Land Suitability Evaluation for Paddy Cultivation Using GIS for Sweta Nadi Basin, Tamil Nadu, India

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Abstract: *Agricultural land suitability for paddy is carried out in the Sweta Nadi Basin (15 Sub-Watersheds). There are many factors determine the land suitability for paddy cultivation such as geomorphology, soil, slope, land use/land cover, rainfall, land capability, land Irrigability, soil erosion, soil texture and soil drainability. The land evaluation criteria were adopted form soil suitability manual of National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), India and literature survey. The qualitative approach given by FAO (1976) has also been used to classify the land on the basis of their suitability ranked classes e.g. highly suitable (S1), moderately suitable (S2), marginally suitable (S3), currently not suitable (N1) and permanently not unsuitable (N2). The weighting of each parameter was conducted using systematic process and an integrated methodology for analysing and mapping of land suitability using Arc GIS software. The agriculture land suitability evaluation results based on 36 soil series of sweta nadi basin and present study identify that in the study area 26.4 % of total area under highly suitable and 23.6 % area comes under moderately suitable areas. The research provided information at local level that could be used by farmers to select a crop for suitable land conditions.*

Keywords: *Agriculture land, Paddy, Soil factor, Topographic factor, Land Suitability Classes(S1, S2, S3, N1, N2), Overlay Analysis and Sweta Nadi Basin, Tamil Nadu, India.*

1. INTRODUCTION

land suitability assessment is define as the process of assessment of land performance when used for alternative kinds of agriculture. Bandyopadhyay in 2009 studied on the land suitability refers to capability of a part of land to abide the production of crops in a sustainable way. Its assessment provides information on the constraints and opportunities for the use of the land , land use planning and development. Additionally, identifying the main limiting factors, optimal utilization of resources and develop a crop management. Land could be categorized into spatially distributed agriculture potential zones based on the soil factors, topographic factors and analyzing present land use [1]. Ravindra and Laxmi in 2011 evaluated the Potential of the system of rice intensification for systemic improvement in rice production and water use in Andhra Pradesh [2]. Mustafa in 2011 attempted suitability is a function of crop requirements and land characteristics [3]. Coleman and Galbraith in 2000 made a study development of a GIS-based thematic database on soils is vital in crop-suitability analysis for optimal utilization of available resources [4]. Perveen in 2007 evaluated and each weighted according to their relative importance on the optimal growth conditions for crops [5]. Land suitability evaluation for some of these crops in the north of Iran coastal plains has been done by Mahmoud Soltani [6], Torabi [7], Khaksarian [8] and Akef [9] and in other parts of the world by Kuria et al. [10] and Ismail [11]. Sys in 1993 studied on the specified crops requirements suggested for crops, were used for rice, wheat, barley, triticale, lettuce, carrot, beans, kidney beans, clover, rape seed, spinach, shallot cress, garlic and radish. Eleven soil series and 24 soil units were derived from the semi-detailed soil study of the central Guilan [12].

2. STUDY AREA

The Sweta River basin lies in the districts of Namakkal, Salem, Tiruchirappalli and Perambalur of Tamil Nadu State. River originates from the northern parts of Kolli hills in Namakkal District. It is located between 11^0 15' N and 11^0

45' N latitudes and 78^0 15' E and 78^0 58' E longitudes (as read from the survey of Indian Topographic sheets C44A6 (58 I/6), C44A7 (58 I/7), C44A10(58 I/10), C44A11(58 I/11) and C44A15(58 I/15). The river originates from the northern parts of Kolli hills, a part of Manmalai, adjoining Kolli hills and Palakkadu Malai in Pachamalai. The total geographical area of the basin is 1,034.43 Sq.km (1,03,443 ha) within 82 Revenue villages. The study area is based upon the three major relief orders such as the hills, uplands, and the plains. The river runs over 116 kms from the west to the east, and joins Vellar River, which runs into the Bay of Bengal (Fig.1).
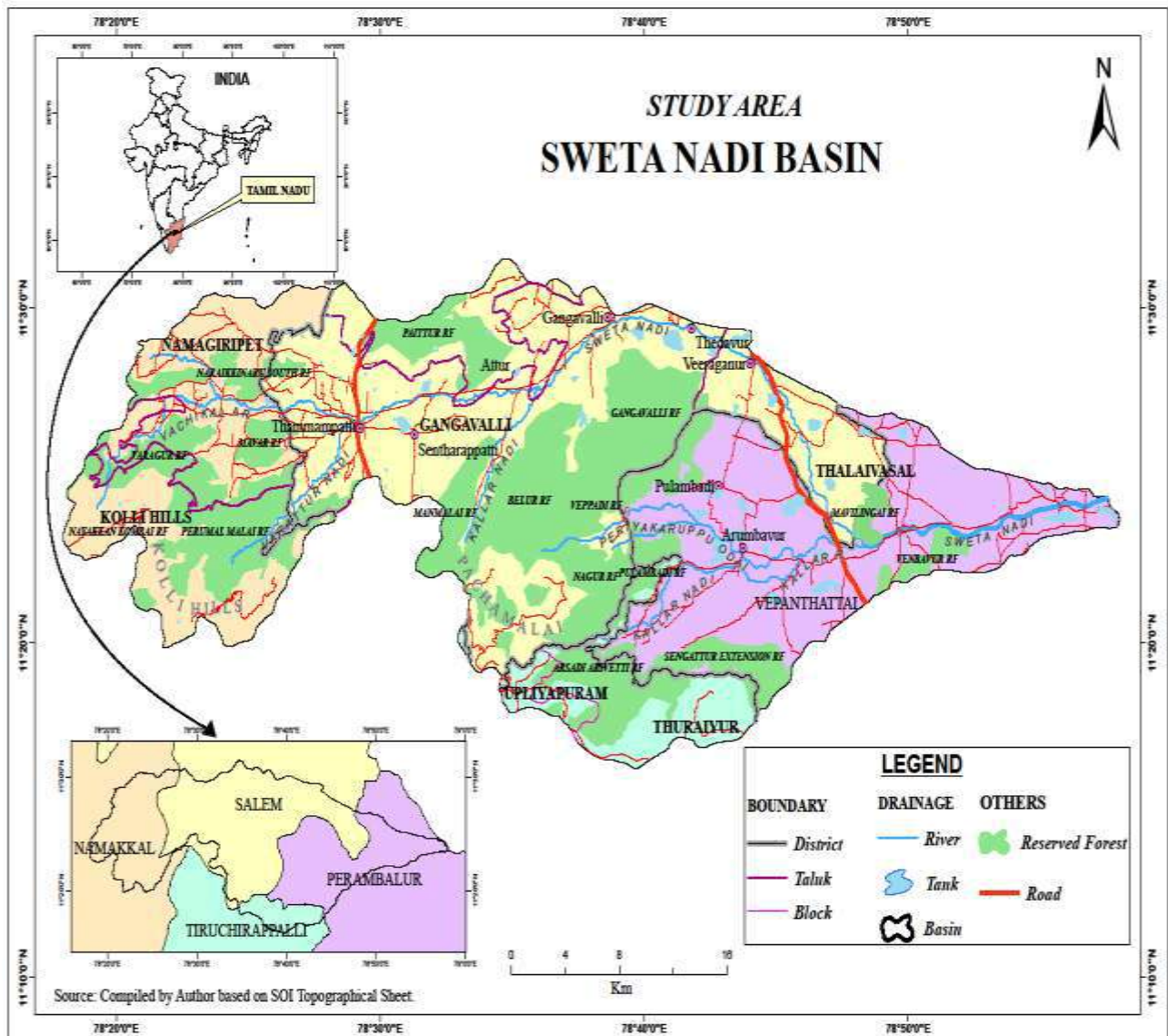

Fig -1: *Study Area-Sweta Nadi Basin*

3. MATERIALS AND METHODS

In this present study, different types of data have been used for land suitability analysis for paddy cultivation. The sub – watershed boundaries were demarcated on the basis of contour value, slope, relief, elevation and outlet point, further divided in to 15 sub-watersheds. The Survey of India Toposheets, Land use, land cover of the study area was mapped based NRSA classification, Resourcesat-2 LISSIII Image (bhuvan.nrsc.gov.in) Hyderabad, has been analysed to get land use and land cover map 2012. Slope map Compiled based on Advanced Specborne Thermal Emission and Reflection Radiometer data (ASTER), geomorphology map created based on Survey of India Toposheets and Landsat ETM False Color Composite Image, The monthly rainfall data for 30 years (1980 – 2010) have been collected for 16 stations from Data of Directorate of Economics and Statistics, Chennai, Soil data(land capability,

land Irrigability, soil erosion, soil texture and soil drainability), (Department of Remote Sensing & GIS, Tamil Nadu Agricultural University (TNAU), Coimbatore and soil suitability manual of National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), India and literature survey. Finally all data values are ranked and compiled by author then using weighted overlay analysis through the GIS Software (Arc GIS 10.1) after that results displayed land suitability classes for paddy, Table and maps (Table.1&2, Fig.2,3 and 4).
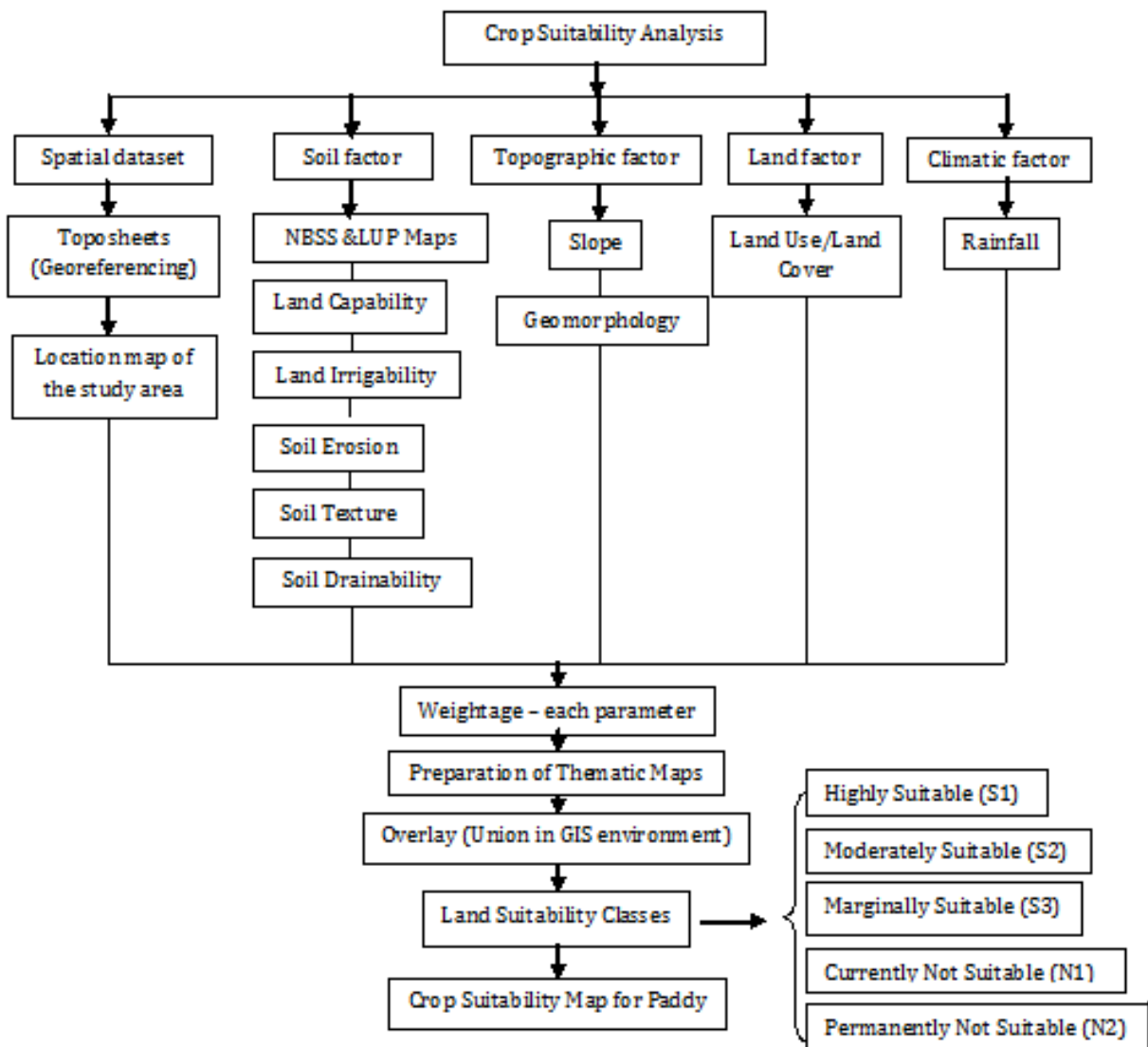

Fig -2: *Flow chart showing the methodology*

Table 1: *Parameters and weightage Land characteristics for Paddy in Sweta Nadi Basin*

| Paddy	Land Suitability Classes	N2	N1	S3	S2	S1
	weightage	1	2	3	4	5
Land Characteristics	Geomorphology	Dome type Residual Hills,Structural Hills	Dome type Denudational Hills (Large), Linear Ridge, Moderately weathered Pediplain	Hilltop Weatered, Pediment - Valley Floor, Piedmont Slope, Valley Fill	Inselberg, Shallow weathered Pediplain	Shallow Buried Pediment, Shallow Flood Plain
	Soil	Alagapuri, Ammapalayam, Chattirapatti, Ilaiyamuttur, Kadiripuram, Kanakanur, Kommalapatti, Madattupatti, Palladam, Periyamalai, Tulukkanur, Vadamalapuram, Vanavasi, Velimadurai, Virapandi	Chittodu, Kirakad, Upparapatti	Kombuthuki, Nagalur, Periyanaickenpalaiyam	Ammapettai, Kottayam	Bhavanisagar, Chinnamettur, Kadiyampatti,Kollihills, Kombaikkadu, Kunnattur, Kuruvakkadu, Maramangalam, Ooty, Salem, Settuppalapatti, Thoppur, Tolurpatti
	Slope	Very Steep	Moderately Steep to Steep	Strongly sloping	Moderately Sloping	Nearly Level, Gently Sloping,Very Gently Sloping
	Land use/Land Cover	Gullied/Ravinous Land, Sandy Area, Waste land with Scrub, Waterbody	EvergreenForest, Rural, Urban	Scrub Forest	Decidous Forest	Agriculture Plantation, Crop Land, Fallow/Agriculture
	Rainfall	<700	700-800	800-900	900-1000	>1000
	Land Capability	VI es, VII e(Not Suitable for Cultivation(drainage), erosion soil)	V s(Not Suitable for Cultivation (Pasture & Grazing), Soil)	IV es(Fairly good cultivable land, erosion soil)	IV s, IV ws(Fairly good cultivable land, wetness soil)	III e, III s, III w(Moderately good cultivable land, erosion,soil, wetness)
	Land Irrigability	Sever Limitation, Very Sever Limitation, Not Suitable for sustaines use, Not Suitable	-	-	-	Moderate Limitation, Moderate Limitation with soil problem
	Soil Erosion	Severe erosion	-	-	Moderate erosion	None to Slight erosion
	Soil Texture	-	-	Loamysand, Sandyloam	Loam, Sandyclayloam	Clay, Clayloam, Sandyclay, Siltyclay
	Soil Drainability	Excessively drained	Poor drained	Somewhat Excessively drained, Well Drained	Moderately well drained	Imperfectly drained

Source: *Compiled by Author*
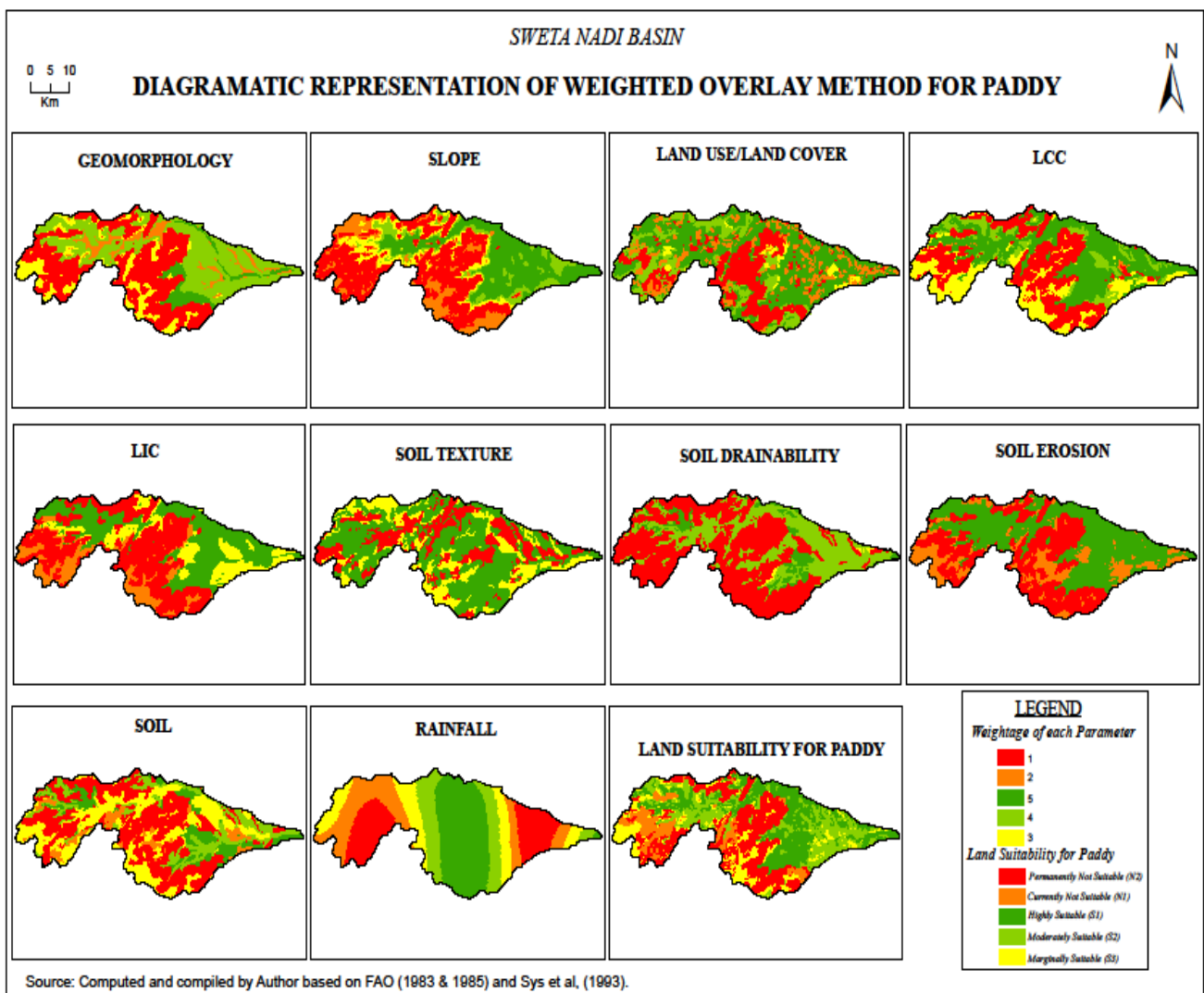
Fig -3: *Diagramatic representation of weighted overlay method for Paddy*

4. RESULTS AND DISCUSSION

4.1. LAND SUITABILITY FOR PADDY

Paddy is the most important food crop. It provides major calories and important staple food in our country. In the study area, paddy is cultivated in monsoon seasons. Above 1000 mm of rainfall is well suited for this type of crop cultivation, plain lands with clay, clay loam, sandy clay, sandy silty clay soils in very gentle slope of flood plains and pediplain complex areas with imperfectly and poor drainability. None to slight erosion is applicable with pH between 5.5 and 6.5, gravel surface should be less than 3 cm and sub surface less than 15 cm and $CaCo_3$ content of 0 – 5 percent. Cation Exchange Capacity (CEC) should be greater than 20 are preferable for cultivation. Strictly speaking, these physical conditions ensure that paddy be grown with maximum yield under the suitability class of S1. Marginal to larger farmers are cultivating paddy more than their subsistence level and small farmers are growing paddy only for their daily food. As it is not a commercial option and fetching good income, the farmers are reluctant to grow more than their survival levels. Farmers of the basin grow paddy necessarily as a food crop, either for subsistence or for sale in excess. However, farmers own such lands where nothing but paddy can be grown during the seasons. As such some of them may be left with a field, which they sell and such sales do not bring big money to the cultivator. Farmers of Sweta nadi basin are expert paddy cultivators as they have been cultivating this crop for a very long time. After the development of technology since green revolution, farmers are widely utilising modern machineries and modern techniques of cultivation and the farmers themselves.

Table 2: *Sub-Watersheds wise Land Suitability classes for Paddy based on Land Characteristics in Sweta Nadi Basin*

Sl. No	Name of the sub watersheds	Total area in ha.	N1	N2	S1	S2	S3	each sub-watersheds area in ha./S1*100
1	Ettikkadu	5677.6	141.0	1114.8	1148.7	2557.9	712.3	20.2
2	Kadampur	3652.7	7.4	1068.3	1021.4	842.5	709.0	28.0
3	Kondayampalli	5463.0	225.0	917.8	773.4	3129.1	417.0	14.2
4	Krishnapuram	5205.9	155.2	2831.5	687.4	537.3	994.4	13.2
5	Lakshnanapuram	8528.5	7.9	2595.9	1733.9	196.9	3990.4	20.3
6	Mullukuruchi	8744.9	1324.6	847.5	1078.5	1825.9	3659.7	12.3
7	Naripadi	3347.7	1150.2	1102.5	327.1	551.9	205.9	9.8
8	Palakkadu	8464.9	0.1	3436.3	3331.4	609.3	1087.8	39.4
9	Periyammapalayam	3456.8	13.3	668.4	2014.3	569.7	191.1	58.3
10	Solakkadu	11292.2	2474.6	4803.0	316.9	1185.5	2508.0	2.8
11	Tembadi	7110.4	124.0	2545.7	2363.6	518.7	1557.3	33.2
12	Tondamandurai	5752.2	374.7	922.0	829.8	2428.8	1196.6	14.4
13	Udumbiyam	10429.6	68.1	1681.4	5887.9	2054.6	735.3	56.5
14	Ulipuram pudur	5644.0	491.9	770.4	1317.2	2447.6	613.3	23.3
15	Vembavur	10672.9	0.0	12.9	4480.4	4920.0	1255.1	42.0
	Area of the Basin in Ha.	103443.4	6558.1	25318.3	27312.0	24375.6	19833.2	26.4
	Total Area in Percentage		6.3	24.5	26.4	23.6	19.2	

Source: *Compiled by Author*

4.1.1 Highly suitable land for Paddy (S1)

The lands under Shallow Buried Pediment and Shallow Flood Plain regions along the river courses, stretching from west to east and south to northeastern of the basin supported by the fertile soil with clay, sandy clay loam and sandysilt caly texture which are suited for paddy cultivation. The fertile soils presented in these areas are the Periyanaickenpalaiyam, Salem, Thoppur and Tolurpatti soil series highly suitable for cultivation in this basin. Hence, occupies an area of 26.4 % (27312.0 ha) of the total area of the basin. It includes the villages of Gangavalli, Anayampatti, Thedavur, Veeraganur, Udumbiyam, pulambadi, Arumbavur, Malayalappatti and Thaluthalai. Udumbiyam (5887.9 ha), Vembavur (4480.4 ha), Palakkadu (3331.4 ha), Tembadi (2363.6 ha) and Periyammapalayam (2014.3 ha) sub watersheds are highly concentrated with paddy cultivation and compared with other watersheds.

4.1.2 Moderately suitable land for Paddy (S2)

The lands under a pediplain complex system in the basin, well irrigated lands under flood plain regions along river courses located in the vicinity of hills and good ground water potential are the major positive factors for growing paddy. The soil series presented in these areas are the Ammapettai, Bhavanisagar, Kottayam, Kuruvakkadu and Upparapatti are falling in this class, soil series from the same family but slightly different in their characteristics. Loan, silty clay loam texture is the available requirement for paddy whereas these areas have the combination of sandy clay loam soil with low water holding capacity and moderately well drained surface coarse texture. Additionally, rainfall and water availability is also less. Hence, these limitations brought these areas under S2 class. Therefore, care is to be taken in the selection of salt tolerant varieties. Organic mannur like daincha, sespania and calotropis may be added as green manure during the preparation of land for paddy cultivation. This land under paddy covers an area of 24375.6 ha or 23.6 percentage of the total area of the basin.
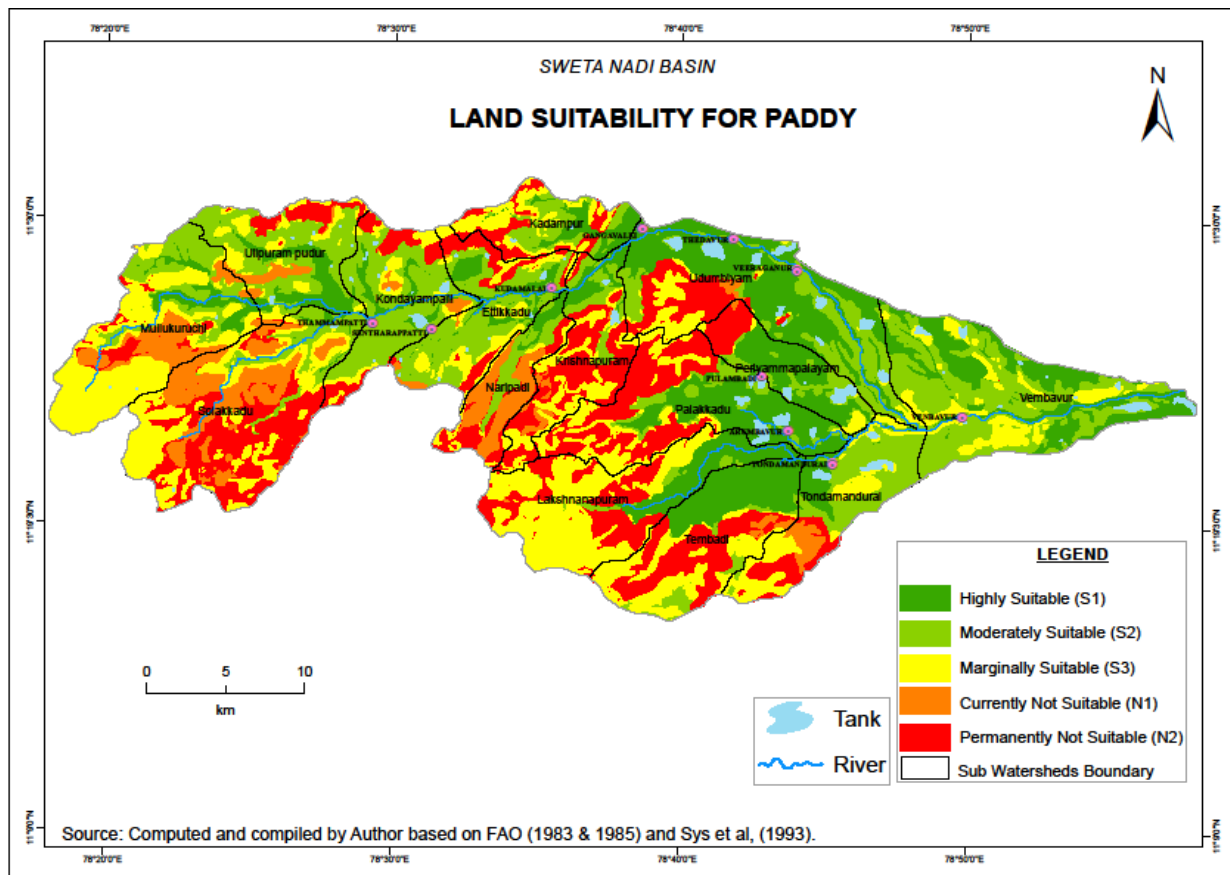
Fig -4: *Land Suitability Map for Paddy in Sweta Nadi Basin*

4.1.3 Marginally suitable land for Paddy (S3)

This land system like shallow weathered pediplain and pediments valley fills are found to have land marginally suitable where the soil series are the Alagapuri, Chinnamettur, Kadiyampatti, Kombaikkadu, Maramangalam, Nagalur, Ooty, Settuppalapatti and Vadamalapuram. More topographical and soil constrains restrict the paddy cultivation in these areas. Further, the lands are under rain shadow region, where the rainfall is less than 800 mm. they are depending on the monsoon rains and hence, dry farming is carried out. The runoff is high and hence, poor ground water potential is found. Moderately well drainability is occurring because sandy clay loam and sandyloam soil texture are not holding the water properly, so poor soil condition aggravate the land to imperfect for cultivation. Further, all the these are located along the main path of the river. Though water is available, the alkalinity increases from the middle part of the basin and reaches the lower part. It is evident that the osil series from the upper basin to the tail end are arranged and the ph value is assessed, which increases towards the middle and the upper parts. Further, the land is plain and has high alkaline levels. These are the major reasons that have kept these areas under class S3. The above description has made clear the distribution of lands marginally suitable for paddy in such a way that it is too widely scattered, but mainly in the middle and the tail end along major tributaries and rivers. This class covers an area about 19833.2 ha or 19.2 percent of the total area of the basin.

5. CONCLUSIONS

GIS is effectively used in this attempt to compute and generate maps. The overall observation shows the results highly suitable land for *paddy* (S1) 26.4 % (27312.0 ha) occupies plain region. Moderately suitable for paddy (S2) accounts for 23.6 %(24375.6 ha) and area under marginally suitable land for paddy (S3) is 19.2 % (19833.2 ha). Highly suitable(S1) area found in following sub-waterheds Periyammapalayam(58.3%), Udumbiyam(56.5), Vembavur(42.0) and Palakkadu(39.4). These results would be useful to the local farmers for increasing their economic production by selecting highly and moderately suitable land areas for cultivation of paddy.

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