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Soil Phase: Base for Deriving Land Capability Class and Crop Suitability

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Authors' contributions

This work was carried out in collaboration among all authors. Author NLR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KK and VR managed the analyses of the study. Author VR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A detailed land resource study of Gadagi-2 micro watershed, Lingasusgur taluk, Raichur district, Karnataka state, India, was carried out during summer 2017, at the scale of 1:8000 using cadastral map overlaid on IRS Cartosat-1 merged with LISS IV satellite imagery. Initially, a detailed survey was carried out to derive soil phase units based on land surface and profile characters. Five soil series were identified and mapped into five soil phase units. It is revealed that soil were non-saline with EC <4 dSm^{-1}. The OC, available P_2O_5 and available K_2O content of the study area were low to medium, and soil available N and S status were low in all the five soil phases. HEGiC2 soil phase was classified as class III land capability class with limitation of rooting and slope. Rest of the soil phases *viz.*, KALhC2g1S1R1, VKRhD2g2S2R3, CHRhC2g1S1R1 and BHGhE2g2S2R2 were classified as class IV land capability with limitation of slope, texture, erosion, rooting condition and organic carbon. Suitability for horticulture and field crops were derived based on soil phase, site characteristics and climatic regimes. Proposed crop plan for field crops and horticulture crops for all five soil phase units was prepared. Suitable soil and water conservation measures such as deep

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and wider size pit and drip irrigation for fruit crops and forest trees, cultivation on raised beds with mulches and drip irrigation, graded bunds and strengthening of field bunds, crescent bunds were found suitable for vegetables, flowers and sole crops based on the soil phase characteristics.

Keywords: Soil phase; land capability; crop suitability; crop plan; remote sensing and GIS.

1. INTRODUCTION

Soil properties vary spatially from a field to a larger regional scale and it is affected by intrusive and extrinsic factors such as soil management practices, fertility status, crop rotation etc. [1]. The variation of soil morphological and chemical properties should be monitored and quantified to understand the effects of land use and management systems on soils. Soil characteristic assessment provides an accurate and scientific inventory of different soils, their kind, nature and extent of distribution so that one can make prediction about their characters and potentialities Ravikumar et al. [2]. It also provides adequate information in terms of land form, terraces and vegetation [3]. The importance of reliable and timely information on soils cannot be overlooked, acquiring spatial information of the soil properties like morphological and chemical information are necessary in the implementation of effective management strategies for sustainable agricultural production. Remote sensing (RS) and Geographical information system (GIS) technologies have great potentials in the field of soil and has opened newer possibilities of improving soil statistic system as it offers accelerated, repetitive, spatial and temporal synoptic view. It also provides a cost effective and accurate alternative to understanding landscape dynamics. GIS has the capability to support spatial statistical analysis, thus there is a great scope to improve the accuracy of soil survey through the application of RS and GIS technologies.

Therefore, assessing the land for deriving soil phase units was undertaken in Gadagi-2 micro watershed of North Eastern Dry Zone of Karnataka to classify land into different capability classes with soil limitations. Further land suitability to field and horticulture crops can be derived in consideration with the climatic regimes. The suitable soil and water conservation measures along with crop plans are proposed with respect to soil phase units for site specific management in maximizing the agriculture input use efficiency and farm income.

2. MATERIALS AND METHODS

Gadagi-2 micro-watershed is located in Lingasugur taluk of Raichur district, Karnataka, lies between 76° 38' 49.257" to 76° 40' 37.757" East latitudes and 16° 21' 36.485" to 16° 20' 18.843 North longitudes, having total area of 741.29 ha. The micro watershed is surrounded by Lingadahalli, Veergol, Gadagi and Golpalli villages (Fig. 1).

The detailed soil survey and soil resource mapping was carried out at 1:8000 scales. Initially traversing was made and soil surface characteristics were recorded by using cadastral map (Fig. 2) overlaid on IRS Cartosat-1 merged with LISS IV imaginary having 2.5 m spatial resolution (Fig. 3). Erosion hazards were judged through existing site conditions, texture by feel method and slope with the help of dumpy level. The soil chemical properties (horizon-wise) were estimated using standard laboratory procedures. Organic Carbon (OC) was determined by Walkely and Black (1965) wet oxidation method ; available N was determined by modified alkaline potassium permanganate method as described by Subbiah and Asija [4]; available P_2O_5 by Olsen method [5] and available K_2O through a flame photometer after extraction with ammonium acetate [6]. Five soil series were identified in the study area and mapped into five soil phases as soil phases (Fig. 4).

2.1 Morphological Properties (Table 1)

After soil survey, the first step is the establishment of the soil phases of classification to be shown on the map. The soil phases are phases of soil series. Five different types of soil series were identified under the study area namely Heggapur (HEGiC2), Kallarhatti (KALhC2g1S1R1), Vyakarnal (VKRhD2g2S2R3), Bhogapur (BHGhE2g2S2R2) and Chatra (CHRhC2g1S1R1) series (Soil Survey Staff) [7].

Land capability classification involves an evaluation of the degree of limitation posed by permanent or semi-permanent attributes of land

to one or more land use [1,8]. By combining the slope, physiographic and land capability criteria, land has been classified according to its capability as shown in (Table 4).

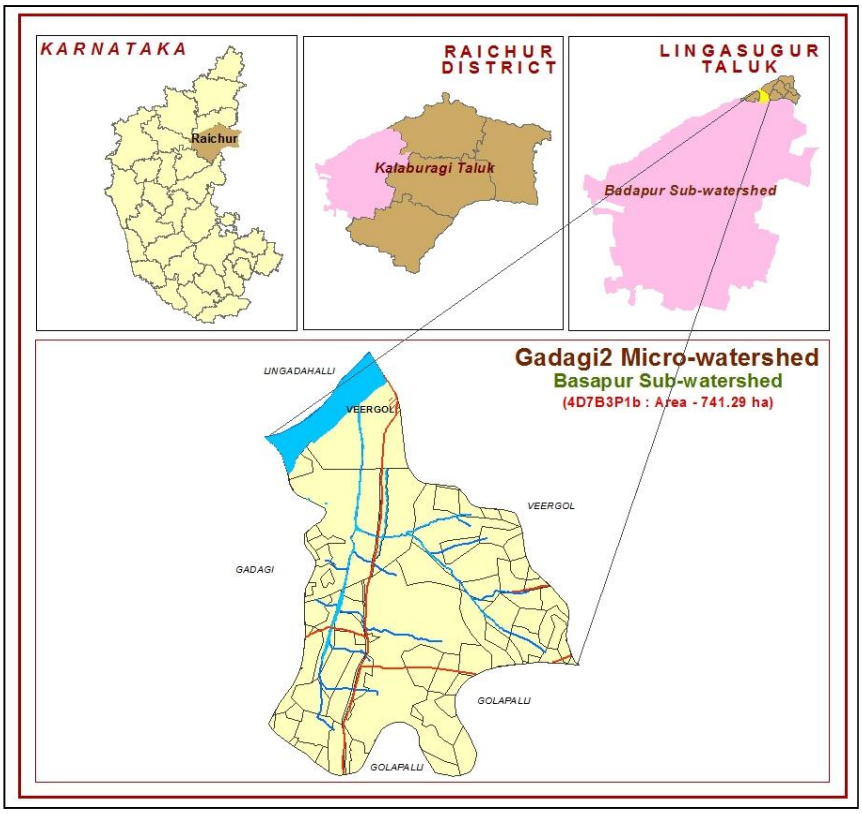

Fig. 1. Location map of Gadagi-2 micro watershed

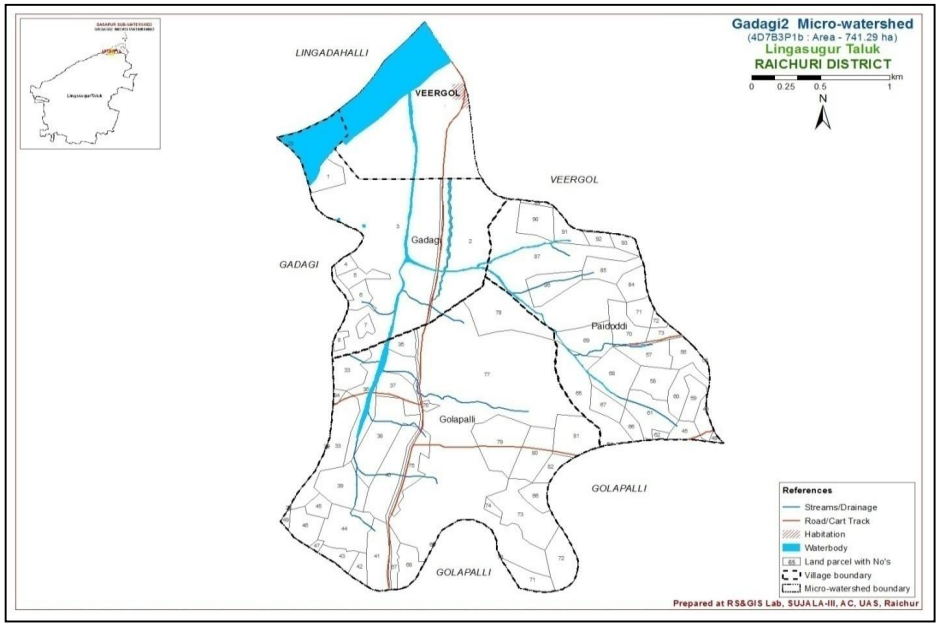

Fig. 2. Cadastral map of Gadagi-2 micro watershed

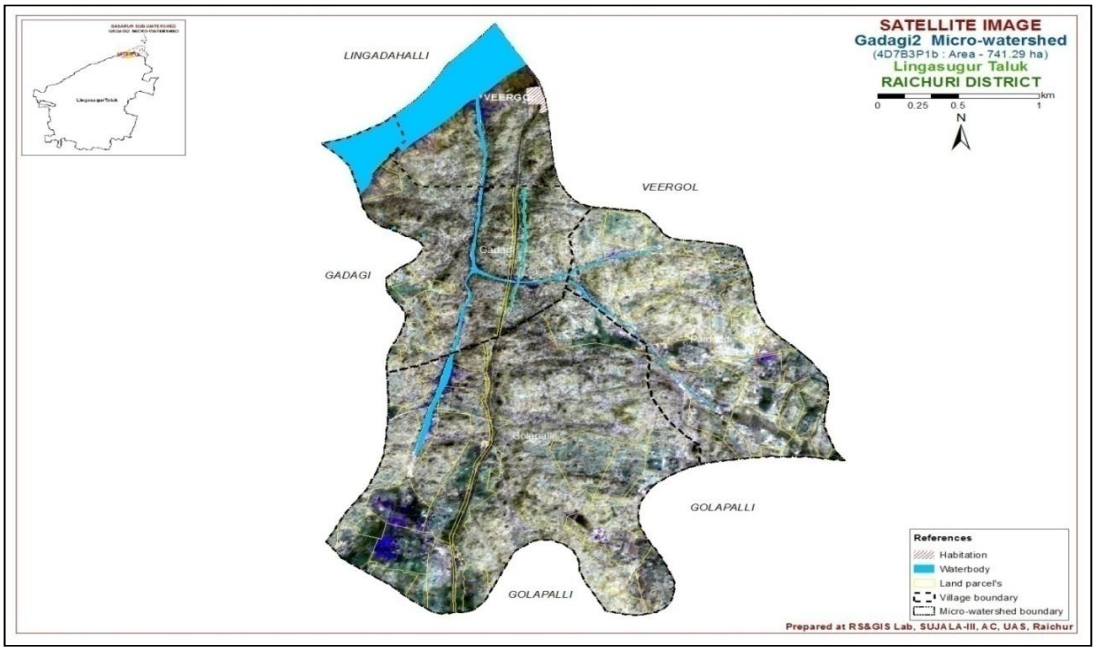

Fig. 3. Cartosat-I merged with LISS - IV imagery overlaid with Cadstral map

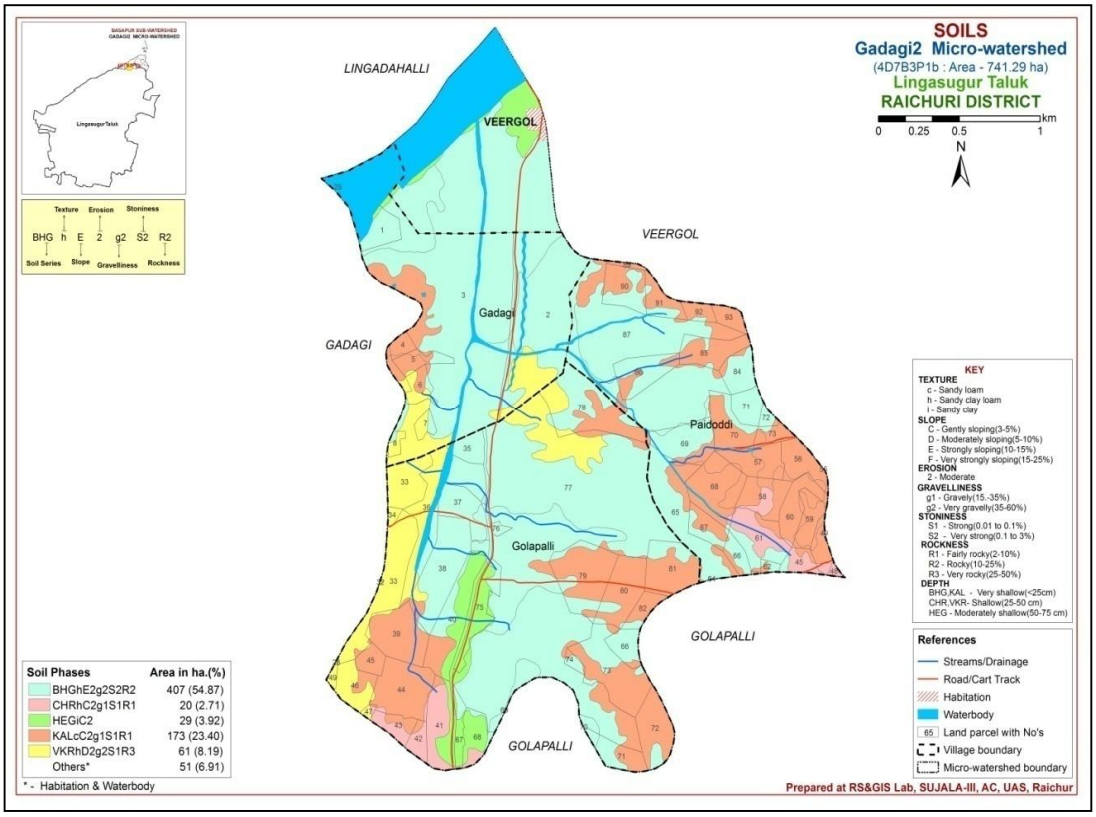

Fig. 4. Soil phase of Gadagi-2 micro watershed

Table 1. Morphological features of the soils of Gadagi-2 MWS

Name of Soil series	Mapping unit	Geology	Colour		Soil depth (cm)		Slope (%)	Physiography	Texture	
			Surface	Subsurface	Surface	Sub surface			Surface	Sub surface
Heggapur	**HEGiC2**	Granite	10YR 3/4 (D) & 3/3 (M)	10YR 4/4(D) & 3/6(M)	0-9	9-64	3-5	Upland	sc	sc
Kallarhatti	**KALhC2g1S1R1**	Granite	5YR 4/4(D) & 3/3 (M)	5 YR 4/3 (D) & 3/3 (M)	0-9	9-21	3-5	Upland	scl	scl
Vyakarnal	**VKRhD2g2S2R3**	Granite	7.5YR4/3(D) & 3/3(M)	7.5YR 3/2 (D) & 3/3(M)	0-10	10-30	5-10	Upland	scl	scl
Bhogapur	**BHGhE2g2S2R2**	Granite	2.5YR3/4(D) & 3/3(M)	2.5 YR 3/3 (D) & 3/2(M)	0-12	12-32	10-15	Upland	gscl	gscl
Chatra	**CHRhC2g1S1R1**	Granite	5YR3/3(D) & 3/2(M)	5 YR 3/4 (D) & 3/3(M)	0-16	16-29	3-5	Upland	scl	scl

Name of Soil series	Mapping units	Structure		Consistency		Efferve scence	Gravelliness		Erosion	Rooting size		Stoniness	Drainage
		Surface	Sub surface	Surface	Sub surface		Surface	Sub surface		Surface	Sub-surface		
Heggapur	**HEGiC2**	1msbk	2mabk	sh, fr, ss, sp	h, fi, vs, vp	Slight	Nil	Nil	Moderate	fc	fc	Nil	Moderately well drained
Kallarhatti	**KALhC2g1S1R1**	1 msbk	1msbk	sh, fr, ss, sp	sh, fr, ss, sp	Nill	Nil	Nil	Moderate	fc	fc	Nil	Well drained
Vyakarnal	**VKRhD2g2S2R3**	1 msbk	2 msbk	sh, fr, ss, sp	sh, fr, ss, sp	Nill	Nil	Nil	Moderate	fc	fc	Nil	Well drained
Bhogapur	**BHGhE2g2S2R2**	1 mgr	2 msbk	sh, fr, ss, sp	sh, fr, ss, sp	Nill	Slight	Nil	Moderate	fc	fc	Nil	Well drained
Chatra	**CHRhC2g1S1R1**	1 msbk	1msbk	sh, fr, ss, sp	sh, fr, ss, sp	Nill	Nill	Nil	Moderate	fc	fc	Nil	Well drained

Note: sh – slighly hard, fr – friable, ss – slightly sticky, sp – slightly plastic, fi – firm, vs – very sticky, v p – very plastic, h – hard, m – medium, sbk – subangular blocky, abk-angular bloky, gr-granular, c – coarse, fc –few common roots, f-fine root

3. RESULTS AND DISCUSSION

3.1 Soil Depth

Soil depth of all the five soil phases varied from 29-64 cm (shallow to moderately shallow). The depth of soil belonging to HEGlC2 soil phase was moderately shallow and remaining soil phases were shallow. The depth of pedon was manifestation of topography. This is due to Thicker soil profile in soils where ratio of rate of weatherability of parent materials to the rate of soil erodability was more. Similar observations were also recorded by Sitanggang *et al*. (2006) [9] in Shikolpur watershed area of Gurgaon district, Haryana.

3.2 Soil Colour

The soil colour of HEGiC2 soil phase was dark yellowish brown in both dry and moist soil (10YR3/4D & 10YR4/4 M), similarly KALhC2g1S1R1 soil phase was reddish brown in both moist and dry soil (5YR4/4D & 5YR4/3M). Whereas VKRhD2g2S2R3 soil phase was brown in dry condition and dark brown in moist (7.5YR4/3D & 7.5YR3/2M), BHGhE2g2S2R2 soil phase was dark reddish brown in both dry and moist (2.5YR 3/4D & 2.5YR 3/3M) and CHRhC2g1S1R1 soil phase was dark reddish brown (5YR 3/3 D & M).The colour of the soil is mainly depend on the parent material and climate. Similar results are observed by Nagraj et al. [10].

3.3 Soil Texture

Soil texture in HEGiC2 soil phase was sandy clay, BHGhE2g2S2R2 soil phase was gravelly sandy clay and the remaining three mapping unit's *viz*., KALhC2g1S1R1, VKRhD2g2S2R3 and CHRhC2g1S1 were sandy clay loam in texture Piper [11]. Texture of the soil is mainly depend on the parent material and other soil forming factors. Similar observations were also made by Tripathi et al. [12] in Kymore plateau and Satapura hills of Madhya Pradesh.

3.4 Soil Structure

The surface structure of HEGiC2 soil phase was moderate, medium, sub angular blocky (grade, size and type) and sub surface was strong, medium, angular blocky, KALhC2g1S1R1 and CHRhC2g1S1R1 soil phases were weak, medium, sub-angular blocky in both surface and subsurface horizon, whereas VKRhD2g2S2R3 soil phase were weak, medium, sub angular blocky in surface horizon and strong, medium, subangular blocky structure in sub surface horizon and BHGhE2g2S2R2 soil phase was weak, medium, granular structure in both surface and sub surface. The soil structure is depend on texture, cultivation practices and other factors influence it. Similar observations were also made by Tripathi et al. [12] in Kymore plateau and Satapura hills of Madhya Pradesh.

3.5 Soil Consistency

The soil consistency of surface horizons in HEGiC2 soil phase under dry, moist and wet condition was slightly hard, friable, slightly sticky and slightly plastic, respectively. In subsurface horizon, was hard, friable, slightly sticky and slightly plastic and reaming four soil phases were *viz*., KALhC2g1S1R1, VKRhD2g2S2R, BHGhE2g2S2R2 and CHRhC2g1S1R1; exhibited under dry, moist and wet condition were slightly hard, friable, slightly sticky and slightly plastic respectively in both surface and sub surface horizon.

3.6 Chemical Properties (Tables 2 and 3)

3.6.1 Soil reaction

The soil reaction (pH) was slightly alkaline in HEGiC2 soil phase which ranged from 7.22 to 7.48 and the reaming four soil phases were neutral. The pH was increasing from surface to sub surface due to their accumulation of bases in the solum as they were poorly leached from upper horizons [13].

3.6.2 Electrical Conductivity (EC)

All the soil phases showed low EC values ranging from 0.07 to 0.23 dS m^{-1} indicating the non-saline nature of the soils. The upper solum relatively less EC values which was due to free drainage conditions which favored the removal of released bases by percolating water. The results were in accordance with the study conducted by Pillai and Natarajan [14] in Garakahalli watershed using remote sensing and GIS.

3.6.3 Organic carbon

The OC content of study area was found to be low to high which ranged between 0.14 to 0.92 g kg^{-1}. The OC in HEGiC2 soil phase which ranged from 0.52 to 0.86 g kg^{-1}, in KALhC2g1S1R1 soil

phase was 0.32 to 0.52, VKRhD2g2S2R soil phase was 0.52 to 0.54 g kg^{-1}, BHGhE2g2S2R2 soil phase was 0.26 to 0.32 g kg^{-1} and CHRhC2g1S1R1 soil phase was 0.14 to 0.92 g kg^{-1}. OC content of the soils followed decreasing trend with depth in all the mapping units. This was attributed to the addition of farm yard manure and plant residues to surface horizons which resulted in higher organic carbon content in surface horizons than that of lower horizons. It reflects the rapid rate of organic matter mineralization in these soils. Similar findings were reported by and Shadaksharappa et al. [15] in Malaprabha command area soils.

3.6.4 Free $CaCO_3$

The free calcium carbonate ($CaCO_3$) of all the five soil phases was ranged from 21.85 to 24.65%. This is mainly due to the leaching effect. Similar findings were reported by Barade and Gowaikar [16,17]. However the soils were non calcareous but were tending towards the calcareous.

3.6.5 Exchangeable cations

The HEGIC2 soil phase of Ca and Mg were ranged from 34.5 to 41.5 and 10.5 to 19 ppm respectively, KALhC2g1S1R1 soil phase was 39.5 to 49 and 10.5 to 14.5 ppm respectively. VKRhD2g2S2R soil phase was 27 to 20.5 and 8.5 to 14.5 ppm respectively, BHGhE2g2S2R2 soil phase was 29.5 to 37 and 12 to 7 ppm and CHRhC2g1S1R was 33 to 41.5 and 14.5 to 13 ppm respectively. The exchangeable bases in all the five soil phases were in order of $Ca^{2+} > Mg^{2+}$ on the exchange complex. From the distribution of Ca^{2+} and Mg^{2+}, it is evident that Ca^{2+} shows the strongest relationship in all the soil phases comparison to Mg^{2+}, it was clear that Mg^{2+} is present in low amount than Ca^{2+} because of its higher mobility. Similar results are observed by Nagraj et al. [10].

Table 2. Chemical properties of the soil phase of Gadagi-2 micro watershed

Sl. no.	Soil series (Mapping Unit)	Depth (cm)	pH	EC (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)
1	Heggapur	0-9	7.22	0.17	0.86	21.85
	HEGiC2	9-22	7.28	0.14	0.60	22.90
		22-38	7.30	0.20	0.54	22.55
		38-49	7.32	0.19	0.32	23.60
		49-64	7.48	0.23	0.52	23.95
2	Kallarhatti	0-9	6.98	0.09	0.32	23.95
	KALhC2g1S1R1	9-21	7.14	0.11	0.52	24.65
3	Vyakarnal	0-10	6.68	0.07	0.54	21.85
	VKRhD2g2S2R	10-30	6.84	0.10	0.52	23.60
4	Bhogapur	0-12	6.56	0.08	0.26	22.55
	BHGhE2g2S2R2	12-31	6.78	0.10	0.32	24.30
5	Chatra CHRhC2g1S1R1	0-16	7.01	0.17	0.92	23.60
		16-29	7.34	0.19	0.14	24.30

Table 3. Distribution of available nutrients in different soil phases of Gadagi-2 MWS

Sl. no.	Soil series (Mapping unit)	Depth (cm)	Available				Exchangeable cations	
			N (Kg ha^{-1})	P_2O_5	K_2O	S	Ca [ppm]	Mg
1	Heggapur	0-9	269.34	44.68	355.37	12.59	34.5	10.5
	HEGIC2	9-22	248.19	41.24	219.08	10.40	37	18.5
		22-38	240.16	37.81	204.56	10.79	30.5	13.5
		38-49	238.70	41.24	188.44	8.20	44.5	14.5
		49-64	219.52	27.49	220.69	5.60	41.5	19
2	Kallarhatti	0-9	175.62	24.06	266.92	5.20	39.5	10.5
	KALhC2g1S1R1	9-21	150.53	3952	200.12	4.40	49	14.5
3	Vyakarnal	0-10	156.80	32.27	172.17	12.59	27	8.5
	VKRhD2g2S2R	10-30	144.26	22.92	136.15	5.60	20.5	14.5
4	Bhogapur	0-12	162.24	21.03	427.66	2.80	29.5	12
	BHGhE2g2S2R2	12-31	126.79	19.21	196.49	5.60	37	7
	Chatra	0-16	233.42	41.24	203.48	9.79	33	14.5
	CHRhC2g1S1R1	16-29	225.79	25.78	154.43	2.80	41.5	13

4. DISTRIBUTION OF AVAILABLE NUTRIENTS IN DIFFERENT MAPPING UNITS (TABLE 3)

4.1 Available N

Soil available N status was low in all the five soil phases and ranged from 144.26 to 269.34 kg ha^{-1}. The lowest soil available N was noticed in BHGhE2g2S2R2 soil phase due to severe erosion Available N content was decreasing with the depth in all the mapping units, this could be attributed to Low organic matter content in these areas due to low rainfall and low vegetation cover facilitate faster degradation and removal of organic matter leading to N deficiency. The results were in accordance with study conduct by Shiva Prasad et al. [18].

4.2 Available P_2O_5

The available P_2O_5 was low to medium in all the five soil phases which ranged from 19.21 to 44.68 kg ha^{-1}. The lowest available P_2O_5 was observed in BHGhE2g2S2R2 soil phase due to lower clay content. The content of available P_2O_5 was decreased with the depth which may be attributed to high phosphorous fixation capacity, similar result were found by Sathisha and [19] in Western Ghats of Dakshina Kannada district.

4.3 Available K_2O

The available K content of soils was low to medium in all the five soil phases which ranged from 154.43 to 355.37 kg ha^{-1}. High content of available K found in surface horizon than sub surface horizons may be due to more intense weathering and release of labile potassium from organic residues. Similar results were reported by Basavaraju et al. [20] in Chandragiri soils.

4.4 Available S

The available S in all the five soil phases was ranged from 2.80 to 12.59 kg ha^{-1} indicating these soils are low to medium in sulphur. The lowest available sulphur noticed in BHGhE2g2S2R2 soil phase due to low OC and continuous removal of sulphur by crop because of severe erosion limitation. These results in conformity with findings of Pulakeshi [21] in Mantagani village of Haveri district in Karnataka.

5. LAND CAPABILITY CLASSIFICATION (TABLE 4)

The study area showed that HEGiC2 soil phase was classified into III*esr* land capability class with moderate limitation of slope, erosion, rooting condition and organic carbon. Whereas soil phases KALhC2g1S1R1, VKRhD2g2S2R, BHGhE2g2S2R2 and CHRhC2g1S1R1 were classified into IV land capability class with sub class *rlts* (marginal limitation of texture, rooting condition, slope and organic carbon respectively).

6. CROP SUITABILITY FOR DIFFERENT SOIL PHASES (TABLE 5)

The optimum requirements of a crop are always region specific. Climate and soil-site parameters play significant role in maximizing the crop yields. The soil properties from the study area were matched with soil-site suitability criteria and climatic regimes for different crops [22].

The HEGC2 soil phases were found to be moderately suitable for Bajra, Redgram, Sorghum, paddy and cotton cultivation with moderate limitations of rooting condition and slope. Whereas and BHGhE2g2S2R2 soil phases were not suitable for Bajra, Paddy, Redgram, cotton and sorghum cultivation with severe limitation of rooting condition, texture, slope and gravel. CHRhC2g1S1R1 soil phase was marginally suitable for Bajra, Paddy, Redgram, cotton and sorghum with marginal limitation of rooting condition, texture, slope and gravel. VKRhD2g2S2R soil phases was marginal suitable for Bajra, Redgram and sorghum with marginal limitation of rooting condition, slope, texture and gravel. In case of Paddy and Cotton crop was not suitable with limitation of rooting condition, slope, gravel and texture.

All the soil phases of the study area were found to be non suitable for mango plantation. Mango tree requires more depth for its better growth and development. Whereas HEGlC2 soil phase was marginal suitable for Sapota, Jamun and guava with marginal limitation of rooting condition, texture and slope and reaming soil phases were not suitable with severe limitation of rooting condition, texture, slope and gravel. Similarly KALhC2g1S1R1, BHGhE2g2S2R2 and CHRhC2g1S1R1 soil phases were not suitable for custard apple with limitation of rooting

Table 4. Land capability classification of Gadagi-2 MWS

Soil Phase	Land form characteristics			Physical characteristics (s)			Chemical characteristic (f)	LCC
	Slope (%) (l)	Erosion (e)	Drainage (w)	Texture (t)	Soil depth (r)	Pedon Development	Organic carbon OC g kg^{-1}	
Heggapur HEGlC2	III	III	II	II	III	III	III	IIIrs
Kallarhatti KALhC2g1S1R1	III	III	III	IV	IV	IV	IV	IVtrs
Vyakarnal VKRhD2g2S2R	IV	III	III	IV	IV	IV	III	IVlrts
Bhogapur BHGhE2g2S2R2	IV	IV	III	IV	IV	IV	IV	IVlerts
Chatra CHRhC2g1S1R1	III	III	III	IV	IV	IV	III	IVrt

Table 5. Crop suitability of Gadagi-2 MWS

Soil phases	Bajra	Paddy	Redgram	Cotton	Sorghum	Mango	Sapota	Jamun	Guava	Custard apple
Heggapur HEGlC2	S2rl	S2rl	S2rl	S2rl	S2rl	Nrl	S3rl	S3rl	S3rtl	S2rl
Kallarhatti KALhC2g1S1R1	Nrtl	Nrtlg	Nrtlg	Nrtlg	Nrtlg	Nrlg	Nrtlg	Nrtlg	Nrtlg	Nrtlg
Vyakarnal VKRhD2g2S2R	S3rl	Nrtlg	S3rtlg	Nrtlg	S3rtlg	Nrlg	Nrtlg	Nrtlg	Nrtlg	S3rlg
Bhogapur BHGhE2g2S2R2	Nrlg	Nrtlg	Nrtlg	Nrtlg	Nrtlg	Nrlg	Nrtlg	Nrtlg	Nrtlg	Nrtlg
Chatra CHRhC2g1S1R1	S3rlg	S3rtlg	S3rtlg	S3rtlg	S3rtlg	Nrlg	Nrtlg	Nrtlg	Nrtlg	Nrtlg

Table 6. Proposed crop plan for Gadagi-2 micro watershed

LMU	Soil phase	Survey number	Characters	Crops proposed				
				Field crops	**Forestry Crop/Grasses**	**Horticulture crops (Rainfed Condition)**	**Horticulture crops with suitable intervention**	**Suitable Intervention**
1	BHGhE2g2S1R3	**Gadagi:-** 1,2. **Golapalli:**35,37,38,40,60,, 77,76,79,66,87,84,71,72. **Paidoddi:-** 87,86,84,71,72,65,64.	**Bhogapur Series,** very Shallow (0-25 cm), gently sloping (3-5 %) to moderately sloping (5-10 %), very gravelly to gravelly clay loam to sandy clay loam textured moderate to severe erosion	**Sole crop;** Sorghum, Bajra, Navni, Red gram, Green gram, Cotton, Maize, Sun flower,	Simaruba, Glyricidia, Neem, Jatropa.	**Fruit crops:** Custard apple, Tamarind, Ber, Amla.	Custard apple, Tamarind, Amla, Ber, and Aonla **Vegetables:** Onion, Tomato, Brinjal, Chilli, Bhendi, Green leaf, Cury leaf, **Flowers-**Gaillardia, Marigold, Chrysanthemum, Lilly	Deep and wider size pit, Drip irrigation Cultivation on raised bunds with mulches and drip. Soil and land manage needs with Crescent bunds
2	KALcC2g1S1R1 KALhc2S2R1	**Gadagi:-**4,5,6. **Golapalli:-** 39,45,44,79,80,82,81,7,72. **Paidoddi:-** 90,91,92,93,83,68,67,68,57 ,56,55,60,59,49.	Kallarhatti series, Shallow (25-50 cm), gently sloping (3-5%), non gravelly to very gravelly clay loam & clay textured moderate to severe erosion	**Sole crop;** Sorghum, Bajra, Navni, Red gram, Green gram, Cotton, Maize, Sun flower, Black gram, Bengal gram, Ground nut , Maize	Glyricidia,SubabulSimaruba, Gly, *Butea,* Neem, Acacia, Tamrind, Baniyan **Grasses:** *Styloxanthes hamata, styloxanthes scabra*, Hybrid Napier, Sesbania, Khus grass	**Fruit crops:** Custard apple, Tamarind, Ber, Amla, **Vegetables:** Clusterbean, bhendi, Phundi, Brinjal, Onion, Chilli, Green leaf, Cury leaf **Flowers:** Gaillardia, Spider lilly, Mari gold	Custard apple, Tamarind, Jamun, Ber, Sapota, Anola, **Vegetables:** Onion, Tomato, Brinjal, Chilli, Bhendi, Green leaf, Cury leaf, Tomato, **Flowers-**Gaillardia, Marigold, Chrysanthemum, Lilly	Deep and wider size pit, Drip irrigation Cultivation on raised beds with mulches and drip.
3	VKRhD2g2S1R2	**Gadagi:-** 8,7 **Golapalli:-** 33,34,36,33,49,47,42,41. **Paidoddi:-** 58,61,45,48.	Vyakarnal series, moderately shallow (50-75 cm), Very gently (1-3%)to gently sloping (3-5%) with moderate to severe erosion,	**Sole crop;** Sorghum, Bajra, Navni, Red gram, Green gram, Cotton, Maize, Sun	Simaruba, Glyricidia, Subabul, Butea spp. Neem, Jatropa, Sandalwood **Grasses:**	**Fruit crops:** Sapota, Jamun, Guava, Tamarind, Lime, Musambhi, Custard apple, Jackfruit, Amla, Pomegranate,	Sapota, Jamun, Guava, Tamarind, Lime, Musambhi, Custard apple, Jackfruit, Amla, Pomegranate,	Deep and wider size pit, Drip irrigation

LMU	Soil phase	Survey number	Characters	Crops proposed				
				Field crops	**Forestry Crop/Grasses**	**Horticulture crops (Rainfed Condition)**	**Horticulture crops with suitable intervention**	**Suitable Intervention**
			gravely clay textured soil.	flower, Black gram, Bengal gram, Ground nut , Maize	Styloxanthes hamata, styloxanthes scabra, Hybrid Napier, Sesbania, Khus grass	**Vegetables:** Clusterbean, Bhendi, Phundi, Brinjal, Onion, Chilli, Tomato, Green leaf, Cury leaf **Flowers:** Gaillardia, Spider lilly, Mari gold	**Veg:** Onion, Tomato, Brinjal, Chilli, Bhendi, Green leaf, Cury leaf, Tomato, **Flowers-** Glircidia, Marigold, Chrysanthemum, Lilly	Cultivation on raised beds with mulches and drip. Graded bunds and strengthening of field bunds
4	HEGiC2	Golapalli:-75,65,68.	Heggapurseries, moderately shallow (50-75 cm), Very gently (1-3%)to gently sloping (3-5%) with moderate to severe erosion, gravely clay textured soil.	**Sole crop;** Sorghum, Bajra, Navni, Red gram, Green gram, Cotton, Maize, Sun flower, Black gram, Bengal gram, Ground nut , Maize	Simaruba, Glyricidia, Subabul, Butea spp. Neem, Jatropa, Sandalwood **Grasses:** Styloxanthes hamata, styloxanthes scabra, Hybrid Napier, Sesbania, Khus grass	**Fruit crops:** Sapota, Jamun, Guava, Tamarind, Lime, Musambhi, Custard apple, Jackfruit, Amla, Pomegranate, **Vegetables:** Clusterbean, Bhendi, Phundi, Brinjal, Onion, Chilli, tomato, Green leaf, Cury leaf **Flowers:** Gaillardia, Spider Lilly, Mari gold	Sapota, Jamun, Guava, Tamarind, Lime, Musambhi, Custard apple, Jackfruit, Amla, Pomegranate, **Vegetables:** Onion, Tomato, Brinjal, Chilli, Bhendi, Green leaf, Cury leaf, Tomato, **Flowers-**Gaillardia, marigold, Chrysanthemum, Lilly	Deep and wider size pit. Drip irrigation Cultivation on raised beds with mulches and drip Graded bunds and strengthening of field bunds

condition, texture, slope and gravel. HEGlC2 soil phase was moderately suitable for custard apple with limitation of rooting condition and slope; and VKRhD2g2S2R soil phase was marginally suitable with marginal limitation of rooting condition, slope and gravel.

7. LAND RESOURCES MANAGEMENT (TABLE 6)

Crop plan for field crops and horticulture crops for BHGhE2g2S2R2, KALhC2g1S1R, VKRhD2g2S1R2 and HEGiC2 soil phases has suitable interventions such as, deep and wider size pit, drip irrigation with suitable soil and water conservation measures cultivation on raised beds with mulches and drip. Graded bunds and strengthening of field bunds. Soil and land manage needs with crescent bunds.

Among all the five soil phases BHGhE2g2S2R2 soil phase was classified under IV*lerts* LCC with severe limitation of erosion. Soil erosion is one of the major factors affecting the soil health in the micro watershed and such parcel of the land can be managed with various soil and water conservation measures *viz.*; contour cultivation, field bunding, vegetative barriers, nala bund and management interventions like plantations, silvipasture and agri-horticulture have been suggested for sustainable development.

The OC content of study area was found to be low to high. The areas that are low in OC needs to be further improved by applying farmyard manure and rotating crops with cereals and legumes or mixed cropping. Soil available N status was low in all the five soil phases so there is an urgent need to increase the dose of N for all the five soil phases by 25% over the recommended dose to realize better crop performance. The available P and K was low to medium in all the five soil phases. Hence for all the crops, 25% additional P and K needs to be applied, where it is low or medium in available P content. The available S in all the five soil phases was low to medium. These areas need to be applied with magnesium sulphate or gypsum or Factamphos (p) fertilizer (13% S) for 2-3 years for the deficiency to be corrected [23].

8. CONCLUSION

This study was carried out to observe the land capability in North-eastern dry zone of Karnataka under semi-arid tropics. All the five soil phases obtained from same landforms *viz.,* upland, texture was sandy clay to sandy clay loam in nature. HEGiC2 soil phase was classified into III land capability and reaming four soil phases were classified under IV land capability, among four mapping units, BHGhE2g2S2R2 soil phase was severe limitation of erosion. Hence such area of land can be managed by adapting good soil and water conservation practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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