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A report of Siwalik forest around Letang Raja-Rani wetland, Morang, eastern Nepal

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Abstract

Species composition, phytosociological status and soil characteristics of Siwalik forest occurring around Raja-Rani wetland, Letang municipality, eastern Nepal was studied. A total of 47 tree species belonging to 40 genera and 26 families were reported. Dominant and co-dominant trees were *Shorea robusta* (IVI=133.4) and *Schima wallichii* (IVI=70.6), respectively. In the forest total tree density, basal cover area, seedling density, fallen dead density and dead standing density were 378.4 trees ha^{-1}, 163.7 m^2 ha^{-1}, 105250 individual ha^{-1}, 4 trees ha^{-1} and 1.6 trees ha^{-1}, respectively. Irregular girth class distribution and high stump density (136.8 tree ha^{-1}) denote disturbance. Soil physicochemical characteristics were: acidic soil (pH 4.8), moisture (12.5%), water holding capacity (50.05%), bulk density (1.17 g cm^{-3}), porosity (0.55%), humus (8.6%), organic carbon (0.52%), nitrogen (0.1%), phosphorus (33 kg ha^{-1}), and potassium (300 kg ha^{-1}). Regulating human encroachment to ensure natural regeneration of species to maintain the viability of the Letang Raja-Rani wetland site and integrity of the local ecosystem is strongly recommended.

Key words: Girth class, phytosociology, *Shorea robusta*, soil characteristics

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Introduction

Forests exhibit a significant proportion of global biodiversity (Naidu and Kumar, 2016). Forest itself being versatile and rich natural resources has uplifted a wide range of economic, social, environmental and cultural benefits and services. The analysis of structural and functional parameters of the plant community is fundamental for the conservation of natural areas (Zhang *et al*., 2013). Continuous loss of forest area is a major threat to biodiversity. In the past eight decades (1930-2014) Nepal lost 37318 km^2 (48.6%) of its primary forest cover but net deforestation for the recent period (2005-2014) indicates 0.01% forest loss per year (Reddy *et al*., 2018).

The tropical forest of eastern Nepal holds significant importance because it falls under the Eastern Himalayas Biodiversity hotspot. The tropical region of Nepal bears gradients of Terai plain and Siwalik hills (Chure). Siwalik occupies 12.7% of the total land and contributes to 23.09% of the forest cover of the country (LRMP, 1986; Uddin *et al*., 2015). They are the youngest and the southernmost mountain chain of the Himalayan system (Hagen, 1998) having tertiary unconsolidated and highly erodible fluviatile sediments (Carson, 1985). Due to steep slopes with erodible and poor soil, the area is

unsuitable for agriculture and settlements. In eastern Nepal, Siwalik has widespread human settlements and associated disturbances. Siwalik Forest decreased by 23% (150 km^2) in less than 35 years in eastern Nepal (Bhuju *et al*., 2007).

Few studies are confined to the Siwalik range of eastern Nepal (Nirola and Jha, 2011; Bhattrai and Mandal, 2016). Although a diverse climate and vegetation exist on the Siwalik range, the biodiversity is poorly understood. Furthermore, occurrence of moist and humid environment of the forest around the Raja-Rani wetland supports unique diversity, from tropical to temperate climate. In this context, the present study aims to provide baseline information about forest species composition, phytosociology, leaf litter mass and soil properties of the area.

Materials and methods

Study area

The study was conducted during 2017 to 2018 in Raja-Rani community forest area (1700 ha, 26°44.9'22" N latitude, 87°28.9'10" E longitude, 470 m altitude) situated in Letang Municipality-1, Morang district, Eastern Nepal (Fig. 1). The climate of the study has three distinct seasons, hot and humid summer; rain rich monsoon; cold and dry winters. In this region the average annual minimum temperature ranges from 12-19°C, the average annual maximum temperature ranges from 22-30°C and annual rainfall ranges from 1138-2671 mm (DFRS, 2014).

The forest lies around the Raja-Rani wetland with rich biological diversity. It is a religious and historic place of the Dhimal tribe and an important tourist destination of eastern Nepal. Local community depends on the area for collection of fodder, fuel wood, wild foods, medicinal plants and livestock grazing.

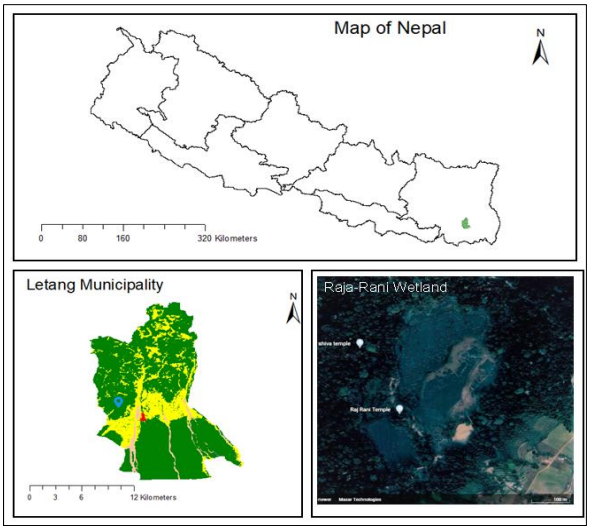

Figure 1. Map of the study area.

Vegetation and litter mass analysis

Quadrants of 25×25 m^2 were randomly established for the study of trees (large, small and poles). Similarly, five quadrates of 5×5 m^2 and 2×2 m^2 were used for sapling and seedling respectively. Diameters of more than 15 cm were large trees, between 10 to 15 cm small trees, between 5 to 10 cm poles, between 2 to 5 cm sapling and diameter below 2 cm were recorded as seedlings. A total of nine girth classes (10 to 510 cm with an interval of 30) were established, dead stump, standing dead and fallen trees was recorded. Herbarium of trees were prepared and brought to the Department of Botany, Post Graduate Campus, Tribhuvan University, Biratnagar for identification. Density, relative density, frequency, relative frequency, basal area and relative basal area and IVI were determined as Mishra (1968) and Zobel *et al*. (1987). Species diversity parameters such as Equitability (Evenness) (Pielou, 1966), Simpson index (Simpson, 1949), Shannon-Wiener index (Shannon and Weaver, 1963), and species richness (Margalef, 1958) were calculated. Leaf litter mass was measured seasonally from the litter trap (1×1 m^2) fixed on the forest floor in each sampling plot from April 2017 to March 2018.

Soil analysis

Soil samples were collected from randomly placed pits of 10×10×15 cm^3 depth. Large pieces of plant materials, fine roots and pebbles were removed carefully from each sample. Each sample was mixed and pooled as one replicate. Soil moisture, water holding capacity, organic matter, soil texture, porosity, bulk density, carbon, pH, total nitrogen, total phosphorus and potassium were analyzed using standard methods (Table 1).

Table 1. Method of soil analysis used in the study.

S.N.	Soil property	Analysis method	Unit	References
1	Soil moisture	Oven drying method	%	(Piper, 1966)
2	Water holding capacity	-	%	(Zobel *et al*., 1987)
3	Humus	-	%	(Zobel *et al*., 1987)
4	Soil texture	Sieve method	%	(Piper, 1966)
5	Porosity	-	%	(Blake, 1965)
6	Bulk density	Core sampling method	g cm^{-3}	(Blake, 1965)
7	Soil Organic Carbon	Titrimetric method	%	(Kalembasa and Jenkinson, 1973)
8	Organic Matter	Titrimetric method	%	(Kalembasa and Jenkinson, 1973)
9	pH	pH meter		(Piper, 1966)
10	Total nitrogen	Micro Kjeldahl Method	%	(Bremner, 1960)
11	Phosphorus	Olsen's method	Kg ha^{-1}	(Jackson, 1958)
12	Potassium	Flame photometer method	Kg ha^{-1}	(Knudsen *et al*., 1983)

Results

A total of 47 tree species belonging to 26 families and 40 genera are recorded from the area (Table 2). Euphorbiaceae was the largest family with 5 species followed by Fabaceae (4), Combretaceae, Myrtaceae, Rubiaceae and Theaceae (3 species in each). Apocynaceae, Fabaceae, Meliaceae, Rosaceae had 2 species in each and the rest of the families had single species in each.

Shorea robusta was the dominant species (IVI=133.4); *Schima wallichii* (IVI 70.57) was co-dominant, followed by *Croton roxburghii* (IVI 36.56) in the forest (Table 3). The tree density and basal area were 378.38 trees ha^{-1}, 163.66 m^2 ha^{-1}, respectively (Table 4). The higher dead stump denotes (136.8 stump ha^{-1}) denotes the disturbance.

The forest has more seedlings than saplings and poles (Fig.2). There was a higher density of young tree species in the study area. The relationship between girth class distribution and density of total trees, *S. robusta* and *S. wallichii* of Siwalik forest around Letang Raja-Rani wetland, Eastern Nepal is given in figure 3.

The summer season had maximum litter mass (27025 kg ha^{-1}) followed by the winter season (9000 kg ha^{-1}) and least in the rainy season (1705 kg ha^{-1}).

The soil was acidic, rich in organic matter and clayey (Table 5).

Table 2. Enumeration of Siwalik forest trees around Letang Raja-Rani wetland, eastern Nepal.

S.N.	Family	Species	Local Name
1	Alangiaceae	*Alangium salvifolium* (L.f)	Asare
2	Anacardiaceae	*Rhus succedanea* L.	Bhalayo
3	Apocynaceae	*Alstonia scholaris* (L.) Benth.	Chhativan
4	Apocynaceae	*Holarrhena pubenscens* (Buch-Ham.) Wall.ex DC.	Aulekhirro
5	Arecaceae	*Caryota urens* L.	Rang vang
6	Burseraceae	*Garuga pinnata* Roxb.	Dabdabe
7	Combretaceae	*Terminalia alata* Heyneex. Roth	Saaj
8	Combretaceae	*T. chebula* Retz.	Harro
9	Combretaceae	*T. bellirica* (Gaerth.) Roxb.	Barro
10	Corditaceae	*Ehretia acuminate* R.Br.	Dhatrunga
11	Dipterocarpaceae	*Shorea robusta* Gaertn.	Sal/ Sakhuwa
12	Ebenaceae	*Diospyros tomentosa* Roxb.	Kalikath
13	Elaeagnaceae	*Elaeagnus infundibularis* Momiy.	Guyelo
14	Euphorbiaceae	*Croton roxburghii* N.P.Balakr.	Aaulea

15	Euphorbiaceae	*Mallotus philippensis* (Lam.) Mull.Arg.	Sindure
16	Euphorbiaceae	*Trewia nudiflora* (L.)	Pithari
17	Euphorbiaceae	*Macaranga indica* Wight	Malata
18	Euphorbiaceae	*Phyllanthus emblica* L.	Ban amala
19	Fabaceae	*Albizia julibrissin* (Durazz)	Ratosiris
20	Fabaceae	*A. lebbeck* (L.) Benth	Padkesiris
21	Fabaceae	*Albizia* sp.	Laharesiris
22	Fabaceae	*Cassia fistula* L.	Rajbrikshya
23	Fagaceae	*Castanopsis indica* (Roxb.)	Dhalnekatush
24	Fagaceae	*C. tribuloides* (Sm.) A.DC.	Musurekatush
25	Lauraceae	*Litsea monopetala* (Roxb.)	Kutmero
26	Lecythidaceae	*Careya arborea* Roxb.	Kumbhi
27	Lythraceae	*Lagerstroemia parviflora* Roxb.	Botdhayero
28	Magnoliaceae	*Michelia doltsopa* (L.) Bill.explore	Chaap
29	Malvaceae	*Sterculia villosa* (Roxb.)	Odane/Odal
30	Meliaceae	*Trichilia connaroides* (Wight&Am.) Bentv.	Akhataruwa
31	Meliaceae	*Toona serrata* (Royle) M.Roem.	Tooni
32	Myristicaceae	*Knema tenuinervia* W.J.de Wilde	Ban suntala
33	Myrtaceae	*Cleistocalyx operculatus* (Roxb.)	Kyamuna
34	Myrtaceae	*Syzygium cumini* (L.) Skeels	Jamun
35	Myrtaceae	*S. nervosum* (DC)	Fadir
36	Rosaceae	*Prunus* sp.	-
37	Rosaceae	*Docynia indica* (Wall.) Decne	Mehel
38	Rubiaceae	*Adina cordifolia* (wild.ex. Roxb) Benth. & Hook.	Karam
39	Rubiaceae	*Cephalanthus tetrandra* (Roxb).	Paanisimali
40	Rubiaceae	*Hymenopogon parasiticus* Wall.	Hansraj
41	Rutaceae	*Zanthoxylum armatum* (DC., Prodr.)	Timur
42	Sapindaceae	*Acer oblongum* Wall.ex.DC.	Phirphire
43	Sterculiaceae	*Pterospermum acerifolium* (L.) Willd.	Hatti Pailey
44	Sonneratiaceae	*Duabanga grandiflora* (Roxb.ex.DC.) Walpers.	Lampate
45	Theaceae	*Schima wallichii* (DC.) Korth.	Uttish
46	Theaceae	Unidentified sp.1	Chari dane
47	Theaceae	Unidentified sp.2	Tilke

Table 3. Density, frequency, basal area and importance value index (IVI) Siwalik forest trees around Letang Raja-Rani wetland, eastern Nepal. (Mean ± S.E.)

S.N.	Species	Density (tree ha^{-1})	Frequency (%)	Basal area (m^2 ha^{-1})	IVI
1	*Acer oblongum*	0.8±0.4	5±1	0.007±0.04	0.94±0.4
2	*Adina cordifolia*	4.8±0.98	15±1.73	0.123±0.16	3.67±0.8
3	*Alangiu msalvifolium*	1.6±0.5	10±1.41	0.013±0.05	2.14±0.6
4	*Albizia julibrissin*	1.6±0.5	10±1.41	0.0014±0.017	2.13±0.6
5	*Albizia lebbeck*	0.8±0.4	5±1	0.001±0.014	1.5±0.5
6	*Albizia* sp. (Laharesiris)	0.8±0.4	5±1	0.0007±0.01	1.42±0.5
7	*Alstonia scholaris*	0.8±0.4	5±1	0.06±0.11	0.76±0.4
8	*Careya arborea*	0.8±0.4	5±1	0.0098±0.04	1.43±0.5
9	*Cassia fistula*	1.6±0.5	5±1	0.015±0.05	0.88±0.4
10	*Castanopsis indica*	0.8±0.4	5±1	0.004±0.03	0.71±0.4
11	*Cleistocalyx operculatus*	0.8±0.4	5±1	0.003±0.02	0.71±0.4
12	*Croton roxburghii*	14.4±1.7	40±2.83	0.34±0.26	36.56±2.7
13	*Duabanga grandiflora*	1.6±0.5	10±1.41	0.006±0.03	2.44±0.7
14	*Diospyros tomentosa*	3.2±0.8	15±1.73	0.012±0.05	4.21±0.9
15	*Docynia indica*	0.8±0.4	5±1	0.0008±0.01	0.71±0.4
16	*Elaeagnus infundibularis*	0.8±0.4	5±1	0.006±0.034	0.94±0.4
17	*Garuga pinnata*	0.8±0.4	5±1	0.007±0.04	0.71±0.4

18	*Holarrhena pubescens*	3.2±0.8	15±1.73	0.17±0.18	2.53±0.7
19	*Hymenopogon parasiticus*	7.2±1.7	10±1	0.4013±0.28	2.96±0.7
20	*Knema tenuinervia*	0.8±0.4	5±1	0.001±0.01	1.42±0.5
21	*Lagerstroemia parviflora*	8±1.3	35±2.65	0.62±0.35	9.58±1.4
22	*Litsea monopetala*	0.8±0.4	5±1	0.002±0.02	0.71±0.4
23	*Macaranga indica*	0.8±0.4	5±1	0.0007±0.01	1.42±0.5
24	*Mallotus philippensis*	0.8±0.4	5±1	0.003±0.02	1.50±0.5
25	*Michelia doltsopa*	0.8±0.4	5±1	0.04±0.09	1.59±0.6
26	*Phyllanthus emblica*	0.8±0.4	5±1	0.005±0.03	1.56±0.6
27	*Prunus* sp.	0.8±0.4	5±1	0.001±0.01	1.56±0.6
28	*Pterospermum acerifolium*	2.4±0.7	10±1.41	0.008±0.04	2.03±0.6
29	*Rhus succedanea*	1.6±0.5	5±1	0.002±0.02	1.70±0.6
30	*Schima wallichii*	72.18±3.8	90±4.24	29.26±2.42	70.57±3.7
31	*Shorea robusta*	135.2±5.2	100±4.47	131.07±5.12	133.4±5.2
32	*Sterculia villosa*	21.6±2.1	45±3	0.64±0.36	11.65±1.5
33	*Syzygium cumini*	1.6±0.5	10±1.41	0.02±0.06	1.66±0.6
34	*Syzygium nervosum*	0.8±0.4	5±1	0.093±0.14	0.8±0.4
35	*Terminalia alata*	1.6±0.5	10±1.41	0.16±0.18	1.57±0.6
36	*Terminalia bellirica*	0.8±0.4	5±1	0.0045±0.03	0.94±0.4
37	*Terminalia chebula*	1.6±0.5	5±1	0.003±0.02	0.87±0.4
38	*Toona serrata*	0.8±0.4	5±1	0.0007±0.01	1.42±0.5
39	*Trewia nudiflora*	5.6±1.06	15±1.73	0.0098±0.04	3.31±0.8
40	*Trichilia connaroides*	0.8±0.4	5±1	0.004±0.03	0.71±0.4
41	Unidentified sp.1	14.4±1.7	35±2.65	0.59±0.34	7.79±1.2
42	Unidentified sp.2	0.8±0.4	5±1	0.010±0.04	0.94±0.4
43	*Zanthoxylum armatum*	0.8±0.4	5±1	0.0003±0.008	1.42±0.5
	Total	**323.38±8.04**	**605±11**	**163.72±5.7**	**300±7.7**

Table 4. Status of forest stand around Raja-Rani wetland, eastern Nepal.

Parameter	Status
Density (Trees ha^{-1})	378.38
Basal area (m^2 ha^{-1})	163.66
Diversity index H'	1.65
Concentration of dominance	0.33
Species richness	2.65
Evenness	0.59
Standing dead (Trees ha^{-1})	1.6
Fallen tree (Trees ha^{-1})	4.0
Rotten trees (Trees ha^{-1})	0.8
Dead stump (Trees ha^{-1})	136.8

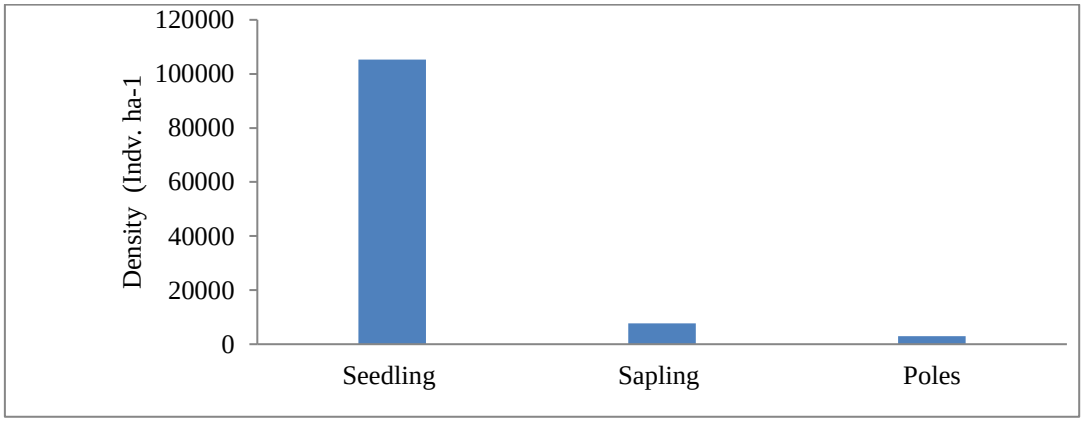

Figure 2. Occurrence of seedlings, saplings and poles in the forest of Raja-Rani wetland.

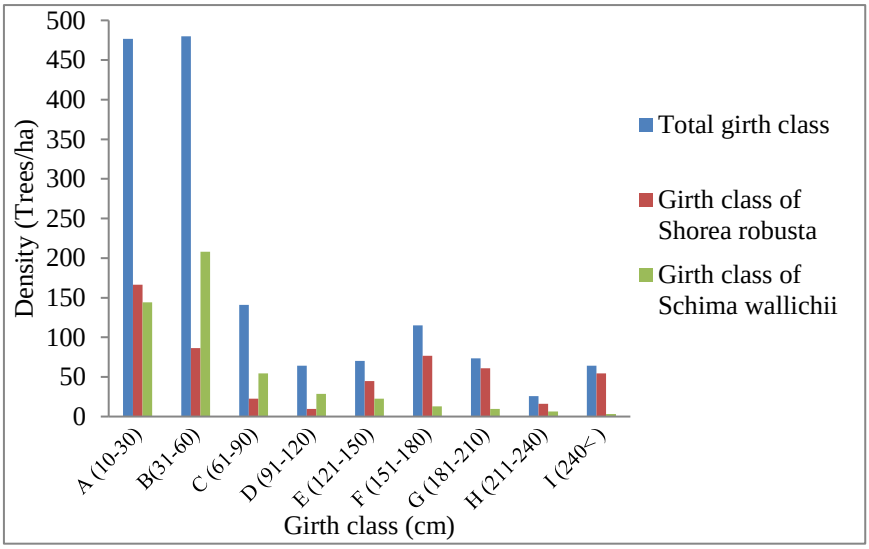

Figure 3. The relationship between girth class distribution and density of total trees, *Shorea robusta* and *Schima wallichii* of Siwalik forest around Letang Raja-Rani wetland, eastern Nepal.

Table 5. Soil physicochemical characteristics (0-15 cm depth) from Raja-Rani forest (Mean± Standard Error).

S.N.	Soil properties	Mean±SE
1	Soil Moisture (%)	12.5±0.9
2	pH	4.8±0.17
3	BD (g cm^{-3})	1.17±0.07
4	Porosity	0.55±0.01
5	WHC (%)	50.05±1.43
6	Soil Texture	
	Sand (%)	15.67±2.71
	Silt (%)	23.57±1.4
	Clay (%)	60.8±2.54
7	Humus (%)	8.64±2.85
8	Soil Organic Carbon (%)	0.52±0.09
9	Organic matter (%)	0.89±0.12
10	Total Nitrogen (%)	0.13±0.02
11	Phosphorus (Kg ha^{-1})	33±3.33
12	Potassium (Kg ha^{-1})	300±9.38

Discussion

Soil characteristics

The humus rich (8.64 %), clayey soil (60.8 %) had acidic pH (4.8) in the forest. More acidic pH (4.2) was reported in pure *Shorea* forest of Udaypur district (Paudel and Sah, 2003); the soil pH was between 5.6 and 6.2 in Chure range of Ilam district (Nirola and Jha, 2011). Comparative study of bulk density, pH, water holding capacity (WHC), organic matter and soil texture in the teraisal forest, Jhapa; tropical moist forest Sunsari and tropical hill sal forest, Ilam is presented in figure 4.

Forest status

In *S. robusta* dominated forest, Bhattarai (2008) reported similar IVI (130) in Namuna community forest Salbari, Jhapa; lower IVI (60.95-64.61) in churia range of Ilam (Nirola and Jha, 2011); higher IVI (183) in Tropical moist sal forest, Sunsari (Mandal, 1999). In the Namuna community forest Salbari, Jhapa higher tree density (1790 tree ha^{-1}) and lower basal area (31.45 m^2 ha^{-1}) were observed

than the present study. Gautam and Mandal (2018) reported higher species richness (9.11), diversity index (3.08) and evenness (0.59) in the tropical moist forest of Sunsari. In the present study, a higher concentration of dominance (0.33) is due to sharing of large proportions by a few species (Singh and Singh, 1991).

The Shannon-Wiener index of the tree species from the present study is compared with different forest stands of eastern Nepal (Table 6), which indicated that a similar diversity index of the forest stand was observed by Mandal (1999) in Tropical Plateau Sal forest but diversity index of the present study was lowest among them. The close canopy of the present forest stand may be the reason for the low diversity index.

A similar density of the sapling was recorded by Bhattarai (2008) in Namuna community forest Salbari, Jhapa. The highest number of seedlings also supports the properties of soil or litter. Minimum records of sapling and poles density of trees showed the impact of human encroachment. Further, irregular girth class distribution of tree, high stump density indicated the disturbance. The occurrence of dead stump marked the cutting of trees.

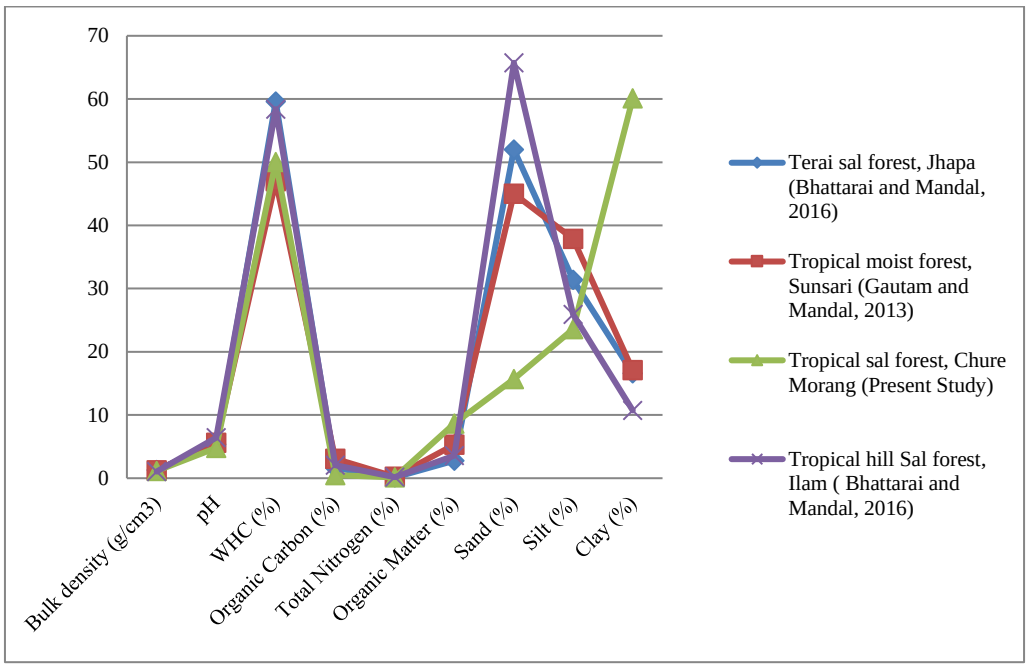

Figure 4. Comparative study of soil characteristics in different forest stand of eastern Nepal.

Table 6. Shannon-Wiener index (H') of tree species in different forest stands of eastern Nepal.

Forests and localities	H' index	References
Tropical Plateau Sal forest	1.66	(Mandal, 1999)
Temperate Zone forest, TinjureMilke area	2.4-2.61	(Koirala, 2004)
Tropical moist forest, Sunsari	3.08	(Gautam and Mandal, 2018)
Temperate Zone forest, Ilam	3.22-3.68	(Chettri and Shrestha, 2019)
Tropical forest Siwalik hill, Eastern Nepal	1.65	Present study

Conclusion

The forest is under stress due to uncontrolled visitors, collection of forest products, livestock grazing, tree cutting and forest fire. Minimum diversity index (H^{-1}), species richness (d), high stump density and irregular girth class are threats.

Regulating human encroachment to ensure natural regeneration of species to maintain the viability of Letang Raja-Rani wetland site and integrity of the local ecosystem is strongly recommended.

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