1   **Original Research Article**

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Land resources inventory of Central Dry Agro-climatic Zone of Karnataka- A case study from in Gollarahatti-2 micro-watershed employing geo-spatial techniques

6 **Abstract:**

7   Detailed land resource inventory (1:7920 scale) was carried out in Gollarahatti-2 micro-watershed located in Jagalur taluk of Davanagere district, Karnataka using geo-spatial techniques. Based on the landform and physiographic units, the Gollarahatti-2 micro-watershed soils were categorized into eleven soil series and twenty two soil phases and mapping units and all the typifying soil pedons representing the study area were sampled. Morphological, Physical, Chemical and Physico-chemical properties of the identified soils were characterized under field and laboratory conditions and the soils were classified into family level as per USDA soil taxonomy. The soils were very shallow or shallow and deep, reddish brown (5 YR4/4 to very husky red (2.5YR2.5/2), slightly acidic to alkaline and non-saline. The texture of the soil was varied into sandy clay, clay loam and clay. The organic carbon ranged between low to medium. Further, the soils have high base saturation. Pedon 11 had higher exchangeable sodium percentages in sub soil layers. The differentiated soils were grouped under 11 soil series mapped into 22 mapping units and classified into Lithic Ustorhents, Typic Haplustepts, Typic Rhodustalfs, Kanhaplic Rhodustalfs and Rhodic Kanhaplustalfs at sub group level as per USDA soil taxonomy.

22

23   **Key words:** Land resource inventory, Soil classification, Geo-spatial techniques, Land form,

24   Physiographic units and soil series

Introduction

26   In the recent years land resources are under pressure due to degradation of soil and water,

27   which play an important role in human as well as plant life. Soil as a medium, supports the plant

28   growth through supply of essential nutrients and man in-turn depends on plant for food. Soil is a

29   dynamic natural resource developed over a period of thousands of years by weathering of arable

30   lands because of growing population, and competing demands of the various land uses.

31   Indiscriminate use of land resources, in general, leads to their degradation and in-turn decline in

32   productivity. Degradation of land resources happening at an alarming rate minimizes

33   productivity and stability of production. Self-sufficiency and food security are the biggest tasks

34   for most populous nation like India. They need to be used according to their capacity to satisfy

35   the needs of its inhabitants. This can be achieved through proper inventory of land resources and

36   their scientific evaluation. Soil survey provides a valuable resource inventory connected with the

37   survival of life on earth. It provides an accurate and scientific inventory of different soils, their

38   kind and nature and extent of distribution so that one can make prediction about their limitations

39   and potentialities. It also provides adequate information in terms of land form, slope, land use as

40   well as characteristics of soils *viz.*, texture, depth, structure, stoniness, drainage, acidity, salinity

41   *etc.*, which can be utilized for the planning and development. Information of soil and related

42   properties obtained from the soil survey and soil classification can help in better delineation of

43   soil and land suitability for irrigation and efficient irrigation water management. So, depending

44   on the suitability of the mapped agro-ecological units for a set of crops, optimum cropping

45   patterns have to be suggested taking into consideration the present cropping systems and the

46   socio-economic conditions of the farming community (Sehgal *et al.,* 1996). Integrated

47   management of land resources is the best way to solve the present day challenges. Therefore the

48   knowledge of soil and land resources with respect to their spatial distribution, characteristics,

49   potentials, limitations and their suitability for alternate land use helps in formulating strategies to

50   obtain higher productivity on sustained basis. This calls for systematic and reliable inventory of

51   natural resources like soil, water, land use, *etc*., at a quicker pace through scientific and modern

52   tools like remote sensing and geographic information system (GIS). Satellite remote sensing data

53   provides information on geology, geomorphology, soil and land use or land cover through

54   systematic appraisal following the synoptic and multispectral coverage of a terrain and the

55   information generated can be interpreted for various themes *viz*., land capability, land irrigability

56   and crop suitability *etc.* for better management and conservation of resources on watershed basis.

57   Keeping these facts in view, the detailed soil survey of Gollarahatti-2 micro-watershed, Jagalur

58   taluk, Davanagere district representing Central Dry Zone of Karnataka state was carried out with

59   the objective of characterization and classification of Gollarahatti-2 micro-watershed, Jagalur

60   taluk, Davanagere district**,** using remote sensing and GIS techniques.

61   **Material and methods**

62   The study area is Gollarahatti-2 micro-watershed in Jagalur taluk, Davanagere district, Karnataka

63   and falls under central dry zone (zone no-04) of Karnataka and agro ecological sub region of 8.2

64   (AESR), which receives its major annual rainfall during *kharif* season (June-September). The

65   length of growing period is 120-150 days. The major crops growing are Ragi, Maize, Ground nut

66   and cotton etc. Red soils occupy major portion of the area. The study area located at 50 km from

67   Davanagere district. It covers an area of 719 ha, lies between 13° 23' 42" and 31° 25' 39" N

68   latitudes and 77° 33' 36.8"and 77° 33' 54.3"E longitudes. The elevation is in the range of 575 m

69   to 687 m MSL. The dominant geology of the study area is Archean schist with small patches of

70   granite gneiss. Neem, Pongamia, *Mimosa pudica* and grasses are the major natural vegetation

71   apart from forest species. Detailed soil survey was carried out by using 1:7920 (scale) cadastral

72   map, Google Earth Image and high resolution satellite imagery of the watershed were used as

73   base map in conjunction with Survey of India toposheet to map the land resources. Physiography

74   soil relationship was established using ground truth data by using satellite imagery of the

75   Gollarahatti-2 micro-watershed. Pedon sites were located in transects along the slope from the

76   upper to lower slopes. Totally in this micro-watershed, 25 profiles were exposed and studied for

77   morphological characteristics as per Soil Survey Manual (Soil Survey Staff, 2014). The

78   representative 11 master profiles of typifying pedons of series identified were selected. Horizon-

79   wise soil samples were collected, air dried and passed through 2 mm sieve and analyzed for

80   particle-size distribution following International Pipette method (Richards, 1954), pH and

81   electrical conductivity (EC) in 1:2.5 soil: water suspension (Piper, 1966). Organic carbon was

82   estimated by Walkley and Black (1934) method. The cation exchange capacity (CEC) and

83   exchangeable cations were determined as described by Jackson (1973). The soils were classified

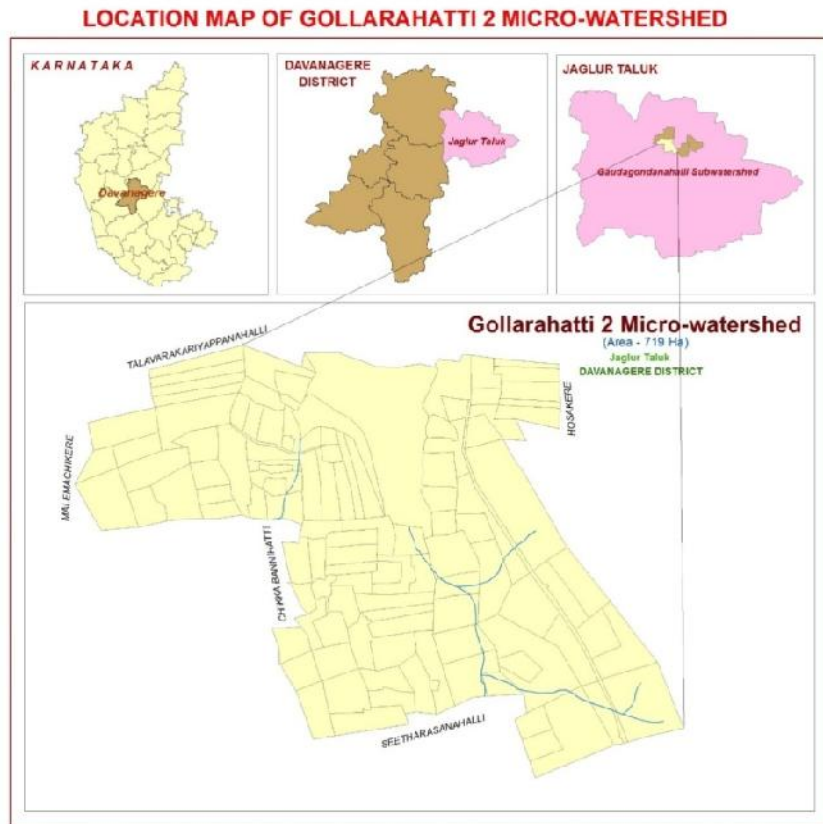84   following the USDA system of soil classification (Soil Survey Staff, 2014).

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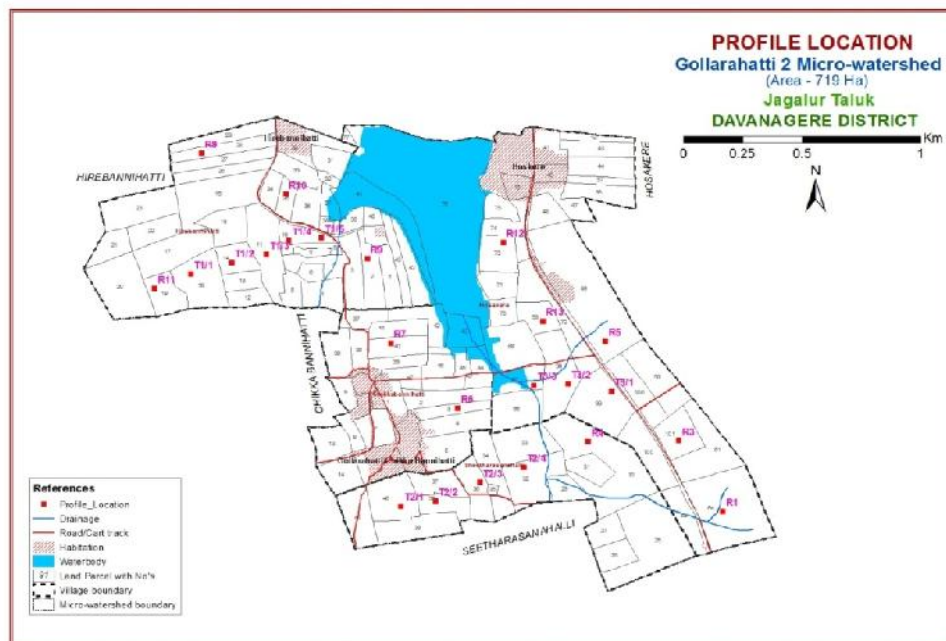86
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88 **Fig. 1: Location map of study area**
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95 **Fig. 2: Cadastral map with profile location of Gollarahatti -2 Micro Watershed, showing**
96 **plot numbers and soil profile locations.**
97

98 **Results and discussion**

99 *Morphological properties*

100   The study area have a combination of moderately shallow (3) or shallow/very shallow

101 soils (3) and deep (3) or moderately deep (2) soils. The pedons 6, 8, 9, 10 and 11 were in deep

102 category, remaining all pedons (pedons 1 to 5 & 7) were in shallow group. The depth resulted

103 shallow soils in uplands and deeper soils in lowland physiographic units. The depth of pedons

104 were varied because of manifestation of topography. Similar observations were made by Vinay

105 (2007) in Bhanapur micro-watershed of Koppal. The variation of depth in relation to

106 physiography, mainly because of non-availability of adequate amount of water for prolonged

107 period on upland soils associated with removal of finer particles and their deposition at lower

108 pediplain. The results obtained in the present study are in agreement with the findings of

109 Ramprakash and Rao (2002). In all soil pedons, hue was 2.5YR-5YR. This colour hue was due to

110 dominance of sesquioxides over silica. The darker colour values in the surface horizons (2.5-3)

111 than sub-surface horizon (2.5-4) was due to the presence of relatively high organic matter

112 content (Tripathi *et al.*, 2006). The sub-surface horizons had comparatively brighter colour

113 chroma (3-6) against 3-4 of surface, which might be due to low organic matter content and

114 higher iron oxide there. The results obtained in the present study are in agreement with the

115 findings of Sidhu *et al.* (1994). This variation in colour is a function of chemical and

116 mineralogical composition, topographic position, textural makeup and moisture regimes of the

117 soils. The results of the were in accordance with the findings of Thangaswamy *et al.* (2005), who

118 also indicated the gradation in the colour from higher topographic position to the lower

119 topographic units. The structure was sub-angular blocky in surface and sub-surface horizons. The

120 consistency was slightly hard to hard when dry and friable to firm when moist.

121 ***Soil physical properties***

122 The clay content in different pedons in surface horizon ranged from 26.9 to 69.7 per cent.

123 The sub-surface horizons exhibited higher clay content as compared to surface horizons due to

124 the illuviation process occurring during soil development. Similarly, the illuviation process also

125 affected the vertical distribution of silt and sand content. Similar observations were made by

126 Dasog and Patil (2011) in soils of North Karnataka. Silt content ranged from 10.2 to 43.6 per

127 cent. It exhibited an irregular trend with depth. This might be due to variation in weathering of

128 parent material. These results were in agreement with the findings of Naidu and Hunsigi (2001),

129 who observed an irregular trend in silt content with depth in sugarcane growing soils of

130 Karnataka. Similar results were also reported by Kumar *et al.* (2002). Sand content varied from

131 10.2 to 54.8 per cent it was more in the surface compared to sub-surface horizons. The sand

132 content is much higher than the silt and clay fractions. The coarser fractions dominate in

133 silicaceous, granite-gneiss parent material (Dutta *et al.*, 1999). The texture of pedons varied from

134 clay, clay loam, sandy clay loam to sandy clay. The texture was clay loam because of lesser

135 mobilization and translocation of finer fractions. Similar findings were reported by Pulakeshi *et*

136 *al.* (2014). The major area of red soil pedons varied between sandy clay and sandy clay loam.

137 Water holding capacity of various pedons ranged from 36.5 to 63.1 per cent. Irrespective of the

138 pedons, the water holding capacity of sub-soil was higher than surface soil. These differences

139 were due to the variation in clay and organic carbon content of the pedons. Similar results were

140 reported by Singh *et al.* (1999) in soils of Ramganga catchment in Uttar Pradesh and

141 Thangasamy *et al.* (2005) in soils of Sivagiri micro-watershed in Chittoor district of Andhra

142   Pradesh. Bulk density of the pedon samples varied from 1.22 to 1.41 Mg m^{-3} (Table 1), followed

143   a common pattern of increasing with increasing depth. It was attributed to the pressure of the

144   overlying horizons and diminishing amounts of organic matter. Similar results were quoted by

145   Marathe *et al.* (2003) in mandarin orchards of Nagpur and in rice soils of Eastern region of

146   Varanasi (Singh and Agrawal, 2005).

147   ***Soil chemical properties***

148   The pH of red soil pedons ranged from slightly acidic to neutral and alkaline. Iron

149   hydroxide species might have contributed for higher H^{+} concentration leading to lower pH

150   values. Similar observations were made by Dasog and Patil (2011) and Satyanarayana and

151   Biswas (1970). In soils of all the pedons, EC ranged from 0.03 to 0.98 dS m^{-1} indicating non-

152   saline nature of soils. These soils did not show any specific relationship with depth. This may be

153   due to free drainage conditions, which removed the released bases by percolation or by drainage

154   water. These results were in confirmation with the findings of Kumar (2011) and Shivasankaran

155   *et al.* (1993). Organic carbon content in surface horizons ranged from 0.34 to 0.72 per cent and

156   in sub-surface horizon it varied from 0.11 to 0.6 per cent. The lower contents of organic carbon

157   apparently resulted because of high temperature, which induced rapid rate of organic matter

158   oxidation, while the declining trend towards accumulation of crop residues every year, without

159   substantial downward movement. These observations are line with the-findings of Balpande *et*

160   *al.* (2007). Similar results were reported by Basavaraju *et al.* (2005) in soils of Chandragiri

161   mandal of Chittoor district in Andhra Pradesh. The exchangeable bases in all the pedons were in

162   order of Ca^{+2}> Mg^{+2}> Na^{+}> K^{+} on the exchange complex. From the distribution of Ca^{+2} and

163   Mg^{+2}, it is evident that Ca^{+2} shows the strongest relationship with all the species, comparing

164   these ions (Ca^{+2}, Mg^{+2}, K^{+} and Na^{+}) it was clear that Mg^{+2} was present in low amount than Ca^{+2}.

165   These results were in conformity with findings of Sharma (1996). The low value of

166   exchangeable monovalents as compared to divalents was due to preferential adsorption of

167   divalents than monovlent. These findings were in accordance with the reports of Das and Roy

168   (1979). Cation exchange capacity of the pedons varied both location-wise and depth-wise. The

169   values of cation exchange capacity of soils increased with profile depths and followed the trend

170   of clay content. Similar findings have been reported by Mruthunjaya and Kenchanagowda (1993)

171   and Shadaksharappa *et al.* (1995) in Vanivilas command and Malaprabha command area,

172   respectively. There was a high degree of correlation between clay and CEC in red soils. The ESP

173   ranged from 0.06 to 13.2 percent indicated initiation of the process of sodification in a downward

174   direction. A measure of relative amounts of exchangeable sodium in comparison with the total

175   cations in the soil are dependent on factors such as type of minerals, concentration of electrolytes

176   and status of soluble cations (Sehgal, 1996). The findings were in accordance with the works of

177   Srinath (1979) and Pulakeshi (2010).

178   The soils in the Gollarahatti-2 micro-watershed were highly base saturated. The base

179   saturation was high in all surface horizons. In most of the soils, the base saturation increased

180   with the depth. The increase of base saturation with the depth is due to the downward movement

181   of bases along with percolating water from the upper horizon to the lower horizons. Similar

182   results were found by Sitanggang *et al.* (2006) (Table 2).

183   ***Soil taxonomy***

184   Based on morphological characteristics of the pedons, physical, chemical characteristics (Challa,

185   2000) eleven pedons from the study area were classified into order, suborder, great group and

186   sub-group. Pedons 2, 3, 4, 5, 6, 7, 8 and 9 have argillic sub-surface horizon and do not have

187   plaggan epipedon and spodic or oxic sub-surface horizons above the argillic horizon. Further, the

9

188   argillic horizon was developed due to clay illuvation and was identified by the presence of clay

189   cutans and the thickness of the horizon is more than 7.5 cm and also more than one-tenth as thick

190   as the sum of the thickness of all the overlying horizons. The base saturation was more than 35

191   per cent throughout the depth of the argillic horizon. Hence, Pedons 2, 3, 4, 5, 6, 7, 8 and 9 are

192   keyed out as Alfisol at order level. Pedon 1 is classified into Entisols owing to root restricting

193   layer within 25 cm and no diagnostic horizons either on surface or subsurface. Pedons 10 and 11

194   are classified into Inceptisols due to the absence of any other diagnostic horizons other than

195   colour or texture altered cambic horizon. As the moisture regime is Ustic, Pedons 2, 3, 4, 5, 6, 7,

196   8 and 9 were classified as Ustalfs at sub-order level. Pedon 1 classified at sub-order level as

197   Orthents as they are better drained than Aquents, non-fluviatile. Pedon 10 and 11were classified

198   as Ustepts. Pedon 5 did not have either Duripan or Calcic horizon and the base saturation was

199   more than 60 per cent at a depth between 0.2 to 0.7 m from the soil surface. These characters

200   indicated that these pedons confirmed to the central concept of Ustalfs. So, this pedon grouped

201   under Haplustalfs at great group level. Similarly, the pedons 10 and 11 were keyed out as

202   Haplustepts, as they do not have Duripan, Kandic and Petrocalcic horizons. Pedon 2, 3, 5, 6, 7, 8,

203   9 keyed out as Rhodustalfs at great group level as they have within upper 100 cm or the entire

204   argillic horizon more than 50 per cent 2.5YR or redder, and values (moist) $\leq$ 3 and dry values are

205   no more than 1 unit higher than moist values. Pedon 1 classified as Ustorthonts as they have

206   Ustic moisture regime. At the sub-group level, pedon 5 do not exhibit inter-gradation with other

207   taxa or an extra-gradation from the central concept, hence keyed out as Typic Haplustalfs.

208   Pedons 2, 6, 7, 9 keyed out as Typic Rhodustalfs. Pedon 10 and 11 as Typic Haplustepts,

209   Whereas pedon 1 was classified as Lithic Usterthents due to lithic contact within 100 cm of

210   mineral soil surface. Pedon 3 and 8 were classified as Kanhaplic Rhodustalfs, owing to a lower

211 CEC per kg clay of less than 24 cmol(p+) kg^{-1} in the argillic horizon. Pedon 4 as Rhodic

212 Kanhaplustalfs, owing to the presence of kandic horizon with very low CEC per kg clay of less

213 than 24 cmol (p+) kg^{-1} in the argillic horizon. CEC per kg clay of less than 16 cmol (p+) kg^{-1} in

214 the kandic horizon with a hue redder than or equal to 2.5 YR in at least half of the depth of

215 kandic horizon (Soil Survey Staff, 2014).

216 **Conclusions**

217 Gollarahatti-2 micro-watershed soils are grouped under eleven soil series and they were

218 characterized and mapped into 22 mapping unis. These soils come under Entisol, Inceptisol, and

219 Alfisol soil orders. Based on base saturation, organic carbon content and clay content of the soil,

220 the soils of the study area are classified as Lithic Ustorhents, Typic Haplustepts, Typic

221 Rhodustalfs, Kanhaplic Rhodustalfs, Rhodic Kanhaplustalfs at sub-group level. The major crops

222 cultivated in this watershed are in the order of short duration and rainfed in a combination of

223 pulse crop adjusting monsoon, main cereal or millet crop, followed by a very short duration oil

224 seed crop (sesamum, ground nut or mustard) or coriander, utilizing the residual moisture and all

225 based on rainfall probability. The climate is highly responsible for the crop selection. Since, the

226 probable length of growing period is 120-150 days, the farmers can go for deep ploughing before

227 first showers, harrowing to keep land ready to receive and accept water reaching through rainfall

228 and to provide crops, two subsequent short duration crops (Maize, sorghum, Ragi) to reap higher

229 economic benefits.

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314

315   Table 1: Physical properties of Gollarahatti-2 micro-watershed pedons

Horizon	Depth (cm)	Colour	Coarse sand (2-0.25 mm)	Fine sand (0.25-0.05 mm)	Total sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Texture	B.D Mg m^{-3}	WHC (%)
			------------------------%----------------------							
					Pedon 1					
Ap	0-21	5 YR 3/4	31.30	14.40	45.70	16.60	37.70	sc	1.34	39.88
					Pedon 2					
Ap	0-15	2.5 YR 2.5/4	37.60	12.10	49.70	16.60	33.70	sc	1.31	36.14
Bt1	15-30	2.5 YR 2.5/4	24.25	16.75	44.00	22.02	33.98	cl	1.35	51.00
Bt2	30-41	2.5 YR 2.5/4	32.25	9.50	41.75	23.75	34.50	cl	1.39	53.02
BC	41-50	2.5 YR 2.5/4	32.50	9.25	41.75	21.75	36.50	cl	1.41	52.16
					Pedon 3					
Ap	0-15	5 YR 3/4	37.10	12.60	49.70	12.50	37.80	sc	1.31	39.88
Bt	15-32	2.5 YR 2.5/4	12.75	21.50	34.25	22.50	43.00	c	1.34	56.33
BC	32-50	2.5 YR 2.5/4	23.20	11.30	34.50	24.65	41.10	c	1.36	59.18
					Pedon 4					
Ap	0-22	2.5 YR 2.5/4	38.20	15.60	53.80	10.40	35.80	sc	1.26	37.27
Bt1	22-32	2.5 YR 2.5/2	22.50	16.50	39.00	25.00	36.00	cl	1.32	39.76
Bt2	32-47	2.5 YR 3/6	22.50	15.40	37.90	22.60	39.50	cl	1.35	52.15
Bt3	47-60	2.5 YR 2.5/3	26.26	10.15	36.40	22.46	41.14	cl	1.36	55.45
BC	60-74	2.5 YR 3/4	25.50	10.50	36.00	23.50	40.50	cl	1.36	53.02
					Pedon 5					

Ap	0-19	5 YR 3/4	25.50	18.75	44.25	26.00	29.75	scl	1.31	33.63
Bt1	19-38	5 YR 4/4	8.82	11.75	20.57	43.23	36.20	cl	1.34	58.18
Bt2	38-54	5 YR 3/2	28.09	8.31	19.40	42.48	38.12	cl	1.36	57.51
Pedon 6										
Ap	0-24	2.5 YR 2.5/3	21.43	18.57	43.00	27.50	29.50	scl	1.27	35.24
Bt1	24-34	2.5 YR 3/6	13.75	10.50	24.25	16.25	59.50	c	1.28	59.20
Bt2	34-51	2.5 YR 2.5/4	8.75	5.75	14.50	16.75	68.75	c	1.34	61.52
Bt3	51-69	2.5 YR 2.5/4	8.75	5.25	14.00	17.25	68.75	c	1.34	62.76
BC	69-81	2.5 YR 3/4	7.75	6.25	14.00	16.28	69.72	c	1.35	63.15
Pedon 7										
Ap	0-22	2.5 YR 3/4	34.4	11.20	45.60	18.70	35.70	sc	1.22	51.96
Bt1	22-48	2.5 YR 2.5/2	6.00	12.50	18.50	23.25	58.25	c	1.29	39.09
Bt2	48-60	2.5 YR 2.5/3	5.75	6.25	12.00	18.25	69.75	c	1.34	61.52
BC	60-74	2.5 YR 2.5/3	6.00	7.61	13.61	33.00	53.39	c	1.38	62.76
Pedon 8										
Ap	0-20	2.5 YR 3/4	39.20	15.60	54.80	18.30	26.90	scl	1.26	31.02
Bt1	20-47	2.5 YR 4/6	12.10	13.77	25.87	31.79	42.34	c	1.31	57.24
Bt2	47-66	2.5 YR 2.5/3	5.87	8.74	14.61	32.06	53.33	c	1.33	60.67
Bt3	66-76	2.5 YR 2.5/4	14.09	7.52	21.61	33.32	45.07	c	1.35	56.79
Pedon 9										
Ap	0-17	2.5 YR 2.5/4	27.75	18.75	46.50	26.15	27.35	scl	1.30	33.56
Bt1	17-32	2.5 YR 2.5/4	27.50	17.00	44.50	27.25	28.25	scl	1.28	36.53
Bt2	32-55	2.5 YR 2.5/4	28.50	16.50	45.00	24.25	30.75	scl	1.31	36.98
Bt3	55-80	2.5 YR 2.5/4	38.20	15.60	53.80	10.40	35.80	sc	1.31	37.28

Bt4	80-104	2.5 YR 3/6	27.75	17.25	45.00	28.75	36.25	cl	1.33	50.13
Pedon 10										
Ap	0-30	5 YR 3/3	37.00	15.80	52.80	12.10	35.10	sc	1.29	35.47
Bw1	30-70	5 YR 3/3	22.50	17.50	40.00	24.50	35.50	cl	1.32	51.00
Bw2	70-87	5 YR 3/3	21.50	17.00	38.50	25.25	36.25	cl	1.32	55.02
Bw3	87-107	5 YR 3/3	29.50	9.75	39.25	22.25	39.50	cl	1.35	59.16
Bw4	107-142	5 YR 3/3	5.65	5.00	10.25	31.50	58.25	c	1.41	54.56
Pedon 11										
Ap	0-21	5 YR 3/4	30.1	13.40	43.50	12.40	44.10	c	1.27	52.44
Bw1	21-46	5 YR 2.5/2	35.50	5.70	41.20	10.10	48.70	c	1.31	58.14
Bw2	46-71	5 YR 3/4	23.40	15.20	38.60	8.10	53.30	c	1.32	59.65
Bw3	71-102	5 YR 3/4	1.48	17.30	18.78	43.61	37.61	cl	1.34	57.63
Bw4	102-140	5 YR 3/4	1.05	25.50	26.55	37.85	35.60	cl	1.34	55.98

317 **Table 2: Chemical properties of Gollarahatti-2 micro-watershed pedons**

Horizons	Depth (cm)	pH (1:2.5) Water	EC (1:25) (dS m^{-1})	O.C. (%)	Exch.Ca	Exch.Mg	Exch. Na	Exch. K	CEC	BS	ESP
					--------------- cmol (p+)kg^{-1} ------------					----%---	
Pedon 1											
Ap	0-21	6.88	0.38	0.53	11.14	5.78	0.16	0.18	19.92	86.64	0.80
Pedon 2											
Ap	0-15	6.65	0.08	0.50	11.20	4.40	0.61	0.31	19.02	86.85	3.20
Bt1	15-30	7.05	0.09	0.38	12.60	3.40	0.79	0.38	21.37	80.35	3.70
Bt2	30-41	7.30	0.08	0.33	9.60	1.90	0.35	0.09	14.87	80.29	2.35
BC	41-50	7.33	0.08	0.31	12.50	0.80	0.29	0.10	15.89	86.16	1.82
Pedon 3											
Ap	0-15	6.81	0.08	0.34	11.12	2.80	0.86	0.33	19.31	78.25	4.45
Bt	15-32	7.24	0.06	0.30	12.60	3.40	0.79	0.38	21.37	80.35	3.70
BC	32-50	7.43	0.06	0.11	10.26	3.60	0.68	0.23	18.51	79.80	3.67
Pedon 4											
Ap	0-22	6.71	0.11	0.51	5.80	3.80	0.57	0.23	14.00	74.29	4.07
Bt1	22-32	6.72	0.10	0.48	8.40	5.20	0.76	0.41	17.94	82.17	4.24
Bt2	32-47	6.71	0.17	0.45	10.00	3.00	0.81	0.33	16.72	84.45	4.85
Bt3	47-60	6.75	0.14	0.39	11.00	1.20	0.74	0.28	15.55	81.99	4.76
BC	60-74	6.90	0.14	0.32	12.45	4.01	0.30	0.33	19.40	88.14	1.57
Pedon 5											

Horizons	Depth (cm)	pH (1:2.5) Water	EC (1:25) (dS m^{-1})	O.C. (%)	Exch.Ca	Exch.Mg	Exch. Na	Exch. K	CEC	BS	ESP
					---------------- cmol (p+)kg^{-1} ------------					----%---	
Ap	0-19	6.19	0.15	0.54	6.85	3.10	0.09	0.03	13.00	75.38	0.69
Bt1	19-38	6.45	0.08	0.43	7.01	3.45	0.10	0.02	15.50	68.25	0.64
Bt2	38-54	6.94	0.05	0.35	6.98	3.47	0.13	0.01	14.60	72.53	0.89
Pedon 6											
Ap	0-24	6.46	0.06	0.57	7.46	3.00	0.10	0.02	12.50	84.64	0.80
Bt1	24-34	6.27	0.09	0.55	8.00	3.40	0.21	0.20	13.85	85.27	1.51
Bt2	34-51	6.76	0.06	0.51	10.46	4.10	0.28	0.09	16.95	88.08	1.65
Bt3	51-69	7.10	0.06	0.45	11.20	4.56	0.23	0.18	18.90	85.55	1.21
BC	69-81	7.14	0.05	0.32	11.22	5.40	0.13	0.19	19.15	88.45	0.67
Pedon 7											
Ap	0-22	6.58	0.05	0.62	8.30	3.40	0.10	0.21	12.73	83.50	0.78
Bt1	22-48	6.56	0.04	0.57	8.50	2.30	0.02	0.01	15.10	71.72	0.13
Bt2	48-60	6.61	0.05	0.51	10.10	4.40	0.01	0.01	16.60	87.57	0.06
BC	60-74	6.64	0.03	0.40	10.60	3.40	0.02	0.01	17.02	87.07	0.11
Pedon 8											
Ap	0-20	6.65	0.07	0.63	10.23	3.80	0.35	0.29	17.09	84.24	1.96
Bt1	20-47	7.16	0.07	0.51	11.20	4.40	0.61	0.31	19.02	86.85	3.20
Bt2	47-66	7.90	0.15	0.51	12.60	2.60	0.48	0.31	17.90	89.30	2.67
Bt3	66-76	8.11	0.11	0.43	7.40	2.60	0.48	0.36	14.08	76.98	3.40
Pedon 9											
Ap	0-17	6.36	0.04	0.56	4.81	2.40	0.15	0.11	9.60	77.81	1.56

Horizons	Depth (cm)	pH (1:2.5) Water	EC (1:25) (dS m^{-1})	O.C. (%)	Exch.Ca	Exch.Mg	Exch. Na	Exch. K	CEC	BS	ESP
					--------------- cmol (p+)kg^{-1} ------------					----%---	
Bt1	17-32	6.45	0.04	0.53	5.20	2.50	0.26	0.09	11.01	73.11	2.36
Bt2	32-55	6.47	0.03	0.52	7.11	3.40	0.37	0.10	14.10	77.23	2.62
Bt3	55-80	6.55	0.05	0.48	8.00	3.40	0.28	0.09	14.29	83.20	1.95
Bt4	80-104	6.61	0.03	0.45	8.50	4.30	0.41	0.09	15.58	87.22	2.63
Pedon 10											
Ap	0-30	7.93	0.25	0.72	11.50	3.30	0.48	0.39	16.42	83.25	2.92
Bw1	30-70	7.87	0.20	0.69	13.53	2.50	0.58	0.31	19.89	85.06	2.91
Bw2	70-87	8.03	0.21	0.64	11.80	1.50	0.43	0.25	16.08	86.94	2.60
Bw3	87-107	8.05	0.20	0.41	12.40	5.70	0.58	0.31	22.50	88.84	2.57
Bw4	107-142	8.09	0.22	0.40	15.60	7.20	0.45	0.36	25.05	88.84	1.79
Pedon 11											
Ap	0-21	7.74	0.11	0.51	7.45	3.67	0.18	0.04	12.70	89.29	1.41
Bw1	21-46	8.13	0.55	0.43	9.18	5.32	1.44	0.04	17.10	93.45	8.41
Bw2	46-71	8.11	0.96	0.39	11.56	5.35	1.97	0.04	19.40	97.52	10.15
Bw3	71-102	8.12	0.98	0.35	9.67	4.30	2.43	0.08	18.30	90.05	13.27
Bw4	102-140	8.01	0.49	0.19	10.43	4.24	1.57	0.10	18.50	88.32	8.48

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