



हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

AgriSearch with a human touch

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

NELKUD-1 (4D5B7F2f) 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



ICAR - NBSS & LUP



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



About ICAR - NBSS&LUP

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

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

Citation: Rajendra Hegde, Ramesh Kumar, S.C., K.V. Niranjana, S. Srinivas, M.Lalitha, B.A. Dhanorkar, R.S. Reddy and S.K. Singh (2019). "Land Resource Inventory and Socio-Economic Status of Farm Households for Watershed Planning and Development of Nelkud-1 (4D5B7F2f) Microwatershed, Gulbarga Taluk, Gulbarga District, Karnataka", ICAR-NBSS&LUP Sujala MWS Publ.60, ICAR – NBSS & LUP, RC, Bangalore. p.79 & 29.

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



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

NELKUD-1 (4D5B7F2f) 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**



ICAR - NBSS & LUP



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



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 Nelkud-1 Microwatershed, Gulbarga Taluk, Gulbarga District, Karnataka” for integrated development was taken up in collaboration with the State Agricultural Universities, IISC, KRSRAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers 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

Date: 01.02.2018

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, T.N.
	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. M. Jayaramaiah	Sh. Veerabhadrappa
Sh. Paramesha, K.	Sh. Anand
	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.Yogेशha 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

Contents

Preface		
Contributors		
Executive Summary		
Chapter 1	Introduction	1
Chapter 2	Geographical Setting	3
2.1	Location and Extent	3
2.2	Geology	3
2.3	Physiography	4
2.4	Drainage	5
2.5	Climate	5
2.6	Natural Vegetation	6
2.7	Land Utilization	7
Chapter 3	Survey Methodology	9
3.1	Base maps	9
3.2	Image Interpretation for Physiography	9
3.3	Field Investigation	11
3.4	Soil Mapping	13
3.5	Laboratory Characterization	13
Chapter 4	The Soils	17
4.1	Soils of Basalt Landscape	17
4.2	Soils of laterite Landscape	21
Chapter 5	Interpretation for Land Resource Management	23
5.1	Land Capability Classification	23
5.2	Soil Depth	25
5.3	Surface Soil Texture	26
5.4	Soil Gravelliness	27
5.5	Available Water Capacity	28
5.6	Soil Slope	29
5.7	Soil Erosion	30
Chapter 6	Fertility Status	33
6.1	Soil Reaction (pH)	33
6.2	Electrical Conductivity (EC)	33
6.3	Organic Carbon (OC)	33
6.4	Available Phosphorus	33
6.5	Available Potassium	34
6.6	Available Sulphur	34
6.7	Available Boron	34
6.8	Available Iron	34

6.9	Available Manganese	34
6.10	Available Copper	34
6.11	Available Zinc	34
Chapter 7	Land Suitability for Major Crops	41
7.1	Land suitability for Sorghum	41
7.2	Land suitability for Maize	44
7.3	Land suitability for Red gram	45
7.4	Land suitability for Sunflower	46
7.5	Land suitability for Cotton	48
7.6	Land suitability for Sugarcane	49
7.7	Land suitability for Soybean	50
7.8	Land suitability for Bengal gram	51
7.9	Land suitability for Mango	52
7.10	Land suitability for Sapota	54
7.11	Land suitability for Guava	55
7.12	Land suitability for Jackfruit	56
7.13	Land suitability for Jamun	57
7.14	Land Suitability for Musambi	58
7.15	Land Suitability for Lime	59
7.16	Land Suitability for Cashew	61
7.17	Land Suitability for Custard Apple	61
7.18	Land Suitability for Amla	62
7.19	Land Suitability for Tamarind	63
7.20	Land Use Classes	64
7.21	Proposed Crop Plan	64
Chapter 8	Soil Health Management	67
Chapter 9	Soil and Water conservation Treatment Plan	71
9.1	Treatment Plan	72
9.2	Recommended Soil and Water Conservation measures	75
9.3	Greening of microwatershed	76
	References	79
	Appendix I	I-VIII
	Appendix II	IX-XIV
	Appendix III	XV-XVII

LIST OF TABLES

2.1	Mean Monthly Rainfall, PET, 1/2 PET at Gulbarga Taluk, Gulbarga District	5
2.2	Land Utilization in Gulbarga Taluk	7
3.1	Differentiating Characteristics used for Identifying Soil Series	12
3.2	Soil Map Unit Description of Nelkud-1 microwatershed	14
7.1	Soil-Site Characteristics of Nelkud-1 microwatershed	42
7.2	Crop suitability criteria for Sorghum	43
7.3	Crop suitability criteria for Maize	44
7.4	Crop suitability criteria for Red gram	45
7.5	Crop suitability criteria for Sunflower	47
7.6	Crop suitability criteria for Cotton	48
7.7	Crop suitability criteria for Sugarcane	49
7.8	Crop suitability criteria for Mango	53
7.9	Crop suitability criteria for Sapota	54
7.10	Crop suitability criteria for Guava	56
7.11	Crop suitability criteria for Lime	60
7.12	Proposed Crop Plan for Nelkud-1 Microwatershed	65

LIST OF FIGURES

2.1	Location map of Nelkud-1 microwatershed	3
2.2	Rock formations in Nelkud-1 microwatershed	4
2.3	Rainfall distribution in Gulbarga Taluk, Gulbarga District	6
2.4	Natural Vegetation in Nelkud-1 microwatershed	6
2.5	Current Land use – Nelkud-1 microwatershed	8
2.6	Location of Wells- Nelkud-1 microwatershed	8
3.1	Scanned and Digitized Cadastral map of Nelkud-1 microwatershed	10
3.2	Satellite image of Nelkud-1 microwatershed	10
3.3	Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Nelkud-1 microwatershed	11
3.4	Location of profiles in a transect	12
3.4	Soil phase or management units of Nelkud-1 microwatershed	15
5.1	Land Capability Classification of Nelkud-1 microwatershed	25
5.2	Soil Depth map of Nelkud-1 microwatershed	26
5.3	Surface Soil Texture map of Nelkud-1 microwatershed	27
5.4	Soil Gravelliness map of Nelkud-1 microwatershed	28
5.5	Soil Available Water Capacity map of Nelkud-1 microwatershed	29
5.6	Soil Slope map of Nelkud-1 microwatershed	30
5.7	Soil Erosion map of Nelkud-1 microwatershed	31
6.1	Soil Reaction (pH) map of Nelkud-1 microwatershed	35
6.2	Electrical Conductivity (EC) map of Nelkud-1 microwatershed	35
6.3	Soil Organic Carbon (OC) map of Nelkud-1 microwatershed	36
6.4	Soil Available Phosphorus map of Nelkud-1 microwatershed	36
6.5	Soil Available Potassium map of Nelkud-1 microwatershed	37
6.6	Soil Available Sulphur map of Nelkud-1 microwatershed	37
6.7	Soil Available Boron map of Nelkud-1 microwatershed	38
6.8	Soil Available Iron map of Nelkud-1 microwatershed	38
6.9	Soil Available Manganese map of Nelkud-1 microwatershed	39
6.10	Soil Available Copper map of Nelkud-1 microwatershed	39

6.11	Soil Available Zinc map of Nelkud-1 microwatershed	40
7.1	Land Suitability map of Sorghum	43
7.2	Land Suitability map of Maize	44
7.3	Land Suitability map of Red gram	46
7.4	Land Suitability map of Sunflower	47
7.5	Land Suitability map of Cotton	49
7.6	Land Suitability map of Sugarcane	50
7.7	Land Suitability map of Soybean	51
7.8	Land Suitability map of Bengal gram	52
7.9	Land Suitability map of Mango	53
7.10	Land Suitability map of Sapota	55
7.11	Land Suitability map of Guava	56
7.12	Land Suitability map of Jackfruit	57
7.13	Land Suitability map of Jamun	58
7.14	Land Suitability map of Musambi	59
7.15	Land Suitability map of Lime	60
7.16	Land Suitability map of Cashew	61
7.17	Land Suitability map of Custard Apple	62
7.18	Land Suitability map of Amla	63
7.19	Land Suitability map of Tamarind	63
7.20	Land Use Classes map of Nelkud-1 microwatershed	64
9.1	Soil and Water Conservation map of Nelkud-1 microwatershed	76

EXECUTIVE SUMMARY

The land resource inventory of Nelkud-1 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 649 ha in Nelkud-1 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 94 per cent is covered by soils, six per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- ❖ The soils belong to 7 soil series and 16 soil phases (management units) and four 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 the degree of suitability along with constraints were generated.
- ❖ About 82 per cent area is suitable for agriculture and 12 per cent is not suitable for agriculture.
- ❖ About 73 per cent area has shallow to moderately shallow (25-75 cm) and about 22 per cent are very shallow (<25 cm) soils.
- ❖ Entire area in the microwatershed has clayey soils at the surface.
- ❖ About 17 per cent of the area has non-gravelly soils and 78 per cent gravelly to very gravelly soils (15-60 % gravel).
- ❖ About 31 per cent of the area has soils that are very low (<50mm/m), 46 per cent medium (100-150 mm/m) and about 17 per cent low (51-100 mm/m) in available water capacity.
- ❖ About 69 per cent of the area has very gently sloping (1-3%) lands, about 13 per cent is gently (3-5%) sloping and about 12 per cent has moderately sloping (5-10%) lands.
- ❖ An area of about 10 per cent has soils that are slightly eroded (e1), 60 per cent moderately eroded (e2) and 24 per cent severely eroded (e3).
- ❖ An area of about 25 per cent has soils that are slightly alkaline (pH 7.3 to 7.8), 18 per cent moderately alkaline (pH 7.8-8.4), 2 per cent strongly alkaline (pH 8.4-9.0) and 49 per cent area is neutral (pH 6.5-7.3) in soil reaction.

- ❖ *The Electrical Conductivity (EC) of the soils are dominantly $<2 \text{ dsm}^{-1}$ indicating that the soils are non-saline.*
- ❖ *About 14 per cent medium (0.5-0.75%) and 80 per cent high ($>0.75\%$) in organic carbon.*
- ❖ *Major area of 7 per cent has soils that are low ($<23 \text{ kg/ha}$) and 88 per cent medium (23-57 kg/ha) in available phosphorus.*
- ❖ *About 27 per cent low ($<145 \text{ kg/ha}$), 57 per cent medium (145-337 kg/ha) and 10 per cent high ($>337 \text{ kg/ha}$) in available potassium.*
- ❖ *Available sulphur is low ($<10 \text{ ppm}$) in about 51 per cent area and medium (10-20 ppm) in 43 per cent area.*
- ❖ *Available boron is low ($<0.5 \text{ ppm}$) in about 32 per cent area, 62 per cent medium (0.5-1.0 ppm) and 1 per cent high ($>1.0 \text{ ppm}$).*
- ❖ *About 5 per cent area has soils that are deficient ($<4.5 \text{ ppm}$) in available iron and 90 per cent sufficient ($>4.5 \text{ ppm}$).*
- ❖ *Available manganese and copper are sufficient in all the soils.*
- ❖ *About 21 per cent area has soils that are deficient ($<0.6 \text{ ppm}$) in available zinc and 73 per cent sufficient ($>0.6 \text{ ppm}$).*
- ❖ *The land suitability for 19 major agricultural and horticultural 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)	Moderately suitable (S2)
<i>Sorghum</i>	-	386 (59)	<i>Guava</i>	-	-
<i>Maize</i>	-	386 (59)	<i>Jackfruit</i>	-	-
<i>Red gram</i>	-	389 6(59)	<i>Jamun</i>	-	-
<i>Sunflower</i>	-	-	<i>Musambi</i>	-	-
<i>Cotton</i>	-	386 (59)	<i>Lime</i>	-	-
<i>Sugarcane</i>	-	-	<i>Cashew</i>	-	-
<i>Soybean</i>	-	386 (59)	<i>Custard apple</i>	-	386 (59)
<i>Bengal gram</i>	296(46)	123 (19)	<i>Amla</i>	-	389 (59)
<i>Mango</i>	-	-	<i>Tamarind</i>	-	-
<i>Sapota</i>	-	-			

Apart from the individual crop suitability, a proposed crop plan has been prepared for the four 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 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 help in not only supplementing the farm income but also provide fodder and fuel and generate lot of biomass. This helps in maintaining an ecological balance and also contributes to mitigating the climate change.*

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socioeconomic development of its people. Soils provide food, fodder, fibre and fuel for meeting the basic human and animal needs. With the ever increasing growth in human and animal population, the demand on soil for more food and fodder production is on the increase. The area available for agriculture is about 51 per cent of the total geographical area and more than 60 per cent of the people are still dependant on agriculture for their livelihood. However, the capacity of a soil to produce is limited and the limits to the production are set by its intrinsic characteristics, agroclimatic setting, and, use and management. There is, therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. Soil erosion alone has degraded about 35 lakh ha. Almost all the uncultivated areas are facing various degrees of degradation, particularly soil erosion; salinity and alkalinity has emerged as a major problem in more than 3.5 lakh ha in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

In this critical juncture, the challenge before us is not only to increase the productivity per unit area which is steadily declining and showing a fatigue syndrome, but also to prevent or at least reduce the severity of degradation. If the situation is not reversed at the earliest, then the sustainability of the already fragile crop production system and the overall ecosystem will be badly affected in the state. 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. These 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 Nelkud-1 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 Nelkud-1 microwatershed (Halikher subwatershed) is located in the northern part of Karnataka in Gulbarga Taluk, Gulbarga District, Karnataka State (Fig.2.1). It comprises parts of Kathalli, Itga, Rampur, Patvada, Gobbarwadi and Chintota villages. It lies between $17^{\circ} 39'$ and $17^{\circ} 41'$ North latitudes and between $77^{\circ} 06'$ and $77^{\circ} 08'$ East longitudes and covers an area of 649 ha. It is about 50 km from Gulbarga town and is surrounded by Kathalli on the northwest, Itga on the northeast, Rampur on the east, Patvada on the south, Gobbarwadi on the southwest and Chintota village on the west.

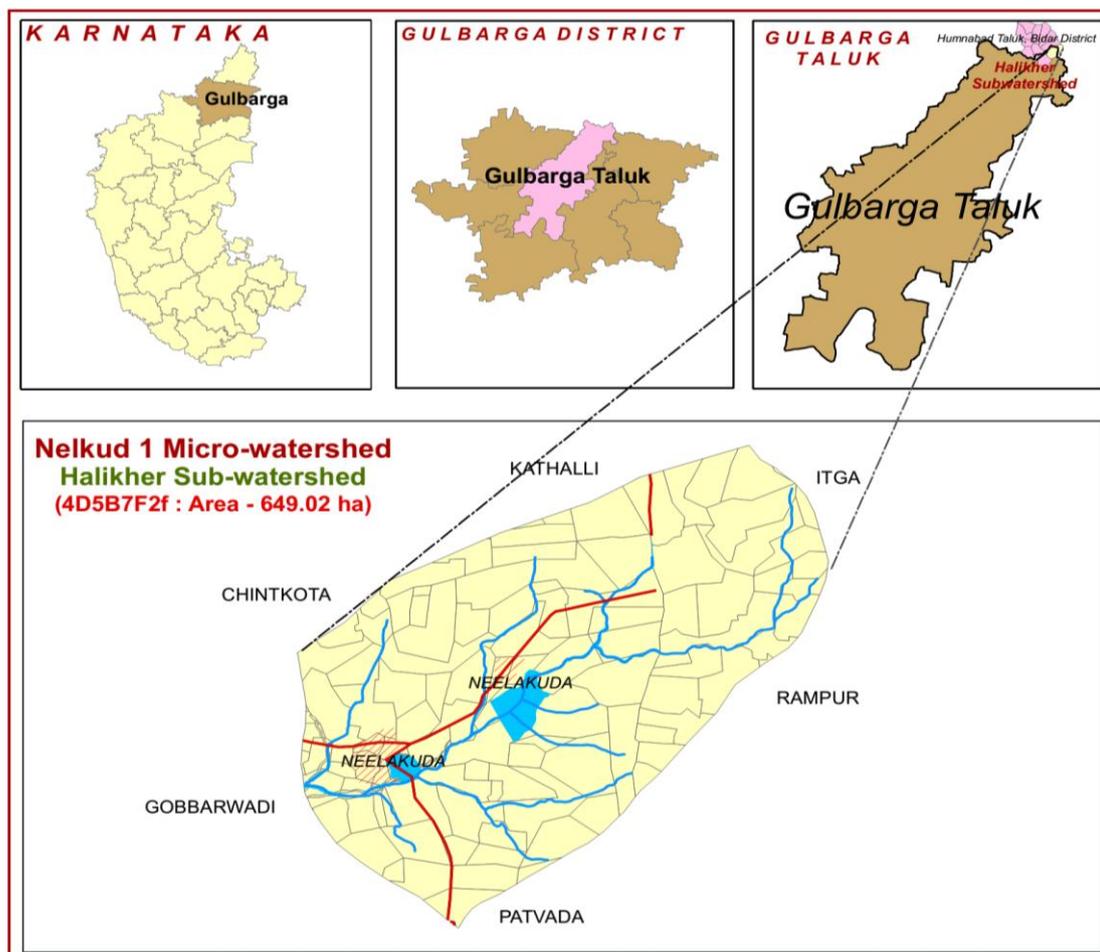


Fig.2.1 Location map of Nelkud-1 Microwatershed

2.2 Geology

Major rock formations observed in the microwatershed are Basalt (Fig.2.2) or Deccan Trap and Laterites. The Deccan Traps cover 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.

The laterites are formed from *insitu* alteration of underlying rocks, may be basalt, gneiss or any other sedimentary rocks. It seems very likely that in most cases an upper detrital layer of ferruginous debris was the starting point to set in motion the laterization process. Laterites of north Karnataka are younger than the Deccan Trap and older than the black soils which they underline. Laterites are porous and clay-like, generally soft and can be cut into blocks but becomes hard on exposure. The exposed surface is generally dark brown, the rock is mottled with various shades of reddish brown and yellow, consisting mainly of Raolin, gibbsite, goethite and quartz having a vesicular and vermicular appearance.



Fig. 2.2 Basalt rocks

2.3 Physiography

Physiographically, the area has been identified as basalt and laterite landscapes 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 590 to 673 m. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

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

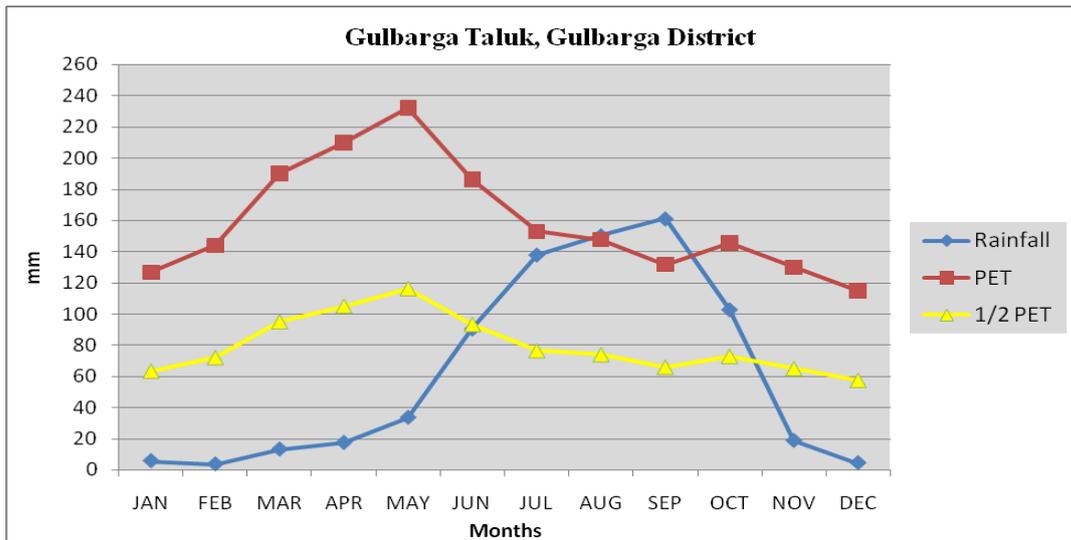


Fig 2.3 Rainfall distribution in Gulbarga Taluk

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 Nelkud-1 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. The cropping intensity is about 102 per cent. 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 Nelkud-1 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, conservation structures and other water bodies in the Nelkud-1 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
11	Current Fallows	18760	10.8

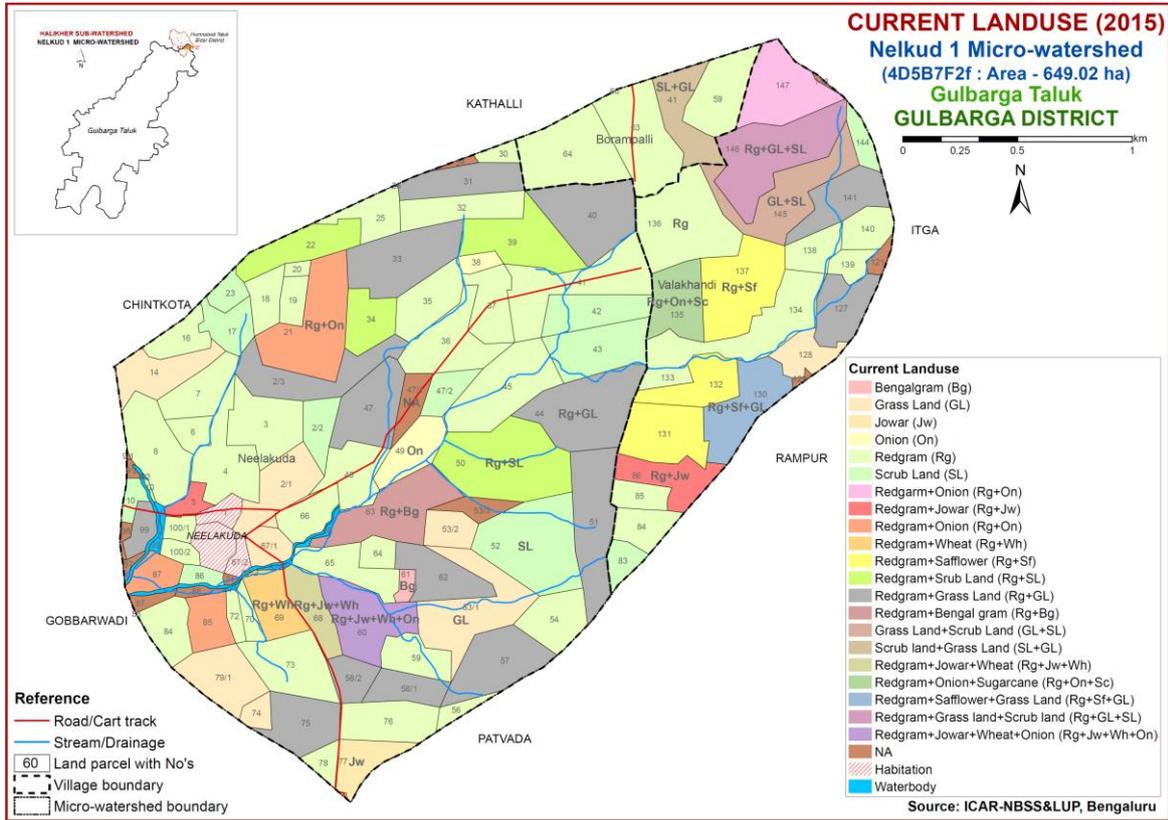


Fig.2.5 Current Land Use map of Nelkud-1 Microwatershed

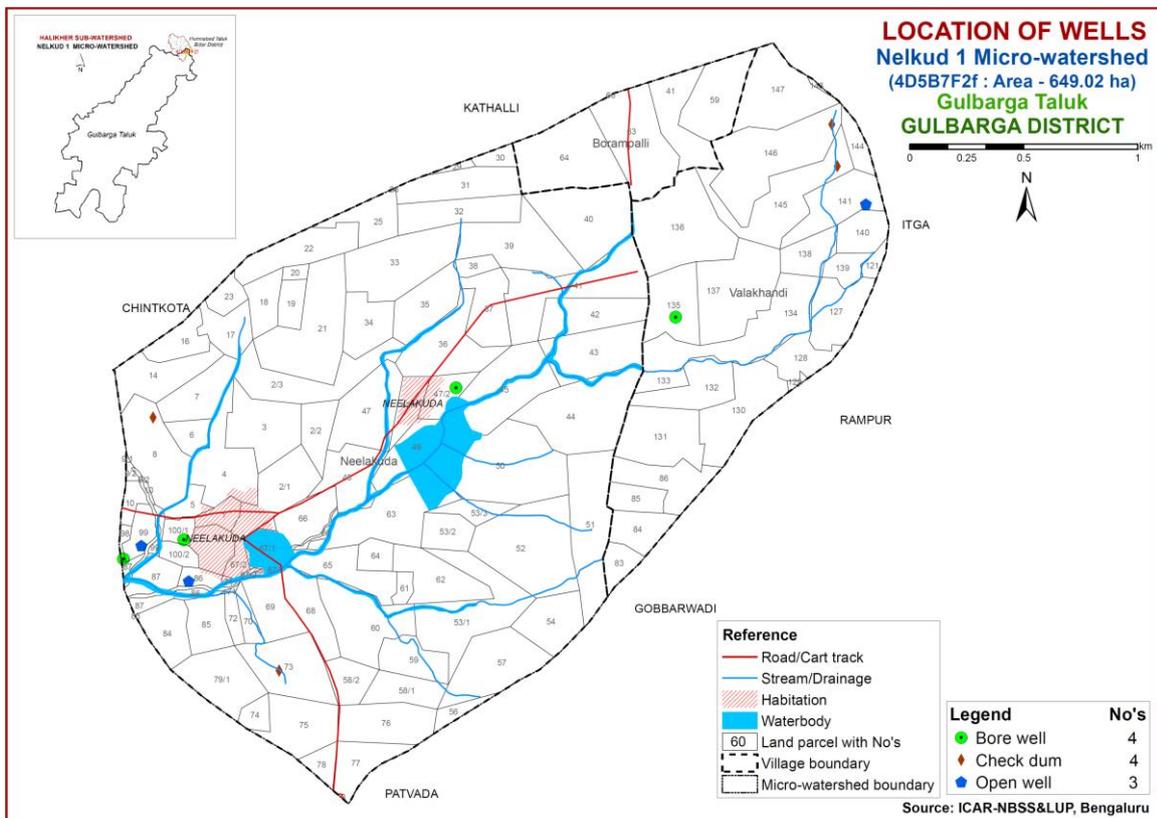


Fig.2.6 Location of Wells and Structures in Nelkud-1 Microwatershed

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 Nelkud-1 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 649 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 and laterite landscapes. 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.

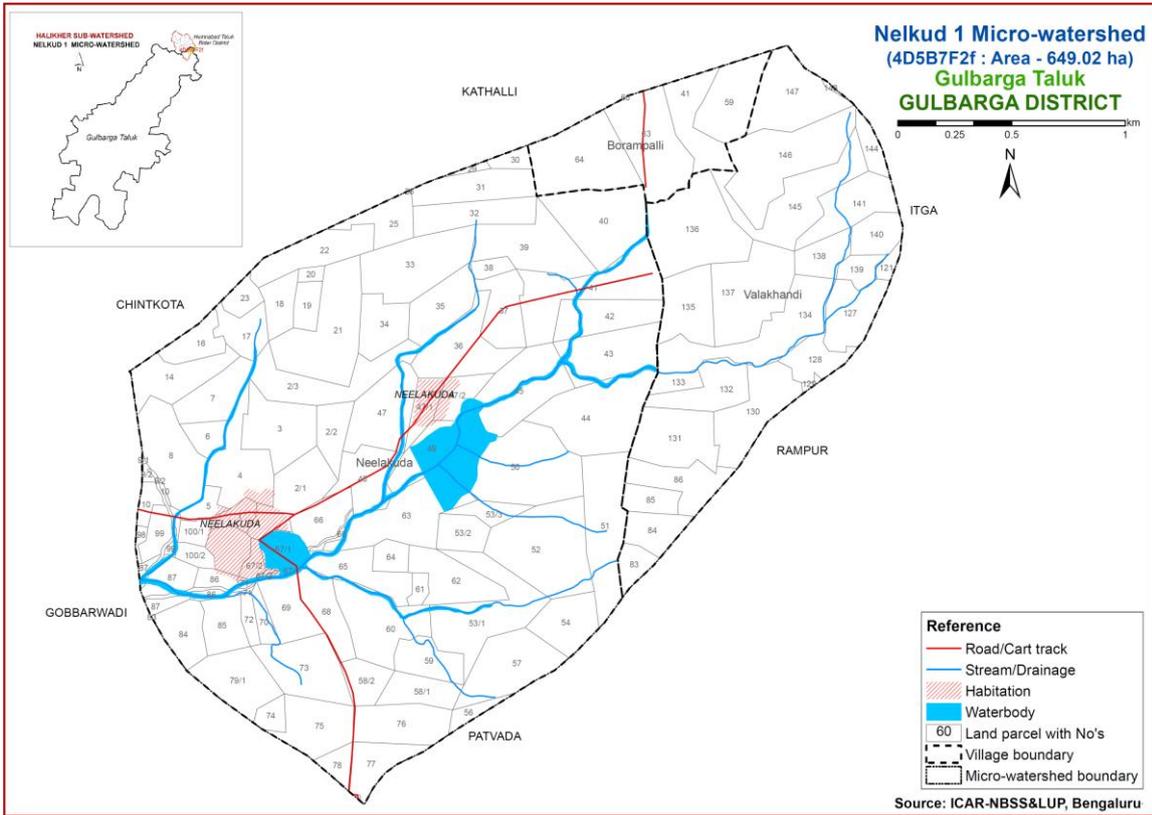


Fig 3.1 Scanned and Digitized Cadastral map of Nelkud-1 Microwatershed

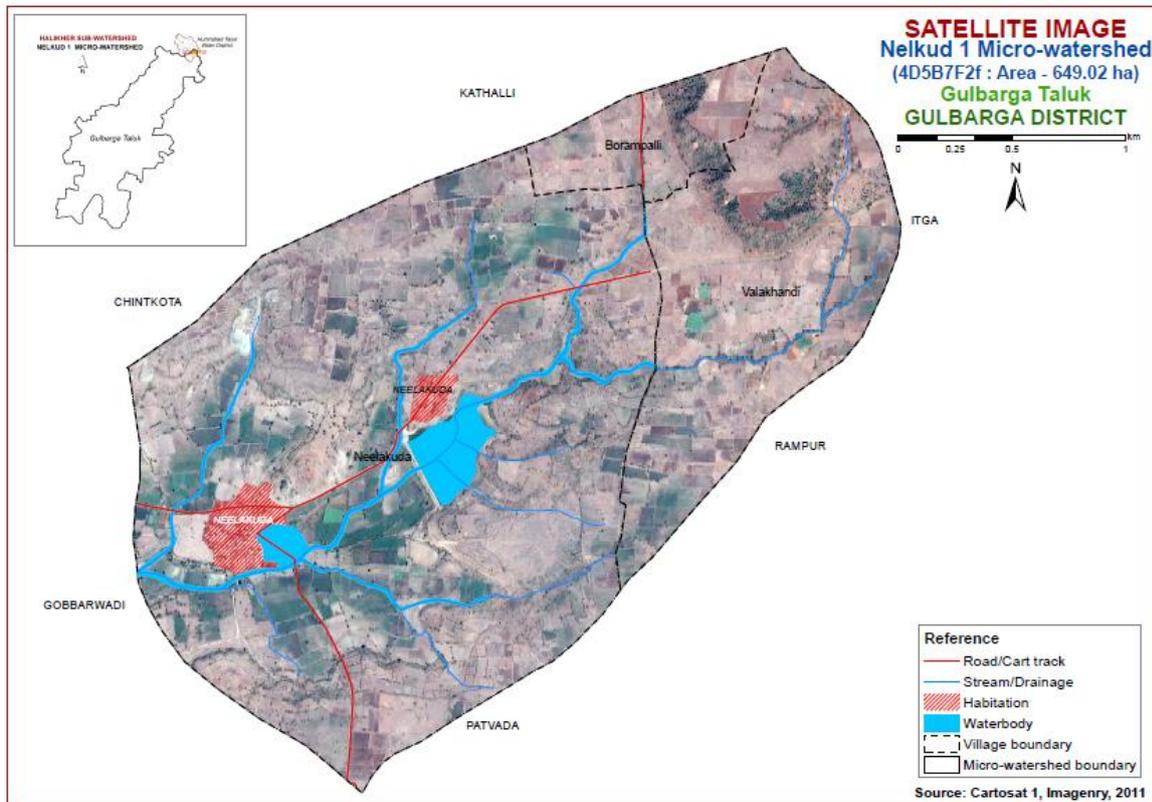


Fig.3.2 Satellite Image of Nelkud-1 Microwatershed

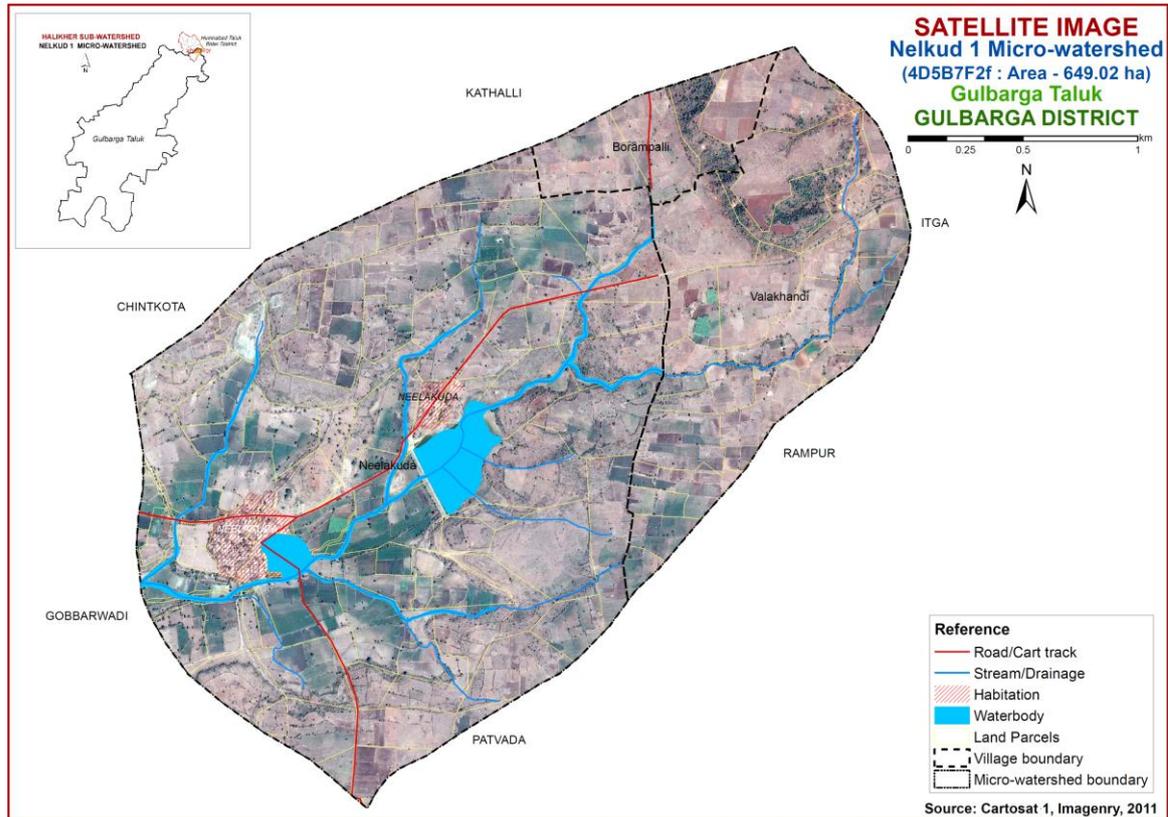


Fig.3.3 Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Nelkud-1 Microwatershed

3.3 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).

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, soil 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.

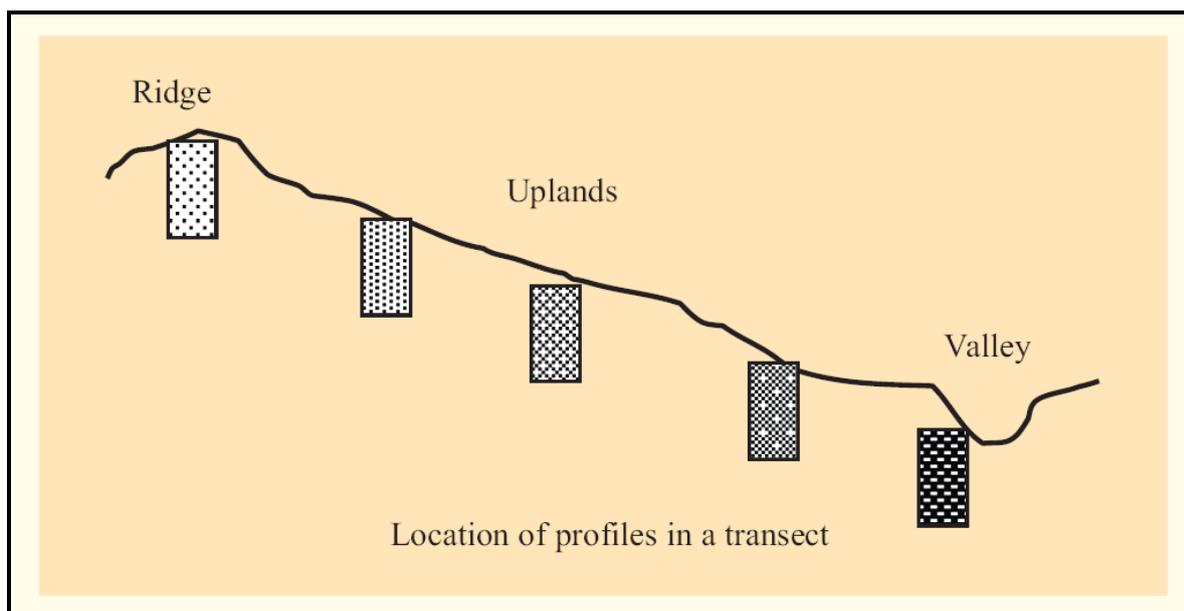


Fig: 3.4. Location of profiles in a transect

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, 7 soil series were identified in the Nelkud-1 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	Margutti (MGT)	<25	10YR3/3,4/3,5/47. 5YR4/3	c	15-35	Ap- cr	-
2	Bhimanahalli (BHI)	25-50	10YR3/2,3/3,3/17. 5YR3/2, 4/2	c	15-35	Ap-Bw- cr/R	-
3	Kalamundargi (KGI)	25-50	10YR4/3,4/27.5Y R3/3, 3/4,4/3	c	35-60	Ap-Bw- cr/R	-
4	Dinsi (DSI)	50-75	10YR3/2,3/3,4/3	c	<15	Ap-BA- Bss	-
5	Gutti (GTT)	50-75	10YR3/2,3/17.5Y R3/3,4/3	c	15-35	Ap-BA- Bss-cr	-
6	Hobli(HBL)	50-75	10YR3/2,3/3,4/3,4 /47.5YR3/4,4/3	c	<15	Ap-BA- Bss-cr	-
SOILS OF LATERITE LANDSCAPE							
7	Kinhi(KNH)	<25	2.5YR3/35YR4/6	c	35-60	Ap-R	-

3.3 Soil Mapping

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

The soil mapping units are shown on the map (Fig.3.5) in the form of symbols. During the survey about 13 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. 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 16 mapping units representing 7 soil series occurring in the microwatershed. The soil map unit (soil legend) description is presented in Table 3.2. The soil phase map (management units) shows the distribution of 16 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 soil phase will have similar management needs and have to be treated accordingly.

The 16 soil phases identified and mapped in the microwatershed were grouped into four 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 Nelkud-1 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.

3.4 Laboratory Characterization

Soil samples were collected from representative master profiles for each soil series for laboratory characterization by following the methods outlined in the Laboratory Manual (Sarma *et al*, 1987). Surface soil samples collected in the year 2015 from farmer's fields (105 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.

Table 3.2 Soil Map Unit Description of Nelkud-1 Microwatershed

Soil map Unit No	Soil Series	Soil Phases	Mapping Unit description	Area in ha (%)
Soils of Basalt Landscape				
	MGT	Margutti soils are very shallow (<25cm), well drained, have very dark grayish brown to dark brown clay soils occurring on very gently sloping to moderately sloping uplands.		102.53 (15.79)
1		MGTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	11.24 (1.73)
2		MGTmC2g1	Clay surface, 3-5% slope, moderate erosion, gravelly (15-35%)	7.42 (1.14)
3		MGTmC3g2	Clay surface, 3-5% slope, severe erosion, very gravelly (35-60%)	57.46 (8.85)
4		MGTmD3g2	Clay surface, 5-10 % slope, severe erosion, very gravelly (35-60%)	26.41 (4.07)
	BHI	Bhimnalli soils are shallow (25-50 cm), well drained, have dark brown to very dark brown cracking clay soils occur on very gently sloping to moderately sloping uplands.		59.57 (9.71)
5		BHiiD3g2	Sandy clay surface, 5-10 % slope, severe erosion, very gravelly (35-60%)	35.46 (5.46)
6		BHImB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	24.11 (3.71)
	KGI	Kalamundargi soils are shallow (25-50 cm), well drained, have very dark grayish brown to dark brown gravelly clay soils occurring on gently sloping to moderately sloping uplands.		28.42 (4.32)
7		KGIImC3g2	Clay surface, 3-5% slope, severe erosion, very gravelly (35-60%)	9.02 (1.39)
8		KGIImD3g2	Clay surface, 5-10 % slope, severe erosion, very gravelly (35-60%)	19.04 (2.93)
	DSI	Dinsi soils are moderately shallow (50-75 cm), moderately well drained, have very dark gray to brown cracking clay soils occurring on very gently sloping uplands		49.75 (7.67)
9		DSImB1	Clay surface, 1-3% slope, slight erosion	49.75 (7.67)
	GTT	Gutti soils are moderately shallow (50-75 cm), moderately well drained, have very dark grayish brown to dark brown cracking clay soils occurring on very gently sloping uplands		246.3 (37.94)
10		GTTmB1	Clay surface, 1-3% slope, slight erosion	14.09 (2.17)
11		GTTmB2	Clay surface, 1-3% slope, moderate erosion	16.72 (2.58)
12		GTTmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	215.42 (33.19)
	HBL	Hobli soils are moderately shallow (50-75 cm), well drained, have very dark brown to dark brown cracking clay soils occurring on very gently sloping uplands.		89.53 (13.8)
13		HBLmB2g1	Clay surface, 1-3% slope, moderate erosion, gravelly (15-35%)	68.64 (10.58)
14		HBLmB2g2	Clay surface, 1-3% slope, moderate erosion, very gravelly (35-60%)	20.89 (3.22)
SOILS OF LATERITE LANDSCAPE				
	KNH	Kinihi soils are very shallow (<25 cm), well drained, have yellowish red to dark reddish brown clay soils occurring on very gently to gently sloping uplands		37.39 (5.76)
15		KNHmB2	Clay surface, 1-3% slope, moderate erosion	27.46 (4.23)
16		KNHmC3g1	Clay surface, 3-5% slope, severe erosion, gravelly (15-35%)	9.93 (1.53)

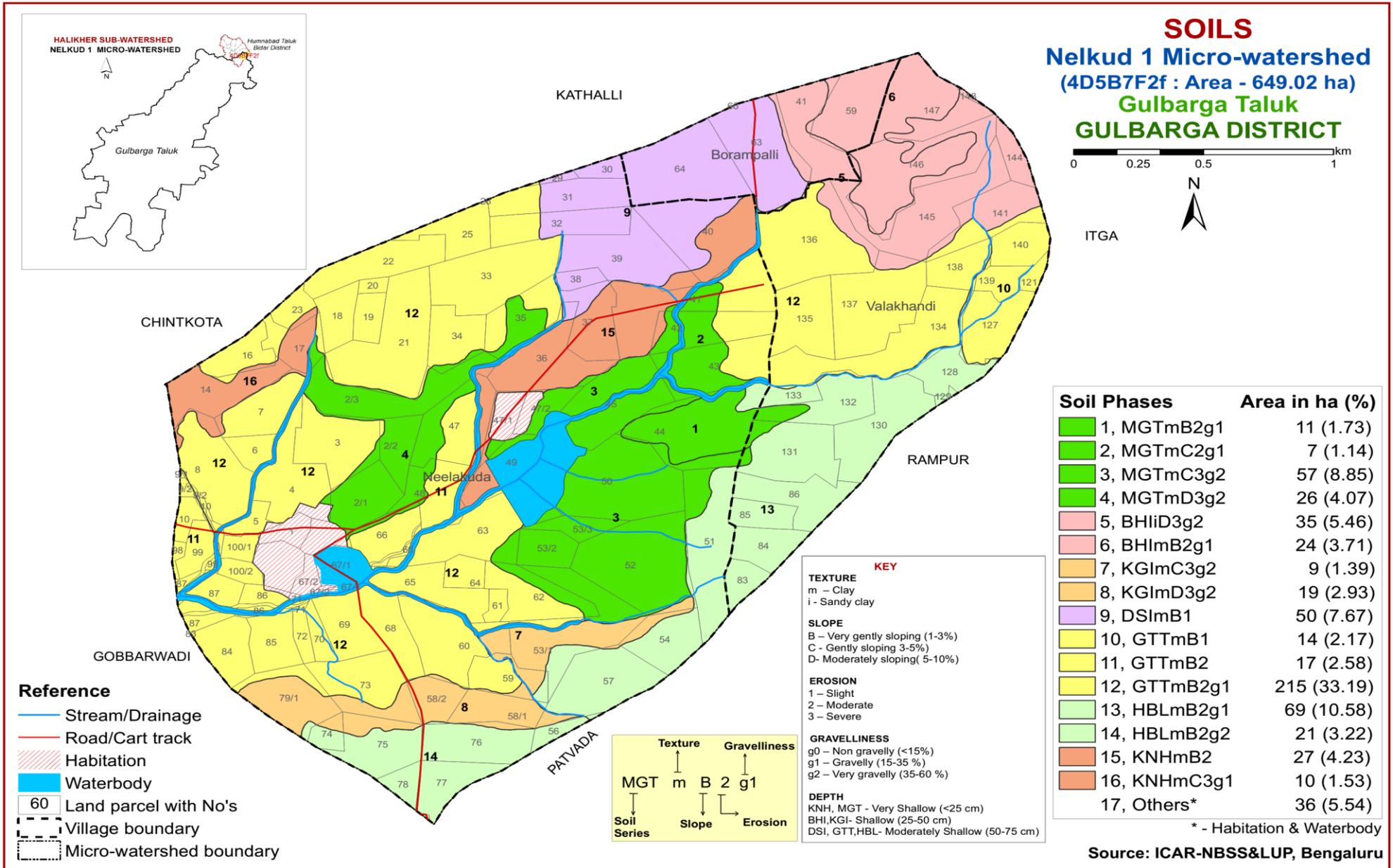


Fig 3.5 Soil phase or management units map of Nelkud-1 Microwatershed

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Nelkud-1 microwatershed is provided in this chapter. The microwatershed area has been identified as basalt and laterite landscapes. In all, 7 soil series were identified in these landscapes. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In both the landscapes, it is by parent material relief and climate. A brief description of each of the 7 soil series identified and mapped under each series is furnished below. The soil phases identified and mapped under each soil 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-characteristic 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, 6 soil series are identified and mapped as soil phases. Gutti (GTT) soil series occupies maximum area of about 246 ha (38%) followed by Margutti (MGT) about 103 ha (16%). Brief description of each series identified and mapped is given below.

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

The total depth of the soil ranges from 10 to 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. Its texture is clay with 15 to 35 per cent gravel. The available water capacity is very low (<50 mm/m). Four phases were identified and mapped.



Landscape and Soil Profile Characteristics of Margutti (MGT) Series

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

The thickness of the solum ranges from 25 to 50 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 and 4 and chroma 2 to 4. The texture is clay with 15 to 35 per cent gravel. The thickness of B horizon ranges from 12 to 34 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 15 to 35 per cent. The available water capacity is very low (<50 mm/m). Two phases were identified and mapped.



Landscape and Soil Profile Characteristics of Bhimanahalli (BHI) Series

4.1.3 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 gently sloping to moderately 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). Two phases were identified and mapped.



Landscape and Soil Profile Characteristics of Kalamundargi (KGI) Series

4.1.4 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 very gently sloping uplands.

The thickness of the solum ranges from 51 to 71 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). Only one phase was identified and mapped.



Landscape and Soil Profile Characteristics of Dinsi (DSI) Series

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

The thickness of the solum ranges from 50 to 75 cm. The thickness of A horizon ranges from 7 to 18 cm. Its colour is in 10 YR and 7.5YR hue with value 3 and 4 and chroma 2 to 3. The texture is clay with 5 to 10 per cent gravel. The thickness of B horizon ranges from 47 to 64 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 less than 15 per cent. The available water capacity is low (51-100 mm/m). Three phases were identified and mapped.



Landscape and Soil Profile Characteristics of Gutti (GTT) Series

4.1.6 Hobli (HBL) Series: Hobli soils are moderately shallow (50-75 cm), well drained, have very dark brown to dark brown cracking clay soils. They have developed from basalt and occur on very gently sloping uplands.

The thickness of the solum ranges from 50 to 75 cm. The thickness of A horizon ranges from 9 to 25 cm. Its colour is in 10 YR and 7.5 YR hue with value 3 and 4 and chroma 2 to 4. The texture is dominantly clay. The thickness of B horizon ranges from

31 to 45 cm. Its colour is in 10 YR and 7.5YR 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 low (51-100 mm/m). Two phases were identified and mapped.



Landscape and Soil Profile Characteristics of Hobli (HBI) Series

4.2 Soils of Laterite Landscape

In this landscape, only one soil series was identified and mapped. The brief description of this series is given below.

4.2.1 Kinhi (KNH) Series: Kinhi soils are very shallow (<25 cm), well drained, have yellowish red to dark reddish brown clay soils. They have developed from weathered laterite and occur on very gently to gently sloping uplands.

The total thickness of the soil is <25 cm. The thickness of A horizon ranges from 9 to 16 cm. Its colour is in 5 YR and 2.5 YR hue with value 3 to 4 and chroma 3 to 6. The texture is clay with gravel content of 35 to 60 per cent. The available water capacity is very low (<50 mm/m). Two phases were identified and mapped.



Landscape and Soil Profile Characteristics of Kinhi (KNH) 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

Soil Characteristics: Depth, texture, gravelliness, calcareousness

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

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

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

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

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

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

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

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

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

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

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

The land capability subclasses are recognised based on the dominant limitations observed within a given land capability class. The subclasses are designated by adding a lower case letter like ‘e’, ‘w’, ‘s’, or ‘c’ to the class numeral. The subclass “e” indicates that the main hazard is risk of erosion, “w” indicates drainage or wetness as a limitation for plant growth, “s” indicates shallow soil depth, coarse or heavy textures, calcareousness, salinity/alkalinity or graveliness 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 16 soil map units identified in the Nelkud-1 microwatershed are grouped under two land capability classes and three land capability subclasses. About 82 per cent area in the microwatershed is suitable for agriculture (Fig. 5.1) and 12 per cent is not suitable for agriculture.

Of the lands suitable for agriculture, fairly good cultivable lands (Class IV) cover maximum area of about 82 per cent and are distributed in all parts of the microwatershed. They have severe limitations of erosion and soil. Lands not suitable for agriculture (Class VI) cover an area of about 12 per cent and are distributed in the southern, central and northeastern part of the microwatershed. They are well suited for pasture, forestry, wild life and recreation with severe limitations of soil and erosion.

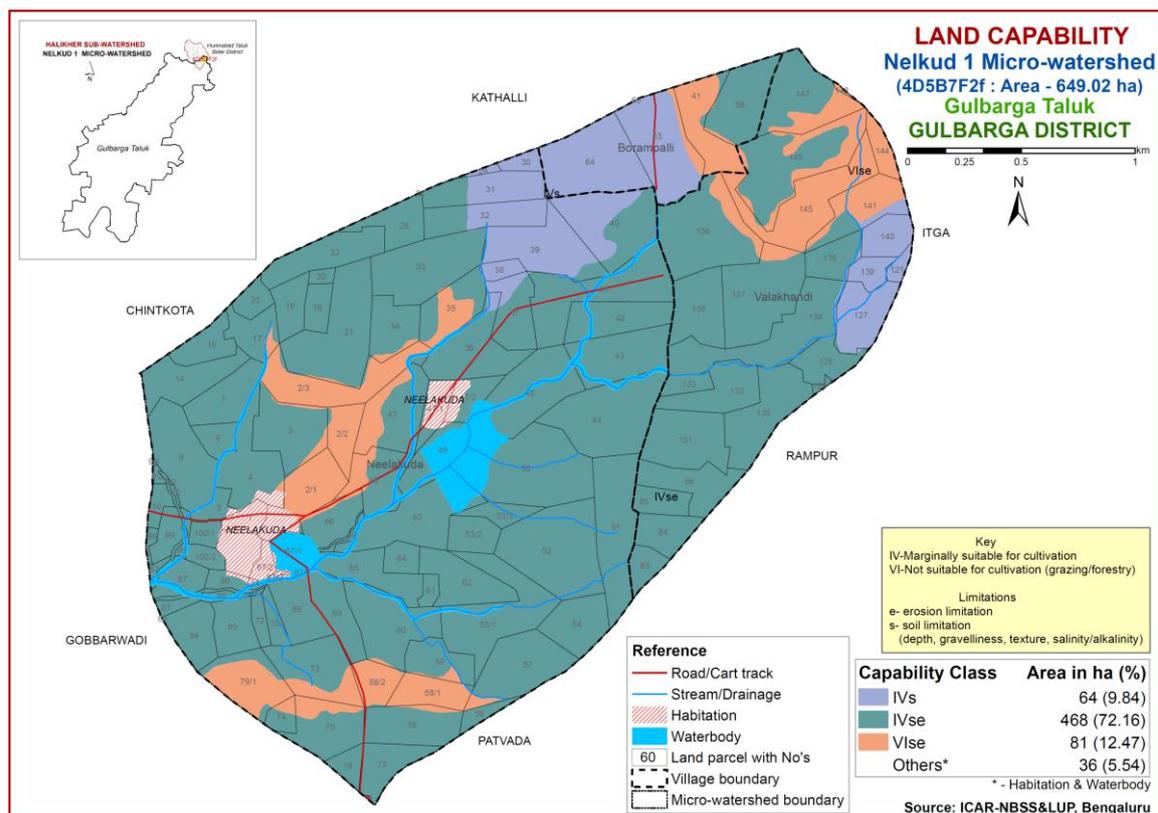


Fig. 5.1 Land Capability map of Nelkud-1 Microwatershed

5.2 Soil Depth

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

An area of about 140 ha (22%) is very shallow soils (<25 cm) and are distributed in the central and western part of the microwatershed. Shallow soils (25-50 cm) occupy an area of about 88 ha (13%) and are distributed in the southern and northeastern part of the microwatershed. Moderately shallow soils (50-75 cm) occupy maximum area of about 386 ha (59%) and are distributed in all parts of the microwatershed.

The most problem lands with an area of about 228 ha (35%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occur in the southern, central, western and southeastern part 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.

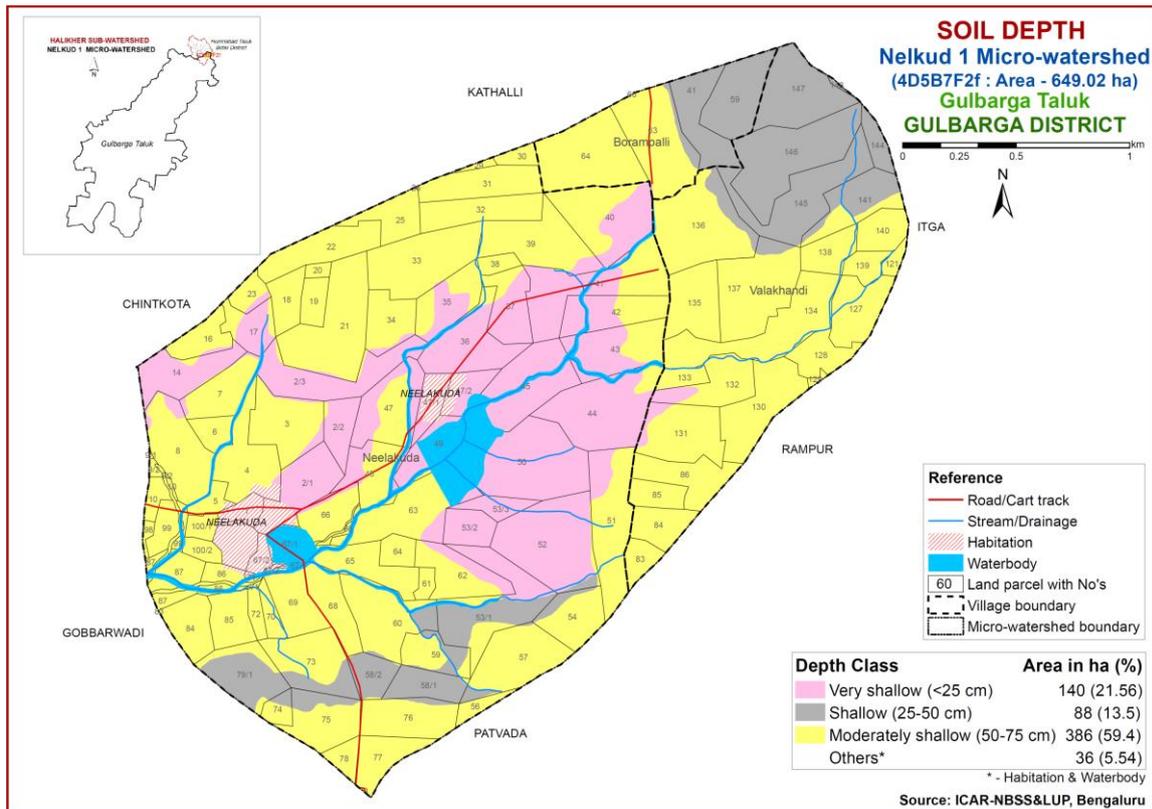


Fig. 5.2 Soil Depth map of Nelkud-1 Microwatershed

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 613 ha (94%) has soils that are clayey at the surface. All the lands are productive (94%) with respect to surface soil texture that have high potential for soil-water retention and availability, and nutrient retention and availability, but have more problems of drainage, infiltration, workability and other physical problems.

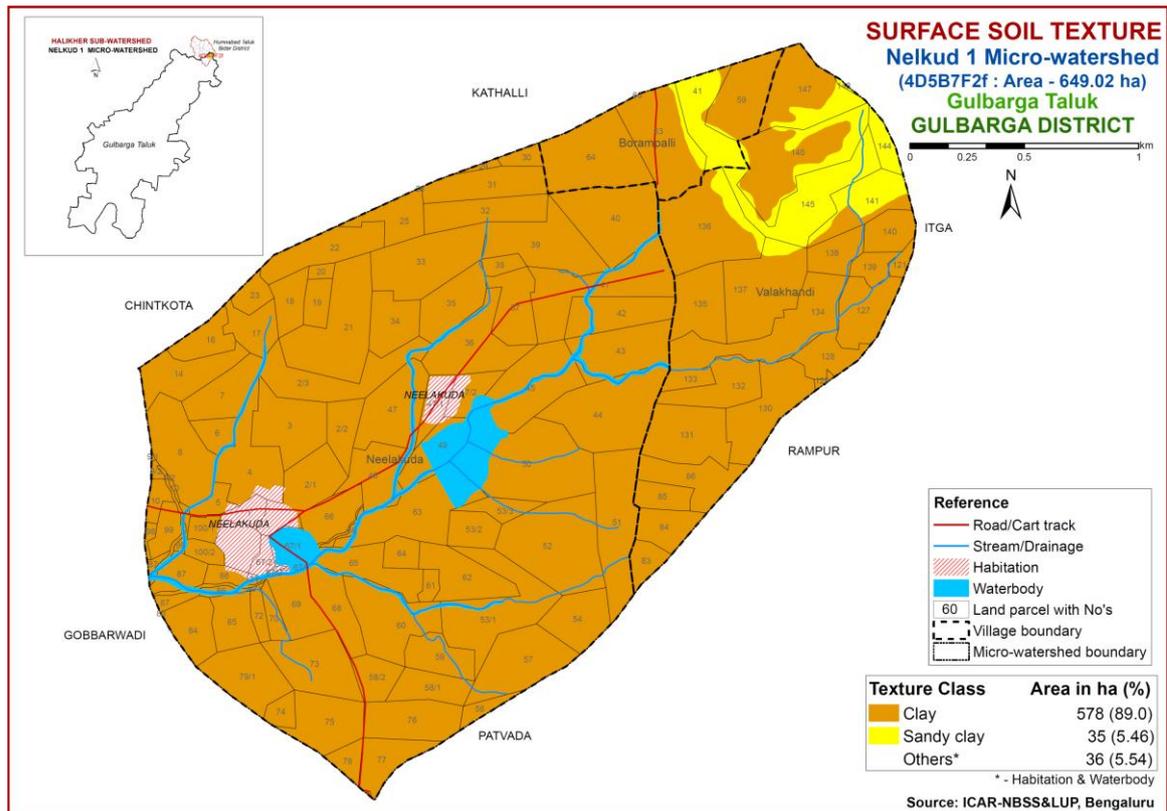


Fig. 5.3 Surface Soil Texture map of Nelkud-1 Microwatershed

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 mm diameter and stones for those between 7.5 mm and 25 mm. 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 gravelly (15-35%) covering about 337 ha (52%) and are distributed in all parts the microwatershed (Fig.5.4). About 108 ha (17%) area in the microwatershed has soils that are non gravelly (<15%) and are distributed in the central, northern, northeastern and southwestern part of the microwatershed. Very gravelly (35-60%) soils covering about 168 ha (26%) are distributed in the southern, central and northern part of the microwatershed.

The most productive lands with respect to gravelliness are found to be 69 per cent. They are non gravelly (<15%) and gravelly (15-35%) and have potential for growing both annual and perennial crops.

The problem soils that are very gravelly (35-60%) are found to cover about 26 per cent area, where only short duration crops can be grown.

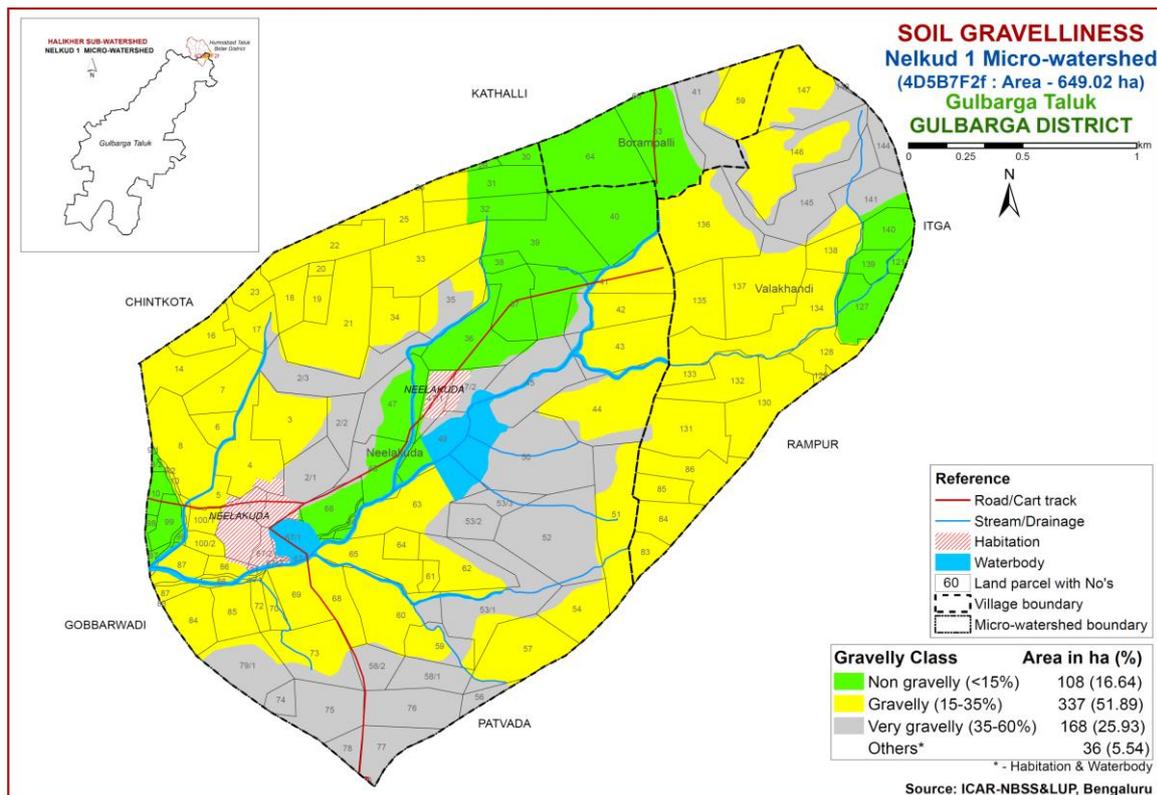


Fig. 5.4 Soil Gravelliness map of Nelkud-1 Microwatershed

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 203 ha (31%) has soils that are very low (<50 mm/m) in available water capacity and are distributed in the central, southern, western and northeastern part of the microwatershed. An area of about 114 ha (17%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in the southern, eastern southeastern and northeastern part of the microwatershed. An area in the microwatershed has soils that are medium (101-150 mm/m) in available water capacity. They occur in maximum area of about 296 ha (46%) and are distributed in all parts of the microwatershed.

About 317 ha (49%) 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.

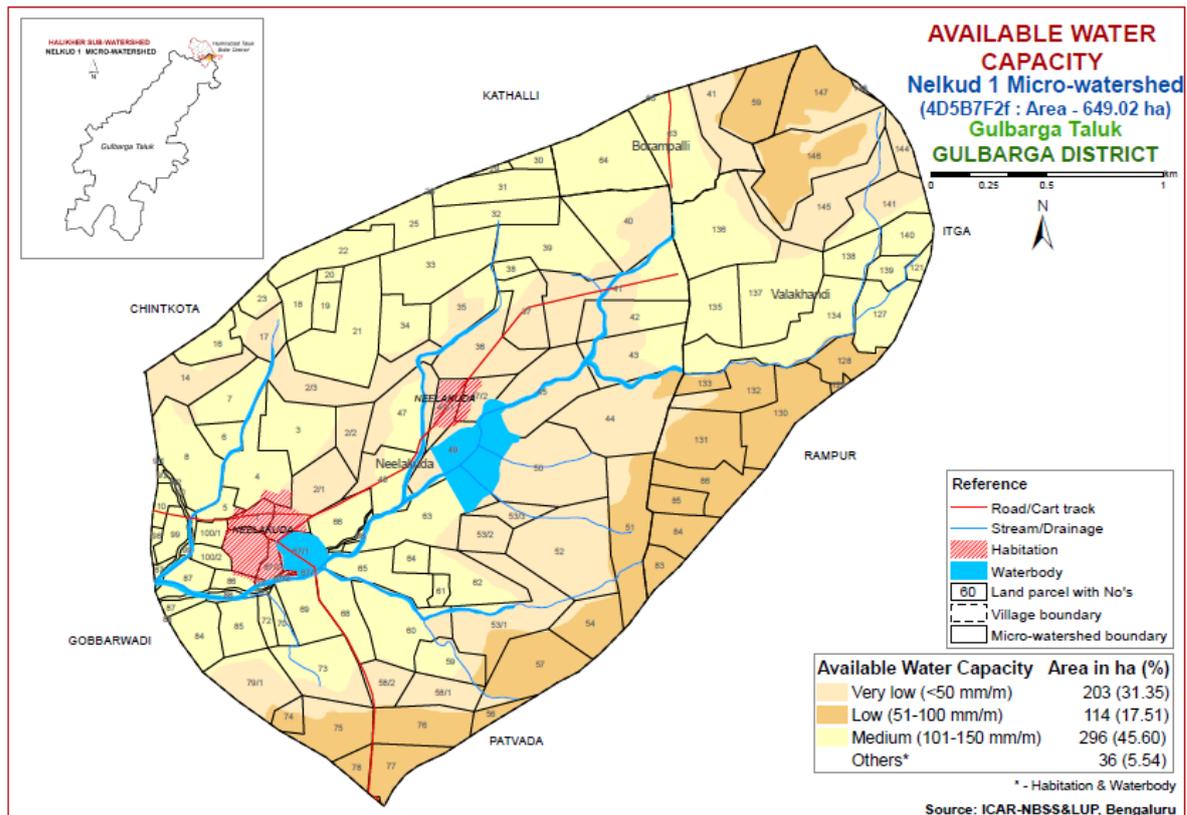


Fig. 5.5 Soil Available Water Capacity map of Nelkud-1 Microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3%) lands. It covers an area of about 448 ha (69%) and is distributed in all parts of the microwatershed. An area of about 84 ha (13%) falls under gently sloping (3-5%) lands and is distributed in the central part of the microwatershed. Moderately sloping (5-10%) lands cover an area of about 81 ha (12%) and is distributed in the southern, central and northeastern part of the microwatershed.

An area of about 448 ha (69%) 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 81 ha (12%) are problematic with respect to slopes and requires soil and water conservation and other land development measures.

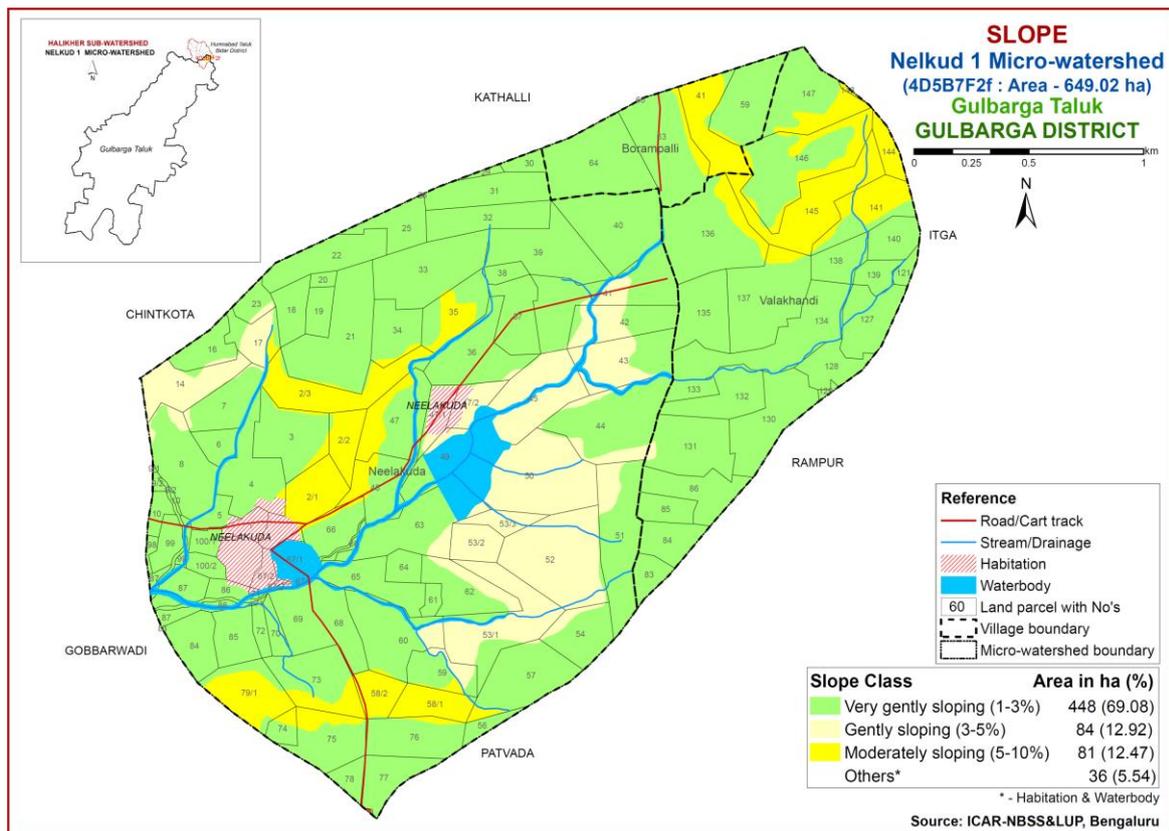


Fig. 5.6 Soil Slope map of Nelkud-1 Microwatershed

5.7 Soil Erosion

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

Soils that are slightly eroded (e1 class) cover an area of about 64 ha (10%) and are distributed in the northwestern and northeastern part of the microwatershed. Soils that are moderately eroded (e2 class) cover major area of about 392 ha (60%) and are distributed in all parts of the microwatershed. Severely eroded (e3 class) soils cover an area of about 157 ha (24%) and are distributed in the southern, central, southwestern and northern part of the microwatershed.

Top priority is to be given to 157 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 392 ha.

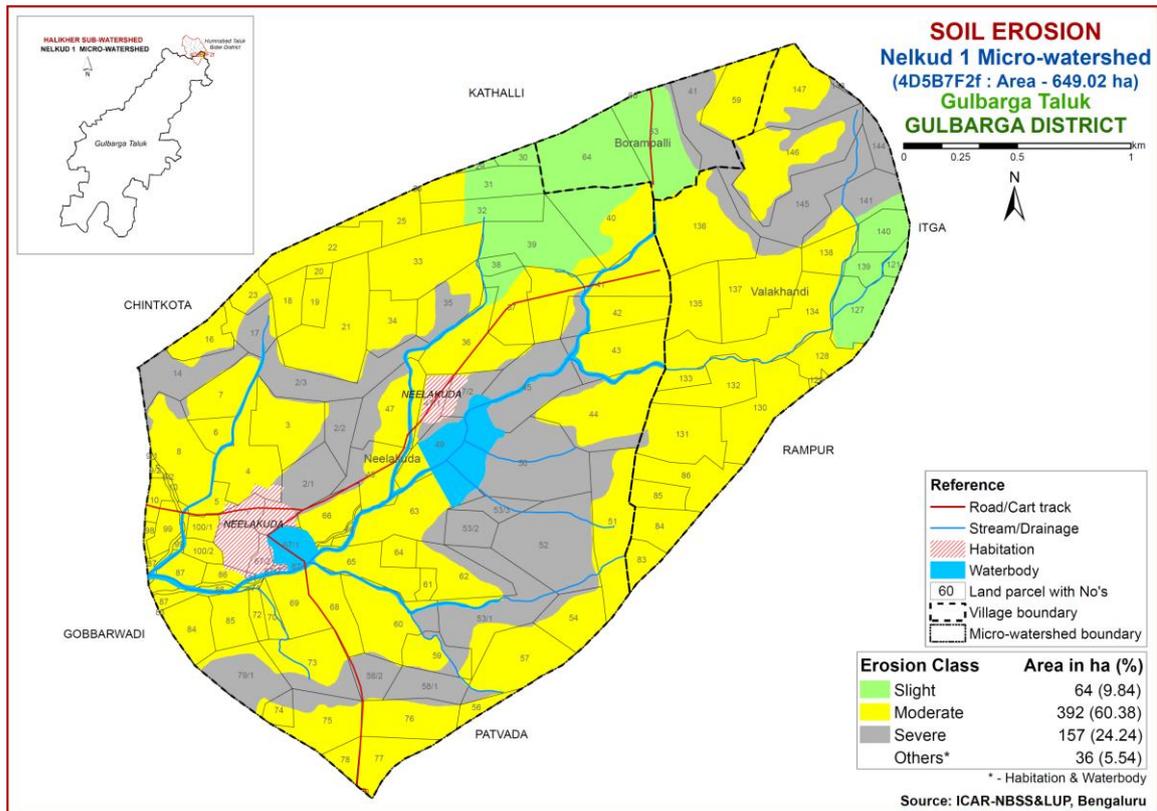


Fig. 5.7 Soil Erosion map of Nelkud-1 Microwatershed

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 characterised by low rainfall and high temperatures. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2015 were analysed for pH, EC, organic carbon, available phosphorus and potassium and for micronutrients like zinc, copper, iron and manganese and secondary nutrient sulphur.

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

6.1 Soil Reaction (pH)

The soil fertility analysis of the Nelkud-1 microwatershed for soil reaction (pH) showed that major area of about 320 ha (49%) is neutral (pH 6.5-7.3) in reaction and is distributed in the southern, central, western, eastern and northern part of the microwatershed (Fig.6.1). An area of about 163 ha (25%) is slightly alkaline (pH 7.3-7.8) and is distributed in the southwestern, northwestern and northeastern part of the microwatershed. Moderately alkaline (pH 7.8-8.4) is around 118 ha (18%) area and is distributed in the central, southwestern and northwestern part of the microwatershed. A small area of about 12 ha (2%) is strongly alkaline (pH 8.4-9.0) and is distributed in the central 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 (an index of available Nitrogen) of the soils in the microwatershed (Fig.6.3) is high ($>0.75\%$) in maximum area of about 522 ha (80%) and are distributed in all parts of the microwatershed. Medium (0.5-0.75%) organic carbon content accounts an area of about 91 ha (14%) and is distributed in the central, southwestern and northern part of the microwatershed.

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low ($<23 \text{ kg/ha}$) in an area of about 44 ha (7%) and is distributed in the central, southeastern and northern part of the microwatershed (Fig.6.4). There is an urgent need to increase the dose of

phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. Major area of about 569 ha (88%) is medium (23-57 kg/ha) in available phosphorus and is distributed in all parts of the microwatershed.

6.5 Available Potassium

Available potassium content is medium (145-337 kg/ha) in major area of about 373 ha (57%) and is distributed in all parts of the microwatershed (Fig.6.5) except northern part. Low available potassium (<145 kg/ha) content accounts for an area of 176 ha (27%) and is distributed in the northern, northeastern and southern part of the microwatershed. High available potassium (>337 kg/ha) content accounts for an area of 64 ha (10%) and is distributed in the southwestern and central part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is medium (10-20 ppm) in an area of about 280 ha (43%) and is distributed in the southern, southwestern, central and eastern part of the microwatershed. Available sulphur is low (<10 ppm) in major area of 333 ha (51%) and is distributed in the western, central, northern, northeastern and northwestern part of the microwatershed (Fig.6.6).

6.7 Available Boron

Available boron content is medium (0.5-1.0 ppm) in major area of about 401 ha (62%) and is distributed in all parts of the microwatershed. An area of about 206 ha (32%) low (<0.5 ppm) in available boron and are distributed in the central, northwestern and northern parts of the microwatershed. A very small area of about 5 ha (1%) is high (>1.0 ppm) in available boron and are distributed in the southwestern part of the microwatershed.

6.8 Available Iron

Available iron content is deficient (<4.5 ppm) in an area of about 30 ha (5%) and is distributed in the central and southwestern part of the microwatershed. It is sufficient (>4.5 ppm) in major area of about 583 ha (90%) and is distributed in all parts of the microwatershed (Fig 6.8).

6.9 Available Manganese

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

6.10 Available Copper

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

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in an area of about 138 ha (21%) and is distributed in the northern, northeastern and southwestern part of the microwatershed. It

is sufficient (>0.6 ppm) in an area of about 475 ha (73%) (Fig 6.11) and is distributed in all parts except northern part of the microwatershed.

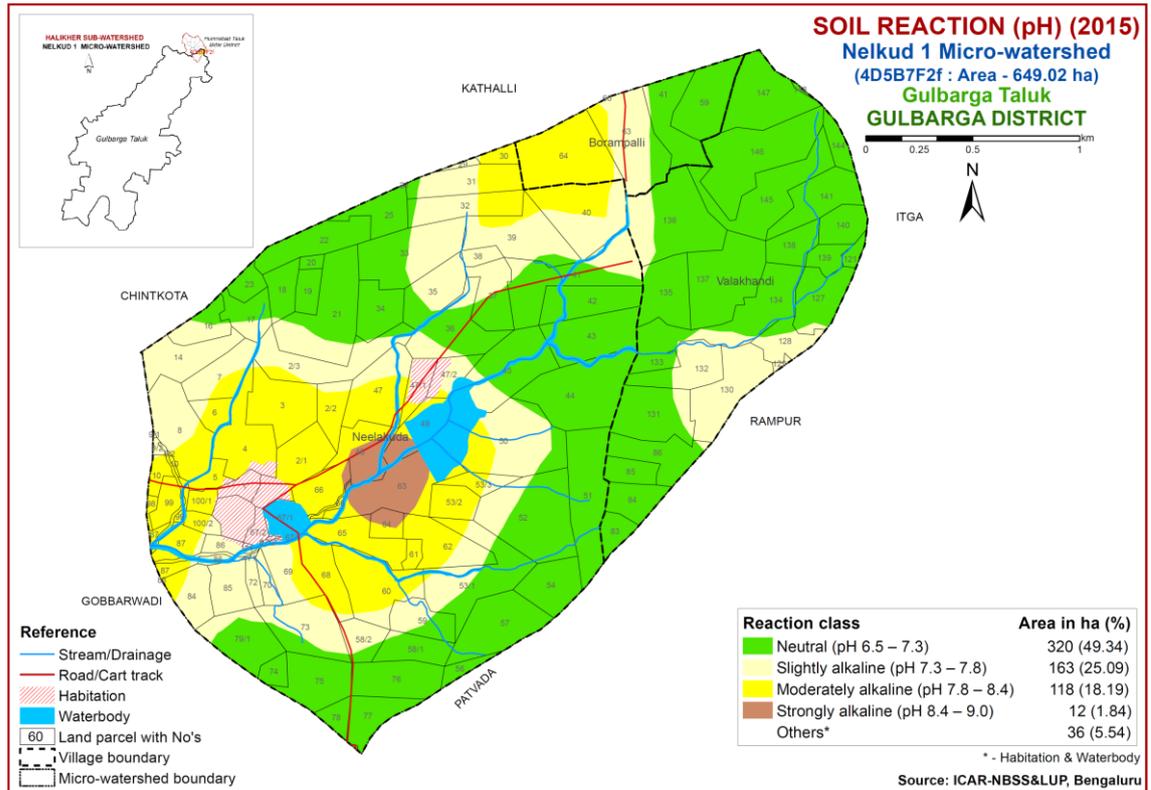


Fig.6.1 Soil Reaction (pH) map of Nelkud-1 Microwatershed

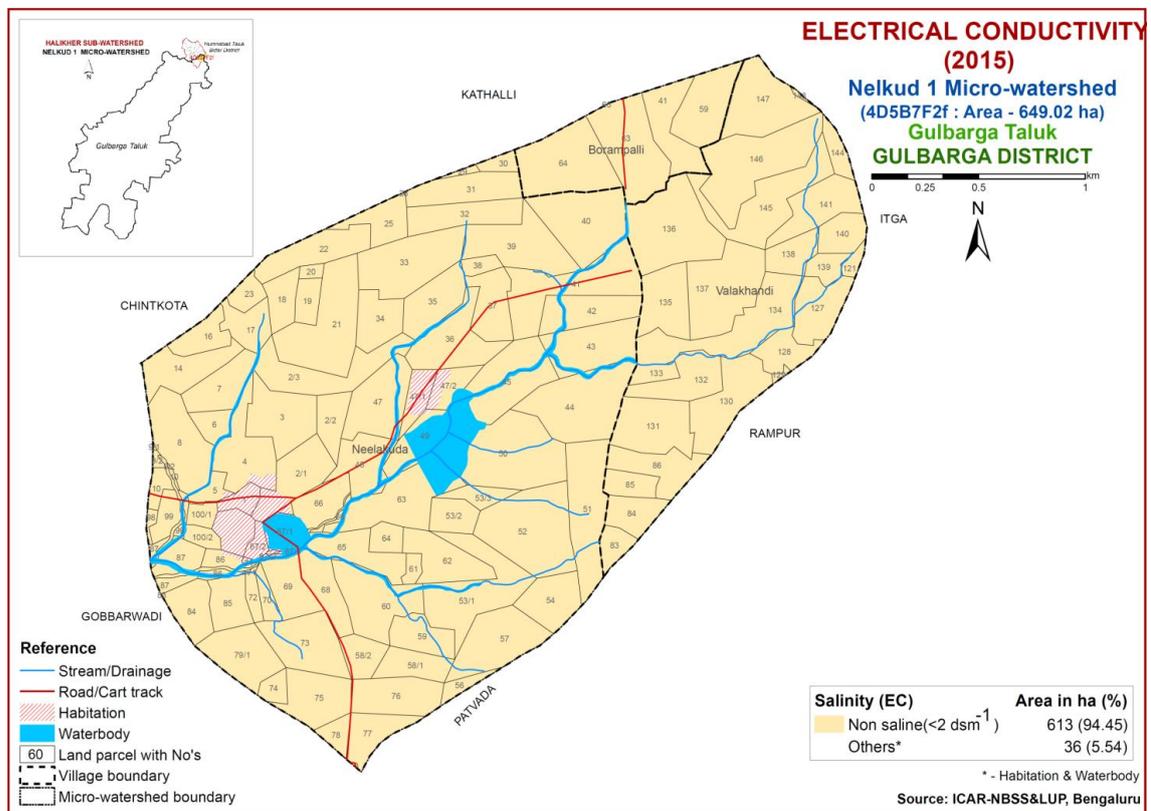


Fig.6.2 Electrical Conductivity (EC) map of Nelkud-1 Microwatershed

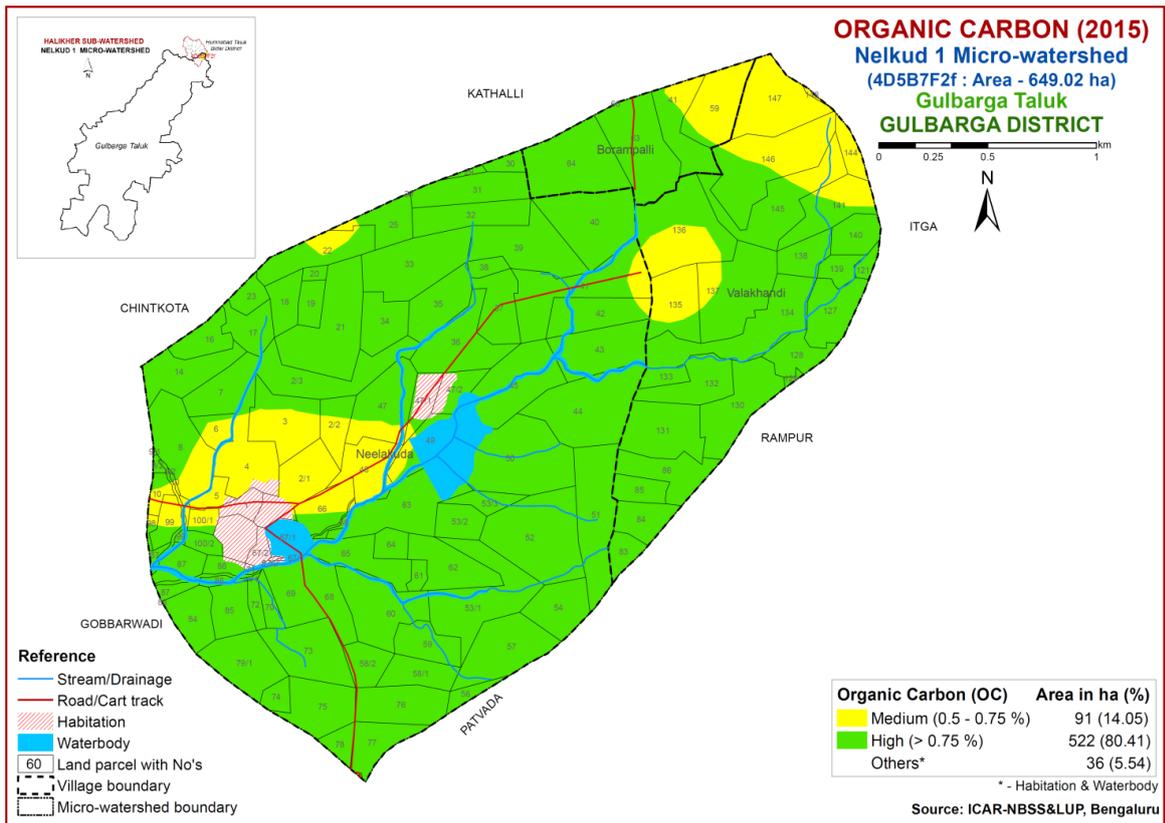


Fig.6.3 Soil Organic Carbon map of Nelkud-1 Microwatershed

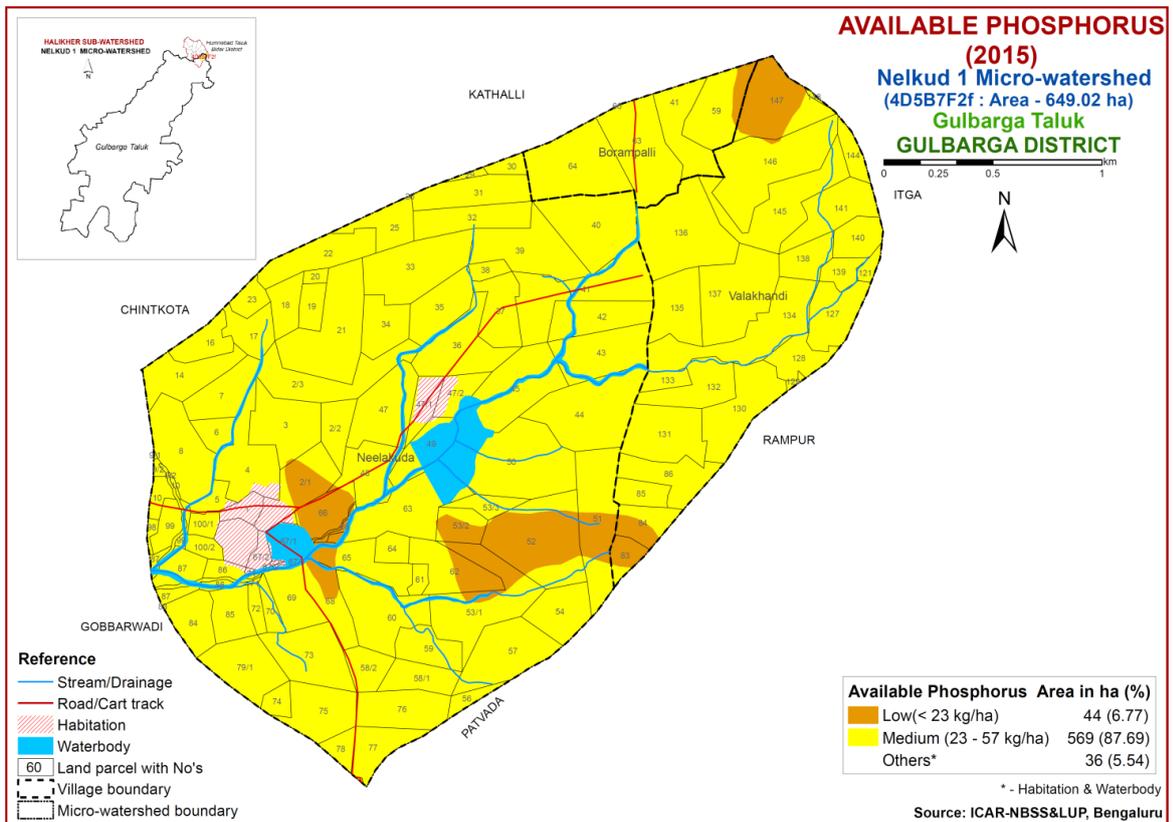


Fig.6.4 Soil available Phosphorus map of Nelkud-1 Microwatershed

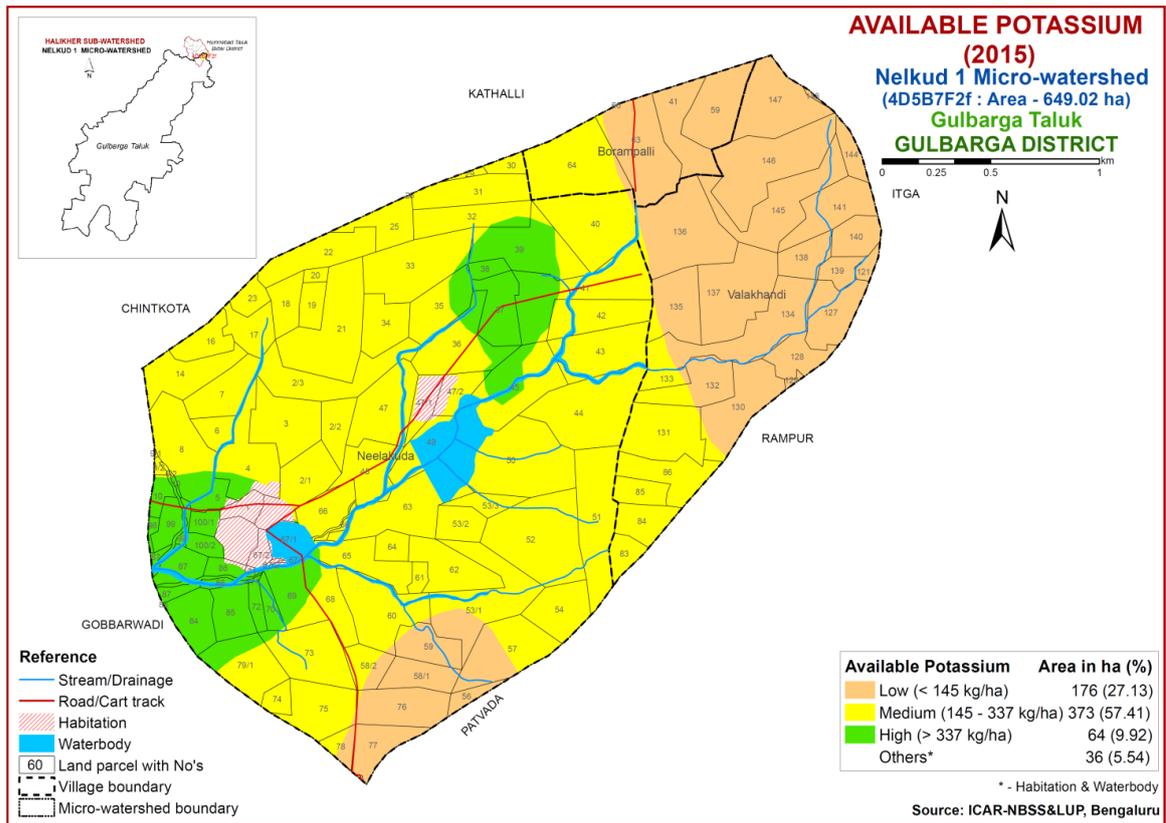


Fig.6.5 Soil available Potassium map of Nelkud-1 Microwatershed

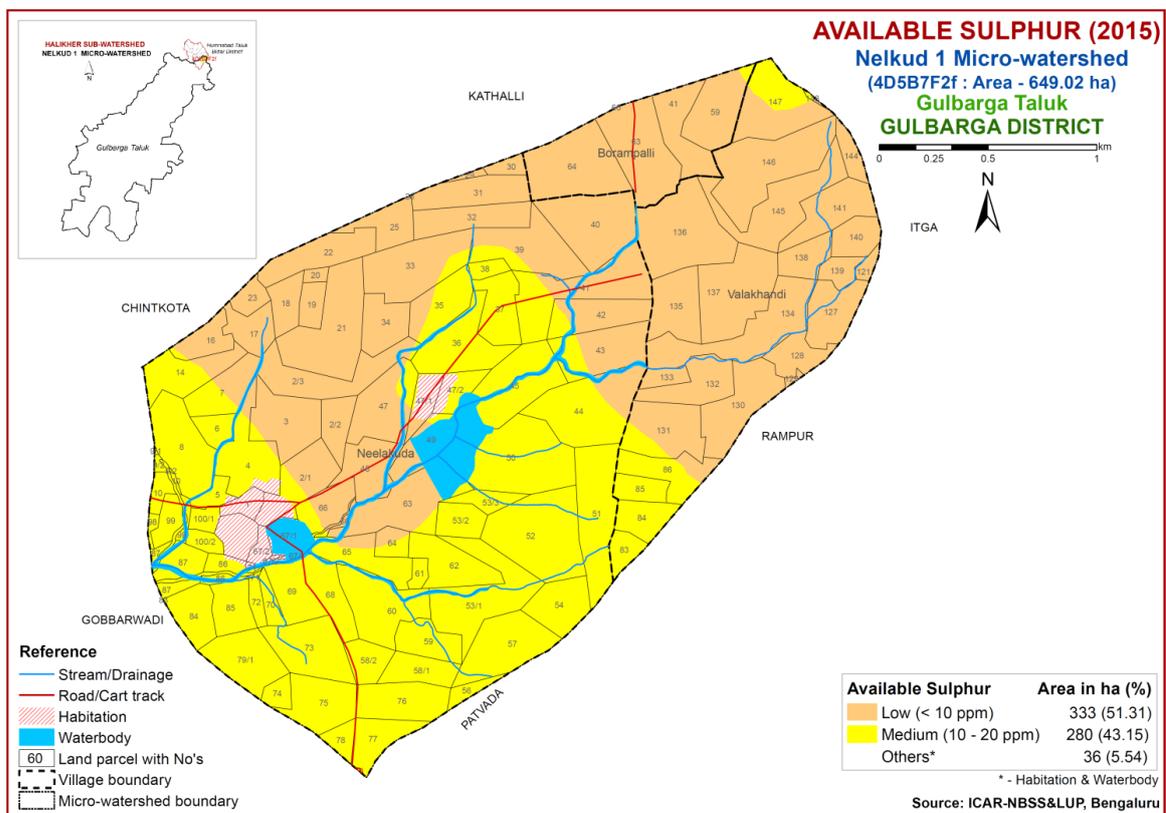


Fig.6.6 Soil available Sulphur map of Nelkud-1 Microwatershed

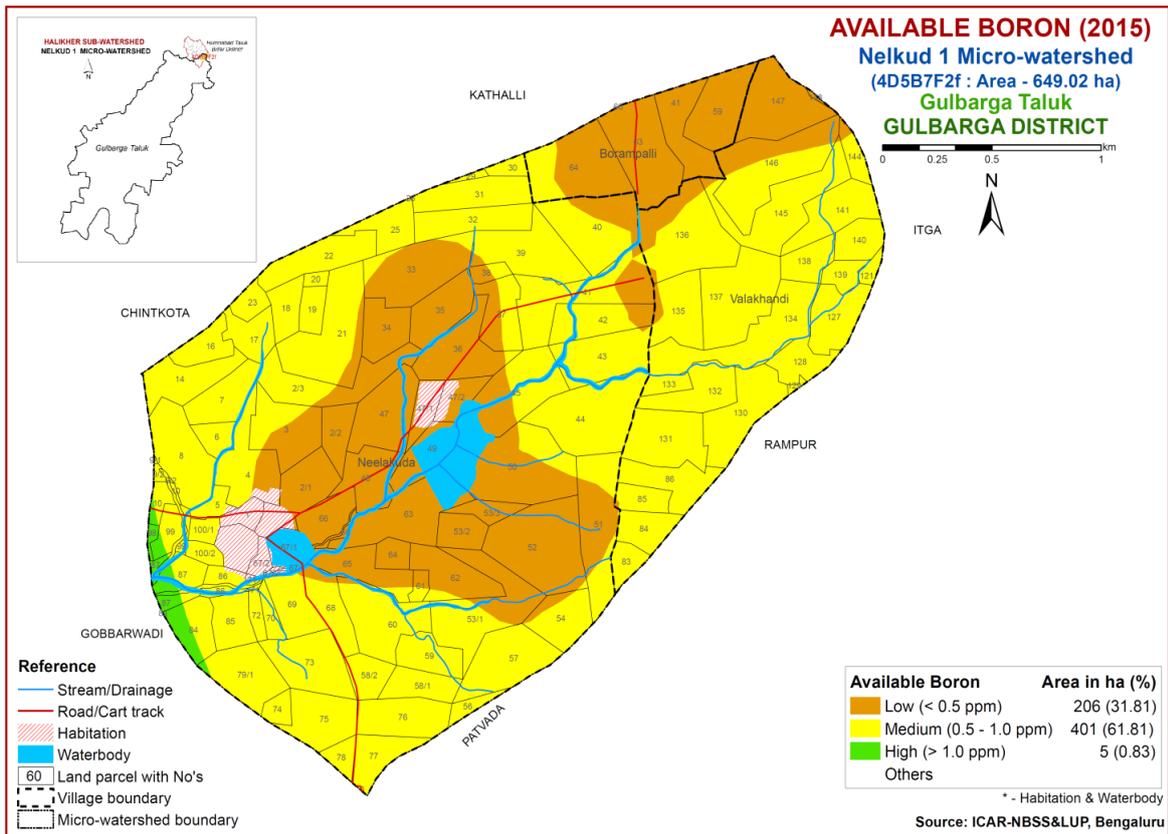


Fig.6.7 Soil available Boron map of Nelkud-1 Microwatershed

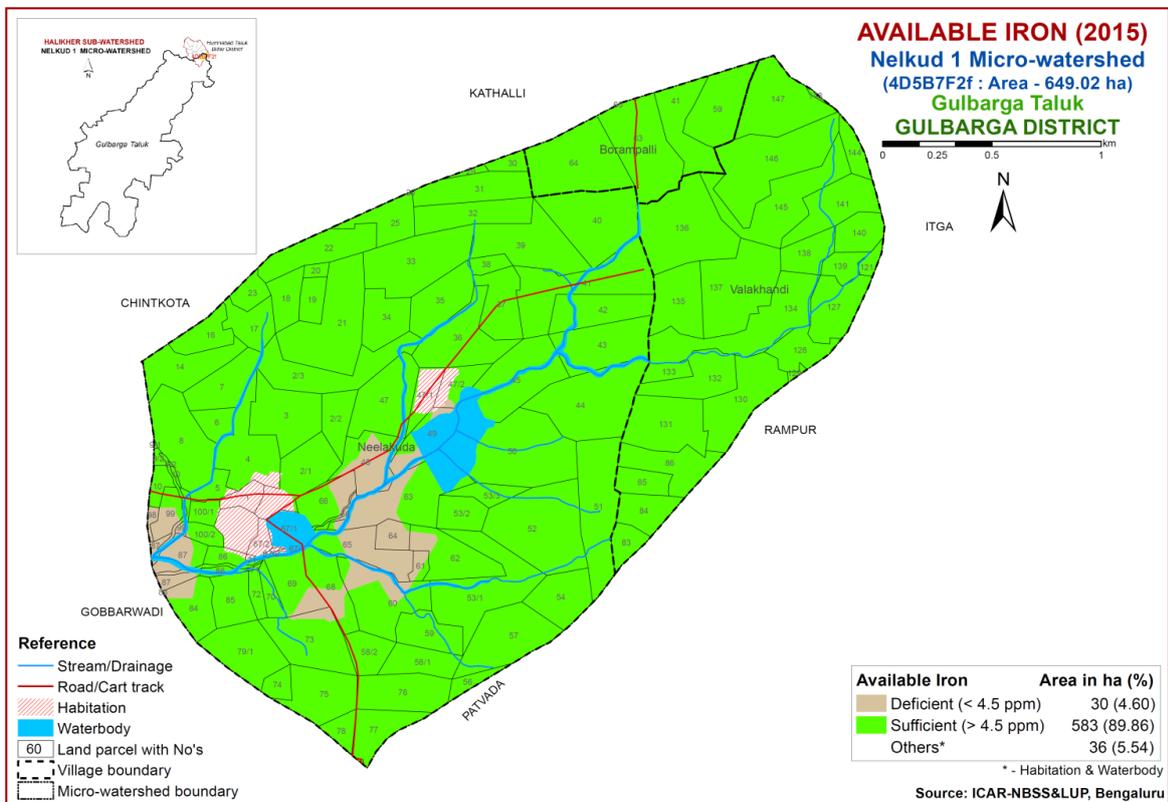


Fig.6.8 Soil available Iron map of Nelkud-1 Microwatershed

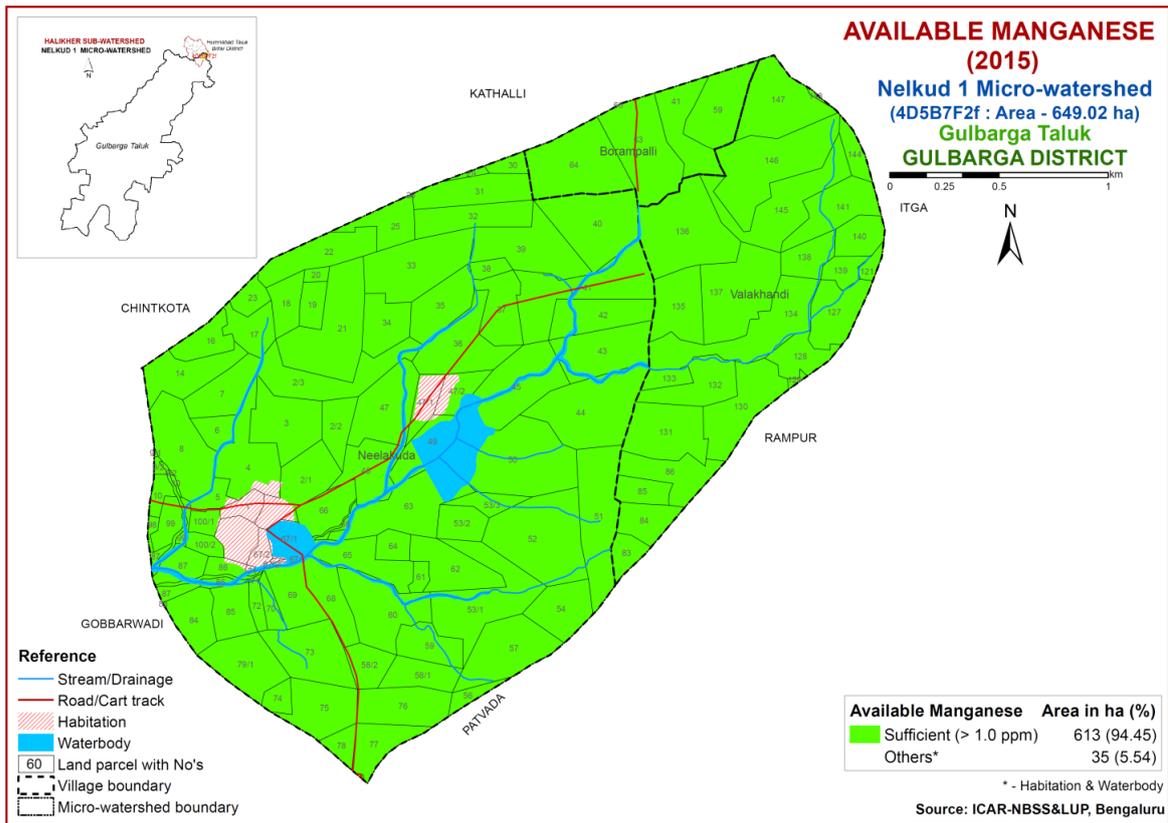


Fig.6.9 Soil available Manganese map of Nelkud-1 Microwatershed

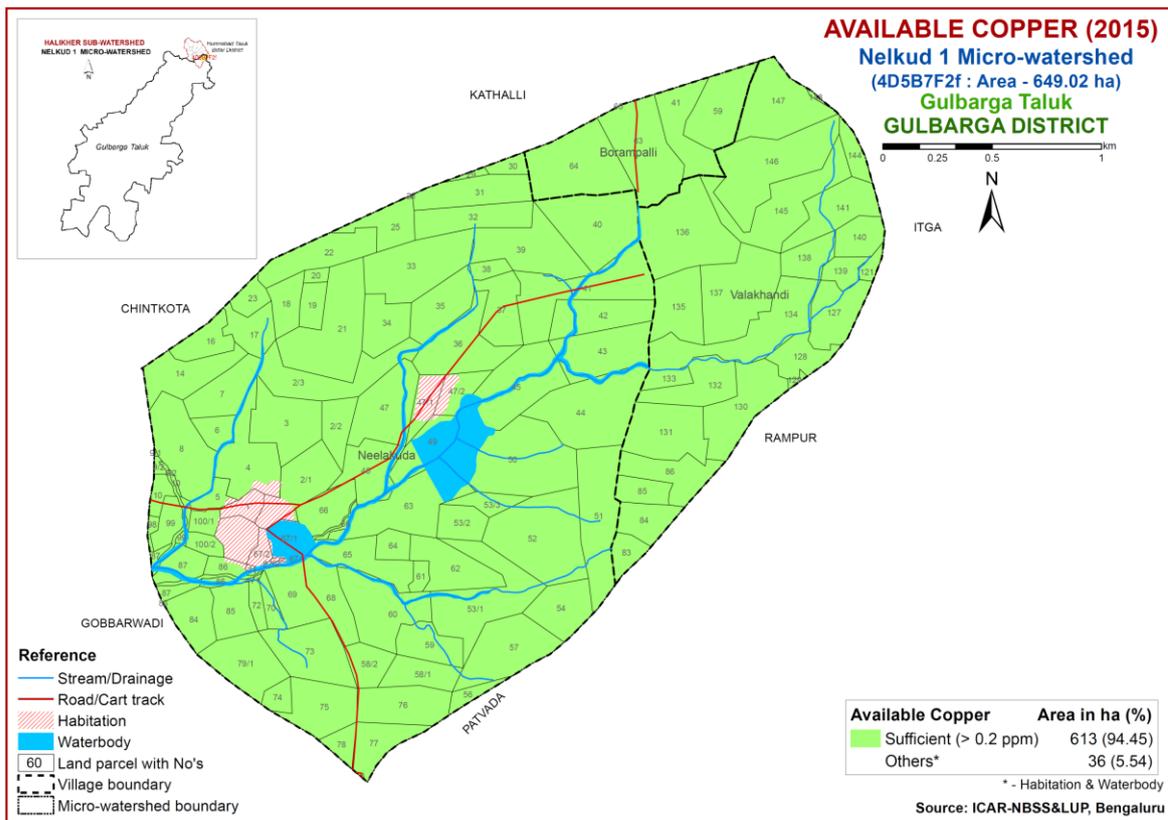


Fig.6.10 Soil available Copper map of Nelkud-1 Microwatershed

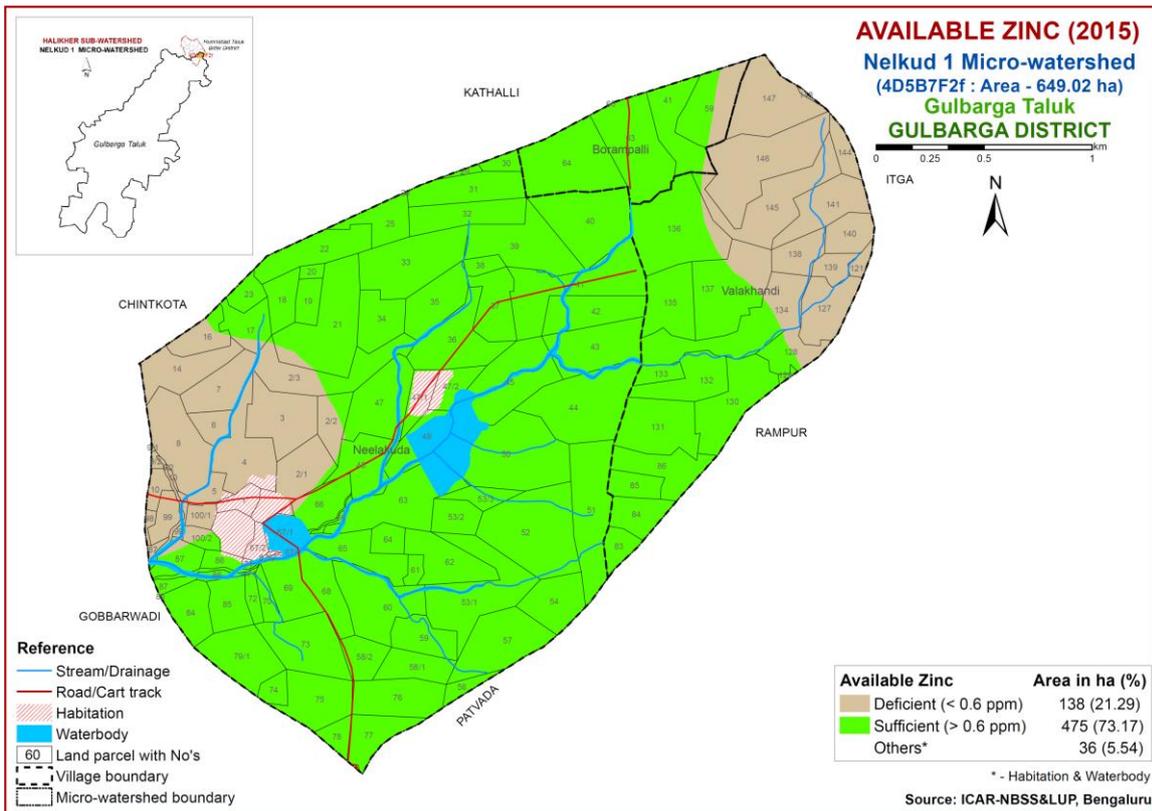


Fig.6.11 Soil available Zinc map of Nelkud-1 Microwatershed

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Nelkud-1 microwatershed were assessed for their suitability for growing food, fibre, fodder and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983. Crop requirements were developed for each of the crop from the available research data, and also by referring to Naidu *et. al.* (2006) and Natarajan *et. al.* (2015). The crop requirements were matched with the soil and land characteristics (Table 7.1) to arrive at the crop suitability. In FAO land suitability classification, two orders are recognized. Order S-Suitable and Order N-Not suitable. The orders have classes, subclasses and units. Order-S has three classes, Class S1-Highly Suitable, Class S2-Moderately Suitable and Class S3-Marginally Suitable. Order N has two classes, N1-Currently not Suitable and N2-Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are ‘c’ for erratic rainfall and its distribution and length of growing period (LGP), ‘e’ for erosion hazard, ‘r’ for rooting condition, ‘t’ for lighter or heavy texture, ‘g’ for gravelliness or stoniness, ‘n’ for nutrient availability, ‘l’ for topography, ‘m’ for moisture availability, ‘z’ for calcareousness and ‘w’ for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 19 major agricultural and horticultural crops were generated. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum (*Sorghum bicolor*)

Sorghum is one of the major crops grown in Karnataka in an area of 10.47 lakh ha in 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.

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing sorghum. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing sorghum and are distributed in all parts of the microwatershed.

Table 7.1 Soil-Site Characteristics of Nelkud-1 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drainage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC [Cmol (p ⁺) kg ⁻¹]	BS (%)
					Surface	Subsurface	Surface (%)	Subsurface (%)								
MGTmB2g1	740	150	WD	<25	c	c	15-35	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
MGTmC2g1	740	150	WD	<25	c	c	15-35	15-35	<50	3-5	Moderate	6.8	0.3	0.2	46	100
MGTmC3g2	740	150	WD	<25	c	c	35-60	15-35	<50	3-5	Severe	6.8	0.3	0.2	46	100
MGTmD3g2	740	150	WD	<25	c	c	35-60	15-35	<50	5-10	Severe	6.8	0.3	0.2	46	100
BHId3g2	740	150	WD	25-50	sc	c	35-60	15-35	<50	5-10	Severe	6.8	0.3	0.2	46	100
BHImB2g1	740	150	WD	25-50	c	c	15-35	15-35	<50	1-3	Moderate	6.8	0.3	0.2	46	100
KGImC3g2	740	150	WD	25-50	c	c	35-60	35-60	<50	3-5	Severe	7.2	0.1	0.3	40	100
KGImD3g2	740	150	WD	25-50	c	c	35-60	35-60	<50	5-10	Severe	7.2	0.1	0.3	40	100
DSImB1	740	150	WD	50-75	c	c	-	<15	101-150	1-3	Slight	7.2	0.1	0.3	40	100
GTTmB1	740	150	WD	50-75	c	c	-	15-35	51-100	1-3	Slight	7.2	0.1	0.3	40	100
GTTmB2	740	150	WD	50-75	c	c	-	15-35	51-100	1-3	Moderate	7.2	0.1	0.3	40	100
GTTmB2g1	740	150	WD	50-75	c	c	15-35	15-35	51-100	1-3	Moderate	7.2	0.1	0.3	40	100
HBLmB2g1	740	150	WD	50-75	c	c	15-35	35-60	51-100	1-3	Moderate	7.0	0.1	0.2	28	100
HBLmB2g2	740	150	WD	50-75	c	c	35-60	35-60	51-100	1-3	Moderate	7.0	0.1	0.3	62	100
KNHmB2	740	150	WD	<25	c	c	-	35-60	<50	1-3	Moderate					
KNHmC3g1	740	150	WD	<25	c	c	15-35	35-60	<50	3-5	Severe					

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

They have minor limitations of erosion, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing sorghum and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion and rooting depth.

Table 7.2 Crop suitability criteria for Sorghum

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

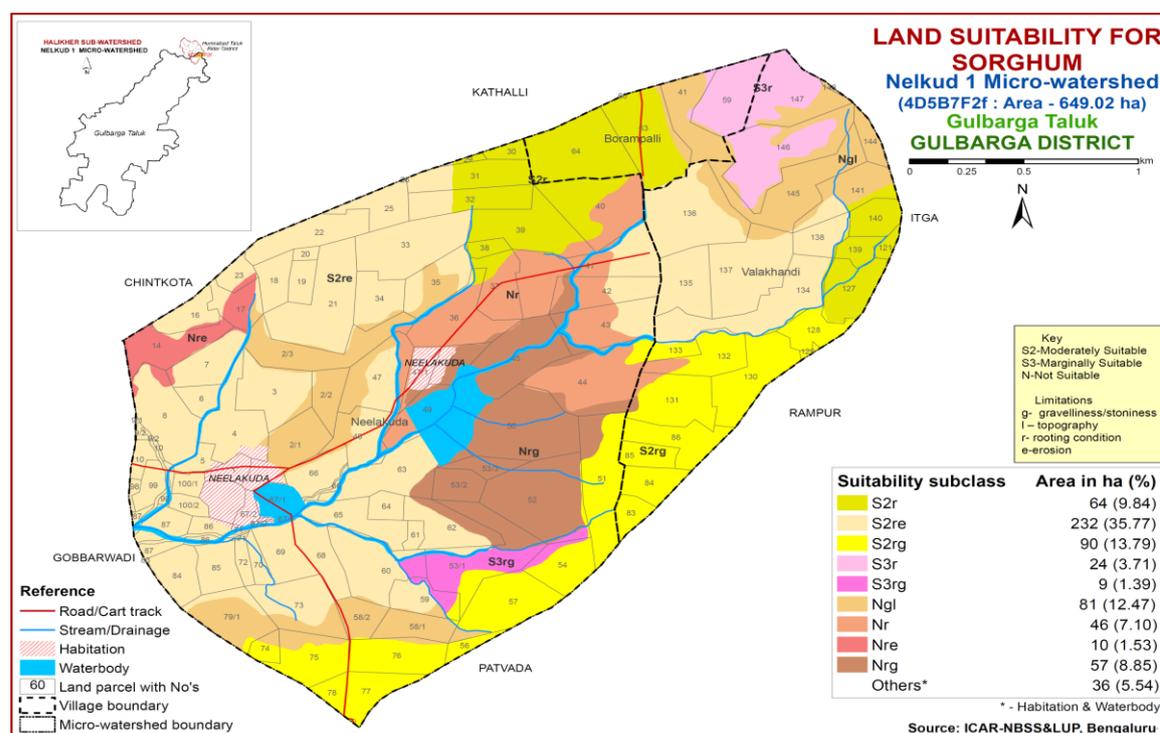


Fig. 7.1 Land Suitability map of Sorghum

7.2 Land Suitability for Maize (*Zea mays*)

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

Table 7.3 Crop suitability criteria for Maize

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

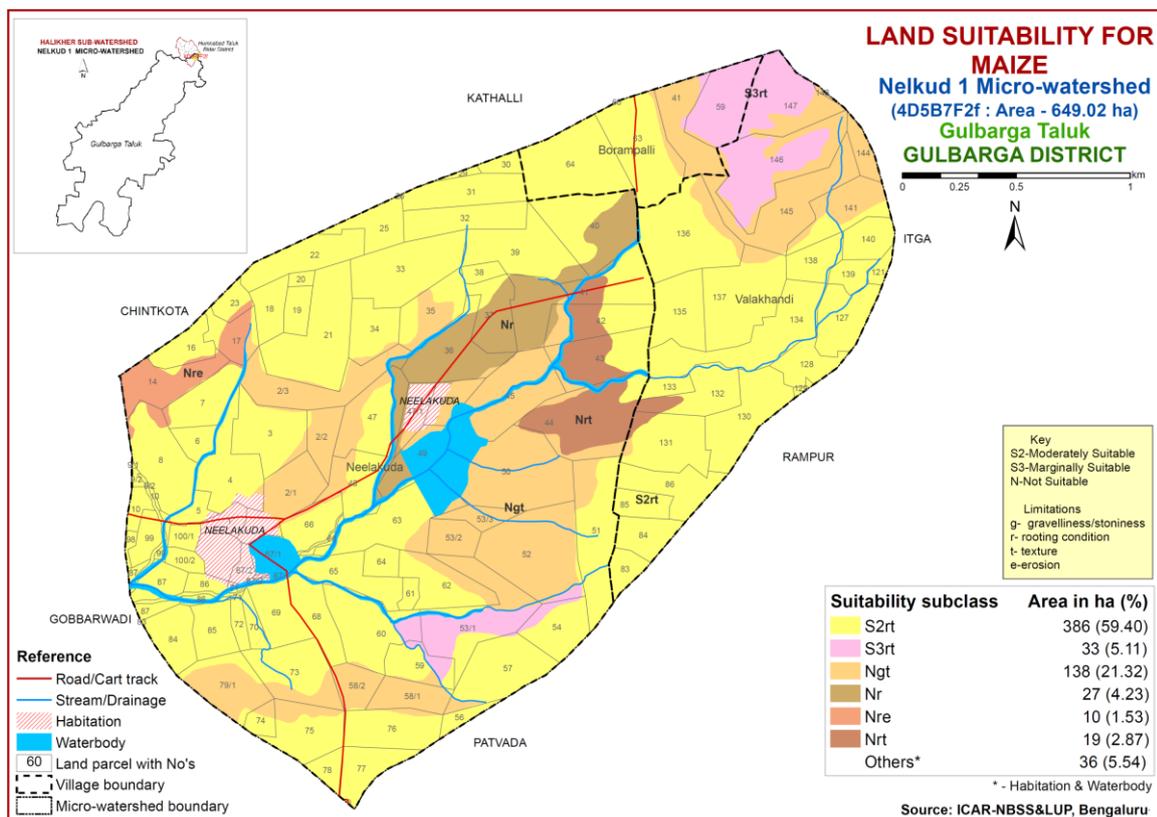


Fig. 7.2 Land Suitability map of Maize

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing maize. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing maize and are distributed in all parts of the microwatershed. They have minor limitations of texture and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing maize and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

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	

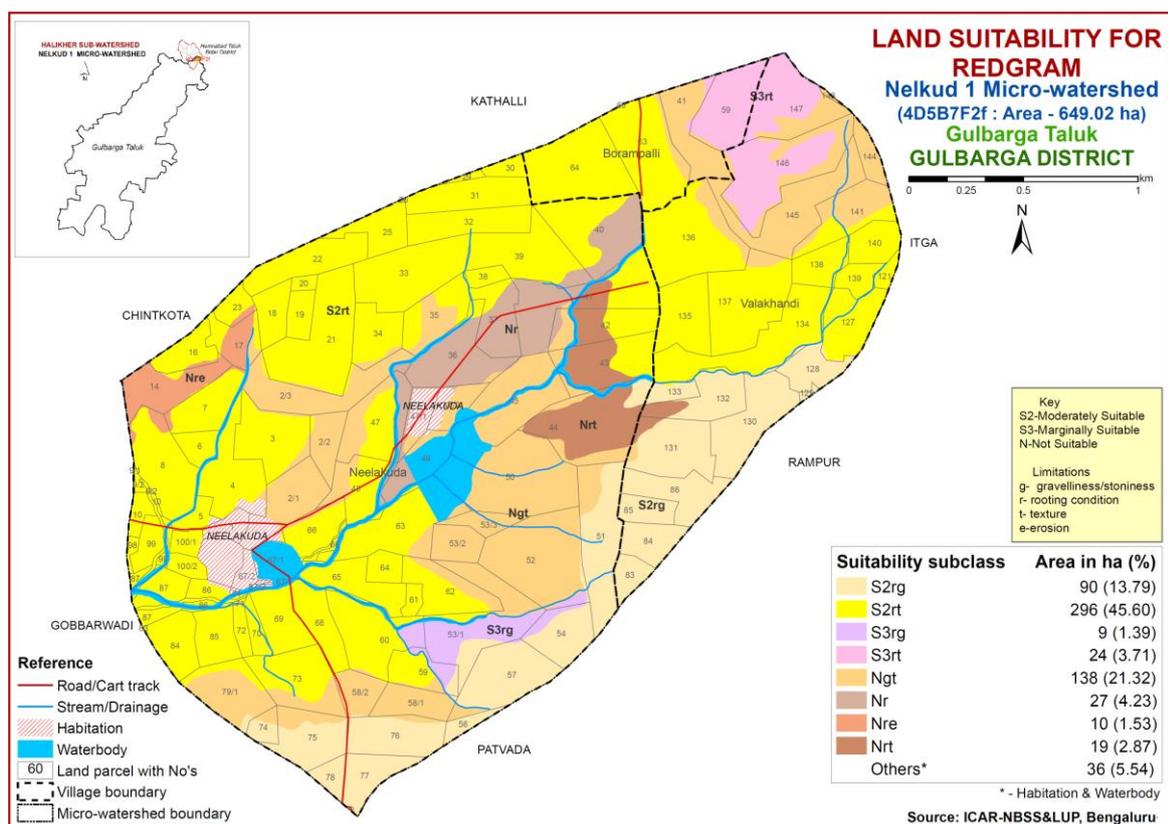


Fig. 7.3 Land Suitability map of Red gram

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing redgram. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing redgram and are distributed in all parts of the microwatershed. They have minor limitations of texture, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness, texture and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing redgram and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

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.

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) and moderately (Class S1) suitable for growing sunflower. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and gravelliness. They are distributed in all parts of the

microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing sunflower and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion and rooting depth.

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	

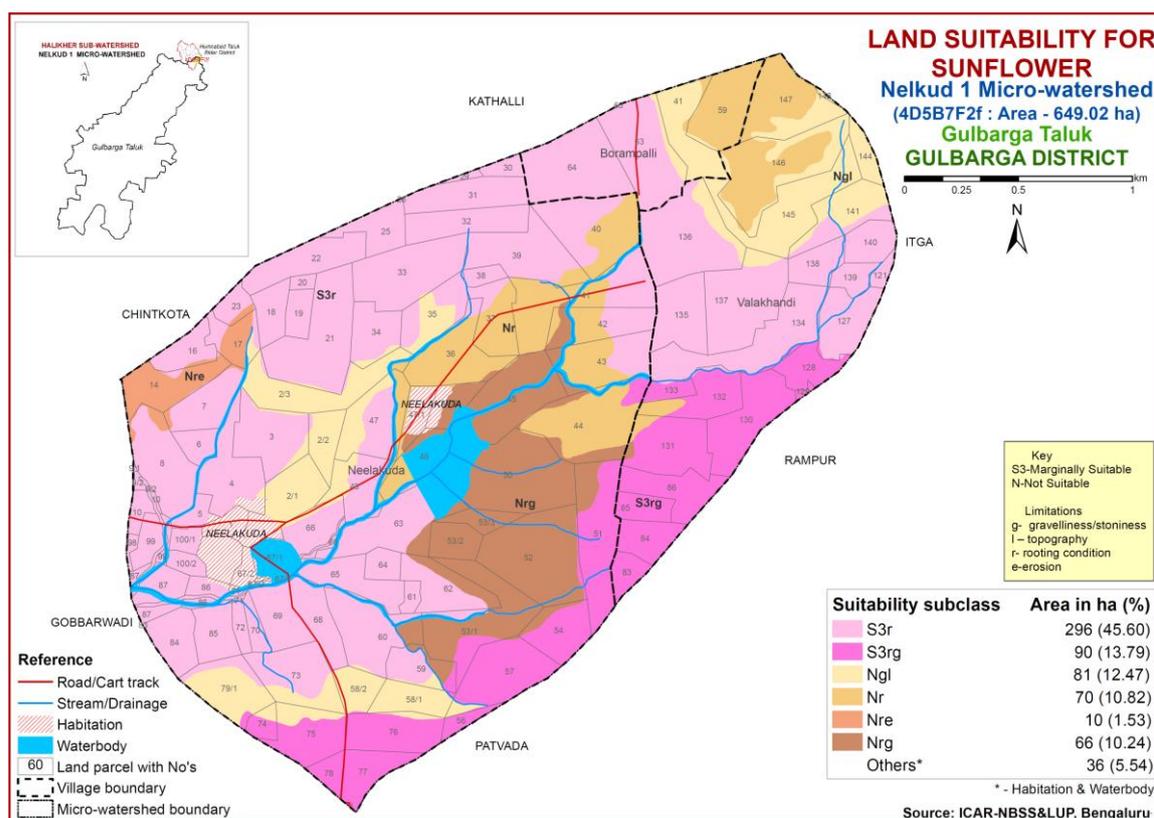


Fig. 7.4 Land Suitability map of Sunflower

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.

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing cotton. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing cotton and are distributed in all parts of the microwatershed. They have minor limitations of erosion, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing cotton and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion 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

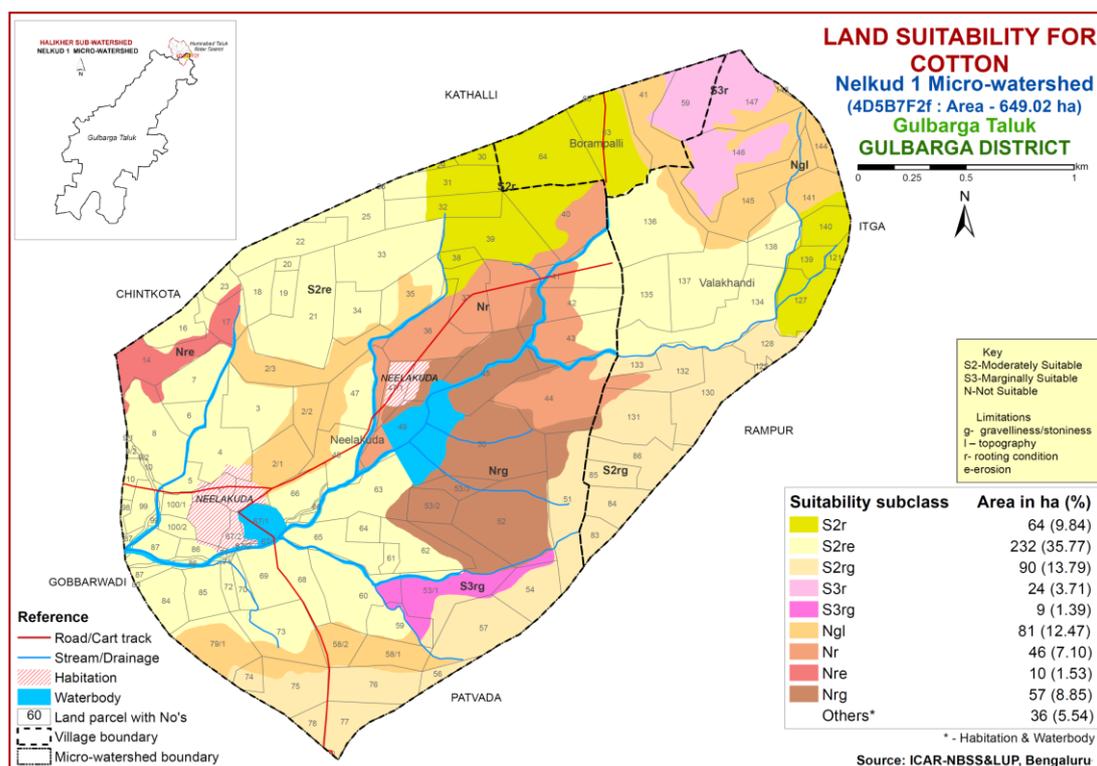


Fig. 7.5 Land Suitability map of Cotton

7.6 Land Suitability for Sugarcane (*Saccharum officinarum*)

Sugarcane is the most important commercial crop grown in 6.9 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

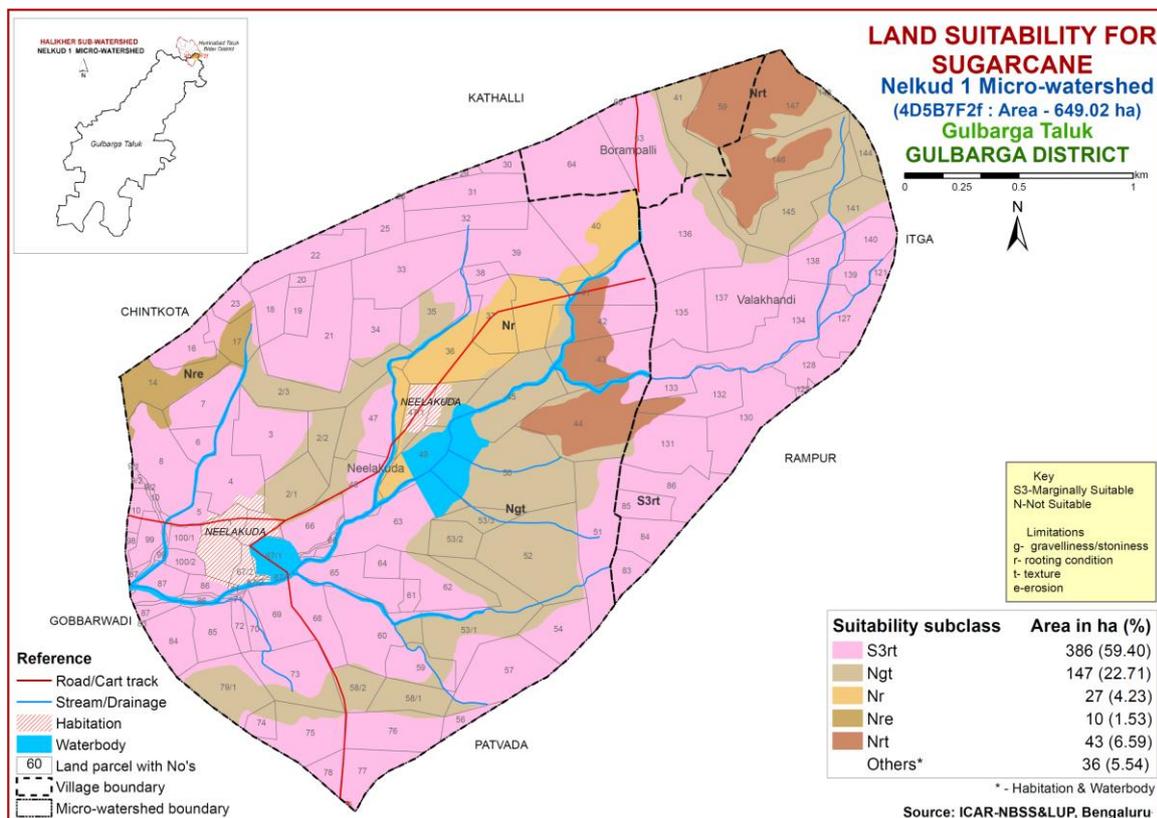


Fig. 7.6 Land Suitability map of Sugarcane

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing sugarcane in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and texture. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing sugarcane and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion 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.

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing soybean. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing soybean and are distributed in all parts of the microwatershed. They have minor limitations of erosion, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and

rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing soybean and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, topography, texture, erosion and rooting depth.

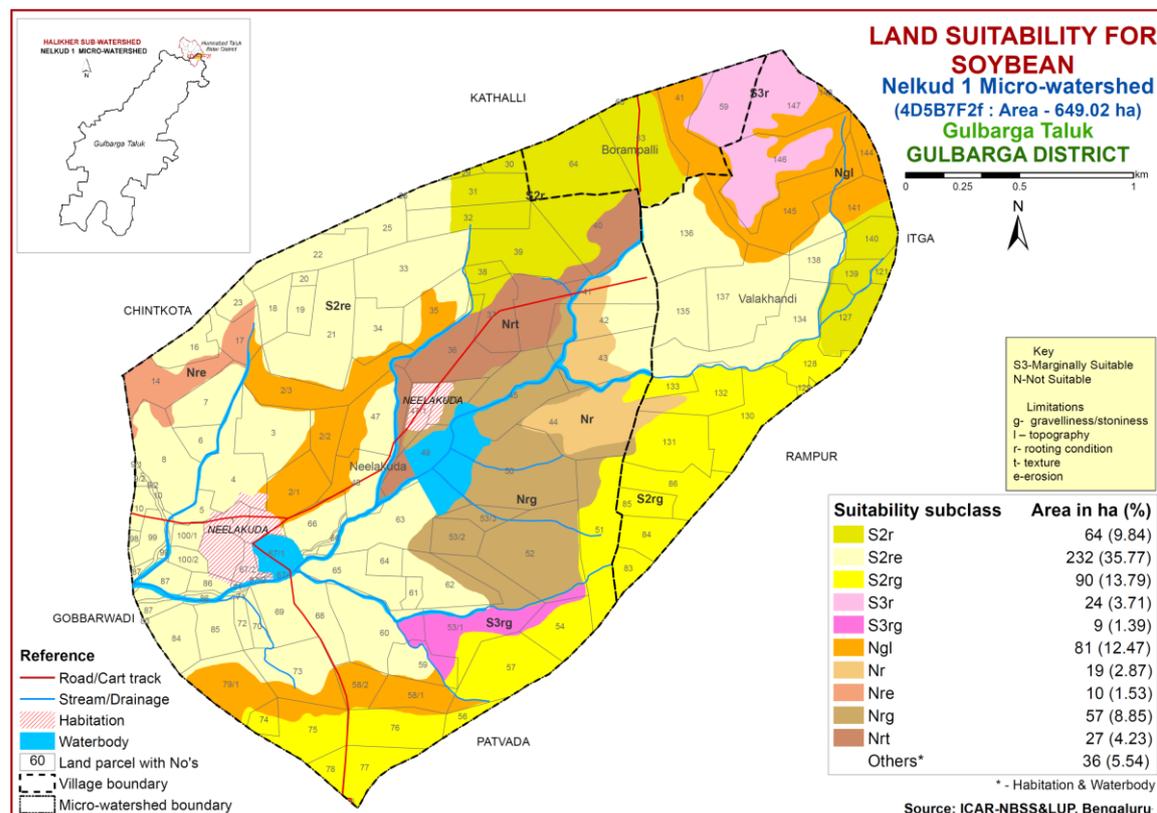


Fig. 7.7 Land Suitability map of Soybean

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

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 296 ha (46%). 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 123 ha (19%). The soils have minor limitations of gravelliness and rooting depth. They are distributed in the southern, eastern and northern part of the microwatershed. The marginally suitable (Class S3) lands cover an area of about 65 ha (10%) and are distributed in the central and southern part of the microwatershed. They have moderate limitations of gravelliness, texture and rooting depth. An area of about 129 ha (22%) is not suitable (Class N) for growing bengalgram and occur in the central, southwestern and

northern part of the microwatershed. They have severe limitations of gravelliness, erosion, rooting depth and topography.

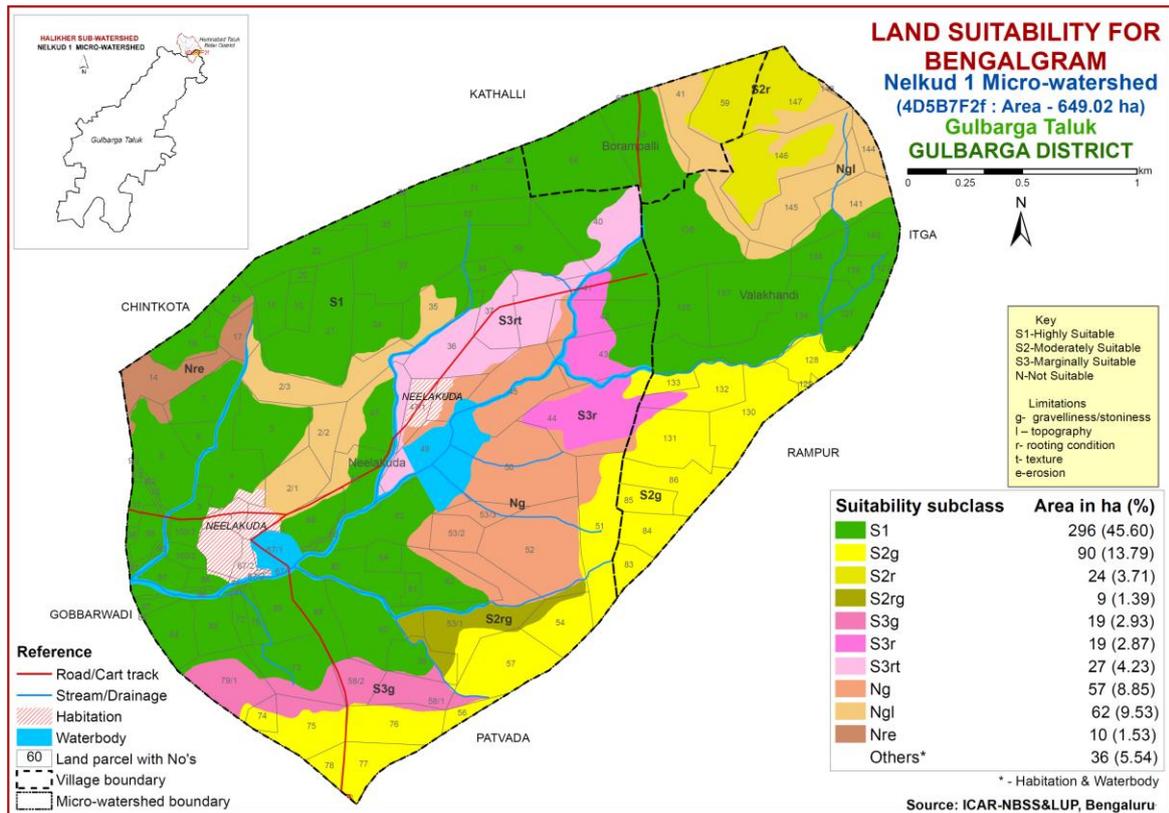


Fig. 7.8 Land Suitability map of Bengalgram

7.9 Land Suitability for Mango (*Mangifera indica*)

Mango is the most important fruit crop grown in 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), moderately (Class S2) and marginally (Class S3) suitable lands are available for growing mango in the Nelkud-1 microwatershed. Major area of about 613 ha (94%) is not suitable (Class N) for growing mango and occur in all parts of the microwatershed. They have severe limitations of gravelliness, erosion, rooting depth and texture.

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	

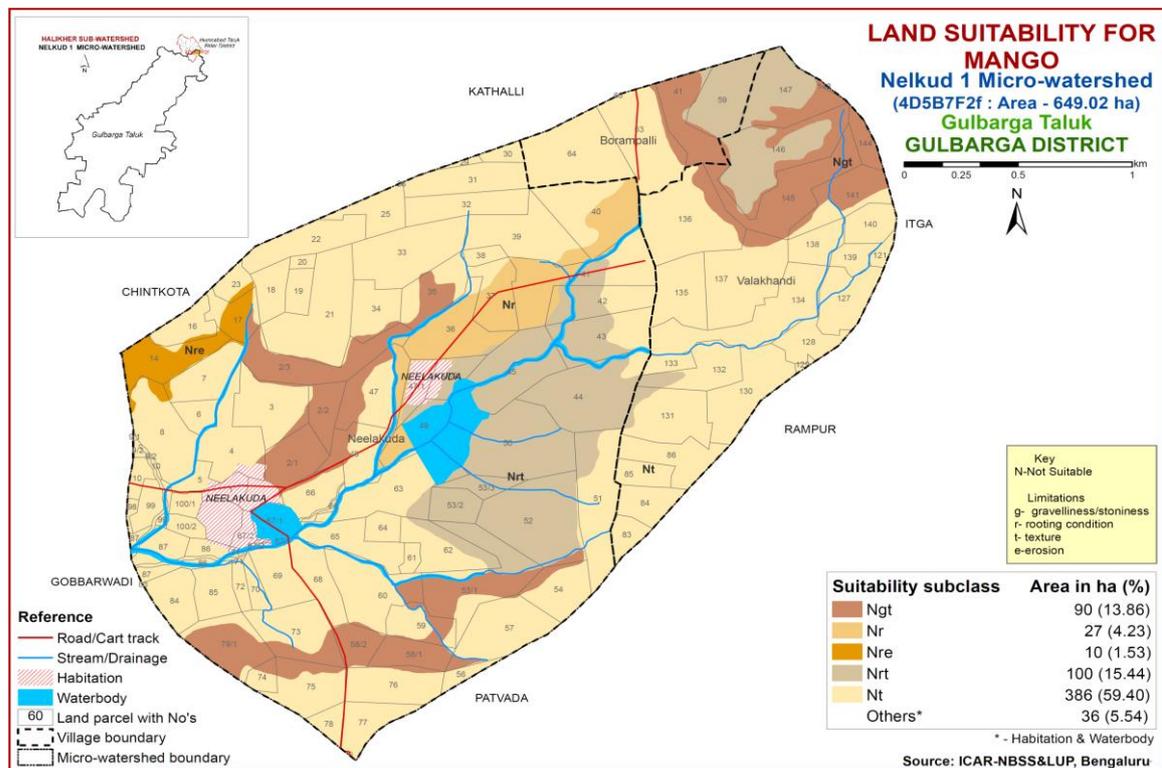


Fig. 7.9 Land Suitability map of Mango

7.10 Land Suitability for Sapota (*Manilkara zapota*)

Sapota is the most important fruit crop grown in 29373 ha in 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.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing sapota in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and texture. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing sapota and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

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	^o 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

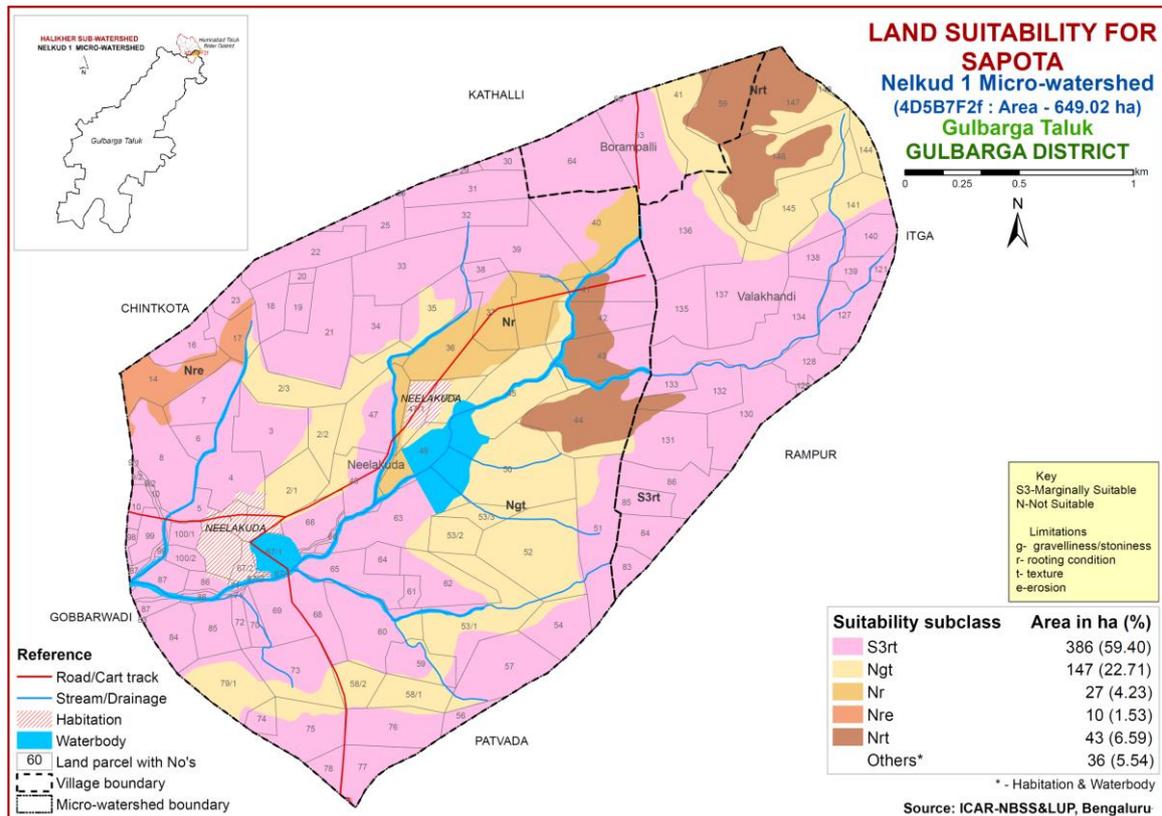


Fig. 7.10 Land Suitability map of Sapota

7.11 Land Suitability for Guava (*Psidium guajava*)

Guava is the most important fruit crop grown in about 6558 ha 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.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing guava in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and texture. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing guava and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

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	°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

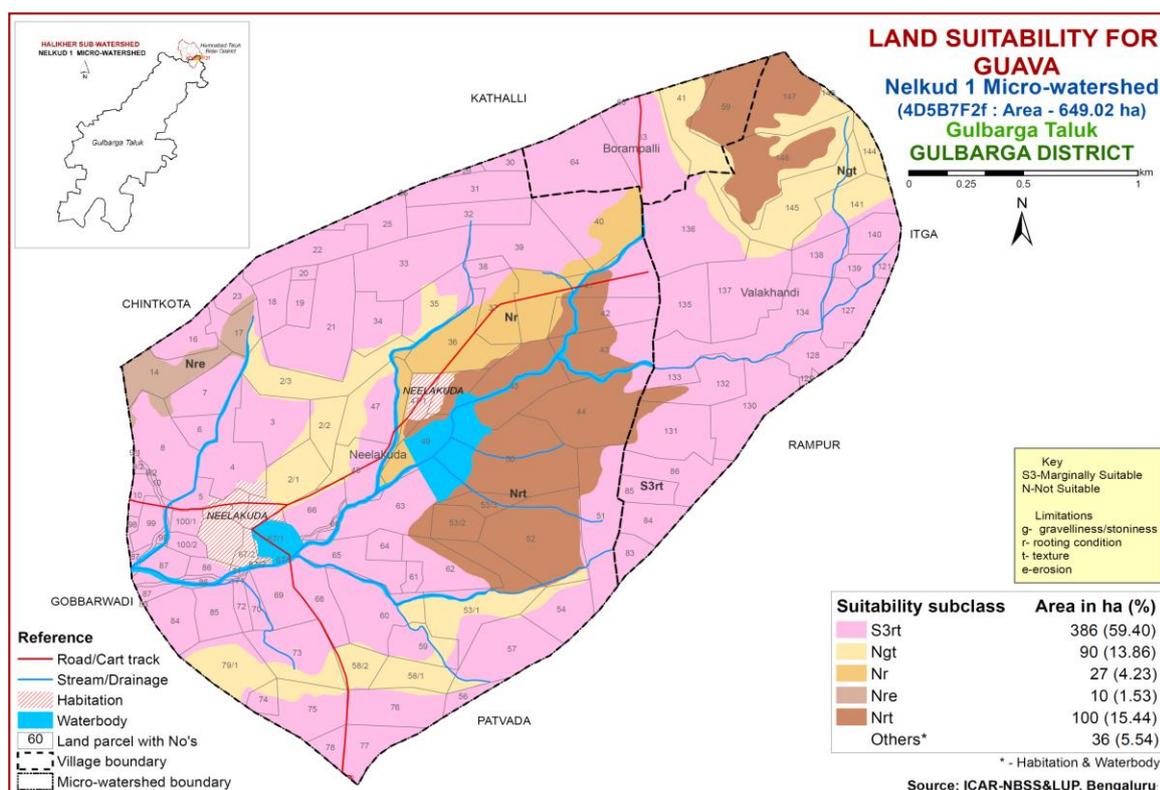


Fig 7.11 Land Suitability map of Guava

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.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing jackfruit in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and texture. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing jackfruit and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

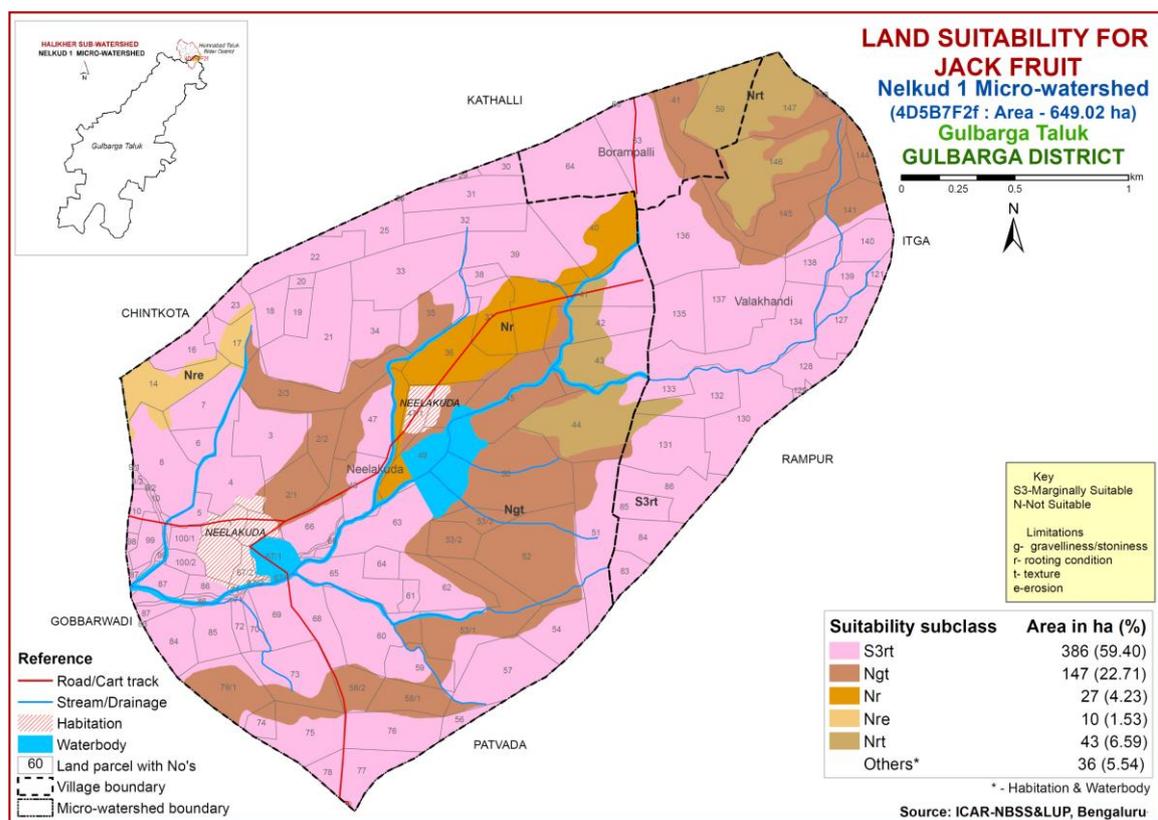


Fig 7.12 Land Suitability map of Jackfruit

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.

Highly (Class S1) and moderately (Class S2) suitable lands are not available for growing jamun in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations

of rooting depth and texture. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing jamun and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, texture, erosion and rooting depth.

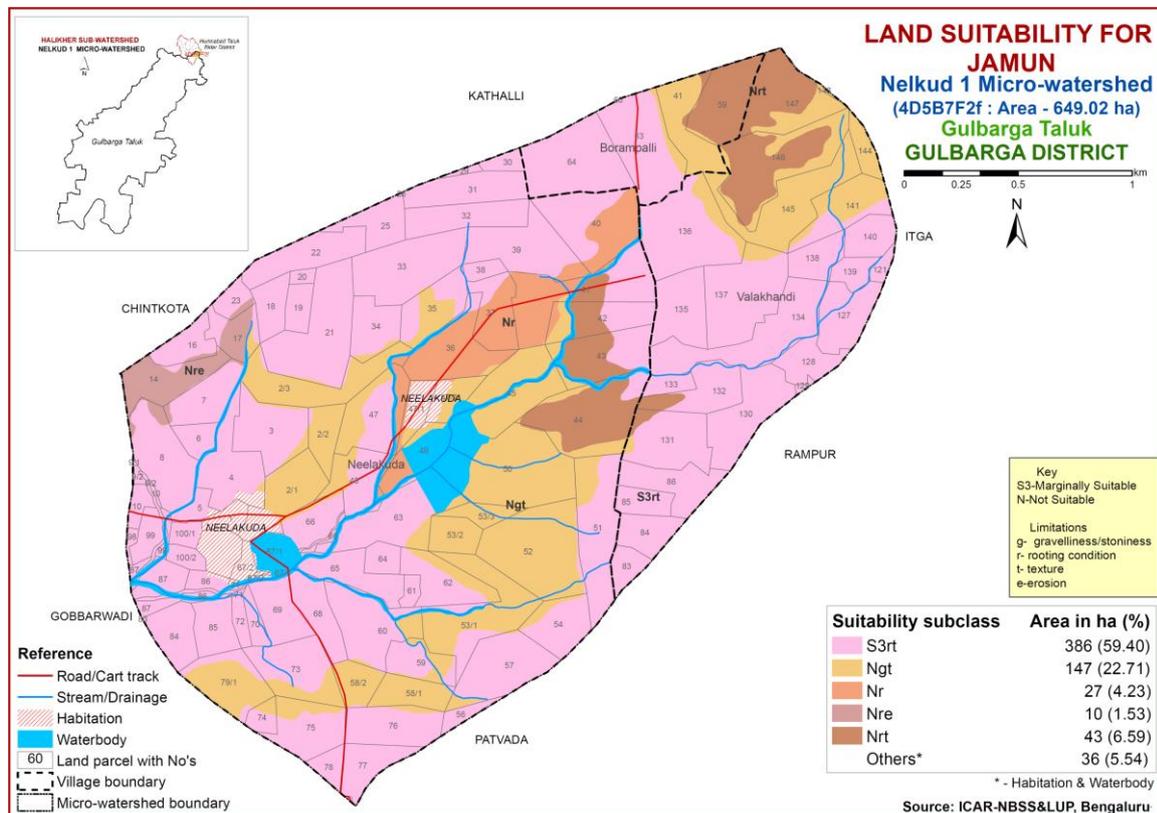


Fig 7.13 Land Suitability map of Jamun

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 (Class S1) and moderately (Class S2) suitable lands are not available for growing musambi in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and gravelliness. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing musambi and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, topoghaphy, erosion and rooting depth.

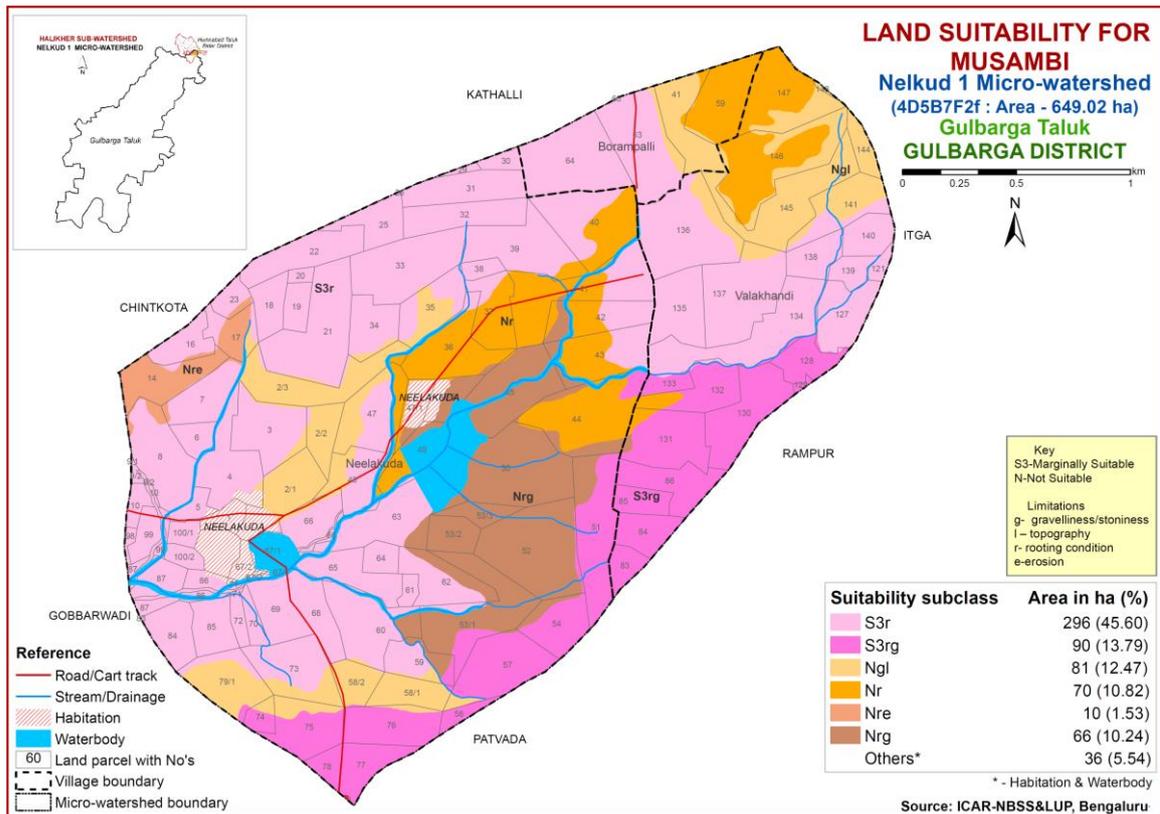


Fig 7.14 Land Suitability map of Musambi

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 (Class S1) and moderately (Class S2) suitable lands are not available for growing lime in Nelkud-1 microwatershed. Marginally suitable (Class S3) lands are found to occur in a major area of about 386 ha (59%). The soils have moderate limitations of rooting depth and gravelliness. They are distributed in all parts of the microwatershed. An area of about 227 ha (35%) is not suitable (Class N) for growing lime and occur in the central, southern, southwestern and northern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion and rooting depth.

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	°C	28-30	31-35 24-27	36-40 20-23	>40 <20
Soil moisture	Growing period	Days	240-265	180-240	150-180	<150
Soil aeration	Soil drainage	class	Well drained	Mod. to imperfectly drained	poorly	Very poorly
Nutrient availability	Texture	Class	Scl, l, sicl, cl, s	Sc, sc, c	C (>70%)	S, ls
	pH	1:2.5	6.0-7.5	5.5-6.4/ 7.6-8.0	4.0-5.4 8.1-8.5	<4.0 >8.5
	CaCO ₃ in root zone	%	Non calcareous	Upto 5	5-10	>10
Rooting condition	Soil depth	cm	>150	100-150	50-100	<50
	Gravel content	% vol.	Non gravelly	15-35	35-55	>55
Soil toxicity	Salinity	dS/m	Non saline	Upto 1.0	1.0-2.5	>2.5
	Sodicity	%	Non sodic	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-10	

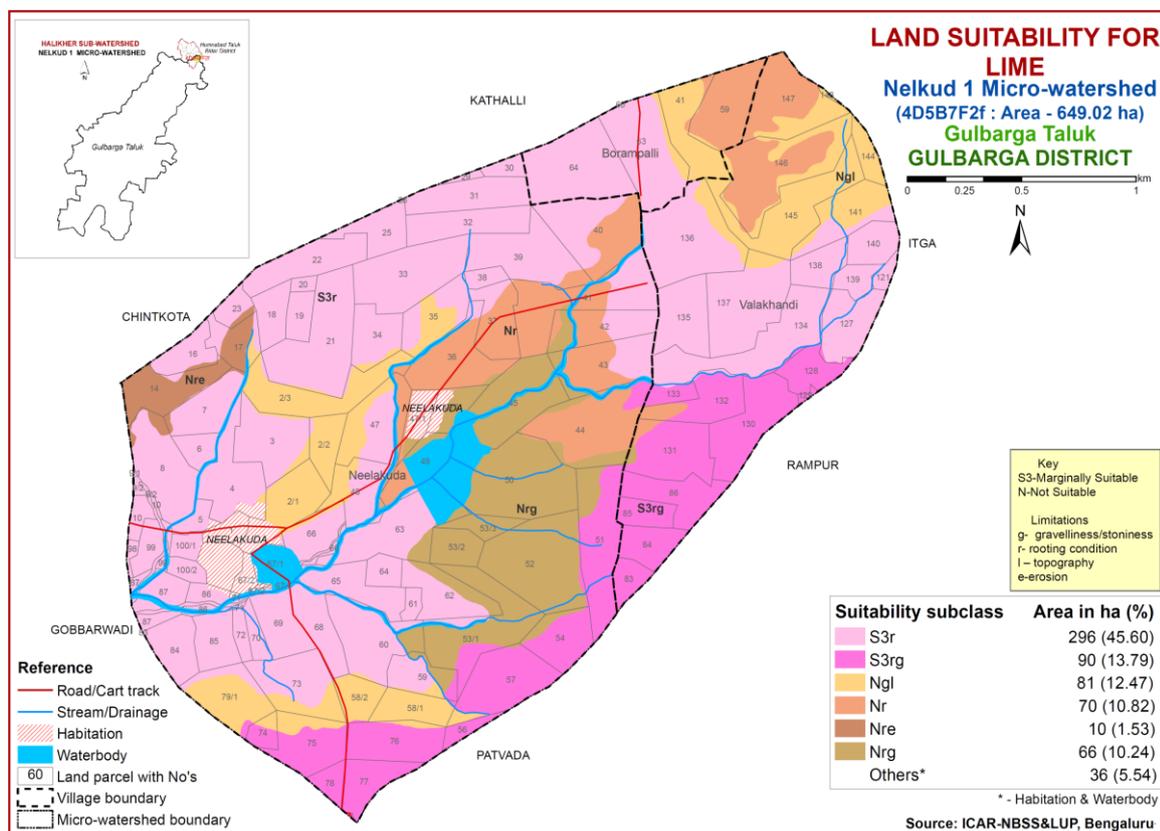


Fig 7.15 Land Suitability map of Lime

7.16 Land Suitability for Cashew (*Anacardium occidentale*)

Cashew is the most important plantation nut 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 extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.16.

Entire area of 613 ha (94%) is not suitable (Class N) for growing cashew in the microwatershed. They have severe limitations of rooting depth, heavy texture and erosion.

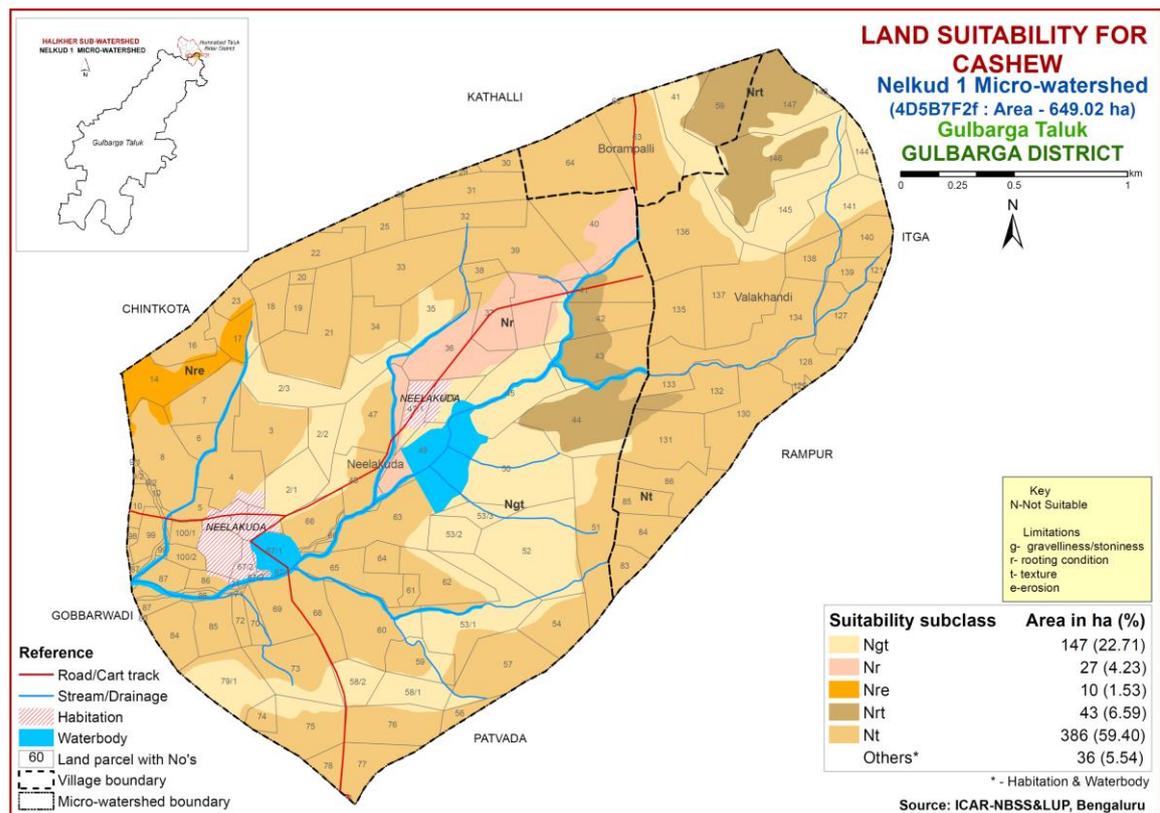


Fig 7.16 Land Suitability map of Cashew

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

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

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing custard apple. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing custard apple and are distributed in all parts of the microwatershed. They have minor limitations of erosion, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are

distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing custard apple and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion and rooting depth.

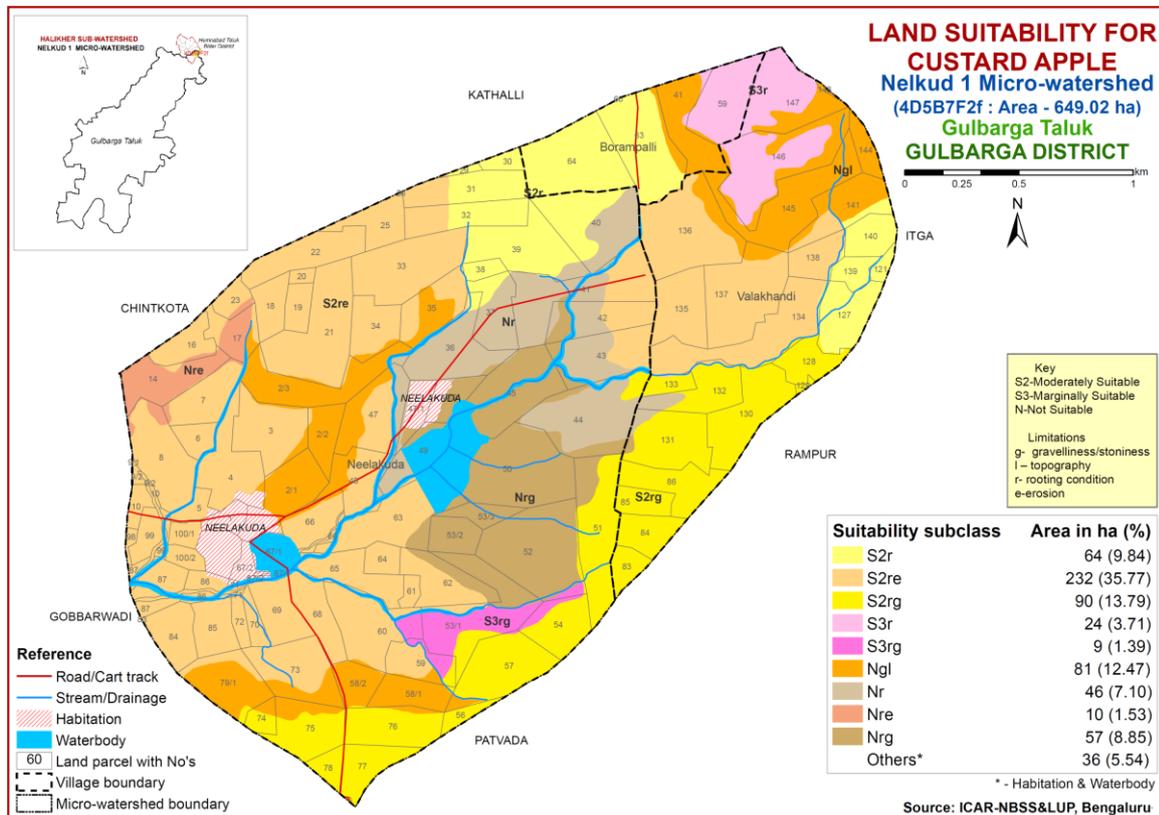


Fig 7.17 Land Suitability map of Custard Apple

7.18 Land Suitability for Amla (*Phyllanthus emblica*)

Amla is the most important medicinal fruit 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.

In Nelkud-1 microwatershed, there are no lands that are highly (Class S1) suitable for growing amla. Maximum area of about 386 ha (59%) is moderately suitable (Class S2) for growing amla and are distributed in all parts of the microwatershed. They have minor limitations of erosion, gravelliness and rooting depth. Marginally suitable lands (Class S3) occupy an area of about 33 ha (5%) and are distributed in the southeastern and northern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. An area of about 194 ha (30%) is not suitable (Class N) for growing amla and are distributed in the central, northern and southwestern part of the microwatershed. They have severe limitations of gravelliness, topography, erosion and rooting depth.

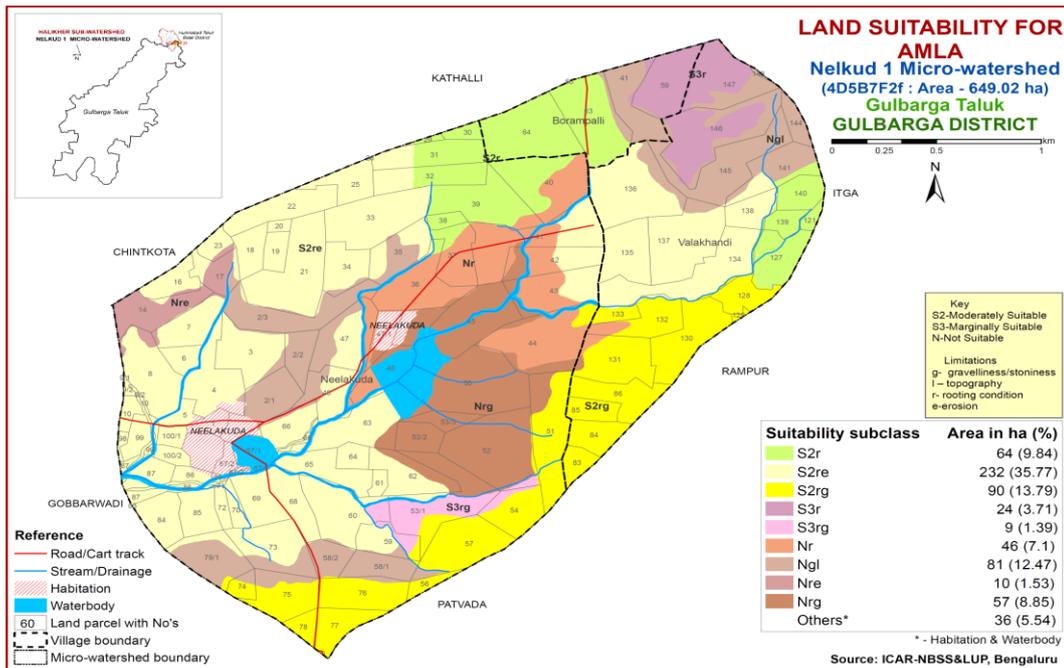


Fig 7.18 Land Suitability map of Amla

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.

Entire area of about 613 ha (84%) is not suitable (Class N) for growing tamarind in the microwatershed. The soils have severe limitations of texture, graveliness, erosion and rooting depth.

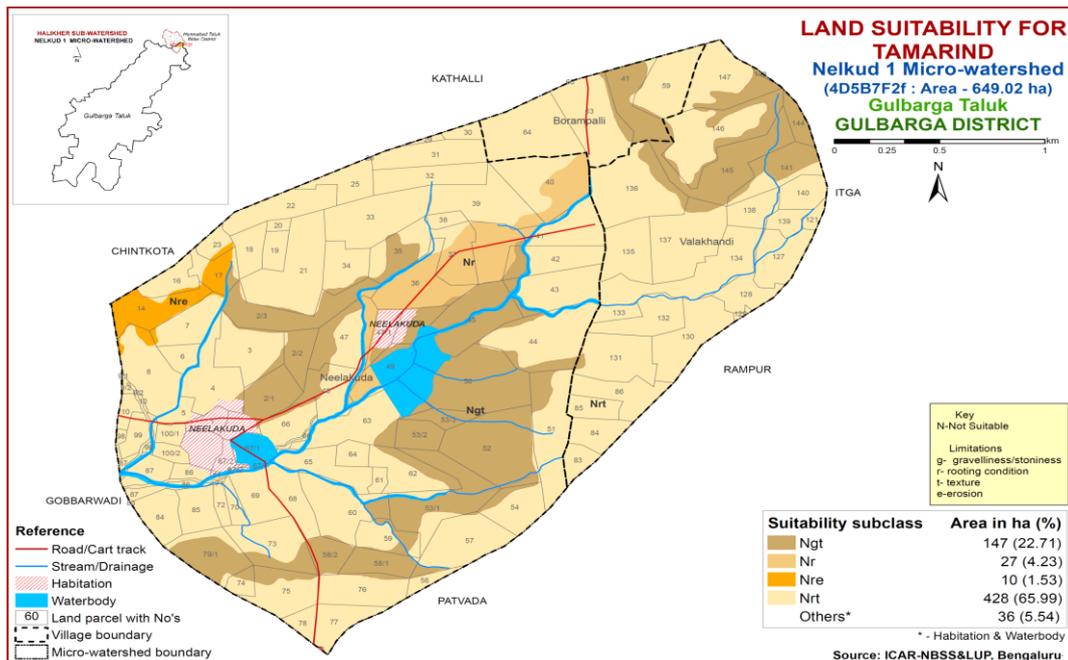


Fig 7.19 Land Suitability map of Tamarind

7.20 Land Use Classes (LUCs)

The 16 soil map units identified in Nelkud-1 microwatershed have been grouped into four 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 four land use classes along with brief description of soil and site characteristics are given below.

LMUs	Soil map units	Soil and site characteristics
1	MGTmC3g2, MGTmD3g2, BHIiD3g2, KGImC3g2, KGImD3g2, NHmC3g1	Very shallow to shallow black soils with 3-10 % slopes, gravelly to very gravelly (15-60%) and severe erosion
2	MGTmB2g1, MGTmC2g1, KNHmB2	Very shallow black soils with 1-5 % slope, gravelly (15-35%) and moderate erosion
3	BHImB2g1, HBLmB2g1, HBLmB2g2	Shallow to moderately shallow black soils with 1-3 % slopes, gravelly to very gravelly (15-60%) and moderate erosion
4	DSImB1, GTTmB1, GTTmB2, GTTmB2g1	Moderately shallow black soils with 1-3 % slope, gravelly (15-35%) and slight to moderate erosion

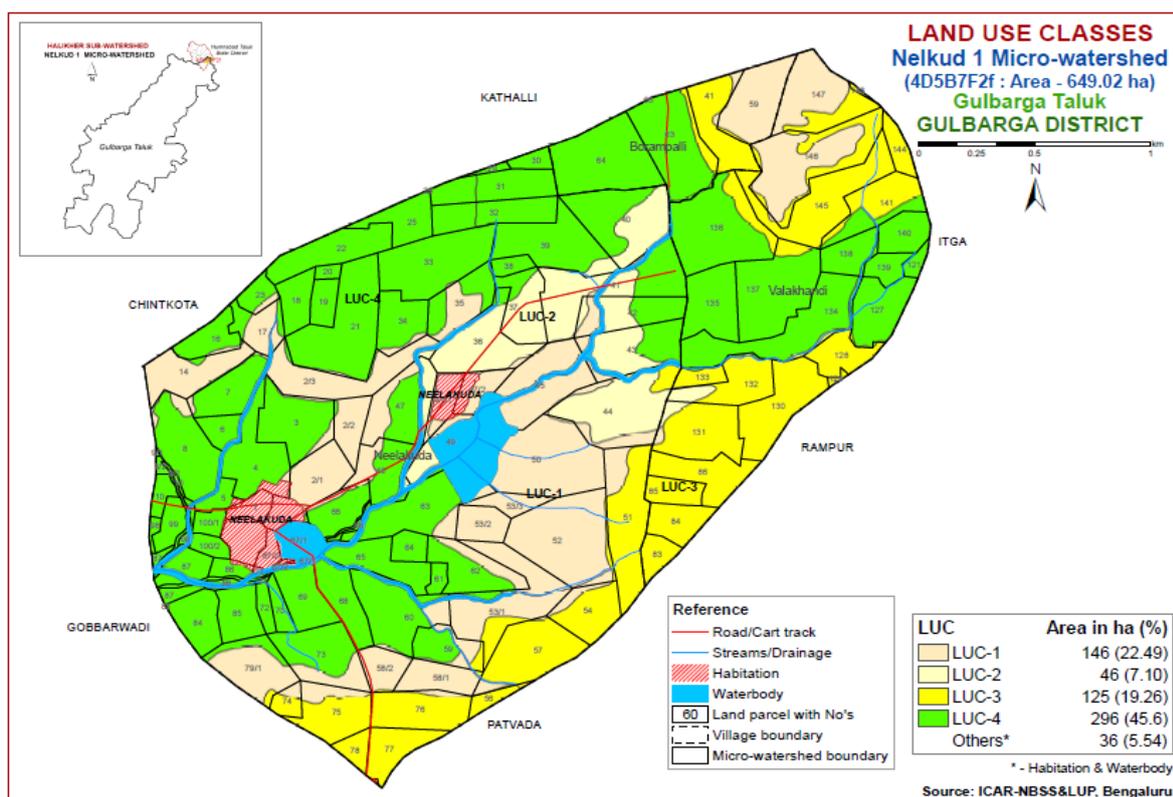


Fig. 7.20 Land Use Classes map of Nelkud-1 Microwatershed

7.21 Proposed Crop Plan for Nelkud-1 Microwatershed

After assessing the land suitability for the 19 crops, a proposed crop plan has been prepared for the four 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 Nelkud-1 Microwatershed

LUC	Mapping unit	Survey No	Soil-site Characteristics	Crop Proposed				Suitable Intervention
				Field crops	Forestry Crop/Grasses	Horticulture crops (Rainfed Condition)	Horticulture crops with suitable intervention	
LUC-1	3MGTmC3g2 4MGTmD3g2 6BHliD3g2 7KGIImC3g2 8KGIImD3g2 16KNHmC3g1	Borampalli: 59 Neelakuda: 2/1,2/2,2/3,14,17,4 5,47/2,50,52,53/1, 53/2,53/3,58/1,58/2 ,79/1 Valakhandi: 146,147	Very shallow to shallow black soils, depth (<25 -50cm), gravelly to very gravelly, 3-10 % slopes, severe erosion	-	Neem, Glyricydia , Silviculture, Agave, Simaroba	-	-	Crescent bunds
LUC-2	1MGTmB2g1 2MGTmC2g1 15KNHmB2	Neelakuda: 36,37,41,43,44	Very shallow black soils, depth (<25 cm), gravelly, 1-5 % slopes, moderate erosion	Horse gram, Green gram, chick pea	Neem, Glyricydia , Silviculture, Agave, Simaroba	-	-	Crescent bunds
LUC-3	5BHImB2g1 13HBLmB2g1 14HBLmB2g2	Borampalli: 41 Neelakuda: 51,54,56,57,74,75, 76,77,78 Valakhandi: 83,84,85,86,128,12 9,130,131, 132,133, 141,144,145,148	Shallow to moderately shallow black soil, depth(25-75 cm), gravelly to very gravelly, 1-3 % slopes, moderate erosion	Bajra, Linseed, Green gram, Black gram, Chick pea, Safflower, Coriander	Subabhul, Neem, Teak	Custard apple, Charoli, Ber, Amla Vegetables: Ladies finger, Brinjal, Cowpea, Flowers: Marigold, Chrysanthemum	Custard apple, Charoli, Ber, Amla Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi Flowers: Marigold, Chrysanthemum	Drip irrigation, suitable soil and water conservations like cultivation on raised beds with mulches and drip

LUC-4	<p>9DSImB1</p> <p>10GTTmB1</p> <p>11GTTmB2</p> <p>12GTTmB2g1</p>	<p>Borampalli: 63,64,66</p> <p>Neelakuda: 3,4,5,6,7,8,9/1,9/2, 10,16,18,19,20,21, 22,23,25,26,29,30, 31,32,33,34,35,38, 39,40,42,47,48,59, 60,61,62,63,64,65, 66,68,69,70,72,73, 83,84,85,86,87,98, 99,100/1, 100/2, STREAM Valakhandi: 121,127,134,135,1 36,137,138, 139, 140</p>	<p>Moderately shallow black soils depth (50- 75 cm), 1-3 % slopes, gravelly, slight to moderate erosion</p>	<p>Sorghum, Cotton, Red Gram, Black gram, Green gram, Soybean, Sesame, Sunflower, Safflower Rabi: Sorghum, Chickpea, Coriander, Linseed</p>	<p>Subabhul, Neem, Teak</p>	<p>Custard apple, Charoli, Ber, Amla</p> <p>Vegetables: Ladies finger, Brinjal, Cowpea,</p> <p>Flowers: Marigold, Chrysanthe mum</p>	<p>Custard apple, Charoli, Ber, Amla, Papaya, Banana, Lime, Citrus</p> <p>Vegetables: Onion, Tomato, Brinjal, Chillies, Bhendi</p> <p>Flowers: Marigold, Chrysanthemum</p>	<p>-do-</p> <p>Graded bunds, Strengthening of field bunds</p>
-------	--	--	---	---	---------------------------------	--	--	---

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 Nelkud-1 Microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of GTT (246 ha), MGT (103 ha), HBL (90 ha), BHI (60 ha), DSI (50 ha), KNH (37 ha) and KGI (28 ha).
- As per land capability classification, nearly 82 per cent area comes under arable land category (Class IV) and 12 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, about 163 ha (25%) area is slightly alkaline (pH 7.3-7.8) followed by moderately alkaline (pH 7.8-8.4) soils in 118 ha (18%). An area of about 320 ha (49%) is neutral (pH 6.5-7.3) in reaction and 12 ha (2%) is strongly

alkaline (pH 8.4-9.0) in reaction. Thus, about 45 per cent of the soils in the microwatershed are alkaline in reaction.

Soil Health Management

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

Alkaline soils

(Slightly alkaline to moderately alkaline soils)

1. Regular addition of organic manure, green manuring, green leaf manuring, crop residue incorporation and mulching needs to be taken up to improve the soil organic matter status.
2. Application of biofertilizers (Azospirillum, Azotobacter, Rhizobium).
3. Application of 25% extra N and P (125 % RDN&P).
4. Application of ZnSO₄ – 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.

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 649 ha in the microwatershed, major area of 549 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 communication of benefits

Any large scale implementation of soil health management requires that supporting information is made available widely, particularly through channels familiar to farmers and extension workers. Given the very high priority attached to soil health especially by the Central Government on issuing Soil-Health Cards to all the farmers, media outlets like Regional and 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, radish, 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 Nelkud-1 microwatershed.
- ❖ **Organic Carbon:** In about 91 ha (14%) 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

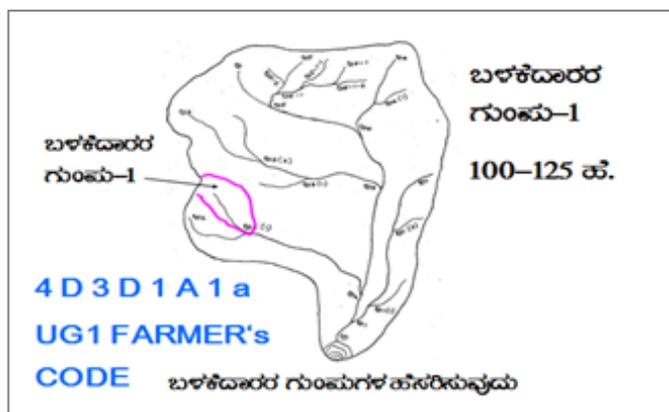
and medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- ❖ **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 91 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 44 ha (7%) area, the available phosphorus is low and an area of about 569 ha (88%) it is medium in the microwatershed. Hence for all the crops, 25% additional P-needs to be applied.
- ❖ **Available Potassium:** Available potassium is medium in 373 ha (57%) area of the microwatershed, low in 176 ha (27%) area. Hence, in all these plots, where available potassium is medium or low, for all crops, an additional 25 % potassium may be applied. It is high in 64 ha (10%) area of the microwatershed.
- ❖ **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 333 ha (51%) area of the microwatershed and medium in 280 ha (43%). These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertilizer (13% sulphur) for 2-3 years for the deficiency to be corrected.
- ❖ **Available iron:** It is deficient in 30 ha (5%) area of the microwatershed and it is sufficient in 583 ha (90%) area in the microwatershed.
- ❖ **Available Zinc:** It is deficient in 138 ha (21%) area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied. It is sufficient in 475 ha (73%) area in the microwatershed.
- ❖ **Soil alkalinity:** The microwatershed has 293 ha area with soils that are alkaline in reaction. 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 Nelkud-1 microwatershed, the land resource inventory database generated under Sujala-III project has been transformed as information through series of interpretative (thematic) maps using soil phase map as a base. The various thematic maps (1:7920 scale) generated were

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



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

Steps for Survey and Preparation of Treatment Plan

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

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

9.1 Treatment Plan

The treatment plan recommended for arable lands is briefly described below

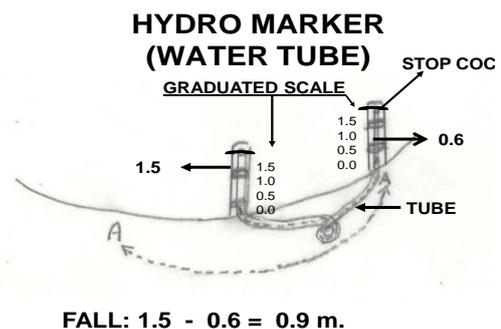
9.1.1 Arable Land Treatment

A. BUNDING

Steps for Survey and Preparation of Treatment Plan		USER GROUP-1
<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)	<p>CLASSIFICATION OF GULLIES</p> <p>ಕೊರಕಲಿನ ವರ್ಗೀಕರಣ</p> <p>• ಮೇಲ್ಭಾಗ 15 ಹಾ.</p> <p>• ಮಧ್ಯಭಾಗ 15+10=25 ಹಾ.</p> <p>• ಕೆಳಭಾಗ 25 ಹೆಚ್ಚಿನ ಗಾತ್ರ ಅಧಿಕ</p> <p>POINT OF CONCENTRATION</p>
Medium gullies	(5-15 ha catchment)	
Ravines	(15-25 ha catchment) and	
Halla/Nala	(more than 25ha catchment)	

Measurement of Land Slope

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



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

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

Note: (i) The above intervals are maximum.

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

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

Section of the Bund

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

Recommended Bund Section

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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below:

TRENCH CUM BUND

WATER STORAGE AREA
0.45 Sq.m section
IDEAL FOR HORTICULTURE CROPS

'A' FRAME FOR INTERBUND MANAGEMENT

ಇಳವಾರು
ಸಮವಾರಗಳ ರೇಖೆ

1. ಸಮವಾರಗಳ ಉಳುವಾರು
2. ಸಮವಾರಗಳ 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
			L(m)	W(m)	D(m)	QUANTITY (m ³)		
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 Bunds are formed in the field.

9.1.3 Treatment of Natural Water Course/ Drainage Lines

- a) The cadastral map has to be updated as regards the network of 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 228 ha (35%) requires crescent bunds and 386 ha (59%) area requires for trench cum bunding.

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

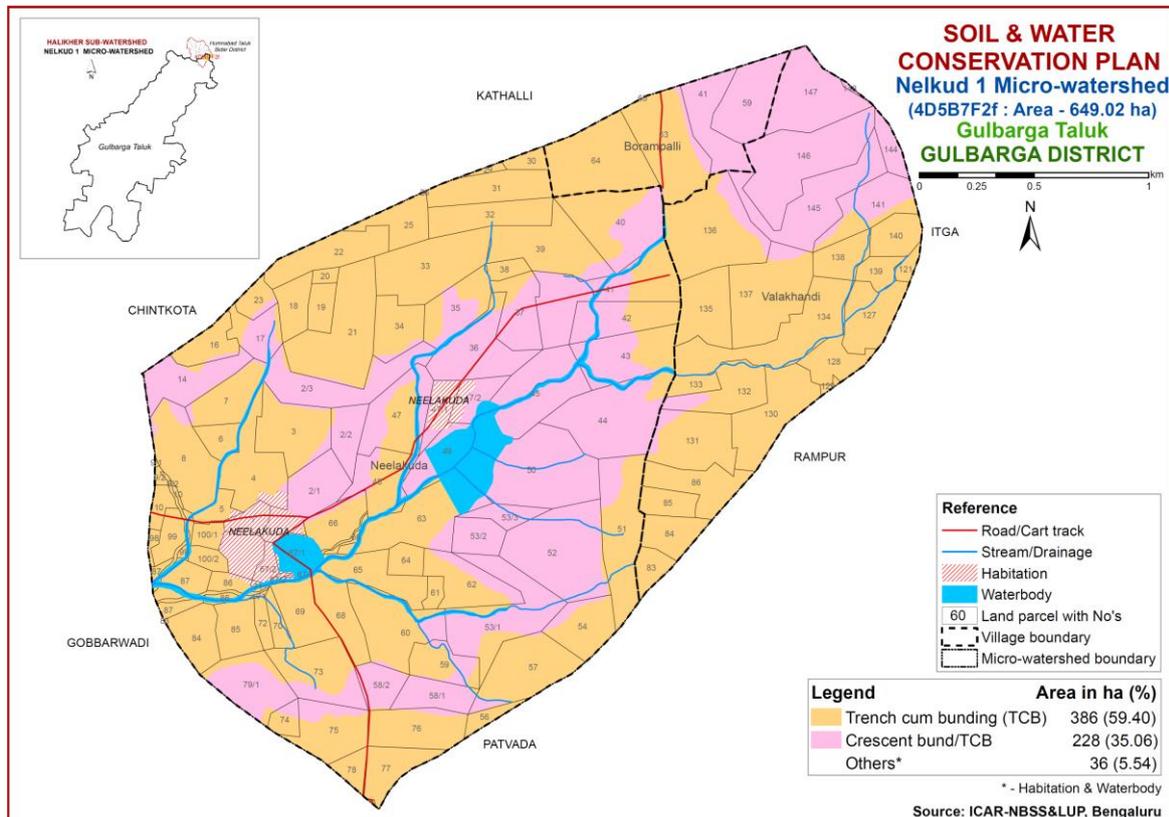


Fig. 9.1 Soil and Water Conservation Plan map of Nelkud-1 Microwatershed

9.3 Greening of Microwatershed

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

It is recommended to open pits during the 1st week of March along the contour and heap the dug out soil on the lower side of the slope in order to harness the flowing water and facilitate weathering of soil in the pit. Exposure of soil in the pit also prevents spread of pests and diseases due to scorching sun rays. The pits should be filled with mixture of

soil and organic manure during the second week of April and keep ready with sufficiently tall seedlings produced either in poly bags or in root trainer nurseries so that planting can be done during the 2nd or 3rd week of April depending on the rainfall.

The tree species suitable for the area considering rainfall, temperature and adaptability is listed below; waterlogged areas are recommended to be planted with species like 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 chelanooides</i>	25 - 45	500 -2000
12.	Dhupa	<i>Boswella Serrata</i>	20 - 40	500 - 2000
13.	Nelli	<i>Emblca 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 arborea</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>Emblca officinalis</i>	20 - 40	500 - 2000
29.	Nerale	<i>Syzgium 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

References

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

Appendix I
Nelkud-1 Microwatershed
Soil Phase Information

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	1	1.79	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others
Neelakuda	2/1	7.2	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Grass Land (GL)	Not Available	VIse	Crescent bund/TCB
Neelakuda	2/2	3.48	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Scrub Land (SL)	Not Available	VIse	Crescent bund/TCB
Neelakuda	2/3	8.87	MGTmD3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram+ Grass Land (Rg+GL)	Not Available	VIse	Crescent bund/TCB
Neelakuda	3	8.04	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	4	7.99	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	5	1.66	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Jowar (Rg+Jw)	Not Available	IVse	TCB
Neelakuda	6	2.25	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	7	5.49	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	8	9.06	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Check dum	IVse	TCB
Neelakuda	9/1	0.04	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	TCB
Neelakuda	9/2	0.35	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	TCB
Neelakuda	10	1.56	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Not Available	IVse	TCB
Neelakuda	14	6.4	KNHmC3g1	LUC-1	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Grass Land (GL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	16	3.55	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	17	3.93	KNHmC3g1	LUC-1	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Scrub Land (SL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	18	3.33	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	19	2.28	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	20	0.7	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	21	12.97	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Onion (Rg+On)	Not Available	IVse	TCB
Neelakuda	22	6.81	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Srub Land (Rg+SL)	Not Available	IVse	TCB
Neelakuda	23	2	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Not Available	IVse	TCB
Neelakuda	25	4.25	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	26	0.01	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	TCB
Neelakuda	29	0.43	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IVs	TCB
Neelakuda	30	1.32	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Neelakuda	31	6.48	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Grass Land (Rg+GL)	Not Available	IVs	TCB
Neelakuda	32	6.23	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Neelakuda	33	10.99	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	34	4.96	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Srub Land (Rg+SL)	Not Available	IVse	TCB
Neelakuda	35	6.03	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	36	8.5	KNHmB2	LUC-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Neelakuda	37	5.52	KNHmB2	LUC-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Neelakuda	38	1.32	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Onion (On)	Not Available	IVs	TCB
Neelakuda	39	9.65	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Srub Land (Rg+SL)	Not Available	IVs	TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	40	11.07	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Grass Land (Rg+GL)	Not Available	IVs	TCB
Neelakuda	41	12.06	KNHmB2	LUC-2	Very shallow (<25 cm)	Clay	Non gravelly (<15%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Neelakuda	42	6.42	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Not Available	IVse	TCB
Neelakuda	43	8.49	MGTmC2g1	LUC-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Scrub Land (SL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	44	12.95	MGTmB2g1	LUC-2	Very shallow (<25 cm)	Clay	Gravelly (15-35%)	Very low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	45	11.35	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Neelakuda	47	8.39	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	47/1	2.74	Habitation	Others	Others	Others	Others	Others	Others	Others	NA	Not Available	Others	Others
Neelakuda	47/2	2.98	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Scrub Land (SL)	Bore well	IVse	Crescent bund/TCB
Neelakuda	48	5.95	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	49	5.18	Waterbody	Others	Others	Others	Others	Others	Others	Others	Onion (On)	Not Available	Others	Others
Neelakuda	50	16.2	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Redgram+ Srub Land (Rg+SL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	51	11.07	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	52	14.44	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Scrub Land (SL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	53/1_GRA SS_FIELD	12.03	KGImC3g2	LUC-1	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Grass Land (GL)	Not Available	IVse	Crescent bund/TCB
Neelakuda	53/2	3.32	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	Grass Land (GL)	Not Available	IVse	Crescent bund/TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	53/3	2.25	MGTmC3g2	LUC-1	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Gently sloping (3-5%)	Severe	NA	Not Available	IVse	Crescent bund/TCB
Neelakuda	54	5.73	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	56	1.4	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	57	9.27	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	58/1	4.12	KGI mD3g2	LUC-1	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram+ Grass Land (Rg+GL)	Not Available	VIse	Crescent bund/TCB
Neelakuda	58/2	3.24	KGI mD3g2	LUC-1	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram+ Grass Land (Rg+GL)	Not Available	VIse	Crescent bund/TCB
Neelakuda	59	4.46	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	60	9.4	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Jowar+ Wheat+Onion (Rg+Jw+Wh+On)	Not Available	IVse	TCB
Neelakuda	61	1.02	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Bengalgram (Bg)	Not Available	IVse	TCB
Neelakuda	62	6.42	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	63	10.85	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Bengalgram (Rg+Bg)	Not Available	IVse	TCB
Neelakuda	64	2.02	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	65	5.77	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	66	4.54	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	67/1	3.04	Waterbody	Others	Others	Others	Others	Others	Others	Others	Grass Land (GL)	Not Available	Others	Others
Neelakuda	67/2	1.2	Habitation	Others	Others	Others	Others	Others	Others	Others	Habitation	Not Available	Others	Others

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	68	4.92	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar+Wheat (Rg+Jw+Wh)	Not Available	IVse	TCB
Neelakuda	68	4.92	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Jowar+Wheat (Rg+Jw+Wh)	Not Available	IVse	TCB
Neelakuda	69	5.2	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Wheat (Rg+Wh)	Not Available	IVse	TCB
Neelakuda	70	1.58	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	71	0.36	Waterbody	Others	Others	Others	Others	Others	Others	Others	NA	Not Available	Others	Others
Neelakuda	72	1.3	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	73	8.37	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Check dum	IVse	TCB
Neelakuda	74	1.62	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Grass Land (GL)	Not Available	IVse	TCB
Neelakuda	75	6.88	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Grass Land (Rg+GL)	Not Available	IVse	TCB
Neelakuda	76	6.98	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	77	4.58	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Jowar (Jw)	Not Available	IVse	TCB
Neelakuda	78	1.82	HBLmB2g2	LUC-3	Moderately shallow (50-75 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	79/1_GRA SS_FELD	7.31	KGImD3g2	LUC-1	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Grass Land (GL)	Not Available	Vlse	Crescent bund/TCB
Neelakuda	83	0	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	TCB
Neelakuda	84	4.62	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Neelakuda	85	4.17	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Onion (Rg+On)	Not Available	IVse	TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Neelakuda	86	2.1	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Open well	IVse	TCB
Neelakuda	87	4.39	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Onion (Rg+On)	Not Available	IVse	TCB
Neelakuda	98	0.48	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Bore well	IVse	TCB
Neelakuda	99	2.82	GTTmB2	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass Land (Rg+GL)	Open well	IVse	TCB
Neelakuda	100/1	1.44	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Bore well	IVse	TCB
Neelakuda	100/2	1.42	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Borampalli	41	6.54	BHliD3g2	LUC-3	Shallow (25-50 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Scrub land+Grass Land (SL+GL)	Not Available	Vlse	Crescent bund/TCB
Borampalli	59	7.67	BHImB2g1	LUC-1	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	Crescent bund/TCB
Borampalli	63	11.4	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Borampalli	64	11.93	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Borampalli	66	0	DSImB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IVs	TCB
Valakhandi	83	2.3	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Scrub Land (SL)	Not Available	IVse	TCB
Valakhandi	84	3.91	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	85	2.78	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	86	5.98	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Jowar (Rg+Jw)	Not Available	IVse	TCB
Valakhandi	121	0.98	GTTmB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	NA	Not Available	IVs	TCB
Valakhandi	127	6.17	GTTmB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram+ Grass Land (Rg+GL)	Not Available	IVs	TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Valakhandi	128	3.82	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Grass Land (GL)	Not Available	IVse	TCB
Valakhandi	129	0.27	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	NA	Not Available	IVse	TCB
Valakhandi	130	8.92	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Safflower+Grass Land (Rg+Sf+GL)	Not Available	IVse	TCB
Valakhandi	131	8.59	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Safflower (Rg+Sf)	Not Available	IVse	TCB
Valakhandi	132	6.14	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Safflower (Rg+Sf)	Not Available	IVse	TCB
Valakhandi	133	1.74	HBLmB2g1	LUC-3	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	134	11.97	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	135	6.94	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Onion+Sugarcane (Rg+On+S c)	Bore well	IVse	TCB
Valakhandi	136	13.67	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	137	11.87	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+Safflower (Rg+Sf)	Not Available	IVse	TCB
Valakhandi	138	3.65	GTTmB2g1	LUC-4	Moderately shallow (50-75 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram (Rg)	Not Available	IVse	TCB
Valakhandi	139	2.09	GTTmB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Valakhandi	140	3.59	GTTmB1	LUC-4	Moderately shallow (50-75 cm)	Clay	Non gravelly (<15%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Redgram (Rg)	Not Available	IVs	TCB
Valakhandi	141	6.86	BHliD3g2	LUC-3	Shallow (25-50 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Redgram+Grass Land (Rg+GL)	Open well	Vlse	Crescent bund/TCB
Valakhandi	144	2.07	BHliD3g2	LUC-3	Shallow (25-50 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Scrub Land (SL)	Not Available	Vlse	Crescent bund/TCB
Valakhandi	145	10.76	BHliD3g2	LUC-3	Shallow (25-50 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Grass Land+Scrub Land (GL+SL)	Check dum	Vlse	Crescent bund/TCB

VILLAGE	Survey Number	Area (ha)	Soils phase	LUC	Soil Depth	Surface Soil Texture	Soil Gravellines	Available Water Capacity	Slope	Soil Erosion	CLU code	WELLS	Land Capability	Conservation Plan
Valakhandi	146	14.06	BHImB2g1	LUC-1	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgram+ Grass land+Scrub land (Rg+GL+S L)	Check dum	IVse	Crescent bund/TCB
Valakhandi	147	9.78	BHImB2g1	LUC-1	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Redgarm+ Onion (Rg+On)	Not Available	IVse	Crescent bund/TCB
Valakhandi	148	0.17	BHId3g2	LUC-3	Shallow (25-50 cm)	Sandy clay	Very gravelly (35-60%)	Very low (<50 mm/m)	Moderately sloping (5-10%)	Severe	NA	Not Available	VIse	Crescent bund/TCB

Appendix III
Nelkud-1 Microwatershed
Soil Suitability Information

VILLAGE	Survey Number	Sorghum	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Musambi	Lime	Cashew	Custardapple	Amla	Tamarind	Bengal gram	Jamun	Sugarcane	Soyabean	Red gram
Neelakuda	1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	2/1	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Neelakuda	2/2	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Neelakuda	2/3	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Neelakuda	3	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	4	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	5	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	6	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	7	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	8	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	9/1	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	9/2	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	10	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	14	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre
Neelakuda	16	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	17	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre	Nre
Neelakuda	18	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	19	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	20	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	21	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	22	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	23	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	25	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	26	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	29	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	30	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	31	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	32	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	33	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	34	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	35	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	36	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3rt	Nr	Nr	Nrt	Nr
Neelakuda	37	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3rt	Nr	Nr	Nrt	Nr
Neelakuda	38	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	39	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	40	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Neelakuda	41	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	Nr	S3rt	Nr	Nr	Nrt	Nr
Neelakuda	42	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	43	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nrt	Nrt	S3r	Nrt	Nrt	Nr	Nrt
Neelakuda	44	Nr	Nrt	Nr	Nr	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	Nr	Nrt	Nrt	S3r	Nrt	Nrt	Nr	Nrt
Neelakuda	45	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt

VILLAGE	Survey Number	Sorghum	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Musambi	Lime	Cashew	Custardapple	Amla	Tamarind	Bengalgram	Jamun	Sugarcane	Soyabean	Redgram
Neelakuda	47	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	47/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	47/2	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt
Neelakuda	48	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	49	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	50	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt
Neelakuda	51	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	52	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt
Neelakuda	53/1_GRA SS_FIELD	S3rg	S3rt	Nrg	S3rg	Ngt	Ngt	Ngt	Ngt	Nrg	Nrg	Ngt	S3rg	S3rg	Ngt	S2rg	Ngt	Ngt	S3rg	S3rg
Neelakuda	53/2	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt
Neelakuda	53/3	Nrg	Ngt	Nrg	Nrg	Nrt	Ngt	Nrt	Ngt	Nrg	Nrg	Ngt	Nrg	Nrg	Ngt	Ng	Ngt	Ngt	Nrg	Ngt
Neelakuda	54	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	56	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	57	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	58/1	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	S3g	Ngt	Ngt	Ngl	Ngt
Neelakuda	58/2	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	S3g	Ngt	Ngt	Ngl	Ngt
Neelakuda	59	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	60	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	61	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	62	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	63	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	64	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	65	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	66	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	67/1	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	67/2	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	68	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	69	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	70	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	71	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Neelakuda	72	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	73	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	74	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	75	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	76	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	77	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	78	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Neelakuda	79/1_GRA SS_FIELD	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	S3g	Ngt	Ngt	Ngl	Ngt
Neelakuda	83	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	84	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt

VILLAGE	Survey Number	Sorghum	Maize	Sunflower	Cotton	Mango	Sapota	Guava	Jackfruit	Musambi	Lime	Cashew	Custardapple	Amla	Tamarind	Bengal gram	Jamun	Sugarcane	Soyabean	Red gram
Neelakuda	85	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	86	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	87	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	98	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	99	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	100/1	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Neelakuda	100/2	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Borampalli	41	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Borampalli	59	S3r	S3rt	Nr	S3r	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	S2r	Nrt	Nrt	S3r	S3rt
Borampalli	63	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Borampalli	64	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Borampalli	66	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Valakhandi	83	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	84	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	85	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	86	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	121	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Valakhandi	127	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Valakhandi	128	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	129	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	130	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	131	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	132	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	133	S2rg	S2rt	S3rg	S2rg	Nt	S3rt	S3rt	S3rt	S3rg	S3rg	Nt	S2rg	S2rg	Nrt	S2g	S3rt	S3rt	S2rg	S2rg
Valakhandi	134	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Valakhandi	135	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Valakhandi	136	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Valakhandi	137	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Valakhandi	138	S2re	S2rt	S3r	S2re	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2re	S2re	Nrt	S1	S3rt	S3rt	S2re	S2rt
Valakhandi	139	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Valakhandi	140	S2r	S2rt	S3r	S2r	Nt	S3rt	S3rt	S3rt	S3r	S3r	Nt	S2r	S2r	Nrt	S1	S3rt	S3rt	S2r	S2rt
Valakhandi	141	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Valakhandi	144	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Valakhandi	145	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt
Valakhandi	146	S3r	S3rt	Nr	S3r	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	S2r	Nrt	Nrt	S3r	S3rt
Valakhandi	147	S3r	S3rt	Nr	S3r	Nrt	Nrt	Nrt	Nrt	Nr	Nr	Nrt	S3r	S3r	Nrt	S2r	Nrt	Nrt	S3r	S3rt
Valakhandi	148	Ngl	Ngt	Ngl	Ngl	Ngt	Ngt	Ngt	Ngt	Ngl	Ngl	Ngt	Ngl	Ngl	Ngt	Ngl	Ngt	Ngt	Ngl	Ngt

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

CONTENTS

1.	Executive summary	1-3
2.	Introduction	5
3.	Methodology	7-11
4.	Results and discussions	13-29

LIST OF TABLES

I. Social status		
1	Human population among sample households	13
2	Basic needs of sample households	14
3	Institutional participation among the sample population	16
4	Migration details among the sample households	16
II. Economic status		
5	Occupational pattern in sample households	16
6	Domestic assets among samples households	17
7	Farm assets among samples households	18
8	Livestock assets among sample households	18
9	Milk produced and Fodder availability of sample households	19
10	Women empowerment of sample households	19
11	Per capita daily consumption of food among the sample households	20
12	Annual average Income from various sources	21
13	Average annual expenditure of sample households	21
14	Distribution of land holding among the sample households	22
15	Land holding among samples households	23
III. Resource use pattern		
16	Number of tree/plants covered in sample farm households	23
17	Present cropping pattern among samples households	23
18	Distribution of soil series in the watershed	24
IV. Economic land evaluation		
19	Cropping pattern on major soil series	25
20	Alternative land use options for different size group of farmers (Benefit Cost Ratio)	25
21	Economics Land evaluation and bridging yield gap for different crops	26
22	Estimation of onsite cost of soil erosion	27
23	Ecosystem services of food grain production	28
24	Ecosystem services of water supply for crop production	28
25	Farming constraints	29

LIST OF FIGURES

1	Location of study area	8
2	ALPES Framework	9
3	Basic needs of sample households	15
4	Domestic assets among the sample households	17
5	Farm assets among samples households	18
6	Livestock assets among sample households	19
7	Per capita daily consumption of food among the sample households	20
8	Average annual expenditure of sample households	22
9	Estimation of onsite cost of soil erosion	27

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: *Nelkud-1 micro-watershed (Halikher sub-watershed, Gulbarga taluk, Gulbarga district) is located in between 17°39'–17°41' North latitudes and 77°6'–77°8' East longitudes, covering an area of about 649 ha, bounded by Kathalli, Itga, Rampur, Patvada, Gobbarwadi and Chintkota villages with length of growing period (LGP) 120-150 days. We used soil resource map as basis for sampling farm households to test the hypothesis that soil quality influence crop selection, and conservation investment of farm households. The level of technology adoption and productivity gaps and livelihood patterns were analyses. The cost of soil degradation and ecosystem services were quantified.*

Results: *The socio-economic outputs for Nelkud-1 Microwatershed (Halikher sub-watershed, Gulbarga taluk, Gulbarga district) are presented here.*

Social Indicators;

- ❖ *Male and female ratio is 68.2 to 31.8 per cent to the total sample population.*
- ❖ *Younger age 18 to 50 years group of population is around 75 per cent to the total population.*
- ❖ *Literacy population is around 63.6 per cent.*
- ❖ *Social groups belong to other backward caste (OBC) is around 80.0 per cent.*
- ❖ *Fire wood is the source of energy for a cooking among 90.0 per cent.*
- ❖ *Only 30 per cent farm households are having MGNREGA card for rural employment.*
- ❖ *Dependence on ration cards for food grains through public distribution system is around 80.0 per cent.*
- ❖ *Swach bharath program providing closed toilet facilities around 40.0 per cent of sample households.*
- ❖ *Institutional participation is only 2.3 per cent of sample households.*
- ❖ *Rural migration to urban centre for employment is prevalent among 30.0 per cent of farm households.*
- ❖ *Women participation in decisions making are around 90.0 per cent of households*

Economic Indicators;

- ❖ *The average land holding is 2.0 ha indicates that majority of farm households are belong to small and medium farmers. The total cultivated land is dry land area among the sample farmers.*
- ❖ *Agriculture is the main occupation among 22.7 per cent and agriculture is the main and agriculture labour is subsidiary occupation for 68.2 per cent of sample households.*
- ❖ *The average value of domestic assets is around Rs.19597 per household. Mobile and television are popular media mass communication.*
- ❖ *The average value of farm assets is around Rs.7389 per household, about 30.0 per cent of sample farmers having plough and sprayer (30 %).*
- ❖ *The average value of livestock is around Rs.29375 per household; about 64.3 per cent of household are having livestock.*
- ❖ *The average per capita food consumption is around 979 grams (1999.6 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 30 per cent of sample households are consuming less than the NIN recommendation.*
- ❖ *The annual average income is around Rs.225742 per household. About 40 per cent of farm households are below poverty line.*
- ❖ *The per capita average monthly expenditure is around Rs.2418.*

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. 2388 per ha/year. The total cost of annual soil nutrients is around Rs. 1463607 per year for the total area of 649.02 ha.*
- ❖ *The average value of ecosystem service for food grain production is around Rs. 22688/ha/year. Per hectare food grains production services is maximum in cotton (Rs. 28348) followed by redgram (Rs. 7027).*
- ❖ *The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The per hectare value of water used and value of water was maximum in red gram (Rs.53573) and cotton (Rs.49758).*

Economic Land Evaluation;

- ❖ *The major cropping pattern is redgram (88.2 %) and cotton (11.8 %).*

- ❖ *In Nelked 1 Microwatershed, major soil is soil of Kinhi (KNH) series is having very shallow soil depth cover around 5.8 % of area. On this soil farmers are presently growing cotton. Dinsi (DSI) soil series having moderately shallow soil depth cover 7.67 % of area; crops grown are red gram. Gutti (GTT) soil series having moderately shallow soil depth cover around 37.9 % of areas, crops grown are cotton (27.5 %) and redgram (72.5 %) and Hobli (HBL) soil series having moderately shallow soil depth cover around 13.8 % of area, crops grown are redgram.*
- ❖ *The total cost of cultivation and benefit cost ratio (BCR) in study area for redgram ranges between Rs.30897/ha in GTT soil (with BCR of 1.36) and Rs.11496/ha in DSI soil (with BCR of 3.29).*
- ❖ *In cotton the cost of cultivation range between Rs.26856/ha in KNH soil (with BCR of 1.98 and Rs 15248/ha in GTT soil (with BCR of 2.99).*
- ❖ *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 fertilizer recommendation, there is scope to increase yield in redgram (22.6 to 10.2 %) and cotton (33.3 to 22.1 %).*

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

Nelkud 1 Microwatershed 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 of Agro Ecological Sub Region (AESR) 6.2 with having LGP 120-150 days.

Nelkud 1 Microwatershed (Halikher sub-watershed, Gulbarga taluk, Gulbarga district) is located in between 17⁰39'-17⁰41' North latitudes and 77⁰6'-77⁰8' East longitudes, covering an area of about 649 ha, bounded by Kathalli, Itga, Rampur, Patvada, Gobbarwadi and Chintkota 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 NELKUD-1 MICRO WATERSHED

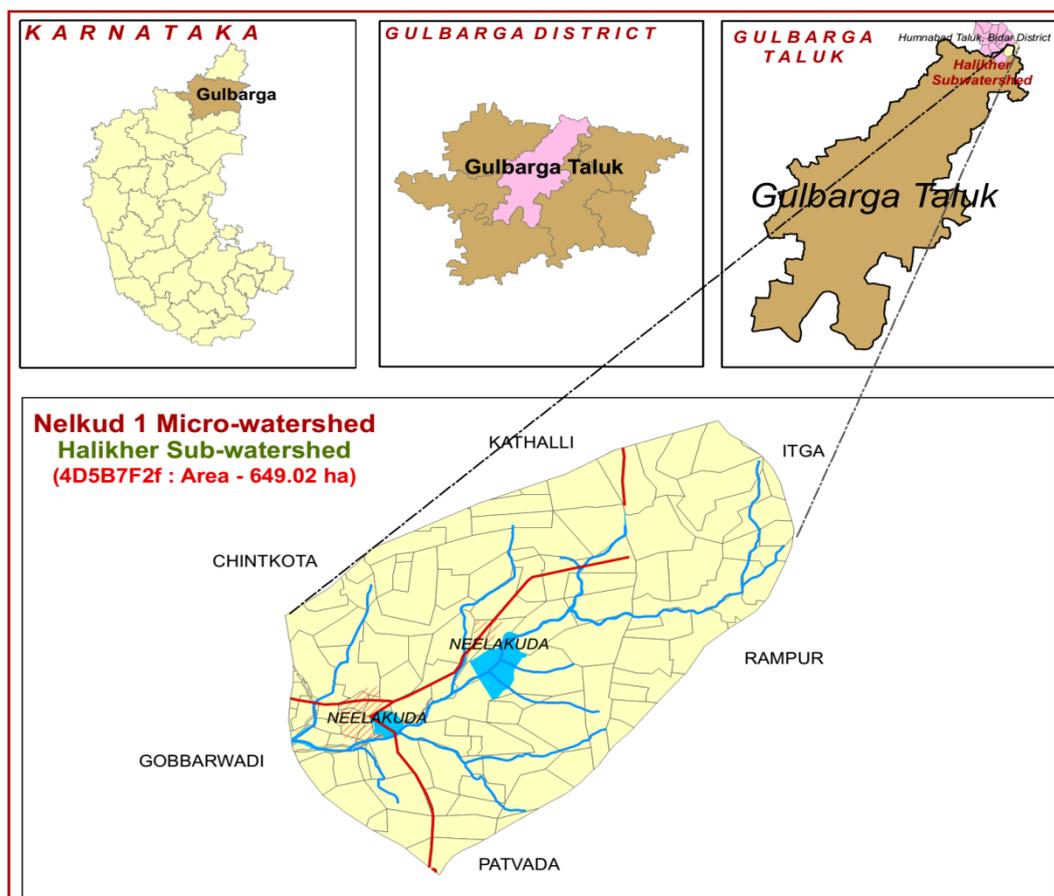


Figure 1: Location of study area

Steps followed in socio-economic assessment

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

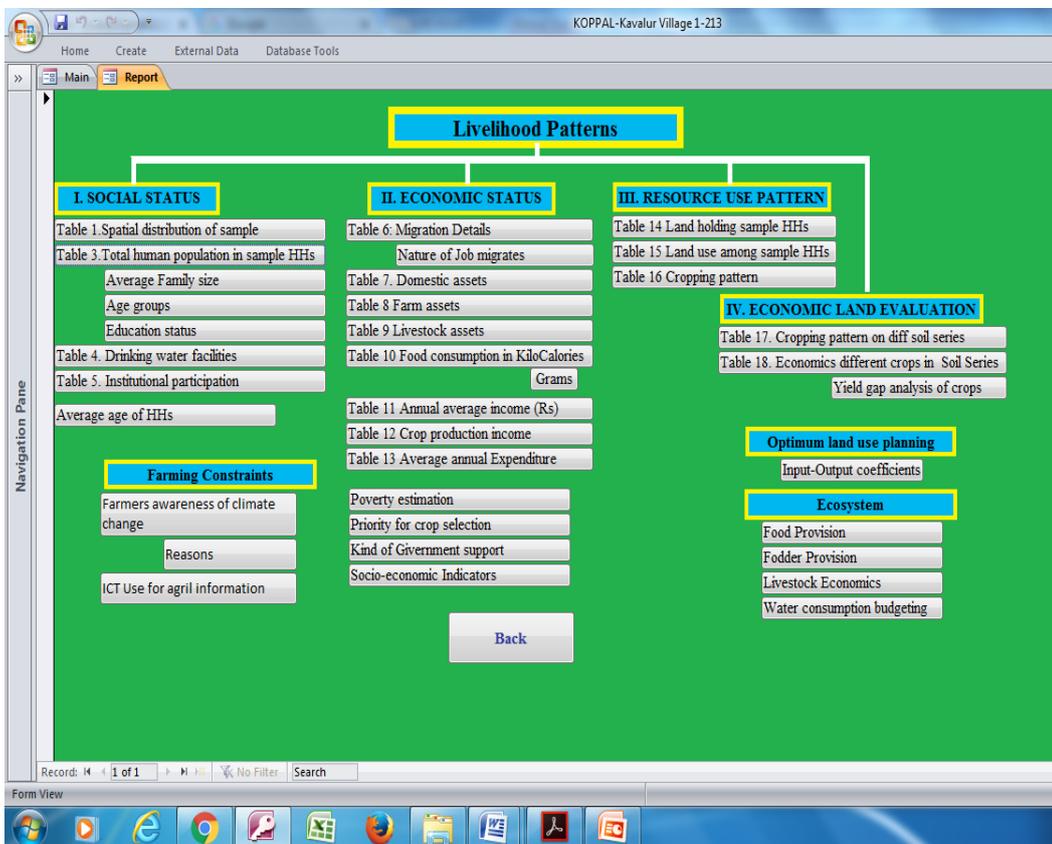
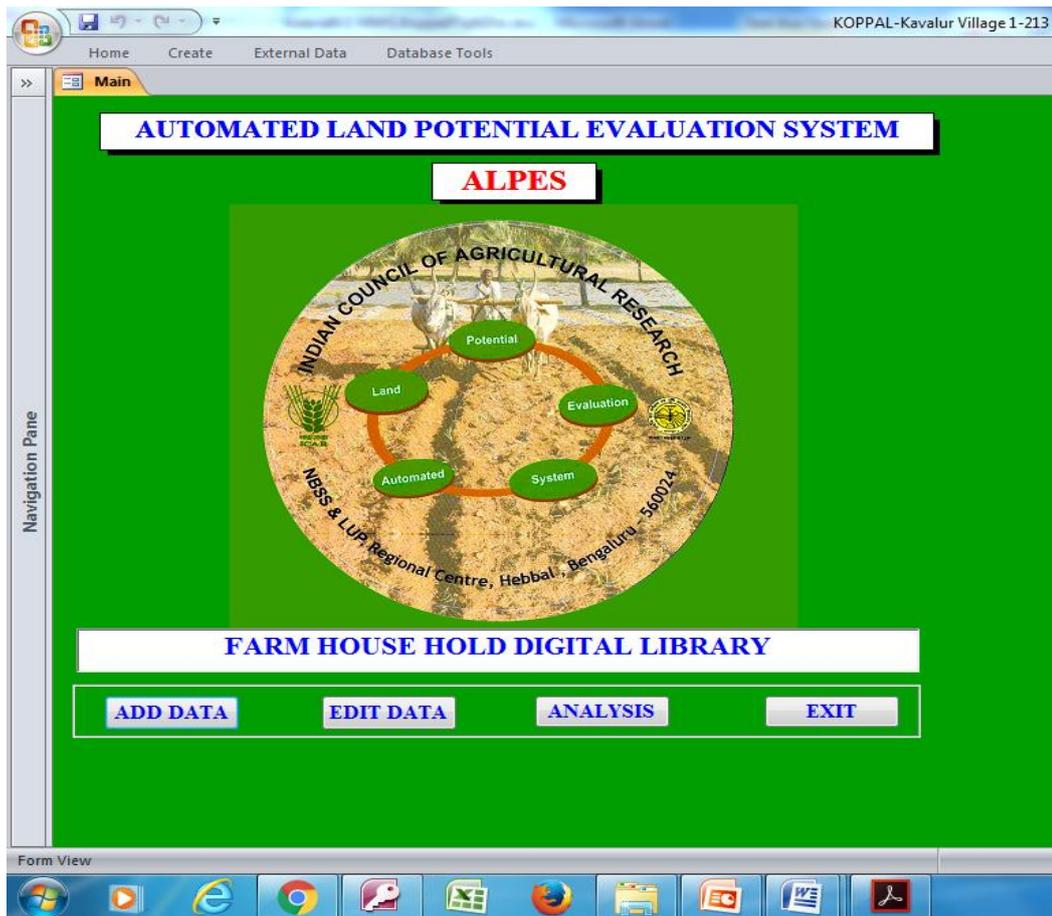


Figure 2: ALPES FRAMEWORK

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

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

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

Net returns = Gross returns-Operational cost.

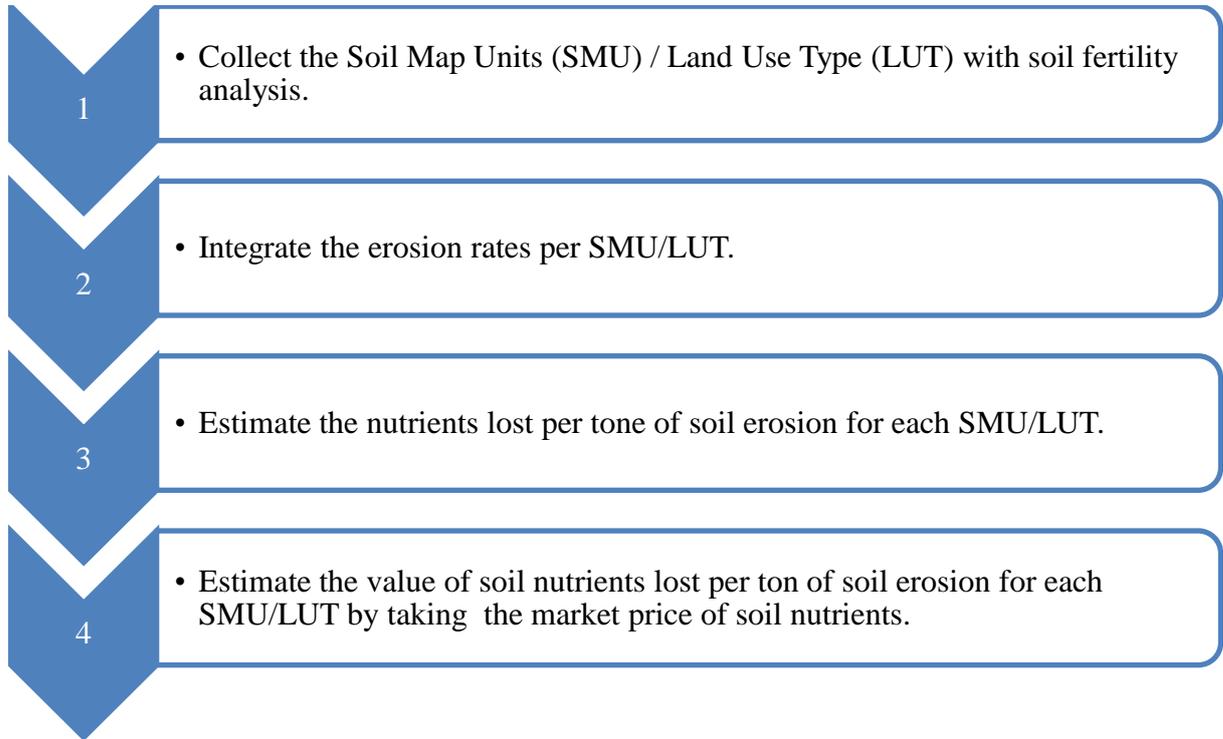
Benefit Cost Ratio = Net returns/Total cost.

Economic suitability classes: once each land use –land area combination has been assigned an economic value by the land evaluation, the question arises as to its ‘suitability’, that is, the degree to which it satisfies the land user. The FAO framework defines two suitability orders: ‘S’(suitable if benefit cost ratio (BCR) >1) and ‘N’(not suitable if (BCR <1), which are 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 44, out of which 68.2 per cent were males and 31.8 per cent females. Average family size of the households is 4.4. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 18 to 30 years (38.6 %) followed by 30 to 50 years (36.4 %) more than 50 years (13.6 %), and 0 to 18 years (11.4 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 36.4 per cent of respondents were illiterate and 63.6 per cent literate (Table 1).

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

Particulars	Units	Value
Total human population in sample HHs	Number	44
Male	% to total Population	68.2
Female	% to total Population	31.8
Average family size	Number	4.4
Age group		
0 to 18 years	% to total Population	11.4
18 to 30 years	% to total Population	38.6
30 to 50 years	% to total Population	36.4
>50 years	% to total Population	13.6
Average age	Age in years	35.5
Education Status		
Illiterates	% to total Population	36.4
Literates	% to total Population	63.6
Primary School (<5 class)	% to total Population	20.5
Middle School (6- 8 class)	% to total Population	2.3
High School (9- 10 class)	% to total Population	18.2
Others	% to total Population	22.7

The ethnic groups among the sample farm households found to be 80 per cent belonging to other backward castes (OBC) and general 20 per cent (Table 2 and Figure

3). About 90 per cent of sample households are using fire wood as source of fuel for cooking. All the sample farmers are having electricity connection. 30 per cent are having MNREGA job cards for employment generation. About 80 per cent of farm households are having ration cards for taking food grains from public distribution system. About 40 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Nelkud 1 Microwatershed

Particulars	Units	Value
Social groups		
OBC	% of Households	80.0
General	% of Households	20.0
Types of fuel use for cooking		
Fire wood	% of Households	90.0
Gas	% of Households	10.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	0.0
No	% of Households	100.0
MGNREGA Card		
Yes	% of Households	30.0
No	% of Households	70.0
Ration Card		
Yes	% of Households	80.0
No	% of Households	20.0
Households with toilet		
Yes	% of Households	40.0
No	% of Households	60.0
Drinking water facilities		
Tube Well	% of Households	90.0
Lake	% of Households	10.0

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of sample respondents are having tube well source for water supply for domestic purpose (90.0 %) and 10 percent of households are having lake source for water supply.

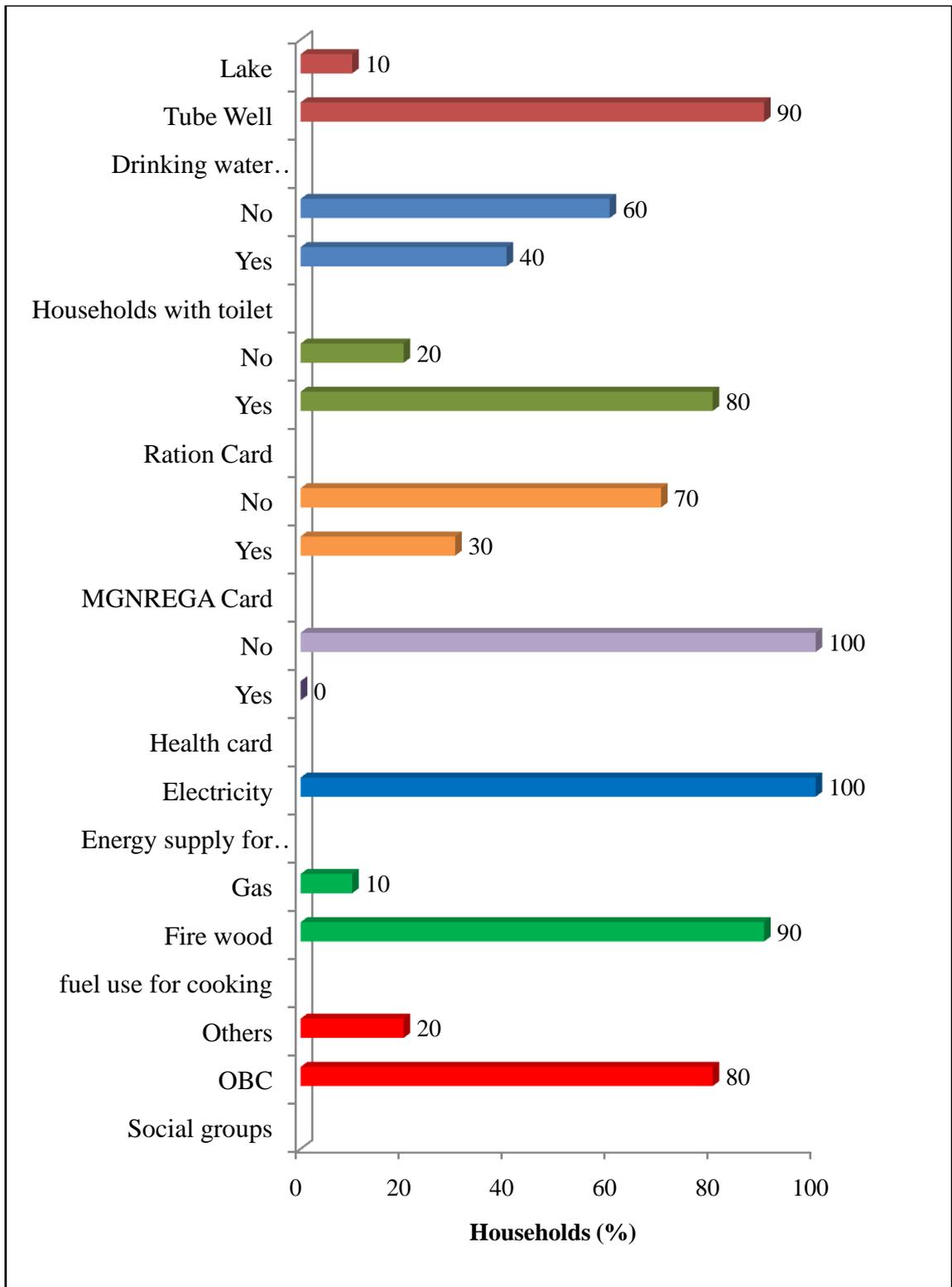


Figure 3: Basic needs of sample households in Nelkud 1 Microwatershed

Only 2.3 per cent of the farmers are participating in community based organizations (Table 3). Among them majority were participating in village panchayath (2.3%)

Table 3: Institutional participation among the sample population in Nelkud 1 Microwatershed

Particulars	Units	Value
No. Of people participating	% to total	2.3
Village panchayath	% of total	2.3
No. Of people not participating	% to total	97.7

The data on migration in Nelkud 1 Microwatershed is given in Table 4. It indicated that around 30 per cent of samples households were migrated. The average distance travelled for seeking employment is 173 km.

Table 4: Migration details among the sample households in Nelkud 1 Microwatershed

Particulars	Value
% of households showing migration	30.0
% of persons migrating	6.8
No. of months migrated in a year	8.0
Average Distance of migration(Km)	173
Nature of job (%)	
Job/wage/work	100

The occupational pattern (Table 5) among sample households shows that agriculture is the main occupation around 22.7 per cent of farmers followed by subsidiary occupation agricultural labour is 68.2 per cent, private service 2.3 per cent and non agriculture labour 2.3 percent and govt service as main occupation is only 4.5 percent of sample household

Table 5: Occupational pattern in sample population in Nelkud 1 Microwatershed

Occupation		% to total
Main	Subsidiary	
Agriculture	Agriculture	22.7
	Agriculture labour	68.2
	Non Agriculture labour	2.3
	Private service	2.3
Govt. service		4.5
Grand total		100
Family labour availability		Man days/month
Male		30.0
Female		20.0
Total		50.0

The important assets especially with reference to domestic assets were analyzed and are given in Table 6 and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (90 %) followed by television (80 %) and motorcycle (10 %). The average value of domestic assets is around Rs 19597 per households.

Table 6: Domestic assets among the sample households in Nelkud 1 Microwatershed

Particulars	% of households	Average value in Rs
Mobile Phone	90.0	4667
Motorcycle	10.0	45000
Television	80.0	9125
Average Value		19597

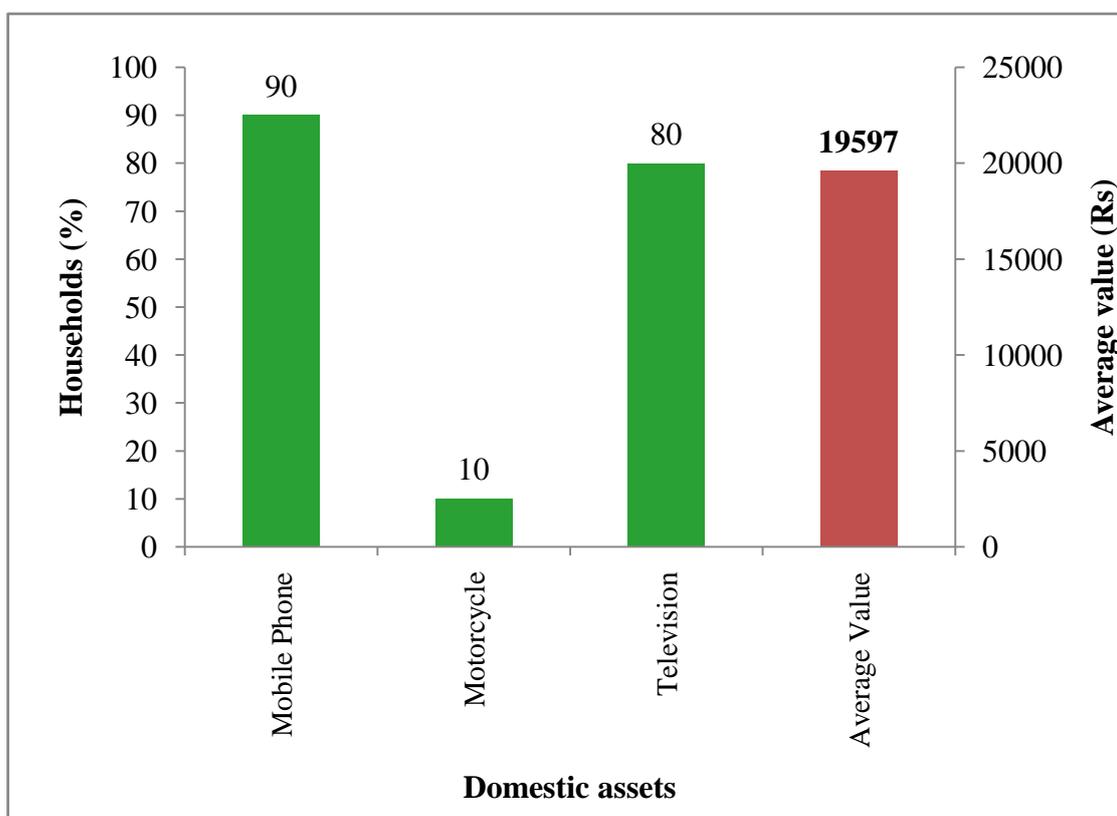


Figure 4: Domestic assets among the sample households in Nelkud 1 Microwatershed

The most popularly owned farm equipments were sickles, plough, cattle shed; pump sets, chaff cutter, bullock cart, sprayer and thresher. Plough and sickle were commonly present in all the sampled farmers; these were primary implements in agriculture. The per cent of households owned plough (30 %), sprayer (30 %) and bullock cart (20 %) was found highest among the sample farmers. The average value of farm assets is around Rs. 7389 per households (Table 7 and Figure 5).

Table 7: Farm assets among samples households in Nelkud 1 Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	20.0	12500
Plough	30.0	5667
Sprayer	30.0	4000
Average Value	7389	

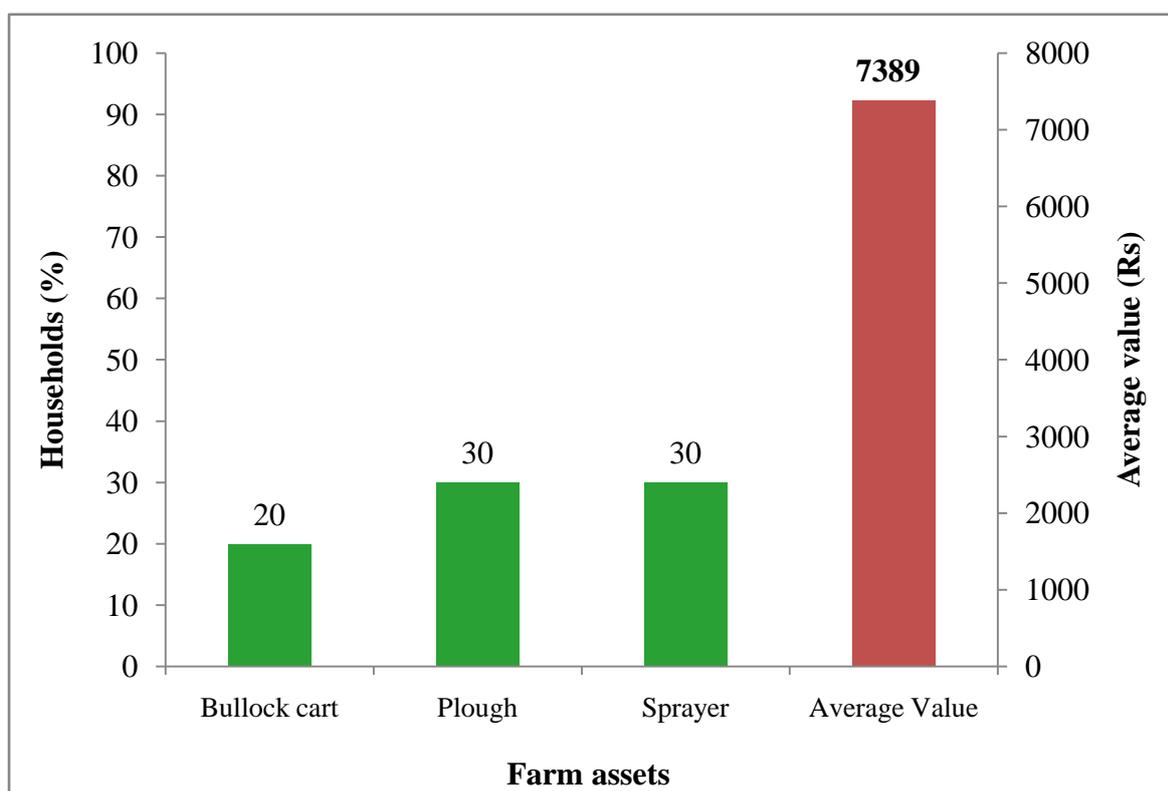


Figure 5: Farm assets among sample households in Nelkud 1 Microwatershed

Livestock is an integral component of the conventional farming systems (Table 8 and Figure 6). The highest livestock population is bullocks were around 44.4 per cent followed by local milching cow (33.3 %), local dry cow (11.1 %) and dry buffalos (11.1 %). The average livestock value was Rs 29375 per household.

Table 8: Livestock assets among sample households in Nelkud 1 micro-watershed

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	11.1	10000
Local Milching Cow	33.3	20000
Dry Buffalos	11.1	40000
Bullocks	44.4	47500
Average value	29375	

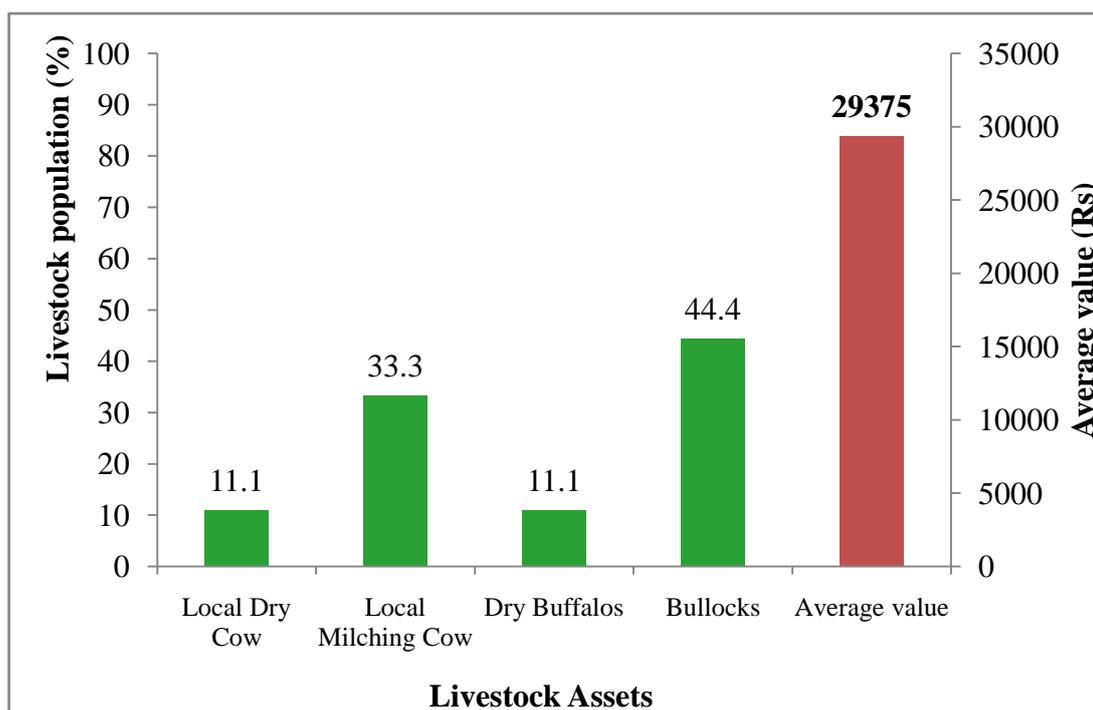


Figure 6: Livestock assets among sample households in Nelkud 1 micro-watershed

Average milk produced in sample households is 5000 liters/ annum (Table 9). The maximum produces livestock was local milching cow. The livestock having households was 64.3 per cent.

Table 9: Milk produced of sample households in Nelkud 1 Microwatershed

Particulars	
Name of the Livestock	Ltr./Lactation/animal
Local Milching Cow	5000
Livestock having households (%)	64.3
Livestock population (Numbers)	20

A woman participation in decision making in this Microwatershed is presented in Table 10. About 90 per cent of women earning for her family requirement and 90 per cent of women taking decision in her family and agriculture related activities.

Table 10: Women empowerment of sample households in Nelkud 1 Microwatershed
% to Grand Total

Particulars	Yes	No
Women participation in local organization activities	0.0	100.0
Women elected as panchayat member	0.0	100.0
Women earning for her family requirement	90.0	10.0
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 11 and Figure 7. More quantity of cereals is consumed by sample farmers which accounted for 1236.1 kcal per person. The other important food items consumed was pulses 151.7 Kcal followed by cooking oil 190.6 kcal, milk 144.1 kcal, Egg 203.3 kcal, vegetables 37.5 kcal and meat 36.3 kcal. In the sampled households, farmers were consuming less (1999.6 kcal) than NIN- recommended food requirement (2250 kcal).

Table 11: Per capita daily consumption of food among the sample households in Nelkud 1 Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396.0	363.6	1236.1
Pulses	43.0	44.2	151.7
Milk	200.0	221.7	144.1
Vegetables	143.0	156.4	37.5
Cooking Oil	31.0	33.4	190.6
Egg	0.5	135.5	203.3
Meat	14.2	24.2	36.3
Total	827.7	979.0	1999.6
Threshold of NIN recommendation		827 gram*	2250 kcal*
% Below NIN		30	80
% Above NIN		70	20

Note: * day/person

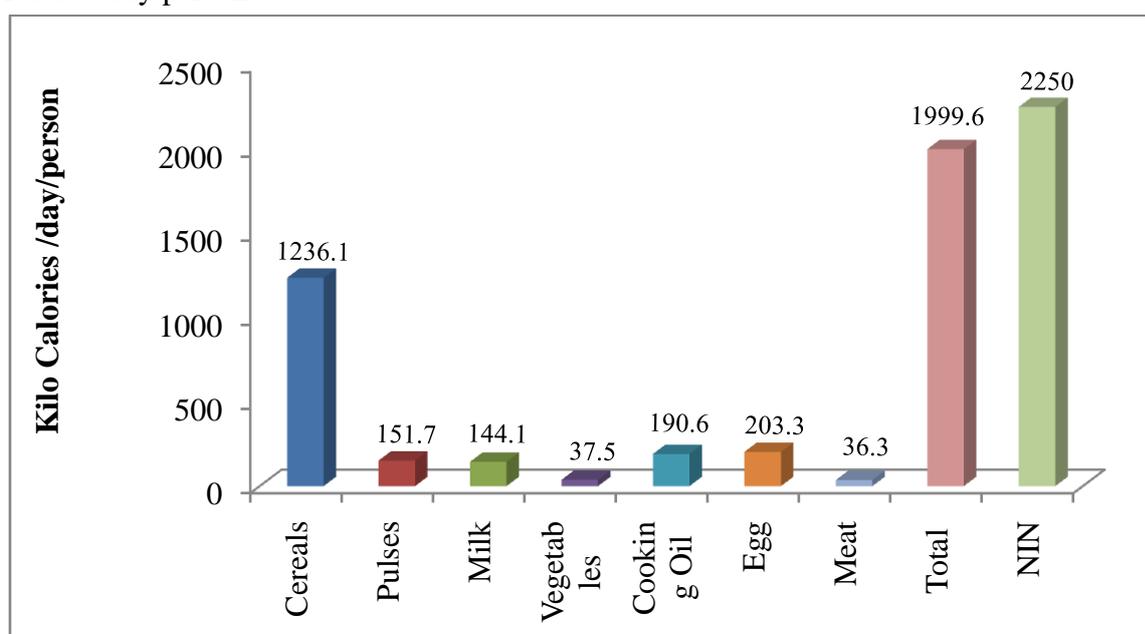


Figure 7: Per capita daily consumption of food among the sample households in Nelkud 1 Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 225742. Major source of income to the farmers in the study area is from crop production (Rs 55101) followed by livestock (Rs.168753).The monthly per capita income is Rs. 4275, which is greater than the threshold monthly income of Rs 975 for considering below 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 12).

Table 12: Annual average income of HHs from various sources in Nelkud 1 Microwatershed

Particulars	Income *
Nonfarm income (Rs)	1888 (30)
Livestock income (Rs)	168753 (30)
Crop Production (Rs)	55101 (100)
Total Annual Income (Rs)	225742
Average monthly per capita income (Rs)	4275
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	40.0
% of households above poverty line	60.0

* 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. 50671) 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 2418 and about 40 per cent of farm households are below poverty line and 60 per cent of farm households are above poverty line (Table 13 and Figure 8).

Table 13: Average annual expenditure of sample HHs in Nelkud 1 Microwatershed

Particulars	Value in Rupees	Per cent
Food	50671	39.7
Education	33300	26.1
Clothing	7800	6.1
Social functions	24500	19.2
Health	11400	8.9
Total Expenditure (Rs/year)	127671	100
Monthly per capita expenditure (Rs)	2418	

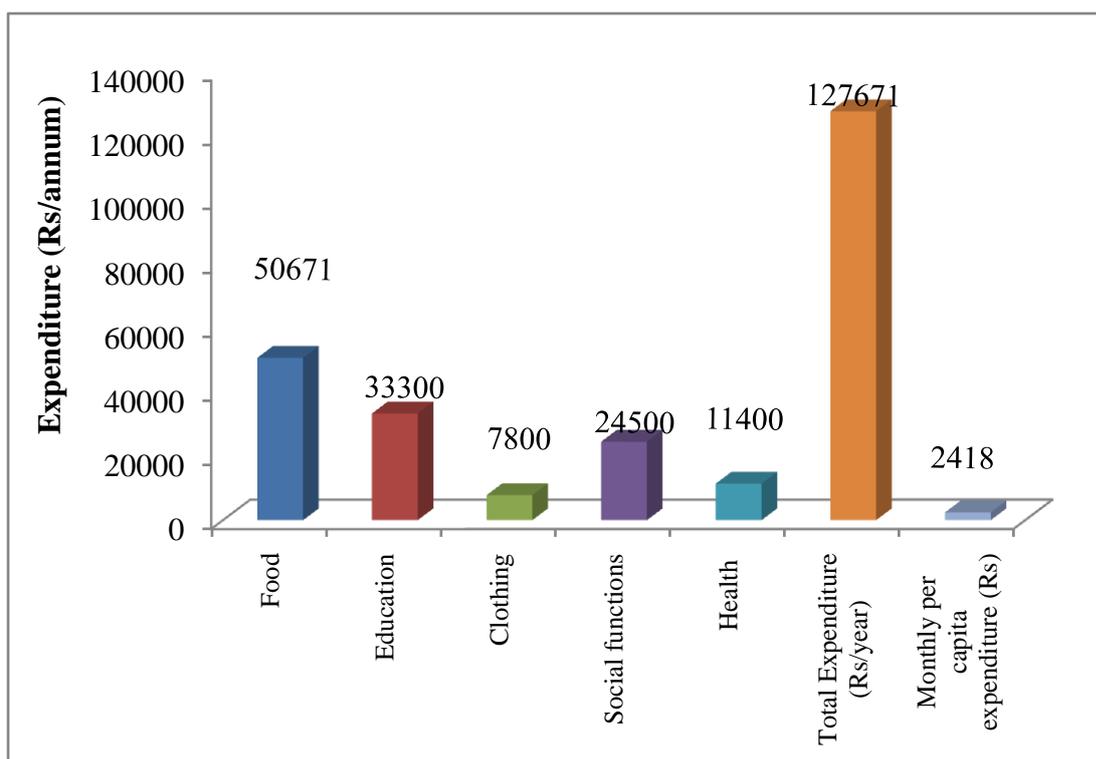


Figure 8: Average annual expenditure of sample HHs in Nelkud 1 Microwatershed

Land holding: The total area cultivated by them is 12.1 hectare. The average land holding of sample HHs is 2.4 hectare. small number of sample HHs (40%) belong to small size group with an average land holding size of 0.9 ha followed by medium farmers (50 %) with an average land holding size of 2.4 ha and large farmers (10 %) with an average holding size of 4.9 hectare.(Table 14)

Table 14: Distribution of land holding among the sample households in Nelkud 1 Microwatershed

Particulars	Units	Values
Small farmers		
Total land	ha	3.4
Sample size	Percent	40
Average land holding	ha	0.9
Medium farmers		
Total land	ha	12.1
Sample size	Percent	50
Average land holding	ha	2.4
Large farmers		
Total land	ha	4.9
Sample size	Percent	10
Average land holding	ha	4.9
Total sample households		
Total land	ha	20.4
Sample size	Percent	100
Average land holding	ha	2.0

Land use: The total land holding in the Nelkud 1 micro-watershed is 20.3 hectare is rain fed land (Table 15). The average land holding per household is worked out to be 2.4 ha.

Table 15: Land use among samples households in Nelkud 1 Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	0.0	0.0
Rain fed Land	100	20.4
Fallow Land	0.0	0.0
Total land holding	100	20.4
Average land holding	2.0	

In the Microwatershed, the prevalent present land uses under perennial plants are neem tree (82.1 %) followed by teak (10.7 %) and banyan tree (7.1 %) (Table16).

Table 16: Number of trees/plants covered in sample farm households in Nelkud 1 Microwatershed

Particulars	Number of Plants/trees	Per cent
Neem trees	23	82.1
Teak	3	10.7
Banyan tree(Alada)	2	7.2
Grand Total	28	100

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

The present dominant crops grown in dry lands in the study area were by redgram (88.2 %) and cotton (11.8%) (Table 17).

Table 17: Present cropping pattern and cropping intensity in Nelkud 1 Microwatershed
% to Grand Total

Crops	Kharif	Grand Total
Cotton	11.8	11.8
Redgram	88.2	88.2
Grand Total	100.0	100

Economic land evaluation

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

In Nelkud 1 Microwatershed, 7 soil series are identified and mapped (Table 18). The distribution of major soil series are Gutti covering an area around 246.2 ha (37.9 %) followed by Marguthi 102.5 ha (15.8 %), Hobli 89.53 ha (13.8 %), Bheemnahalli 59.6 ha (9.2 %), Kinhi 37.39 ha (5.8%) and Kalamundargi 28.0 ha (4.3 %).

Table 18: Distribution of soil series in Nelkud 1 Microwatershed

Sl.No	Soil Series	Mapping Unit Description	Area in ha (%)
1	MGT	Marguti soils are very shallow (<25cm), well drained. They have very dark grayish brown to dark brown, clayey soils and occur on very gently sloping to moderately sloping uplands	102.5 (15.8)
2	BHI	Bhimanahalli soils are shallow (25-50 cm), well drained. They have very dark gray to brown clay soils and occur on very gently sloping to gently sloping uplands.	59.6 (9.2)
3	KGI	Kalamundargi soils are shallow (25-50 cm), well drained. They have very dark grayish brown to brown clay soils and occur on gently sloping to moderately sloping uplands.	28.0 (4.3)
4	DSI	Dinsi soils are moderately shallow (50-75 cm), moderately well drained. They have very dark gray to brown clayey soils and occur on nearly level to very gently sloping uplands	49.75 (7.67)
5	GTT	Gutti soils are moderately shallow (50-75 cm), moderately well drained. They have very dark grayish brown to brown, clayey soils and occur on very gently sloping to gently sloping uplands	246.2 (37.9)
6	HBL	Hobli soils are moderately shallow (50-75 cm), well drained. They have dark brown to brown clay soils and occur on very gently sloping uplands.	89.53 (13.8)
7	KNH	Kinhi soils are very shallow (<25 cm), well drained to somewhat excessive drained. They have dark reddish brown to yellowish red gravelly clay soils and occur on very gently to gently sloping uplands	37.39 (5.8)

Present cropping pattern on different soil series are given in Table 19. Crops grown on Kinhi soils are cotton. Red gram on Dinsi soils. Cotton and redgram on Gutti soils. Red gram on Hobli soils is growing.

Table 19: Cropping pattern on major soil series in Nelkud 1 Microwatershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Grand Total
			Kharif	
KNH	Very shallow (<25 cm)	Cotton	100	100
DSI	Moderately shallow (50-75 cm)	Redgram	100	100
GTT	Moderately shallow (50-75 cm)	Cotton	27.5	27.5
		Redgram	72.5	72.5
HBL	Moderately shallow (50-75 cm)	Redgram	100	100

Land is used for agricultural use for growing cereals, pulse, oilseeds and commercial crops. The soil/ land potential are measures in terms of physical yield and net income. The alternative land use options for each Microwatershed are given below (Table 20).

Table 20: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Nelkud 1 Microwatershed.

Soil Series	Small Farmers	Medium Farmers	Large Farmers
DSI		Redgram (3.3)	
GTT	Redgram (1.3)	Cotton (3), Redgram (1.5)	
HBL		Redgram (2.3)	Redgram (2.7)
KNH	Cotton (2.0)		

The productivity of different crops grown in Nelkud 1 microwatershed under potential yield of the crops is given in Table 21.

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 21. The total cost of cultivation in study area for red gram ranges between Rs.30892/ha in GTT soil (with BCR of 1.36) and Rs.11496/ha in DSI soil (with BCR of 3.29) and cotton ranges between Rs.26856/ha in KNH soil (With BCR of 1.98) and Rs 15248/ha in GTT soil (with BCR of 2.99).

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 21. 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 8266 in cotton and a minimum of Rs.3273 in redgram cultivation.

Table 21: Economic land evaluation and bridging yield gap for different crops in Nelkud 1 Microwatershed

Particulars	KNH (<25 cm)	GTT (50-75 cm)		DSI (50-75 cm)	HBL (50-75 cm)
	Cotton	Cotton	Redgram	Redgram	Redgram
Total cost (Rs/ha)	26856	15248	30892	11496	18678
Gross Return (Rs/ha)	53200	45600	40853	37782	46241
Net returns (Rs/ha)	26344	30353	9961	26286	27563
BCR	1.98	2.99	1.36	3.29	2.48
Farmers Practices (FP)					
FYM (t/ha)	2.3	1.5	2.0	1.0	1.2
Nitrogen (kg/ha)	34.6	49.2	52.8	30.6	45.9
Phosphorus (kg/ha)	88.5	35.4	50.1	22.0	39.9
Potash (kg/ha)	0.0	0.0	0.0	0.0	0.0
Grain (Qtl/ha)	13.5	11.5	9.6	9.6	11.1
Price of Yield (Rs/Qtl)	4000	4000	4400	4000	4250
Soil test based fertilizer Recommendation (STBR)					
FYM (t/ha)	12.4	12.4	7.4	7.4	7.4
Nitrogen (kg/ha)	111.2	111.2	19.8	18.5	18.5
Phosphorus (kg/ha)	74.1	74.1	49.4	49.4	49.4
Potash (kg/ha)	74.1	74.1	24.7	18.5	27.8
Grain (Qtl/ha)	17.3	17.3	12.4	12.4	12.4
% of Adoption/yield gap (STBR-FP) / (STBR)					
FYM (%)	81.3	87.5	72.6	87.1	83.2
Nitrogen (%)	68.9	55.7	-167.2	-65.1	-147.9
Phosphorus (%)	-19.4	52.2	-1.5	55.5	19.2
Potash (%)	100.0	100.0	100.0	100.0	100.0
Grain (%)	22.1	33.3	22.4	22.6	10.2
Value of yield and Fertilizer (Rs)					
Additional Cost (Rs/ha)	11811	14740	5445	7886	6808
Additional Benefits (Rs/ha)	15314	23006	12155	11159	5334
Net change Income (Rs/ha)	3503	8266	6710	3273	-1474

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 22 and Figure 9. The average value of soil nutrient loss is around Rs 2387.6 per ha/year. The total cost of annual soil nutrients is around Rs 1463607 per year for the total area of 649.02 hectare.

Table 22: Estimation of onsite cost of soil erosion in Nelkud 1 Microwatershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	324.02	198623	2041.32	1251327
Phosphorus	0.29	179	12.86	7886
Potash	1.91	1169	38.13	23376
Iron	0.25	156	12.23	7497
Manganese	0.80	492	220.77	135333
Copper	0.09	58	52.62	32257
Zinc	0.02	9	0.61	375
Sulphur	0.22	132	8.62	5284
Boron	0.01	7	0.44	272
Total	327.61	200826	2387.6	1463607

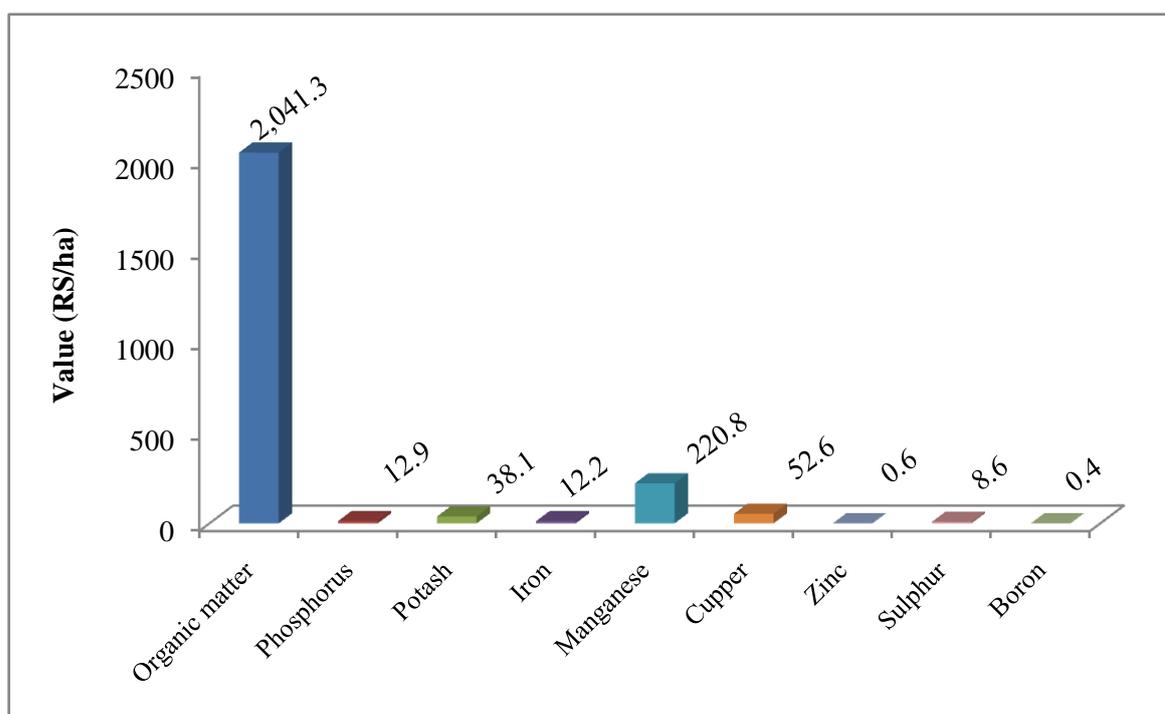


Figure 9: Estimation of onsite cost of soil erosion in Nelkud 1 Microwatershed

The average value of ecosystem service for food grain production is around Rs.22688/ ha/year (Table 23). Per hectare food grain production services is maximum in cotton (Rs. 28348) followed by red gram (Rs.17027).

Table 23: Ecosystem services of food grain production in Nelkud 1 Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Gross Returns (Rs/ha)	Cost of Cultivation (Rs/ha)	Net returns (Rs/ha)
Pulses	Redgram	16.0	9.8	4313	42441	25414	17027
Commercial Crops	Cotton	7.9	12.4	4000	49400	21052	28348
Average value		23.9	11.1	4156	45920	23233	22688

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 24) in red gram (Rs.53573) followed by cotton (Rs.49758).

Table 24: Ecosystem services of water supply in Nelkud 1 Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Cotton	12.4	4976	49758	403
Redgram	9.8	5358	53576	544
Grand Total	11.1	5167	51667	473.5

The main farming constraints in Nelkud 1 Microwatershed to be found are less rainfall, lack of good quality seeds, lack of storage, non availability fertilizers, high crop pests & disease, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on bank and 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 mobile, newspaper, mobile and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 25).

Table 25: Farming constraints related land resources of sample households Nelkud 1 Microwatershed

Sl.No	Particulars	Per cent
1	Less Rainfall	100
2	Lack of good quality seeds	100
3	Non availability Fertilizers	30.0
4	High Crop Pests & Diseases	20.0
5	Animal Pests & Diseases	20.0
6	Lack of transportation	100
7	Lack of storage	90.0
8	Damage of crops by Wild Animals	90.0
9	Non availability of Plant Protection Chemicals	90.0
	Source of loan	
10	Bank	50.0
	Money Leander	50.0
	Grand Total	100
	Village merchants	0.0
	Market for selling	
11	Village market	100
	Grand Total	100
	Sources of Agri-Technology information	
12	Mobile	20.0
	Newspaper	80.0
	Grand Total	100

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