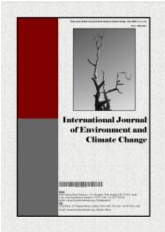

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Land Inventorization at Tardi-Babhlaj Villages of Shirpur Taluka Maharashtra State using RS and GIS

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Scientific evaluation of the land is essential in order to understand the suitability for agricultural and non-agricultural purposes and identification of capabilities and constraints of the land for various crops and their cultivation helps in appropriate and sustainable usage. In order to uplift the production, productivity as well as profitability from a farm land, the knowledge regarding various land resources and soil properties become pre-requisites. In this, direction, a land inventorization was carried out using RS and GIS techniques. The prime objective was to carry out land evaluation studies based on land based on land capability classification and suitability of lands for commonly cultivated crops in the region. Soil morphological features, physical, physico-chemical and fertility properties of the land were analysed and the results indicated that the soils are good in inherent properties even with the slight variation in the morphological and physicochemical properties. Land evaluation based on Land Capability Classification (LCC) revealed that, all the blocks fall under Class-IV with some of the limitations like, erosion, texture and low organic carbon content in soils. Suitability of land to the crops indicated that there are limitations with respect to erosion, slope and soil fertility. Based on the obtained results, corrective measures were suggested for all the blocks to reduce the erosion losses improve the soil properties for higher productivity of the cultivated crops. The study concludes that variation in soils in all blocks is due to the close relationship between soils, physiography and climate which are interrelated.

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Keywords: Soil characterization; soil constraints; land capability; remote sensing and GIS.

1. INTRODUCTION

Soil is a potential natural resource and a life supporting system which is being used to meet the basic necessities of food and fodder since time immemorial. As the population is growing year after year, pressure on land resources for more food production has been consistently increasing on account of limited production capacity of the soil owing to its inherent properties, agro-climatic conditions, usage and its managing practices. Information regarding spatial distribution, in-built properties, production potentiality, limitation/constraints and suitability of soils help in framing the strategies to achieve greater and sustainable crop production.

Soil health management is gaining greater importance these days as a consequence of irrational use and poor management of soils in several agricultural, industrial and urban development activities. Appropriate management of soils in accordance to their inherent properties is essential in order to improve soil productivity as well as sustainability. In this context, soil quality has been a crucial consideration. Basically, soil quality consists of two components- i) soils' inherent properties defined by pedological processes and ii) an active fragment which comes under the influence by the user or manager of the soil. The interactions between chemical, physical and biological properties outline quality parameters of a particular soil and decide upon the performance of the functions *viz*., i) apportioning the rain water into runoff and/or infiltration at the soil surface; ii) water holding and release to plants or groundwater or as runoff; iii) retaining as well as release of mineral nutrients; v) being a buffering agent to toxic compounds and v) resistance against water and wind erosion. Further, portioning of the soil quality parameters can be done as chemical properties- organic carbon content, C:N ratio, pH, available forms of nutrients and trace elements, acidic and saline conditions, CEC, etc. and physical indicators- texture, infiltration and bulk density. Soil characterization and land evaluation techniques like, land capability and crop suitability are becoming popular means for studying soils and managing soil health by using advanced tools such as RS and GIS [1-3]. Use of these advanced techniques helps a soil scientist to decide upon the soil characters and assist in suggesting farmers with suitable soil management practices for higher productivity and maintain the soil health [4,5].

Based on these considerations, a study was planned to understand the various soil properties of the land situated at Tardi and Babhlaj village boundaries to identify the potentiality as well as to improve the land and environmental features by overcoming the constraints for use in various activities concerning agriculture and allied sciences based on sustainable practices for management of land resources and water.

2. MATERIALS AND METHODS

Total land selected for this particular study was 111 acres which lies in two villages namely, Tardi and Bablaj in Shirpur taluka of Dhule district, Maharashtra state, India. A preliminary survey of the land was carried out during the year 2019-20. The geographical position of the land lies between North latitude 21^0 16′24.40″ to 21^0 16′18.63″ and East longitude 75^0 03′26.99″ to 75^0 04′24.66″ (Fig. 1). Average annual rainfall is 592 mm of which more than 85 percent is received during Southwest monsoon season (June-August). Weather conditions the area was generally dry except during rainy season. Maximum recorded temperature of 46^0C and minimum was 8.9 ^{0} C [6] in the area.

2.1 Soil Sampling

The entire study area was divided into 8 blocks based on the existing boundaries (Fig. 2). Collection of soil samples was done at 0-20 cm depth. Adequate samples were collected from all the blocks and composite samples were prepared and analysed for various properties.

Soil samples were kept for drying at ambient temperature; using pestle and mortar samples were ground then sifted with 2 mm sieve. Analyses for various soil parameters carried out based on the standard procedures. pH and EC by potentiometric method. Physical parameters were estimated by Keens Cup Method [7]. Chemical properties of the soil like organic carbon (OC), nitrogen, phosphorous, potassium, calcium, magnesium, cation exchange capacity etc. were analysed and calculated based on the procedures given by Piper [8]. The morphological data on soil slope were identified for each block using abney level, erosion was classified by field observation and comparing the slope percent, drainage is identified by movement of streams in the field, gravelliness and stoniness were collected through visual observation of the blocks as suggest by McGarry [9].

The land evaluation techniques were drawn by using the climatic data, physical and fertility properties; crop suitability and land capability classes for each block were established following the criteria given by Sehgal [10].

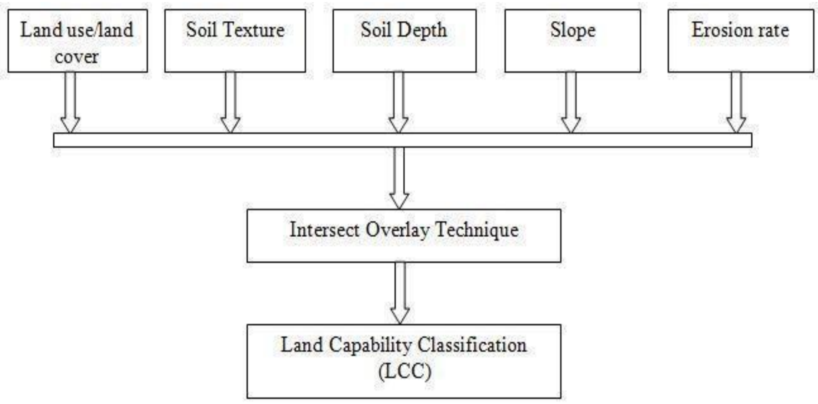
2.2 Preparation of Base Map

A base map is prepared by traversing the field boundaries in the study area using a cadastral map (village map) which is collected form local revenue department. The ground control points were identified and imported in GIS Environment. Thus all blocks were delineated. Later a Google earth image was also used for better understanding by geo referencing the co ordinates using Google earth software and geo rectified the image and boundaries were drawn using the image and ground control points.

3. RESULTS

3.1 Morphological Features

The soil type in all the Babhlaj blocks were Black cotton soils with clayey texture, Tardi South blocks were with black cotton soils with moderate clay content and Tardi North blocks were transitional soils with course texture. The profile in all blocks were well developed except, both Tardi North-1 and 2 blocks (Table 1).



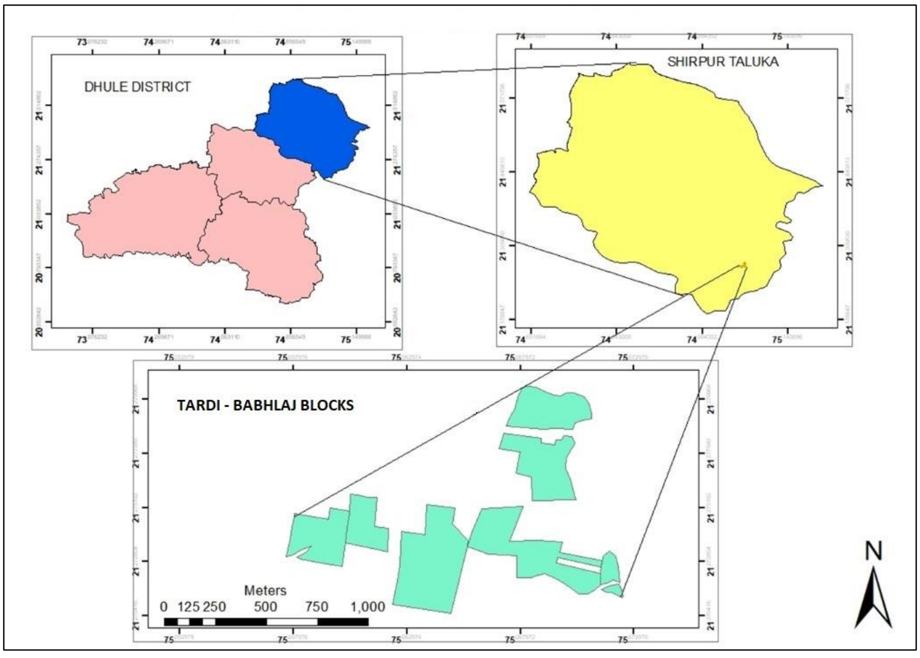


Fig. 1. Geographical location of the land selected for the study

Table 1. Morphological features of the land in different blocks

Blocks	Area (acres)	Soil Type	Texture	Profile development	Slope	Erosion	Drainage	Gravelliness	Stoniness	Land type
Babhlaj South-1	28.44	Black cotton soils	Clayey	Well developed	< 1 %	Slight	Well drained	Nil	Nil	Almost levelled
Babhlaj South-2	9.22	Black cotton soils	Clayey	Well developed	< 1 %	Slight	Well drained	Nil	Nil	Almost levelled
Babhlaj South-3	13.50	Black cotton soils	Clayey	Well developed	< 1 %	Slight	Well drained	Nil	Nil	Moderate
Tardi South-1	24.90	Black cotton soils	Moderately Clayey	Well developed	1-3 %	Moderate	Well drained	Nil	Nil	Moderate
Tardi South-2	2.73	Black cotton soils	Moderately Clayey	Well developed	1-3 %	Slight	Well drained	Nil	Nil	Moderate
Tardi South-3	1.24	Black cotton soils	Moderately Clayey	Well developed	1-3 %	Slight	Well drained	Nil	Nil	Moderate
Tardi North-1	14.10	Transitional soils	Course textured	Not well developed	3-5 %	Moderate	Well drained	10-20 %	< 1 %	Undulating topography
Tardi North-2	17.00	Transitional soils	Course textured	Not well developed	3-5 %	Moderate	Well drained	10-20 %	< 1 %	Undulating topography
Total	111.13									

Slope classes: < 1%: Nearly level; 1-3%: Gently slope; 3-5%: Very gently slope

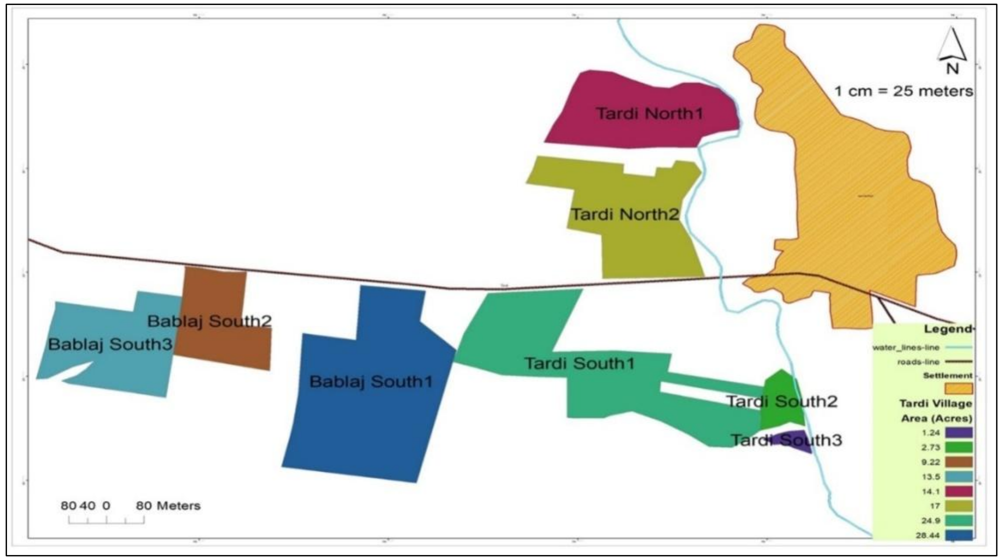


Fig. 2. On Site distribution of the blocks

The land was nearly level with less than 1 per cent slope in Babhlaj South blocks; there was very gentle slope (1-3%) in Tardi South blocks whereas, Tardi North blocks were observed with gentle slope ranging from 3-5 per cent. Moderate erosion was observed in Tardi South-1, Tardi North-1 and Tardi North-2 blocks whereas, remaining blocks were observed with slight erosion. Soils in all the blocks were well drained. However, 10-20% gravelliness and less than 1% stoniness were recorded in Tardi North-1 and Tardi North-2 blocks, remaining blocks did not show any gravelliness or stoniness. The land topography in Tardi North-1 and Tardi North-2 were undulating; moderate topography was recorded for Babhlaj South-3 and Tardi South-1, 2 and 3 blocks but Babhlaj South-1 and 2 were observed to be almost levelled.

3.1.1 Physical and physico-chemical properties

Based on the samples collected, various physical properties and physico-chemical properties of soils were analysed and pertaining results are presented in Table 2. Bulk density in all the blocks ranged from 1.06 to 1.28 Mg/m^3 and particle density was found nearer to 2.65 Mg/m^3. Porosity in Babhlaj South-2 was 45.59% whereas it was more than 50% in remaining blocks. Babhlaj South-2 block was recorded with 22.35% MWHC and rest of the blocks were found to be nearer and above 50%.

With respect to physico-chemical properties, the pH was neutral to slightly saline in the soils of the studied area with a range of 7.37 to 8.00. Similarly, electrical conductivity of the soils was also non-saline with a range of 0.16 to 0.27 dS/m. Organic carbon content was low in all the blocks ranging between 0.14 to 0.49%.

3.1.2 Chemical and fertility properties

Among the fertility properties of the soil studied, available nitrogen content was low in all the blocks whereas, the range of available phosphorous and available potassium was medium to high (Table 3). Calcium and magnesium contents were approximately in the ratio of 2:1. Sodium content was found to be lower and ESP was less than 15 in all the blocks. The CEC was recorded more than 60 % in all the blocks.

3.1.3 Land capability classification and crop suitability

Based on the land capability classification, the evaluated blocks were categorized under Class IV (Fig. 3) with some limitations with respect soil physical properties (Tardi North-1 and 2) and further all the blocks were reported with fertility limitation.

Based on the crop suitability criteria, the blocks were evaluated for the major crops grown in the area. Tardi South-1, Tardi South-3, Tardi North-1 and Tardi North-2 blocks were marginally suitable (S3) for sorghum crop whereas, remaining blocks were moderately suitable (S2). Further, fertility limitation (f) was reported in Babhlaj South-1, Babhlaj South-2, Tardi South-2 and Tardi South-3 blocks; erosion limitation (e) was reported in all the blocks except Tardi South-3. While studying maize suitability, Babhlaj South-3, Tardi South-2 and Tardi North-2 were found moderately suitable and remaining blocks were marginally suitable. Fertility limitation was reported across the blocks; however, Tardi North-2 was reported with slope (t) and erosion (e) limitations in addition.

Pearl millet suitability studies indicated that, Tardi South-1, Tardi North-1 and Tardi North-2 blocks were marginally suitable (S3) whereas, all the remaining blocks were moderately suitable (S2). However, all of the blocks were reported with erosion limitation (e) in common. Babhlaj South-3 and Tardi South-2 blocks were found highly suitable (S1) for pigeon pea cultivation; Tardi South-3 block was marginally suitable with fertility limitation. Rest of the blocks were moderately suitable (S2) with fertility limitation in common, Tardi North-1 and Tardi North-2 blocks were reported additionally with slope (t) and erosion (e) limitations.

With respect to suitability for cotton and groundnut, all the blocks were reported as marginally suitable (S3) with fertility limitations (f) in common further, erosion limitation was associated with Tardi South-1, Tardi North-1 and Tardi North-2 blocks for groundnut cultivation.

4. DISCUSSION

4.1 Soil Characterization

The results on soil morphological features indicated that soil type in all the blocks was generally black cotton soil with moderate clayey to clayey texture. According to Nayak et al. [11] texture variation is mainly due to differences in physiography. Slope of the land in all the blocks were nearly level to gentle slope; erosion was slight to moderate with well drained condition. Regarding gravelliness, all the blocks were classified non-gravelly but, Tardi North-1 and Tardi North-2 blocks were gravelly (10-20%) and stony (less than 1%) as suggested by Natarajan and Sarkar [12].

Table 2. Physical and Physico-chemical properties

Blocks	Physical properties				Physico-chemical properties		
	BD ±	PD ±	Porosity ¥	MWHC ¥	pH	EC †	O.C.*
Babhlaj South-1	1.15	2.98	64.07	67.18	7.37	0.18	0.25
Babhlaj South-2	1.08	1.39	45.59	22.35	7.70	0.23	0.44
Babhlaj South-3	1.06	2.67	59.83	74.79	7.50	0.16	0.32
Tardi South-1	1.10	2.14	57.00	47.29	7.72	0.20	0.49
Tardi South-2	1.21	2.56	67.59	49.67	7.80	0.22	0.38
Tardi South-3	1.22	2.74	69.46	49.93	8.00	0.27	0.14
Tardi North-1	1.28	2.65	68.74	48.95	7.50	0.22	0.45
Tardi North-2	1.14	2.59	65.17	60.02	7.73	0.24	0.39

*± Mg/m^3; ¥ per cent (%); † dS/m; * Organic carbon (%)*

Table 3. Chemical properties of the soils in different blocks

Blocks	Available N †	Available P_2O_5 †	Available K_2O †	Na ‡	Ca §	Mg §	CEC	ESP
Babhlaj South-1	118.77	54.04	385.28	1.76	34.17	13.17	85.64	2.06
Babhlaj South-2	211.87	70.95	483.84	1.82	33.00	12.00	92.72	1.96
Babhlaj South-3	154.08	88.63	376.32	1.45	35.25	12.00	84.40	1.71
Tardi South-1	237.55	68.61	291.20	1.46	39.67	5.17	73.92	1.97
Tardi South-2	182.98	48.42	302.40	1.30	31.25	6.00	67.23	1.94
Tardi South-3	67.58	100.34	295.68	1.30	31.00	6.50	66.85	1.94
Tardi North-1	216.68	54.00	403.20	1.70	35.00	3.25	78.20	2.17
Tardi North-2	187.79	95.19	362.88	1.42	39.25	13.75	88.85	1.61

† Kg/ha ;‡ cmol (P$^+$)/Kg of soil;§ meq/100 gm of soil

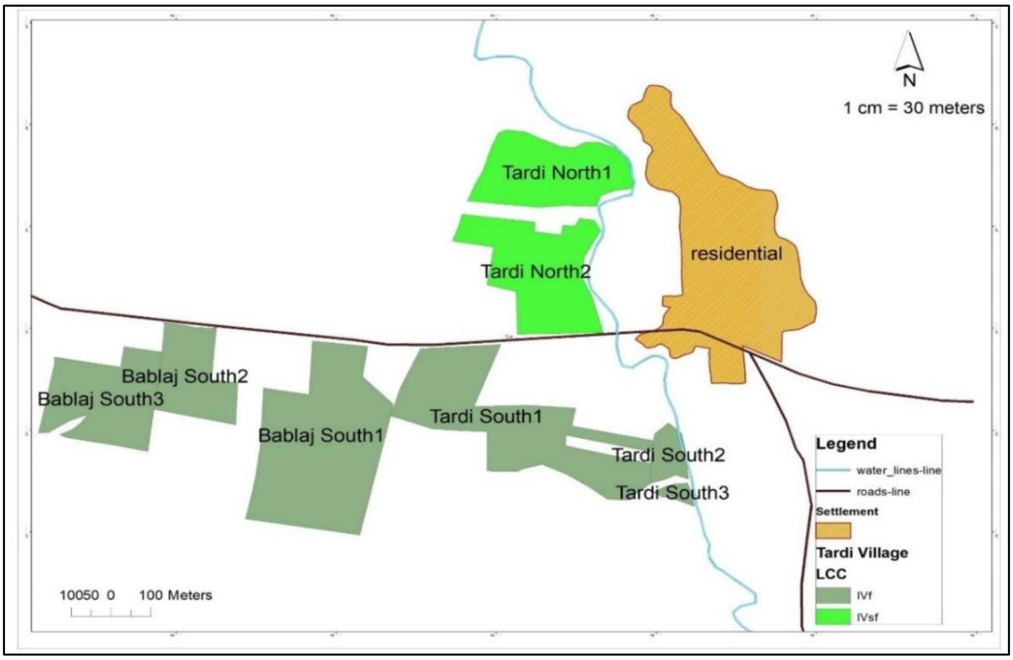


Fig. 3. Grouping of the blocks based on land capability classification
IV: Land capability class (LCC) IV; S: Constraints regarding physical properties; f: Constraints regarding chemical (fertility) properties

Outcomes regarding physical properties of the soil indicated slight variation in the obtained values however, the range of values are not deviated from the acceptable ranges. Similarly, physico-chemical properties indicated that the soil chemical reaction was neutral to slightly saline; electrical conductivity was less than 1 dS/m indicating normal condition of the soil without any problems to the cultivated crops. However, organic carbon was found low in all the soil samples which may be attributed to non-application of organic matter to the lands. Even though, there were variation in the calculated values for physico-chemical properties the obtained range indicate that the inherent characteristics of soil are in good condition. Similar results were in accordance with Badrinath et al*.* [13]; Balangoudar [14] and Vara Prasad Rao [15].

The fertility properties showed that the available nitrogen was low in all the blocks however, the range of available phosphorous and available potassium was medium to high. Calcium and magnesium content were not in the range which causes soil salinity. Further, calcium and magnesium content was found almost in the ratio of 2:1 indicates stability in the soil reaction. Sodium content and ESP were found lesser than 5 and 15, respectively which are considered safe for cultivated crops. The CEC was recorded more than 60 in all of the blocks which might be attributed to higher content of 2:1 type of expanding clay minerals which positively correlate with CEC and the amount of exchangeable sodium in the soil in relation to total cations is determined by nature of the mineral/s, electrolyte concentration as well as the soluble-cations [16]. Higher CEC and restricted drainage resulted in high base saturation in all blocks. These results are in accordance with Maji et al*.* [17].

4.1.1 Land evaluation studies

Land evaluation was carried out under land capability and crop suitability studies.

4.1.2 Land capability classes

Based on the land capability or limitation, eight classes have been designated for categorization of lands. Accordingly, the lands are categorized under Class-I to Class-IV when they are found suitable for common crop cultivation and are distinguished based on soil depth, degree of slope, erosion, etc. Class-V to Class-VIII lands categories are considered unsuitable for growing crops however, they are suggested for growing grasses, forestry or used for wildlife habitation and recreation [18]. Following the guidelines used by Mani et al*.* [19] in upper Vellar basin and Rajeev Srivastava et al*.* [20] in basaltic terrain, the micro watershed was classified under land capability classes *viz.,* class III and IV, and sub classes on the basis of their susceptibility to erosion.

Based on land capability classification, all the blocks were categorized under class-IV (Fig. 3) indicating the suitability of the lands for crop cultivation. However, all the blocks were reported with fertility limitations owing to low organic carbon content. These observations were in line with the findings of Basava Raju et al*.* [21] in soils of Chandragiri mandal of Chittoor district of Andhra Pradesh and Tardi North-1 and Tardi North-2 blocks were further observed with soil physical constraints as they were reported with course texture. Higher coarser fraction was mainly attributed to the silicaceous and granite gneiss parent material [22].

4.2 Crop Suitability

Based on the crop suitability criteria, the blocks were evaluated for suitability to cultivate common crops like sorghum, maize, cotton, etc. Sorghum requires clay loam to loam textured soils having good water holding capacity for obtaining higher yields [23]. For higher productivity of maize, soils with loamy sand to clay loam texture, high organic matter and WHC, neutral to slight alkaline pH are considered good [24].

4.2.1 Sorghum

Suitability studies for sorghum crop revealed moderately to marginally suitability of the lands. The major limiting factors were erosion and fertility and few of the blocks were observed with both (Fig. 4).

4.2.2 Maize

Severe fertility (S3f) limitation was recorded in five of the blocks and three blocks were observed to be moderately (S2f) constrained with fertility, among which Tardi North-2 was further, recorded with slope and erosion limitations for maize cultivation (Fig. 5). Similar results were reported by Manojkumar [25]; Nagaraju et al*.* [26].

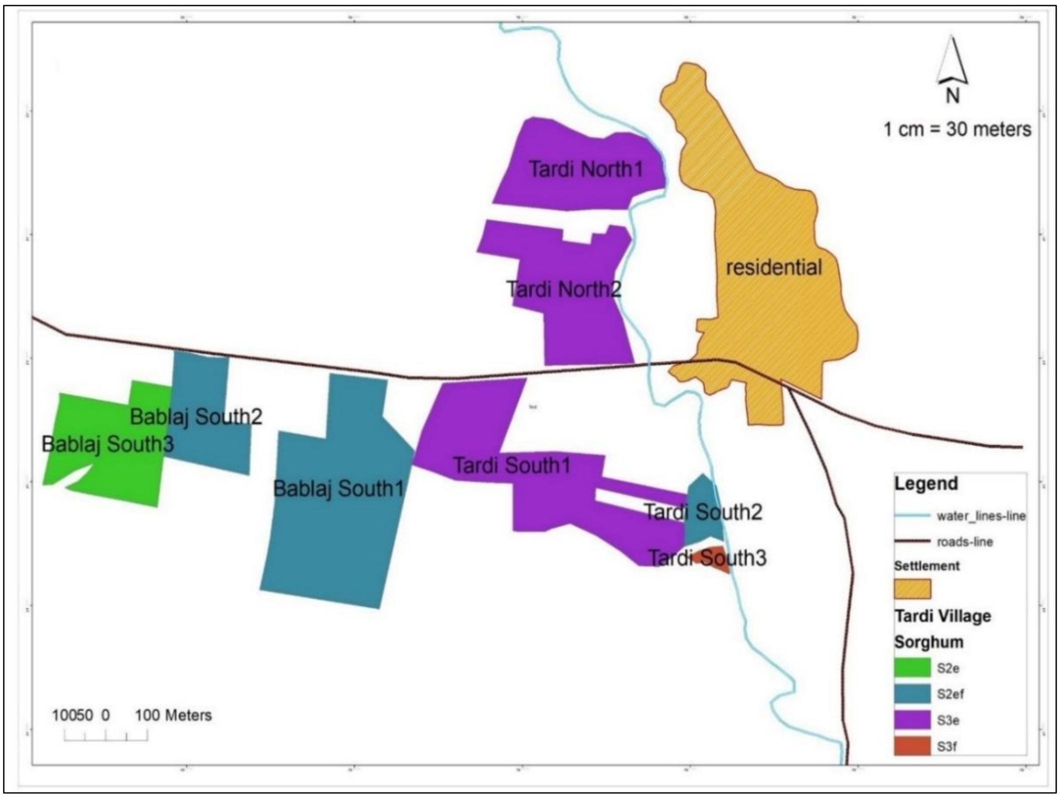


Fig. 4. Sorghum suitability map

S2: Moderately suitable; S3: Marginally suitable; e: Erosion constraint; f: Fertility constraint

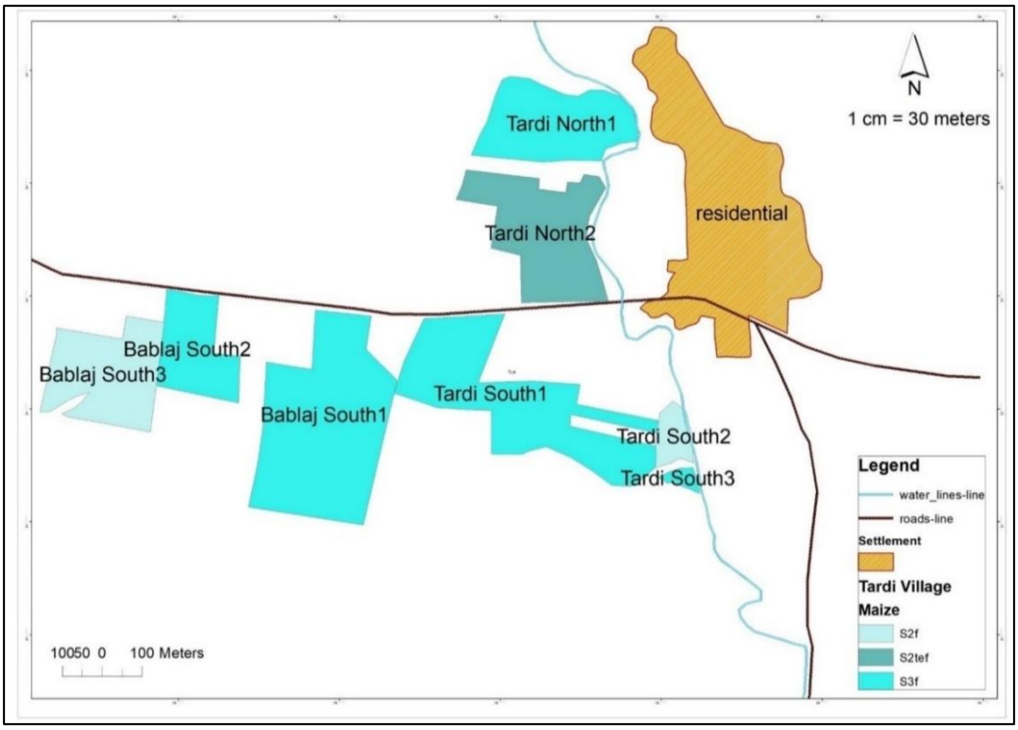


Fig. 5. Maize suitability map

S2: Moderately suitable; S3: Marginally suitable; t: Slope constraint; e: Erosion constraint;f: Fertility constraint

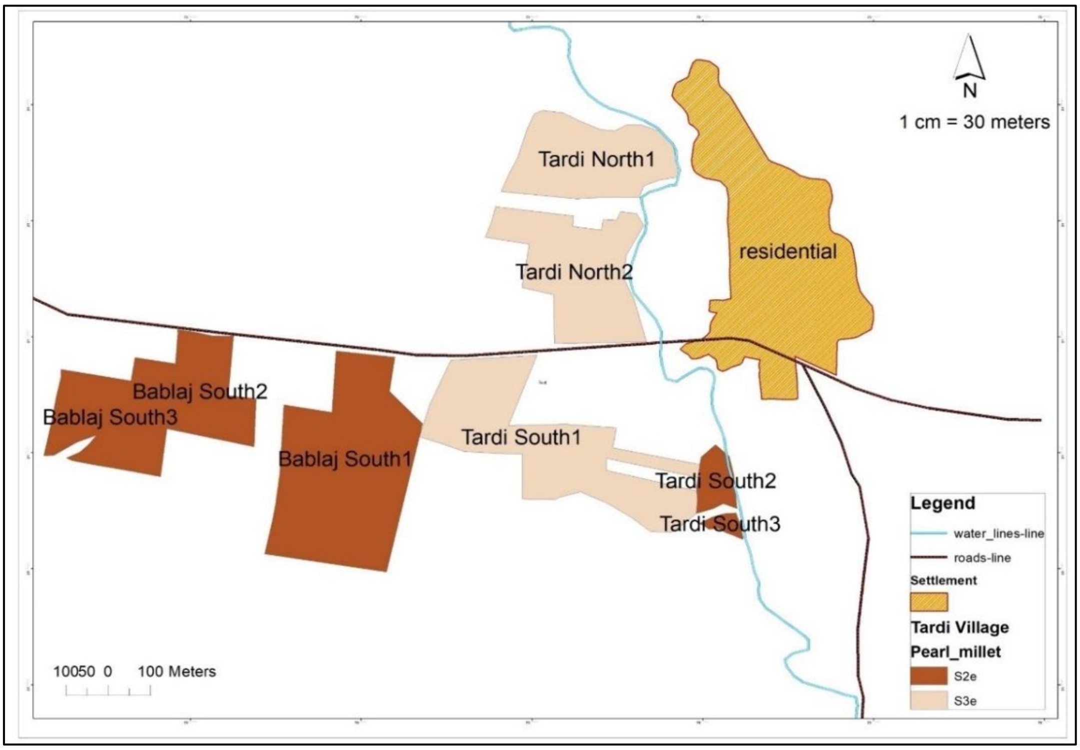


Fig. 6. Pearl millet suitability map

S2: Moderately suitable; S3: Marginally suitable; e: Erosion constraint

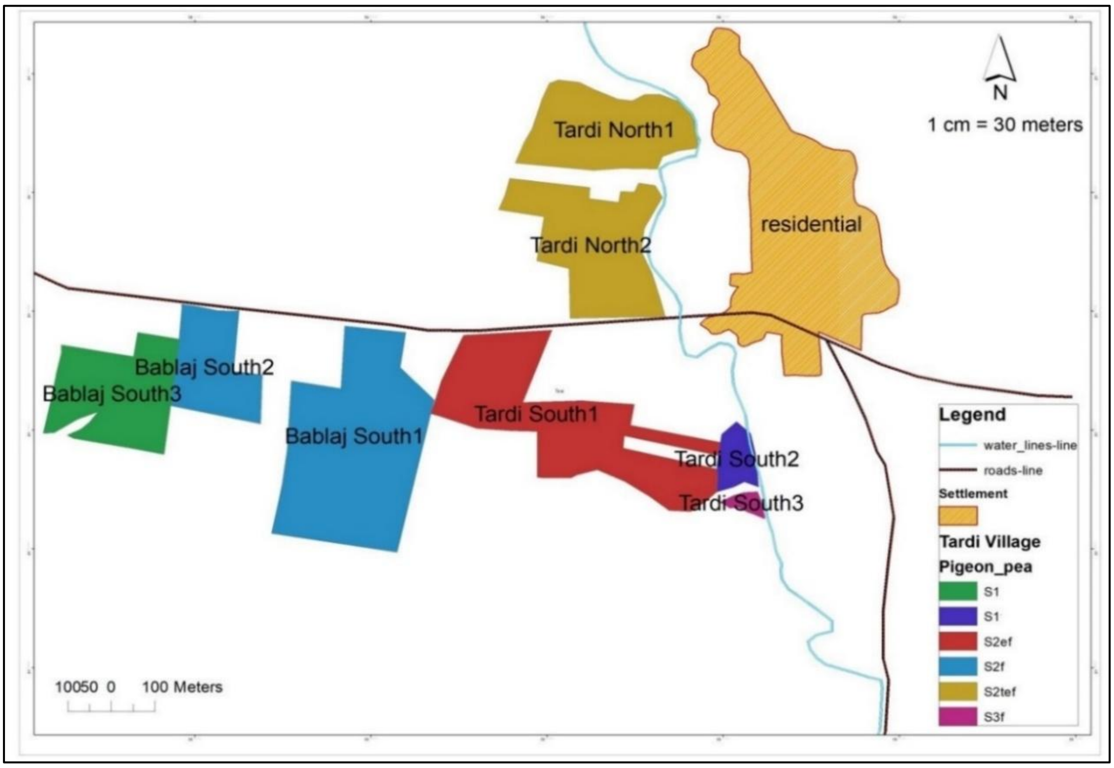


Fig. 7. Pigeon pea suitability map

S1: Highly suitable; S2: Moderately suitable; S3: Marginally suitable; e: Erosion constraint; f: Fertility constraint; t: Slope constraint

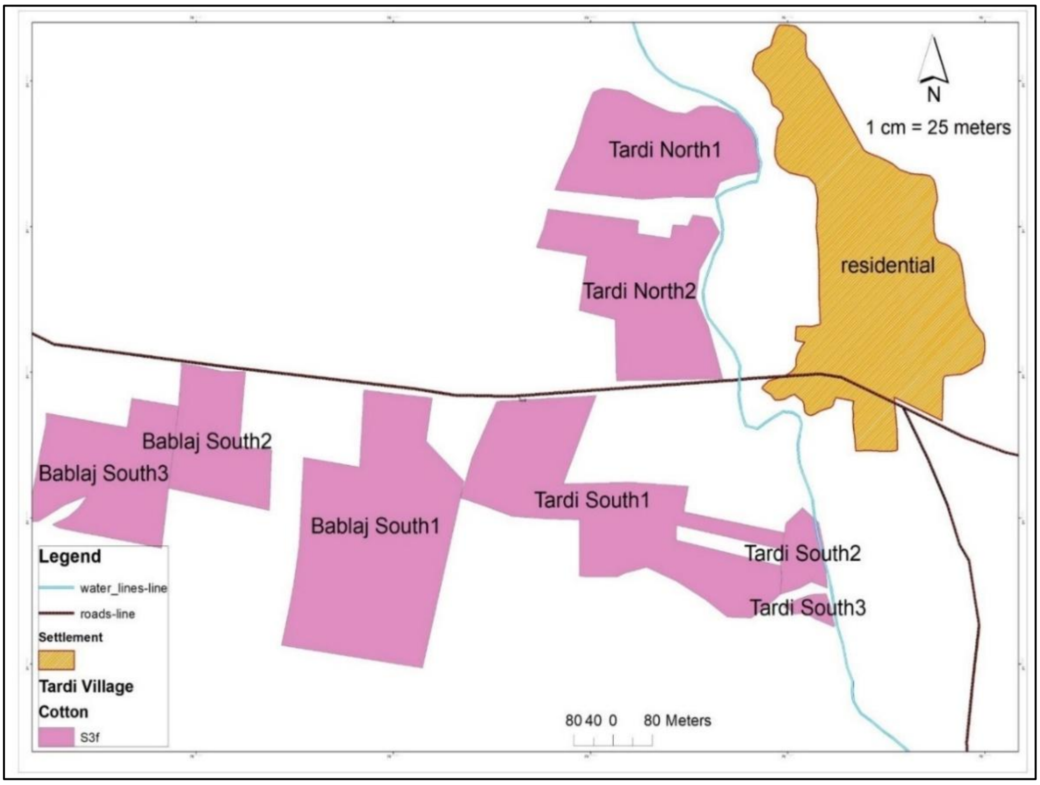


Fig. 8. Suitability map for cotton
S3: Marginally suitable; f: Fertility constraint

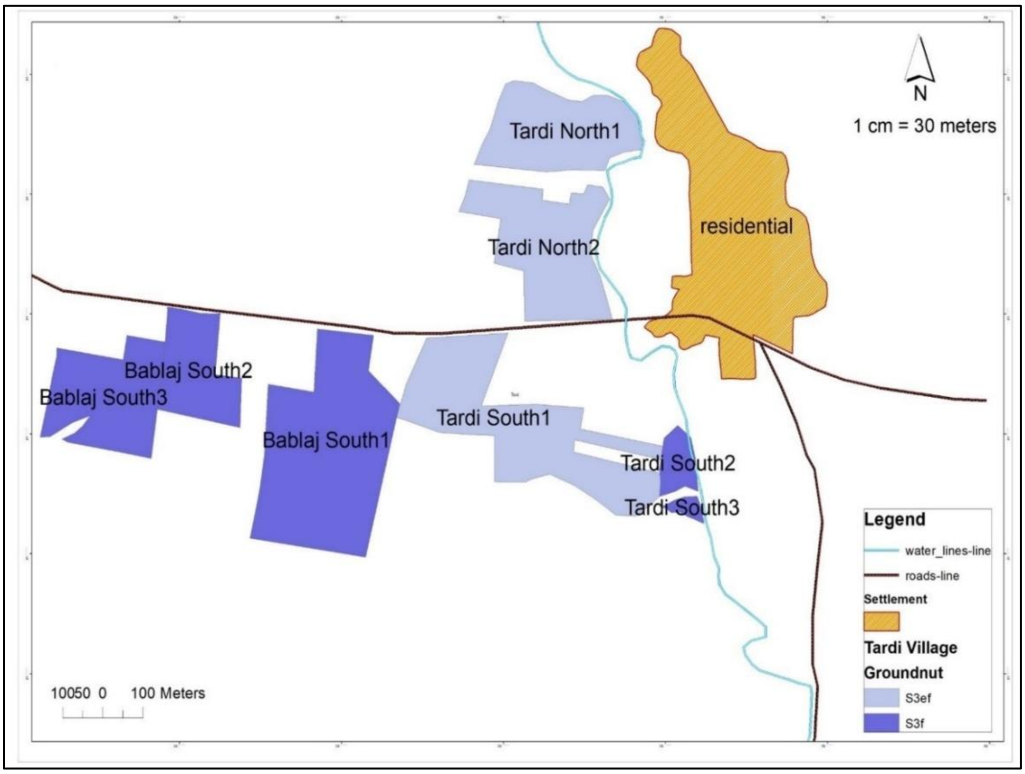


Fig. 9. Suitability map for groundnut
S3: Marginally suitable; e: Erosion constraint; f: Fertility constraint

4.2.3 Pearl millet

To obtain higher yields in pearl millet loamy sand to loamy soils having good drainage and without salinity or alkalinity are ideal. Cultivation of pigeon pea can be done on wide range of soils from sand to heavy clay loams with good drainage and medium heavy texture [24]. However, in the present study, the lands were observed with only erosion limitation in all the blocks among which five were found moderately suitable and three were marginally suitable for pearl millet cultivation (Fig. 6).

4.2.4 Pigeon pea

Babhlaj South-3 and Tardi South-2 blocks were found highly suitable (S1) for pigeon pea cultivation without any limiting factors with respect to soil and climatic features. But, Tardi South-3 block was marginally (S3f) suitable with severe fertility limitations and remaining blocks were reported with moderate fertility, erosion and slope limitations for pigeon pea cultivation (Fig. 7). Similar results were reported by Manojkumar [25]; Nagaraju et al*.* [26].

4.2.5 Cotton

Cotton prefers a deep, friable soil with good fertility and higher water holding capacity. Whereas, ideal soils for groundnut cultivation are sandy and loamy soils with good drainage, with high organic matter having pH in the range of 5.5-7.0 [27]. Patil et al. [28] recorded similar results during the study of Bhanapur micro watershed. Even though soils in all the majority of blocks were black cotton with clayey texture, cotton crop was found marginally suitable with severe fertility (S3f) limitation (Fig. 8).

4.2.6 Groundnut

Land evaluation for suitability of groundnut crop revealed that, there were severe limitations with respect to fertility in all of the blocks; Tardi South-1, Tardi North-1 and Tardi North-2 blocks were further observed with erosion limitation (Fig. 9). According to Ravikumar et al*.* [29] sandy loam textured red soils may do well for groundnut crop and Nagaraju et al*.* [26] also evaluated suitability for groundnut crop.

Considering the land evaluation studies, following corrective measures were drawn against the identified limitations to improve the soil properties and increase crop productivity. Soils were more prone to erosion at moderate level (e) and found sloppy and undulating lands (t) with gravelly and stony land in patches. The corrective measures are suggested that cconstruction of contour bund for sloppy lands to reduce the erosion losses, Growing crops across and along the slope minimizes soil and water loss through erosion. Soil and water erosion can be controlled by various agronomic measures like ridge and furrow system, broad bed furrow methods and intercropping methods. Collection of excess water and diverted to the streams and channels. It was also found that low organic matter content and low level of available primary nutrients can be corrected by Growing and incorporation of green manure crops like, sun hemp (*Crotalaria Juncea*), *Sesbania* sp. Application of FYM manure at 25 t/ha before sowing of the crops and Summer ploughing should be done in order to expose the soil to high temperature by sun to kill pathogens, weed seeds and insect pests.

5. CONCLUSIONS

Based on the results obtained from various properties, the soils in all the blocks were reportedly good in inherent physical properties and chemical properties considering few limitations. However, the results drawn from these soil properties and land capability classification as well as crop suitability indicated that the lands in all of the blocks fall under Class-IV along with limitations *viz*., soil physicals characteristics like texture in Tardi 1 and Tardi 2 and it was also reported that all the blocks were constrained with soil fertility. Among the evaluated six of the commonly grown crops for suitability, only pigeon pea was reported with high suitability in Babhlaj South-3 and Tardi South-2 blocks. But, remaining blocks were reported to have some limitations like, erosion, slope and soil fertility for cultivating the crops. However, all the blocks can be grown by all the suggested crops by correcting the limitations by suitable measure. The study concludes that variation in soils in all blocks is due to the close relationship between soils, physiography and climate which are interrelated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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