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RESEARCH ARTICLE

AGROPEDOLOGICAL ASSESSMENT OF TRADITIONAL RICE GROWING HYDRIC SOILS IN MAJULI RIVER ISLAND, ASSAM, INDIA

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Abstract

The rice cultivation in neutral to slightly alkaline hydric soils of Majuli island is a unique in maintaining ecology and geo - environment due to endosaturated conditions throughout year with depleted matrix having hue 10YR, 2.5Y and 5Y and chroma less than 2. The assessment of land capability and soil quality for rice production of hydric soils was made with soil map of twenty five units after reconnaissance soil survey on 1:50000 scale. The arable soils were assessed as good (class II) to fairly good (IV) with low fertility status, moderate to severe wetness and moderate to rapid permeability. The soil quality on active and old flood plains were estimated as medium meeting the threshold value of 35 to 65%. The colour indices, total iron, manganese and clay were used for tracing out the soil hydrology and redoximorphic features in defining the saturation class responsible for silicate clay destruction with abrupt textural changes and poor base status. Thirty five per cent of total area is suitable for rice cultivation as against the current cropped area of 7.2 per cent with potassium and zinc deficiency.

Introduction

Majuli, one of the largest river island in the world, has 92460 hectares (ha) supporting the population of 15.53 per cent (135378) of Jorhat district, Assam. This island experiences seasonal floods and severe bankline erosion causing loss of 50km^2 of land mass during 1969 to 1994 (Nayak and Singh, 1996), decline in drainage density from 0.963 km/km^2 to 0.442km/km^2 and stream frequency of 0.346/km^2 to 0.144/km^2 during 1917 to 1966-72. The frequent fury of floods may be attributed to the great earthquakes of 1897 and 1950affecting the upper Brahmaputra valley including Majuli with severe bank erosion at the rate of 5.63sq / km after a period of 80 years (1915, 1245.59 sq.km to 645 sq. km in 1995) thereby maintaining an average rate of erosion in the order of 7.4 sq. km/year (Sarma and Phukhan, 2004).

The island has low cropping intensity (102 per cent) with an average productivity of rice 487kg/ha in post rainy season (November – February) and 1325 kg/ha in rainy season (June – November) as against district average productivity of 1700kg/ha. Rice is grown on wet soils during raining season and described as the "bread basket in the region. The conversion of wetlands to agricultural use has led to higher frequency and severity of flooding, severe bankline erosion, disruption of water flow regulation and deterioration of environmental quality. Development of agriculture in the island can only be possible with assessing these wetland resources for proper land use planning (Vadivelu *et al*., 2005 and Bhaskar *et al*., 2010a). The wide spread of *aquepts* and *fluvents* in Brahmaputra valley with stratified textures, free carbonates and high organic carbon in surface layers were reported (Dey and Sehgal, 1997 and Bhaskar *et al*., 2009). These lowlands are important for agricultural development but less information is available for its utilization and intensification on a sustainable basis. Therefore, the present chapter will focus upon surveying the rice growing hydric soils resources to discuss the characteristics, potentials and constraints to optimize the rice based land use in the Majuli island.

MATERIALS AND METHODS

The Majuli island ($93^{o}30'$ - $94^{o}35'$ E and $26^{o}50'$ and $27^{o}10'$ N) is situated in north of Jorhat district. The elevation on the island varies from 60 to 85 m above mean sea level. The island is bounded by three important rivers *viz;* Kherkutia Suti, the Subansiri in the north and the Brahmaputra river in the south. The island is marked by seventy bils (local name for water bodies), which break the monotony of flat relief. The Majuli island experiences subtropical monsoonic climate with *aquic*/*udic* soil moisture regime and *hyperthermic* soil temperature regime. The island supports the growth of evergreen, semi-evergreen and deciduous trees, grasses and marshy vegetation (Bhagabati, 2001). The grasses in wetlands include *Phragmites karka*, *Arundo donax*, *Chrysopogon aciculatus*, *Imperata cylindrical*, *Cynodon dactylon* and V*etiveria zizaniodes*. The marshy vegetation includes *Eichhornia crassipes*, *Pistia stratiotes*, *Nymphaea nouchali*, *Nelumbo nucifera*, *Trapa bispinosa*, *Euryale ferox*, *Cyperus rotandus*, *Alisma plantago* , *Polygonum hydropiper*, *Alpinia allughas* and *Ipomea reptan*s .

The soil resource inventory started with the interpretation of IRS-ID imagery and corresponding toposheets of Survey of India (83F/3, 83I/4, 83I/8, 83J/1 and 83J/5) dated 18^{th} January, 2003 (scale of 1:50000) with the emphasis on transects that cut across the segments of inland valleys from the top to the bottom. A total of 64 soil profiles were described and recorded morphological characteristics (Schoeneberger *et al.*, 2012) and classified soils as per USDA soil taxonomy (Soil Survey Staff, 2006). The munsell colour notation was converted to a single numerical colour index as per the scheme of Evans and Franzmeier (1988). The scheme consists of three steps (1) condense the munsell notations of soil colour into a single number, (2) apply that number to the various parts of features of a soil horizon to obtain a number of that horizon , and (3) integrate horizon values into a single number to represent the pedon.

Hue index (C1) = (i=1m∑X matrix,i C matrix , i) + (i=1n∑X mottles, i C mottles ,i)

Chroma index (C2) = [i=1m∑X matrix, i (45- H matrix, I +⁽ C matrix , i)]+ [(i=1n∑X mottles,i.e., 20(45- H mottle + Cmottle,i)]

Where X = abundance (Fraction), C = munsell chroma, m = total number of matrix colors, n = total number of redox concentration and depletion colors described, H is function of munsell hue rated as : 10R = 10, 2.5YR = 12.5, 5YR = 15……2.5Y = 22.5, 5Y = 25…..and 5BG=45, abundance assigned values (few = 0.01, common = 0.11, many = 0.35)

Horizonwise soil samples of identified thirteen hydric soil series were collected for laboratory analysis. Particle size analysis (International pipette method), P^{H} (1:2 soil water ratio), organic carbon (wet oxidation method), exchangeable bases extracted 1N neutral NH4oAC by atomic absorption spectrophotometer (Perkin Elmer model 2380), cation exchange capacity by distillation method and total elements in triacid digestion and available N,P,and K were determined as per the standard procedures (Gee and Bauder, 1986 and Page *et al.*, 1982).

Twenty four soil mapping units in the island (Bhaskar *et al.*, 2010) strongly advocated to adopt modified and simplified version of land capability classification (Grose, 1999). The ground water and flood frequency are included as major factors in deciding capability class. There are generally three levels to the land capability classification: - The land capability class - which gives an indication of the general degree of limitation to use; subclass - which identifies the nature of the dominant limitation; and the unit which groups together similar types of land requiring the same kind of management.

Soil quality assessment

The soil quality indicators for crop production were selected using the approach (Cameron *et al.*,1998). The approach is based on the equation: A = (S, U, M, I, R) where A = acceptance score for indicators, S = sensitivity of the indicators to degradation or remediation process, U = ease of understanding of indicator value, M = ease and / or cost effectiveness of measurement of soil indicators, I = predictable influence of properties on soil, plant and animal health and productivity, R = relationship to ecosystem processes (especially those reflecting wider aspects of environmental quality and sustainability). Each parameter in the equation was given a score of 1 to 5 based on experience. The acceptance score for indicators were derived by dividing sum of scores of an individual indicator by total score (25) and then multiplied with 100.

For example, the assigned score for organic carbon was as follows (S = 4, U = 5, M = 3,I = 4 and R = 4), then the Acceptance score (A) = 20 / 25 x 100 = 80%. The following indicators were selected for soil quality assessment: pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases, cation exchange capacity, texture, structure, effective rooting depth and available water holding capacity as suggested by Lal (1994) in the tropical region. The quality of the hydric soils for crop production was assessed using multiple variable indicator transform (MVIT) (Smith *et al*., 1994). The indicators were transformed on the basis of their ability to attain critical level or range scored as 1 and anyone below critical as 0. Later, these were integrated into per centage quality rating (% Q rating) as %Q = Number of indicators that attain critical level / total number of indicators assessed X100.These ratings were further grouped as High (% Q rating > 65), medium (% Q rating 35 to 65) and low (% Q rating

RESULTS AND DISCUSSION

Morphology and soil taxonomy in relation to landforms

Field morphology of paddy growing hydric soils of Majuli island were diversely developed based on the source of parent material, the texture sequence in the profile and the degree of drainage. The main diagnostic epipedons are ochric and mollic with diagnostic subsurface horizons predominantly cambic horizons (Bw). These soils displayed the distinct morphological features of gleyzation of surface soil, formation of compact subsurface layer (plowpan), surface accurnulation of organic matter, formation of redoximorphic features such as Fe/Mn nodules and clay/Fe depletions, chloritization of clay minerals in the surface soils by submergence and redistribution of base cations. Six landforms were delineated as per the classification scheme of floodplains of Majuli island (Nanson and Croke, 1992) viz., active floodplains, sandbars, swamps, old flood plains, channel fills and natural levees. The occurrence of similar kinds of fluvial landforms in Brahmaputra valley were reported (Sarma, 2005).

The flat active flood plains cover 16.3 per cent of the area with dominant soil series such as Kamalabari (Kb), Puranibari (Pb), Dakshinpat (Dh) and Bhakat (Bt). These soils have Ap – AC - C horizon sequence, dark grey (10YR4/1) A horizons, clay loam to silt loam textures with moderate, medium subangular blocky structures. The AC horizons are dark grey (10YR4/1) and loamy but changed to loamy sand in C horizons. These soils are classified as *Humaqueptic Fluvaquents* (Kamalabari series, Kb), *Humic Endoaquepts* (Dakshinpat,Dh), *Typic Fluvaquents* (Bhakat, Bt) and *Fluvaquentic Endoaquepts* (Puranibari, Pb). The sandbars cover 43.2 per cent of area with dominant soil series of Majuli (Mj, *Typic Fluvaquents*) and Garumara (Ga, *Typic Endoaquepts*). These soils have olive grey to dark grey A horizons, coarse loamy and slightly alkaline pH. These bars are mostly adjacent to swamps and marshes suitable for habitat of migratory birds in the region.

The swamps are lowlying, featureless flat surfaces of active or abondanded channels enriched with suspended sediments consisting of silt, clay and fine sands. This unit covers 14 per cent of area with dominant soil series of Bharaki (Bi, *Fluvaquentic Endoaquepts*) and Bongaon (Bn, *Typic Fluvaquents*). These soils have dark grey and silt loam textured with weak subangular blocky structures. The neutral to slightly alkaline, cambic B horizons have dark grey matrix with silt loam to silty clay loam and moderate angular blocky structures (Table 1). The old floodplains are concentrated in south central parts of tuni river and cover 6.3 per cent of area. This unit is occasionally flooded during rainy season. Adielengi (Ae) and Chilkala (Ch) are dominant with grey matrix, silty loam A horizons to dark grey silty clay B horizons followed by sandy C horizons. These soils are classified as *Typic Endoaquepts*.

The channel fills are convex downward portions rich in sediments of fine sand, silt and clay. These channels are mostly concentrated in northern parts of subansiri river banks. These channel fills cover 11.8 per cent of total area. Gayangaon (Gy, *Typic Endoaquepts*) and Boritika (Ba, *Fluvaquentic Endoaquepts*) are dominant with Ap - B/A – Bw - BC horizon sequence. The Ap horizon is 13 cm thick, olive grey (5Y5/2) and silty clay loam textured. The B horizons are dark grey (5Y4/1) to very dark grey (5Y3/1) or dark greyish brown (2.5Y4/2), silt loam textures and yellowish brown mottles. Natural levees are depositional land units covering 8.9 per cent of total area. This unit has interbedding coarse to fine sediments of sand, silt and silty clay with dominant soil series of Sonaribari (Sb, *Typic Endoaquepts*).These soils have neutral A horizons with olive grey matrix and silty clay loam texture.

Thes soils in majuli island have displayed stripped zones or horizons of Fe, Mn or C due to reduced soluble forms under anaerobic conditions. Using the formulae of colour indexes as proposed to relate soil wetness and aeration characteristics by Evans and Franzmeier (1988), the calculated hue (C1) and chroma (C2) indices (Table 1) show that the dark grey to dark reddish brown Kamalabari soils (P1) on active flood plains have decreasing trends of hue index (0.35 to 0.11) with little changes in chroma index with depth (9.1 to 9.5). This soil has loamy soil material with chroma 2 or less without any redox depletions. The grey Adielengi soil (Ae) on swamps (P2) have low hue index (0.11) in upper 34 cm but increased to 0.55 in brown B horizons. This soil has sandy gleyed matrix in C horizons and chroma 1 or 2 .This soil has low chroma index with little changes with depth (2.3 to 2.97). The Sonari bari soil (P3) on channel fills have stratified textures with olive grey to dark greyish brown matrix and brown mottles from 38 to 90cm. The hue shows inflections with depth generally having index value of 0.7 in 30cm surface layers but decreased to 0.11 in C horizons. The chroma index varies from 2.1 to 2.98 with depth. The Boritka soil (P4) on old floodplains have dark grey to dark greyish brown matrix with chroma 1 or 2. This soil has 0.11 to 0.22 hue index and 2.25 to 2.36 chroma index with slight changes with depth. The hue index has strong positive relation with Fe (0.43*) and Mn contents (0.42*) where as chroma index has a negative weak relation with Fe (- 0.32) and Mn (- 0.42). This colour index had a nonlinear relationship with time of saturation (Fiedler and Sommer, 2004). Such kind of relations were reported in hydric soils of Brahmaputra valley by Bhaskar *et al*.(2009). The negative relation of chroma index with saturation duration at a depth of 50 to 100cm in soils of Chungli quaternary terraces of northern Taiwan by Jien *et al*.(2004).

Chemical characteristics of soils

All soils are neutral to slightly alkaline except Kamalbari soil (P1) on active flood plains with moderately acid to neutral pH. The organic carbon varies from 9.7g/kg (P2) to 19.5 g/kg (P3) in Ap horizons but decreased to 0.6 g/kg in C horizons of all soils (Table 2). These soils have low cation exchange capacity (3.5 cmol/kg in C horizons of P2 to 20 cmol/kg in 2Bw2 (P4) with variable depth distribution. The low cation exchange capacity in these soils is due to destruction of silicate clay during ferrolysis (Brinkman, 1970) causing replacement of exchangeable bases by Fe^{2+} upon the onset of reduced conditions. These cations are leached out. Under oxidized conditions, iron gets precipitated and produces H^+ that causes charge reduction and loss of Al^{3+} from octahedral layer. The cation exchange capacity of these soils is positively and strongly related with organic carbon (0.63**) and clay (0.86**). The linear relation between CEC, organic carbon and clay is expressed in regression equation as :-

(i)CEC (cmol(p+)kg^{-1}=0.853(organic carbon (g/kg) – 3.99

(ii)CEC (cmol(p+)kg^{-1}=2.15 (clay %) - 10.35

Soil site suitability analysis

Thirteen soils series information was used to generate soil map with twenty five mapping units (series association) in GIS environment (ARCINFO. 8 version). Attempts were made to link transect information of both physical and agronomic characteristics with geographically defined mapping units (Bhaskar *et al*., 2009 and 2010a). The soil - site suitability analysis for rice based cropping systems was done as per the land evaluation methods (Sys *et al*., 1993) where in soil characteristics were matched with crop requirements at different limitation levels. Suitability classes and subclasses of moderately suitable (S2) for different crops were considered in generating land use map. A comprehensive crop plan was prepared by considering suitability class and a minimum area of 500 ha. Rice is the principal crop in the rainy season but possible crop combinations were workedout for post rainy season. It was estimated that 20578 ha (18 per cent of total geographical area) in the flood plains is suitable for mustard, cabbage, potato, French bean, tomato, maize, alfalfa, cowpea and banana during post rainy season. About 2806ha of marshy land mostly flooded during rainy season is unfit for rice cultivation but during post rainy season (November to February), water recedes and water table goes down and more than 50 per cent of marshy land dried up. The dried up parts in marshes are put for mustard and vegetable cultivation. The best use of permanent water bodies may be used for fisheries to support migratory birds and their surrounding dry parts could be used for maize, legumes and vegetables. The proposed crop plan estimated 35 per cent of total area is suitable for rice cultivation as against the current cropped area of 7.2 per cent.

Soil quality assessment

The arable soil mapping units (from class II to class IV) were grouped further in accordance with landforms and soil quality (Table 4). The fourteen soil mapping units in class II (17306 ha, 15.72%), are further grouped as per quality rating into three categories such as low (2 units in active flood plains), medium (11 units) and high (1 unit). The Puranibari - Sonaribari soil mapping unit (18) has high quality of selected indicators above the threshold values except total nitrogen content whereas medium quality soils are seasonally flooded with shallow ground water tables throughout year and neutral to slightly alkaline with low potassium reserves. The low quality rating is due to pH and total nitrogen (Bharaki – Chilkala - Adielengi, 3) and (Dakshinpat - Bhakat and Bharaki, 7). The class III has 13 soil units covering 16.9 per cent of area but have only 1.11 per cent (1217 ha) under high quality, 7.19 per cent (7903 ha) under medium quality and 2.35 per cent (2583 ha) under low quality. The class IV has 14 units covering 8.22 per cent of area (9046 ha), of which 3.88 per cent of area is under high quality soil associations followed by 1.39 per cent of area (1541 ha) under medium quality and 2.93 per cent of area (3229 ha) under low quality. The soil quality and its relationship with capability classes implies that pH and organic matter are crucial in modifying soil structure and its influence in water retention and nutrient availability. The soil quality assessment in riverine islands with flat to gentle slopes is helpful to identify the areas subjected to ferrolysis (Brinkman, 1970) and compare units under different rice management systems of special interest such as Bao and Boro/ Ahu seasonal systems. Similar kind of the selected soil properties were reported in sagware tehsil of Durgapur district in crop lands (Choudhary *et al.*, 2008) where as nutrient status of lake sediments in Gulbarga district , Karnataka by Rajasekhar and Vijay Kumar (2008).

Agronomic interpretation

The soils in the island are saturated for more than 200 days per year with depleted matrix with chroma less than 2 and moderate structural B horizons. The fine loamy Puranibari (Pb), Dakshinpat (Dh) soils have mean clay content of 18 to 27 per cent while in other soils , the clay content is less than 16 per cent. It is ascertained from the literature that clay textures are superior to silt and sand textures for rice production (Moormann and Dudal, 1964). It was further reported that application of recommended dose (75% NPKS) of inorganic fertilizers along with organic manures (@ 5t FYM ha-1), biofertilizers and the micronutrients, gave the highest nutrients content (N, P, K, S and Zn), protein and test weight of rice as compared to inorganic fertilizer alone under optimal as well as sub optimal soil moisture regimes of vertisols in Madhya Pradesh (Sahu *et al.*, 2014). These soils are slightly acid to neural in reaction exhiting stratic layers with elemental variations specially Fe and Mn oxides as soft nodules near the zone of fluctuating water tables (Vespraskas, 2000). These soils are subjected to ferrolysis due repeated regular cycles of oxidation and reduction leading to silicate clay destruction with abrupt textural changes and leaching of exchangeable bases resulting to poor cation exchange capacity. The modifier “g*” is used to designate prolonged waterlogging and gleying in these soils with an additional modifier “e” for nitrogen management and “k” for nutrient imbalance such as Ca, K and Mg. All soils are deficielnt in available potassium where as 9.2 % of soils are basic mostly occurring on channel fills with Fe deficiency when aerobic, Zn deficiency when waterlogged and high N voltalization losses from broadcast N application. Thirty five per cent of soils have low cation exchange capacity, less gradual N release and potential Fe toxicity if adjacent uplands have Fe rich soils (Table 5). The flooded rice soils have high iron favouring deficiencies of phosphorus, potassium (akagare type-1) and zinc deficiency (khaira, Tanaka and Yoshida, 1970). The soil units in active and old flood plains have potassium deficiency (Bhaskar *et al.*, 2010b) as the ratio between exchangeable calcium and magnesium to exchangeable potassium is more than 100 (Tandon and Sekhon, 1988) and also have K saturation less than 1.5 per cent (Dobermann and Fairhurst, 2000).

Table 5.Distribution and extent of modifiers in fertility capability units of wetlands

FCC modifiers	Extent of area(ha)			Total area	
	Active flood plains	Oldflood plains	Channel fills	(ha)	(%)
g*(pergleyic , soil profile saturated for more than 200 days)	11195(42.6%)	3565(13.6%)	11525(43.9%)	26285	78.6
k-low reserves of potassium and weatherable minerals)	16015(47.9%)	5911(17.7%)	11525(34.45%)	33451	100
b-basic reaction(pH>7.3)	1751(57.18%)	1311(42.82%)	-	3062	9.2
e-Low cation exchange capacity	2540(21.48%)	1022(8.64%)	8260(69.86%)	11822	35.3

Table 1. Morphology of rice soils

Soil series	Depth (cm)	Horizon	Colour		Texture	Hue index(C1)	Chroma index(C2)	Structure	Consistence	Boundary
			Matrix	Mottle						
P1.Sonaribar(Sb)	0-13	Ap	5Y5/2		sic	0.7	2.42	f1sbk	s,p	cs
	13-31	B/A	5Y4/2		sicl	0.7	2.42	f1sbk	s,p	cs
	31-38	Bw1	5Y4/1		l	0.35	2.31	m1sbk	ss,sp	as
	38-47	Bw2	5Y4/2	f2d,10YR4/3	sil	0.70	2.70	m1sbk	ss,sp	cs
	47-56	Bw3	5Y3/1	f2d, 10YR4/3	sil	0.22	2.6	m1sbk	ss,sp	cs
	56-66	Bw4	2.5Y4/2	f2d, 10YR4/3	sil	0.22	2.9	m1sbk	s,p	cs
	66-90	C	5Y4/1	m2d, 10YR4/3	sil	0.11	2.6	m1sbk	s,p	cs
P2.Bharaki (Bi)	0-20	Ap	10YR3/1		sil	0.35	2.86	c2sbk	s,p	cw
	20-30	C1	10YR6/1		s	0.35	2.86	sg	so,po	as
	30-48	2Bw1	5Y4/1		sicl	0.35	2.31	m1sbk	s,p	cs
	48-68	2Bw2	10YR4/4	fif,10YR3/4	sil	1.46	3.48	m2sbk	ss,sp	gw
	68-99	2Bw3	10YR4/3	fif,10YR4/4	sicl	1.09	3.37	m2sbk	s,p	gw
	99-140	2Bw4	10YR5/1	fif,10YR4/4	sic	0.15	3.5	m3sbk	vs,vp	
P3.Bhakat (Bt)	0-27	Ap	5Y5/2		sicl	0.70	6.3	f1sbk	vfr,ss,sp	cs
	27-46	AC	5Y6/1		sil	0.35	6.65	f2sbk	fr,ss,sp	cs
	46-85	C1	5Y6/1		s	0.11	6.65	sg	so,po	as
	85-98	C2	5Y4/2		sil	0.22	6.30	m1sbk	ss,po	as
	98-180	C3	5Y6/1		s	0.11	6.65	sg	so,po	
P4.Boritika (Ba)	0-26	Ap	2.5Y4/1		sicl	0.11	2.37	c2sbk	vs,vp	cs
	26-52	C1	2.5Y5/1		s	0.11	2.37	f1sbk	so,po	cs
	52-64	2Bw1	2.5Y3/1		sicl	0.11	2.37	m2sbk	vs,vp	cs
	64-79	2Bw2	2.5Y4/2		sicl	0.22	2.26	m2sbk	s,p	cs
	79-113	C2	2.5Y5/2		s	0.22	2.26	sg	so,po	
P5.AdiElengi (Ae)	0-13	Ap	10YR5/1		sil	0.11	2.31	f1sbk	fr,ss,sp	cs
	13-34	Bw1	10YR4/1		sicl	0.11	2.31	m2sbk	sh,s,p	cs
	34-60	Bw2	10YR4/2	m1f, 10YR4/3	sicl	0.55	2.70	m2sbk	sh,s,p	as
	60-98	C1	10YR4/2		s	0.22	2.97	sg	So,po	as
	98-225	C2	10YR7/1		s	0.11	2.86	sg	so,po	
P6.Puranibari (Pb)	0-14	Ap	10YR5/1		l	0.11	2.64	m2sbk	ss,sp	cs
	14-27	A/B	10YR5/2		sil	0.22	2.53	m1sbk	ss,sp	cs
	27-46	C1	10YR6/1		s	0.35	2.64	sg	so,po	as
	46-71	C2	10YR5/2	f2c,7.5YR4/3	ls	0.73	2.78	m1sbk	so,po	cw
	71-86	2Bw1	10YR4/2	f2d, 7.5YR3/3	sicl	0.73	2.78	m2sbk	s,p	cw
	86-105	2Bw2	10YR4/1	f1d,7.5YR4/4	sic	0.15	2.86	m2sbk	vs,vp	cw
	105-175	2Bw3	10YR4/1	f1d,10YR4/3	sic	0.14	2.86	m2sbk	vs,vp	cs
P7.Kamalabari (Kb)	0-19	Ap	10YR3/1		cl	0.35	9.1	m2sbk	ss,sp	cs
	19-39	AC	10YR4/1		sil	0.35	9.1	m2sbk	ss,po	cs
	39-61	C1	10YR4/2		sl	0.22	9.5	f1sbk	so,po	cs
	61-89	C2	10YR4/1		sl	0.11	9.1	f1sbk	so,po	cs
	89-130	C3	10YR4/1		s	0.11	9.1	sg	so,po	cs
P8.Chilkala (Ch)	0-16	Ap	10YR5/1		sicl	0.11	9.1	m2sbk	fr,s,sp	cs
	16-35	Bw1	10YR4/1		sic	0.11	9.1	m3sbk	fr,s,p	gs
	35-59	Bw2	10YR4/1		sic	0.35	9.1	m2sbk	fr,s,p	gs
	59-170	C1	10YR6/1		s	0.35	9.1	sg	vfr,so,po	cs
P9.Gayangaon (Gn)	0-13	Ap	10YR5/1		sicl	0.11	9.1	m1sbk	fr,s,sp	cs
	13-39	Bw1	10YR5/2		sicl	0.22	9.5	f1sbk	fr,s,sp	cs
	39-54	Bw2	10YR5/2	fif,10YR3/4	sicl	0.26	9.7	m1sbk	fr,s,sp	gw
	54-72	Bw3	10YR3/1		cl	0.11	2.9	m2sbk	fr,s,sp	gw
	72-94	Bw4	10YR4/1		cl	0.11	2.9	f1sbk	fr,s,sp	gw
	94-169	C	10YR8/1		s	0.11	2.9	sg	so,po	gs
P10.Dakshinpat (Dh)	0-13	Ap	5Y3/1		l	0.35	7.35	massive	ss,sp	cs
	13-34	Bw1	5Y4/1		sic	0.35	7.35	m3sbk	s,p	cs
	34-55	Bw2	5Y4/2		sic	0.72	7.72	m2sbk	s,p	gs
	55-105	Bw3	5Y4/3		sic	1.05	8.05	m2sbk	s,p	gs
	105-200	BC	5Y5/4		sl	1.40	8.40	f1sbk	ss,sp	
P11.Bongaon (Bn)	0-13	Ap	10YR4/1		sl	0.35	9.1	f1sbk	ss,po	cs
	13-38	AC	10YR5/1	f1f,10YR4/4	l	0.39	9.39	m1sbk	ss,sp	cs
	38-68	C1	10YR5/1	f1f, 10YR4/4	ls	0.39	9.39	m1sbk	ss,sp	cs
	68-80	C2	10YR4/1		s	0.35	9.10	sg	so,po	cs
	80-105	C3	5Y3/1	f1d,10YR4/3	sl	0.38	7.63	f1sbk	so,po	cs
	105-170	C4	5Y5/1		s	0.35	7.35	sg	so,po	cs
P12.Garumara (Ga)	0-14	Ap	10YR5/1	7.5YR3/3	cl	0.35	9.10	m1sbk	s,sp	cs
	14-43	Bw1	10YR5/1	m2d,7.5YR4/4	cl	0.68	9.41	m1sbk	fr,ss,sp	cs
	43-64	Bw2	10YR4/2	f1d,10YR4/4	l	1.62	12.92	f1sbk	fr,ss,sp	cw
	64-75	BC	10YR4/1		cl	0.39	3.15	f1sbk	vfr,ss,sp	cw
	75-160	C	10YR8/1		c	0.35	2.86	m1sbk	vfr,ss,sp	
P13.Majuli (Mi)	0-33	Ap	10YR7/1		s	0.35	9.1	sg	so,po	cs
	33-57	AC1	10YR4/2		ls	0.70	9.45	f1sbk	so.po	gs
	57-82	AC2	10YR4/1		ls	0.35	9.1	f1sbk	so,po	gs

Table 2. Selected physical and chemical properties of surface 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^{+}	
Sonaribar(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 (Mi)	ls-l-l	61.6	31.8	6.6	7.3	2.2	3.0	2.7	0.7	0.08	7.1

Table 3. Nutrient status in surface horizons of soils

Soil series	**Available**			**DTPA extractable**				**Total**			
	N	**$P_2 0_5$**	**K_2O**	**Mn**	**Fe**	**Cu**	**Zn**	**Mn**	**Fe**	**Cu**	**Zn**
	($kgha^{-1}$)			**(mg/kg)**				**(g/kg)**		**(mg/kg)**	
Sonaribari(Sb)	874 (H)	46.2(M)	584 (H)	17.3	128	10.4	0.84	0.65	45.1	50	104
Bharaki (Bi)	655 (H)	12.6(L)	206 (M)	4.9*	110	9.7	0.46*	0.46	38.7	45	86
Bhakat (Bt)	437 (M)	8.4 (L)	172 (M)	2.3*	23.0	3.6	0.34*	0.63	36.8	32	80
Boritika (Ba)	582 (H)	37.8(M)	275 (M)	13.3	444	6.0	0.54*	0.58	36.2	36	87
AdiElengi (Ae)	509 (M)	46.2(M)	310 (H)	5.1*	1.5	4.4	0.48*	0.64	38.3	39	77
Puranibari (Pb)	655 (H)	37.8(M)	344 (H)	30.8	2500	3.3	0.52*	0.57	32.5	23	64
Kamalabari (Kb)	655 (H)	5.2(L)	378 (H)	11.0	114	4.7	0.54*	0.37	30.1	28	109
Chilkala (Ch)	291 (M)	23.6(L)	344 (H)	1.0*	156	7.5	0.58*	0.52	36.2	45	105
Gayangaon (Gn)	801 (H)	25.2(L)	378 (H)	3.6*	101	5.7	0.36*	0.44	38.2	38	138
Dakshinpat (Dh)	1456 (H)	26.2(L)	447 (H)	30.0	495	10.5	0.52*	0.54	39.5	52	94
Bongaon (Bn)	510 (M)	25.2(L)	206 (M)	7.5*	82	3.9	0.30*	0.67	30.5	30	74
Garumara (Ga)	582 (H)	31.2(M)	344 (H)	23.6	226	3.8	0.62*	0.48	32.6	29	189
Majuli (Mi)	582 (H)	25.1(L)	104 (L)	9.5	34	7.4	1.28	0.49	24.6	17	63

Table 4. Mapping unit wise soil quality rating in relation to landforms and capability class

Soil quality rating	Landforms	Land capability class					
		II		III		IV	
		Soil mapping unit	Area **ha** / %	Soil mapping unit	Area **ha** / %	Soil mapping unit	Area **ha** / %
Low (<35%)	Active flood plains	3.Bi-Ch-Ae 7.Dh-Bt-Bi	**3717**/3.38	5.Ch-Ae-Bt	**250**/0.23		
	Old flood plains			1.Ae-Bt-Ch 2.Ba-Bt-Ga	**2333**/2.12	3.Bi-Ch-Ae 7.Dh-Bt-Bi	**2153**/1.95
	Channel fills					5.Ch-Ae-Bt	**1076**/0.98
Medium (35-65%)	Active flood plains	10.Ga-Bn 12.Kb-Ga-Ch 13.Kb-Pb-Bn 16.Mj-Sb 17.Pb-Kb-Mj	**6145**/5.59	4.Bt-Ga-Bn 15.Mj-Kb 19.Sb-Ba-Bt 20.Sb-Ba-Mj	**2054**/1.88	8.Dh-Bt-Ga 14.Mj-Ga	**944**/0.86
	Old flood plains	4.Bt-Ga-Bn 12.Kb-Ga-Ch 13.Kb-Pb-Bn 19.Sb-Ba-Bt 21.Sb-Bn	**2252**/2.04			15.Mj-Kb	**86**/0.08
	Channel fills	13.Kb-Pb-Bn	**1816**/1.65	19.Sb-Ba-Bt 20.Sb-Ba-Mj	**5849**/5.31	4.Bt-Ga-Bn 14.Mj-Ga	**333**/0.29
	Natural levees			15.Mj-Kb	**5789**/5.26	21.Sb-Bn	**178**/0.16
High (>65%)	Active flood plains	18.Pb-Sb	**3376**/3.07	9.Dh-Kb-Gn	**711**/0.65	22.Sb-Ga-Mj 25.Sb-Mj-Kb	**686**/0.62
	Old flood plains			11.Gn-Bn-Ga	**85**/0.08	18.Pb-Sb	**38**/0.04
	Channel fills			22.Sb-Ga-Mj	**421**/0.38		
	Natural levees					**23.Sb-Mj-Bn** **24.Sb-Mj-Pb**	**3552**/3.22

CONCLUSION

The wetland soil resource inventorty in Majuli island for rice production clearly showed that 35 per cent of total area is suitable for rice cultivation as against the current cropped area of 7.2 per cent. The welands have six fluvial landforms viz. sandbars (43.2 per cent of total area) followed by active flooplains (16.3per cent), old floodplains (6 per cent), channel fills (11.8 per cent), swamps (14 per cent) and natural levees (8.9 per cent) with thirteen soil series showing distinct variations in total iron and manganese in relation to clay content and effect of seasonal changes in modifying soil colours. The prolonged saturated paddy soils in 26285 hectares have low available potassium with Fe deficiency when aerobic and Zn deficiency when waterlogged. The island had 43 per cent of arable land with 12.39 per cent of soil units under medium quality, 8.66 per cent of soil units under low quality and 8.1 per cent of soil units with high quality. Flood frequency and erosion risk hazard were two important factors influencing land capability whereas soil organic matter, pH, available phosphorus and exchangeable bases are soil quality controlling factors. The soil mapping units in channel fills have low cation exchange capacity and low potassium reserves as compared to active and old flood plains. The rice grown on these soils (8.22 % of total area) have high iron with deficiencies of phosphorus, potassium and zinc. Hereby concluded that the land capability and soil quality assessment are jointly responsible for workable solutions to rice production under different management systems in the island.

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