

Land Suitability Evaluation of Soils for Crop Production

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ABSTRACT:Land suitability analysis allows identifying the main limiting factors for the agricultural production and enables decision makers to develop crop managements and able to increase the land productivity. Objectives of this study were to develop a GIS based approach for land use suitability assessment which will assist land managers and land use planners to identify areas with physical constraints for a range of nominated land uses. Georeferenced soil survey data and field work observations have been integrated in a GIS based land use suitability assessment for agricultural planning in T.G. Halli Catchment, Karnataka, India. Also GIS has been used to match the suitability for main crops based on the requirements of the crops and the quality and characteristics of land. The land topographic and physiochemical characteristics evaluated based on parametric method and Geographical Information System (GIS) techniques were used to develop irrigation land suitability map of the studied area. The results showed that, overall suitability of applying drip irrigation is more than other irrigation methods and the results also showed that the capability of GIS to analyse information across space and time make it proper in evaluating land suitability for irrigation methods.

KEYWORDS:Land suitability, thematic maps, sustainable, Drip irrigation, Sprinkler irrigation, Crop Production.

I. INTRODUCTION

India is an agricultural and populous country. About 70 per cent of people depend on agriculture. In order to grow food-crops and agricultural products in large quantities to feed the growing millions, intensive farming and rotation of crops are essential. It is essential to select crops for cultivation according to the soil suitability, so that maximum profit may be achieved while maintaining the ecological sustainability. The crop land use planning involves decisions about land use and the environment. Soil information is a vital component in the planning process, reflecting directly upon land-use suitability [1]. The Land suitability is the process of assessing the suitability or ability of a given type of land, evaluation and grouping of specific areas of land in terms of their suitability for defined agricultural use. It involves evaluation of the factors like climate, terrain, soil etc. Land suitability is a function of crop requirements and soil/land characteristics. Matching the land characteristics with the crop requirements provides suitability. So, "suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use" [2]. In many cases, especially in semi-arid regions, the limited availability of agricultural land is a critical factor. This increased pressure on the available land resources may result in land degradation [3]. Reliable and accurate land evaluation is therefore indispensable to the decision-making processes involved in developing land use policies that will support sustainable rural development. If self-sufficiency in agricultural production is to be achieved in developing and transitional countries, land evaluation techniques will be required to develop models for predicting the land's suitability for different types of agriculture [4].

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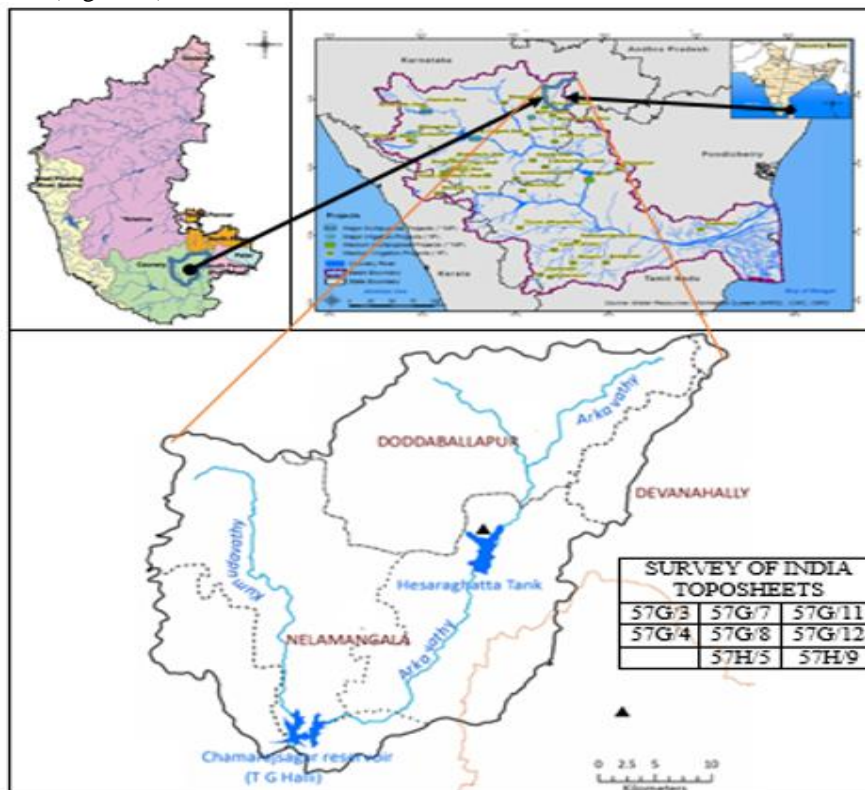
II. LITERATURE SURVEY

Land suitability refers to the ability of a portion of land to tolerate the production of crops in a sustainable way. Its evaluation provides information on the constraints and opportunities for the use of the land and therefore guides decisions on optimal utilizations of resources, whose knowledge is an essential prerequisite for land use planning and development. Moreover, such a kind of analysis allows identifying the main limiting factors for the agricultural production and enables decision makers such as land users, land use planners, and agricultural support services to develop a crop management able to overcome such constraints, increasing the productivity. Land could be categorized into spatially distributed agriculture potential zones based on the soil properties, terrain characteristics and analysing present land use [5]. Production could be met through systematic survey of the soils, evaluating their potentials for a wide range of land use options and formulating land use plans which were economically viable, socially acceptable and environmentally sound [6]. Albaji et al. [7] compared the different irrigation methods based on the parametric evaluation approach in Shoibieh plain, Iran, using a parametric evaluation system. The results demonstrated that by applying sprinkler irrigation instead of surface and drip irrigation methods, the arability of 48 805.43 ha (98.3%) in the Shoibieh Plain will improve.

Hired et al. [8] and Bond [9] developed classification systems for assessing site suitability for effluent irrigation and suitability of land for irrigation water [10]. Both systems include topographic criteria as well as soil attributes that are taken into consideration when assessing the overall land suitability for irrigation.

III. STUDY AREA

The study area lies between the Longitude 77° 3' 58" E to 77° 50' 40" E and Latitude 13° 7' 2" N to 12° 14' 24" N. The study area covers about 1447 km² of Devanahalli, Doddaballapur, Magadi, Nelamangala, Bangalore north and Bangalore South Taluks. (Figure.1.).



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Name of the Taluk	Area covered (Sq. km)	% of area
Devanahalli	64.05	4.43
Doddaballapur	481.20	33.26
Magadi	106.92	7.39
Nelamangala	398.47	27.54
Bangalore north	355.40	24.56
Bangalore South	28.28	1.95
Chikkaballapura	12.67	0.88
Total area	1447	100.00

Figure.1: Location map of Study Area

The present study area lies in the Eastern dry agro-climatic zone which allows the farmers to cultivate not only a variety of crops in a season but also a number of crops like cereals, pulses, oilseeds, cash crops and horticultural crops across different seasons of the year. The cultivable area in the study area is 72.48 percent of the total area of the watershed. Since no other source is available for irrigation, farmers depend on groundwater and rainfall for the agriculture. Although some areas such as Doddaballapur taluk have a large number of minor irrigation tanks. Irrigation is done by tube wells and huge amount of water is being extracted from the ground. Table 1 gives the details of growth in area of major Cereals, Pulses, oilseeds, cash crops and horticultural crops in TGHalli catchment are presented in Tables below. (Source: Directorate of Economics & Statistics, Karnataka 2014-15).

Table1 : Area of irrigated crops in 2014-15 (Area in Hectors)

	CEREALS				PULSES							Total Food grains
	Paddy	Ragi	Maize	Total Cereals Minor Millets	Tur	Horse Gram	Black Gram	Avare	Cowpea	Others	Total Pulses	
Devanahalli	74	278	387	739	77	8	1	206	12	0	304	1043
Doddaballapur	109	398	3142	3649	70	201	0	38	24	0	333	3982
Nelamangala	228	552	84	864	37	42	0	108	28	1	216	1080

	VEGETABLES																total vegetables	
	Potato	Onion	Brinjal	Tomato	Beans	Cabbage	Cauli Flower	Ladies Finger	Radish	Beet Root	Carrot	Bitter Gourd	Ridge Gourd	Bottle Gourd	Pumpkin	Cucumber		Other vegetables
Devanahalli	301	20	81	359	212	90	142	35	27	65	103	28	49	26	8	72	100	1718
Doddaballapur	271	14	37	327	148	59	71	31	7	4	16	5	28	9	0	53	202	1282
Nelamangala	16	2	34	377	382	67	22	42	4	0	1	11	13	0	5	56	267	1299

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FRUITS												
	mango	grapes	banana	jack fruit	papaya	pineapple	pomegranate	total fruits	guava	pear	sapota	Total Fruits
Devanahalli	113	1110	72	1	18	1	4	1319	92	0	234	326
Doddaballapur	128	473	617	2	21	0	4	1245	94	0	200	294
Nelamangala	145	5	345	0	22	0	4	521	59	3	138	200

	OILSEEDS				CASH CROPS							NON-FOOD CROPS
	Coconut	Groundnut	Other oil seeds	Total oil seeds (except coconut)	cotton	tobacco	mulberry	flowers	Nilagiri & others	coffee	others	
Devanahalli	417	13	24	37	0	0	2060	348	413	0	81	2902
Doddaballapur	977	52	26	78	2	17	188	189	406	3	62	867
Nelamangala	799	77	20	97	0	27	17	207	119	6	181	557

Three different maps were collected and utilized, starting from the most useful one, the land use –land cover map of T.G.halli watershed at 1:50,000 scales and the other maps were geology and geomorphology maps from KRSRAC, Bengaluru (Figure 2).

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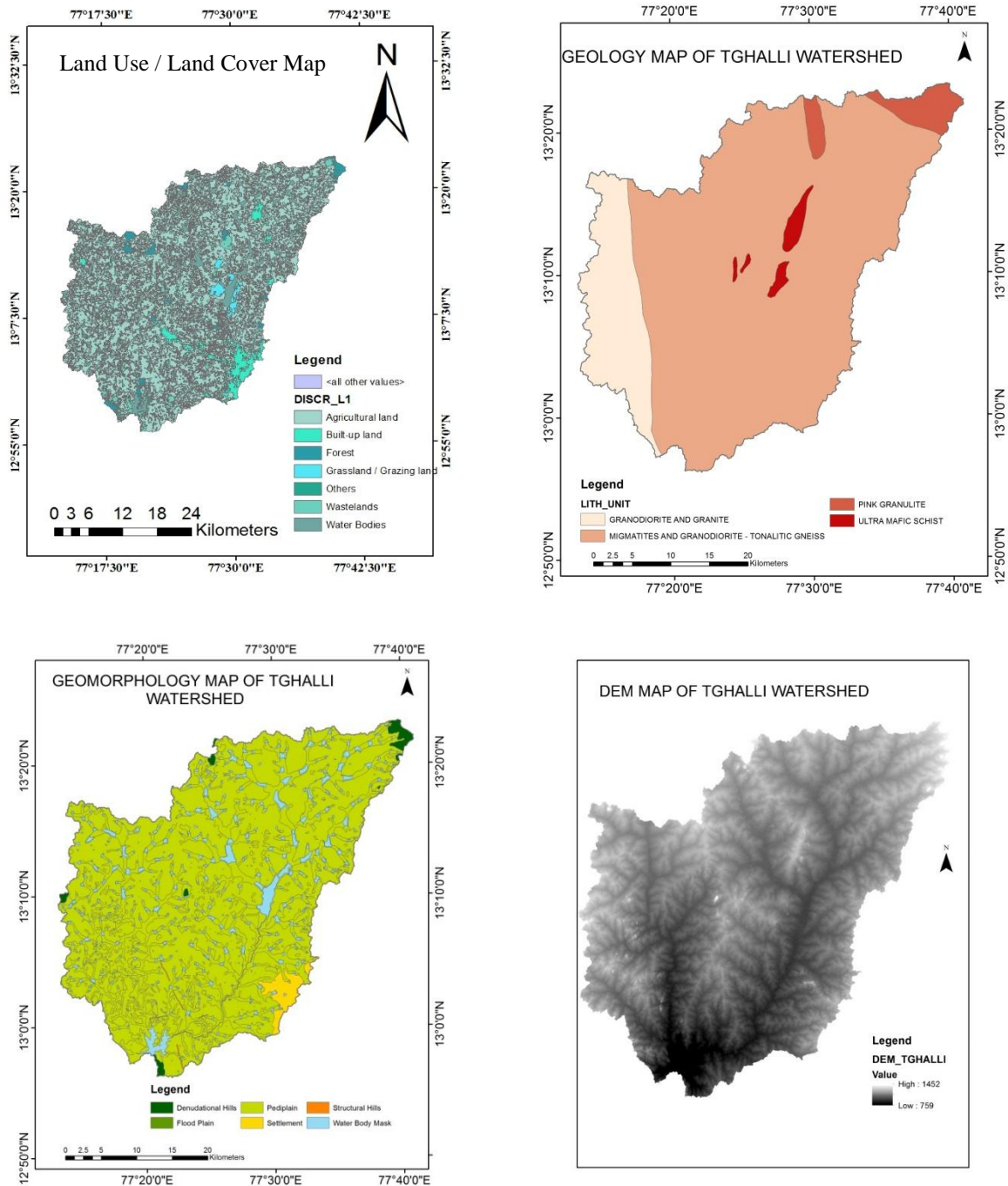


Figure 2: Land Use / Land Cover, Geology, Geomorphology and DEM Maps of Study Area

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IV. METHODOLOGY

In this study the method that was used to evaluate the land suitability for irrigations and crops was based on FAO guideline [2] and parametric evaluation method as explained above. These guidelines are standard and are also accepted by many researches. This guideline has procedures to evaluate the suitability of the land for intended land use. Evaluation of land suitability is the most central part of land evaluation. Generally the procedure answers the following questions:

- ✓ For any specified kind of land use, which areas of land are best suited?
- ✓ For any given area of land, for which kind of use is it best suited?

In simplified form, the procedures used were as follows:

- Description of land-use types
- Selection of land qualities and land characteristics
- Mapping of land units and their characteristics.
- Generation of suitability maps

The obtained suitability classes for different crops and irrigation systems are added into the respective land units in the land unit map which was created using GIS to generate the suitability maps (figure 3).

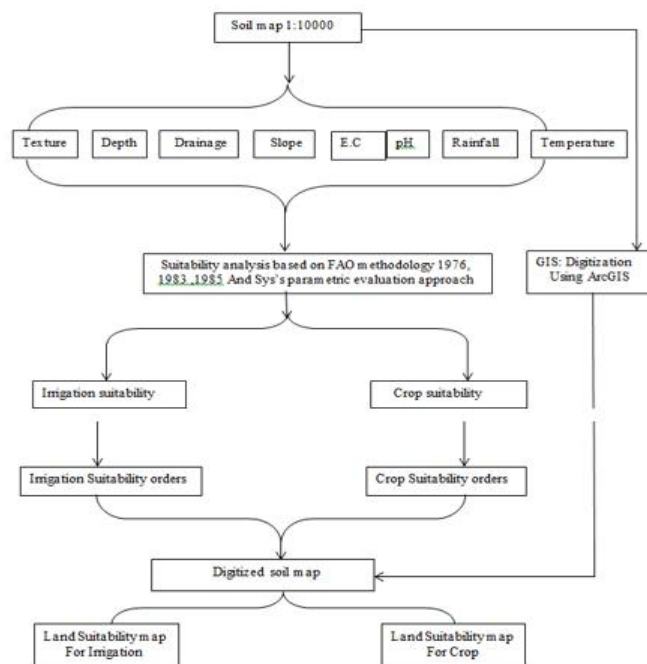


Figure. 3: Methodology used for Land Suitability Analysis

V. EXPERIMENTAL RESULTS

Evaluation of land suitability takes account of all the inventory attributes of land and compares them with the requirements of the crops, to get a suitability map which is easy to understand for crop production. The methodology used for the evaluation is according to the Sys *et al.*[11] Parametric method, based on FAO guidelines for land evaluation for agriculture. It requires matching land characteristics against crop requirements and assigning a suitability rating for each land characteristic. Crop requirements were further adjusted to fit better with the study area. In order to evaluate land suitability, data regarding landform, soil properties and climate condition collected from the field and analysed in the soil laboratory. Landform parameters include depth, slope, Soil parameters include: texture, EC (electrical conductivity), and pH (Figure. 4.). To obtain suitability classes for each crop type in each Land Unit, firstly, the value of the established parameters was calculated for each land unit. Then, according to the crop requirements, a

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rating was assigned to each parameter value and the final score for each land unit was computed using the following mathematical formula:

$$SI = S_i \times \frac{S_d}{100} \times \frac{S_t}{100} \times \frac{S_\theta}{100} \times \frac{S_{dr}}{100} \times \frac{S_s}{100}$$

Where: S_i : suitability index for irrigation; S_d : rating of soil profile/depth; S_t : rating of soil texture; S_θ : Slope rating; S_{dr} : drainage rating; S_s : Salinity rating. The ranges of suitability index and the consistent suitability classes are shown at Table 2

Table 2: Suitability classes for the irrigation suitability index (S_i)

suitability index	Definition	Symbol
>75	Highly suitable	S1
50-74	Moderately suitable	S2
25-50	Marginally suitable	S3
12-24	Currently not suitable	N1
0-12	Permanently not suitable	N2

The overall suitability of soil for different irrigation for different land units are calculated by summation of product of percent area in each suitability class with productive potential of each class (highly suitable 0.75, moderately suitable 0.60, marginally suitable 0.40 currently not suitable 0.25 and permanently not suitable 0).

$$\text{Overall suitability} = \sum (\% \text{ (area in suitability class)} \times (\text{productivity potential}))$$

The land suitability maps for crop production, in the study area, are shown in Figure 4. 29% of the study area is categorized under the class NR (Not Relevant), because this percentage is occupied by villages and water bodies, hill and rock outcrops. According to the obtained result, the suitability of the study area for different crops ranges from highly suitable to permanently not suitable. The suitability class percentage for the different types of crops is different; for example, the study area is relatively high suitable for wheat and less suitable for bean cultivation. Currently not suitable land of each crop occupied most part of the study area.

Finger Millet: Finger millet crops comes up well on soils having soil depth of 100 cm, the areas represented by upland pedons were moderately suitable, because of moderate limitation of soil. The midlands were moderately suitable, because of moderate limitation of soil and climate. The climate and soil requirement of Finger Millet is reported in Table 3. As it may be observed in the suitability map (Figure 4.) from the total coverage of the study area, about 87% is suitable for the growth of this crop and about 11% is not suitable. The soil depth and Rainfall is the main limiting parameter for the optimal growth of Finger millet in the TG Halli micro-watershed. The rest of the other parameters are optimum for the suitability.

VI. CONCLUSION

The results obtained showed that the drip and sprinkler irrigation methods are more suitable than the surface irrigation method (Table 4 & Figure 5). Therefore, the sprinkler and drip irrigation methods are highly recommended for a sustainable use of the soil in the study area. The main limiting factors for the surface, sprinkler and drip irrigation methods were drainage, texture, salinity. The change from surface irrigation to drip irrigation can increase cultivation in the present study area to double the current level without the need to withdraw more water from groundwater source. Soil texture is the main limiting factor in all the three irrigation systems.

Table 3 .Soil-site suitability criteria (crop-soil requirements) for Finger millet.

Soil characteristics	Suitability classes	S1	S2	S3	N
	Ratings	100-85	85-60	60-40	40-0
Temperature	^o C	28-34	(25-27)(35-38)	(39-40)(20-24)	> 40, <20
Rainfall	Mm	750-900	600-750	450-600	< 450
Soil drainage	Class	well, moderately	imperfectly	poorly, excessively	

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Texture	Class	l,sil,sl,cl,sicl,scl	sic,c,sc	ls,s	
pH	Scale	5.5-7.5	7.6-8.5 4.5-5.4	8.6-9.5,4-4.4	< 4
Soil depth	Cm	>75	51-75	25-50	<25
EC	dS/m	<1	1.0-2	2.0-4	>4
Slope	%	0-3	3.0-5	5.0-10	>10

l (Loam), sl (Sandy loam), ls (Loamy sand), Si (Silt), scl (Sandy clay loam), sil (Silty loam), cl (Clay loam), sic (Silty clay), sc (Sandy clay), s (Sand), and c (Clay).

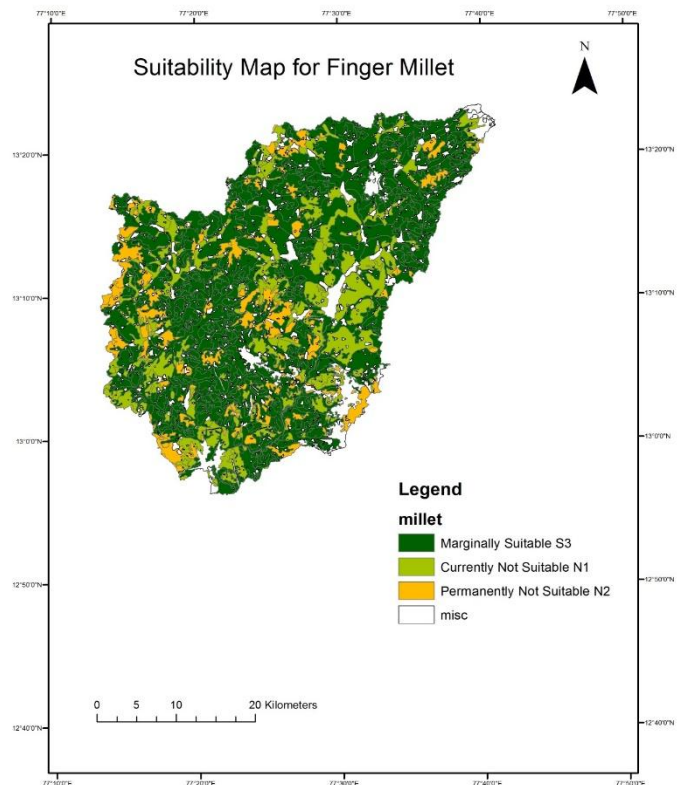
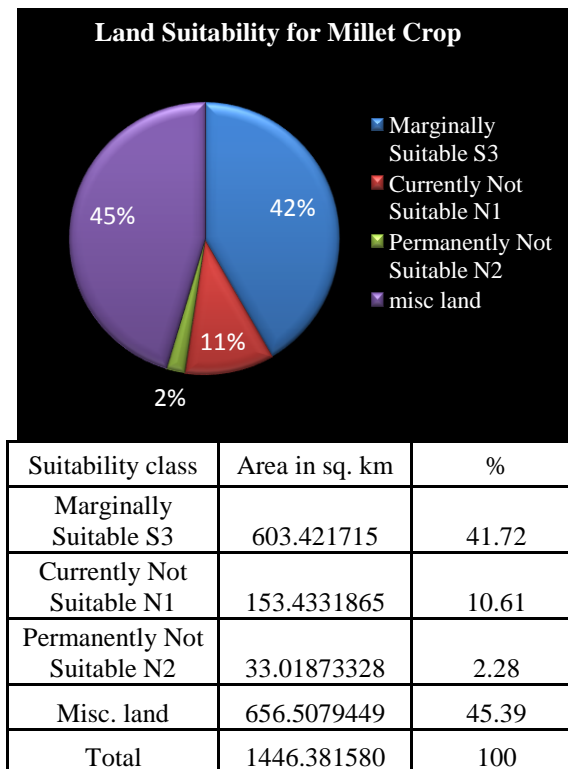


Figure 4.. Land suitability map for Finger millet

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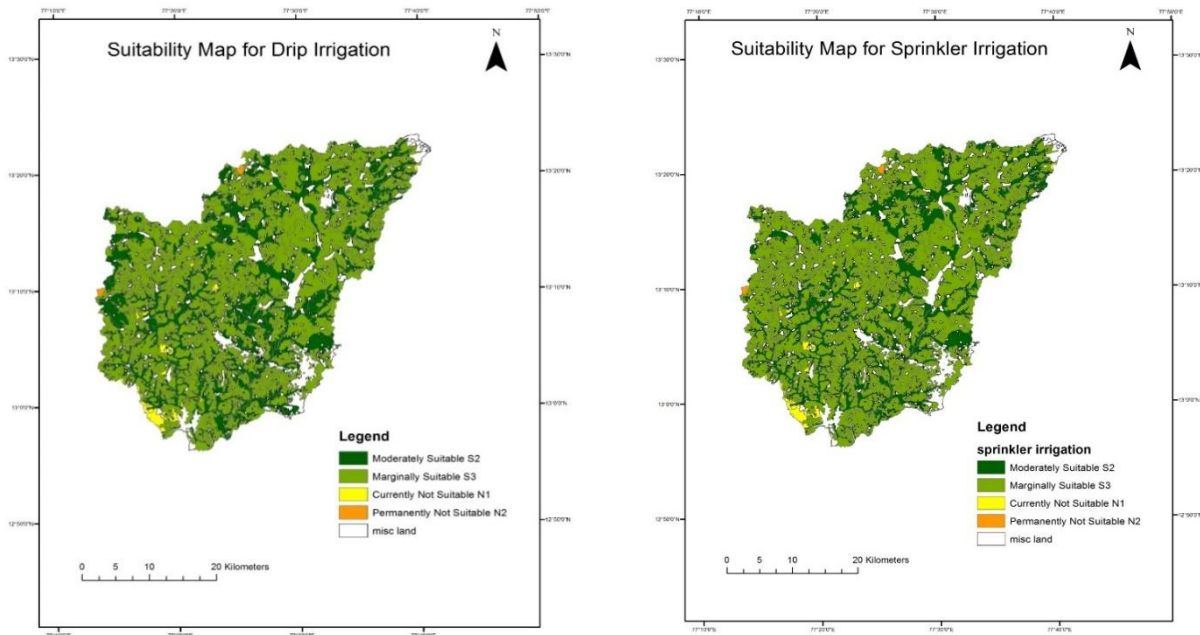


Figure 5: Land suitability map for Drip irrigation & Sprinkler irrigation.

Table 4: Distribution of Surface, Sprinkler and Drip irrigation

Class	Moderately suitable	Marginally suitable	Currently not suitable	Permanently not suitable	Misc. land	Total
Area in Sq.km	126.436558	427.863156	226.7497471	8.824172889	656.50794	1446.3815
%	9.58	32.42	17.18	0.67	49.74	100.00

Drip Irrigation

Class	Moderately suitable	Marginally suitable	Currently not suitable	Permanently not suitable	Misc. land	Total
Area in Sq.km	224.2546076	541.5976731	21.45877031	2.562583774	656.50794	1446.3815
%	15.50	37.45	1.48	0.18	45.39	100

Sprinkler irrigation

Class	Moderately suitable	Marginally suitable	Currently not suitable	Permanently not suitable	Misc. land	Total
Area in Sq.km	185.7564343	580.0958465	21.45877031	2.562583774	656.50794	1446.3815
%	12.84	40.11	1.48	0.18	45.39	100

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