Forest structure and biodiversity patterns along elevational gradients in Eastern Nepal

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Abstract: This study aimed to assess the forest structure, composition, and diversity pattern at different elevations in Morang District, eastern Nepal, using stratified random vegetation sampling technique in five forests: Bhaunne, Raja-Rani, Murchungi, Adheri, and Sagma. Trees, shrubs and herbs of each forest was sampled through quadrat of 20 × 20 m^2, 5 × 5 m^2, and 1 × 1 m^2 each respectively. A total of 315 plant species belonging to 82 families and 255 genera found by this study. A total of 50 quadrats each for trees, shrubs and herbs sampled during this study. A total 10 quadrats studied for each life form from each forest. This study obtained 5,037 individuals across all forests. The highest number of species (55) was recorded from Raja Rani forest, and the highest tree density (985 ind ha^{-1}) was observed in Adheri forest. The highest density of shrub (24400 ind. ha^{-1}) and herbs (44.1 ind.m^{-2}) were recorded in Sagma forest. The Shannon Wiener index value of herb layer was found to be the highest (3.79) at Bhaunne forest. This value for shrub layer was 2.98 and tree layer was 3.12 at Sagma which was the maximum among forests. The concentrations of dominance value were high for herb and shrub layer in Bhaunne forest, and it was maximum for the tree layer in Adheri forest. The forest species composition were significantly different ($p \leq 0.001$) among each other. Total basal area of shrub layer and tree layer recorded were maximum (111.52 m^2 ha^{-1} and 612.08 m^2 ha^{-1}) in Sagma and Adheri forest, respectively. The number of trees decreased with increasing elevation, while shrubs increased, and herbs showed a U-shaped trend. The dominant tree species were *Senegalia catechu*, *Shorea robusta*, *Terminalia alata*, and *Schima wallichii* in Bhaunne, Raja-Rani, Murchungi, and Sagma forest, respectively, with *Shorea robusta* being dominant in Adheri forest. These findings have important implications for forest management and conservation efforts in the region.

Keywords: Diversity; Community structure; Dominance; Niche; Tropics; Species Richness.

Introduction

The structure and biodiversity of forests along elevational gradients in Eastern Nepal hold immense significance for understanding and conserving terrestrial ecosystems[1]. Forests are characterized by their complex assemblage of plant species. Plant species play a crucial role in maintaining the overall biodiversity and ensuring the stability and functionality of ecosystems[2, 3]. The study of forest structure and biodiversity patterns along elevational gradients provides valuable insights into the organization, composition, and dynamics of these ecosystems, offering a foundation for effective conservation and management strategies[4].

Forest structure encompasses the physical characteristics and arrangement of trees and other vegetation components within a forest ecosystem. It includes elements such as tree density, canopy cover, tree size distribution, and vertical stratification. The structural attributes of forests influences ecological processes, habitat availability, and ecosystem functioning.[5] By examining forest structure, researchers can gain insights into the resilience and adaptability of forests to changing environmental conditions, as well as their ability to provide ecosystem services such as carbon sequestration, soil stabilization, and water regulation[6,7,8]. Biodiversity patterns, on the other hand, capture the distribution and abundance of plant species across

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different elevations[7,9]. Elevational gradients in Eastern Nepal exhibit significant variations in climatic conditions, including temperature, rainfall, and soil properties. These gradients create distinct ecological niches and vegetation zones, resulting in diverse forest ecosystems. The study of biodiversity patterns along elevational gradients helps to elucidate the relationship between environmental factors and the distribution patterns of plant species, providing critical information for understanding ecosystem dynamics and guiding conservation efforts[10,11].

Eastern Nepal, with its diverse topography and climatic conditions, presents a unique opportunity to investigate forest structure and biodiversity patterns along elevational gradients[9]. The region encompasses a range of forest types, including tropical lowland forests, subtropical forests, temperate forests, and subalpine forests, each associated with specific elevational ranges[13,14,15]. However, these forests face numerous threats, including deforestation, habitat degradation, climate change impacts[16] etc. Therefore, it is essential to study the structure and biodiversity of these forests to guide conservation efforts, promote sustainable forest management, and ensure the long-term survival of these valuable ecosystems and human.

Species diversity is an important index in community ecology[17]. This research aims to comprehensively examine the forest structure and biodiversity patterns along elevational gradients in Eastern Nepal. The specific objectives of this research were: 1) to determine the plant community composition pattern among different forests, and 2) to know their taxonomic diversity.

By gaining a comprehensive understanding of forest structure and biodiversity patterns in Eastern Nepal, this research will contribute to the broader knowledge of forest ecology and provide valuable insights for conservation planning and management. The findings will help identify key conservation priorities, develop effective strategies for sustainable forest management, and contribute to the broader scientific understanding of forest dynamics and ecosystem functioning. Ultimately, this research holds significant implications for both scientific understanding and practical conservation initiatives in mountainous regions facing environmental challenges.

Materials and Methods

Study area

This study was conducted in five forests along an elevation (100–1300 m a.s.l.) in Morang District, east Nepal (Figure 1). The latitude and longitude of study area were ranged from 26°39'45.69"N to 26°48'28.68"N and 87°28'2.08"E to 87°28'45.06"E respectively. The five study sites: Bhaunne (B), Raja-Rani (R), Murchungi (M), Adheri (A) and Sagma (S) included the Belbari-Chisang Raja-Rani, Akashe, Shat Kanya and Kuwapani community forests respectively. Among these forest sites, Bhaunne is located at ward number 10 of Belbari Municipality and other four sites belonged to ward number-1 of Letang Municipality.

Figure 1: Map of the study area.

Climate of the studied forests

Studied area has prevalent monsoon climate with dry winters and rainy summers. From June through September, there is significant rainfall. Up to 1000 m above sea level, there is a hot monsoon climate with hot, wet summers and mild, warm, dry winters. Mean annual minimum temperatures ranged from 11°C to 25°C and mean annual maximum temperature ranged from 21°C to 35°C (Figure 2a). Mean annual rainfall ranged from 64.4 mm to 10630.12 mm (Figures 2a, b). All these forests were moist tropical forest. The elevation zone between

100 and 1000 m a.s.l. was commonly described as tropical zone. The forests were dominated by the tropical species such as *Shorea robusta* (Dipterocarpaceae), and subtropical species associated with the forests are *Adina cordifolia, Careya arborea, Dillenia pentagyna, Terminalia bellirica, Terminalia chebula, Lagerstroemia parviflora and Dalbergia sissoo*[13]. The 5th site, Sagma, however, lies above 1000 m above sea level, has a warm temperate monsoon climate with warm, wet summers and chilly, dry winters. The maximum annual rainfall (4908.6) was during July (Figure 2d). Mean annual minimum temperatures ranged between 7°C to 21°C and mean annual maximum temperature ranged from 20°C to 29°C (Figure 2c). It is dominated by *Schima wallichii*.

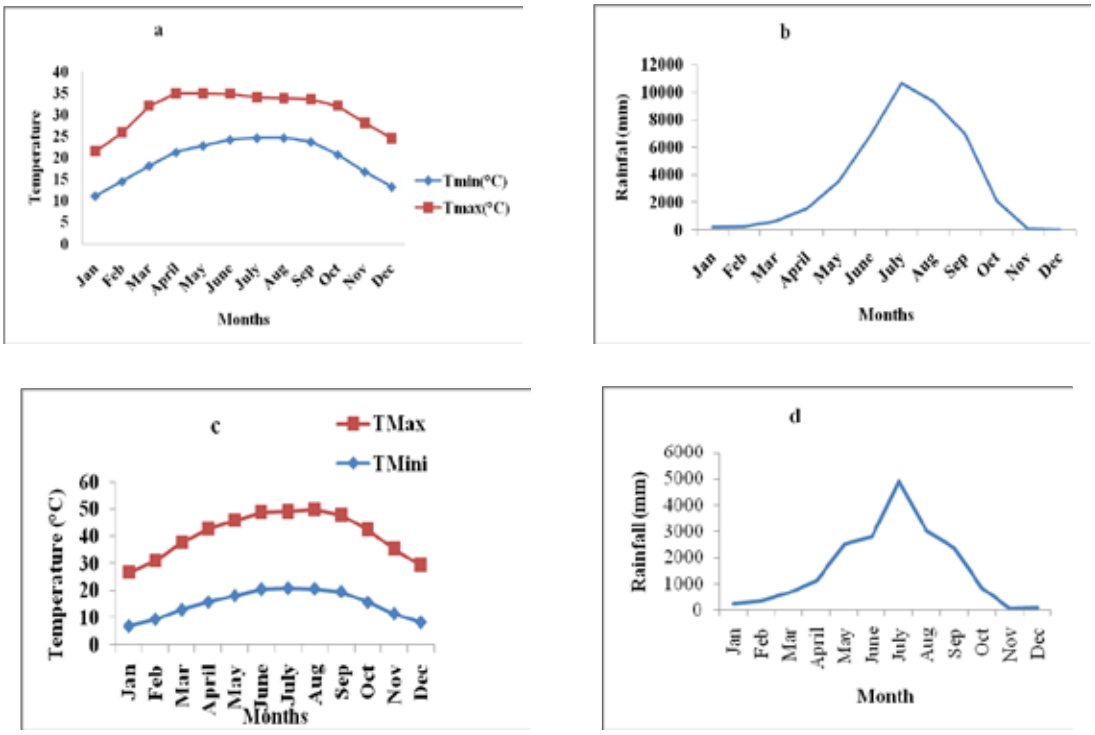

Figure 2: Summary of rainfall and temperature of the study area. 'a' & 'b' are monthly average minimum and maximum temperature and total rainfall in B, R, M and A forests; 'c' & 'd' represents average minimum & maximum temperature and rainfall in forest S.

Vegetation

Vegetation Sampling and data collection

Five forests: Baunne, Raja-Rani, Murchungi, Adheri and Sagma of Morang District, Koshi Province were selected as the study area. The elevation of these forests were ranged from 100 - 300 m a.s.l,, 380- 600 m a.s.l., 700- 880 m a.s.l, 900-1080 m a.s.l and 1100-1300 m a.s.l. respectively. Data on plant species composition were collected by setting up 20 m x 20 m sized quadrat for trees, 5 m x 5 m nested quadrat for shrubs and 1 m x 1 m nested quadrat for herbs. All trees, shrubs and herb species rooted inside each of their respective quadrat were recorded. Density of each plant species and their cover were recorded. Diameter at breast height (DBH) for all trees and shrubs inside each quadrat were recorded. Trees were defined as species having diameter ≥ 10 cm[18]. Similarly, girths at 10 cm above the ground level were measured for shrubs, whereas, for the herbs, each species were counted and weighted separately. Oven dried herbs again weighted to calculate their biomass. Total number of quadrats sampled were 50 (10 per site or forest). We measured the elevation and aspects by using a GPS (Garmin Colorado-300). Plant species occurring inside each quadrat was counted, tagged, collected for herbarium preparation and identification. Species not identified in the field were identified after consulting with experts and comparing with identified species that were deposited to the National Herbarium and Plant Laboratories, Godawari, Lalitpur of Nepal (KATH). Standard literature used for nomenclature[19,20,21]. Density and relative density, frequency and relative frequency, basal area and Importance Value Index (IVI) of each species for herbs,

shrubs and tree were calculated in each forest stand by following Kershaw and Looney[22]. Species diversity parameters like species richness, Shannon Wiener index, Equitability (evenness), and Simpson index were determined. Gathered data were analyzed by using Microsoft Excel and R Core Team [23].

Data analysis

Community composition among five forests were analyzed after following Permutational Multivariate Analysis of Variance using Distance matrices technique (ADONIS) in vegan package in R[24]. Sharing of species in different niches were analyzed through Venn diagram Package of R[24].

Diversity indices such as Shannon Wiener index, Equitability (evenness) index, and Simpson index, frequency, relative frequency, density, relative density, basal area and relative basal were calculated after using the standard formula[22].

Nomenclature

This research followed APG-III[25] system of plant taxonomic nomenclature and all latest names were checked through POWO-2023[21,26].

Results and Discussions

Species diversity

This study found a total of 315 plant species belonging to 82 families across all stands (Table 3). Among these species, the herbaceous life form made up the greatest percentage (45%) followed by trees (33%), and shrubs (22%) (Figure 3).

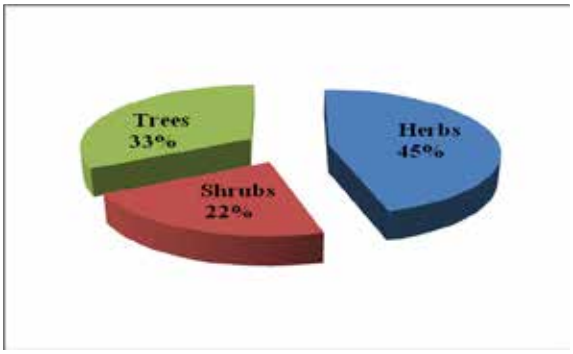

Figure 3: Percentage of plant habits throughout the study area

The total species richness was found decreased according to elevation of these forests. Total richness was found as 142, 126, 121, 121 and 137 species to Bhaunne, Raja-Rani, Murchungi, Adheri and Sagma forest stands, respectively (Figure 4).

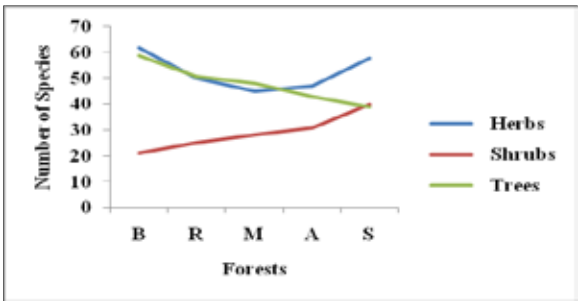

Figure 4: Trend of growth forms according to elevation of the studied forests of Morang district, east Nepal.

The maximum numbers of tree and herbs species were in Bhaunne, and highest species of shrubs were in Sagma forest (Table 1). Similarly, number of species was 127, 108, 109, 111 and 123 in B, R, M, A and S respectively (Table 1). Temperature, rainfall, humidity, soil characteristics, and other variables all have an impact on an area's vegetation, which in turn is influenced by elevation[27]. Maximum number of herbs i.e. (87%) among 266 species (201 genera, 71 families were found the study on vegetation structure and species diversity of Wadi Turbah Zahran, Albaha area, southwestern Saudi Arabia[28]. Forest composition varied continuously with elevation. Species richness is inversely proportional to the elevation gradient. In other word, species richness decreases with the increase of elevations[11,29,30,31,32,33]. Forest of low elevation are heterogeneous (more diverse) and spatially more patchy[29].

This study found only 51 species unique to Bhaunne forest; likewise 24, 13, 17 and 44 species unique to Raja-Rani, Murchungi, Adheri and Sagma forests correspondingly. There were 21 species common among all five forests (Figure 5). There were 13 species common to S and R forests, 6 species present in both B and S forests, another 6 species were common among S, R and M forests. Further, 6 species belonged to M and B forests. Likewise, the number species common to S and A forest were 12. Seven species were found common to R and A forests. Seven species were dwelled among three forests: B, M and R. Five species were common to A and B forests. Five species were common in A and M forests.

Four species were common to B, M and A forests, additionally four species were common among three forests: A, M and R. On the other hand, 12 species were encountered common to S, A and M forests, only one species was common in S and B and another one species was common among the three forests B, A and R. the number of species belonged to four forests namely: S, R, A and M were 13. Eight species were found both in S and M forests, another eight species were common in R and B forests. Extra six species were resided in M as well as B forests. Further, 13 species were common to four forests S, R, A and M. Two species only were common for A and R forests and 14 species were present among A, M, and R forests (Table 3, Figure 5).

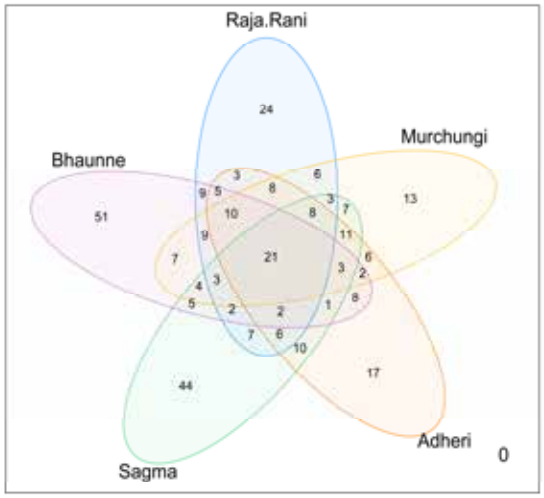

Figure 5: Venn-diagram showing community composition variation among forest types.

Species diversity and species evenness were also found decreased from low to high elevation[34,35].

The present study investigated Shannon Wiener index (H') ranged between 2.22 to 3.12 for trees, 2.21 to 2.98 for shrub, and 3.58 to 3.79 for herb among these investigated forest stands. The value of concentration of dominance (Cd) depends on the species richness and its lower values are associated with high species richness[36]. Index of dominance or concentration of dominance (cd) value ranged between 0.03 to 0.92 in herb layers, 0.08 to 0.19 in shrub layers and 0.08 to o.46 in tree layers (Table 2).

The species evenness or equitability value in this study were found ranged between 0.09 to 1.93, 0.72 to 0.8, and 0.59 to 0.88 for herbs, shrubs, and trees respectively. Margalef diversity index or species richness were ranged between 14.81 to 19.3 for herbs, 2.09 to 3.86 for shrubs, and 5.94 to 8.48 for tree layer (Table 2). Density showed positive relationship with species richness and Shannon Wiener diversity index[11,31].

The tree stand density was maximum i.e, 985 individuals ha^{-1} in Adheri forest and minimum in Sagma (602.5 individual ha^{-1}) forest. The tree density and tree basal area were found decreased with increase of elevation in a study done in Manang[31], which is contrast to present study. The highest herbs density was observed in Sagma (44.1 individuals ha^{-1}), whereas the lowest density was observed in Raja-Rani (18 individual ha^{-1}). These differences may be differences in climatic conditions.

Similarly, shrub stand density was highest in Sagma (24400 individual/ha) and lowest in Adheri forest (11320 individual ha^{-1}) among the forests (Table 1). According to study done by Kuma and Shibru, [37] in Ethiopia, Malik and Bhatt [38] in Badri Kedarnath region of India found elevation, aspects and slopes caused differences in the density and basal area, dominance and frequency of the plant species. There was also a study done in the south east facing slopes of Parroha community forest in Rupandehi District by Acharya and Shrestha[16]. They found higher species evenness, Simpson's index of dominance for all life forms in the south east slope. Alfa diversity for shrub layer was higher in the south east slope whereas beta diversity for tree layer was higher in south west slope[16].

Shorea robusta and *Schima wallichii* association was found increasing in forests of higher elevation to Adheri as their association increases with elevation. These findings also supported by study done by Sharma et al. in the western Himalayas[1]. Most of study showed unimodal trend of life form with elevation such as Bhattarai and Vetaas[11,] Gairola [32] etc. that is dissimilar of present study.

Family composition of species

The total number of family was 82 recorded by this study (Table 1). Among them Asteraceae had the maximum number of species (31 species, 28 genera) followed by Fabaceae (27 species, 21 genera) and Lamiaceae (24 species, 17 genera); Poaceae (19 species, 15 genera); Acanthaceae (13 species, 9 genera) and Rubiaceae (13

species, 12 genera) and so on. Studies such as Rawat[39] done in East Himalaya, Tegene and Gamo[40] done in Ethiopia found Myrsinaceae and Rubiaceae were the dominant families with the highest number of species. Based on individuals' density, Asteraceae contributed 744 in this study area followed by Lamiaceae, 638 individuals and Dipterocarpaceae, 544 individuals (Table 3). The numbers of families were 54 in B, 55 in R, 50 in M and S, and 52 in A (Table1). According to Dangol 2005[41], among the angiosperms, Fabaceae was the largest families in a study done in western Chitwan, which supports our present findings.

Basal area and Importance value index

The basal area of shrubs in the study area found ranging from 36.57 m^2 ha^{-1} (Bhaunne) to 111.52 m^2 ha^{-1} (Sagma) and the basal area of trees ranging from 343.53 m^2 ha^{-1} (Sagma) to 612.08 m^2 $ha^{-1,}$ (Murchungi) (Table 1). The important value index of herbs varied from 1.54 (*Ageratum conyzoides*) to 25.02 (*Oplismenus compositus*), 1.94 (*Colocasia esculenta*) to 20.07 (*Koenigia mollis*), 1.94 (*Digitaria ciliaris*) to 18.64 (*Imperata cylindrica*), 1.83 (*Globba clarkei*) to 27.52 (*Elsholtzia blanda*) and 1 (*Curculigo orchioides*) to 19.25 (*Imperata cylindrica*) in B, R, M, A and S respectively.

The importance value index of shrubs found in this study ranged from 1.47 (*Cyathula prostrata*) to 56.43 (*Clerodrendrum infortunatum*), 1.58 (*Uncaria sessilifructus*) to 60.81 (*Maesa chisia*), 2.28 (*Clerodendrum serratum*) to 30.22 (*Maesa chisia*), 1.39 (*Ototropis conferta*) to 68.74 (*Maesa macrophylla*) and 0.83 (*Flacourtia jangomas*) to 57.26 (*Maesa macrophylla*) in B, R, M, A and S forest respectively (Table 3). Likewise, the important value index value of trees was found to be ranged from 0.82 (*Cornus oblonga*) to 65.93 (*Senegalia catechu*), 0.97 (*Cornus oblonga*) to 81.81 (*Shorea robusta)* are similar to a study done by Pardi[42], 1.15 (*Dillenia pentagyna*) to 62.28 (*Terminalia alata*) and 1.05 (*Oroxylum indicum*) to 134.78 (*Shorea robusta*) similar in a study done by Napit in Banke[43] and 1.18 (*Albizia procera*) to 69.08 (*Schima wallichii*) in B, R, M, A and S forests of this study respectively (Table 3). Similar to the result of the present study, Varghese and Balasubramanyan[44] found their forests were also mainly dominated by *Shorea robusta* and *Terminalia alata* as upper canopy and the extent of dominance of tree species was different considerably in the Tarai forest *Shorea robusta* and *Shorea-Terminalia* forest at the south-western part of the Bardia National Park, Nepal. Differences in vegetation composition, and basal area may be because of disturbance as found by Giri et al.[35], the local extinction and immigration of species that is found in tropical forest as done by Bhatt and Khanal[45]. The lower values of basal area may be the result of anthropogenic disruptions as many authors agreed such as [35,45,46,47,48,49], since the forests are closer to human settlement that may lower values of basal area may be the result of anthropogenic disruptions which matches the result with Feroz, Mamun, and Kabir [46]. Human-caused disturbances such as logging, unrestricted grazing, lopping for firewood and fodder, and litter clearance have a significant negative impact on the forest as Chandra, Malik, Pandey and Bhatt [48,49]. Pardi et al.[42] found *Shorea* forest was the dominant tree species at the lower elevation. This result was different from present study.

Community composition variation after analysis of similarity (ANOSIM) showed that community structure was significantly different among 5 different forests. An ANOSIM result showed the value of R = 0.805 and p = 0.001. This indicated statistical significant difference in community composition among five forests (Figure 6).

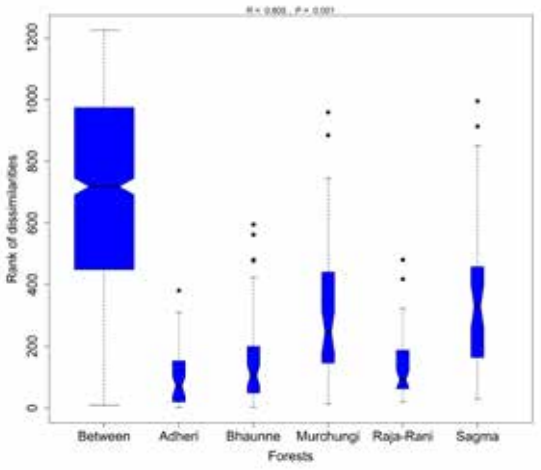

Figure: 6. Change in community composition with forest type in the study area.

According to Jha[15], diversification among different communities might be due to different environment factors such human disturbances, extensive grazing, invasive species and soil erosion resulting in fragmentation of vegetation types which in turn make impact on the community structure. This view has also been supported by similar studies such as Malik and Bhatt[51] , Shahid[52] and Joshi etc.

Table 1: Total values of phytosociological attribute of forests located at different elevation in Morang district, eastern Nepal.

Parameters	**Forest stands**				
	Bhaunne	**Rajarani**	**Murchungi**	**Adheri**	**Sagma**
Number of species					
Herbs	62	50	45	47	58
Shrubs	21	25	28	31	40
Trees	59	51	48	43	39
Total Species	142	126	121	121	137
Density					
Herbs (ind.m^{-2})	23.6	18	19.5	20.5	44.1
Shrubs (ind. ha^{-1})	14000	11720	14240	11320	24400
Trees (ind.ha^{-1})	935	950	775	985	602.5
Number of families	54	55	50	52	50
Number of genera	127	108	109	111	123
Basal area of shrubs (m^2 ha^{-1})	36.57	57.86	55.05	60.60	111.52
Basal area of Trees (m^2 ha^{-1})	543.09	439.82	612.08	501.04	343.53

Table 2: Diversity indices of forests located at different elevation in Morang district, eastern Nepal

Components					
Species richness (*d*)	**Bhaunne**	**Raja-Rani**	**Murchungi**	**Adheri**	**Sagma**
Herbs	19.3	16.95	14.81	15.23	15.05
Shrubs	2.09	2.56	2.82	3.21	3.86
Trees	8.48	7.28	7.06	6.11	5.94
Equitability/ Simpson's evenness (*e*)					
Herbs	0.92	1.84	1.87	0.93	0.92
Shrubs	0.72	0.78	0.85	0.84	0.8
Trees	0.76	0.72	0.72	0.59	0.88
Index of dominance (*cd*)					
Herbs	0.92	0.06	0.03	0.04	0.03
Shrubs	0.19	0.13	0.08	0.08	0.1
Trees	0.12	0.11	0.16	0.46	0.08
Shannon-Wiener index (*H'*)					
Herbs	3.79	3.67	3.65	3.58	3.78
Shrubs	2.2	2.45	2.91	2.9	2.98
Trees	3.08	2.85	2.77	2.22	3.12

Table 3: List of plant species with their importance value index (IVI) in five different forests of Morang District, Eastern Nepal.

S.N.	Site/Forests	Scientific name	Habit	Family	Occurrence	B	R	M	A	S
1	B	*Abutilon indicum* (L.) Sweet	H	Malvaceae	1	2.23	-	-	-	-
2	B,R,M,A,S	*Acer oblongum* Wall. ex DC.	T	Sapindaceae	13	4.68	2.29	2.84	5.11	5.00
3	B,R,M,A,S	*Achyranthes aspera* L.	H	Amaranthaceae	12	7.52	5.09	7.07	9.11	4.15
4	R,A,S	*Achyranthes bidentata* Blume	H	Amaranthaceae	8	-	5.09	-	4.43	6.41
5	M,A,S	*Actinodaphne lanceolata* Daizell & A. Gibson.	T	Lauraceae	8	-	-	3.85	3.21	2.36
6	R,S	*Adenostemma lavenia* (L.) Kuntze	H	Asteraceae	7	-	5.36		2.78	-
7	B,R,M,A	*Adina cordifolia* (Roxb.) Brandis	T	Rubiaceae	22	12.47	6.97	12.27	5.02	
8	B	*Aegle marmelos* (L.) Correa	T	Rutaceae	5	2.00	-	-	-	-
9	B,R,M,A,S	*Ageratina adenophora* (Spreng.) R. M. King & H. Rob.	S	Asteraceae	44	19.16	18.93	29.04	29.26	36.43
10	B,R,M,A,S	*Ageratum conyzoides* L.	H	Asteraceae	14	1.54	8.52	9.81	9.43	8.61
11	A	*Ageratum houstonianum* Miller	H	Asteraceae	2	-	-	-	4.52	-
12	B,R,M	*Alangium salviifolium* (L.f.) Wangerin	T	Cornaceae	21	15.50	7.32	6.11	-	-
13	B,R	*Albizia lebbeck* (L.) Benth.	T	Fabaceae	3	0.88	2.11	-	-	-
14	B, R, A, S	*Albizia julibrissin* Durazz.	T	Fabaceae	6	1.79	0.99		1.18	2.45
15	S	*Albizia lucidor* (Steud.) I. Neielsen ex H. Hara	T	Fabaceae	2	-	-	-	-	2.34
16	B,M,A,S	*Albizia procera* (Roxb.) benith.	T	Fabaceae	7	1.75	-	1.45	3.96	1.18
17	R,M,S	*Alnus nepalensis* D. Don	T	Betulaceae	12	-	2.22	3.06	-	12.72
18	R,S	*Alocasia fornicata* (Kunth) Schott	H	Araceae	2	-	4.32	-	-	1.49
19	B,R,A	*Alstonia scholaris* (L.) R. Br.	T	Apocynaceae	12	5.97	4.41	-	2.52	-
20	B,R,M	*Alysicarpus vaginalis* (L.) DC.	H	Fabaceae	10	2.34	4.32	7.64	-	-
21	M	*Cocculus laurifolius* DC.	H	Menispermaceae	3	-	-	10.39	-	-
22	S	*Anisomeles indica (*L.) Kuntze	H	Lamiaceae	2	-	-	-	-	3.28
23	R	*Aporosa octandra* (Buch.-Ham. ex D.Don) Vickery	T	Phyllanthaceae	3	-	3.25	-	-	-
24	B,R,S	*Ardisia solanacea* Roxb.	S	Myrsinaceae	16	34.04	4.75	-	-	5.07
25	A	*Ipomoea atropurpurea* (Wall.) Choisy	H	Convolvulaceae	2	-	-	-	3.61	-

26	M	*Arisaema erubescens* (Wall.) Schott	H	Araceae	2	-	-	5.10	-	-
27	M,A,S	*Artemisia indica* Willd.	S	Asteraceae	10	-	-	3.69	4.44	8.27
28	B	*Arthraxon lancifolius* (Trin.) Hochst.	H	Poaceae	2	9.34	-	-	-	-
29	M,A	*Arundinella nepalensis* Trin.	H	Poaceae	2	-	-	6.26	6.27	-
30	R,S	*Axonopus compressus* (Sw.) P. Beauv.	H	Poaceae	6	-	13.00	-	-	6.26
31		*Barleria strigosa* Willd.	S	Acanthaceae	1	2.70	-	-	-	-
32	R,A,S	*Barleria cristata* L.	H	Acanthaceae	8	-	7.07	-	7.80	2.70
33	B	*Bauhinia malabarica* Roxb.	T	Fabaceae	2	1.71	-	-	-	-
34	A	*Begonia picta* Sm.	H	Begoniaceae	2	-	-	-	4.78	-
35	S	*Berberis napaulensis* (DC.) Spring.	S	Berberidaceae	2	-	-	-	-	2.46
36	B,R,M	*Bergera koenigii* L.	S	Rutaceae	9	22.03	8.15	12.44	-	-
37	M	*Bidens pilosa* L.	H	Asteraceae	3	-	-	6.62	-	-
38	B	*Biophytum sensitivum* (L.) DC.	H	Oxalidaceae	3	6.06	-	-	-	-
39	B	*Blainvillea acmella* (L.) Philipson	H	Asteraceae	2	4.16	-	-	-	-
40	M	*Blumea balsamifera* (L.) DC.	H	Asteraceae	3	-	-	8.27	-	-
41	S	*Blumea eriantha* DC.	H	Asteraceae	2	-	-	-	-	2.51
42	B,M,A,S	*Blumea lacera* (Burm.f.) DC	H	Asteraceae	7	5.10	-	5.56	3.06	2.65
43	M,S	*Boehmeria ternifolia* D.Don	S	Urticaceae	5	-	-	3.40	-	2.93
44	S	*Boenninghausenia albiflora* (Hook) Rchb. ex Meisn.	S	Rutaceae	2	-	-	-	-	2.05
45	B	*Boerhavia diffusa* L.	H	Nyctaginaceae	2	4.18	-	-	-	-
46	B,S	*Bombax ceiba* L.	T	Malvaceae	4	4.01	-	-	-	1.67
47	R	*Breynia retusa* (Dennst.) Alston	S	Phyllanthaceae	1	-	2.27	-	-	-
48	B,M,S	*Bridelia retusa* (L.) A. Juss.	T	Euphorbiaceae	8	2.05		3.80		3.99
49	S	*Brucea javanica* (L.) Merr.	T	Simaroubaceae	3	-	-	-	-	3.59
50	S	*Brugmansia suaveolens* (Humb. & Bonpl. ex Willd.) Sweet	S	Solanaceae	2	-	-	-	-	2.35
51	M,A,S	*Butea buteiformis* (Voigt) Grierson	S	Fabaceae	15	-	-	7.40	11.74	9.04
52	S	*Cajanus Scarabaeoides* (L.) Thouars	H	Fabaceae	1	-	-	-	-	1.92
53	R,M,A,S	*Callicarpa arborea* Roxb.	T	Lamiaceae	11		7.54	1.26	2.13	2.42

54	B	*Callicarpa macrophylla* Vahl	S	Lamiaceae	2	9.81	-	-	-	-
55	M,A	*Campylotropis macrostyla* (D. Don) Lindl. ex Miq.	H	Fabaceae	3	-	-	5.04	2.56	-
56	M,S	*Carex elongata* L.	H	Cyperaceae	6	-	-	9.24	-	4.26
57	R,M	*Carex hirta* L.	H	Cyperaceae	5	-	4.27	3.42	-	-
58	R	*Carex nubigena* D. Don	H	Cyperaceae	4	-	5.68	-	-	-
59	B,R,M	*Careya arborea* Roxb.	T	Lecythidaceae	7	1.72	2.04	5.05	-	-
60	R	*Caryota urens* L.	T	Arecaceae	2	-	1.99	-	-	-
61	B,R,M,A	*Casearia graveolens* Dalzell	T	Salicaceae	24	6.98	3.17	1.28	8.97	-
62	B,R	*Cassia fistula* L.	T	Fabaceae	9	4.42	5.13	-	-	-
63	R,M,A,S	*Castanopsis indica* (Roxb. ex Lindl.) A. DC.	T	Fagaceae	19	-	6.23	4.47	3.21	24.23
64	A,S	*Castanopsis tribuloides* (Sm.) A. DC.	T	Fagaceae	8	-	-	-	3.82	4.36
65	R	*Catunaregam spinosa* (Thunb.) Tirveng.	S	Rubiaceae	2	-	6.26	-	-	-
66	A	*Celastrus paniculatus* Wild.	S	Celastraceae	2	-	-	-	3.07	-
67	S	*Celastrus stylosus* Wall.	S	Celastraceae	2	-	-	-	-	1.75
68	B,R,M,S	*Centella asiatica* (L.) Urb.	H	Apiaceae	9	5.95	6.18	7.62	-	4.47
69	M,A,S	*Chonemorpha fragrans* (Moon) Alston.	S	Apocynaceae	11	-	-	5.64	3.27	6.80
70	B,R,M,A,S	*Chromolaena odorata* (L.) R. M. King & H. Rob.	S	Asteraceae	40	13.28	13.88	19.37	25.07	23.96
71	B	*Chrysopogon aciculatus* (Retz.) Trin.	H	Poaceae	2	4.97	-	-	-	-
72	M,A	*Chrysopogon zizanioides* (L.) Roberty	H	Poaceae	4	-	-	8.76	4.61	-
73	S	*Cinnamomum tamala* (Buch-Ham.) T. Nees & C.H.Eberm.	T	Lauraceae	5	-	-	-	-	4.12
74	R,A,S	*Cipadessa baccifera* (Roxb. Ex Roth) Miq.	S	Meliaceae	8	-	6.88	-	4.88	1.94
75	M,S	*Clematis buchananiana* DC.	H	Ranunculaceae	3	-	-	3.65	-	2.56
76	S	*Clerodendrum colebrookianum* Walp.	S	Lamiaceae	5	-	-	-	-	3.74
77	B,R,M,A,S	*Clerodendrum japonicum* (Thunb.) Sweet	S	Lamiaceae	16	7.33	5.45	4.35	4.52	3.06
78	M,A	*Clerodendrum serratum* Spreng.	S	Lamiaceae	3	-	-	2.28	2.21	-
79	B,R,M,A,S	*Clerodrendrum infortunatum* L.	S	Lamiaceae	32	56.43	33.38	20.91	13.70	4.80

80	B,R,M,A,S	*Colebrookea oppositifolia* Sm.	S	Lamiaceae	31	11.81	11.31	28.45	18.55	9.08
81	R,M	*Colocasia esculenta* (L.) Schott	H	Araceae	5	-	1.94	5.37	-	-
82	S	*Colquhounia coccinea* Wall.	S	Lamiaceae	5	-	-	-	-	6.19
83	R,M	*Combretum roxburghii* Spreng.	S	Combretaceae	4	-	10.71	19.92	-	-
84	B,R,M,A	*Commelina benghalensis* L.	H	Commelinaceae	10	5.22	5.38	8.01	8.80	-
85	S	*Commelina caroliniana* Walter	H	Commelinaceae	2	-	-	-	-	2.37
86	R	*Commelina suffruticosa* Blume	H	Commelinaceae	6	-	10.53	-	-	-
87	B,R,M	*Cornus oblonga* Wall.	T	Cornaceae	4	0.82	0.97	3.08	-	-
88	B,A	*Cosmos bipinnatus* Cav.	H	Asteraceae	4	2.60	-	-	4.66	-
89	A,S	*Crassocephalum crepidioides* (Benth.) S. Moore	H	Asteraceae	2	-	-	-	2.62	1.44
90	B,R	*Croton persimilis* Mull. Arg.	T	Euphorbiaceae	21	8.93	25.74	-	-	-
91	B,R,M,A,S	*Curculigo orchioides* Gaertn.	H	Hypoxidaceae	7	1.54	2.89	4.17	5.74	1.00
92	R	*Curcuma angustifolia* Roxb.	H	Zingiberaceae	3		5.58	-	-	-
93	A	*Cyanotis cristata* (L.) D. Don	H	Commelinaceae	2	-	-	-	4.38	-
94	B,A	*Cyanthillium cinereum* (L.) H. Rob.	H	Asteraceae	3	2.67	-	-	4.33	-
95	B	*Cyathula prostrata* (L.) Blume	S	Amaranthaceae	1	1.47	-	-	-	-
96	B,R,M,A,S	*Cynodon dactylon* (L.) Pers.	H	Poaceae	11	10.18	2.08	12.12	10.90	15.55
97	B,R,A,S	*Cyperus brevifolia* Rottb. Hassk	H	Cyperaceae	10	4.12	14.37	-	8.27	3.85
98	R	*Cyperus difformis* L.	H	Cyperaceae	7	-	13.92	-	-	-
99	R,M	*Cyperus exaltatus* Retz.	H	Cyperaceae	6	-	3.33	5.18	-	-
100	B	*Cyperus rotundus* L.	H	Cyperaceae	1	2.28	-	-	-	-
101	B,R,M,A	*Dalbergia latifolia* Roxb.	T	Fabaceae	10	1.74	3.08	5.23	4.51	
102	B	*Dalbergia sissoo* Roxb.	T	Fabaceae	2	1.95	-	-	-	-
103	R,M,A	*Dalbergia stipulacea* Roxb.	T	Fabaceae	15	-	9.59	14.35	4.63	-
104	R	*Debregeasia longifolia* (Burm. f.) Wedd.	S	Urticaceae	2	-	3.78	-	-	-
105	R	*Desmos chinensis* Lour.	S	Annonaceae	2	-	3.22	-	-	-
106	S	*Dicliptera bupleuroides* Nees.	H	Acanthaceae	2	-	-	-	-	5.16
107	M	*Dicliptera chinensis* (L.) Juss.	H	Acanthaceae	2	-	-	6.52	-	-

108	B	*Dictyospermum montanum* Wight	H	Commelinaceae	2	3.73	-	-	-	-
109	B,R,M,A,S	*Digitaria ciliaris* (Retz.) Koeler	H	Poaceae	11	5.95	15.44	1.94	6.20	3.33
110	B	*Digitaria setigera* Roth	H	Poaceae	1	2.62	-	-	-	-
111	B,R,M,A	*Dillenia pentagyna* Roxb.	T	Dilleniaceae	9	5.50	1.78	1.15	3.41	
112	S	*Dimetia scandens* (Roxb.) R.J.Wang	H	Rubiaceae	2	-	-	-	-	3.57
113	B,R,A	*Diospyros chloroxylon* Roxb.	T	Ebenaceae	11	2.64	3.03	-	2.16	-
114	M	*Diospyros montana* Roxb.	T	Ebenaceae	2	-	-	1.53	-	-
115	B,M,A	*Diploknema butyracea* (Roxb.) H. J. Lam	T	Sapotaceae	15	6.76	-	2.82	5.99	-
116	R	*Docynia indica* (Colebr.ex Wall.) Decne.	T	Rosaceae	1	-	1.03	-	-	-
117	B,R,M,A,S	*Drymaria diandra* Blume	H	Caryophyllaceae	8	1.54	4.42	5.70	6.00	5.15
118	R,M,S	*Duabanga grandiflora* (Roxb. ex DC.) Walp	T	Lythraceae	6	-	1.01	2.66	-	4.53
119	M,A,S	*Duhaldea cappa* (Buch.-Ham. ex D. Don) Pruski & Anderb.	S	Asteraceae	12	-	-	7.10	6.33	5.24
120	B	*Eclipta prostrata* (L.) L.	H	Asteraceae	1	2.28	-	-	-	-
121	B,R,A	*Ehretia acuminata* (DC.) R. Br.	T	Boraginaceae	20	9.09	4.76	-	2.10	-
122	B,R,M,A,S	*Elaeagnus infundibularis* Momiy.	S	Elaeagnaceae	11	9.91	8.15	9.92	4.08	11.47
123	A	*Elaeodendron glaucum* (Rottb.) Pers.	T	Celastraceae	2	-	-	-	2.14	-
124	S	*Elatostema platyphyllum* Wedd.	H	Urticaceae	1	-	-	-	-	1.36
125	B,M	*Eleusine indica* (L.) Gaertn.	H	Poaceae	2	1.76	-	2.11	-	-
126	A,S	*Elsholtzia blanda* (Benth.) Benth.	H	Lamiaceae	16	-	-	-	27.52	14.14
127		*Emilia sonchifolia* (L.) DC.	H	Asteraceae	2	3.73	-	-	-	-
128	M,A,S	*Engelhardia spicata* Lechen ex Blume	T	Juglandaceae	17	-	-	4.80	7.41	44.25
129	B,M	*Eragrostis tenella* (L.) P. Beauv.ex Roem. & Schult.	H	Poaceae	3	5.52	-	6.69	-	-
130	R	*Erigeron canadensis* L.	H	Asteraceae	3	-	5.26	-	-	-
131	S	*Erythrina stricta* Roxb. ·	T	Fabaceae	2	-	-	-	-	4.62
132	R,M,A	*Eschenbachia leucantha* (D. Don) Brouillet	H	Asteraceae	6	-	4.14	4.63	3.06	-
133	B,R,S	*Euphorbia hirta* L.	H	Euphorbiaceae	5	2.02	2.00	-	-	4.91

134	S	*Eurya acuminata* DC.	T	Pentaphylacaceae	3	-	-	-	-	5.39
135	B,R	*Evolvulus nummularius* (L.) L.	H	Convolvulaceae	5	4.24	6.17	-	-	-
136	B,M,A,S	*Falconeria insignis* Royle	T	Euphorbiaceae	21	5.51	-	5.29	3.19	11.29
137	M	*Ficus hispida* L. f.	S	Moraceae	3	-	-	8.57	-	-
138	B	*Ficus lacor* Buch.-Ham.	T	Moraceae	1	1.06	-	-	-	-
139	S	*Ficus neriifolia* Sm.	T	Moraceae	4	-	-	-	-	6.10
140	B	*Ficus racemosa* L.	T	Moraceae	2	2.03	-	-	-	-
141	B,M,S	*Ficus semicordata* Buch.-Ham. ex Sm.	T	Moraceae	7	1.68	-	3.32	-	3.53
142	S	*Flacourtia jangomas* (Lour.) Raeusch.	S	Salicaceae	1	-	-	-	-	0.83
143	M,A	*Flemingia paniculata* Wall. ex Benth.	S	Fabaceae	4	-	-	2.76	2.84	-
144	B	*Flemingia strobilifera* (L.) W. T. Aiton	S	Fabaceae	2	4.27	-	-	-	-
145	R	*Floscopa scandens* Lour.	H	Commelinaceae	5	-	3.42	-	-	-
146	B,R,M	*Garuga pinnata* Roxb.	T	Burseraceae	10	2.30	2.19	3.81	-	-
147	S	*Girardinia diversifolia* (Link) Friis	S	Urticaceae	3	-	-	-	-	3.33
148	R,M,A	*Globba clarkei* Baker	H	Zingiberaceae	5	-	3.02	2.79	1.83	-
149	B	*Globba racemosa* Sm.	H	Zingiberaceae	2	5.10	-	-	-	-
150	B,M	*Gmelina arborea* Roxb. ex Sm.	T	Lamiaceae	5	2.91	-	2.67	-	-
151	B	*Gnaphalium polycaulon* Pers.	H	Asteraceae	1	1.74	-	-	-	-
152	M,A,S	*Gonostegia hirta* (Blume) Miq.	H	Urticaceae	6	-	-	3.62	7.02	4.21
153	B,M,S	*Grewia optiva* J. R. Drumm. ex Burret	T	Malvaceae	5	1.76	-	1.50	-	2.48
154	B,S	*Grona triflora* (L.) H. Ohashi & K. Ohashi	H	Fabaceae	5	8.10	-	-	-	3.80
155	S	*Gynocardia odorata* R. Br.	T	Achariaceae	3	-	-	-	-	5.86
156	B	*Hedychium ellipticum* Buch.-Ham. ex Sm.	H	Zingiberaceae	3	6.29	-	-	-	-
157	R,M	*Hedychium flavescens* Carey ex Roscoe	H	Zingiberaceae	3	-	4.25	2.08	-	-
158	B	*Hedyotis diffusa* Willd.	H	Rubiaceae	2	3.88	-	-	-	-
159	B	*Hemarthria compressa* (L. f.) R. Br.	H	Poaceae	2	5.42	-	-	-	-
160	B,R,M	*Heynea trijuga* Roxb. ex Sims	T	Meliaceae	5	1.97	4.63	2.70	-	-

161	B,R	*Holarrhena pubescens* Wall. ex G. Don.	T	Apocynaceae	5	2.52	1.94	-	-	-
162	B	*Holoptelea integrifolia* (Roxb.) Planch.	T	Ulmaceae	1	4.19	-	-	-	-
163	R,S	*Homalium napaulense* (DC) Benth.	T	Salicaceae	3	-	3.27	-	-	1.19
164	R	*Hydrocotyle sibthorpioides* L.	H	Araliaceae	2	-	4.10	-	-	-
165	B	*Hygrophila auriculata* (Schumach.) Heine	H	Acanthaceae	2	3.99	-	-	-	-
166	B,R,M,A,S	*Imperata cylindrica* (L.) Raeusch.	H	Poaceae	16	2.67	3.28	18.64	25.67	19.25
167	S	*Indigofera* sp.	S	Fabaceae	1	-	-	-	-	1.07
168	S	*Isodon coetsa* (Buch.-Ham. ex D. Don) Kudô	H	Lamiaceae	2	-	-	-	-	5.11
169	A	*Isodon* sp.	S	Lamiaceae	2	-	-	-	2.70	-
170	B	*Jasminum amabile* H. Hara	S	Oleaceae	2	3.44	-	-	-	-
171	B,R,M,A,S	*Justicia adhatoda* L.	S	Acanthaceae	15	8.43	5.34	6.05	2.38	6.58
172	R	*Knema tenuinervia* W. J. de Wilde	T	Myristicaceae	2	-	1.03	-	-	-
173	R,A,S	*Koenigia mollis* (D. Don) T. M.Schust. & Reveal	H	Polygonaceae	11	-	20.07	-	5.65	4.17
174	B,R,A	*Lagerstroemia parviflora* Roxb.	T	Lythraceae	23	9.65	7.31	-	3.90	-
175	R,M	*Laggera alata* S. Moore	S	Asteraceae	6		3.29	5.24	-	-
176	B,A	*Lannea coromandelica* (Houtt.) Merr.	T	Anacardiaceae	6	1.32	-	-	2.40	-
177	B,R,M,A,S	*Lantana camara* L.	S	Verbenaceae	22	8.22	10.52	9.54	9.32	7.34
178	B,S	*Leea indica* (Burm. f.) Merr.	S	Vitaceae	12	34.24	-	-	-	5.18
179	R,M,A	*Leea macrophylla* Roxb. ex Hornem.	S	Vitaceae	16	-	54.45	24.10	4.46	-
180	S	*Leucas decemdentata* (Willd.) Sm.	H	Lamiaceae	2	-	-	-	-	5.02
181	R,M,A	*Leucomeris spectabilis* D. Don	S	Asteraceae	6	-	3.59	3.94	3.27	
182	S	*Leucosceptrum canum* Sm.	T	Lamiaceae	2	-	-	-	-	2.76
183	A	*Ligustrum robustum* (Roxb.) Blume	T	Oleaceae	2	-	-	-	2.10	-
184	A	*Lindenbergia grandiflora* Benth.	H	Orobanchaceae	1	-	-	-	3.06	-
185	R,M,A,S	*Litsea monopetala* (Roxb.) Pers.	T	Lauraceae	14	-	3.38	5.22	3.69	8.67
186	B	*Litsea salicifolia* (Roxb. ex Nees) Hook. f.	S	Lauraceae	6	22.19	-	-	-	-
187	R,M,A,S	*Macaranga indica* Wight	T	Euphorbiaceae	12	-	3.72	3.55	3.20	3.53

188	B,R,M,A,S	*Maesa chisia* D. Don.	S	Primulaceae	41	25.83	60.81	30.22	24.37	18.95
189	R,M,A,S	*Maesa macrophylla* (Wall.) A. DC.	S	Primulaceae	33	-	3.86	20.14	68.74	57.26
190	B,R	*Mallotus nudiflorus* (L.) Kulju & Welzen	T	Euphorbiaceae	8	6.55	3.08	-	-	-
191	B,R,M,A,S	*Mallotus philippensis* (Lam.) Müll. Arg.	T	Euphorbiaceae	17	5.95	3.61	1.53	3.24	5.59
192	M	*Martynia annua* L.	S	Martyniaceae	2	-	-	3.17	-	-
193	B,A,S	*Melastoma malabathricum* L.	S	Melastomataceae	10	1.90	-	-	5.41	7.29
194	S	*Mentha canadensis* L.	H	Lamiaceae	3	-	-	-	-	7.05
195	M,S	*Micromelum integerrimum* (Roxb. ex DC.) Wight & Arn. ex Voigt	T	Rutaceae	4	-	-	2.70	-	4.00
196	B,R,M,A,S	*Mikania micrantha* Kunth	H	Asteraceae	11	3.40	7.98	3.02	8.16	4.40
197	B,M	*Miliusa velutina* (DC) Hook. f. & Thomson	T	Annonaceae	4	2.05	-	1.53	-	-
198	M,A	*Millettia extensa* (Benth.) Benth. ex Baker	S	Fabaceae	4	-	-	2.82	3.21	-
199	B,S	*Mimosa pudica* L.	H	Fabaceae	6	4.73	-	-	-	5.17
200	M	*Murdannia nudiflora* (L.) Brenan	H	Commelinaceae	2	-	-	5.54	-	-
201	R	*Mussaenda macrophylla* Wall.	S	Rubiaceae	4	-	12.35	-	-	-
202	B	*Neolamarckia cadamba* (Roxb.) Bosser	T	Rubiaceae	2	1.91	-	-	-	-
203	R,M,A	*Neolitsea cuipala* (D. Don) Kosterm.	T	Lauraceae	8	-	2.62	1.21	4.93	-
204	S	*Notholithocarpus densiflorus* (Hook. & Arn.) Manos, Cannon & S. H. Oh	T	Fagaceae	3	-	-	-	-	4.33
205	A	*Nyctanthes arbor-tristis* L.	S	Oleaceae	3	-	-	-	7.73	-
206	B,R,M,A,S	*Oplismenus compositus* (L.) P. Beauv.	H	Poaceae	20	25.02	6.49	8.53	18.35	15.90
207	B,R,M	*Oplismenus hirtellus* (L.) P. Beauv.	H	Poaceae	5	2.82	10.62	4.48	-	-
208	B,A	*Oroxylum indicum* (L.) Kurz	T	Bignoniaceae	5	1.73	-	-	1.05	-
209	R	*Orthosiphon incurvus* Benth.	H	Lamiaceae	2	-	10.25	-	-	-
210	M,S	*Osbeckia stellata* Buch.-Ham. ex D. Don	S	Melastomataceae	6	-	-	3.22	-	4.56
211	S	*Ostodes paniculata* Blume	T	Euphorbiaceae	5	-	-	-	-	7.72
212	B, A	*Ototropis conferta* (DC.) H. Ohashi & K. Ohashi	S	Fabaceae	2	1.90	-	-	1.39	-

213	B	*Ougeinia oojeninensis* (Roxb.) Hochr.	T	Fabaceae	4	2.44	-	-	-	-
214	B,R	*Oxalis corniculata* L.	H	Oxalidaceae	4	6.60	3.28	-	-	-
215	R	*Oxalis latifolia* Kunth.	H	Oxalidaceae	1	-	3.14	-	-	-
216	B,A	*Paederia* foetida L.	H	Rubiaceae	4	3.27	-	-	4.60	-
217	R	*Paramignya monophylla* Wight	S	Rutaceae	4	-	2.07	-	-	-
218	A,S	*Paspalum conjugatum* P.J. Bergius	H	Poaceae	6	-	-	-	10.01	12.55
219	M	*Paspalum notatum* Flüggé	H	Poaceae	3	-	-	11.01	-	-
220	A	*Peperomia pellucida* (L.) Kunth	H	Piperaceae	1	-	-	-	3.32	-
221	S	*Persicaria capitata* (Buch.-Ham. ex D. Don) H. Gross	H	Polygonaceae	2	-	-	-	-	2.57
222	S	*Persicaria pubescens* (Blume) H. Hara	H	Polygonaceae	2	-	-	-	-	2.41
223	B,R,M,A	*Phanera vahlii* (Wight & Arn.) Benth.	T	Fabaceae	13	3.62	4.46	4.22	3.79	-
224	A	*Phragmites karka* (Retz.) Trin. ex Steud.	H	Poaceae	1	-	-	-	2.95	-
225	B	*Phyllanthus amarus* Schumach. & Thonn.	H	Phyllanthaceae	2	4.08	-	-	-	-
226	S	*Phyllanthus clarkei* Hook. f.	S	Phyllanthaceae	3	-	-	-	-	3.19
227	B,R,M,A	*Phyllanthus emblica* L.	T	Phyllanthaceae	8	1.68	2.07	1.49	3.69	-
228	B	*Phyllanthus virgatus* G. Forst.	H	Phyllanthaceae	2	4.75	-	-	-	-
229	S	*Pilea symmeria* Wedd.	H	Urticaceae	1	-	-	-	-	1.34
230	B,M	*Piper longum* L.	H	Piperaceae	4	5.46	-	2.28	-	-
231	S	*Platostoma hispidum* (L.) A. J. Paton	H	Lamiaceae	2	-	-	-	-	5.02
232	B,M	*Pleurolobus gangeticus* (L.) J. St.-Hil.ex H. Ohashi & Ohashi	H	Fabaceae	4	3.40	-	5.93	-	-
233	R,S	*Pogonatherum crinitum* (Thunb.) Kunth	H	Poaceae	2	-	2.95	-	-	2.38
234	R,S	*Pogostemon amaranthoides* Benth.	H	Lamiaceae	4	-	3.14	-	-	6.48
235	B,R,M,S	*Pogostemon benghalensis* (Burm. f.) Kuntze	H	Lamiaceae	21	24.01	11.64	12.51		10.22
236	A	*Pouzolzia rugulosa* (Wedd.) Acharya & Kravtsova	T	Urticaceae	2	-	-	-	1.35	-
237	B	*Pouzolzia zeylanica* (L.) Benn.	H	Urticaceae	2	3.70	-	-	-	-
238	B	*Prasoxylon excelsum* (Spreng.) Mabb.	T	Meliaceae	3	1.16	-	-	-	-

239	B	*Premna mollissima* Roth	T	Verbenaceae	12	0.93	-	-	-	-
240	A,S	*Pseudocaryopteris bicolor* (Roxb. ex Hardw.) P. D. Cantino	S	Lamiaceae	6	-	-	-	5.22	8.52
241	S	*Pseudognaphalium adnatum* (Dc.) Y. S. Chen	H	Asteraceae	1	-	-	-	-	1.92
242	R	*Pseudognaphalium affine* (D. Don) Anderb.	H	Asteraceae	2	-	4.12	-	-	-
243	B	*Pseudognaphalium luteoalbum* (L.) Hilliard & B. L. Burtt	H	Asteraceae	3	6.86	-	-	-	-
244	R	*Pterospermum acerifolium* (L.) Willd.	T	Malvaceae	1	-	1.17	-	-	-
245	S	*Firmiana colorata* (Roxb.) R. Br.	T	Malvaceae	2	-	-	-	-	2.95
246	B	*Rauvolfia serpentina* (L.) Benth. ex Kurz.	S	Apocynaceae	1	1.61	-	-	-	-
247	S	*Reinwardtia indica* Dumort.	S	Linaceae	2	-	-	-	-	1.73
248	A	*Rhynchoglossum obliquum* Blume	H	Gesneriaceae	1	-	-	-	2.95	-
249	B,M,S	*Rostellularia obtusa* Nees	H	Acanthaceae	11	5.99	-	11.64	-	8.68
250	M	*Rotheca serrata* (L.) Steane & Mabb.	S	Lamiaceae	2	-	-	2.70	-	-
251	S	*Rubia manjith* Roxb.	H	Rubiaceae	1	-	-	-	-	1.49
252	A,S	*Rubus ellipticus* Sm.	S	Rosaceae	8	-	-	-	5.20	5.55
253	R,A,S	*Rungia himalayensis* C.B. Clarke	H	Acanthaceae	6	-	3.37	-	4.89	5.09
254	B,M,A	*Rungia pectinata* (L.) Nees	H	Acanthaceae	6	1.84	-	11.29	4.48	-
255	S	*Sambucus javanica* subsp. *Chinensis* (Lindl.) Fukuoka	S	Adoxaceae	1	-	-	-	-	1.47
256	S	*Sarcococca coriacea* (Hook.) Sweet	S	Buxaceae	3	-	-	-	-	4.80
257	A,S	*Saurauia napaulensis* DC.	T	Actinidiaceae	4	-	-	-	2.51	2.47
258	R,M,A,S	*Schima wallichii* (DC.) Korth.	T	Theaceae	40	-	48.22	16.29	19.81	69.08
259	B,M	*Schleichera oleosa* (Lour.) Oken	T	Sapindaceae	3	2.61	-	2.43	-	-
260	B	*Scoparia dulcis* L.	H	Plantaginaceae	1	3.19	-	-	-	-
261	B,A	*Scutellaria repens* Buch.-Ham. ex D.Don	H	Lamiaceae	3	10.04	-	-	1.83	-
262	S	*Scutellaria scandens* D. Don	H	Lamiaceae	3	-	-	-	-	4.08
263	B,R,M,A	*Semecarpus anacardium* L.f.	T	Anacardiaceae	16	6.24	4.27	15.71	5.17	-
264	B	*Senegalia catechu* (L.f.) P. J. H. Hurter & Mabb.	T	Fabaceae	1	65.93	-	-	-	-

265	M	*Senegalia intsia* (L.) Maslin, Seigler & Ebinger	T	Fabaceae	2	-	-	3.71	-	-
266	B,R,M,A	*Shorea robusta* C.F. Gaertn.	T	Dipterocarpaceae	40	37.04	81.81	47.08	134.78	-
267	M,A,S	*Sida acuta* Burm f.	H	Malvaceae	8	-	-	7.07	7.28	4.91
268	A	*Sida cordata* (Burm. f.) Borss. Waalk.	H	Malvaceae	1	-	-	-	2.62	-
269	S	*Sida rhombifolia* L.	H	Malvaceae	3	-	-	-	-	4.24
270	R	*Smilax aspera* L.	H	Smilacaceae	3		7.12	-	-	-
271	B	*Solanum nigrum* L.	H	Solanaceae	1	2.34	-	-	-	-
272	R,S	*Solanum viarum* Dunal	S	Solanaceae	2	-	5.02	-	-	1.02
273	R,A	*Solanum virginianum* L.	H	Solanaceae	5	-	6.17	-	4.43	-
274	B	*Sonchus asper* (L.) Hill	H	Asteraceae	1	2.81	-	-	-	-
275	S	*Spermacoce alata* Aubl.	H	Rubiaceae	3	-	-	-	-	7.63
276	B,A	*Spermacoce ocymoides* Burm.f.	H	Rubiaceae	2	1.74	-	-	3.06	-
277	A,S	*Spermadictyon suaveolens* Roxb.	S	Rubiaceae	5	-	-	-	4.67	1.60
278	B	*Spondias pinnata* (L. f.) Kurz	T	Anacardiaceae	1	1.10	-	-	-	-
279	B,R,A	*Sterculia villosa* Roxb.ex Sm.	T	Malvaceae	7	0.97	1.39	-	1.89	-
280	B	*Streblus asper* Lour.	T	Moraceae	2	1.67	-	-	-	-
281	R,M,A,S	*Strobilanthes capitata* (Nees) T. Anderson	H	Acanthaceae	9	-	2.07	5.81	8.72	8.16
282	R,M,S	*Strobilanthes glutinosa* Nees.	H	Acanthaceae	6	-	2.95	5.33		4.70
283	B	*Strobilanthes hirta* (Vahl) Blume	H	Acanthaceae	1	2.02	-	-	-	-
284	B	*Synedrella nodiflora* (L.) Gaertn.	H	Asteraceae	4	8.30	-	-	-	-
285	A	*Synotis cappa* (Buch.-Ham. ex D. Don) C. Jeffrey & Y. L. Chen	H	Asteraceae	1	-	-	-	2.88	-
286	B,R,M,A,S	*Syzygium cumini* (L.) Skeels	T	Myrtaceae	20	3.78	2.30	5.31	7.01	7.64
287	B,R	*Syzygium nervosum* A. Cunn. ex DC.	T	Myrtaceae	2	0.86	1.08	-	-	-
288	B	*Tamarindus indica* L.	T	Fabaceae	2	2.16	-	-	-	-
289	B,R,M	*Terminalia bellirica* (Gaertn.) Roxb.	T	Combretaceae	3	0.86	1.08	3.64	-	-
290	B,R,M,S	*Terminalia chebula* Retz.	T	Combretaceae	7	1.86	1.05	3.35	-	3.04
291	M	*Terminalia myriocarpa* Van Heurck & Müll. Arg.	T	Combretaceae	3	-	-	6.02	-	-

292	B,R,M,A	*Terminalia alata* Dietr.	T	Combretaceae	6	2.22	1.29	62.28	4.24	-
293	M,A,S	*Tetradium fraxinifolium* (Hook.) T.G. Hartley	T	Rutaceae	10	-	-	3.01	4.15	7.38
294	R	*Tetrameles nudiflora* R. Br.	T	Tetramelaceae	1	-	1.40	-	-	-
295	A,S	*Tetrastigma serrulatum* (Roxb.) Planch.	H	Vitaceae	5	-	-	-	7.74	2.58
296	A	*Thalictrum punduanum* Wall.	S	Ranunculaceae	3	-	-	-	4.27	-
297	R,A	*Thunbergia alata* Bojer ex Sims.	H	Acanthaceae	2	-	2.00	-	3.06	-
298	S	*Thyrsanthella* sp.	H	Apocynaceae	2	-	-	-	-	2.99
299	M,A,S	*Thysanolaena latifolia* (Roxb. ex Hoenem.) Honda	S	Poaceae	7	-	-	3.61	5.04	3.06
300	R,M,A	*Toona ciliata* M. Roem.	T	Meliaceae	3	-	1.02	1.29	2.05	
301	R	*Torenia crustacea* (L.) Cham. & Schltdl.	H	Linderniaceae	2	-	5.25	-	-	-
302	R,M,A,S	*Toxicodendron succedaneum* (L.) Kuntze	T	Anacardiaceae	9	-	1.00	2.34	4.61	4.23
303	B	*Trema orientalis* (L.) Blume.	T	Cannabaceae	2	1.68	-	-	-	-
304	B	*Tridax procumbens* L.	H	Asteraceae	1	1.57	-	-	-	-
305	M,S	*Triumfetta pilosa* Roth	H	Malvaceae	5	-	-	3.16	-	5.44
306	R,S	*Uncaria sessilifructus* Roxb.	S	Rubiaceae	4	-	1.58	-	-	2.95
307	B,S	*Urena lobata* L.	H	Malvaceae	5	1.84	-	-	-	5.50
308	M,S	*Urtica dioica* L.	H	Urticaceae	5	-	-	8.41	-	2.43
309	B	*Veronica javanica* Blume	H	Plantaginaceae	1	4.35	-	-	-	-
310	R,M,A	*Wendlandia heynei* (Schult.) Santapau & Merchant	T	Rubiaceae	6	-	1.97	1.20	1.33	-
311	A,S	*Woodfordia fruticosa* (L.) Kurz	S	Lythraceae	10	-	-	-	8.64	7.08
312	M,A,S	*Wrightia arborea* (Dennst.) Mabberly	T	Apocynaceae	8	-	-	4.57	3.39	2.94
313	B,R	*Youngia japonica* (L.) DC.	H	Asteraceae	2	3.32	2.95	-	-	-
314	R,A,S	*Zanthoxylum armatum* DC.	T	Rutaceae	6	-	0.97	-	1.05	4.01
315	B	*Zizyphus jujuba* Mill.	T	Rhamnaceae	3	2.75	-	-	-	-

B = Bhaunne; R = Raja-Rana; M = Murchungi; A = Adheri; S = Sagma

Conclusions

Understanding the distribution of species along the forests at different elevation, it is essential for the conservation of biodiversity and prioritizing areas for conservation planning. The present study was carried out to assess the variation in community structure, composition and diversity of plant species along different forests. It supported the 'U shaped' species richness pattern wherein higher number of species are 142 reported at lower elevation i.e, at Bhaunne forest. The results indicated that Sagma is the most favorable region for growth of shrub species and least favorable for tree species. Herb also showed U shaped pattern among the forests, while tree species was in decreasing order and shrub species was in increasing pattern along the forest at high elevations. Thus, we can say that more diverse plant communities exist at studied forests. The present study assists the policymakers in developing the sound strategies for conservation and sustainable management of ecosystem. The stakeholders such as Ministry of Forests, Departments, University, Province level ministry, Forest Division and local community forest user group, and other related organizations might plan approaches for regeneration and sustainable forest management together with conservation actions of plant species.

The present study revealed that Bhaunne forest is having the highest species richness for herbs and tree species, Shannon's diversity and commonness of species. The number of species across forests (alpha diversity) did not vary greatly, but species composition among forests differed appreciably resulting into a fair compositional heterogeneity (beta diversity). The presence of Asteraceae with 31 species, 28 genera was remarkable. A pattern of mixed dominance of trees 65.93 (*Senegalia catechu*), 81.81 (*Shorea robusta),* 62.28 (*Terminalia alata*), 134.78 (*Shorea robusta*) and 69.08 (*Schima wallichii*) in B, R, M, A and S forest respectively was noteworthy.

The density of herbs and shrubs was maximum in Sagma forests and density of tree was high in Adheri forests. The value of basal area of shrubs and trees was considerably high in Sagma and Murchungi forests.

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