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

KINHI (4D5B7G1a) MICROWATERSHED

Gulbarga Taluk, Gulbarga District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project



ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING



**WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE**



About ICAR - NBSS&LUP

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

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

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TO OBTAIN COPIES,

Please write to:

Director, ICAR - NBSS & LUP,

Amaravati Road, NAGPUR - 440 033, India

Phone : (0712) 2500386, 2500664, 2500545 (O)

Telefax : 0712-2522534

E-Mail : director@nbsslup.ernet.in

Website URL : nbsslup.in

Or

Head, Regional Centre, ICAR - NBSS&LUP, Hebbal, Bangalore - 560 024

Phone : (080) 23412242, 23510350 (O)

Telefax : 080-23510350

E-Mail : nbssrcb@gmail.com



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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 Inventory. 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 Kinhi Microwatershed, Gulbarga Taluk, Gulbarga District, Karnataka” for integrated development was taken up in collaboration with the State Agricultural Universities, IISC, KSRISAC, KSNDC 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 randomly selected representing landed and landless class of farmers in the microwatershed. 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, agricultural extension personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

Nagpur

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S.K. SINGH

Director, ICAR - NBSS&LUP, Nagpur

Contributors

Dr. RajendraHegde Principal Scientist, Head & Project Leader, Sujala-III Project ICAR-NBSS&LUP, Regional Centre Bangalore	Dr. S.K.Singh Director, ICAR-NBSS&LUP Coordinator, Sujala-III Project Nagpur
Soil Survey, Mapping & Report Preparation	
Dr. B.A. Dhanorkar	Sh. R.S. Reddy
Dr. K.V. Niranjana	Sh. Nagendra, B.R.
	Smt. Chaitra, S.P.
	Sh. Somashekar
	Dr. H. R. Savitha
	Dr. B. Gayathri
	Dr. Gopali Bardhan
Field Work	
Sh. C.BacheGowda	Sh. Mahesha, D.B.
Sh. Somashekar	Sh. Ashok S. Sindagi
Sh. VenkataGiriyappa	Sh. Veerabhadrappe
Sh. M. Jayaramaiah	Sh. Anand
Sh. Paramesha, K.	Sh. Arun N Kambar
	Sh. Shankarappa, K.
	Sh. Kamalesh K. Avate
	Sh. Sharan Kumar Huppar
	Sh. Yogesh, H.N.
	Sh. Kalaveerachari R. Kammar
GIS Work	
Dr. S.Srinivas	Sh. A.G.Devendra Prasad
Dr. M.Ramesh	Sh. Prakashanaik, M.K.
Sh. D.H.Venkatesh	Sh. AbhijithSastry, N.S.
Smt.K.Sujatha	Sh. Sudip Kumar Suklabaidya
Smt. K.V.Archana	Sh. Mahamad Ali, M.
Sh. N.Maddileti	Sh. Avinash, K.N.
	Sh. Amar Suputhra, S
	Sh. Anudeep, Y.
	Sh. Deepak, M.J.
	Smt. K.Karunya Lakshmi
	Ms. Seema, K.V.
	Ms. A. Rajab Nisha

Laboratory Analysis		
Dr. K.M.Nair	Ms. Thara, V.R	
Smt. ArtiKoyal	Ms. Steffi Peter	
Smt. Parvathy, S.	Ms. Roopa, G.	
	Sh. Shantaveera Swami	
	Ms. Shwetha, N.K.	
	Smt. Ishrat Haji	
	Ms. P. PavanKumari	
	Ms. Padmaja	
	Ms. Veena, M.	
Soil & Water Conservation		
Sh. Sunil P. Maske		
Socio-Economic Analysis		
Dr. S.C. Ramesh Kumar	Sh. M. K. Prakashanaik	
	Ms. Sowmya K.B	
	Sh.Manjunath M	
	Sh.Veerabhadraswamy R	
	Sh.Lankesh RS	
	Sh.Kalaveerachari R Kammar	
	Sh.Pradyumma U	
	Sh.Yogesha HN	
	Sh.Vijay kumar lamani	
	Sh.Arun N Kambar	
	Sh.Vinay	
	Sh.Basavaraj.Biradar	
	Sh.Vinod R	
	Sh.Praveenkumar P Achalkar	
	Sh.Rajendra D	
Watershed Development Department, GoK, Bangalore		
Sh. Rajeev Ranjan IFS Project Director & Commissioner, WDD	Dr. A. Natarajan NRM Consultant, Sujala-III Project	
Dr. S.D. Pathak IFS Executive Director & Chief Conservator of Forests, WDD		

PART-A

LAND RESOURCE INVENTORY

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EXECUTIVE SUMMARY

The land resource inventory of Kinh 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 microwatershed.

The present study covers an area of 650 ha in Kinh microwatershed in Gulbarga taluk of Gulbarga district, Karnataka. The climate is semiarid and categorized as drought-prone with an average annual rainfall of 740 mm, of which about 540 mm is received during south-west monsoon, 126 mm during north-east and the remaining 74 mm during the rest of the year. An area of about 93 per cent is covered by soils, seven per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- ❖ *The soils belong to 8 soil series and 19 soil phases (management units) and 5 land use classes.*
- ❖ *The length of crop growing period is about 120-150 days starting from the 3rd week of May to 1st week of October.*
- ❖ *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- ❖ *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- ❖ *Land suitability for growing 19 major agricultural and horticultural crops were assessed and maps showing degree of suitability along with constraints were generated.*
- ❖ *About 92 per cent area is suitable for agriculture and 8 per cent is not suitable for agriculture.*
- ❖ *About 15 per cent of the soils are moderately deep to deep (75-150 cm), 3 per cent of the soils are very deep (>150cm), 67 per cent are shallow to moderately shallow (25-75 cm) and about 8 per cent are very shallow (<25 cm) soils.*
- ❖ *Entire area in the microwatershed has clayey soils at the surface.*
- ❖ *About 66 per cent of the area has non-gravelly soils, 28 per cent gravelly to very gravelly soils (15-60 % gravel).*
- ❖ *About 15 per cent of the area has soils that are very high (>200mm/m) in available water capacity, 42 per cent medium (100-150 mm/m) and about 37 per cent low (51-100 mm/m) to very low (<50 mm/m).*
- ❖ *About 74 per cent of the area has very gently sloping (1-3%) lands, about 16 per cent area is gently (3-5%) to moderately sloping (5-10%) lands and about 3 per cent area is nearly level (0-1%) lands.*
- ❖ *An area of about 40 per cent has soils that are slightly eroded (e1), 30 per cent moderately eroded (e2) and 23 per cent severely eroded (e3).*
- ❖ *An area of about 32 per cent has soils that are slightly alkaline to moderately alkaline (pH 7.3 to 8.4), 13 per cent slightly acid (pH 6.0-6.5) and 48 per cent area is neutral (pH 6.5-7.3) in soil reaction.*
- ❖ *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm⁻¹ indicating that the soils are non-saline.*
- ❖ *About 12 per cent medium (0.5-0.75%), 80 per cent high (>0.75%) and 1 per cent low (<0.5%) in organic carbon.*

- ❖ Major area of 89 per cent has soils that are low (<23 kg/ha), 3 per cent medium (23-57 kg/ha) and 1 per cent high (>57 kg/ha) in available phosphorus.
- ❖ About 58 per cent medium (145-337 kg/ha), 1 per cent high (>337 kg/ha) and 34 per cent low (<145 kg/ha) in available potassium.
- ❖ Available sulphur is low (<10 ppm) in about 24 per cent area, medium (10-20 ppm) in 69 per cent and less than one per cent high (>20 ppm).
- ❖ Available boron is low (<0.5 ppm) in about 55 per cent area, 37 per cent medium (0.5-1.0 ppm) and high (>1.0 ppm) in 1 per cent area.
- ❖ Available iron, manganese and copper are sufficient in all the soils.
- ❖ About 42 per cent area has soils that are deficient (<0.6 ppm) in available zinc and 52 per cent sufficient (>0.6 ppm).
- ❖ The land suitability for 19 major crops grown in the microwatershed was assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.

Land suitability for various crops in the microwatershed

Crop	Suitability Area in ha (%)		Crop	Suitability Area in ha (%)	
	Highly suitable (S1)	Moderately suitable (S2)		Highly suitable (S1)	Moderate ly suitable (S2)
Sorghum	99 (15)	246 (38)	Guava	-	315(49)
Maize	-	222(34)	Jackfruit	-	-
Red gram	-	345 (53)	Jamun	-	99(15)
Sunflower	99 (15)	-	Musambi	21 (3)	294(45)
Cotton	95 (15)	250 (38)	Lime	21 (3)	294(45)
Sugarcane	-	-	Cashew	-	-
Soybean	99 (15)	246 (38)	Custard apple	316 (49)	209(32)
Bengalgram	322(50)	200(31)	Amla	316 (49)	177 (27)
Mango	-	-	Tamarind	-	99 (15)
Sapota	-	315(49)			

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 5 identified LUCs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops that helps in sustained production and also 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, field bunds and also in the hillocks, mounds and ridges. This would helps in not only supplementing the farm income but also provide fodder and fuel, generate lot of biomass which would help in maintaining an ecological balance also also contribute to mitigating the climate change.

INTRODUCTION

Soil is a finite natural resource that is central to sustainable agriculture and food security. Over the years, this precious resource is faced with problems of erosion, salinity, alkalinity, degradation, depletion of nutrients and even decline in the availability of land for agriculture. It is a known fact, that it takes thousands of years to form a few centimetres of soil; thus, soil is a precious gift of nature. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agro-climatic setting, and use and management. There is, therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. Soil erosion alone has degraded about 35 lakh ha. Almost all the areas are facing various degrees of degradation, particularly soil erosion; salinity and alkalinity has emerged as a major problem in more than 3.5 lakh ha in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situation to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. Added to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Thus, developing strategies to slow down the degradation process or reclaim the soils to normal condition and ensure sustainability of production system are the major issues today. This demands a systematic appraisal of our soil and land resources with respect to their extent, geographic distribution, characteristics, behaviour and use potential, which is very important for developing an effective land use and cropping systems for augmenting agricultural production on a sustainable basis.

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

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

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

The land resource inventory aims to provide site specific database for Kinhi microwatershed in Gulbarga Taluk, Gulbarga District, Karnataka state for the Karnataka Watershed Development Department. The database was generated by using cadastral map of the village as a base along with high resolution IRS LISS IV and Cartosat-1 merged satellite imagery.

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

GEOGRAPHICAL SETTING

2.1 Location and Extent

The study area of Kinhi microwatershed (Sonath subwatershed) is located in the northern part of Karnataka in Gulbarga Taluk, Gulbarga District, Karnataka State (Fig.2.1). It comprises parts of Dongargaon, Dhanura, Hallikhedra and Dharjamga villages. It lies between $17^{\circ} 38'$ and $17^{\circ} 40'$ North latitudes and $77^{\circ} 02'$ and $77^{\circ} 03'$ East longitudes and covers an area of 650 ha. It is about 50 km from Gulbarga town and is surrounded by Dongargaon on the west, Dhanura on the northwest, Hallikhedra on the northeast and Dharjamga village on the southeast.

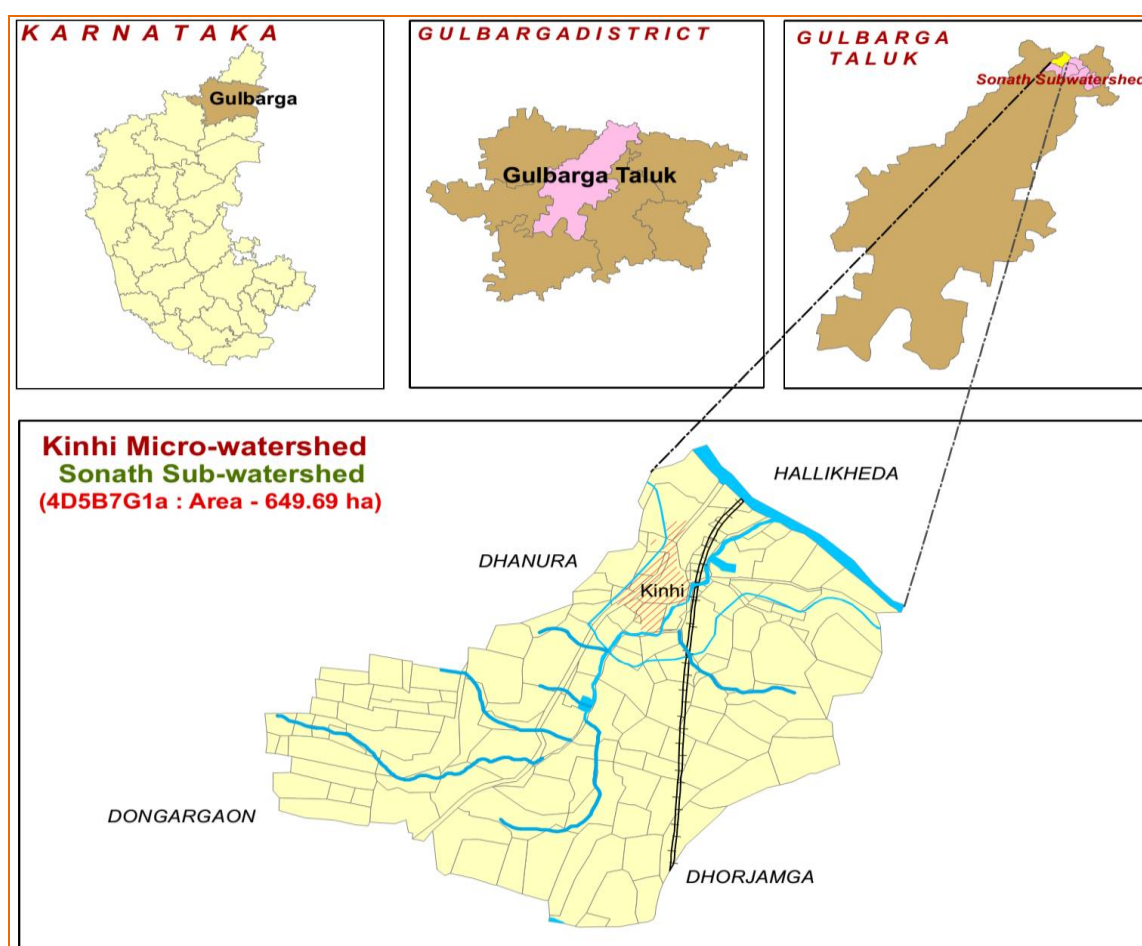


Fig.2.1 Location map of Kinhi Microwatershed

2.2 Geology

Major rock formation observed in the microwatershed is Basalt (Fig.2.2) or Deccan Trap. The Deccan Traps covers the whole of Bidar, parts of Gulbarga, 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 rocks

2.3 Physiography

Physiographically, the area has been identified as basalt landscape based on geology. The area has been further subdivided into four landforms, viz; mounds/ridges, summits, side slopes and very gently sloping uplands based on slope and its relief features. The elevation ranges from 543 to 628 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 down stream joins Awarja river along its course. Though, it is not a perennial one, during rainy season it carries large quantities of rain water. The microwatershed has only few small tanks which are not capable of storing the water that flows during the rainy season. Due to this, the ground water recharge is very much affected. This is reflected in the failure of many bore wells in the villages. If the available rain water is properly harnessed by constructing new tanks and recharge structures at appropriate places in the villages, then the drinking and irrigation needs of the area can be easily met. The drainage network is parallel to sub parallel and dendritic.

2.5 Climate

The Gulbarga 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 740 mm (Table 2.1). Of the total rainfall, maximum of 540 mm is received during the south–west monsoon period from June to September, the north-east monsoon from October to early December contributes about 126 mm and the remaining 74 mm during the rest of the year. December is the coldest month with mean daily maximum and minimum temperatures being 29.5⁰C and 15⁰ to 10⁰C respectively. During peak summer, temperatures shoot up to 45⁰C. Relative humidity varies from 26 per cent in summer to 62 per cent in winter. Rainfall distribution is shown in Figure 2.3. The average Potential Evapo-Transpiration (PET) is 159 mm and varies from a low of 115 mm in December to 232 mm in the month of May. The PET is always higher than precipitation in all the months except August and September. Generally, the Length of crop Growing Period (LGP) is 120-150 days and starts from 3rd week of May to first week of October.

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

Sl. No.	Months	Rainfall	PET	1/2 PET
1	January	5.7	126.8	63.40
2	February	3.6	143.9	71.95
3	March	13.2	189.9	94.95
4	April	17.4	209.8	104.9
5	May	33.6	232.2	116.1
6	June	90.4	186.4	93.2
7	July	138.0	152.8	76.4
8	August	150.4	147.6	73.8
9	September	161.2	131.7	65.85
10	October	102.8	145.5	72.75
11	November	18.7	129.8	64.9
12	December	4.4	114.8	57.4
Total		739.4	159.2	

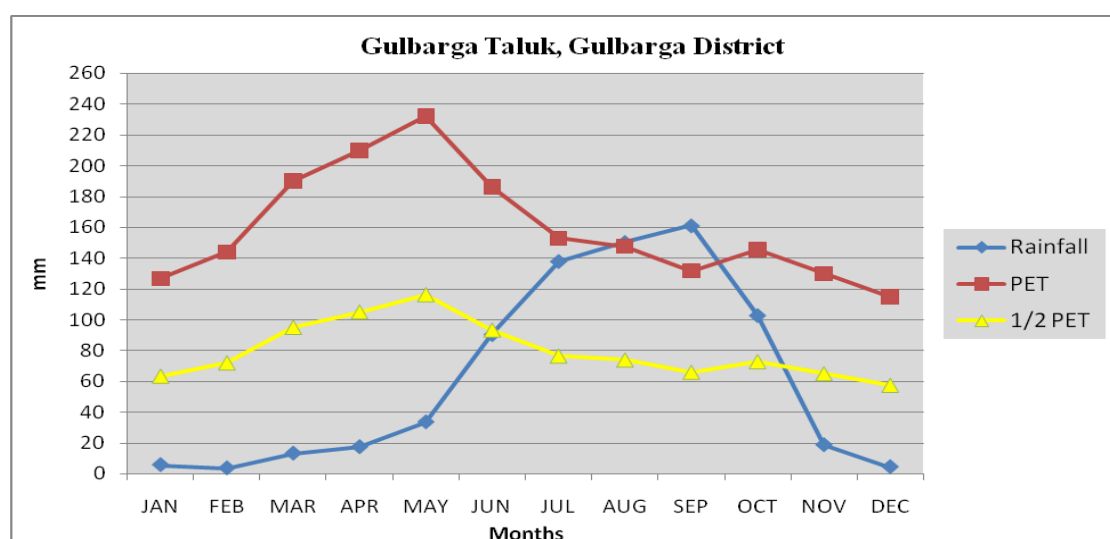


Fig 2.3 Rainfall distribution in Gulbarga Taluk,

2.6 Natural Vegetation

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

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



Fig. 2.4 Natural Vegetation (Scrubs) of Kinhi Microwatershed

2.7 Land Utilization

About 77 per cent area (Table 2.2) in Gulbarga taluk is cultivated at present. An area of about 2 per cent is permanently under pasture, 11 per cent under current fallows, 5 per cent under nonagricultural land and 2 per cent under currently barren. Forests occupy an area of about 2 per cent and the tree cover is in a very poor state. Most of the mounds, ridges and bouldery areas have very poor vegetative cover. Major crops grown in the area are sorghum, maize, cotton, sugarcane, red gram and sapota. While carrying out land resource inventory, the land use/land cover particulars are collected from all the survey numbers and a current land use map of the microwatershed is prepared. The current land use map prepared shows the arable and non-arable lands, other land uses and different

types of crops grown in the area. The current land use map of Kinhi microwatershed is presented in Fig.2.5. Simultaneously, enumeration of wells (bore wells and open wells) and existing conservation structures 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 Kinhi microwatershed is given in Fig.2.6.

Table 2.2 Land Utilization in Gulbarga Taluk

Sl. No.	Agricultural land use	Area (ha)	Per cent
1	Total geographical area	173165	
2	Total cultivated area	132954	76.77
3	Area sown more than once	2510	1.44
4	Cropping intensity	-	101.89
5	Trees and grooves	67	0.038
6	Forest	4121	2.37
7	Cultivable wasteland	78	0.045
8	Permanent Pasture land	4322	2.49
9	Barren land	4223	2.43
10	Non- Agriculture land	8150	4.70
12	Current Fallows	18760	10.8

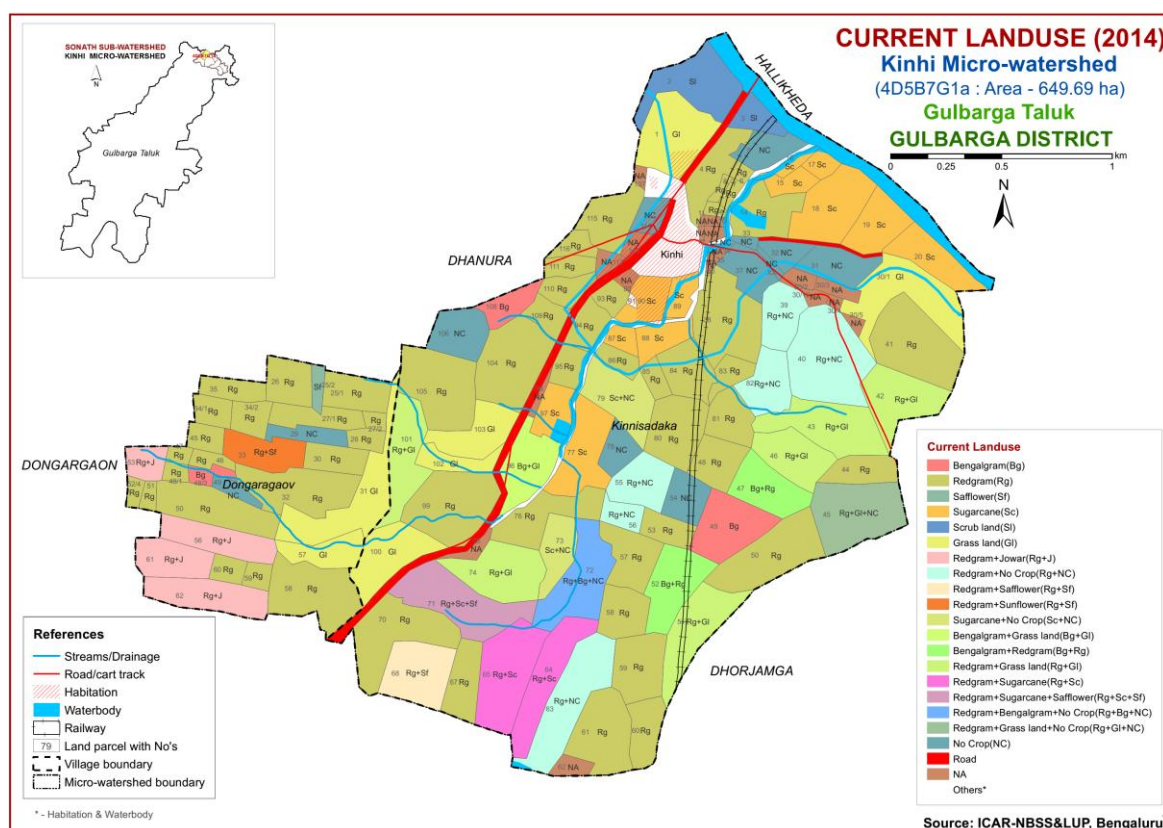


Fig.2.5 Current Land Use map of Kinhi Microwatershed

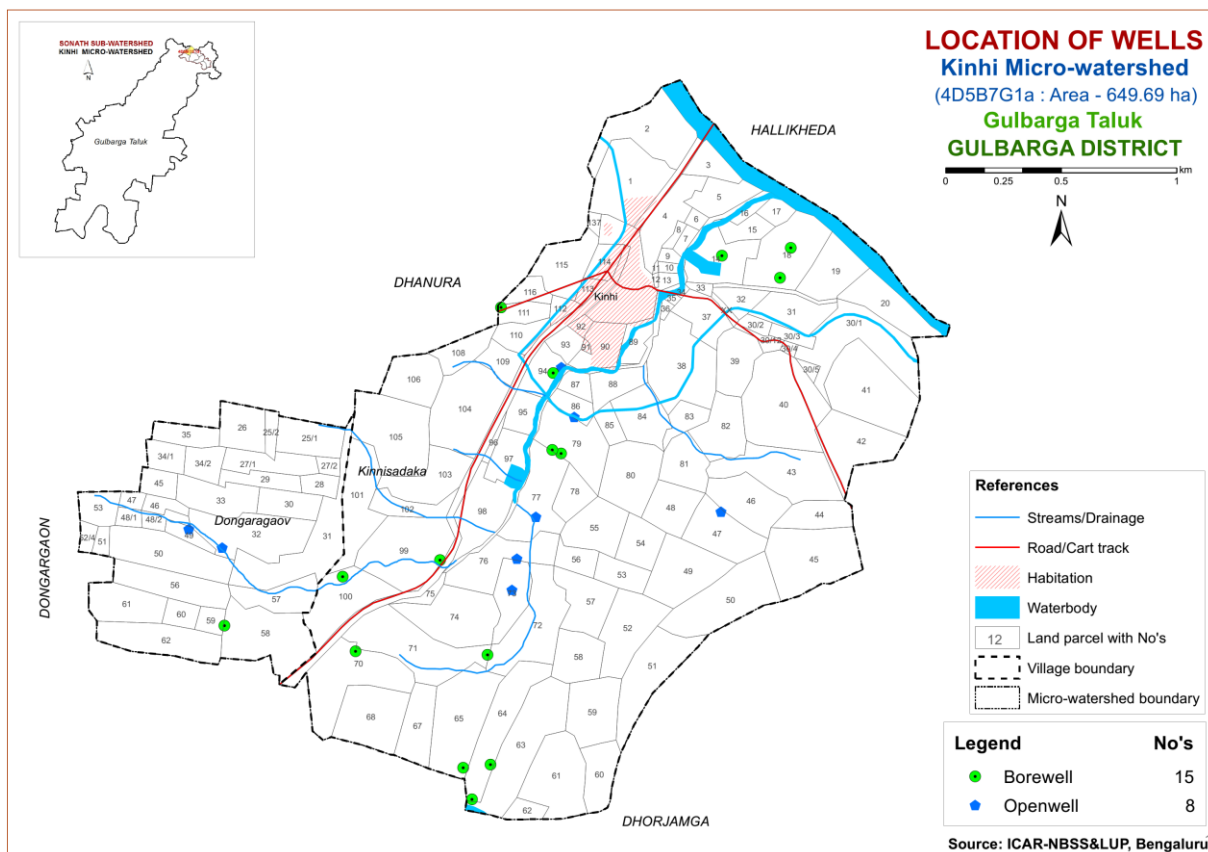


Fig.2.6 Location of Wells in Kinhi Microwatershed

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 Kinhí 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 650 ha area. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan *et al.*, 2015) which is briefly described below.

3.1 Base Maps

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

3.2 Image Interpretation for Physiography

False Colour Composites (FCCs) of Cartosat-I and LISS-IV merged satellite data covering microwatershed area was visually interpreted using image interpretation elements and all the available collateral data with local knowledge. The delineated physiographic boundaries were transferred on to a cadastral map overlaid on satellite imagery. Physiographically, the area has been divided as basalt landscape. It was divided into three landforms, *viz*; ridges and mounds, uplands and lowlands based on slopes and image characteristics. They were further subdivided into physiographic/image interpretation units based on image characteristics.

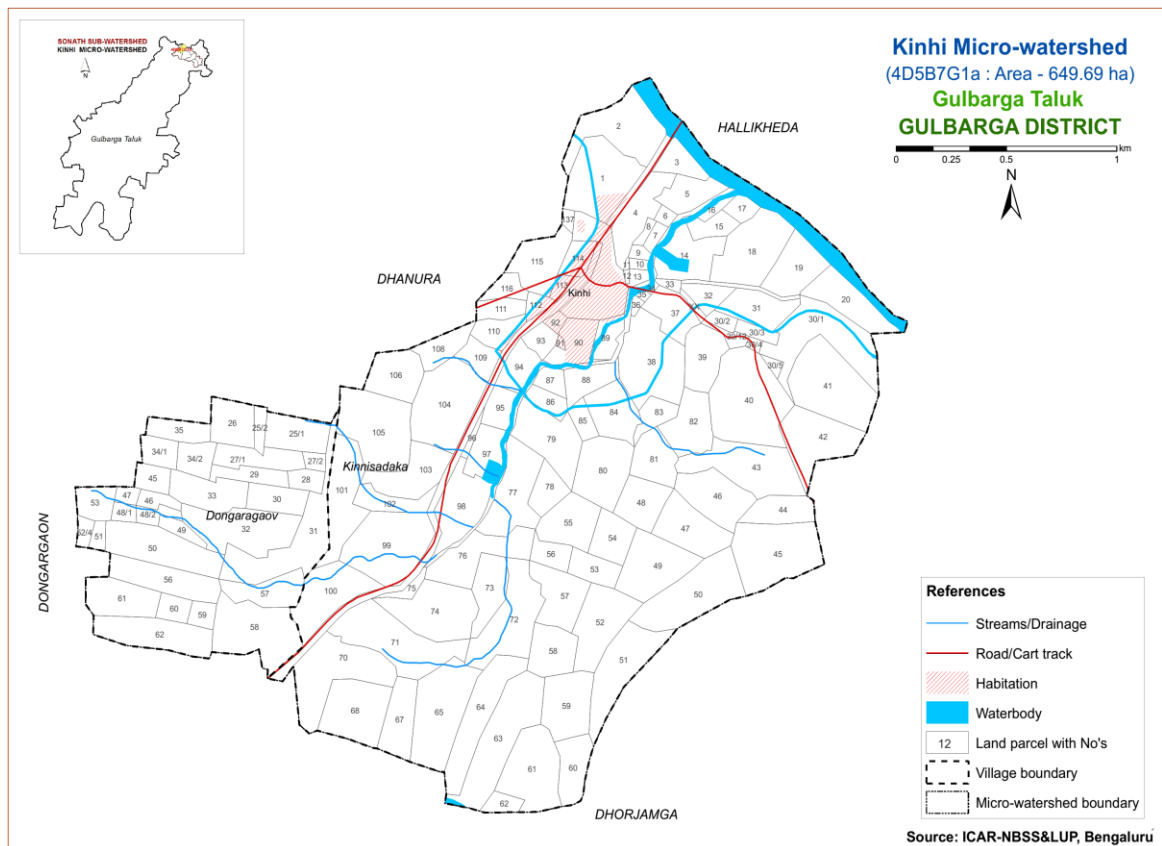


Fig 3.1 Scanned and Digitized Cadastral map of Kinhi Microwatershed

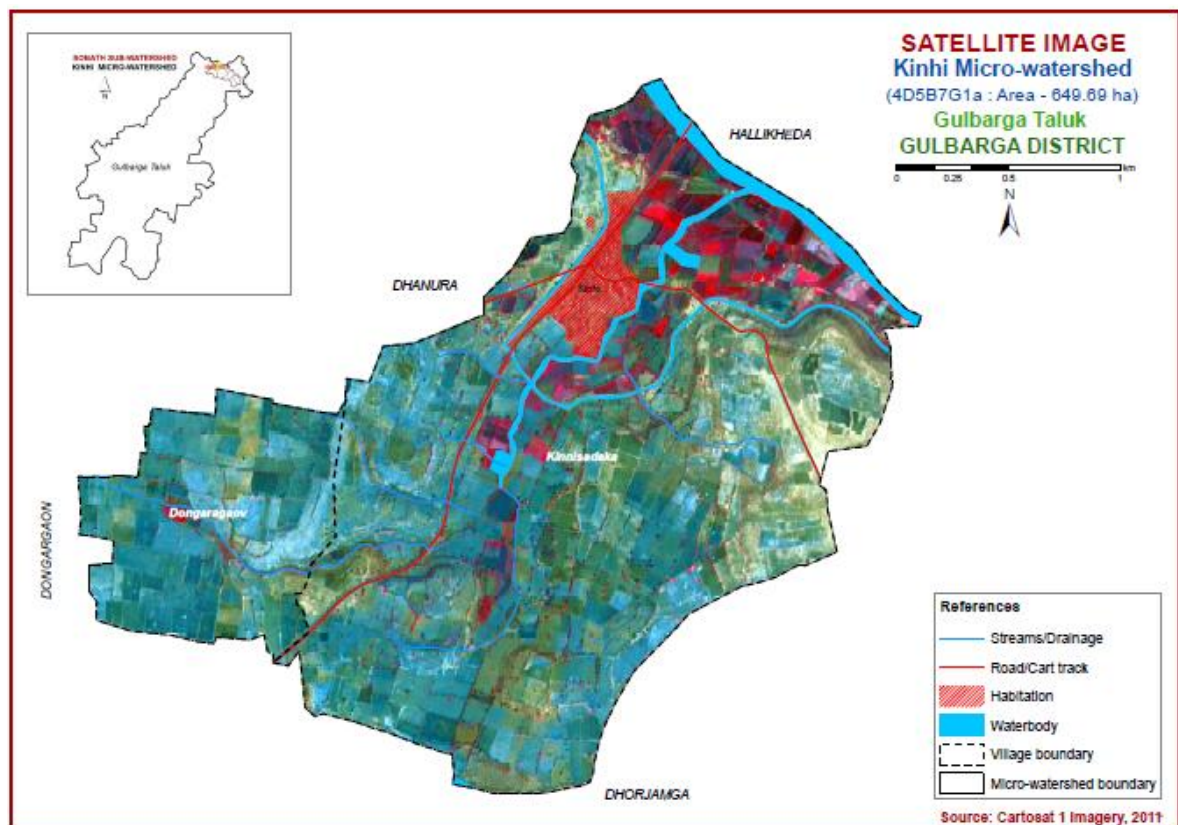


Fig.3.2 Satellite Image of Kinhi Microwatershed

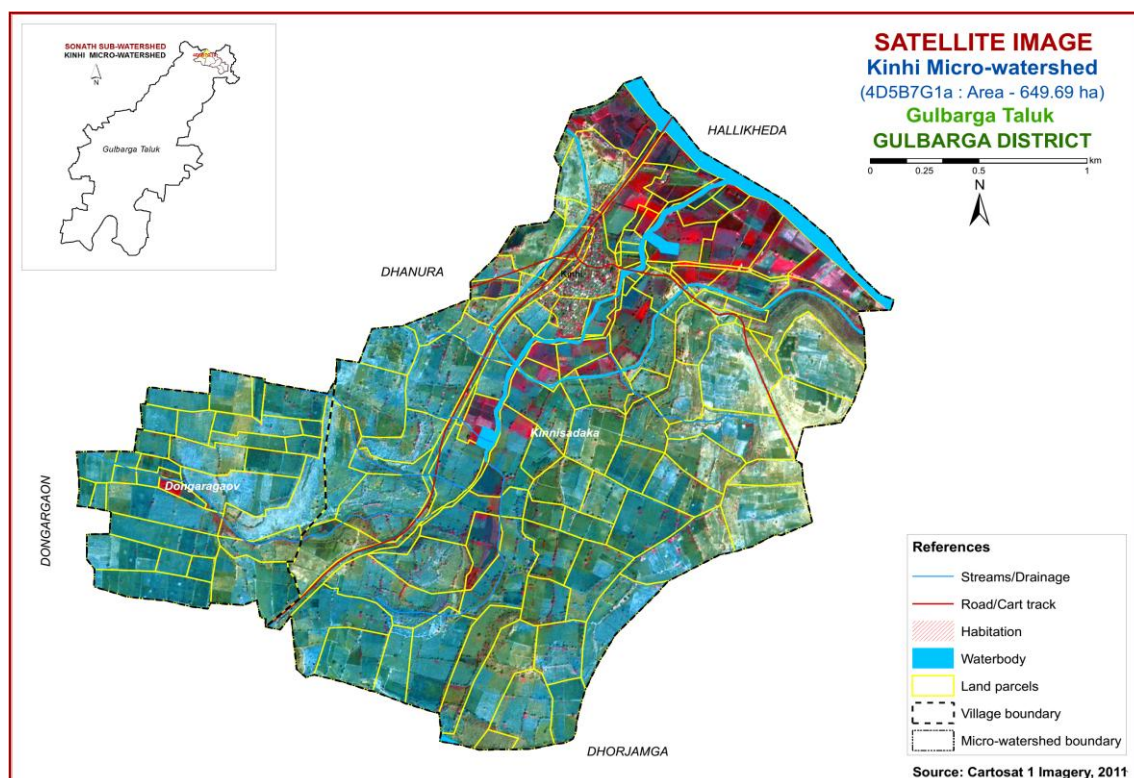


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Kinhi Microwatershed

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).

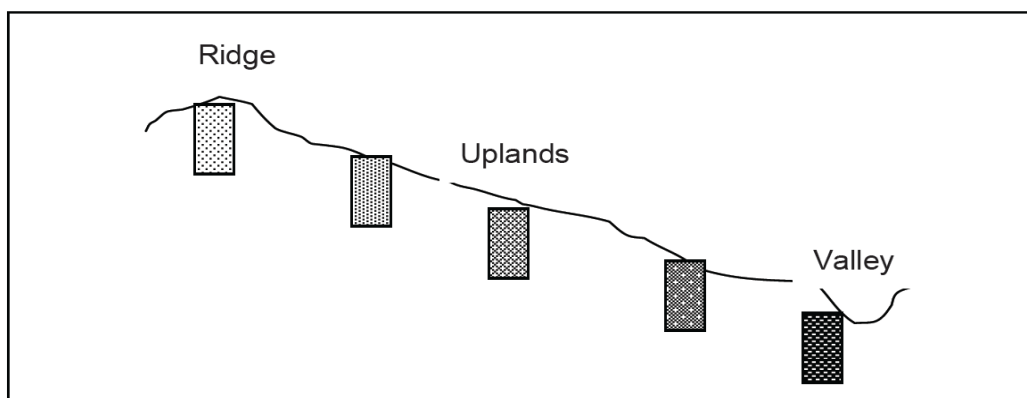


Fig: 3.4. Location of profiles in a transect

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, calcareousness etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying soil series are given in Table 3.1. Based on the above characteristics, 8 soil series were identified in the Kinhi 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)	Texture	Gravel (%)	Horizon sequence	Calcareousness
1	Dinsi (DSI)	50-75	10YR3/2, 4/2	c	<15	Ap-BA-Bss	-
2	Kalamundargi (KGI)	25-50	10YR 4/3,4/2 7.5YR3/3,3/4,4/3	c	35-60	Ap-Bt-cr	-
3	Kamalapur (KMP)	75-100	10YR3/2,3/1	c	<15	Ap-Bw-Bss-cr	
4	Mahagaon (MAN)	>150	10YR3/2,3/1	c	<15	Ap-BA-Bss	-
5	Margutti (MGT)	<25	10YR3/3,4/3,5/ 7.5YR4/3	c	15-35	Ap- cr	-
6	Novinihala (NHA)	25-50	10YR3/2,3/1,4/2 7.5YR3/4	c	<15	Ap-Bw-cr/R	-
7	Ramnelli (RMN)	75-100	10YR3/1,3/2,4/2, 4/3	c	35-60	Ap-Bw-Bss	-
8	Rajanala (RNL)	100-150	10YR3/2,3/1,4/2, 4/3	c	<15	Ap-BA-Bss-cr	-

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 in the year 2014 from farmer's fields (96 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 using kriging method, soil fertility maps for the 11 elements including pH and EC were generated 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 19 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 19 mapping units representing 8 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 19 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 19 soil phases identified and mapped in the microwatershed were grouped into 5 Land Use Classes (LUC's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Use Classes (LUCs) based on the management needs. One or more than one soil site characteristic having influence on the management have been chosen for identification and delineation of LUCs. For Kinhi microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LUCs. The land use classes are expected to behave similarly for a given level of management.

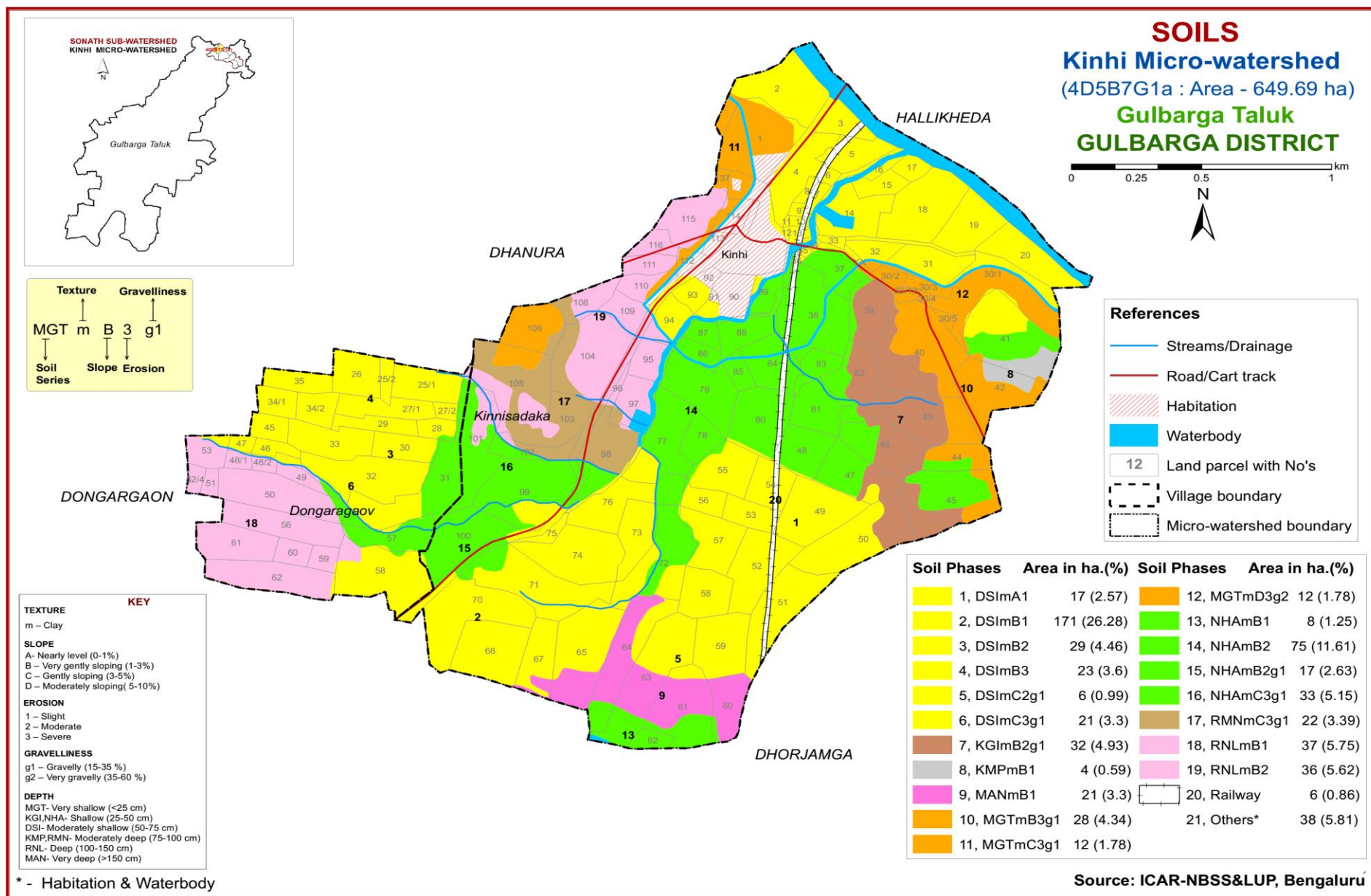


Fig 3.5 Soil phase or Management Units map of Kinhi Microwatershed

Table 3.2 Soil Unit Map Description of Kinhi Mirowatershed

Soil Map Unit No.	Soil Series	Soil Phases	Mapping Unit description	Area in ha (%)
Soils of Basalt Landscape				
	DSI	Dinsi soils are moderately shallow (50-75 cm), moderately well drained, have very dark gray to brown cracking clay soils occurring on nearly level to gently sloping uplands		268.4 (41.2)
1		DSImA1	Clay surface on 0-1 % slope, slightly eroded	16.70 (2.57)
2		DSImB1	Clay surface on 1-3% slope, slightly eroded	170.75 (26.28)
3		DSImB2	Clay surface on 1-3% slope, moderately eroded	28.99 (4.46)
4		DSImB3	Clay surface on 1-3% slope, severely eroded	23.37 (3.60)
5		DSImC2g1	Clay surface on 3-5 % slope, moderately eroded, gravelly (15-35%)	6.43 (0.99)
6		DSImC3g1	Clay surface on 3-5 % slope, severely eroded, gravelly (15-35%)	21.46 (3.30)
	KG I	Kalamundargi soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown gravelly clay soils occurring on very gently sloping uplands.		32.06 (4.93)
7		KGImB2g1	Clay surface on 1-3% slope, moderately eroded, gravelly (15-35%)	32.06 (4.93)
	KM P	Kamalapur soils are moderately deep (75-100 cm), moderately well drained, have very dark grayish brown to dark brown cracking clay soils occurring on very gently sloping uplands.		3.86 (0.59)
8		KMPmB1	Clay surface on 1-3% slope, slightly eroded	3.86 (0.59)
	MA N	Mahagaon soils are very deep (>150 cm), moderately well drained, have very dark gray to very dark grayish brown cracking clay soils occurring on very gently sloping uplands.		21.47 (3.30)
9		MANmB1	Clay surface on 1-3% slope, slightly eroded	21.47 (3.30)
	MG T	Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clay soils occurring on very gently sloping to moderately sloping uplands.		51.31 (7.90)
10		MGTmB3g1	Clay surface on 1-3% slope, severely eroded, gravelly (15-35%)	28.20 (4.34)
11		MGTmC3g1	Clay surface on 3-5 % slope, severely eroded, gravelly (15-35%)	11.54 (1.78)

12		MGTmD3g 2	Clay surface on 5-10 % slope, severely eroded, very gravelly (35-60%)	11.57 (1.78)
	NH A	Novinihala soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown clay soils occurring on very gently sloping to gently sloping uplands.		134.1 (20.64)
13		NHAmB1	Clay surface on 1-3% slope, slightly eroded	8.09 (1.25)
14		NHAmB2	Clay surface on 1-3% slope, moderately eroded	75.45 (11.61)
15		NHAmB2g1	Clay surface on 1-3% slope, moderately eroded, gravelly (15-35%)	17.10 (2.63)
16		NHAmC3g1	Clay surface on 3-5% slope, severely eroded, gravelly (15-35%)	33.45 (5.15)
	RM N	Ramnelli soils are moderately deep (75-100 cm), moderately well drained, dark gray to very dark grayish brown cracking clay soils occurring on gently sloping uplands		22.01 (3.39)
17		RMNmC3g 1	Clay surface on 3-5 % slope, severely eroded, gravelly (15-35%)	22.01 (3.39)
	RN L	Rajanala soils are deep (100-150 cm), moderately well drained, have very dark gray to brown cracking clay soils occurring on very gently sloping uplands.		73.88 (11.37)
18		RNLmB1	Clay surface on 1-3 % slope, slightly eroded	37.38 (5.75)
19		RNLmB2	Clay surface on 1-3 % slope, moderately eroded	36.50 (5.62)

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Kinhi microwatershed is provided in this chapter. The microwatershed area has been identified as basalt landscape. In all, 8 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, relief and climate. A brief description of each of the 8 soil series identified and mapped under each series is furnished below. The soil phases identified and mapped under each series are described and given in Table 3.2. 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, 8 soil series are identified and mapped as soil phases. Of these, Dinsi (DSI) soil series occupies maximum area of about 268 ha (41%) followed by Novinihala (NHA) about 134 ha (21%). The brief description of each series identified and mapped is given below.

4.1.1 Dinsi (DSI) Series: Dinsi soils are moderately shallow (50-75 cm), moderately well drained, have very dark gray to brown cracking clay soils. They have developed from basalt and occur on nearly level to gently sloping uplands.

The thickness of the solum ranges from 51 to 74 cm. The thickness of A horizon ranges from 9 to 24 cm. Its colour is in 10 YR hue with value 3 and chroma 1 to 3. The texture is clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 27 to 62 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 2 to 4. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is medium (101-150 mm/m). Six phases were identified and mapped.



Landscape and Soil Profile Characteristics of Dinsi (DSI) Series

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

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



Landscape and Soil Profile Characteristics of Kalamundargi (KGI) Series

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

The thickness of the solum ranges from 75 to 98 cm. The thickness of A horizon ranges from 10 to 30 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 1 to 4. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 45 to 84 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 4. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is medium (101-150 mm/m). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Kamalapur (KMP) Series

4.1.4 Mahagaon (MAN) Series Mahagaon soils are very deep (>150 cm), moderately well drained, have very dark gray to very dark grayish brown cracking clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum is >150 cm. The thickness of A horizon ranges from 18 to 22 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 1 to 3. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 130 to 160 cm. Its colour is in 10 YR hue with value 3 to 4 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). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Mahagaon (MAN) Series

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

The total depth of the soil ranges from 10 to 21 cm. The thickness of A horizon ranges from 10 to 24 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 to 4 and chroma 2 to 3. The texture is clay with 15 to 35 per cent gravel. The available water capacity is very low (<50 mm/m). Three phases were identified and mapped.



Landscape and Soil Profile Characteristics of Margutti (MGT) Series

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

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



Landscape and Soil Profile Characteristics of Novanihala (NHA) Series

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

The thickness of the solum ranges from 76 to 100 cm. The thickness of A horizon ranges from 12 to 27 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 4. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 60 to 78 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 2 to 3. Its texture is clay with gravel content is 35-60 per cent. The available water capacity is low (51-100 mm/m). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Ramnelli (RMN) Series

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

The thickness of the solum ranges from 108 to 150 cm. The thickness of A horizon ranges from 14 to 23 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 2. The texture is clay with less than 10 per cent gravel. The thickness of B horizon ranges from 85 to 130 cm. Its colour is in 10 YR hue with value 3 to 4 and chroma 1 to 3. Its texture is clay with gravel content of less than 15 per cent. The available water capacity is very high (>200 mm/m). Two phases were identified and mapped.



Landscape and Soil Profile Characteristics of Rajanala (RNL) Series

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 interpretative and 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 interpretative and thematic maps generated are described below.

5.1 Land Capability Classification

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The 19 soil map units identified in the Kinhi microwatershed are grouped under 4 land capability classes and 5 land capability subclasses. About 92 per cent area in the microwatershed is suitable for agriculture (Fig. 5.1) and 8 per cent is not suitable for agriculture but well suited for grazing or forestry, recreation and wildlife.

Of the lands suitable for agriculture, good cultivable lands (Class II) cover about 49 per cent area and are distributed in all parts of the micowatershed with minor problems of soil. Moderately good cultivable lands (Class III) cover an area of about 32 per cent and are distributed in the western, eastern and central part of the microwatershed with moderate problems of erosion and soil. The fairly good cultivable lands (Class IV) cover about 11 per cent area. They have severe limitations of erosion and soil and are distributed in the central, western, northern and northwestern part of the microwatershed. The class VI lands cover about 2 per cent and are distributed in the northeastern part of the microwatershed. They are well suited for pasture, forestry, wild life and recreation. They have severe limitations of erosion.

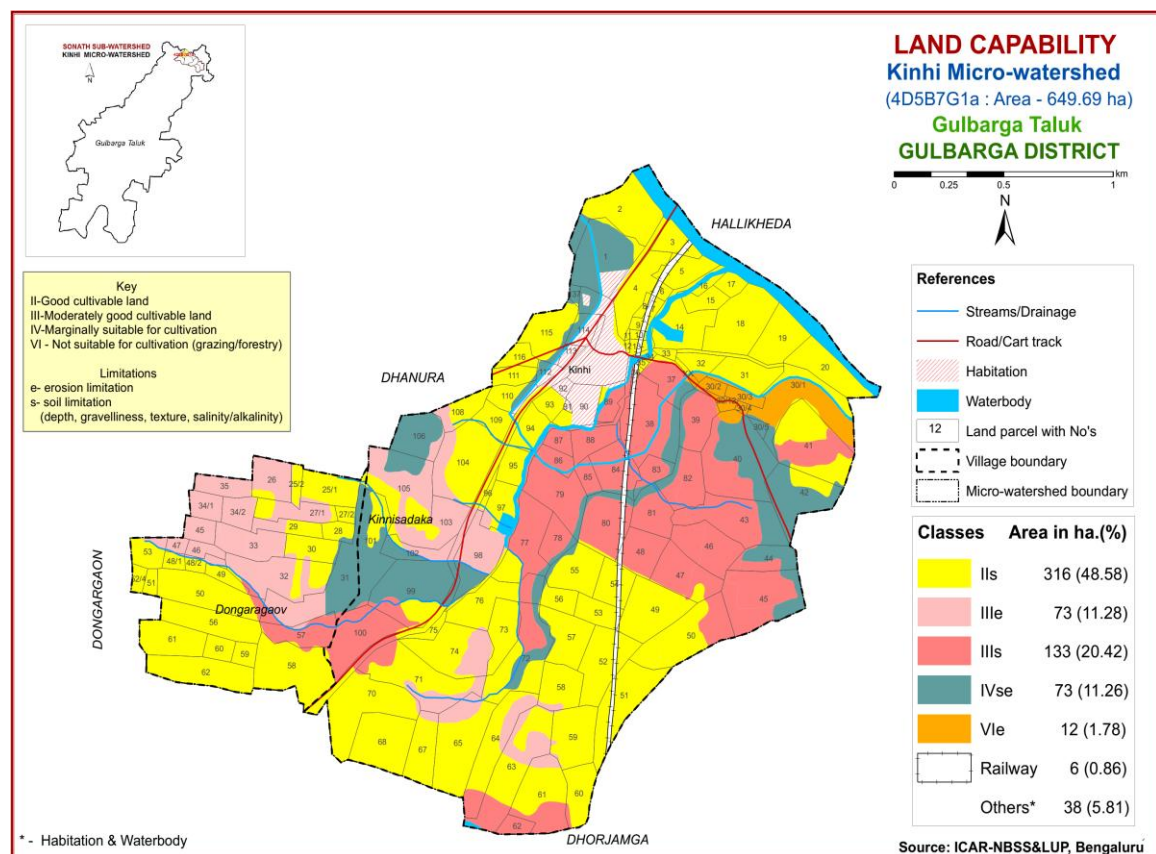


Fig. 5.1 Land Capability map of Kinhi Microwatershed

5.2 Soil Depth

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

Moderately shallow (50-75 cm) soils occupy major area of about 268 ha (41%) and are distributed in all parts followed by shallow soils (25-50 cm) in about 166 ha (26%) and are distributed in the central, eastern, southwestern and southeastern part of the microwatershed. Very shallow soils (<25 cm) occur in an area of about 51 ha (8%) and are distributed in the western, northwestern and eastern part of the microwatershed. An area of about 74 ha (11%) is deep soils (100-150 cm) and are distributed in the western and southwestern part followed by moderately deep (75-100 cm) soils occurring in about 26 ha (4%) and are distributed in the western part of the microwatershed. Very deep soils

(>150 cm) occupy an area of about 21 ha (3%) and are distributed in the southeastern part of the microwatershed.

The most productive lands covering about 95 ha (15%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep (100-150 cm) to very deep soils (>150 cm) occurring in the southwestern, central and southeastern part of the microwatershed.

The most problem lands with an area of about 217 ha (33%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occur in all parts of the microwatershed. They are not suitable for growing agricultural crops but well suited for pasture, forestry or other recreational purposes. Occasionally, short duration crops may be grown if rainfall is normal.

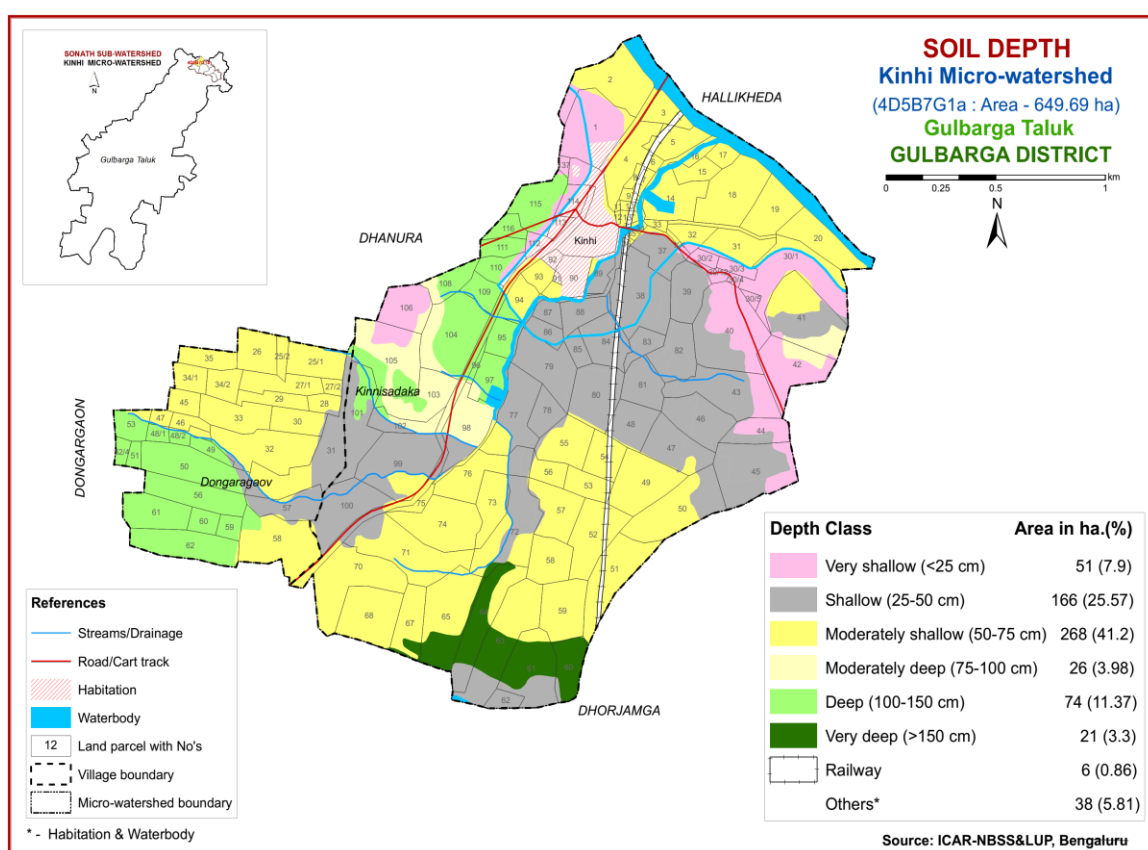


Fig. 5.2 Soil Depth map of Kinhi Microwatershed

5.3 Surface Soil Texture

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

LRI were used to classify and a surface soil texture map was generated. The area extent and their geographical distribution in the microwatershed is shown in Figure 5.3.

The entire area of about 606 ha (93%) has soils that are clayey at the surface. All the soils in the microwatershed are most productive (93%) with respect to surface soil texture. They 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.

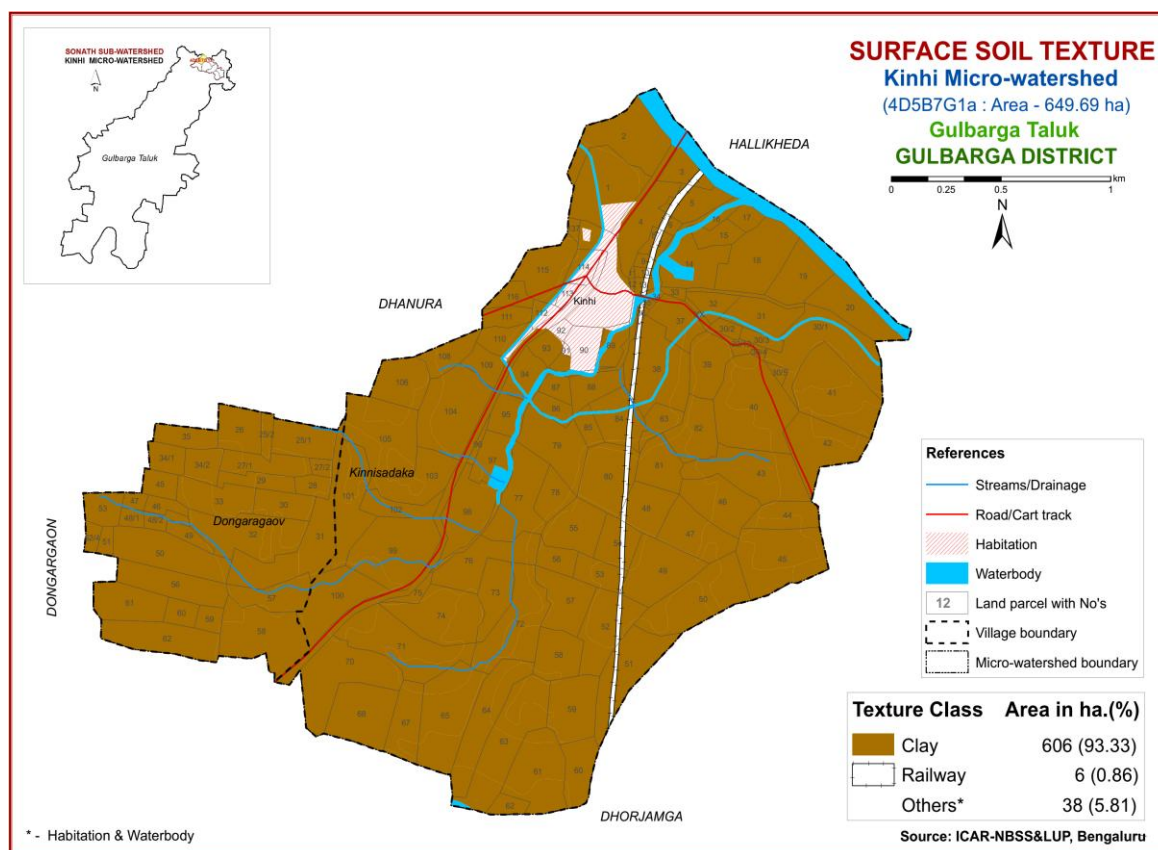


Fig. 5.3 Surface Soil Texture map of Kinhi Microwatershed

5.4 Soil Gravelliness

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

Maximum area has soils that are non gravelly (<15%) covering about 428 ha (66%) and are distributed in all parts of the microwatershed (Fig.5.4). About 172 ha (26%) area in the micro watershed has soils that are gravelly (15-35%) and are distributed in the western, eastern, central and northwestern part of the microwatershed followed by soils that are very gravelly (35-60%) covering very small area of about 12 ha (2%) and are distributed in the northeastern part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 66 per cent. They are non gravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops.

The problem soils that are very gravelly (35-60%) are found to cover about 2 per cent area, where only short duration crops can be grown.

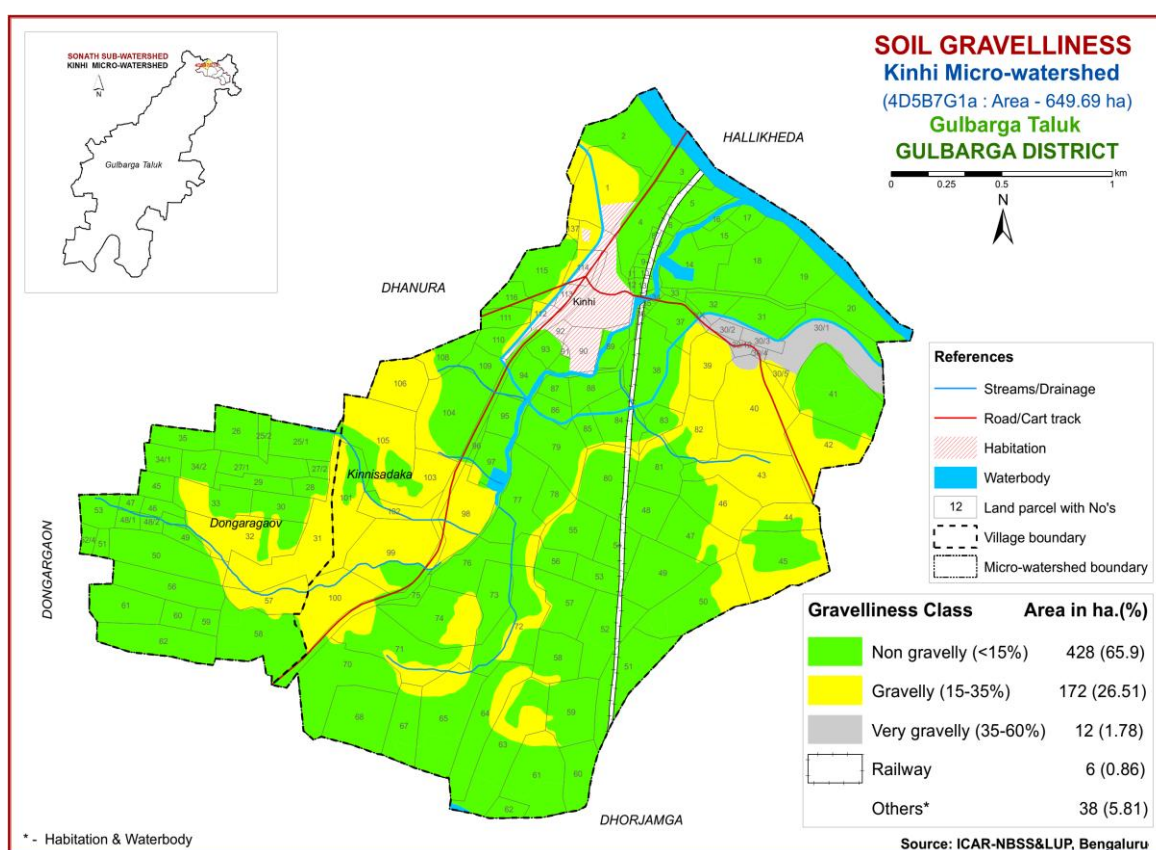


Fig. 5.4 Soil Gravelliness map of Kinhi Microwatershed

5.5 Available Water Capacity

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

area extent and their geographical distribution in the microwatershed is shown in Figure 5.5.

An area of about 83 ha (13%) has soils that are very low (<50 mm/m) in available water capacity and are distributed in the eastern, western and northeastern part of the microwatershed. An area of about 156 ha (24%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the western, central, southwestern and southeastern part of the microwatershed. An area of about 272 ha (42%) in the microwatershed has soils that are medium (101-150 mm/m) in available water capacity. They are distributed in all parts of the microwatershed. The soils that are very high (>200 mm/m) in AWC covering an area of about 95 ha (15%) are distributed in the southern, western and central part of the microwatershed.

An area of about 95 ha (15%) has soils that have very high potential (>200 mm/m) with regard to available water capacity and are distributed in the central part of the microwatershed. In these areas, if the rainfall is normal and well distributed, all climatically adapted long duration annual and perennial crops can be grown.

About 239 ha (37%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only the short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses.

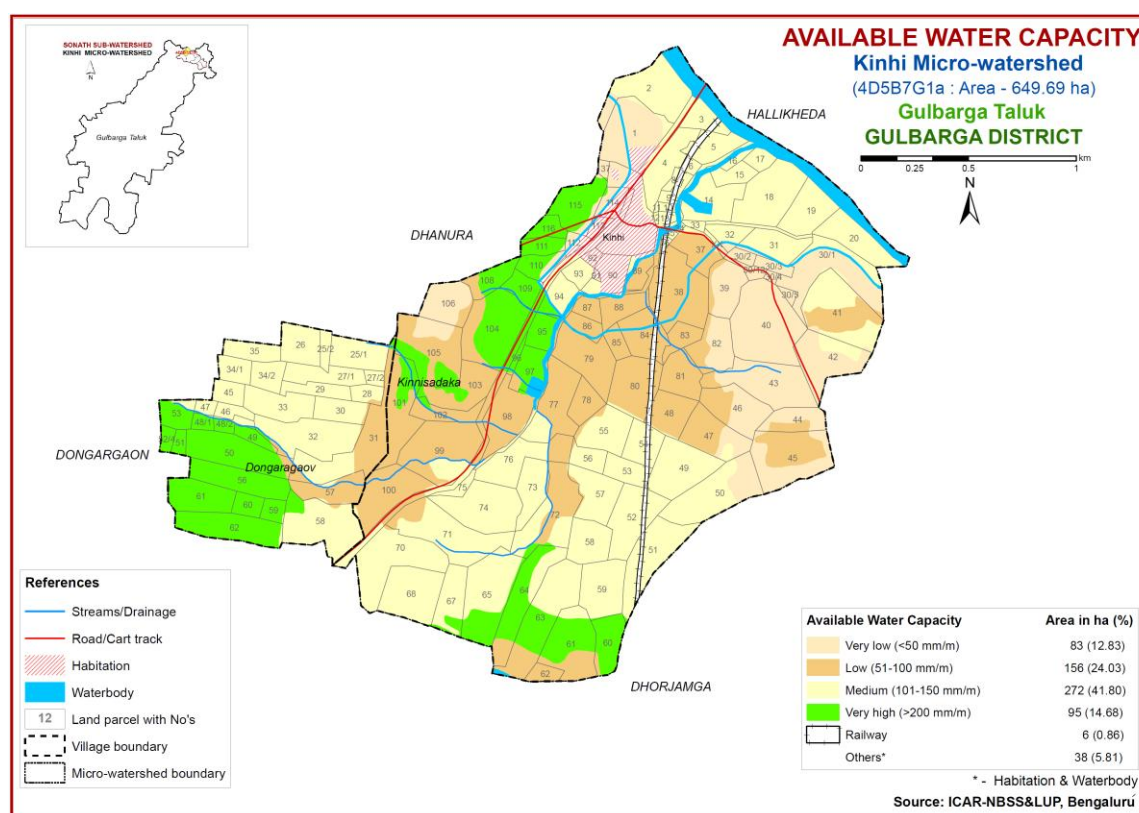


Fig. 5.5 Soil Available Water Capacity map of Kinhi Microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3%) lands. It covers an area of about 483 ha (74%) and are distributed in all parts of the microwatershed. An area of about 95 ha (15%) falls under gently sloping (3-5%) lands and are distributed in the central, western and northwestern part of the microwatershed. Moderately sloping (5-10%) lands cover a small area of about 12 ha (2%) and are distributed in the central and northeastern part and nearly level (0-1%) lands cover small area of about 17 ha (3%) and are distributed in the eastern part of the microwatershed.

An area of about 500 ha (77%) in the microwatershed has soils that have high potential in respect of soil slopes. In these areas, all climatically adapted annual and perennial crops can be grown without much soil and water conservation and other land development measures. An area of about 12 ha (2%) are problematic with respect to slopes and require soil and water conservation and other land development measures.

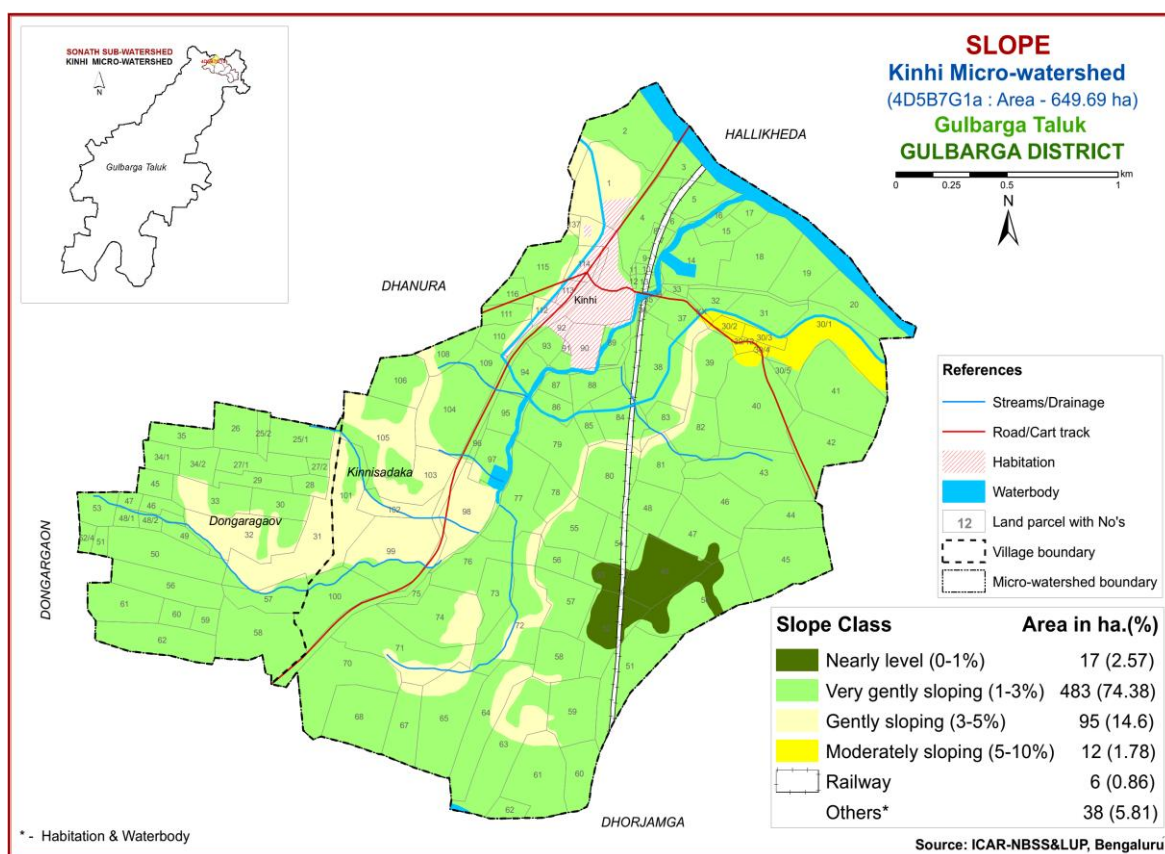


Fig. 5.6 Soil Slope map of Kinhi Microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover maximum about area of about 258 ha (40%) and are distributed in the southern, southwestern, southeastern, central and northern part of the microwatershed. Soils that are moderately eroded (e2 class) cover an area of about 197 ha (30%) and are distributed in the southwestern, central, eastern and northwestern part of the microwatershed. Severely eroded (e3 class) soils cover an area of about 152 ha (23%) and are distributed in the western, central, northeastern and northwestern part of the microwatershed.

Top priority is to be given to 152 ha area where they are severely eroded for taking up soil and water conservation and other land development measures followed by moderately eroded lands that cover about 197 ha for restoring soil health.

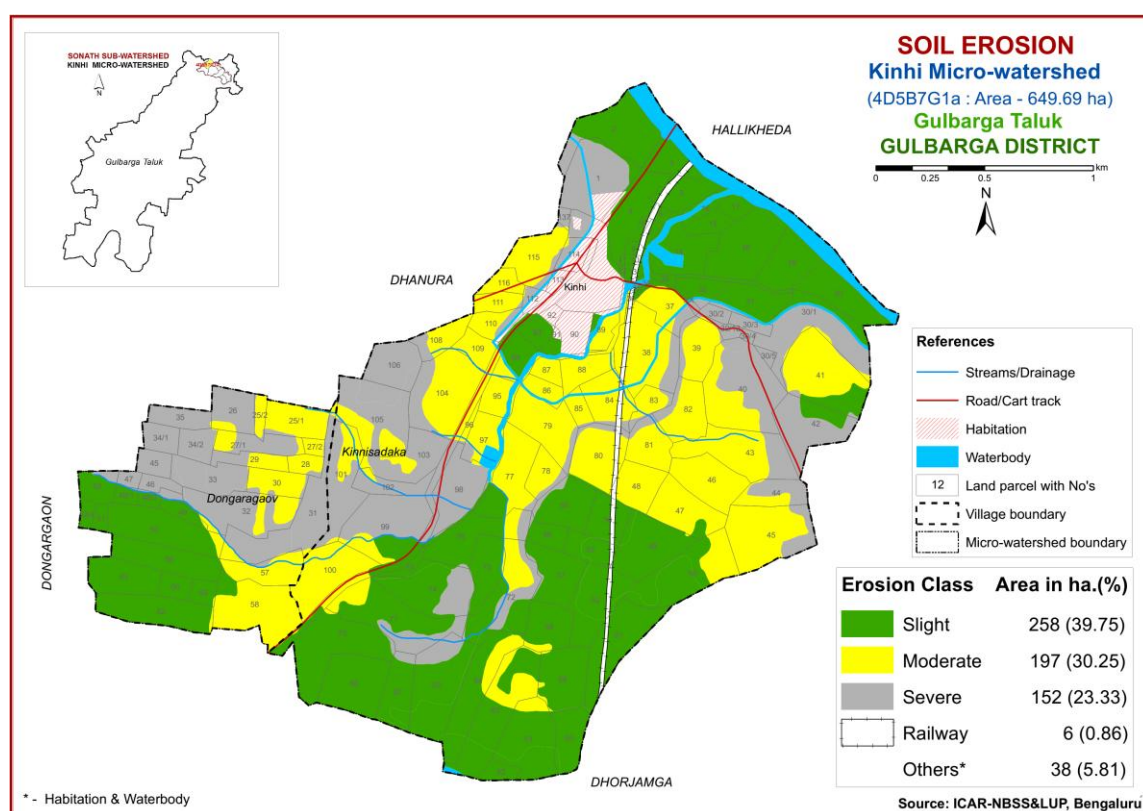


Fig. 5.7 Soil Erosion map of Kinhi Microwatershed

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 areas 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 2014 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, copper, iron and manganese, and secondary nutrient sulphur.

Soil fertility data generated has been assessed and individual maps for all the nutrients for the microwatershed have been 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 Kinhi microwatershed for soil reaction (pH) showed that maximum area of about 313 ha (48%) is neutral (pH 6.5-7.3) in reaction and is distributed in all parts of the microwatershed (Fig.6.1). Slightly alkaline (pH 7.3-7.8) is around 177 ha (27%) area and is distributed in the southern, central, eastern, northern and northwestern part of the microwatershed. An area of about 86 ha (13%) is slightly acid (pH 6.0-6.5) and is distributed in the southwestern, central and northeastern part of the microwatershed. Moderately alkaline (pH 7.8-8.4) soils covering an area of about 31 ha (5%) are distributed in the central and northern part of the microwatershed.

6.2 Electrical Conductivity (EC)

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

6.3 Organic Carbon

The soil organic carbon content of the soils in the microwatershed is high ($>0.75\%$) in major area of about 522 ha (80%) and are distributed in all parts of the microwatershed (Fig.6.3). Medium (0.5-0.75%) organic carbon content accounts for 77 ha (12%) area and is distributed in the central, western and eastern part of the microwatershed. Low ($<0.5\%$) organic carbon content accounts for a small area of 8 ha (1%) and is distributed in the central part of the microwatershed.

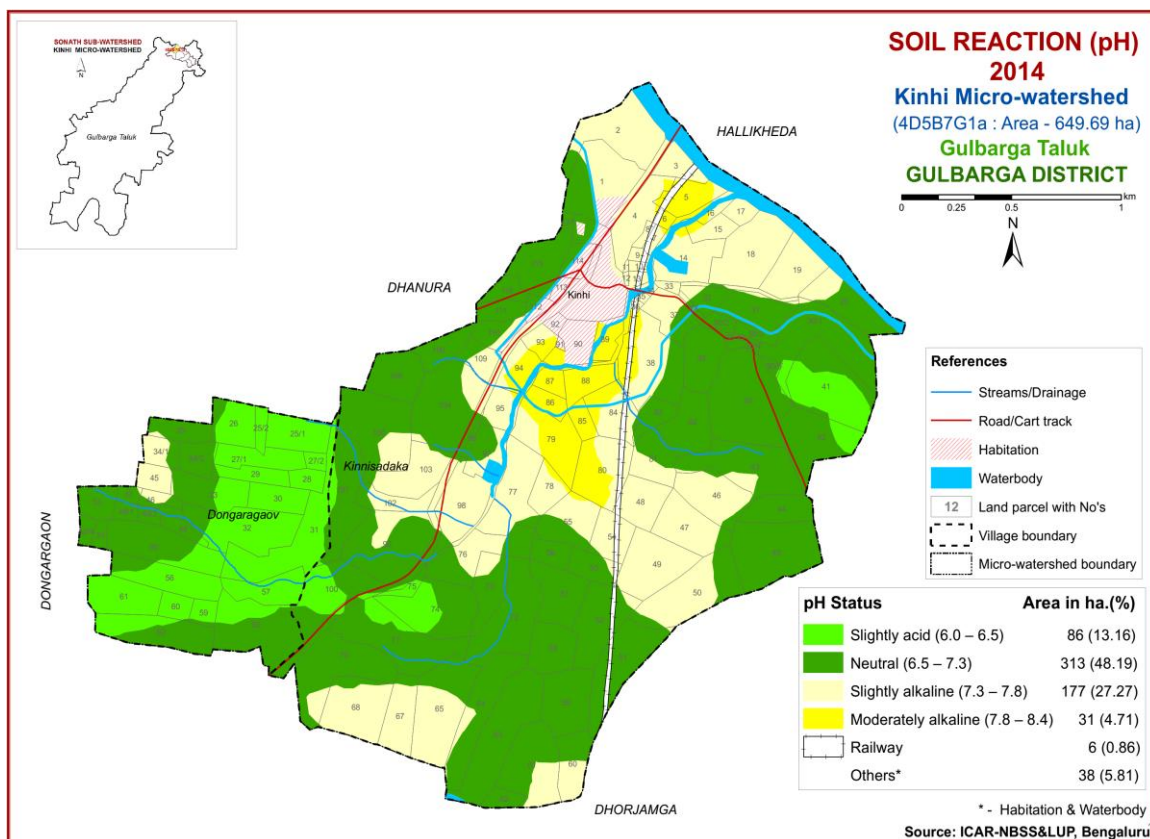


Fig.6.1 Soil Reaction (pH) map of Kinhi Microwatershed

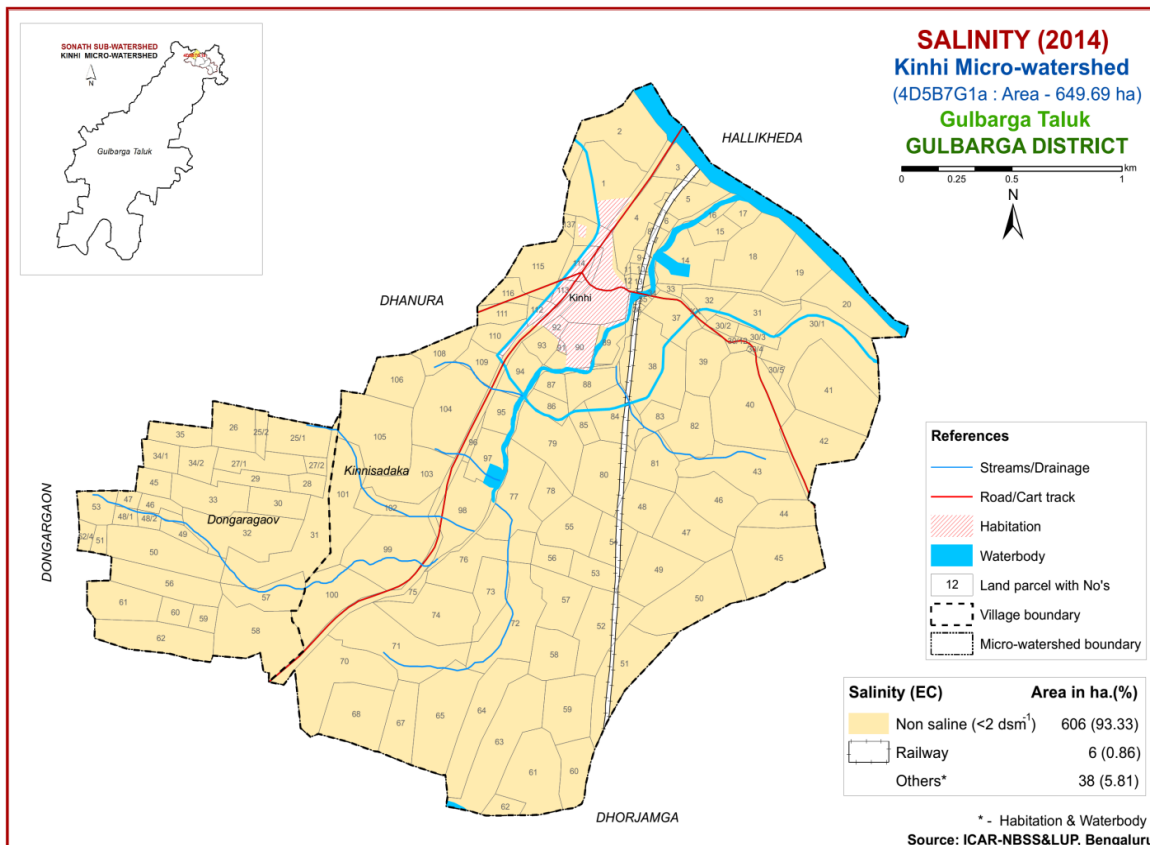


Fig.6.2 Electrical Conductivity (EC) map of Kinhi Microwatershed

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in major area of about 581 ha (89%) and is distributed in all parts of the microwatershed (Fig.6.4). There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. About 19 ha (3%) area is medium (23-57 kg/ha) and is distributed in the central and northwestern part of the microwatershed and very small area of about 7 ha (1%) is high (>57 kg/ha) and is distributed in the central part of the microwatershed.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in major area of about 377 ha (58%) and is distributed in all parts of the microwatershed (Fig.6.5), high available potassium (>337 kg/ ha) content accounts for an area of 6 ha (1%) and is distributed in the central and northwestern part of the microwatershed. Low available potassium (<145 kg/ha) content accounts for an area of 224 ha (34%) and is distributed in the southwestern, western, central, northeastern and eastern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) in major area of about 447 ha (69%) area and is distributed in all parts of the microwatershed. A very small area of about 2 ha (<1%) is high (>20 ppm) in available sulphur and is distributed in the southern part of the microwatershed (Fig.6.6). Available sulphur is low (<10 ppm) in an area of about 157 ha (24%) and are distributed in the western, northern, northeastern and southwestern part of the microwatershed.

6.7 Available Boron

Available boron content is low (<0.5ppm) in major area of about 361 ha (55%) and is distributed in all parts of the microwatershed. About 239 ha (37%) has soils that are medium (0.5-1.0 ppm) in available boron (Fig 6.7) and is distributed in the southern, southwestern, southeastern, eastern, central and northwestern part of the microwatershed and about only 6 ha (1%) area is high (>1.0ppm) in available boron and distributed in southeastern part of the microwatershed.

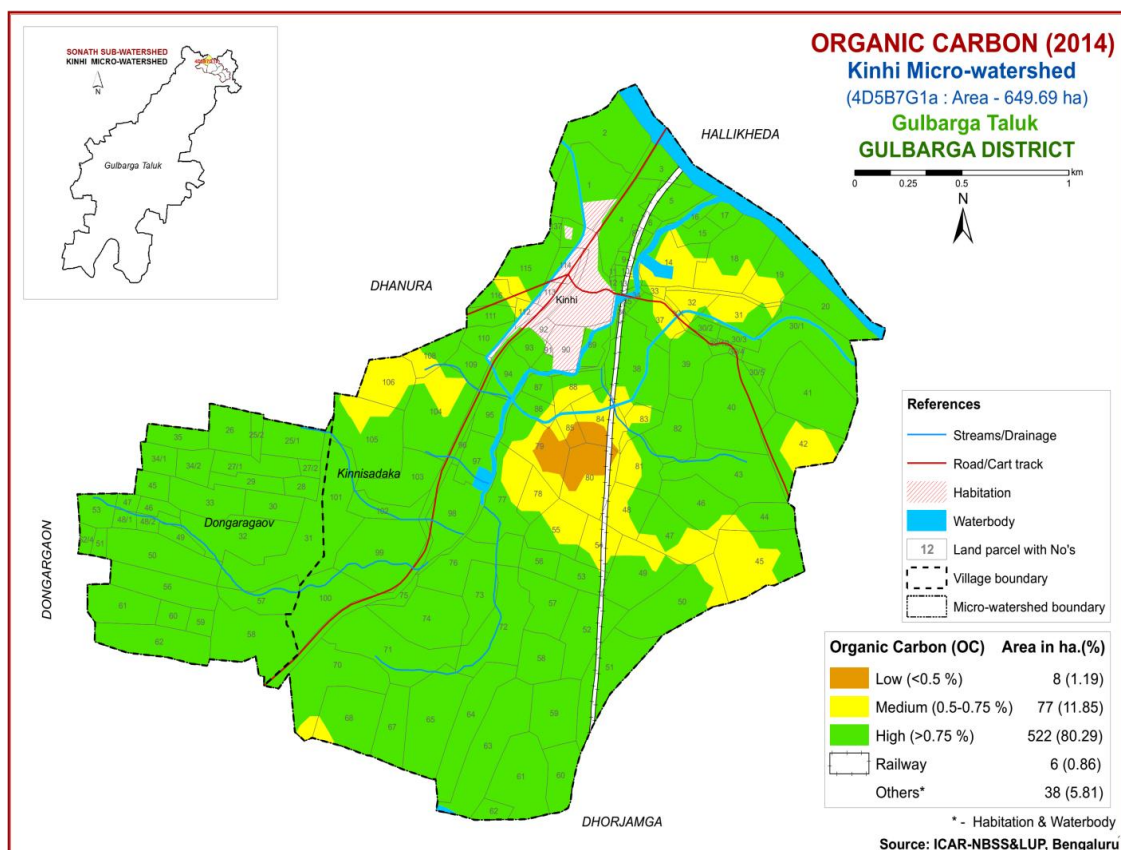


Fig.6.3 Soil Organic Carbon map of Kinhi Microwatershed

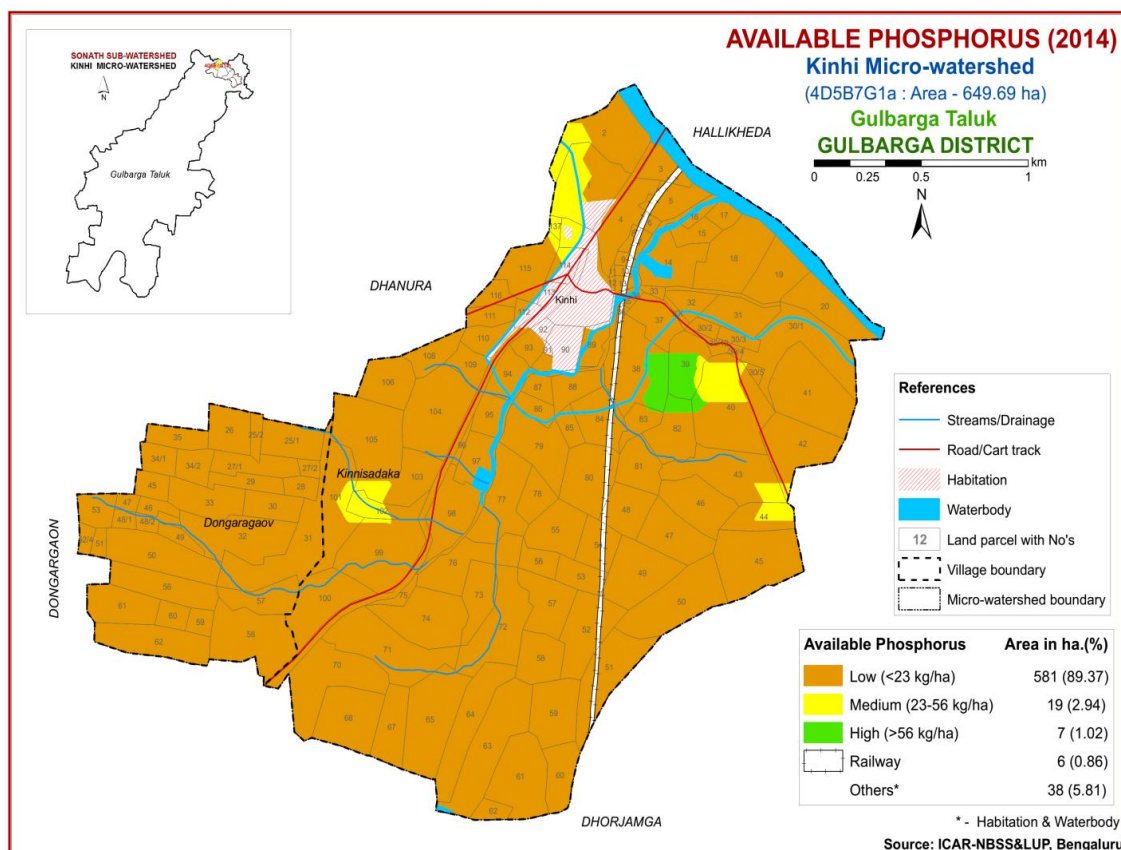


Fig.6.4 Soil available Phosphorus map of Kinhi Microwatershed

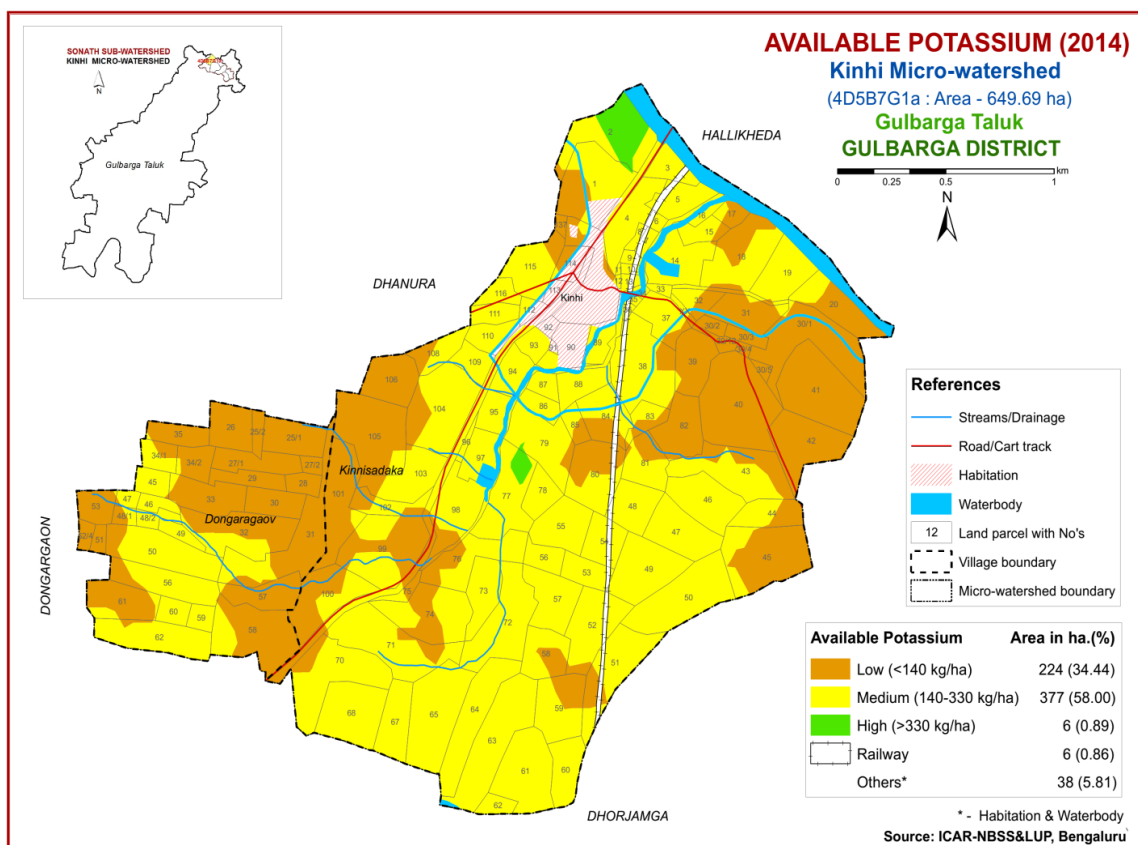


Fig.6.5 Soil available Potassium map of Kinhi Microwatershed

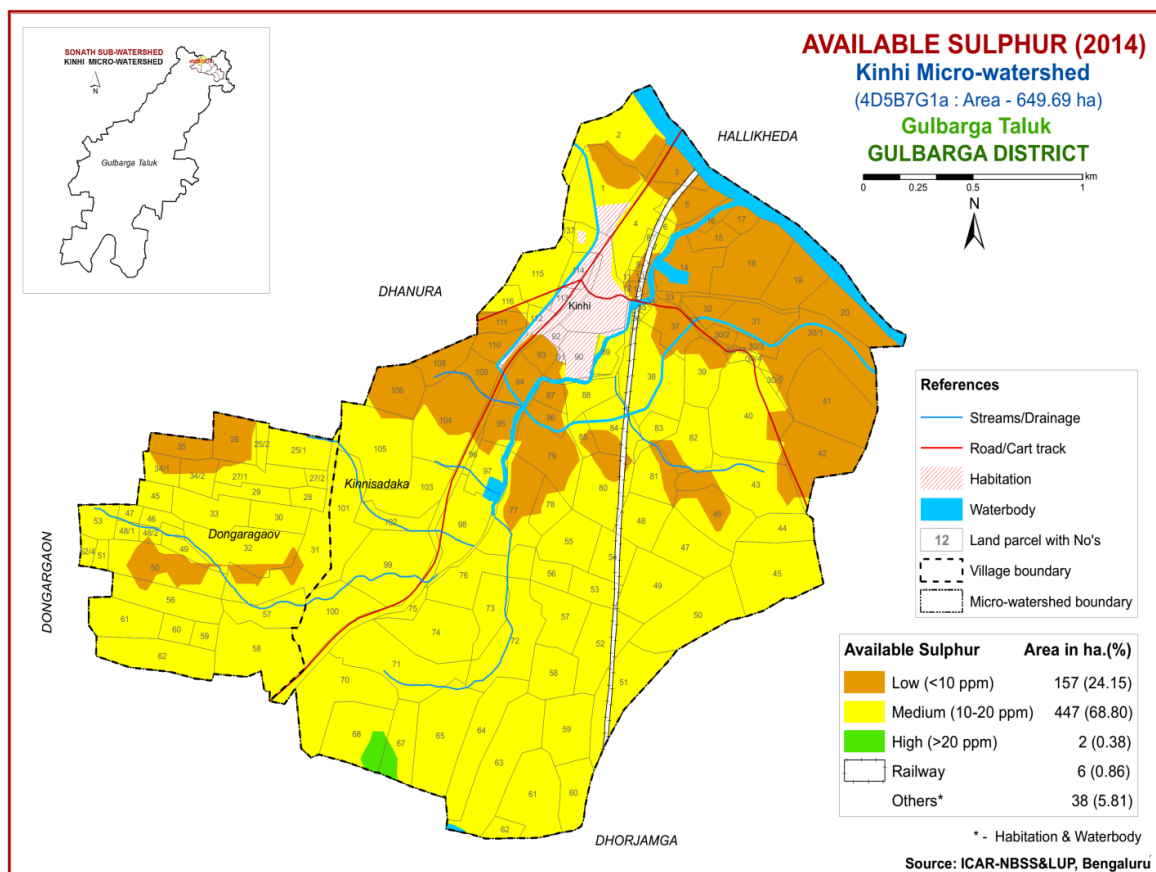


Fig.6.6 Soil available Sulphur map of Kinhi Microwatershed

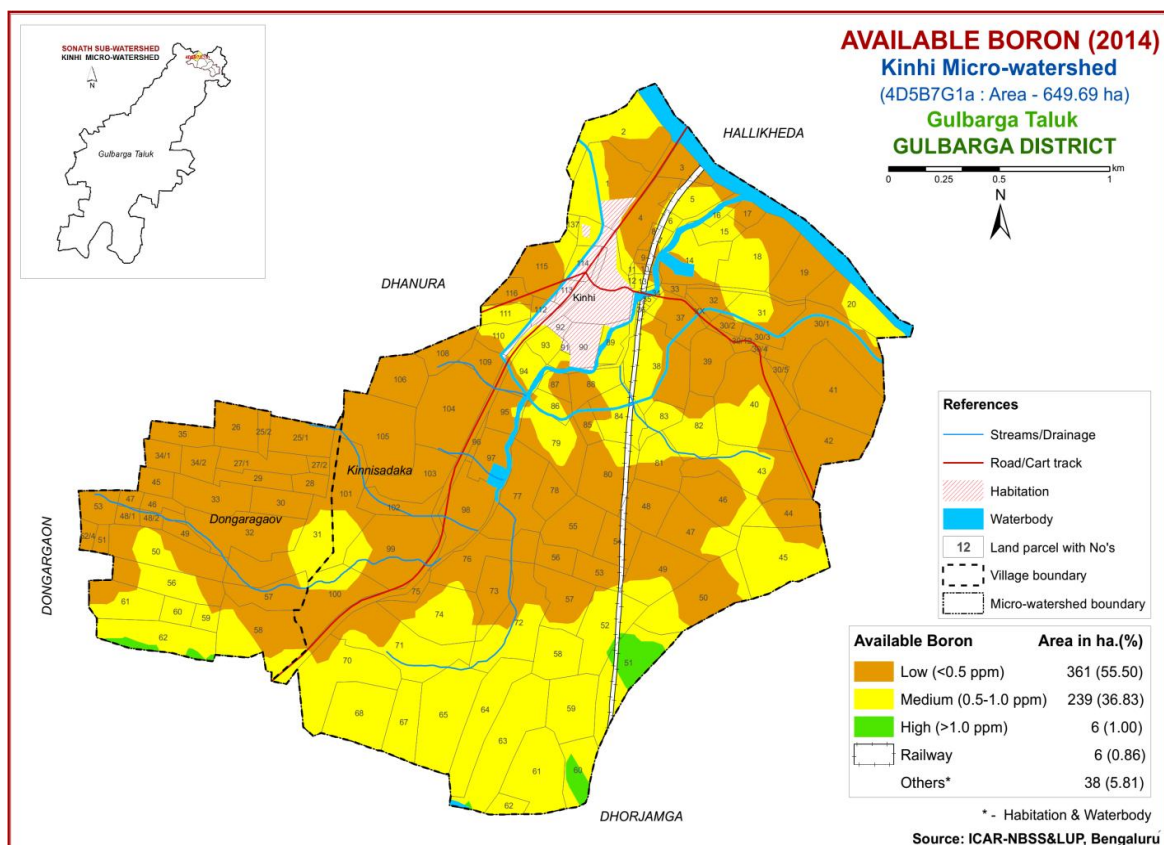


Fig.6.7 Soil available Boron map of Kinhi Microwatershed

6.8 Available Iron

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

6.9 Available Manganese

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

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 an area of about 271 ha (42%) and is distributed in the southern, central, western and northeastern part of the microwatershed (Fig 6.11). It is sufficient (>0.6 ppm) in an area of about 335 ha (52%) and is distributed in all parts of the microwatershed.

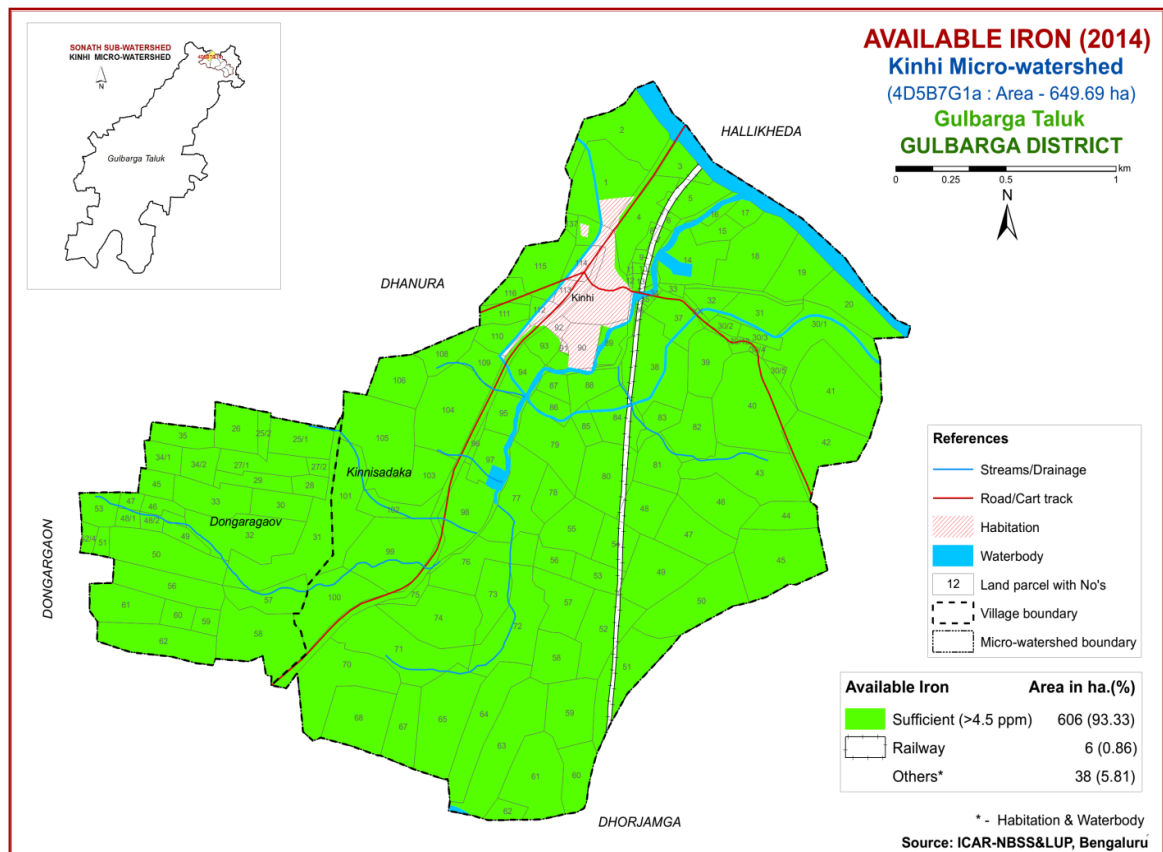


Fig.6.8 Soil available Iron map of Kinhi Microwatershed

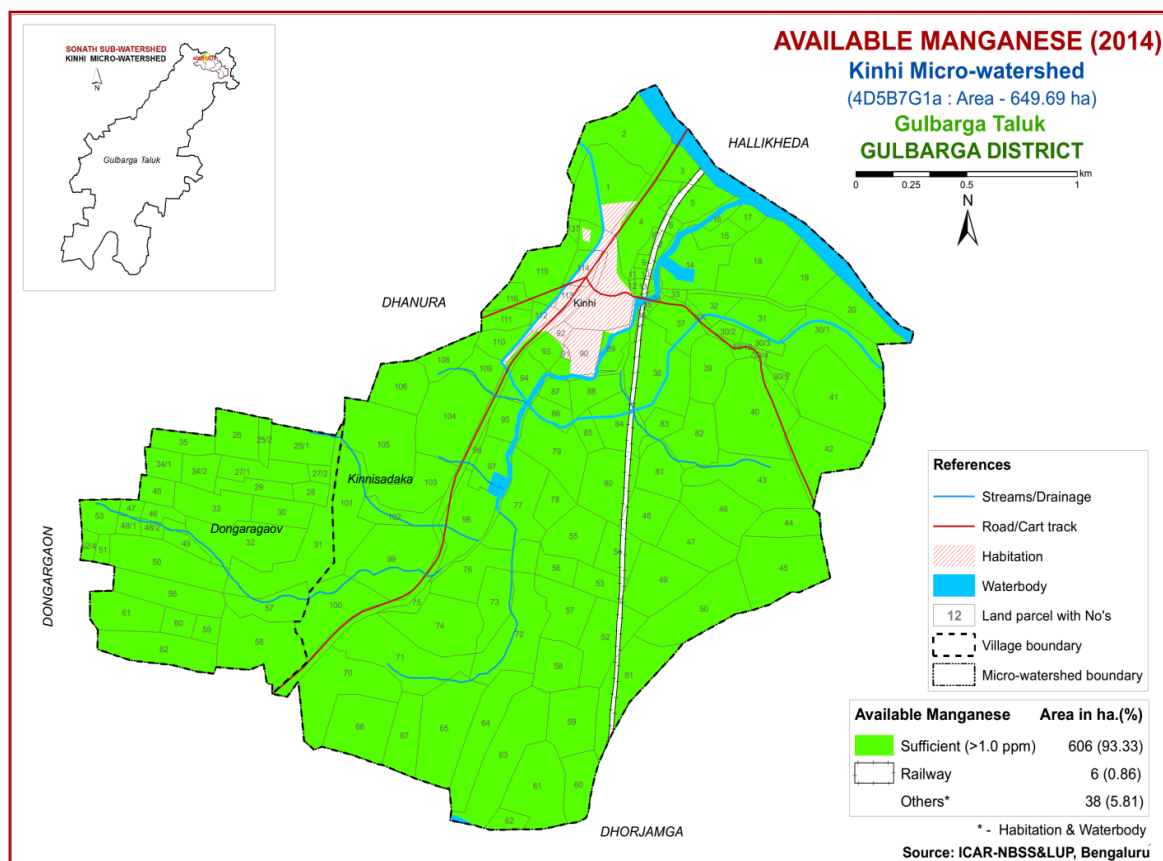


Fig.6.9 Soil available Manganese map of Kinhi Microwatershed

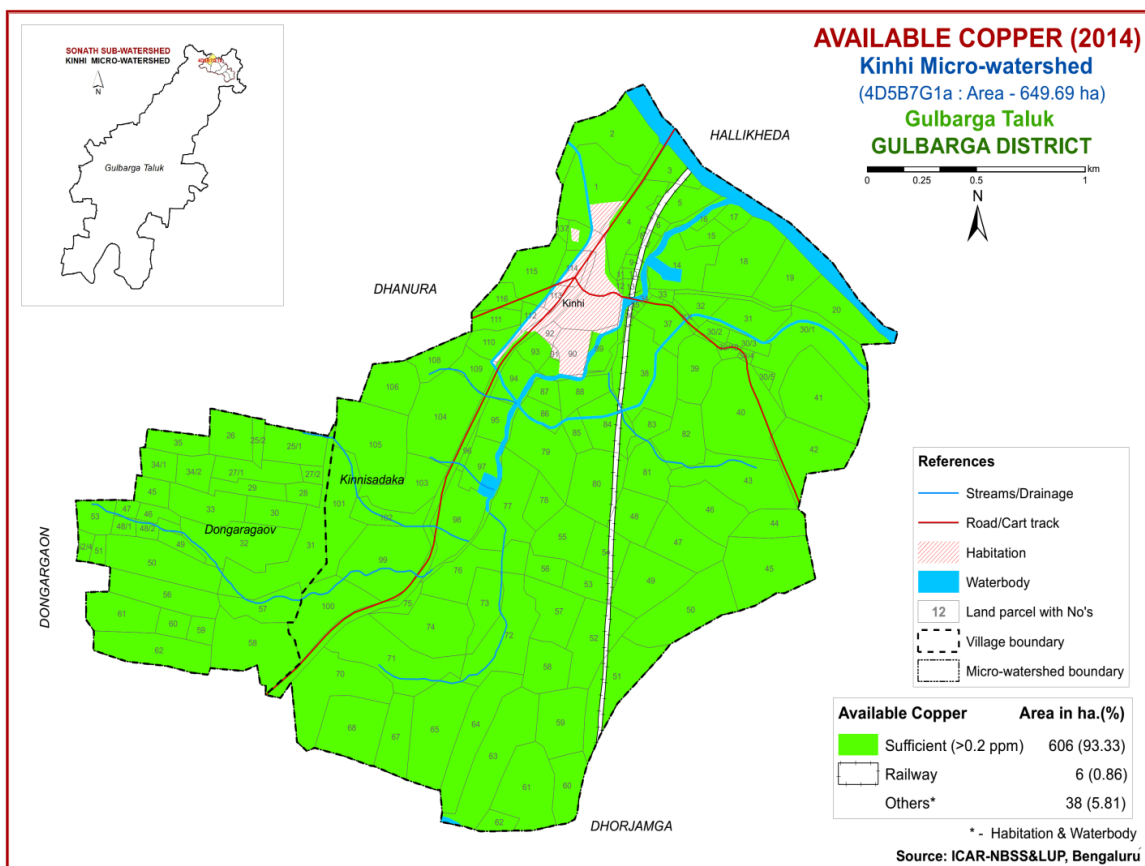


Fig.6.10 Soil available Copper map of Kinhi Microwatershed

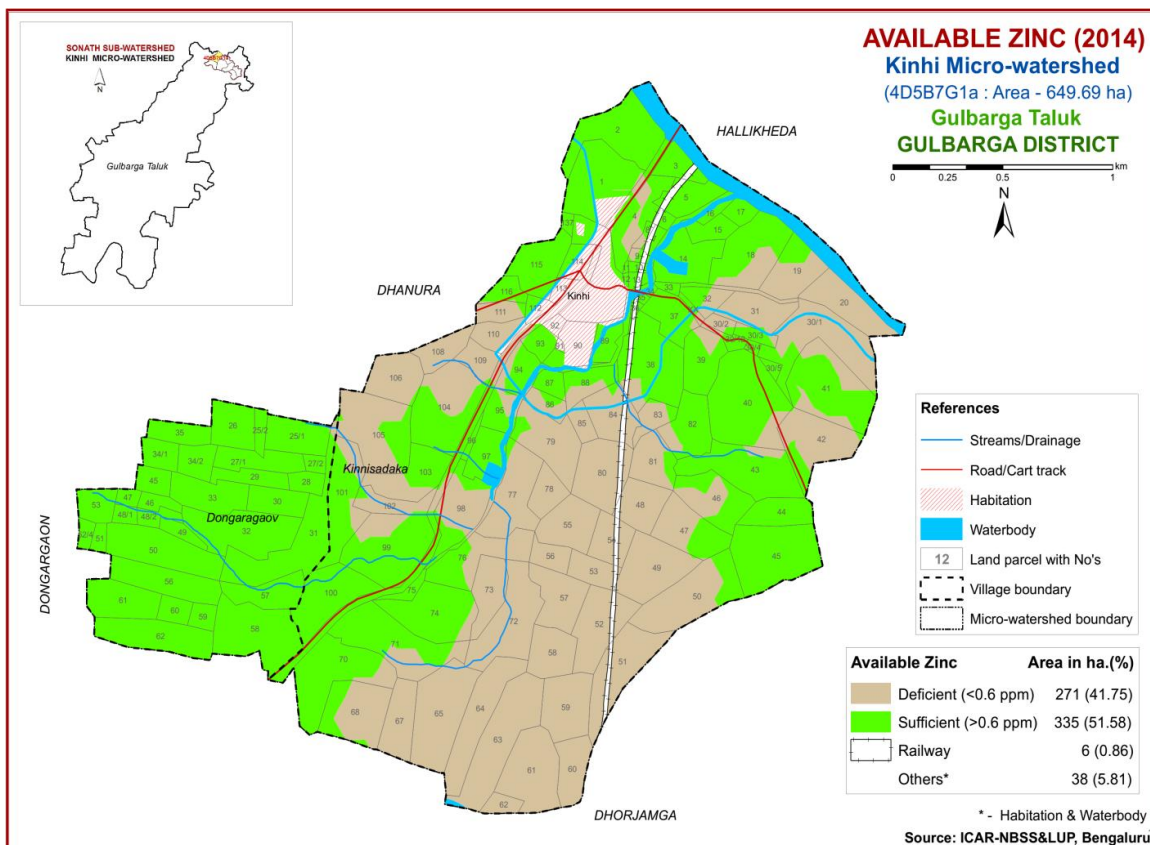


Fig.6.11 Soil available Zinc map of Kinhi Microwatershed

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Kinh 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 soil and land characteristics (Table 7.1) were matched with the crop requirements 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’ calcareousness and ‘w’ for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 19 major annual and perennial 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 a 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.

An area of about 99 ha (15%) in the microwatershed has soils that are highly suitable (Class S1) for growing sorghum. They have minor or no limitations for growing sorghum and are distributed mainly in the southwestern, southeastern, western and central part of the microwatershed.

Table 7.1 Soil-Site Characteristics of Kinh Watershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p ⁺) kg ⁻¹]	BS (%)
					Surface	Subsurface	Surface (%)	Subsurface (%)								
DSImA1	740	150	WD	50-75	c	c	-	<15	101-150	0-1	Slight	6.8	0.3	0.2	46	100
DSImB1	740	150	WD	50-75	c	c	-	<15	101-150	1-3	Slight	6.8	0.3	0.2	46	100
DSImB2	740	150	WD	50-75	c	c	-	<15	101-150	1-3	Moderate	6.8	0.3	0.2	46	100
DSImB3	740	150	WD	50-75	c	c	-	<15	101-150	1-3	Severe	6.8	0.3	0.2	46	100
DSImC2g1	740	150	WD	50-75	c	c	15-35	<15	101-150	3-5	Moderate	6.8	0.3	0.2	46	100
DSImC3g1	740	150	WD	50-75	c	c	15-35	<15	101-150	3-5	Moderate	6.8	0.3	0.2	46	100
KGImB2g1	740	150	WD	25-50	c	c	15-35	35-60	<50	1-3	Moderate	7.2	0.1	0.3	40	100
KMPmB1	740	150	WD	75-100	c	c	-	<15	101-150	1-3	Slight	7.2	0.1	0.3	40	100
MANmB1	740	150	WD	>150	c	c	-	<15	>200	1-3	Slight	7.2	0.1	0.3	40	100
MGTmB3g1	740	150	WD	<25	c	c	15-35	15-35	<50	1-3	Slight	7.2	0.1	0.3	40	100
MGTmC3g1	740	150	WD	<25	c	c	15-35	15-35	<50	3-5	Slight	7.2	0.1	0.3	40	100
MGTmD3g2	740	150	WD	<25	c	c	35-60	15-35	<50	5-10	Moderate	7.2	0.1	0.3	40	100
NHAmB1	740	150	WD	25-50	c	c	-	<15	51-100	1-3	Slight	7.0	0.1	0.2	28	100
NHAmB2	740	150	WD	25-50	c	c	-	<15	51-100	1-3	Moderate	7.0	0.1	0.3	62	100
NHAmB2g1	740	150	WD	25-50	c	c	15-35	<15	51-100	1-3	Moderate					
NHAmC3g1	740	150	WD	25-50	c	c	15-35	<15	51-100	3-5	Severe					
RMNmC3g1	740	150	WD	75-100	c	c	15-35	35-60	51-100	3-5	Severe					
RNLmB1	740	150	WD	100-150	c	c	-	<15	>200	1-3	Slight					
RNLmB2	740	150	WD	100-150	c	c	-	<15	>200	1-3	Moderate					

*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

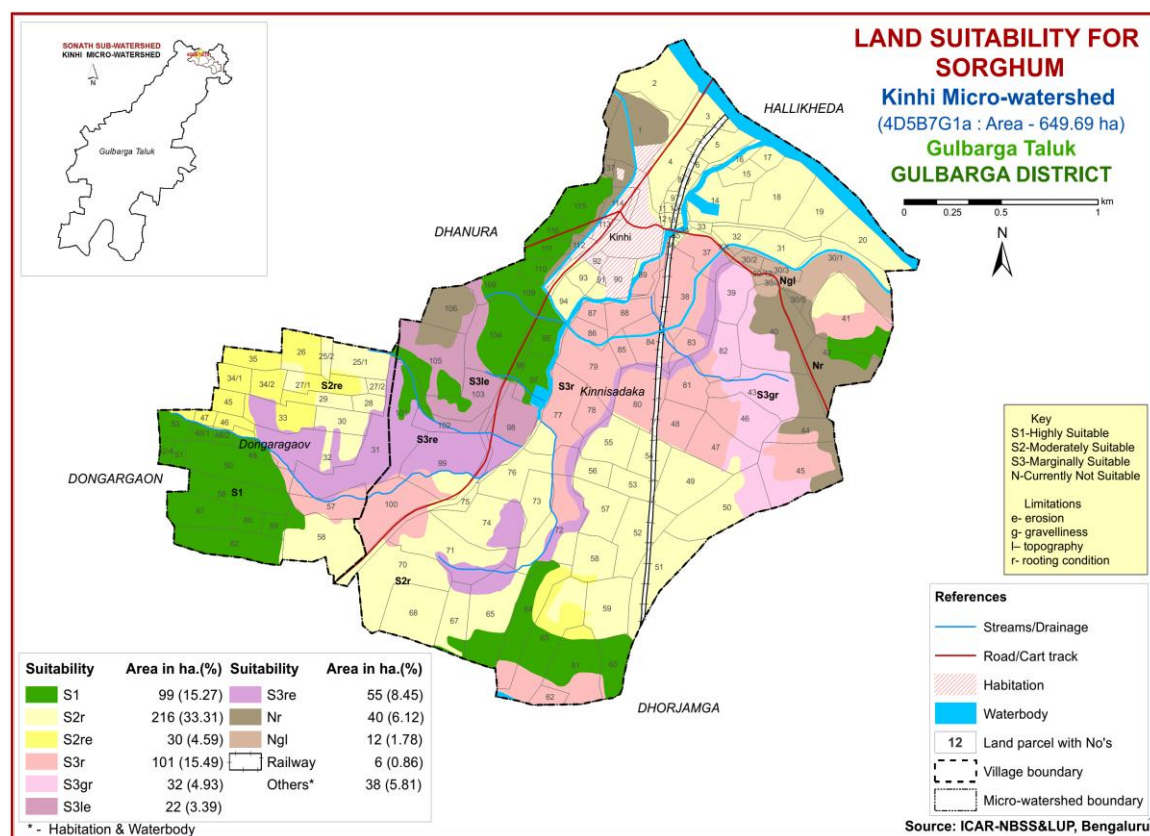


Fig. 7.1 Land Suitability map of Sorghum

Major area of about 246 ha (38%) is moderately suitable (Class S2) for growing sorghum and are distributed in the southern, eastern, southwestern, central and northern part of the microwatershed. They have minor limitations of erosion and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 210 ha (32%) and are distributed in the central, western, eastern and southeastern part of the microwatershed.

They have moderate limitations of rooting depth, erosion, topography and gravelliness. An area of about 52 ha (8%) is not suitable (Class N) for growing sorghum and are distributed in the eastern, western and northwestern part of the microwatershed. They have severe limitations of gravelliness, rooting depth and topography.

7.2 Land Suitability for Maize (*Zea mays*)

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

In Kinhi microwatershed, there are no lands that are highly (Class S1) suitable lands for growing maize. An area of about 222 ha (34%) is moderately suitable (Class S2) for growing maize and are distributed in the southern, southwestern, southeastern, eastern, central and northern part of the microwatershed. They have minor limitations of erosion, texture and rooting depth. The marginally suitable (Class S3) lands cover a maximum area of about 332 ha (51%) and occur in all parts of the microwatershed. They have moderate limitations of gravelliness, texture, erosion and rooting depth. About 52 ha (8%) area is not suitable (Class N) for growing maize and occur in the western, northeastern and northwestern part of the microwatershed. They have severe limitations of gravelliness, rooting depth and 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	

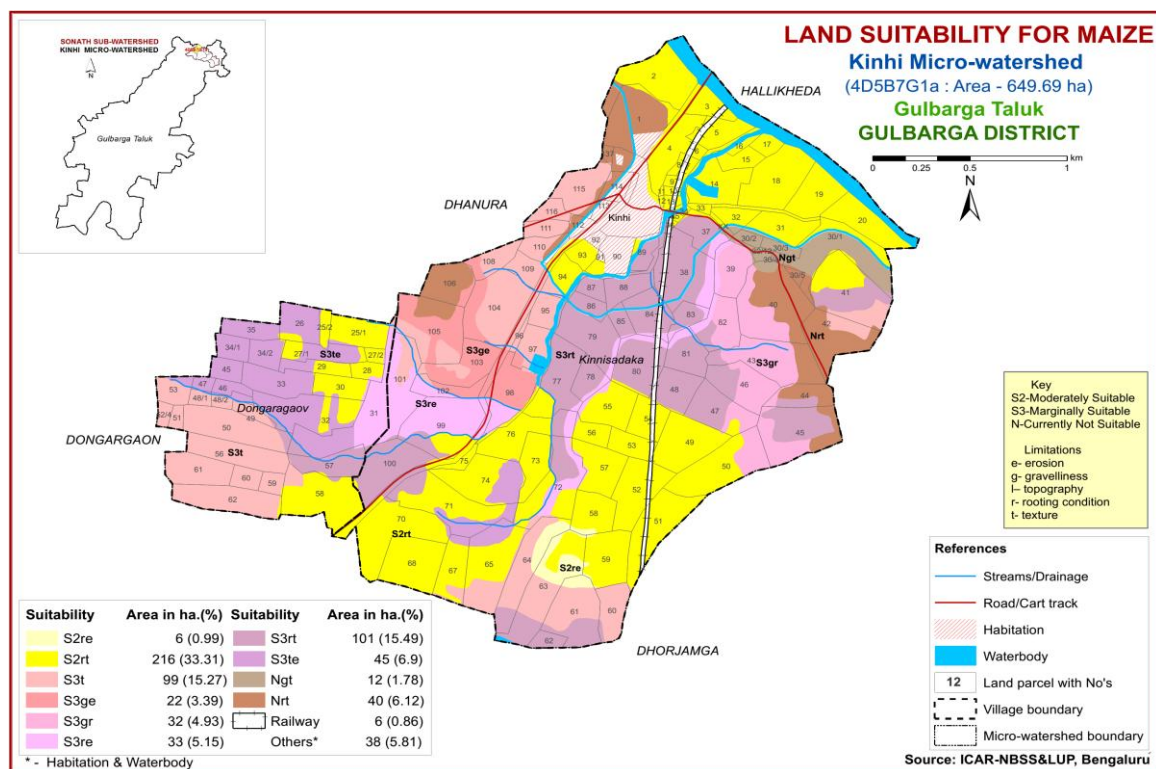


Fig. 7.2 Land Suitability map of Maize

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 a land suitability map for growing red gram was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

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	

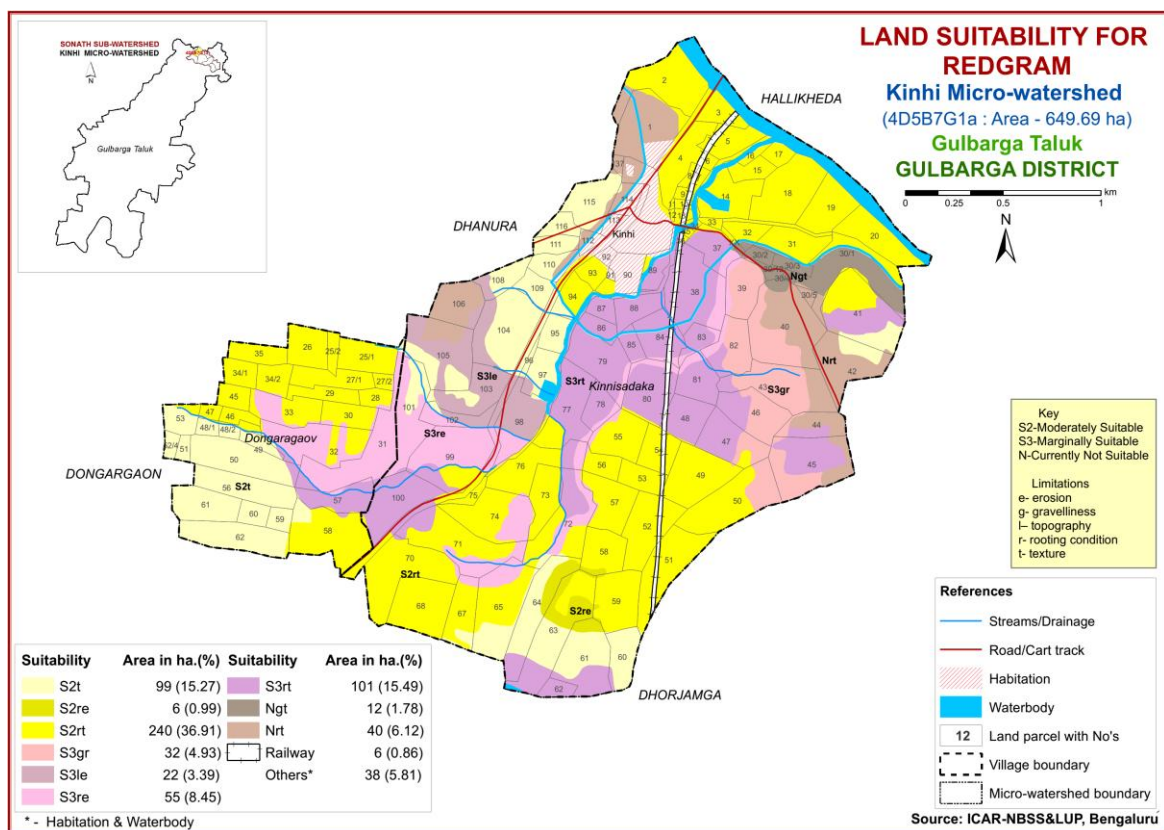


Fig. 7.3 Land Suitability map of Red gram

In Kinhi microwatershed, there are no lands that are highly (Class S1) suitable for growing redgram. Major area of about 345 ha (53%) is moderately suitable (Class S2) for red gram and are distributed in all parts of the microwatershed. They have minor limitations of texture, rooting depth and erosion. An area of about 210 ha (32%) is marginally suitable (Class S3) for growing red gram and are distributed in the central, eastern, and northeastern part of the microwatershed. They have moderate limitations of rooting depth, texture, gravelliness, topography and erosion. An area of about 52 ha (8%) is not suitable (Class N) for growing red gram and are distributed in the northeastern, northwestern and western part of the microwatershed. They have severe limitations of gravelliness, rooting depth and texture.

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.

Highly suitable (Class S1) lands are found to occur in an area of 99 ha (15%) and are distributed in the southern, southwestern and western part of the microwatershed. They have minor or no limitations for growing sunflower. Marginally suitable (Class S3)

lands are found to occur in major area of about 322 ha (49%). The soils have moderate limitations of gravelliness, erosion and rooting depth. They are distributed in all parts of the microwatershed. An area of about 185 ha (29%) is not suitable (Class N) for growing sunflower and occur in the central, northeastern, northwestern, southwestern and southeastern part of the microwatershed. They have severe limitations of gravelliness, erosion, rooting depth and topography.

Table 7.5 Crop suitability criteria for Sunflower

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

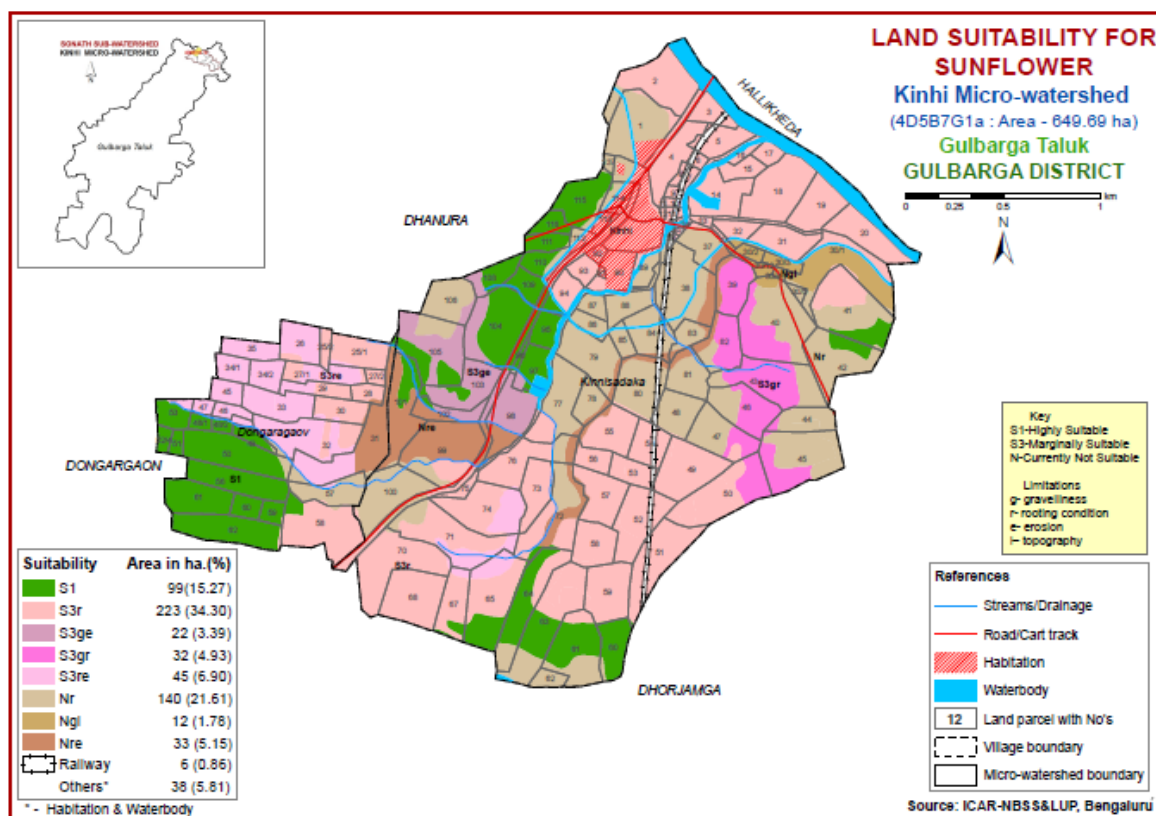


Fig. 7.4 Land Suitability map of Sunflower

7.5 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 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.

An area of about 95 ha (15%) in the microwatershed has soils that are highly suitable (Class S1) for growing cotton. They have minor or no limitations for growing cotton and are distributed in the southwestern, southeastern, central and northwestern part of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 250 ha (38%). The soils have minor limitations of erosion and rooting depth. They are distributed in all parts of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 210 ha (32%) and are distributed in the central, western, eastern, and southwestern part of the microwatershed. They have moderate limitations of rooting depth, topography, erosion and gravelliness. An area of about 52 ha (8%) is not suitable (Class N) for growing cotton and are distributed in the western, northwestern and northeastern part of the microwatershed. They have severe limitations of gravelliness, topography and rooting depth.

Table 7.6 Crop suitability criteria for Cotton

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

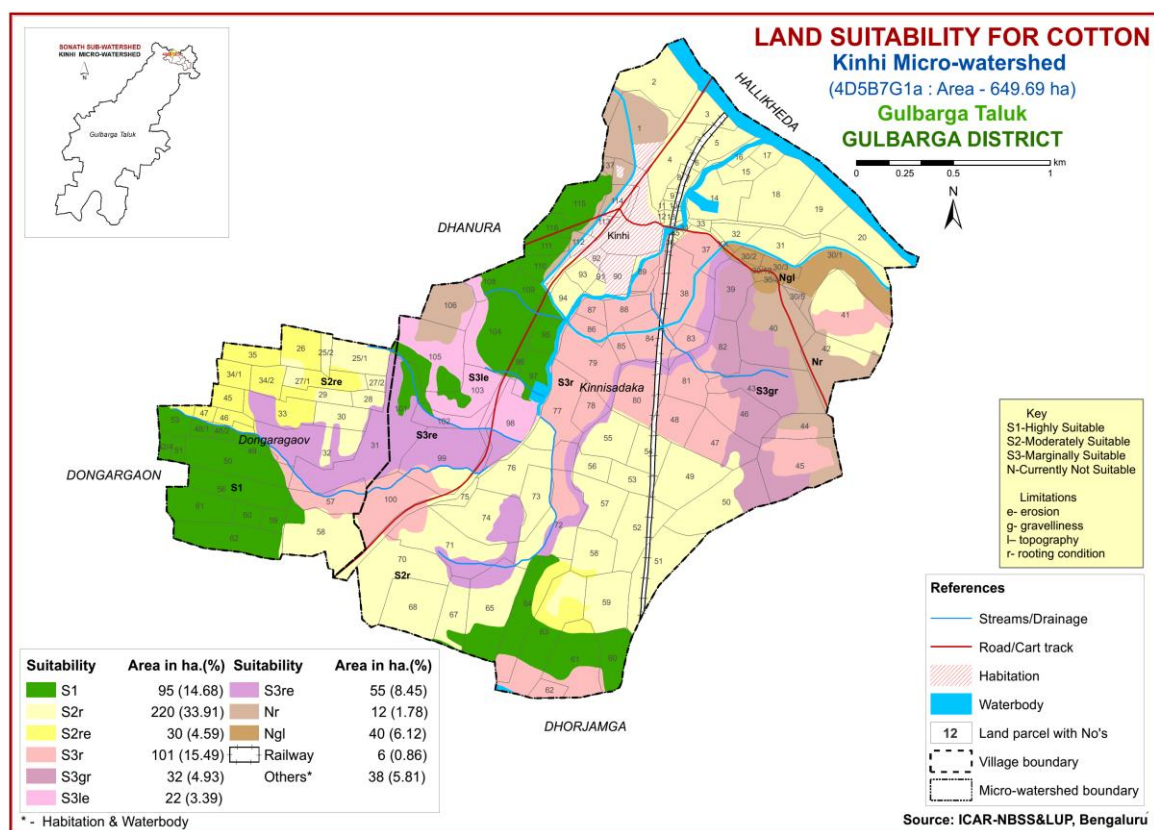


Fig. 7.5 Land Suitability map of Cotton

7.6 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.7 lakh ha area in Kalaburgi, Bijapur, Bagalkot, Bidar, Mysore, Chamarajanagar and Mandya districts under irrigated conditions. The crop requirements for growing sugarcane (Table 7.7) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing sugarcane was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

Table 7.7 Crop suitability criteria for Sugarcane

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

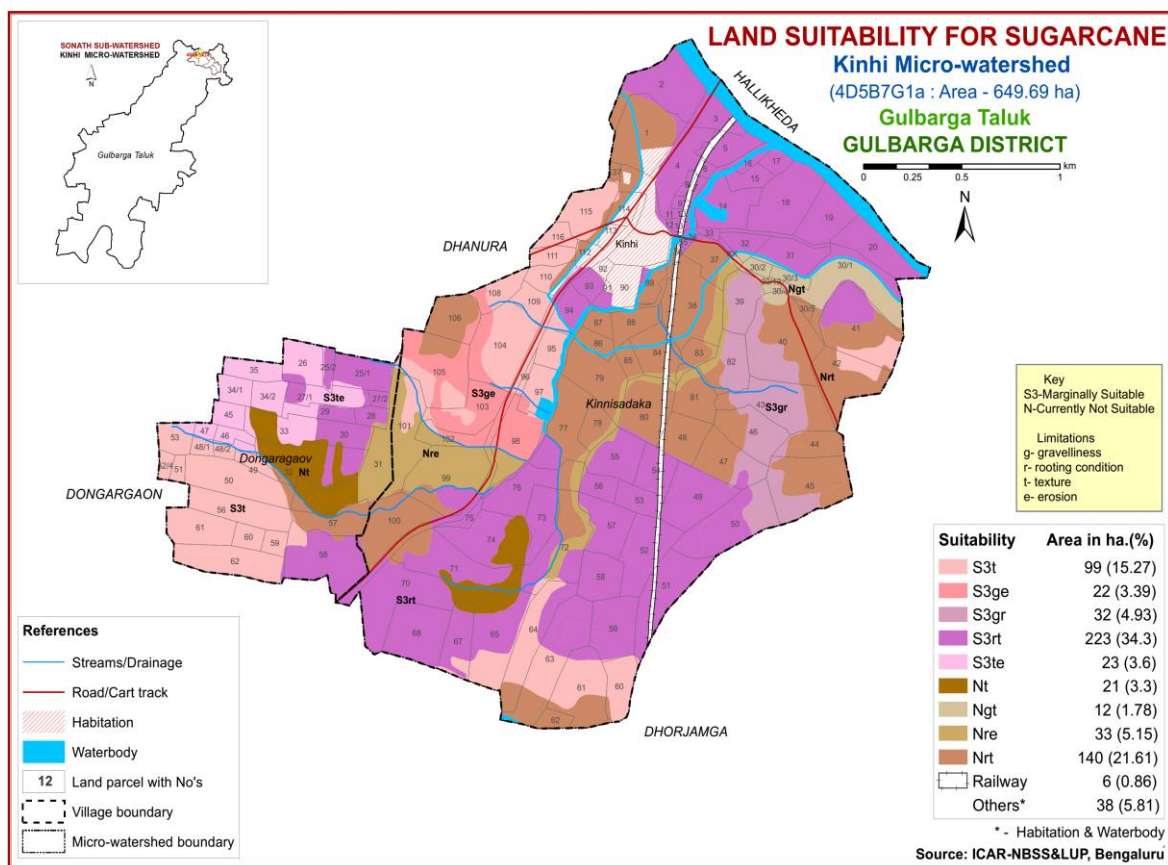


Fig. 7.6 Land Suitability map of Sugarcane

Highly (Class S1) and moderately suitable (Class S2) lands are not available for growing sugarcane in Kinhi microwatershed. The marginally suitable (Class S3) lands cover major area of about 399 ha (61%) and are distributed in all parts of the microwatershed. They have moderate limitations of gravelliness, erosion and texture. An area of about 206 ha (32%) is not suitable (Class N) for growing sugarcane and occur in the southeastern, central, western, eastern, northwestern and northeastern part of the microwatershed. They have severe limitations of gravelliness, erosion, texture and rooting depth.

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.

An area of about 99 ha (15%) in the microwatershed has soils that are highly suitable (Class S1) for growing soybean. They have minor or no limitations for growing soybean and are distributed mainly in the southwestern, southeastern, western and central part of the microwatershed. Major area of about 246 ha (38%) is moderately suitable

(Class S2) for growing soybean and are distributed in the southern, eastern, southwestern, central and northern part of the microwatershed. They have minor limitations of erosion and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 210 ha (32%) and are distributed in the central, western, eastern and southeastern part of the microwatershed. They have moderate limitations of rooting depth, erosion, and gravelliness. An area of about 52 ha (8%) is not suitable (Class N) for growing soybean and are distributed in the eastern, western and northwestern part of the microwatershed. They have severe limitations of gravelliness, rooting depth and topography.

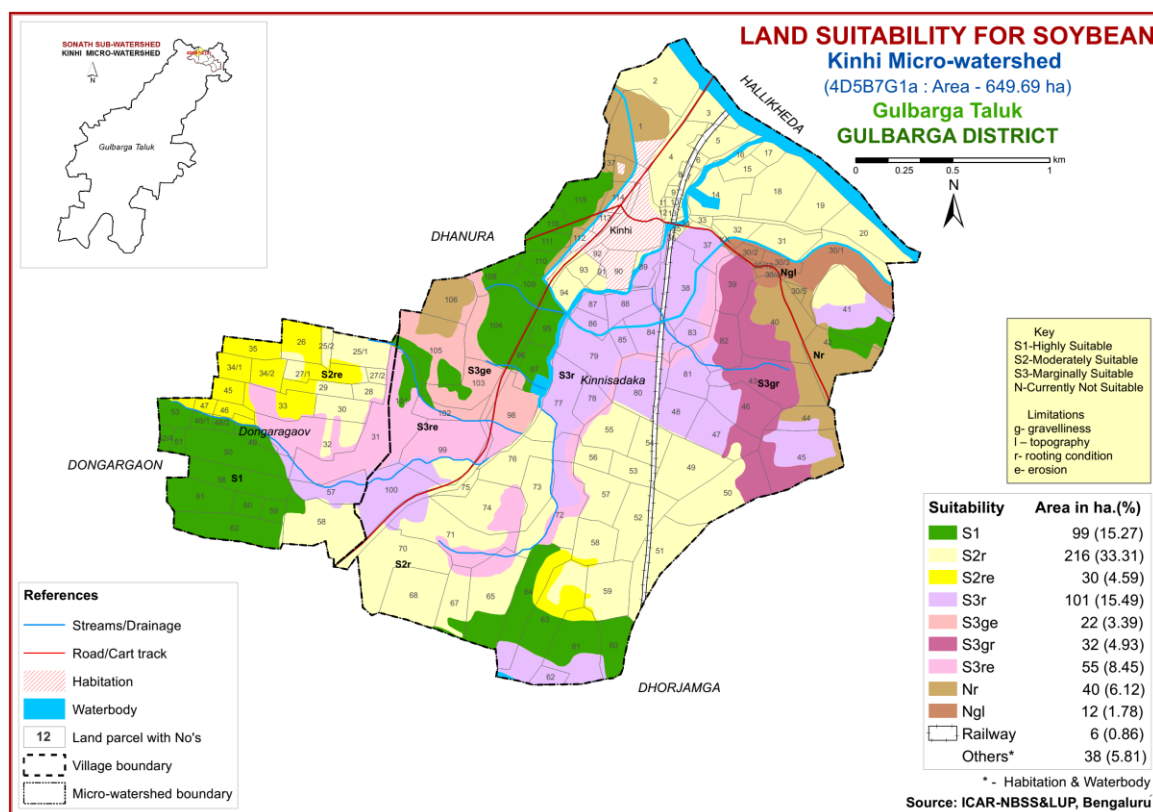


Fig. 7.7 Land Suitability map of Soybean

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

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

Highly suitable (Class S1) lands are found to occur in major area of 322 ha (50%). They have minor or no limitations for growing bengalgram and are distributed in all parts of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 200 ha (31%). The soils have minor limitations of gravelliness, erosion and

rooting depth. They are distributed in the central, southwestern, southeastern and eastern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 72 ha (11%) and are distributed in the eastern, northeastern, northwestern and western part of the microwatershed. They have moderate limitations of rooting depth and gravelliness. An area of about 12 ha (2%) is not suitable (Class N) for growing bengalgram and occur in the northeastern part of the microwatershed. They have severe limitations of gravelliness and topography.

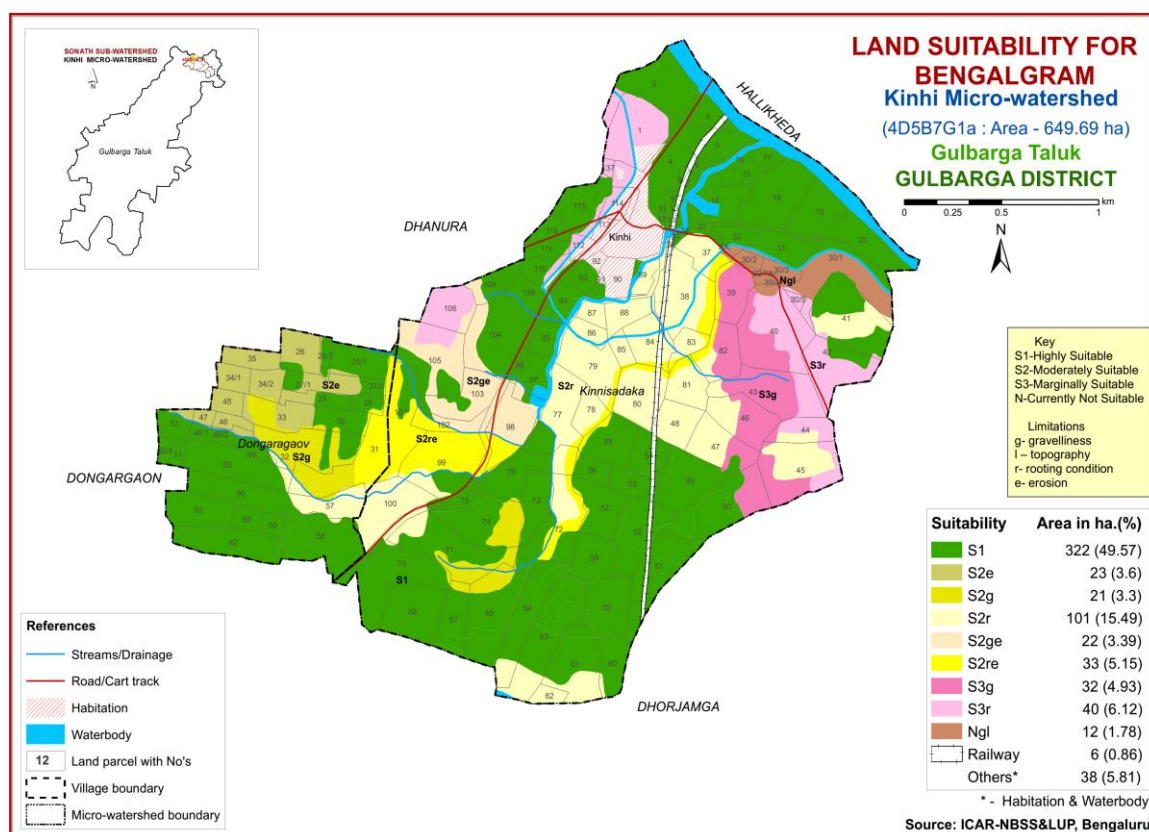


Fig. 7.8 Land Suitability map of Bengalgram

7.9 Land Suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in about 1.73 lakh ha in all the districts of the State. The crop requirements for growing mango (Table 7.8) were matched with the soil-site characteristics (Table 7.1) and a land suitability map for growing mango was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.9.

No highly (Class S1) and moderately suitable (Class S2) lands are available for growing mango in the Kinhi microwatershed. The marginally suitable (Class S3) lands cover an area of about 99 ha (15%) and mainly occur in the southwestern, southeastern, western and central part of the microwatershed. They have moderate limitations of texture and rooting depth. Major area of about 507 ha (78%) is not suitable (Class N) for growing mango and occur in all parts of the microwatershed.

Table 7.8 Crop suitability criteria for Mango

Crop requirement			Rating			
soil-site characteristics		Unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temp in growing season	⁰ C	28-32	24-27 33-35	36-40	20-24
	Min. temp. before flowering	⁰ C	10-15	15-22	>22	
Soil moisture	Growing period	Days	>180	150-180	120-150	<120
Soil aeration	Soil drainage	class	Well drained	Mod. To imperfectly drained	Poor drained	Very poorly drained
	Water table	M	>3	2.50-3.0	2.5-1.5	<1.5
Nutrient availability	Texture	Class	Sc, l, sil, cl	Sl, sc, sic, l, c	C (<60%)	C (>60%),
	pH	1:2.5	5.5-7.5	7.6-8.55.0-5.4	8.6-9.0 4.0-4.9	>9.0 <4.0
	OC	%	High	medium	low	
	CaCO ₃ in root zone	%	Non calcareous	<5	5-10	>10
Rooting conditions	Soil depth	cm	>200	125-200	75-125	<75
	Gravel content	% vol.	Non gravelly	<15	15-35	>35
Soil toxicity	Salinity	dS/m	Non saline	<2.0	2.0-3.0	>3.0
	Sodicity	%	Non sodic	<10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

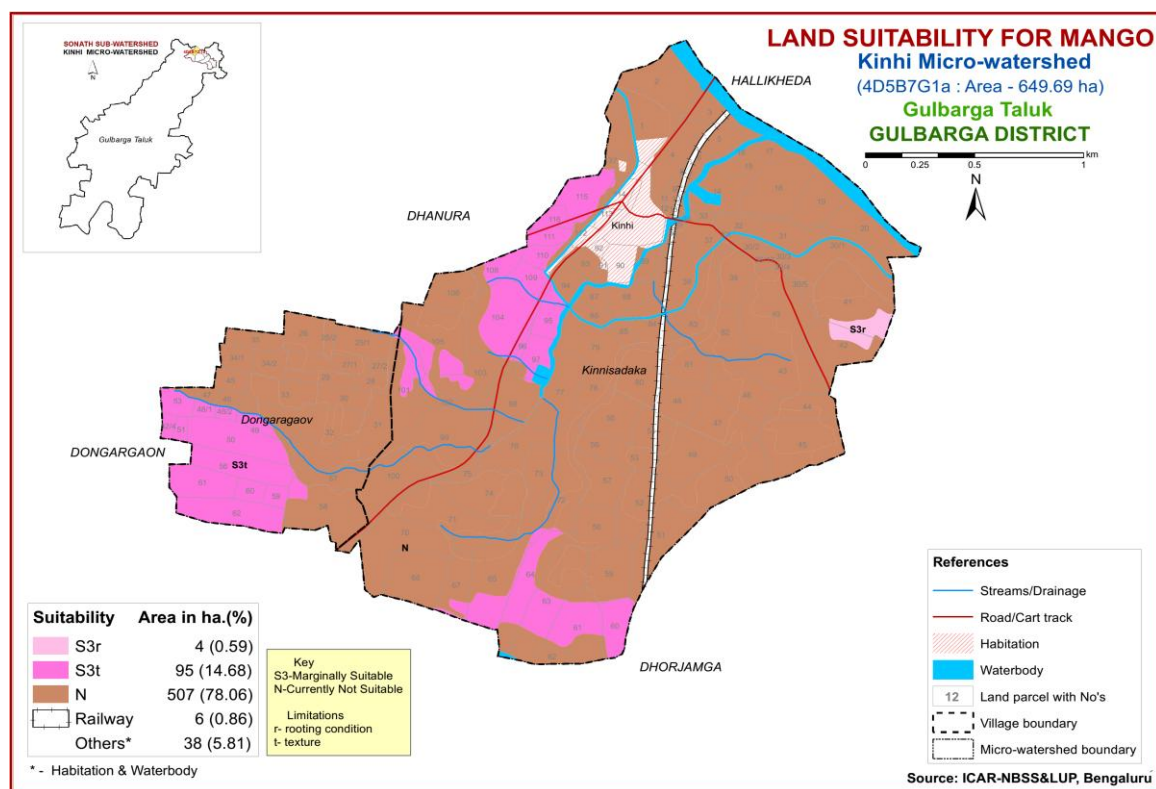


Fig. 7.9 Land Suitability map of Mango

7.10 Land Suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in about 29373 ha in almost all the districts of the state. The crop requirements for growing sapota (Table 7.9) 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.

In Kinhi microwatershed, there are no lands that are highly (Class S1) suitable for growing sapota. Moderately suitable (Class S2) lands are found to occur in major area of about 315 ha (49%). The soils have minor limitations of texture, erosion and rooting depth and are distributed in all parts of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 51 ha (8%) and mainly occur in the central and southwestern part of the microwatershed. They have moderate limitations of rooting depth, erosion and topography. An area of about 239 ha (37%) is not suitable (Class N) for growing sapota and occur in the central, western, eastern and northwestern part of the microwatershed.

Table 7.9 Crop suitability criteria for Sapota

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

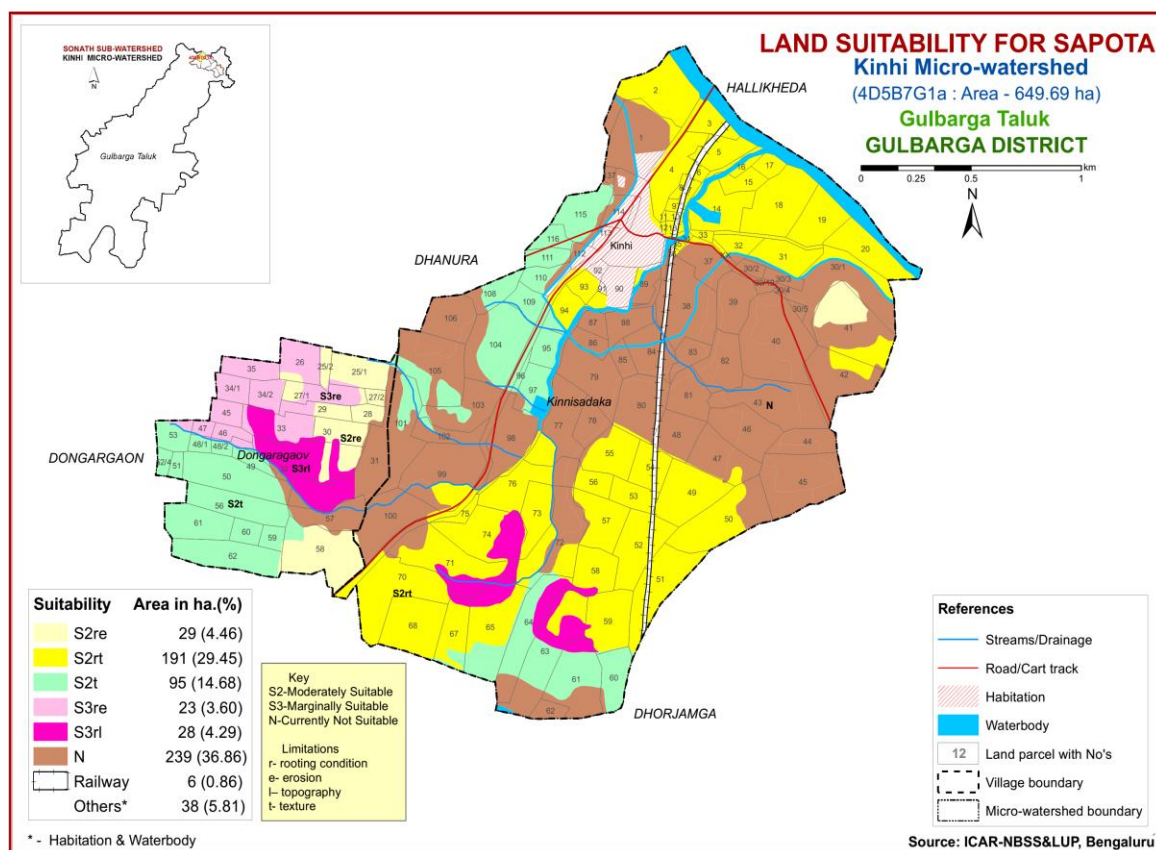


Fig. 7.10 Land Suitability map of Sapota

7.11 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in about 6558 ha area in the State in Raichur, Dharwad, Belgaum, Kalaburgi, Bijapur, Bidar, Bellary, Chitradurga, Bangalore and Chamarajnagar districts. The crop requirements for growing guava (Table 7.10) 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 7.11.

In Kinhi microwatershed, there are no highly (Class S1) suitable lands available for growing guava. Moderately suitable (Class S2) lands are found to occur in major an area of about 315 ha (49%). The soils have minor limitations of texture, erosion and rooting depth. They are distributed in all parts of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 51 ha (8%) and mainly distributed in the southern and southwestern part of the microwatershed. They have moderate limitations of texture, erosion and rooting depth. An area of about 239 ha (37%) is not suitable (Class N) for growing guava and occur in the central, western, eastern and northwestern part of the microwatershed.

Table 7.10 Crop suitability criteria for Guava

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

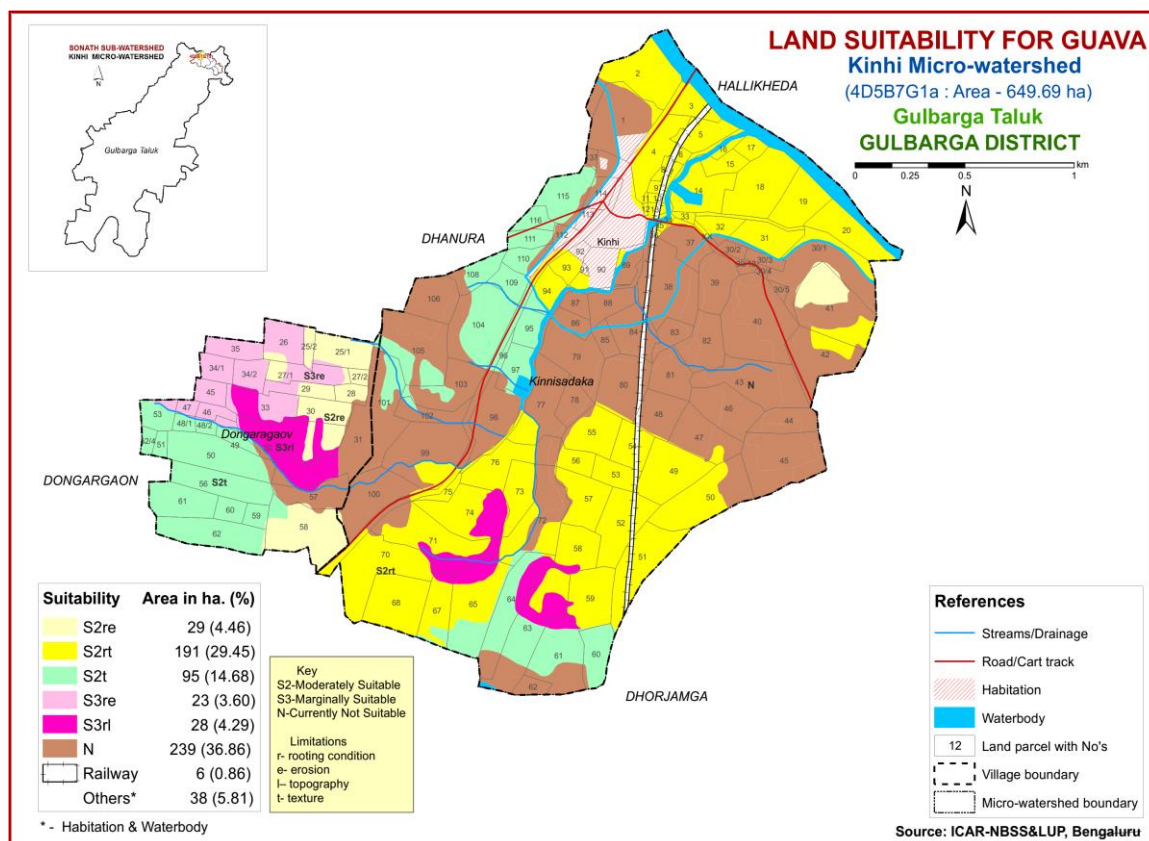


Fig 7.11 Land Suitability map of Guava

7.12 Land Suitability for Jackfruit (*Artocarpus heterophyllus*)

Jackfruit is the most important fruit crop grown in 5368 ha 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 7.12.

No highly (Class S1) and moderately (Class S2) suitable lands are available for growing jackfruit in the microwatershed. The marginally suitable (Class S3) lands cover major area of about 339 ha (52%) and mainly occur in all parts of the microwatershed. They have moderate limitations of texture and rooting depth. An area of about 267 ha (41%) is not suitable (Class N) for growing jackfruit and occur in the central, southwestern, eastern and northwestern part of the microwatershed.

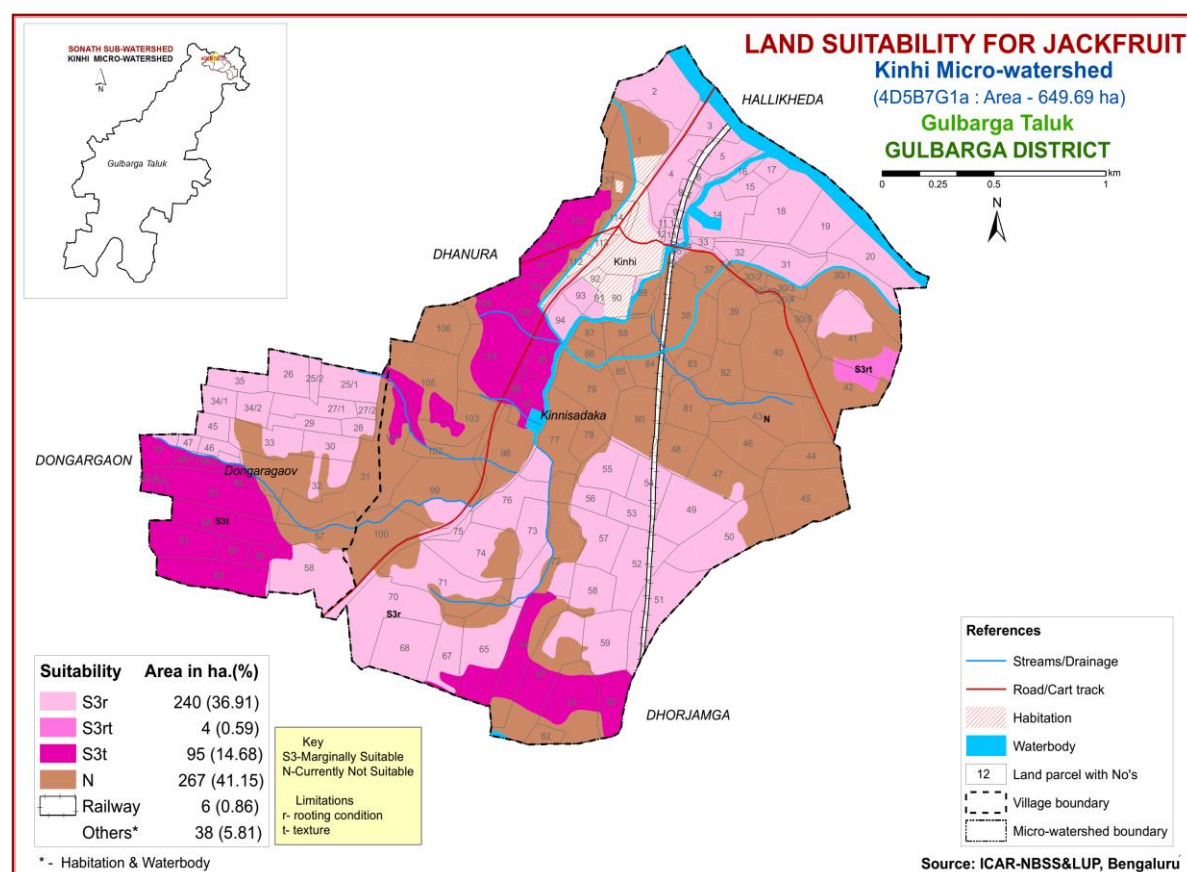


Fig 7.12 Land Suitability map of Jackfruit

7.13 Land Suitability for Jamun (*Syzygium cumini*)

Jamun is the most important fruit crop grown in almost all the districts of the state. The crop requirements for growing jamun 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 7.13.

No highly (Class S1) suitable lands are available for growing jamun in the microwatershed. The moderately suitable (Class S2) lands are found to occur in an area of about 99 ha (15%). The soils have minor limitations of texture and rooting depth. They are distributed in the southeastern, southwestern, western and central part of the microwatershed. The marginally suitable (Class S3) lands cover an area of 239 ha (37%) and mainly occur in the southern, central, southwestern, eastern and northern part of the microwatershed. They have moderate limitations of rooting depth and erosion. Major area of about 267 ha (41%) is not suitable (Class N) for growing jamun and occur in the central, southwestern, northeastern and southeastern part of the microwatershed.

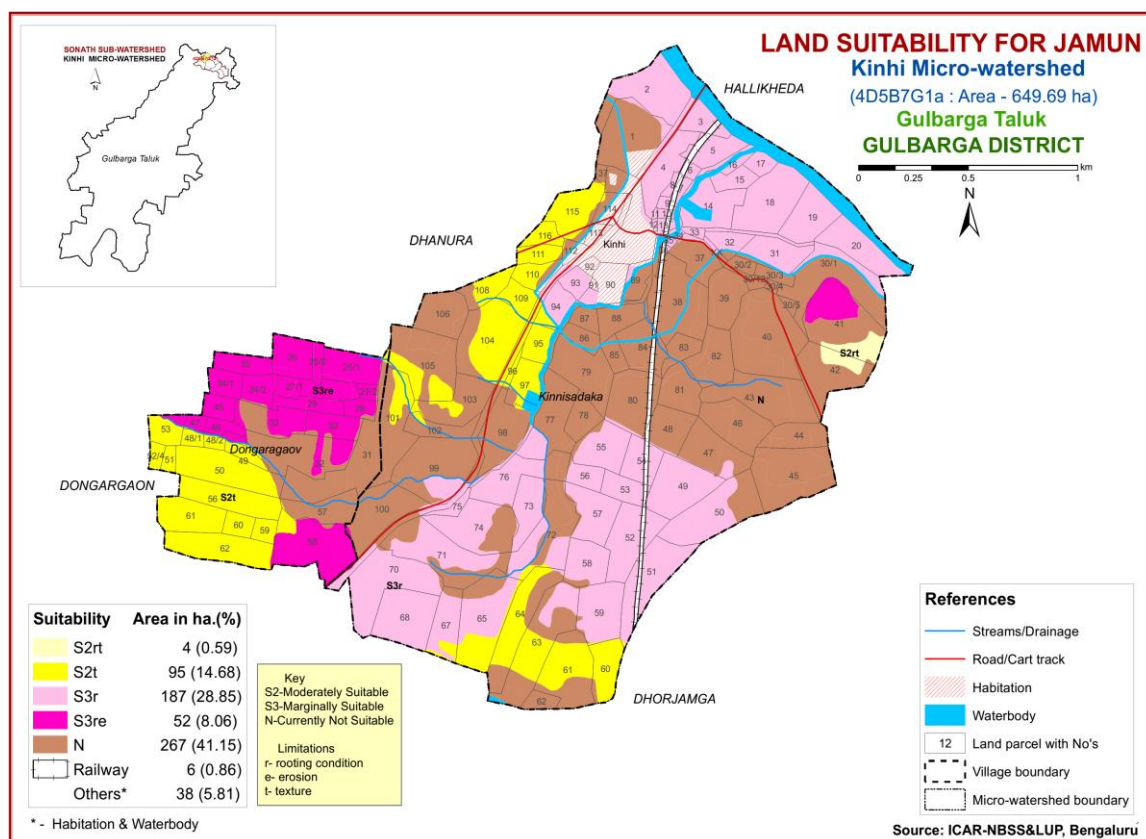


Fig 7.13 Land Suitability map of Jamun

7.14 Land Suitability for Musambi (*Citrus limetta*)

Musambi is the most important fruit crop grown in an area of 5446 ha in almost all the districts of the state. The crop requirements for growing musambi were matched with the soil-site characteristics and a land suitability map for growing musambi was generated. The area extent and their geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

Highly suitable (Class S1) lands are found to occur in an area of about 21 ha (3%) and are distributed in the southeastern part of the microwatershed. They have minor or no limitations for growing musambi. The moderately suitable (Class S2) lands occur in major area of about 294 ha (45%). The soils have minor limitations of texture, erosion and rooting depth. They are distributed in all parts of the microwatershed. The marginally suitable (Class S3) lands cover an area of 51 ha (8%) and mainly occur in the

southwestern and southeastern part of the microwatershed. They have moderate limitations of rooting depth, topography and erosion. An area of about 239 ha (37%) is not suitable (Class N) for growing musambi and occur in the western, southwestern, eastern, central and northeastern part of the microwatershed.

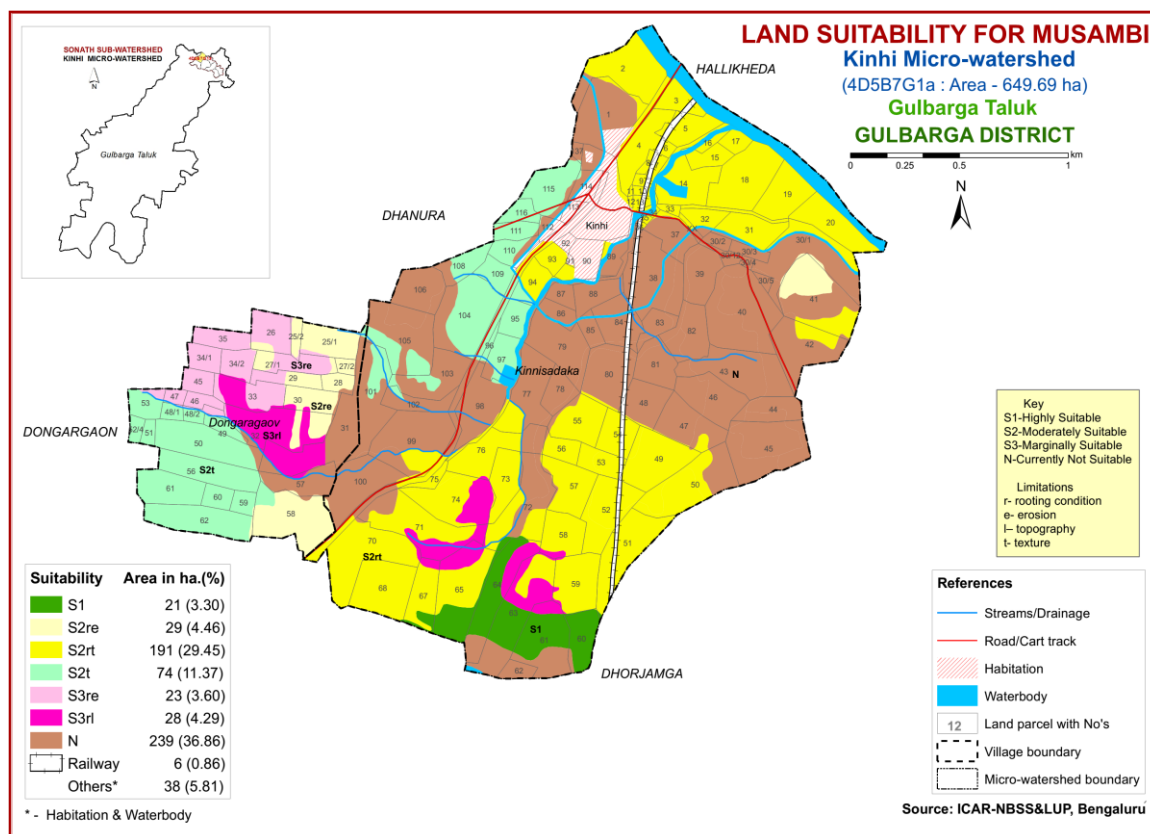


Fig 7.14 Land Suitability map of Musambi

7.15 Land Suitability for Lime (*Citrus sp*)

Lime is the most important fruit crop grown in 11752 ha 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 7.15.

Highly suitable (Class S1) lands are found to occur in an area of about 21 ha (3%) and are distributed in the southeastern part of the microwatershed. They have minor or no limitations for growing lime. The moderately suitable (Class S2) lands occur in major area of about 294 ha (45%). The soils have minor limitations of texture, erosion and rooting depth. They are distributed in all parts of the microwatershed. The marginally suitable (Class S3) lands cover an area of 51 ha (8%) and mainly occur in the southwestern and southeastern part of the microwatershed. They have moderate limitations of rooting depth, topography and erosion. An area of about 239 ha (37%) is not suitable (Class N) for growing lime and occur in the western, southwestern, eastern, central and northeastern 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	36-40	>40
				24-27	20-23	<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	

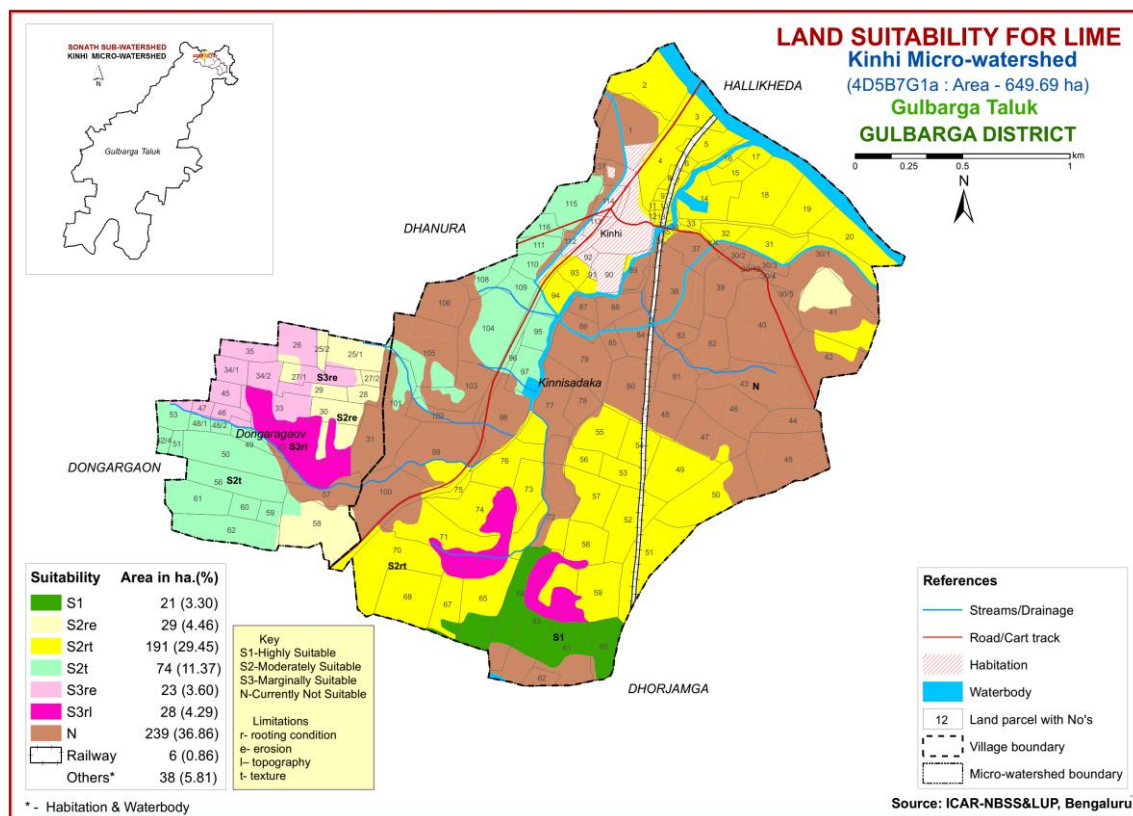


Fig 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale*)

Cashew is the most important plantation crop grown in an area of about 70552 ha 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 and geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

Entire area is not suitable (Class N) for growing cashew in the microwatershed.

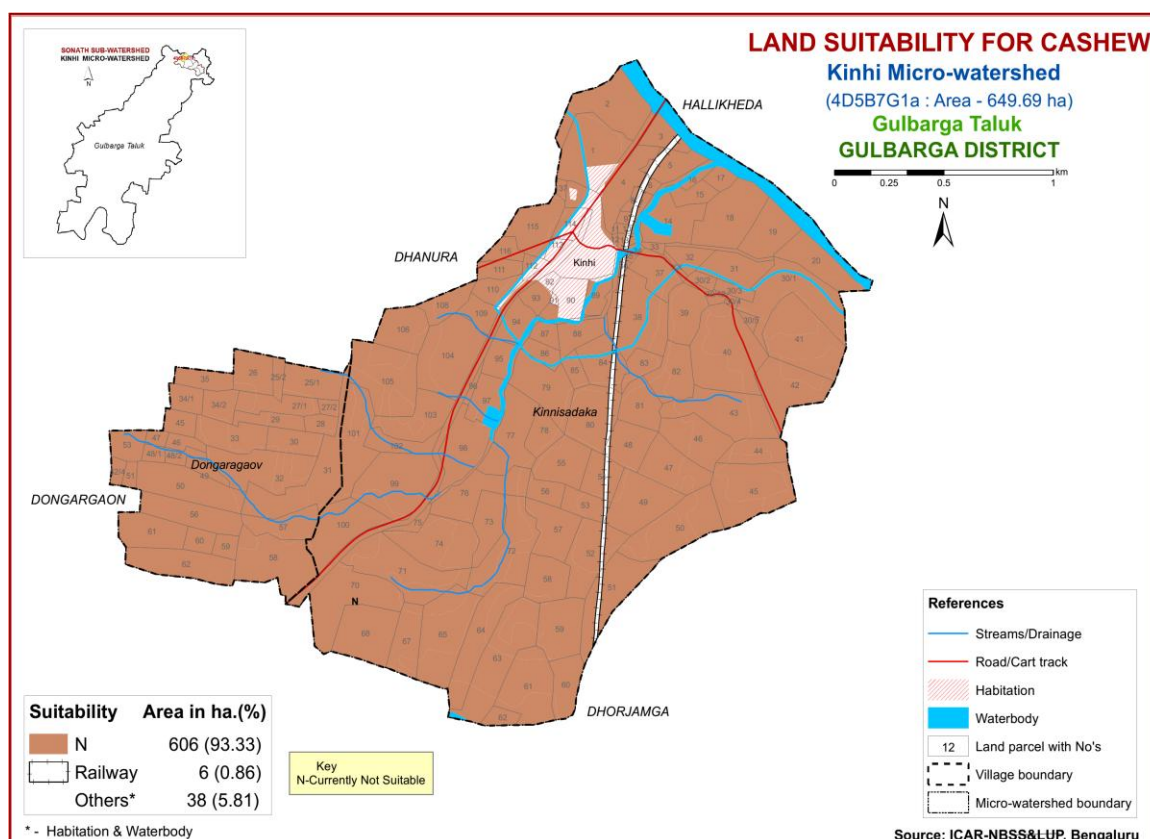


Fig 7.16 Land Suitability map of Cashew

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

Custard apple is the most important fruit crop grown in 1426 ha 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 7.17.

Highly suitable (Class S1) lands are found to occur in major area of 316 ha (49%) and are distributed in all parts of the microwatershed. They have minor or no limitations for growing custard apple. Moderately suitable (Class S2) lands are found to occur in an area of about 209 ha (32%). The soils have minor limitations of gravelliness, erosion and rooting depth. They are distributed in the southwestern, central and eastern part of the microwatershed. The marginally suitable (Class S3) lands cover 40 ha (6%) area and

occur in the western, northwestern and eastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 42 ha (6%) is not suitable (Class N) for growing custard apple and occur in the western, southeastern and northeastern part of the microwatershed.

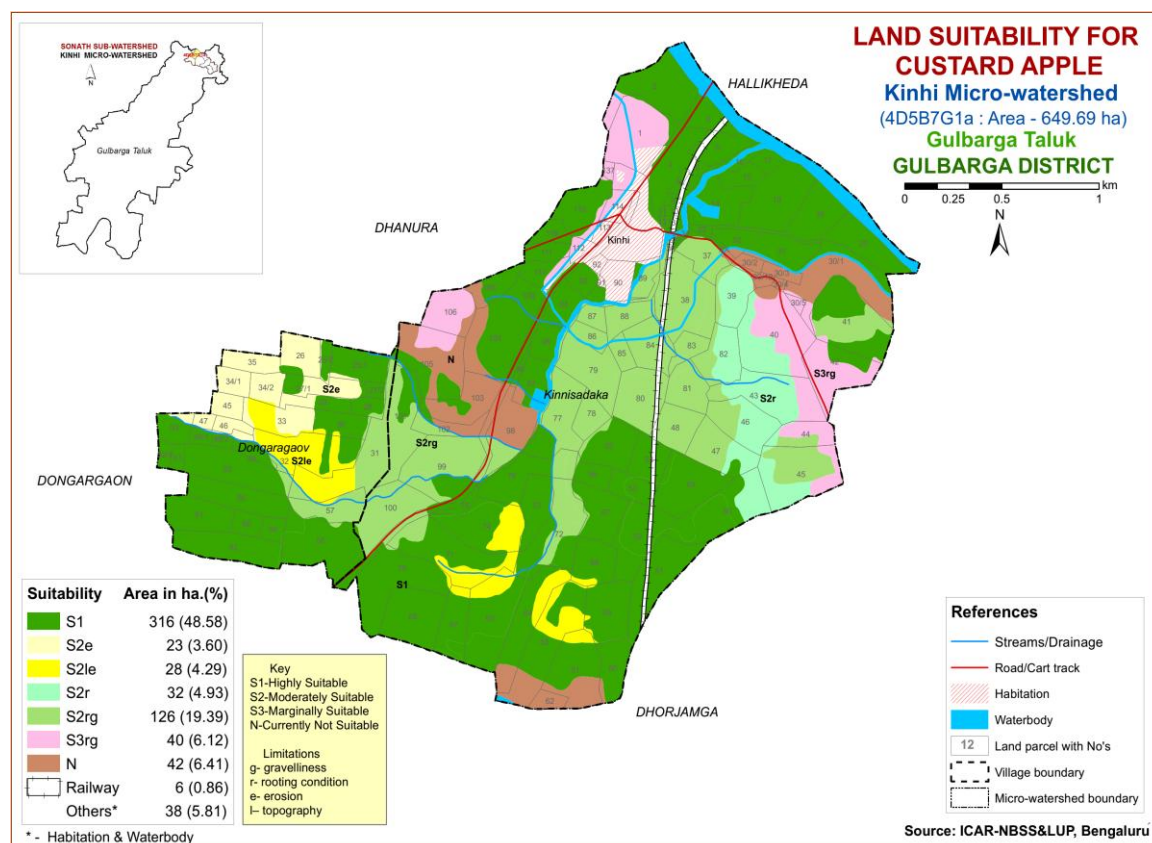


Fig 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is the most important fruit and medicinal crop grown in 151 ha 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 7.18.

Highly suitable (Class S1) lands are found to occur in major area of 316 ha (49%). They have minor or no limitations for growing amla and are distributed in all parts of the microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 177 ha (27%). The soils have minor limitations of gravelliness, erosion and rooting depth. They are distributed in the central, southwestern, and northeastern part of the microwatershed. The marginally suitable (Class S3) lands are found to occur in an area of about 32 ha (5%). The soils have moderate limitation of rooting depth. They are distributed in the eastern and central part of the microwatershed. An area of about 81 ha

(13%) is not suitable (Class N) for growing amla and are distributed in the southeastern, western, northeastern and northwestern part of the microwatershed.

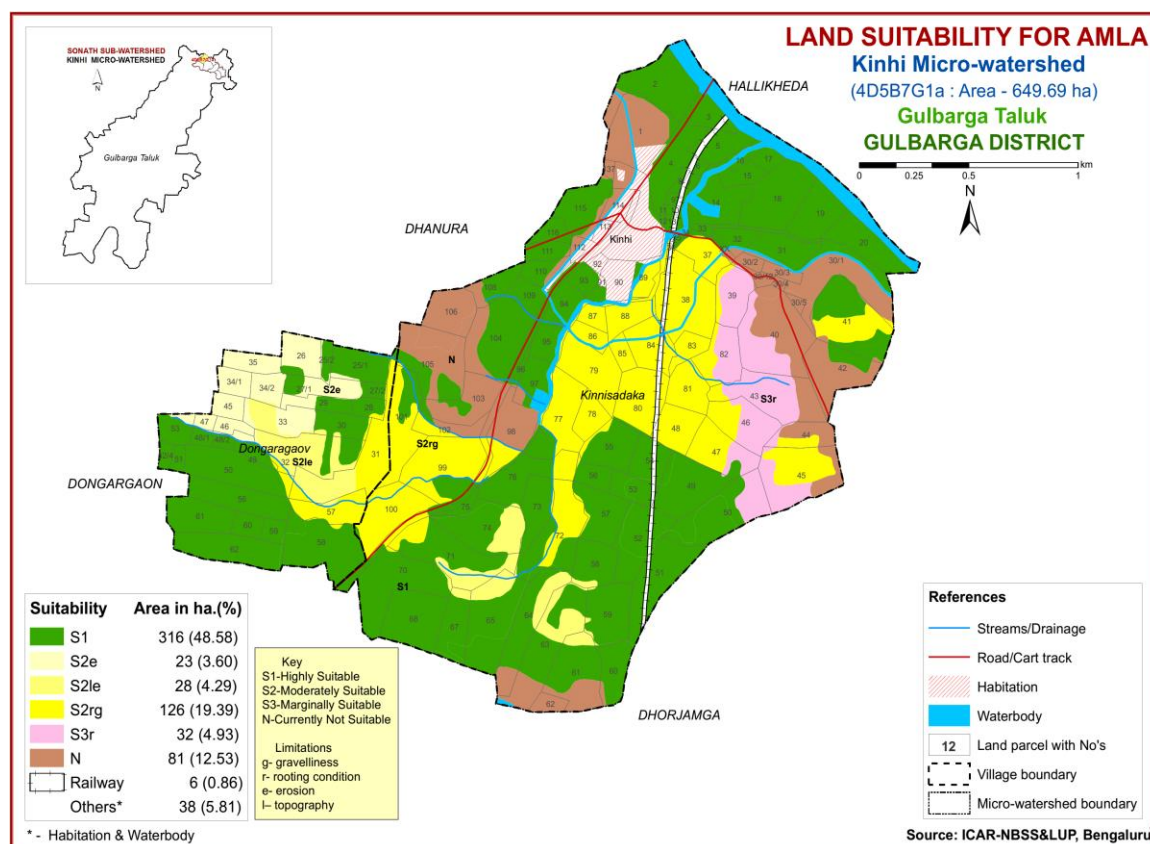


Fig 7.18 Land Suitability map of Amla

7.19 Land Suitability for Tamarind (*Tamarindus indica*)

Tamarind is the most important spice crop raised in 14897 ha in all the districts of the state. The crop requirements for growing tamarind were matched with the soil-site characteristics and a land suitability map for growing tamarind was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.19.

No highly (Class S1) suitable lands are available for growing tamarind in the Kinhi microwatershed. Moderately suitable (Class S2) lands are found to occur in an area of about 99 ha (15%). The soils have minor limitations of texture and rooting depth. They are distributed in the southwestern, southeastern, central and western part of the microwatershed. The marginally suitable (Class S3) lands cover about 245 ha (38%) area and mainly occur in the southern, northern, southeastern, northeastern, northwestern and central part of the microwatershed. The soils have moderate limitations of erosion, topography and rooting depth. Major area of about 261 ha (40%) is not suitable (Class N) for growing tamarind and occur in all parts of the microwatershed.

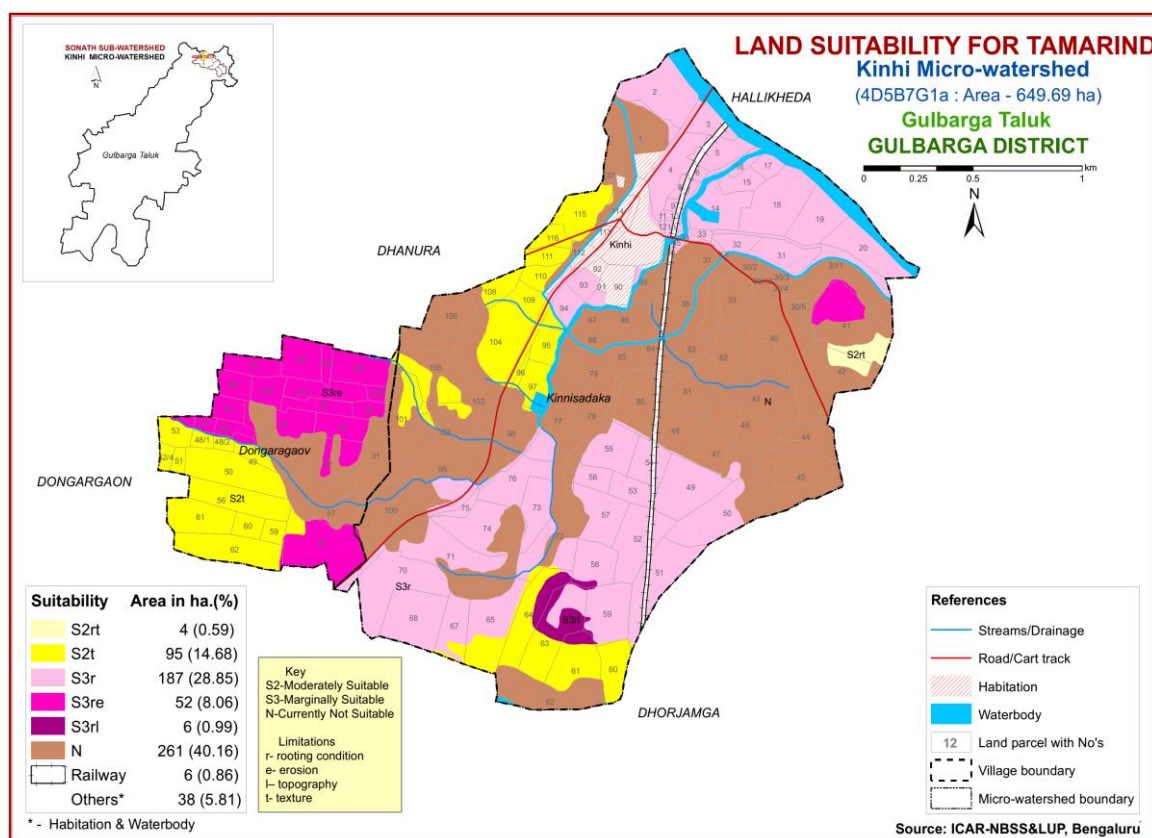


Fig 7.19 Land Suitability map of Tamarind

7.20 Land Use Classes (LUCs)

The 19 soil map units identified in Kinhi microwatershed have been grouped into 5 Land Use Classes (LUC's) for the purpose of preparing a Proposed Crop Plan. Land Use Classes are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Use Classes map (Fig.7.20) has been generated. These Land Use Classes are expected to behave similarly for a given level of management.

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

LUCs	Soil map units	Soil and site characteristics
1	MGTmB3g, MGTmC3g1 MGTmD3g2	Very shallow, black clay soils with slopes of 1-10%, gravelly to very gravelly (15-60%) and severe erosion
2	KGIImB2g1, NHAmB1 NHAmB2, NHAmB2g1 NHAmC3g1, DSImC3g1	Shallow to moderately shallow, black clayey soils with slopes of 1-5%, gravelly (15-35%) and slight to moderate erosion
3	DSImA1, DSImB1 DSImB2, DSImB3 DSImC2g1	Moderately shallow, black clayey soils with slopes of 1-5%, gravelly (15-35%) and slight to severe erosion
4	KMPmB1 RMNmC3g1	Moderately deep to deep, black clayey soils with slopes of 1-5%, gravelly (15-35%) and slight to severe erosion
5	RNLmB1, RNLmB2 MANmB1	Deep, black clayey soils with slopes of 1-3% and slight to moderate erosion

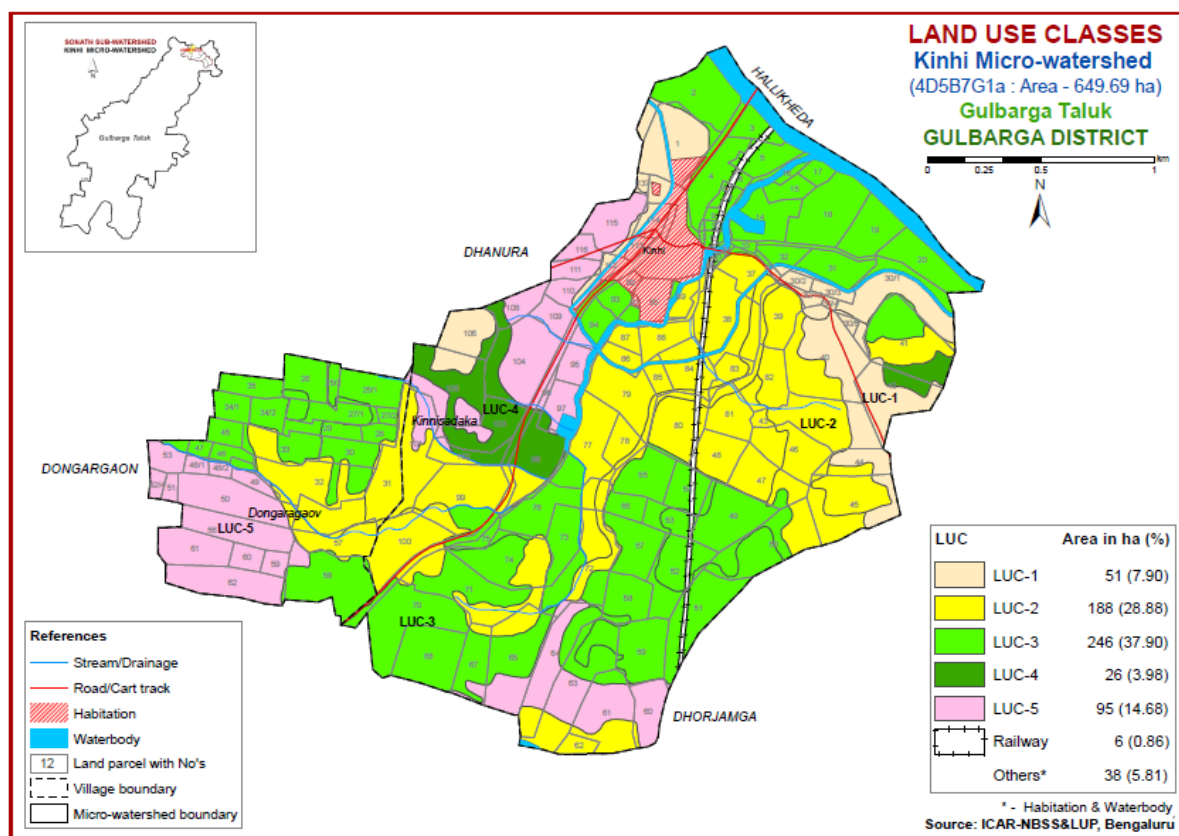


Fig. 7.20 Land Use Classes map of Kinhi Microwatershed

7.21 Proposed Crop Plan for Kinhi Microwatershed

After assessing the land suitability for the 19 crops, a proposed crop plan has been prepared for the 5 identified LUCs by considering only the highly (Class S1) and moderately (Class S2) suitable lands for each of the nineteen crops. The resultant proposed crop plan is presented below in Table 7.12

Table 7.12 Proposed Crop Plan for Kinhi Microwatershed

	Mapping unit	Survey No	Soil Characteristics	Field crops	Forestry Crop/Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops with suitable intervention	Suitable Intervention
LMU -1	10MGTmB3g1 11MGTmC3g1 12MGTmD3g2	Kinnisadaka: 1,30/1_GRASS_FIEL D, 30/12, 30/2, 30/3, 30/4, 30/5, 40, 42, 44, 106, 137	Very shallow Soils, depth (<25 cm) slight to very gravelly, severely eroded	-	Silvipast ure, Neem, Glyricyd ia, Teak, Agave	-	-	Crescent bunds
LMU -2	7KGImB2g1 13NHAmB1 14NHAmB2 15NHAmB2g1 16NHAmC3g1 6 DSIImC3g1	Dongaragaon: 31, 32, 57 Kinnisadaka: 37, 38, 39, 41, 43, 45, 46, 47, 48, 62, 72, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 99, 100, 101	Shallow black soils (25-50 cm), 1-3 % slopes, slight to severely eroded, slightly gravelly.	Bajra, Linseed, Green gram, Black gram, Chick pea	Subabhu l, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea, Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemu m	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip
LMU -3	1DSImA1 2DSImB1 3DSImB2 4DSImB3 5DSImC2g1	Dongaragaon: 25/1, 25/2, 26, 27/1, 27/2, 28, 29, 30, 33, 34/1, 34/2, 35, 45, 46, 47, 58 Kinnisadaka: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 31, 32, 33, 35, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,	Moderately shallow black soils (50-75 cm) 1-3 % slopes, moderately eroded, gravelly	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower Rabi: Sorghum, Chickpea	Subabhu l, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea, Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers:	-do- Graded bunds, Strengthening of field bunds

		59, 65, 67, 68, 70, 71, 73, 74, 75, 76, 93, 94, XX					Marigold, Chrysanthemum	
LMU -4	8 KMPmB1 17RMNmC3g1	Kinnisadaka: 98, 102, 103, 105	Moderately deep black soils (75-100 cm), 1-5 % slopes, slight to severely eroded	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower Rabi: Sorghum, Chickpea	Subabhu l, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea, Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservation measures like cultivation on raised beds with mulches and drip Graded bunds, Strengthening of field bunds
LMU -5	18RNLMb1 19RNLMb2 9MANmB1	Dongaragaon: 48/1, 48/2, 49, 50, 51, 52/4, 53, 56, 59, 60, 61, 62 Kinnisadaka: 60, 61, 63, 64, 95, 96, 97, 104, 108, 109, 110, 111, 115, 116	Deep to very deep black soils (100-150 & >150 cm), 1-3 % slopes, slight to moderate erosion	Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower, Rabi: Sorghum, Chickpea	-	Vegetables: Ladies finger, Brinjal, Cowpea, coriander Field crops: Sorghum, Cotton, Red Gram, Sunflower, Safflower, Perennial component: Guava, Tamarind, Sapota, Lime, Mosambi Flowers : Marigold, Chrysanthemum	Banana, Papaya, Lime, Mosambi, Guava, Tamarind Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	-do-

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

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

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

The most important characteristics of a healthy soil are

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

Characteristics of Kinh Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of DSI (268 ha), NAH (134 ha), RNL (74 ha), MGT (51 ha), KGI (32 ha), RMN (22 ha), MAN (21 ha) and KMP (4 ha).
- As per land capability classification, nearly 92 per cent area comes under arable land category (Class II, III and IV) and 2 per cent area belongs to nonarable land (Class VI) category. The major limitations identified in the arable lands were soil and erosion.
- On the basis of soil reaction, an area of about 177 ha (27%) is slightly alkaline (pH 7.3-7.8) followed by moderately alkaline (pH 7.8-8.4) soils in 31 ha (4%).

Maximum area of about 313 ha (48%) is neutral (pH 6.5-7.3) in reaction. Slightly acid (pH 6.0-6.5) soils cover an area of about 86 ha (13%). Thus, about 32 per cent of the soils in the microwatershed are alkaline in reaction and about 13 per cent under slightly acid.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

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

Acid soils

(Slightly acid to strongly acid soils)

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

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 650 ha in the microwatershed, major area of 349 ha is suffering from either moderate or severe erosion. These areas need immediate soil and water conservation and other land husbandry practices for restoring soil health.

Dissemination of information and communicate benefits

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

Inputs for Net Planning (Saturation Plan) and Interventions needed

Net planning (Saturation Plan) 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 (Saturation plan) are briefly presented below.

- ❖ **Soil Depth:** The depth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on the rooting depth and the length of growing period available for raising any crop. Deeper the soil, better for a wide variety of crops. If sufficient depth is not available for growing deep rooted crops either choose medium or short duration crops or deeper planting pits need to be opened and additional good quality soil brought from outside has to be filled into the planting pits.
- ❖ **Surface soil texture:** Lighter soil texture in the top soil means, better rain water infiltration, less run-off and soil moisture conservation, less capillary rise and less evaporation losses. Lighter surface textured soils are amenable to good soil tilth and are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka 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 Kinhi microwatershed.
- ❖ **Organic Carbon:** In about 8 ha (1%) area, the OC content is low (<0.5%), in about 77 ha (12%) area, the OC content is medium (0.5-0.75%) and in about 522 ha (80%) area, it is high (>0.75%). The areas that are low and medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.
- ❖ **Promoting green manuring:** Growing of green manuring crops cost Rs. 1250/ha (green manuring seeds) and about Rs. 2000/ha towards cultivation that totals to Rs. 3250/- per ha. On the other hand, application of organic manure @ 10 tons/ha costs Rs. 5000/ha. The practice needs to be continued for 2-3 years or more. Nitrogen fertilizer needs to be supplemented by 25% in addition to the recommended level in 85 ha area where OC is low to medium. 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 581 ha (89%) area, the available phosphorus is low, about 19 ha (3%) area it is medium and it is high in 7 ha (1%) area of the microwatershed. Hence for all the crops, 25% additional P-needs to be applied to those areas where it is low and medium.
- ❖ **Available Potassium:** Available potassium is medium in 377 ha (58%) area, low in 224 ha (34%) area. Hence, in all these plots, for all crops, an additional 25 % potassium may be applied. It is high in 6 ha (1%) area of the microwatershed.
- ❖ **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 157 ha (24%) area of the microwatershed and medium in 447 ha (69%). These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertilizer (13% sulphur) for 2-3 years for the deficiency to be corrected. Only 2 ha (<1%) area has soils that are high in available sulphur.
- ❖ **Available iron:** It is sufficient in the entire area of the microwatershed.
- ❖ **Available manganese:** It is sufficient in the entire area of the microwatershed.
- ❖ **Available copper:** It is sufficient in the entire area of the microwatershed.
- ❖ **Available zinc:** It is deficient in 271 ha (42%) area of the microwatershed. It is sufficient in 335 ha (52%) area in the microwatershed.
- ❖ **Soil acidity:** The microwatershed has 86 ha area with soils that are acidic. These areas need application of lime (CaCO_3) and wherever acidity is in excess, rock phosphate and basic slag can be recommended. Management practices like soil management, water

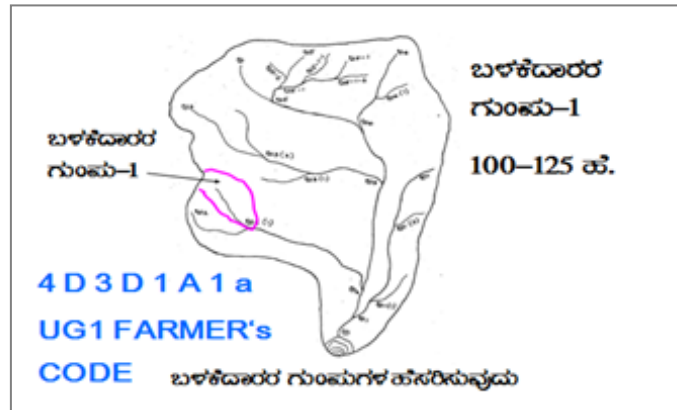
management *etc.* increase the efficiency of nitrogen and potassic fertilizers and growing of acid tolerant crops like Rice, Potato, Tomato, Barley, Wheat *etc.*, are recommended.

- ❖ **Soil alkalinity:** The microwatershed has 208 ha area with soils that are alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts and, provision of subsurface drainage and growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber *etc.*, are recommended.
- ❖ **Land Suitability for various crops:** Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example, in case of cotton, gravel content and rooting depth are the major constraints in various plots. With suitable management interventions, the productivity can be enhanced. In order to increase water holding capacity of light textured soils, growing of green manure crops and application of organic manure is recommended.

SOIL AND WATER CONSERVATION TREATMENT PLAN

For preparing soil and water conservation treatment plan for Kinhimicrowatershed, 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)



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

Steps for Survey and Preparation of Treatment Plan

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

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

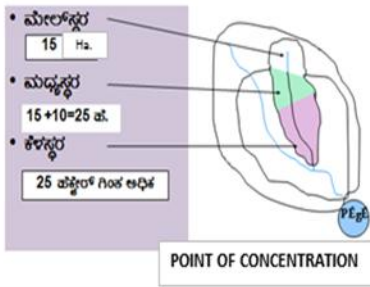
9.1 Treatment Plan

The treatment plan recommended for arable lands is briefly described below

9.1.1 Arable Land Treatment

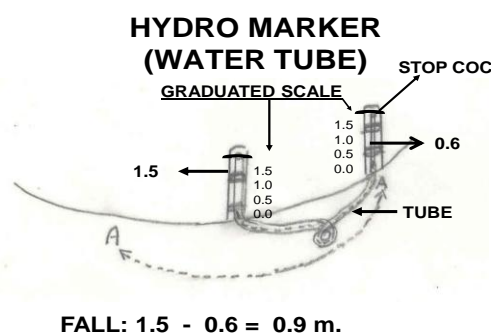
A. BUNDING

Steps for Survey and Preparation of Treatment Plan	
<ul style="list-style-type: none">• Cadastral map (1:7920 scale) is enlarged to a scale of 1:2500 scale• Existing network of waterways, pothissa boundaries, grass belts, natural drainage lines/ watercourse, cut ups/ terraces are marked on the cadastral map to the scale• Drainage lines are demarcated into	
Small gullies	(up to 5 ha catchment)
Medium gullies	(5-15 ha catchment)
Ravines	(15-25 ha catchment) and
Halla/Nala	(more than 25ha catchment)

USER GROUP-1	
CLASSIFICATION OF GULLIES	
<p>ಪೊರಕಲಿನ ವರ್ಗೀಕರಣ</p>  <p>UPPER REACH</p> <p>MIDDLE REACH</p> <p>LOWER REACH</p> <p>POINT OF CONCENTRATION</p>	

Measurement of Land Slope

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



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

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

Note: (i) The above intervals are maximum.

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

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

Section of the Bund

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

Recommended Bund Section

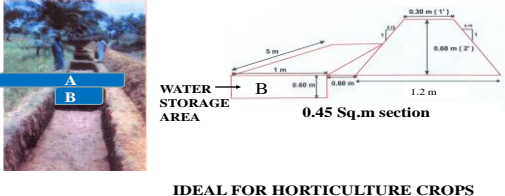
Top width (m)	Base width (m)	Height (m)	Side slope (Z:1;H:V)	Cross section (sq m)	Soil Texture	Remarks
0.3	0.9	0.3	01:01	0.18	Sandy loam	Vegetative bund
0.3	1.2	0.3	1.5:1	0.225	Sandy clay	
0.3	1.2	0.5	0.9:1	0.375	Red gravelly soil	
0.3	1.2	0.6	0.75:1	0.45		
0.3	1.5	0.6	01:01	0.54	Red sandy loam	
0.3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

TRENCH CUM BUND

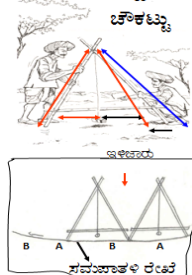


WATER STORAGE AREA

0.45 Sq.m section

IDEAL FOR HORTICULTURE CROPS

'A' FRAME FOR INTERBUND MANAGEMENT



1. ಸಮಸಾತಳ ಉಳುವು

2. ಸಮಸಾತಳ ಬಿತ್ತನೆ/ನಾಟಿ

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

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

B. Water Ways

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

C. Farm Ponds

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

D. Diversion Channel

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

9.1.2 Non-Arable Land Treatment

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

9.1.3 Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation Measures

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

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

A map (Fig. 9.1) showing soil and water conservation plan with different kinds of structures recommended has been prepared which shows the spatial distribution and extent of area. An area of about 12 ha (2%) requires for bench terracing and an area of about 595 ha (92%) needs graded bunding / strengthening of field bunds.

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

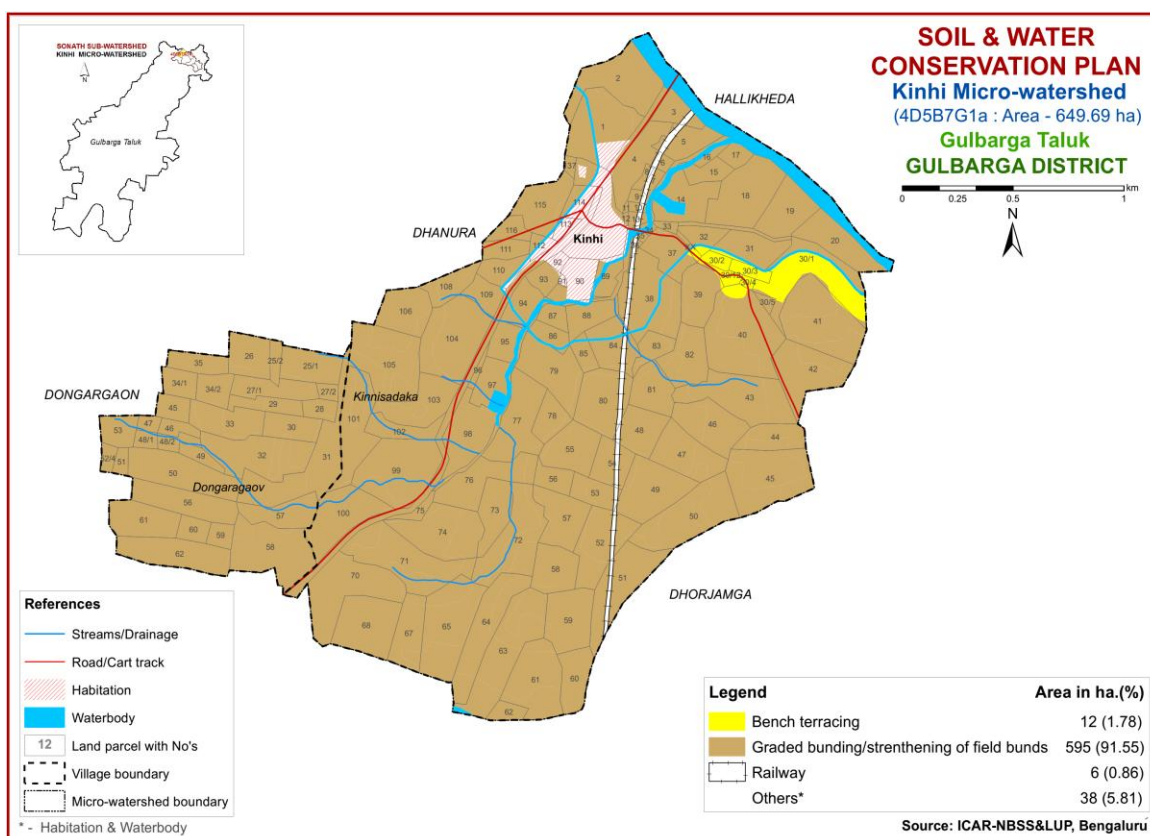


Fig. 9.1 Soil and Water Conservation Plan map of Kinhi Microwatershed

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 and field bunds for growing annual and perennial crops. The method of planting these trees is given below.

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

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; waterlogged areas are recommended to be planted with species like Neral (*Syzgium 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	<i>Azadiracta indica</i>	21–32	400 –1,200
2.	Tapasi	<i>Holoptelia integrifolia</i>	20-30	500 - 1000
3.	Seetaphal	<i>Anona Squamosa</i>	20-40	400 - 1000
4.	Honge	<i>Pongamia pinnata</i>	20 -50	500– 2,500
5.	Kamara	<i>Hardwickia binata</i>	25 -35	400 - 1000
6.	Bage	<i>Albezzia lebbek</i>	20 - 45	500 - 1000
7.	Ficus	<i>Ficus bengalensis</i>	20 - 50	500–2,500
8.	Sisso	<i>Dalbargia Sissoo</i>	20 - 50	500 -2000
9.	Ailanthus	<i>Ailanthus excelsa</i>	20 - 50	500 - 1000
10.	Hale	<i>Wrightia tinctoria</i>	25 - 45	500 - 1000
11.	Uded	<i>Steriospermum chelanoides</i>	25 - 45	500 -2000
12.	Dhupa	<i>Boswellia Serrata</i>	20 - 40	500 - 2000
13.	Nelli	<i>Embllica Officinalis</i>	20 - 50	500 -1500
14.	Honne	<i>Pterocarpus marsupium</i>	20 - 40	500 - 2000
Moist Deciduous Species			Temp (°C)	Rainfall (mm)
15.	Teak	<i>Tectona grandis</i>	20 - 50	500-5000
16.	Nandi	<i>Legarstroemia lanceolata</i>	20 - 40	500 - 4000
17.	Honne	<i>Pterocarpus marsupium</i>	20 - 40	500 - 3000
18.	Mathi	<i>Terminalia alata</i>	20 -50	500 - 2000
19.	Shivane	<i>Gmelina arboria</i>	20 -50	500 -2000
20.	Kindal	<i>T.Paniculata</i>	20 - 40	500 - 1500
21.	Beete	<i>Dalbargia latifolia</i>	20 - 40	500 - 1500
22.	Tare	<i>T. belerica</i>	20 - 40	500 - 2000
23.	Bamboo	<i>Bambusa arundinasia</i>	20 - 40	500 - 2500
24.	Bamboo	<i>Dendrocalamus strictus</i>	20 – 40	500 – 2500
25.	Muthuga	<i>Butea monosperma</i>	20 - 40	400 - 1500
26.	Hippe	<i>Madhuca latifolia</i>	20 - 40	500 - 2000
27.	Sandal	<i>Santalum album</i>	20 - 50	400 - 1000
28.	Nelli	<i>Embllica officinalis</i>	20 - 40	500 - 2000
29.	Nerale	<i>Sizyzium cumini</i>	20 - 40	500 - 2000
30.	Dhaman	<i>Grevia tilifolia</i>	20 - 40	500 - 2000
31.	Kaval	<i>Careya arborea</i>	20 - 40	500 - 2000
32.	Harada	<i>Terminalia chebula</i>	20 - 40	500 - 2000

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Appendix I
Kinihi Microwatershed
Soil Phase Information

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Subsurface Texture	Soil Gravelliness	Sub-Surface-Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Dongar agaov	25/1	4.53	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	25/2	1.12	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	Sf	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	26	4.12	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	27/1	3.89	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	27/2	0.79	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	28	1.57	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	29	2.44	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	NC	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	30	3.31	DSImB2	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strenthening of field bunds
Dongar agaov	31	10.12	NHAmC3g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Gl	Not Available	IVse	Graded bunding/strenthening of field bunds
Dongar agaov	32	9	DSImC3g1	LUC-2	Moderately shallow (50-75 cm)	Clay	c	Gravelly (15-35%)	g0	Medium (101-150 mm/m)	Gently sloping (3-5%)	Severe	Rg	1 Openwell	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	33	5.1	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg+Sf	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	34/1	2.23	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	34/2	2.55	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	35	2.76	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds
Dongar agaov	45	1.93	DSImB3	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIle	Graded bunding/strenthening of field bunds

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Subsurface Texture	Soil Gravelliness	Sub-Surface-Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Dongar agaov	46	1.28	DSImB3	LUC -3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIIe	Graded bunding/strengthening of field bunds
Dongar agaov	47	0.83	DSImB3	LUC -3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IIIe	Graded bunding/strengthening of field bunds
Dongar agaov	48/1	0.93	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	48/2	1.3	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Bg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	49	1.34	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	NC	1 Openwell	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	50	8.21	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	51	0.86	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	52/4	0.92	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	53	2.6	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+J	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	56	6.2	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+J	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	57	4.34	NHAmB2g1	LUC -2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Gl	Not Available	IIIs	Graded bunding/strengthening of field bunds
Dongar agaov	58	9.84	DSImB2	LUC -3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Rg	1 Borewell	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	59	1.38	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	60	1.72	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	61	5.31	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+J	Not Available	IIs	Graded bunding/strengthening of field bunds
Dongar agaov	62	7.25	RNLmB1	LUC -5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+J	Not Available	IIs	Graded bunding/strengthening of field bunds

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Subsurface Texture	Soil Gravelliness	Sub-Surface-Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Kinnisadaka	1	9.42	MGTmC3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Gl	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	2	8.76	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sl	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	3	2.52	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sl	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	4	5.18	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	5	3.56	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	6	0.63	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	7	0.77	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	8	0.54	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	9	0.57	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	10	0.46	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	11	0.11	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	12	0.15	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	13	0.67	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	14	5.88	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	1 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	15	2.04	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	16	1.16	Waterbody	Others	Others	Others	Others	Others	Others	Others	Others	Others	Sc	Not Available	Others	Others

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Kinnisadaka	17	1.4	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	18	8.63	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc	2 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	19	5.27	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	20	5.55	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	30/1_GRASS_FIEL D	10.62	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Very gravelly (35-60%)	g2	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Gl	Not Available	VIe	Bench terracing
Kinnisadaka	30/12	0.91	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Very gravelly (35-60%)	g2	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIe	Bench terracing
Kinnisadaka	30/2	0.9	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Very gravelly (35-60%)	g2	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIe	Bench terracing
Kinnisadaka	30/3	1.18	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Very gravelly (35-60%)	g2	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIe	Bench terracing
Kinnisadaka	30/4	0.36	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Very gravelly (35-60%)	g2	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIe	Bench terracing
Kinnisadaka	30/5	0.5	MGTmB3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Severe	NA	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	31	4.47	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	32	2.07	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	33	0.49	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	34	0.25	Waterbody	Others	Others	Others	Others	Others	Others	Others	Others	Others	NC	Not Available	Others	Others
Kinnisadaka	35	0.29	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	36	0.35	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	NA	Not Available	Railway	Railway

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Kinnisadaka	37	3.87	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	NC	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	38	10.13	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	39	4.79	KGImB2g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg+NC	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	40	13.17	MGTmB3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Rg+NC	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	41	11.09	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	42	7.77	MGTmB3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Rg+Gl	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	43	9.57	KGImB2g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg+Gl	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	44	3.84	MGTmB3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Severe	Rg	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	45	10.65	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg+Gl+NC	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	46	6.35	KGImB2g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg+Gl	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	47	6.2	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Bg+Rg	1 Openwell	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	48	4.44	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisadaka	49	7.73	DSImA1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Bg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	50	10.07	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	51	8.3	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Gl	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	52	7.32	DSImA1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Bg+Rg	Not Available	IIs	Graded bunding/strengthening of field bunds

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Kinnisa daka	53	2.85	DSImA1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Nearly level (0-1%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	54	3.72	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	55	5.34	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	56	2.14	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	57	5.54	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	58	4.6	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	59	6.43	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	60	4.12	MANmB1	LUC-5	Very deep (>150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	61	8.54	MANmB1	LUC-5	Very deep (>150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	62	1.4	NHAmB1	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	63	11.21	MANmB1	LUC-5	Very deep (>150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	64	8.11	MANmB1	LUC-5	Very deep (>150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Sc	2 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	65	10.54	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Sc	1 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	67	4.79	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	68	7.82	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Sf	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	70	10.35	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	1 Borewell	IIs	Graded bunding/strengthening of field bunds

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Kinnisa daka	71	10.71	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Sc+Sf	1 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	72	9.3	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+Bg+NC	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	73	4.38	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Sc+NC	1 Openwell	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	74	8.6	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg+GI	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	75	0.96	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	76	6.83	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	1 Openwell	IIs	Graded bunding/strengthening of field bunds
Kinnisa daka	77	7.66	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc	1 Openwell	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	78	2.79	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	NC	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	79	7.04	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc+NC	2 Borewell	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	80	7.08	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	81	4.26	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	82	5.25	KGImB2g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg+NC	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	83	2.21	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	84	5	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	85	1.56	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIIs	Graded bunding/strengthening of field bunds
Kinnisa daka	86	1.78	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	1 Openwell	IIIs	Graded bunding/strengthening of field bunds

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Kinnisadaka	87	1.46	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc	Not Available	III	Graded bunding/strengthening of field bunds
Kinnisadaka	88	3.18	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc	Not Available	III	Graded bunding/strengthening of field bunds
Kinnisadaka	89	2.2	NHAmB2	LUC-2	Shallow (25-50 cm)	Clay	c	Non gravelly (<15%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc	Not Available	III	Graded bunding/strengthening of field bunds
Kinnisadaka	90	3.61	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	Sc	Not Available	Others	Others
Kinnisadaka	91	0.19	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	Settlement	Not Available	Others	Others
Kinnisadaka	92	0.63	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	NA	Not Available	Others	Others
Kinnisadaka	93	1.7	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	Not Available	II	Graded bunding/strengthening of field bunds
Kinnisadaka	94	2.92	DSImB1	LUC-3	Moderately shallow (50-75 cm)	Clay	c	Non gravelly (<15%)	g0	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Rg	1 Borewell, 1 Openwell	II	Graded bunding/strengthening of field bunds
Kinnisadaka	95	2.5	RNLmB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	II	Graded bunding/strengthening of field bunds
Kinnisadaka	96	0.52	RNLmB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	NA	Not Available	II	Graded bunding/strengthening of field bunds
Kinnisadaka	97	3.65	RNLmB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Sc	Not Available	II	Graded bunding/strengthening of field bunds
Kinnisadaka	98	6.5	RMNmC3g1	LUC-4	Moderately deep (75-100 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Bg+Gl	Not Available	IIIe	Graded bunding/strengthening of field bunds
Kinnisadaka	99	10.72	NHAmC3g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Rg	1 Borewell	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	100	7.44	NHAmB2g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Very gently sloping (1-3%)	Mode rate	Gl	1 Borewell	III	Graded bunding/strengthening of field bunds
Kinnisadaka	101	7.46	NHAmC3g1	LUC-2	Shallow (25-50 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Rg+Gl	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	102	2.93	RMNmC3g1	LUC-4	Moderately deep (75-100 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Gl	Not Available	IIIe	Graded bunding/strengthening of field bunds
Kinnisadaka	103	5.91	RMNmC3g1	LUC-4	Moderately deep (75-100 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Gl	Not Available	IIIe	Graded bunding/strengthening of field bunds

Village	Survey No.	Area (ha)	Soil Phase	LUC	Soil Depth	Surface Soil Texture	Subsurface Texture	Soil Gravelliness	Sub-Surface-Gravelliness	Available Water Capacity	Slope	Soil Erosion	Current Land Use	WELLS	Land Capability	Conservation Plan
Kinnisadaka	104	10.34	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	105	10.3	RMNmC3g1	LUC-4	Moderately deep (75-100 cm)	Clay	c	Gravelly (15-35%)	g2	Low (51-100 mm/m)	Gently sloping (3-5%)	Severe	Rg	Not Available	IIIe	Graded bunding/strengthening of field bunds
Kinnisadaka	106	5.08	MGTmB3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Very gently sloping (1-3%)	Severe	NC	Not Available	IVse	Graded bunding/strengthening of field bunds
Kinnisadaka	108	3	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Bg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	109	2.33	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	110	2.57	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	111	2.02	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	1 Borewell	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	112	1.07	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	NA	Not Available	Others	Others
Kinnisadaka	113	0.92	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	NA	Not Available	Others	Others
Kinnisadaka	114	2.02	Habitat ion	Others	Others	Others	Others	Others	Others	Others	Others	Others	NC	Not Available	Others	Others
Kinnisadaka	115	5.6	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	116	1.8	RNLMB2	LUC-5	Deep (100-150 cm)	Clay	c	Non gravelly (<15%)	g0	Very high (>200 mm/m)	Very gently sloping (1-3%)	Mode rate	Rg	Not Available	IIs	Graded bunding/strengthening of field bunds
Kinnisadaka	137	0.48	MGTmC3g1	LUC-1	Very shallow (<25 cm)	Clay	sc-c	Gravelly (15-35%)	g2	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	NA	Not Available	IVse	Graded bunding/strengthening of field bunds

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Appendix II

Kinihi Microwatershed Soil Fertility Information

[illegible]

Appendix III

Kinihi Microwatershed

Soil Suitability Information

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Bengalgram	Redgram	Soyabean
Dongaragaov	25/1	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	25/2	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	26	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	27/1	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	27/2	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	28	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	29	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	30	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	31	S3re	S3re	Nre	S3re	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nre	S2re	S3re	S3re
Dongaragaov	32	S3re	S3te	S3re	S3re	N	S3rl	S3rl	N	N	S3rl	S3rl	N	S2le	S2le	N	Nt	S2g	S3re	S3re
Dongaragaov	33	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	34/1	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	34/2	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	35	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	45	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	46	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	47	S2re	S3te	S3re	S2re	N	S3re	S3re	S3r	S3re	S3re	S3re	N	S2e	S2e	S3re	S3te	S2e	S2rt	S2re
Dongaragaov	48/1	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	48/2	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	49	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	50	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	51	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	52/4	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	53	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	56	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	57	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Dongaragaov	58	S2r	S2rt	S3r	S2r	N	S2re	S2re	S3r	S3re	S2re	S2re	N	S1	S1	S3re	S3rt	S1	S2rt	S2r
Dongaragaov	59	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	60	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	61	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Dongaragaov	62	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	1	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	2	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	3	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	4	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	5	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	6	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	7	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	8	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	9	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	10	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	11	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	12	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Bengalgram	Redgram	Soyabean
Kinnisadaka	13	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	14	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	15	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	16	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	17	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	18	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	19	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	20	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	30/1_G RASS_FI ELD	Ngl	Ngt	Ngl	Ngl	N	N	N	N	N	N	N	N	N	N	N	Ngt	Ngl	Ngt	Ngl
Kinnisadaka	30/12	Ngl	Ngt	Ngl	Ngl	N	N	N	N	N	N	N	N	N	N	N	Ngt	Ngl	Ngt	Ngl
Kinnisadaka	30/2	Ngl	Ngt	Ngl	Ngl	N	N	N	N	N	N	N	N	N	N	N	Ngt	Ngl	Ngt	Ngl
Kinnisadaka	30/3	Ngl	Ngt	Ngl	Ngl	N	N	N	N	N	N	N	N	N	N	N	Ngt	Ngl	Ngt	Ngl
Kinnisadaka	30/4	Ngl	Ngt	Ngl	Ngl	N	N	N	N	N	N	N	N	N	N	N	Ngt	Ngl	Ngt	Ngl
Kinnisadaka	30/5	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	31	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	32	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	33	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	34	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	35	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	36	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway	Railway
Kinnisadaka	37	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	38	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	39	S3gr	S3gr	S3gr	S3gr	N	N	N	N	N	N	N	N	S2r	S3r	N	S3gr	S3g	S3gr	S3gr
Kinnisadaka	40	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	41	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	42	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	43	S3gr	S3gr	S3gr	S3gr	N	N	N	N	N	N	N	N	S2r	S3r	N	S3gr	S3g	S3gr	S3gr
Kinnisadaka	44	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	45	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	46	S3gr	S3gr	S3gr	S3gr	N	N	N	N	N	N	N	N	S2r	S3r	N	S3gr	S3g	S3gr	S3gr
Kinnisadaka	47	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	48	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	49	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	50	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	51	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	52	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	53	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	54	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	55	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	56	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	57	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	58	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Bengalgram	Redgram	Soyabean
Kinnisadaka	59	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	60	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	61	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	62	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	N	N	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	63	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	64	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S1	S1	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	65	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	67	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	68	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	70	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	71	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	72	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	73	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	74	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	75	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	76	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	77	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	78	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	79	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	80	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	81	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	82	S3gr	S3gr	S3gr	S3gr	N	N	N	N	N	N	N	N	S2r	S3r	N	S3gr	S3g	S3gr	S3gr
Kinnisadaka	83	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	84	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	85	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	86	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	87	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	88	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	89	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	90	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	91	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	92	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	93	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	94	S2r	S2rt	S3r	S2r	N	S2rt	S2rt	S3r	S3r	S2rt	S2rt	N	S1	S1	S3r	S3rt	S1	S2rt	S2r
Kinnisadaka	95	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	96	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	97	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	98	S3le	S3ge	S3ge	S3le	N	N	N	N	N	N	N	N	N	N	N	S3ge	S2ge	S3le	S3ge
Kinnisadaka	99	S3re	S3re	Nre	S3re	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nre	S2re	S3re	S3re
Kinnisadaka	100	S3r	S3rt	Nr	S3r	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nrt	S2r	S3rt	S3r
Kinnisadaka	101	S3re	S3re	Nre	S3re	N	N	N	N	N	N	N	N	S2rg	S2rg	N	Nre	S2re	S3re	S3re
Kinnisadaka	102	S3le	S3ge	S3ge	S3le	N	N	N	N	N	N	N	N	N	N	N	S3ge	S2ge	S3le	S3ge
Kinnisadaka	103	S3le	S3ge	S3ge	S3le	N	N	N	N	N	N	N	N	N	N	N	S3ge	S2ge	S3le	S3ge
Kinnisadaka	104	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1

Village	Survey Number	Sorgham	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Jamun	Musambi	Lime	Cashew	Custard-apple	Amla	Tamarind	Sugarcane	Bengalgram	Redgram	Soyabean
Kinnisadaka	105	S3le	S3ge	S3ge	S3le	N	N	N	N	N	N	N	N	N	N	N	S3ge	S2ge	S3le	S3ge
Kinnisadaka	106	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr
Kinnisadaka	108	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	109	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	110	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	111	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	112	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	113	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	114	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Kinnisadaka	115	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	116	S1	S3t	S1	S1	S3t	S2t	S2t	S3t	S2t	S2t	S2t	N	S1	S1	S2t	S3t	S1	S2t	S1
Kinnisadaka	137	Nr	Nrt	Nr	Nr	N	N	N	N	N	N	N	N	S3rg	N	N	Nrt	S3r	Nrt	Nr

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

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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: *Kinhi micro-watershed (Sonath sub-watershed, Gulbarga taluk and district) is located in between 17°38' – 17°40' North latitudes and 77°2' – 77°3' East longitudes, covering an area of about 649 ha, surrounded by Dongargaon, Dhanura, Hallikheda and Dhorjamga villages with an length of grown period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for Kinhi micro-watershed (Sonath sub-watershed) in Gulbarga taluk and district are presented here.*

Social Indicators;

- ❖ *Male and female ratio is 48.1 to 51.9 per cent to the total sample population.*
- ❖ *Younger age 18 to 50 years group of population is around 61.5 per cent to the total population.*
- ❖ *Literacy population is around 92.3 per cent.*
- ❖ *Social groups belong to other backward caste (OBC) is around 80 per cent.*
- ❖ *Wood is the major source of energy for a cooking among 80 per cent.*
- ❖ *About 10 per cent of households have a yashaswini health card.*
- ❖ *Majority of farm households (20%) are having MGNREGA card for rural employment.*
- ❖ *Dependence on ration cards for food grains through public distribution system is around 30 per cent.*
- ❖ *Swach bharath program providing closed toilet facilities around 30 per cent of sample households.*
- ❖ *Rural migration to urban centre for employment is prevalent among 11.5 per cent of farm households.*
- ❖ *Women participation in decisions making are around 90 per cent of households were found.*

Economic Indicators;

- ❖ *The average land holding is 1.41 ha indicates that majority of farm households are belong to small and medium farmers. The farmer cultivated land on dry land of sample farmers.*
- ❖ *Agriculture is the main occupation among 6.06 per cent and agriculture is the main and agriculture labour is subsidiary occupation for 75.76 per cent of sample households.*
- ❖ *The average value of domestic assets is around Rs.16500 per household. Mobile and television are popular media mass communication.*
- ❖ *The average value of farm assets is around Rs. 4339 per household; about 30.0 per cent of sample farmers own plough and bullock cart.*
- ❖ *The average value of livestock is around Rs. 42222 per household; about 47 per cent of household are having livestock.*
- ❖ *The average per capita food consumption is around 765.6 grams (1603.63 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Among all sample households are consuming less than the NIN recommendation.*
- ❖ *The annual average income is around Rs. 37021 per household. About 70 per cent of farm households are below poverty line.*
- ❖ *The per capita monthly average expenditure is around Rs.2381.*

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. 2011 per ha/year. The total cost of annual soil nutrients is around Rs. 1220753 per year for the total area of 649 ha.*
- ❖ *The average value of ecosystem service for food grain production is around Rs. 7638/ ha/year. Per hectare food grain production services is maximum in sugarcane (Rs. 47224) followed by red gram (Rs. 44128) and bengal gram (Rs. 7119).*
- ❖ *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 sugar cane Rs. 174190 followed by red gram (Rs. 106399) and bengal gram (Rs. 46606).*

Economic Land Evaluation;

- ❖ *The major cropping pattern is red gram (78.7 %) followed by bengal gram (12.27 %) and sugar cane (9.0 %).*

- ❖ *In Kinh Microwatershed, major soil is Basaltic landforms of Margutti (MGT) series is having very shallow soil depth cover around 7.9 % of area. On this soil farmers are presently growing red gram. Novinihala (NHA) is also having shallow soil depth cover 20.64 % of area, the crops are red gram (66.7 %) and bengal gram (33.3 %). Dinsi (DSI) soil series having moderately shallow soil depth cover around 41.2 % of areas, crops are red gram (80.1%) and sugar cane (19.9 %). Mahagaon (MAN) soil series having very deep soil depth cover around 3.3 % of area, crops are red gram.*
- ❖ *The total cost of cultivation and benefit cost ratio (BCR) in study area for red gram ranges between Rs.164793/ha in MGT soil (with BCR of 0.33) and Rs.19150/ha in DSI soil (with BCR of 1.85).*
- ❖ *In bengal gram cost of cultivation in NHA soil is Rs 19876/ha (with BCR of 1.36) and sugarcane cost of cultivation in DSI soil is Rs. 35724/ha (with BCR of 2.32).*
- ❖ *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 in watershed planning helps in strengthening 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 strengthening agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- ❖ *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in red gram (10.7 to 39.8%), bengal gram (53.9 %) and sugarcane (38.2 %).*

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

Kinhi 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 of the zone are jowar, bajra, oilseeds, pulses, cotton and sugarcane. It's represented Agro Ecological Sub Region (AESR) 6.2 having LGP 120-150 days.

Kinhi micro-watershed (Sonath sub-watershed, Gulbarga taluk and district) is located in between 17°38' – 17°40' North latitudes and 77°2' – 77°3' East longitudes, covering an area of about 649 ha, surrounded by Dongargaon, Dhanura, Hallikheda and Dhorjamga villages.

Sampling Procedure:

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

Sources of data and analysis:

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

LOCATION MAP OF KINHI MICRO WATERSHED

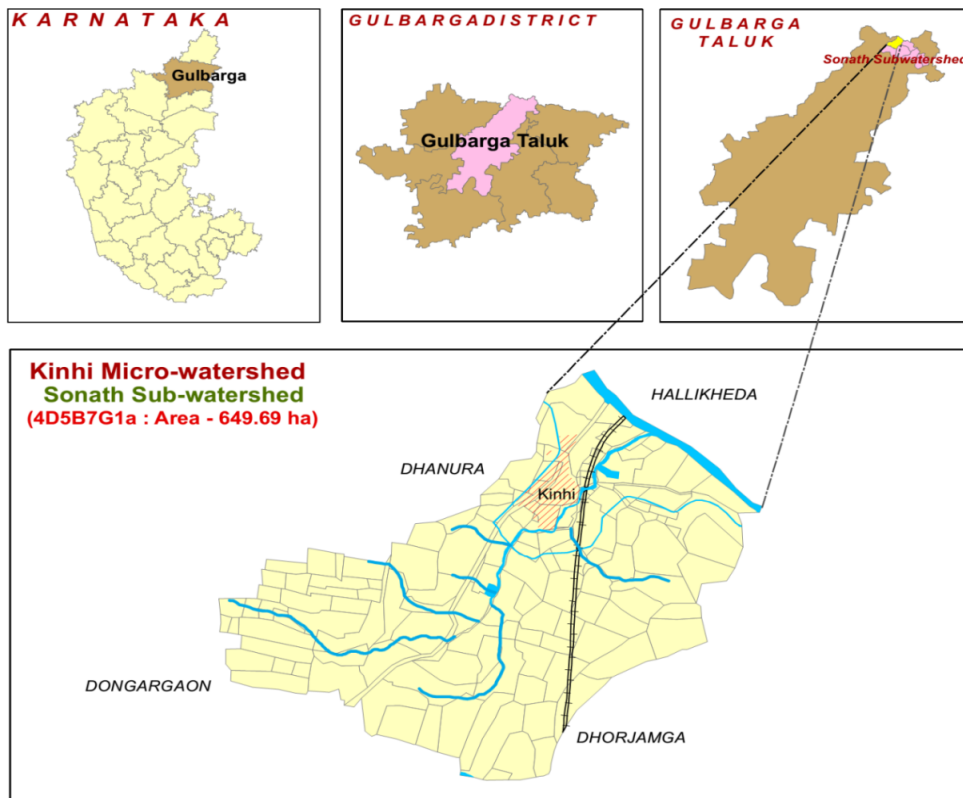
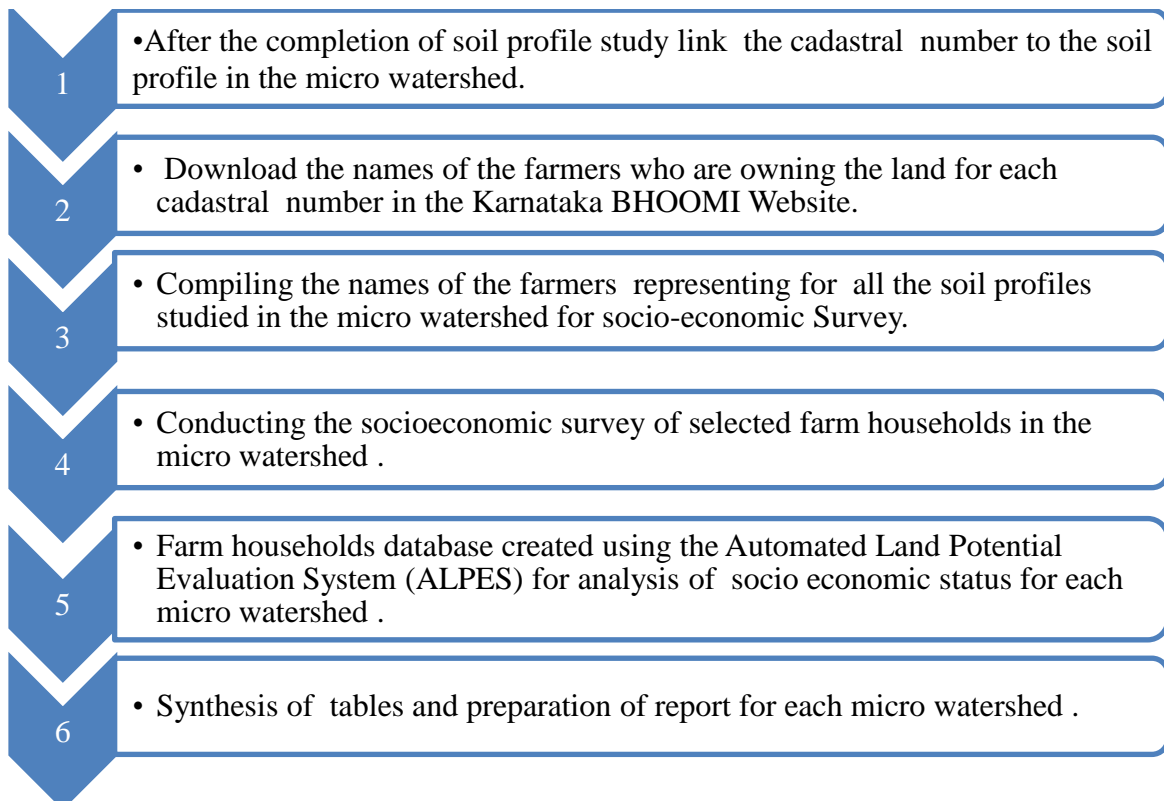


Figure 1: Location of study area

Steps followed in socio-economic assessment



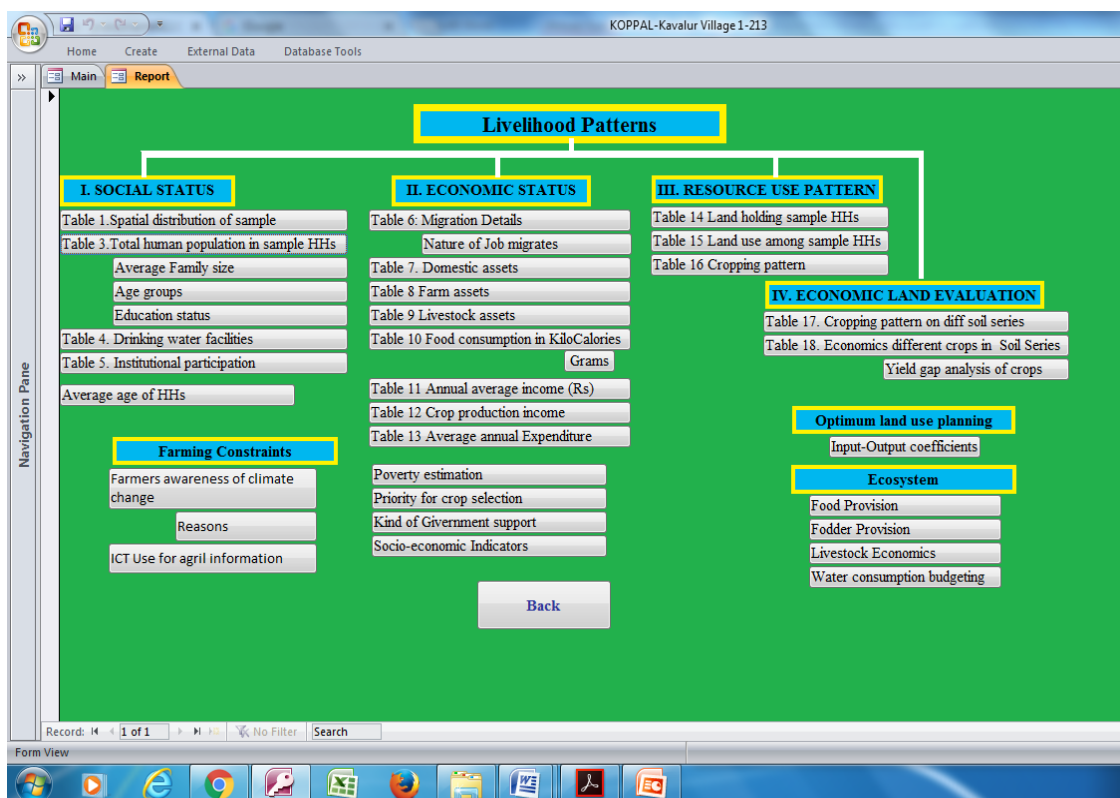


Figure 2: ALPES FRAMEWORK

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.

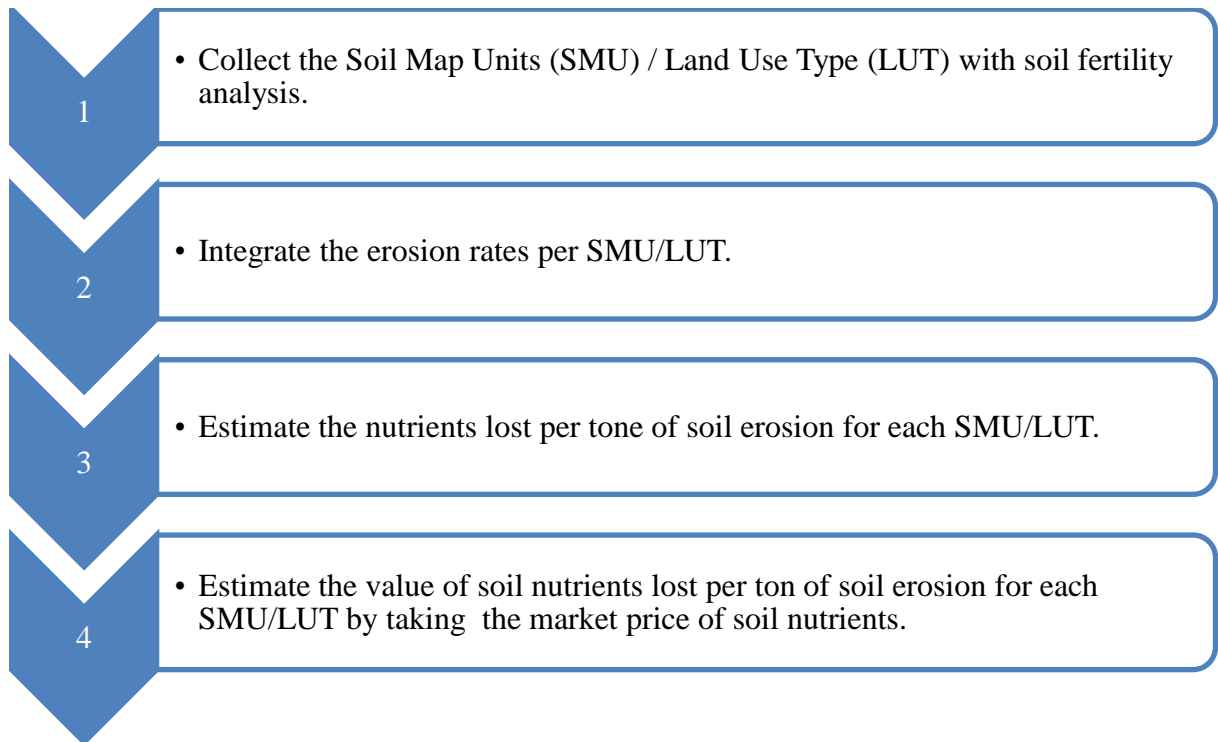
Benefit Cost Ratio = Net returns/Total cost.

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 divided 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 methods 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



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 52, out of which 48.1 per cent were males and 51.9 per cent females. Average family size of the households is 5.2. 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 (32.7 %) followed by 18 to 30 years (28.8 %), 0 to 18 years (21.2 %) and more than 50 years (17.3%). 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 7.7 per cent of respondents were illiterate and 92.3 per cent literate (Table 1).

Table 1: Human population among sample households in Kinhi Microwatershed

Particulars	Units	Value
Total human population in sample HHs	Number	52
Male	% to total Population	48.1
Female	% to total Population	51.9
Average family size	Number	5.2
Age group		
0 to 18 years	% to total Population	21.2
18 to 30 years	% to total Population	28.8
30 to 50 years	% to total Population	32.7
>50 years	% to total Population	17.3
Average age	Age in years	33.8
Education Status		
Illiterates	% to total Population	7.7
Literates	% to total Population	92.3
Primary School (<5 class)	% to total Population	5.8
Middle School (6- 8 class)	% to total Population	15.4
High School (9- 10 class)	% to total Population	15.4
Others	% to total Population	55.8

The ethnic groups among the sample farm households found to be 80 per cent belonging to other backward caste (OBC) followed by 20 per cent belonging to general castes (Table 2 and Figure 3). About 80 per cent of sample households are using fire

wood as source of fuel for cooking. All the sample farmers are having electricity connection. About 10 per cent are sample households having health cards. Majority (20 %) are having MNREGA job cards for employment generation. About 30 per cent of farm households are having ration cards for taking food grains from public distribution system. About 30 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Kinhi Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	80.0
General category	% of Households	20.0
Types of fuel use for cooking		
Fire wood	% of Households	80.0
Gas	% of Households	20.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	10.0
No	% of Households	90.0
MGNREGA Card		
Yes	% of Households	20.0
No	% of Households	80.0
Ration Card		
Yes	% of Households	30.0
No	% of Households	70.0
Households with toilet		
Yes	% of Households	30.0
No	% of Households	70.0
Drinking water facilities		
Tube Well	% of Households	90.0
Tank	% of Households	10.0

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well source for water supply for domestic purpose (90 %) and 10 per cent was tank.

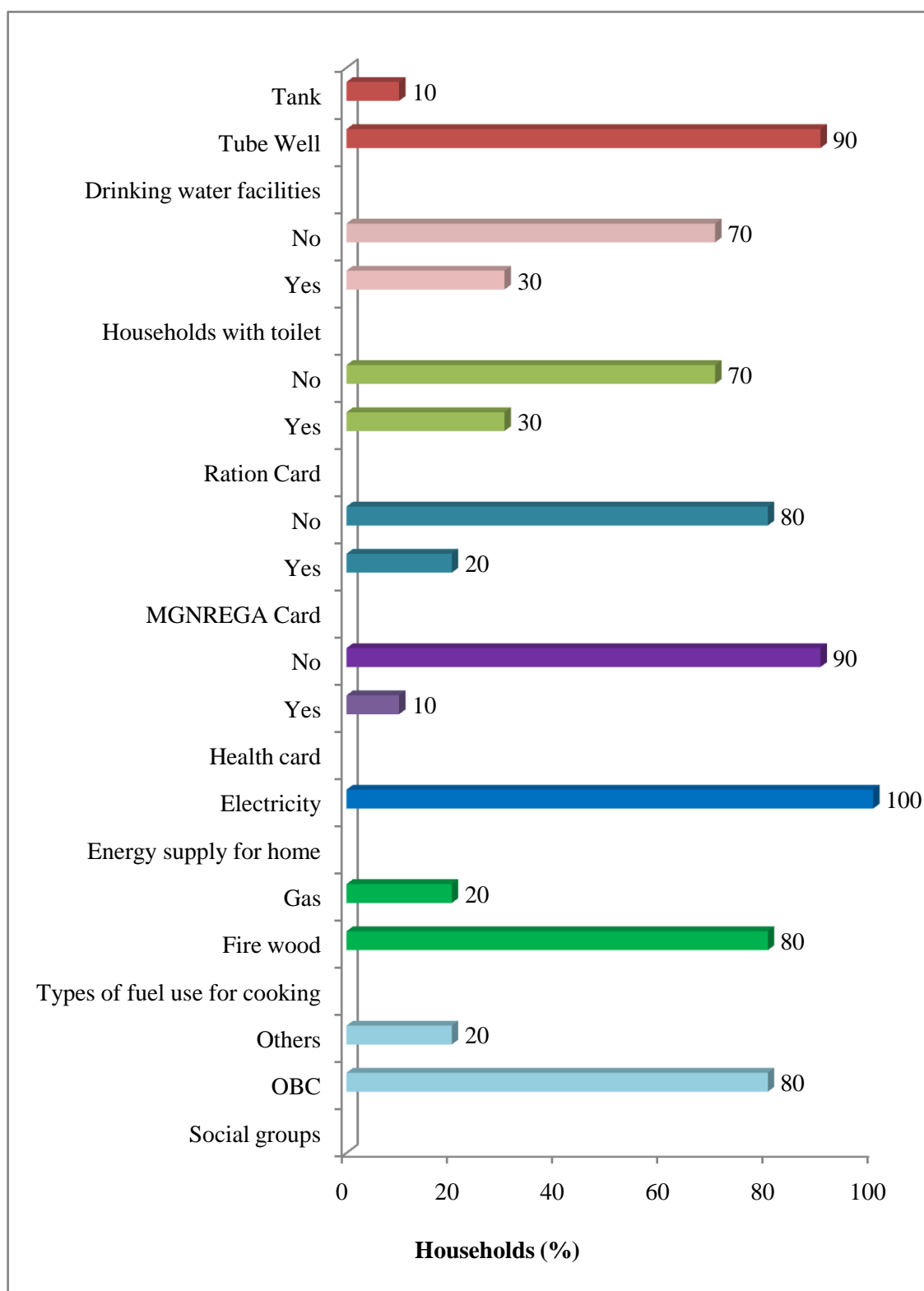


Figure 3: Basic needs of sample households in Kinhi Microwatershed

The data on migration in Kinhi Microwatershed is given in Table 3. It indicated that around 11.5 per cent of samples households were migrated. The average distance travelled for seeking employment is 46.3 km.

Table 3: Migration details among the sample households in Kinhi micro-watershed

Particulars	Value
% of households showing migration	11.5
% of persons migrating	40.0
No. of months migrated in a year	9.5
Average Distance of migration(Km)	46.3
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 6.1 per cent of farmers followed by subsidiary occupations like agricultural labour (75.76 %). The non agriculture is the main occupation and government service of 15.1 per cent and a private service is 3.0 per cent of subsidiary occupation.

Table 4: Occupational pattern in sample population in Kinhi Microwatershed

Occupation		% to total
Main	Subsidiary	
Agriculture	Agriculture	6.1
	Agriculture Labour	75.8
Non Agriculture	Govt. service	15.1
	Private service	3.0
Family labour availability		Man days/month
Male		27.5
Female		18.0
Total		45.5

The important assets especially with reference to domestic assets were analyzed and are given in Table 5 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (100 %) followed by television (100 %), mixer/grinder (80 %) and motorcycle (20%). The average value of domestic assets is around Rs 16500 per households.

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

Particulars	% of households	Average value in Rs
Mixer/grinder	80.0	3000
Mobile Phone	100.0	9500
Motorcycle	20.0	36000
Television	100.0	17500
Average Value	16500	

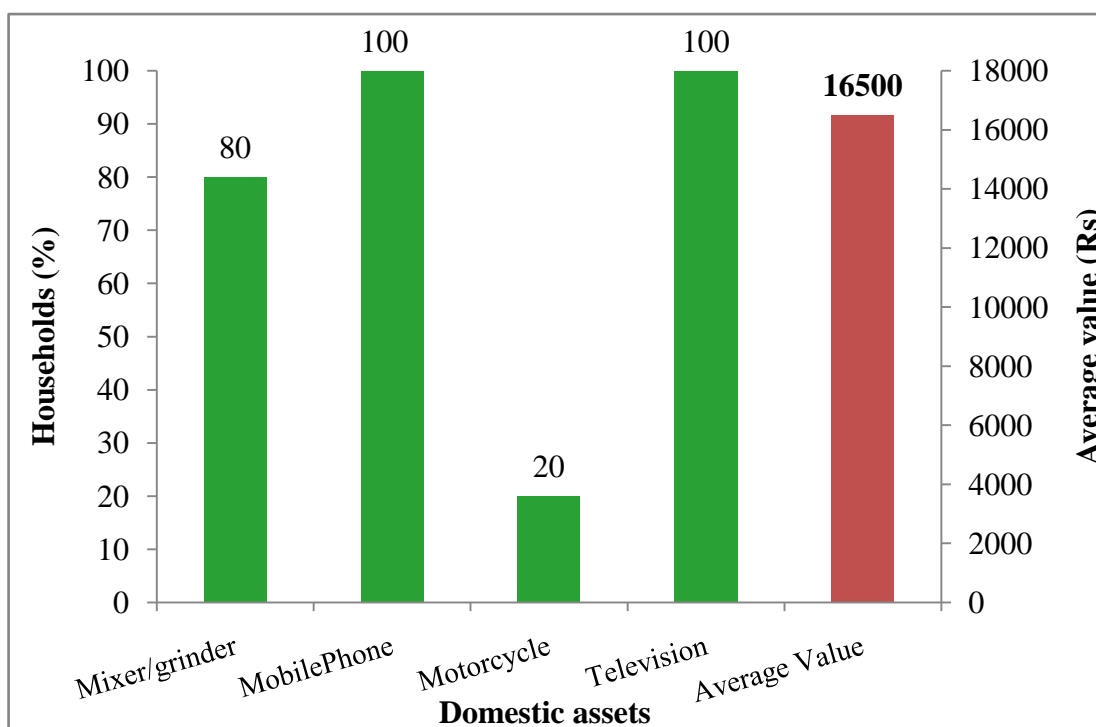


Figure 4: Domestic assets among the sample households in Kinhi Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned weeder (30 %), plough (30 %) and bullock cart (30 %). The average value of farm assets is around Rs 4339 per households (Table 6 and Figure 5).

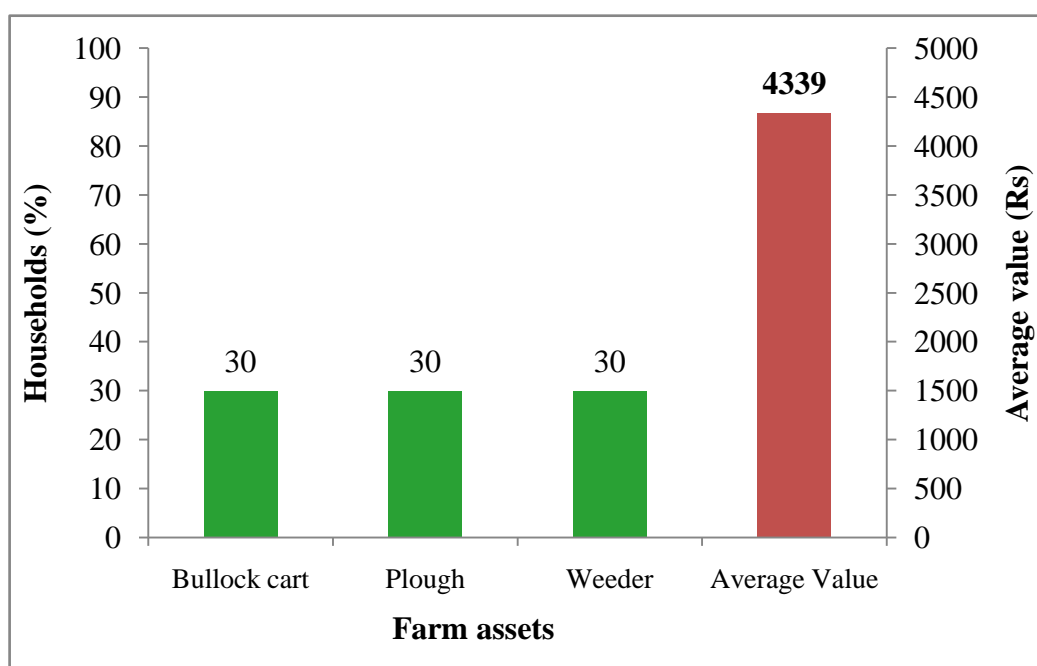


Figure5: Farm assets among samples households in Kinhi Microwatershed

Table 6: Farm assets among samples households in Kinhi Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	30.0	7333
Plough	30.0	5333
Weeder	30.0	350
Average Value	4339	

Livestock is an integral component of the conventional farming systems (Table 7 and Figure 6). The highest livestock population is bullocks were around 42.9 per cent followed by local dry cow (42.9 %) and milching buffalos (14.3 %). The average livestock value was Rs 42222 per household.

Table 7: Livestock assets among sample households in Kinhi Microwatershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	42.9	20000
Milching Buffalos	14.3	20000
Bullocks	42.9	86667
Average value	42222	
Livestock having households (%)	47.0	
Livestock population (Numbers)	12	

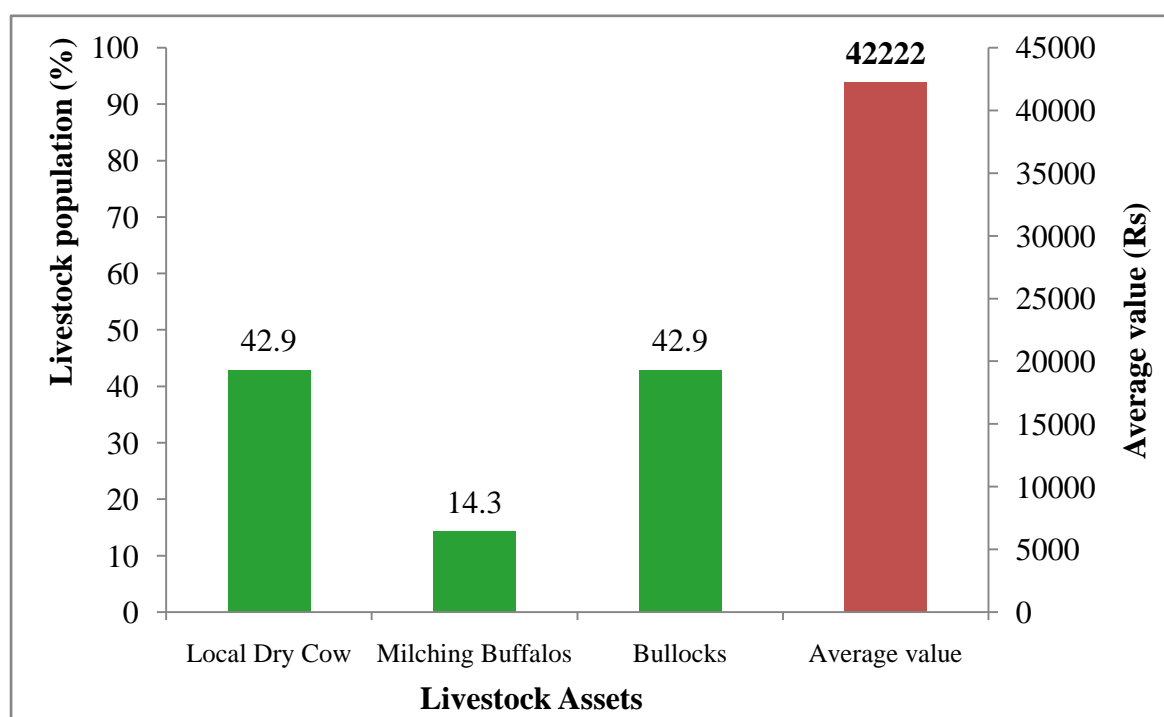


Figure 6: Livestock assets among sample households in Kinhi Microwatershed

A woman participation in decision making in this micro-watershed is presented in Table 8. About 10 per cent of women participation in local organisation activates, 100 per cent women earning for her family requirement and 90 per cent of women taking decision in her family and agriculture related activities.

Table 8: Women empowerment of sample households in Kinhi Micro watershed

% to Grand Total

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

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 9 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1078.6 kcal per person. The other important food items consumed was pulses 120.1 kcal followed by cooking oil 89.6 kcal, milk 81.3 kcal, vegetables 33.3 kcal, egg 172.4 kcal and meat 28.3 kcal. In the sampled households, farmers were consuming less (1603.63 kcal) than NIN- recommended food requirement (2250 kcal).

Table 9: Per capita daily consumption of food among the sample households in Kinhi Micro watershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	317.2	1078.6
Pulses	43	35.0	120.1
Milk	200	125.0	81.3
Vegetables	143	138.8	33.3
Cooking Oil	31	15.7	89.6
Egg	0.5	114.9	172.4
Meat	14.2	18.9	28.3
Total	827.7	765.6	1603.6
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		40.0	100
% Above NIN		60.0	0

Note: * day/person

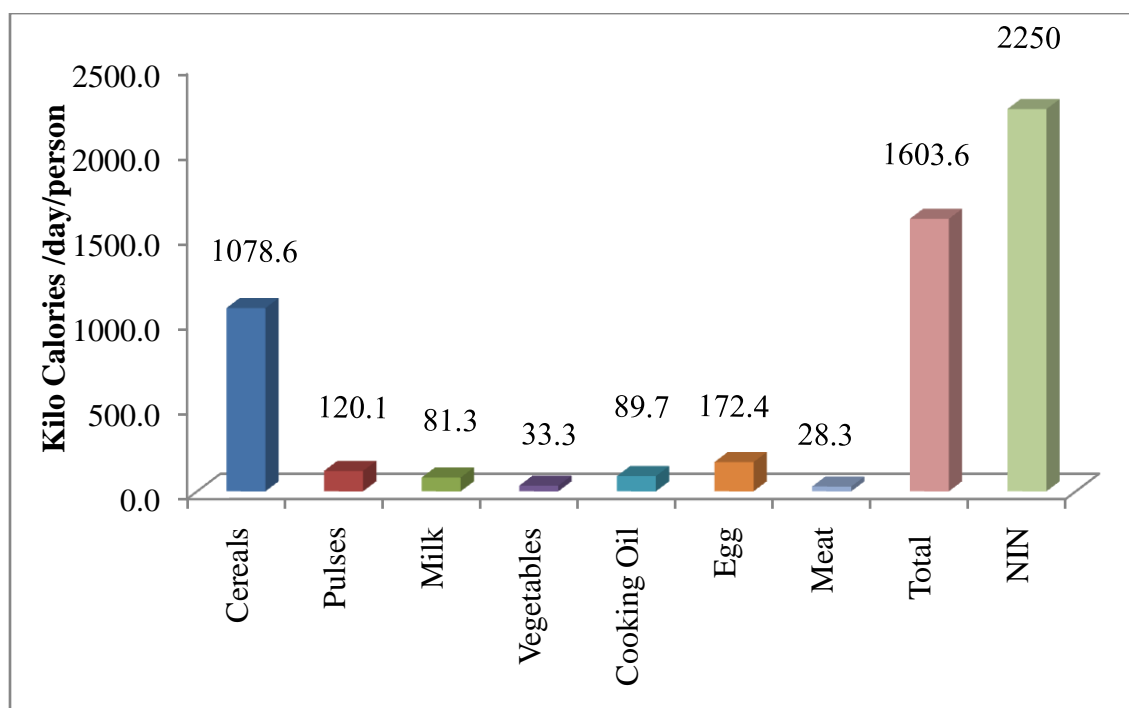


Figure 7: Per capita daily consumption of food among the sample households in Kinhi Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 37022. Major source of income to the farmers in the study area is from crop production (Rs 48416). The income from Non farm income was low at Rs 4366. The monthly per capita income is Rs.593, which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 10).

Table 10: Annual average income of HHs from various sources in Kinhi Microwatershed

Particulars	Income *
Nonfarm income (Rs)	4366 (40)
Livestock income (Rs)	-15760 (10)
Crop Production (Rs)	48416 (100)
Total Annual Income (Rs)	37022
Average monthly per capita income (Rs)	593
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	70.0
% of households above poverty line	30.0

* 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. 38598) 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 2381 and about 70 per cent of farm households are below poverty line and 30 per of farm households are above poverty line (Table 11 and Figure 8).

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

Particulars	Value in Rupees	Per cent
Food	38598	26.0
Education	35100	23.6
Clothing	8500	5.7
Social functions	60000	40.4
Health	6400	4.3
Total Expenditure (Rs/year)	148598	100.0
Monthly per capita expenditure (Rs)	2381	

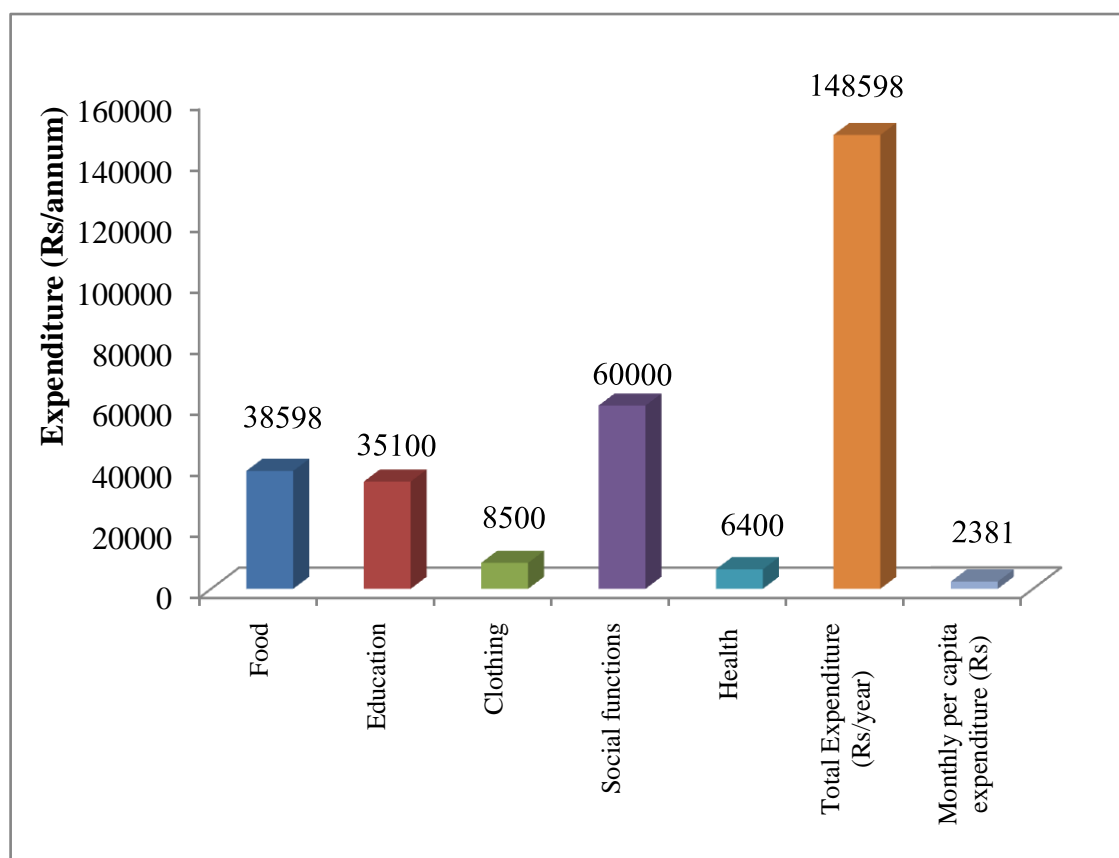


Figure 8: Average annual expenditure of sample HHs in Kinhi Microwatershed

Land holding: Total area cultivated by them is 24.1 ha. The average land holding of sample HHs is 2.4 ha. Medium number of sample HHs (90%) belong to small size group with an average holding size of 0.1 ha followed by medium farmers an average holding size of 2.7 ha. (Table 12)

Table12: Distribution of land holding among the sample households in Kinhi Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	0.1
Sample size	Percent	10.0
Average land holding	ha	0.1
Medium farmers		
Total land	ha	24.0
Sample size	Percent	90.0
Average land holding	ha	2.7
Total Sample household farmers		
Total land	ha	24.1
Sample size	Percent	100.0
Average land holding	ha	2.4

Land use: The total land holding in the Kinhi Microwatershed is 14.1 ha (Table 13) for rainfed land cultivation. The average land holding per household is worked out to be 1.41 ha.

Table 13: Land use among samples households in Kinhi Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	0.0	0.0
Rainfed Land	100.0	14.1
Fallow Land	0.0	0.0
Total land holding	100.0	14.1
Average land holding	1.41	

In the micro-watershed, the prevalent present land uses under perennial plants are Neem trees (83 %) followed by mango (8.5 %) and jackfruit (8.5 %) (Table 14).

Table 14: Number of trees/plants covered in sample farm households in Kinhi microwatershed

Particulars	Number of Plants/trees	Per cent
Mango	4	8.5
Neem trees	39	83.0
Jack fruit	4	8.5
Grand Total	47	100.0

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

The present dominant crops grown in dry lands in the study area were by red gram (78.7 %) followed by bengal gram (12.3 %), and sugarcane (9 %) which are taken during Kharif season (Table 15 and Figure 9).

Table 15: Present cropping pattern and cropping intensity in Kinhi Micro watershed
% to Grand Total

Crops	Kharif	Grand Total
Bengal gram	12.3	12.27
Redgram	78.7	78.7
Sugarcane	9.0	9.0
Grand Total	100.0	100.0

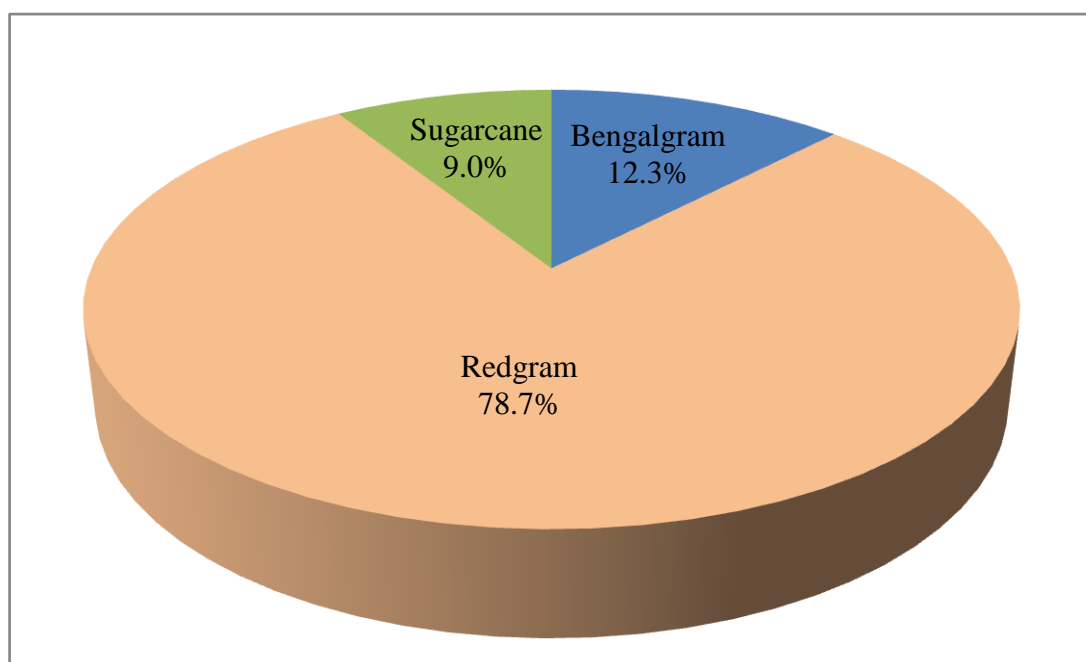


Figure 9: Present cropping pattern in Kinhi Microwatershed

Economic land evaluation

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

In Kinh micro-watershed, 8 soil series are identified and mapped (Table 16). The distribution of major soil series are Dinsi covering an area around 267.7 ha (41.2 %) followed by Novinihala 134.1 ha (20.6 %), Ranjala 73.9 ha (11.4 %), Margutti 51.3 ha (7.9 %), Kalamundaragi 32.1 ha (4.9 %) and Kamalapur 3.9 ha (0.6 %).

Table 16: Distribution of soil series in Kinh Microwatershed

Sl. No	Map unit	Description	Area in ha. (%)
1	DSI mA1	Moderately shallow, black clayey soils developed from weathered basalt on nearly level uplands; clay surface on 0-1 % slope, slightly eroded	16.7 (2.6)
	DSI mB1	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	170.7 (26.3)
	DSI mB2	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded	30.0 (4.5)
	DSI mB3	Moderately shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, severely eroded	23.4 (3.6)
	DSI mC2g1	Moderately shallow, black clayey soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, moderately eroded, slightly gravelly, 15-35 per cent gravels.	6.4 (1.0)
	DSI mC3g1	Moderately shallow, black clayey soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, moderately eroded, severely gravelly, 15-35 per cent gravels.	21.5 (3.3)
2	KGI mB2g1	Shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded, slightly gravelly, 15-35 per cent gravels.	32.1 (4.9)
3	KMP mB1	Moderately deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	3.9 (0.6)
4	MAN mB1	Very deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	21.5 (3.3)
5	MGT mB3g1	Very shallow, black gravelly clay soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, severely eroded, slightly gravelly, 15-35 per cent gravels.	28.2 (4.3)
	MGT mC3g1	Very shallow, black gravelly clay soils developed from weathered basalt on gently sloping uplands; clay surface on 3-5 % slope, severely eroded, slightly gravelly, 15-35 per cent gravels.	11.5 (1.8)

	MGT mD3g2	Very shallow, black gravelly clay soils developed from weathered basalt on moderately sloping uplands; clay surface on 5-10 % slope, severely eroded, moderately gravelly, 35-60 per cent gravels.	11.6 (1.8)
6	NHA mB1	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, slightly eroded	8.1 (1.2)
	NHA mB2	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded	75.4 (11.6)
	NHA mB2g1	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3% slope, moderately eroded, slightly gravelly, 15-35 per cent gravels.	17.1 (2.6)
	NHA mC3g1	Shallow, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 3-5% slope, severely eroded, slightly gravelly, 15-35 per cent gravels.	33.4 (5.1)
7	RMN mC3g1	Deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 3-5 % slope, severely eroded, slightly gravelly, 15-35 per cent gravels.	22.0 (3.4)
8	RNL mB1	Deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, slightly eroded	37.4 (5.7)
	RNL mB2	Deep, black clayey soils developed from weathered basalt on very gently sloping uplands; clay surface on 1-3 % slope, moderately eroded	36.5 (5.6)

Present cropping pattern on different soil series are given in Table 17. Crops grown on Margutti soils are red gram. Bengal gram and red gram on Novinihala soils is grown. Red gram and sugarcane are grown on Dinsi soils and red grams on Mahagaon soils are grow.

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

(Area in per cent)

Soil Series	Soil Depth	Crops	Kharif		Grand Total
			Dry	Irrigated	
MGT	Very shallow (<25 cm)	Red gram	100.0	0.0	100.0
NHA	Shallow (25-50 cm)	Bengal gram	33.3	0.0	33.3
		Red gram	66.7	0.0	66.7
DSI	Moderately shallow (50-75 cm)	Red gram	100.0	0.0	80.1
		Sugarcane	0.0	100.0	19.9
MAN	Very deep (>150 cm)	Red gram	100.0	0.0	100.0

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

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

Soil Series	Small Farmers	Medium Farmers
MGT	Red gram (0.33).	
NHA		Bengal gram (1.36), Red gram (2.13).
DSI		Red gram (1.85), Sugar cane (2.32).
MAN		Red gram (2.26).

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

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

Particulars	MGT	NHA		DSI		MAN
	Red gram	Bengal gram	Red gram	Red gram	Sugar cane	Red gram
Total cost (Rs/ha)	164793	19876	19872	19150	35724	19372
Gross Return (Rs/ha)	54485	26995	41731	35369	82948	42874
Net returns (Rs/ha)	-110307	7119	21859	16219	47224	23502
BCR	0.33	1.36	2.13	1.85	2.32	2.26
Farmers Practices (FP)						
FYM (t/ha)	14.7	1.0	1.5	1.1	1.4	1.4
Nitrogen (kg/ha)	301.5	95.3	89.8	97.0	149.3	88.2
Phosphorus (kg/ha)	338.2	62.8	58.9	70.5	107.3	55.4
Potash (kg/ha)	0.0	0.0	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	11.0	6.8	9.4	7.4	839.6	53.1
Price of Yield (Rs/Qtl)	5000	4000	4500	4833	100	2475
Soil test based fertilizer Recommendation (STBR)						
FYM (t/ha)	7.4	7.4	7.4	7.4	24.7	7.4
Nitrogen (kg/ha)	24.7	13.9	18.5	18.5	185.3	18.5
Phosphorus (kg/ha)	61.8	46.3	61.8	61.8	123.5	61.8
Potash (kg/ha)	30.9	46.3	30.9	24.7	123.5	24.7
Grain (Qtl/ha)	12.4	14.8	12.4	12.4	1358.5	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)						
FYM (%)	-98.5	86.2	79.3	84.8	94.3	80.5
Nitrogen (%)	-1120.5	-585.8	-384.5	-423.6	19.4	-376.3
Phosphorus (%)	-447.7	-35.7	4.7	-14.1	13.1	10.2
Potash (%)	100.0	100.0	100.0	100.0	100.0	100.0
Grain (%)	10.7	53.9	24.0	39.8	38.2	-329.8
Value of yield and Fertilizer (Rs)						
Additional Cost (Rs/ha)	-22165	5608	5763	5453	26917	5898
Additional Benefits (Rs/ha)	6603	31958	13337	23777	51895	-100806
Net change Income (Rs/ha)	28768	26350	7573	18324	24978	-106704

The data on cost of cultivation and BCR of different crops is given in Tables 19. The total cost of cultivation in study area for red gram ranges between Rs.164793/ha in

MGT soil (with BCR of 0.33) and Rs.19150/ha in DSI soil (with BCR of 1.85), bengal gram cost of cultivation in NHA soil is Rs 19876/ha (with BCR of 1.36) and sugarcane cost of cultivation in DSI soil is Rs. 35724/ha (with BCR of 2.32).

The data on FYM, Nitrogen, Phosphorus and Potash application by the farmers to different crops and recommended FYM for different crops is given in Table 19. There is a huge gap between FYM application by farmers and recommended FYM in all the crops across the soils. There is a larger yield gap in crops grown across different soil series. Adequate knowledge about recommended package of practices is the pre-requisite for their use in cultivation of crops. It is a fact that, recommended practices are major contributing factors to yield. Inadequate knowledge about recommended practices leads to their improper adoption. Strengthening of extension services by concerned agency is required to increase adoption of recommended cultivation practices and ultimately reducing the gap. By adopting soil-test fertiliser recommendation, there is scope to increase yield and income to a maximum of Rs 28768 in red gram and a minimum of Rs 24978 in sugarcane cultivation.

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 20 and Figure 10. The average value of soil nutrient loss is around Rs 2011.13 per ha/year. The total cost of annual soil nutrients is around Rs 1220753 per year for the total area of 649 ha.

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

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	279.81	169846	1762.82	1070031
Phosphorous	0.12	75	5.43	3293
Potash	1.25	757	24.93	15132
Iron	0.28	172	13.58	8245
Manganese	0.56	340	154.24	93624
Copper	0.07	45	41.12	24962
Zinc	0.02	10	0.67	404
Sulphur	0.20	122	8.06	4893
Boron	0.01	4	0.28	169
Total	282.32	171371	2011.13	1220753

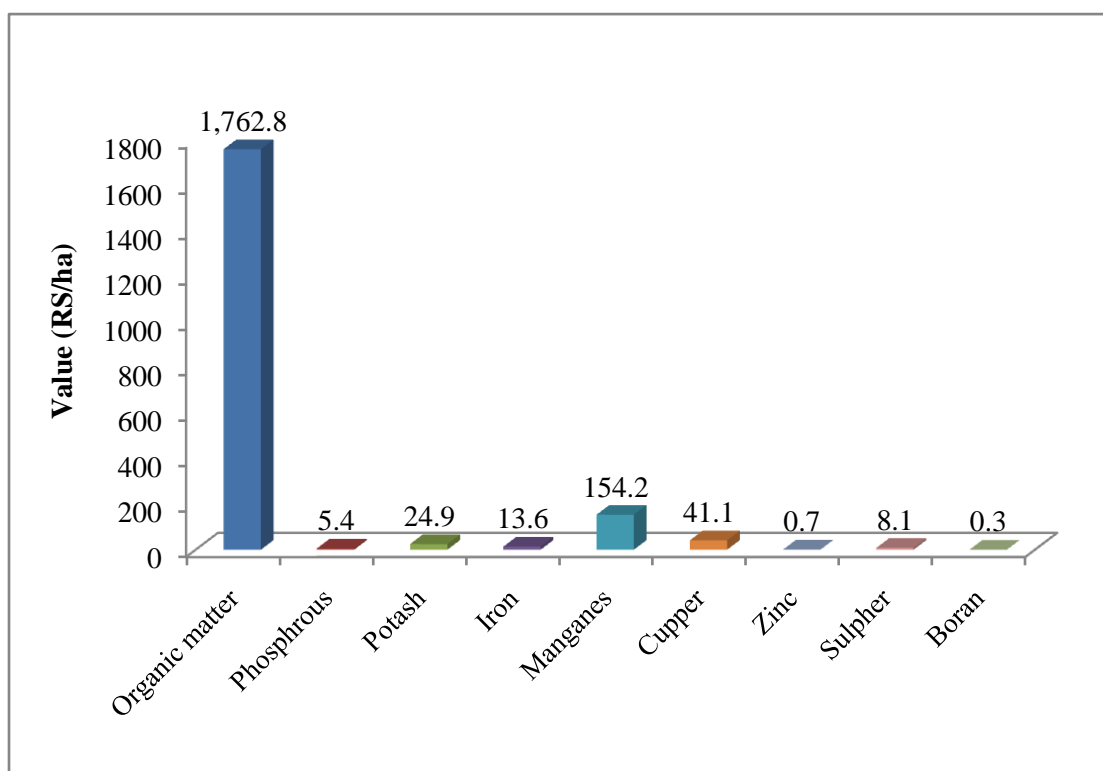


Figure 10: Estimation of onsite cost of soil erosion in Kinhi Microwatershed

The average value of ecosystem service for food grain production is around Rs 7638/ ha/year (Table 21 and Figure 11). Per hectare food grain production services is maximum in sugarcane (Rs 47224) followed by red gram (Rs 44128) and bengal gram (Rs 7119).

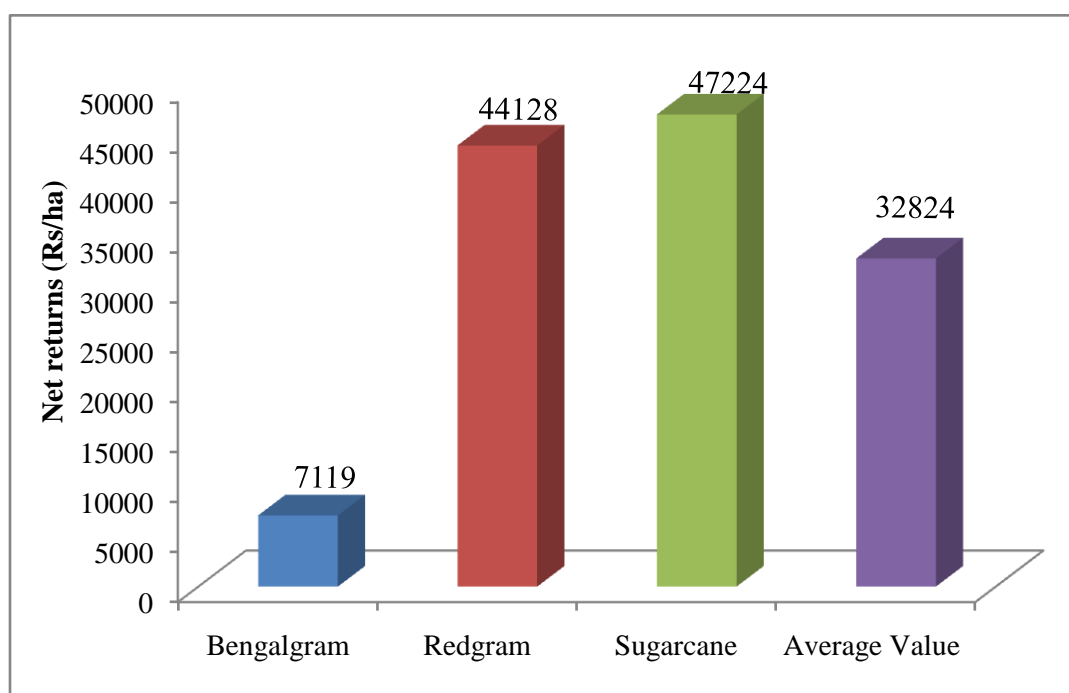


Figure 11: Ecosystem services of food production in Kinhi Microwatershed

Table 21: Ecosystem services of food production in Kinhi 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	3.0	7	4000	26995	19876	7119
	Redgram	19.0	20	4181	81719	37591	44128
Commercial Crops	Sugarcane	2.2	829	100	82948	35724	47224
Grand Total		24.2	285	2760	63887	31063	32823

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 22 and Figure 12) in sugar cane Rs 174190 followed by red gram (Rs 106399) and bengal gram (Rs 46606).

Table 22: Ecosystem services of water supply in Kinhi Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Bengal gram	6.7	4661	46606	691
Red gram	19.5	10640	106399	544
Sugarcane	829.5	17419	174190	21
Grand Total	285	10907	109065	419

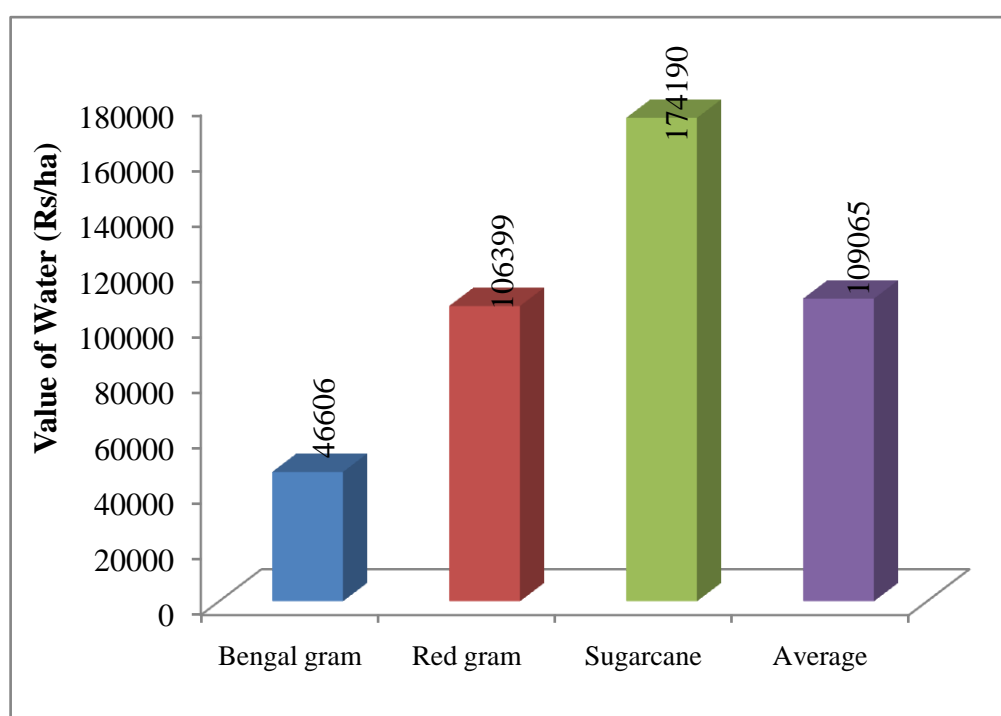


Figure 12: Ecosystem services of water supply in Kinhi Microwatershed

The main farming constraints in Kinhi Microwatershed to be found are less rainfall, lack of good quality seeds, lack of storage, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 23).

Table 23: Farming constraints related land resources of sample households in Kinhi Micro watershed

Sl. No	Particulars	Per cent
1	Less Rainfall	90
2	Lack of good quality seeds	10
3	High Crop Pests & Diseases	60
4	Animal Pests & Diseases	20
5	Lack of transportation	20
6	Lack of storage	60
7	Damage of crops by Wild Animals	100
8	Non availability of Plant Protection Chemicals	100
9	Source of loan	
	Bank	10
	Money Leander	90
10	Market for selling	
	Village market	100
11	Sources of Agri-Technology information	
	Newspaper	80
	Television	20

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.