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Characterization of depositional soils in dynamic fluvial landforms of Majuli island for land use-related issues

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Abstract: The appraisal of floodplain-wetland soil resources of one of the world's largest river island Majuli in the Brahmaputra valley was done to develop a frame work for land use management. The soil–site information in the island was generated through reconnaissance soil survey on 1:50000 scale. Six major land units were delineated as active flood plains, sand bars, swamps, old flood plains, channel fills and natural levees. The soils showed grey-matrix with high chroma mottles in Puranibari, Adi Elengi, Garumara, Gayangaon and Bharaki soil series. The generic grouping of soils developed on young geomorphic surfaces were Typic Fluvaquents (Bhakat, Kamalabari, Bangaon and Majuli) and Typic/Humic or Fluvaquentic Endoaquepts in active/old flood plains and swamps. The soils are coarse loamy, slightly acid to neutral, low organic carbon (1.5 to 5.2 gkg^{-1}), low exchangeable potassium (0.08 to 0.24 cmol $(+)kg^{-1}$) and low DTPA-extractable Zn (0.29 to 0.75 $mgkg^{-1}$). The soil map was generated with twenty five soil mapping units for land use interpretations. The soil-site suitability analysis for rice based cropping systems indicated that rice is grown successfully in active/old flood plains and in channel fills during rainy season, whereas mustard, potato and cabbage in post rainy season in natural levees and dried parts of swamps. Growing cowpea, peas and frenchbean in paddy fallows, paddy-fish integrated farming near swampy areas and sparing the *bils* for migratory birds are recommended.

Additional Keywords: *Brahmaputra, valley, geomorphic features, geocoded IRS-ID data*

Introduction

Majuli, one of the largest inhabitated river island of the world and a char land, have an area of 92,460 hectares supporting the population of 1, 35, 378 (15.53 per cent of total population) in the Jorhat district of Assam. The problems of island are flood inundation and severe river bank erosion in its southern side and repoted that 50 km^2 of land mass was lost during the period of 1969 to 1994 (Nayak and Singh 1996). According to the first geographical report, Majuli was a cluster of 15 large and numerous islands in 1792 but in recent times the maximum rate of bankline migration to northern bank is 0.146 km $year^{-1}$ leading to heavy silting and reduction of area under swamps (Sarma and Phukan 2004). The biophysical (climatic, peodological, ecological) characteristics of land are key elements of land management, resulting in low cropping intensity (102 per cent) and very low rice productivity (1325 kg ha^{-1}) in the island. An understanding of spatial distribution of soils is important for refining agricultural management and their effects on soil productivity and crop yield. The soil-site suitability for rice-based cropping systems in the island have been reported based on the four soil series namely Majuli,

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Pakajara, Lahangaon and Ratanpur occurring on three physiographic units such as active flood plains, lower and upper terraces (Vadivelu *et al.* 2005). The present study was aimed at characterizing soils in fluvial landforms by using satellite imageries with sufficient ground truth and evaluating soil-sites for rice- based cropping systems.

Materials and Methods

Study area

Majuli, situated in north of Jorhat district, lies between 93°30' and 94°35' E longitude and 26°50' and 27°10' N latitude at an elevation ranging from 60 m to 85 m above mean sea level. The island is bounded by three important rivers such as Kherkutia Suti (an anabranch of the Brahmaputra), the Subansiri (a tributary of the Brahamaputra) in the north and the Brahmaputra river in the south (Fig.1). The island is marked with more than seventy *bils*, which occasionally break the monotony of flat relief.

Geomorphic history

The island formation through historical records say that the Brahmaputra was located north of Majuli in the late part of the 17th century, when the most important *Sattras* were established. There is no dependable record in which southward migration of the Brahmaputra took place. This event was propably due to a series of frequent earthquakes and attendant floods that occurred during the period 1661 – 1696 as stated by Bhuyan (1968). Two major earthquakes of magnitude 8.7 in Richter Scale (M) was occurred in 1897 and 1950. Five more earthquakes above 7.0 M took place since 1930 together with numerous earthquakes of smaller magnitude (Valdia 1987). Movements along active basement faults have caused tilting of the recent alluvium leading to shifts in courses of many rivers (Sarma and Phukan 2004).

Climate and natural vegetation

Majuli experiences subtropical monsoon type of climate with aquic / udic soil moisture regime and hyperthermic soil temparature regime. The island supports the growth of evergreen, semi-evergreen and deciduous trees, grasses and marshy vegetation (Bhagabati 2001). The grasses in wet land include *Phragmites karka (*Ikora), *Arundo donax* (Nol), *Chrysopogon aciculatus* (Bongooti), *Imperata cylindrical* (Ulu Kher), *Cynodon dactylon* (Duboribon) and *Vetiveria zizaniodes* (Biringa). The marshy vegetation includes *Eichhornia crassipes* (Water hyacinth), *Pistia stratiotes* (Borpuni), *Nymphaea nouchali* (Indian red water lily), *Nelumbo nucifera* (Podum phool), *Trapa bispinosa* (Pani singori), *Euryale ferox* (Pani khola), *Cyperus rotandus* (Mutha), *Alisma plantago* (Panikola), *Polygonum hydropiper* (Pothorua bihlononi), *Alpinia allughas* (Deo) and *Ipomea reptans* (Swamp cabbage).

Field survey

The Survey of India toposheets that cover the island were 83F/3, 83I/4, 83I/8, 83J/1 and 83J/5. The corresponding geocoded IRS-ID of 18th January, 2003 were visually interpreted and identified six major landforms in the flood plains of Majuli on the basis of tone, colour, texture and pattern (Jensen 1986). The reconnaissance soil survey was carried out on 1:50000 scale as per procedures outlined (Soil Survey Division Staff 1995) and recorded latitude and longitude with the help of hand held GPS receiver (global map 100, Lowrance). Thirteen soil series were identified and horizon-wise soil samples were collected for laboratory analysis. The physical and chemical analysis of soils was carried out as per standard procedures (Black *et al.* 1965; Sarma *et al.* 1987) and classified (Soil Survey Staff 1998). Five soil parameters such as clay, organic carbon, pH, cation exchange capacity and exchangeable potassium were used to cluster the soils into three management groups as per Index of similarity values (Is) computed as = 2W x 100/ (A+B) where W is sum of lower value of each property of soils as compared to same property of soil B and (A+B) is sum of two different profile marks (Hole and Hironka 1960). The soil-site suitability analysis for rice based cropping systems was done as per land evaluation methods described by Sys *et al.* (1993).

Results and Discussion

Geomorphology- Six landforms in the flood plains of island were delineated as per genetic classification of

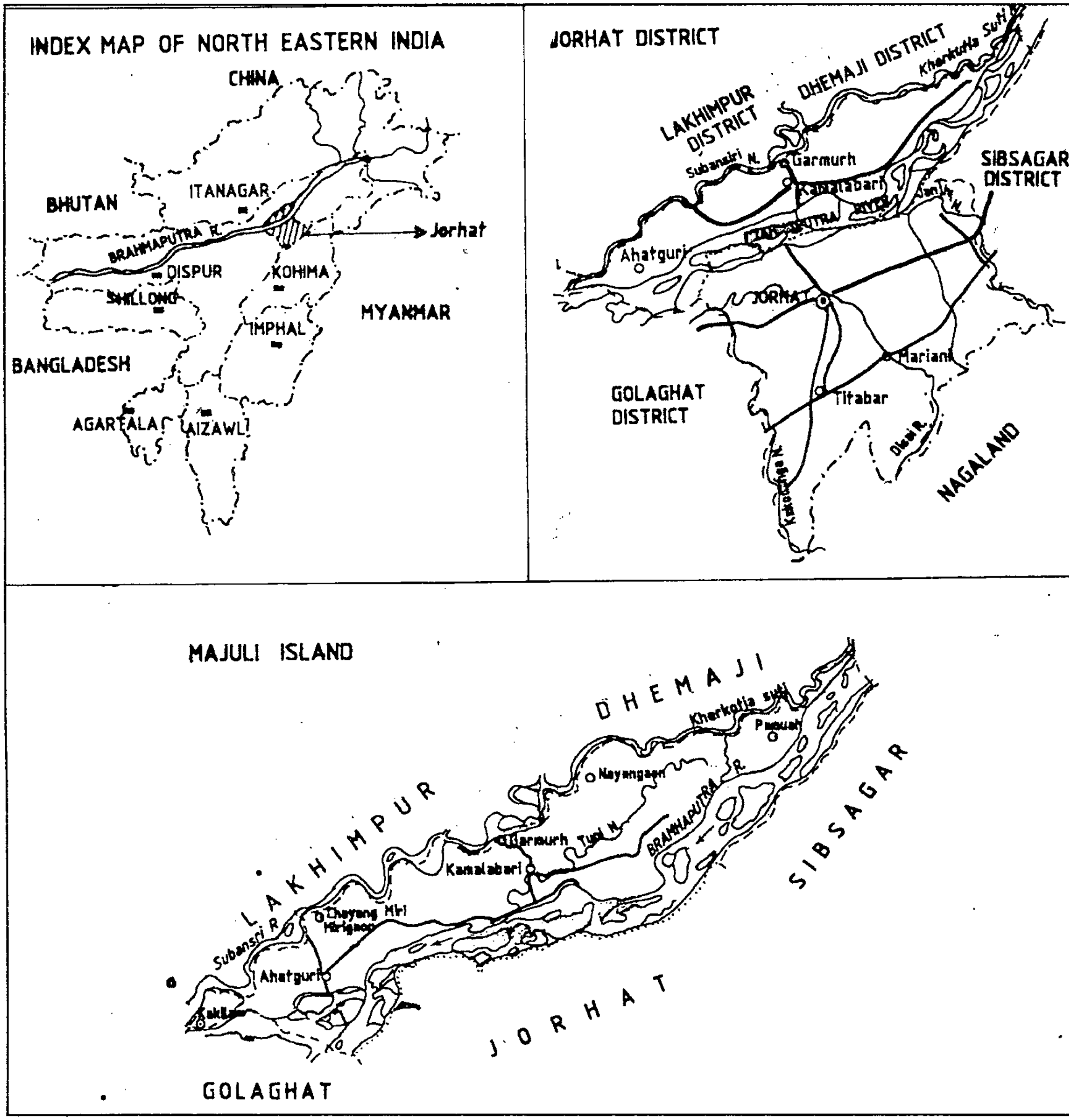


Fig. 1. Location of Majuli island, Jorhat district.

floodplains by Nanson and Croke (1992) and the description of geomorphic features reported in Brahmaputra valley by Sarma (2005). These are described in brief as:

i) *Active flood plains*: This unit frequently flooded during rainy season. The land is flat with very gentle slopes. This covers an area of 16.3 per cent (17991 hectares) with its strong association with swamps.

(ii) *Sand bars in the river beds:* It is a sediment body formed inside of a river bend by lateral accretion and contains unvegetated body of sand within the channel. With

Table 1. Selected physical and chemical characteristics of soils

Soil series	Textural sequence	Particle-size distribution (%)			pH	OC (gkg^{-1})	Exchangeable bases ($cmol(p+)kg^{-1}$)				CEC ($cmol(p+)\ kg^{-1}$)
		Sand	Silt	Clay			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
Sonaribari(Sb)	sicl-sil-l-sil	12.9	69.9	17.2	7.6	8.5	10.0	4.2	0.50	0.50	12.7
Bharaki (Bi)	sil-sl-l-sil-sicl	28.8	54.4	16.8	7.4	3.7	5.3	4.3	0.46	0.21	13.3
Bhakat (Bt)	sil-sl-ls-sl-s	76.6	16.4	7.0	7.9	1.5	8.7	1.2	0.31	0.08	7.2
Boritika (Ba)	l-sl-sicl-s	55.5	27.9	16.6	7.4	5.2	4.3	2.2	0.34	0.15	14.4
AdiElengi (Ae)	sil-sicl-sil-s	71.9	15.7	10.6	7.1	3.8	3.4	1.2	0.47	0.08	6.7
Puranibari (Pb)	sl-l-s-sl-sil-sicl	31.4	45.9	22.7	6.5	3.3	4.3	2.5	0.53	0.17	17.1
Kamalabari (Kb)	l-sil-l-ls	57.1	33.2	9.7	6.9	3.6	3.3	1.3	0.8	0.24	10.3
Chilkala (Ch)	sill,sic, sicl-s	65.8	17.8	16.4	6.9	4.0	3.0	2.4	0.7	0.15	7.1
Gayangaon (Gn)	sil-l-s	52.4	33.7	13.9	7.0	4.6	3.4	2.1	0.7	0.12	10.1
Dakshinpat (Dh)	sicl-sic-sil-s	35.4	47.4	19.7	7.1	8.9	5.5	3.5	0.7	0.10	14.4
Bongaon (Bn)	sil-l-sl-l-s	63.5	31.0	5.6	7.8	3.0	7.8	5.2	0.7	0.13	5.1
Garumara (Ga)	l-sl-s	57.9	31.2	11.9	6.1	4.7	2.4	2.0	0.8	0.16	10.1
Majuli (Mj)	ls-l-l	61.6	31.8	6.6	7.3	2.2	3.0	2.7	0.7	0.08	7.1

sicl = silty clay loam, sil = silt loam, l = loam, s = sand, sl = sandy loam, ls = loamy sand, sic = silty clay.

Table 2. Nutrient status in surface horizons of soils

Soil series	Available ($kgha^{-1}$)			DTPA extractable ($mgkg^{-1}$)	
	N	P_2O_5	K_2O	Mn	Zn
Sonaribari(Sb)	874 (H)	46.2(M)	584 (H)	17.3	0.84
Bharaki (Bi)	655 (H)	12.6(L)	206 (M)	4.9*	0.46*
Bhakat (Bt)	437 (M)	8.4 (L)	172 (M)	2.3*	0.34*
Boritika (Ba)	582 (H)	37.8(M)	275 (M)	13.3	0.54*
AdiElengi (Ae)	509 (M)	46.2(M)	310 (H)	5.1*	0.48*
Puranibari (Pb)	655 (H)	37.8(M)	344 (H)	30.8	0.52*
Kamalabari (Kb)	655 (H)	5.2(L)	378 (H)	11.0	0.54*
Chilkala (Ch)	291 (M)	23.6(L)	344 (H)	1.0*	0.58*
Gayangaon (Gn)	801 (H)	25.2(L)	378 (H)	3.6*	0.36*
Dakshinpat (Dh)	1456 (H)	26.2(L)	447 (H)	30.0	0.52*
Bongaon (Bn)	510 (M)	25.2(L)	206 (M)	7.5*	0.30*
Garumara (Ga)	582 (H)	31.2(M)	344 (H)	23.6	0.62*
Majuli (Mj)	582 (H)	25.1(L)	104 (L)	9.5	1.28

Note:- *Critical values for Mn =4-8 $mgkg^{-1}$, Zn =0.8 – 3 $mgkg^{-1}$; Rating class for N ,Low <275 $kgha^{-1}$, medium =275-550$kgha^{-1}$ and high = >550$kgha^{-1}$; P_2O_5 low = < 33.75 $kgha^{-1}$, medium = 33.75-61 $kgha^{-1}$, high = >61 $kgha^{-1}$; K_2O, low= <137.5 $Kgha^{-1}$, medium = 137.5 – 275 $kgha^{-1}$, high = >275 $kgha^{-1}$

continued sedimentation, it grows into a pronounced ridge until it is vegetated and flooded. This unit covers 46371 hectares (43.4 per cent of total area) and mainly concentrated in the Brahmaputra river bed in southern bank and a major part of Majuli sub-division.

(iii) *Swamps:* These are the lowest lying parts, poorly drained and flat (featureless) areas of little or no relief between the active or abandoned channels. The deposition is through settling of suspended fine grained sediments from overbank flows and consists of silty and clayey sediments with varying amounts of very fine sands. Soil horizons are commonly observed in the back swamp areas with organic accumulations and mottled structures.

(iv) *Old flood plains:* This unit is mainly confined to the adjoining areas of the Tuni river with silty clay soils and is intensively used for cultivation in south central parts of island. This unit covers 6946 hectares (6.3 per cent) and are occasionally flooded during rainy season.

(v) *Channel fills:* These are convex downward sediments deposited mainly from suspension and contribute to point bar swale fill deposits. It consists of fine grained sands, silts and clays. This unit covers 11.8 per cent of area with coarse loamy soils of Majuli, Sonaribari and Bhakat series. This unit is mainly concentrated near northern parts of Subansiri banks and has strong association with swamps.

(vi) Natural levees: Morphologically, levees are the most prominent depositional landforms with the wedge-shaped ridges sloping away from the channel into the flood plains. The coarser deposits of overbank environments are the reflection of the proximity of levees to the active channels. These depositional units have interbedding of coarse with fine sediments ranging from fine sands through silty sands and silty clays and covers 8.9 percent area.

Soils and soil characteristics

Thirteen soil series were identified and characterized for land use interpretations. The important soil characteris-

Table 3. Soil mapping units and their extent in each geomorphic units

Soil mapping unit	Area of Geomorphic units (ha)							Total area (ha)
	Active flood Plains	Sand bars with grass cover	Sand bars	Swamps	Old flood plains	Channel fills	Natural levees	
1.Ae-Bt-Ch	—	-	-	119	1311	-	-	1430
2.Ba-Bt-Ga	94	-	-	677	1022	-	-	1792
3.Bi-Ch-Ae	261	-	-	2022	1810	-	-	4093
4.Bt-Ga—Bn	1051	-	-	2977	1232	225	-	5485
5.Ch-Ae-Bt	250	-	-	39	-	1076	-	1364
6.Dh-Ae-Kb	13	-	-	1086	-	-	-	1099
7.Dh-Bt-Bi	3456	-	-	-	343	20	-	3819
8.Dh-Bt-Ga	745	-	-	-	-	595	-	1340
9.Dh-Kb-Gn	711	-	-	-	-	1549	-	2260
10.Ga-Bn	744	4539	1346	1979	-	39	-	8647
11.Gn-Bn-Ga	-	-	26	448	85	-	-	559
12.Kb-Ga-Ch	3579	-	-	59	230	640	-	4508
13.Kb-Pb-Bn	139	-	-	370	75	1816	-	2398
14.Mj-Ga	199	2629	9160	-	-	108	-	12096
15.Mj-Kb	700	1137	14911	-	86	-	5789	22623
16.Mj-Sb	30	820	4456	-	-	81	-	5381
17.Pb-Kb-Mj	1653	-	736	58	-	487	108	3042
18.Pb-Sb	3376	615	355	806	38	49	-	5239
19.Sb-Ba-Bt	62	-	926	315	179	2323	-	3805
20.Sb-Ba-Mj	241	-	-	623	-	3526	-	4390
21.Sb-Bn	-	-	-	-	536	-	178	714
22.Sb-Ga-Mj	455	-	-	961	-	421	42	1879
23.Sb-Mj-Bn	-	109	74	2393	-	-	344-	2921
24.Sb-Mj-Pb	-	4441	360	-	-	-	3208	8009
25.Sb-Mj-Kb	231	112	765	-	-	—	78	1186
Total	17991	14402	31969	14931	6946	12953	9747	110085
Per cent	16.3	13.1	30.1	13.6	6.3	11.8	8.9	100

Table 4. Soil-site suitability for crops in Majuli

Soil series	Rice	Wheat	Mustrard	Potato	Cabbage	Pea	French bean	Tomato	Maize	Alfalfa	Cowpea	Banana
Sonaribari	S2sw	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Bharaki	S3sw	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Bhakat	S3sw	S1	S1	S2f	S1	S1	S1	S2f	S1	S1	S1	S2f
Boritika	S2ws	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
AdiElengi	S2ws	S1	S1	S2f	S1	S1	S1	S1	S1	S1	S1	S1
Puranibari	S3ws	S3s	S2s	S1	S1	S2	S2s	S2s	S2s	S1	S2s	S3s
Kamalabari	S2sw	S2sf	S2f	S1	S2f	S2f	S1	S2f	S1	S2f	S2f	S1
Chilakala	S2fs	S3f	S3f	S2f	S3f	S3f	S2fs	S3f	S2fs	S2f	S3f	S2f
Gayangaon	S3sf	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Dakshinpat	S2sf	S2f	S3f	S2f	S3f	S3f	S2f	S3f	S3fs	S3f	S3f	S2f
Bongaon	S2sw	S1	S1	S2f	S1	S2f	S2f	S2f	S1	S1	S1	S2f
Garumara	S3fs	N1	N1	N1	N1	N1	N1	N1	N1	N1	N1	S3f
Majuli	S3sw	S3s	S3s	S2f	S1	S1	S2fs	S2s	S2s	S2s	S2s	S3sf

tics are presented in table 1. The soils, in general, have dark grey (5Y 4/1) to olive grey (5Y 5/2) matrix with coarse-loamy particle-size in control section and moderately acid (pH 5.9) to moderately alkaline (pH 7.9) in reaction. The soil characteristics of soils are in agreement with sand deposits of flood areas in Dhemaji District of Assam (Vadivelu *et al.* 2001). Brief description of soils and their classification are given below:

Sonaribari: It is a member of coarse-loamy, mixed, hyperthermic family of Typic Endoaquepts. This soils had olive grey, silty clay loam, neutral (pH 6.7) A horizons and very dark grey to dark greyish brown, loam or silt loam, slightly alkaline (pH 7.8) B horizons. The clay content is 35 per cent in A horizons and decreased to 9.5 per cent in B horizons. The distribution of organic carbon is irregular with depth and its content varied from 3.9 to 19.5 gkg^{-1}.

Bharaki- It is a member of coarse-loamy, mixed, hyperthermic family of Fluvaquentic Endoaquepts. It is associated with dark grey, silt loam, neutral A horizons and dark grey or dark yellowish brown, loam or silt loam, neutral B horizons with grey, sandy loam, neutral C horizons. The B horizons had 14 to 28 per cent clay and few fine dark yellowish brown mottles. The organic carbon ranged from 2.5 to 12 g kg^{-1}.

Bhakat: It is a member of coarse-loamy, mixed, hyperthermic family of Typic Fluvaquents. It had olive grey, silt loam, slightly alkaline (pH 7.7) A horizons and grey or olive grey, sandy loam or loamy sand, slightly alkaline C horizons. The thickness of A horizon is between 13 and 27 cm and had 10 to 14 per cent clay.

Boritika: It is a member of coarse-loamy, mixed, hyperthermic family of Fluvaquentic Endoaquepts. It had dark grey, loam, neutral A horizons, very dark grey or dark greayish brown, silty clay loam, neutral B horizons and grey, sandy loam or sand, slightly alkaline C horizons. The clay content ranged from 6 to 6.5 per cent in C horizons, 30 to 35 per cent in B horizons and 24 per cent in A horizons.

Adi Elengi: It is a member of coarse-loamy, mixed,

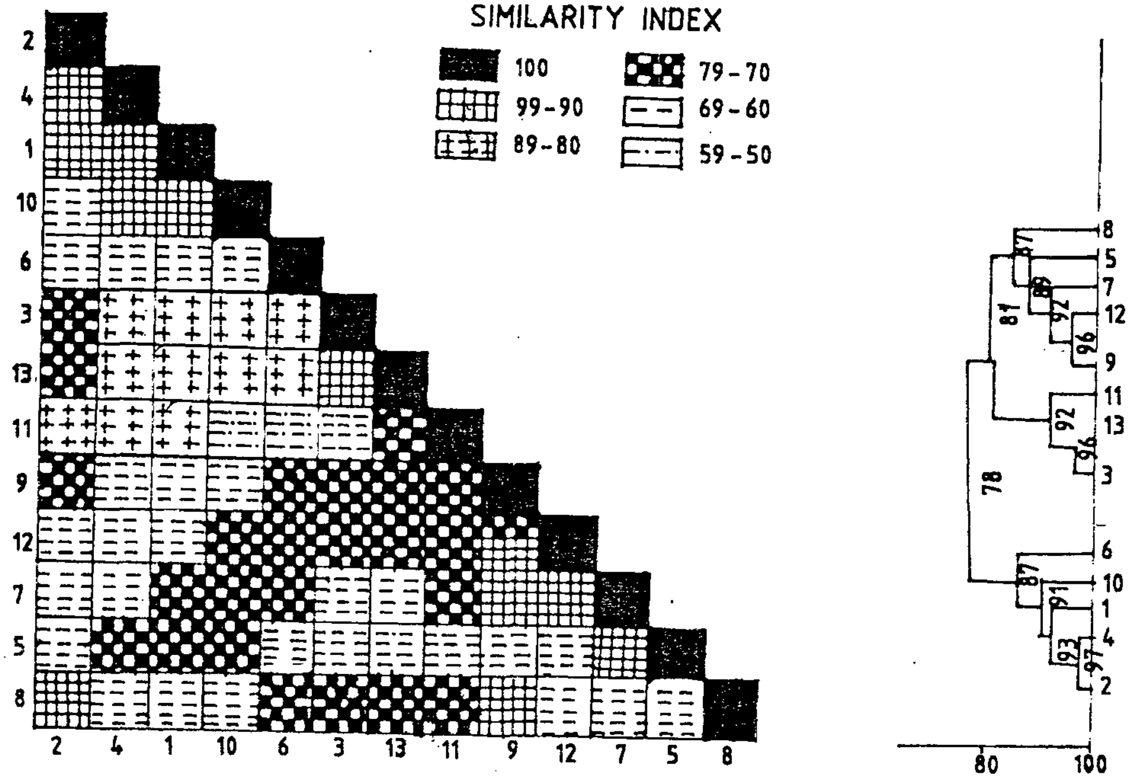


Fig. 2. Matrix and Dendogram based on similarity between soils

hyperthermic family of Typic Endoaquepts. It had grey, silt loam, neutral Ap horizons; dark grey, silt loam or silty clay loam B horizons and light grey, sand C horizons.

Puranibari: It is a member of coarse-loamy, mixed, hyperthermic family of Fluvaquentic Endoaquepts. It had dark grey, sandy loam, slightly acid A horizons; dark grey or dark greyish brown, silt loam or silty clay loam, slightly acid B horizons and grey to greyish brown, sandy loam or sand, slightly acid C horizons.

Kamalabari: It is a member of coarse-loamy, mixed, hyperthermic family of Humaqueptic Fluvaquents. It had very dark grey, loam, moderately acid A horizons; dark grey, loam, neutral AC horizons and dark grey or dark reddish brown , silt loam or loamy sand , neutral C horizons.

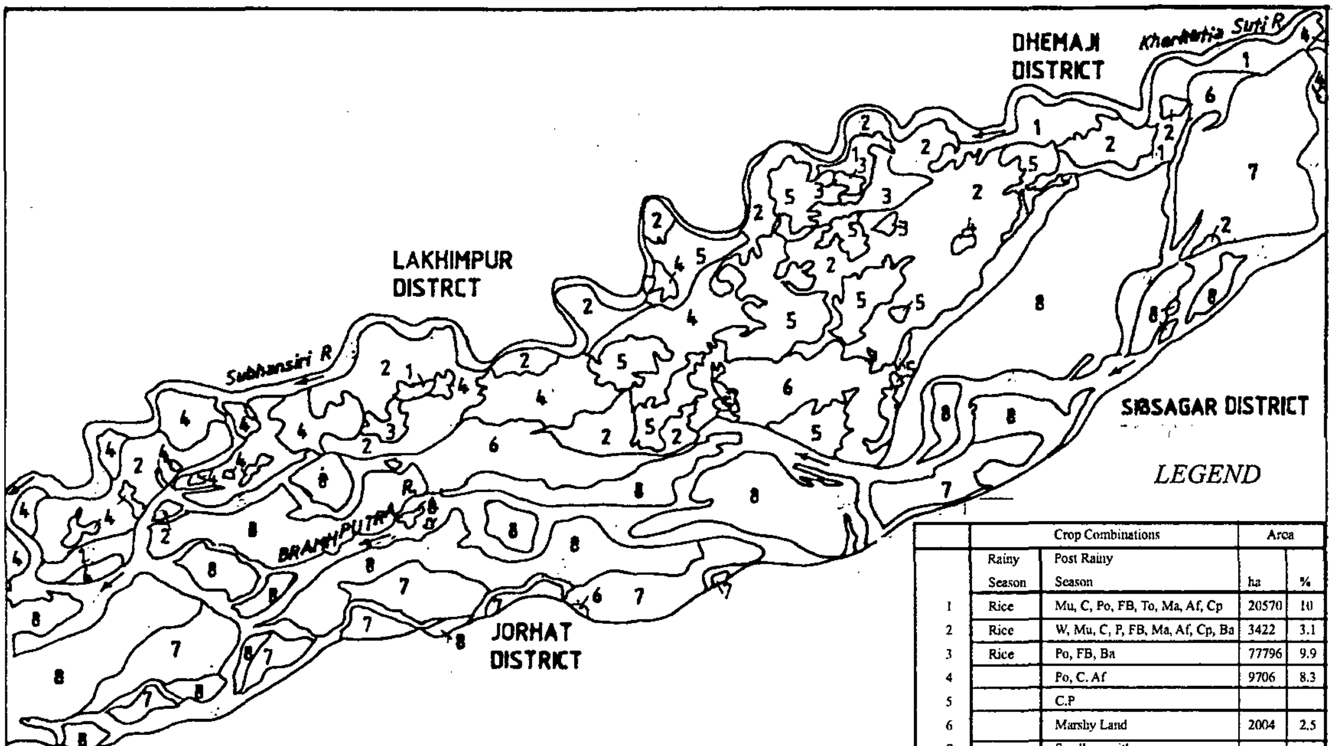
Chilakala: It is a member of coarse-loamy, mixed, hyperthermic family of Typic Endoaquepts. It had grey, silty clay loam, strongly acid (pH 5.5) Ap horizons: dark grey, silty clay loam or silty clay, slightly acid (pH 6.4) to neutral (pH 6.8) B horizons and grey, sand, neutral C horizons.

Gayangaon: It is a member of fine-loamy, mixed, hyperthermic family of Typic Endoaquepts. It had grey, silt loam, moderately acid Ap horizons; greyish brown or very dark grey/ dark grey, silt loam, neutral B horizons and white sand, neutral C horizons. The clay ranged from 4.5 to 26.5 per cent and irregular with depth.

Dakshinpat: It is a member of coarse-loamy, mixed, hyperthermic family of Humic Endoaquepts. It had very dark grey, silty clay loam, strongly acid A horizons and dark grey or olive grey, silty clay or silt loam, slightly to neutral B horizons. The clay ranged from 11.5 to 43.5 per cent and decreased with depth. The mean organic carbon was 8.87 g kg^{-1}.

Bangaon: It is a member of coarse-loamy, mixed, hyperthermic family of Typic Fluvaquents. It had dark grey, silt loam, slightly alkaline A horizons, grey, silt loam, slightly alkaline AC horizons and grey or dark grey, loam or sandy loam or sandy C horizons. The organic carbon ranged from 1.2 to 8.3 g kg^{-} (mean 3gkg^{-1}) The clay content ranged from 3 to 8.5 per cent (mean 5.6%).

Garumara: It is a member of coarse-loamy, mixed,



	Crop Combinations		Area	
	Rainy Season	Post Rainy Season	ha	%
1	Rice	Mu, C, Po, FB, To, Ma, Af, Cp	20570	10
2	Rice	W, Mu, C, P, FB, Ma, Af, Cp, Ba	3422	3.1
3	Rice	Po, FB, Ba	77796	9.9
4		Po, C. Af	9706	8.3
5		C.P		
6		Marshy Land	2004	2.5
7		Sandbars with grass cover		
8		Sand Bar		

Note :- Mu - Mustard, C- Cabbage, Po-Potato, FB - French , To - Tomato, Ma - Maize, Af - Alfalts, Cp - Cowpea, W - Wheat, P - Pea, Ba - Banana

Fig. 3. Lans use of Majuli Island Jorhat District, Assam

hyperthermic family of Typic Endoaquepts. It had grey, loam, very strongly acid A horizons; grey or dark reddish grey, loam, moderately acid or neutral B horizons and grey or white sandy loam or sand, slightly acid to neutral C horizons. It had 11.9 per cent clay, 4.7 g kg^{-1} organic carbon and 10 cmol (p^+) kg^{-1} cation exchange capacity.

Majuli: It is a member of coarse-loamy, mixed, hyperthermic family of Typic Fluvaquents. It had light grey, loamy sand, slightly alkaline A horizons and dark grey or brown, loam, neutral AC horizons. The water table is between 25 and 150 cm throughout year as it is near to the southern part of Brahmaputra river bank. This soil had mean clay of 6.6 per cent, organic carbon of 2.2 g kg^{-1} and cation exchange capacity of 7.1 cmol (p+) kg^{-1}.

Nutrient status : The nutrient status in (surface horizons) indicated that these soils are, in general, low in organic carbon, high to medium in available nitrogen and potassium, low in available phosphorus and DTPA-extractable zinc and manganese (Table 2).

Similarity of soils : Thirteen soil series are grouped into three management groups and their grouping is in agreement with soil taxonomy (Fig. 2). The Group I includes five soil series namely Bharaki, Boritika, Sonaribari, Puranibari and Dakshinpat. These soils had clay ranging from of 16.6 to 22.7 per cent, organic carbon 3.3 to 8.9 gkg^{-1} , pH of 6.5 to 7.6, CEC of 12.7 to 14.7 cmol(p^+)kg^{-1} and exchangeable K of 0.1 to 0.5 cmol (p^+)kg^{-1}. The high similarity were between Bharaki and Boritika owing to an index value of 97 (Fig. 2) and joined with Sonaribari (93), Dakshinpat (91) and Puranibari (87).

The Group II includes five soil series namely Kamalabari, Gayangaon, Garumara, Adi Elengi and Chilkala. The clay content varied from 9.7 to 16.4 per cent, organic carbon 3.6 to 4.7 g kg^{-1}, pH of 6.1 to 7.1, CEC of 6.7 to 10.3 cmol (p+) kg^{-1} and exchangeable potassium of 0.08 to 0.16 cmol (p+) kg^{-1}. Gayangaon and Garumara soils had index value of 96, Kamalabari 92, Adi Elengi 89 and Chilkala 87.

The Group III includes three soil series namely Bhakat, Majuli and Bangaon. These soils had clay content ranging from 5.6 to 7.6 per cent, organic carbon 1.5 to 3.0 gkg^{-1}, pH 7.3 to 7.9, CEC of 5.2 to 7.2 cmol $(p^{+})kg^{-1}$ and exchangeable potassium of 0.08 to 0.13 cmol$(p^{+})kg^{-1}$.

Soil mapping units and their association

Twenty five soil mapping units (soil series associations) and their spatial distribution is presented in table 3. The data indicated that sand bars cover an area of 43.2 per cent of total area in the island and is mainly associated with active flood plains (16.3 per cent) and swamps (13.6 per cent). The soils associated in active flood plains are Dakshinpat, Bhakat, Bharaki, Chilkala and Puranibari series while in swamps, Adi Elengi, Sonaribari and Bharaki soils are common. The old flood plains cover 6947 hectares (6.3 per cent) with dominant soils of Garumara and Bangaon series. It is mainly concentrated in northeastern parts near Tuni river and villages of Pakajara and Hazarikagaon.

Soil –site suitability analysis

The thirteen soil series were evaluated for their suitability to 12 crops namely rice, wheat, mustard, potato, cabbage, peas, french bean, tomato, maize, alfalfa, cowpea and banana (Table 4). The major soil limiting factors are coarse texture, pH, poor organic carbon status and low CEC. Similar soil properties were also identified as limiting factors for rice based cropping systems in Majuli (Vadivelu *et al.* 2003).

Crop plan

A comprehensive crop plan has been prepared for the flood plains of Majuli Island (Fig 3). Rice is the principal crop in rainy season but for post-rainy season, the possible crop combinations were worked out and grouped into five crop zones. It is estimated that eighteen per cent of area in flood plains (20578 hectares) is suitable for mustard, cabbage, potato, french bean, tomato, maize, alfalfa, cowpea and banana.

The marshy lands cover 2806 hectares (2.5 per cent of total area). This unit is mostly flooded during rainy season and is difficult to cultivate rice. During post-rainy season, as water recedes and water table goes down, more than 50 per cent land dries up (November to February), this unit may be put under mustard and vegetables. The best use of permanent water bodies in this unit may be used for fisheries and its surrounding dry parts may be used for cultivation of maize, legumes and vegetables. Near embankments, there is a possibility to grow cabbage, potato, mustard, frenchbean and banana. The similar pattern of crops for flood affected areas of Dhemaji was suggested by Baruah *et al.*(2003). The sand bars adjoining to swamps and marshy lands are ideal sites for bird sanctuary. It is a natural habitat for some migratory birds in the region but posing danger from local people in recent times.

Techniques for soil improvement and management

The soil improvement measures include the following practices such as (i) when the sand deposit is less than 30 cm, deep ploughing with mould-board plough should be given to improve infiltration capacity and water holding capacity of soil (ii) to grow rice in sandy soils, soil compaction is needed to create a layer of high bulk density and slow permeability in order to reduce excessive mobility of water and nutrients (iii) addition of pond sediments at the rate of 150 t ha^{-1} to improve physical condition of soils and increase nitrogen mineralization (iv) subsoil barrier with bentonite clay to reduce deep percolation losses and soil mulching to conserve soil water and moderate surface soil temperature during post rainy season. (v) split application of nitrogen fertilizers along with phosphorus and zinc for maximizing crop yields. (vi) sprinkler system of irrigation is effective and saves 15 to 45 per cent of water (viii) desiltation and regular removal aquatic vegetation in the bils is needed. It is better to link the bils as concentrated in north eastern parts of island with the Tuni river.

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