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Research Article

IDENTIFICATION OF MINIMUM DATA SET FOR SOIL QUALITY ASSESSMENT IN UPPER KRISHNA PROJECT AREA

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Abstract- Assessment of soil quality index is one of the most important factor for Agricultural production because of salinity and alkalinity in the irrigation command areas. For this reason, a minimum data set (MDS) was determined with principle component analysis (PCA) for soil quality assessment in irrigation command areas based on normalized scoring function. The results found that the among the all the reaches the middle reach transition soils found best suitable for crop production with highest soil quality index of 0.874 and 0.826 in middle reach compare to 0.710 and 0.560 in head reach, 0.632 and 0.364 in tail reach command area of laterals-1 and 2. Therefore, best management practices should follow in head reach with respect to increase the water holding capacity in sandy soils and to solve drainage problems in tail reach clay soils The result of this study throw a light on general guideline to manage irrigation command area of UKP.

Keywords- Soil quality index, Minimum data set, Normalized scoring function

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Introduction

Soil and water in irrigated agriculture have a major role to play in meeting the country's escalating needs of food production. The north-eastern Karnataka, also called Hyderabad-Karnataka (H-K) region occupies about one-fourth of the state geographical area (44.96 lakh ha) and covers three agro-climatic zones *viz.,* north-eastern transitional zone, north-eastern dry zone and northern dry zone [1]. The cultivable area is 30.57 lakh ha and the region is endowed with a variety of climate, soils and crops, which facilitate diversified crops and cropping systems. Paddy, cotton, chillies, groundnut, sunflower, pigeon pea, chickpea, sorghum, sesame, niger, linseed, tobacco are the major field crops besides horticultural crops. The region is unique with commands of Upper Krishna project (UKP) and boost of a total irrigation potential of about 6.08 lakh ha including medium and minor projects and vast area under rainfed agriculture, most of which is drought prone. Though the north-eastern Karnataka is blessed with good soil / land and water resources, the region still remains the most backward regions in the state due to various reasons like the problems of violation of cropping pattern dominated by rice-rice syndrome, water logging and salinity problems, water shortage problems and lower agricultural productivity in tail-end areas, shift to low-value crops or practice of leaving land fallow *etc* [2]. About 59 per cent of the command constitutes deep black soils, 27 per cent comprises of shallow to medium deep black soils and the remaining 14 per cent consists of red soils. While the black soils are fertile compared to the red soils, they are prone to water logging and salinity problems due to their poor permeability and internal drain ability. With low hydraulic conductivity of 5-15 cm d^{-1} and swelling and shrinkage type in nature, black soils warrant good management strategies. The clay soils swell on wetting and shrink on drying which leads to soil cracks. Particularly during summer, the network of cracks develops to a large extent [14].

To identify the smallest list of measurable soil properties that define the major processes functioning in soil, PCA based MDS [7,10,3] have been used for semi-arid region of UKP, Karnataka for assessment of soil quality in head, middle and tail region of both laterals-1 and -2 [15,4,11].

Materials and Methods

Site description

The location details of the study area shown in [Fig-1] comes under Gabbur hobli, Devadurga taluk, Raichur district, Karnataka state, situated between 16° 16' 52" to 16° 17' 50"N latitudes and 77° 09' 20" to 77° 30' 50" E longitudes at an altitude ranging from 389 to 410 m above the mean sea level (MSL). The study area comes under the command area of Branch Distributary (BD)-5 of the tail end Distributary-18, starting at chainage of 23.33 km in the UKP Narayanapura right bank canal (NRBC). The investigation was carried out in the farmers' fields during *kharif* and *rabi* seasons of 2012-'13 and 2013-'14 in the command areas of Lateral -1 starting at chainage 0.22 km, covering 113.16 ha GCA with 95.40 ha CCA and Lateral-2 starting at chainage 0.45 km, covering 88.70 ha GCA with 74.03 ha CCA. By taking into account 3 replicate sites (head, middle and tail reach) for each sample sites could be identified, however only 24 were found and sampled.

Soil sampling and laboratory analyses

Soil samples for determining chemical properties were collected from the top 15 cm of soil [Fig-2]. The fine earth fractions (<2 mm) were retained for chemical analyses. Soil pH was determined using an electrode pH metre for a saturated soil paste using deionised water [9]. The electrical conductivity (EC) was also measured in the saturated paste extract Conductivity bridge [9] Organic carbon

was determined using the Wet oxidation method [9]. Cation Exchange Capacity (CEC) was determined for soil samples from Flame photometer as described by [5]. These samples were collected from different land use randomly. Sodium Absorption Ratio (SAR) was calculated using analyses of saturated paste extracts for Na+ by flame photometry [9]., and Ca^{2+} and Mg^{2+} by Versanate titration method [9]. To assess soil structure, Particle size analysis Mechanical sieve analysis followed by International pipette method [12]. The field capacity was measured by Field method [6]. The water retained between field capacity and wilting point (water holding capacity) and he minimal point of soil moisture the plant requires not to wilt) permanent wilting point (PWP) was determined by using pressure plate operates method [13]. Similarly, to measure infiltration in the field double ring infiltrometer [5] was used.

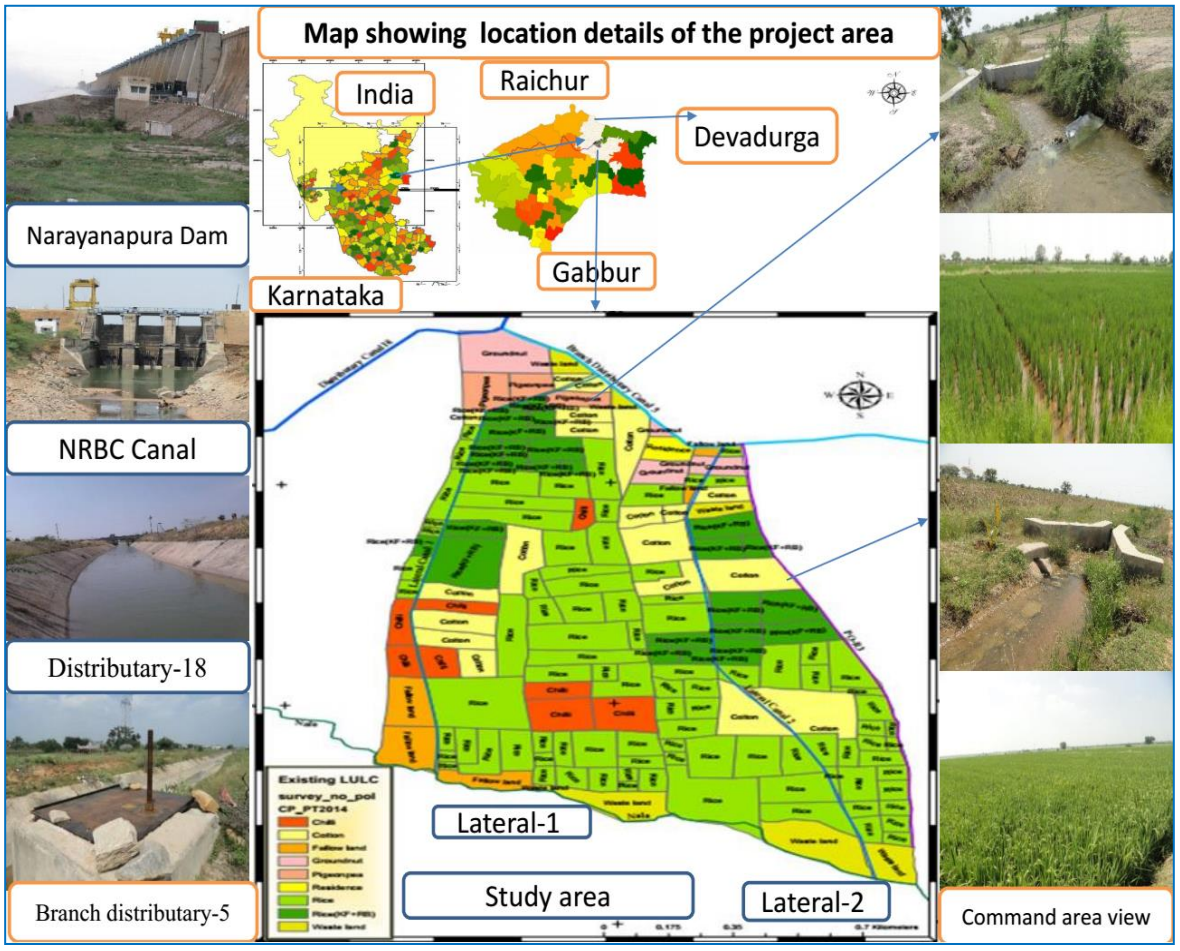

Fig-1 Location details of the study area coming under NRBC in UKP command area

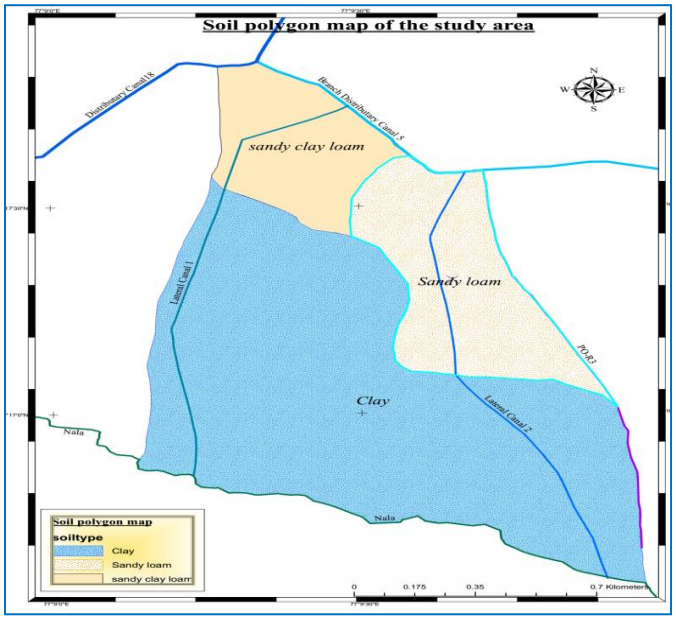

Fig-2 Soil type of the study area

Statistical approach

Statistical analysis was conducted with SPSS 22 version. Variables were grouped into land farm, physical and chemical categories. Principal Component Analysis (PCA) was employed to find the 'best' low dimension space that conveys maximum useful information. The number of components was determined by the Eigen value-one criterion. A VARIMAX rotation was performed to enhance interpretability of the independent components. All significant loadings were considered in the interpretation of principal components (PC), which were considered significant if >5% of the total variance was explained.

Scoring function

In this approach, each soil parameter was first assigned unit less score ranging from o to 1 by employing linear scoring functions. Soil parameters were divided into groups based on three mathematical algorithm functions: more, less and optimum depending on soil properties. Then scores were combined using weighted additive approach into single index value for each region of both lateral [8].

$$SQI = \sum W_i S_i$$

where PCA-SQI is principal component analysis (PCA) based soil quality index, is the PCA weighing factor equal to the ratio of variance of each factor to total cumulative variance coefficients in the equation, and is scored value of each SQ indicator.

Result and Discussion

The result of principle component analysis (PCA) is shown in [Table-1]. Considering factors with eigen value more than one, 1, 2, 3 and 4 factors were selected for soil quality indicator in head, mid and tail reach respectively and cumulative percentage for the first 4 accounts 89.74%, 93.27% and 91.14% of the total variance for head, mid and tail reach of lateral-1. In case of lateral-2 head reach possess 5 factors, mid reach 4 factor and tail reach 4 factor are considered based on cumulative percentage values like 92.89%, 92.70% and 87.10% respectively.

Mean slope%, Erosion, Depth (cm), PWP%, pH, EC, in factor loading 1, TAW% in factor loading two, CEC in factor loading 3 and ESP in factor loading four showing highest positive value respectively in head reach of lateral-1. Texture, FC%, PWP%, TAW%, pH, EC, CEC, ESP and Infiltration showing highest positive value in middle reach of lateral-1 presented in [Table-2]. Mean Slope %, Erosion, Texture, FC%, TAW%, pH, EC, $CaCO_3$, CEC are showing highest positive value respectively in tail reach of lateral one of Upper Krishna Project area. FC%, PWP%, EC, $CACO_3$ and Infiltration showing highest positive value respectively in head reach of lateral two. Texture, FC%, PWP%, TAW%, pH, EC, OC, CEC, ESP and Infiltration showing highest positive value in mid reach of lateral-3 presented in [Table-2]. Mean Slope %, PWP%, TAW%, and $CaCO_3$ are showing highest positive value respectively in tail reach of lateral two of Upper Krishna Project area. In order to assess soil quality for both the laterals, the normalized scoring function was calculated using [Eq-1] and scoring function parameters were estimated with measured soil properties

The result of soil quality index in Upper Krishna Project area were mentioned in [Table-4] showed that 85% of soil was within the optimum range with highest soil quality index of 0.874 and. 0.826 in head reach when compare to 0.710 and 0.560 in head reach and 0.632 and 0.364 in tail reach command area of laterals-1 and 2 [15]. This is help full in finding the best decision for cropping pattern suggestion in the command area.

Table-1 *Eigen value and Corresponding variation for both laterals-1 and 2 of UKP*

Lateral 1	Initial Eigenvalues								
	Head reach			Middle reach			Tail reach		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.07	50.43	50.43	9.55	59.69	59.69	7.88	49.22	49.22
2	2.87	17.92	68.35	2.39	14.91	74.59	2.85	17.83	67.05
3	1.99	12.46	80.81	1.90	11.85	86.44	2.47	15.41	82.46
4	1.43	8.93	89.74	1.09	6.83	93.27	1.39	8.68	91.14
5	0.67	4.17	93.90	0.51	3.18	96.45	0.72	4.49	95.63
6	0.59	3.70	97.61	0.28	1.77	98.22	0.37	2.32	97.95
7	0.27	1.70	99.30	0.18	1.10	99.32	0.17	1.09	99.04
8	0.09	0.55	99.86	0.08	0.51	99.83	0.12	0.73	99.77
9	0.02	0.14	100.00	0.03	0.17	100.00	0.04	0.24	100.00
10	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
11	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
12	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
13	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
14	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
15	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
16	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
	Initial Eigenvalues								
Lateral 2	Head reach			Middle reach			Tail reach		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.27	57.94	57.94	8.27	51.69	51.69	5.74	35.85	35.85
2	1.75	10.95	68.89	3.07	19.17	70.86	3.45	21.56	57.40
3	1.56	9.75	78.64	2.28	14.27	85.14	2.26	14.09	71.49
4	1.22	7.63	86.26	1.21	7.57	92.70	1.37	8.58	80.07
5	1.06	6.62	92.89	0.63	3.92	96.62	1.12	7.03	87.10
6	0.57	3.53	96.42	0.27	1.69	98.31	0.89	5.55	92.65
7	0.40	2.48	98.90	0.18	1.09	99.41	0.68	4.22	96.87
8	0.12	0.73	99.62	0.08	0.49	99.89	0.40	2.50	99.37
9	0.06	0.38	100.00	0.02	0.11	100.00	0.10	0.63	100.00
10	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
11	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
12	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
13	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
14	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
15	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00
16	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00	100.00

Table-2 *Principal Rotated Component Matrix (factor loading) for both, only soil chemical and physical properties of lateral-1 region of UKP.*

Rotated Component Matrix												
Lateral 1	PC1				PC2				PC 3			
	PC1	PC2	PC 3	PC 4	PC 5	PC 1	PC 2	PC 3	PC 4	PC 1	PC 2	PC 3
Mean slope %	0.85	0.25	-0.31	-0.04	-0.60	-0.76	-0.12	-0.13	0.86	0.18	-0.11	-0.30
Erosion	0.16	0.08	0.90	-0.22	-0.76	-0.64	-0.05	-0.07	0.10	0.96	0.18	-0.07
Drainage	-0.45	-0.07	-0.30	-0.64	-0.32	0.24	-0.38	0.73	-0.92	-0.12	0.33	0.02
Depth (cm)	0.96	0.20	0.01	0.12	0.69	0.20	0.55	0.33	0.73	0.10	0.47	0.20
Texture	-0.31	-0.04	0.81	0.24	-0.16	0.96	0.23	0.08	0.10	0.96	0.18	-0.07
FC%	0.60	0.79	-0.10	-0.01	0.98	0.05	0.02	0.04	0.87	0.39	-0.08	0.00
PWP%	0.89	0.41	-0.15	0.02	0.99	0.06	0.00	0.04	0.58	0.41	-0.35	0.49
TAW%	-0.08	0.96	0.13	0.13	0.95	0.09	0.09	-0.08	0.91	0.15	0.17	-0.18
PH	0.87	-0.11	-0.08	0.46	0.89	0.02	0.18	-0.29	-0.15	0.02	0.93	0.20
EC	-0.03	-0.14	-0.12	0.91	0.91	0.11	0.08	0.19	0.86	0.01	0.35	-0.15
OC	0.76	-0.17	0.23	-0.02	-0.26	0.21	0.87	-0.20	-0.63	0.39	0.08	0.63
CACO3	0.82	0.53	-0.12	-0.12	0.76	0.23	0.46	0.23	0.96	0.11	0.08	0.02
CEC	0.96	-0.17	-0.08	-0.07	0.97	0.01	-0.18	0.15	0.96	0.06	-0.10	0.07
Base saturation	-0.03	-0.93	-0.01	0.31	0.68	0.18	0.65	0.10	0.41	0.33	0.75	0.11
ESP	0.91	0.04	-0.04	0.17	0.92	0.01	0.02	-0.18	0.33	0.75	-0.46	0.19
Infiltration	-0.82	-0.18	-0.41	-0.13	0.17	0.01	0.11	0.94	0.10	0.21	-0.35	-0.86

Table-3 *Principal Rotated Component Matrix (factor loading) for both, only soil chemical and physical properties of lateral 2 reach of UKP*

Rotated Component Matrix														
Lateral 2	Head reach					Middle reach				Tail reach				
	PC1	PC2	PC 3	PC 4	PC 5	PC 1	PC 2	PC 3	PC 4	PC 1	PC 2	PC 3	PC 4	PC 5
Mean Slope %	0.13	0.41	0.39	-0.10	0.76	-0.95	0.13	0.29	-0.01	0.95	0.24	0.06	0.06	-0.10
Erosion	-0.36	-0.23	0.14	0.82	0.02	-0.98	-0.20	0.01	-0.03	0.82	0.28	0.11	0.32	0.12
Drainage	-0.48	-0.21	-0.16	-0.74	0.11	-0.03	-0.03	0.85	-0.42	0.35	0.75	0.06	0.31	0.37
Depth (cm)	0.80	0.40	-0.25	0.20	0.26	0.94	0.27	0.05	0.05	0.78	-0.11	0.57	0.04	0.12
Texture	0.84	0.37	-0.01	0.20	-0.10	-0.09	-0.32	0.68	0.10	-0.20	0.58	-0.03	-0.57	0.41
FC%	0.92	0.26	0.23	-0.03	-0.04	0.46	0.76	-0.13	0.41	-0.24	-0.93	0.12	-0.07	0.10
PWP%	0.94	0.20	0.21	0.01	-0.04	0.40	0.86	-0.23	-0.01	0.88	0.13	-0.24	-0.01	0.24
TAW%	0.80	0.51	0.27	-0.03	0.09	0.51	0.78	-0.28	0.05	0.16	0.27	-0.10	0.05	0.90
PH	0.83	0.28	0.42	-0.17	-0.04	0.47	0.69	0.46	0.00	0.38	0.22	0.39	0.55	0.14
EC	0.23	0.90	0.20	-0.14	0.08	0.59	0.75	-0.24	0.14	0.76	-0.48	0.02	0.32	-0.05
OC	0.42	0.29	0.62	0.23	-0.01	0.52	0.11	0.69	0.40	-0.12	0.79	0.27	-0.04	0.08
CACO3	0.93	0.06	0.32	-0.14	0.03	0.86	0.42	0.21	0.14	0.10	0.16	-0.34	0.90	0.03
CEC	0.34	0.91	0.17	0.09	0.02	0.13	0.03	-0.90	-0.06	0.61	0.21	-0.34	0.38	-0.55
Base saturation	0.16	0.53	0.35	-0.02	-0.73	0.91	0.37	-0.03	0.15	0.26	0.07	0.77	-0.17	0.06
ESP	0.51	0.79	0.30	0.01	-0.11	-0.24	0.95	0.04	0.17	0.24	0.76	-0.06	0.35	0.43
Infiltration	0.19	0.24	0.90	0.15	0.05	-0.10	-0.19	-0.03	-0.94	0.23	-0.04	-0.77	0.01	0.15

Table-4 *Soil quality index for lateral-1 and 2 of UKP command area.*

Soil quality index	Lateral 1			Lateral 2		
	Head reach	Middle reach	Tail reach	Head reach	Middle reach	Tail reach
	0.710	0.874	0.632	0.560	0.826	0.364

Conclusion

The MDSs were utilized for soil quality assessment with respect to the management goals of soil productivity and stability. Principle component analysis was used for making MDS Data set for head, middle and tail reach of both laterals-1 and 2 of UKP command area. Among the all the reaches the middle reach transition soils found which best suitable for crop production with highest soil quality index of and 0.874 and. 0.826 in head reach when compare to 0.710 and 0.560 in head reach and 0.632 and 0.364 in tail reach command area of laterals-1 and 2. Therefore, best management practices should follow in head reach with respect to increase the water holding capacity in sandy soils and drainage problems in tail reach clays soils.

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Conflict of Interest: None declared

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