Final Technical Report

(1st Feb. 2017 to 30th Sep. 2021)

EXPLORATION OF BIODIVERSITY AND CONSERVATION ISSUES OF TALLEY VALLEY WILDLIFE SANCTUARY, ARUNACHAL PRADESH WITH REFERENCE TO WILDLIFE SPECIES DISTRIBUTION ALONG CLIMATE AND TOPOGRAPHICAL GRADIENTS

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INTRODUCTION:

Arunachal Pradesh is one of the largest states of northeast India and its boundary shares nationally with Assam, Nagaland, and internationally with Bhutan, Myanmar, and China. It is a part of the Eastern Himalayas biodiversity hotspot and one of the 200 important ecological regions (Olson & Dinerstein 1998). It is estimated that over 5000 species of flowering plants occur in the state, out of which 238 are endemic to the state. As a biodiversity hotspot, it is home to many known and still unknown species related to its varied geography with distinct climatic characteristics. It is located between 26.28° N and 29.30° N latitude and 91.20° E and 97.30° E longitude with an area of around 83,743 km^2. The land here has a great altitudinal range from 100m to 7000m, providing several habitats suitable for number of animals. The topography is filled with a range of mountain and sub-mountain terrains along with the northern parts, making it difficult terrain to work in and the rivers flowing through it create a valley in the state, which is a significant feature of the state. The state occupies a range of forest types like tropical wet evergreen, sub-tropical broadleaf, subtropical conifer, temperate broadleaf, temperate conifer and subalpine forest/alpine scrub. The mountain slopes and hills are covered with alpine, temperate, and subtropical forests with rhododendron, oak, pine, maple and fir (Champion & Seth 1968). The state is divided into twenty-six (26) districts home to more than 30 various languages.

The climate of Arunachal Pradesh varies with elevation. The low altitude (100 – 1500 m) has a humid subtropical climate, high altitude ranges (3500 – 5500 m) have a subtropical highland climate and alpine climate. The state receives annual rainfall of 2,000-5,000 mm (Dhar and Nandargi, 2004), out of which 70 - 80% is recorded between May and October.

Objectives:

1. To explore animal communities' distribution, status, and diversity along the climatic and topographical gradient.
2. To study the distribution of plant communities along with a climatic, edaphic and topographical gradient in wildlife surveyed areas and other parts of the sanctuary.
3. To quantify the local community pressure on the biodiversity of sanctuary due to their day-to-day household needs and find a solution to manage it on a sustainable basis.
4. Identify the species-specific conservation and management issues of keystone species in the study area.

Study area:

Arunachal Pradesh lies in the Indo-Myanmar Global Biodiversity Hotspot region. This state is very rich in the floral and faunal biodiversity of India. Due to high richness of biodiversity Arunachal Pradesh is also known as biodiversity frontier of India (Borges 2005). It is recorded as one of the richest diversity in the world having about 869 species of birds in this region (Athreya 2006, Alström et al. 2016)

Talley Valley wildlife sanctuary (TVWLS) is situated in the Lower Subansiri district of Arunachal Pradesh, India (27^0 34' 4" N and 27^0 35' 14" N; 93^0 58' 58" and93^0 59' 49"), which covers an area of about 337 sq. km. It has a vast altitude ranging from 130- 2900 meters with many rivers like Pange, Sipu, Karing and Subansiri flowing through it, which acts as a key for more biodiversity (Figure 1). The Pange river flanks it in the west, Sipu river and its tributaries

in the south, and densely forested hillocks and various streams in the East and North. It has two main camp points, namely Pange and Talley Valley. The human habitation and disturbance in the sanctuary are low, making it a better place for floral and faunal diversity. It mainly consists of subtropical and temperate broad leaves with bamboo patches along the valley. The forest is most dominated by Lauraceae, followed by Fagaceae, Magnoliaceae, Ericaceae, and Rutaceae (Yam & Tripathi 2016). TVWLS holds a great diversity of Rhododendrons along with different bamboo species. As it is a biodiversity hotspot, the sanctuary harbors many herpetofauna, birds, insects and shy mammals.

The climatic condition of TVWLS varies seasonally with respect to amount of rainfall and temperature. Maximum annual rainfall occurred during June in (419.50 mm) while minimum annual rainfall during December (5 mm). Maximum temperature in July records 31.6°C and minimum temperature in January is 1.1°C. (http://arunachalforests.gov.in/ accessed on 3rd January 2022).

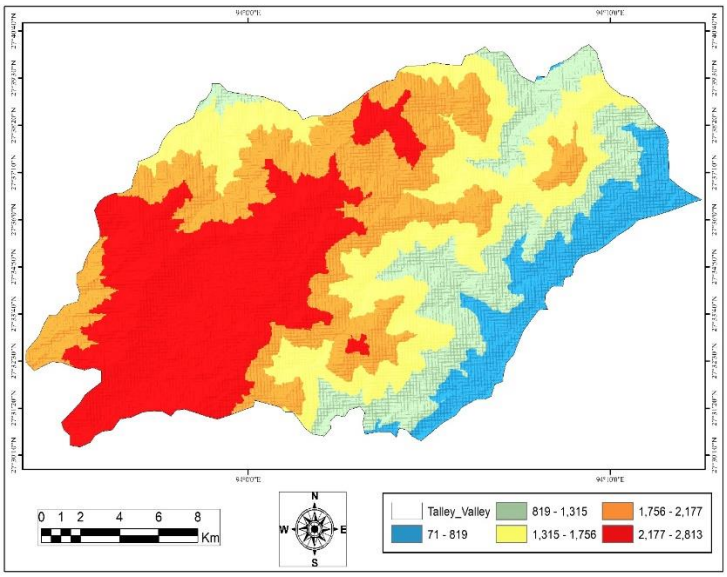

Figure 1: Map of study site, Talley Valley Wildlife Sanctuary showing its elevation range.

Objective 1: To explore animal communities' distribution, status, and diversity along the climatic and topographical gradient.

Survey of mammals at Talley valley Wildlife Sanctuary, Arunachal Pradesh

India has about 410 mammals and 31 species found in Talley Valley wildlife sanctuary (Chaudhuri & Choudhury 1994) (Yania 2017). No human habitation is present in this area. There is huge diversity of herbivores, carnivores, ungulates, and various lesser cats, amphibians and reptiles. It is also essential to monitor the diversity and population of other mammals in Talley Valley wildlife sanctuary as the mammal population faces different threats due to climate change, habitat loss, and poaching. Area surveyed using camera trap

are namely, Pange, Tasi Buidang, Oli buidang, Lebya Peng Pass and Tale valley (Figure 2)

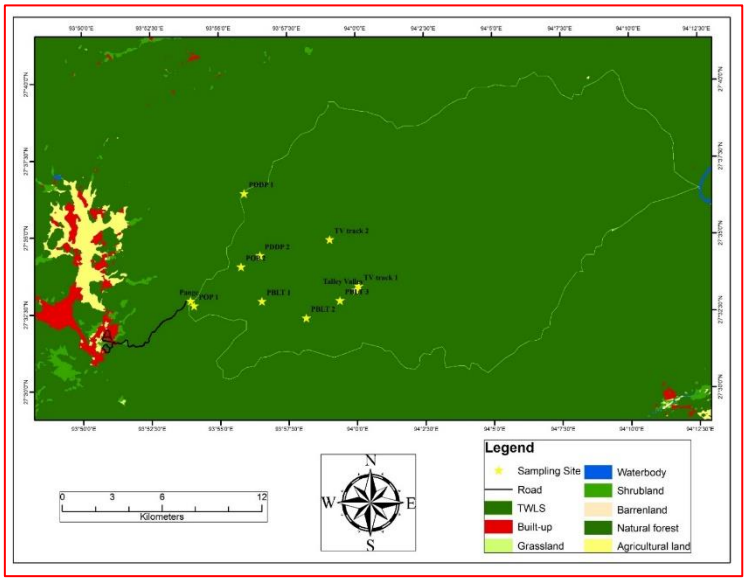

Figure 2: Map of Talley Valley Wildlife Sanctuary showing location of camera trap points.

Methodology:

Animal Diversity Surveys:

The primary objective of the study was to record presence of different mammals at the study site during the field survey. Both direct and indirect methods (Direct sighting and Sign survey method) were used to explore the animal diversity in the study sites. Scat samples were photographed for identification of a particular mammal. The complete table of sampling effort during the field survey is given in Table 1.

Table1: Details of study sites where field survey was done for faunal diversity

Sl. No.	Site	Duration	Elevation	Vegetation
1	Pange camp	28.03.2017-16.04.2017 09.01.2018-25.01.2018 15.03.2018-06.04.2018 08.05.2021-26.05.2021	1864 m	Mixed vegetation with *Quercus lamellose, Acer pictum*
2	Tasi Buidang	28.03.2017-16.04.2017 09.01.2018-25.01.2018 15.03.2018-06.04.218 08.05.2021-26.05.2021	2134 m	*Exbucklandia populnea* with different understory plants
3	Oli Buidang	28.03.2017-16.04.2017 09.01.2018-25.01.2018 15.03.2018-06.04.2018 08.05.2021-26.05.2021	2200 m	Mixed vegetation with *Exbucklandia sps., Acer pictum* and different herbaceous plants

4	Lebya peng pass	28.03.2017-16.04.2017 09.01.2018-25.01.2018 15.03.2018-06.04.2018 08.05.2021-26.05.2021	2567 m	*Rhododendron sps.* and *Cinamomum sps.*
5	Tale valley	28.03.2017-16.04.2017 09.01.2018-25.01.2018 15.03.2018-06.04.2018 08.05.2021-26.05.2021	2300 m	*Abies densa, Cedrus deodara* and patch of bamboo forest

Results and Discussion:

Based on direct and indirect sighting, the study recorded a total of 20 species of mammal belonging to 17 genera, 10 families, and Six orders from the sanctuary (Table 2). One species of large Indian civet, barking deer, mouse, yellow-throated marten was sighted directly apart from sightings of four species of squirrels. With nine species, Carnivora dominated (47%) the mammal diversity in Talley Valley Wildlife Sanctuary, followed by Rodentia with six species, three species in Artiodactyla, and only one species falls in the order Chiroptera and Cetartiodactyla (Figure 3).

The recorded species fall under Twelve families, with the Felidae and Sciuridae families having the most (4) species, and the Cervidae, Suidae, Viverridae, Muridae, Hystricidae, Cercopithecidae, Ursidae, Canidae, Mustelidae, and Bovidae families having one species each.

The International Union for Conservation of Nature and Natural Resources (IUCN) guidelines were followed to determine recorded mammals' status and population trend on a global scale. Species are classified into five (5) groups according to the IUCN Red List: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), and Least Concern (LC). Among 20 species recorded, Clouded leopard (*Neofelis nebulosa)*, Leopard (*Panthera pardus*), Marble cat (*Pardofelis marmorata*), Himalayan Black Bear (*Ursus thibetanus laniger*) and Capped langur (*Trachypithecus pileatus*) are vulnerable, two species are Near threatened, one species is Endangered, and the rest of the ten species comes under the category of Least concerned.

Table 2: Complete list of mammal species which is encountered during field survey by direct and indirect evidence

Sl. No.	Common name	Scientific name	Family	Order	IUCN Status	Direct/Indirect Method	Indirect sign
1	Orange-bellied Himalayan squirrel	*Dremomys lokriah*	Sciuridae	Rodentia	LC	Direct sighting	-
2	Himalayan striped squirrel	*Tamiops macclellandi*	Sciuridae	Rodentia	LC	Direct sighting	-
3	Himalayan giant squirrel	*Ratufa bicolor*	Sciuridae	Rodentia	NT	Direct sighting	-
4	Hoary-bellied squirrel	*Callosciurus pygerythrus*	Sciuridae	Rodentia	LC	Direct sighting	-
5	Barking Deer	*Muntiacus muntjak*	Cervidae	Artiodactyla	LC	Direct sighting and indirect evidence	Pellet
6	Wild boar	*Sus scrofa*	Suidae	Artiodactyla	LC	Indirect evidence	Camera trap photo
7	Large Indian Civet	*Viverra zibetha*	Viverraidae	Carnivora	LC	Direct sighting	-
8	Leopard	*Panthera pardus*	Felidae	Carnivora	VU	Indirect evidence	Scat
9	Clouded Leopard	*Neofelis nebulosa*	Felidae	Carnivora	VU	Indirect evidence	Camera trap photo

10	Leopard Cat	*Prionailurus bengalensis*	Felidae	Carnivora	LC	Indirect evidence	Camera trap photo
11	Marble Cat	*Pardofelis marmorata*	Felidae	Carnivora	VU	Indirect evidence	Camera trap photo
12	Jungle Cat	*Felis chaus*	Felidae	Carnivora	LC	Indirect evidence	Scat
13	Malayan porcupine	*Hystrix brachyura*	Hystricidae	Rodentia	LC	Indirect evidence	Quills found
14	Jungle dog (Dhole)	*Cuon alpinus*	Canidae	Carnivora	EN	Indirect evidence	Scat, Secondary information through questionnaire survey
15	Capped Langur	*Trachypithecus pileatus*	Cercopithecidae	Primate	VU	Direct sighting	-
16	Yellow throated marten	*Martes flavigula*	Mustelidae	Carnivora	LC	Direct sighting	-
17	Himalayan Serow	*Capricornis thar*	*Bovidae*	Cetartiodactyla	NT	Indirect evidence	Camera trap photo
18	Himalayan Black Bear	*Ursus thibetanus laniger*	Ursidae	Carnivora	VU	Indirect evidence	Scat
19	Mouse (Yet to be identified)	-	Muridae	Rodentia		Direct sighting	-
20	Bat (Yet to be identified)	-	-	Chiroptera	-	Direct sighting	-

Note: LC= Least Concern, VU= Vulnerable, NT= Near Threatened, EN= Endangered

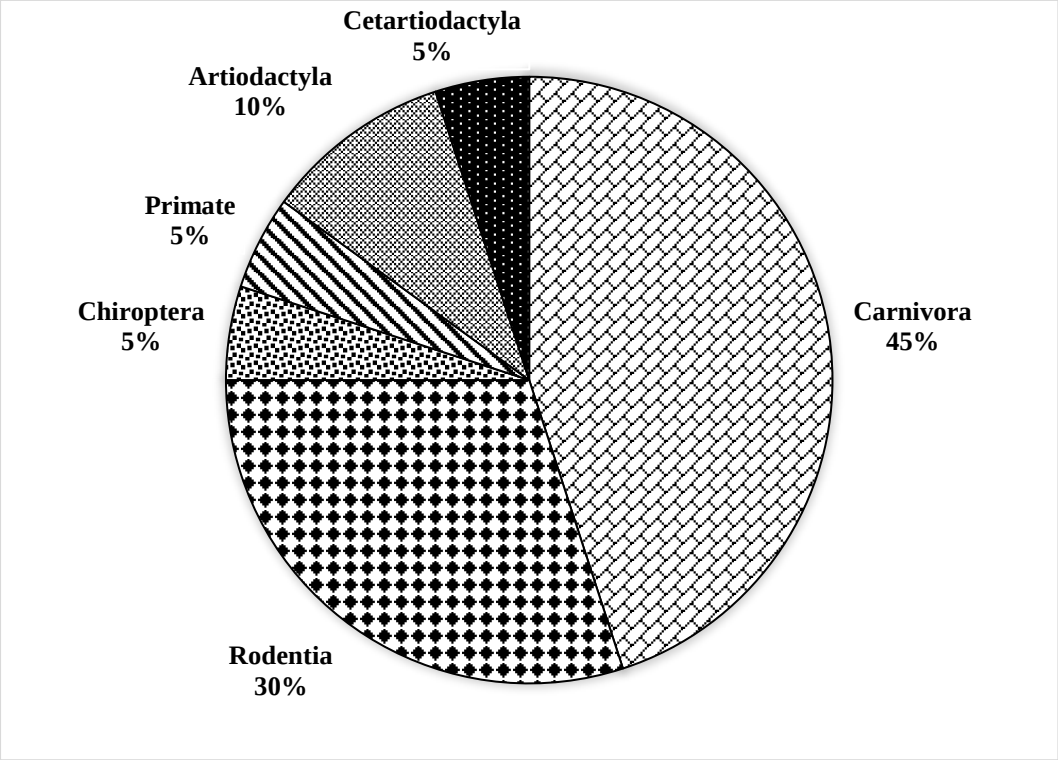

Figure 3: Contribution of mammal species in each of the recorded order.

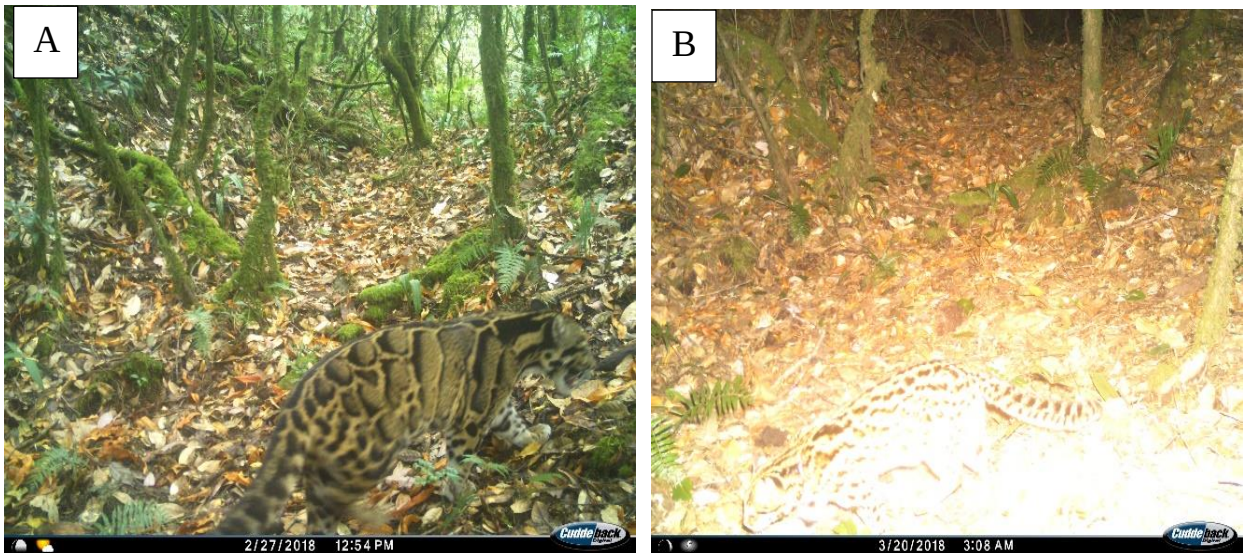

Photo plate 1: (A) *Neofelis nebulosi* (Clouded leopard) and (B) *Prionailurus bengalensis* (Leopard cat).

Survey of Avian diversity

Background of the study

In Talley Valley wildlife sanctuary (TVWLS), the habitat preference of birds varies from dense canopy to thick undergrowth of Rainforest floor and bamboo thickets, where they can camouflage easily. These diverse habitat of Talley Valley Wildlife Sanctuary confers a suitable place for numerous biodiversity, including avifaunal wealth (Krishna et al. 2015). The number of species tends to increase as the new species are every year from the region.

The survey of avian diversity started from February 2017 to September 2018 in TVWLS, following both direct and indirect methods. Regularly field visit was made in the sanctuary during the study period (2017-2018) covering all the seasons for study of bird diversity.

Methodology:

Following the direct method, line transects method was employed in the existing trials of the sanctuary. A walked along the transect was done during peak bird activity time between 06.00 to 09.00 am and 03.00 pm to 05.00 pm, covering 10-15 km a day (Javed & Kaul 2002). Whenever birds are sighted, stopped for a while, and took photographs of the species, observed the habitat type, record the number of individuals and GPS point. The identification of the species and their IUCN status was made using the Birds field guide books (Grimmett et al., 2011). Indirect information of birds was also recorded by showing photographs of birds from the field guidebook to the local people and forest staff to ensure the presence of the species in the sanctuary.

Birds were observed using 8X40 Action EX Nikon Binocular and took photographs using Nikon D7100 with 200-500mm lens and Nikon D5200 with 200mm lens.

Results:

All the data is based on field observation from February 2017 to September 2018. A total of 80 bird species was recorded which belongs to 23 families (Table 3). Muscicapidae family recorded the highest number of species (n=19) followed by Garrulacinae (n=10), Nectariniidae (n=9), Corvidae and Motacillidae (n=5each) and Passeridae and Sylviidae (n=4 each) (Figure 4). One species, i.e., Rufous-throated partridge (*Arborphila rufogularis*), falls under the category of Vulnerable and one species, i.e., Blyth's Kingfisher (*Alcedo Hercules*) falls under Near-Threatened as per IUCN red list threatened species conservation status (Figure 5).

Table 3: List of bird species encountered during the field survey in Talley Valley wildlife sanctuary

Sl. No.	Common Name	*Scientific Name*	Family	IUCN status
1	Red whiskered bulbul	*Pycnonotus jocosus*	Pycnonotidae	LC
2	Verditer flycatcher	*Eumyias thalassinus*	Muscicapidae	LC
3	Grey headed canary flycatcher	*Culicicapa ceylonensis*	Stenostiridae	LC
4	Beautiful sibia	*Heterophasia pulchella*	Leiothrichidae	LC
5	Blue fronted redstart	*Phoenicurus frontalis*	Muscicapidae	LC
6	Paddyfield pipits	*Anthus rufulus*	Passeridae	LC

7	Ashy drongo	*Dicrurus leucophaeus*	Corvidae	LC
8	Common hoopoe	*Upupa epops*	Upupidae	LC
9	Green backed tit	*Parus monticolus*	Paridae	LC
10	Green tailed sunbird	*Aethopyga nipalensis*	Nectariniidae	LC
11	Plumbeous water redstart	*Rhyacornis Fulginosus*	Muscicapidae	LC
12	Black throated sunbird	*Aethopyga Saturata*	Nectariniidae	LC
13	Longtailed minivet	*Pericrocotus ethologus*	Corvidae	LC
14	White capped redstart	*Chaimarrornis leucocephalus*	Muscicapidae	LC
15	Russet sparrow	*Passer rutilans*	Passeridae	LC
16	White throated fantail	*Rhipidura albicollis*	Corvidae	LC
17	Black redstart*	*Phoenicurus ochruros*	Muscicapidae	LC
18	White collared black bird	*Turdus albocinctus*	Turdidae	LC
19	Whiskered yuhina	*Yuhina flavicollis*	Sylviidae	LC
20	Yellow cheeked tit	*Parus spilonotus*	Paridae	LC
21	Red billed leiothrix	*Leiothrix lutea*	Sylviidae	LC
22	Blyths kingfisher	*Alcedo hercules*	Alcedinidae	NT
23	Ashy wood pigeon	*Columba pulchricollis*	Columbidae	LC
24	Grey chinned minivet	*Pericrocotus solaris*	Corvidae	LC
25	Sultan tit	*Melanochlora sultanea*	Paridae	LC
26	Stripe throated yuhina	*Yuhina gularis*	Sylviidae	LC
27	Black bulbul	*Hypsipets leucocephalus*	Pycnonotidae	LC
28	Bhutan laughing thrush	*Trochalopetron imbricatum*	Leiothrichidae	LC
29	Grey bushchat	*Saxicola ferrea*	Muscicapidae	LC
30	Golden brested fulvetta	*Alcippe chrysotis*	Sylviidae	LC
31	Mrs. Goulds sunbird	*Aethopyga gauldiae*	Nectariniidae	LC
32	Fire brested flowerpecker	*Dicaeum ignipectus*	Nectariniidae	LC
33	Scaly brested munia	*Lonchura punctulata*	Passeridae	LC
34	Scarlet minivet	*Pericrocotus flanmeus*	Corvidae	LC
35	Rufous-throated Patridge	*Arborophila rufogularis*	Phasianidae	VU
36	Greater Yellownape	*Chrysophlegma flavinucha*	Picidae	LC
37	Creasted/Pied Kingfisher	*Megaceryle lugubris*	Alcedinidae	LC
38	Rufous-breasted Accentor	*Prunella strophiata*	Passeridae	LC
39	Orange-bellied leafbird	*Chloropsis hardwickii*	Irenidae	LC
40	White-crested laughingthrush	*Garrulax leucolophus*	Garrulacinae	LC
41	Scaly-laughingthrush	*Garrulax subunicolor*	Garrulacinae	LC
42	Black-faced laughingthrush	*Garrulax affinis*	Garrulacinae	LC
43	Chestnut-crowned laughingthrush	*Garrulax erythrocephalus*	Garrulacinae	LC
44	Red-faced liocichla	*Liocichla phoenicea*	Garrulacinae	LC
45	Greater-necklaced laughingthrush	*Garrulax pectoralis*	Garrulacinae	LC
46	Grey-sided laughingthrush	*Garrulax caerulatus*	Garrulacinae	LC
47	White-throated laughingthrush	*Garrulax albogularis*	Garrulacinae	LC
48	Slaty-blue flycatcher	*Ficedula monileger*	Muscicapidae	LC

49	Pale blue flycatcher	*Cyornis unicolor*	Muscicapidae	LC
50	Fire-tailed sunbird	*Aethopiga ignicauda*	Nectariniidae	LC
51	Mrs gould's sunbird	*Aethopyga gouldiae*	Nectariniidae	LC
52	Green-tailed sunbird	*Aethopyga nipalensis*	Nectariniidae	LC
53	Black-throated sunbird	*Aethopyga saturate*	Nectariniidae	LC
54	Streaked spiderhunter	*Arachnothera magna*	Nectariniidae	LC
55	Scaly-breasted munia	*Lonchura punctulata*	Estrildidae	LC
56	Long-tailed broadbill	*Psarisomus dalhIousiae*	Eurylaimidae	LC
57	Oriental hobby	*Falco severus*	Falconidae	LC
58	Common kestrel	*Falco tinnunculus*	Falconidae	LC
59	Striated laughingthrush	*Garrulax striatus*	Garrulacinae	LC
60	Spotted laughingthrush	*Garrulax ocellatus*	Garrulacinae	LC
61	Great barbet	*Megalaima virens*	Megalaiminae	LC
62	Golden-throated barbet	*Megalaima franklinii*	Megalaiminae	LC
63	Blue-throated barbet	*Megalaima asiatica*	Megalaiminae	LC
64	Striated grassbird	*Megalurus palustris*	Megaluridae	LC
65	White wagtail	*Motacilla alba*	Motacillidae	LC
66	Yellow wagtail	*Motacilla flava*	Motacillidae	LC
67	Grey wagtail	*Motacilla cinerea*	Motacillidae	LC
68	Olive-backed pipit	*Anthus hodgsoni*	Motacillidae	LC
69	Rosy pipit	*Anthus roseatus*	Motacillidae	LC
70	Dark-sided flycatcher	*Muscicapa sibirica*	Muscicapidae	LC
71	Rufous-gorgetted flycatcher	*Ficedula strophiata*	Muscicapidae	LC
72	Snowy-browed flycatcher	*Ficedula hyperythra*	Muscicapidae	LC
73	Verditer flycatcher	*Eumyias thalassina*	Muscicapidae	LC
74	Large niltava	*Niltava grandis*	Muscicapidae	LC
75	Rufous-bellied niltava	*Niltava sundara*	Muscicapidae	LC
76	Small niltava	*Niltava macgrigoriae*	Muscicapidae	LC
77	Grey-headed canary flycatcher	*Culicicapa ceylonensis*	Muscicapidae	LC
78	Little pied flycatcher	*Ficedula westermanni*	Muscicapidae	LC
79	Ultramarine flycatcher	*Ficedula superciliaris*	Muscicapidae	LC
80	Sapphire flycatcher (r)	*Ficedula sapphire*	Muscicapidae	LC

Note: LC= Least Concern, VU= Vulnerable, NT= Near Threatened

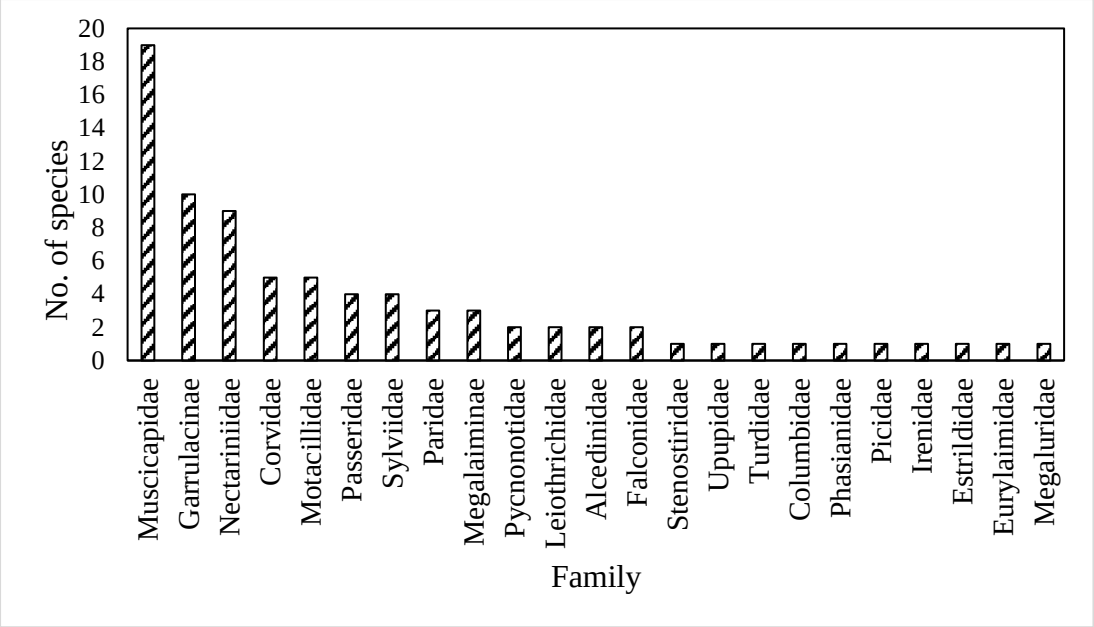

Figure 4: Number of bird species with respect to their recorded families

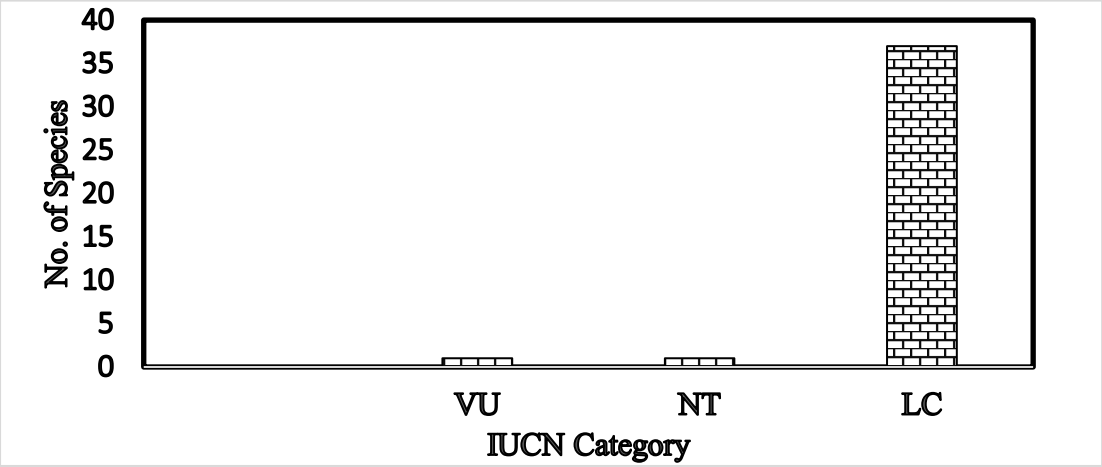

Figure 5: Bird species under IUCN conservation status

Discussion:

Birds are a familiar feature of any natural habitat due to their varied lifestyles, conspicuousness, diurnal habits and interesting plumage and calls. Thus, it attracts any visitors in the habitat. Birds are also regarded as good indicators of biodiversity (Green and Baker, 2002). Birds occupy almost all habitat types and diversity of birds often serves as a good indication of overall diversity of a given area. Vegetation of the Talley Valley Wildlife sanctuary provides food and habitat for diverse bird species. Krishna et al. (2015) reported a total of 130 species from 90 genera belonging to 37 families and 12 orders. Global biodiversity conservation has become prime importance in recent decades for conservationists who are tackling with conservation challenges occurring due to anthropogenic disturbances to biodiversity.

Herpetofauna

Background of the study

Amphibians and reptiles are a diverse group of fauna that is widely distributed all over the world. However, the study is instead a challenging task because these animals are not active the whole day and the observation is mainly based on opportunistic sightings. The number of amphibian species estimated is to be around 5000 species in the world. It contains around 4204 species of frog and toads; 411 salamanders and 165 caecilians (Daniels 2005).

The number of amphibian species in India is estimated to be more than 300 species and it is growing continuously every year (Daniels 2005). The number of reptile species found in India is around 518 species, including three species of crocodiles, 34 of turtles & tortoises, 202 lizards, and 279 snakes (Aengals et al. 2011). The book "Amphibians and Reptiles of Northeast India- A Photographic Guide" (Schaffer 2011) provides detailed information about 100 species of amphibians and reptiles in the northeast. It also provides a checklist of around 275 different species present in northeast India.

Arunachal Pradesh, being a biodiversity hotspot, holds a great diversity of amphibians and reptiles in its different habitats along different altitudinal variations. Major work on amphibians and reptiles in Arunachal Pradesh has been done in Eagle nest wildlife sanctuary. Various checklists of amphibians and reptiles were already been prepared by different researchers (Zambre et al. 2009, Agarwal et al. 2010, Sondhi & Ohler 2011).

Methodology

The herpetofauna survey was carried out in different areas of Talley Valley wildlife sanctuary using the Visual Encounter Survey (VES) as per Campbell & Christman (1982), one of the most widely used and efficient methods to observe the presence of amphibians and reptiles in the area. VES can be conducted using three ways (Crump 1994), i.e., Randomised walk, Transects and Quadrat. During the study the survey was conducted using the line transect method to estimate encounter rate of each species sighted during the survey. Transects were laid based on the habitat type and altitude and repeated during the survey period (Chetry & Chetry 2011). Four permanent transects were established with 2 m band on both sides of a transect. Transects were surveyed for the number of days and the different species found along the transact was recorded in terms of their number of individuals with time, GPS points and habitat characteristics. While walking through the tracts, light touch technique (Lowe & Bolger 2002)i.e., checking for species under fallen wood and stones and the leaves deposit and both terrestrial and arboreal observations were made. During the night survey, torchlights were used for observing species along and in the water bodies.

Result

Amphibians:

A total of 13 species (including two unidentified) of amphibians belong to 5 known families (Rhacophoridae, Megophryidae, Bufonidae, Ranidae and Dicroglossidae) and 8 genera were recorded (Table 4). The genus Rhacoporus was found more prominently with the highest percentage (78.95%) followed by Xenophrys (7.46 %), Odorrana (5.26%) (Figure 6).

Table 4: Amphibian species diversity of Talley Valley wildlife sanctuary and its adjacent areas.

Sl. No.	Common Name	Scientific Name	Family	IUCN status
1	Twin spotted frog	*Rhacophorus bipunctatus*	Rhacophoridae	LC
2	-	*Rhacophorus subansiriensis*	Rhacophoridae	-
3	-	*Odorrana arunachalensis*	Ranidae	-
4	Common asian toad	*Duttaphrynus melanostictus*	Bufonidae	LC
5	Glandular Horned Toad	*Xenophrys cf. major*	Megophryidae	LC
6	Large Tree Frog	*Rhacophorus maximus*	Rhacophoridae	LC
7	Himalayan tree frog	*Polypedates himalayensis*	Rhacophoridae	LC
8	-	*Polypedates cf. himalayensis*	Rhacophoridae	LC
9	-	*Nanorana spp.*	Dicroglossidae	-
10	Smith's litter frog	*Leptobrachium smithi*	Megophryidae	LC
11	-	*Amolops spp.*	Ranidae	-
12	-	Unidentified sp 1	-	-
13	-	Unidentified sp 2	-	-

Note: LC= Least Concern

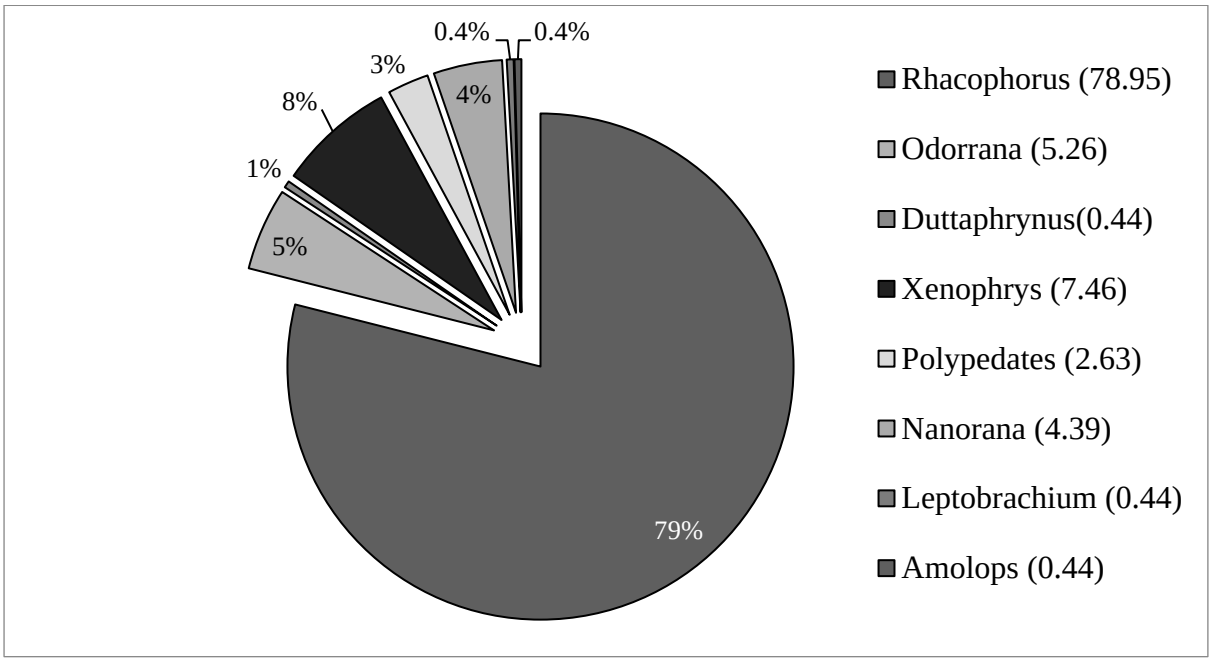

Figure 6: Diversity and its proportion of amphibian species

Reptiles:

5 species of lizard belonging to 4 genera (Eutropis, Japalura, Pseudocalotes and Ophisaurus) under 3 families (Scincidae, Agamidae, Anguidae), and 7 species (including 1 unidentified) of

snake belonging to 5 genera (Lycodon, Ovophis, Protobothrops, Ptyas and Psedoxendon) under 2 families (Colubridae and Viperidae) were recorded.

Table 5: List of reptile species observed in Talley Valley Wildlife Sanctuary

Sl. No.	Common Name	Scientific Name	Family	IUCN status
1	Bronze grass skink	*Eutropis macularia*	Scincidae	LC
2	Many lined sun skink	*Eutropis multifasciata*	Scincidae	LC
3	Annandale's Mountain Lizard	*Japalura andersoniana*	Agamidae	LC
4	Arunachal lizard	*Pseudocalotes cf. austeniana*	Agamidae	LC
5	Asian glass Lizard	*Ophisaurus gracilis*	Anguidae	LC
6	Gammie's wolf snake	*Lycodon gammiei*	Colubridae	NT
7	White-banded wolf snake	*Lycodon septentrionalis*	Colubridae	LC
8	Mountain pit viper	*Ovophis monticola*	Viperidae	LC
9	Jerdon's pit viper	*Protobothrops jerdonii*	Viperidae	LC
10	Large eyed false cobra	*Pseudoxenodon macrops*	Colubridae	LC
11	Green rat snake	*Ptyas nigromarginata*	Colubridae	LC
12	-	Unidentified sp 3	-	-

Note: LC= Least Concern, NT= Near Threatened

Discussion

Herpetofauna (reptiles and amphibians) are essential components of terrestrial and wetland ecosystems as they play a significant role in the energy flow and nutrients cycle. Both are also excellent indicators of environmental degradation. Northeast is home to more than 146 species of amphibian out of which 53 are considered to be endemic (Saikia & Kharkongor 2017). Arunachal Pradesh in Northeast India is the land where many unknown species of amphibians and reptiles live as new species are continuously being discovered each coming year. In Arunachal Pradesh, Talley valley wildlife sanctuary harbours tremendous biodiversity for different species of reptiles and amphibians. Different areas of Talley valley wildlife sanctuary were covered during the study period. A total of 25 samples were collected and identified, including 13 species of amphibians and 12 species of reptiles.

Butterfly diversity

Butterflies are considered as good indicators of the health of any specified terrestrial ecosystem (New 1991, Pollard et al. 1994, Kunte 2000, Thomas 2005). The presence of butterflies is considered as the reflection of level of human disturbance and habitat features (Kunte et al. 1999, Kocher & Williams 2000, Kunte 2000) due to its greater sensitivity than many other taxonomic groups (Thomas et al. 2004, Thomas 2005). These species respond more quickly to environmental changes than other taxonomic groups, such as vascular plants or birds (Erhardt & Thomas 1991, Thomas et al. 2004). Butterfly populations are influenced by climate change and also increase in temperature can extend the geographic range of many temperate region butterflies (Settele et al. 2008). Change in their habitat can also influence the declination of the

butterfly population. The Indian subcontinent has a diverse landscape and vegetation that host many species of butterflies. Many studies regarding butterflies have been done in India as it reflects the ecosystem's health.

Methodology:

The butterflies were observed and recorded directly in the field following "Pollard Walk" method (Pollard 1977, Pollard et al. 1994) with necessary modifications. Data that has been collected from a transect walk provide an index of abundance (Zonneveld 1991). The transact walk occur along fixed path through butterfly flight period. For each site two transect route of 1 kilometre (1000m each) in 200m-gap was selected for this study and Individuals were counted on either side of the path (at a distance of 2.5 m). Butterfly species were identified directly in the field. No capture or collections of butterflies were made during the observation period. Butterflies were photographed from different angles to enable positive identification of species. Butterflies were identified using suitable keys (Kehimkar 2008). Photographs of the butterflies were taken using camera Nikon D7100 with 200-500mm lens and Nikon D5200 with 200mm lens during the survey.

Results:

During this study, 18 butterfly species were observed in the study site (Table 6), and these belonged to eight families (Papilionidae, Hesperiidae, Lycaenidae, Nymphalidae, Pieridae, Limenitidinae, Danainae and Riodinidae). Nymphalidae showed maximum species richness, comprising of (4 species 22%), followed by Papillionidae (17%), Lycaenidae (17%), Hesperiidae (17%) and Limemitidae (11 %) (Figure 7).

Table 6: List of butterfly species encountered during field survey at Talley valley wildlife sanctuary

Sl. No	Common Name	Scientific Name	Family
1	Common peacock	*Papilio crino*	Papilionidae
2	Mussoorie pied flat	*Celaenorrhines pero*	Hesperiidae
3	Tailed punch	*Dodona eugenes*	Lycaenidae
4	Common woodbrown	*Lethe sidonis*	Nymphalidae
5	Large silverstripe	*Childrena childreni*	Nymphalidae
6	Blue tit	*Chliaria kina*	Lycaenidae
7	Common wind mill	*Atrophaneura polyeuuctes*	Papilionidae
8	Patkai dark jezebel	*Delias berinda*	Pieridae
9	The banded tit	*hipolycaena narada*	Lycaenidae
10	Bhutanese dusky labyrinth	*Neope yama yama*	Nymphalidae
11	Himalayan rusty sailor	*Neptis sappho pllas*	Limenitidinae
12	Himalayan chestnut tiger	*Parantica sita*	Danainae
13	Himalayan spotted demon	*Tocrypta feisthamelii alysos*	Hesperiidae
14	Variable ace	*Thoressa hyrie*	Hesperiidae
15	Nepalese tawny mime	*Papilio agestor agestor*	Papilionidae

16	Himalayan lesser punch	*Dodona dipoea*	Riodinidae
17	Baron	*Euthalia* spp.	Limenitidinae
18	Dull forester	*Lethe gulnihal gulnihal*	Nymphalidae

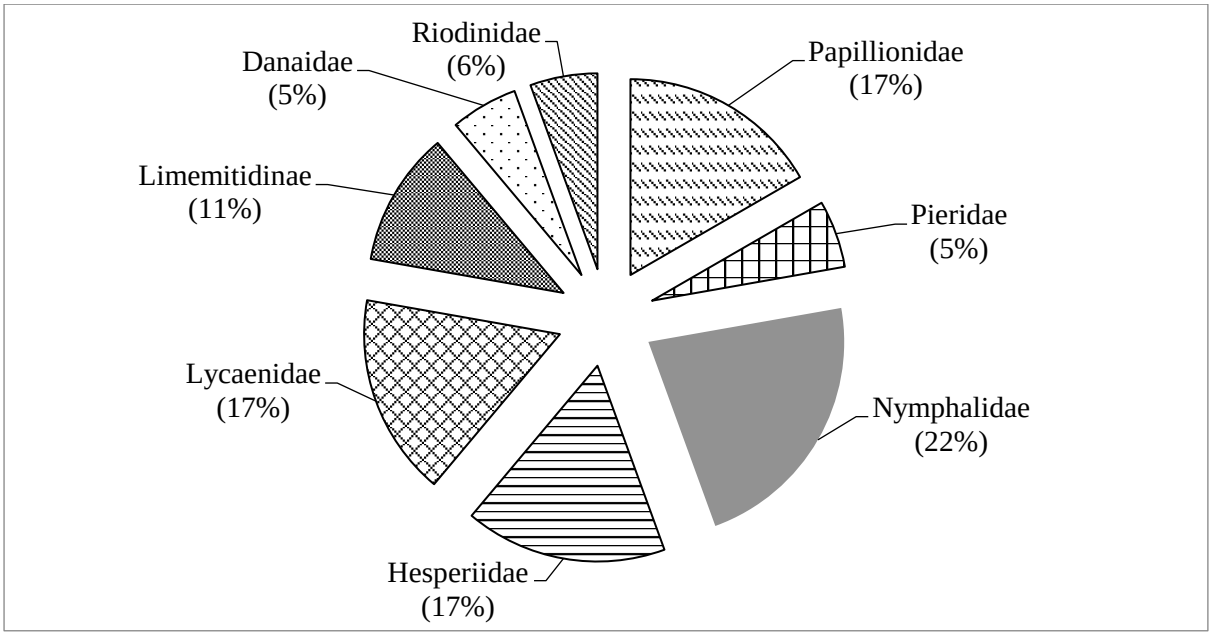

Figure 7: Percentage composition of butterfly species in each recorded family.

Discussion:

Survey tour which had been conducted within the studied time frame can covered a little portion of Talley Valley Wildlife Sanctuary, so it would be harder to estimate the abundance of different butterfly species present in this magnificent and diverse land. It provides diverse habitat to a wide variety of butterfly species and plays an important role in butterfly conservation and maintain a healthy forest.

Objective 2: To study the distribution of plant communities along with a climatic, edaphic and topographical gradient in wildlife surveyed areas and other parts of the sanctuary.

Methodology:

Vegetation survey:

Vegetation analysis of the areas were studied as per the standard taxonomic procedure through collection and identification of plant species by using quadrats and belt transects methods as per the suitability of the geographical area of the study site. Quadrats and transects were laid randomly to cover all representative areas of sanctuary in 100 m altitude intervals. Random quadrat of 10m x 10m size were laid for trees and within the same 10m x 10m quadrat, one 5mx5m quadrat for shrubs and two 1m x 1m quadrats for herbs were laid (Schemnitz 1980). In each plot, all woody plants with > 5 cm DBH (diameter at breast height, 1.3 m) were identified at the species level and their height were measured with hypsometer and DBH with a measuring tape. Plant species which were unable to identify in the field, specimens were collected for future identification. The collected specimen was identified consulting relevant literature like, Flora of Arunachal Pradesh (Hajra et al. 1996) and based on personal taxonomic knowledge.

Herbariums for all the collected species were prepared following Jain (1977). Each plot's spatial location (latitude, longitude and altitude) was recorded by using a Global Positioning System (GPS). All the variables such as vegetation types, varied elevations, slopes, aspects, and temperature gradients were taken into consideration for the study.

Data analysis

The collected data were analysed for community parameters and relative values of frequency, density, abundance, based area, basal cover, importance value index, species diversity and similarity index following standard community analysis methods (Muller-Dombois n.d., 1974; Kent & Coker 1994). Further these data were analysed for the number of species, stand density (trees) ha^{-1}, basal area m^2ha^{-1}, diversity (Shannon index, (Shannon & Weiner 1949) and Simpson dominance index (Simpson 1949). The altitude, slope and aspect were generated in a digital format with the aid of a digital elevation model (following QGIS software procedures) from the Survey of India map sheets (Figure 8).

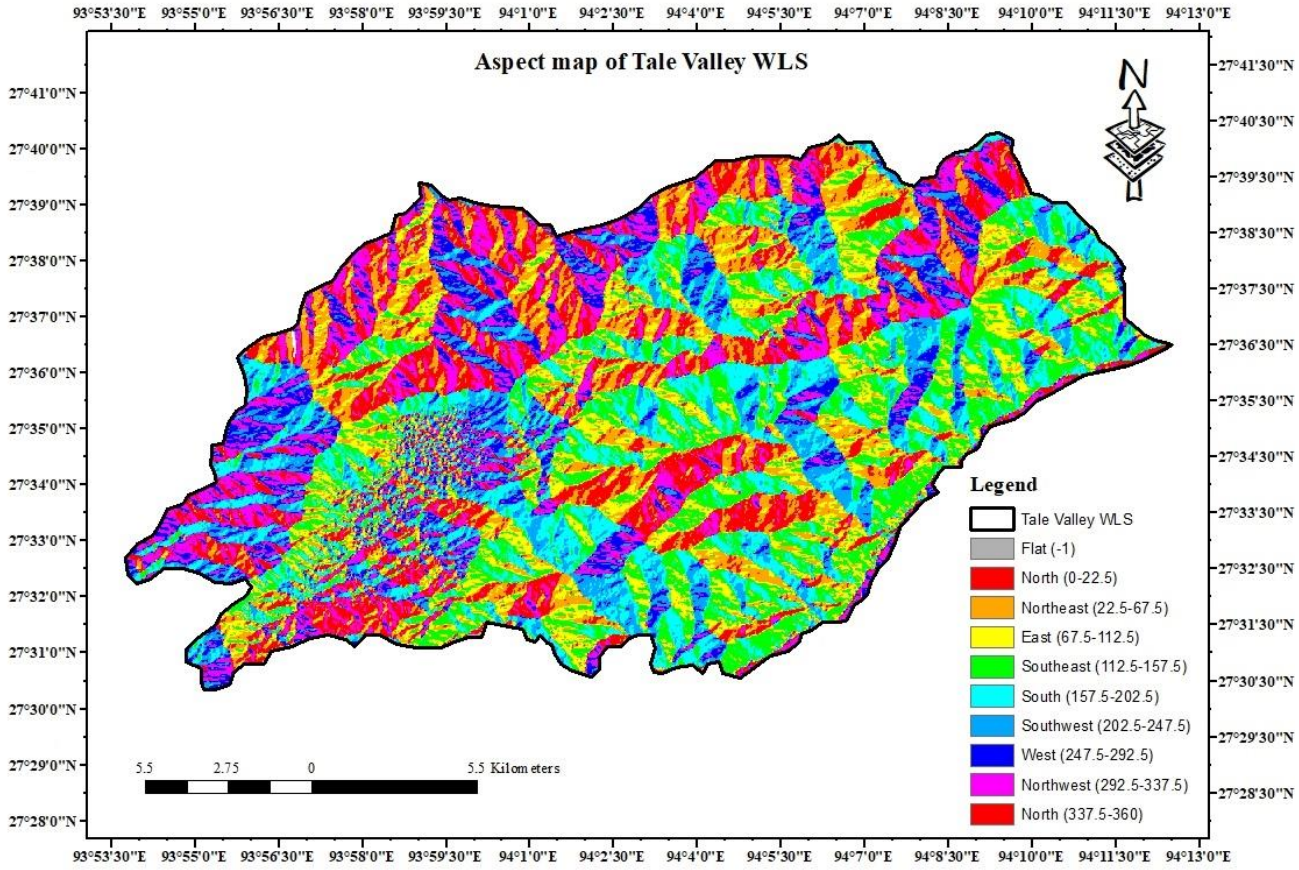

Figure 8: Aspect map of Talley valley Wildlife Sanctuary

Result:

A total of 158 plant species belonging to 102 genera under 67 families were recorded. 99 species were trees with 51 genera under 32 families; 12 species were recorded for shrubs belonging to 11 genera and 10 families; 47 species were herbs belonging to 40 genera and 28 families. The Ericaceae family (19) was recorded as the highest number of species in tree species, followed by Lauraceae and Fagaceae having 10 species each. In shrubs, Acanthaceae

and Rosaceae were the dominant families having two species each and in herbs, Rosaceae and Urticaceae (4) was the dominant family followed by Araceae and Rananculaceae with three species each.

Among trees, *Acer pictum* Thunb. (30.52; SI- 0.01) was found to be the most dominant species followed by *Cedrus deodara* (Roxb. ex D.Don) G.Don (IVI-17.78; SI- 0.003) and *Abies densa* Griff (IVI- 14.80), whereas *Garcinia lancifolia* (G. Don) Roxb. (IVI-0.432) was the least dominant species followed by *Cupressus torulosa* D.Don (IVI-0.433) (Table 7). Among shrub, *Debregeasia longifolia* (Burm.f.) Wedd., (IVI-69.06) was the most dominant species followed by *Gaultheria fragrantissima* Wall., (IVI-62.16) and *Oxyspora corniculata* (IVI- 38.06), whereas *Ardisia crenata* Roxb., and *Justicia adhatoda* L., (IVI-4.68) was the least dominant species followed by *Rubus foliolosus* D.Don, (IVI-7.65) (Table 8). Among herbs, *Potentilla indica* (Andrews) Th.Wolf, (IVI-26.68) was found to be the most dominant species followed by *Plantago major* L. (IVI- 26.45) and *Rubus calycinus* Wall. (IVI-20.36), whereas *Colocasia esculenta* (IVI-0.56) was the least dominant species followed by *Smilax perfoliata* Blume. (IVI-0.92) (Table 9).

Diversity, Evenness, dominance, and Menhinick index

For tree species, the values of Shannon Weiner and Simpson diversity index were found to be 3.90 and 0.968, respectively. The Menhinick index of species richness was observed at 3.85 and the evenness was 0.849 (Table 10). Concerning distribution pattern, most tree species were recorded as contagious distribution.

For shrub species, the value of Shannon Weiner diversity of shrub layer was found 2.16, Simpson diversity index as 0.859, Menhinick as 0.751, evenness as 0.871 (Table 10). The abundance and frequency ratio showed a contagious distribution pattern with 12 (100%).

Among the different diversity indices for herb species, the Shannon Weiner diversity was recorded as 3.51, Simpson as 0.962, Menhinick index as 0.784 and evenness 0.913 (Table 10). The abundance and frequency ratio exhibit a contagious distribution pattern.

Table 7: Overall density (individuals ha^{-1}), Frequency, basal area (m^2ha^{-1}) and Importance value index of tree species Talley Valley Wildlife Sanctuary, Arunachal Pradesh

Sl. No.	Scientific Name	Family	Density (ha^{-1})	Freq-uency (%)	Basal area (m^2 ha^{-1})	IVI
1	*Abies densa* Griff	Pinaceae	39.06	20.31	4.07	14.80
2	*Abies spectabilis* (D.Don) Mirb	Pinaceae	31.25	15.63	3.39	11.98
3	*Acer acuminatum* Wall. ex D.Don	Sapindaceae	14.06	7.81	0.23	3.17
4	*Acer oblongum* Wall. ex DC	Sapindaceae	7.81	6.25	0.91	3.53
5	*Acer pictum* Thunb.	Sapindaceae	139.06	56.25	3.87	30.50
6	*Acer sikkimense* Miq	Sapindaceae	48.44	29.69	0.99	11.75
7	*Actinodaphne obovata* (Nees) Blume	Lauraceae	1.56	1.56	0.01	0.44

8	*Alnus nepalensis* D.Don	Betulaceae	4.69	3.13	0.08	1.15
9	*Amoora wallichii* King	Meliaceae	1.56	1.56	0.00	0.43
10	*Berchemia floribunda* (Wall.) Brongn.	Rhamnaceae	26.56	10.94	0.50	5.43
11	*Betula alnoides* Buch.-Ham. ex D.Don	Betulaceae	7.81	6.25	0.25	2.33
12	*Brassaiopsis glomerulata* (Blume) Regel	Araliaceae	4.69	4.69	0.26	1.76
13	*Camellia lutescens* Dyer	Theaceae	1.56	1.56	0.00	0.44
14	*Castanopsis armata* (Roxb.) Spach	Fagaceae	4.69	4.69	0.25	1.73
15	*Castanopsis hystrix* Hook. f. & Thomson ex A. DC	Fagaceae	21.88	9.38	1.36	6.26
16	*Castanopsis indica* (Roxb. ex Lindl.) A.DC	Fagaceae	3.13	1.56	0.17	0.89
17	*Castanopsis tribuloides* (Sm.) A.DC.	Fagaceae	18.75	7.81	1.12	5.25
18	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Pinaceae	35.94	17.19	6.17	17.79
19	*Chukrasia tabularis* A.Juss	Meliaceae	3.13	3.13	0.02	0.88
20	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	Lauraceae	4.69	4.69	0.57	2.32
21	*Cinnamomum glaucescens* (Nees) Hand.-Mazz	Lauraceae	18.75	17.19	1.12	6.90
22	*Cinnamomum sps*	Lauraceae	7.81	6.25	1.06	3.81
23	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm	Lauraceae	4.69	3.13	0.20	1.37
24	*Cinnamomum verum* J.Presl	Lauraceae	1.56	1.56	0.04	0.51
25	*Corylopsis sinensis* Hemsl.	Hamamelidaceae	4.69	1.56	0.01	0.75
26	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	Cupressaceae	15.63	6.25	0.91	4.29
27	*Cupressus torulosa* D.Don	Cupressaceae	1.56	1.56	0.00	0.43
28	*Daphne papyracea* Wall. ex G. Don	Thymelaeaceae	9.38	7.81	0.04	2.37
29	*Engelhardtia spicata* Lechen ex Blume	Juglandaceae	1.56	1.56	0.12	0.65
30	*Exbucklandia populnea* (R.Br. ex Griff.) R.W.Br	Hamamelidaceae	68.75	21.88	0.82	12.04
31	*Garcinia lancifolia* (G. Don) Roxb.	Clusiaceae	1.56	1.56	0.00	0.43
32	*Hydrangea paniculata* Siebold	Hydrangeaceae	3.13	1.56	0.01	0.59
33	*Ilex dipyrena* Wall.	Aquifoliaceae	1.56	1.56	0.00	0.44
34	*Itea macrophylla* Wall.	Iteaceae	1.56	1.56	0.12	0.64

35	*Lindera pulcherrima* (Nees) Hook. f	Lauraceae	9.38	9.38	0.06	2.67
36	*Lithocarpus dealbatus* (Hook.f. & Thomson ex Miq.) Rehder	Fagaceae	35.94	20.31	3.47	13.41
37	*Lithocarpus elegans* (Blume) Hatus. ex Soepadmo	Fagaceae	1.56	1.56	0.07	0.55
38	*Litsea cubeba* (Lour.) Pers.	Lauraceae	7.81	6.25	0.14	2.12
39	*Machilus gamblei* King ex Hook. f.	Lauraceae	1.56	1.56	0.00	0.44
40	*Maesa indica* (Roxb.) A. DC	Primulaceae	3.13	3.13	0.01	0.87
41	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	4.69	3.13	0.24	1.45
42	*Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar	Magnoliaceae	7.81	6.25	0.49	2.75
43	*Mahonia napaulensis* DC	Berberidaceae	4.69	3.13	0.01	1.03
44	*Melliodendron xylocarpum* Hand.-Mazz.	Styracaceae	1.56	1.56	0.67	1.66
45	Moreh sapi (Apatani name)		1.56	1.56	0.00	0.44
46	*Phoebe paniculata* (Nees) Nees	Lauraceae	6.25	6.25	0.55	2.72
47	*Photinia integrifolia* Lindl.	Rosaceae	1.56	1.56	0.06	0.54
48	*Photinia serratifolia* (Desf.) Kalkman	Rosaceae	1.56	1.56	0.00	0.44
49	*Pinus roxburghii* Sarg	Pinaceae	15.63	9.38	0.60	4.26
50	*Pinus wallichiana* A.B.Jacks	Pinaceae	25.00	12.50	1.03	6.51
51	*Prunus cerasoides* Buch.-Ham. ex D.Don	Rosaceae	28.13	12.50	0.76	6.32
52	*Prunus nepalensis* Hook.f.	Rosaceae	9.38	6.25	0.14	2.28
53	*Prunus sps.*	Rosaceae	3.13	1.56	0.06	0.68
54	*Pterospermum acerifolium* (L.) Willd.	Malvaceae	6.25	3.13	0.04	1.23
55	*Quercus glauca* Thunb.	Fagaceae	32.81	12.50	3.52	11.83
56	*Quercus lamellosa* Sm.	Fagaceae	37.50	15.63	2.61	11.17
57	*Quercus lineata* Blume	Fagaceae	10.94	4.69	0.77	3.29
58	*Quercus semiserrata* Roxb.	Fagaceae	12.50	4.69	0.49	2.93
59	*Rhododendron arboreum* Sm.	Ericaceae	6.25	6.25	0.42	2.47
60	*Rhododendron boothii* Nutt.	Ericaceae	7.81	4.69	0.06	1.69
61	*Rhododendron edgeworthii* Hook. f.	Ericaceae	1.56	1.56	0.12	0.65
62	*Rhododendron grande* Wight	Ericaceae	4.69	1.56	0.11	0.92
63	*Rhododendron kendrickii* Nutt.	Ericaceae	1.56	1.56	0.01	0.45
64	*Rhododendron keysii* Nutt.	Ericaceae	3.13	3.13	0.01	0.87
65	*Rhododendron lindleyi* T. Moore	Ericaceae	10.94	4.69	0.28	2.41
66	*Rhododendron maddenii Hook. f.*	Ericaceae	1.56	1.56	0.07	0.55

67	*Rhododendron moulmainense* Hook.	Ericaceae	7.81	4.69	0.07	1.71
68	*Rhododendron neriiflorum* Franch.	Ericaceae	1.56	1.56	0.01	0.45
69	*Rhododendron nuttallii* Booth ex Nutt.	Ericaceae	1.56	1.56	0.01	0.44
70	*Rhododendron pangeanum* A.A. Mao & Bhaumik	Ericaceae	1.56	1.56	0.02	0.47
71	*Rhododendron sinogrande* Balf. f. & W.W. Sm.	Ericaceae	9.38	6.25	0.36	2.66
72	*Rhododendron sp. 4*	Ericaceae	3.13	1.56	0.01	0.60
73	*Rhododendron sp. 5*	Ericaceae	1.56	1.56	0.00	0.44
74	*Rhododendron sp. 6*	Ericaceae	1.56	1.56	0.19	0.77
75	*Rhododendron sps 1*	Ericaceae	1.56	1.56	0.06	0.54
76	*Rhododendron sps 2*	Ericaceae	4.69	1.56	0.01	0.75
77	*Rhododendron sps 3*	Ericaceae	1.56	1.56	0.00	0.43
78	*Sapium baccatum* Roxb.	Euphorbiaceae	1.56	1.56	0.02	0.46
79	**Sarlang (Apatani name)**		1.56	1.56	0.27	0.93
80	*Saurauia napaulensis DC.*	Actinidiaceae	3.13	1.56	0.03	0.63
81	*Schefflera digitata* J.R.Forst. & G.Forst.	Araliaceae	4.69	4.69	0.20	1.64
82	*Schefflera glomerulata* H.L.Li	Araliaceae	14.06	9.38	1.58	5.90
83	*Schima wallichii* Choisy	Theaceae	4.69	4.69	0.19	1.62
84	*Stereospermum chelonoides* (L.f.) DC.	Bignoniaceae	18.75	10.94	0.24	4.19
85	*Symplocos lucida* (Thunb.) Siebold & Zucc.	Symplocaceae	4.69	3.13	0.08	1.15
86	*Taxus wallichiana* Zucc.	Taxaceae	4.69	3.13	0.03	1.06
87	*Tetracentron sinense* Oliv.	Trochodendraceae	3.13	1.56	0.01	0.59
88	*Toona ciliata M.Roem.*	Meliaceae	7.81	4.69	0.14	1.84
89	*Tsuga dumosa* (D.Don) Eichler	Pinaceae	7.81	6.25	3.64	8.50
90	**Tagin (Apatani name)**		15.63	6.25	0.91	4.29
91	Unidentified 1		3.13	1.56	0.06	0.68
92	Unidentified 2		1.56	1.56	0.03	0.48
93	Unidentified 3		3.13	3.13	0.04	0.93
94	Unidentified 4		3.13	1.56	0.02	0.62
95	Unidentified 5		1.56	1.56	0.01	0.45
96	Unidentified 6		1.56	1.56	0.02	0.46
97	*Unidentified 7*		10.94	4.69	0.83	3.41
98	*Viburnum sps.*	Adoxaceae	3.13	1.56	0.05	0.67
99	*Wendlandia glabrata DC.*	Rubiaceae	1.56	1.56	0.10	0.62

Table 8: Density (individuals ha^{-1}), Frequency and Importance value index of shrub species Talley Valley Wildlife Sanctuary, Arunachal Pradesh

Sl. No.	Scientific name	Family	Density (ha^{-1})	Frequency	IVI
1	*Ardisia crenata* Roxb.,	Primulaceae	6.25	1.5625	4.69
2	*Debregeasia longifolia* (Burm.f.) Wedd.	Urticaceae	487.5	21.875	69.06
3	*Dichroa febrifuga* Lour.,	Hydrangeaceae	18.75	1.5625	10.62
4	*Gaultheria fragrantissima* Wall.,	Ericaceae	431.25	17.1875	62.16
5	*Justicia adhatoda* L.,	Acanthaceae	6.25	1.5625	4.69
6	*Melastoma malabathricum* L.	Melastomataceae	56.25	3.125	18.55
7	*Oxyspora corniculata*	*Oxalidaceae*	212.5	12.5	38.06
8	*Phlogocanthus wallichi*	Acanthaceae	106.25	7.8125	24.03
9	*Rubus ellipticus* Sm.,	Rosaceae	168.75	12.5	33.06
10	*Rubus foliolosus* D.Don,	Rosaceae	12.5	1.5625	7.65
11	*Vitis sps.*	Vitaceae	25	3.125	10.16
12	*Zanthoxylum armatum* DC.,	Rutaceae	62.5	6.25	17.25

Table 9: Density (individuals ha^{-1}), Frequency and Importance value index of herb species Talley Valley Wildlife Sanctuary, Arunachal Pradesh

Sl. No.	Scientific name	Family	Density (ha^{-1})	Frequency	IVI
1	*Aconitum ferox* Wall.	Ranunculaceae	1250.00	2.34	2.83541
2	*Allium hookeri* Thwaites	Alliaceae	312.50	0.78	1.65265
3	*Arisaema costatum* (Wall.) Mart. ex Schott	Araceae	8593.75	25.78	10.8084
4	*Arisaema sps.*	Araceae	1796.88	4.69	3.13021
5	*Arisaema tortuosum* (Wall.) Schott	Araceae	781.25	2.34	1.99803
6	*Arthraxon sps.*	Poaceae	1171.88	3.91	2.42726
7	*Boehmeria ternifolia*	Urticaceae	5546.88	8.59	6.35001
8	*Bothrichloa sps.*	Poaceae	234.38	1.56	0.98784
9	*Centella asiatica* (L.) Urb	Apiaceae	8046.88	7.81	8.32943
10	*Colocasia esculenta* (L.) Schott.	Araceae	78.13	0.78	0.56376
11	*Cyathea gigantea* (Wall. ex Hook.) Holttum,	Cyatheaceae	7187.50	17.19	8.38238
12	*Dicranopteris linearis* (Burm.f.) Underw.	Gleicheniaceae	8515.63	16.41	8.99325
13	*Diplazium esculetum*	Athyriaceae	546.88	1.56	1.76949
14	*Elatostema acuminatum*	Urticaceae	13046.88	10.16	11.5683
15	*Elatostema dissectum* Wedd.	Urticaceae	10703.13	6.25	11.1622

16	*Eupatorium adenophorum* Hort.Berol. ex Kunth,	Asteraceae	3984.38	6.25	5.16369
17	*Fragaria nilgerrensis* Schltdl. ex J.Gay	Rosaceae	7265.63	6.25	8.0932
18	*Galeola falconeri* Hook.f	Orchidaceae	3828.13	7.03	4.99694
19	*Gleichenia* Neck.	Gleicheniaceae	4453.13	6.25	5.58219
20	*Globba racemosa* Sm.	Zingiberaceae	234.38	1.56	0.98784
21	*Hedychium aurantiacum* Wall.	Zingiberaceae	859.38	3.13	2.03123
22	*Helichrysum luteoalbum*	Asteraceae	10078.13	12.50	9.5089
23	*Impatiens tripetala* Roxb. & DC	Balsaminaceae	3359.38	10.94	5.03858
24	*Lycopodium clavatum* L.	Campanulaceae	13125.00	10.94	11.5134
25	*Nephrolepsis cordifolia*	Lycopodiaceae	8515.63	10.16	8.45717
26	*Oxalis corniculata* L.	Nephrolepidaceae	2109.38	3.91	3.56585
27	*Panax biffinatifidus*	Oxalidaceae	2421.88	2.34	4.92885
28	*Panax sikkimensis* R.N.Banerjee	Araliaceae	1406.25	3.13	2.81269
29	*Paris polyphylla* Sm	Araliaceae	2109.38	8.59	3.78365
30	*Persicaria capitata*	Melanthiaceae	937.50	2.34	2.27716
31	*Plantago erosa* Wall.	Polygonaceae	3125.00	4.69	4.55333
32	*Plantago major* L.	Plantaginaceae	3515.63	7.03	4.73655
33	*Podophyllum hexandrum Royle*	Plantaginaceae	27968.75	57.81	26.4555
34	*Portuleca oleraceae*	Berberidaceae	312.50	1.56	1.18326
35	*Potentilla indica* (Andrews) Th.Wolf,	Portulacaceae	2890.63	2.34	5.76622
36	*Pratia begonifolia Lindl.*	Rosaceae	40000.00	32.03	26.6834
37	*Primula sps.*	Primulaceae	3046.88	7.03	4.34598
38	*Ranunculus diffuses*	Ranunculaceae	11093.75	7.03	11.0509
39	*Rubia cordifolia* L.	Rubiaceae	937.50	4.69	2.20937
40	*Rubus calycinus* Wall.	Rosaceae	28046.88	26.56	20.3683
41	*Rubus lineatus Reinw.* ex Blume.	Rosaceae	3046.88	3.91	4.70444
42	*Rumex acetosa* L.	Polygonaceae	312.50	0.78	1.65265
43	*Rumex crispus* L.	Polygonaceae	781.25	2.34	1.99803
44	*Scirpus sps.*	Cyperaceae	13125.00	14.06	11.423
45	*Smilax perfoliata* Blume.	Smilacaceae	156.25	0.78	0.92673
46	*Thalictrum foliolosum* DC.	Ranunculaceae	4375.00	6.25	5.51244
47	*Urtica diocia*	Urticaceae	5156.25	4.69	6.72986

Table 10: Species richness, diversity index, the concentration of dominance and evenness index in Talley valley Wildlife Sanctuary, Arunachal Pradesh.

Parameters	**Trees**	**Shrubs**	**Herbs**
Species richness	99	12	47
No. of genera	51	11	40
No. of families	32	10	28
Density ha^{-1}	1028	1593	280391
Basal area m^2ha^{-1}	54.79	-	-
Species diversity index	3.85	0.75	0.78
Shannon- Wiener diversity index (H')	3.90	2.16	3.51
Simpson index ($C_{D)}$	0.032	0.141	0.038
Simpson diversity Index	0.968	0.859	0.962
Evenness index (e)	0.849	0.871	0.913

Discussion

Understanding species diversity and distribution patterns are significant for helping managers evaluate the complexity and prospects of forest ecosystems. The study area is well represented with trees (99 spp.), shrubs (12 spp.) and herbs (47 spp.), indicating rich biodiversity of the region. Tree species contribute the highest species (51%), followed by herbs (24.4%) and shrubs (14.2%). A higher diversity of woody plants was observed in the present study, as compared to herbaceous species; however, reverse data (herbaceous plants > trees and shrubs) was presented from Northwest Himalayan forests of India (Sharma et al. 2014). The greater richness of woody plants, mainly observed in the trees, could also result from the succession process that tends to increase species diversity in the studied forests. In tropical forests, trees form the principal structural and functional basis of forest ecosystems and serve as important indicators of changes and stressors of the landscape (Jayakumar & Nair 2013). The abundance of trees in Arunachal Pradesh has also been reported (Saikia et al., 2017). The plant species richness and species diversity index in the Talley valley followed the order of trees>herbs>shrubs. The structure of a vegetation unit depends upon the species composition, their relative number, and diversity (Rawat & Chandra 2014).

The Shannon-Wiener diversity index is generally high for tropical forests of the Indian subcontinent and ranges from 0.81 to 4.1 (Singh et al. 1984, Parthasarathy et al. 1992, Bhuyan et al. 2003). The recorded Shannon-Wiener diversity values for trees, herb and shrub in the present study were 3.90, 3.51 and 2.16, which is in between the range of previously recorded values. In general, species diversity and concentration dominance show an inverse relationship (Singh & Misra 1969, Joshi & Behera 1991). The species diversity values corresponded to the general trend, i.e., tree > herb, while the concentration dominance displayed the opposite trend, i.e., herb > tree, in the present study area. The high diversity and low concentration dominance in the analysed forests may be due to different levels of anthropogenic pressure in different forests at varied locations. The distribution of plant species showed contagious distribution. Contagious distribution has been accepted as a characteristic pattern of plant occurrence in nature (Odum 1971). A similar type of result has been reported by (Mehta et al. 1997, Kumar & Bhatt 2006, Paul 2008).

Analysis of Physico-chemical properties of Soil of the sanctuary:

Physico-chemical properties of soil, samples collected at two different season (Monsoon and winter) at 0-15 cm depths, were determined following the soil standard test method (Carter & Gregorich 2007). For physical analysis, bulk density, water holding capacity (WHC), and soil texture were determined whereas, for chemical analysis, pH, conductivity, potassium, calcium, sodium and magnesium, available phosphorus, available sulfur, total nitrogen, nitrate, and micronutrients (Ni, Cr, Pb, Fe, Co, Cd, Zn) were analysed following the standard laboratory procedures. The Keen box method was followed to estimate bulk density (BD) and water holding capacity (Keen & Raczkowski 1921). The hydrometer method was used for the particle size distribution of soil samples (Bouyoucos 1951). pH was taken using Oakton PC2700 Meter while conductivity with a conductivity meter (WTW pH/Cond 340i). Systronic flame photometer 128 was used to analyse the exchangeable potassium and sodium (Mehlich 1978). At the same time, soluble calcium and soluble magnesium were determined by the EDTA titration method (Barrows & Simpson 1962). The available sulphur was determined in spectrometer following the Turbidimetric method, and available phosphorus was determined using spectrometer as per Bray and Kurtz method (Bray & Kurtz 1945). Total Carbon and Nitrogen were analysed in a CHNS-O analyzer (Thermo Fisher CHNS-O analyzer Flash 2000). For the analysis of micronutrients, the soil was digested with acid mixtures performing wet digestion method (Twyman 2005) and analysis was performed in ICP-MS (Thermo Fisher ICP-MS iCAP RQ).

Results

The soil of the Talley Valley Wildlife Sanctuary was silty loam in texture and slightly acidic with pH ranging from 5.27 to 6.46. The physicochemical characteristics of soil are presented in Table 11.

Table 11: Physico-chemical characteristics of soils of the Talley Valley Wildlife sanctuary, Arunachal Pradesh

Parameters	**Monsoon**	**Winter**
Soil texture	Silt loam	Silt loam
pH	6.46	5.27
Soil conductivity (ms/cm)	0.03	0.054
Water holding capacity (%)	50.82	50.63
Bulk density (g/cm3)	0.73	0.74
Nitrogen (ppm)	4.26	5.26
Available phosphorus (ppm)	2.33	3.02
Exchangeable potassium (ppm)	1.17	0.79
Soluble calcium (ppm)	16.69	12.00
Soluble magnesium (ppm)	8.42	9.60
Available sulphate (ppm)	1.13	0.69
Chromium (ppm)	2.85	4.34
Cobalt (ppb)	0.022	0.029
Iron (ppm)	181.66	26.76
Lead (ppm)	0.63	1.05

Aluminium (ppm)	179.51	89.40
Zinc (ppm)	25.63	3.39
Cadmium (ppb)	22.52	23.10
Nickel (ppm)	1.03	0.31

Discussion

The soil textural class of Talley Valley Wildlife Sanctuary was silt loam, which has a bulk density of 0.73 g/cm^3 and 0.74 g/cm^3 for monsoon 2018 and winter 2018, respectively. This soil condition is suitable for easier root penetration, and water and air movement in the soil. Soil bulk density is less than 1.5 g/cm^3 is easier root penetration and water and air movement in the soil (Hunt, N ; Gilkes 1992). In this study, soil pH for TVWS was 6.46 and 5.27 during monsoon and winter, respectively. A study conducted by (Poddar et al. 1999) in Itanagar had recorded a pH range of 5.3 to 5.9, which is quietly similar to the present study. It might be due to the weathering of the quartzite and gneissic metamorphic rock in the steep sides of the hills in the area (Ground et al., 2013). The soils below pH 6.0 are considered acidic soil (Brady 1984) and provide micronutrients (Tale & Ingole 2016).

All heavy metals concentration and abundance in the soil are correlated with soil pH, iron and aluminium oxides, clay content, organic matter and cation exchange capacity (Goorley & Olsher 2005). In the Sanctuary, the abundance of heavy metals was found to be Fe>Al >Cd Cr>Ni >Pb in monsoon and in winter the abundance of the heavy metals was Al>Fe>Cd Cr>Zn>Pb >Ni. The abundance of Fe and Al in Talley Valley Wildlife Sanctuary may be due to the weathering of parental rock material.

Objective 3: To quantify the local community pressure on the biodiversity of sanctuary due to their day-to-day household needs and find a solution to manage it on a sustainable basis.

The study was conducted using questionnaire by interacting with local people to understand about their socio-economic livelihood and dependability on natural resources and any evidence of threats in sanctuary was also observe during each field survey. In this regard, a semi-structured questionnaire sheet containing 40-45 questions was prepared to survey the socio-economic conditions of the local people inhabited in forest fringe villages around Talley valley Wildlife Sanctuary. In addition to local people, forest personnel were also interviewed during the field visit.

Result and Discussion

The present survey focused on livelihood and dependability in forest fringe villages of Talley valley wildlife sanctuary. Two villages namely Manipolyang and Siro were surveyed to recognised about the livelihood and dependability of local people. It was observed that human activities like logging, cultivation and settlement were recorded during the field survey in fringe areas of the sanctuary. Still, there is a report of the occasional illegal hunting of wildlife in the sanctuary and the fringe areas of the forests. In addition, it is reported that some plant products (medicinal purposes) are extracted from the forest for illicit commercial purposes. Bird hunting and trapping are not common in the sanctuary, but during the survey, it was encountered that a few local people used to kill some birds using locally made guns and licensed Air gun rifles for game hunting.

Objective 4: Identify the species-specific conservation and management issues of keystone species in the study area.

The keystone species notion has proven both promising and elusive in both theoretical and applied ecology. It contains organisms that can regulate potential dominants, provide vital resources, and have the power to influence the environment (Payton et al. 2002). However, identifying keystone species can be difficult. Several techniques were used, but no viable methodology has been created yet.

Herbivores have an important role in regulating the structure and composition of the plants in terrestrial ecosystems; hence grazers can operate as a keystone but are frequently top-down regulated by predators. Based on secondary data acquired by semi-structured questionnaires, the findings of the current study may assume that the wild dog may operate as a possible keystone species, eliminating herbivores and lowering grazing pressure, supporting a more species varied flora in the study region. A habitat is adequately preserved in certain circumstances even when a keystone species is not there (Tanner et al. 1994).

Plants represents another form of keystone species that provides a vital resource to various organisms and determine the population size at a time of scarcity (Payton et al. 2002). In the present study, several *Rhododendron* and *Quercus* species were recorded that may operate as suppliers or providers of fruits, which may be used to assess the species variety of fruit eaters. Although the species is not exceptionally plentiful, if it is destroyed, the dependent species cannot bridge the gap supplies. several frugivore animals such as birds, bats, primates and insects were recorded during the study period. Because each plant species has its unique phenological pattern, the availability of fruits and flowers varies significantly throughout the year (Fenner 1998). Rhododendron also aids in the prevention of soil erosion on mountain slopes. It also supports a diverse range of plants and animals and provides food and shelter to a diverse range of fauna along an altitudinal gradient (Paul et al. 2005).

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TALLEY VALLEY WILDLIFE SANCTUARY
ARUNACHAL PRADESH

Appendix I

CONSOLIDATED UTILIZATION CERTIFICATE
MINISTRY OF ENVIRONMENT AND FORESTS

(To be sent in duplicate)

For the financial year (from 1st April 2021 to 31st March 2022)

1	Title of the Project/Scheme/Programme	:	Exploration of Biodiversity and conservation issues of Talley Valley Wildlife sanctuary, Arunachal Pradesh with reference to wildlife species distribution along climate and topographical gradient
2	Name of the Principal Investigator & Organization.	:	Dr. (Mrs.) Ashalata Devi Associate Professor Department Environmental Science, Tezpur University, Napaam – 784028, Tezpur, Assam, India
3	Ministry of Environment & Forests Letter No. and date of sanctioning the project.	:	F. No. 14/8/2014-RE dated: 27th June, 2016
4	Amount brought forward from the previous financial year, quoting the Ministry of Environment & Forests Letter No. and date on which the Authority to carry forward the said amount was given	:	Rs, 5,38,300.00
5	Amount received from Ministry of Environment& Forests during the financial year (Please give number and dates of sanction orders showing the amount paid)	:	Nil
6	Total amount that was available for expenditure (including commitments) incurred during the financial year (S.No. 4+5)	:	Rs, 5,38,300.00 (5,25,171.00 + 13,129.00)
7	Actual expenditure (excluding commitments) incurred during the financial year	:	Rs, 3,71,826.00
8	Unspent Balance amount refunded, if any (Please give details of Cheque No., etc.)	:	Nil
9	Balance amount available at the end of financial year.	:	Rs, 1,66,474.00
10	Amount allowed to be Carried forward to the next financial year vide Letter No. and date	:	Nil
11	Accrued bank Interest	:	Rs. 4162.00

Certified that the expenditure of **Rs 3,71,826.00 (Three Lakh seventy-one thousand eight hundred and twenty-six only)** mentioned against Column 7 was actually incurred on the Project/Scheme for the purpose which it was sanctioned.

Date:

7/4/2022

(Signature of Principal Investigator)

25/4/2022

(Signature of Registrar/ Accounts Officer)

Finance Officer
Tezpur University

25/4/22

(Signature of Head of the Organization)

Registrar
Tezpur University

OUR REF. NO.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
MINISTRY OF ENVIRONMENT & FORESTS

7/4/2022

Signature of Principal Investigator

25/4/22

Head of the Institution

Registrar
Tezpur University

25/4/22

Registrar

Registrar
Tezpur University

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

8/9/22

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 305054

Appendix II

CONSOLIDATED EXPENDITURE STATEMENT
MINISTRY OF ENVIRONMENT & FORESTS

Statement showing the expenditure of the period from **1st April 2021 to 31st March 2022**

Sanction No. & Date: F. No. 4/8/2014-RE dated: 27th June, 2016

1. Total outlay of the project: Rs. 38,96,640.00
2. Date of Start of the project: 1st February, 2017
3. Duration: 3 years
4. Date of Completion: 31st January, 2020 **(Extension granted up to 30th September 2021)**
   a) Amount received during the financial year: Rs. **Nil**
   b) Unspent amount carried forward from previous financial year: Rs,5,38,300.00
   c) Total amount available for Expenditure (a + b): Rs. 5,38,300.00

S. No.	Budget head	Amount carried forward (Rs.)	Amount received (Rs.)	Amount Spent	Amount Balance/ excess expenditure (Rs.)
1	Salaries	1,55,200	NIL	1,66,933	-11,733
2	Permanent Equipment Purchased (item-wise)	NIL	NIL	NIL	NIL
3	Expendables/ Consumables	75,478	NIL	78,421	-2,943
4	Travel	1,40,074	NIL	44,235	95,839
5	Contingencies	60,712	NIL	60,712	0
6	Other Project Costs, if any (please specify)	NIL	NIL	NIL	NIL
7	Dissemination of Research Work	90,000	NIL	21,525	68,475
8	Institutional Charges	3,707	NIL	NIL	3,707
9	Accrued Interest	13,129	4,162	NIL	17,291
10	Total	5,38,300	4,162	3,71,826	1,70,636
11	Amount allowed to be Carried forward to the next financial year.				

Certified that the expenditure of **Rs 3,71,826.00 (Three Lakh seventy-one thousand eight hundred and twenty-six only) actually** incurred on the Project/Scheme for the purpose for which it was sanctioned.

(Signature of Principal Investigator)	(Signature of Registrar/ Accounts Officer)	(Signature of Head of the Organization)
	Finance Officer Tezpur University	Registrar Tezpur University

OUR REF. NO.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
MINISTRY OF ENVIRONMENT & FORESTS

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 305054

8/9/22