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RESEARCH ARTICLE

LAND RESOURCE DATA AND ITS EVALUATION FOR VILLAGE LEVEL LAND USE PLANNING OF AYAMMANAHALLI MICRO-WATERSHED

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ABSTRACT

The detailed soil survey of Ayyammanahalli village of Doddaballapur Taluk, Bangalore Rural District, Karnataka, falling in Eastern Dry Zone, was undertaken to provide site-specific database in planning for developmental programme. Four soil series, namely Ayyammanahalli 1, Ayyammanahalli 2, Ayyammanahalli 3, Ayammanahalli 4 and Ayyammanahalli 5 were identified. The Soil pH varied from strongly acidic to neutral, low CEC, low soil organic carbon. These soIls are grouped under classes II, III and IV land capability classes, 1, 2, 3, 4 and 6 land irrigability classes and 32.1 , 26.6, 20.2, 16.9 and 21.1 percent of land is highly suitable for maize, ragi, ground nut, sorghum and eucalyptus cultivation respectively.

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INTRODUCTION

Land and soil are the vital natural resources for the survival of life on earth. The natural resources assessment is the prerequisite for the assessment of productivity of land and the sustainability of the ecosystem. The land resources are under severe strain due to the pressure of the growing population and competing demands of the various land uses. In reality most of the arable lands are degraded, water resources are depleting and the degradation of land resources is at an alarming rate that has not only rendered the enhanced stability of production questionable but also causing numerous environmental problems. It has been recognized that the land assessment and its reliability for land use decisions depend largely on the quality of soil information. In this connection, detailed soil survey and geographical information system were used for land evaluation. Keeping this in the view, the present study was attempted.

MATERIALS AND METHODS

The study area (80.5 ha) lies between 13º 23′ 35.7″ to 13º 24′ 08.2″N latitude and 77º 33′ 40.2″ to 77º 33′ 57.2″ E longitude in Ayyammanahalli village of Bangalore Rural District, Karnataka. The geology of the area is granite. The area receives a mean annual rainfall of 826.3 mm (IMD, 2001) and the moisture regime is ustic. The mean air temperature is 23.8 °C and the soil temperature is isohyperthermic. The base map, (cadastral map) on 1:12,500 Scale (Fig.1) was interpreted for different geomorphic units. Representative pedons for each unit were exposed and studied morphological properties and mapped. Horizon wise samples were collected from each pedon, air dried ground in wooden morter and pestle, passed through a 2 mm sieve and analyzed for various parameters, particle-size was determined by international pipette method. Soil pH and EC were measured in 1:2.5 soil water suspension using glass electrode pH meter and Conductivity Bridge. Organic carbon was determined by wet digestion method (Jackson 1973). Cation exchange capacity was determined by standard method. The soils were classified as per USDA soil taxonomy (Soil survey staff 1998). The final soil map was prepared under GIS environment. Thematic maps were developed by exporting digitized soil map through Arc GIS software. Data base on soil properties were developed and uploaded and updated with map unit symbols using Microsoft excel package. Land capability, land irrigability and land suitability classification for major crops were attempted as per the standard procedures (Soil Survey Manual, 1970)

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RESULTS AND DISCUSSION

Soil characterization: Five soil series, namely, Ayyammanahalli 1 (A1), Ayyammanahalli 2 (A2), Ayyammanahalli 3 (A3), Ayyammanahalli 4 (A4) and Ayyammanahalli 5 (A5) are identified in the study area.

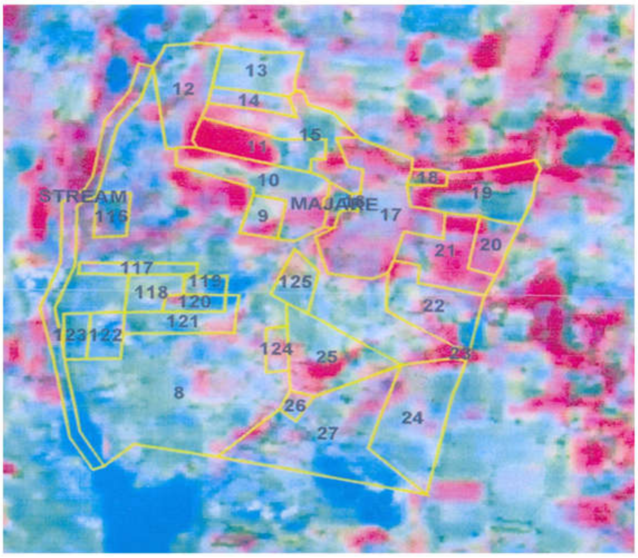

Fig.1. Cadastral map of Ayyammanahalli-village

Morphological characteristics (Table 1)

Soil depth was varying from 66 cm to more than 150 cm, this was due to the variation in topography and slope gradient. Pedon 1 is deep (119 cm) due to more erosion compared to other pedons (3 and 5) of upland and the land have not been protected well in the past and the top soil was eroded (Sitanggang *et al* 2006). The Pedon 2 was moderately deep with moderate slope indicating the process of denudation and erosion were more active than the vertical advancement of the weathering front (Dutta *et al.*, 2001). Pedon 4 was moderately shallow because it is situated on gently sloping low land where the erosion is moderate, similar observation was made by Mahapatra *et al.* (2000) in the subhumid region of Kashmir. Soil colour of the Pedon 1, 2, 3 and 5 varied from strong brown, dark reddish brown and yellowish red to dark red respectively, due to differential degrees of erosion, organic matter accumulation and iron oxide content. Intense leaching of bases leaving sesquioxide and further oxidation might be the reason for the development of strong brown, dark reddish brown, dark reddish brown and yellowish red to dark red colour. The colour of Pedon 4 varies from yellowish brown to dark brown. Base saturation in this soil was more than the other four pedons and it was located in upland lower sector and leaching is less and the presence of non hydrated iron oxides (Sharma *et al.*, 1996). Surface structure varied from weak medium sub-angular blocky to moderate fine sub-angular blocky. In subsurface, the structure varies from strong coarse sub-angular blocky to strong medium sub-angular blocky. The dominant structure recorded was moderate medium sub-angular blocky. The weak structure development in pedon is due to low clay and low organic carbon content similar results were observed by Sitanggang *et al.* (2006). Thin and thick clay cutans are observed in all pedons except A-4 of Bt horizon. There was no observable clay cutans in the surface. This may be due to the continuous ploughing which must have obliterated the clay cutans (Dutta *et al.,* 2001).

Physical characteristics (Table 2)

Total sand percent is much higher than the silt and clay fractions in all the pedons. The coarser fractions dominate which could be largely of silicaceous nature because of granite gneiss parent material (Dutta *et al.*, 2001). Pedons of upland summit and lower sector under different land use were observed with rock fragments on the surface. This might be due to the removal of clay, silt and fine sand particles by sheet erosion, leaving rock fragments and heavy soil particles. Rock fragments were observed in subsurface horizons of Pedon 1 only. During laterization process, when the soil is brought under saturation, iron nodules are formed with different sizes in the subsurface which might be the reason for the gravelly nature of subsoils. In Pedon 1, the texture was lighter in the surface horizon and subsurface it varied from loam to sandy clay loam. Clay content was increasing with the depth as observed by Rajamannar and Krishnamoorthy (1978). Dispersion and eluviations of clay from surface horizon resulted in lower clay content in surface horizons (sandy to sandy clay loam). There is an evidence of illuviation of clay and formation of argillic horizon in the subsurface layer and similar result was observed by Sitanggang *et al.*, (2006). In Pedon 2, the soil texture was mostly clayey except at the surface horizon. The clay increase was high in the solum indicating advanced profile development. In Pedon 3 surface texture was sandy clay loam and subsurface varies from sandy clay to sandy clay loam, in Pedon 4 surface texture was loamy sand and subsurface varied from sandy clay to sandy clay loam and in Pedon 5 surface texture was sandy loam and in subsurface it varied from sandy clay to sandy clay loam. In Pedon 3 and 4, the clay content showed some marginal increase initially and decreased and confirmed the presence of less weathered parent material below the solum or less matured soil and the development of cambic horizon (Gangopadyay *et al.,* 2001). In Pedon 5 clay increase was high upto a depth of 60 cm then decrease upto a depth of 88 cm then showed an increasing trend, indicating the advanced soil profile development. Textural variations are mainly attributed to the type of parent material, degree of weathering and topography and similar result was observed by Sitanggang *et al.* (2006). It was observed that the bulk density in Pedon 1 and 4 decreases with the depth. This might be due to the formation of compacted layer on the surface horizon and less compaction at subsurface horizons. In Pedon 2, 3 and 5, the bulk density showed increasing trend. This is due to the severity of erosion and most of the soil material was removed leaving only the compact layer below (Bhaskar and Subbaiah, 1995).

Chemical characteristics

Soil pH varied from very strongly acidic to neutral. The pH was increasing with the depth (Table 3) similar results were recorded by Walia and Rao (1997) in red soil. It might be attributed to intense and uniform leaching of bases through out the profile (Sitanggang *et al.*, 2006). Mean EC values of all 5 pedons ranged from 0.01 to 0.14 ds/m. Thus these soils are non-saline in nature. EC of all the pedons was very low due to the leaching caused by land slope and rainfall as observed by Sivasankaran *et al.* (1993). The organic carbon content was high in the surface horizon and decreased down the profile (Table 3). The organic carbon values are low, ranging from 0.18 to 0.34 per cent. In all the pedons the value showed a decreasing trend of organic carbon with the depth (Shiva prasad *et al.*, 1998 and Walia and Rao., 1996). This might be due to low rain fall and high temperature, the rainfall greatly influenced the vegetative cover by contributing less organic carbon of the soil. CEC of the soils was generally low in all the pedons and was positively related with the amount of clay present Das *et al.* (1992). CEC varied from 2.3 to 12.2 cmol(p+)/kg of soil.

Table 1. Morphological characteristics of pedons

Depth (cm)	Horizon	Colour	Structure	Rock fragments	Clay cutans	Mottles
Pedon-1						
0-22	Ap	7.5YR4/4	M1sbk	5-10	-	-
22-57	Bt1	2.5YR3/4	M2sbk	15	Ttkp	-
57-79	Bt2	2.5YR3/6	M2sbk	25-30	Ttkp	-
79-119	Bt3C	2.5YR4/6	C2sbk	40	Ttnp	-
119-146	C1	2.5YR4/8	C2sbk	50	-	-
146-159+	C2	7.5YR7/6	Msbk	30	-	-
Pedon -2						
0-16	Ap	5YR3/4	2Fsbk	10	-	-
16-42	Bt1	2.5YR 3/6	2Msbk	-	Ttkp	-
42-76+	Bt2	2.5YR4/6	2Msbk	-	Ttkp	-
Pedon-3						
0-15	Ap	5YR3/4	2Msbk	-	-	-
15-39	Bt1	2.5YR 3/6	3Msbk	-	Ttnp	-
39-58	Bt2	2.5YR 3/6	3Msbk	-	Ttnp	-
58-79	Bt3	2.5YR 3/6	2Msbk	-	Ttkp	-
79-108	Bt4	10R3/6	2Msbk	-	Ttkp	-
108-105+	Bt5	2.5Yr3/6	2Msbk	-	Ttnp	-
Pedon-4						
0-18	A	7.5YR4/4	1Fsbk	-	-	-
18-41	Bw	7.5YR4/4	2Msbk		-	-
41-65	BC	10YR4/4	2Csbk		-	f1 f
65-99	CB	10YR4/6	3Csbk		-	f1 f
99-137	Cr1	10YR5/6	2Csbk		-	f1 f
137-160+	Cr2	10YR5/6	M	15-20	-	-
Pedon-5						
0-12	Ap	2.5YR 4/6	2Fsbk	-	-	
12-39	Bt1	2.5YR 3/6	2Msbk	-	Ttn c	-
39-60	Bt2	5YR 3/4	3msbk	-	T tk c	-
60-88	Bt3	5YR4/6	2Msbk		T tk c	-
88-130	Bt4C	5YR4/6	2Msbk		T tk c	-
130-150+	Bt5C	5YR4/6	2Msbk		T tk c	-

Table 2. Physical characteristics of pedons

Depth (cm)	Horizon	Sand %	Silt%	Clay %	Texture	BD (Mgm^{-3})
Pedon-1						
0-22	Ap	89.0	3.0	8.0	s	1.69
22-57	Bt1	64.5	4.0	31.5	gscl	1.68
57-79	Bt2	59.5	5.0	35.5	gscl	1.54
79-119	Bt3C	64.0	10.0	26.0	vgscl	1.84
119-146	C1	72.0	9.0	19.0	vgsl	-
146-159+	C2	77.0	10.0	13.0	gls	-
Pedon -2						
0-16	Ap	69.5	5.0	25.5	scl	1.38
16-42	Bt1	43.5	9.0	47.5	c	1.22
42-76+	Bt2	40	11.0	49.0	c	1.27
Pedon-3						
0-15	Ap	67	6.0	27	scl	1.36
15-39	Bt1	71.5	2.0	26.5	scl	1.38
39-58	Bt2	62.5	2.0	35.5	sc	1.40
58-79	Bt3	57.5	3.5	39	sc	1.31
79-108	Bt4	59	6.5	34.5	sc	1.22
108-105+	Bt5	63	5.5	31.5	sc	1.30
Pedon-4						
0-18	A	86.5	2.0	11.5	ls	1.74
18-41	Bw	83.5	1.0	15.5	sl	1.77
41-65	BC	61.5	5.5	33	sc	1.77
65-99	CB	68.0	8.0	24	scl	1.75
99-137	Cr1	76.5	13.5	20	sl	
137-160+	Cr2	71.0	13.0	16	gsl	1.74
Pedon-5						
0-12	Ap	Ap	77.0	5.5	17.5	sl
12-39	Bt1	Bt1	62.5	3.0	34.5	scl
39-60	Bt2	Bt2	61.5	0.5	38.0	sc
60-88	Bt3	Bt3	68.0	5.0	27.0	scl
88-130	Bt4C	Bt4C	66.0	1.5	32.5	scl
130-150+	Bt5C	Bt5C	54.5	7.0	38.5	Sc

Table 3. Chemical characteristics of pedons

Depth	Horizon	pH	EC	Ca	Mg	Na	K	Total	CEC	CEC/ clay	OC	Base saturation
(cm)				cmol (P+)/kg							%	%
Pedon-1												
0-22	Ap	4.94	0.014	1.76	0.42	0.12	0.06	2.36	3.00	0.13	0.40	79
22-57	Bt1	5.14	0.028	2.03	0.93	0.13	0.09	3.18	4.90	0.16	0.32	65
57-79	Bt2	5.36	0.027	1.68	1.03	0.16	0.11	2.98	4.25	0.12	0.21	70
79-119	Bt3C	5.68	0.014	1.15	0.74	0.16	0.10	2.15	3.1	0.12	0.18	69
119-146	C1	6.08	0.011	1.03	8.67	0.18	0.09	1.97	2.55	0.08	0.10	77
146-159+	C2	6.44	0.010	1.01	0.60	0.17	0.07	1.85	2.25	0.25	0.03	82
Pedon-2												
0-16	Ap	7.35	0.150	2.17	1.07	0.42	0.44	4.10	6.05	0.24	0.47	68
16-42	Bt1	7.48	0.137	2.25	1.16	0.58	0.20	4.11	10.10	0.21	0.36	41
42-76+	Bt2	7.08	0.137	2.38	1.33	0.89	0.13	4.73	12.15	0.25	0.21	39
Pedon-3												
0-15	Ap	7.03	0.28	2.40	0.66	0.23	0.18	3.47	4.60	0.17	0.43	75
15-39	Bt1	7.64	0.04	2.42	0.90	0.30	0.09	3.71	6.95	0.26	0.40	53
39-58	Bt2	7.43	0.06	2.75	1.05	0.30	0.09	4.11	5.00	0.14	0.29	84
58-79	Bt3	7.26	0.05	3.25	1.04	0.30	0.07	4.66	5.45	0.14	0.21	86
79-108	Bt4	6.93	0.04	3.32	1.10	0.26	0.09	4.77	8.65	0.25	0.10	55
108-105+	Bt5	6.62	0.04	1.57	0.53	0.25	0.10	2.45	3.35	0.11	0.07	73
Pedon-4												
0-18	A	5.20	0.01	0.62	0.24	0.12	0.07	1.05	1.68	0.15	0.43	63
18-41	Bw	5.37	0.01	0.47	0.33	0.13	0.05	0.98	2.25	0.15	0.40	65
41-65	BC	6.12	0.01	0.90	0.75	0.18	0.08	1.91	6.20	0.19	0.29	55
65-99	CB	6.40	0.01	1.27	0.83	0.18	0.08	2.36	7.50	0.31	0.21	94
99-137	Cr1	7.50	0.02	1.70	0.69	0.19	0.17	2.75	3.9	0.20	0.10	96
137-160+	Cr2	7.5	0.06	1.43	0.7	0.15	0.07	2.42	3.4	0.21	0.07	95
Pedon-5												
0-12	Ap	4.48	0.08	1.37	0.60	0.16	0.09	2.23	7.23	0.19	0.32	69
12-39	Bt1	5.81	0.04	2.38	0.75	0.13	0.11	3.37	5.75	0.17	0.29	81
39-60	Bt2	6.23	0.03	2.62	0.88	0.20	0.10	3.80	5.85	0.15	0.21	87
60-88	Bt3	6.15	0.03	3.07	1.15	0.20	0.10	4.52	6.05	0.22	0.14	83
88-130	Bt4C	5.90	0.02	2.97	1.15	0.19	0.10	4.41	5.2	0.16	0.10	94
130-150+	Bt5C	6.02	0.01	2.58	1.25	0.25	0.12	4.20	6.55	0.17	0.03	82

Table 4. Soil Classification

Pedon	Order	Sub order	Great group	Sub group	Family	Series
1	Alfisols	Ustalfs	Kanhaplustalfs	Rhodic Kanhaplustalfs	Fine loamy, Kaolinitic, Isohyperthermic, Rhodic Kanhaplustalfs	Aa
2	Alfisols	Ustalfs	Paleustalfs	Rhodic Paleustalfs	Fine mixed isohyperthermic Rhodic Paleustalfs	Ab
3	Alfisols	Ustalfs	Paleustalfs	Kandic Paleustalfs	Fine loamy kaolinitic isohyperthermic Kandic Paleustalfs	Ac
4	Inceptisols	Ustepts	Dystrustepts	Oxic Dystrustepts	Fine loamy kaolinitic isohyperthermic Oxic Dystrustepts	Ad
5	Alfisols	Ustalfs	Haplustalfs	Kanhaplic Haplustalfs	Fine loamy kaolinitic isohyperthermic Kanhaplic Haplustalfs	Ae

Table 5. Land capability classification

Land capability classes	Description	Ayyammanahalli village	
		Area (ha)	Area (%)
I	Good cultivable lands with out any limitations	8.1	10.1
IIe	Good cultivable lands having slight erosion limitations	25.6	31.8
IIs	Good cultivable lands having slight soil limitations	6.6	8.1
IIes	Good cultivable lands having severe erosion and soil limitations	1.7	2.1
IIIes	Moderately cultivable lands having severe erosion and soil limitations	8.0	9.9
IVest	Marginal cultivable lands having very severe erosion, soil and topography limitations	1.7	2.1

Table 6. Land Irrigability classification

Land-irrigability classes	Description	Ayyammanahalli village	
		Area (ha)	Area (%)
1	Good irrigable lands with our limitation	8.1	10.1
2s	Good irrigable lands having slight soil limitation	18.2	22.6
2d	Good irrigable lands having-slight drainage limitation	18.1	22.5
3s	Moderate irrigable lands having severe soil limitation	3.8	4.7
4est	Marginal irrigable lands having very severe-soil and topography limitation	5.9	7.3
6std	Non irrigable lands having severe-soil topography and drainage limitation	4.4	5.5

Table 7. Land suitability classification

S.No.	Land Suitabiliy classes	Maize		Red gram		Ragi		Ground nut	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
1	S1	25.8	32.1	-	-	21.4	26.6	16.3	20.2
2	S2	9.8	12.2	32.4	40.3	3.8	4.7	15.5	19.2
3	S2-S1	-	-	9.9	12.3	6.6	8.1	-	-
4	S3	13.7	17.0	1.7	2.1	18.1	22.5	18.1	22.5
5	S3-S2	-	-	2.0	2.5	-	-	-	-
6	N	-	-	8.2	10.2	4.2	5.2	4.2	5.2

Low CEC value of clay indicate the dominance of low activity clay particularly, 1:1 type clay minerals i.e. kaolinite/ mica (Walia and Chamuah, 1988). Soils in the watershed area of Ayyammanahalli were highly base saturated. The base saturation was high in the all surface and subsurface horizons.

Soil classification

The pedon-1, 2, 3 and 5 were classified under order Alfisols as they possessed argillic horizon and base saturation percentage found to be more than 35. Since moisture regime was ustic, it was classified under suborder Ustalfs. Under Alfisols order pedon-1 was classified as Kanhaplustalfs because of the clay increase is more than the 25 percent and CEC is less than 16 cmol (p+) /kg. Pedon-2 and 3 were classified at great group paleustalfs since this pedon have no lithic or paralithic contact within 150 cm of the mineral soil surface. In Pedon 2, the soils are grouped under subgroup Rhodic Paleustalfs and the agrillic horizon has clay decrease with increasing depth of 20 per cent or more (relatively) from the maximum clay content and it has hue redder and chroma of 3 and more so the Pedon 1 and 2 grouped under subgroup Rhodic. In Pedon 4 CEC / kg clay is less than 24 per cent so that it is classified as Kandic Paleustalfs. The soils of pedon-4 were grouped under Inceptisols, because of the presence of cambic horizon, Dystrustepts, because some horizon have base saturation less than 60 percent between 25 to 100 cm depth with ustic soil moisture regime and oxic Dystrustepts (Sub group) as they possessed Cambic horizon with CEC / kg clay is less than 24 cmol (p+) /kg. The pedon-5 is grouped under great group Haplustalfs since they do qualify under other Ustalfs but does not have characteristics of any other great groups (Table 4)

Land evaluation

The soils were classified under land capability classes II, III and IV, on basis of their susceptibility to erosion, soil, slope and climate limitation. It has been grouped into different land capability subclasses (Table 5). A maximum of 41.9 percent of the total area was classified under good cultivable lands having slight erosion limitations followed by moderately cultivable lands having severe erosion and soil limitations (17.6 %).The pedon -1 with deep soils were grouped as good cultivable lands having severe erosion and soil limitations, pedon-2 with moderately deep soils were grouped as good cultivable lands having slight soil limitation. Pedon- 3 with very deep soils is grouped as good cultivable lands having slight erosion limitation, pedon-4 with moderately shallow soils grouped as marginal cultivable lands having very severe erosion, soil and topography limitations and pedon-5 having very deep soils is grouped as moderately cultivable lands having severe erosion and soil limitations. The soils of Ayyammanahalli village has been classified into 1, 2, 3, 4 and 6 land irrigability classes with sub classes showing major limitations like shallow depth, poor drainage, steep slopes and poor quality of water (Table 5). The soils of upland occurring in the granitic landform have soil and topography as major limitation for agriculture. In remaining areas, soil and drainage is the major constraint. The exposed ridges and severely eroded areas, along the steam courses are not suitable for irrigated agriculture. Land irrigability in the study area revealed that 32.7 percent of total area are good irrigable lands having slight soil limitation, good irrigable lands having slight drainage limitation (19.4 per cent), 10.5 per cent are good irrigable lands with climate limitation, moderate irrigable lands having severe soil limitation(10.5 %), 7.1 per cent are non irrigable lands having severe soil, topography and drainage limitation and marginal irrigable lands having very severe-soil and topography limitations (2.2 %). Rock out crops, habitation, gullied land, tank, streams and degraded lands occupy the rest of the area. Semiarid climate is one of the major limitations in Ayyammanahalli village. 32.1, 26.6, 20.2, 16.9 and 21.1 per cent of land is highly suitable for cultivation of maize, ragi, ground nut. Sorghum and eucalyptus respectively.

Agriculture resource development plan

The thematic maps generated using satellite data and topographic maps were integrated along with meteorological conditions and soil analysis data to generate composite resource intensity units. These units have information on soil type, its constraints, drainage condition and topography. Each of these resource units were compared with the present land use, in such of the areas where the resources were not utilized up to its potential and potential land use practice was suggested giving weightage to the local needs of the people similar studies were conducted by Dwivedi *et al*. (1999), Gupta *et al.* (2001) and Sathish and Badrinath (2001). Where ever the existing land use was economically viable the same practice was recommended with appropriate management practices as observed in the study conducted by Shreedhara *et al*. (1996). The suggested potential land use plan is discussed.

Agro-horticulture: The areas where moderately deep to deep sandy loam to sandy clay loam soils on nearly level to very gently sloping lands with moderate drainage was observed and mapped irrigated agro-horticulture was advocated in place of kharif crops. This system improves financial status of farmers with regular income from both agriculture and horticulture crops in due coarse of time.

Dry land Horticulture: The horticulture plantation crops were suggested in deep to very deep sandy loam to sandy clay loam soils on gently sloping to moderately sloping lands with moderate or well drained. This system provides incremental returns from the kharif and fallow lands thus generating more income from the rainfed areas.

Silvipasture: In gullied and ravinous lands with shallow to moderately shallow gravelly sandy loam to sandy clay loam soils this system was advocated. This system provides fiber, fuel, fodder and timber from the same piece of land thus attaining self suffiency in fodder and fuel requirement.

Quarrying: In the rocky lands quarrying could be taken up by obtaining the permission from the government, which improve the financial position of both the individual and also government.

Reclamation: The degraded lands were to be reclaimed and brought to productive by soil and water conservation with vegetative barriers. Soil and water conservation methods includes mulching, contour farming, contour bunding, graded bunding, graded trenching, conservation ditches, bench terracing on gentle slopes and water conservation includes runoff harvesting through storage structure and runoff recycling. Vegetative barriers such as *Vetiveria zizanoides* and *Leucaena leucocephala* for the treatment for conserving moisture and increase crop productivity. The area under present cropping pattern has been retained as such but the emphasis should be given to use scientific methods of farming and afforestation programmes. Since the sustainable development of natural resources is based on maintaining a fragile balance between productivity functions and conservation practices through monitoring and identification of problem areas. Through these measures, the productivity in rainfed areas could be enhanced to meet the demand of ever increasing population.

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