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Crop suitability for Char areas of Nalbari District, Assam

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Abstract : A study was undertaken in **Char** areas of Nalbari district to identify and delineate different sub-agroecosystems using remote sensing and GIS techniques for effective crop diversification. Based on soil-site characteristics, hydrology, ground truth and socio-economic parameters, three agro-ecological sub-divisions viz., occasionally flood affected area (OFAA), annually flood affected area (AFAA), and frequently flood affected area (FFAA) were delineated. Among these, OFAA and AFAA were moderately suitable (S2) and FFAA was marginally suitable (S3) for summer rice but AFAA and FFAA were unsuitable (N2) for rabi crops. Some of the soil-site parameters were modified based on average yield efficiency percentage of different crops, hydrology, soil fertility and other relevant characteristics to improve suitability ratings. Cauliflower-knolkhol-summer rice was found suitable and economic in OFAA, garlic-summer rice in AFFA and summer rice cropping sequence was found suitable in FFAA.

Additional key words: *Agro-ecosystems, average yield efficiency, suitability classification*

Introduction

The river Brahmaputra and its tributaries generally carry suspended materials brought from the catchment areas. A small obstruction in the course of the rivers may give rise to **Char** made up of alluvium, silt and sand. Thus, between and by the side of the main bank of the river, there exist a large number of **Char** lands. In Assam, **char** lands cover an area of 3.61 lakh ha, out of which 2.42 lakh ha are under cultivation that support a large population of the farming community (Anonymous 2003). Easily cultivable soils of the chars may assist farmers to take up intensive cultivation of crops (Borkakati *et al.* 1999; Vadivelu *et al. 2005).* Keeping in view such potentialities of these lands, an attempt has been made to identify and delineate different sub-agroecosystems of the **Chars** of Nalbari District and evaluate crop performance and crop suitability and prepare an appropriate crop plan to increase agricultural productivity.

Materials and Methods

The study area is a part of Nalbari district (91°15' to 91°30' E; 26°05' to 26°15' N) characterized by hot and humid summer and cool winter. The mean annual rainfall is 2107.80 mm of which 855.00 mm is received during April to October. The mean maximum and minimum temperatures are 32.3°C and 14.5°C in summer and 27.4°C and 8.9°C in winter, respectively. The mean annual soil temperature is 25.19°C. The mean summer soil temperature is 28.97°C and mean winter soil temperature is 21.41°C. The temperature regime is hyperthermic and moisture regime is Ustic. For the present study, soil map was collected from NBSS&LUP, Regional centre, Jorhat. Revenue map was collected from Nalbari district authority and the geocoded IRS –ID FCC data of the project site (1:50,000 scale) was collected from NDC, Hyderabad. These data were interpreted to identify different agro-ecosystems of the area. In addition, visual interpretation of IRS-ID FCC and

intensive ground truth were collected for delineation of sub-agro-ecosystems as per method suggested by Garrity and Singh (1991) and Singh and Singh (1996).

Socio-economic information of the **Char** areas of Nalbari district of Brahmaputra river basin was collected using standard survey schedule. The schedule was prepared and modified to satisfy the proposed data. Necessary secondary data were collected from sources like District Agricultural Office, Dept of Economics and Statistics, Assam Agricultural University, Jorhat for the period of 2006 to 2008. Relevant data in respect of demography, land tenure system, crop activity, land use and cropping pattern, farming system and price of inputs and outputs, maximum and minimum area under certain crops, net benefit and cost benefit analysis were recorded. Average yield efficiency percentage (AYEP) was calculated as:

$$AYEP = \frac{\text{Average crop yield per ha in the given area}}{\text{Mean crop yield per ha in the state}} \times 100$$

Surface soil samples (0-15 cm) were collected from different **Chars**, processed and analysed. Particle size distribution, soil reaction, electrical conductivity, organic carbon, cation exchange capacity, water holding capacity and available N, P_2O_5, K_2O, exchangeable Ca and Mg were estimated following standard methods. Land use capability and crop suitability for important crops were carried out as per FAO (1976) as modified by Sys *et al.* (1993) to determine soil-site characteristics, crop growth requirements and corresponding environmental parameters.

Field experiments were carried out in these areas during 2006-2007 and 2007-2008 and crops were selected for each experiment based on farmers' needs as reflected in the results of socio-economic survey, and finally soil site suitability was evaluated for the major crops.

Results and Discussion

*Delineation of **Char** sub agro-ecosystem*

It was observed that permanent **chars** cover an area of 143.35 sq km; semi permanent chars 96.33 sq km and sandbars cover 164.27 sq km. Based on soil-site characteristics, hydrology, ground truth and socio-economic parameters, three agro-ecological sub-divisions *viz.* occasionally flood affected area (OFAA), annually flood affected area (AFAA) and frequently flood affected area (FFAA) were delineated in permanent **Char** areas of the district.

Land use pattern

The study indicated that in the **Char** areas of the river Brahmaputra, a large variety of crops can be cultivated during *rabi* and summer seasons due to varied physical and natural features combined with natural fertility of these alluvial deposits. Twenty four different crops were found to be suitable in these areas. Among these crops, rice was the most important crop occupying about 33.52 per cent of the total cropped area. Next to rice, jute occupied 20.52 per cent of the total cropped area. Wheat was the third most important crop of the area occupying 8.53 per cent. Other crops, namely, HYV boro rice, rapeseed, mustard, coriander, lentil, black gram, brinjal and chilli occupied 8.25, 7.21, 3.39, 3.39, 1.67, 1.91, 3.47 and 8.00 per cent of the total cropped area, respectively. It may be noted that percentage of areas under crops like boro rice, black cumin, cole crops, sunhemp, niger, sesamum, onion, turmeric, sugarcane, potato, sweet potato, and garlic were relatively small.

Soil characteristics

Physical and chemical characteristics of soils of different **Chars** of the district are present in table 1. The soil texture of all the **Chars** varied from sand to loamy sand. The organic matter contents of some areas were almost negligible due to existence of pure sand in the top layer, whereas in some areas, these were as high as 3.21%. Significant difference in organic matter contents was found among soil samples collected from AFAA and OFAA *vis-a-vis* FFAA. Higher organic carbon contents of FFAA may be attributed to higher deposition of organic colloids containing higher organic matter as compared to those in OFAA. Particle-size analysis showed textural variation from loamy sand to sandy loam.

Table 1. Physical and chemical characteristics of soils

Chars	Colour	Sand	Silt (%)	Clay	Tex-ture	WHC (%)	pH	EC (dSm^{-1})	O.C. (%)	CEC cmol (p+) kg^{-1}	App.CEC cmol(p+) kg^{-1}
Nislar par	10YR7/1	83.8	10.5	5.7	ls	27	6.9	0.21	1.52	3.50	61.4
Dairy Farm	10YR7/1	77.6	12.5	9.9	ls	33	6.4	0.21	2.02	4.70	49.3
Satlar par	10YR7/1	80.9	13.5	5.5	ls	29	6.8	1.13	1.26	5.40	68.7
Dakhin Kurihamari	10YR6/1	93.4	2.5	4.1	s	27	6.9	1.03	0.24	2.10	51.2
Bejisutir par	10YR7/1	90.2	6.0	3.8	s	26	6.9	0.39	0.52	2.10	55.5
Pashim Kurihamari	10YR7/1	93.7	2.0	4.3	s	27	7.5	0.31	0.02	2.00	46.7
Garighat	10YR7/1	89.6	7.5	2.9	s	27	7.0	0.21	3.19	2.10	71.4
Naubatchar	10YR6/3	87.1	8.0	4.9	ls	29	6.9	0.24	1.78	3.20	64.9
Nepalibasti	10YR6/1	81.7	12.0	6.3	ls	28	6.2	0.32	1.52	3.80	60.4
Pub Naubatchar	10YR7/1	85.9	10.0	4.1	ls	27	7.8	0.32	0.91	3.10	74.9
Bangnaputa	10YR7/1	82.9	12.2	4.8	ls	28	6.3	0.58	1.4	3.90	80.6
Khujuror char	10YR6/1	80.5	14.2	5.3	ls	27	6.4	0.42	1.64	3.80	71.2
Pub Khujuror char	10YR7/1	79.5	11.7	8.8	ls	25	7.0	0.31	1.52	3.90	44.1
Madhya Bhangnamari	10YR7/1	81.5	13.2	5.3	ls	28	7.1	0.34	3.19	3.90	73.0
Bejir par	10YR6/1	82.5	13.2	4.3	ls	28	7.7	0.21	2.03	4.20	96.8
Laupara	10YR6/1	78.9	13.0	8.0	ls	27	7.9	0.36	2.02	4.20	52.4
Pashim Bhangnamari	10YR6/1	76.9	15.5	7.6	ls	27	8.0	0.45	2.93	3.50	46.3
Tilatia	10YR7/1	79.2	16.0	4.8	ls	28	8.3	0.32	1.69	3.45	71.3
Barbilor par	10YR6/1	77.8	11.5	10.7	ls	31	5.9	0.51	3.21	3.40	61.4
Bhakator Kuthi	10YR7/1	77.2	14.5	8.3	ls	30	5.5	0.31	1.41	4.00	31.9
Sajidalir char	10YR6/1	77.5	16.0	6.5	ls	29	5.5	0.31	1.86	3.30	39.6

The overall nutrient status of the soils was found to be medium to high (Table 2). The P_2O_5 and K_2O contents ranged from 41.03 - 82.07 kg ha^{-1} and 165.31 - 423.36 kg ha^{-1}, respectively. Exchangeable Ca and Mg of the soils ranged from 1.80-5.44 cmol(p+)kg^{-1} and 0.29-2.25 cmol(p+)kg^{-1}, respectively. The higher values were due to deposition of organic colloids during floods. The cation exchange capacity of the soils ranged from 2.00-4.00 cmol(p+)kg^{-1} and the water holding capacity varied from 25-33%. Electrical conductivity ranged from 0.21 to 1.13 dS m^{-1} in different soils.

Soil-site suitability evaluation

Suitability evaluation for the major crops as per Sys *et al.* (1993) indicated that the FFAA was moderately suitable (S2) and OFAA was marginally suitable (S3) for summer rice and unsuitable (N2) for other crops. During ground truth and participatory resource appraisal (PRA), however, it was observed that most of the crops were highly productive. This suggested that Sys's limitations partially failed to evaluate soil-site suitability of crops in humid tropical and sub-tropical **Char** soils. Inclusions of some new limitations based on crop requirements, adaptability and net return and exclusion of some irrelevant Sys's limitations under these ecosystems indicated improvement in suitability classes which reflect the actual suitability of the area. While doing so, NPK status and AYEP were considered.

Table 2. Nutrient status of soils

Name of Chars	Available N	Available P_2O_5	Available K_2O	Exch. Ca	Exch. Mg
	---------- (kg ha^{-1}) ----------			------ cmol(p+) kg^{-1} -----	
Nislar par	219.5	75.9	165.3	4.7	2.2
Dairy Farm	31.3	61.5	409.9	1.8	0.2
Satlar par	31.3	55.3	188.1	1.8	1.2
Dakhin Kurihamari	31.3	55.3	194.8	5.4	2.1
Bejisutir par	94.0	52.8	208.3	4.2	0.4
Pashim Kurihamari	94.0	55.3	188.1	5.2	2.1
Garighat	94.0	67.7	268.8	5.3	1.8
Naubatchar	156.8	55.3	349.4	5.4	2.2
Nepalibasti	75.5	95.4	322.5	4.8	1.7
Pub Naubatchar	76.2	67.7	134.4	4.2	1.9
Bangnaputa	31.3	41.0	241.9	4.8	2.0
Khujuror char	94.0	67.7	154.5	5.2	2.2
Pub Khujuror char	94.0	82.0	235.2	5.1	1.0
Madhya Bhangnamari	75.5	79.5	349.4	5.0	0.9
Bejir par	72.8	82.0	168.0	5.2	2.1
Laupara	94.0	55.3	201.6	4.0	2.1
Pashim Bhangnamari	31.3	67.7	282.2	4.2	2.1
Tilatia	46.3	67.7	329.2	4.3	1.9
Barbilor par	94.0	72.0	329.2	5.2	1.2
Bhakator Kuthi	94.0	48.2	403.2	5.2	0.4
Sajidalir char	94.0	48.2	423.3	5.4	0.9

In FFAA, summer rice was widely cultivated due to availability of river water for manual irrigation and high water table during later part of crop growth. The shallower ground water table might have nullified the limitations of soil texture for rice cultivation. It was opined that under such situations, capillary rise of water could have contributed a part of water requirement of crops. Moreover, AYEP of summer rice was almost double (271.08 %) of state average indicating better adaptability of summer rice in that area (Table 3). In addition, medium available NPK status and neutral soil reaction might have helped in the uptake of other secondary nutrients and micronutrients and thus, the limitation of organic carbon was not conspicuous. Considering all these, Sys's suitability class for summer rice could be modified to moderately suitable (S2) in FFAA areas, marginally suitable (S3) in AFAA areas and not suitable (N1) in OFAA areas (Table 4).

Table 3. Average yield efficiency percentage of major crops

Crops	Average yield of study area (kg ha^{-1})	Average yield of state level (kg ha^{-1})	AYEP (%)
Rice	5400	1992	271.08
Wheat	1950	1010	193.06
Jute	2239	1609	139.15
Potato	13500	7940	170.02
Mustard	1200	470	255.32
Green chilli	4500	1515	297.02
Cabbage	13500	7500	180.00
Garlic	1000	2960	33.78
Onion	2400	2290	104.80
Pea	480	1300	36.92
Tomato	5000	3320	150.60
Cauliflower	16000	14000	114.28

Soil-site suitability for wheat, cole crops and potato indicated that the char areas were marginally suitable (S3) for wheat and cole crops due to low precipitation, low temperature during crop growth period and low organic

Table 4. Suggested crop plan in different sub-agro ecosystems

FFAA	AFAA		OFAA		
Post flood	Pre flood	Post flood	Summer	Kharif	Winter
Radish/Spinach-Summer rice (2.42/2.52-1.85)	Summer rice/ Jute (1.85/1.42)	Potato/ Mustard (2.56/2.13)	Jute	Sali rice (with assured irrigation)	Relay crop pea (3.46)
	Foxtail millets (1.10)	Garlic/Onion/Chilli (4.36/2.24/4.21)		Sesamum (2.10)	Rabi vegetables (5.60)
Rapeseed/ Mustard (2.13)	Jute (1.42)	Rabi vegetables (6.54)	Blackgram/ Greengram (1.35/1.25)	Sesamum (2.10)	Mustard/ rabi vegetables
Cole crops (5.60)	Summer Blackgram /Greengram (1.35/1.25)				

Figures in paranthesis denote B:C ratio

carbon content. These areas were not suitable for potato due to low precipitation, high relative humidity and low organic carbon content. In **Chars** of Assam, low precipitation in *rabi* season does not affect crops because of frequent low intensity rainfall, high relative humidity and contribution of dew during that period which substituted most of the requirements of *rabi* crops. Crop stand gap was hardly affected due to low precipitation since available K content of the soils were in medium to high range. Similarly, the effect of low organic carbon content might have been nullified by neutral soil pH, medium fertility and subsequent availability of secondary nutrients and micronutrients in soils. In Assam conditions, light textures of the soils were found to be the best textures for wheat, cole crops and potato crops. Considering all these, Sys's suitability classes were modified to moderately suitable (S2) for all these crops in both the agro-ecosystems of the char areas. Soil-site suitability of both the ecosystems could further be improved to potentially suitable class (S1) by adopting suitable management techniques.

However, though FFAA was moderately suitable for all these crops, but in practice these crops are not recommended because of risk of flooding. In this eco-system, only summer rice and few short duration vegetables could be the viable alternatives.

Suggested cropping plan

Based on soil site suitability of crops, socio-economic conditions, length of growing period, occurrence of flood, benefit-cost ratio and major constraints of the **Char** areas, crop plans for different agro-ecosystems have been suggested (Table 4). While doing so, some of the crops have been eliminated and new ones introduced. Crops like sesamum, radish, spinach, garlic, onion, etc. were introduced. Wheat was eliminated as major crop of the char areas because of threshing and storage problems, chances of occurrence of pre-monsoon rain and less returns. Based on benefit:cost ratio and its suitability in a particular sub-agro ecosystem in FFAA, radish/spinach-summer rice and sole rapeseed/mustard and sole cole crops were suggested. In AFAA, two crops before and after flood could be suggested while in OFAA, three crops could be suggested in summer, *kharif* and winter season, respectively. However, the actual choice of the crop for a particular site may depend on the soils of the farm, the preference of the farmer and the anticipated market demand of the crop. It is expected that implementations of such crop plans would enhance the existing productivity of crops.

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