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Soil Suitability for Growing Pulses in Northern Dry Zone of Karnataka

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ABSTRACT

Background: A soil suitability evaluation of Kanamadi South sub-watershed in the Northern Dry Zone of India was carried out during April 2019 to define the soil fitness for the production of pigeonpea, chickpea, greengram and cowpea the four major pulses that are widely grown in the area.

Methods: A detailed soil survey of Kanamadi South sub-watershed was carried out using IRS P6 LISS-IV image and Vijayapura district toposheet. The soils of Kanamadi south sub watershed were grouped into 19 mapping units based on studied 50 profiles. The studied physical and chemical properties were evaluated using the FAO (1976) framework for land evaluation was followed in the evaluation of soil-site suitability for major crops grown in Kanamadi South sub-watershed. This classification recognized two orders of land suitability, order 'S' (suitable) and order 'N' (not suitable) which are further subdivided into land suitability classes.

Result: The studied 19 mapping units were moderately (S2) to marginally suitable (S3) for pigeonpea and greengram having marginal to severe limitations of rainfall and soil physico-chemical properties and none to slight limitation of land form characteristics. The mapping units were moderately suitable (S2) to marginally suitable (S3) for chickpea and cowpea having moderate to severe limitation of temperature, rainfall, depth and pH and none to slight limitation of land form characteristics. The suitability of the study area for all the pulses were said to be moderately suitable (S2) for growing pulse crop for improving productivity and improving biological nitrogen fixation.

Key words: Biological nitrogen fixation, Marginally suitable, Northern dry zone.

INTRODUCTION

Soil suitability assessment is very important to achieve optimum utilization of available land resources for agricultural production in a sustainable manner. FAO (1976) defined land suitability as 'a function of crop requirements and land characteristics as well as a measure of how well the qualities of a land unit matches the requirements of a particular form of land use'. Land suitability study is necessary for selection of crops and crop rotation for a particular piece of land. The concept of 'land' should not be confused with 'soil' because soil represents only one aspect of land, alongside vegetation, physiography, hydrology, climate, infrastructure, *etc.* (Chiranjit and Kishore, 2016) Land suitability assessment allows identifying the main limiting factors of a piece of land for particular crop production and enables decision-makers to develop a crop management system for increasing land productivity. (Denis *et al*., 2016).

Northern Dry zone of Karnataka covers an area of 4.78 Mha. The annual rainfall ranges from 464.5-785.7 mm and about 52% of the annual rainfall is received during rabi season. The elevation is between 450-900 m. The soils are shallow to deep black clay in major areas. The important crops grown here are rabi jowar, maize, bajra, groundnut, cotton, wheat, sugarcane and tobacco.

Agricultural land suitability is a very significant piece of information in agriculture development and planning (Chiranjit and Kishore, 2016; Ramamurthy *et al*., 2019). Therefore, there is an intense need for land evaluation studies to select the superior land use (Zhang *et al*., 2015; Sabareeshwari *et al*., 2018). Combination of geographic information system with soil survey and land methods were developed and adopted to evaluate soil suitability for different crops (Bhaskar, *et al.,* 2015). Several approaches have continuously been developed and tested to conduct land suitability assessment fulfilling specific criteria for a particular crop or land (FAO,1979; Thilagam and Sivasamy, 2013).

Legumes play a critical role in natural ecosystems, agriculture and agroforestry, where their ability to fix atmospheric N. The area under traditional pulses is less in Karnataka. As, the area has potential for growing legume crops and the farmers are unaware of potentiality of growing the pulses in this area. Hence, this research focuses on finding the suitability of pulse crop for given study area based on measured soil properties.

The study area selected was Kanamadi South subwatershed of Vijayapura district of Karnataka which falls

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in northern dry zone of Karnataka. This area lies in Northern dry zone of Karnataka and has hot arid ecosystem with hot and dry summers and mild winters (K4D2) which belongs to the sub region 6.1 (K4Dd3) of Northern Karnataka Plateau. Kanamadi South sub-watershed (Vijayapura taluk, Vijayapura district) is located in between 16°51' - 16°55' 30" North latitudes and 75°21' - 75°26' 30" East longitudes, covering an area of about 4170.17 ha. The area receives an annual average rainfall of 711 mm distributed over May to October months. The location of sub-watershed is shown in Fig 1.

MATERIALS AND METHODS

Soil survey

A detailed soil survey of Kanamadi South sub-watershed was carried out using IRS P6 LISS-IV image and Vijayapura district toposheet during April 2019. The image and scanned toposheet were geocoded and subset were created in ArcGIS 10.2 on a 1: 12,500 scale. The area was then intensively traversed and 50 pedon locations were fixed on soil heterogeneity. At each pedon location, a fresh profile was opened and horizon-wise samples were collected and analyzed for physico-chemical parameters.

Soil sampling and preparation for analysis

Horizon wise soil samples were collected in polythene bags from all the pedons and taken to the laboratory for analysis. The total of 150 soil samples from 50 profile location were collected. The laboratory analysis was done for following soil properties at the Department of Soil Science and Agricultural Chemistry, UAS, Dharwad.

Soil mapping

Based on soil heterogeneity as revealed by laboratory analysis and visual interpretation of the IRS P6 LISS-IV image, soil mapping units were delineated and evaluated for the soil site suitability for crops.

Soil site suitability evaluation for crops

The FAO (1976) framework for land evaluation was followed in the evaluation of soil-site suitability for major crops grown in Kanamadi South sub-watershed. This classification recognized two orders of land suitability, order 'S' (suitable) and order 'N' (not suitable) which are further subdivided into land suitability classes

The classification includes four categories: orders, classes, subclasses and units. There are two orders (S, N) which reflect the kind of suitability (S for suitable and N for unsuitable). There are three classes (S-1 to S-3) under the suitable order S and two classes (N-1 and N-2) under the order N, reflecting degree of suitability within the order. The appraisal of the classes, within an order is done according to evaluation of land limitations. The sub classes reflect the kinds of limitations or the main kinds of improvement measures required within a class. They are indicated by the symbol, using lower case letters following the arabic numeral used for the class. The land suitability unit suggests the relative importance of land improvement works. It is indicated by arabic numerals enclosed in parenthesis following the sub class symbol.

Order 'S' suitable

Land on which sustained use of the kind is expected to yield benefits which justify the inputs without risk of damage of the land.

Class S1 - Highly suitable

Land having no significant limitations for sustained application to a given use or only minor limitations that will not significantly reduce the productivity.

Class S2 - Moderately suitable

Land having limitations that in the aggregate are moderately severe for sustained application to a given use and may reduce the productivity marginally. These lands have slight limitations and not more than 3 moderate limitations.

Class S3 - Marginally suitable

Land with limitations that in the aggregate are too severe for the sustained application to a given use and as such reduce productivity significantly but are still marginally economical.

Order 'N' not suitable

Land that has qualities that appear to preclude sustained use of the kind under consideration.

Soil parameter	Experimental methods
Particle size Analysis	International pipette method as described by Piper (2002)
Bulk Density	Clod coating method as described by Black (1965)
Maximum water holding Capacity	Keen Raczkowaski brass box experiment as described by Coutts (1930) and Piper (2002)
Field capacity	Field capacity of soils as described by Hendrickson and Viehmeyer (1931) and Piper (2002)
Soil reaction (pH)	Potentiometric method using glass electrode as described by Jackson (1973)
Electrical conductivity	Conductivity bridge as described by Jackson (1973)
Organic Carbon	Walkley and Blacks Wet Oxidation method as described by Jackson(1973)
Free Calcium carbonate	Acid neutralization method as described by USSL staff (1954)
Exchangeable cations	Calcium and Magnesium is determined by Versanate titration and Sodium, Potassium is determined by Flame photometry (Thomas, 1982)
Cation Exchange Capacity	Neutral normal ammonium acetate method as described by NBSS & LUP staff (1984)

Fig 1: Location of the study area.

Table 1: Soil unit description and taxonomy of Kanamadi South sub-watershed.

Mapping unit	Soil classification at family level	Series	Soil mapping units/ soil phases	Area	
				ha	% of TGA
1	Fine, mixed, superactive, isohyperthermic, Typic haplustepts	DMT	DMTmB2g1	58	2.23
2	Fine, mixed, superactive, isohyperthermic, Typic haplustepts	DMT	DMTmB2g1Ca	180	6.90
3	Fine, mixed, superactive, isohyperthermic, Typic haplustepts	DMT	DMTmB2g2Ca	496	2.44
4	Fine, mixed, superactive, isohyperthermic, Typic haplustepts	KGR	KGRmB2	232	0.55
5	Fine, smetitic, superactive, isohyperthermic, Typic haplustepts	KGR	KGRmB2g1	167	1.65
6	Fine, mixed, superactive, isohyperthermic, Typic calciustepts	NHL	NHLmB2	465	0.61
7	Fine, smetitic, isohyperthermic, Typic calciustepts	THL	THLmB2	554	0.65
8	Fine, smetitic, isohyperthermic, Typic calciustepts	THL	THLmB2g1Ca	575	7.98
9	Fine, mixed, superactive, isohyperthermic, Typic calciustepts	THL	THLmB2g2Ca	129	5.14
10	Fine, smetitic, isohyperthermic, Typic haplusterts	RPR	RPRmB2	58	1.39
11	Fine, smetitic, isohyperthermic, Typic calciusterts	BBL	BBLmB2	180	4.31
12	Fine, smetitic, isohyperthermic, Typic calciustepts	NDN	NDNmB2	496	11.90
13	Fine, mixed, superactive, isohyperthermic, Typic calciustepts	NDN	NDNmB2g1Ca	232	5.58
14	Fine, smetitic, isohyperthermic, Typic haplustepts	TSL	TSLmB2g1Ca	167	4.00
15	Fine, smetitic, isohyperthermic, Typic calciusterts	SRD	SRDmB2	465	11.16
16	Fine, smetitic, isohyperthermic, Typic haplusterts	SRD	SRDmB2g1Ca	554	13.29
17	Very Fine, smetitic, isohyperthermic, Typic haplusterts	KRJ	KRJmB2	575	13.80
18	Very Fine, smetitic, isohyperthermic, Typic haplusterts	KRJ	KRJmB2g1Ca	129	3.09
19	Fine, smetitic, isohyperthermic, Typic haplusterts	HNT	HNTmB2g1Ca	90	2.16
20	Others*			49	1.17

Class N1- Currently not suitable

Land having limitations that may under the present technological and economic situation and for other reasons fail to yield sufficient benefits to justify the inputs required.

Class N2 - Permanently not suitable

Lands having limitations that appear to preclude any possibility of successful sustained use in the future.

Soil site suitability for some of the major pulse crops like pigeonpea, chickpea, greengram and cowpea *etc.* were evaluated based on the criteria suggested by FAO (1976) and Sehgal (1996).

RESULTS AND DISCUSSION

The mapping units of soils are phases of soil series considering texture, depth, slope and erosion characteristics of the site. The eleven soil series were identified in the study area were named after eleven villages like DMT (Dadamatti), KGR (Kalguki), NHL (Naihalla), THL (Thenihalli), RPR (Rampura), BBL (Babaleshwar), NDN (Nidoni), TSL (Tonshyala), SRD (Sarawada), KRJ (Karjola) and HNT (Hanchinal) series. In the identification of the soil mapping units of the study area, the soil series, soil texture, soil depth, slope and erosion were employed as inputting parameters. The nineteen mapping unit as given in Table 1 were identified in the study area.

The suitability for growing pulse crop in study area is presented in Table 2.

Pigeonpea

All the mapping units were moderately (S2) to marginally suitable (S3) for pigeonpea having marginal to severe limitations of rainfall and soil physico-chemical properties and none to slight limitation of land form characteristics.

The mapping units were moderately suitable (S2) to marginally suitable (S3) for pigeon pea due to marginal to severe limitation of rainfall, pH and soil depth. (Table 2). An area of 3523 ha (84.49% of TGA) was evaluated as marginally suitable due to severe limitation of pH. The area comprising these mapping units were grouped under suitability sub class S2s. The severe limitation of pH was identified in 598 ha (14.35% of TGA). These areas were grouped under suitability subclass S3s (Fig 2).

Patil *et al.* (2008) while evaluating the soil resources of Bhanapur micro-watershed (Koppal district) in northern dry zone of Karnataka revealed that those soils were marginally

Table 2: Soil-site suitability classification of mapping units for major pulse crops.

Mapping units	Pigeon pea	Chick pea	Greengram	Cowpea
DMTmB2g1	S3s	S3s	S3s	S3s
DMTmB2g1Ca	S3s	S3s	S3s	S3s
DMTmB2g2Ca	S3s	S3s	S3s	S3s
KGRmB2	S3s	S2s	S2s	S2s
KGRmB2g1	S3s	S2s	S2s	S2s
NHLmB2	S3s	S2s	S2s	S2s
THLmB2	S2s	S2s	S2s	S2s
THLmB2g1Ca	S2s	S2s	S2s	S2s
THLmB2g2Ca	S2s	S2s	S2s	S2s
RPRmB2	S2s	S2s	S3s	S2s
BBLmB2	S2s	S2s	S2s	S2s
NDNmB2	S2s	S2s	S2s	S2s
NDNmB2g1Ca	S2s	S2s	S2s	S2s
TSLmB2g1Ca	S2s	S2s	S2s	S2s
SRDmB2	S2s	S2s	S2s	S2s
SRDmB2g1Ca	S2s	S2s	S2s	S2s
KRJmB2	S2s	S2s	S2s	S2s
KRJmB2g1Ca	S2s	S2s	S2s	S2s
HNTmB2g1Ca	S2s	S2s	S2s	S2s

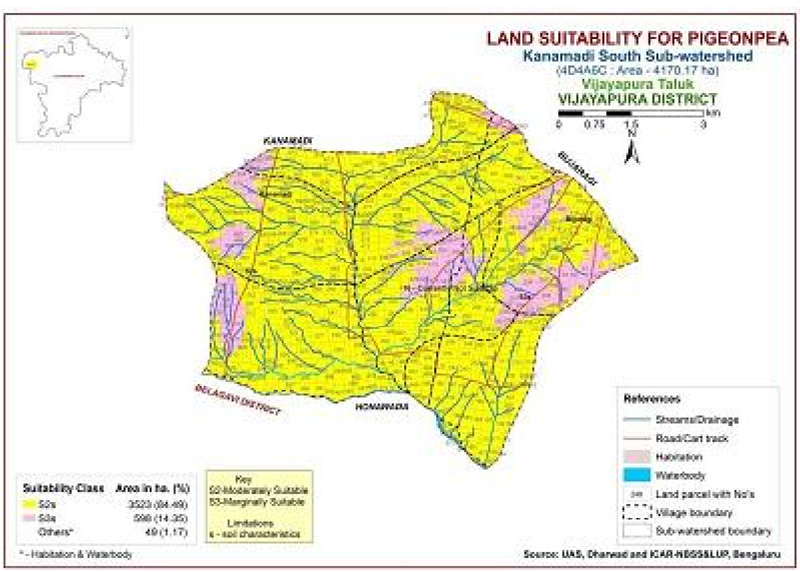

Fig 2: Land suitability for Pigeonpea in Kanamadi South sub-watershed.

suitable for pigeon pea. Anilkumar *et al.* (2019) reported moderately (S2) suitable area exists in 510.4 ha due to gravelliness and rooting depth limitation and the remaining 3.8 ha is marginally suitable (S3) for redgram because it had severe limitations of texture and calcareousness in Haradanahalli microwatershed.

Chickpea

The mapping units KGRmB2, KGRmB2g1, NHLmB2, THLmB2, THLmB2g1Ca, THLmB2g2Ca, RPRmB2, BBLmB2, NDNmB2, NDNmB2g1Ca, TSLmB2g1Ca, SRDmB2, SRDmB2g1Ca, KRJmB2, KRJmB2g1Ca, HNTmB2g1Ca had severe limitation of pH and were grouped under suitability sub class S2s [3640 ha (87.29 % of TGA)] and had moderate limitation of total rainfall, drainage, texture and soil depth with no to slight limitation of length of growing period, coarse fragments, salinity and slope. The mapping unit DMTmB2g1, DMTmB2g1Ca, DMTmB2g2Ca were grouped under suitability S3s [482 ha area (11.55% TGA)] with pH as severe limitation.

The 19 mapping units were moderately suitable (S2) to marginally suitable (S3) for chickpea with limitation of temperature, rainfall, depth and pH and none to slight limitation of land form characteristics. Manojkumar (2011) reported moderate limitations of climate, slope, depth and drainage for growing chick pea in Bastwad micro-watershed (Fig 3).

Greengram

The mapping units were moderately (S2) to marginally (S3) suitable for growing greengram with moderate to severe limitations in respect of rainfall, depth, organic carbon and pH and none to slight limitations of land form characteristics.

In the mapping units such as DMTmB2g1, DMTmB2g1Ca, DMTmB2g2Ca and RPRmB2 had moderate to marginal limitations of pH and organic carbon were observed and grouped under suitability sub class S3s. Limitations such as depth, pH and organic carbon in KGRmB2, KGRmB2g1, NHLmB2, THLmB2, THLmB2g1Ca, THLmB2g2Ca; CEC, pH and organic carbon in BBLmB2, NDNmB2, NDNmB2g1Ca, TSLmB2g1Ca; depth and organic carbon in SRDmB2, SRDmB2g1Ca, KRJmB2, KRJmB2g1Ca, HNTmB2g1Ca were the constraints for growing greengram in this sub-watershed and was grouped into suitability sub class S2s.

Marginal to severe limitations of pH and organic carbon were observed in 3582 ha (85.9% of TGA) limiting their suitability for growing greengram and were grouped under suitability sub class S2s. The marginal suitable area of 539 ha area (12.93% TGA) was grouped as suitability subclass S3s with severe limitation of CEC, pH, OC and depth (Fig.4) According to Ravikumar *et al.* (2009) reported that sandy loam textured red soils may do well as a potential crop for greengram crop and Madhusudan (2019) opined that sandy and loamy soils with fairly rich organic matter are extremely suitable.

Cowpea

Rainfall, drainage, texture, pH and soil depth are the major factors which influence cowpea productivity. The mapping units were moderately (S2) to marginally (S3) suitable for groundnut. Marginal to severe limitations of pH and $CaCO_3$ were observed in 3640 ha (87.29% of TGA) limiting their suitability for growing groundnut and were grouped under suitability sub class S2s. The marginal suitable area of 482 ha area (11.55% TGA) was grouped as suitability subclass S3s with severe limitation of pH and $CaCO_3$ (Fig 6) According to Ravikumar *et al.* (2009b) reported that sandy loam textured red soils may do well as a potential crop for groundnut crop and Madhusudan (2019) opined that sandy and loamy soils with fairly rich organic matter are extremely suitable.

The mapping units such as DMTmB2g1, DMTmB2g1Ca, DMTmB2g2Ca having moderate to marginal limitations of

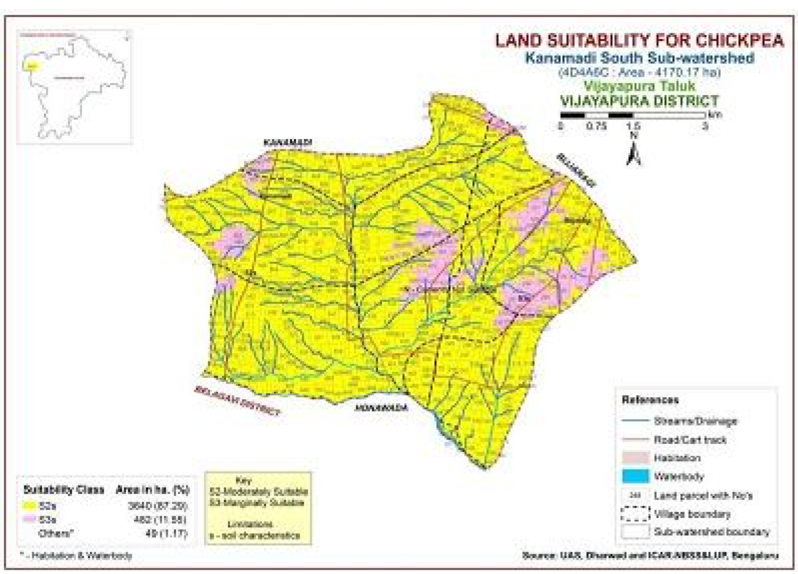

Fig 3: Land suitability for Chickpea in Kanamadi South sub-watershed.

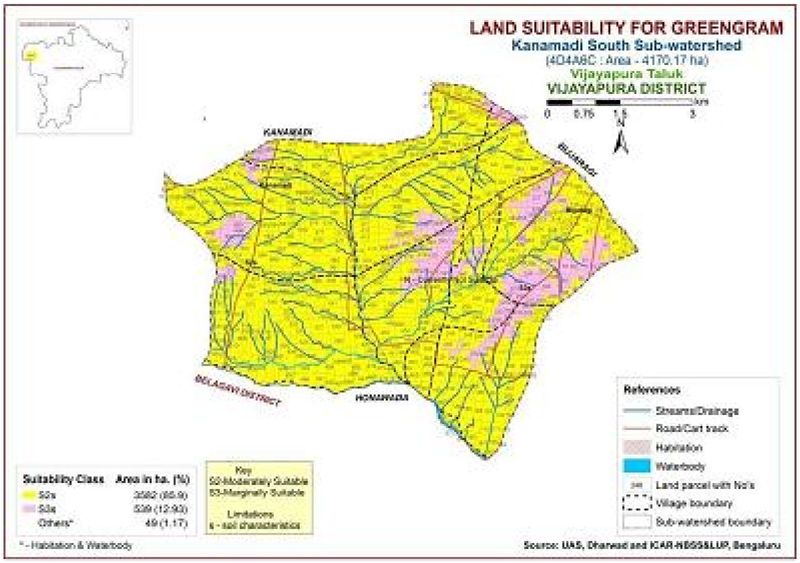

Fig 4: Land suitability for Greengram in Kanamadi South sub-watershed.

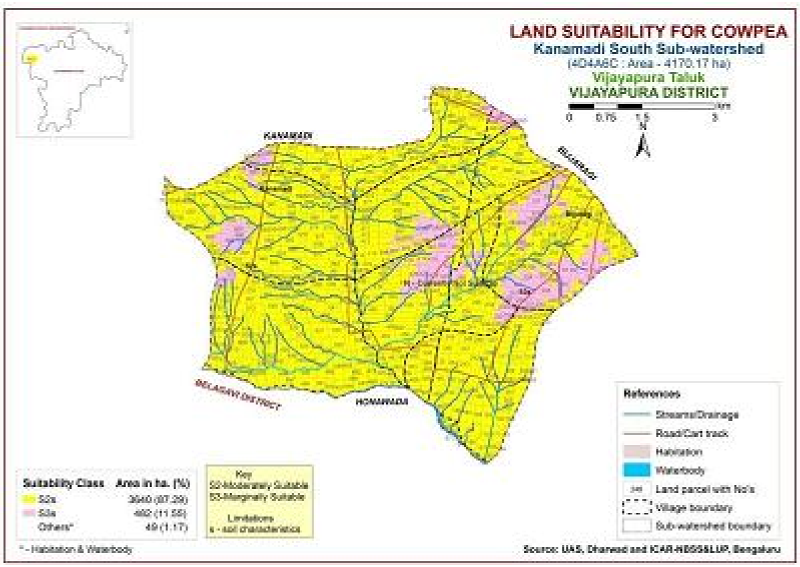

Fig 5: Land suitability for Cowpea in Kanamadi South sub-watershed.

pH and CEC were grouped under suitability sub class S3s. The mapping units such as KGRmB2, KGRmB2g1, NHLmB2, THLmB2, THLmB2g1Ca, THLmB2g2Ca had moderate to marginal limitations of depth and pH. Rainfall and soil depth were the constraints in RPRmB2, BBLmB2, NDNmB2, NDNmB2g1Ca, TSLmB2g1Ca, SRDmB2; rainfall and pH in SRDmB2g1Ca, KRJmB2, KRJmB2g1Ca, HNTmB2g1Ca mapping units and were grouped under suitability sub class S2s.

Overall, the mapping units of the study area were marginally to moderately suitable for cowpea cultivation. Similar revelation was reported by Manojkumar (2011) and Patil *et al*. (2011) reported that black soils were moderately suitable for cowpea with limitation of drainage, depth, texture and soil characteristics.

CONCLUSION

The Kanamadi South subwatesrhed, which falls in northern dry zone of Karnataka was evaluated for its suitability of land to grow pulse crops which in lacking in area and due to monocropping of cereals there was a loss in soil fertility in given area which could be restored by growing potential pulse crops. Based on the soil suitability criteria, the mapping units were evaluated for growing 4 major pulse crops of the area. The suitability evaluation revealed that more than 50% of area were moderately suitable for growing pulse crops. Pigeonpea, chickpea, greengram and cowpea were moderately suitable (S2) (84.49%, 87.29% TGA, 85.9 and 87.29% respectively). About 11-12% of area was marginally suitable for growing these pulse crop. Hence, the area could be potential hotspot for growing pulses. The data on land suitability could be utilized as major data for decision-makers and farmers to develop a pulse crop management system for increasing land productivity.

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