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Case Study

Development of Soil Site Suitability Model for Paddy Crop: A Case Study of Hydromorphic Soils in Indo-Gangetic Plain

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A B S T R A C T

The present study was designed with an aim to develop soil site suitability model for paddy crop of hydromorphic soils under Indo-Gangetic plain. To achieve this target, the demarcation of hydromorphic soils had done based on the visual interpretation of FCC image, which was localized in Alauli (P_1), Gogri (P_2), Mansi (P_3), Khagaria (P_4) and Parbatta blocks (P_5), respectively. The results indicated that P_1 and P_5 were moderately suitable for paddy, whereas, and P_2, P_3 and P_4 were placed under marginal suitable (S_3) on the basis of its actual land suitability class (ALSC). While, inclusion of different management practices like advocation of FYM, BGA and recommended dose of fertilizer based on soil test value, it has been placed brought under moderately suitable class (S_2) on the basis of potential land suitability class (PLSC). These results could be concluded that inculcation of suitable management options to avoid the certain limitation soil fertility constrains like organic carbon, soil wetness and topography enable to enhancement of productivity potential of paddy crop in this region.

Introduction

The Indo-Gangetic Plain mainly alienated with Indus-Ganga Plain and the North Indian River Plain which is account of about 2.5-million km^2. It encompasses fertile plain in the northern regions of the Indian subcontinent, and including most of northern and eastern India. The plain is bound to the north through Himalayas, which feed its numerous rivers and are the source of the fertile alluvium deposited across this region.

However, crop cultivation has always been continue by without knowing the location and its specific inherent capacity including limitations of soil fertility constrains like wetness, low organic carbon, texture which enable to shows significant effect towards decline in productivity and deterioration of soil health (Gandhi and Savalia, 2014; Naidu, Ramamurthy, Challa, Hegde, & Krishnan, 2006). Several researchers have also been evaluated soil suitability for various crops like wheat, barley, rice, maize, sugarcane,

sunflower, potato *etc.,* (Bhagat *et al.,* 2009; Kumar *et al.,* 2010, 2013) with different suitable methods or approaches through inclusion of input factors related to soil properties or the logic of suitability rating and matching procedures etc.

Hydromorphic soils is defined as a suborder of intrazonal soils, consisting of among seven great soil groups formed under poor drainage conditions like marshes, swamps, seepage areas or flats" (WSR, 2006). Despite being the predominant evidence of reduction and segregation of Iron (Fe) stretches to temporarily permanent saturation of pores water, and its causes prolonged deficiency of oxygen (Duchaufour, 1992). The poor drainage and seepage pose to poor aeration, reduced conditions, and reduction of their biological activity, tends to hamper the outright of all soil-forming factors, which is to be essential for normal soil development. The distinctive gley horizons have been resulted from oxido-reduction process, and mottled B horizon with rusty Fe and manganese (Mn) or streak because of slow diffusion process (Ponnamperuma *et al.,* 1985 and Bhattacharya *et al.,* 1997). The wide range of geo-statistical tools is offering newer dimensions to address problems related to site suitability analysis (Bal *et al.,* 2018; Suryabhagavan *and* Balakrishnan, 2016).

The modern tools like remote sensing and Geographic information system aids to gathered voluminous information's regarding multispectral, multi- temporal and multi-sensor with better accuracy and offer more efficient data acquisition and their precise mapping in hydromorphic soils (Kasturirangan *et al.,* 1996). The wide range of geo-statistical tools is offering newer dimensions to address problems related to site suitability analysis (Bal *et al.,* 2018; Motuma *et al.,* 2016). The GIS also offers integrated resource analysis and generating thematic

maps under existing low land topography, and their validation through ground capture (Reddy *et al.,* 2001). This technique is more acquainted towards contingent crop planning through imposing the soil suitability model (Sys *et al.,* 1991).

Keeping the above facts in mind, development of soils site suitability model for hydromorphic areas were evaluated based on inculcation of several limiting factors. Thereby, present study was carried out for soil site suitability analysis for the promotion of paddy crops was planned in hydromorphic soils.

Materials and Methods

Study area

As per Soil Resource Mapping developed by National Bauru of Soil Survey and Land Use Planning (NBSS& LUP) at smaller scale (1:250 K), these soils were placed under recent alluvial plains with several pockets, and brought under prolonged waterlogged situations, and severally affected the growth and yield of various suitable crops in this region. its occupy the similar physiographic situation especially in the North Bihar, and existing Yazoo-type of landscapes was most predominate, severely affected by the Ganga and partly by the Kosi rivers (Fig. 1). It stretches from Teghra- Barauni in the west to Narayanpur- Thana Bihapur in the east and accompanying with approximately 500 Km^2. They further categorised into five suitability classes like S_1 (No or only four slight limitation, placed under highly suitable), S_2 (more than four slightly limitation or more than three moderate limitation under moderately suitability class), S_3 (more than three moderately limitation /one or more severe limitations under marginally suitable class), N_1 (very severe limitation which can be corrected under currently not suitable) and

N_2 (very severe limitation which cannot be corrected were grasped under unsuitable class, respectively (Sys *et al*., 1991).

Satellite images, hard ware and software

In the present study, the multi temporal satellite images of IRS P6 LISS-III and AWiFS, Land sat 8 were used for the visual interpretation and mapping of land use and land cover pattern. Carto DEM data was also used for the delineation for elevation and slopes. Topographical sheets of the scale of 1:250000 for trace out the administrative boundary of Khagaria district and the topographical sheets of the scale of 1:50000 were used to trace out the administrative boundary of (Circle development block) C.D. block. The QGIS software (Version 3.8) was used for the visual interpretation of satellite images, digitization, digital image processing and mapping. However, topographical maps, documented soil survey reports and ancillary data were also used for reference purposes during validation of research findings.

Soil samples collection and its analysis

The collected soil samples were processed and analysed for pH, electrical conductivity (EC), cation exchange capacity (CEC) and base saturation (BS) through standard methods, and methodology followed by Jackson (1973). The oxidizable organic carbon (OC) was determined by Walkley and Black (1934), available nitrogen (N) by alkaline K permanganate method (Subbiah and Asija 1956), available P by Olsen method (Olsen *et al.,* 1954), and available K by flame photometric method methodology by Jackson (1973).

The soil samples from representative soil layers/horizons were collected, air-dried and crushed in wooden mortar and plastic and passed through 2 mm sieve for further

laboratory analysis adopted the guideline (Soil Survey Staff, 2014), and processed for various parameter analyses. Apart from that, soil suitability, land capability and fertility evaluation of different location such as P_1 (Khagarai), P_2 (Parbatta), P_3 (Gogri), P_4 (Alauli) and P_5 (Mansi), respectively have been rigorously done through procedure followed by Sys *et al.,* (1991) and NBSS & LUP (1994) Nagpur. The weekly data of rainfall, minimum and maximum temperature for past 10 years were collected from Meteorological Observatory, Department of Agronomy, BAU, Sabour.

Results and Discussion

The present investigation was validated through intensive study of pedological study which was conducted in localized patches of hydromorphic region. The various limitations have been identified after imposing the soil site suitability model which was laid down in this region. The various limitation like climate (c), topography (T), wetness (W), physical soil characteristic (S), Soil fertility (F), soil salinity and alkalinity (n) etc., have been integrated to develop the soil site suitability model in account of towards productivity potential for paddy crops. Thereby, site and weighted means of each soil's characteristics was accommodated and well depicted in table 1. Based on criteria laid down by Sys (1985) and Sehgal (1986), our objective is to prepare the list of different crops with identification of some limitation and their suitable management options in hydromorphic soils.

P_1 is moderately suitable (S_2) for paddy and marginal suitable to wheat, soybean, maize and sunflower under actual land suitability class (ALSC) because of major limitations like mean temperature, wetness (drainage), physical soil characteristics (texture) and soil fertility characteristics (organic carbon and calcium carbonate) (Table 2 and 3).

Table.1 Weighted mean of site and soil characterises of paddy crops in hydromorphic areas

Pedons	R.F (cm)	Mean temp (^{0}C)	Wetness (Drainage)	Texture	Coarse Vol. (%)	Soil depth (cm)	pH	ECe	OC %	EESP	CCEC	BBS
P1: Alouli	1175	25.77	Moderately	Clay loam	0	150	7.38	1.01	0.59	70.38	23.14	95.78
P2: Gogri	875	25.81	Moderately	Sandy clay loam	0	130	7.66	1.01	0.49	60.98	14.97	95.74
P3: Mansi	875	25.81	Poorly drain	Clayey	0	170	7.55	1.01	0.54	70.42	21.27	95.99
P4: Khagaria	875	25.81	Moderately	Clay loam	0	116	7.62	1.00	0.5	60.79	15.46	95.7
P5: Parbatta	875	25.81	Poorly drain	Clayey	0	120	7.61	1.00	0.52	70.37	22.01	96.19

Note: ESP (Exchangeable sodium percentage), CEC (Cation exchange capacity) and BS (Base saturation percentage)

Table.2 Weighted rating of soil site suitability for paddy in hydromorphic areas

| Pedons	Climate (c)		Physical constrains (s)				Fertility constrains (f)						
	R.F (cm)	Mean temp (^{0}C)	Wetness (w), Drainage	Texture (s)	Coarse Fragments (%)	Soil depth (cm)	pHs	ECe (dSm^{-1})	OC (%)	CaCO$_3$ (%)	ESP (%)	CEC (meq/100g)	BS (%)
P1: Alouli	0	2	2	2	0	0	1	0	2	1	0	0	0
P2: Gogri	0	2	2	2	0	0	2	0	3	0	0	1	0
P3: Mansi	0	2	1	1	0	0	2	0	2	1	0	0	0
P4: Khagaria	0	2	2	2	0	0	2	0	3	0	0	0	0
P5: Parbatta	0	2	1	1	0	0	2	0	2	1	0	0	0

Note: ESP (Exchangeable sodium percentage), CEC (Cation exchange capacity) and BS (Base saturation percentage)

Table.3 Overall suitability of paddy crop based on their actual and potential suitability sub-class in Hydromorphic areas

Pedons	*ALSC	**PLSC
P1: Alouli	S2 (w, s, f)	S1 (w, s)
P2: Gogri	S3 (w,s,f)	S2 (w,s)
P3: Mansi	S3 (w,s,f)	S2 (w,s)
P4: Khagaria	S3 (w,s,f)	S2 (w,s)
P5: Parbatta	S2 (w,s, f)	S1 (w,s)

*Actual Suitability Sub-Class (ALSC) and **Potential Suitability Sub-Class (PLSC)

Fig.1 Location map of hydromophic areas in Khagaria district
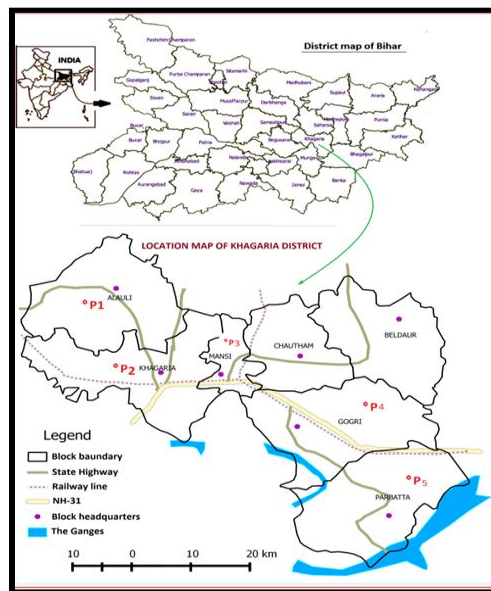
P_2 and P_4 have been placed under marginal suitable (S_3) for paddy, wheat, soybean, maize and sunflower, respectively as per actual land suitability class (ALSC), and inculcation of potential management practices, these pedons placed under S_2 class. Similar results was also corroborated by several workers (Bhattacharyya *et al.,* 2014; Ray *et al.,* 2014; Tiwary *et al.,* 2014; Srivastava *et al.,* 2014 and Velmourougane *et al.,* 2014), and who has been suggested that integration of crop, and suitable management factors governs the crop performance, and soil as well as land quality too.

P_3 and P_5 were belongs to moderately suitable class (S_2) for paddy as per actual land suitability class (ALSC), and given that, suitable management practices would be placed under S_1 class which is being considered as highly suitable (S_1). The results have been suggested that P_1, P_2 and P_4 were marginally suitable for paddy except P_1 (paddy placed under moderately suitable class), whereas, P_2, and P_5 and would be placed under moderately suitable class (S_2) as per potential land suitability class (PLSC). Similar findings were also corroborated by Leelvathi (2007) who reported that marginal suitability for growing rice crop. These

findings are also being harmony with Sugarcane growing areas in Karnataka by Naidu and Hunsigi (2003), and they noticed that soils of Mandya and Bhadravati district belongs to moderately suitable class. Similar results were also suggested by Devi and Naidu (2016) in sugarcane growing areas in Chittoor district, Andhra Pradesh. Naidu *et al.,* (2006) also made the suitability for major crops across India, and Mandal *et al.,* (2008) evaluate the productivity potential for turmeric crops in Wardha district, Maharashtra, respectively.

Based on ongoing discussion, we could be concluded that paddy crops are moderately suitable (S$_2$) in P1 and marginal suitable (S3) in P$_2$ and P$_4$, respectively based on their actual land suitability class (ALSC). While consideration of potential management options, it was further placed under S$_2$ sub class.

However, P$_3$ and P$_5$ were moderately suitable (S$_2$) through consideration of actual land suitability sub-class (ALSC) because of different limitation like soil texture, wetness and soil fertility constraints, and induction of suitable management practices like provision of drainage facility, advocating of FYM and BGA, *etc.,* enable to managing the sustainable agricultural productions especially for paddy crops, and potentially placed under highly suitable (S$_1$).

Acknowledgement

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