ICAR-NBSS&LUP Sujala MWS Publ.4

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

SHIRUNJ (4D4A3L2a) MICROWATERSHED

Gadag Taluk, Gadag District, Karnataka

Karnataka Watershed Development Project – II

SUJALA – III

World Bank funded Project

The World Bank

ICAR – NATIONAL BUREAU OF SOIL SURVEY AND LAND USE PLANNING

ICAR - NBSS & LUP

WATERSHED DEVELOPMENT DEPARTMENT
GOVT. OF KARNATAKA, BANGALORE

About ICAR - NBSS&LUP

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

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

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 Shirunj (4D4A3L2a) Microwatershed, Gadag Taluk, Gadag District, Karnataka”, ICAR-NBSS&LUP Sujala MWS Publ.4, ICAR – NBSS & LUP, RC, Bangalore. p.87 & 33.

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PREFACE

In Karnataka, as in other Indian States, the livelihoods of rural people are intertwined with farming pursuits. Thechallenges in agriculture are seriously threatening the livelihood of a large number of farmers as they have been practicing farming in contextual factors beyond their control. Climatic factors are the most important ones and have become much more significant in recent times due to rapid climate changes induced by intensive anthropogenic activities affecting our ecosystem in multiple ways. Climate change has become the reality, it is happening and efforts to evolve and demonstrate climate resilient technologies have become essential. Due to the already over stressed scenario of agrarian sector, the climate change is resulting in manifold increase in the complexities, pushing the rural mass to face more and more unpredictable situations. The rising temperatures and unpredictable rainfall patterns are going to test seriously the informed decisions farmers have to make in order to survive in farming and sustain their livelihood.

It is generally recognized that impacts of climate change shall not be uniform across the globe. It is said that impact of climate change is more severe in South Asia. Based on the analysis of meteorological data, it is predicted that in India, there will be upward trend in mean temperature, downward trend in relative humidity, annual rainfall and number of wet days in a year. Also, in general, phenomena like erratic monsoon, spread of tropical diseases, rise in sea levels, changes in availability of fresh water, frequent floods, droughts, heat waves, storms and hurricanes are predicted. Each one of these adverse situations are already being experienced in various parts of India and also at the global level. Decline in agricultural productivity of small and marginal farmers becoming more vulnerable is already witnessed.

In Karnataka, more than 60 per cent of the population live in rural areas and depend on agriculture and allied activities for their livelihood. Though the state has achieved significant progress in increasing the yield of many crops, there is tremendous pressure on the land resources due to the growing and competing demands of various land uses. This is reflected in the alarming rate of land degradation observed. Already more than 50 per cent of the area is affected by various forms of degradation. If this trend continues, the sustainability of the fragile ecosystem will be badly affected. The adverse effects of change in the climatic factors are putting additional stress on the land resources and the farmers dependent on this.

The natural resources (land, water and vegetation) of the state need adequate and constant care and management, backed by site-specific technological interventions and investments particularly by the government. Detailed database pertaining to the nature of

the land resources, their constraints, inherent potentials and suitability for various land based rural enterprises, crops and other uses is a prerequisite for preparing location-specific action plans, which are in tune with the inherent capability of the resources. Any effort to evolve climate resilient technologies has to be based on the baseline scientific database. Then only one can expect effective implementation of climate resilient technologies, monitor the progress, make essential review of the strategy, and finally evaluate the effectiveness of the implemented programs. The information available at present on the land resources of the state are of general nature and useful only for general purpose planning. Since the need of the hour is to have site-specific information suitable for farm level planning and detailed characterization and delineation of the existing land resources of an area into similar management units is the only option.

ICAR-NBSS&LUP, Regional Centre, Bangalore has taken up a project sponsored by the Karnataka Watershed Development Project-II, (Sujala-III), Government of Karnataka funded by the World Bank under Component -1 Land Resource Inventry. This study was taken up to demonstrate the utility of such a database in reviewing, monitoring and evaluating all the land based watershed development programs on a scientific footing. To meet the requirements of various land use planners at grassroots level, the present study on "Land Resource Inventory and Socio Economic Status of Farm Households for Watershed Planning and Development of Shirunj Microwatershed, Gadag Taluk and District, Karnataka"for integrated development was taken up in collaboration with theState Agricutural Universities, IISC, KSRSAC, KSNDMC as Consortia partners. The project provides detailed land resource information at cadastral level (1:7920 scale) for all the plots and socio-economic status of farm households covering thirty per cent farmers randomely selected representing landed and landless class of farmers in the micowatershed. The project report with the accompanying maps for the microwatershed will provide required detailed database for evolving effective land use plan, alternative land use options and conservation plans for the planners, administrators, agricutural extention personnel, KVK officials, developmental departments and other land users to manage the land resources in a sustainable manner.

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

Nagpur **S.K. SINGH**

Date: 10.05.2016 Director, ICAR - NBSS&LUP, Nagpur

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PART-A

LAND RESOURCE INVENTORY

Contents

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The land resource inventory of Shirunj 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 area extent, characteristics, classification and use potentials of the soils in the microwartershed.

The present study covers an area of 611 ha in Gadag taluk of Gadag district, Karnataka. The climate is semiarid and categorized as drought prone with an average annual rainfall of 652 mm of which about 379 mm is received during south –west monsoon, 149 mm during north-east and the remaining 124 mm during the rest of the year. An area of about 92 per cent is covered by soils, 5 per cent by rock lands and 3 per cent by waterbodies, settlements and others. The salient findings from the land resource inventory are summarized briefly below.

- *The soils belong to 9 soil series and 30 soil phases (management units) and 7 land management units.*
- *The length of crop growing period is about 150 days starting from the 3rd week of June to 1rd week of October.*
- *From the master soil map, several interpretative and thematic maps like land capability, soil depth, surface soil texture, soil gravelliness, available water capacity, soil slope and soil erosion were generated.*
- *Soil fertility status maps for macro and micronutrients were generated based on the surface soil samples collected at every 250 m grid interval.*
- *Land suitability for growing major agricultural and horticultural crops were assessed and maps showing degree of suitability along with constraints were generated.*
- *About 92 per cent area is suitable for agriculture and 5 per cent is not suitable for agriculture but well suited for forestry, pasture, agroforestry, silvi-pasture, installation of wind mills and as habitat for wildlife.*
- *About 15 per cent of the soils are deep (100- 150 cm), 23 per cent are moderately shallow to shallow (25-75 cm) and about 12 per cent are moderately deep (75-100 cm) soils.*
- *About 67 per cent of the area has clayey soils at the surface and 26 per cent loamy soils.*
- *About 4 per cent of the area has non-gravelly soils, 20 per cent has gravelly soils (15-35 % gravel) and 68 per cent has very gravelly and extremely (35- 80% gravel) gravelly soils.*
- *About 9 per cent of the area has soils that are very high (>200mm/m) in available water capacity, 14 per cent medium (100-150 mm/m) and about 69 per cent low (50-100 mm/m) and very low (<50mm/m).*
- *About 68 per cent of the area has very gently sloping (1-3% slope) lands and about 24 per cent gently (3-5% slope) to moderately sloping (5-10% slope) lands.*
- *An area of about 27 per cent has soils that are slightly eroded (e1), 56 per cent moderately eroded (e2) and 9 per cent severely eroded (e3).*

- *An area of about 45 per cent has soils that are moderately to strongly alkaline (pH 7.8 to 9.0), 41 per cent slightly alkaline (pH 7.3 to7.8) and a small area of about 6 per cent has soils that are neutral (pH 6.5 to 7.3).*
- *The Electrical Conductivity (EC) of the soils are dominantly <2 dsm^{-1}indicating that most of the soils are non-saline.*
- *About less than one per cent area has soils that are low (<0.5%), 23 per cent medium (0.5-0.75%) and 69 per cent high (>0.75%)in organic carbon.*
- *Major area of 82 per cent has soils that are low (<23 kg/ha), 9 per cent medium (23-57 kg/ha) and one per cent high (>57 kg/ha) in available phosphorus.*
- *About 43 per cent medium (145-337 kg/ha) and49 per cent low (<145 kg/ha) in available potassium.*
- *Available sulphur is low (<10 ppm) in about 51per cent area and medium (10-20 ppm) in about 41 per cent area.*
- *Available boron is low (0.5 ppm) in about 43 per cent area, 44 per cent medium (0.5-1.0 ppm) and 5 per cent high (>1.0 ppm).*
- *Available iron content is deficient (<4.5 ppm) in about 4 per cent area and sufficient (>4.5 ppm) in 88 per cent area.*
- *Available manganese and copper is sufficient in all the soils.*
- *About 78 per cent area has soils that are deficient (<0.6 ppm) in available zinc and 14 per cent is sufficient (>0.6 ppm).*
- *The land suitability for 14 major crops grown in the microwatershed were assessed and the areas that are highly suitable (S1) and moderately suitable (S2) are given below. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, price and finally the demand and supply position.*

Land suitability for various crops in the microwatershed

Crop	*Suitability Area in ha (%)*			*Crop*	*Suitability Area in ha (%)*	
	Highly suitable (S1)	*Moderately suitable (S2)*			*Highly suitable (S1)*	*Moderately suitable (S2)*
Sorghum	*127 (21)*	*55 (9)*		*Banana*	-	*167 (27)*
Maize	-	*55 (9)*		*Pomegranate*	-	*167 (27)*
Red gram	-	*168(27)*		*Onion*	-	*143(23)*
Bengalgram	-	*74 (12)*		*Chillies*	-	*88(14)*
Groundnut	-	*55 (9)*		*Tomato*	-	*88(14)*
Sunflower	*26 (4)*	*48 (8)*		*Marigold*	-	*182 (30)*
Cotton	*55 (9)*	*87 (14)*		*Chrysanthemum*	-	*182(30)*

Apart from the individual crop suitability, a proposed crop plan has been prepared for the 7 identified LMUs by considering only the highly and moderately suitable lands for different crops and cropping systems with food, fibre and horticulture crops.

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

Chapter 1

INTRODUCTION

Soil being a vital natural resource on whose proper use depends the life supporting systems of a country and the socioeconomic development of its people. Soils provide food, fodder 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, agro climatic setting, and use and management. There is, therefore, tremendous pressure on land and water resources, which is causing decline in soil-health and stagnation in productivity. The soils have been degrading at an estimated rate of one million hectares per year and ground water levels have been receding at an alarming rate resulting in decline in the ground water resource. Further, land degradation has emerged as a serious problem which has already affected about 38 lakh ha of cultivated area in the State. Soil erosion alone has degraded about 35 lakh ha. Almost all the uncultivated areas are facing various degrees of degradation, particularly soil erosion,salinity and alkalinity has emerged as a major problem (>3.5 lakh ha) in the irrigated areas of the State. Nutrient depletion and declining factor productivity is common in both rainfed and irrigated areas. The degradation is continuing at an alarming rate and there appears to be no systematic effort among the stakeholders to contain this process. In recent times, an aberration of weather due to climate change phenomenon has added another dimension leading to unpredictable situations to be tackled by the farmers.

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

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

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

Therefore, the land resource inventory required for farm level planning is the one which investigates all the parameters which are critical for productivity *viz.*, soils, site characteristics like slope, erosion, gravelliness and stoniness, climate, water, topography, geology, hydrology, vegetation,

crops, land use pattern, animal population, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government etc. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed.

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

The Karnataka state has been divided into three major physiographic divisions, namely the Deccan Plateau, Hill Ranges and Coastal Plain (NATMO, 1980). These divisions have been subdivided into four regions based on their geographic location, namely South Deccan Plateau, Western Ghats, Eastern Ghats and West Coast Plains.

South Deccan Plateau: South Deccan Plateau has been divided into five landscapes based on geological formations. They are granite and granite gneiss, basalt, laterite, sedimentary and metamorphic.

The South Deccan Plateau known locally as the Karnataka Plateau, covers an area of about 15.8 m ha. The major part of the Plateau is peneplain in various stages of development and destruction. The Plateau is divided into Malnad (Hilly area) and Maidan (Plains). Malnad is an area of rolling to undulating uplands with many valleys and is a transitional zone between the Western Ghats and the Maidan. It covers an area of about 6.2 mha. The Maidan has a rolling surface with altitude of 900-1150 m, 600-850 m, 450-550 m and 300-400 m above MSL. The highest surface is in the southwestern part of the state. The lowest surface is in the northeast in the valleys of the Tungabhadra and Hagari rivers.

The northern part of the Plateau is drained by the Krishna river and its tributaries, the Bhima, Malaprabha, Ghataprabha and Tungabhadra and the southern part by the Cauvery river and its tributaries, the Hemavathi, Kabini and Lakshmanthirtha.

The plateau has been divided into five landscapes, namely,

1. Granite and gneiss landform (Dsa)
2. Basalt landform (Dsb)
3. Laterite landform (Dsc)
4. Metamorphic landform (Dsd 1) and
5. Sedimentary landform (Dsd 2)

The climate of the South Deccan Plateau is hot with dry summers and mild winters. The annual rainfall ranges from 600-1000 mm in most of the plateau region except in parts of Bellary, Raichur and

Bijapur districts in northern Karnataka where the rainfall ranges from as low as 350-580 mm. The length of crop growing period ranges from 120-150 days and less than 90 days in the arid regions.Dominant rainfed crops grown in the Plateau region are sorghum, finger millet, groundnut, maize, sunflower, cotton and pulses. The important irrigated crops are paddy, sugarcane, vegetables and flowers.

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

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

GEOGRAPHICAL SETTING

2.1 Location and Extent

The study area of Shirunj microwatershed comprising parts of Shirunj, Shirol and Nabdur village (Shirahatti subwatershed)is located in the central part of northern Karnataka in Gadag Taluk, Gadag District, Karnataka State (Fig.2.1). It lies between $15^0$16' – $15^0$18' North latitudesand $75^0$35' – $75^0$37' East longitudesand covers an area of 611.35 ha. It is about 40 km south of Gadag and is surrounded by Shirol on the east,Hosurvillage in the northwest, Mulgund in the west, Shirunj on the southwest and Yelisiruron the south.

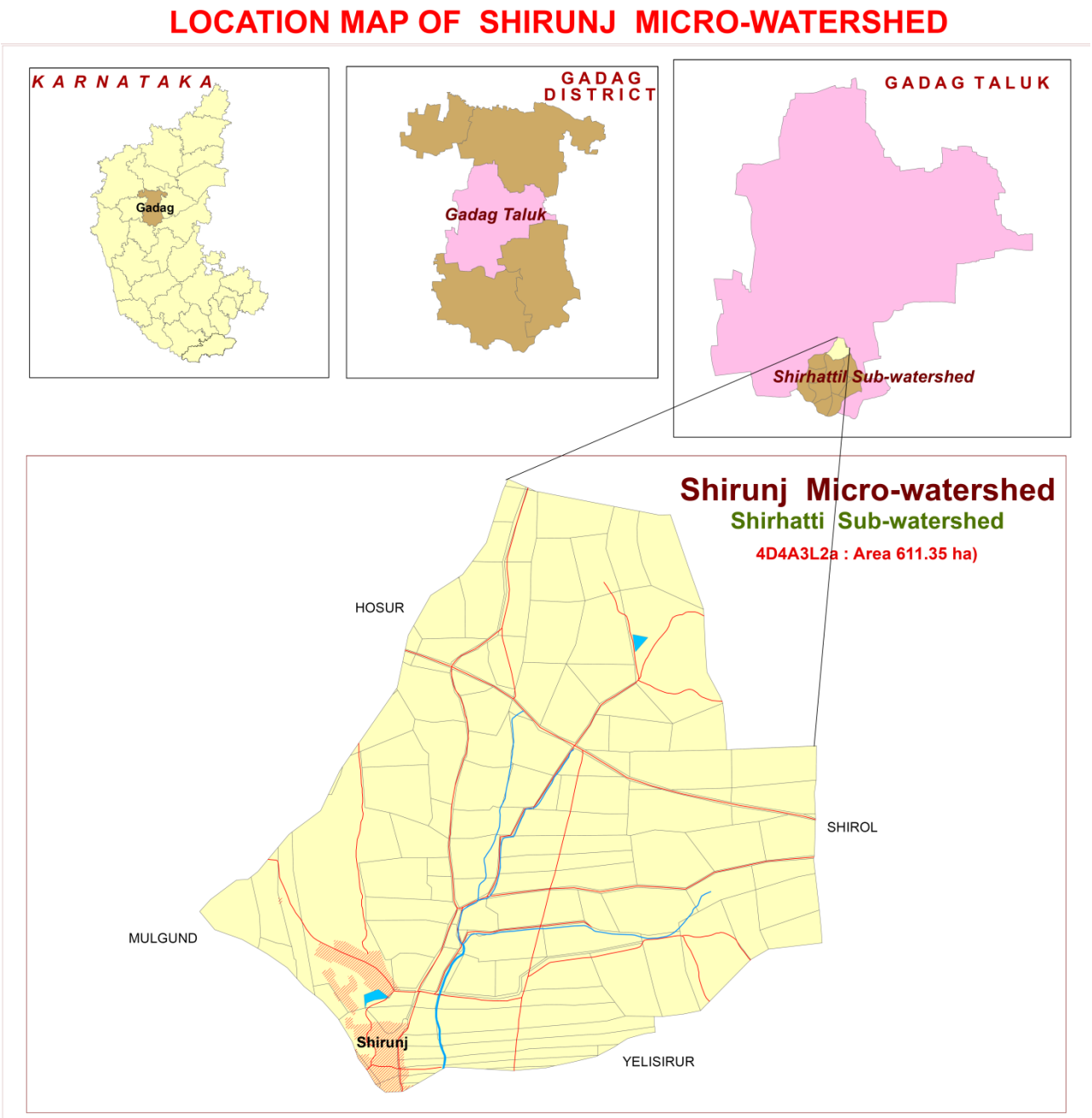


Fig.2.1 Location map of Shirunj microwatershed

2.2 Geology

Major rock formations observed in the microwatershedare Gadag Schist with thick coating of iron oxides and Banded Ferrugenous Quartzite (Fig.2.2aandb). The ridges have capping of Banded Ferrugenous Quartzite (BFQ), whereas side slopes near the streams are dominated by schist. Due to its fine texture, the soils formed from these rocks are mostly clayey in nature. The presence of iron rich banded ferrugenous quartzite is responsible for the dark red colour of the soils observed in the microwatershed.

Fig.2.2.a Banded Ferrugenous Quartzite

Fig.2.2.b Gadag Schist

2.3 Physiography

Physiographically, the area has been broadly divided into two landscapes based on geology. They are Schist and Banded Ferrugenous Quartzite. Based on slope and its relief features, the area has been further divided into four land forms, *viz;*mounds/ridges, summits, side slopes and very gently sloping uplands.The elevation ranges from 681 to705 m in the gently sloping uplands and in the mounds. The mounds and ridges are mostly covered by rock outcrops.

2.4 Drainage

The area is drained by several small seasonal streams that join Dodd Halla 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 capableof storing the water that flows during the rainy season. Due to this, the ground water recharge is very much affected. This is reflected in the failure of many bore wells in the village. If the available rain water is properly harnessed by constructing new tanks and recharge structures at appropriate places in the village, then the drinking and irrigation needs of the entire area can be easily met. The drainage network is dendritic to sub parallel.

2.5 Climate

The district falls under semiarid tract of the state and is categorized as drought prone with average annual rainfall of 652mm (Table 2.1). Of the total rainfall, maximum of 379 mm is recived during the south–west monsoon period from June to September,the north-east monsoon from October to early Decembercontributes about 149 mm and the remaining 124 mm during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 42°C and in December and January, the temperatures go down to 16°C. Rainfall distribution is shown in Figure 2.3. The average potential evapotranspiration (PET) is 137 mm and varies from a low of 109 mm in December to 182 mm in the month of May. Generally, the length of crop growing period (LGP) is 150 days and starts from 3rd week of June to third week of November.

Table 2.1 Mean Monthly Rainfall, PET, 1/2 PET atGadag Taluk, Gadag District

Sl. no.	Months	Rainfall	PET	1/2 PET
1	January	1.50	122.20	61.10
2	February	1.60	131.40	65.70
3	March	15.40	172.00	86.00
4	April	36.10	178.80	89.40
5	May	70.00	182.00	91.00
6	June	99.20	146.20	73.10
7	July	83.70	130.80	65.40
8	August	82.60	130.80	65.40
9	September	113.10	123.20	61.60
10	October	104.20	113.10	56.55
11	November	34.60	112.70	56.35
12	December	9.80	108.70	54.35
TOTAL		651.80	137.66	

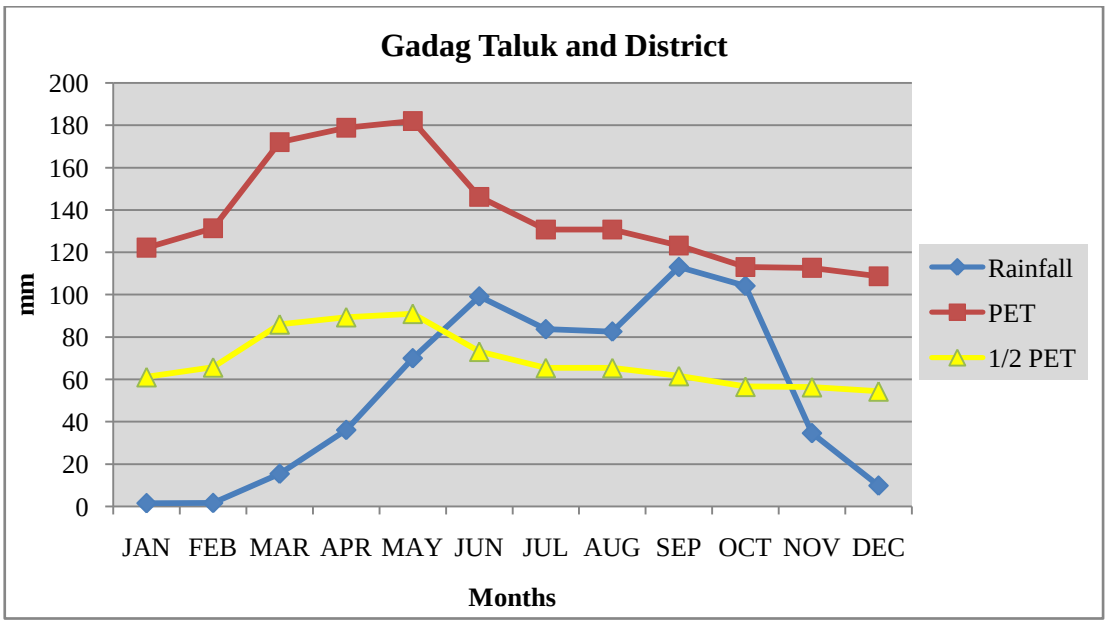


Fig. 2.3 Rainfall distribution in Gadagtaluk,Gadag district

2.6 Natural Vegetation

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

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

2.7 Land Utilization

About 83 per cent area (Table 2.2) in Gadag taluk is cultivated at present and 37 per cent of the area is sown more than once. An area of about 2 per cent is currently barren. Forests occupy an area of about 7 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. 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 Shirunj 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 dominant crops grown in the microwatershed are maize, cotton, groundnut,banana, onion, chilly, sugarcane etc. are shown in Fig.2.4.

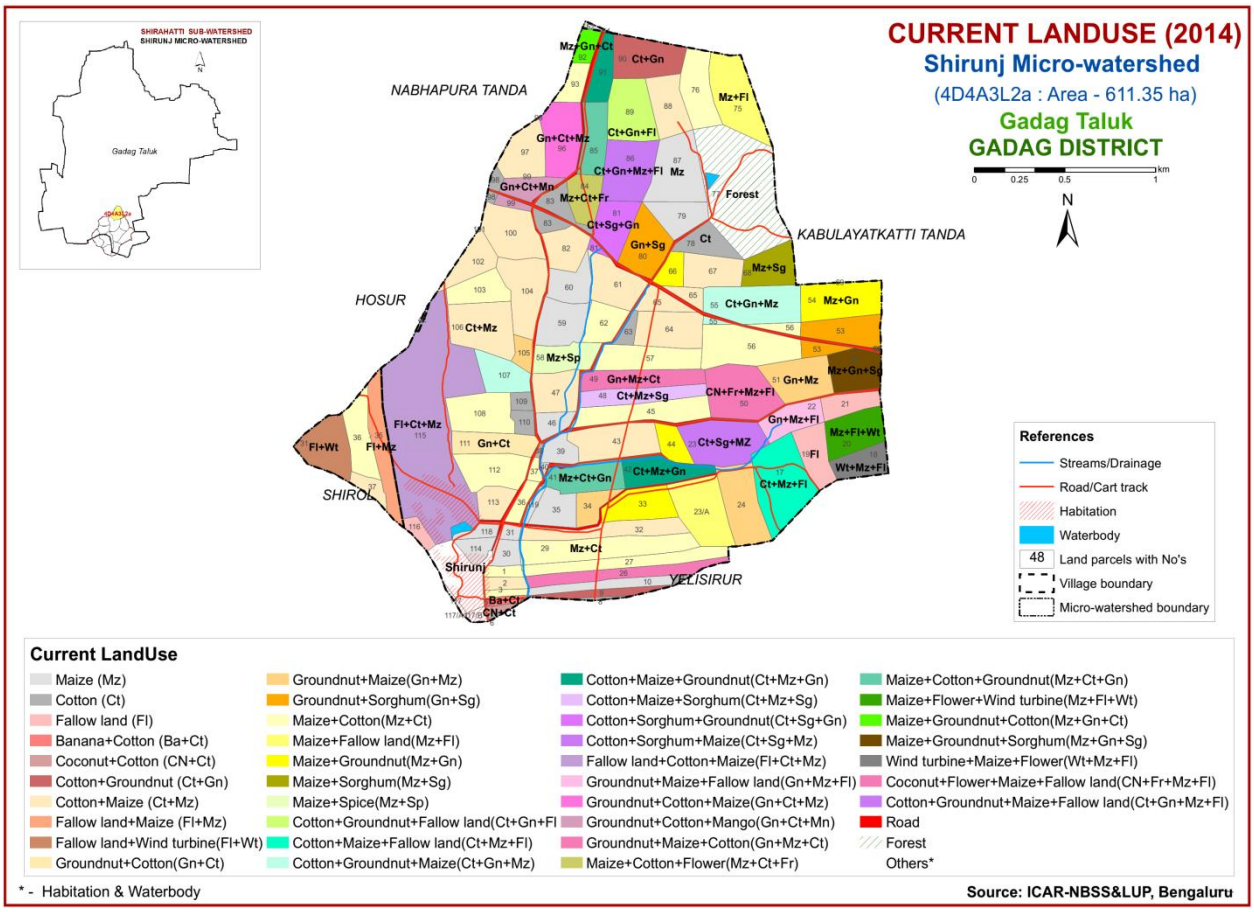


Fig.2.4 Current Land Use – Shirunj microwatershed

Simultaneously, enumeration of wells (bore wells and open wells) in the microwatershed is made and their location in different survey numbers is located on the cadastral map. Map showing the location of wells and other water bodies in the Shirunj microwatershed is given (Fig.2.5).

Table 2.2 Land Utilization in Gadag District

Sl.No.	Agricultural land use	Area (ha)	Per cent
1	Total cultivated area	384731	82.61
2	Cultivable wasteland	1010	0.21
3	Pasture land	2592	0.55
4	Forest	32614	7.0
5	Land put to non-agricultural use	10481	2.25
6	Miscellaneous tree crops and grooves not included in the net area sown	263	0.05
7	Area sown more than once	173802	-
8	Current Barren and uncultivated land	11628	2.5
9	Current fallow	18937	4.06
10	Other fallow	3459	0.74
	Total geographical area	**465715**	-

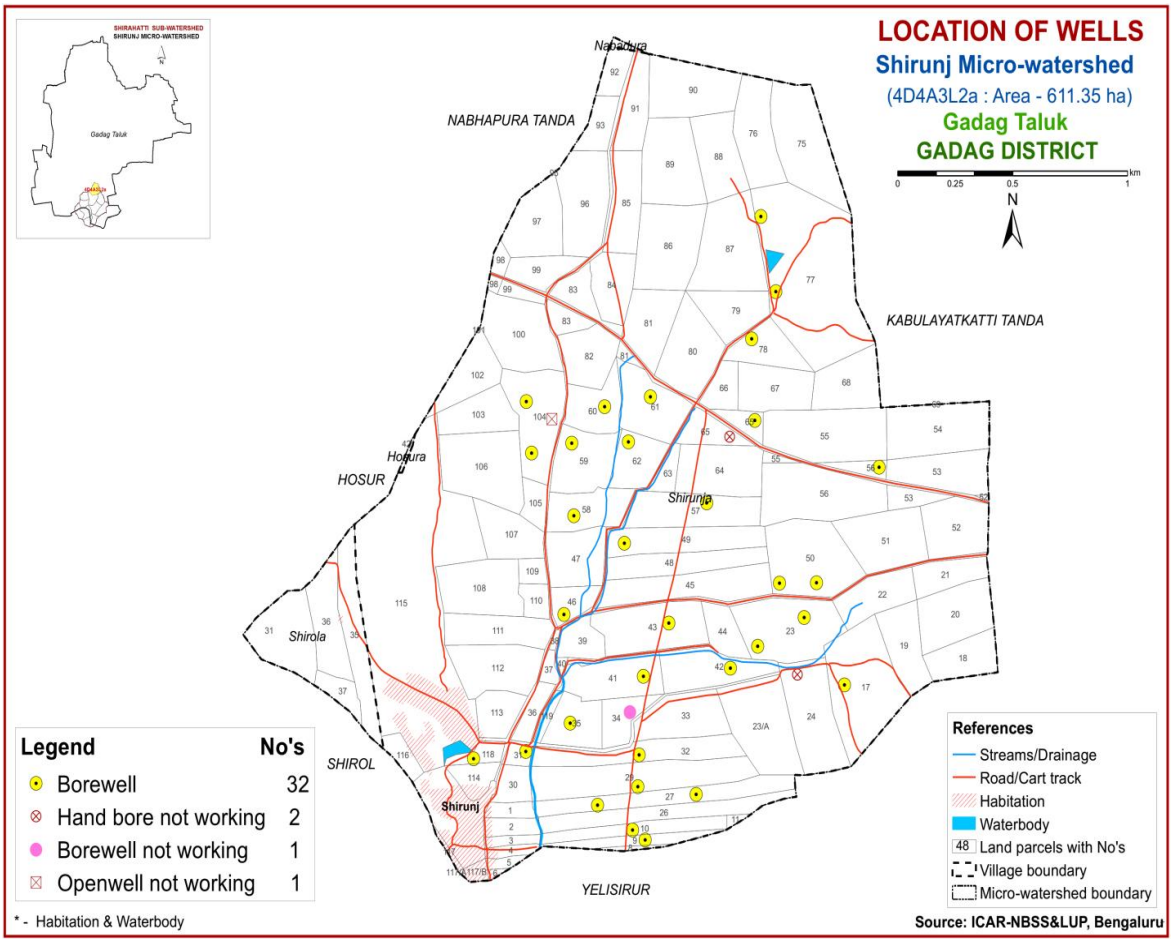


Fig.2.5 Location of Wells- Shirunj microwatershed

Cotton

Sorghum

Chillies

Onion

Sunflower

Maize

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 Shirunj 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.) and followed by grouping of similar areas based on soil-site characteristics into homogeneous (management units) units and showing their extent and geographic distribution on the microwatershed cadastral map. The detailed survey at 1:7920 scale was carried out in 611.35 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 landscapes, landforms and other surface features. The cadastral map was overlaid on the satellite imagery (Fig.3.2) that helps to identify the parcel boundaries and other permanent 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.3.3). 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 for the selection of transects in the microwatershed.

3.2 Image Interpretation for Physiography

False Colour Composites (FCC) 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 into two land scapes, *viz.*,schist and banded ferrugenous quartzite. They were divided into landforms such as ridges, mounds, uplands and lowlands based on slope. They were further subdivided into physiographic/image interpretation units based on image characteristics. The image interpretation legend for physiography is given below.

Image Interpretation Legend for Physiography

S-Schist landform

S1		Uplands
	S11	Summits, greenish blue
	S12	Side slopes, greenish grey
S2		Very gently sloping uplands
	S21	Very gently sloping uplands, greenish grey
	S22	Very gently sloping uplands, medium grey
	S23	Very gently sloping uplands, dark grey
	S24	Very gently sloping uplands, light green (scrub lands)
	S25	Very gently sloping uplands, grey and pink
	S26	Very gently sloping uplands, whitish grey (eroded)

Q- Banded Ferrugenous Quartzite

Q1		Hills/Ridges/Mounds
	Q11	Summit, bluish grey
	Q12	Side slopes
	Q121	Side slopes, grayish green
	Q122	Side slopes, yellowish green

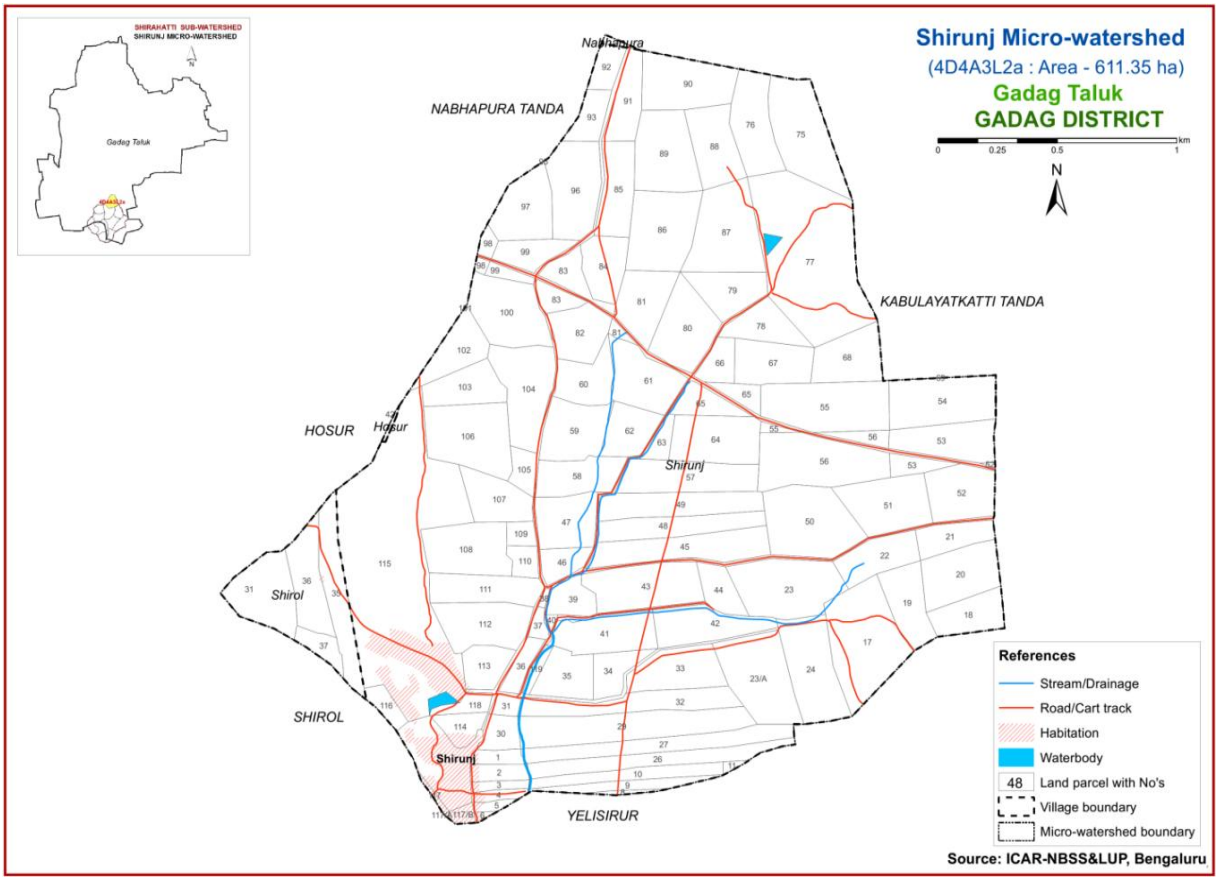


Fig 3.1 Scanned and Digitized Cadastral map of Shirunj microwatershed

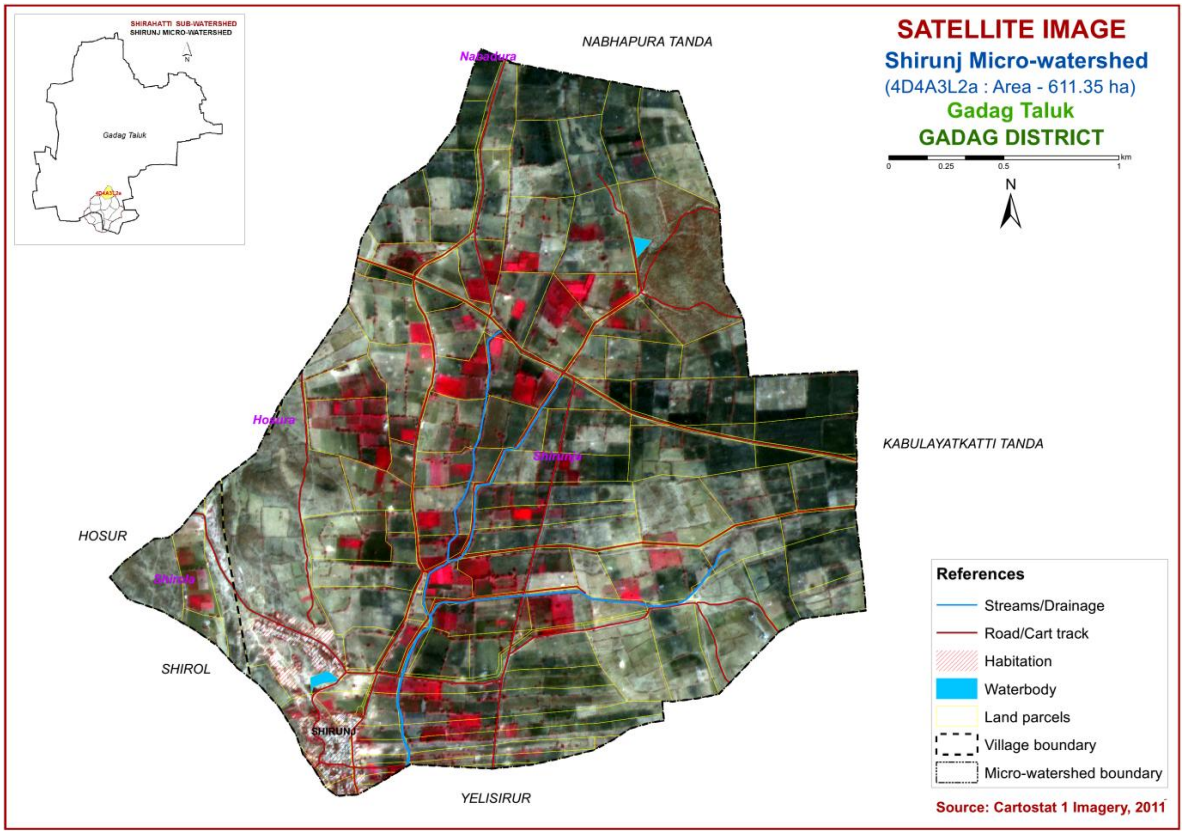


Fig.3.2Cadastral map overlaid on IRS PAN+LISS IV merged imagery of Shirunj microwatershed

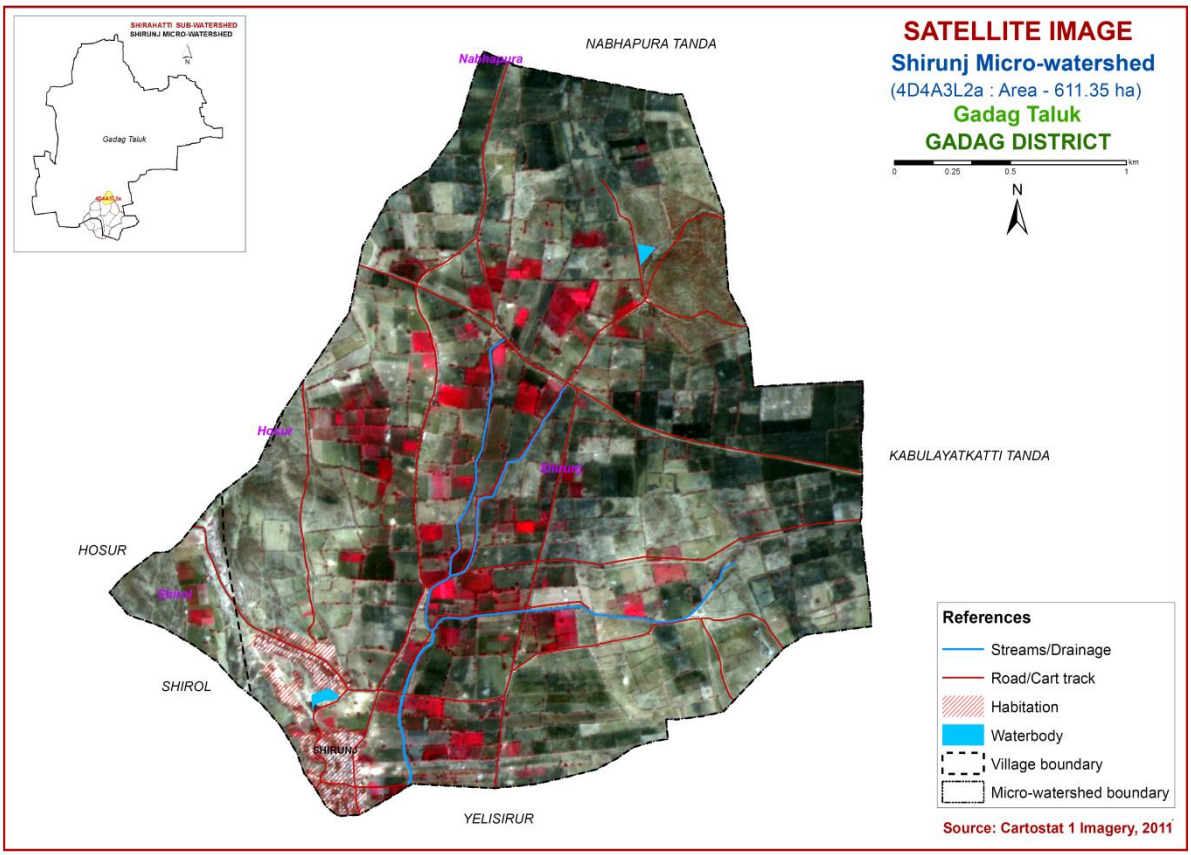


Fig.3.3 Satellite Image of Shirunj microwatershed

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 few selected places.

The field boundaries and survey numbers given on the cadastral sheet were located on the ground by following permanent features like roads, cart tracks, nallas, streams, tanks etc., and wherever changes were noticed, they were incorporated on the microwatershed cadastral map. Then, intensive traversing of each physiographic unit like hills, ridges and uplands was carried out. Based on the variability observed on the surface, transects were selected across the slope covering all the landform units in the microwatershed (Natarajan and Dipak Sarkar, 2010).

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

Based on the soil-site characteristics, the soils were grouped into different soil series. Soil series is the most homogeneous unit having similar horizons and properties and behaves similarly for a given level of management). Soil depth, texture, colour, kind of horizon and horizon sequence, amount and nature of gravel present, nature of substratum etc, were used as the major differentiating characteristics for identifying soil series occurring in the area. The differentiating characteristics used for identifying the soil series are given in Table 3.1. Based on the above characteristics, 9soil series were identified in the Shirunj microwatershed.

Table 3.1 Differentiating Characteristics used for identifying Soil Series
(Characteristics are of Series control section)

SOILS OF BANDED FERRUGENOUS QUARTZITE (BFQ) LANDSCAPE							
Sl.no	**Soil Series**	**Depth (cm)**	**Colour**	**Texture**	**Gravel (%)**	**Horizon sequence**	**Calcar-eousness**
1	Attikatti (Akt)	25-50	2.5YR 3/2, 3/3 5YR 4/4	cl, c	10-30	Ap-Bw-Cr	-
2	Dindur (Ddr)	<25	2.5YR 2.5/3, 2.5/4,3/3, 3/4, 3/6	cl, c	>35	Ap -Cr	-
3	Shirol (Srl)	<25	5YR 3/3, 3/4, 7.5YR 3/2, 3/3	cl, c	10-20	Ap -Cr	-
4	Dhoni (Dni)	100-150	2.5YR 3/4 5YR 3/3, 3/4	cl, sc, c	>35	Ap-Bw-Cr	-
5	Nabhapur (Nbp)	25-50	5 YR 2.5/2, 3/3, 3/4, 4/3 2.5YR 3/3, 3/4, 3/6	cl, c	>35	Ap-Bw-Cr	
6	Jelligeri (Jlg)	75-100	10YR2/1,2/2,3/1 7.5YR2.5/2,3/1, 3/2,3/3	c	-	Ap-Bw-Cr	-

SOILS OF SCHIST LANDSCAPE							
7	Attikatti Tanda (Att)	50-75	10YR2/2,3/1,4/2, 5/4 7.5YR2.5/1,3/2	c	-	Ap-Bw-Crk	-
8	Mahalingapur Tanda (Mpt)	100-150	10YR2/2,3/1,3/2, 3/3,4/2 7.5YR2.5/3, 3/2	c	-	Ap-Bw-Crk	-
9	Yelisirunj (Ysj)	25-50	7.5YR2/2,2.5/3,4/2 10YR3/1,3/2	cl-c	<15	Ap-Bw-Cr	-

3.4 Laboratory Characterization

Soil samples were collected from representative master profiles for laboratory characterization by following the methods outlined in the Laboratory Manual(Sarma *et al* (1987).Surface soil samples collected from farmer`s fields (93 samples) for fertility status (major and micronutrients) at 250m grid interval were analyzed in the laboratory (Katyal and Rattan, 2003). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated for the microwatershed.

3.5 Finalization of Soil Maps

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

The soil mapping units are shown on the map(Fig.3.4) in the form of numbers and symbols. During the survey about 26 profile pits, few minipits and a few auger bores representing different landforms occurring in the microwatershed were studied. All the profile locations are indicated on the village cadastral map in the form of a triangle. In addition to the profile study, spot observations in the form of minipits, road cuts, terrace cuts etc., were studied to validate the soil boundaries on the soil map.The soil map shows the geographic distribution of 30 mapping units representing 9 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 30 phases mapped in the microwatershed. Each mapping unit (soil phase) delineated on the map has similar soil and site characteristics. In other words, all the farms or survey numbers included in one phase will have similar management needs and they have to be treated accordingly.

The 30 soil phases identified and mapped in the microwatershed were regrouped into 10 Land Management Units (LMU's) for the purpose of preparing a proposed crop plan for sustained development of the microwatershed. The database (soil phases) generated under LRI was utilized for identifying Land Management Units (LMUs) based on the management needs. One or more than one soil site characteristic having influence on the management have been choosen for identification and delineation of LMUs. For Shirunj microwatershed, five soil and site characteristics, namely soil depth, soil texture, slope, erosion and gravel content have been considered for defining LMUs. The land management units are expected to behave similarly for a given level of management.

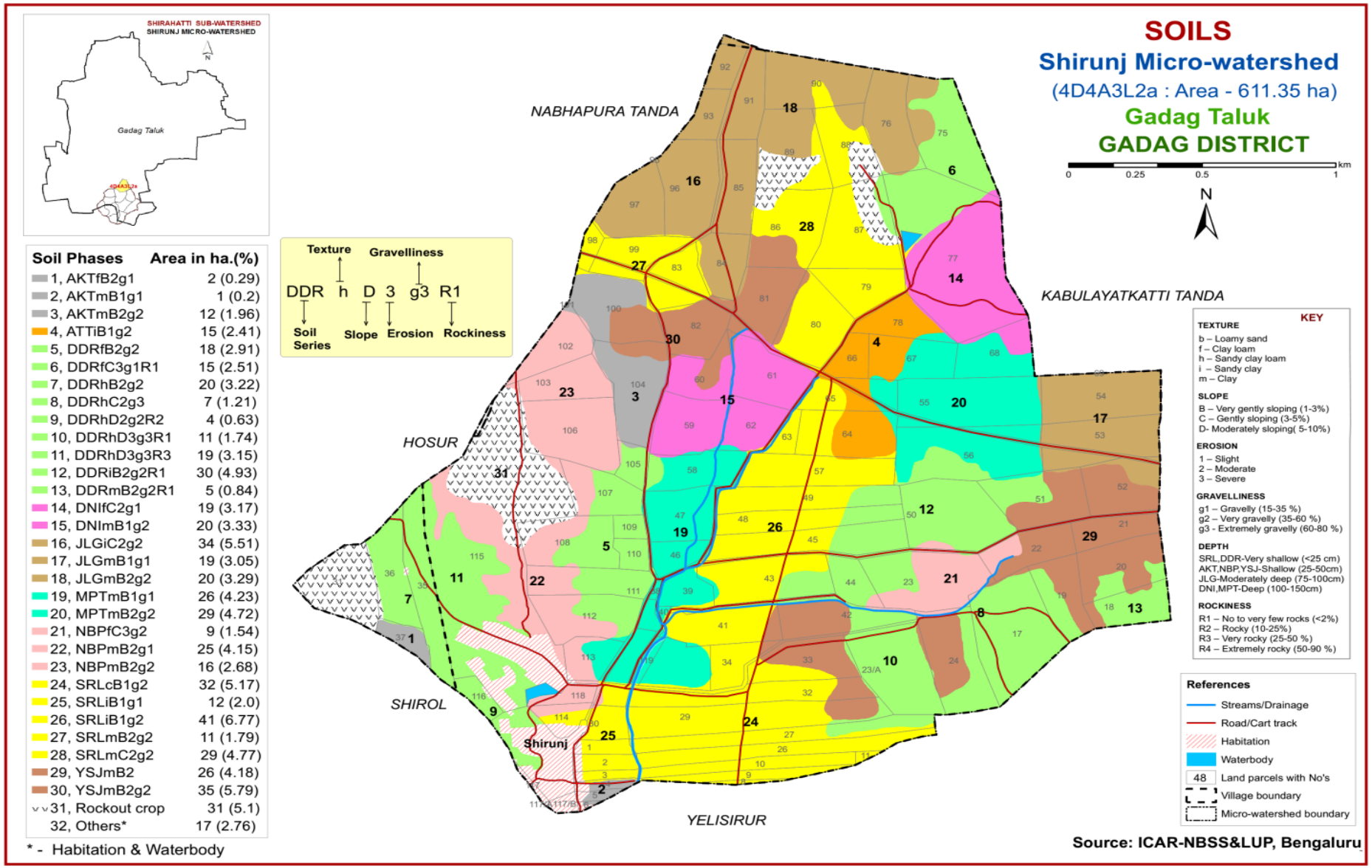


Fig 3.4 Soil phase or management units map of Shirunj microwatershed

Table 3.2 Soil Legend

Soil mapping unit	Soil Series	Soil phases	Mapping unit description	Area in ha (%)
	AKT	Attikatti soils are shallow (25-50 cm), well drained, have dark reddish brown to dusky red clay loam to clay soils developed on Banded Ferrugenous Quartzite and occur on very gently to gently sloping uplands under cultivation		**14.99 (2.45)**
1		AKTfB2g1	Clay loam surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)	1.78 (0.29)
2		AKTmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	1.24 (0.20)
3		AKTmB2g2	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	11.97 (1.96)
	ATT	Attikatti Tanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clay soils developed on schist and occur on very gently sloping uplands under cultivation		**14.75 (2.41)**
4		ATTiB1g2	Sandy clay surface, slope 1-3 %, slight erosion, very gravelly (35-60 %)	14.75 (2.41)
	DDR	Dindur soils are very shallow (<25 cm), well drained, have dark reddish brown to dark red gravelly clay loam to gravelly clay soils developed on Banded Ferrugenous Quartzite and occur on very gently to moderately sloping uplands under cultivation		**129.23 (21.14)**
5		DDRfB2g2	Clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	17.79 (2.91)
6		DDRfC3g1R1	Clay loam surface, slope 3-5 %, severe erosion, gravelly (15-35%), fairly rocky (2-10%)	15.32 (2.51)
7		DDRhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	19.67 (3.22)
8		DDRhC3g3	Sandy clay loam surface, slope 3-5 %, severe erosion, extremely gravelly (60-80 %)	7.38 (1.21)
9		DDRhD2g2R2	Sandy clay loam surface, slope 5-10%, moderate erosion, very gravelly (35-60%), rocky (10-25 %)	3.87 (0.63)
10		DDRhD3g3R1	Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (60-80%), fairly rocky (2-10%)	10.66 (1.74)
11		DDRhD3g3R3	Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (60-80%), very rocky (25-50%)	19.25 (3.15)
12		DDRiB2g2R1	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60%), fairly rocky (2-10 %)	30.14 (4.93)
13		DDRmB2g2R1	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %), fairly rocky (2-10 %)	5.15 (0.84)

	DNI	Dhoni soils are deep (100-150 cm), well drained, gravelly clay soils, developed from banded ferruginous quartzite and occur on gently to very gently sloping uplands under rainfed cultivation		**39.72 (6.5)**
14		DNIfC2g1	Clay loam surface, slope 3-5 %, moderate erosion, gravelly (15-35%)	19.36 (3.17)
15		DNImB1	Clay loam surface, slope 1-3 %, slight erosion	20.36 (3.33)
	JLG	Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils developed on schist and occur on very gently sloping uplands under cultivation		**72.45 (11.85)**
16		JLGiC2g2	Sandy clay surface, slope 3-5%, moderate erosion, very gravelly (35-60 %)	33.68 (5.51)
17		JLGmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)	18.63 (3.05)
18		JLGmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60 %)	20.14 (3.29)
	MPT	Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, have very dark brown to very dark grayish brown cracking clay soils developed on schist and occur on very gently sloping uplands under cultivation		**54.74 (8.95)**
19		MPTmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	25.87 (4.23)
20		MPTmB2g2	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	28.87 (4.72)
	NBP	Nabhapur soils are shallow (25-50 cm), well drained, have reddish brown to dark reddish brown gravelly clay loam to gravelly clay soils developed on Banded Ferrugenous Quartzite and occur on gently to moderately sloping uplands under cultivation		**51.16 (8.37)**
21		NBPfC3g2	Clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%)	9.42 (1.54)
22		NBPmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	25.36 (4.15)
23		NBPmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	16.38 (2.68)
	SRL	Shirol soils are very shallow (<25 cm), well drained, clayey soils developed on Banded Ferrugenous Quartzite and occur on very gently to gently sloping uplands under cultivation		**125.31 (20.50)**
24		SRLcB1g2	Sandy loam surface, slope 1-3%, slight erosion, very gravelly (35-60%)	31.63 (5.17)
25		SRLiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	12.20 (2.00)
26		SRLiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)	41.39 (6.77)

27		SRLmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	10.94 (1.79)
28		SRLmC2g2	Clay surface, slope 3-5%, moderate erosion, very gravelly (35-60%)	29.15 (4.77)
	YSJ	Yelisirunj soils are shallow (25-50 cm), well drained, have very dark brown to very dark grayish brown clay soils developed on schist and occur on very gently sloping uplands under cultivation		**60.95 (9.97)**
29		YSJmB2	Clay surface, slope 1-3%, moderate erosion	25.55 (4.18)
30		YSJmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60 %)	35.40 (5.79)
MISCELLANEOUS LANDS				
31		Rock outcrops	Rock lands with more than 90% rock outcrops	31.00 (5.10)
32		Others	Habitation and water bodies	17.00 (2.76)

THE SOILS

Detailed information pertaining to the nature, extent and distribution of different kinds of soils occurring in Shirunj microwatershed is provided in this chapter. The microwatershed area has been divided into schistand banded ferrugenous quartzite landscapes based on geology, In all, 9 soil series (five each) were identified in both the landscapes. Soil formation is the result of the combined effect of environmental and terrain factors that are reflected in soil morphology. In the schist landform, it is by parent material and climate and in BFQ landform, it is by parent material, relief and climate. Maximum area of about 203 ha (33%) has soils that are developed from schist followed by about 361 ha (59%) under BFQ.

A brief description of each of the 9 soil series identified followed by 30 soil phases (management units) mapped under each series are furnished below. The soils in any one map unit differ from place to place in their depth, texture, slope, gravelliness, erosion or any other site characteristics that affect management. The soil phase map can be used for identifying the suitability of areas for growing specific crops or for other alternative uses and also for deciding the type of conservation structures needed. The detailed information on soil and site-characteristics like soil depth, surface soil texture, slope, ersion, 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 Banded Ferrugenous Quartzite (BFQ) Landscapes

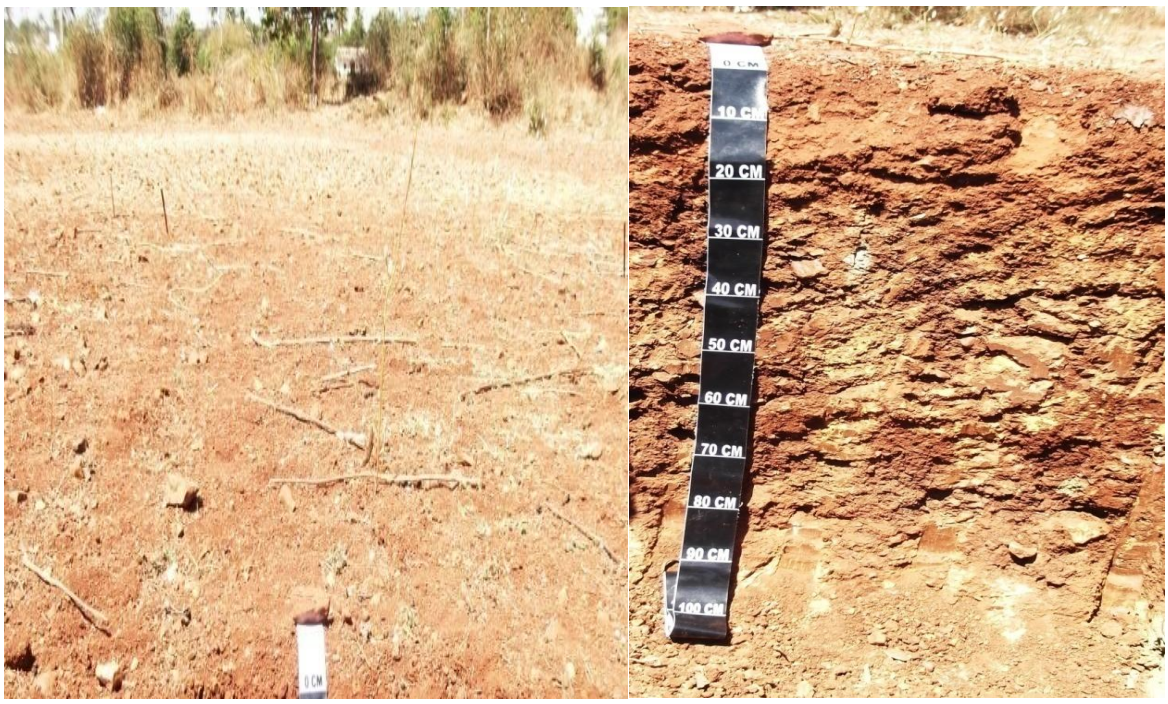
In thislandscapes, 5 soil series are identified and mapped. Of these, Dindur (DDR) soil series occupies maximum area of about 129 ha (21%). The brief description of each series along with the soil phases identified and mapped is given below.

4.1.1 Attikatti (AKT) Series: Attikatti soils are shallow (25-50 cm), well drained, have dark reddish brown to dusky redclay loam to clayey soils. They are developed from banded ferrugenous quartzite and occur on very gently to gently sloping uplands.

The thickness of the solum ranges from 26 to 48 cm. Thickness of A horizon ranges from 12 to 18 cm. Its colour is in hue 5 YR and 2.5 YR with value 3 and chroma 3 to 4. The texture is clay loam to clay. The thickness of B horizon ranges from 14 to 30 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 to 4 and chroma 2 to 4. Its texture is dominantly clay. The available water capacity is very low (50 mm/m).

Three phases were identified

AKTfB2g1	Clay loam surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)
AKTmB1g1	Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)
AKTmB2g2	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)



Landscape and Soil Profile Characteristics of Attikatti (AKT) Series

4.1.2 Dindur (DDR) Series: Dindur soils are very shallow (<25 cm), well drained, have dark reddish brown to dark redgravelly clay loam to gravelly clay soils. They are developed from banded ferruginous quartzite and occuron very gently to moderately sloping uplands.

The thickness of the solum ranges from 11 to 25 cm. Thickness of A horizon ranges from 7 to 19 cm. Its colour is in hue 2.5 YR with value 2.5 to 3 and chroma 3 to 6. The texture is dominantly clay. The available water capacity is very low (25 mm/m).

Nine phases were identified

DDRfB2g2	Clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)
DDRfC3g1R1	Clay loam surface, slope 3-5 %, severe erosion, gravelly (15-35%), fairly rocky (2-10%)
DDRhB2g2	Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)
DDRhC3g3	Sandy clay loam surface, slope 3-5 %, severe erosion, extremely gravelly (60-80 %)
DDRhD2g2R2	Sandy clay loam surface, slope 5-10%, moderate erosion, very gravelly (35-60%), rocky (10-25 %)
DDRhD3g3R1	Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (60-80%), fairly rocky (2-10%)
DDRhD3g3R3	Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (60-80%), very rocky (25-50%)
DDRiB2g2R1	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60%), fairly rocky (2-10 %)
DDRmB2g2R1	Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %), fairly rocky (2-10 %)


Landscape and Soil Profile Characteristics of Dindur (DDR) Series

4.1.3 Shirol (SRL) Series: Shirol soils are very shallow (<25 cm), well drained, reddish brown to dark red clayey soils. They are developed from Banded Ferruginous Quartzite (BFQ) and occur on very gently to gently sloping uplands.

The depth of the soil is less than 25 cm. Its colour is in hue 5 YR and 7.5 YR with value 2.5 to 3 and chroma 3 to 6. Texture is dominantly clay with less than 15 per cent gravel. The available water capacity is very low (<50 mm/m).

Five phases were identified

SRLcB1g2	Sandy loam surface, slope 1-3%, slight erosion, very gravelly (35-60%)
SRLiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
SRLiB1g2	Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)
SRLmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)
SRLmC2g2	Clay surface, slope 3-5%, moderate erosion, very gravelly (35-60%)

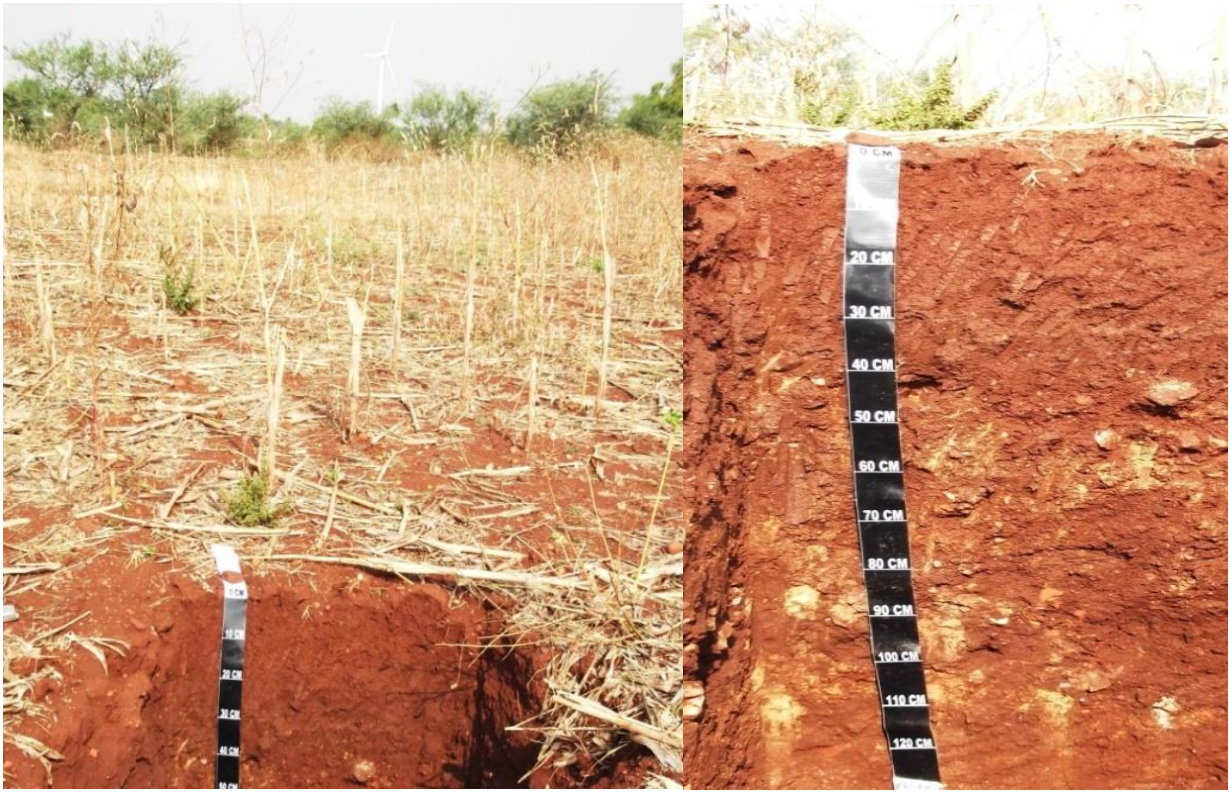
Landscape and Soil Profile Characteristics of Shirol (SRL) Series

4.1.4 Dhoni Series (DNI) Series: Dhoni soils are deep (100-150 cm), well drained, dark reddish brown to dark red gravelly clay soils. Theyare developed from banded ferruginous quartzite and occur on gently to very gently sloping uplands.

The thickness of the solum ranges from 117 to 145 cm. The thickness of A horizon ranges from 13 to 21 cm. Its colour is in hue 7.5YR, 5YR with value 2 to 3 and chroma 3 to 4. Its texture is clay. The thickness of B horizon ranges from 104 to 124 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 and chroma 4. Its texture isclay loam to clay. The available water capacity is low (75 mm/m).

Two phases were identified

DNIfC2g1	Clay loam surface, slope 3-5 %, moderate erosion, gravelly (15-35%)
DNImB1	Clay loam surface, slope 1-3 %, slight erosion



Landscape and soil Profile Characteristics of Dhoni (DNI) Series

4.1.5 Nabhapur (NBP) Series: Nabhapur soils are shallow (25-50 cm), well drained, have reddish brown to dark reddish brown gravelly clay loam to gravelly clay soils.They have developed frombanded ferruginous quartzite and occuron gently to moderately sloping uplands.

The thickness of the solum ranges from 30 to 50 cm. Thickness of A horizon ranges from 15 to 18 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 to 4 and chroma 3 to 6. The texture is clay loam to clay. The thickness of B horizon ranges from 15 to 35 cm. Its colour is in hue 5 YR and 2.5 YR with value 2.5 to 3 and chroma 4 to 6. Its texture is clay loam to clay. The available water capacity is very low (25 mm/m).

Three phases were identified

NBPfC3g2	Clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%)
NBPmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)
NBPmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)

4.2 Soils of Schist Landscape

In this landscape, 5soil series are identified and mapped. Of these, Jelligeri (JLG) soil series occupies maximum area of about 72 ha (12%). The brief description of each series along with the soil phases identified and mapped is given below.

4.2.1 Attikatti Tanda (ATT) Series: Attikatti Tanda soils are moderately shallow (50-75 cm), well drained, have dark brown to very dark brown clayey soils. They are developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 51-73 cm. Thickness of A horizon ranges from 12 to 18 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1to 3. The texture is dominantly clay. The thickness of B horizon ranges from 39 to 55 cm. Its colour is in hue 2.5 YR and 5 YR with value 3 to 4 and chroma 2 to 4. Its texture is dominantly clay. The available water capacity is very low (50 mm/m).

Only one phasewas identified

ATTiB1g2	Sandy clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)

Landscape and Soil Profile Characteristics of Attikatti Tanda (ATT) Series

4.2.2 Jelligeri (JLG) Series: Jelligeri soils are moderately deep (75-100 cm), moderately well drained, very dark brown to dark brown and black cracking clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 78 to 98 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 63 to 78cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 3 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is high (150-200 mm/m).

Threephases were identified

JLGiC2g2	Sandy clay surface, slope 3-5%, moderate erosion, very gravelly (35-60 %)
JLGmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35 %)
JLGmB2g2	Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60 %)

Landscape and Soil Profile Characteristics of Jelligeri (JLG) Series

4.2.3 Mahalingapur Tanda (MPT) Series: Mahalingapur Tanda soils are deep (100-150 cm), moderately well drained, very dark brown to very dark grayish brown cracking clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 117 to 145 cm. The thickness of A horizon ranges from 13 to 21 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The thickness of B horizon ranges from 104 to 124 cm. Its colour is in hue 10 YR and 7.5 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is very high (200-250 mm/m).

Two phases were identified

MPTmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
MPTmB2g1	Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)

Landscape and Soil Profile Characteristics of Mahalingapur Tanda (MPT)Series

4.2.4Yelisirunj (YSJ) Series: Yelisirunj soils are shallow (25-50 cm), well drained, have very dark brown to very dark grayish brown clay soils. They have developed from schist and occur on very gently sloping uplands.

The thickness of the solum ranges from 28 to 49 cm. The thickness of A horizon ranges from 12 to 20 cm. Its colour is in hue 7.5 YR and 10 YR with value 2 to 4 and chroma 1 to 3 . Texture is dominantly clay loam. The thickness of B horizon ranges from 16 to 29 cm. Its colour is in hue 7.5 YR and 10 YR with value 2 to 4 and chroma 1 to 3. Its texture is dominantly clay. The available water capacity is low (50-100 mm/m).

Three phases were identified

YSJmB1g1	Clay surface, slope 1-3%, slight erosion, gravelly (15-35%)
YSJmB2	Clay surface, slope 1-3%, moderate erosion
YSJmB2g2	Clay surface, slope 1-3% moderate erosion, very gravelly (35-60%)

Landscape and Soil Profile Characteristics of Yelisirunj (YSJ) Series

Chapter 5

INTERPRETATION FOR LAND RESOURCE MANAGEMENT

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

5.1 Land Capability Classification

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

Soil characteristics: Soil depth, soil texture, coarse fragments, soil reaction, available water capacity, calcareousness, salinity/alkali *etc*.

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

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

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

Class I: The soil map units have few or very few limitations that restrict their use.

Class II: The soil map units have moderate limitations that reduce the choice of crops or that require moderate conservation practices.

Class III: The soil map units have severe limitations that reduce the choice of crops or that require special conservation practices.

Class IV: The soil map units have very severe limitations that reduce the choice of crops or that require very careful management.

Class V: Soils in the mapping units are not likely to erode, but have other limitations that are impractical to remove and as such not suitable for agriculture.

Class VI: The landshave severe limitations that make them generally unsuitable for cultivation.

Class VII: The landshave very severe limitations that make them unsuitable for cultivation.

Class VIII: Soil and other miscellaneous areas that have very severe limitations that nearly preclude their use for any crop production.

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

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

The 30 soil map units identified in the Shirunj microwatershed are grouped under 3land capability classes and 4 land capability subclasses (Fig. 5.1) About 92 per cent area in the microwatershed is suitable for agriculture and about 5per cent is not suitable for agriculture but well suited to pasture, forestry, silvi-pastoral system, agri-horti-silvipastoral system, mining, quarrying, location of wind mills and as habitat for wildlife and recreation.

Moderatelygood cultivable lands (Class III) cover about 32 per cent and are distributed in northern, eastern and central partsof the microwatershed with moderate problems of erosion and soil.

The fairly cultivable lands (Class IV) cover maximum area of about 60 per cent and are distributed all over the microwatershed with severe limitations of erosion and soil.

The class VIIIlands cover about 5 per cent area and represent mostly rock lands with rock outcrops and are distributed in western and northern parts of the micro watershed. They are well suited for wild life and recreation.

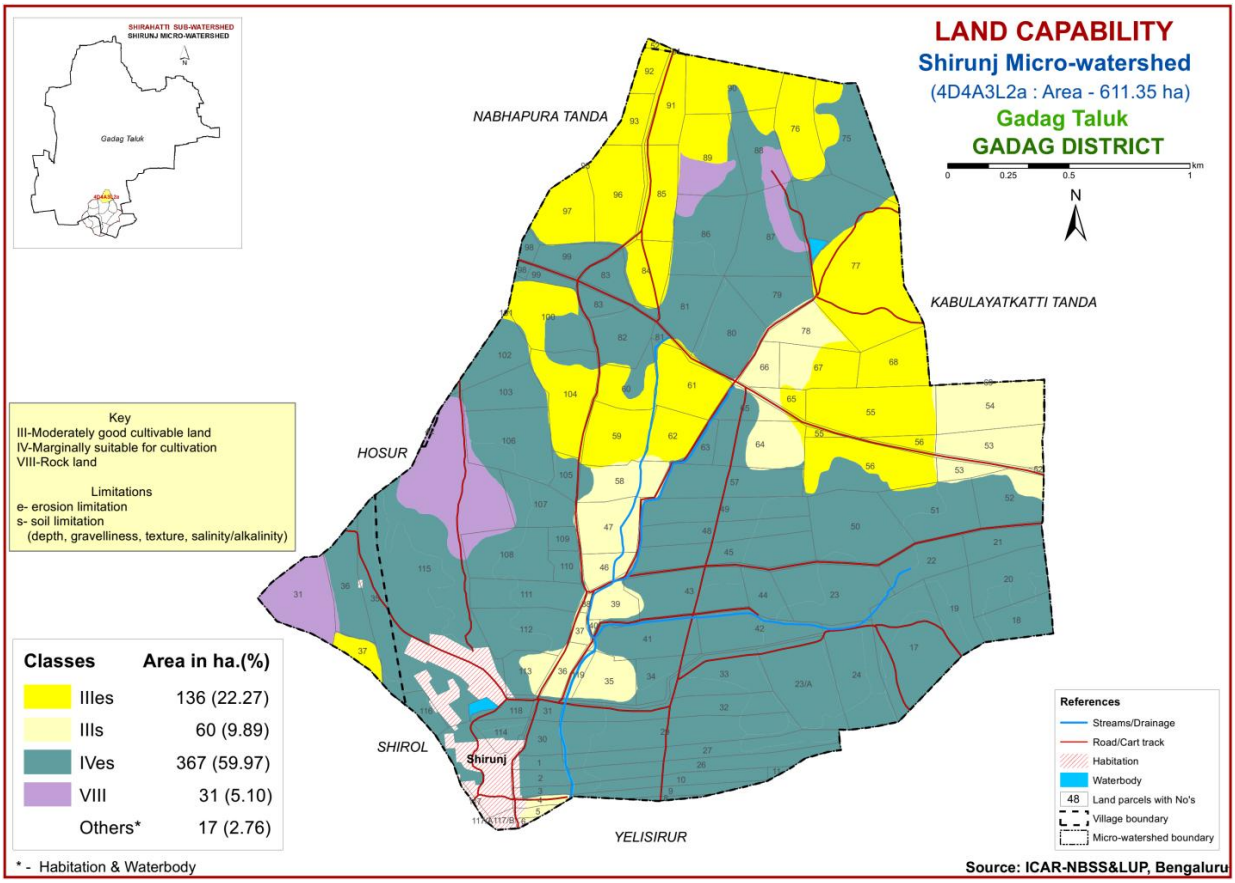


Fig. 5.1 Land Capability map of Shirunj microwatershed

5.2 Soil Depth

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

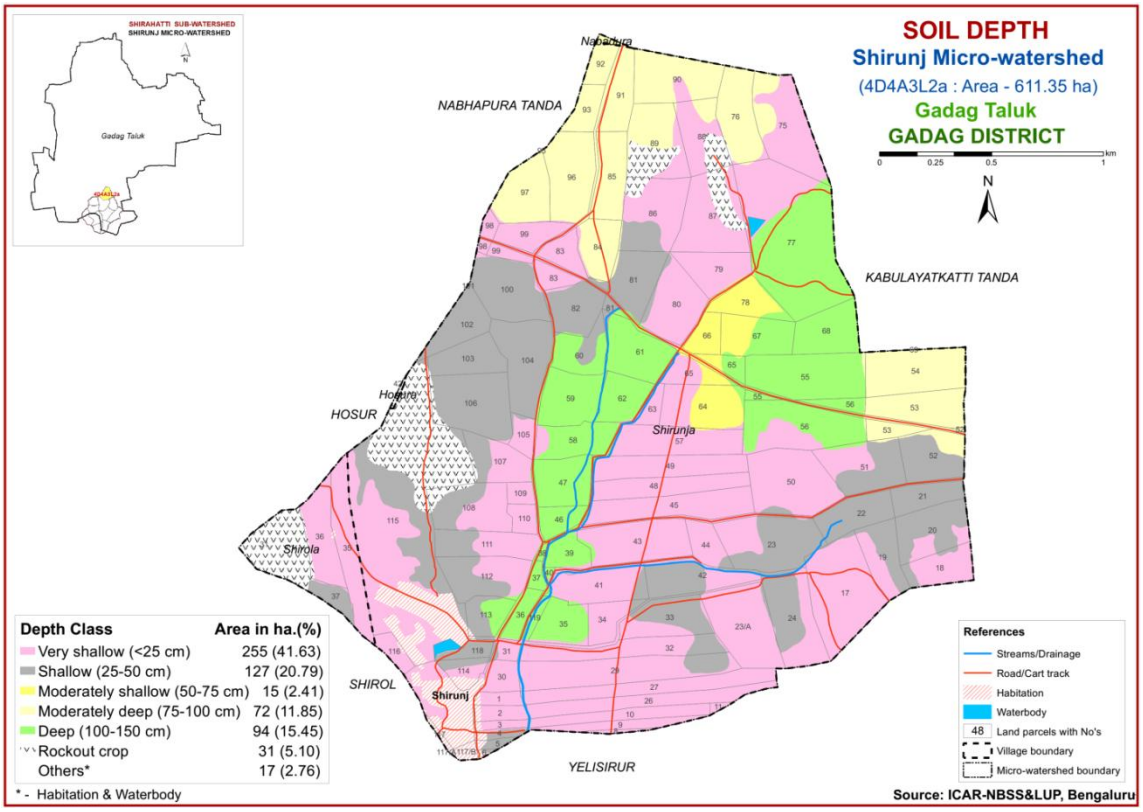


Fig. 5.2Soil depth map of Shirunj microwatershed

Major area of about 255 ha (42%) are under very shallow (<25 cm) and is distributed all over the microwatershed. Shallow soils (25-50 cm) occupy about 127 ha (21%) in the eastern and western parts of the microwatershed. Moderately shallow (50-75 cm) soils occupy smaller area of about 15 ha (2%) and are distributed in central part of the microwatershed. Moderately deep (75-100 cm) soils occupy about 72 ha (12%) in the northern and eastern parts of the microwatershed. Deep soils (100-150 cm) occur in about 94 ha (15%) and are distributed in the central and eastern parts of the microwatershed. About 31 ha (5%) area is covered under rock lands with outcrops of rock everywhere.

The most productive lands (15%) with respect to soil rooting depth where all climatically adapted annual and perennial crops can be grown are deep soils (100-150 cm depth) occurring in the central and eastern parts of the microwatershed.

The most problem lands (63%) having very shallow (<25 cm) and shallow (25-50 cm) rooting depth occurs all over 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.

5.3 Surface Soil Texture

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

Maximum area of 275 ha (45%) has soils that are clayey and are distributed all over the microwatershed.Sandy clay soils account for 132 ha (22%) and are distributed in central and northern part of the microwatershed. Clay loam soils account for 64 ha (10%) area and are distributed in northern and central partsof the microwatershed. Sandy clay loam account for 61 ha (10%) and are distributed in southeastern and southwestern parts of the microwatershed (Fig 5.3).

The most productive lands (67%) with respect to surface soil texture are the clayey soils that have high potential for soil-water retention and availability, and nutrient retention and availability, but have problems of drainage, infiltration, workability and other physical problems.

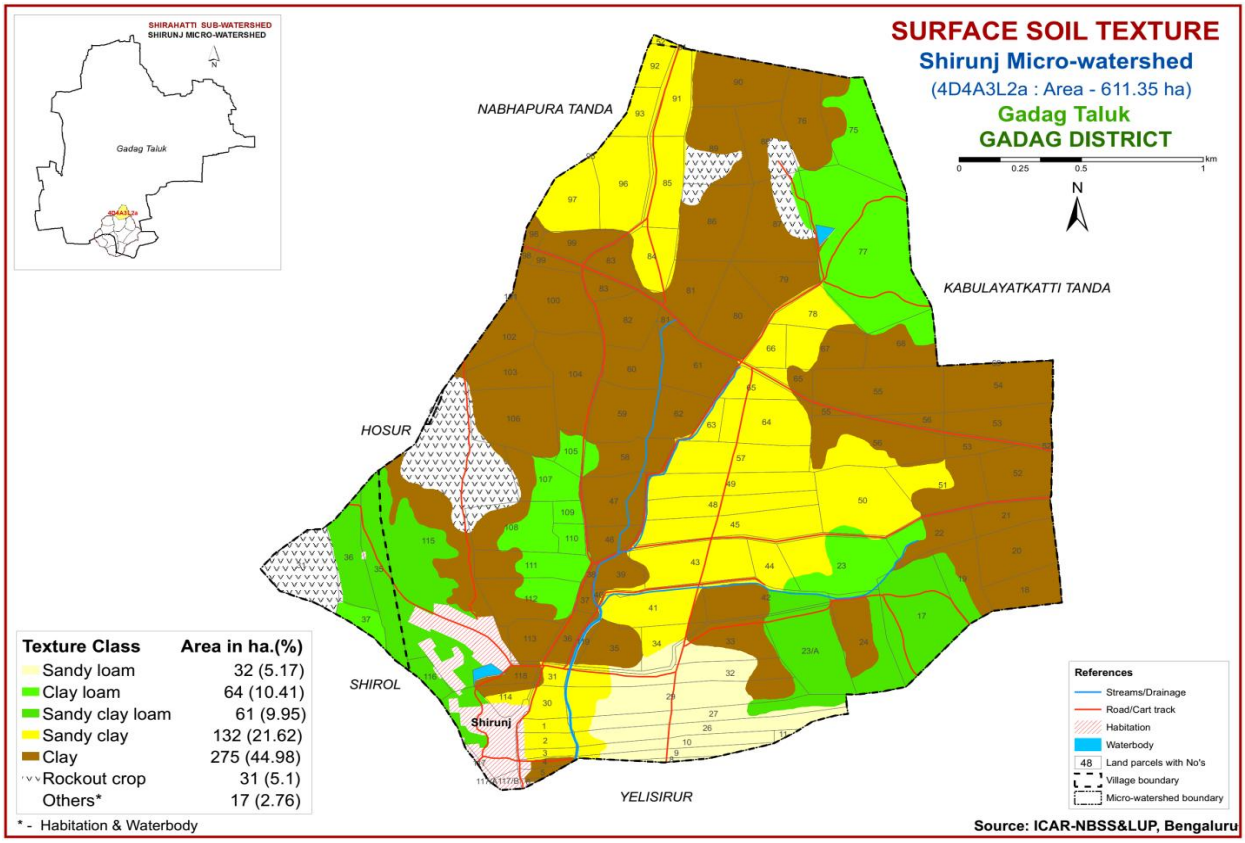


Fig. 5.3 Surface Soil Texture map of Shirunj microwatershed

5.4 Soil Gravelliness

Gravel is the term used for describing coarse fragments between 2 mm and 7.5 cm diameter and stones for those between 7.5 cm and 25 cm. The presence of gravel and stones in soil reduces

the volume of soil responsible for moisture and nutrient storage, drainage, infiltration and runoff and hinders plant growth by impeding root growth and seedling emergence, intercultural operations and farm mechanization.

Maximum area in the microwatershed has soils that are very gravelly (35-60%) covering about 381 ha (62%) and are distributed all over the microwatershed followed by soils that are gravelly (15-35%) covering about 120 ha (20%)area and are distributed in the southwestern and northeastern parts of the microwatershed. Small areas have soils that are nongravelly (<15%) covering about 26 ha (4%) area and are distributed in southwestern part of the microwatershed and extremely gravelly (60-80%) covering about 37 ha (6%) area and are distributed in southwestern and southeastern parts of the microwatershed (Fig.5.4).

The most productive lands with respect to gravelliness is found to be 4 %. They are nongravelly with less than 15 per cent gravel and have potential for growing both annual and perennial crops.

The problem soilsthat are very gravelly (35-60%) cover about 62 per cent and extremely gravelly (60-80%) cover about 6 per cent, where only short duration crops can be grown.

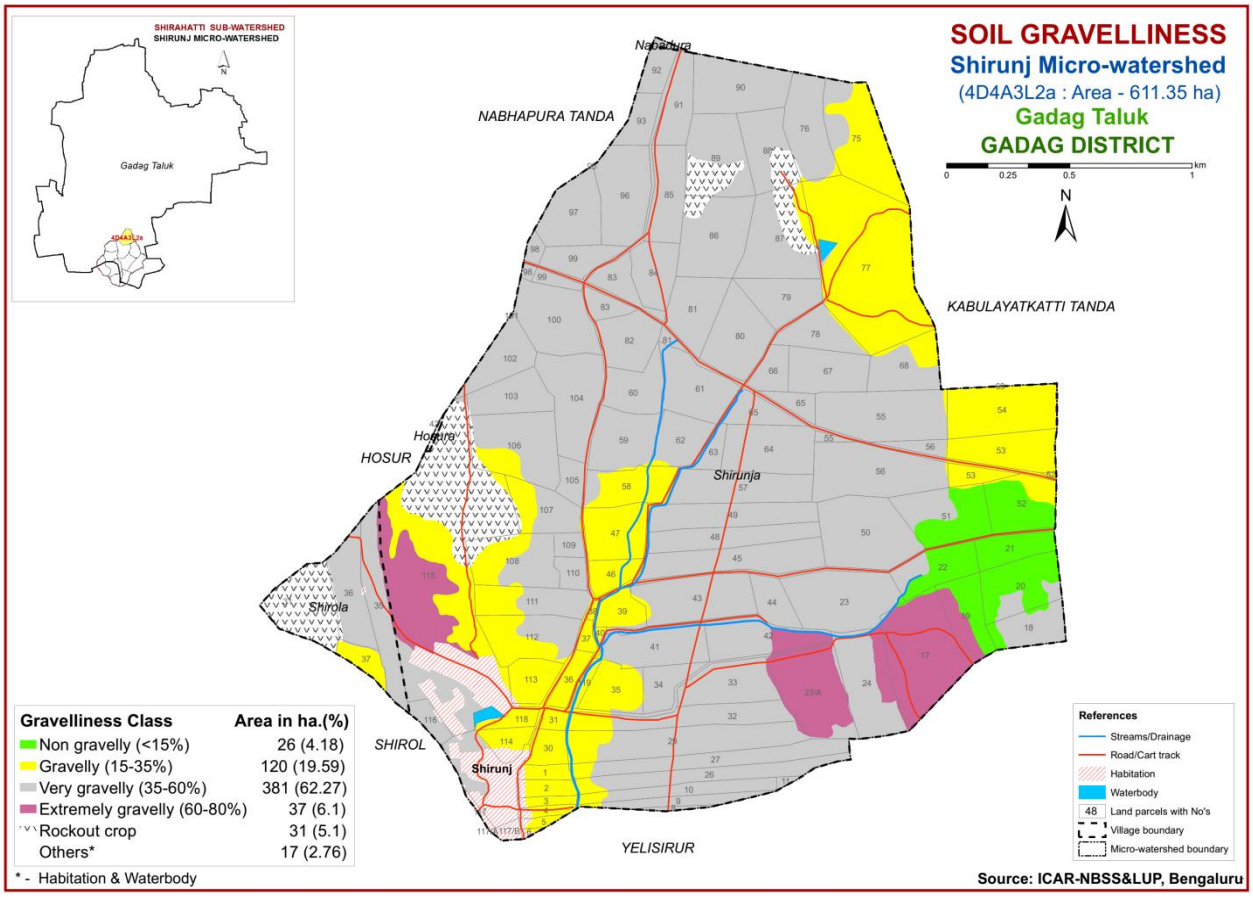


Fig. 5.4 Soil Gravelliness map of Shirunjmicrowatershed

5.5 Available Water Capacity

The soil available water capacity (AWC) is estimated based on the ability of the soil column to retain water between the tensions of 0.33 and 15 bar in a depth of 100 cm or the entire solum if the soil is shallower. The AWC of the soils (soil series) as estimated by considering the soil texture, mineralogy, soil depth and gravel content (Sehgal *et al.*, 1990) and accordingly the soil map units

were grouped into five AWC classes *viz*, very low (<50 mm/m), low (50-100 mm/m), medium (100-150 mm/m), high (150-200 mm/m) and very high (>200 mm/m) and using these values, an AWC map was prepared (Fig. 5.5).

Major area in the microwatershed has soils that are very low (<50 mm/m) in available water capacity. They occur in about 321 ha (52%) and are distributed in all parts of the microwatershed.An area of about 101 ha (16%) has soils that are low (51-100 mm/m) in available water capacity and are distributed in central and southeastern part of the microwatershed. About 87 ha (14%) area has soils that are medium (101-150 mm/m) in available water capacity and are distributed in northern and eastern part of the microwatershed.An area of about 55 ha (9%) in the microwatershed has soils that have very high (>200 mm/m) available water capacity and are distributed in the southern and eastern part of the microwatershed.

In these areas, if the rainfall is normal and well distributed, all climatically adapted long duration annual and perennial crops can be grown.

About 422 ha (68%) area in the microwatershed has soils that are problematic with regard to available water capacity. Here, only short or medium duration crops can be grown and the probability of crop failure is very high. These areas are best put to other alternative uses.

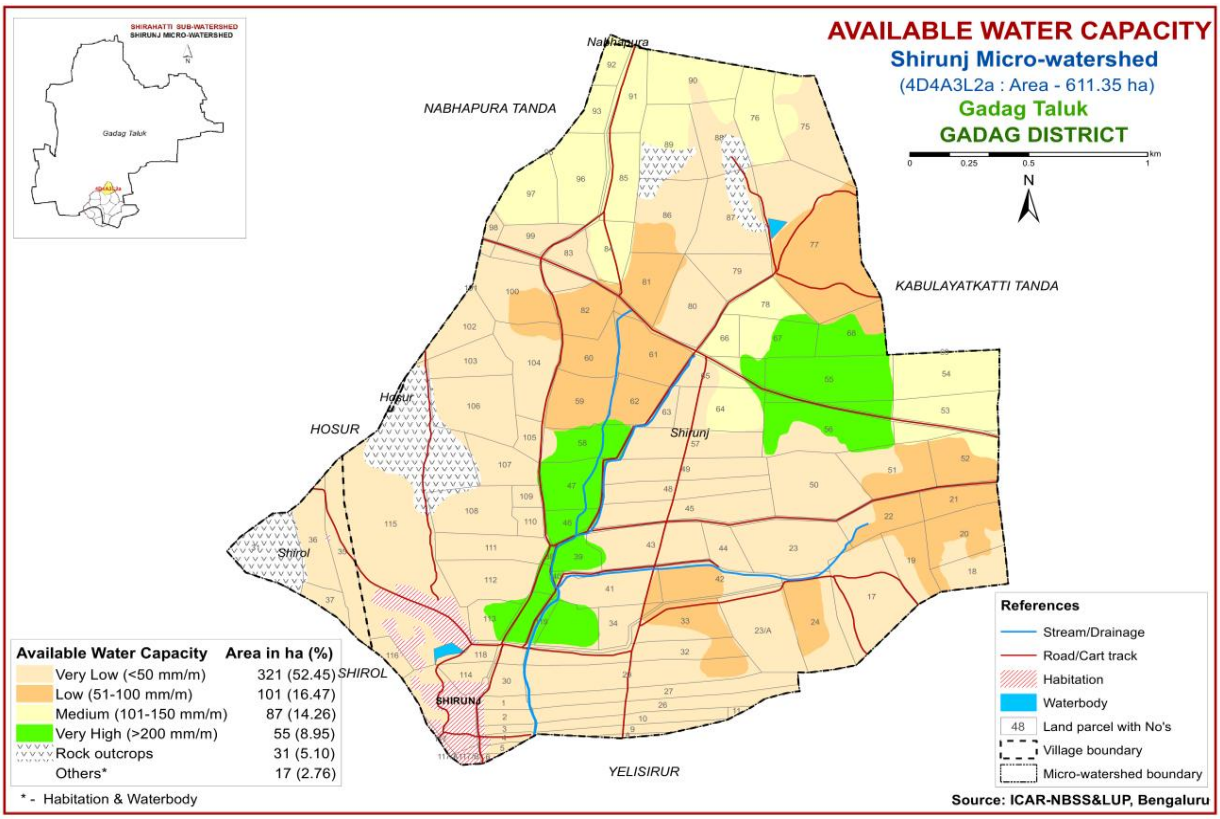


Fig. 5.5 Soil Available Water Capacity map of Shirunj microwatershed

5.6 Soil Slope

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

Major area of the microwatershed falls under very gently sloping (1-3% slope) slope class. It covers an area of about 415 ha (68%) and distributed in all parts of the microwatershed. About 114 ha (18%) area falls under gently sloping (3-5% slope) class and distributed in the northern part of the microwatershed. Moderately sloping (5-10% slope) lands cover about 34 ha (6%) area and is distributed in southeastern and southwestern parts of the microwatershed.

An area of about 415 ha (68%) 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.

About 148 ha (24%) area has problem with respect to slopes. They require proper soil and water conservation measures for sustained production.

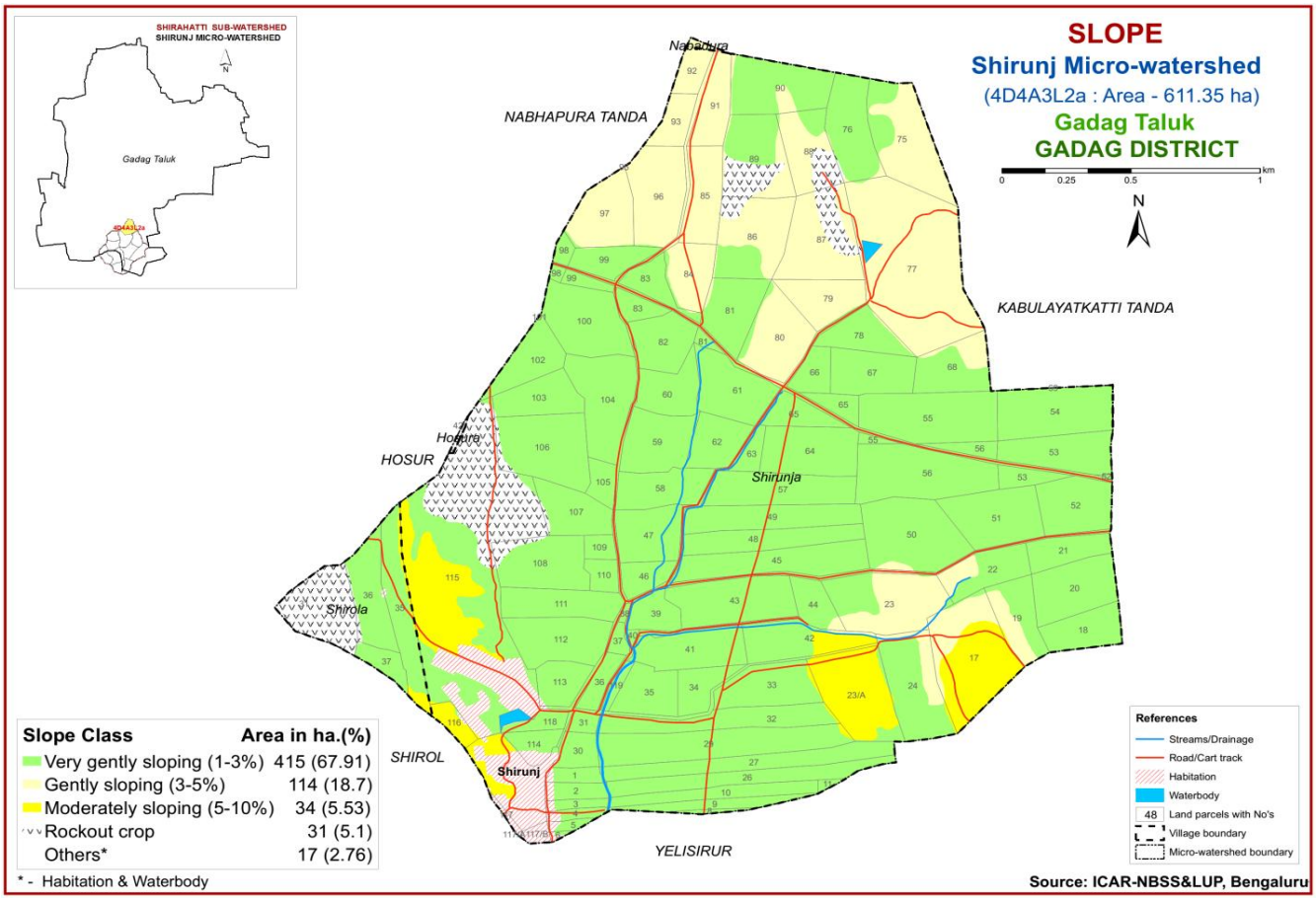


Fig. 5.6 Soil Slope map of Shirunj microwatershed

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 sheets, 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 is prepared. The area extent and their spatial distribution in the microwatershedis given in Figure 5.7.

Soils that are slightly eroded (e1 class) cover an area of about 166 ha (27%) and are distributed in southeastern and central part of the microwatershed. Moderately eroded (e2 class) soils cover a maximum area of about 343 ha (56%) and are distributed in all parts of the microwatershed. Severely eroded (e3 class) soils cover an area of about 55 ha (9%) and are distributed in the southeastern and southwestern parts of the microwatershed.

An area of about 166 ha (27%) is relatively stable terrain which needs minimum soil and water conservation and other land development measures.

An area of about 55 ha (9%) in the microwatershed is problematic because of severe erosion. Top priority is to be given to these areas for taking up soil and water conservation and other land development measures. Next in priority would be an area of about 343 ha (56%) where the soils are moderately eroded and need proper conservation measures.

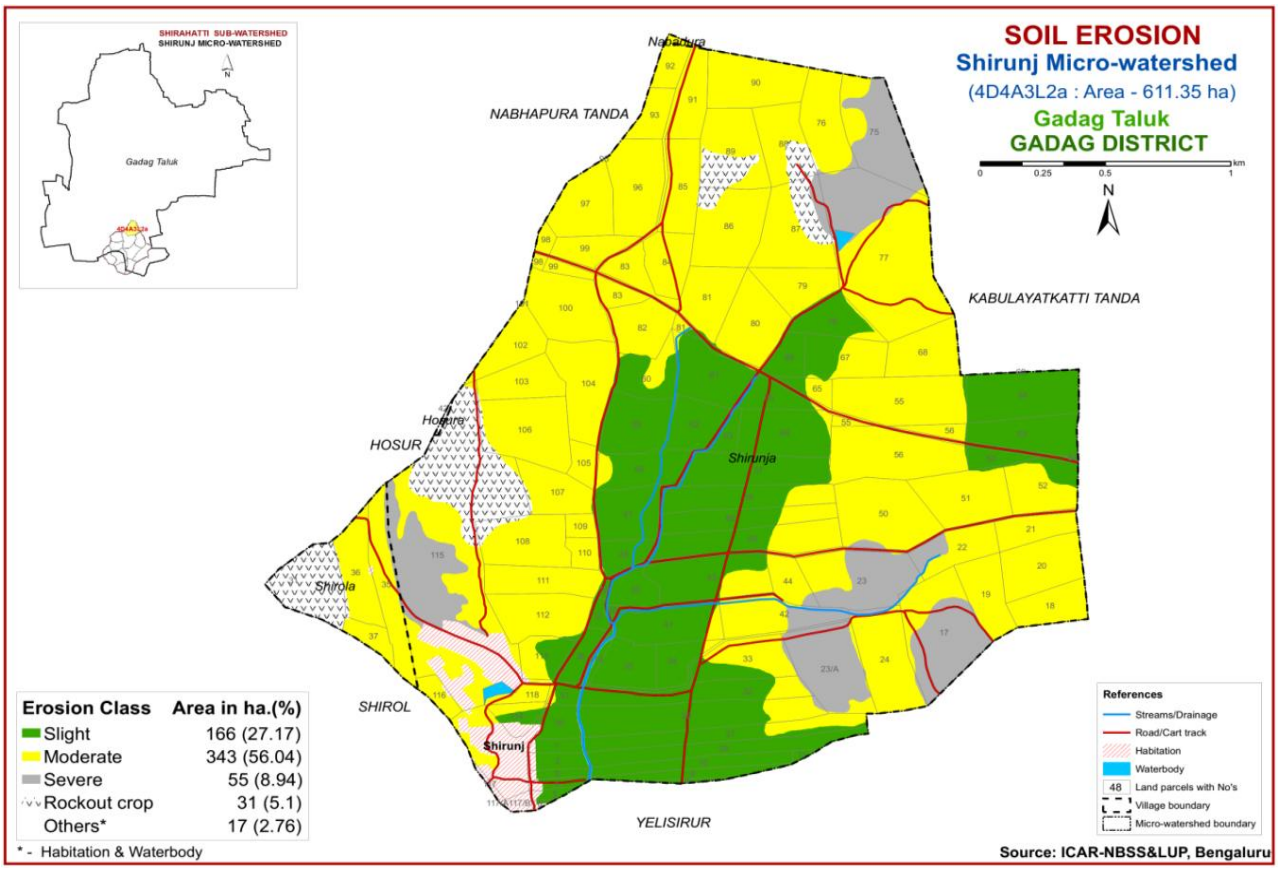


Fig. 5.7 Soil Erosion map of Shirunj microwatershed

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. Hence, it is necessary to know the fertility (macro and micro nutrients) status of the soils of the watersheds for assessing the kind and amount of fertilizers required for each of the crop intended to be grown. For this purpose, the surface soil samples collected from the grid points (one soil sample at every 250 m interval) all over the microwatershed through land resource inventory in the year 2014 were analysed for pH, EC, Organic Carbon, available Phosphorus and Potassium and for micronutrients like Zinc, Copper, Iron and Manganese, and secondary nutrient Sulphur.

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

6.1 Soil Reaction (pH)

The soil analysis of the Shirunj microwatershed for soil reaction (pH) showed that about 36 ha (6%) area is neutral (pH 6.5-7.3)and is distributed in the northern and southern part of the microwatershed.About 250 ha (41%) area is slightly alkaline (pH 7.3-7.8)and distributed in northern and southeastern part of the microwatershed; about 266 ha (43%) area is moderately alkaline (pH 7.8-8.4) and is distributed in the central part of the microwatershed and a very minor area of about 11 ha (2%) is under strongly alkaline (pH 8.4-9.0) and is distributed in the central part of the microwatershed (Fig.6.1).

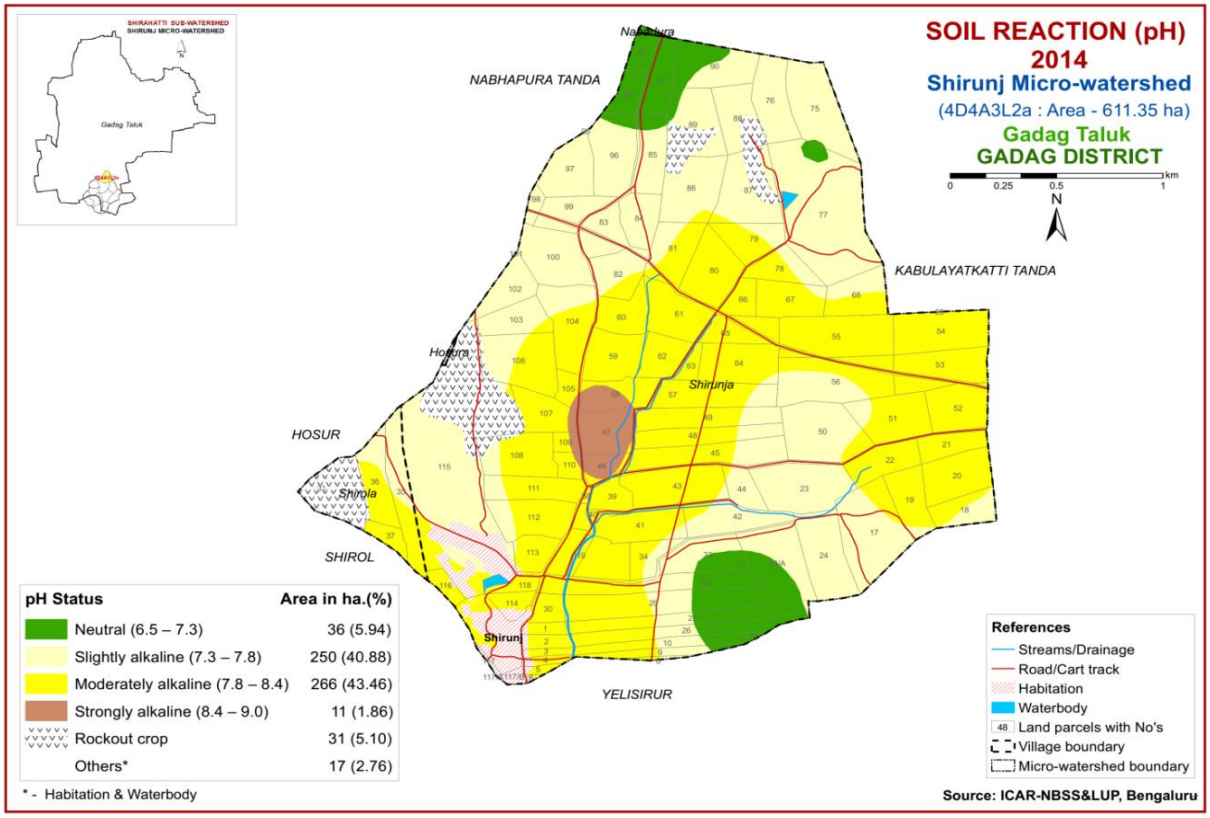


Fig.6.1 Soil Reaction (pH) map of Shirunj microwatershed

6.2 Electrical Conductivity (EC)

The Electrical Conductivity of the soils show that all the soils are is nonsaline (<2dSm^{-1})(Fig 6.2) in the entire microwatershed.

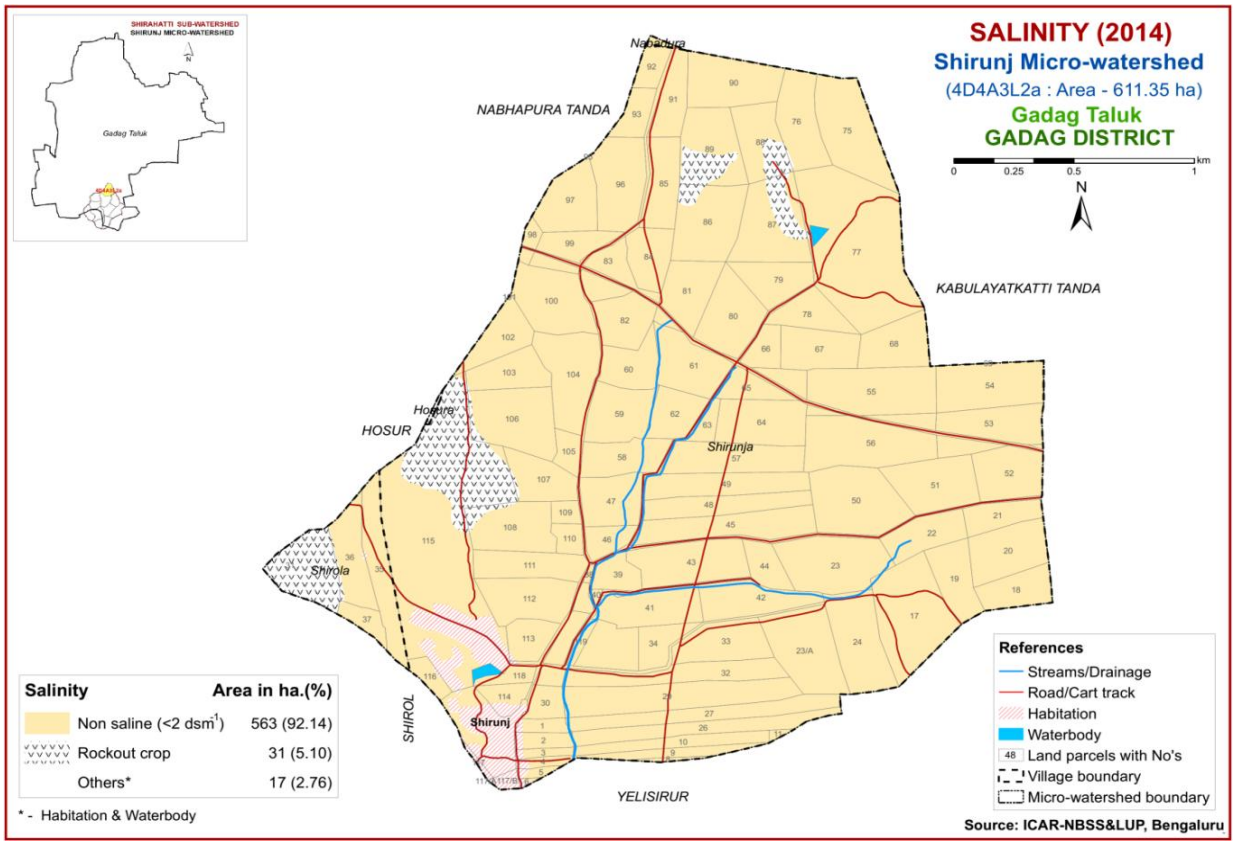


Fig.6.2Electrical Conductivity (EC) map of Shirunj microwatershed

6.3 Organic Carbon

The soil organic carbon content of the soils is high (>0.75%) and accounts for about 422 ha (69%) that are distributed in all parts of the microwatershed (Fig. 6.3). About 140 ha (23%) has soils that are medium (0.5-0.75%) in organic carbon and are distributed in the central and southwestern part of the microwatershed. A very minor area of about 2 ha has soils that are low (<0.5%) in organic carbon.

6.4 Available Phosphorus

The soil fertility analysis revealed that available phosphorus is low (<23 kg/ha) in 502 ha (82%) area distributed all over the microwatershed (Fig.6.4). There is an urgent need to increase the dose of phosphorous for all the crops by 25 per cent over the recommended dose to realize better crop performance. About 55 ha (9%) area in the microwatershed is medium (23-57 kg/ha) and is distributed in southern and central part of the microwatershed. A small area of about 6 ha (1%) is high (>57 kg/ha) in available phosphorus and is distributed in the southern part of the microwatershed.

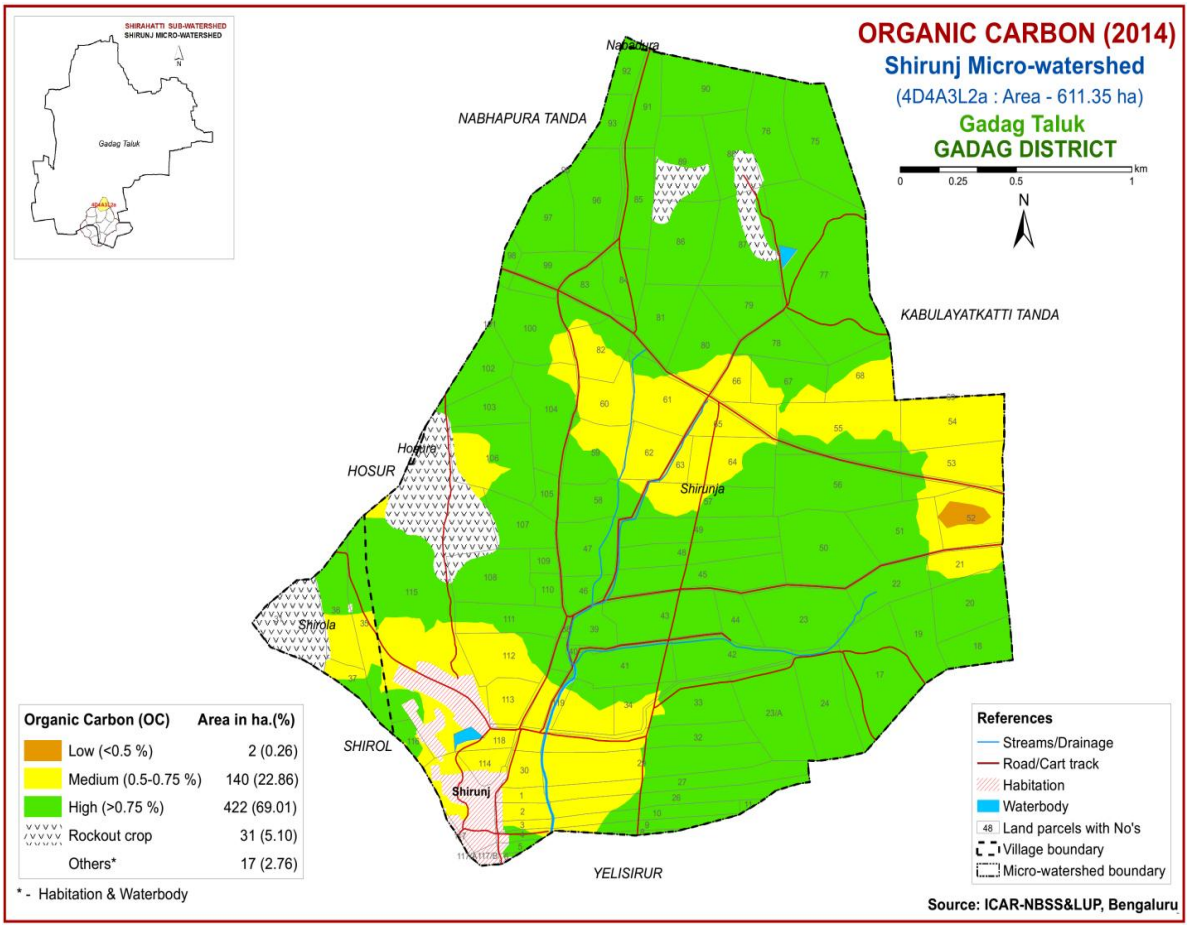


Fig.6.3Soil Organic Carbon map of Shirunj microwatershed

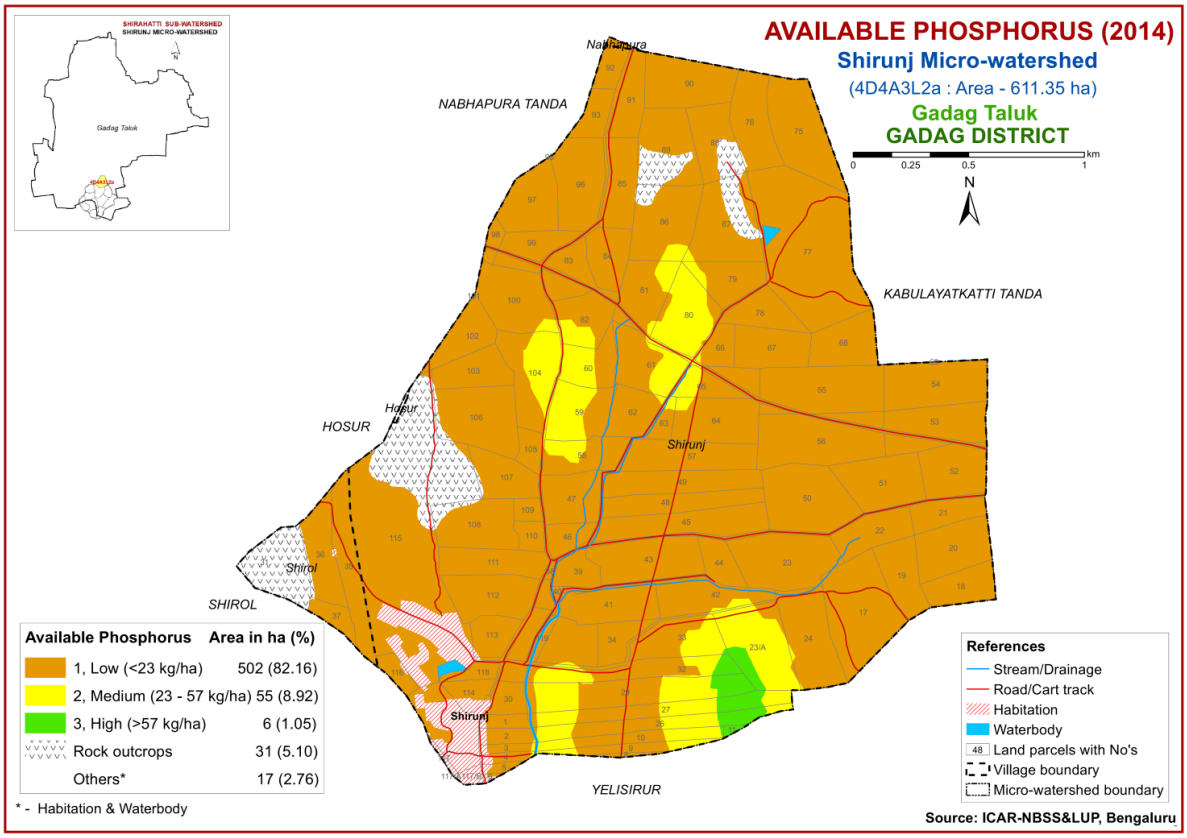


Fig.6.4Soil available Phosphorus map of Shirunj microwatershed

6.5 Available Potassium

Available potassium content is low (<145 kg/ha) in 302 ha (49%) area and is distributed in all parts of the microwatershed (Fig.6.5). About 261 ha (43%) area in the microwatershed is medium (145-337 kg/ha) and is distributed in southern and southeastern part of the microwatershed.

6.6 Available Sulphur

Available sulphur content is low (<10 ppm) in 314 ha (51%) area and is mainly distributed in the northern and southeastern part of the microwatershed. Theavailable sulphur is medium (10-20 ppm) in 249 ha (41%) is medium (10-20 ppm) and isdistributed in the central, eastern and southern part of the microwatershed(Fig.6.6).

6.7 Available Boron

Available boron content is low (<0.5 ppm) in 265 ha (43%) area and is distributed in the southern and northern part of the microwatershed. An area of about 268 ha(44%) has soils that are medium (0.5-1.0 ppm) in available boronand are distributed in the central part of the microwatershed (Fig 6.7). A small area of about 30 ha (5%) area is high (>1.0 ppm) in available boronand distributed in the central part of the microwatershed.

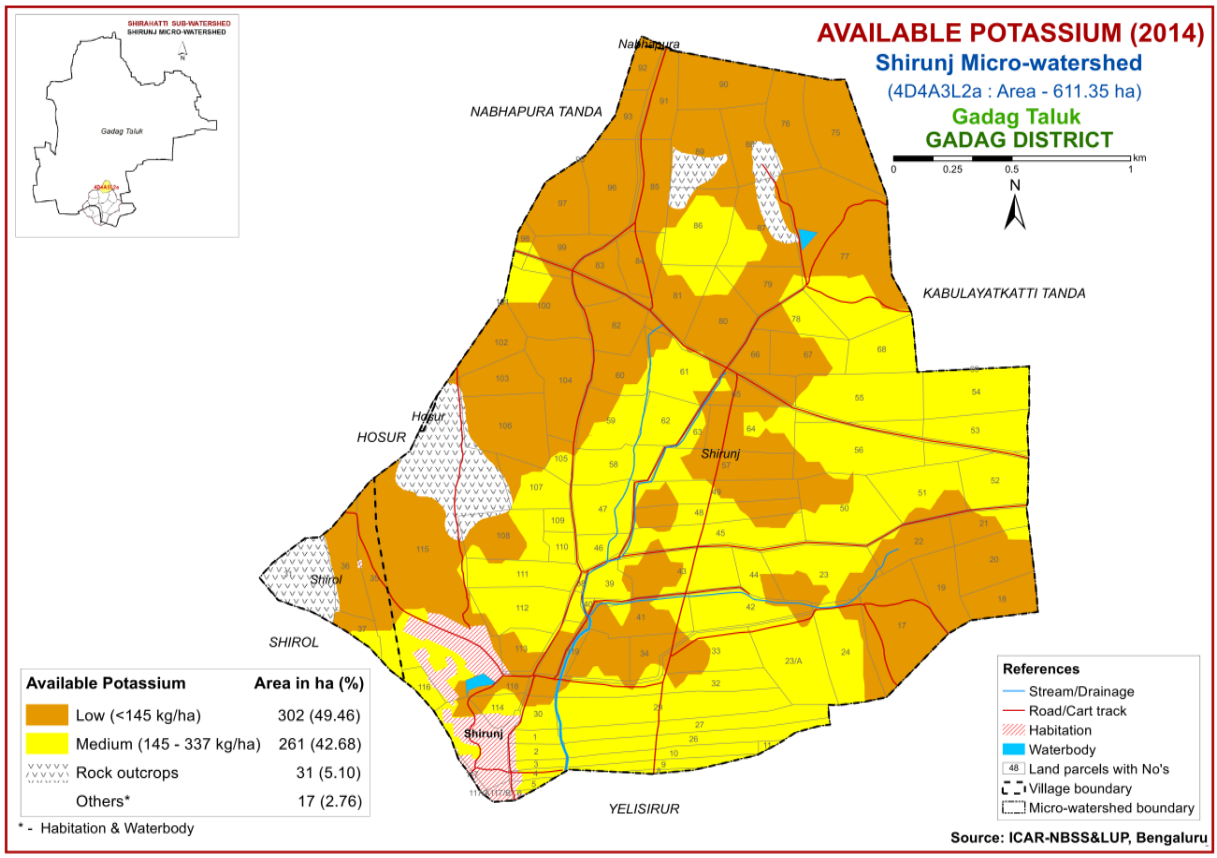


Fig.6.5Soil available Potassium map of Shirunj microwatershed

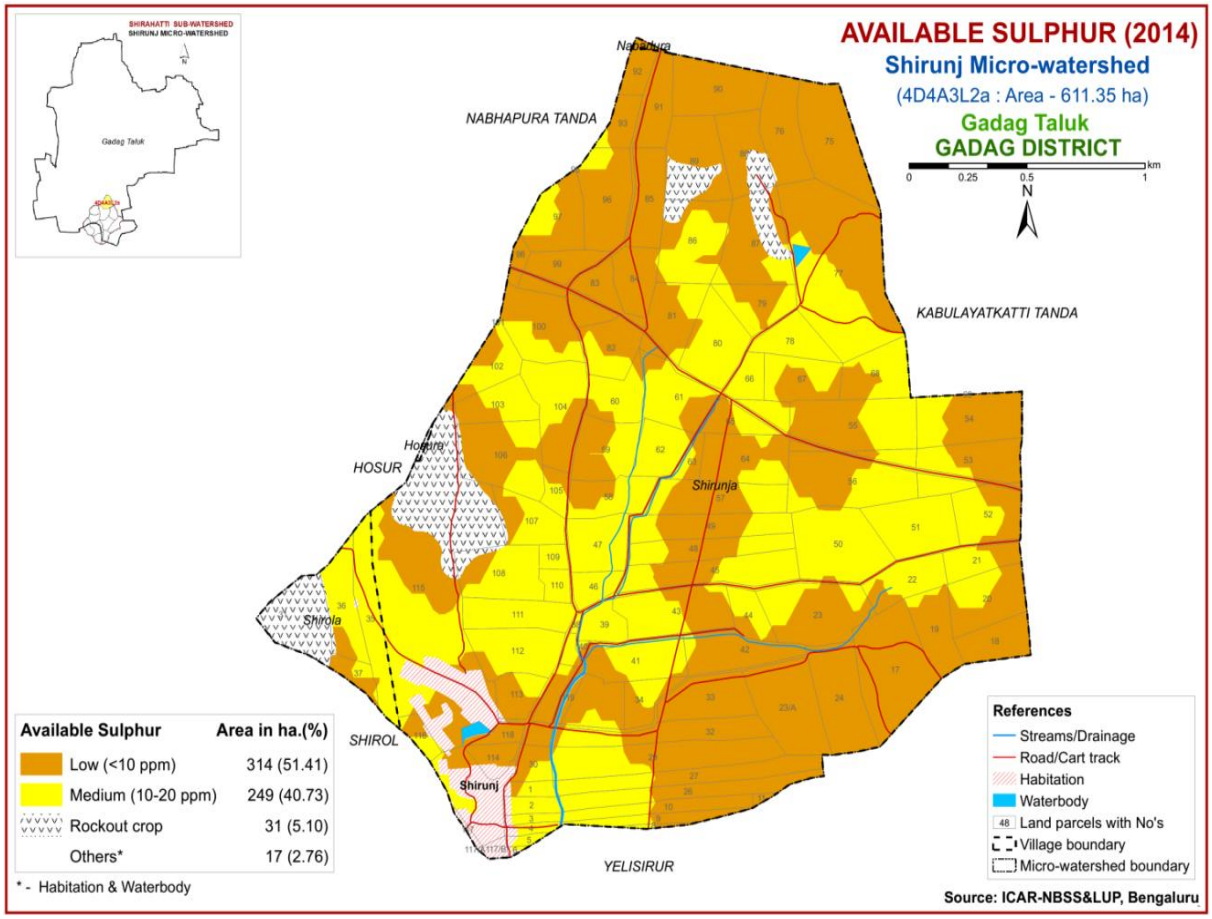


Fig.6.6Soil available Sulphurmap of Shirunj microwatershed

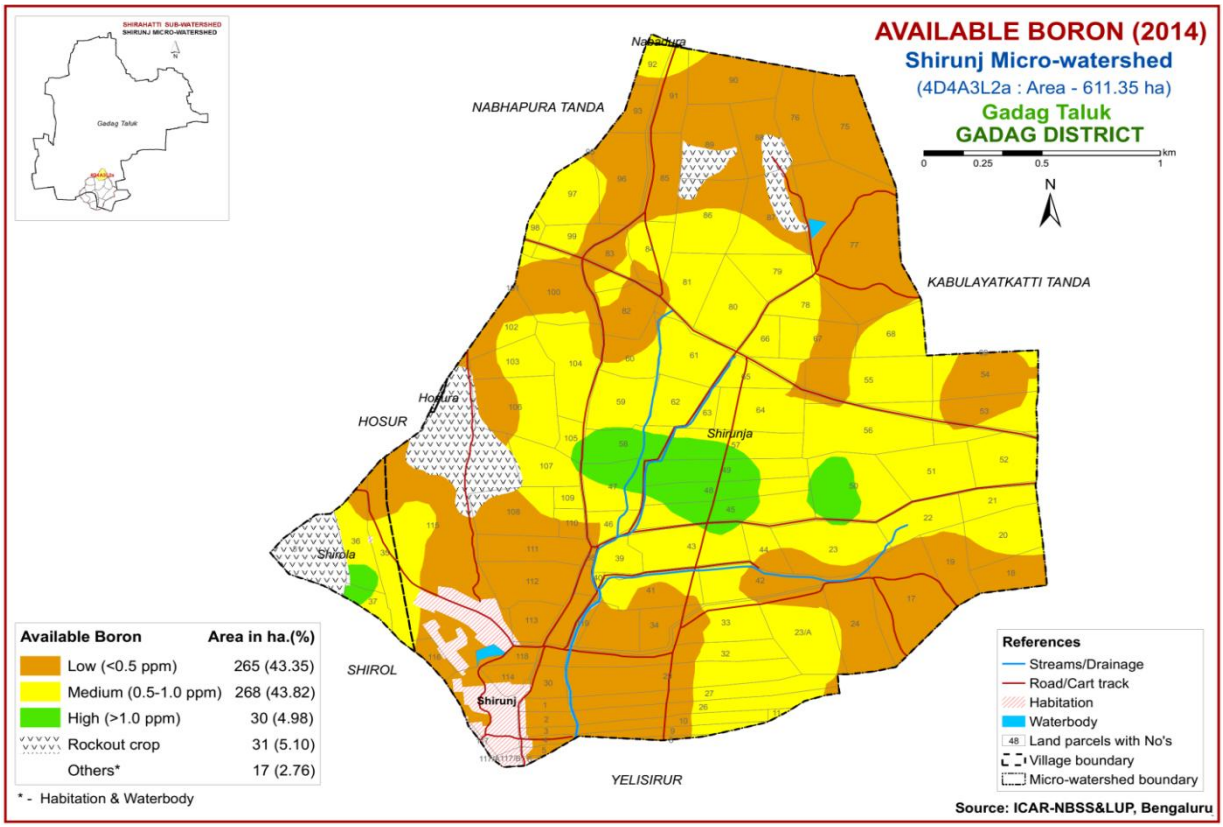


Fig.6.7Soil available Boronmap of Shirunj microwatershed

6.8 Available Iron

Available iron content is sufficient (>4.5 ppm) in 537 ha (88%) and is distributed all over the microwatershed. It is deficient in 27 ha (4%) area and is distributed in the southern part of the microwatershed (Fig 6.8).

6.9 Available Manganese

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

6.10 Available Copper

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

6.11 Available Zinc

Available zinc content is deficient (<0.6 ppm) in major area of 477 ha (78%) of the microwatershed and is distributed in all parts of the microwatershed. It is sufficient (>0.6 ppm) in 86 ha (14%) area of the microwatershed and is distributed in the northwestern and southern part of the microwatershed(Fig 6.11).

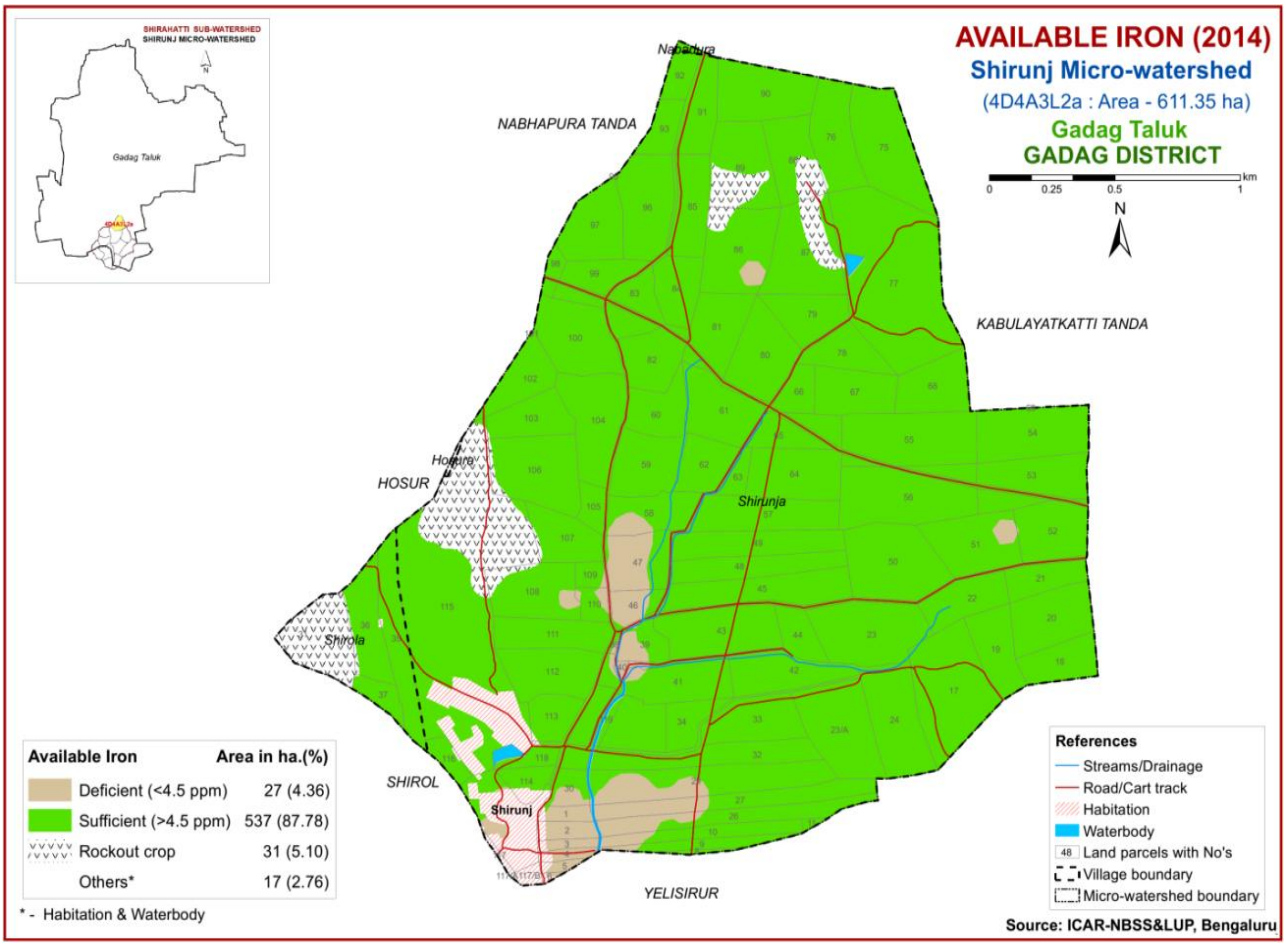


Fig.6.8Soil available Iron map of Shirunj microwatershed

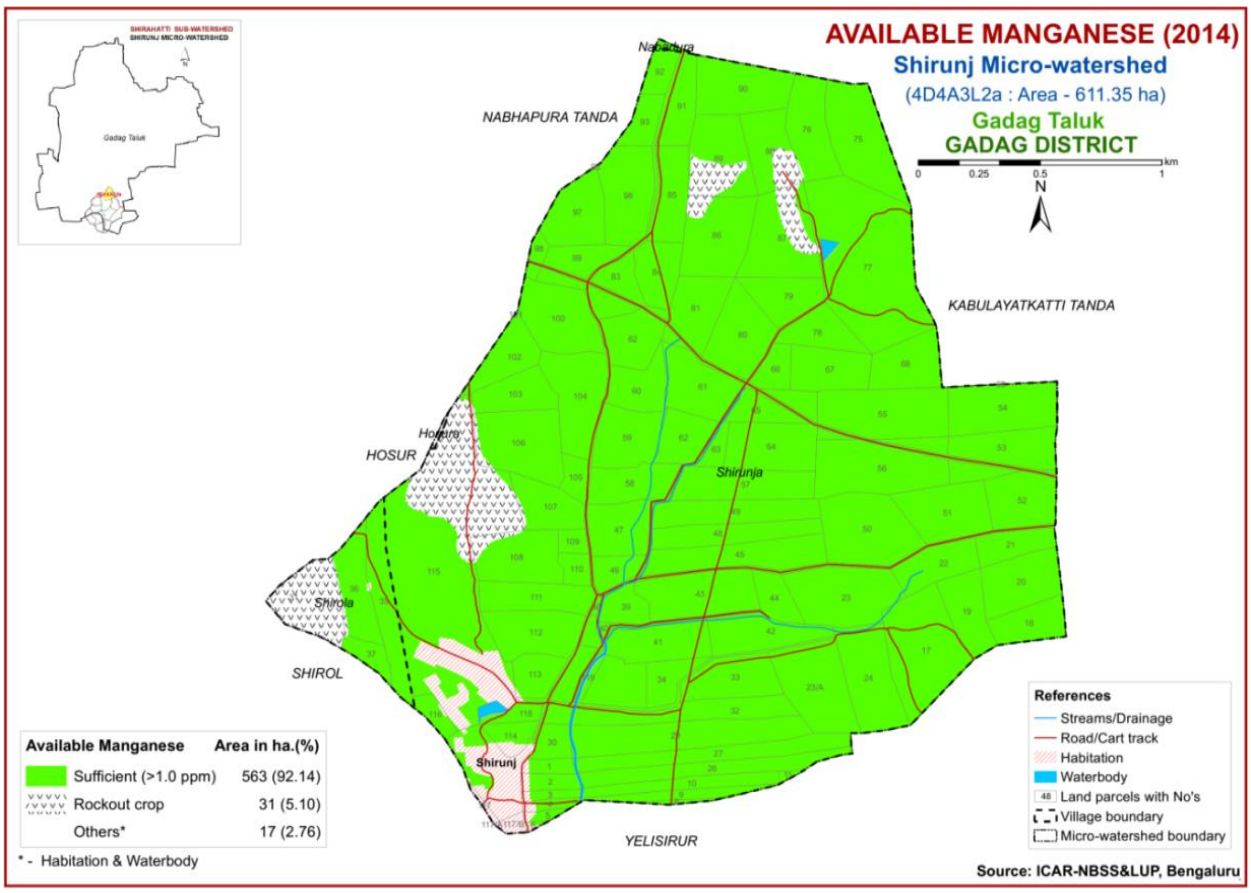


Fig.6.9Soil available Manganese map of Shirunj microwatershed

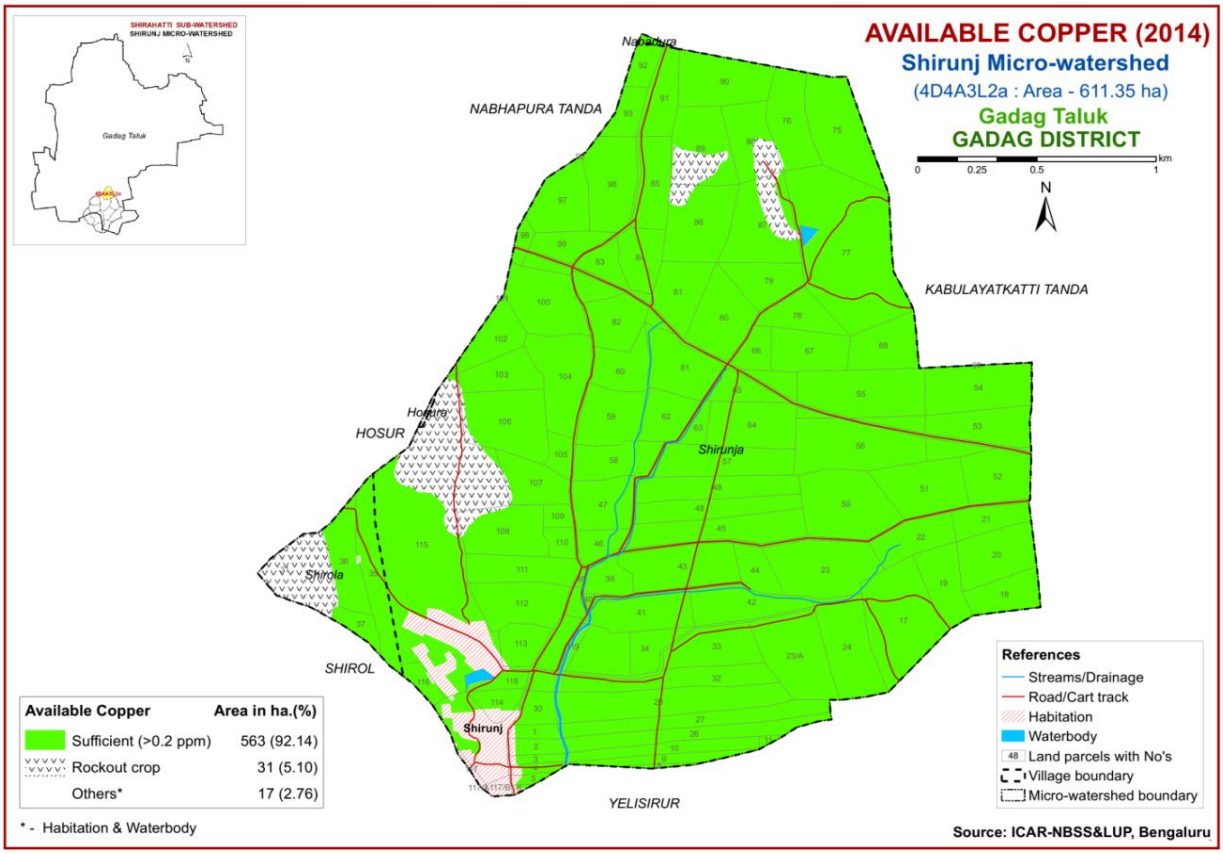


Fig.6.10Soil available Copper map of Shirunj microwatershed

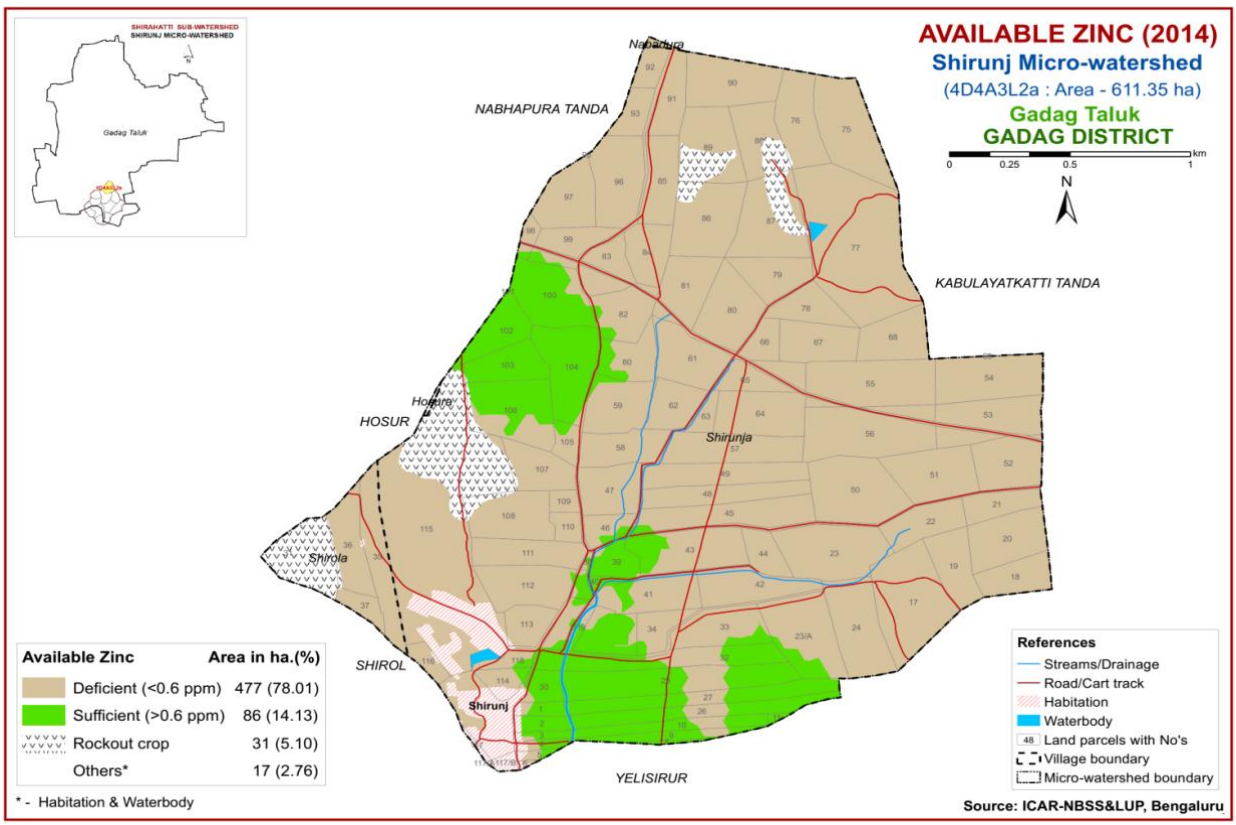


Fig.6.11Soil available Zinc map of Shirunj microwatershed

LAND SUITABILITY FOR MAJOR CROPS

The soil and land resource units (soil phases) of Shirunj microwatershed were assessed for their suitability for growing food, fodder, fibre and 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, 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 Suitableand Class S3-Marginally Suitable. Order N has two classes, N1- Currently not Suitable and N2-Permanently not Suitable. There are no subclasses within the class S1 as they will have very minor or no limitations for crop growth. Classes S2 and S3 are divided into subclasses based on the kinds of limitations encountered. The limitations that affect crop production are 'c' for erratic rainfall and its distribution and length of growing period (LGP), 'e' for erosion hazard, 'r' for rooting condition, 't' for lighter or heavy texture, 'g' for gravelliness or stoniness, 'n' for nutrient availability, 'l' for topography, 'm' for moisture availability and 'w' for drainage. These limitations are indicated as lower case letters to the class symbol. For example, moderately suitable land with the limitations of soil depth and erosion is designated as S2re. For the microwatershed, the soil mapping units were evaluated and classified up to subclass level only; land suitability units are not worked out.

Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for 14 major annual and perenneal crops were prepared. The detailed information on the kind of suitability of each of the soil phase for the crops assessed are given village/ survey number wise for the microwatershed in Appendix-III.

7.1 Land Suitability for Sorghum(*Sorghum bicolor*)

Sorghum is one of the major crop grown in Karnataka in an area of 11.02 lakh ha in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad, Bellary, Chitradurga, Mysore and Chamarajnagar districrts. The crop requirements for growing sorghum (Table 7.2) were matched with the soil-site characteristics (Table 7.1) of the soils of the microwatershed and land suitability map for growing sorghum was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure. 7.1.

An area of about 127 ha (21%) in the microwatershed has soils that are highly suitable (class S1) for growing sorghum crop. They are distributed mainly in the northeastern, northern and small areas insouthern part of the microwatershed. About 55 ha (9%) area is moderately suitable (class S2) for growing sorghum anddistributed in the central and northeastern part of the microwatershed. They have major limitations of gravelliness and rooting depth. Marginally suitable lands (class S3) for growing sorghum occupy about 127 ha (21%) andmainly occur in thesouthwestern, northwestern and southeasternpart of the microwatershed. They have severe limitation of gravelliness and rooting depth. Major area of about 255 ha (42%) is not suitable for growing sorghum in the microwatershed and are distributed in southern, central and northern part of the microwatershed.

Table 7.1 Soil-Site Characteristics of Shirunj microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drai-nage class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC	ESP	CEC Cmol $(p^+)kg^{-1}$	BS (%)
					Surf-ace	Sub-surface	Surface (%)	Subsurface (%)								
AKTfB2g1	652	150	wd	25-50	cl	cl, c	15-35	10-30	50	1-3	moderate					
AKTmB1g1	652	150	wd	25-50	c	cl, c	15-35	10-30	50	1-3	slight					
AKTmB2g2	652	150	wd	25-50	c	cl, c	15-35	10-30	50	1-3	slight					
ATTiB1g2	652	150	wd	50-75	sc	c	35-60	-	50	1-3	moderate					
DDRfB2g2	652	150	wd	<25	cl	cl, c	35-60	>35	25	1-3	moderate					
DDRfC3g1R1	652	150	wd	<25	cl	cl, c	15-35	>35	25	3-5	severe					
DDRhB2g2	652	150	wd	<25	scl	cl, c	35-60	>35	25	1-3	moderate					
DDRhC3g3	652	150	wd	<25	scl	cl, c	60-80	>35	25	3-5	severe					
DDRhD2g2R2	652	150	wd	<25	scl	cl, c	35-60	>35	25	5-10	moderate					
DDRhD3g3R1	652	150	wd	<25	scl	cl, c	60-80	>35	25	5-10	severe					
DDRhD3g3R3	652	150	wd	<25	scl	cl, c	35-60	>35	25	5-10	severe					
DDRiB2g2R1	652	150	wd	<25	sc	cl, c	35-60	>35	25	1-3	moderate					
DDRmB2g2R1	652	150	wd	<25	c	cl, c	35-60	>35	25	1-3	moderate					
DNIfC2g1	652	150	wd	100-150	cl	cl, sc, c	15-35	>35	75	3-5	moderate					
DNImB1	652	150	wd	100-150	c	cl, sc, c	-	>35	75	1-3	slight					
JLGiC2g2	652	150	mwd	75-100	sc	c	35-60	-	150-200	3-5	moderate					
JLGmB1g1	652	150	mwd	75-100	c	c	15-35	-	150-200	1-3	slight					
JLGmB2g2	652	150	mwd	75-100	c	c	35-60	-	150-200	1-3	moderate					
MPTmB1g1	652	150	mwd	100-150	c	c	15-35	-	>200	1-3	slight					
MPTmB2g2	652	150	mwd	100-150	c	c	35-60	-	>200	1-3	moderate					
NBPfC3g2	652	150	wd	25-50	cl	cl, c	35-60	>35	25	3-5	severe					
NBPmB2g1	652	150	wd	25-50	c	cl, c	15-35	>35	25	1-3	moderate					
NBPmB2g2	652	150	wd	25-50	c	cl, c	35-60	>35	25	1-3	moderate					
SRLcB1g2	652	150	wd	<25	sl	cl, c	35-60	10-20	50	1-3	slight					
SRLiB1g1	652	150	wd	<25	sc	cl, c	15-35	10-20	50	1-3	slight					
SRLiB1g2	652	150	wd	<25	sc	cl, c	35-60	10-20	50	1-3	slight					
SRLmB2g2	652	150	wd	<25	c	cl, c	35-60	10-20	50	1-3	moderate					
SRLmC2g2	652	150	wd	<25	c	cl, c	35-60	10-20	50	3-5	moderate					
YSJmB2	652	150	wd	25-50	c	cl-c	-	<15	50-100	1-3	moderate					
YSJmB2g2	652	150	wd	25-50	c	cl-c	35-60	<15	50-100	1-3	moderate					

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

Table 7.2Crop 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

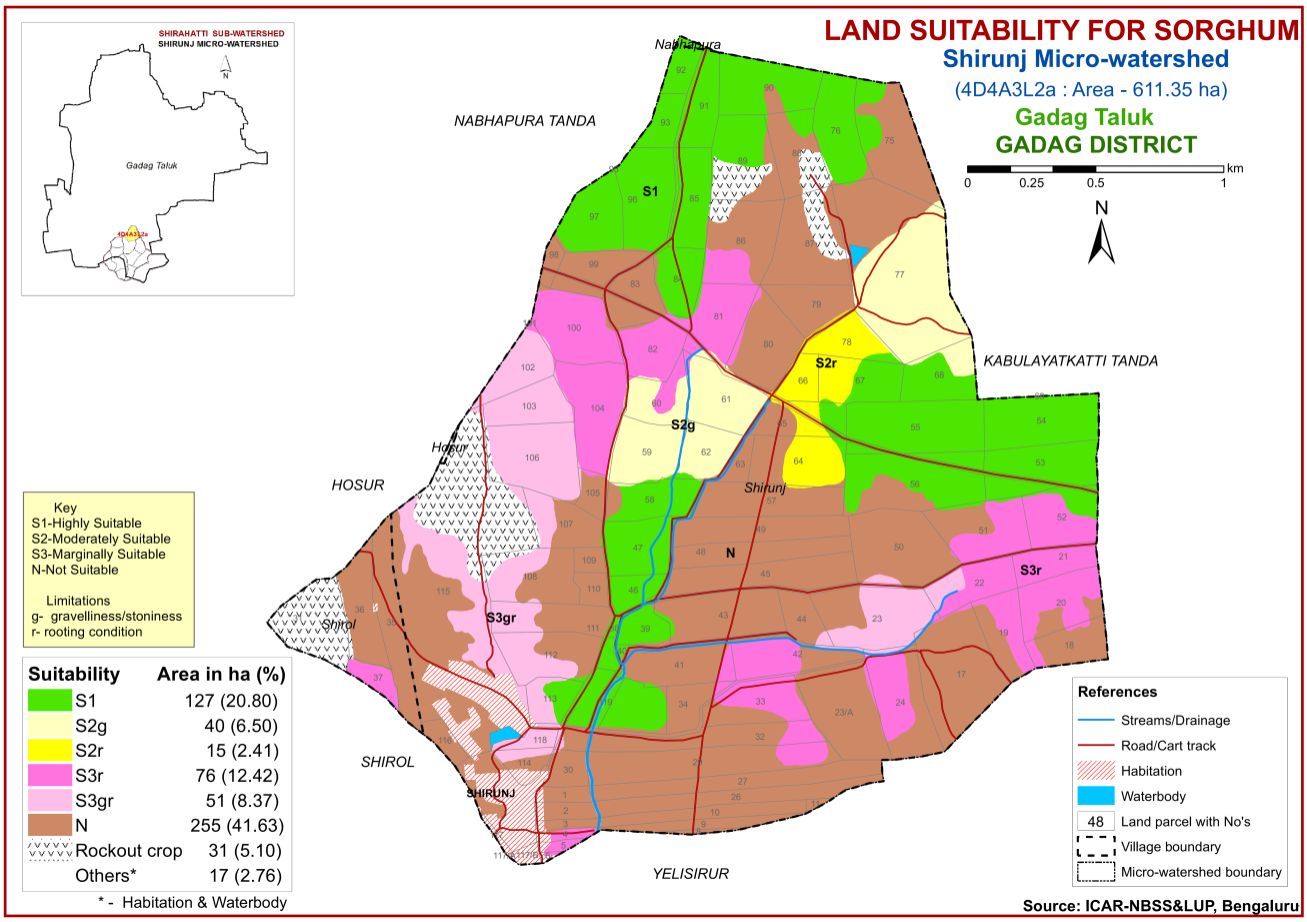


Fig. 7.1 Land Suitability map of Sorghum -Shirunj microwatershed

7.2 Land Suitability for Maize(*Zea mays*)

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

Moderately suitable (class S2) lands found to occur in about 55 ha (9%) that have moderate limitations of gravelliness and rooting depth. They are distributed in central and northeastern parts of the microwatershed. The marginally suitable (class S3) lands cover about 254 ha (42%) area in the microwatershed and dominantly occur in the southwestern, southeastern, northeastern and northwestern part of the microwatershed. They have severe limitations of texture, gravelliness and rooting depth. Major area of about 255 ha (42%) is not suitable for growing maize and they occur mainly in southern, central and northern part of the microwaershed.

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	

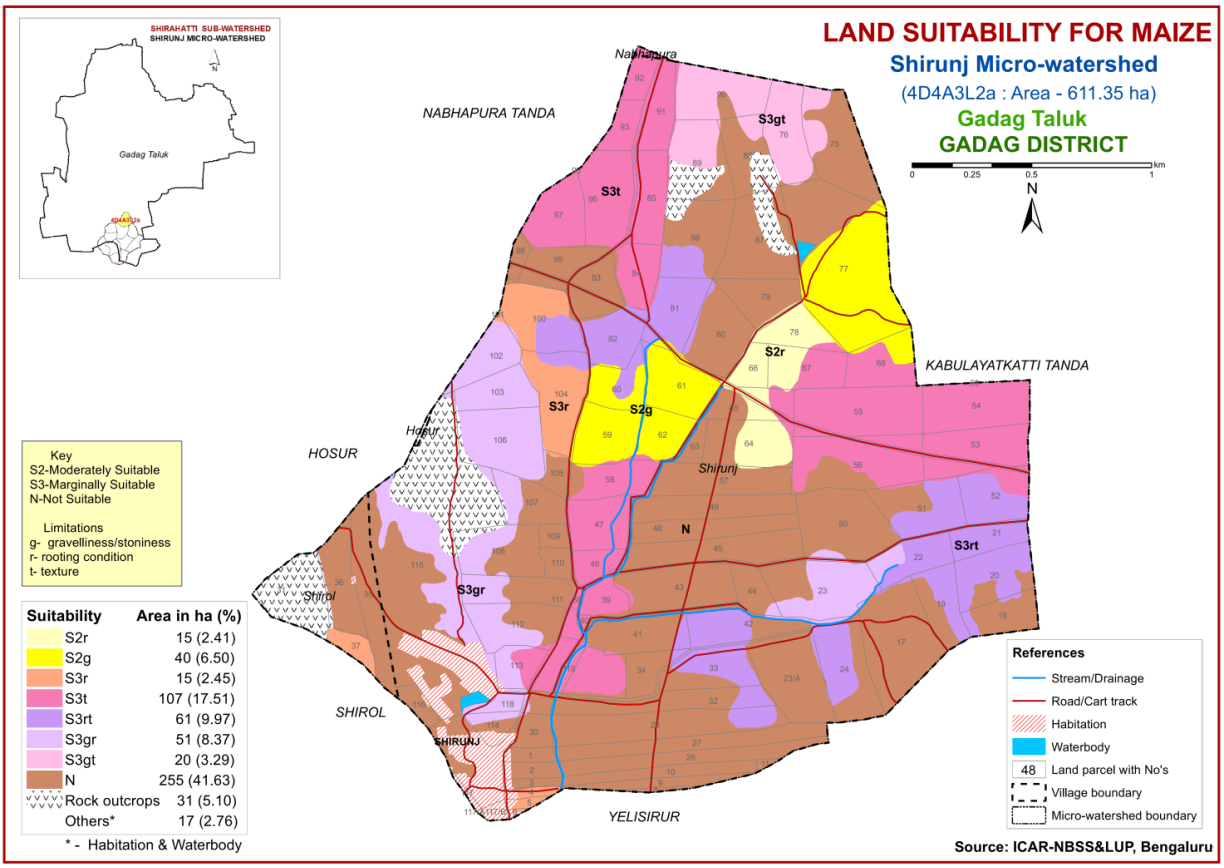


Fig. 7.2 Land Suitability map of Maize-Shirunj microwatershed

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

Red gram is one of the major pulse crop grown in an area of 8.23 lakh ha in northern Karnataka in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad and Bellary districrts. The crop requirements for growing red gram (Table 7.4) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and land suitability map for growingred gram was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.3.

About 168 ha (27%) area is moderately suitable (class S2) for red gram and they are distributed in thenorthern, eastern and central part of the microwatershed. They have major limitations of gravelliness, texture and rooting depth. Marginally suitable lands (class S3) for growing red gram occupy about 15 ha (2%) and mainly occur inthe northeastern part of the microwatershed. It has severe limitations of rooting depth. Major area of about 382 ha (62%) is not suitable for growing red gram andoccurall part ofthe microwatershed.

Table 7.4 Crop suitability criteria for Red gram

Crop requirement		Rating			
Soil–site characteristics	unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	>210	180-210	150-180	<150
Soil drainage	class	Well drained	Mod. to well drained	Imperfectly drained	Poorly drained
Soil reaction	pH	6.5-7.5	5.0-6.5 7.6-8.0	8.0-9.0	>9.0
Surface soil texture	Class	l, scl, sil, cl, sl	sicl, sic, c(m)	ls	S, fragmental
Soil depth	Cm	>100	85-100	40-85	<40
Gravel content	% vol.	<20	20-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	>2.0	
Sodicity (ESP)	%	<10	10-15	>15	

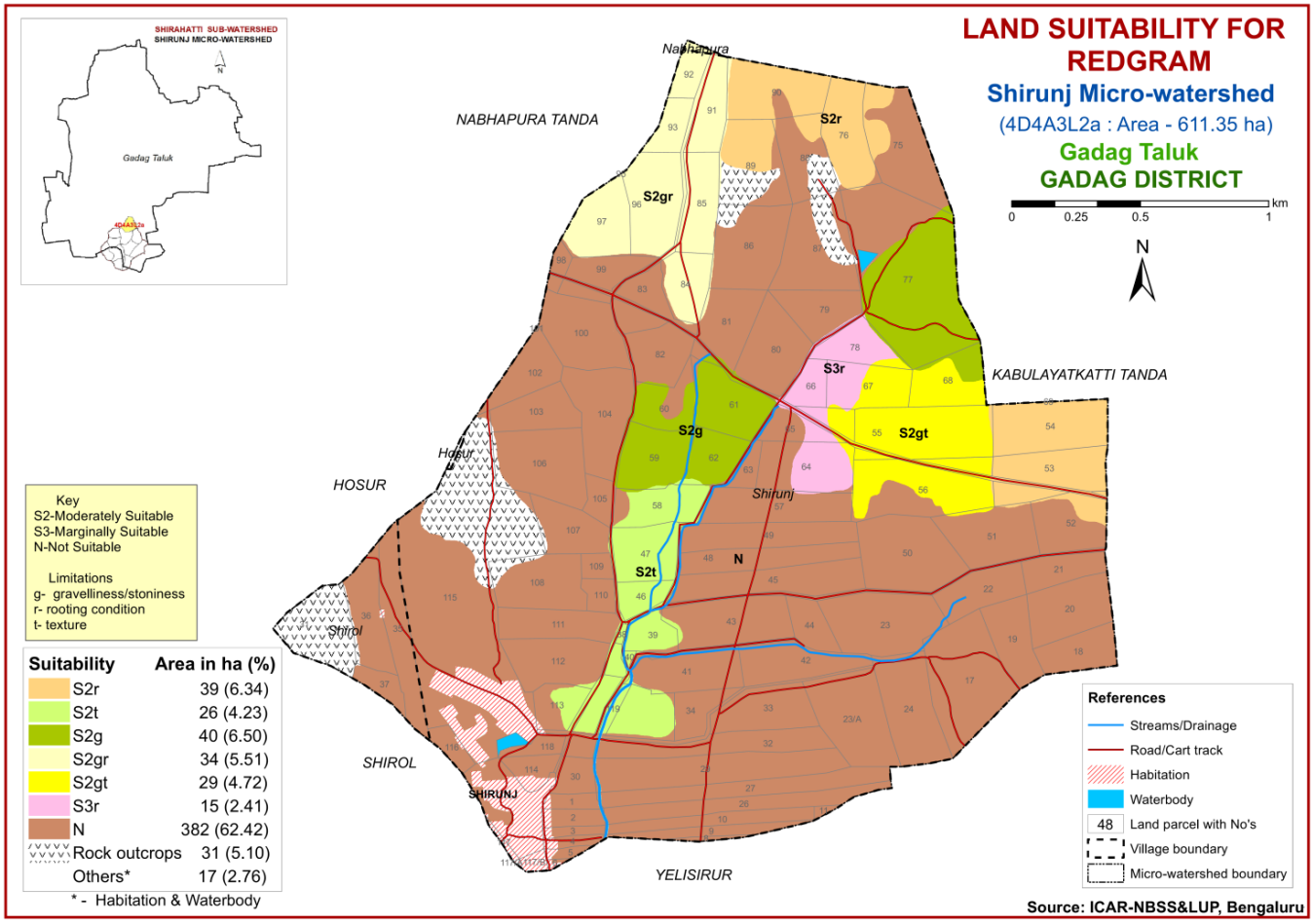


Fig. 7.3 Land Suitability map of Redgram-Shirunj microwatershed

7.4 Land Suitability for Bengalgram(*Cicer arietinum*)

Bengalgram is one of the major pulse crop grown in an area of 9.26 lakh ha in northen Karnataka in Bijapur, Gulbarga, Raichur, Bidar, Belgaum, Dharwad and Bellary districrts. The crop requirements for growing bengalgram (Table 7.5) were matched with the soil-site characteristics of the soils of the microwatershed(Table 7.1) and land suitability map for growing bengal gram was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.4.

About 74 ha (12%) area is moderately suitable (class S2) for bengalgram and distributed in the central and eastern part of the microwatershed. They have major limitations of gravelliness and rooting depth. Major area ofabout 359 ha (59%) occurs in marginally suitable lands (class S3) for growing bengalgram and distributed in all part of the microwatershed. They have severe limitations of rooting depth and gravelliness. An area of about 129 ha (21%) is not suitable for growing bengalgram in the microwatershed and distributed in the northerneastern, southeastern and southwestern part of the microwatershed.

Table 7.5 Crop suitability criteria for Bengal gram

Crop requirement		Rating			
Soil–site characteristics	unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	>100	90-100	70-90	<70
Soil drainage	class	Well drained	Mod. to well drained; imperfectly drained	Poorly drained; excessively drained	Very Poorly drained
Soil reaction	pH	6.0-7.5	5.5-5.7 7.6-8.0	8.1-9.0;4.5-5.4	>9.0
Surface soil texture	Class	l, scl, sil, cl,	sicl, sic, c	Sl, c>60%	S, fragmental
Soil depth	Cm	>75	51-75	25-50	<25
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	

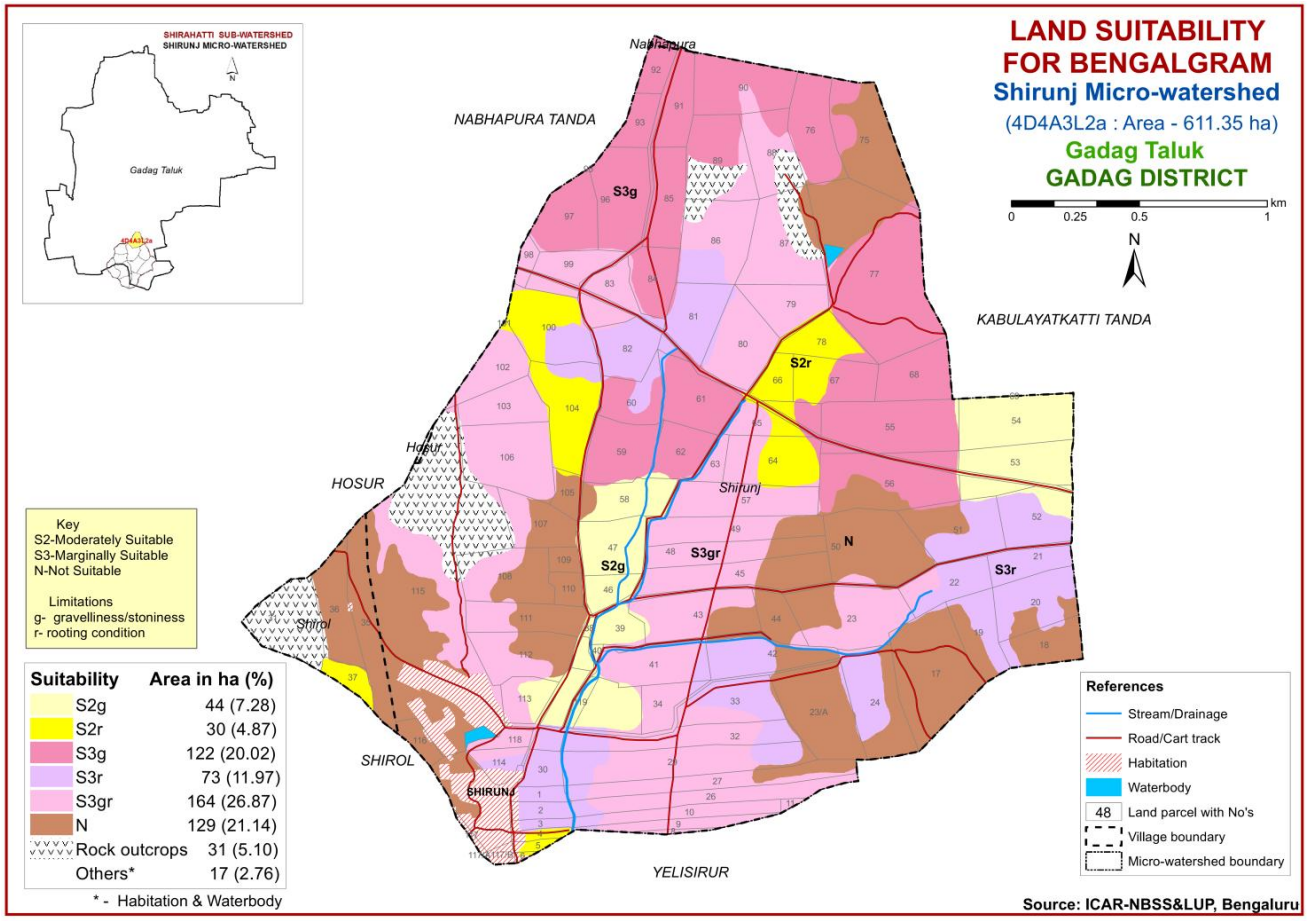


Fig. 7.4 Land Suitability map of Bengalgram-Shirunj microwatershed

7.5 Land Suitability for Groundnut(*Arachis hypogaea*)

Groundnut is one of the major oilseed crop grown in an area of 6.53 lakh ha in Karnataka in most of the districts either as rainfed or irrigated crop. The crop requirements for growing groundnut (Table 7.6) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and land suitability map for growing groundnut was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.5.

An area of about 55 ha (9%) is moderately suitable (class S2) for growing groundnut and these areas are distributed in the central and northeastern part of the microwatershed. They have moderate limitations of gravelliness and rooting depth. Marginally suitable lands (class S3) for growing groundnut occupy about 254 ha (42%) and mainly occur in the southern and central part of the microwatershed. They have severe limitations of rooting depth and texture. Major area of about 255 ha (42%) is not suitable for growing groundnut anddistributed throughout the microwatershed.

Table 7.6 Crop suitability criteria for Groundnut

Crop requirement		Rating			
Soil–site characteristics	unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Slope	%	<3	3-5	5-10	>10
LGP	Days	100-125	90-105	75-90	
Soil drainage	class	Well drained	mod. Well rained	imperfectly drained	Poorly drained
Soil reaction	pH	6.0-8.0	8.1-8.5 5.5-5.9	>8.5 <5.5	
Surface soil texture	Class	l, cl, sil, sc, sicl	Sc, sic, c,	S, ls, sl c (>60%)	fragmental
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<35	35-50	>50	
$CaCO_3$ in root zone	%	high	Medium	low	
Salinity (EC)	dSm^{-1}	<2.0	2.0-4.0	4.0-8.0	
Sodicity (ESP)	%	<5	5-10	>10	

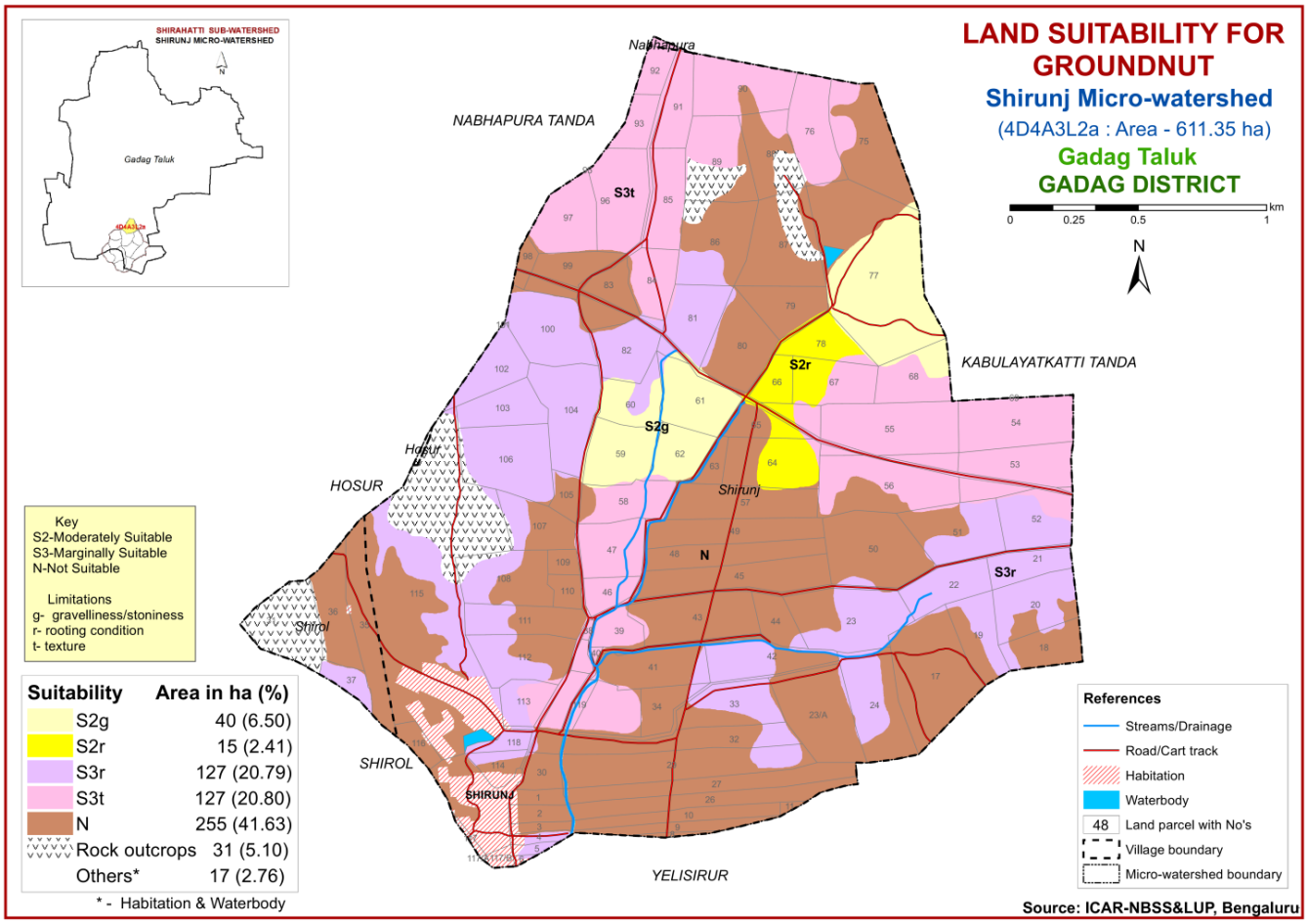


Fig. 7.5 Land Suitability map of Groundnut-Shirunj microwatershed

7.6 Land Suitability for Sunflower(*Helianthus annus*)

Sunflower is the most important oilseed crop grown in an area of 4.16 lakh ha in the State in all the districts. The crop requirements for growing sunflower (Table 7.7) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and a land suitability map for growing sunflower was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.6.

About 26 ha (4%) area in the microwatershed is highly suitable (class S1) for growing sunflower and distributed in central and southwestern part of the microwatershed. Moderately suitable (class S2) lands are found to occur in about 48 ha (8%). They have moderate limitations of gravelliness. They are dominantly distributed in eastern part of the microwatershed. The marginally suitable (class S3) lands cover about 109 ha (18%) area in the microwatershed and dominantly occur in thecentral and northern part of the microwatershed. They have severe limitations of gravelliness and rooting depth. Major area of about 382 ha (62%) area is not suitable for growing sunfloweranddistributed all part of the microwatershed.

Table 7.7 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 rained	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, S, fragmental
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	

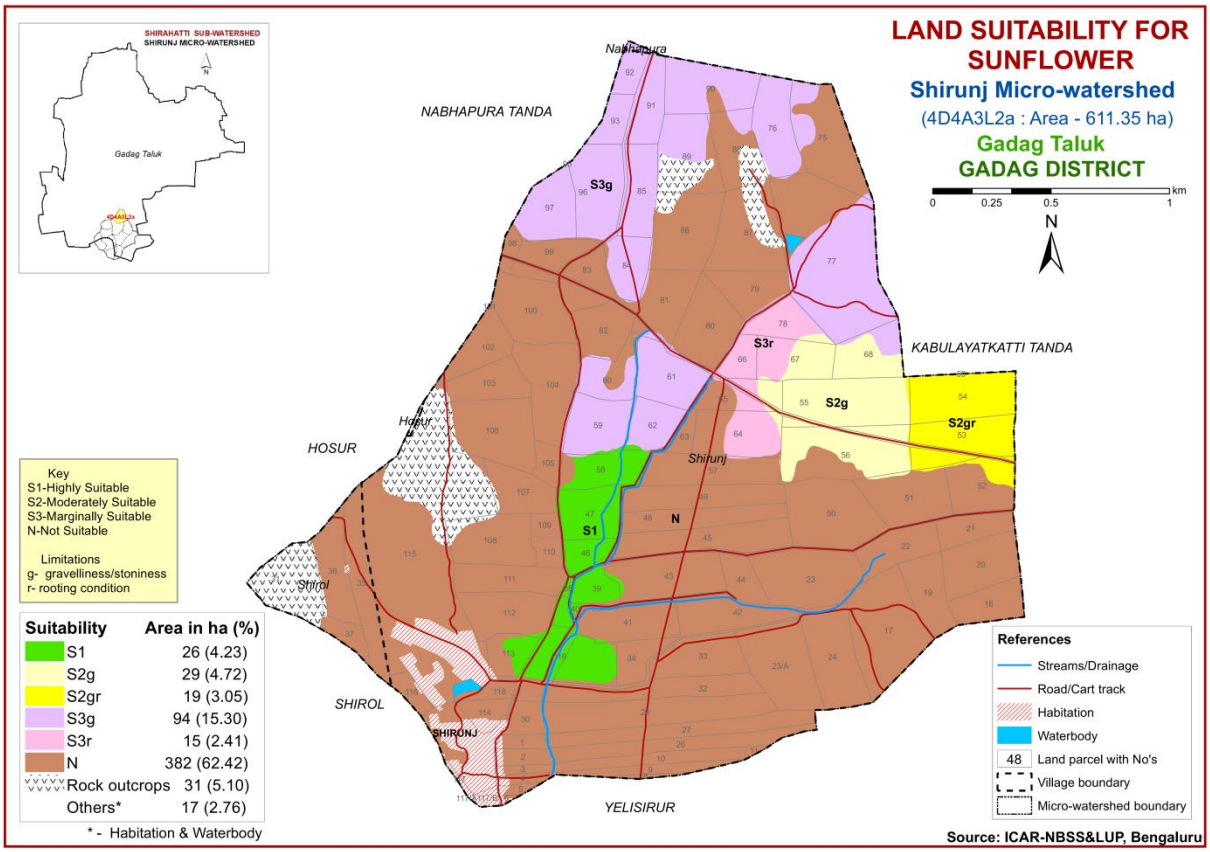


Fig. 7.6 Land Suitability map of Sunflower-Shirunj microwatershed

7.7 Land Suitability for Cotton (*Gossypium hirsutum*)

Cotton is the most important fibre crop grown in the State in about 6.61 lakh ha in Raichur, Dharwad, Belgaum, Gulbarga, Bijapur, Bidar, Bellary, Chitradurga and Chamarajnagar districts. The crop requirements for growing cotton (Table 7.8) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and a land suitability map for growing cotton was generated and the area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.7.

About 55 ha (9%) area in the microwatershed is highly suitable (class S1) for growing cotton and distributedin the eastern and southwestern part of the microwatershed.An area of about 87 ha (14%) has soils that are moderately suitable (class S2) with moderate limitations of rooting depth. They are mainly distributed in the northern and eastern part of the microwatershed. The marginally suitable (class S3) lands cover about 167 ha (27%) area in the microwatershed and mainly occur in thesoutheastern, western and northwestern part of the microwatershed. They have severe limitations of rooting depth and gravelliness. Major area of about 255 ha (42%) is not suitable for growing cotton and is distributed in all parts of the microwatershed.

Table 7.8 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, ls, s
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

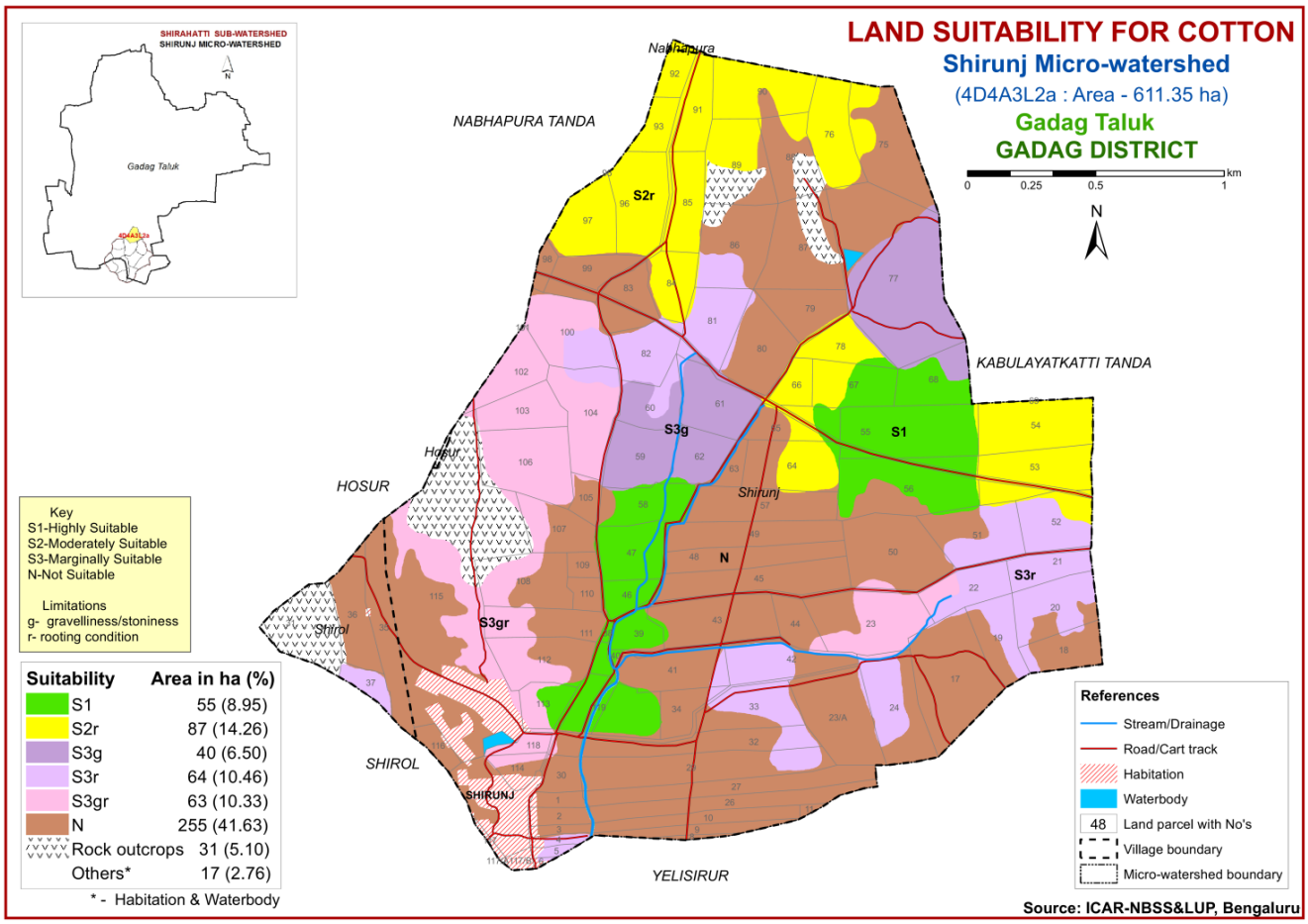


Fig. 7.7 Land Suitability map of Cotton-Shirunj microwatershed

7.8 Land Suitability for Banana(*Musa paradisiaca*)

Banana is one of the major fruit crop grown in an area of 1.02 lakh ha in Karnataka State. The crop requirements for growing banana (Table 7.9) were matched with the soil-site characteristics of the soils of the microwatershed(Table 7.1) and land suitability map for growing banana was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.8.

An area of about 167 ha (27%) area is moderately suitable (class S2) for growing banana and distributed in thecentral, northern and eastern part of the microwatershed. They have major limitations of gravelliness and texture. Marginally suitable (class S3) lands for growing banana occupy about 15 ha (2%) and mainly occur in thenortheastern part of the microwatershed. They have severe limitations of rooting depth. Major area of about 382 ha (62%) is not suitable for growing banana in the microwatershed and is distributed in all parts of the microwaterhed.

Table 7.9 Crop suitability criteria for Banana

Crop requirement			Rating			
Soil –site characteristics		unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temperature in growing season	^{0}C	26-33	34-36 24-25	37-38	>38
Soil aeration	Soil drainage	class	Well drained	Moderately to imperfectly drained	Poorly drained	Very poorly drained
Nutrient availability	Texture	Class	l,cl, scl,sil	Sicl, sc, c(<45%)	C (>45%), sic, sl	ls, s
	pH	1:2.5	6.5-7.0	7.1-8.55.5-6.4	>8.5<5.5	
Rooting conditions	Soil depth	cm	>125	76-125	50-75	<50
	Stoniness	%	<10	10-15	15-35	>35
Soil toxicity	Salinity	dS/m	<1.0	1-2	>2	
	Sodicity	%	<5	5-10	10-15	>15
Erosion	Slope	%	<3	3-5	5-15	>15

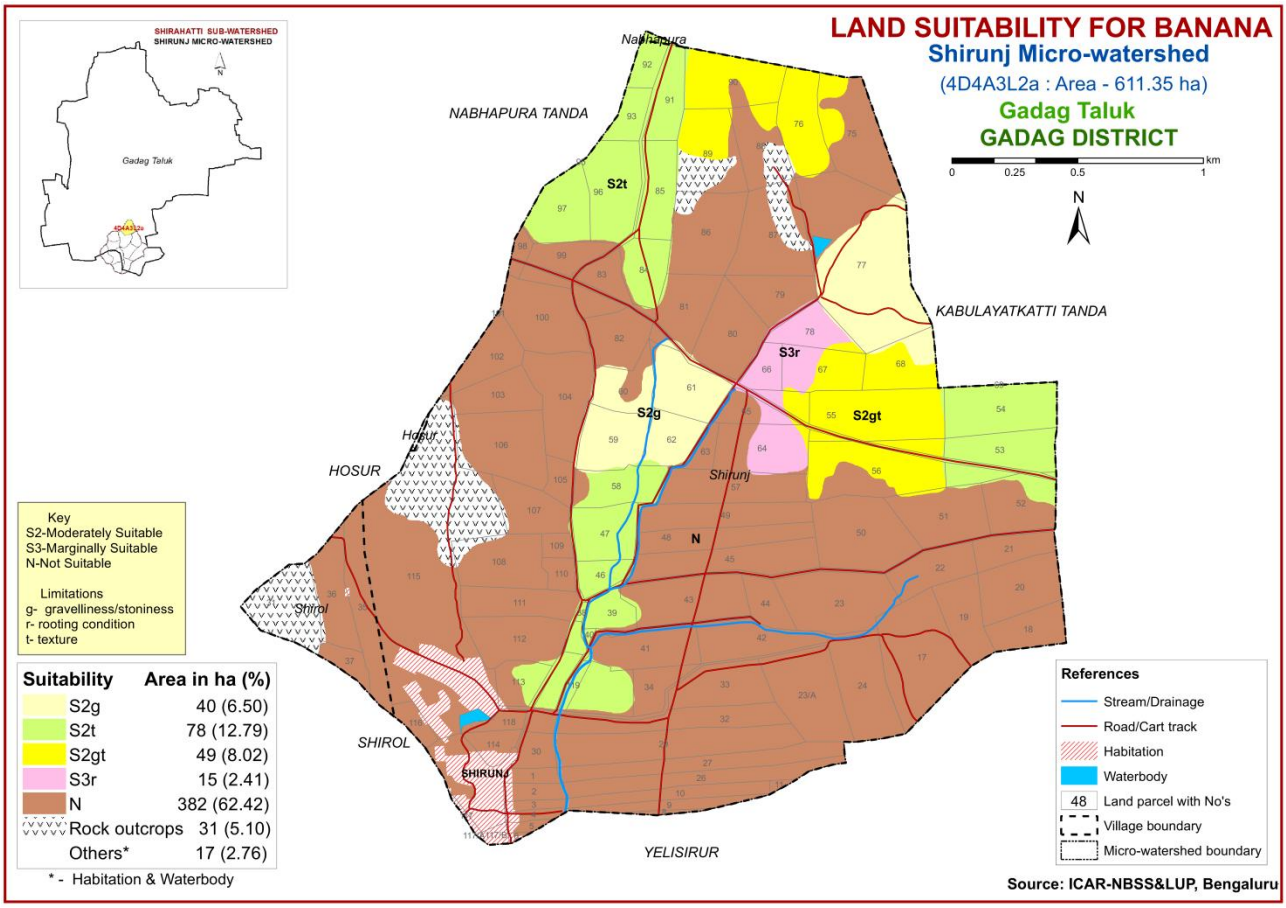


Fig. 7.8 Land Suitability map of Banana-Shirunj microwatershed

7.9 Land Suitability for Pomegranate (*Punica granatum*)

Pomegranate is one of the commercially grown fruit crop in Karnataka in an area of 0.16lakh ha mainly in Bijapur, Bagalkot, Koppal, Gadag and Chitradurga districts. The crop requirements for growing pomegranate (Table 7.10) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and land suitability map for growing pomegranate was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.9.

An area of about 167 ha (27%) area is moderately suitable (class S2) for growing banana and distributed in the central, northern and eastern part of the microwatershed. They have major limitations of gravelliness and texture. Marginally suitable (class S3) lands for growing banana occupy about 15 ha (2%) and mainly occur in thenortheastern part of the microwatershed. They have severe limitations of rooting depth. Major area of about 382 ha (62%) is not suitable for growing banana in the microwatershed and are distributed in all parts of the microwaterhed.

Table 7.10 Crop suitability criteria for Pomegranate

Crop requirement			Rating			
Soil –site characteristics		unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temperature in growing season	^{0}C	30-34	35-38 25-29	39-40 15-24	
Soil moisture	Growing period	Days	>150	120-150	90-120	<90
Soil aeration	Soil drainage	class	Well drained	imperfectly drained		
Nutrient availability	Texture	Class	Sl, scl, l, cl	C, sic, sicl	Cl, s, ls	fragmental
	pH	1:2.5	5.5-7.5	7.6-8.5	8.6-9.0	
Rooting conditions	Soil depth	Cm	>100	75-100	50-75	<50
	Gravel content	% vol.	nil	15-35	35-60	>60
Soil toxicity	Salinity	dS/m	nil	<9	>9	<50
	Sodicity	%	nil			
Erosion	Slope	%	<3	3-5	5-10	

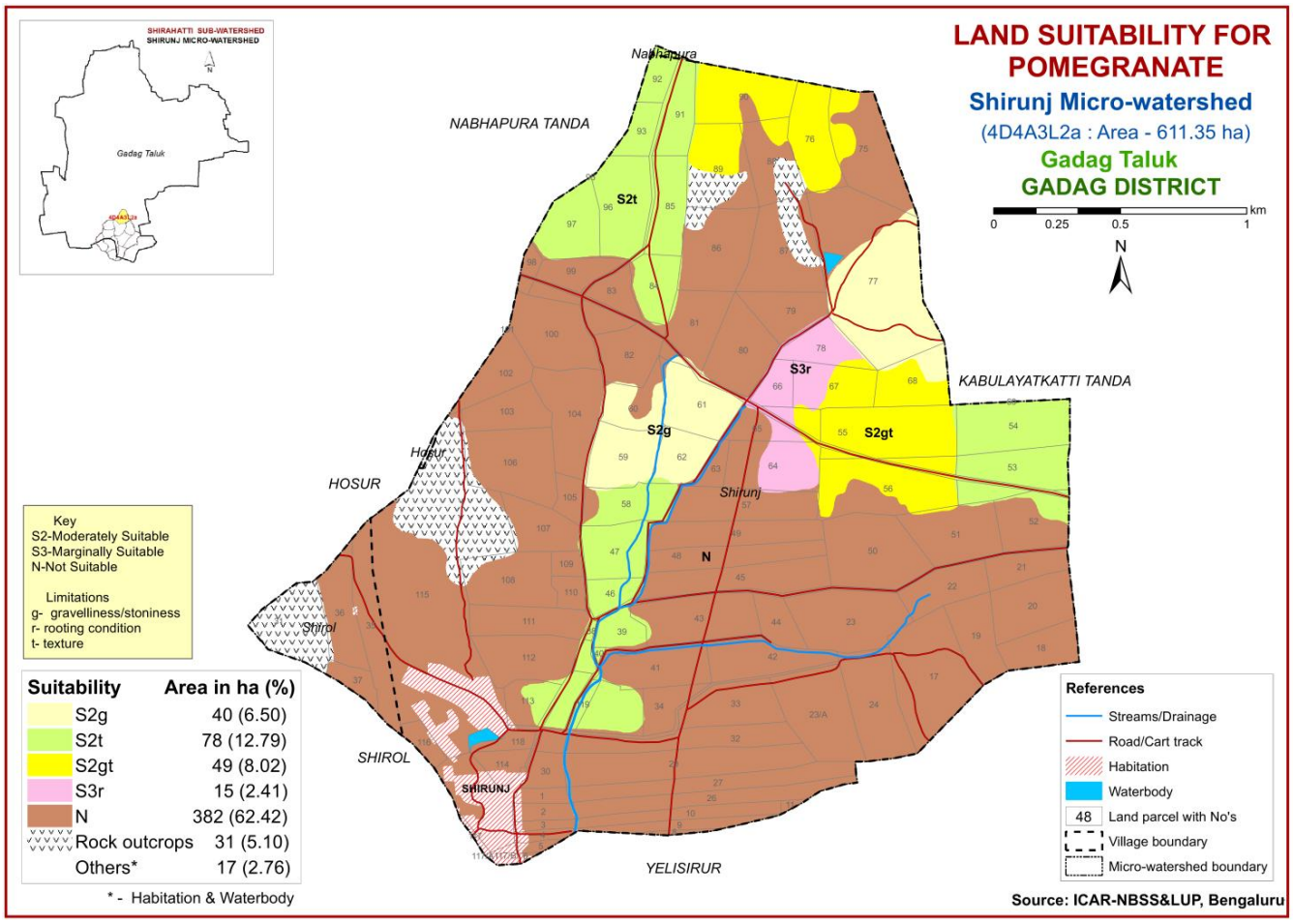


Fig. 7.9 Land Suitability map of Pomegranate-Shirunj microwatershed

7.10 Land Suitability for Onion(*Allium cepa*)

Onion is one of the major vegetablecrop grown in an area of 1.59 lakh ha in Karnataka State. The crop requirements for growing onion were matched with the soil-site characteristics of the soils of the microwatershed and land suitability map for onion was prepared. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Figure 7.10.

An area of about 143 ha (23%) is moderately suitable (class S2) for growing onion and they are distributed in the northern, eastern and central part of the microwatershed. They have major limitations of gravelliness, rooting depth and texture. Marginally suitable (class S3) lands for growing onion occupy about 168 ha (27%) and mainly occur in the western, southeastern and central part of the microwatershed. They have severe limitations of rooting depth and gravelliness. Major area of about 255 ha (42%) is not suitable for growing onion in the microwatershed and are distributed in all parts of the microwaterhed.

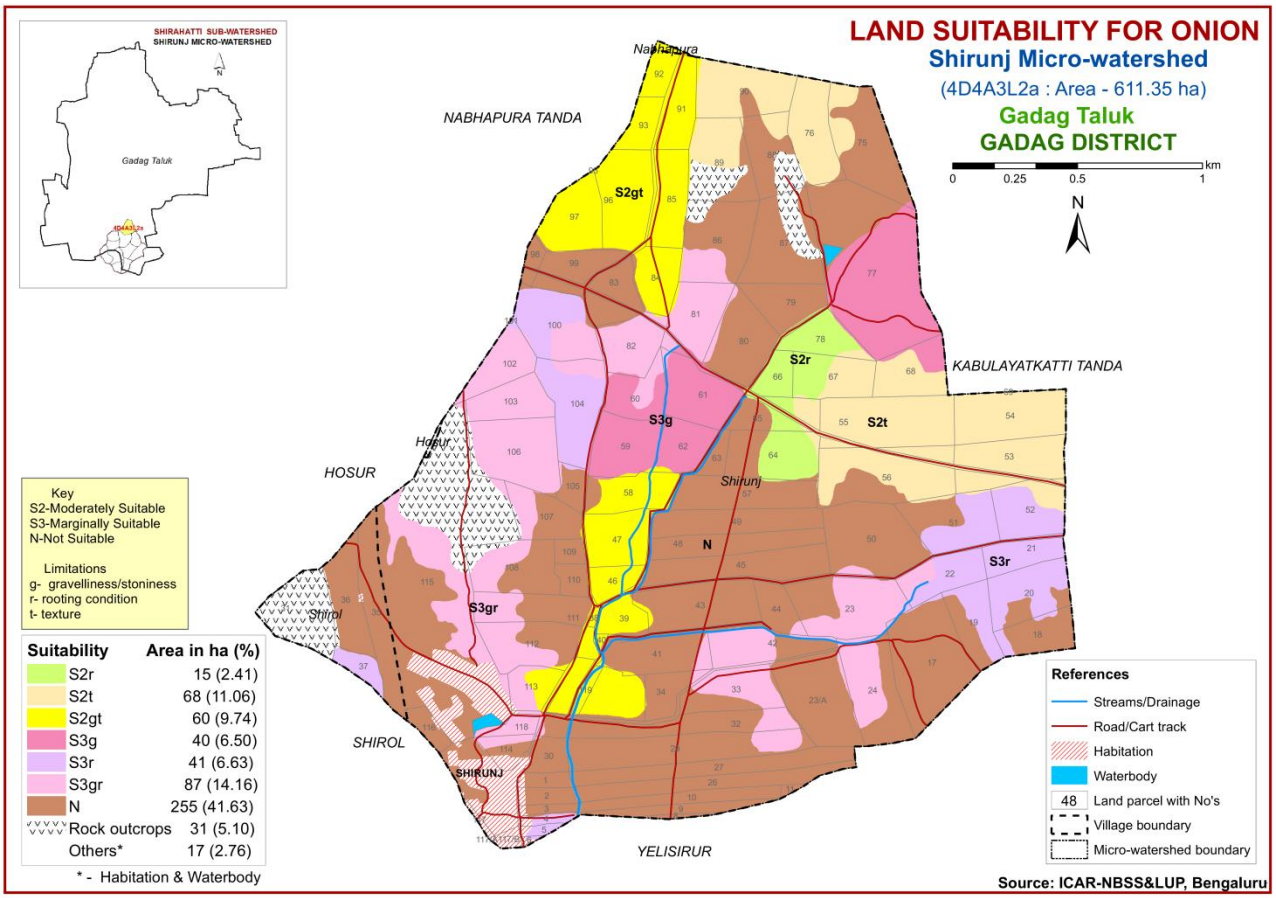


Fig. 7.10 Land Suitability map of Onion-Shirunj microwatershed

7.11 Land Suitability for Chillies(*Capsicum annuum*)

Chilli is one of themajor vegetable/ spice crop grown in an area of 2.04 lakh ha in all the districts of the State. The crop requirements for growingchilli (Table 7.11) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and a land suitability map for growing chilli was generated.The area and geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.11.

An area of about 88 ha (14%) has soils that are moderately suitable (class S2) with moderate limitations of gravelliness, texture and rooting depth. They are dominantly distributed in the eastern part of the microwatershed. The marginally suitable (class S3) lands cover about 222 ha (36%) area in the microwatershed and mainly occur in thenorthern, northwestern and southeastern part of the microwatershed. They have severe limitations of rooting depth and gravelliness. Major area of about 255 ha (42%) is not suitable for growing chillies in the microwatershed and are distributed in all parts of the microwaterhed.

Table 7.11Crop suitability criteria for Chillies

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	
LGP	Days	>150	120-150	90-120	<90
Soil drainage	class	Well drained	Mod.to imperfectly drained	Poor drained/excessively	Very poorly drained
Soil reaction	pH	6.0-7.0	7.1-8.0	8.1-9.05.0-5.9	>9.0
Surface soil texture	Class	L, scl, cl, sil	sl,sc,sic,c(m/k)	C(ss), ls, s	fragmental
Soil depth	Cm	>75	50-75	25-50	<25
Gravel content	% vol.	<15	15-35	35-60	>60
Salinity (EC)	dSm^{-1}	<1.0	1.0-2.0	2.0-4.0	<4
Sodicity (ESP)	%	<5	5-10	10-15	

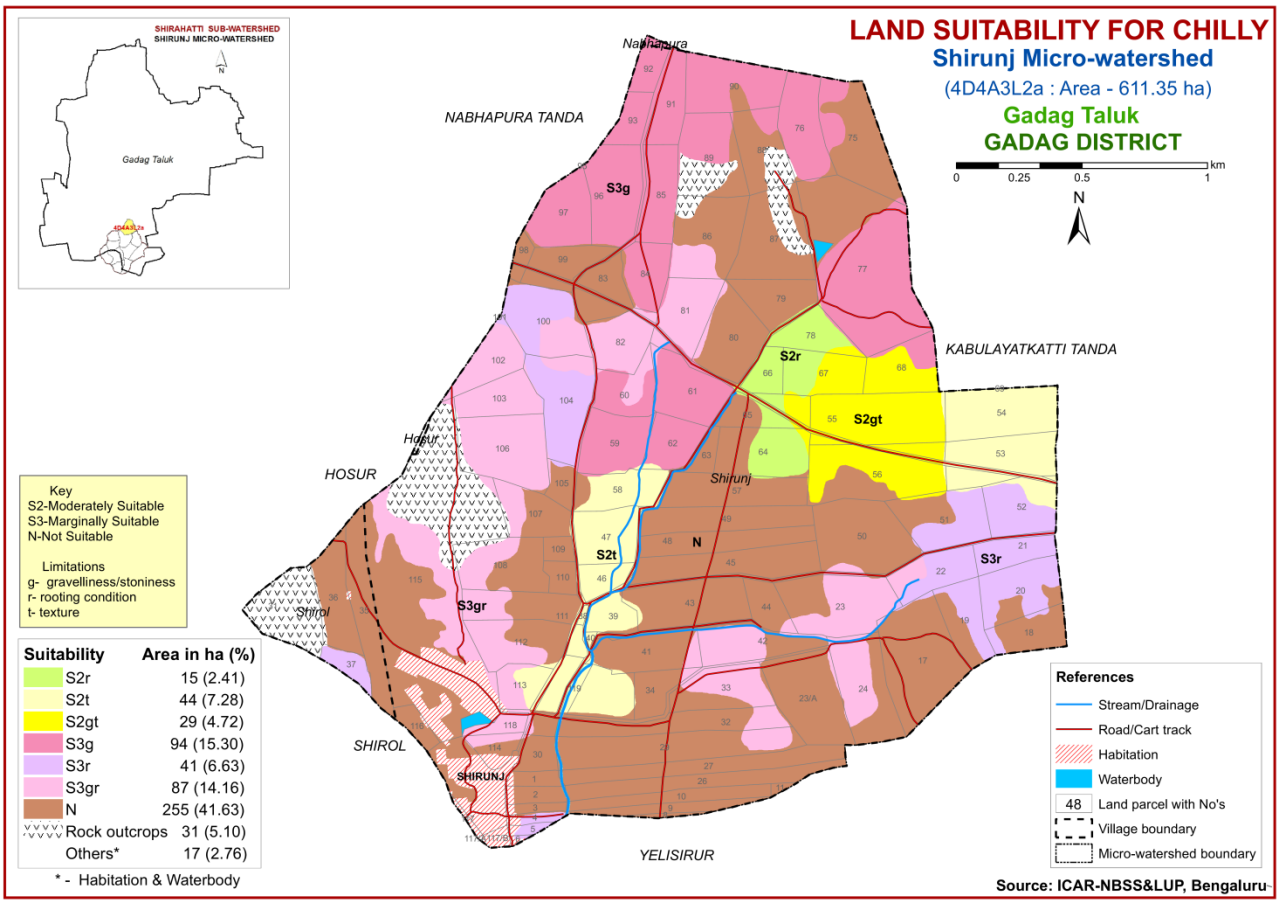


Fig. 7.11 Land Suitability map of Chilli-Shirunj microwatershed

7.12 Land Suitability for Tomato(*Lycopersicon esculentum*)

Tomato is the most important vegetable crop grown in an area of 0.57 lakh ha in in all the districts of Karnataka State. The crop requirements for growing tomato (Table 7.12) were matched with the soil-site characteristics of the soils of the microwatershed (Table 7.1) and a land suitability map for growing tomato was generated and the area and geographical distribution of different suitability subclasses in the microwatershed are given in Figure 7.12.

An area of about 88 ha (14%) has soils that are moderately suitable (class S2) with moderate limitations of texture and rooting depth. They are dominantly distributedin the central and eastern part of the microwatershed. The marginally suitable (class S3) lands cover about 222 ha (36%) area in the microwatershed and dominantly occur in the northern, northwestern and southeastern part of the microwatershed. They have severe limitations of rooting depth and gravelliness. Major area of about 255 ha (42%) is not suitable for growing tomato and are distributed in all parts of the microwaterhed.

Table 7.12 Crop suitability criteria for Tomato

Crop requirement			Rating			
Soil–site characteristics		unit	Highly suitable (S1)	Moderately Suitable (S2)	Marginally suitable (S3)	Not suitable (N)
climate	Temperature in growing season	^{0}C	25-28	29-32 20-24	15-19 33-36	<15 >36
Soil moisture	Growing period	Days	>150	120-150	90-120	
Soil aeration	Soil drainage	class	Well drained	Moderate	Imperfect	Poor
Nutrient availability	Texture	Class	l, sl, cl, scl	Sic,sicl,sc,c(m/k)	C (ss)	ls, s
	pH	1:2.5	6.0-7.0	5.0-5.97.1-8.5	<5;>8.5	
	$CaCO_3$ in root zone	%	Non calcareous	Slightly calcareous	Strong calcareous	
Rooting conditions	Soil depth	Cm	>75	50-75	25-50	<25
	Gravel content	% vol.	<15	15-35	>35	
Soil toxicity	Salinity	dS/m	Non saline	slight	strongly	
	Sodicity	%	Non sodic	slight	strongly	
Erosion	Slope	%	1-3	3-5	5-10	>10

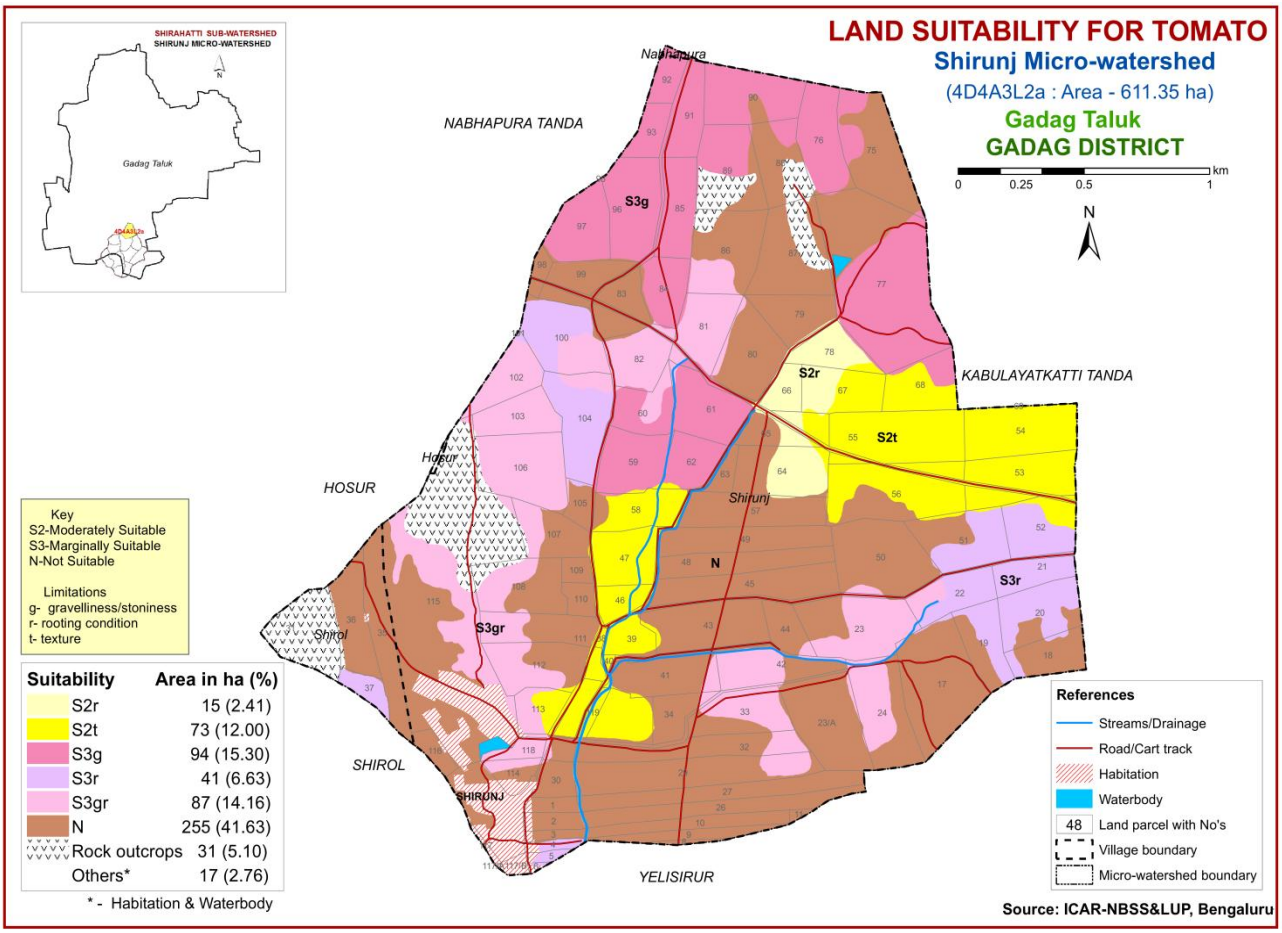


Fig. 7.12 Land Suitability map of Tomato-Shirunj microwatershed

7.13 Land Suitability for Marigold (*Tagetes erecta*)

Marigold is the most important flower crop grown in an area of 1858 ha in almost all the districts of the state. The crop requirements for growing marigold were matched with the soil-site characteristics of the soils of the microwatershed and a land suitability map for growing marigold was generated. The area and geographical distribution of different suitability subclasses in the microwatershed is given in Figure 7.13.

Moderately suitable (class S2) lands found to occur in about 182 ha (28%) that have moderate limitations of gravelliness, rooting depth and texture. They are distributed in northern and northeastern part of the microwatershed. The marginally suitable (class S3) lands cover about 127 ha (21%). They are dominantly distributed in the eastern, western and southeastern part of the microwatershed. They have severe limitations of rooting depthand gravelliness. Major area of about 255 ha (42%) is not suitable for growing marigoldand are distributed in all parts of the microwaterhed.

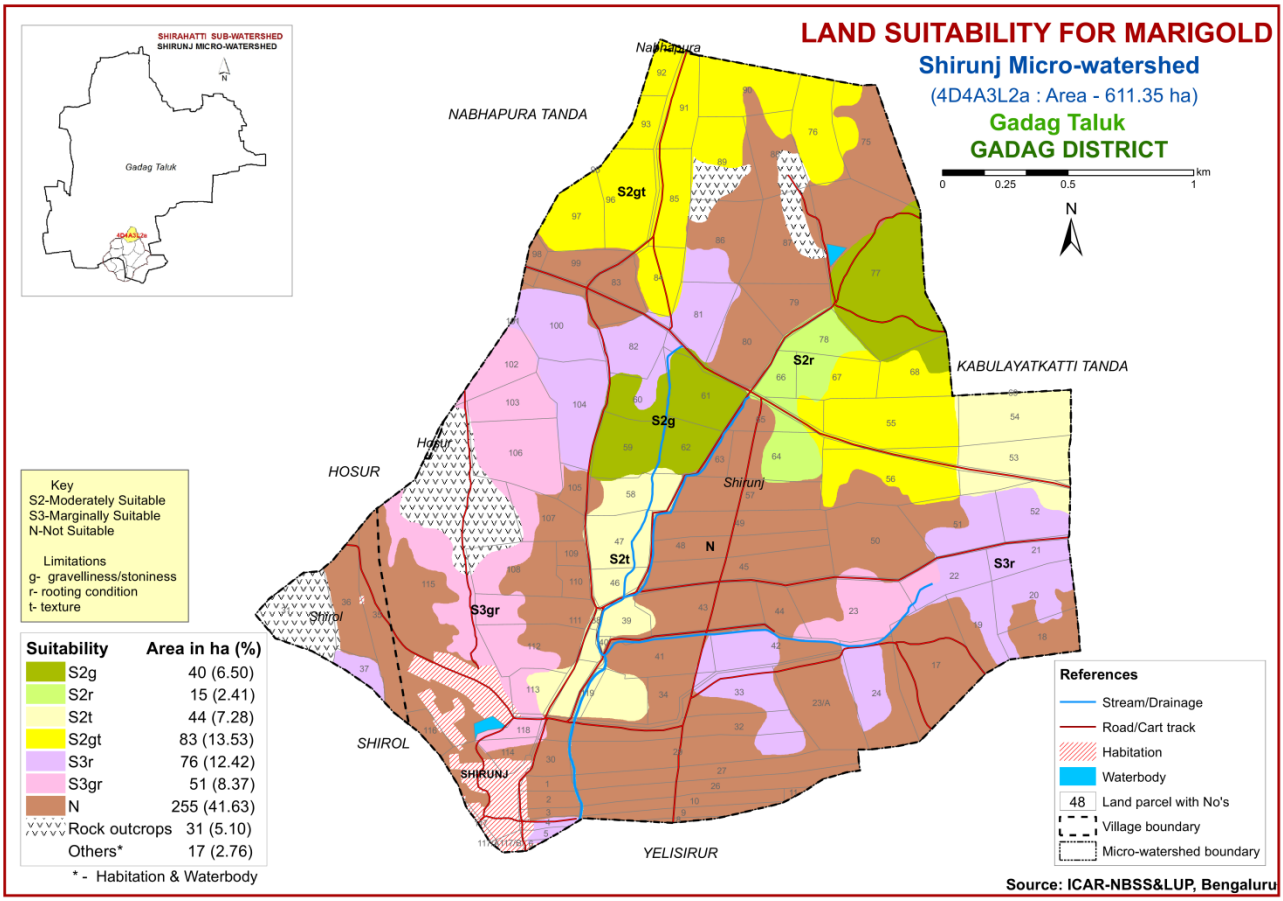


Fig. 7.13 Land Suitability map of Marigold-Shirunj microwatershed

7.14 Land Suitability for Chrysanthemum(*Chrysanthemum indicum*)

Chrysanthemum is the most important flower crop grown in an area of 803 ha in almost all the districts of the State. The crop requirements for growingchrysanthemum were matched with the soil-site characteristics of the soils of the microwatershed and a land suitability map for growing chrysanthemum was generated. The area extent and geographic distribution of different suitability subclasses in the microwatershed is given in Figure 7.14.

Moderately suitable (class S2) lands found to occur in about 182 ha (28%) that have moderate limitations of gravelliness, rooting depth and texture. They are dominantly distributed in the northern and northeastern part of the microwatershed. The marginally suitable (class S3) lands cover about 127 ha (21%). They are dominantly distributed in the eastern, western and southeastern part of the microwatershed. They have severe limitations of rooting depthand gravelliness. Major area of about 255 ha (42%) is not suitable for growing chrysanthemum and are distributed in all parts of the microwaterhed.

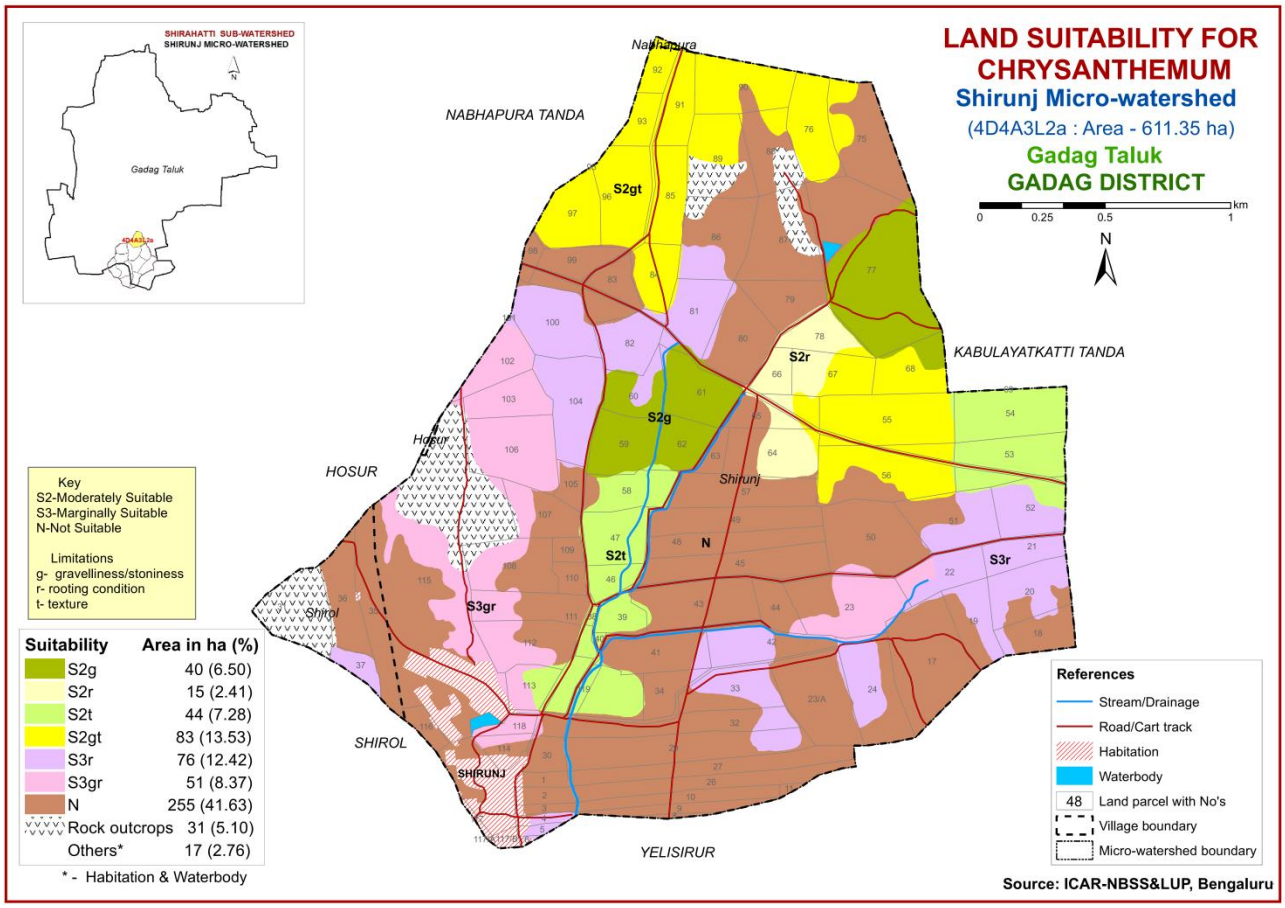


Fig. 7.14 Land Suitability map of Chrysanthemum-Shirunj microwatershed

7.15 Land Management Units (LMUs)

The 30 soil map units identified in Shirunjmicrowatershed have been regrouped into 7 Land Management Units (LMU's) for the purpose of preparing Proposed Crop Plan. Land Management Units are grouped based on the similarities in respect of the type of soil, the depth of the soil, the surface soil texture, gravel content, AWC, slope, erosion etc. and a Land Management Units map (Fig.7.15) has been prepared. These Land Management Units are expected to behave similarly for a given level of management.

The map units that have been grouped into 7 land management units along with brief description of soil and site characteristics are given below.

LMUs	Soil Map units	Soil and Site characteristics
1	DNIfC2g1, DNImB1	Deep, red gravelly clay soilswith slopes of 1-5%, gravelly (15-35%) and slight to moderate erosion
2	MPTmB1g1, MPTmB2g2	Deep, cracking clay soils with slopes of 1-3%, gravelly to very gravelly (15-60%) and slight to moderate erosion
3	JLGiC2g2, JLGmB1g1, JLGmB2g2	Moderately deep, cracking clay soils with slopes of 1-5%, gravelly to very gravelly (15-60%) and slight to moderate erosion
4	ATTiB1g2	Moderately shallow, clay soils with slopes of 1-3%, very gravelly (35-60%) and slight erosion
5	AKTfB2g1, AKTmB1g1, AKTmB2g2, NBPfC3g2, NBPmB2g1, NBPmB2g2	Shallow, gravelly clay soils with slopes of 1-5%, gravelly to very gravelly (15-60%) and slight to severe erosion
6	YSJmB2, YSJmB2g2	Shallow, clay soils with slopes of 1-3%, very gravelly (35-60%) and moderate erosion
7	DDRfB2g2, DDRfC3g1R1, DDRhB2g2, DDRhC3g3, DDRhD2g2R2,DDRhD3g3R1, DDRhD3g3R3, DDRiB2g2R1, DDRmB2g2R1, SRLcB1g2, SRLiB1g1,SRLiB1g2, SRLmB2g2, SRLmC2g2	Very shallow, gravelly clay soilswith slopes of 1-10%, gravelly to extremely gravelly (15-80%) and slight to severe erosion

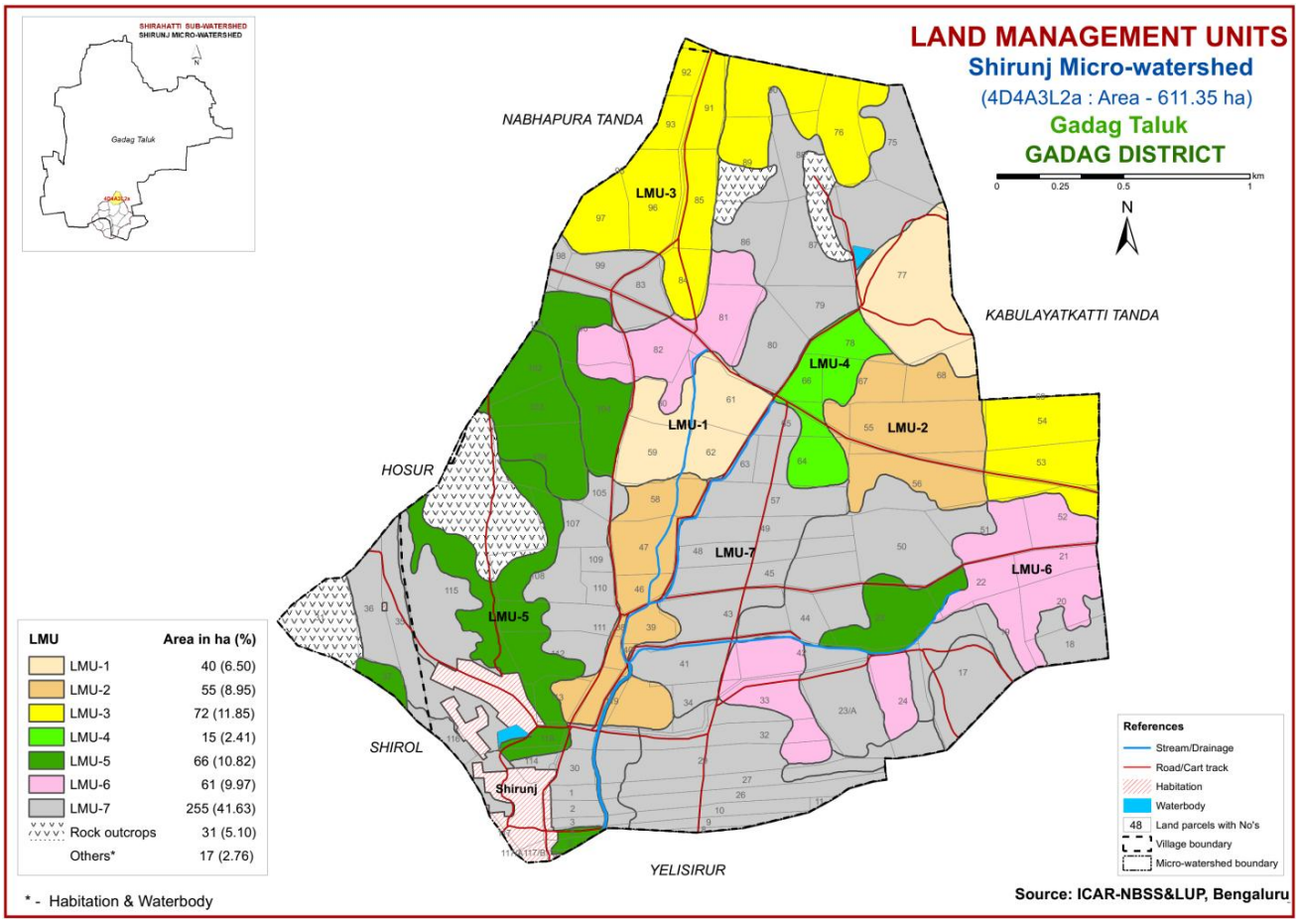


Fig. 7.15 Land Management Unit map- Shirunjmicrowatershed

7.16 Proposed Crop Plan for Shirunj Microwatershed

The proposed Crop Plan has been prepared for the 7 Land Management Units taking into consideration the similarities in soil and site characteristics and also the crop suitability for 14 crops. The proposed crop plan includes only the highly (class S1) and moderately (class S2) suitable lands for each of the fourteen crops. The resultant proposed crop plan is presented below in Table 7.13

Table 7.13Proposed Crop Plan for Shirunj microwatershed

LMU No	Mapping Units	Survey Number	Field Crops/Forestry	Suitable Horticulture Crops under Irrigation	Horticulture Crops with suitable Interventions	Suitable Interventions
LMU1	14,15(40 ha) (100-150cm)	Shirunj: 59, 60, 61, 62, 77	Maize, Jowar, Redgram, Cotton, Sunflower **Multiple crop rotation:** Redgram+Maize, Redgram+Groundnut Reg gram+Fodder Sorghum Pulses+ Sorghum	Mango, Sapota, Tamarind, Jamun **Intercrops:** Groundnut, Coriander Vegetables: Tomato, Chillies, Bhendi, Drumstick, Flower crop, Marigold, Aster	Mango, Sapota, Papaya. **Mixed orchards:** Mango+Guava+Drumstick, Guava+Drumstick+Curry leaf **Vegetables:** Tomato, Green chillies, Bhendi, Crucifers. **Flower crops:** Tuberose, Aster, Chrysanthemum, Jasmine	Drip Irrigation, Mulching, suitable conservation (like bunding with catch pit)
LMU 2	19,20 (55 ha) (100-150 cm)	Shirunj: 35, 36, 37, 38, 39, 40, 46, 47, 55, 56, 58, 67, 68, 119	Sorghum, Redgram, Cotton, Sunflower, Bengalgram, Safflower, Linseed, Bajra. **Multiple crop rotation:** Redgram+Fodder sorghum Pulses+Sorghum	Vegetables: Chillies, Tomato, Bhendi, Cabbage, Drumstick **Perenial components:** Sapota, Tamarind, Custard apple, Amla, Lime, Moosambi	**Flower crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial components:** Sapota, Tamarind, Custard apple, Amla, Lime, Moosambi. **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, suitable conservation practises

LMU 3	16,17,18 (72 ha) (75-100cm)	Nabadur: 51, 52 Shirunj: 53, 54, 69, 76, 84, 85, 89, 90, 91, 92, 93, 95, 96, 97	Sorghum, Redgram, Cotton, Sunflower, Bengalgram, Safflower, Linseed, Bajra **Multiple crop rotation:** Redgram+Fodder sorghum Pulses+Sorghum	Vegetables: Chillies, Tomato, Bhendi, Cabbage, Drumstick **Perenial components:** Sapota, Tamarind, Custard apple, Amla, Lime, Moosambi	**Flower crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum **Perenial components:** Sapota, Tamarind, Custard apple, Amla, Lime, Moosambi. **Vegetables:** Chillies, Bhendi, Crucifers	Drip irrigation, Mulching, suitable conservation practises
LMU 4	4 (15 ha) (50-75 cm)	Shirunj: 64, 66, 78	-do-	Perenial component: Custard apple, Amla **Annual vegetables:** Tomato, Chillies, Bhendi, Crucifers	**Perenial components:** Custard apple, Amla **Vegetables:** Tomato, Chillies, Bhendi, Crucifers **Flower crops:** Marigold, Gaillardia, Tuberose, Chrysanthemum	Drip irrigation, Mulching, suitable conservation practises
LMU 5	1,2,3,21, 22,23 (66 ha) (25-50 cm)	Shirol: 37 Shirunj: 4, 5, 23, 100, 101, 102, 103, 104, 106, 112, 113, 114, 118	Groundnut, Horsegram Silviculture, Accasia, Glyricidia, Simaruba, Subabul, Agave, Cassia	Custard apple, Amla, Wood apple	Fig, Amla	Pit size, Drip irrigation, Mulching, suitable conservation practises (Crescent bunding with catch pit etc..)

LMU 6	29,30 (61 ha) (25-50 cm)	Shirunj: 19, 20, 21, 22, 24, 33, 42, 51, 52, 81, 82	Silviculture, Accasia, Glycirdia, Simaruba, Subabul, Agave, Cassia	Ber, Custard apple **Vegetable:** Ridge guard, Ash guard	Ber, Fig, Amla	-
LMU 7	5,6,7,8,9,10,11,12,13,24, 25,26,27,28 (62 ha) (<25 cm)	Shirol: 35, 36 Shirunj: 1, 2, 3, 8, 9, 10, 11, 17, 18, 23/A, 26, 27, 29, 30, 31, 32, 34, 41, 43, 44, 45, 48, 49, 50, 57, 63, 65, 75, 79, 80, 83, 86, 87, 88, 98, 99, 105, 107, 108, 109, 110, 111, 116	Silviculture, Accasia, Glycirdia, Simaruba, Subabul, Agave, Cassia	Pasture, grasses	-	-

Chapter 8

SOIL HEALTH MANAGEMENT

8.1 Soil Health

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

Soil health 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.

Characteristics of Shirunj microwatershed

- The soil phases with sizeable area identified in the microwatershed belonged to the soil series of DDR (129 ha), SRL (125 ha), JLG (72 ha), YSJ (61 ha), MPT (55 ha), NBP (51 ha), DNI (40 ha), AKT (15 ha) and ATT (15 ha). As per land capability classification, nearly 92 per cent area comes under arable land category (Class III and IV) and 5 per cent area belongs to nonarable land category. The major limitations identified in the arable lands were rooting depth, texture, erosion, gravelliness and alkalinity.
- On the basis of soil reaction, about 266 ha(43%) area is moderately alkaline (pH 7.8-8.4) followed by slightly alkaline (pH 7.3-7.8) 250 ha(41%) and strongly alkaline (pH 8.4-9.0)11 ha(2%) of the area. Thus, about 86 per cent of the soils are alkaline in reaction. However, the soils with neutral reaction (pH 6.5-7.3) occur in a minor area of 36 ha (6%)of the total area.

Soil Health Management

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

Alkaline soils

Slightly alkaline to moderately alkaline soils

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

Neutral soils

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

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

Disseminate information and communicate benefits. Any large scale implementation of soil health management requires that supporting information is made availablewidely, 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 national newspapers and radio programs in local languages but also modern information and communication technologies such as cellular phones and the Internet, which can be much more effective in reaching younger farmers.

Inputs for Net Planning and Interventions needed

Net planning in IWMP is focusing on preparation of

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

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

- **Soil Depth:** Thedepth of a soil decides the amount of moisture and nutrients it can hold, what crops can be taken up or not, depending on theeffective 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, 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 textururedsoils are highly suitable for crops like groundnut, root vegetables (carrot, raddish, potato etc) but not ideal for crops that need stagnant water like lowland paddy. Heavy textured soils are poor in water infiltration and percolation. They are prone for sheet erosion; such soils can be improved by sand mulching. The technology that is developed by the AICRP-Dryland Agriculture, Vijayapura, Karnataka can be adopted.

- **Gravelliness:** More gravel content is favorable for run-off harvesting but poor in soil moisture storage and nutrient availabilty. 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, rooting depth, gravelliness and alkalinity are the major constraints in Shirunj microwatershed.

- **Organic Carbon:** In about 422 ha (69%) area, the OC content is high (>0.75%) and in about 140 ha (23%) area it is medium (0.5-0.75%). The areas that are medium in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping.

- **Promoting green manuring:** Green manuringcosts 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 1933 ha area where OC is less than 0.5%. 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 502 ha (82%), the available phosphorus is low (<23 kg/ha) and about 55 ha (9%) is medium (23-57 kg/ha) in available phosphorus. A small area of about 6 ha (1%) is high (>57 kg/ha) in available phosphorus. Hence, for all the crops, 25% additional P-needs to be applied.

- **Available Potassium:** Available Potassium is low in 302 ha (49%)area of the microwatershed.For these areas, 25 % extra K needs to be applied. It is medium in 261 ha (43%) of area in the microwatershed.Hence, in all these plots, for all crops, 25 % additional potassium needs to be applied.

- **Available Sulphur:** Available sulphur is a very critical nutrient for oilseed crops. It is low in 314 ha (51%) area of the microwatershed. These areas need to be applied magnesium sulphate or gypsum or Factamphos (p) fertitilizer (13% sulphur) for correcting the deficiency and medium in 249 ha (41%) of area in the microwatershed.

- **Available iron:** It is deficient in major area of 537 ha (88%) of the microwatershed. To manage iron defieciency, iron sulphate @ 25kg /ha needs to be applied for 2-3 years to correct iron deficiency.

- **Available Zinc:** It is deficient in 477 ha (78%) area of the microwatershed. Application of zinc sulphate @25kg/ha is to be applied.

- **Soil alkalinity:** The microwatershed hasmajor area of 527 ha area with soils that are slightly to strongly alkaline. These areas need application of gypsum and wherever calcium is in excess, iron pyrites and element sulphur can be recommended. Management practices like treating repeatedly with good quality water to drain out the excess salts, growing of salt tolerant crops like Casuarina, Acasia, Neem, Ber etc**.**

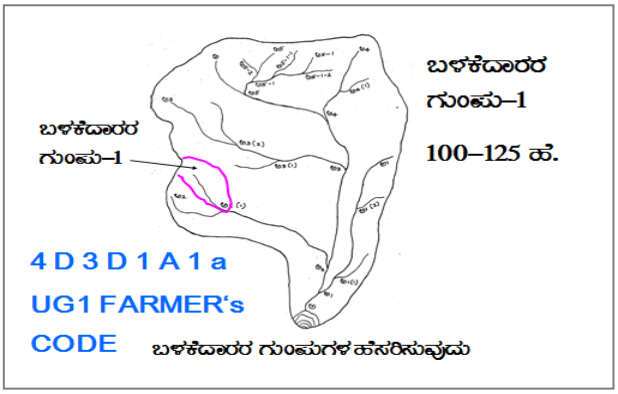
Land Suitability for various crops: Areas that are highly, moderately and marginally suitable for growing various crops are indicated. Along with the suitability, various constraints that are limiting the productivity are also indicated. For example in case of cotton, gravel content, rooting depth and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

Chapter 9

SOIL AND WATER CONSERVATION TREATMENT PLAN

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

- Soil depth
- Surface soil texture
- Available water capacity
- Soil slope
- Soil gravelliness
- Land capability
- Present land use &land cover
- Crop suitability maps
- Rainfall map
- Hydrology
- Water Resources
- Socio-economic data
- Contour plan with existing features- Network of water ways, pothissa boundaries, cutup/ 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' Listhas 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

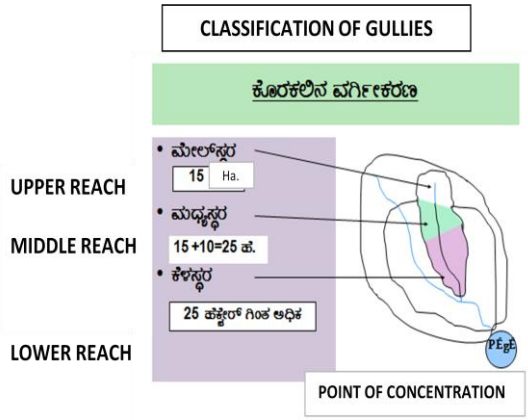
- Identification of arable and non arable lands
- Identification of drainage lines and gullies
- Identification of non treatable areas
- Identification of priority areas in the arable lands
- Treatment plan for arable lands
- Location of water harvesting and recharge structures

9.1Treatment Plan

The treatment plan recommended for arable lands is briefly described below

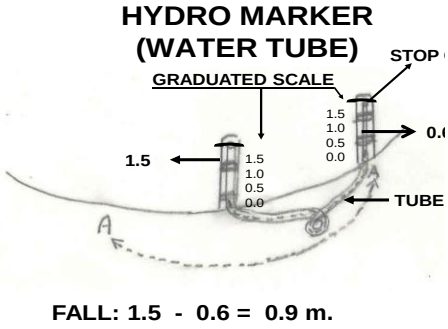
9.1.1 Arable Land Treatment

A. Bunding

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

Measurement of Land Slope

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



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

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

Note: i) The above intervals are maximum.

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

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

Section of the Bund

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

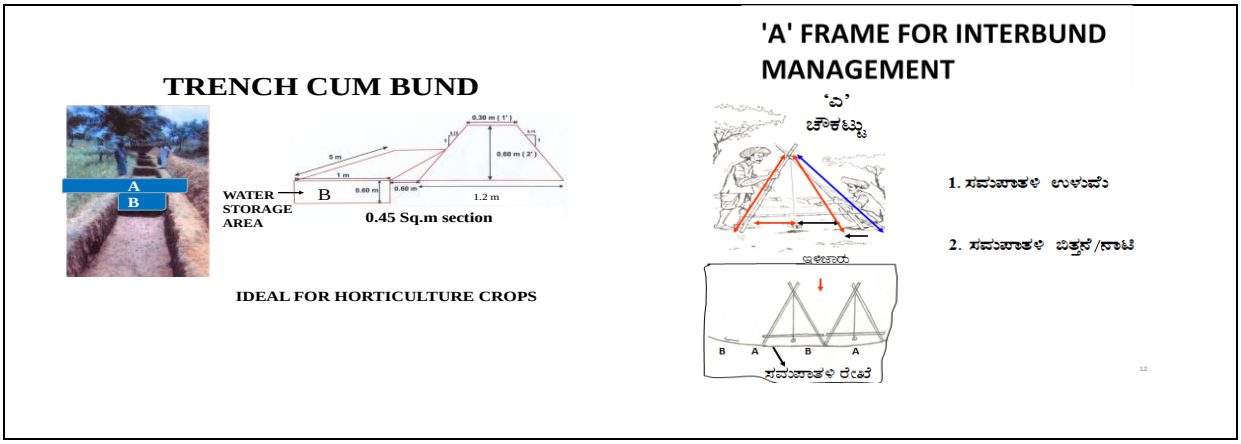
Recommended Bund Section

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

Formation of Trench cum Bund

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

Details of Borrow Pit dimensions are given below



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

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

B. Water ways

a) Existing water ways are marked on the cadastral map (1:7920scale) andtheir dimensions are recorded.

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

c) The design details are given in the Manual.

C. Farm ponds

Water ways 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.

9.1.3Treatment of Natural Water Course/ Drainage Lines

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

9.2 Recommended Soil and Water Conservation measures

The important steps involved and the inputs needed for the preparation of soil and water conservation plan are listed below.

- Cadastral map and satellite imagery
- Soil map, land capability map, climatic map, hydrologic data, socio-economic data and land suitability maps
- 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

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 165 ha (27%) requires trench cum bunding and about 365 ha (60%) area needs graded bunds. About 34ha (6%) area requires terracing.

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

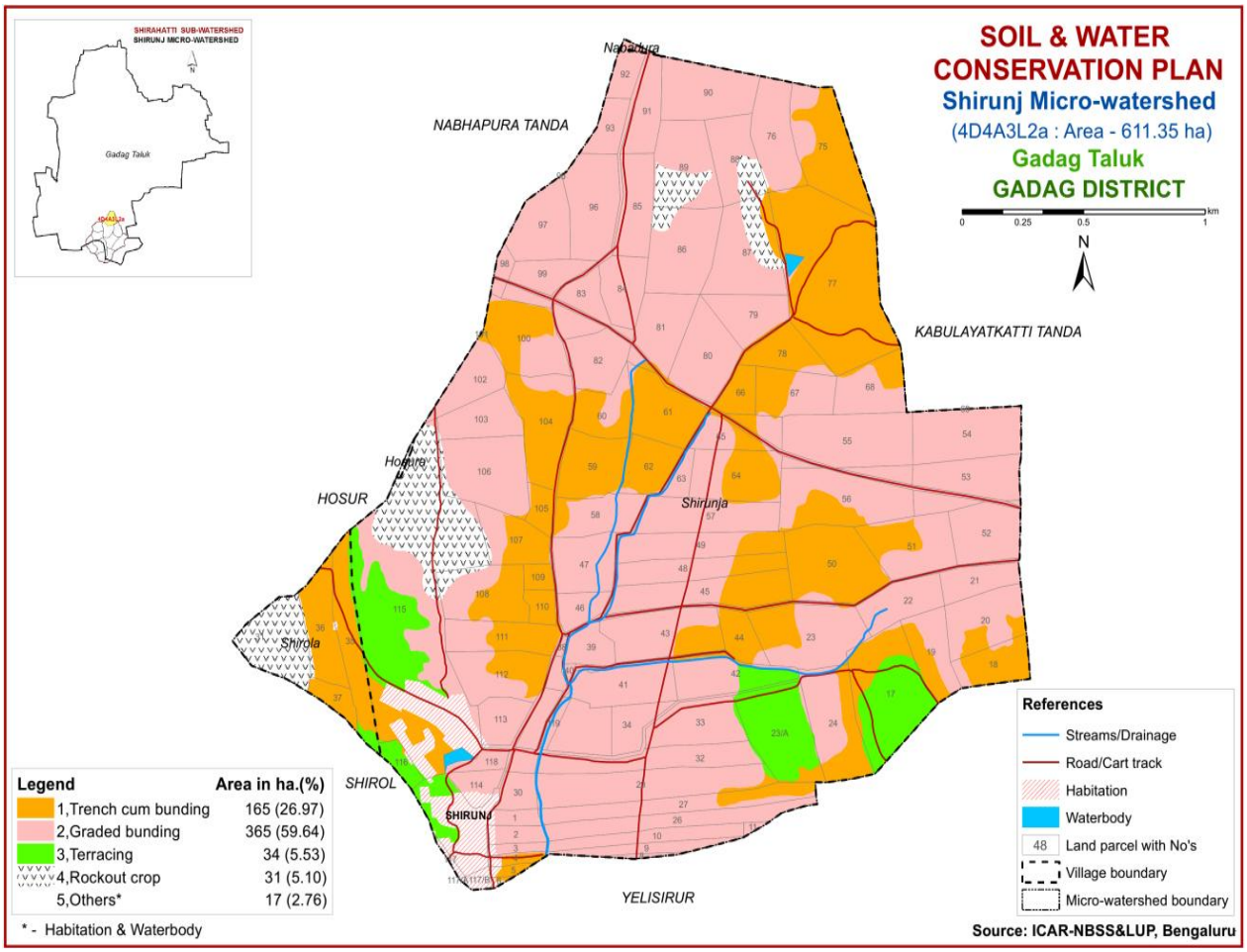


Fig. 9.1 Soil and Water Conservation Planmap of Shirunj microwatershed

9.3 Greening of microwatershed

As part of the greening programme in the watersheds, it is envisaged to plant a variety of horticultural and other tree plants that are edible, economical and produce lot of biomass which helps to restore the ecological balance in the watersheds. The lands that are suitable for

greening programme are non-arable lands (land capability classes V, VI and VII) and also the lands that are not suitable or marginally suitable for growing annual and perennial crops. The method of planting these trees is given below.

It is recommended to open pits during the 1st week of March along the contour and heap the dugout 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 and temperature is listed below; water logged areas are recommended to be planted with species like Neral (*Sizyziumcumini*) and Bamboos. Dry areas are to be planted with species like Honge, Bevu, Seetaphal*etc*.

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

Moist Deciduous Species				
15.	Teak	*Tectona grandis*	20 - 50	500-5000
16.	Nandi	*Legarstroemia lanceolata*	20 - 40	500 - 4000
17.	Honne	*Pterocarpus marsupium*	20 - 40	500 - 3000
18.	Mathi	*Terminalia alata*	20 -50	500 - 2000
19.	Shivane	*Gmelina arboria*	20 -50	500 -2000
20.	Kindal	*T.Paniculata*	20 - 40	500 - 1500
21.	Beete	*Dalbargia latifolia*	20 - 40	500 - 1500
22.	Tare	*T. belerica*	20 - 40	500 - 2000
23.	Bamboo	*Bambusa arundinasia*	20 - 40	500 - 2500
24.	Bamboo	*Dendrocalamus strictus*	20 – 40	500 – 2500
25.	Muthuga	*Butea monosperma*	20 - 40	400 - 1500
26.	Hippe	*Madhuca latifolia*	20 - 40	500 - 2000
27.	Sandal	*Santalum album*	20 - 50	400 - 1000
28.	Nelli	*Emblica officinalis*	20 - 40	500 - 2000
29.	Nerale	*Sizyzium cumini*	20 - 40	500 - 2000
30.	Dhaman	*Grevia tilifolia*	20 - 40	500 - 2000
31.	Kaval	*Careya arborea*	20 - 40	500 - 2000
32.	Harada	*Terminalia chebula*	20 - 40	500- 2000

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Appendix - I

Shirunj Micro-watershed

Soil Phase Information

Village	Survey No.	Total Area (ha)	Soil Phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capability	Conservation Plan
Hosura	42	0.2	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Ct	Not Available	VIII	Rockout crop
Nabadura	51	0.03	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Ct	Not Available	IIIes	Graded bunding
Nabadura	52	0.28	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Mz	Not Available	IIIes	Graded bunding
Shirola	31	7.16	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Fl+Wt	Not Available	VIII	Rockout crop
Shirola	35	6.57	DDRhB2g2	LMU-7	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Fl+Mz	Not Available	IVes	Trench cum bunding
Shirola	36	5.62	DDRhB2g2	LMU-7	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Not Available	IVes	Trench cum bunding
Shirola	37	1.86	AKTfB2g1	LMU-5	Shallow (25-50 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IIIes	Trench cum bunding
Shirunja	1	1.27	SRLiB1g1	LMU-7	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	2	1.65	SRLiB1g1	LMU-7	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	3	0.91	SRLiB1g1	LMU-7	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	4	0.97	AKTmB1g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ba+Ct	Not Available	IIIs	Trench cum bunding
Shirunja	5	0.64	AKTmB1g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	CN+Ct	Not Available	IIIs	Trench cum bunding
Shirunja	6	0.23	Habitation	Others	Others	Others	Others	Others	Others	Others	Ct	Not Available	Others	Others
Shirunja	8	0.41	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct	Not Available	IVes	Graded bunding
Shirunja	9	2.56	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Gn	Borewell	IVes	Graded bunding
Shirunja	10	3.88	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IVes	Graded bunding

Village	Survey No.	Total Area (ha)	Soil Phase	Land Management Unit	Soil Depth	Surface Soil Texture	Soil Gravelliness	AWC	Slope	Soil Erosion	CLU Code	WELLS	Land Capability	Conservation Plan
Shirunja	11	0.3	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct	Not Available	IVes	Graded bunding
Shirunja	17	12.35	DDRhD3g3R3	LMU-7	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very Low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Ct+Mz+Fl	Borewell	IVes	Terracing
Shirunja	18	4.28	DDRmB2g2R1	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Wt+Mz+Fl	Not Available	IVes	Trench cum bunding
Shirunja	19	5	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Fl	Not Available	IVes	Graded bunding
Shirunja	20	6.71	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Fl+Wt	Not Available	IVes	Graded bunding
Shirunja	21	3.42	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Fl	Not Available	IVes	Graded bunding
Shirunja	22	4.74	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Mz+Fl	Not Available	IVes	Graded bunding
Shirunja	23	9.55	NBPfC3g2	LMU-5	Shallow (25-50 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Severe	Ct+Sg+MZ	Borewell,Bore well	IVes	Graded bunding
Shirunja	23/A	9.28	DDRhD3g3R1	LMU-7	Very shallow (<25 cm)	Sandy clay loam	Extremely gravelly (60-80%)	Very Low (<50 mm/m)	Moderately sloping (5-10%)	Severe	Mz+Fl	Not Available	IVes	Terracing
Shirunja	24	8.6	YSJmB2g2	LMU-6	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Mz	Hand bore not working	IVes	Graded bunding
Shirunja	26	6.27	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Gn+Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	27	6.97	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Borewell,Bore well	IVes	Graded bunding
Shirunja	29	10.8	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Borewell	IVes	Graded bunding
Shirunja	30	2.13	SRLiB1g1	LMU-7	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Not Available	IVes	Graded bunding
Shirunja	31	0.91	SRLiB1g1	LMU-7	Very shallow (<25 cm)	Sandy clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IVes	Graded bunding
Shirunja	32	6.82	SRLcB1g2	LMU-7	Very shallow (<25 cm)	Sandy loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Borewell	IVes	Graded bunding
Shirunja	33	6.01	YSJmB2g2	LMU-6	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Gn	Not Available	IVes	Graded bunding
Shirunja	34	2.97	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Gn+Mz	Borewell not working	IVes	Graded bunding

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Shirunja	35	4.25	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IIIs	Graded bunding
Shirunja	36	1.76	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Not Available	IIIs	Graded bunding
Shirunja	37	0.72	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Not Available	IIIs	Graded bunding
Shirunja	38	0.18	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Ct	Not Available	IIIs	Graded bunding
Shirunja	39	2.58	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Not Available	IIIs	Graded bunding
Shirunja	40	0.18	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Not Available	IIIs	Graded bunding
Shirunja	41	6.26	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct+Gn	Borewell	IVes	Graded bunding
Shirunja	42	5.9	YSJmB2g2	LMU-6	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz+Gn	Borewell	IVes	Graded bunding
Shirunja	43	8.1	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Borewell	IVes	Graded bunding
Shirunja	44	2.8	DDRiB2g2R1	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Gn	Not Available	IVes	Trench cum bunding
Shirunja	45	7.79	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	46	2.28	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IIIs	Graded bunding
Shirunja	47	5.35	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Not Available	IIIs	Graded bunding
Shirunja	48	5.58	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz+Sg	Not Available	IVes	Graded bunding
Shirunja	49	6.58	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Gn+Mz+Ct	Borewell	IVes	Graded bunding
Shirunja	50	10.05	DDRiB2g2R1	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	CN+Fr+Mz+Fl	Borewell,Borewell	IVes	Trench cum bunding
Shirunja	51	7.4	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Mz	Not Available	IVes	Graded bunding

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Shirunja	52	6.01	YSJmB2	LMU-6	Shallow (25-50 cm)	Clay	Non gravelly (<15%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Gn+ Sg	Not Available	IVes	Graded bunding
Shirunja	53	7.44	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Gn+Sg	Not Available	IIIs	Graded bunding
Shirunja	54	8.55	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Gn	Not Available	IIIs	Graded bunding
Shirunja	55	10.55	MPTmB2g 2	LMU-2	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Gn+ Mz	Not Available	IIIes	Graded bunding
Shirunja	56	11.42	MPTmB2g 2	LMU-2	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Borewell	IIIes	Graded bunding
Shirunja	57	7.18	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Borewell	IVes	Graded bunding
Shirunja	58	5.04	MPTmB1g 1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Sp	Borewell	IIIs	Graded bunding
Shirunja	59	6.11	DNImB1g2	LMU-1	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IIIes	Trench cum bunding
Shirunja	60	4.44	DNImB1g2	LMU-1	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Borewell	IIIes	Trench cum bunding
Shirunja	61	6.38	DNImB1g2	LMU-1	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Borewell	IIIes	Trench cum bunding
Shirunja	62	4.01	DNImB1g2	LMU-1	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Ct	Borewell	IIIes	Trench cum bunding
Shirunja	63	1.42	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct	Not Available	IVes	Graded bunding
Shirunja	64	7.09	ATTiB1g2	LMU-4	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Not Available	IIIs	Trench cum bunding
Shirunja	65	4.18	SRLiB1g2	LMU-7	Very shallow (<25 cm)	Sandy clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Slight	Ct+Mz	Hand bore not working,Borewell	IVes	Graded bunding
Shirunja	66	2.28	ATTiB1g2	LMU-4	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mz+Gn	Not Available	IIIs	Trench cum bunding
Shirunja	67	5.49	MPTmB2g 2	LMU-2	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IIIes	Graded bunding
Shirunja	68	5.58	MPTmB2g 2	LMU-2	Deep (100-150 cm)	Clay	Very gravelly (35-60%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Sg	Not Available	IIIes	Graded bunding

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Shirunja	69	0.01	JLGmB1g1	LMU-3	Moderately deep (75-100 cm)	Clay	Gravelly (15-35%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Not Available	IIIs	Graded bunding
Shirunja	75	9.72	DDRfC3g1R1	LMU-7	Very shallow (<25 cm)	Clay loam	Gravelly (15-35%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Severe	Mz+Fl	Not Available	IVes	Trench cum bunding
Shirunja	76	6.71	JLGmB2g2	LMU-3	Moderately deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Not Available	IIIes	Graded bunding
Shirunja	77	24.59	DNIfC2g1	LMU-1	Deep (100-150 cm)	Clay loam	Gravelly (15-35%)	Low (51-100 mm/m)	Gently sloping (3-5%)	Moderate	Forest	Borewell,Bore well	IIIes	Trench cum bunding
Shirunja	78	4.02	ATTiB1g2	LMU-4	Moderately shallow (50-75 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Slight	Ct	Borewell	IIIs	Trench cum bunding
Shirunja	79	4.67	SRLmC2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Mz	Not Available	IVes	Graded bunding
Shirunja	80	6.97	SRLmC2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Gn+Sg	Not Available	IVes	Graded bunding
Shirunja	81	5.9	YSJmB2g2	LMU-6	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Sg+Gn	Not Available	IVes	Graded bunding
Shirunja	82	4.7	YSJmB2g2	LMU-6	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Low (51-100 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	83	4.2	SRLmB2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct	Not Available	IVes	Graded bunding
Shirunja	84	4.36	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Mz+Ct+Fr	Not Available	IIIes	Graded bunding
Shirunja	85	5.33	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Mz+Ct+Gn	Not Available	IIIes	Graded bunding
Shirunja	86	8.76	SRLmC2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Ct+Gn+Mz+Fl	Not Available	IVes	Graded bunding
Shirunja	87	9.52	SRLmC2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Mz	Not Available	IVes	Graded bunding
Shirunja	88	5.92	SRLmC2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Gently sloping (3-5%)	Moderate	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	89	8.05	JLGmB2g2	LMU-3	Moderately deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Gn+Fl	Not Available	IIIes	Graded bunding
Shirunja	90	7.78	JLGmB2g2	LMU-3	Moderately deep (75-100 cm)	Clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Gn	Not Available	IIIes	Graded bunding

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Shirunja	91	4.06	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Ct+Mz+ Gn	Not Available	IIIes	Graded bunding
Shirunja	92	2.01	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Mz+Gn+ Ct	Not Available	IIIes	Graded bunding
Shirunja	93	2.56	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Mz+Ct	Not Available	IIIes	Graded bunding
Shirunja	95	0	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Ct	Not Available	IIIes	Graded bunding
Shirunja	96	7.84	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Gn+Ct+ Mz	Not Available	IIIes	Graded bunding
Shirunja	97	6.11	JLGiC2g2	LMU-3	Moderately deep (75-100 cm)	Sandy clay	Very gravelly (35-60%)	Medium (101-150 mm/m)	Gently sloping (3-5%)	Moderate	Ct+Mz	Not Available	IIIes	Graded bunding
Shirunja	98	1.06	SRLmB2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct	Not Available	IVes	Graded bunding
Shirunja	99	3.95	SRLmB2g2	LMU-7	Very shallow (<25 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Ct+ Mn	Not Available	IVes	Graded bunding
Shirunja	100	7.84	AKTmB2g 2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IIIes	Trench cum bunding
Shirunja	101	0.02	AKTmB2g 2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct	Not Available	IIIes	Trench cum bunding
Shirunja	102	4.53	NBPmB2g2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	103	4.63	NBPmB2g2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	104	8.13	AKTmB2g 2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Borewell,Open well not working,Bore-well	IIIes	Trench cum bunding
Shirunja	105	1.74	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Mz	Not Available	IVes	Trench cum bunding
Shirunja	106	9.24	NBPmB2g2	LMU-5	Shallow (25-50 cm)	Clay	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	107	4.81	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Gn+ Mz	Not Available	IVes	Trench cum bunding

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Shirunja	108	7.21	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Not Available	IVes	Trench cum bunding
Shirunja	109	1.17	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct	Not Available	IVes	Trench cum bunding
Shirunja	110	1.52	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct	Not Available	IVes	Trench cum bunding
Shirunja	111	5.33	DDRfB2g2	LMU-7	Very shallow (<25 cm)	Clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Gn+Ct	Not Available	IVes	Trench cum bunding
Shirunja	112	6.72	NBPmB2g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz+Ct	Not Available	IVes	Graded bunding
Shirunja	113	3.1	NBPmB2g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Ct+Mz	Not Available	IVes	Graded bunding
Shirunja	114	2.09	NBPmB2g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz	Not Available	IVes	Graded bunding
Shirunja	115	44.84	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Rockout crop	Rock outcrops	Rockout crop	Rockout crop	Fl+Ct+Mz	Not Available	VIII	Rockout crop
Shirunja	116	1.56	DDRhD2g2R2	LMU-7	Very shallow (<25 cm)	Sandy clay loam	Very gravelly (35-60%)	Very Low (<50 mm/m)	Moderately sloping (5-10%)	Moderate	Fl	Not Available	IVes	Terracing
Shirunja	117	0.35	Habitation	Others	Others	Others	Others	Others	Others	Others	Settlement	Not Available	Others	Others
Shirunja	117/A	0.03	Habitation	Others	Others	Others	Others	Others	Others	Others	Settlement	Not Available	Others	Others
Shirunja	117/B	0.7	Habitation	Others	Others	Others	Others	Others	Others	Others	Settlement	Not Available	Others	Others
Shirunja	118	1.48	NBPmB2g1	LMU-5	Shallow (25-50 cm)	Clay	Gravelly (15-35%)	Very Low (<50 mm/m)	Very gently sloping (1-3%)	Moderate	Mz	Borewell	IVes	Graded bunding
Shirunja	119	0.8	MPTmB1g1	LMU-2	Deep (100-150 cm)	Clay	Gravelly (15-35%)	Very High (>200 mm/m)	Very gently sloping (1-3%)	Slight	Mz	Not Available	IIIs	Graded bunding
Shirunja	SETTLEMENT	7.19	Habitation	Others	Others	Others	Others	Others	Others	Others	Settlement	Not Available	Others	Others
Shirunja	TANK	0.86	Waterbody	Others	Others	Others	Others	Others	Others	Others	Waterbody	Not Available	Others	Others

Appendix II

Soil Fertility Information

Village	Survey No.	Soil Reaction	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Hosura	42	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Nabadura	51	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Nabadura	52	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirola	31	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Shirola	35	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirola	36	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirola	37	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	1	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	2	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	3	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	4	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	5	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	6	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	8	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	9	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	10	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	11	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	High (>57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	17	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	18	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	19	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	20	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Shirunja	21	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	22	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	23	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	23/A	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	24	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	26	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	27	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	29	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	30	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	31	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	32	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	33	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	34	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	35	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	36	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	37	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	38	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	39	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	40	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	41	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	42	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	43	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	44	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	45	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Shirunja	46	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	47	Strongly alkaline (pH 8.4 – 9.0)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Deficient (<4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	48	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	49	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	50	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	51	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	52	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	53	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	54	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	55	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	56	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	57	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	58	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	High (>1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	59	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	60	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Medium (23 - 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	61	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	62	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	63	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	64	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	65	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	66	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	67	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	68	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	69	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Shirunja	75	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	76	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	77	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	78	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	79	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	80	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Medium (23 - 57 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	81	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	82	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	83	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	84	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	85	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	86	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	87	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	88	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	89	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	90	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	91	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	92	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	93	Neutral (pH 6.5 – 7.3)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	95	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	96	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	97	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	98	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	99	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)

Village	Survey No.	Soil Reaction	EC	Organic Carbon	Available Phosphorus	Available Potassium	Available Sulphur	Available Boron	Available Iron	Available Manganese	Available Copper	Available Zinc
Shirunja	100	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	101	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	102	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	103	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	104	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	105	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	106	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	107	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	108	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	109	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Medium (0.5-1.0 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	110	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	111	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	112	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	113	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	114	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	115	Slightly alkaline (pH 7.3 – 7.8)	Non saline (<2 dsm)	Rock outcrops	Low (<23 kg/ha)	Low (<145 kg/ha)	Rock outcrops	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	116	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	High (>0.75 %)	Low (<23 kg/ha)	Medium (145 - 337 kg/ha)	Medium (10-20 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	117	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	117/A	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	117/B	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	118	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Deficient (<0.6 ppm)
Shirunja	119	Moderately alkaline (pH 7.8 – 8.4)	Non saline (<2 dsm)	Medium (0.5-0.75 %)	Low (<23 kg/ha)	Low (<145 kg/ha)	Low (<10 ppm)	Low (<0.5 ppm)	Sufficient (>4.5 ppm)	Sufficient (>1.0 ppm)	Sufficient (>0.2 ppm)	Sufficient (>0.6 ppm)
Shirunja	SETTLEMENT	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	TANK	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Appendix III

Soil Suitability Information

Village	Survey No.	Sorghum	Maize	Redgram	Bengalgram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Tomato	Onion	Chilly	Marigold	Chrysanthemum
Hosura	42	Rockout crop	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Nabadura	51	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Nabadura	52	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirola	31	Rockout crop	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Shirola	35	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirola	36	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirola	37	S3r	S3r	N	S2r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	1	N	N	N	S3r	N	N	N	N	N	N	N	N	N	N
Shirunja	2	N	N	N	S3r	N	N	N	N	N	N	N	N	N	N
Shirunja	3	N	N	N	S3r	N	N	N	N	N	N	N	N	N	N
Shirunja	4	S3r	S3r	N	S2r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	5	S3r	S3r	N	S2r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	6	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	8	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	9	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	10	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	11	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	17	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	18	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	19	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	20	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	21	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	22	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	23	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	23/A	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	24	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3gr	S3gr	S3gr	S3r	S3r

Village	Survey No.	Sorghum	Maize	Redgram	Bengalgram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Tomato	Onion	Chilly	Marigold	Chrysanthemum
Shirunja	26	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	27	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	29	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	30	N	N	N	S3r	N	N	N	N	N	N	N	N	N	N
Shirunja	31	N	N	N	S3r	N	N	N	N	N	N	N	N	N	N
Shirunja	32	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	33	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3gr	S3gr	S3gr	S3r	S3r
Shirunja	34	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	35	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	36	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	37	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	38	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	39	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	40	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	41	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	42	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3gr	S3gr	S3gr	S3r	S3r
Shirunja	43	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	44	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	45	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	46	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	47	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	48	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	49	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	50	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	51	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	52	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	53	S1	S3t	S2r	S2g	S3t	S2gr	S2r	S2t	S2t	S2t	S2t	S2t	S2t	S2t
Shirunja	54	S1	S3t	S2r	S2g	S3t	S2gr	S2r	S2t	S2t	S2t	S2t	S2t	S2t	S2t
Shirunja	55	S1	S3t	S2gt	S3g	S3t	S2g	S1	S2gt	S2gt	S2t	S2t	S2gt	S2gt	S2gt

Village	Survey No.	Sorghum	Maize	Redgram	Bengalgram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Tomato	Onion	Chilly	Marigold	Chrysanthemum
Shirunja	56	S1	S3t	S2gt	S3g	S3t	S2g	S1	S2gt	S2gt	S2t	S2t	S2gt	S2gt	S2gt
Shirunja	57	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	58	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	59	S2g	S2g	S2g	S3g	S2g	S3g	S3g	S2g	S2g	S3g	S3g	S3g	S2g	S2g
Shirunja	60	S2g	S2g	S2g	S3g	S2g	S3g	S3g	S2g	S2g	S3g	S3g	S3g	S2g	S2g
Shirunja	61	S2g	S2g	S2g	S3g	S2g	S3g	S3g	S2g	S2g	S3g	S3g	S3g	S2g	S2g
Shirunja	62	S2g	S2g	S2g	S3g	S2g	S3g	S3g	S2g	S2g	S3g	S3g	S3g	S2g	S2g
Shirunja	63	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	64	S2r	S2r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S2r	S2r	S2r	S2r	S2r
Shirunja	65	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	66	S2r	S2r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S2r	S2r	S2r	S2r	S2r
Shirunja	67	S1	S3t	S2gt	S3g	S3t	S2g	S1	S2gt	S2gt	S2t	S2t	S2gt	S2gt	S2gt
Shirunja	68	S1	S3t	S2gt	S3g	S3t	S2g	S1	S2gt	S2gt	S2t	S2t	S2gt	S2gt	S2gt
Shirunja	69	S1	S3t	S2r	S2g	S3t	S2gr	S2r	S2t	S2t	S2t	S2t	S2t	S2t	S2t
Shirunja	75	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	76	S1	S3gt	S2r	S3g	S3t	S3g	S2r	S2gt	S2gt	S3g	S2t	S3g	S2gt	S2gt
Shirunja	77	S2g	S2g	S2g	S3g	S2g	S3g	S3g	S2g	S2g	S3g	S3g	S3g	S2g	S2g
Shirunja	78	S2r	S2r	S3r	S2r	S2r	S3r	S2r	S3r	S3r	S2r	S2r	S2r	S2r	S2r
Shirunja	79	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	80	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	81	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3gr	S3gr	S3gr	S3r	S3r
Shirunja	82	S3r	S3rt	N	S3r	S3r	N	S3r	N	N	S3gr	S3gr	S3gr	S3r	S3r
Shirunja	83	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	84	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	85	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	86	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	87	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	88	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	89	S1	S3gt	S2r	S3g	S3t	S3g	S2r	S2gt	S2gt	S3g	S2t	S3g	S2gt	S2gt

Village	Survey No.	Sorghum	Maize	Redgram	Bengalgram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Tomato	Onion	Chilly	Marigold	Chrysanthemum
Shirunja	90	S1	S3gt	S2r	S3g	S3t	S3g	S2r	S2gt	S2gt	S3g	S2t	S3g	S2gt	S2gt
Shirunja	91	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	92	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	93	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	95	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	96	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	97	S1	S3t	S2gr	S3g	S3t	S3g	S2r	S2t	S2t	S3g	S2gt	S3g	S2gt	S2gt
Shirunja	98	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	99	N	N	N	S3gr	N	N	N	N	N	N	N	N	N	N
Shirunja	100	S3r	S3r	N	S2r	S3r	N	S3gr	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	101	S3r	S3r	N	S2r	S3r	N	S3gr	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	102	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	103	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	104	S3r	S3r	N	S2r	S3r	N	S3gr	N	N	S3r	S3r	S3r	S3r	S3r
Shirunja	105	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	106	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	107	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	108	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	109	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	110	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	111	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	112	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	113	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	114	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	115	Rockout crop	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops	Rock outcrops
Shirunja	116	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Shirunja	117	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	117/A	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	117/B	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

Village	Survey No.	Sorghum	Maize	Redgram	Bengalgram	Groundnut	Sunflower	Cotton	Banana	Pomegranate	Tomato	Onion	Chilly	Marigold	Chrysanthemum
Shirunja	118	S3gr	S3gr	N	S3gr	S3r	N	S3gr	N	N	S3gr	S3gr	S3gr	S3gr	S3gr
Shirunja	119	S1	S3t	S2t	S2g	S3t	S1	S1	S2t	S2t	S2t	S2gt	S2t	S2t	S2t
Shirunja	SETTLEMENT	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others
Shirunja	TANK	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others	Others

PART-B

SOCIO-ECONOMIC STATUS OF FARM HOUSEHOLDS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

EXECUTIVE SUMMARY

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

Methodology: *Shirunj micro-watershed (Shirahatti sub-watershed, Gadag taluk and district) is located in between $15^0 16' – 15^0 18'$ North latitudes and $75^0 35' – 75^0 37'$ East longitudes, covering an area of about 611 ha, and spread across Hosur, Shirol, Yelishirur and Mulgund 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 Shirunj micro-watershed (Shirahatti sub-watershed, Gadag taluk and district-watershed, are presented here.*

Social Indicators;

- *Male and female ratio is 42.0 to 58.0 per cent to the total sample population.*
- *Younger age 18 to 50 years group of population is around 62 per cent to the total population.*
- *Literacy population is around 76 per cent.*
- *Social groups belong to other backward caste (OBC) is around 40.0 per cent.*
- *Fire wood is the source of energy for a cooking among all the sample households.*
- *About 40.0 per cent of households have a yashaswini health card.*
- *Majority of farm households (80.0 %) are having MGNREGA card for rural employment.*
- *Dependence on ration cards for food grains through public distribution system is around 70 per cent.*
- *Swach bharath program providing closed toilet facilities around 70 per cent of sample households.*
- *Women participation in decisions making are around 50 per cent of households were found.*

Economic Indicators;

- *The average land holding is 1.15 ha indicates that majority of farm households are belong to small and medium farmers. The dry land of 68.3 % and irrigated land 31.7 % of total Rainfed Land area among the sample farmers.*

- *Agriculture is the main occupation among 95.3 per cent and agriculture is the main and non agriculture labour is subsidiary occupation for 4.8 per cent of sample households.*
- *The average value of domestic assets is around Rs. 18463 per household. Mobile and television are popular communication mass media.*
- *The average value of farm assets is around Rs. 6621 per household, about 40 per cent of sample farmers having plough and sprayer (60 %).*
- *The average value of livestock is around Rs. 19139 per household; about 42.9 per cent of household are having bullocks.*
- *The average per capita food consumption is around 908.2 grams (1380.4 kilo calories) against national institute of nutrition (NIN) recommendation at 827 gram. Around 80 per cent of sample households are consuming less than the NIN recommendation.*
- *The annual average income is around Rs. 120509 per household. Among all the households comes under the above poverty line.*
- *The per capita monthly average expenditure is around Rs. 1449.*

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. 1689 per ha/year. The total cost of annual soil nutrients is around Rs. 952783 per year for the total area of 563.37 ha.*
- *The average value of ecosystem service for food grain production is around Rs. 18147/ha/year. Per hectare food grain production services is maximum in cotton (Rs. 14287) followed by maize (Rs. 4338) and groundnut (Rs. 2436).*
- *The average value of ecosystem service for fodder production is around Rs. 1901/ ha/year. Per hectare fodder production services is maximum in maize (Rs. 2266) and ground nut (Rs. 1535).*
- *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 cotton (Rs. 60922), maize (Rs. 28524) and groundnut (Rs. 19188).*

Economic Land Evaluation;

- *The major cropping pattern is maize (45.7 %) followed by groundnut (45.7 %) and cotton (11.6 %).*
- *In Shirunj micro-watershed, major soil is Dindur (DDR) soils series having very shallow soil depth cover around 124.06 ha of area the major crops are cotton. Yelisirunj (YSJ) soil series having of shallow soil depth cover around 60.94 ha of area. Shirol (SRL) soil series having very shallow soil depth cover around*

125.29 ha of area the major crop are maize and groundnut. Nabhapur (NBP) soil series are having shallow soil depth of 51.13 of area. Jelligeri (JLG) soil series having moderately deep soil depth cover around 72.44 of area; the crops are groundnut on, maize. Mahalingapur Tanda (MPT) and Dhoni (DNI) series are having deep soil depth cover around of 54.72 ha and 39.71 ha of area, respectively; are crops grown by cotton.

- *The total cost of cultivation and benefit cost ratio (BCR) in study area for areca nut ranges between Rs. 170736/ha in KDT soil (with BCR of 2.27) and Rs. 44110/ha in HLK soil (with BCR of 4.90).*
- *In cotton the cost of cultivation range between Rs. 49255/ha in DNI soil (with BCR of 1.45) and Rs 21626/ha in DDR soil (with BCR of 1.18).*
- *In groundnut the cost of cultivation ranges between Rs. 43291/ha in JLK soil (with BCR of 0.97) and Rs 25765/ha in NBP soil (with BCR of 1.31).*
- *In maize the cost of cultivation range between Rs. 31287/ha in SRL soil (with BCR of 1.25) and Rs. 21834/ha in MPT soil (with BCR of 1.11).*
- *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 return.*

Suggestions;

- *Involving farmers is watershed planning helps in strengthing institutional participation.*
- *The per capita food consumption and monthly income is very low. Diversifying income generation activities from crop and livestock production in order to reduce risk related to drought and market prices.*
- *Majority of farmers reported that they are not getting timely support/extension services from the concerned development departments.*
- *By strengthing agricultural extension for providing timely advice improved technology there is scope to increase in net income of farm households.*
- *By adopting recommended package of practices by following the soil test fertiliser recommendation, there is scope to increase yield in cotton (7.3 to 15.7 %), ground nut (48.4 to 65.9 %) and maize (68.8 to 81.0 %).*

Chapter 2

INTRODUCTION

Watershed Development program aim to restore degraded watersheds in rainfed regions to increase their capacity to capture and store rain water, reduce soil erosion, and improved soil nutrients and carbon contents so they can produce greater agricultural yields and other benefits. As majority of rural poor live in these regions and dependent on natural resources for their livelihood and sustenance, improvements in agricultural yields improve human welfare and simultaneously improve national food security.

Sujala–III watershed development project conceptualised and implemented by the Watershed Development Department of Government of Karnataka with tripartite cost-sharing arrangements. The World Bank through International Development Association provided major portion of plan outlay as a loan to Government of India and in turn loan to Government of Karnataka.

The objectives of Sujala-III is to demonstrate more effective watershed management through greater integration of programs related to rain fed agriculture, innovative and science based approaches and strengthened institutions and capacities. The project is implemented in 11 districts of Bidar, Vijayapura, Gulbarga, Yadgir, Koppal, Gadag, Raichur, Davanagere, Tumkur, Chikkamangalur and Chamarajanagar which have been identified by the Watershed Development Department based on rainfall and socio-economic conditions. The project will be implemented over six years and linked with the centrally financed integrated watershed management programme.

Economic evaluations can better guide in watershed planning and implementation, as well as raise awareness of benefits of ecosystem restoration for food security and poverty alleviation program. The present study aims to characterize socio-economic status of farm households, assess the land and water use status, evaluate the economic viability of land use, prioritize farming constraints and suggest the measures for soil and water conservation for sustainable agriculture.

Objectives of the study

1. To characterize socio-economic status of farm households
2. To evaluate the economic viability of land use and land related constraints
3. To estimate the ecosystem service provided by the watershed and
4. To suggest alternatives for sustainable agriculture production.

Chapter 3

METHODOLOGY

Study area

Shirunj micro-watershed located in Northern Transition Zone of Karnataka (Figure 1): Extends over all area of 1.13 M ha of which 0.86 M ha is under cultivation. Nearly 0.052 M ha in the zone enjoys irrigation facilities. Elevation ranges between 450-900 m MSL with most parts situated between 800 and 900 m. Shallow to black soils and red loams are distributed in equal proportion. The average annual rainfall ranges from 620 to 1300 mm of which more than 60 per cent is received during the southwest monsoon (*kharif*). Sorghum, rice, groundnut, maize, chilli, pulses, sugarcane, tobacco and cotton are the major crops of the zone. It represents Ecological Region (AER) – 3 having LPG150-180 days

Shirunj micro-watershed (Shirahatti sub-watershed, Gadag taluk and district) is located in between $15^0$16' – $15^0$18' North latitudes and $75^0$35' – $75^0$37' East longitudes, covering an area of about 611 ha, and spread across Hosur, Shirol, Yelishirur and Mulgund villages.

Sampling Procedure:

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

Sources of data and analysis:

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

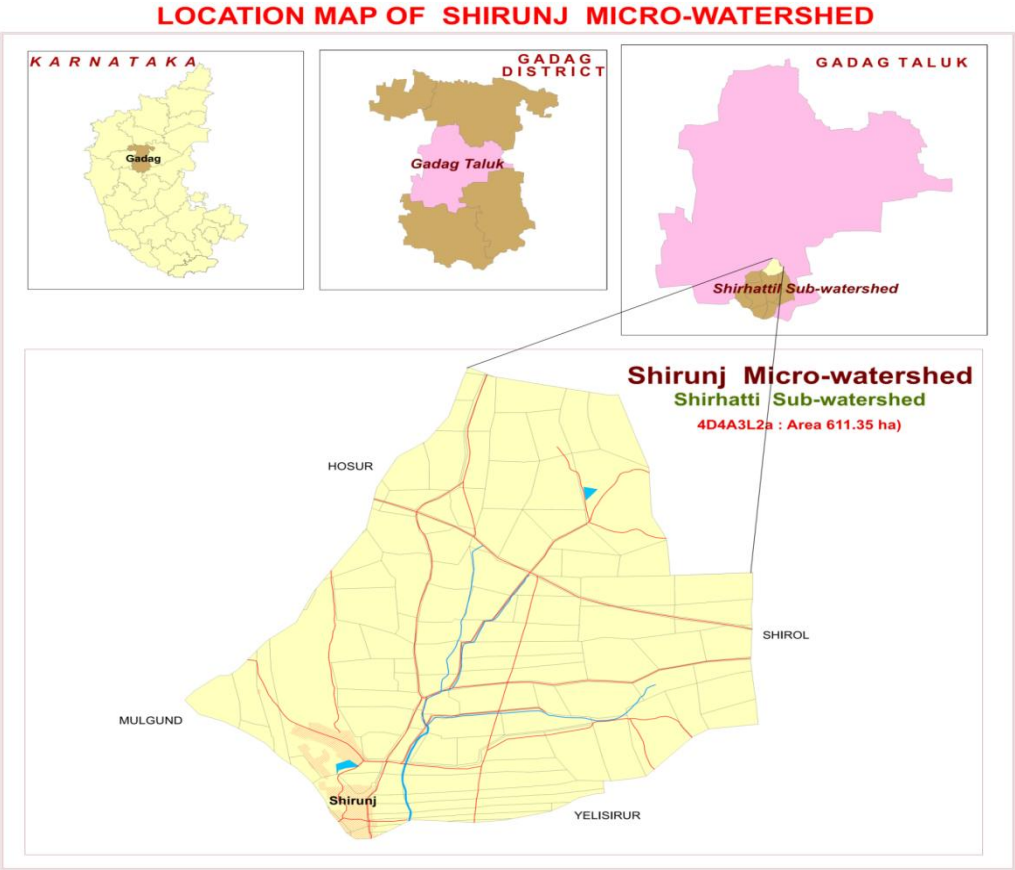
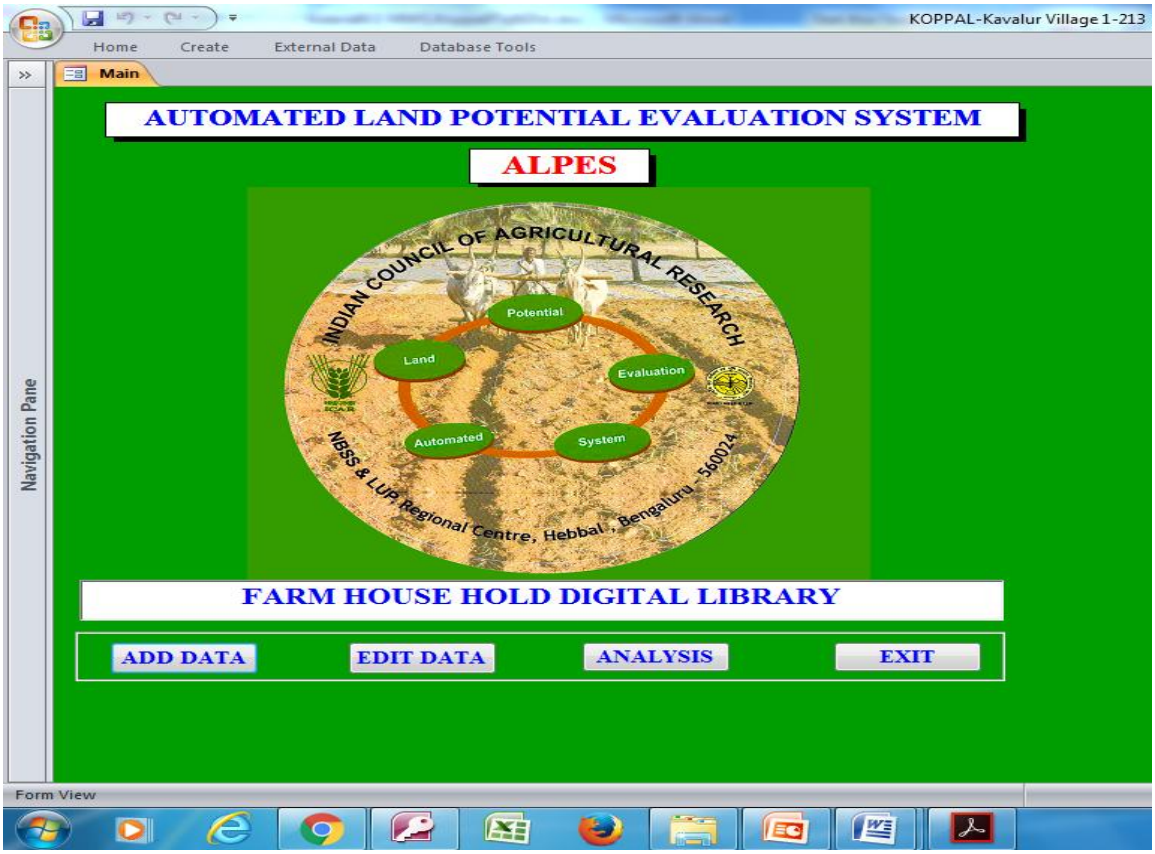


Figure 1: Location of study area

Steps followed in socio-economic assessment

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



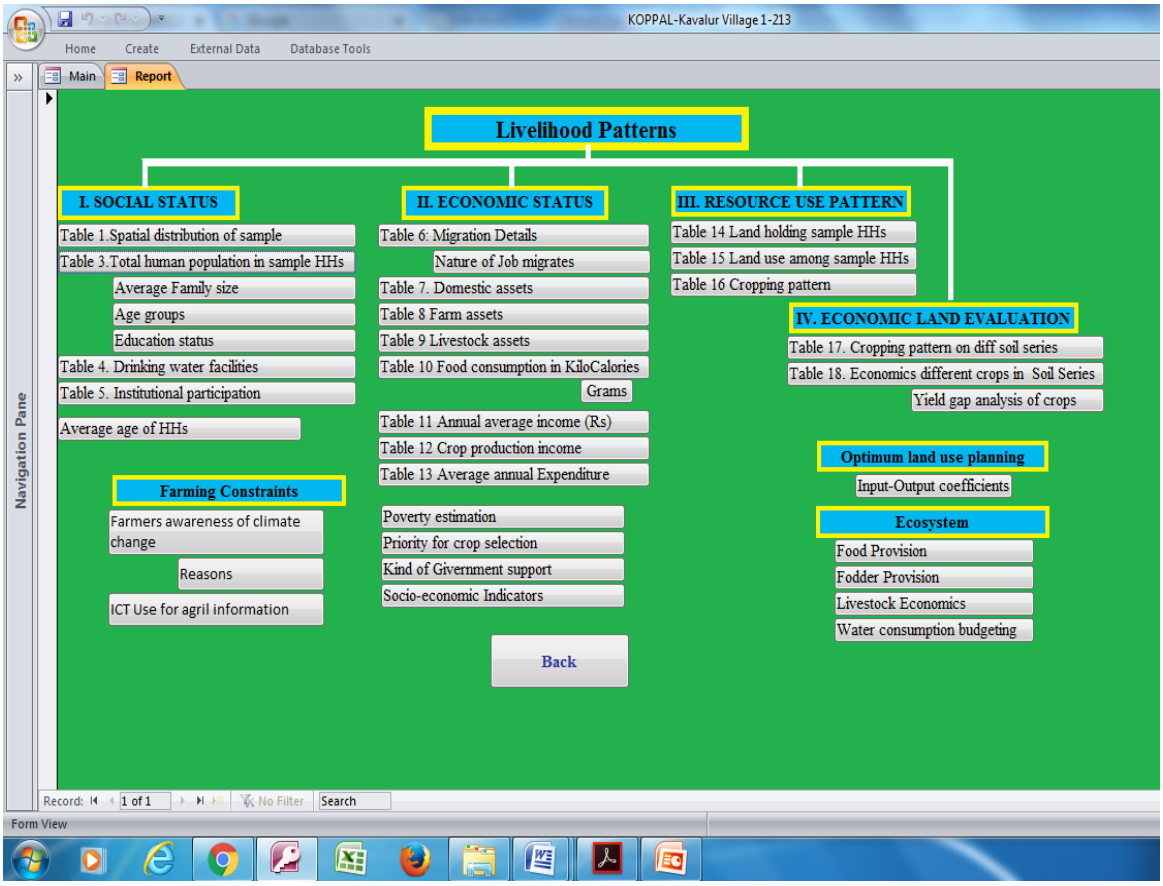


Figure 2: ALPES FRAMEWORK

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

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

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

Economic Valuation of Soil ecosystem services:

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

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

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

Chapter 4

RESULTS AND DISCUSSIONS

The demographic information shows that the household population dynamics encompasses the socioeconomic status of the farmer. For a rural family, the household size should be optimal to earn a comfortable livelihood through farm and non-farm wage earning. The total number of population in watershed area was 50, out of which 58.0 per cent were males and 42.0 per cent females. Average family size of the households is 5.3. Age is an important factor, which affects the potential employment and mobility status of respondents. The data on age wise distribution of farmers in the sample households indicated that majority of the farmers are coming under the age group of 30 to 50 years (62.0 %) followed by more than 50 years (22.0 %), 18 to 30 years (34.0 %) and 0 to 18 years (28.0 %). Hence, in the study area in general, the respondents were of young and middle age, indicating thereby that the households had almost settled with whatever livelihood options they were practicing and sample respondents were young by age who could venture into various options of livelihood sources. Data on literacy indicated that 76.0 per cent of respondents were illiterate and 24.0 per cent literate (Table 1).

Table 1: Human population among sample households in Shirunj Microwatershed

Particulars	**Units**	**Value**
Total human population in sample HHs	Number	50
Male	% to total Population	58.0
Female	% to total Population	42.0
Average family size	Number	5.0
Age group		
0 to 18 years	% to total Population	16.0
18 to 30 years	% to total Population	34.0
30 to 50 years	% to total Population	28.0
>50 years	% to total Population	22.0
Average age	Age in years	37.3
Education Status		
Illiterates	% to total Population	24.0
Literates	% to total Population	76.0
Primary School (<5 class)	% to total Population	18.0
Middle School (6- 8 class)	% to total Population	16.0
High School (9- 10 class)	% to total Population	32.0
Others	% to total Population	10.0

The ethnic groups among the sample farm households found to be 40.0 per cent belonging to other backward castes (OBC) followed by 30.0 per cent belonging to general castes, scheduled tribes (ST) (20 %) and scheduled caste (SC) (10 %) (Table 2 and Figure 3). All the sample households of sample households are using wood as source of fuel for

cooking. All the sample farmers are having electricity connection. About 40.0 per cent are sample households having health cards. Majority (80.0 %) are having MNREGA job cards for employment generation. About 70.0 per cent of farm households are having ration cards for taking food grains from public distribution system. About 70.0 per cent of farm households are having toilet facilities.

Table 2: Basic needs of sample households in Shirunj Microwatershed

Particulars	**Units**	**Value**
Social groups		
SC	% of Households	10.0
ST	% of Households	20.0
OBC	% of Households	40.0
General	% of Households	30.0
Types of fuel use for cooking		
Fire wood	% of Households	100.0
Energy supply for home		
Electricity	% of Households	100.0
Number of households having Health card		
Yes	% of Households	40.0
No	% of Households	60.0
MGNREGA Card		
Yes	% of Households	80.0
No	% of Households	20.0
Ration Card		
Yes	% of Households	70.0
No	% of Households	30.0
Households with toilet		
Yes	% of Households	70.0
No	% of Households	30.0
Drinking water facilities		
Tube Well	% of Households	90.00
Tank	% of Households	10.00

The data collected on the source of drinking water in the study area is presented in Table 2. Majority of the sample respondents are having tube well source for water supply for domestic purpose (90.0 %) and tank water (10.0%).

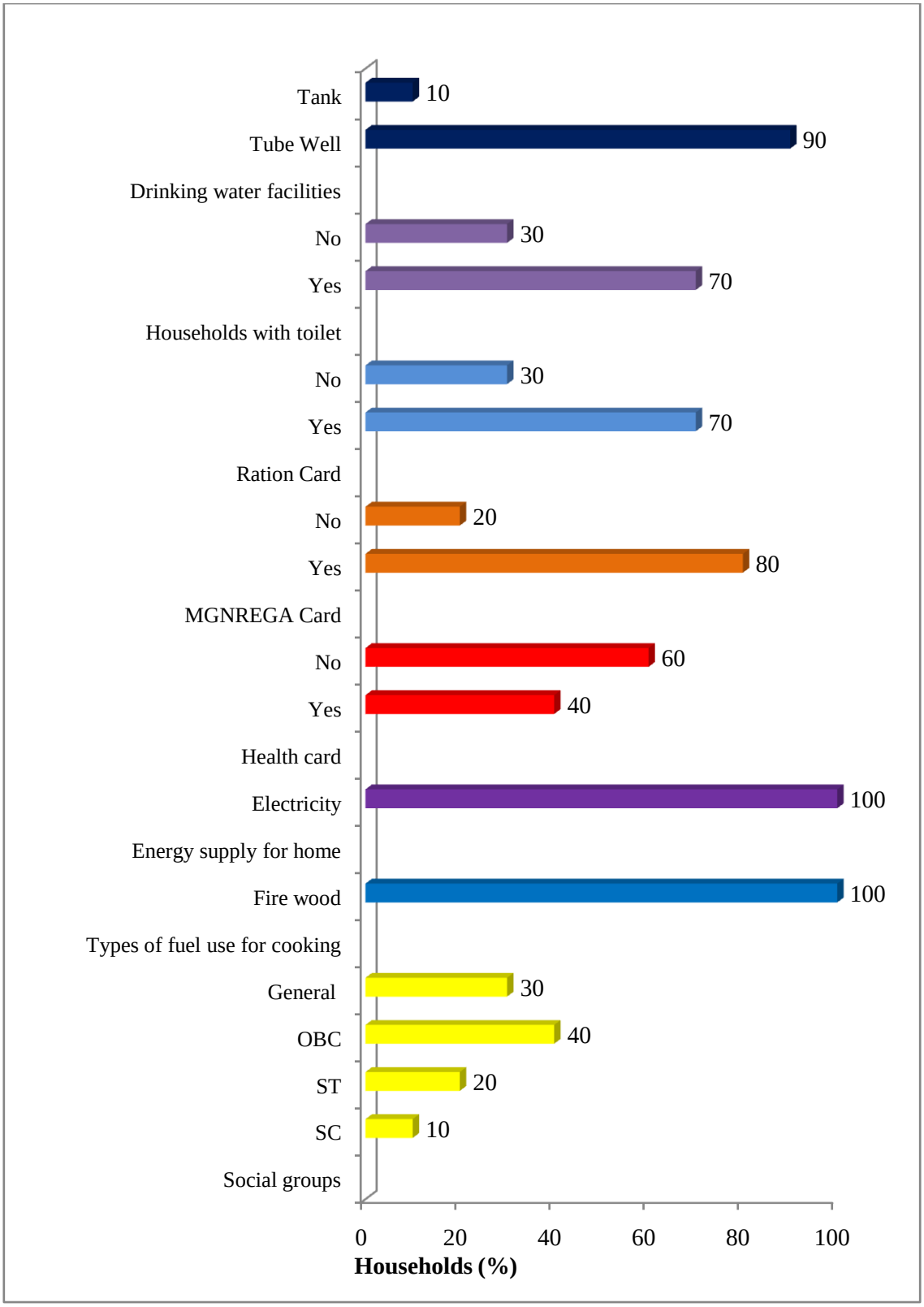


Figure 3: Basic needs of sample households in Shirunj Microwatershed

The data on migration in Shirunj microwatershed is given in Table 3. It indicated that 2.0 per cent of sample households are migration and about 10.0 per cent population were migrated. The average distance travelled for seeking employment is 225 km.

Table 3: Migration details among the sample households in Shirunj Microwatershed

Particulars	Value
% of households showing migration	2.0
% of persons migrating	10.0
No. of months migrated in a year	11.0
Average Distance of migration(Km)	225.0
Nature of job (%)	
Job/wage/work	100.0

The occupational pattern (Table 4) among sample households shows that agriculture is the main occupation around 4.8 per cent and Agriculture Labour (90.5) of farmers followed by subsidiary occupations like Agriculture labour (2.4 %), Private service (2.4 %).

Table 4: Occupational pattern in sample population in Shirunj Microwatershed

Occupation		% to total
Main	**Subsidiary**	
Agriculture	Agriculture	4.8
	Agriculture Labour	90.5
Private service	Private service	2.4
Agriculture labour		2.4
Family labour availability		**Man days/month**
Male		47.5
Female		32.0
Total		79.5

The important assets especially with reference to domestic assets were analyzed and are given in Table 5and Figure 4. The important domestic assets possessed by all categories of farmers are mobile phones (100 %) followed by television (90 %), mixer/grinder (30 %), motorcycle (20 %). The average value of domestic assets is around Rs 18463 per households.

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

Particulars	% of households	Average value in Rs
Mixer/grinder	30.0	2500
Mobile Phone	100.0	2850
Motorcycle	20.0	60000
Television	90.0	8500
Average Value	18463	

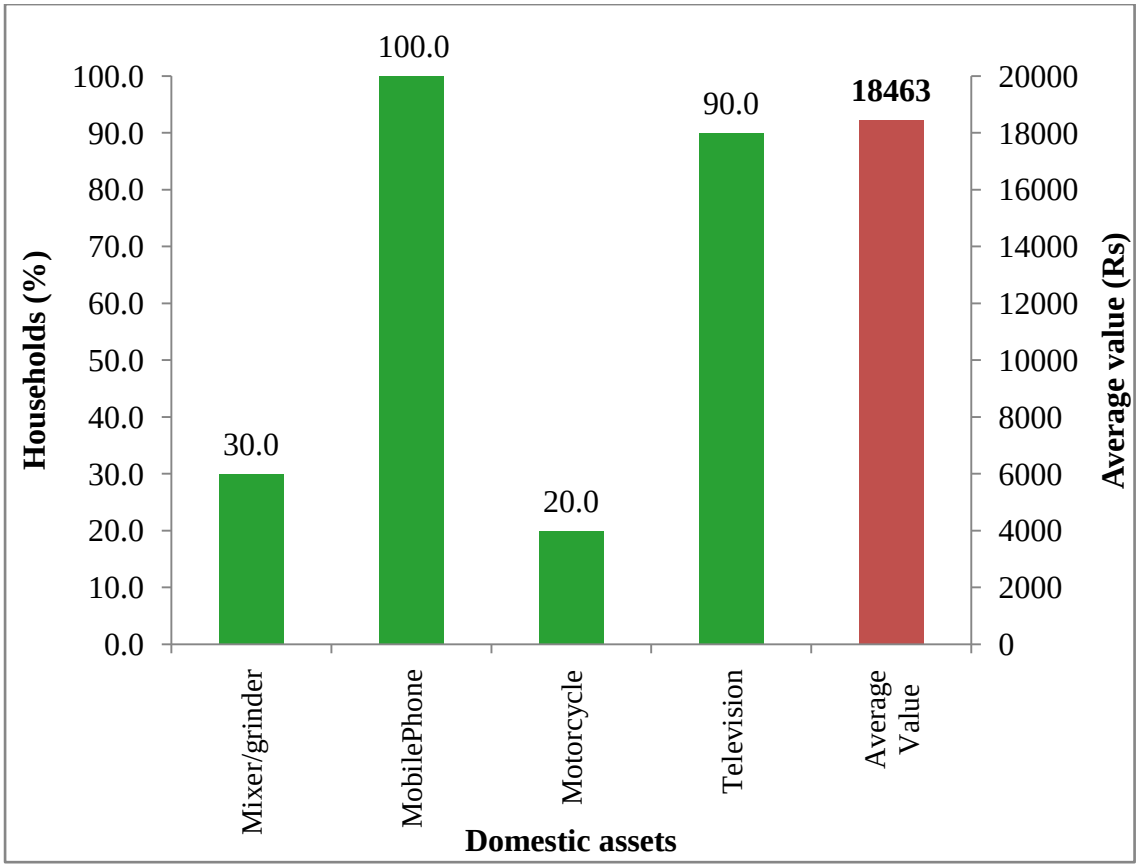


Figure 4: Domestic assets among the sample households in Shirunj Micro watershed

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 (60), bullock cart (60 %), sprayer (50 %), weeder (50 %), seed cum fertiliser drill (20 %), drip/sprinkler (10 %) was found among the sample farmers. The average value of farm assets is around Rs. 6621 per households (Table 6 and Figure 5).

Table 6 Farm assets among samples households in Shirunj Microwatershed

Particulars	% of households	Average value in Rs
Bullock cart	60.0	13500
Drip/Sprinkler	10.0	4000
Plough	60.0	4217
Seed cum fertiliser drill	20.0	13500
Sprayer	50.0	4200
Weeder	50.0	310
Average Value	6621	

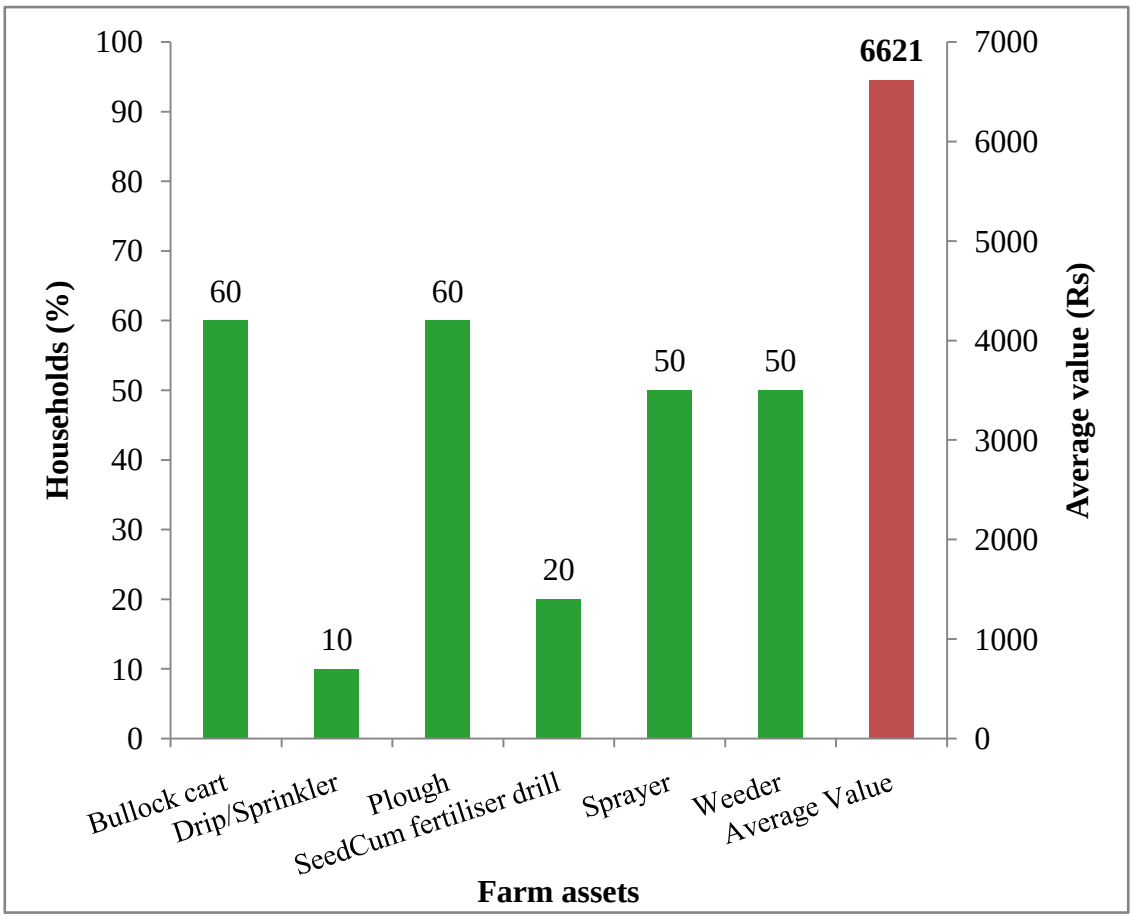


Figure5: Farm assets among samples households in Shirunj Microwatershed

Livestock is an integral component of the conventional farming systems (Table 7and Figure 6). The highest livestock population is bullocks were around 42.9 per cent fallowed by milching buffalos (14.3 %), local dry cow (14.3 %), dry buffalos (7.1 %) and poultry (7.1 %). The average value of livestock was Rs 19139 per household.

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

Particulars	% of livestock population	Average value in Rs
Local Dry Cow	14.3	19000
Local Milching Cow	14.3	13500
Dry Buffalos	7.1	15000
Milching Buffalos	14.3	32500
Bullocks	42.9	34333
Poultry	7.1	500
Average value	19139	

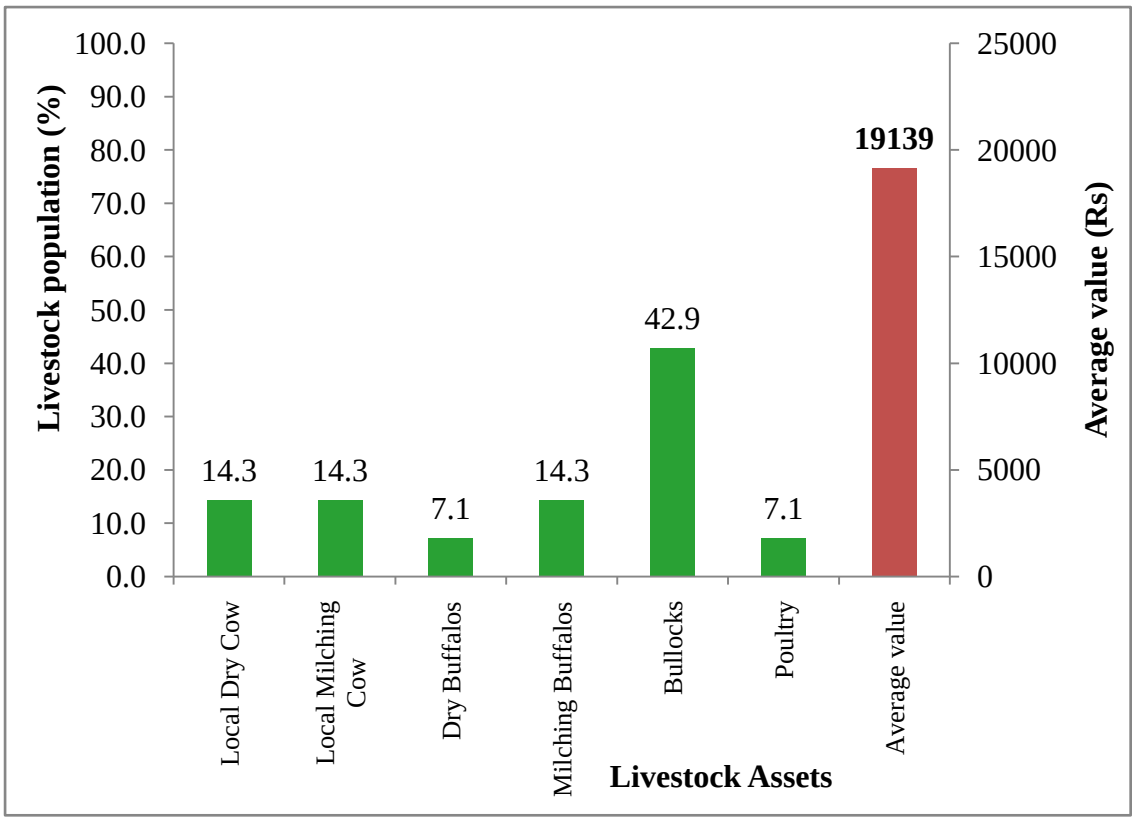


Figure 6: Livestock assets among sample households in Shirunj micro-watershed

Average milk produced in sample households is 840 litters/ annum. Among the farm households of fodder Groundnut are the main crops for domestic food and fodder for animals. About 171 kg /ha of average fodder is available per season for the livestock feeding (Table 8).

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

Particulars	
Name of the Livestock	**Ltr./Lactation/animal**
Milching Buffalos	840
Average Milk Produced	840
Fodder produces	**Fodder yield (kg/ha.)**
Groundnut	1538
Average fodder availability	171
Livestock having households (%)	82
Livestock population (Numbers)	74

A woman participation in decision making is in this micro-watershed is presented in Table 9. All the sample households' women taking decision in her family and agriculture related activities, all the women participation in women earning for her family requirement.

Table 9: Women empowerment of sample households in Shirunj 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	100.0	0.0
Women taking decision in her family and agriculture related activities	100.0	0.0

The food intake in terms of kilo calorie (kcal) per person per day was calculated and presented in the Table 10and Figure 7. More quantity of cereals are consumed by sample farmers which accounted for 1280.9 kcal per person. The other important food items consumed was pulses 197.2 kcal followed by cooking oil 175.2 kcal, milk 114.1 kcal, vegetables 36.7 kcal, egg 154.8 kcal and meat 17.8 kcal. In the sampled households, farmers were consuming less (1976.1 kcal) than NIN- recommended food requirement (2250 kcal).

Table 10: Per capita daily consumption of food among the sample households in Shirunj Microwatershed

Particulars	NIN recommendation (gram/ per day/ person)	Present level of consumption (gram/ per day/ person)	Kilo Calories /day/person
Cereals	396	376.7	1280.9
Pulses	43	57.5	197.2
Milk	200	175.6	114.1
Vegetables	143	153.1	36.7
Cooking Oil	31	30.7	175.2
Egg	0.5	102.8	154.2
Meat	14.2	11.9	17.8
Total	827.7	908.2	1976.1
Threshold of NIN recommendation		827 gram*	2250 Kcal*
% Below NIN		80.0	40.0
% Above NIN		20.0	60.0

Note: * day/person

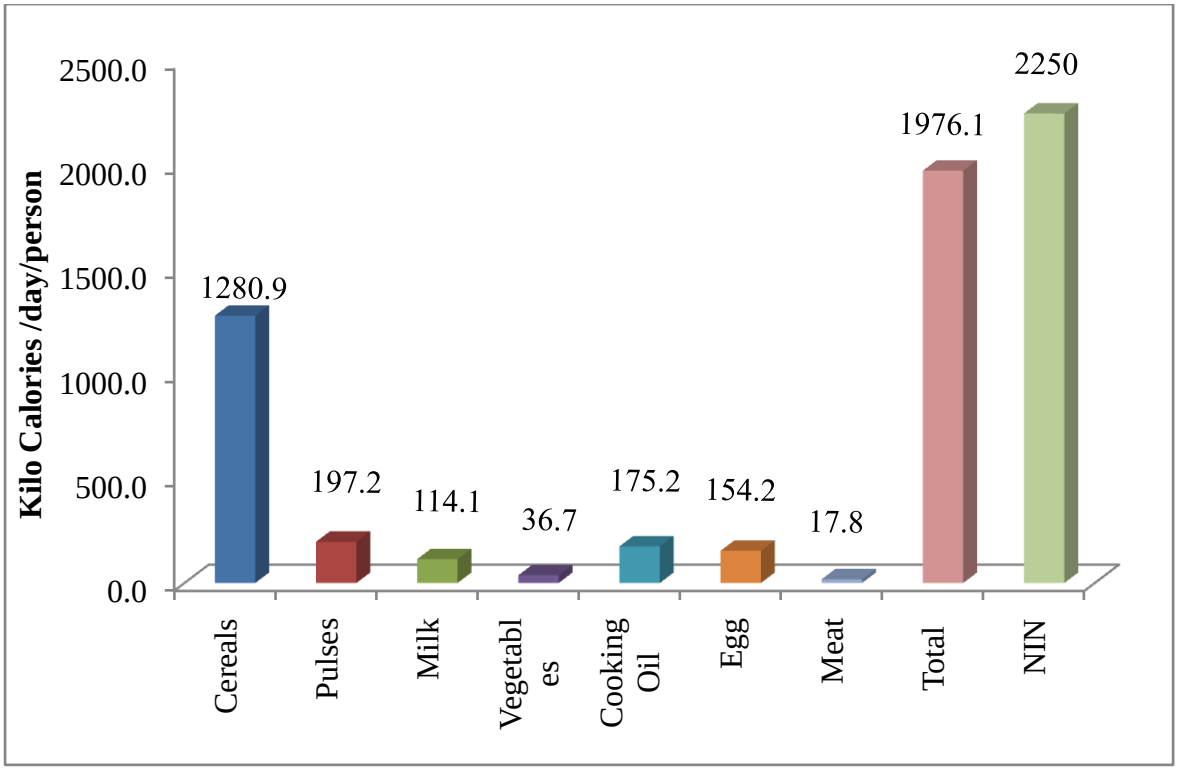


Figure 7: Per capita daily consumption of food among the sample households in Shirunj Microwatershed

Annual income of the sample HHs: The average annual household income is around Rs 14070. Major source of income to the farmers in the study area is from crop production (Rs 7651) followed by livestock (Rs. 3823) nonfarm income (Rs. 2596). The monthly per capita income is Rs. 234 which is less than the threshold monthly income of Rs 975 for considering above poverty line. Due to the fact that erratic rainfall and shortage of water, farmers are diverting from crop production activities to enable the household for a comfortable livelihood. The incomes from the other aforesaid sources are very meagre (Table 11).

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

Particulars	Income *
Nonfarm income (Rs)	2596 (10)
Livestock income (Rs)	3823 (40)
Crop Production (Rs)	7651 (100)
Total Annual Income (Rs)	***14070***
Average monthly per capita income (Rs)	235
Threshold for Poverty level (Rs 975 per month/person)	
% of households below poverty line	90.0
% of households above poverty line	10.0

* 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. 48804) 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 1449 and about 90.0 per cent of farm households are below poverty line and 10.0 per cent of farm households are above poverty line (Table 12 and Figure 8).

Table 12: Average annual expenditure of sample HHs in Shirunj Microwatershed

Particulars	Value in Rupees	Per cent
Food	48804	56.1
Education	3200	3.7
Clothing	8800	10.1
Social functions	16250	18.7
Health	9900	11.4
Total Expenditure (Rs/year)	86954	100.0
Monthly per capita expenditure (Rs)	1449	

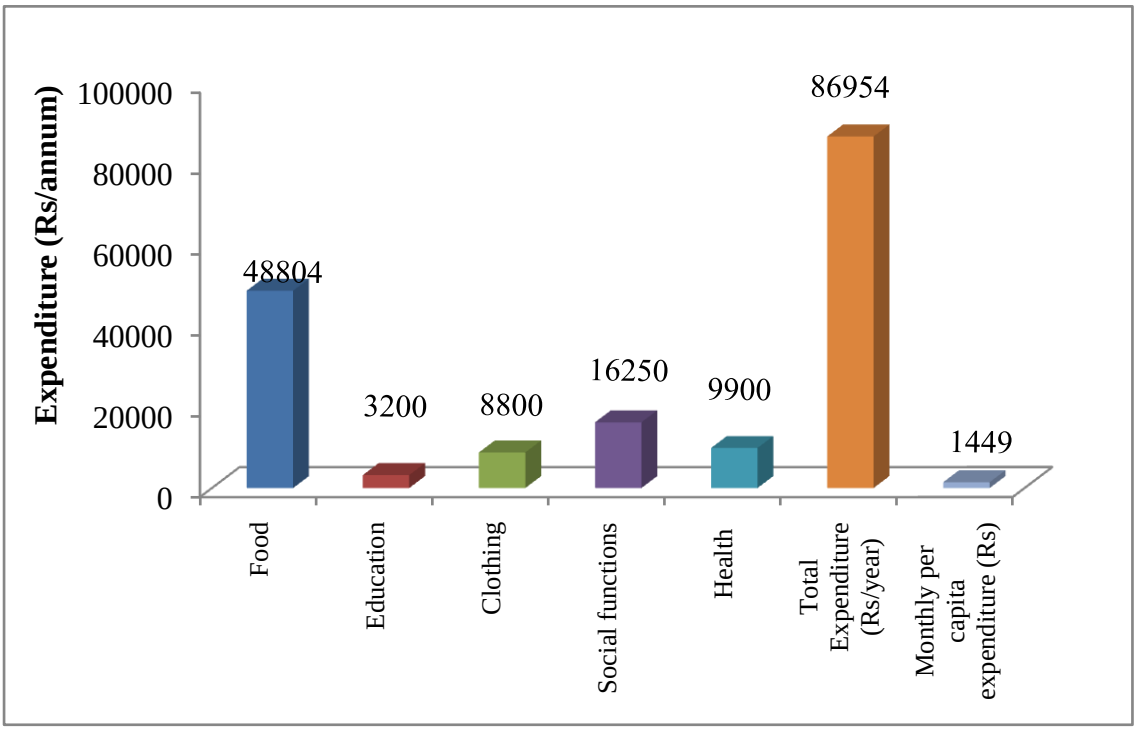


Figure 8: Average annual expenditure of sample HHs in Shirunj Microwatershed

Land holding: Total sample households are total area cultivated by them is 11.5 ha. The average land holding of sample HHs is 1.2 ha. Large number of sample HHs (80%) belong to small size group with an average holding size of 0.8 ha and medium farmer (20%) with a average land holding size of 2.6 ha (Table 13)

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

Particulars	Units	Values
Small farmers		
Total land	ha	6.4
Sample size	Per cent	80
Average land holding	ha	0.8
Medium farmers		
Total land	ha	5.1
Sample size	Per cent	20
Average land holding	ha	2.6
Total sample households		
Total land	ha	11.5
Sample size	Per cent	100
Average land holding	ha	1.2

Land use: The total land holding in the Shirunj micro-watershed is 11.5 ha (Table 14). Of which 7.9 ha is rain fed land and 3.7 ha is irrigated land. The average land holding per household is worked out to be 1.15 ha.

Table 14: Land use among samples households in Shirunj Microwatershed

Particulars	Per cent	Area in ha
Irrigated land	31.7	3.7
Rainfed Land	68.3	7.9
Fallow Land	0.0	0.0
Total land holding	100.0	11.5
Average land holding	1.15	

In the micro-watershed, the prevalent present land uses under perennial plants are neem trees (87.7 %) followed by coconut (9.9 %), peeple tree (1.2 %) and banyan tree (1.2 %).

Table 15: Number of trees/plants covered in sample farm households in Shirunj Microwatershed

Particulars	Number of Plants/trees	Per cent
Banyan tree(Alada)	1	1.2
Coconut	8	9.9
Neem trees	71	87.7
Peeple tree(Arali)	1	1.2
Grand Total	81	100.0

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

The present dominant crops grown in dry lands in the study area were by groundnut (45.7 %) followed by maize (42.7 %) and cotton (11.6 %). which are taken

during Kharif season respectively. The cropping intensity was 100 per cent (Table 16 and Figure 9).

Table 16: Present cropping pattern and cropping intensity in Shirunj Microwatershed

% to Grand Total

Crops	Kharif	Grand Total
Cotton	11.6	11.6
Groundnut	45.7	45.7
Maize	42.7	42.7
Grand Total	100.0	100.0

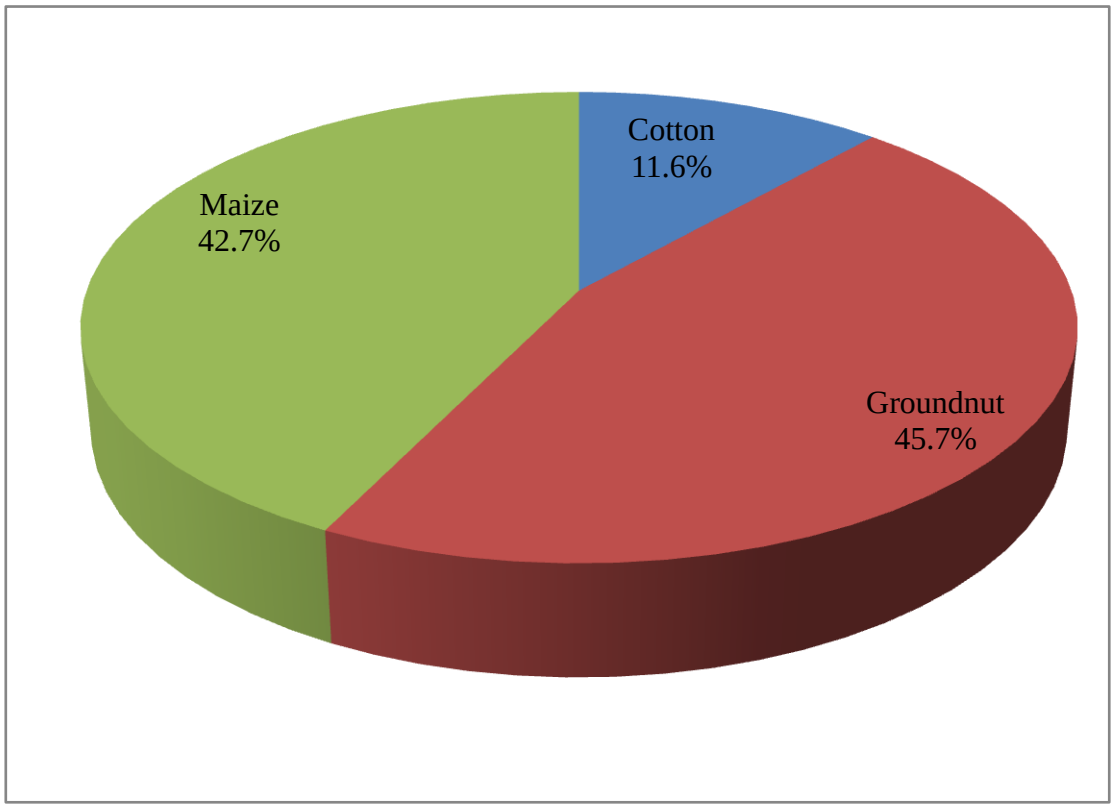


Figure 9: Present cropping pattern in Shirunj Microwatershed

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 Shirunj micro-watershed, 10 soil series are identified and mapped (Table 17). The distribution of major soil series are Dindur (DDR) covering an area around 124.06 ha followed by shirol (SRL) 125.29 ha**,** Jelligeri (JLG) 72.62 ha, Yelisirunj (YSJ) 60.94 ha, Mahalingapur Tanda (MPT) 54.72 ha, Nabhapur (NBP) 51.13ha, DNI 39.72 ha, Attikatti (AKT) 14.99 ha, Attikatti Tanda (ATT) 14.75 ha and (DR) 5.15 ha.

Table 17: Distribution of soil series in Shirunj Microwatershed

Sl. No.	Soil series	Description	Area (ha)
1	AKTfB2g1	Shallow (25-50 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay loam surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)	1.78
	AKTmB1g1	Shallow (25-50 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay surface, slope 1-3 %, slight erosion, gravelly (15-35 %)	1.24
	AKTmB2g1	Shallow (25-50 cm), well drained clayey soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3 %, moderate erosion, gravelly (15-35 %)	11.97
2	ATTiB1	Moderately shallow (50-75 cm), well drained, clayey soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	14.75
3	DDRfB2	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	17.78
	DDRfC3g1R1	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay loam surface, slope 3-5 %, severe erosion, gravelly (15-35%) and fairly rocky (2-10%)	15.31
	DDRhB2g2	Very shallow (<25cm), well drained, gravelly clay soils developed from schist, occurring on very gently sloping uplands. Sandy clay loam surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	19.67
	DDRhC3g3	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on gently sloping uplands. Sandy clay loam surface, slope 3-5 %, severe erosion extremely gravelly (>60 %).	7.38
	DDRhD2g2R_2	Very shallow (<25 cm), well drained, gravelly clay soil, developed from banded ferruginous quartzite, occurring on moderately sloping mounds and side slopes mostly under forest. Sandy clay loam surface, slope 5-10%, moderate erosion, very gravelly (35-60%), 10-25 % rock outcrops.	3.87
	DDRhD3g3R1	Very shallow (<25 cm), well drained, gravelly clay soil, developed from banded ferruginous quartzite, occurring on moderately sloping mounds and side slopes mostly under forest. Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (>60%), 2-10% rock outcrops.	10.66
	DDRhD3g3R3	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on moderately sloping mounds and side slopes mostly under forest. Sandy clay loam surface, slope 5-10%, severe erosion, extremely gravelly (>60%), 25-50% rock outcrops.	19.25
	DDRiB2g2R1	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Sandy clay surface, slope 1-3 %, moderate erosion, very	30.14

		gravelly (35-60 %), 2-10 % rock outcrops.	
	DRmB2g2R1	Very shallow (<25 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay surface, slope 1-3 %, moderate erosion, very gravelly, (35-60 %), 2-10 % rock outcrops.	5.15
	DNIfC2g1	Deep (100-150 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands under rain fed cultivation. Clay loam surface, slope 3-5 %, moderate erosion, gravelly (15-35%)	19.36
	DNImB1	Deep (100-150 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands under rain fed cultivation. Clay loam surface, slope 1-3 %, moderate erosion, gravelly (15-35%)	20.36
	JLGiC2g2	Moderately deep (75-100 cm), moderately well drained cracking clay soils developed from schist, occurring on gently sloping uplands. Sandy clay surface, slope 3-5%, moderate erosion, very gravelly (35-60 %).	33.680
	JLGmB1g1	Moderately deep (75-100 cm), moderately well drained, cracking clay soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3%, slight erosion, gravelly (15-35 %).	18.63
	JLGmB2g2	Moderately deep (75-100 cm), moderately well drained, cracking clay soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60 %).	20.13
	MPTmB1g1	Deep (100-150 cm), moderately well drained, cracking clay soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3 %, slight erosion, 15-35 % gravelly	25.86
	MPTmB2g2	Deep, (100-150 cm), well drained, cracking clay soil, developed from schist, occurring on very gently sloping uplands mostly under rainfed cultivation. Clay surface, slope 1-3 %, moderate erosion, very gravelly (35-60 %)	28.86
	NBPfC3g2	Shallow (25-50 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on gently sloping uplands mostly under rain fed cultivation. Clay loam surface, slope 3-5%, severe erosion, very gravelly (35-60%), 30-40 % rock outcrops.	9.41
	NBPmB2g1	Shallow (25-50 cm), well drained, gravelly clay soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands mostly under rainfed cultivation. Clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	25.35
	NBPmB2g2	Shallow (25-50 cm), well drained, gravelly clay soil, developed from banded ferruginous quartzite, occurring on very gently sloping uplands mostly under rainfed cultivation. Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	16.37
	SRLcB1g2	Very shallow (<25 cm), well drained, clayey soils developed from schist, occurring on very gently sloping uplands, Sandy loam surface, slope 1-3%, slight erosion very gravelly (35-60%)	31.63
	SRLiB1g1	Very shallow (<25 cm), well drained, clayey soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands, Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	12.20

	SRL iB1g2	Very shallow (<25 cm), well drained, clayey soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Sandy clay surface, slope 1-3%, slight erosion, very gravelly (35-60%)	41.39
	SRL mB2g2	Very shallow (<25 cm), well drained, clayey soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	10.93
	SRL mC2g2	Very shallow (<25 cm), well drained, clayey soils developed from banded ferruginous quartzite, occurring on very gently sloping uplands. Clay surface, slope 3-5%, moderate erosion, very gravelly (35-60%)	29.14
	YSJ mB2	Shallow (25-50 cm), well drained, clayey soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3%, moderate erosion	25.55
	YSJ mB2g2	Shallow (25-50 cm), well drained, clayey soils developed from schist, occurring on very gently sloping uplands. Clay surface, slope 1-3%, moderate erosion, very gravelly (35-60 %)	35.39

Present cropping pattern on different soil series are given in Table 18. Crops grown on Dindur (DDR) soils are cotton. Maize and ground nut on shirol (SRL) soils, groundnut on Yelisirunj (YSJ), Nabhapur (NBP) and Jelligeri (JLG) soils, maize on Mahalingapuratanda (MPT) soils and Dhoni (DNI) soils are crops grown by cotton.

Table 18: Cropping pattern on major soil series in Shirunj micro-watershed

(Area in per cent)

Soil Series	Soil Depth	Crops	Dry	Irrigated	Grand Total
			Kharif	Kharif	
DDR	Very shallow (<25 cm)	Cotton	100	0.0	100
SRL	Very shallow (<25 cm)	Groundnut	49.0	0.0	49.0
		Maize	33.0	18.0	51.0
YSJ	Shallow (25-50 cm)	Groundnut	100	0.0	100
NBP	Shallow (25-50 cm)	Groundnut	100	0.0	100
JLG	Moderately deep (75-100 cm)	Groundnut	100	0.0	100
MPT	Deep (100-150 cm)	Maize	100	0.0	100
DNI	Deep (100-150 cm)	Cotton	0.0	100	100

Land is used for agricultural use for growing cereals, pulse, oilseeds and commercial crops. The soil/ land potential are measures in terms of physical yield and net income. The alternative land use options for each micro-watershed are given below (Table 19).

Table 19: Alternative land use options for different size group of farmers (Benefit Cost Ratio) in Shirunj Microwatershed.

Soil Series	Small Farmers	Medium Farmers
DDR	Cotton 1.18	
SRL	Maize 1.25	Groundnut 1.09
YSJ	Groundnut 1.17	
NBP	Groundnut 1.31	
JLG	Groundnut 0.97	
MPT		Maize 1.11
DNI	Cotton 1.45	

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

The data on cost of cultivation and benefit cost ratio (BCR) of different crops is given in Table 20. The total cost of cultivation in study area for cotton range between Rs 49255/ha in DNI soil (with BCR of 1.45) and Rs 21626/ha in DDR soil (with BCR of 1.18), followed by groundnut range between Rs.43291/ha in JLK soil (with BCR of 0.97) and Rs 25765/ha in NBP soil (with BCR of 1.31), maize range between Rs 31287/ha in SRL soil (with BCR of 1.25) and Rs 21834/ha in MPT soil (with BCR of 1.11).

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 94121 in maize and a minimum of Rs 34274 in ground nut cultivation

Table 20: Economic land evaluation and bridging yield gap for different crops in Shirunj micro-watershed

Particulars	DDR (<25 cm)	SRL (<25 cm)		YSJ (25-50 cm)	NBP (25-50 cm)	JLG (75-100 cm)	MPT (100-150 cm)	DNI (100-150 cm)
	Cotton	**Groundnut**	**Maize**	**Groundnut**	**Groundnut**	**Groundnut**	**Maize**	**Cotton**
Total cost (Rs/ha)	41626	27343	31287	38700	25765	43291	21834	49255
Gross Return (Rs/ha)	48988	29904	38873	45210	33836	41990	24227	71250
Net returns (Rs/ha)	7363	2561	7586	6510	8070	-1301	2393	21995
BCR	1.18	1.09	1.25	1.17	1.31	0.97	1.11	1.45
Farmers Practices (FP)								
FYM (t/ha)	2.1	1.6	2.3	2.2	2.9	5.0	1.2	4.3
Nitrogen (kg/ha)	84.4	75.5	119.9	71.4	63.9	80.0	120.4	43.8
Phosphorus (kg/ha)	65.6	54.2	87.9	51.3	54.2	57.5	73.4	49.1
Potash (kg/ha)	17.7	0.0	0.0	0.0	0.0	0.0	0.0	32.1
Grain (Qtl/ha)	14.6	5.9	26.2	8.9	6.8	6.3	15.9	16.0
Price of Yield (Rs/Qtl)	3400	5000	1400	5000	5000	6000	1500	4500
Soil test based fertilizer Recommendation (STBR)								
FYM (t/ha)	12.4	8.6	8.6	8.6	8.6	8.6	8.6	12.4
Nitrogen (kg/ha)	111.2	18.5	92.6	18.5	18.5	18.5	92.6	148.2
Phosphorus (kg/ha)	92.6	77.2	77.2	77.2	77.2	77.2	77.2	92.6
Potash (kg/ha)	74.1	38.6	40.1	30.9	38.6	38.6	32.1	74.1
Grain (Qtl/ha)	17.3	17.3	84.0	17.3	17.3	17.3	84.0	17.3
% of Adoption/yield gap (STBR-FP) / (STBR)								
FYM (%)	83.1	81.8	73.8	74.2	67.0	42.2	86.2	65.4
Nitrogen (%)	24.1	-307.4	-29.4	-285.6	-245.1	-331.8	-30.0	70.4
Phosphorus (%)	29.1	29.7	-13.9	33.5	29.8	25.5	5.0	46.9
Potash (%)	76.1	100.0	100.0	100.0	100.0	100.0	100.0	56.7
Grain (%)	15.7	65.9	68.8	48.4	60.4	63.9	81.0	7.3
Value of yield and Fertilizer (Rs)								
Additional Cost (Rs/ha)	12904	8171	6387	7533	7029	4545	7926	12083
Additional Benefits (Rs/ha)	9203	56969	80914	41807	52203	66240	102047	5690
Net change Income (Rs/ha)	-3701	48798	74527	34274	45175	61695	94121	-6394

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

The onsite cost of different soil nutrients lost due to soil erosion is given in Table 21 and Figure 10. The average value of soil nutrient loss is around Rs 1689.3 per ha/year. The total cost of annual soil nutrients is around Rs 952783 per year for the total area of 563.37 ha.

Table 21: Estimation of onsite cost of soil erosion in Shirunj micro-watershed

Particulars	Quantity(kg)		Value (Rs)	
	Per ha	Total	Per ha	Total
Organic matter	242.08	136536	1525.13	860175
Phosphorous	0.08	43	3.36	1892
Potash	0.88	496	17.58	9914
Iron	0.13	71	6.01	3390
Manganese	0.38	216	105.22	59343
Cupper	0.05	26	25.96	14641
Zinc	0.01	3	0.23	129
Sulpher	0.14	78	5.54	3124
Boron	0.01	4	0.31	175
Total	243.75	137473	1689.33	952783

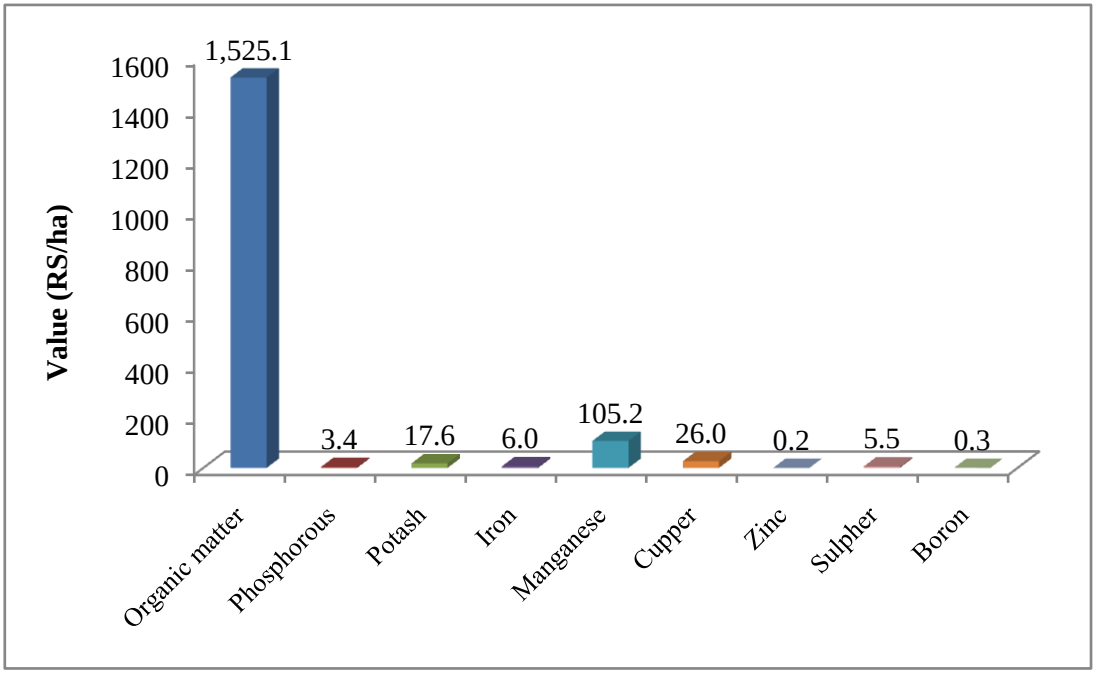


Figure 10: Estimation of onsite cost of soil erosion in Shirunj micro-watershed

The average value of ecosystem service for food grain production is around Rs. 18147/ ha/year (Table 22 and figure 11). Per hectare food grain production services is maximum in cotton (Rs. 14287) followed by maize (Rs. 4338) and groundnut (Rs. 2436).

Table 22: Ecosystem services of food grain production in Shirunj 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)
Cereals	Maize	5.2	23	1425	33262	28924	4338
Oil seeds	Groundnut	5.7	7	5250	36211	33775	2436
Commercial Crops	Cotton	1.4	15	3950	59727	45440	14287
Average value		12.3	15	3542	43067	36046	7020

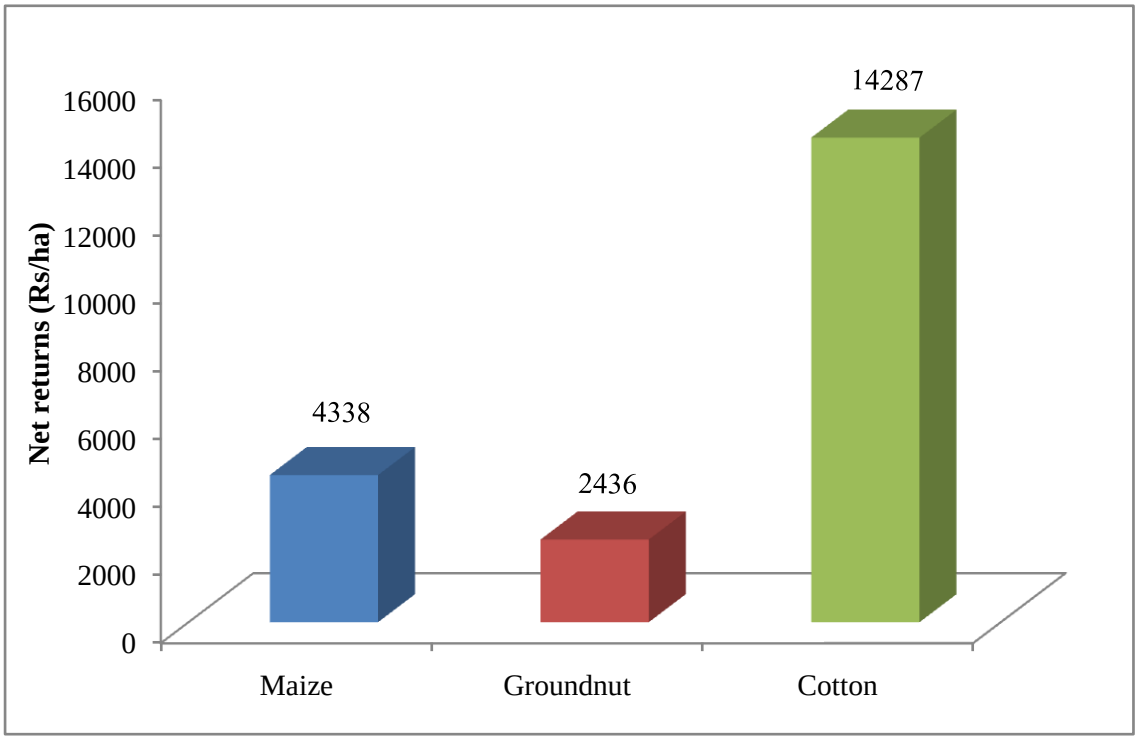


Figure 11: Ecosystem services of food grain production in Shirunj Microwatershed

The average value of ecosystem service for fodder production is around Rs 1901/ ha/year (Table 23). Per hectare fodder production services is maximum in Maize (Rs 2266) and ground nut (Rs 1535).

Table 23: Ecosystem services of fodder production in Harve 1Microwatershed

Production items	Crops	Area in ha	Yield (Qtl/ha)	Price (Rs/Qtl)	Net Returns (Rs/ha)
Cereals	Maize	5.2	3.2	700	2266
Oil seeds	Groundnut	5.7	1.2	1250	1535
Average value		10.9	2.2	975	1901

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 and Figure 12) in cotton (Rs 60922), maize (Rs 28524) and groundnut (Rs 19188).

Table 24: Ecosystem services of water supply in Shirunj Microwatershed

Crops	Yield (Qtl/ha)	Virtual water (cubic meter) per ha	Value of Water (Rs/ha)	Water consumption (Cubic meters/Qtl)
Cotton	15.1	6092	60922	403
Groundnut	6.9	1919	19188	278
Maize	23.3	2852	28524	122
Average value	45.3	3621	36211	268

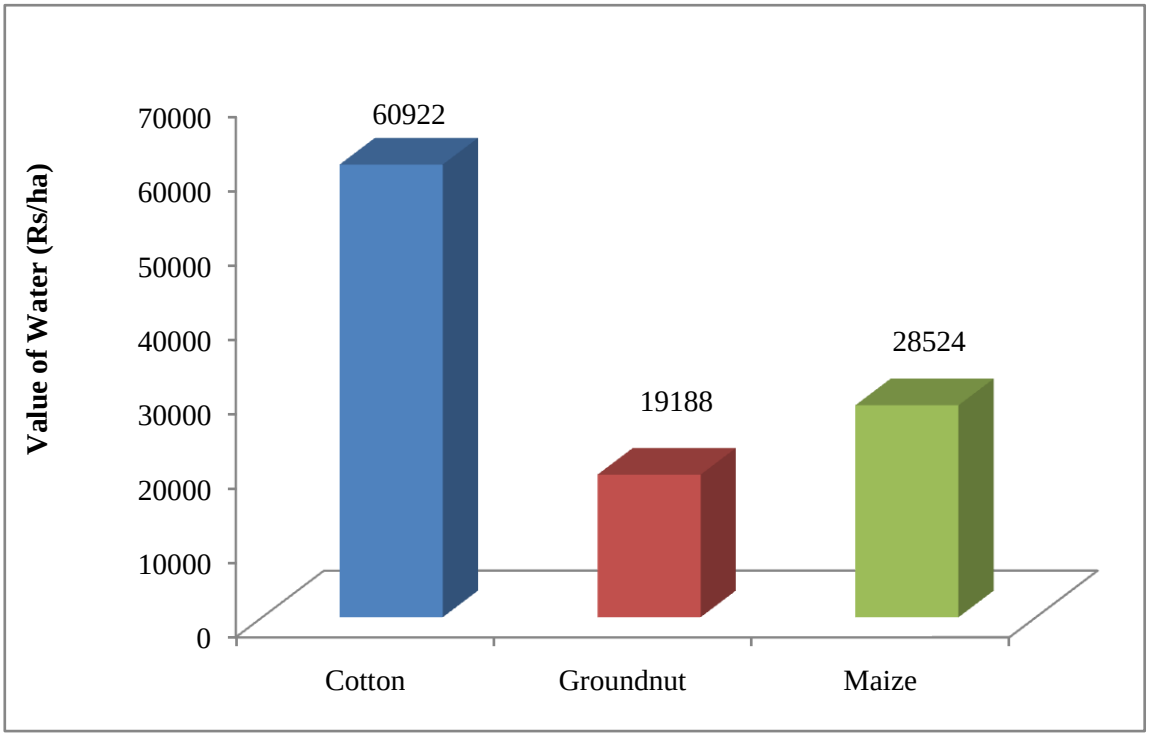


Figure 12: Ecosystem services of water supply in Shirunj Microwatershed

The main farming constraints in Shirunj micro-watershed to be found are less rainfall, lack of good quality seeds, damage of crops by wild animals and non availability of plant protection chemicals. Majority of farmers depend up on money lender of the sources of loan for purpose of crop production. Farmers to sell the agriculture produce through village market and the farmers getting the agriculture related information on newspaper and television. Farmers reported that they are not getting timely support/extension services from the concerned development department (Table 25).

Table 25: Farming constraints related land resources of sample households in Shirunj Microwatershed

Sl.No	Particulars	Per cent
1	Less Rainfall	100.0
2	Lack of good quality seeds	60.0
3	Non availability Fertilizers	20.0
4	High Crop Pests & Diseases	10.0
6	Lack of transportation	100.0
7	Lack of storage	100.0
8	Damage of crops by Wild Animals	100.0
9	Non availability of Plant Protection Chemicals	100.0
10	**Source of loan**	
	Bank	20.0
	Money Leander	80.0
11	**Market for selling**	
	Regulated	10.0
	Village market	90.0
12	**Sources of Agri-Technology information**	
	Newspaper	90.0
	Television	10.0

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