AGROCLIMATIC CHARACTERIZATION FOR RAINFED CROPPING IN ARANTHANGI BLOCK, PUDUKKOTTAI DISTRICT, INDIA

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Abstract: **Potential of climate as an agricultural resource has not been used or ever realized. In this context, knowledge on agroclimatology of a region is a valuable tool and it involves evaluation of the factors like climate, terrain, soil etc. Land suitability is a function of crop requirements and soil characteristics. In the present study aims to characterise the agroclimatic elements to identify the potential areas for groundnut, gingelly and niger for Aranthangi block of Pudukkottai district, Tamil Nadu with the aid of Arc GIS 9.1 and Cropwat 8.0 software. Potential area has been identified as 'high', 'moderate', 'marginal' and 'not advisable' using GIS tool based on the crop specific threshold limits of the temperature, rainfall, texture, pH, OC and EC. Of which soil texture and its moisture holding capacity are the vital factor determines potential variation of the land. Accordingly, 1.6 % of the area is estimated with higher potential as for as gingelly and groundnut concerned. Another 14, 9 and 1 % of area have comes under moderate potential for gingelly, niger and groundnut respectively. Over 50 % of area the block has been identified with marginally potential for the entire three crops concerned. The potential is variable over the 20 % land, varied between moderate to marginal as for as the all the three crops concerned.**

Index Terms: **Agroclimate, Crop water requirement, soil characterization, crop specific threshold, Climatic Potential, Cropwat 8.0 and Arc GIS.**

I. INTRODUCTION

An integrated approach to planning and management of land resources is a key factor in a solution which warrants that landuse is allocated with providing the sustainability. Over the last two decades, FAO has developed and successfully applied the agro-ecological zones methodology to analyse solutions for sustainable agricultural development at regional, national and sub-national levels. Currently, diverse agroclimatic zoning approaches has allowed the implementation of public policy for agricultural development. Those mainly include the assessment of agroclimatic risk through agroclimatic indices. In general, most agroclimatic zoning methodologies, which consider the soil within their analysis, include information from water-storage capacity parameters or from physiochemical aspects, but not an integration of both as well not in the village level. For planning and effective utilization of soil resources, the information relating to the soil-site characteristics for cultivation of crops is necessary. The objective of the present study is to characterise the agroclimatic elements in on order to identify the potential areas for groundnut, gingelly and niger, which are the dominant oil seeds followed over the Aranthangi block of Pudukkottai district, Tamil Nadu, relies directly on the rainfed cultivation and through by system tanks. Due to the aforementioned, the present study warrants the crop-specific potential areas terms of physical-chemical and water balance at the block level.

II. STUDY AREA

Aranthangi developmental block have been selected for the present study is one out of 13 blocks of the Pudukkottai district, Tamil Nadu. It lies between 10° N and 10.70°N latitude and 8.33°E to 8.38°E longitude. As per the village papers, total geographical area of the block is 413 km^2. Administratively the block is divided in to 6 Firkas, namely Aranthangi , Silattur , Nagudi , Poovatakudi , Athani and Arasarkulam. It Comprises 52 Panchayat villages, 94 Revenue Villages. The block is bounded by Thiruvarankulam block in North , Manamelkudi block in south, Peravurani block in east and Arimalam block in west **(Fig.1)**. The Population of the block is 1,87,390 of which 88 % are rural and the rest are urban. The density of population is 291 persons per sq. km. About 56 % of the people are engaged in agricultural activities. The dominant soil type is red loam. The temperature ranges between 20.4^o C in January and 38^o C in May. The mean annual rainfall is 890 mm. The non-perennial rivers such as Vellar, Agniyar, Koraiyar and Ambuliar drain the district. The area of 40 - 186 m forms the hilly namely, Viralimalai that covers 5 sq.km and the rest are plains bisected by Vellar river. In general, the slope decreases from NW to SE. The soils are red fertile, river alluvium and saline coastal alluvium that account for 58.2, 32.4 and 9.4 percents respectively. Paddy, maize, groundnut, chilly, vegetables and coconut are the major crops.

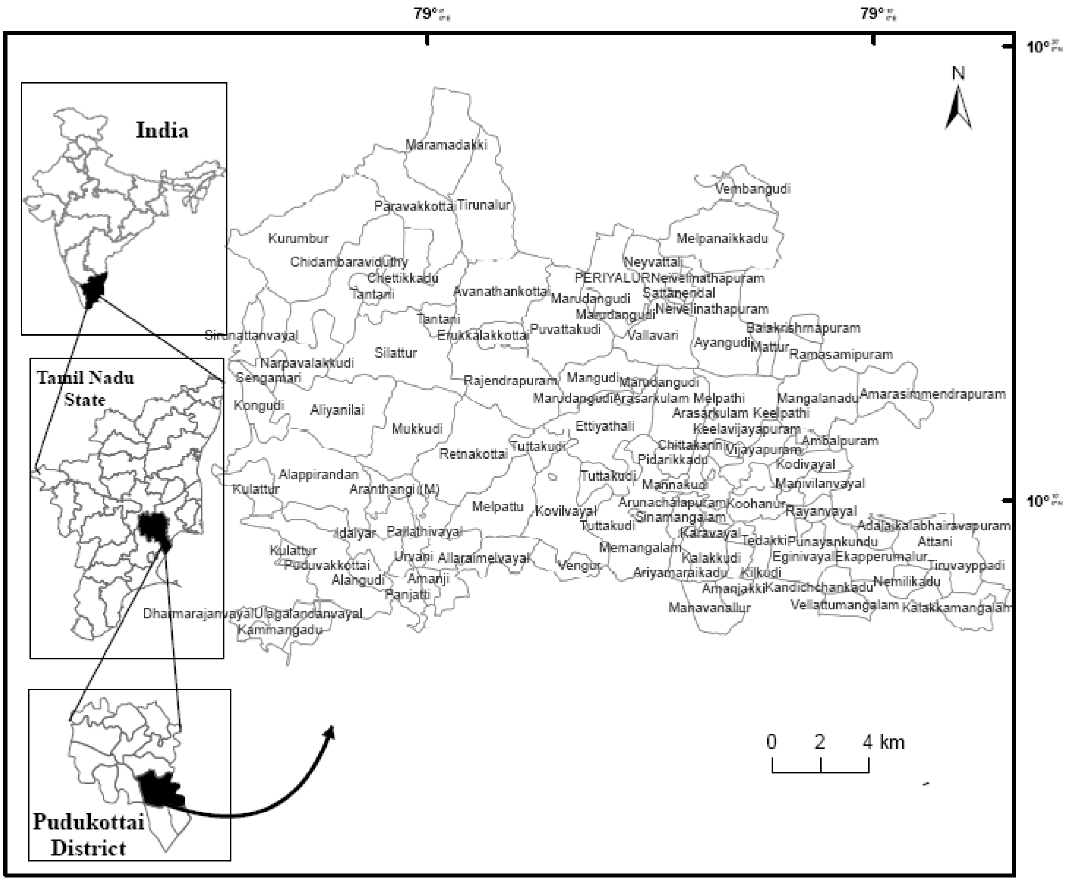

Figure 1 Study Area: Aranthangi Block

III. METHODOLOGY

The base map of the study area has been prepared using Survey of India topographic sheets on 1: 50,000 scale. Primary and secondary base line data have been collected from the published and unpublished reports / data of different departments and analysed in order to understand the existing physical, economic and social condition of the study area. The rainfall data of more than 67 consecutive years (1951-2017) for Aranthangi rainguage station were considered to analyze the long term mean monthly, seasonal, annual rainfall and growing period computation. Data on rainfall were collected from the Directorate of Economics and statistics, Tamil Nadu. Cropwat 8, modeling software which was developed by the Land and Water Development Division of Food Agricultural Organization (FAO) have used for the computation of agroclimatic parameters such as potential evapotranspiration, actual evapotranspiration and crop water parameters. Data on soil types and their characteristics were collected from Department of Soil Science, TNAU, Coimbatore, and Tamil Nadu. Condition of existing cropping pattern has been revealed with reference to the G- return data collected from the district statistical office, Pudukkottai. Integration and spatial analysis of the data have been carried with aid of GIS modules available with Arc GIS 9.1.

IV. RESULT AND DISCUSSION

To identify management options to upgrade rainfed agriculture, it is essential to assess different types of water stress in rainfed farming. Hence, in the present study, agroclimatic factors such as temperature, rainfall, potential evapotranspiration and growing periods have been taken into consideration. **Table 1** summarizes climatic normal (1951-2017) of Aranthangi block. The mean maximum temperature have observed during the month of May (34.7ºC) and it gradually decreases with commencing of southwest monsoon. The lowest maximum temperature (29ºC) has been observed over the month of December. The range of temperature over the summer monsoon months is greater rather than winter monsoon, varies between 6ºC and 8.7ºC during December and March respectively. Optimum mean daily temperature to grow groundnut is 30°C and growth ceases at 15°C. A minimum of 100 day optimum temperature growing season is necessary for successful groundnut crop production. Most of the sesame varieties, the optimum temperature ranges from 25º C to 27º C. Temperature range between 20 and 30 ºC, favor the seed germination and seedlings growth of Niger.

Table 1 Climatic Normal of Aranthagi Block

Climatic Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Tem. (ºC)	29.8	31.2	32.9	34.2	34.7	34.0	33.2	32.9	32.7	31.4	30.0	29.0
Mean Min Tem. (ºC)	22.2	22.9	24.2	26.3	26.5	26.1	25.4	25.1	25.0	24.3	23.4	22.6
Normal rainfall (mm)	25	16	15	32	41	45	71	94	97	174	163	106
PET(mm)	29.9	34.3	36.7	36.7	35.4	33.4	30.1	30.0	29.7	26.2	25.1	26.7

As for as rainfall concerned, groundnut ***(***Arachis Hypogaea) has been well grown in areas receiving 600 to 1500 mm of rainfall. Sesame (*Sesamum indicum* L.) usually grows in areas with average rainfall less than 600 mm per year. As for as niger (Guizotia abyssinica) oil seed considered, rainfall of 1000–1300 mm is optimum and 500 mm of rainfall may be sufficient depending on distribution and cultivar. For the sake of dividing rainfall zone of the block , annual rainfall of the 7 stations , located in and around of the block, comes within the radius of 28 km, have been taken into account. Accordingly, there is a 140 sq.km area comes under higher rainfall zone (> 900 mm) covering southwestern part of the block and the low rainfall zone (< 800 mm) covering northeastern part of the block have been estimated an area of 108 sq.km. The rest of the middle zone extended northwest to southeastern direction have been comes under normal rainfall zone (800-900 mm) having an area of above 196 sq.km.

Potential Evapotranpiration (PE) and Precipitation (P) and Actual Evapotranspiration (AE) are the important factors, because with help of these parameters the other water balance components may be obtained shown in **Table 2.** For agricultural production, ***effective rainfall*** refers to that portion of rainfall that can effectively be used by plants. In general, the efficiency of rainfall will decrease with increasing rainfall. For most rainfall values below 100 mm/month, the efficiency will be approximately 80 %. The annual mean effective rainfall is only 700 mm and the annual PE is 374 mm. Against the PE, the annual AE is 304 mm and 70 mm is deficit. It is essential to note that this is a annual condition, whereas in the case of monthly PE and AE, it is exhibits unimodal i.e one dry period that separates wet period in a year. It is further clearly exhibited by the occurrence of water surplus during the months between June and December and water deficit during January and May. As agricultural point of view, the ratio (in %) between AE and PE will be helpful to estimate available soil moisture to the plant growth during non-rainy period. In general there is a linear relationship between available soil moisture and the ratio of AE and PE. Accordingly, January to May, there is a considerable soil moisture deficiency would occur and required supplementary irrigation to prevent the crops from low productivity.

Table 2. Monthly Water Balance Parameters – Aranthangi Block

Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Normal rainfall (mm)	25	16	15	32	41	45	71	94	97	174	163	106	**879**
Effective Rainfall (mm)	20	13	12	26	33	36	57	75	78	139	130	85	**703**
PET(mm)	30	34	37	37	35	33	30	30	30	26	25	27	**374**
R/PE	0.2	0.1	0.1	0.2	0.2	0.3	0.6	0.7	0.8	1.6	1.5	0.9	**7**
AE	20	13	12	26	33	33	30	30	30	26	25	27	**304**
WS	0	0	0	0	0	3	27	45	48	113	105	58	**399**
WD	9.9	21.5	24.7	11.1	2.6	0	0	0	0	0	0	0	**70**
AE/PE(%)	67	37	33	70	93	100	100	100	100	100	100	100	**81**

Potential area is a function of crop requirement and land/soil characteristics. It is a prerequisite for sustainable agricultural practices mainly over rainfed area. Groundnut is grown between 40°N and S latitudes. Growing period is 90 to 115 days for the sequential, branched varieties and 120 to 140 days for the alternately branched varieties. The mean daily temperature for optimum growth is 22 to 28°C and reduction in yield occurs above 33°C and below 18°C. For good yields, a rainfed crop requires about 500 to 700 mm of reliable rainfall over the total growing period. The crop is best adapted to. Well-drained, loose, friable medium textured soils. Heavy textures cause problems in lifting the crop at harvest. Also, the top soil should be loose to allow the pegs (on which the fruits are formed) to enter the soil easily. Gingelly, called Sesame is a tropical crop it requires hot climate during its growing period.

The ideal temperature for best production is 25 to 30 degree Celsius. The cultivation of sesame seeds requires soil with neutral reaction or a slightly acidic type. For better growth of the crop, the soil needs to be well-drained and lightly loamy. The pH level of 5.5 to 8.0 is best suited for the growth of sesame seeds. The crop cannot be grown in sandy or saline soils. Niger, which is cultivated as an oil seed crop, sustains in the temperature ranging from warm temperate dry to moist through tropical very dry to moist forest life zones, niger is reported to tolerate annual precipitation of 600 to 1000, annual temperature of 13.6 to 27.5°C and pH of 5.5 to 7.5 . It is adapted to a wide range of soils, from sandy to heavy, growth being poor on light sandy or gravelly soils. As for the rainfall and temperature considered which determines the crop potential in addition to soil factors. Notably, the productivity of the potential area will differ with reference to the inter annual fluctuation of the rainfall over the block. **Table 3** shows the water requirement of the selected crops in the various stages. Crop water requirement computation gives the guide lines for the choice of the particular crop and also gives the idea of the supplementary irrigation requirement in order to avoid the crop failure.

Table 3. Growing Days and water Requirement

S.No	Crop	Stage Days				Total	Total Water Requirement (mm) (5cm depth / irrigation)
		Initial	development	Mid-season	Late-season		
1	Groundnut	25	35	45	25	130	500-700
2	Gingelly	25	20	25	20	90	350-400
3	Niger	20	25	25	20	90	< 500

Table 4 shows the percentage of areal distribution of different land capability classes by each textural class of of the study area. In view of that, sandy clay is the dominant textural group found over 24 % of area, flowed by clay, sandy loam, sandy clay loam occupies the area of 21.6, 21 and 16.5 % respectively.

Table 4. Soil Properties for crops Growth

Texture	*Area (in %)*	*Soil Depth (cm)*	*pH*	*OC (%)*	*EC (dS/m)*	*WHC (mm/m)*
Sandyclay	23.90	10 - 26	6.8	0.60	0.22	120
Clay	21.62	13 - 20	7.3	0.75	0.35	144
Sandyloam	20.74	8 - 20	7.2	0.47	0.33	96
Sandyclayloam	16.48	10 - 24	6.6	0.40	0.45	108
Loamysand	9.35	8-9	6.5	0.81	0.08	60
Clayloam	6.82	9-23	6.8	0.58	0.20	156
Siltyclay	0.46	34	7	0.68	1.25	156
Sand	0.42	12	8.5	0.10	2.50	36
Siltyclayloam	0.22	15	7.6	0.51	3.50	180

The matching of land qualities with crop requirements exercise includes two steps viz. climatic and a soil-physiographic evaluation. Initially, the climate of the soil unit is compared with that of the crop requirements. For this the specific soil and crop-linked growing season is calculated, using rainfall data, in particular, consumptive use of water of the plant as obtained from the calculated PET, the crop factor and the soil moisture storage capacity. The second step refers to the comparison of the individual soil and physiographic properties with the crop requirements in terms of texture, pH, OC, EC, rooting depth, and workability etc. (NBSS 2006). On the basis of the degree and limitations, identified the potential classes is established relatively, viz. high, moderate, margin and not recommended for the specific crop. Accordingly, **Table 5** summarizes the agroclimatic elements used to demarcate the potential sites for groundnut, gingelly, and niger oil seed.

Table 5 Agroclimatic Elements and crop potential

Crop	Temperature	Rainfall	Texure	pH	OC	EC	Potentiality
Gingelly	30-34	500-600	scl,l,sil,cl,sl	5.5-7.5	> 6	<1.0	High
	35-38	400-500	sicl,sc,c	7.6-8	4 -- 6	1--2	Moderate
	39-40	300-400	ls,c	8.1-9	<4	2--4	Margin
	>40	<300	s	<4 & >9	0	> 4	Not advisable
Groundnut	24-30	700-1000	ls,sl	6--8	> 6	<2	High
	22-23/31-33	500-700	cl,sicl,scl	8.1-8.5 / 5.5-5.9	4 -- 6	2--4	Moderate
	20-21/34-40	350-500	c,sic	>8.5/<5.5	<4	4--8	Margin
	<20/>40	<350	0	0	0	>8	Not suitable
Niger	13.5/27.5	900	l,cl,scl,sil	5.5-7.5	> 6	<1.0	High
	33-38	600-900	sl,sicl,sic	7.6-8.5	4 -- 6	1--2	Moderate
	39-40	< 600	c,ls	8.6-9	<4	2--4	Margin
	0		s	0	0	> 4	Not suitable

Source: Natarajan eta1.(2002)

pH Value: In dry climates, soil is alkaline; in wet climates, it's acidic. pH is a scale that use to measure acidity. Values below 7 are considered acidic, values above 7 are alkaline (the opposite of acidic) and 7 is neutral Most plants can tolerate a wide pH range in solution culture, but they cannot tolerate a wide range of acidity in the soil. In Aranthangi taluk the textural average of pH values shows the range between 6.5 and 8.5 associated with loamy sand to sandy texture. Easter parts of the block and western flood plain are associated with normal range of pH value (6-7) have observed which is shown in **Fig.2**

Organic Carbon (OC): Increased organic matter generally produces a soil with increased water holding capacity and conductivity, largely as a result of its influence on soil aggregation and associated increased pore space. The maximum OC value has observed in association with loamy sand soil, followed by clay, silty clay and sandy clay. It is minimum over sand, sandy clay loam and sandy loam which is 0.1,0.4 and 0.5 respectively. **Fig.3** reveals the spatial pattern of OC over the block. Accordingly, It is exhibits a complex nature of distribution over the block, however loamy sand, clay and silty caly soils are associated with higher (0.68- 0.81) OC , where as Sandyloam , Sandyclayloam and Sandy testure are associated with less than 0.5 % of OC. As the agricultural point of view , soil over this block generally subject to poor water holding capacity with reference to the OC composition.

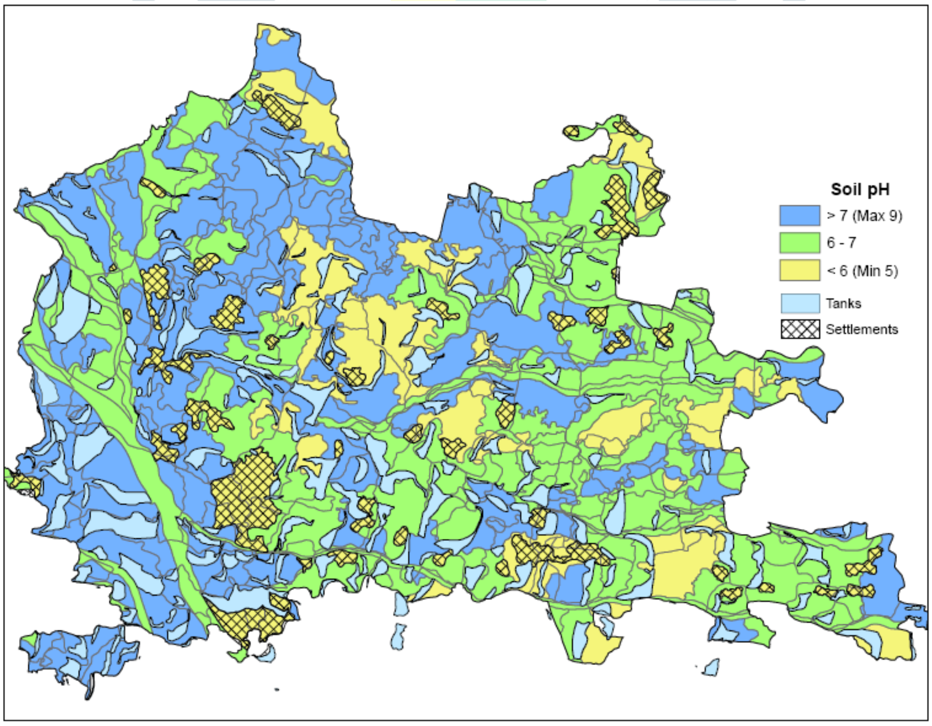

Figure 2. Soil pH Pattern

Based on the thresholds shown in the Table 5, the potential area for gingelly, groundnut and niger have been indentified using Arc GIS shown in **Fig.5**. The textural groups have been given prime importance rather than the rest of the soil factors. Threshold values of pH, OC and EC have been relative importance according to the maximum and minimum value of the parameter over the soil unit. **Table 5** shows the areal distribution of potential area in the order of area distribution.

Table 5 Crop Potential Area Distribution

Crop Potential	Area (Sq.km)	%
Marginall for Groundnut/Gingelly/Niger	201.072	50.0
Moderate - Gingelly	55.691	13.9
Moderate - Gingelly/Niger ; Groundnut Marginal	29.577	7.4
Moderate - Niger	27.146	6.8
Moderate - Groundnut; High -Niger	21.781	5.4
Marginal-Groundnut;Moderate-Niger	16.104	4.0
Moderate - Gingelly/Niger	16.098	4.0
Marginal-Groundnut;Moderate-Niger	12.069	3.0
Moderate-Niger	9.388	2.3
High-Gingelly/Groundnut;Moderate-Niger	6.464	1.6
Moderate-Groundnut	3.136	0.8
Marginal-Groundnut;Moderate-Niger	1.499	0.4
Not Advisable for Groundnut	1.357	0.3
Moderate-Groundnut/Niger	0.708	0.2
Total Area	402.088	100

In view of that ,only 50 % (201 sq.km) area have been identified with either of the potential , rest of the 50 become marginal potential for all these oil seeds and hence the productivity will be subtle low. Higher potential area for groundnut and gingelly has been estimated as 1.6 % (6.464sq.km) covering the villages Puvattakudi, Sillathur and Rajendrapuram. This area also moderately suitable for niger and can be second given less priority. Notably 14 % of the land is identified with moderate potential with reference to the gingelly covering village of western and central villages notably Chidambaranviduthi,Kurumbur,Chettikadu,Paravakkottai,Narpavalakudi,parts of Mukudi,Alapiranthan, Ramasamipuram, Mathur, Arasarkulam and Marudankudi. another 7% of land is moderately suitable for gingelly and niger and it is marginally suitable for groundnut covering Periyalur,Vellavari,Mangudi, and Arasaarkulam melpathi and keelpathi. Over 7 % of area exclusive for niger in moderate potential found over contiguous villages of eastern margin. For ground nut over 5 % of land is identified with moderate suitable covering parts of Kalakudi and Ariyamaraikadu. Another 4 % of the areas are identified with moderate as well as marginal for Gingelly and groundnut. Excessive portion of the block required soil and water management mainly to prevent soil moisture as well as improving organic content. Salinity is not the major issue over the block.

Total Available Soil Moisture: The SPAW (Soil-Plant-Air-Water) Model was developed by the U.S. Department of Agriculture to simulate the daily hydrologic water budgets of agricultural landscapes. An estimating method for soil water holding characteristics has been developed and included in this model have used in the present study to estimate the water holing capacity of the soil. ***Fig. 14*** portrays the spatial distribution of water holding capacity of different textural groups of the block. Clay loam posses the maximum value of water holding capacity (180 mm/m) estimated over northeaster part of the blocks. Notable the low water holding capacity (36 mm) have been associated with higher water holding capacity area shows the complex pattern of soil texture over the block. Major part of the block is associated with 120 -144 mm/m of water holding capacity.

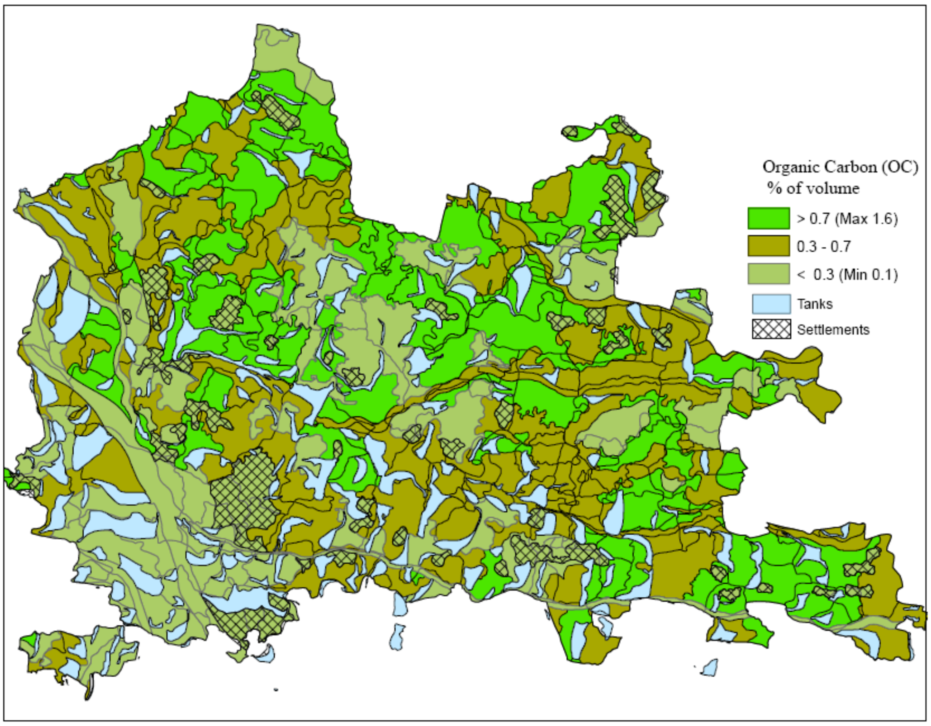

Figure 3. Soil Organic Carbon

V. CONCLUSION

The natural resources like soil and water and associated climatic features deeply influence the cropping pattern and crop productivity in specified areas. Each plant species requires definite soil and site conditions for its optimum growth. In addition to climate, texture of the soil is crucial for determining the type and growth rate of crops, moisture content, rate of evapotranspiration and hence the rate and the time of irrigation. Aranthangi block have been taken for the present study, where groundnut occupies 13.4 % of cropped area by cropping both kharif and rabi seasons which is higher after paddy. Gingelly occupies 8.2 % of cultivated area by both seasons and niger, the drought resisting oil seed crop occupies 12.7 % as a annual crop which is partially under supplementary irrigation. On the basis of degree of difference and limitations owing to temperature, rainfall, texture, pH, OC and EC the potential classes have been established as high, moderate, margin and not recommended for the specific crop. Around 50 % area has been identified with marginally potential for all the three crops and only 1.6 % of the land is estimated with high potential for groundnut and gingelly. Major area comes under moderate potential as for as gingelly concerned.

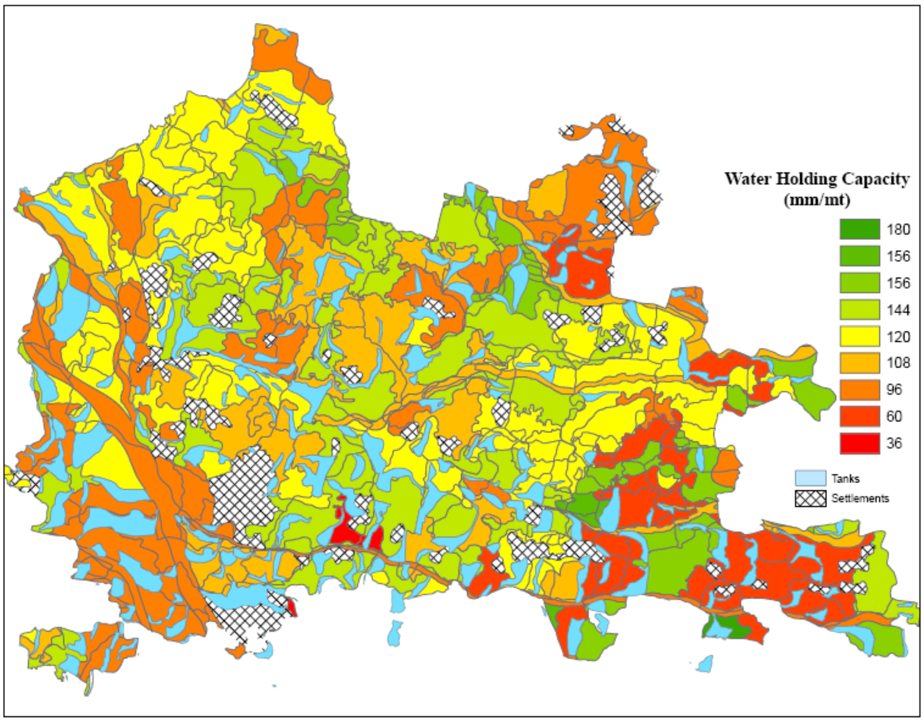

Figure 4. Soil Water Holing Capacity

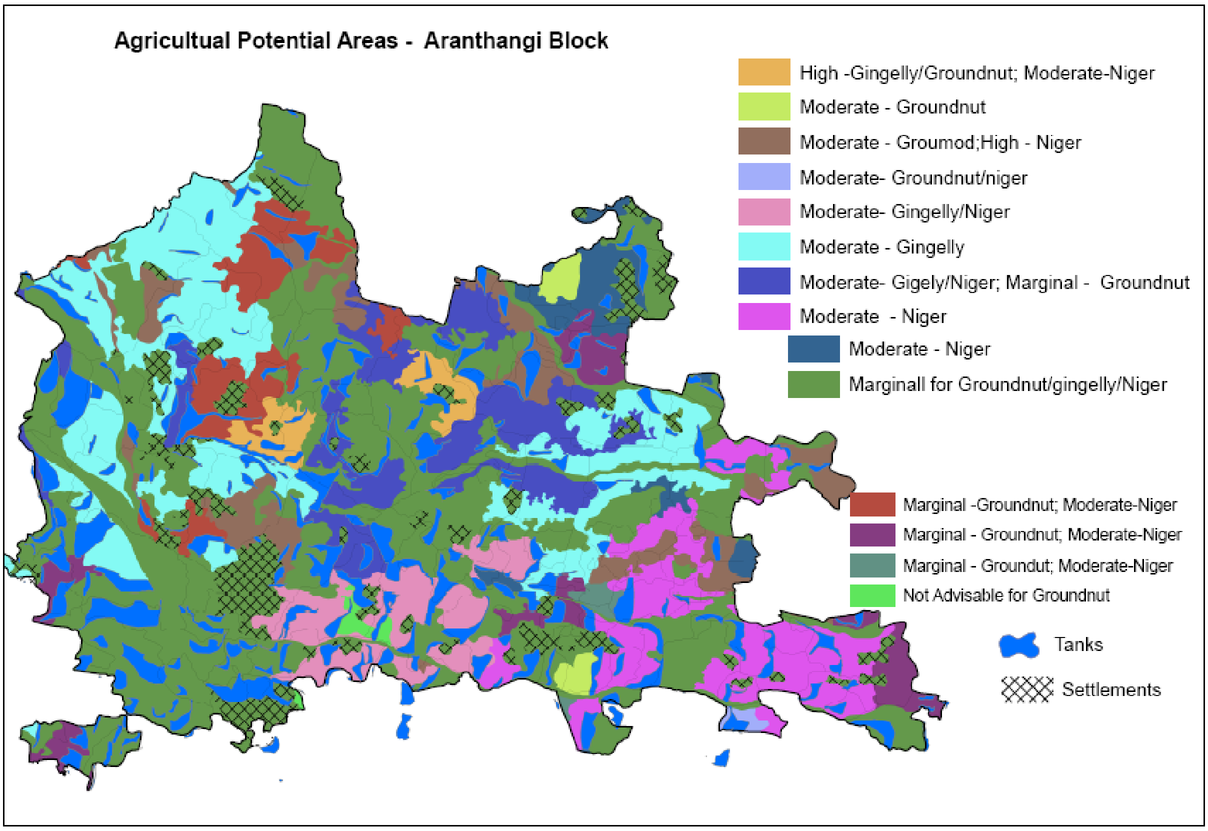

Figure 5. Agricultural Potential Area

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