Land Evaluation of Rice-Wheat Growing Soils of Central Plains of Punjab for Land Use Planning

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A B S T R A C T

Major rice-wheat growing soils of Upper Gangetic Plains, India were studied and evaluated by considering soil-site characteristics by using qualitative and quantitative methods. The qualitative method employed were USDA land capability classification and land suitability classification, while the quantitative evaluation method includes Riquier's parametric approach. The land evaluation methods indicated that information on production potential of soils provide a basis for comparison among different soils. The representative soils of Jalandhar district of Punjab, India were studied and classified into land capability classes IIs, IIIse/sw, IVse, and VIes. However, the land suitability evaluation suggested that majority of these rice-wheat growing soils were suitable to moderately suitable (S1-S2) suitable for wheat while moderately to marginally suitable for rice crop. Soils of active flood plains and recent flood plains are presently not suitable for rice crops. Riquier's parametric approach was found to be good indicator for identification of production potentials of rice-wheat growing soils. The land evaluation study revealed that, soil characteristics and suitability of these soils were highly variable, hence their management must be site and location specific. Soil management strategies based on integrated nutrient management, organic manures, nutrient recycling, mulching, crop residue, crop rotation and inter cropping not only helps to conserve soil and water more effectively in rice-wheat growing soils but also increase organic matter content and improve fertilizer use efficiency. Adoption of suitable soil and water conservation measures and alternate land use not only improves the yields and soil productivity but also sustains the soil health and natural resources.

Introduction

Evaluation of land resources is essential in order to know the potentials and help in identifying the areas suitable for agricultural use and information on soils and their properties have a great value for judging suitability for its uses. It has long been recognized that land suitability is assessed as part of a 'rational' cropping system (FAO, 1976) and optimizing the use of a piece of land for a specified use (Sys *et al.,* 1991a,b)

should be based upon its attributes (Rossiter, 1996). Land evaluation may be defined as the process of assessment of land performance when the land is used for specified purpose (FAO 1985) or as the methods to explain or predict the use potential of land (Van Diepen *et al.,* 1991). Once this potential is determined, land use planning can proceed on a rational basis, at least with respect to what the land resource can offer (FAO 1993). However, land evaluation is a tool for strategic land use planning. It predicts land performance, both in terms of the expected benefits from the constraints to productive land use, as well as the expected environmental degradation due to these uses. Land evaluation is formally defined as the assessment of land performance when use for a specified purpose, involving the execution and interpretation of surveys and studies of land forms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kind of land use in terms of applicable to the objective of the evaluation (FAO, 1976). Conceptually, land evaluation requires matching of the ecological and management requirements of relevant kinds of land use with land qualities, whilst taking local economic and social economic condition into account.

The rice-wheat is the principal cropping system in south Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains (IGP), of which 10 million hectares are in India (Mahajan and Gupta, 2009), This cropping system is dominant in most of the Northern states of Indian, such as Punjab, Haryana, Delhi, Uttar Pradesh, and also in Madhya Pradesh and Bihar, contributes to 75% of the national food grain production. Punjab ranks third in rice-wheat crop area of the country with a share 6.86 and 11.57 per cent to all India in rice and wheat, respectively (Anonymous, 2016). Punjab first in yield by producing 4596 kg/hectares.

(Anonymous, 2016). Jalandhar is one of the agriculturally potential districts and also one of the major rice-wheat growing districts of Punjab cultivated over different landform settings. Monotonous cropping system over a prolonged period leads to several problems, plateauing/decline crop productivity, soil degradation, lowering fertility status and groundwater depth. Though rice-wheat is widely grown in the region, till now studies involving evaluation of rice-wheat growing soils was not attempted to find out potentials and constraint. Keeping this in view, the present studies were undertaken to generate soil information in the district for systematic land use plan.

Materials and Methods

Study area

The study was carried in representative sites of rice-wheat cropping system in Jalandhar district of Punjab. Area lies in between $30^o 58' 00''$ to $31^0 39' 10''$ N Latitude and $76^o 26' 00''$ to $75^o 57' 20''$ E longitude. Jalandhar district is bounded by four districts. The west border of the district touches Kapurthala, east with Ludhiana district, the northern with Hoshiarpur and in south with Ferozepur Ludhiana District. The district covers to an extent of 266200 hectares Jalandhar district is one of the agriculturally potential district of Punjab under rice-wheat, rice-wheat/potato cropping system. Majority of area is under old flood plain followed by recent flood plain and active fold plain (adjoining Sutlej River).

Climate

The climate of the study area is semi-arid and monsoonic with severe summer and winter. The area receives an annual precipitation of 703mm of which 70% was received during July to September. Mean maximum and mean minimum summer air temperature is 41 ^{0}C

and 26 ^{0}C, respectively. Mean maximum and mean minimum winter air temperature is 19 ^{0}C and 6 ^{0}C, respectively. The mean annual air temperature is 23.3^{0}C and the difference between man summer and mean winter temperature is more than 5 ^{0}C. Hence, the district qualifies for 'Hyperthermic' soil temperature regime. The soil moisture control section remains dry for more than 90 cumulative days or 45 consecutive days in four months following summer solstice and qualifies for ustic soil moisture regime. The study area represents semi- arid monsoonic climate with distinct summer, winter and rainy seasons.

Field survey

A reconnaissance soil survey was conducted in rice-wheat growing soils of Jalandhar district as per the procedure outlined by AIS and LUS (1970) on 1:50000 scale. After traversing the area, based on the visual observations and variations in soil-site characteristics and physiographic settings, representative profile sites were selected following the procedure outlined by Soil Survey Division Staff (2006). Horizon-wise soil samples were collected upto 150 cm depth for laboratory analysis in representative profiles. Processed soil samples (<2-mm) were analyzed for various physic-chemical properties following standard procedure (Black *et al.,* 1965; Jackson, 1973; Subbaih and Asija, 1956; Olsen *et al.,* 1954; Lindsay and Norvell, 1978). The soils were classified into the sub-group of Inceptisols, Entisols, and alfisols as per USDA soil taxonomy (Soil Survey Staff, 2014).

The data were interpreted using qualitative and quantitative methods of land evaluation. The quantitative methods include USDA land capability classification (Klingebiel and Montogomery, 1966) and suitability classification methods include Riquier's parameter approach (Riquier *et al.,* 1970).

Results and Discussion

Soil characteristics

The site characteristics such as slope, erosion and drainage varied with the micro-topographic situations, physiographic settings. The Morphological characteristics of the soils showed that most of the soils were deep to very deep having colour in the hue of 10YR, value ranging from 2 to 7 and chroma of 1 to 6 in the study area. The soils of the study area were light olive yellow to very dark brown in colour and had single grain, crumb, angular and sub-angular blocky structure. *Soils of old alluvial plains* area well drained, sandy loam to loam and clay loam soils area most fertile soils of the study area and classified as Typic Haplustepts/ Ustifluvents (Pedon1, P2, P3). *Soils of old alluvial plains with old levees* (P4, P5) are well drained, sandy loam to loamy sand, calcareous soils. P4 (Gorshian Nihal) soils are relatively more developed than Talwan and intensively cultivated to rice and wheat crop. Talwan (P5) soils occurring along the levees and having fluventic characteristics and classified as Typic Ustorthents/ Ustifluvents. *Soils of recent flood plains* well drained to excessively drained, sandy loam to loamy sand to sand, calcareous soils (sandy to coarse loamy, Typic Ustorthents/ Ustipsamments). Soils of active flood plain (P8, P9) are light textured (loamy sand to sandy) soils, stratified calcareous, less fertile soils, even cultivated for rice and wheat only because of availability of water.

Physico-chemical characteristics

Most of the soils were sandy loam to loamy sand in surface horizons and sandy loam to clay loam to loamy sand in texture and in sub-surface horizons. The clay content ranged from 1.99 to 39.13 per cent (Table 1). However, decrease of clay content with depth in soils was observed in most of the pedons

which might be due to variability of weathering in different horizons. Similar trend of irregular decrease of clay was also reported by Sidhu *et al.,* (2014) and Surya *et al.,* (2018). The sand, silt and clay content varied from 45.03 to 94.05 per cent, 9.00 to 28.72 per cent % and 7.55 to 34.25 per cent, respectively. The Soils were near slightly alkaline to moderately in reaction (pH 7.1 to 8.8) and strongly alkaline in patches. In general, pH of the soils did not show any specific trend. The organic carbon content of the soils varied from 0.12 to 0.76 per cent and decreased with depth. The Cation exchange capacity (CEC) in all the profiles followed the pattern of clay distribution in soil. Relatively low CEC is the reflection of parent material and higher degree of weathering leading to depletion of bases. Similar reports were reported by Surya *et al.,* (2016). The per cent base saturation varied from 53.10 to 94.00. The variations in base saturation of the soils might be due to variation in nature and / or content of soil colloids. The higher base saturation observed in some pedons might be due to higher amount of Ca occupying exchange sites on the colloidal complex. Similar results were reported by Sidhu, *et al.,* (2014).

Land evaluation

All the rice-wheat growing soils were evaluated by adopting qualitative or quantitative methods and the results discussed.

Qualitative evaluation

The qualitative evaluation of the soils for crop production has been carried out by two procedure viz., land capability and land suitability classification. In the present study, the land capability has been classified up to capability sub-classes based on their constraints and potentialities for sustained productivity by following USDA land capability classification.

Land capability systems have been designed to evaluate and communicate biophysical constraints on land use, including climatic limitations. By grading land quality, the resulting information is particularly relevant for planners and managers and for land valuation. Higher-class land is more flexible and has more options for land use therefore demonstrating a greater options; however land of a particular capability class also has the potential to be used as specified for any lower classes. Therefore, land capability systems can identify both the capacity of an area of land for different use and also the optimal use from a biophysical, as opposed to socio-economic, perspective. The land capability assessment highlights not only potential changes in agriculture and other productive land uses, but repercussions for biodiversity and terrestrial carbon stocks. Land capability classification is based upon intrinsic biophysical limitations of the land i.e. those that cannot be removed or ameliorated by reasonable management, and therefore act as constraints to use.

The results on land capability classification indicated that pedons P1, P2, P3, and P6 on old alluvial plains and recent flood plains were classified under land capability sub-class IIs and IIsw with good potentials for cultivation of almost all the crops.

Pedons P4, P5, and P7 soils categorized into class IIIse due to constraints of erosion, texture, and inherent soils characteristics. Pedon P8, and P9 on active flood plains have limitations of slope, erosion, drainage, texture, and organic carbon and hence classified as IVes and IVs due to major limitations of drainage, sandy texture, organic carbon, base saturation and CEC.

Suitability is a function of crop requirements and soil/ land characteristics. Matching the land characteristics with crop requirements gives the suitability. So, suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use. Land suitability classification is the evaluation and grouping of specific area of land in terms of their suitability for a defined use. In the present study important soil-site characteristics (Table 2) were evaluated to determine the suitability of the rice-wheat growing soils and the results indicated that the overall suitability of most of the pedons (soils of old alluvial Plains) were suitable to moderately suitable (S1-S2) (P1, P2, P3, and P6), pedons P4, P5, and P8 were marginally suitable while P7, P8 and P9 (soils of active flood plains) were presently not suitable for growing rice and wheat crop with limitations of excessive drainage, coarser to sandy texture, slope, alkaline, low fertility and soil depth and with limitations of wetness, flooding.

The evaluation of soil-site suitability productivity and capability had revealed that, texture, alkalinity, low organic carbon and low CEC were the main limitations in majority of soil units. These limitations override other good qualities in these soils which bring them to lower classes. Erosion as a limitations can be controlled while effective depth and texture are of more permanent characteristics. Since these two properties are relevant to crop production, these soils must be properly managed in a sustainable way to ensure optimum production of crops of them. The use of crop residues, compost and cover are recommended as soil management strategies. Limitations imposed by soil chemical properties can be imaged by applying appropriate fertilizer use to control nutrient deficiency. Low CEC indicates that continues prolonged rice-wheat cultivation may not be feasible without adequate fertilizer application as the soils have limited ability to retain nutrients. If the soil organic matter is poor, it can be properly managed using crop residues, compost, trash mulching and vertical mulching with filter cake and inorganic fertilizer in combination with organics.

Quantitative evaluation

Quantitative evaluation is the assessment of land for its performance in relation to yield and economic variable for the specific use in question. In the present study, for the specific the evaluation was worked out using parametric approaches by Riquier *et al.,* (1970) who suggested productivity index for evaluating soils for the commonly growing crops of the area. Accordingly, the productivity index for the rice-wheat growing soils under the study was calculated by considering nine factors which were related to soil productivity. The Data presented in the table 2 revealed that the actual productivity potential of the studied soils varied between low to high The lowest productivity potential was observed for pedons 8 and 9. In general, most of the pedons over old alluvial plains were categorized under the good productivity potential class. The suitability of soils for cultivation of rice and wheat was compared with the land capability and productivity (Table 3) to know whether a soil unit suitable for rice-wheat cultivation is also productive or not. The results of land evaluation revealed that soils with good fertility qualities in some cases have medium to poor production potential and vice-versa. making the suitability of rice-wheat crop for soil unit not ideal without management practices.

Present land use of soils of suitable for wheat and moderately to marginally suitable for rice (S2-S3) (Pedons 2, 4, 5, and 6) category is under cultivation with wheat, rice, potato, mustard, maize, pulses, and vegetables.

Table.1 Physico-chemical properties of Soils of the study area

Pedon No. and Horizon	Depth (m)	Particle size distribution			Texture	pH (1:2:5)	EC (dSm^{-1})	OC (g kg^{-1})	CaCO$_3$ (g kg^{-1})	CEC [cmol (p$^+$) kg^{-1}]	ESP (%)	BS (%)
		Sand %	Silt %	Clay %								
Pedon 1 Suleman: Fine loamy, Typic Haplustepts (Old Alluvial Plains)												
Surface	0-16	67.53	16.72	15.75	Sl	7.1	0.15	0.62	5	8.7	0.60	91.03
Subsurface*	16-155	45.76	20.99	34.25	cl	8.3	0.10	0.25	10	13.98	0.85	94.68
Pedon 2 Darapur: Coarse loamy, Typic Haplustepts (Old Alluvial Plains)												
Surface	0-18	72.90	14.35	12.75	Sl	6.6	0.38	0.70	2	5.82	1.03	75.26
Subsurface	18-150	45.03	28.72	26.25	l	7.7	0.15	0.38	traces	12.57	0.16	75.97
Pedon 3 Nurpur: Fine loamy, Fluventic Haplustepts (Old Alluvial Plains)												
Surface	0-19	61.00	20.00	19.00	Sl	8.2	0.21	0.62	8	10.00	5.20	88.00
Subsurface	19-155	48.75	21.00	30.25	scl	8.8	0.12	0.37	12	15.23	2.87	78.20
Pedon 4 Gorshian Nihal: Coarse loamy, Typic Ustorthents (Old Alluvial Plains with old levees)												
Surface	0-14	76.69	9.12	14.00	Sl	7.5	0.88	0.39	12.00	7.3	0.82	68.22
Subsurface	14-152	72.41	9.43	17.75	Sl - ls	8.3	0.11	0.25	14.00	7.62	0.74	76.60
Pedon 5 Talwan : sandy, Fluventic Ustifluvents (Old Alluvial Plains with old levees)												
Surface	0-19	80.00	8.91	11.00	Sl	8.2	0.18	0.56	10.00	7.0	0.43	88.00
Subsurface	19-150	90.01	3.54	6.25	Ls-s	8.9	0.11	0.35	20.00	4.53	0.60	81.01
Pedon 6 Shankar : Coarse loamy, Fluventic Haplustepts (soils of Recent Flood Plains)												
Surface	0-16	52.38	26.03	21.58	Scl	7.6	0.49	0.68	12.00	12.2	0.25	84.51
Subsurface	16-150+	63.14	22.86	14.00	sl	7.8	0.27	0.25	18.00	8.73	1.14	86.67
Pedon 7 Mahatpur: coarse loamy to samdy, Typic Ustorthents (Soils of recent flood plains)												
Surface	0-17	81.05	7.95	11.00	Ls	7.6	0.10	0.76	14.00	6.1	0.49	81.31
Subsurface	17-145	77.68	13.82	8.50	sl	8.4	0.12	0.34	28.00	6.0	0.61	88.60
Pedon 8 Madhepur: Sandy, Typic Ustipsamments (Soils of active flood plains)												
Surface	0-15	83.63	7.84	8.50	Ls	7.8	0.11	0.47	6.0	5.50	6.36	95.82
Subsurface	15-140	94.05	2.55	3.44	s	8.2	0.06	0.25	10.00	1.92	23.07	82.00
Pedon 9 Talwandi: Fine loamy, Typic Ustifluvents (Soils of active flood plains)												
Surface	0-18	66.49	17.51	16.00	Sl	8.0	0.31	0.65	-	10.0	0.90	91.20
Subsurface	18-150	83.50	9.00	7.50	Ls-s	8.3	0.14	0.12		2.6	0.38	80.77

*Texture: Sl – sandy loam, cl – clay loam, scl – sandy clay loam, ls- loamy sand, s – sandy

* subsurface - weighted mean value of sub-surface samples

Table.2 Soil-site characteristics selected for suitability evaluation

Soil Profiles	P1	P2	P3	P4	P5	P6	P7	P8	P9
Landform settings	Old Alluvial Plains (OAP)			OAP with old Levees		Recent Flood Plains		Soils of Active Flood Plains	
Soil profiles	Suleman	Darapur	Nurpur	Gorshian Nihal	Talwan	Shankar	Mahetpur	Madhepur	Talwandi
Soil –site characteristics									
Slope(%)	0-1 (S1)	1-3 (S2)	0-1 (S1)	0-1 (S1)	0-1 (S1)	0-1 (S1)	1-3 (S2)	1-3 (S2)	0-1/1-3 (S1)
Drainage	Well (S1)	Well (S1)	Mod Well drained (S2)	Somewhat Ex.c Drained (S3)	Exc. Drained (S3)	Well drained (S2)	Exc. Drained (S3)	Exc Drained (S3)	Some-what Exc Drained
Texture	Scl-cl	Sl-scl	Scl-l	Sl-ls	Sl-ls-s	sl	Ls-sl	Ls-s	Sl-ls/s
Depth (cm)	155+	150+	155	145	150	150+	150	140	150
Clay (%)	34.25	26.25	24.62	14.9	8.63	17.79	10.54	3.45	11.74
CEC [cmol(p$^+$) kg^{-1}]	13.98	12.57	15.23	7.62	4.53	8.73	6.0	1.92	2.6
EC (dS m^{-1})	0.12	0.26	0.16	0.74	0.15	0.38	0.11	0.10	0.23
pH (1:2:5)	8.0	7.5	8.8	7.9	8.5	7.7	8.2	8.0	8.2
ESP	2.02	0.29	0.91	0.77	0.52	1.14	0.86	14.71	0.64
OC (%)	0.45	0.40	0.40	0.23	0.42	0.25	0.40	0.30	0.15
Suitability class	**S1**	**S1**	**S1-S2**	**S2-S3**	**S2-S3**	**S1-S2**	**S3**	**N1**	**S3/N1**
Land Capability class	**IIs**	**IIs**	**IIsw**	**IIIse**	**IIIse**	**IIsw**	**IIIse**	**VIes**	**IVse**
Production Potentials	**High**	**High**	**Medium to High**	**Low to medium**	**Low**	**Medium to High**	**Low to medium**	**Very Low**	**Low**

Table.3 Comparative evaluation of capability, suitability and productivity of soil for alternate land use options

Pedon No.	Present land use	Land capability classification	Soil-site suitability		Production potential		Management practices to be adopted	Suggested land use after adopting management practice
		Class	Class	Constraints	Class	Constraints		
P1	Rice-wheat	IIs	Suitable (S1)	Depletion nutrients; Depletion of ground water; Medium in fertility Depletion nutrients	High	Very good cultivable lands. medium fertility status	Balanced fertilization (macro and micronutrients); Light and frequent irrigation Transplanting paddy with the onset of monsoon to save water; Proper crop rotation and mix cropping	Ideal to grow all climatically adapted crops; Present cropping system may be continued with incorporation of leguminous crops to maintain soil health.
P2	Rice-wheat	IIs	Suitable (S1)	Depletion nutrients; Depletion of ground water; Medium in fertility Depletion nutrients	High	Very good cultivable lands. medium fertility status	Balanced fertilization (macro and micronutrients); Light and frequent irrigation Transplanting paddy with the onset of monsoon to save water; Proper crop rotation and mix cropping	Agro-Horti-Floriculture may be preferred; Ideal to grow all climatically adapted crops; Crop rotations with pulses and oilseeds may be included • Transplanting paddy with the onset of monsoon to save water
P3	Rice-wheat mustard /potato	IIsw	Suitable to Moderate (S1-S2)	Moderate drainage and low fertility status	Medium to high	Moderate drainage and moderate alkalinity, low fertility status.	Balanced fertilization (NPK and micronutrients); Use of good quality water for irrigation; Proper crop rotation and mix cropping, addition of amendments, FYM/ green manuring with legumes.	Agro-Horti-Floriculture may be preferred Ideal to grow all climatically adapted crops Crop rotations with pulses and oilseeds may be included
P4	Rice-wheat mustard	IIIse	Moderate marginal (S2-S3)	Coarser texture soils, low fertility, texture, excessive drainage conditions CEC and ESP	Medium to low	Moderate erosion, exce. drainage Coarse texture soil, low fertility status. Depletion of underground water and nutrients	Improvement in soil fertility and physical conditions by adding organic fertilizers and manures N -fertilizers application in split doses • Light and frequent irrigations	Cultivation of wheat, mustard, potato, maize, and pulses, vegetable crops Rice may be avoided to check groundwater depletion
P5	Rice-wheat mustard /potato	IIIse	Moderate to marginal (S2-S3)	Coarser texture soils, low fertility, texture, excessive drainage conditions CEC and	Low	Moderate erosion, excessive. drainage Coarse texture to sandy textured soil,	Improvement in soil fertility and physical conditions by adding organic fertilizers and manures N -fertilizers application in split	Cultivation of millets, vegetables, pulses and oilseeds can be preferred

				ESP		low fertility status. Depletion of underground water and nutrients	doses; Light and frequent irrigations	
P6	Rice-wheat /mustard/po tato	IIsw	Suitable to moderate (S1-s2)	Depletion nutrients; Depletion of ground water; Medium in fertility; Depletion nutrients	Medium to High	coarse texture soils, slight erosion low fertility status and AWC depletion of underground water; loss of nutrients and water due to leaching	adaption of improved site specific soil and water management practices, integrated nutrient management, fertilization (macro and micronutrients); light and frequent irrigation; improved water management practices like mulching, green manuring, light and frequent irrigation. Transplanting paddy with the onset of monsoon to save water; Proper crop rotation and mix cropping Crop rotations with pulses and oilseeds may be included	• Cultivation of crops like wheat, pigenon pea/ gram, maize, cotton, potato, sunflower may be preferred. • Vegetables and fodder crops • Horticultural crops like guava, pomegranate, goose berry,/black berry and citrus
P7	Rice-wheat mustard /potato	IIIse	Marginal (S3)	Coarser textured soils, excessive drainage leads to low availability of water	Low to medium	Same as above	• Same as above	Same as above
P8	Rice-wheat	VI es	Presently not suitable (NI)	Sandy textured soils, moderate erosion, low fertility,	Low	Not suitable for cultivation because of soil texture, drainage and frequent flooding	soil and water management practices and measures.	Silvi-pasture and grasses soils Best suitable for non-agricultural uses
P9	Rice-wheat	IVse	Marginally suitable (S3/N1)	Sandy textured soils, moderate erosion, low fertility,	Low	Deep, sandy to coarse loamy soils, susceptible to erosion, stratified droughtiness, low in organic matter, depletion of nutrients.	Green manuaring and row cropping of legumes across slopes; light and frequent irrigation and integrated nutrient management, addition Of FYM/vermicompost/ to improve organic carbon status., addition of tank silt to improve texture,	• Vegetables, pulses and oilseeds can be preferred. Silvi-pasture to reclaim theses soils

After improving the soil by managing the constraints like pH, texture, wetness and CEC through the addition of recommended doses of fertilizers, amendments like gypsum, organic manures, green manuring with legumes or application of FYM or crop rotation and providing good irrigation facilities/scheduling, these soils can be upgraded to highly suitable category or actual productivity can be improved form good to excellent potential productivity class. For crop like rice, specific needs finer texture, good water and nutrients holding capacity are necessary. Cultivation of rice -wheat on excessively drained soils with poor texture cause poor uptake of nutrients, thus leads to low productivity, decline in water table and natural resources. In such cases, it is better to go for alternate crop like vegetable, pluses, oil seeds. Soil organic carbon status can be alleviated by incorporation of crop residues, compost, trash mulching and inorganic fertilizer in combination with organics. By following these management practices, productivity of these soils can be improved from good to excellent class and suitability can be taken to higher order i.e. moderately suitable (S2) as most of the limitations were manageable. Vegetables, oil seeds and pulses can also be preferred in these soils. Practices to restrict the erosion hazards following soil management practices, actual productivity can be upgraded from low to average to good and good to excellent productivity. Therefore it is suggested to take up alternate crop like vegetables, pulses, oil seeds, mustard and maize crops which suits better for coarser soils with loamy sand texture in pedons having poor or average productivity than for opting rice-wheat which are marginally suitable for rice-wheat crop.

In conclusion, the USDA land capability classification revealed the general suitability of soils are agriculture with limitations. Land evaluation study revealed that characteristics and suitability of these soils for rice-wheat crop were highly variable, hence their management must be site specific. The identified major limitations to rice-wheat crop soil physical and fertility problems. The fertility problems can be corrected/ managed using appropriate measures such as crop rotation with legumes, incorporation of FYM/ compost/ press-mud to increase the organic carbon status and increase the microbial activity so as to enhance the mineralization process. Green manuring with dhaincha to reduce alkalinity, mulching to improve moisture retention capacity and bunding to reduce erosion. These strategies make soils highly and moderately suitable for rice-wheat and potentially suitable crops on sustainable basis.

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