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Soil-Landscape Relationship in Lohit Valley near Tezu, Arunachal Pradesh, India

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ABSTRACT

The genesis, classification and soil –landscape relationships of eight profiles in tectonically sensitive pedological province of Lohit valley near Tezu of Arunachal Pradesh were studied using satellite data, field survey and laboratory characterization. The soil distribution showed that the hill land soils have shown progressive pedogenic pathway (subgroups of Entisols to Inceptisols) with horizon development, soil deepening and chemical stability but regressive pathway in piedmont plains (Subgroups of Inceptisols to Entisols) with homogenization and chemical instability. The structuring of soils on given landscape was useful in assessing soil development and designing land management strategies in North Eastern parts of India.

1.Introduction

Arunachal pradesh bestowed with rich forest resources have serious problems of landslide activity and erosion of steep lands used for agriculture [3][10]. The soil resource inventories in Arunachal pradesh reported the occurrence of the subgroups of Inceptisols in 37 per cent of area and subgroups of Entisols in 35.6 per cent of area [18]. The hillland soils are shallow with fine or coarse loamy and weakly developed B horizons in subgroups of Inceptisols and little profile differentiation in subgroups of Entisols were reported and evaluated their suitability for rice based cropping systems [28],[29]. The soil landscape relationships showed lower Fed and clay contents under different parent materials [21]. In mountain areas, elevation [5] and impact of fluvial slope wash processes in the foot hills of mountains were decreased with increasing time in a logarithmic curve [7]. The subsoil B horizons of Inceptisols showed maxima of clay and free Fe oxides [8] but in young soils, the subsoil horizons have increasing intensity of weathering [6],[19]. The soils and landscapes provide an opportunity to study pedogenesis of soils in their respective landscape positions wherein riparian wetlands are associated with well drained hill land soils.

2.Utility of Soil-landscape relationships

Soil survey interpretation and soil information systems help to predict potentials, limitations, problems and management needs for soils. However, high expert input, difficulty of producing a large-scale soil map and financial constraints, developing a soil-landscape relationship model for an area helps surveyors to extrapolate results to other areas with similar soil forming factors [11]. Research has provided optimistic results, and some researchers obtained better results than traditional soil surveys [20],[22]. The use of aerial photointerpretation technique being adopted for mapping soils of pediplains in Haryana[2] and in Shiwalik hills of Punjab in India[9] and of satellite data in recent times to complement topographic information improves the mapping of natural resources [11], [21]. These investigations are based on the relationship between landscape pattern and the differentiation of soil types and attributes [1]. The spatial distribution of specific soil properties has been predicted using soil-landscape modeling. This included sand, silt, and organic matter contents; A-horizon thickness; solum depth; extractable phosphorus; and pH. Using different terrain attributes, the empirical models developed in these studies explained 41–68% of the variation in soil properties [1],[11].

3. Objective of the study

The objective of present study in Lohit valley of Tezu was to create soil-geomorphic relationships and characterize the soils associated with these landscapes for conservation-based decision-making, and ultimately helping land managers to develop plans for agriculture.

4.Materials and Methods

4.1. Details of study site

The benchmark site near Tezu covering 14500 hectares (ha) (27^{0}55"–28^{0}00" N latitude and 96^{0}05"-96^{0}15"E longitude) was selected for studing soil –landscape relationships in tectonically sensitive Mishimi mountains of Lohit valley. This site has alluvial plains often inundated by Tabang, Digaru, Derai, Tafru nala and Denning nala flowing from northern hills of Mishmi mountain at an elevation of 190 to 440 metres (m) and having 20 to 30 per cent slopes on hills to 1 to 5 per cent slopes in piedmont plains. This site has poorly cemented pebbles/cobble beds of Komin formations and highly tectonised zone with high seismicity[27]. This site has a cool and humid climate with foggy winters. Yearly precipitation averages 3295 mm, 90 per cent of which falls from April to September. The soil moisture is udic with length of growing period more than 270 days. The difference of air temperature in summer (April, May, June) to winter months (December, January and February) is more than 5^{0}C to define soil temperature regime as hyperthermic[25]. The natural vegetation consists of tree species viz., Hollock (*Dipterocarpus macrocarpus*), Hollock (*Terminalia myriocarpa*), Kadam (*Anthocephalus cadamba*), Nahar (*Mesua ferrea*), Sonaru (*Cassia fistula*) Makai (*Shorea assamica*), Sal (Shorea robusta), Sisoo (*Dalbergia sissoo)* and Teak (*Tectona grandis*) and stream channels have gregarious clumps of screw pine or *Pandanus furcatus* along with tall grasses like *Arundodonax* and *Saccharum spontaneum*.

4.2.Field survey and sampling

The visual interpretation of IRS-1D LISS-III data (FCC 2,3,4 band) of 8th February, 2002 of corresponding Survey of India toposheet 92A/1 scaled at 1:50000 revealed that the benchmark site has two distinct land forms such as hills and piedmont plains in lower reaches of the terrain. The soil survey was carried out and studied thirty two soil profiles to a depth of bed rock or 200 cm and recorded soil morphology[24]. At each site, latitude, longitude and altitude were recorded with GPS receiver (Global map 100, Lawrence). Eight soil series were selected for studying soil landscape relationships and classified in the subgroups of Inceptisols and Entisols[26].

4.3. Laboratory analyses

Horizon wise soil samples were collected, air dried and passed through 2 mm sieve. This fine earth fraction was used for analysis of particle size distribution (sieve and pipette method), pH (1:2.5 soil water ratio), organic carbon (wet oxidation method) [13], cation exchange capacity and exchangeable bases (IN NH_4oAC displacement and distillation method[23], citrate dithionite and carbonate extractable iron[17] and total iron (Triacid digestion method)[12]. The soil development was estimated with clay accumulation index and iron oxide accumulation index as follows: $\sum$ (B-C)T, where B = B horizon clay content (%) / Fed:Fet ratio, C = C horizon clay content(%)/ Fed: Fet ratio and T = Thickness of B horizon(cm)[14].

5. Results and Discussion

5.1. Soil–landscape relationships

The landscape near tezu is simple with hills and piedmont plains having regular repetitive soil subgroups of Entisols and Inceptisols formed under cool, humid climate and tectonically active topography (Fig.1). The Mountain front is steep and linear towards south west against which debris flow dominant and produced alluvial slope deposits typifying regimes of more rapid faulting and fans with longer axial lengths develop adjacent to tectonically less active basin bounding faults. The steep sandstone capping over granitic hill lands (35 to 60 per cent), covering 11.3% of study site have well drained, severely eroded, very shallow (Hatchling, P1) soils in association with moderately deep to deep (Lamu, P2 and Lohitpur, P3, Table 1). The Hutchiliang soil (PI) has 16 cm thick, dark brown (7.5YR3/2) A horizon with sandy loam texture (sand of 55 per cent and clay of 16 per cent), organic carbon of 50.3 g $kg,^{-1}$ gravel content more than 35 per cent and lithic contact below 50 cm. This soil is classified as Humic Lithic Udorthents with loamy skeletal particle size cla**ss**[26]. The Lamu (P2) and Lohitpur (P3) soils have A-Bw horizon sequence with enriched organic carbon content (3 0 to 53 gkg^{-1}), loam to sandy loam texture with silt content of 22 to 34.7 per cent and 10 to 17 per cent of clay. The A horizons are very dark grey with 16 cm (P2) to 20 cm thick (P3). The cambic B horizons are dark brown or dark yellowish brown with 64 cm (P3) to 105 cm (P2). The A horizons are strongly acid (p^H of 5.3 to 5.5) with base saturation less than15 per cent and has cation exchange capacity of 13.6 to 21.7 coml. (+) kg^{-1}(Table 2). The Fe_d is 26.8gkg^{-1} in A horizon with slight increase in Bw horizon to 29.8 gkg^{-1} and then decreased to 23.2 gkg^{-1} with depth (P2), where as in Lohitpur l (P3), the Fe_d is 14.9gkg^{-1} with an increase of 16gkg^{-1}. Both soils have Fe_t contents between 24 and 32 gkg^{-1} with slight increase with depth. These soils were classifed as Humic Pachic Dystrudepts (P2 & P3) with coarse loamy particle size.

The upper piedmonts (57.9 per cent of area) with more than 35 per cent of surface rock outcrops and subjected to seasonal floods for short period (more than 10 days) has two soil series namely Loiliang (P4) and Kuraliang (P5). The shallow and lithic Loiliang (P4) has 17 cm thick and black A horizon having 40.2 gkg^{-1} of organic carbon and loam texture (35 per cent silt, 35 to 50 per cent coarse fragments and 14.5 per cent clay) and 40.5 per cent of base saturation. This soil is classified as Humic Lithic Udorthents. The moderately deep Kuraliang (P5) has mollic epipedon with 73 per cent of base saturation and 8.5 to 11.8 $cmol(^+)kg^{-1}$ CEC. The Fe_d and Fe_t shows increasing trend with values of 8.5 to 13.5 gkg^{-1} for Fe_d and 38.4 to 41.5 $gkg^{-1}Fe_t$. This soil is classified as Humic Dystrudepts.

The lower piedmonts (30.95 per cent of area) with gently sloping to flat lands and frequently flooded with river water during rainy season have two stratified soil subgroups: - Fluventic Humic Dystrudepts have very dark grey to dark greyish brown Ap horizons and dark yellowish brown B horizons of moderately to slightly acid (pH5.5 to 6.5) with base saturation of 31 to 59 per cent (Pomliang, P6 & Makaliang, P7) and Mollic Udifluvents with Ap-AC-C horizon sequence with brown to strong brown matrix, sandy loam texture, moderately acid and decrease of organic carbon from 26.3 gkg^{-1} in Ap horizon to 1.8 gkg^{-1} in C3 horizon. (Tezu,P8).

5.2. Assessment of soil development

The soils in toposequence show high organic carbon status, strongly acid and low base status in hills (P1 to P3) whereas weak development of B horizons with no illuviation of clay on piedmont slopes indicate the influence of stream cutting and severe land slides leaving less residence time in mountain front regions[22]. The exchange sites of these soils have 40 per cent of Ca+Mg saturation that favours to flocculate clays and formation of fine sub angular blocky structures and retards down ward movement of clay[8]. The high clay in summit soils was due to high surface gravel cover that act as mulch to cushion the soil particles[19]. The clay accumulation index in pedon 5 and 7 and high iron accumulation index in pedon 2 (42.3) shows varying degrees of weathering in these soils.

The soil development in toposequence is defined in terms of clay and iron oxide contents in A and B horizons relative to C horizon and its power relation is established with regression equation as : Clay (%) = 4.1459x $Fe_d^{0.41}$ (R^2 = 0.39). This relation is similar to that of linear relationship reported[15],[16]. In young landscapes, the clay and Fe_d to Fe_t ratio diminishes in A and B horizons as reflected in soils of piedmont plains (P4 to P8) . The clay and free iron contents suggest that these soils do not reach steady state and continue to change with the passage of time [5] but organic carbon and base saturation may truly reach steady state under relatively stable climatic conditions over entire period of soil development [9],[16] with high organic carbon status, strongly acid and low base status in hills (P1 to P3). The cation exchange capacity has significant relation at 1 per cent level with organic carbon yielding R^2 of 0.94* and its power equation is described as : cation exchange capacity (CEC, $cmol(^+)kg^{-1}$) = 4.1689x $OC^{0.4217}$. In tectonically mobile landscapes, the shallow soils (P1) in summits slowly becomes deep and organized with thick organic carbon layers (52 to 80cm) indicating the dominance of cumulic processes (P2&P3). The soils in piedmont slopes (P4 to P8) have wide Fe_d to organic carbon ratio in lower horizons of piedmont soils due to surface sedimentation and attains both steady state and continuous evolution of soils with respect to normal fluctuations in environmental conditions[11].

6. Conclusions

The soil-landscape relationships in Lohit valley near Tezu showed that the hill land soils have thick organic enriched mollic epipedons with base saturation less than 20 per cent , low clay accumulation and maxima of Fe_d to Fe_t ratio in cambic B horizons whereas moderately to slightly acid piedmont soils have base saturation of 30 to 60 per cent, loss of clay, iron and irregular distribution of organic carbon. The soil evolution on hills shows progressive pedogenic pathway (subgroups of Entisols to Inceptisols with an increase of clay and iron oxides in the A and B horizons relative to C horizons and its power relation is established with regression equation as : Clay (%) = 4.1459x $Fe_d^{0.41}$ and positive relation of organic carbon of soils with cation exchange capacity (CEC, $cmol(^+)kg^{-1}$) = 4.1689x $OC^{0.42}$ .The regressive pathway in case of piedmont soils (subgroups of Inceptisols to Entisols) is evident with low organic carbon(<1%), loss of exchangeable bases and forms of Fe in B, C horizons . These soils are ecologically highly fragile and are closely associated with topography and climate. The soil properties such as organic carbon , extractable bases and forms of iron appear to be developed rapidly with time and attain quasiequilibrium with exiting climate on each landscape position.

7. Future line of work

The future research work provides new means of acquiring and dessiminating soil-landscape information with precision and accuracy for designing sustainable soil-land management options at regional level.

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Table1.Morphology of soil

Depth (cm)	Horizon	Matrix color	Texture	Structure	consistence	Roots	Boundary
Profile 1.Huchliang-Coarseloamy-Humic Lithic Udorthents(27°59’59”Nlat –96°11’57”,423.9 m)							
0-16	Ap	7.5YR3/2	Sl	vf1sbk	fr,so,po	vf,f-m	cs
16-40	R	10YR5/2	Sl	v f1sbk	vfr,so,po	vf,f-m	-
Profile-2. Lamu-Coarse loamy mixed Humic Pachic Dystrudepts(27°59’43”Nlat—96°11’56”Elong.407m)							

0-20	Ap	7.5YR3/1	L	vf1sbk	vfr,so,po	m,f-m	cs
20-52	Bw1	7.5YR3/1	Sl	vf1sbk	vfr,so,po	vf,f-m	cs
52-81	Bw2	7.5YR3/2	Sl	f1sbk	vfr,so,po	vf-f	cs
81-125	Bw3	10YR3/4	Sl	f1sbk	vfr,so,po	vf-f	cs
Profile 3-Lohitpur- Coarse loamy mixed Humic Pachic Dystrudepts(27^{0}59’37”Nlat—96^{0}12’47”Elong, 399.7m above msl							
0-16	Ap	10YR3/2	Sl	m1sbk	vfr,so,po	m,f-m	cs
16-57	Bw1	10YR3/2	Sl	f1sbk	vfr,so,po	vf,f-c	cs
57-80	Bw2	7.5YR3/3	Sl	fsbk	vfr,so,po	vf,f-f	cw
80+	r						
Profile-4.Loiliang-Loamy skeletal mixed Humic Lithic Udorthents(27059’13”Nlat.-96011’22”Elong. 332m)							
0-17	Ap	7.5YR3/1	L	F1sbk	Vfr,so,po	mf-m	as
17-29	AC	7.5YR3/2	Sl	F1sbk	Fr,so,po	f,m-m	ac
29-50	Cr	7.5YR3/2	Sl	F1sbk	Fr,so,po	vf-f	ac
50+	r						
Profile 5- Kuraliang-Coarseloamy,mixed,Humic Dystrudepts(27^{0}57’55”Nlat.-96^{0}11’14”Elong.,297.8m)							
0-12	Ap	7.5YR4/2	Sl	sg	vfr,so,po	c,vf,f,m-m	as
12-33	A/B	7.5YR5/2	L	m1sbk	vfr,so,po	c,vf-c	cs
33-56	Bw1	7.5YR4/3	L	m1sbk	vfr,so,po	vf,f-c	gs
56-74	Bw2	7.5YR4/3	L	m1sbk	fr,so,po	vf,f-f	gs
74-99	Bw3	7.5YR5/3	L	f1sbk	fr,so,po		
99+	R						
Profile 6. Pomliang-Coarse loamy , mixed, Fluventic Humic Dystrudepts(27^{0}55’47”Nlat—96^{0}10’23”Elong, 223.9m)							
0-16	Ap	10YR3/1	L	f1sbk	vfr,so,po	m,f-m	cs
16-39	Bw1	10YR3/3	L	f1sbk	fr,so,po	vf,f-m	cs
39-68	Bw2	10YR4/4	L	f1sbk	fr,so,po	vf,f-f	cs
68-103	Bw3	10YR4/4	Sl	f1sbk	vfr.so,po	vf,f-f	gs
103-135	Bw4	10YR4/6	L	f1sbk	vfr,so,po	vf,f-f	gs
135-205	Cr	10YR4/6	Ls	sg	vfr,so,po		as
Profile 7. Makailiang -Coarse loamy, mixed, Fluventic Humic Dystrudepts(27^{0}56’55”Nlat-96^{0}08’34”Elong, 220.9m)							
0-16	Ap	10YR3/1	Sl	f1sbk	fr,so,po	vf,f-m	cs
16-43	AB	10YR3/2	Sl	f1sbk	fr,so,po	vf,f-c	cs
43-77	B/A	10YR3/3	Sl	f1sbk	vfr,sopo	vf,f-c	cs
77-110	Bw1	10YR4/4	Sl	f1sbk	vfr,so,po	vs.-f	cs
110-135	C1	10YR4/3	Ls	sg	vfr,so,po		as
135-185	C2	10YR5/2	Ls	sg	vfr,so,po		as
Profile 8.Tezu - Coarse loamy Mollic Udifluvents(27^{0}56’05”Nlat-96^{0}07’41”Elong.,197.6 m)							
0-15	Ap	10YR4/2	Sl	f1sbk	vfr,so,po	vf,f-m	cs
15-41	AC1	10YR4/2	Sl	f1sbk	vfr,so,po	vf-f	cs
41-75	AC2	10YR4/3	Sl	f1sbk	vfr,so,po	vf-f	cs
75-95	C1	10YR4/4	Sl	f1sbk	vfr,so,po	vf-f	cs
95-149	C2	10YR4/4	Sl	f1sbk	vfr,so,po	vf-f	cs
149-190	C3	10YR4/6	Sl	f1sbk	vfr,so,po		

Table 2.Particle size distribution and chemical properties of soils

Horizon	Particle size distribution (%, <2mm)			p^H	OC (gkg^{-1})	Extractable bases cmol(+)kg^{-1}				CEC (cmol (+)kg^{-1}	Base saturation (%)	Fe_d gkg^{-1}	Fe_t gkg^{-1}	Fe_d/Fe_t	Fe_d/OC
	sand	silt	clay			Ca	Mg	Na	K						
Profile 1.Hutchliang															
A	55.2	28.8	16.0	5.3	50.3	1.1	0.34	0.90	0.18	24.4	10.3	22.4	26.6	0.84	0.45
r	56.1	32.4	11.5	5.5	41.0	0.9	0.36	0.88	0.11	21.7	10.3	25.4	28.9	0.88	0.62
Profile 2. Lamu															
A	50.5	32.5	17.0	5.2	53.0	1.54	0.11	1.12	0.17	25.6	11.5	26.8	28.7	0.93	0.51

Bw1	52.4	31.6	16.0	5.4	45.7	1.10	0.13	1.10	0.14	24.2	10.2	29.8	30.3	0.98	0.65
Bw2	57.4	29.6	13.0	5.6	31.7	0.66	0.16	1.20	0.14	18.9	11.4	24.8	31.6	0.78	0.78
Bw3	67.0	22.0	11.0	5.6	18.2	0.66	0.16	1.18	0.11	13.6	15.5	23.2	32.4	0.71	1.27
CI*			37	FeI**										42.3	
Profile 3.Lohitpur															
A	51.8	34.7	13.5	5.3	49.5	1.54	0.11	0.93	0.37	21.7	13.6	14.9	24.0	0.62	0.30
Bw1	54.6	33.4	12.0	5.6	39.1	1.10	0.75	0.85	0.14	19.7	14.4	15.7	25.3	0.62	0.40
Bw2	57.6	32.4	10.0	5.7	30.4	0.88	0.77	0.88	0.15	17.1	15.7	16.0	23.8	0.67	0.53
CI*			114	FeI**										14.6	
Profile 4.Loiliang															
A	50.9	34.6	14.5	5.3	40.2	4.62	2.18	0.76	0.33	19.5	40.5	10.9	24.9	0.43	0.27
AC	60.6	25.9	13.5	6.3	29.4	3.74	1.00	0.59	0.15	16.2	33.7	15.2	25.6	0.59	0.52
Cr	69.9	20.6	9.5	6.5	20.9	3.52	0.60	0.61	0.17	12.6	38.9	9.9	24.4	0.41	0.47
Profile 5.Kuraliang															
A	67.1	22.4	10.5	5.8	8.1	4.18	0.97	0.82	0.27	8.5	73.2	8.5	38.4	0.22	1.05
A/B	49.4	37.4	13.5	5.6	8.9	3.74	0.79	0.86	0.24	10.2	55.5	10.0	39.9	0.25	1.12
Bw1	41.6	39.9	18.5	5.6	13.5	3.30	1.03	0.85	0.17	11.2	47.9	13.2	41.5	0.33	0.98
Bw2	49.9	33.1	17.0	5.6	13.5	3.52	0.19	0.93	0.18	11.8	40.9	13.5	41.5	0.33	1.00
Bw3	56.8	27.2	16.0	5.8	8.5	2.20	0.48	0.83	0.15	9.3	39.2	10.6	41.3	0.26	1.25
CI*			571	FeI**										11.4	
Profile 6.Pomliang															
Ap	43.8	39.2	17.0	5.5	16.6	3.08	0.42	0.89	0.27	15.2	30.6	14.0	42.5	0.33	0.84
Bw1	48.0	38.0	14.0	5.8	10.0	1.98	0.29	0.64	0.14	12.2	25.0	14.3	46.3	0.31	1.43
Bw2	51.6	37.4	11.0	5.9	5.8	0.88	0.36	0.65	0.13	8.3	24.3	13.0	47.8	0.27	2.24
Bw3	69.9	21.6	8.5	6.1	1.9	0.88	0.36	0.64	0.10	5.9	33.6	9.9	48.3	0.21	5.24
Bw4	45.6	44.4	10.0	5.7	3.1	0.88	0.15	0.98	0.24	7.3	30.8	12.7	55.8	0.23	4.09
Cr	87.1	4.4	8.5	6.8	1.2	0.88	0.97	0.69	0.07	3.5	75.7	3.1	23.9	0.13	2.58
CI*			247	FeI**										14.1	
Profile 7.Makailiang															
Ap	55.9	31.6	12.5	6.5	18.2	3.52	2.87	1.23	0.26	13.4	58.8	8.9	26.4	0.34	0.49
A/B	55.1	31.9	13.0	6.2	21.3	2.64	0.86	1.30	0.22	12.4	40.6	9.5	26.6	0.36	0.45
B/A	63.6	24.4	12.0	6.2	6.6	1.76	0.09	1.15	0.23	9.7	33.2	9.4	27.4	0.34	1.42
Bw1	63.6	27.9	8.5	6.4	2.7	0.88	0.35	1.31	0.15	8.7	30.8	9.2	31.5	0.29	3.41
C1	77.1	17.9	5.0	6.3	2.3	0.66	0.16	1.22	0.12	5.7	38.0	6.6	27.3	0.24	2.86
C2	85.5	9.0	5.5	6.6	0.4	0.66	0.37	1.21	0.11	3.9	60.9	4.3	23.3	0.18	10.75
CI*			570	FeI**										13.9	
Profile 8.Tezu															
Ap	55.5	29.5	15.0	5.6	26.3	5.50	2.95	0.89	0.42	17.7	55.3	8.9	26.0	0.34	0.34
AC1	56.2	31.8	12.0	5.8	9.3	3.74	0.38	0.79	0.27	12.4	41.8	9.8	29.0	0.34	1.05
AC2	63.3	29.7	7	5.7	5.8	0.88	0.36	0.83	0.19	9.5	23.7	8.7	23.1	0.38	1.50
C1	67.0	24.5	8.5	6.0	3.9	1.10	0.34	0.76	0.21	5.5	43.9	7.1	28.0	0.25	1.82
C2	61.9	30.1	8.0	5.8	2.7	1.32	0.53	0.52	0.18	5.9	43.3	8.4	29.8	0.28	3.11
C3	73.3	20.2	6.5	6.1	1.9	0.88	0.15	1.37	0.29	4.7	57.6	5.8	25.6	0.23	3.05

Note: - *CI=clay accumulation index, FeI=iron accumulation index

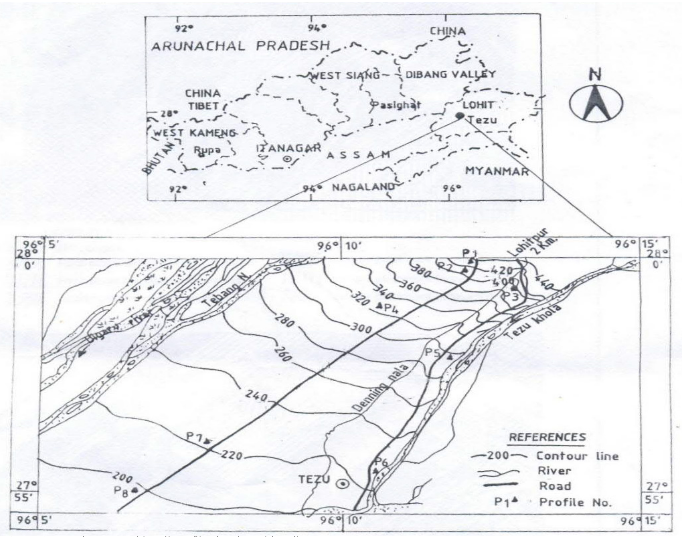

Figure 1. Location map with soil profile sites in Lohit valley

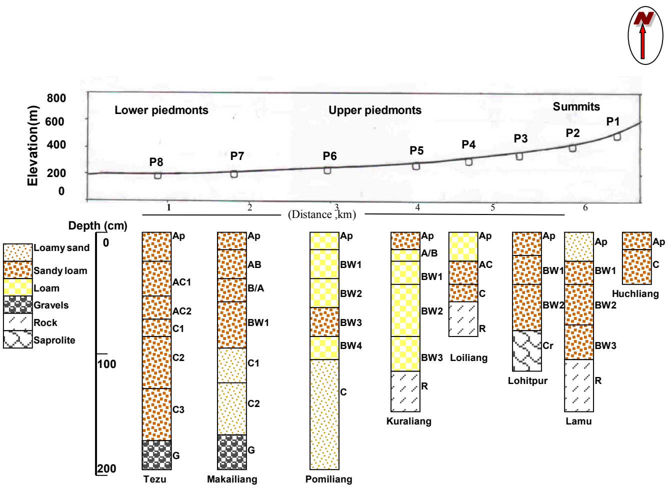

Figure.2. Soil –Landscape relationship along the transect near Tezu, Lohit valley

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