LANDFORM ANALYSIS AND SOIL RESOURCE INVENTORY USING REMOTE SENSING TECHNIQUE IN A WATERSHED OF UTTARANCHAL, INDIA

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ABSTRACT:

The IRS-1D LISS III false colour composite (FCC) decoded imagery belonging to Kosi river watershed of Almora district of Uttaranchal under warm humid Lesser Himalayan agro-ecological region was interpreted and surveyed for soil resource mapping. On the basis of image interpretation and ground truth study ten physiographic units were identified. Soil physiography relationship was established on correlation of the soil-site characteristics and physico-chemical properties of soils. Based on the image characteristics and soil-physiography relationship soil map of the area was prepared. The study revealed that the remote sensing technique was useful in delineating physiographic units and inventory of soil resources in remote/inaccessible areas of mountainous lands, which are important for watershed management as well as agricultural development of an area.

INTRODUCTION

The development of hill and mountain areas and protection of their ecology have become matters of national concern in recent years. These areas differ from the plains in topography, elevation, physiographic feature, diversity of habitats for flora and fauna, ethnic diversity, land use systems and socio-economic conditions. In accessibility, fragility, marginality, heterogeneity, natural instability and human adoption mechanism are the key factors to be focused for sustainable agricultural development in such areas. Soil is the most important natural resource which should be managed effectively, efficiently and optimally for sustainable agricultural production in these areas. Utility of the remote sensing data in such areas has been successfully exploited by Ahuja *et al.* (1992). Kundu *et. al*., (1999), Saxena *et al*., (2000) and Martin *et al.*, (2001). For landform interpretation and extrapolating the information derived from remote sensing data on terrain data to the inaccessible areas. Thus, the present study has been undertaken to identify the kind and distribution of different soils and their problems and potentials in a watershed of Almora district of Uttaranchal for sustainable productivity.

METHODOLOGY

The study area belongs to Kosi river watershed spread over Almora-Takula area (29º 41' to 29º 46' N and 79º 39' to 79º 45' E) of Almora district of Uttaranchal. The area is under warm humid Lesser Himalayan agro-ecological region. The elevation ranges from 800-2400 m above MSL. A 3 tier approach was adopted to carry out soil resource mapping *viz.* image interpretation, ground truth checking and mapping. The IRS-1D LISS III false colour composite (FCC) decoded imageries of bands 2,3 and 4 on 1:50,000 scale and Survey of India toposheets on same scale were used for the study. Based on image characteristics such as colour, texture, size, pattern, location and association and physiographic approach with element analysis (relief, erosion, land use, drainage and vegetation), visual interpretation was undertaken to delineate the physiographic units. Ground truth study was conducted to confirm the physiographic units. Soils of each physiographic unit were studied in the field and soil samples were collected for their characterization. (Black 1965, Jackson 1966). Soils are classified as per Soil Taxonomy (Soil Survey Staff, 1998).

RESULTS AND DISCUSSION

On the basis of image interpretation and ground truth study ten physiographic units were identified in the study area (Table.1). Soil map is depicted in figure.1 and morphological and physico-chemical properties are presented in table.2 and 3, respectively. Soils of escarpments/cliffs occur on steep to very steep slopes and are very shallow, excessively drained, gravelly sandy loam to loam, brown to dark brown in colour, slightly acidic in reaction and developed on mica schist (Lithic Udorthents). Main constraints are rockiness and severe to very severe erosion with low nutrient retention capacity. Soils of summits/ridge tops occur on moderate slope to very steep slopes and are moderately shallow to very shallow, excessively drained, gravelly sandy loam to gravelly loam, brown to dark reddish brown in colour, slightly acidic to neutral and developed on mica schist/quartzite/shale (Lithic/Typic Udorthents). In some areas soils are deep and heavy textured. Major constraints are gravelliness, rockiness and severe erosion with low to medium nutrient retention capacity. The area is mostly covered under shrubs and forest and also cultivation in some areas. Soils of side/reposed slopes occur on moderate slopes to very steep slopes and are shallow to very deep, well drained to excessively drained, sandy loam to loam, gravelly loam in texture, brown to yellowish brown and dark reddish brown in colour, slightly acidic and developed on mica schist/quartzite/shale (Lthic/Typic Udorthents, Typic Dystrudepts). Major constraints are gravelliness and moderate to severe erosion with low nutrient retention capacity. They are mostly covered under forest and cultivation in lower areas. Soils of valleys occur on gentle to moderate steep slopes and are moderately to very deep, well drained to somewhat excessively drained, loamy sand to clay loam in texture, yellowish brown to dark yellowish brown in colour, slightly acidic to neutral and developed on colluvium/alluvium (Typic Udorthents/Typic Dystrudepts). They are mostly under cultivation on terraces and also forests on sloping lands. Major constraints are gravelliness and moderate erosion with low to medium nutrient retention capacity.

CONCLUSION

The study revealed that the remote sensing technique was useful in delineating physiographic units and inventory of soil resources in remote/inaccessible areas of mountainous lands,

which are important for watershed management as well as agricultural development of an area.

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Table. 1 Interpretation of image characteristics

Unit	Image Characteristics	Physiographic Unit	Dominant soils
1	Medium brown to dark grayish and mottled colour with course to rough texture and small, irregularly scattered grains.	Escarpments/cliffs	Very shallow, gravelly sandy loam soils of brown colour developed on sandstone/quartzite
2	Brownish and mottled colour, medium to coarse texture with small, irregular and scattered grains.	Very steeply sloping summits/ridge tops with open scrubs	Moderately shallow, sandy loam soils of dark yellowish brown colour developed over quartzite
3	Reddish brown and mottled colour, medium to coarse texture with small, irregular and scattered grains	Moderately steeply sloping summits/ridge tops with pine forest.	Moderately deep, sandy loam soils of dark yellowish brown colour developed over quartzite
4	Medium brown with coarse mottled colour, smooth to medium coarse texture, evenly scattered fine grains	Moderately sloping summits/ridge tops under cultivation.	Deep, gravelly loam to clay loam soils of dark yellowish brown colour developed from quartzite
5	Reddish with medium brown colour, mottled and medium smooth texture and irregular, medium scattered grains	Very steeply sloping side/reposed slopes with open scrubs.	Moderately deep, gravelly loam soils of dark brown colour developed from quartzite
6	Medium gray to light brown with medium smooth, light mottling	Steeply sloping side/reposed slopes with open scrubs.	Deep, gravelly loam soils of dark yellowish brown colour developed from quartzite
7	Reddish to medium brown with pale yellowish patches & smooth, medium mottled texture	Steeply sloping side/reposed slopes under cultivation.	Moderately shallow, loam soils of dark brown colour developed from colluvium
8	Yellowish to light green with smooth, fine mottled texture and irregular, fine scattered grains	Moderately steeply sloping side/reposed slopes under cultivation	Deep, gravelly sandy loam soils of dark yellowish brown colour developed from colluvium
9	Light green with white patches in diffuse manner and fine mottled appearance	Moderately sloping side/reposed slopes under cultivation	Deep, sandy loam over loamy sand soils of dark brown to dark yellowish brown colour developed over alluvium
10	Light bluish tone with scattered white patches in diffused and irregular grains	Terraced valleys	Very deep, loam soils of dark brown colour developed from alluvium/colluvium

Table.2 Morphological Characteristics of Soils

Soils	Horizon	Depth (cm)	Boundary	Colour	Texture	Structure
Rawani	A	0-9	Clear, smooth	Brown	Sandy loam	Massive
	C	9-35	Abrupt, smooth	Brown	Sandy loam	Massive
	R	35-47	Unconsolidated Rock			
Sunsari	A	0-9	Clear, smooth	Brown	Silt loam	Massive
	C	9-22	Abrupt, smooth	Brown	Silt loam	Massive
	R	22-50	Clear, smooth	Dark brown		
		50-71	Unconsolidated Rock			
Thouli	A1	0-9	Clear, smooth	Brown	Gravelly sandy loam	Massive
	A12	9-26	Smooth	Brown	Gravelly sandy loam	Massive
	AC	26-42	Abrupt, smooth	Brown	Gravelly sandy loam	
Chimtakhal	A1	0-9	Clear, smooth	Strong brown	Gravelly loam	Massive
	A12	9-28	Gradual, smooth	Brown	Gravelly loamy sand	Massive
	AC	28-43	Gradual, smooth	Brown	Gravelly loam	
	C	43+				
Baseri	Ap	0-14	Clear, smooth	Brown	Gravelly sandy loam	Massive
	Bw1	14-35	Gradual, smooth	Brown	Gravelly sandy loam	Massive
	Bw2	35-68	Gradual, smooth	Strong brown	Gravelly sandy loam	Massive
	Bw3	68-86	Gradual, smooth	Lightly yellowish brown	Gravelly sandy loam	f 1 sbk
	AC	86-105		Lightly yellowish brown	Gravelly sandy loam	Massive
	C	67+	Unconsolidated Rock			
Manila	Ap	0-16	Clear, smooth	Brown	Loam	Massive
	A12	16-35	Clear, smooth	Dark yellowish	Clay loam	f 1 sbk
	Bw1	35-56	Gradual, smooth	Dark yellowish brown	Clay loam	f 2 sbk
	Bw2	56-80	Gradual, smooth	Dark yellowish brown	Clay loam	m 2 sbk
	Bw3	80-105	Gradual, smooth	Dark yellowish brown	Clay loam	m 2 sbk
	Bw4	105-135	Gradual, smooth	Dark yellowish brown	Clay loam	m 2 sbk
	BC	135-158			Clay loam	m 1 sbk
Chillanoula	A11	0-7	Clear, smooth	Brown	Gravelly loamy sand	Loose
	A12	7-23	Clear, smooth	Dark yellowish brown	Gravelly loamy sand	Loose
	A13	23-42	Clear, smooth	Grayish brown	Gravelly loamy sand	Loose
	AC	42-67	Clear, smooth	Grayish brown	Gravelly loamy sand	Loose
	C	67-90			Gravelly loamy sand	Loose
	R		Unconsolidated Rock			f1 sbk
Jala	A11	0-15	Clear, smooth	Brown	Gravelly sandy loam	Massive
	A12	15-38	Gradual, smooth	Brown	Gravelly sandy loam	Massive
	C1	38-60	Gradual, smooth	Gradual brown	Gravelly sandy loam	Massive
	C2	60-74	Clear, smooth	Light brown		
Kharkhat	A11	0-13	Gradual, smooth	Dark yellowish brown	Gradual sandy loam	Massive
	A12	13-34	Gradual, smooth	Brown	Gradual sandy loam	Massive
	AC	34-49	Abrupt, smooth	Brown	Gradual sandy loam	f & sbk
	C	47+74	Unconsolidated Rock	Brown	Gradual sandy loam	f1 sbk
	R		Unconsolidated Rock			f1 sbk
Kapharkhan	Ap	0-11	Clear, smooth	Brown	Loamy sand	Massive

	A12	11-36	Clear, smooth	Dark yellowish brown	Loamy sand	Massive
	AC	36-63	Gradual, smooth	Dark yellowish brown	Loamy sand	Massive
	C1	63-97	Gradual, smooth	Dark yellowish brown	Loamy sand	
	C2	97+	Severely stony & Rocky			
Naugaon	A	0-10	Clear, smooth	Brown	Gravelly loamy sand	Massive
	AC	10-25	Clear, smooth	Yellow brown	Gravelly sand	Massive
	C	25-40	Gradual, smooth	Yellow brown	Gravelly sand	
Rinchi	A11	0-9	Clear, smooth	Dark grayish brown	Sandy loam	Massive
	A12	9-24	Gradual, smooth	Brown	Gravelly sandy loam	f sbk
	A13	24-39	Gradual, smooth	Brown	Gravelly sandy loam	m l sbk
	AC	39-54	Gradual, smooth	Brown	Gravelly sandy loam	m l sbk
	C1	54-72	Gradual, smooth	Brown	Gravelly sandy loam	m l sbk
	C2	72+	Gradual, smooth	Brown	Gravelly sandy loam	m l sbk
Jalikhan	A11	0-10	Clear, smooth	Brown	Gravelly loam	Massive
	A12	10-33	Clear, smooth	Brown	Gravelly clay loam	Massive
	A13	33-50	Gradual, smooth	Strong brown	Gravelly clay loam	f 1 sbk
	AC	50-74	Gradual, smooth	Lightly yellowish brown	Gravelly clay loam	m 1 sbk
	C	74-97			Severely stoney	
Bajyolia	Ap	0-20	Clear, smooth	Brown	Gravelly loamy sand	Loose
	AC1	20-40	Clear, smooth	Dark yellowish brown	Gravelly loamy sand	Loose
	AC2	40-60	Gradual, smooth	Dark yellowish brown	Gravelly loamy sand	Loose
	AC3	60-80		Dark yellowish brown	Gravelly loamy sand	Loose
Bhikyasen	A11	0-18	Clear, smooth	Brown	Sand	Single grain
	A12	18-33	Gradual, smooth	Brown	Sand	Single grain
	A13	33-62	Gradual, smooth	Brown	Sand	Single grain
	A14	62-84	Gradual, smooth	Dark yellowish brown	Sand	Single grain
	AC	84-105	Gradual, smooth	Dark yellowish brown	Sand	Single grain
	C	105-130		Dark yellowish brown	Coarse sand	Single grain

Table.3 Physico-chemical Characteristics of Soils

Soils	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	O.C. ($g\ kg^{-1}$)	Sand	Silt	Clay	CEC {C mol $(p+)\ kg^{-1}$}	Base saturation (%)
Rawari	0-12	5.81	0.15	0.86	61.9	24.0	13.75	6.05	69.5
Sunsari	0-9	5.78	0.18	1.47	31.45	53.85	15.00	7.85	63.8
	9-22	5.64	0.18	1.07	31.45	56.05	12.50		
Thouli	0-14	5.27	0.23	1.14	60.4	25.1	14.5	7.82	65.7
	14-32	5.88	0.19	0.54	64.0	22.9	13.2	6.10	68.6
Chimtakhal	0-9	5.55	0.13	3.03	40.80	35.95	23.25	12.50	61.36
	9-28	5.35	0.12	1.06	40.30	37.20	22..50	11.50	58.0
	28-43	5.24	0.12	0.68	37.60	37.40	25.00	12.00	55.75
Baseri	0-14	4.74	0.93	1.85	76.00	15.75	08.25	3.82	61.78
	14-31	5.52	0.37	0.29	59.19	31.06	09.75	4.08	66.91
	31-50	6.12	0.33	0.29	54.80	33.95	11.25	4.08	66.91
	50-68	6.39	0.19	0.29	57.66	28.84	13.50	3.26	65.35
	68-86	6.91	0.17	0.14	55.48	29.77	14.75	4.28	60.04
	86-105	6.77	0.13	0.17	53.82	32.93	13.25	4.08	64.95
Manila	0-16	4.96	0.93	1.11	36.66	37.50	25.25	13.65	58.20
	16-35	6.46	0.30	4.17	28.88	43.75	27.25	12.45	74.77
	35-56	6.91	0.17	0.87	32.96	43.75	23.75	11.85	82.32
	56-80	7.17	0.14	0.52	38.48	37.75	23.25	11.00	83.15
	80-105	7.47	0.14	0.41	34.55	37.25	28.25	11.70	82.32
	105-135	7.47	0.19	0.37	23.27	38.75	37.50	09.30	84.35
	135-158	7.45	0.17	0.25	31.41	39.75	29.25	09.50	86.26
Chillanoula	0-7	5.97	0.36	0.96	56.55	24.95	18.50	10.00	63.60
	7-23	5.87	0.24	1.53	58.00	22.50	19.50	09.60	60.20
	23-42	5.88	0.19	1.53	54.15	26.60	19.25	08.50	59.41
	42-67	5.89	0.13	1.45	55.10	26.40	18.50	08.00	61.75
	67-90	5.89	0.12	1.41	65.30	18.70	16.00	06.70	66.22
Jala	0-13	5.36	0.91	3.64	55.4	33.5	11.0	9.92	58.6
	13-32	5.76	0.24	1.17	61.1	28.5	18.2	10.06	60.5
	32-58	5.74	0.21	0.84	64.0	19.0	16.2	8.96	62.4
	58-83	5.95	0.14	0.53	61.2	26.7	12.0	6.24	63.6
Kharkhet	0-13	5.44	0.39	2.803	48.1	31.5	20.5	9.75	92.82
	13-34	5.20	0.48	2.496	38.48	40.25	25.25	10.65	91.25

	34-49	5.44	0.25	2.112	38.69	95.5	23.75	10.35	95.84
	49-74	5.25	0.37	2.728	33.86	45.25	24.75	10.95	97.71
Kapharkhan	0-14	5.97	0.32	1.07	75.8	19.7	4.5	2.55	56.5
	14-33	6.27	0.13	0.49	74.0	21.5	4.2	1.95	58.2
	33-51	6.58	0.10	0.34	75.6	18.7	5.5	2.55	60.3
	51-70	6.51	0.22	0.30	72.2	23.5	4.2	1.25	62.4
Naugaon	0-12	6.34	0.14	0.76	82.4	16.2	1.5	1.02	59.5
	12-32	6.43	0.12	0.38	86.9	8.5	4.5	2.21	62.4
	32-48	6.51	0.14	0.23	88.8	8.2	3.2	1.53	64..7
Rinchi	0-16	5.2	0.48	2.49	38.4	40.2	21.5	16.64	53.2
	16-39	5.4	0.25	2.11	34.6	41.5	23.7	16.82	55.4
	39-67	5.2	0.37	1.72	33.8	41.2	24.7	15.94	59.4
Jalikhan	0-10	6.12	2.6	1.989	46.21	37.3	16.3	5.69	66.43
	10-33	5.84	0.12	0.643	38.2	37.5	34.5	4.67	71.30
	33-50	5.94	0.10	0.546	33.95	38.3	27.75	4.45	95.28
	50-74	5.69	0.90	0.234	36.3	38.3	25.5	4.13	66.34
	74-97	4.78	0.23	0.154	46.6	37.2	22.2	4.12	91.50
			0.18						
Bajyolia	1-20	5.73	0.41	0.71	84.68	4.50	10.75	5.50	85.09
	0-40	7.90	0.19	0.28	84.21	5.75	10.50	5.40	76.89
	40-60	6.50	0.12	0.15	83.96	4.25	11.75	4.90	82.44
	60-80	6.67	0.12	0.15	81.67	8.50	10.25	4.50	91.11
	0-18	5.86	0.36	0.81	92.0	4.80	3.00	1.53	72.54
Bhikyasen	18-33	5.56	0.24	0.75	93.15	4.10	2.75	1.27	74.80
	33-62	5.66	0.19	0.71	91.80	4.20	4.00	1.27	67.71
	62-84	5.65	0.13	0.25	89.30	7.20	3.50	1.02	73.52
	84-105	5.55	0.12	0.13	90.50	5.50	4.00	1.02	73.32
	105-130	5.44	0.11	0.11	90.18	7.82	2.00	1.02	65.68

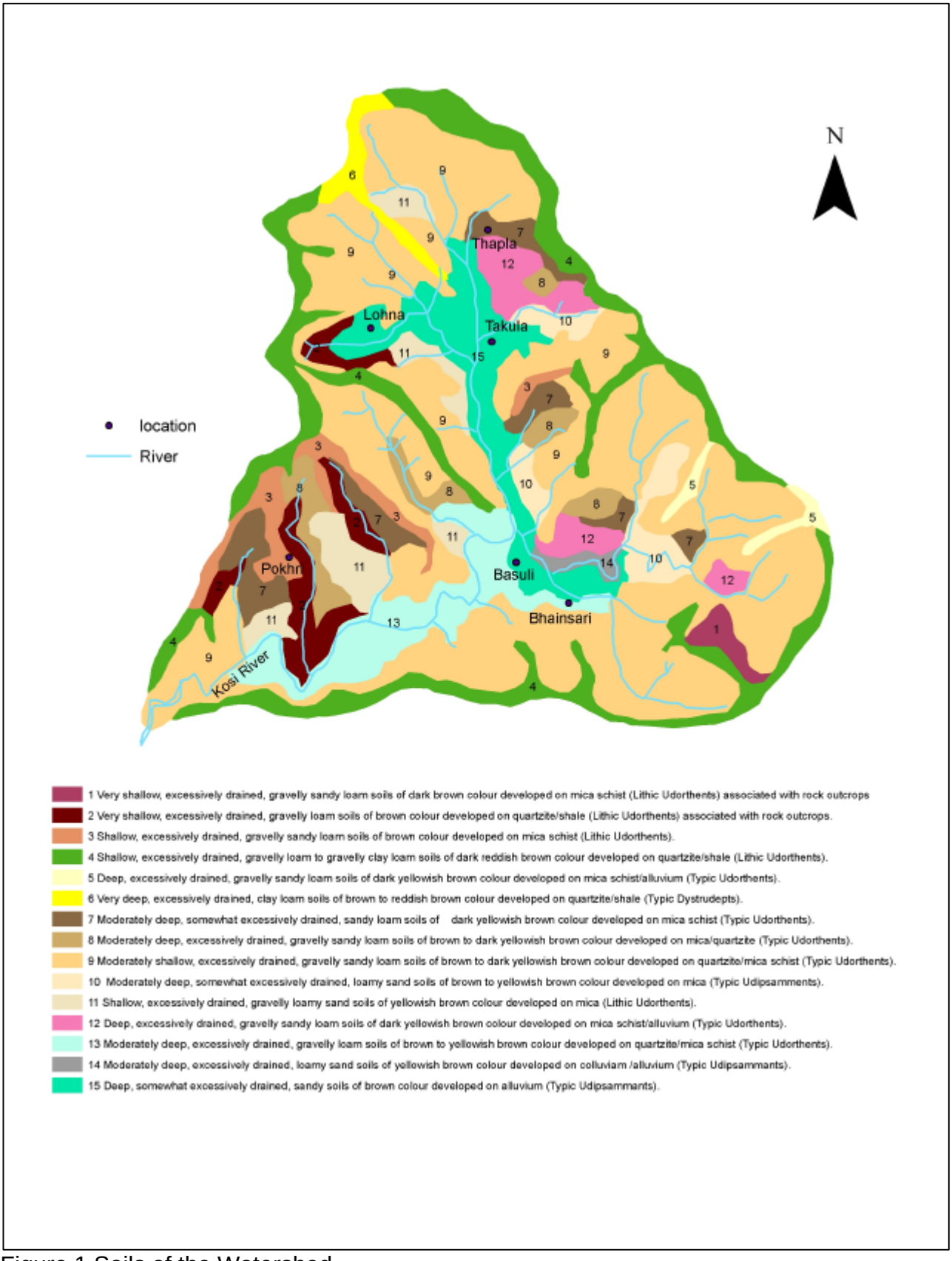

Figure.1 Soils of the Watershed