala 2 Micro watershed

Table 3: Occupational pattern in sample population in Kirinala 2 Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	29.4
	Agriculture Labour	62.7
	Private service	2.0
	Trade and business	2.0
Govt. service		3.9
Family labour availability		**Man days/month**
Male		25.0
Female		20.0
Total		45.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 4 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (100 %) followed by television (70.0 %), mixer/grinder (70 %), motorcycle (20 %) and refrigerator (20 %). The average value of domestic assets is around Rs 20203 per households.

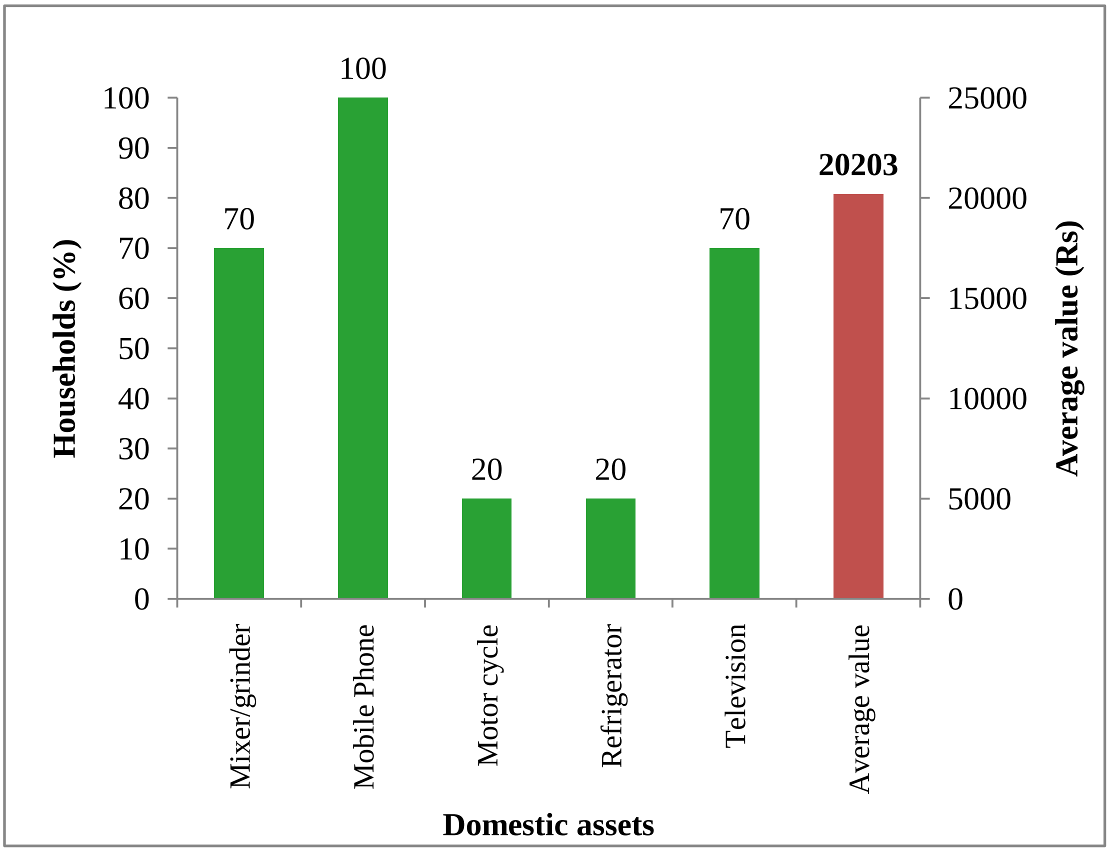

Figure 4: Domestic assets among the sample households in Kirinala 2 Micro watershed

Table 4: Domestic assets among the sample households in Kirinala 2 Microwatershed

Particulars	% of households	Average value in Rs
Mixer/grinder	70	2000
Mobile Phone	100	3870
Motor cycle	20	64000
Refrigerator	20	20000
Television	70	11143
Average value	20203	

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned bullock cart (10 %) followed by plough (10.0 %) and sprayer (10.0 %) was found highest among the sample farmers. The average value of farm assets is around Rs 6500 per households (Table 5 and Figure 5).

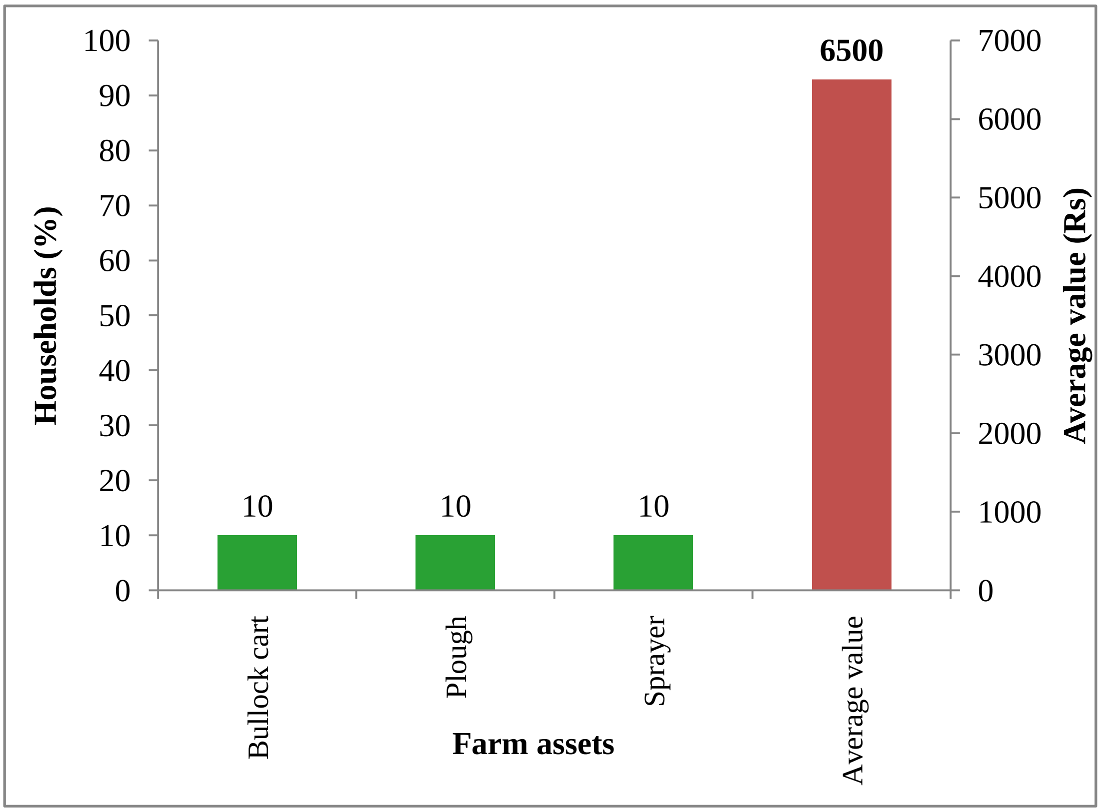

Figure 5: Farm assets among samples households in Kirinala 2 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 6 and Figure 6). The highest livestock population is dry buffalos were around 50.0 per cent followed by local dry cow (25.0 %) and bullocks (25.0 %). The average livestock value was Rs 46667 per household.

Table 5: Farm assets among samples households in Kirinala 2 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	10	15000
Plough	10	2000
Sprayer	10	2500
Average value	6500	

Table 6: Livestock assets among sample households in Kirinala 2 Microwatershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	25.0	25000
Dry Buffalos	50.0	15000
Bullocks	25.0	100000
Average value	46667	

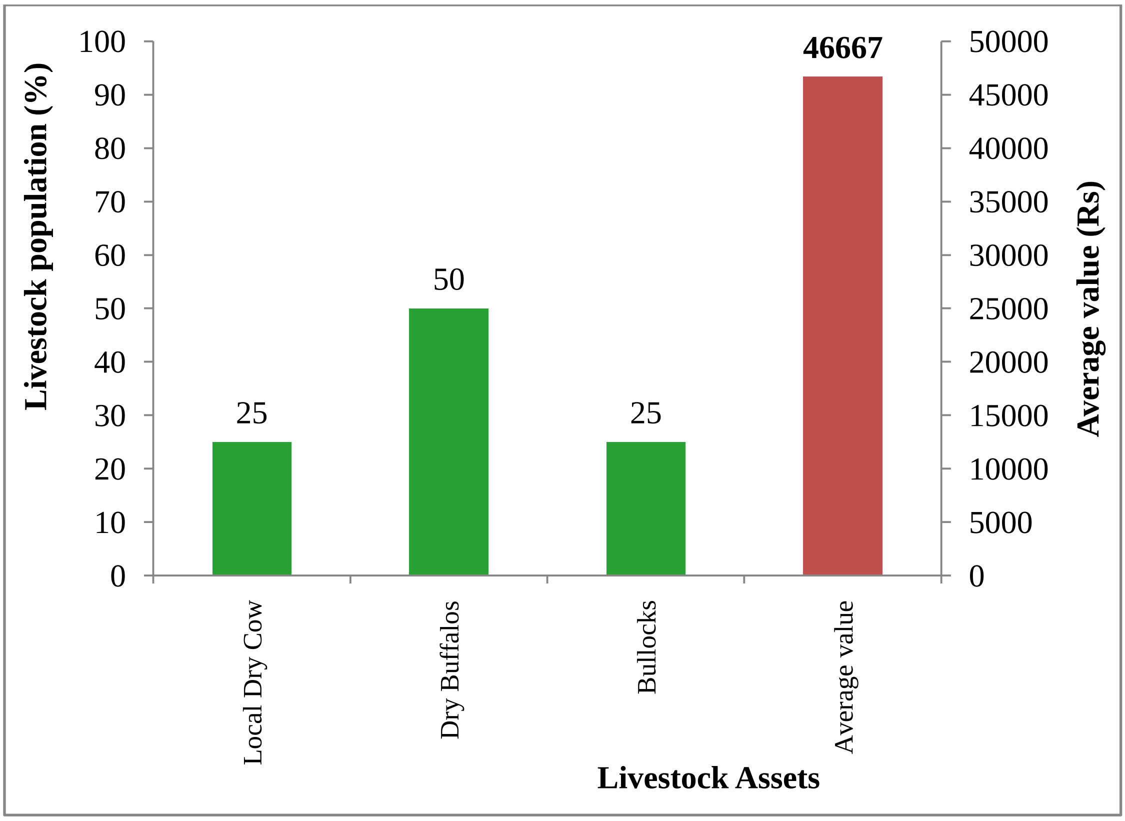

Figure 6: Livestock assets among sample households in Kirinala 2 Microwatershed

A woman participation in decision making is in this Microwatershed is presented in Table 7. About 100 per cent of women earning for her family requirement & agriculture related activities and only 10.0 percent of participated in local organization and 10.0 percent of women panchayat member.

Table 7: Women empowerment of sample households in Kirinala 2 Micro watershed
% to Grand Total

Particulars	Yes	No
Women participation local organization	10.0	90.0
Women Panchayat Member	10.0	90.0
Women earning for her family requirement	100.0	0.0
Women taking decision in her family and agriculture related activities	100.0	0.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 8 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1185.6 kcal per person. The other important food items consumed was pulses 165.7 kcal followed by cooking oil 149.0 kcal, milk 85.7 kcal, vegetables 25.5 kcal, egg 45.8 kcal and meat 2.3 kcal. In the sampled households, farmers were consuming less (1659.6 kcal) than NIN- recommended food requirement (2250.0 kcal).

Table 8: Per capita daily consumption of food among the sample households in Kirinala 2 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396.0	348.7	1185.6
Pulses	43.0	48.3	165.7
Milk	200.0	131.8	85.7
Vegetables	143.0	106.3	25.5
Cooking Oil	31.0	26.1	149.0
Egg	0.5	30.5	45.8
Meat	14.2	1.5	2.3
Total	**827.7**	**693.3**	**1659.6**
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		80.0	90.0
% Above NIN		20.0	10.0

Note: * day/person

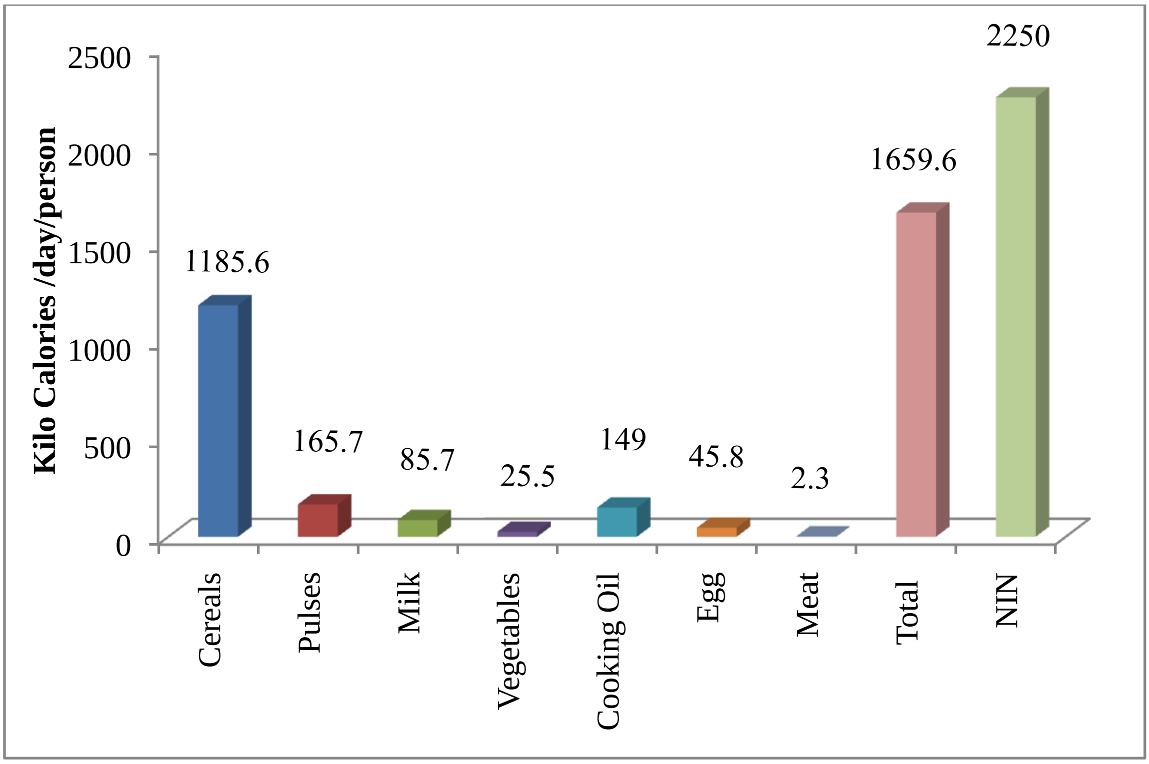

Figure 7: Per capita daily consumption of food among the sample households in Kirinala 2 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 30564. Major source of income to the farmers in the study area is from crop production (Rs 26474). The income from Non farm income was very low at Rs 4090. The monthly per capita income is Rs.499, which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 9).

Table 9: Annual average income of HHs from various sources in Kirinala 2 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	4090(30)
Livestock income (Rs)	0 (0)
Crop Production (Rs)	26474(100)
Total Annual Income (Rs)	***30564***
Average monthly per capita income (Rs)	499
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	80.0
% of households above poverty line	20.0

* 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. 36592) 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 1957.4 and about 80.0 per cent of farm households are below poverty line and 20.0 per of farm households are above poverty line (Table 10 and Figure 8).

Table 10: Average annual expenditure of sample HHs in Kirinala 2 Microwatershed

Particulars	Value in Rupees	Per cent
Food	36592	30.5
Education	2200	1.8
Clothing	6000	5.0
Social functions	51500	43.0
Health	23500	19.6
Total Expenditure (Rs/year)	119792	100
Monthly per capita expenditure (Rs)	1957	

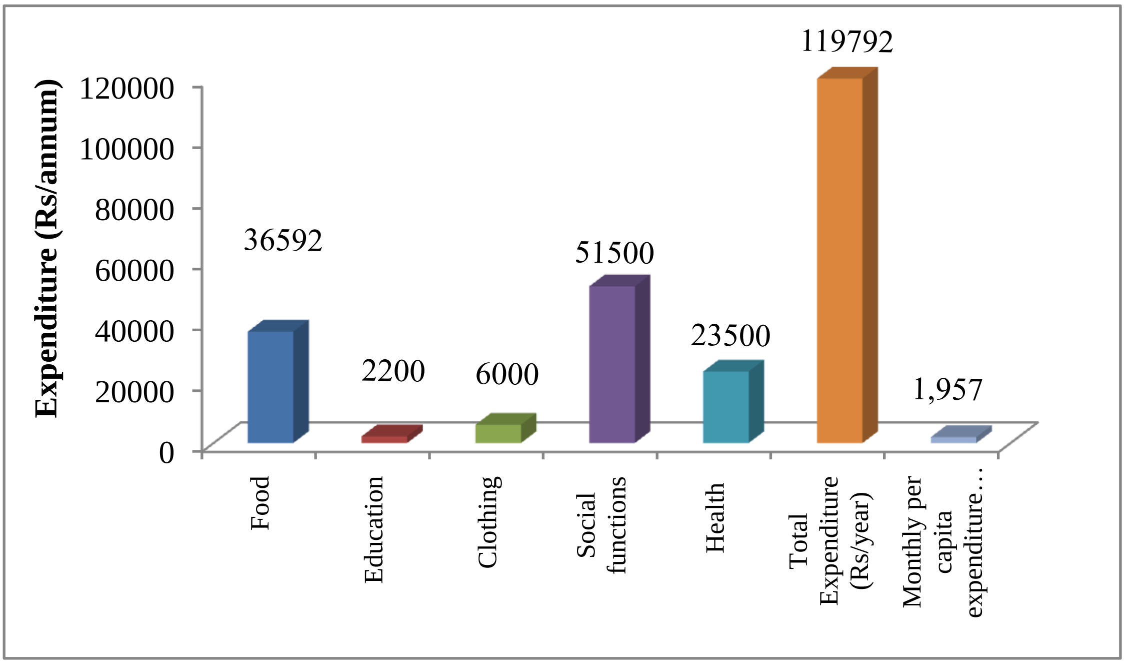

Figure 8: Average annual expenditure of sample HHs in Kirinala 2 Microwatershed

Land holding: The total area cultivated by them is 13.2 ha. The average land holding of sample HHs is 3.3 ha. Large number of sample HHs (70.0 %) belong to small size group with an average holding size of 0.9 ha followed by medium farmers (30.0 %) with an average holding size of 8.9 ha (Table 11).

Table 11: Distribution of land holding among the sample households in Kirinala 2 Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	6.1
Sample size	Percent	70.0
Average land holding	ha	0.9
Large farmers		
Total land	ha	26.6
Sample size	Percent	30.0
Average land holding	ha	8.9
Total sample households		
Total land	ha	13.2
Sample size	Percent	100.0
Average land holding	ha	3.3

Land use: The total land holding in the Kirinala 2 Microwatershed is 32.6 ha is rain fed land (Table 12). The average land holding per household is worked out to be 3.2 ha.

Table 12: Land use among samples households in Kirinala 2 Microwatershed

Particulars	Per cent	Area in ha
Rainfed Land	100.0	32.6
Irrigated land	0.0	0.0
Fallow Land	0.0	0.0
Total land holding	100.0	32.6
Average land holding	3.2	

In the Micro-watershed, the prevalent present land uses under perennial plants are neem tree (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 bengal gram (93.5 %) and red gram (6.5 %) during Rabi season respectively. The cropping intensity was 106 per cent (Table 13).

Table 13: Present cropping pattern and cropping intensity in Kirinala 2 Microwatershed

% to Grand Total

Crops	Kharif	Rabi	Grand Total
Bengal gram	0.0	93.5	93.5
Redgram	6.5	0.0	6.5
Grand total	6.5	93.5	100
Cropping intensity	106		

Economic land evaluation

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

In Kirinala 2 micro-watershed, 2 soil series are identified and mapped (Table 14). The distribution of major soil series are Dimal (DIM) covering an area around 169 ha (22.5 %) and Mannur 582 ha (77.52 %).

Table 14: Distribution of soil series in Kirinala 2 Micro watershed

Sl. No	Map unit	Description	Area in ha. (%)
1	DIM mA1	Deep, calcareous, black clayey soils developed from weathered basalt on nearly level uplands; clay surface on 0-1 % slope, slightly eroded	27 (3.5)
	DIM mB1	Deep, calcareous, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded	26 (3.4)
	DIM mB2	Deep, calcareous, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, moderately eroded	116 (15.5)
2	MAR mA1	Very deep, calcareous, black clayey soils developed from weathered basalt on nearly level sloping uplands; clay surface on 0-1% slope, slightly eroded	423 (56.4)
	MAR mB1	Very deep, calcareous, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	58 (7.7)
	MAR mB2	Very deep, calcareous, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded	101 (13.4)

Present cropping pattern on different soil series are given in Table 15. Crops grown on Dimal soils are Bengalgram, and Redgram and Mannar on (MNR) soils can grow.

Table 15: Cropping pattern on major soil series in Kirinala 2 Microwatershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry		Grand Total
			Kharif	Rabi	
DIM	Deep (100-150 cm)	Bengalgram	0.0	65.4	65.4
		Redgram	34.6	0.0	34.6
MAR	Very deep (>150 cm)	Bengalgram	0.0	94.8	94.8
		Redgram	5.2	0.0	5.2

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 16).

Table 16: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Kirinala 2 Microwatershed

Soil series	Small Farmer	Large Farmer
DIM	Bengal gram (1.3) & Red gram (1.7)	
MAR	Bengal gram (1.5) & Red gram (2.71)	Bengal gram (1.5)

The productivity of different crops grown in Kirinala 2 micro-watershed under potential yield of the crops is given in Table 17.

Table 17: Economic land evaluation and bridging yield gap for different crops in Kirinala 2 Microwatershed

Particulars	**DIM (100-150 cm)**		**MAR (>150 cm)**	
	Bengalgram	**Redgram**	**Bengalgram**	**Redgram**
Total cost (Rs/ha)	28131	24315	18563	15976
Gross Return (Rs/ha)	37678	41496	28030	43225
Net returns (Rs/ha)	9547	17181	9467	27249
BCR	1.34	1.71	1.52	2.71
Farmers Practices (FP)				
FYM (t/ha)	2.1	2.0	1.8	1.3
Nitrogen (kg/ha)	101.7	64.0	74.4	80.0
Phosphorus (kg/ha)	73.1	46.0	53.8	57.5
Potash (kg/ha)	0.0	0.0	0.6	0.0
Grain (Qtl/ha)	9.5	12.0	7.7	12.5
Price of Yield (Rs/Qtl)	4000	3500	3643	3500
Soil test based fertilizer Recommendation (STBR)				
FYM (t/ha)	7.4	7.4	7.4	7.4
Nitrogen (kg/ha)	18.5	24.7	18.5	24.7
Phosphorus (kg/ha)	37.1	49.4	41.0	49.4
Potash (kg/ha)	27.8	18.5	27.8	18.5
Grain (Qtl/ha)	14.8	12.4	14.8	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)				
FYM (%)	71.4	73.0	75.9	83.1
Nitrogen (%)	-449.0	-159.1	-301.8	-223.9
Phosphorus (%)	-97.3	6.9	-31.3	-16.4
Potash (%)	100.0	100.0	97.8	100.0
Grain (%)	35.7	2.8	48.2	-1.2
Value of yield and Fertilizer (Rs)				
Additional Cost (Rs/ha)	3263	5459	4935	5511
Additional Benefits (Rs/ha)	21144	1225	26031	-525
Net change Income (Rs/ha)	17881	-4233	21096	-6035

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 17. The total cost of cultivation in study area for bengal gram ranges between Rs.28131/ha in DIM soil (with BCR of 1.34) and Rs.18563/ha in MAR soil (with BCR of 1.52) and red gram range between Rs 24315/ha in DIM soil (with BCR of 1.1.71) and Rs.15976/ha in BLD soil (with BCR of 2.71).

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 17. 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 range between Rs 21096 and Rs 17883 in bengal gram cultivation.

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 18 and Figure 9. The average value of soil nutrient loss is around Rs 684.81 per ha/year. The total cost of annual soil nutrients is around Rs 512923 per year for the total area of 749.96 ha.

Table 18: Estimation of onsite cost of soil erosion in Kirinala 2 micro-watershed

Particulars	**Quantity(kg)**		**Value (Rs)**	
	Per ha	**Total**	**Per ha**	**Total**
Organic matter	97.16	72770	612.08	458449
Phosphorus	0.09	69	4.07	3046
Potash	2.23	1670	44.58	33394
Iron	0.04	28	1.78	1332
Manganese	0.04	29	10.50	7868
Cupper	0.01	9	6.89	5160
Zinc	0.00	1	0.07	56
Sulphur	0.12	87	4.63	3468
Boron	0.01	4	0.20	150
Total	99.69	74666	684.81	512923

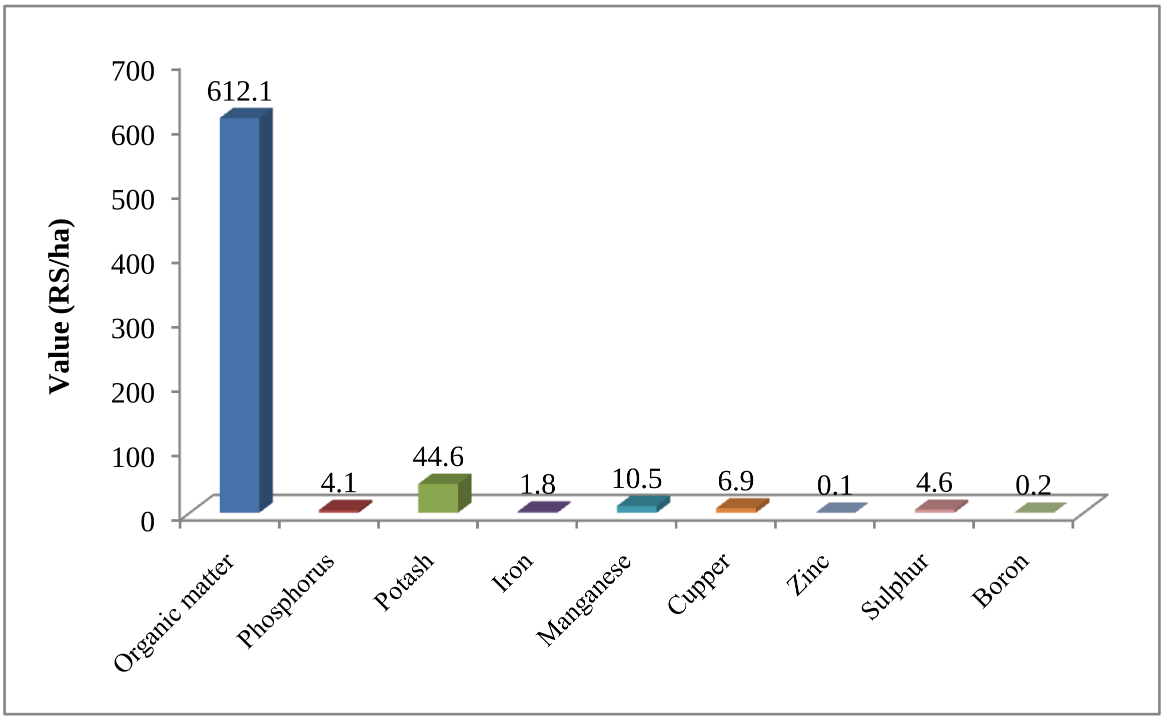

Figure 9: Estimation of onsite cost of soil erosion in Kirinala 2 Microwatershed

The average value of ecosystem service for food grain production is around Rs 15631/ ha/year (Table 19 and Figure 10). Per hectare food grain production services is maximum in red gram (Rs 22215) and bengal gram (9047).

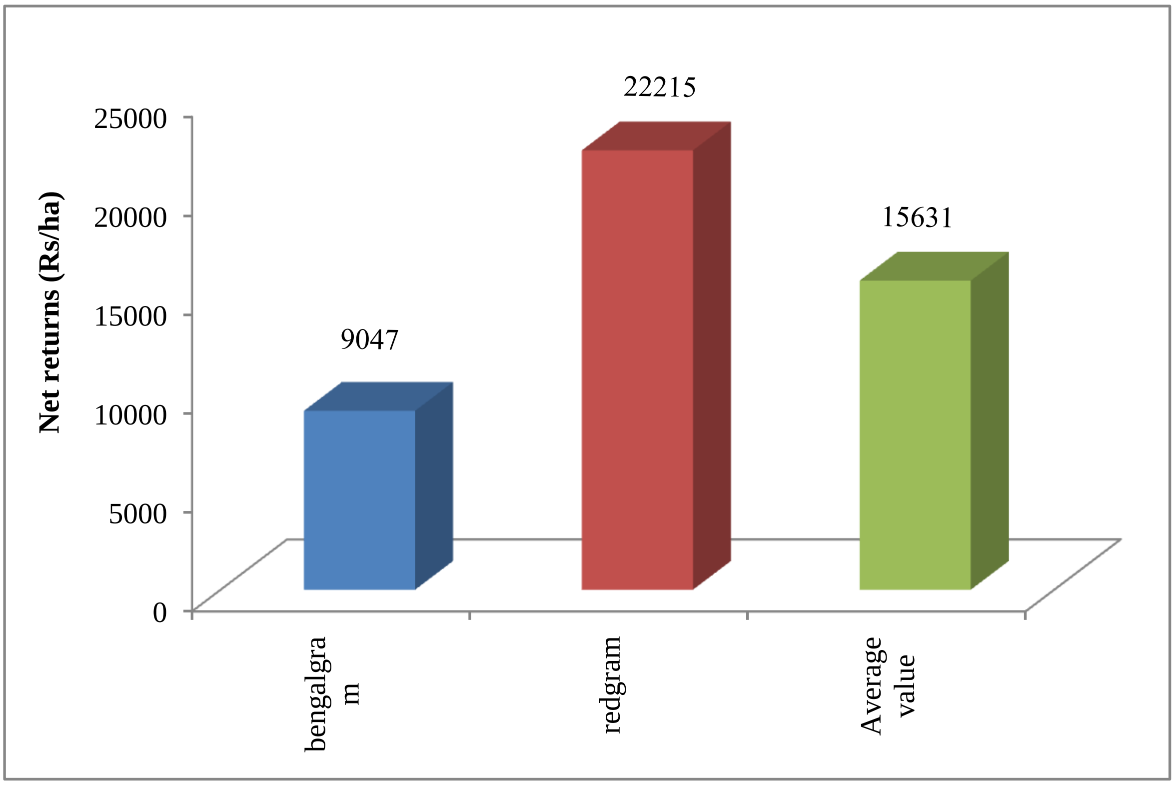

Figure 10: Ecosystem services of food grain production in Kirinala 2 Microwatershed

Table 19: Ecosystem services of food grain production in Kirinala 2 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Pulses	Bengal gram	30.5	7.8	3688	28806	19759	9047
	Red gram	2.1	12.1	3500	42361	20146	22215
Average value		32.6	10.0	3594	35584	19953	15631

The water demand for production of different crops was worked out in arriving at the ecosystem services of water support to crop growth. The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum (Table 20) in red gram (Rs. 65889) and bengal gram (Rs. 53949).

Table 20: Ecosystem services of water supply in Kirinala 2 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Bengalgram	7.8	5394	53949	691
Redgram	12.1	6588	65889	544
Average value	10.0	5992	59919	618

The main farming constraints in Kirinala 2 Microwatershed to be found are damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on bank of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 21).

Table 21: Farming constraints related land resources of sample households in Kirinala 2 Microwatershed

Sl. No	Particulars	Per cent
1	Damage of crops by Wild Animals	10.0
2	Non availability of Plant Protection Chemicals	100.0
3	**Source of loan**	
	Bank	100.0
4	**Market for selling**	
	Village market	100.0
5	**Sources of Agri-Technology information**	
	Newspaper	30.0
	Television	70.0

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.