Original Research Article

Diversity and distribution of medicinal plants along altitudinal gradient in temperate Himalayan ecosystem

Abstract

The present study was carried out to ascertain the floristic diversity and vegetation analysis of Bangus valley of Langate Forest Division of District Kupwara (J&K) India. The phytosociological study was conducted to assess the floristic diversity of the region, whereas, land-use classification and forest cover change analysis was done using remote sensing techniques. The study reveals that the species diversity, different uses and distribution along various altitudinal gradient ranges from 2900 to 3200 meters above mean sea level, in the relatively unexplored area of J&K. Among the sampled sites, an overall 51 species were recorded. The tree vegetation is mostly dominated by *Abies pindrow* Whereas, *Pinus wallichiana* has very rare distribution in the area. The shrubby vegetation was dominated by *Viburnum grandi florum* followed by *Rosa brunie*. Whereas, *Berberis lycium* has less distribution. This paper pertains to the detailed account of floristic diversity and distribution of medicinal plants of Bangus valley of Kashmir, India.

Key words: Bangus valley, Temperate, Medicinal plant, Vascular plants, Himalayas.

Introduction

India is well known for significant geographical diversity which has favored the formation of different habitats and vegetation type. Biological diversity is of fundamental importance to the functioning of all natural and human-engineered ecosystems and by extension to the ecosystem. The survival of man is intimately related to the availability of different plant resources. The plant wealth of a country is its pride and acquiring knowledge wealth of a country is its pride and acquiring knowledge commercial importance. Biodiversity provides to human kind enormous direct economic benefits, an array of kind enormous direct economic benefits, an array of and plays a prominent role in modulating ecosystem function and stability. Tropical forests constitute the most diverse plant communities on earth. These forests are diverse plant communities on earth. These forests are for extraction of firewood and other forest products. The problem with the chronic form of forest disturbance is that plants or ecosystem often do not get time to recover adequately because the human onslaught never stops (basha and Parveen, 2013).

One of the chief features contributing to the global fame of Kashmir is the rich biodiversity that adorns its captivating landscape. Being phytogeographically located at the intersection of Holarctic and Paleotropical Floristic Realms and falling within the North-Western Himalaya, the region is endowed with teeming treasure-troves of plant diversity. It represents a unique bio-region owing primarily to its varied topography and habitat heterogeneity along a wide elevational range. Over the last two centuries, starting from the first recorded botanical collection of William Moorecroft, a nonbotanist, in 1822 up to the present time, numerous workers have explored and documented the plant wealth growing along a variety of topographical and elevational gradients throughout this region. The North-West Himalaya has long been recognized as one of the distinct floristic regions in India (Hooker, 1904).

Western Himalaya has long been recognized as a distinct floristic region in India (Hooker, 1904). This region harbors a rich regional flora due to its diverse topography, wide altitudinal range and location at the intersection of several biogeographically units. The flora of western Himalaya exhibits affinities with that of Mediterranean, Siberian, Tibetan and Indo-Malayan regions. In contrast, the vegetation of eastern Himalaya displays affinities with Chinese and Malayasian elements, and supports luxuriant evergreen broadleaf forests or ‘tropical rainforests’ at lower elevations. Another notable difference between the western and eastern

Himalaya is that conifers are less common and are generally mixed with broadleaved species in the eastern Himalaya as compared to the western Himalaya. In the eastern Himalaya, number of vascular plant species, the number of epiphytes (mostly Orchidaceae), Rhododendron and Quercus species are also several folds greater than that in western Himalaya (Singh and Singh 1987). The Himalayan Mountain Range forms a distinct biogeographic ecoregion with large variation in topography, climate and harbours considerable plant diversity (Olson et al. 2001). The proportion of endemic taxa is substantial in the entire Himalayan Range and thus, this ecoregion has been designated as a global biodiversity hotspot (Myers et al. 2000). Around 4000 species of higher plants and about 29% of the endemic taxa of Indian dicotyledonous flora occur in the Himalaya (Singh and Singh 1987). In the western Himalayan region, the prominent angiosperm families are Asteraceae, Rosaceae, Poaceae, Ranunculaceae and Brassicaceae (Rau 1975). The vegetation is represented by lower and upper western Himalayan temperate forests, dry temperate coniferous forests, sub-alpine forests and scrubs, alpine pastures, dwarf Juniper scrub, and dry alpine scrub communities (Champion and Seth 1968).

The Bangus valley is in the Kupwara district, which is the northern district of Jammu and Kashmir (J&K) India (Fig. 1). This area has a temperate, sub-alpine and alpine climatic conditions and is considered as very rich in biodiversity including some rare species of Non-Timber Forest Resources vis-à-vis Medicinal Plants. The entire region is mountainous bearing very steep slopes pierced by deep valleys at few places. Some parts of the study area is devoid of any good vegetation due to the rocky tract and hill slopes. However, vegetation of the area is disappearing at an alarming pace owing to overexploitation of resources, faulty management practices and intensification of unplanned developmental works. The study on assessment of floristic diversity has received great attention particularly during the past few decades. The floristic diversity and vegetation structure are the significant ecological aspects of any terrestrial ecosystem. The temperate ecosystem in which the study area falls, constitute most diverse plant communities in the region. This area has not received due attention from the researchers in terms of detailed scientific investigations on biodiversity vis-à-vis vegetation analysis. Therefore the present study was carried out to assess the floristic diversity and vegetation analysis using remote sensing techniques and comprehensive onsite field investigations.

There has been an upsurge of medicinal plants in traditional systems of medicines and allopathy. It is reported that, about 1289 botanicals (various parts sold) pertaining to 960 plant taxa and 575 genera spread across 169 families are traded as medicinal plants in India. Wherein about 152 families belong to angiosperm, 5 gymnosperm, 9 pteridophytes and 3 fungi and lichens group of plants with 398 herb, 251 tree, 168 shrub and climber species. The usage of these species in Indian System of Medicine (ISM) is 688 species in Ayurveda, 501 in Siddha, 328 in Unani, 197 in Tibetan and 146 in Homeopathy (Mushtaq *et al*, 2020). People living in and around the Bangus valley are also heavily dependent on plant based medicines for treating various ailments. This area is endowed with rich floristic diversity of medicinal importance owing to its sundry topography along an extensive elevational gradient. However, forests of the area are disappearing at an alarming rate due to deforestation for wood and fuel-wood, uncontrolled grazing and unscrupulous extraction of medicinal plants. The persistent forest disturbances, due to anthropogenic pressures don't allow species to replenish, which has distressed its ecosystem. The diversity and structure of the plants are significant indicators of any healthy ecosystem. Therefore, the detailed information on the floristic diversity of any area is as important, as the flora itself. The studies on the floristic diversity of Kashmir Himalayas have been carried out by various authors. However, no detailed information on the flora of the study area in particular is available. Therefore, this study was undertaken to document the plant diversity of the Bangus valley, to provide more insights into the flora of the area. This paper attempts to outline the plant species richness in different taxanomic groups, endemic, medicinal and threatened categories along the different altitudinal gradients in the study area.

This area has not received due attention from the researchers in terms of detailed scientific investigations on biodiversity vis-à-vis vegetation analysis. Therefore the present study was carried out to assess the floristic diversity and vegetation analysis using remote sensing techniques and comprehensive onsite field investigations. Understanding elevational distribution of medicinal plants, uses and their types may help in detecting the hot-spots of resources in the region and thus contribute to their effective protection. In Himalayan region, relationship between species diversity and elevation is commonly studied (Acharya et al. 2011). Many of these studies attempt to describe the diversity of various organisms along the gradient or compare the elevational distributions of several groups of organisms. However, relatively few studies compare the distributions of subsets of organisms to a total dataset. Moreover, these

studies simply graphically compare different distribution patterns. In such a comparison, it is interesting to consider whether observed differences in relationships between species richness and the gradient studied for different groups of species could be generated by random sampling or whether the distributions really significantly differ. By performing such a test, we can show that species in some parts of the distribution are more likely to be selected to the subset than in another part of the distribution. For medicinal plants along an elevational gradient, this would mean that the plant is more likely to be used as a medicinal plant in certain elevations than in others (Peerzada and Altaf, 2017).

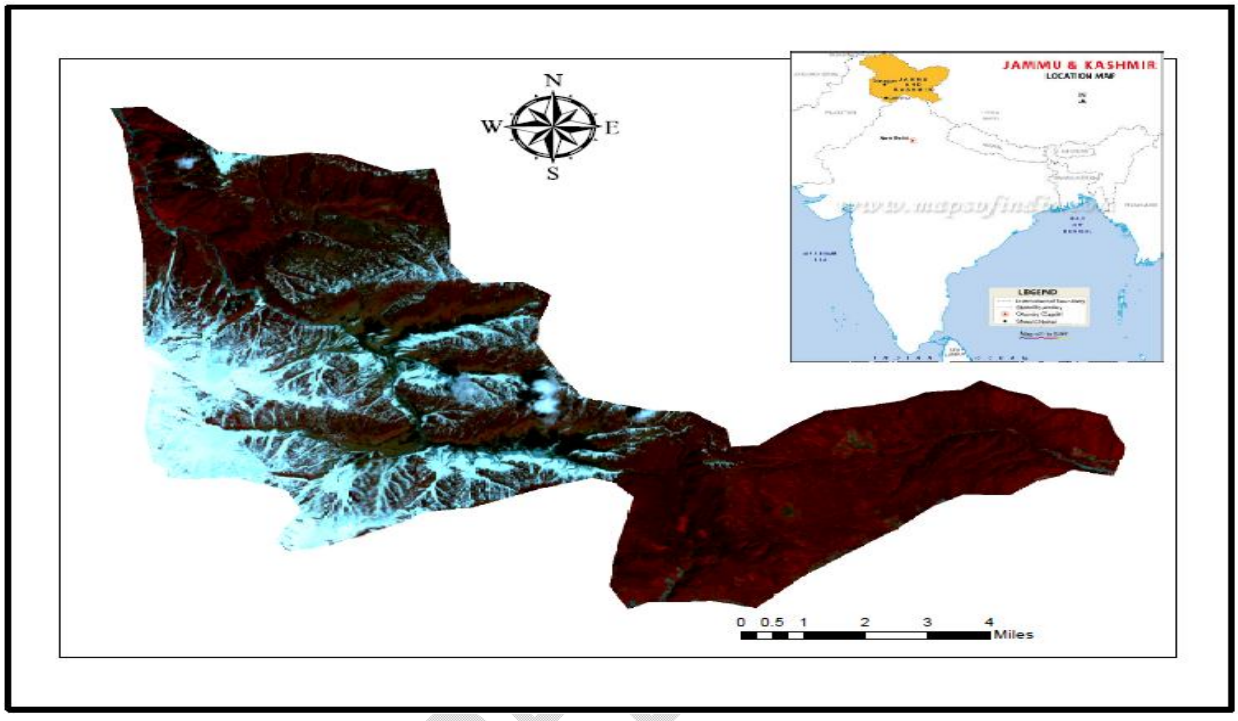
Material & Methods

Study area:

The region falls within the biogeographic zone of the North-Western Himalaya in India (Rodgers & Panwar 1988). It lies between 33° 20′ to 34° 54′ N Latitudes and 73° 55′ to 75° 35′ E Longitudes, covering an area of 15948 sq. km. The Valley of Kashmir is elliptical and bowl-shaped, surrounded on all sides by high mountain ranges; the Middle or the Lesser Himalaya, called as the Pir Panjal Range, in the south and southwest separates the Valley from the Jammu region, while the Great Himalayan Range in the north and east separates it from the Ladakh region**.** The altitude of the main valley itself ranges from 1500 m to 1800 m (amsl), whereas the average height of its surrounding mountain ranges varies from 3000 to 4000 m, the highest peak being Kolahoi (5420 m).

The Present investigation was carried out in the Bangus Valley of Kupwara District (J&K) India (Fig. 1). Bangus is situated between 34° 22′ 2” N latitude and 74° 03′ 27" E longitude at an altitude between 2700 to 3500 meters above mean sea level. Bangus valley is relatively an unexplored area of 300km^2 surrounded by sloppy landscapes. The study area has a temperate and sub-alpine climatic condition with an average annual rainfall of 540 mm. The temperature ranges from 22 °C minimum to 28 °C maximum.

Fig.1 : Map showing study location



Methodology:

This study is based on an extensive field survey of the area conducted during Februaryto May, 2010. The study sties were randomly selected on the basis of reconnaissance survey. The different aspects were established to understand the growth behavior of the vegetation under different microclimatic conditions. In total three sites were selected for the assessment of vegetation. The plant species were identified with the help of herbarium, Botanical Survey of India, Dehradun. Besides the collection of plant species specimen, information was also collected on the vernacular names and uses of plants made by the local inhabitants. A nested quadrates technique was used for sampling the vegetation.

The size and number of quadrates needed were determined using the running's mean method (Kershaw, 1973). To study the vegetation attributes, quadrates of 10 m × 10 m size for trees, 5 m x 5 m size for shrubs and 1m x 1m size for herbs, grasses and seedlings of tree species less than 1.3 cm dbh (diameter at breast height) were randomly laid out at each site at different elevations. The observations on Name of the species, Diameter of the species and the Number of

occurrence of each species in each quadrate were recorded. The enumeration of vegetation in each of the quadrate was done by measuring dbh individually in case of woody vegetation and collar diameter in case of herbs and grasses with Verniers digital caliper. The data collected for vegetation information was quantitatively analyzed for density, frequency and abundance of each species according to the method developed by Curtis and McIntosh (1950). The relative values of frequency, density, and dominance of all the species were summed up (Mishra, 1968) to represent Importance Value Index (IVI).

Reconnaissance Survey

A reconnaissance survey of the study area was conducted during June to September, 2014. Various aspects of the study area were studied e.g. topography, general vegetation composition, plant species variability, local interventions, adjoining communities/villages, cattle type, bonafide utilization of forest products by locals. During the Reconnaissance surveys representative areas for inventorisation were selected. A checklist of locally and commercially used plants available in the area, forest type and existing trails were recorded in details.

Sampling Design

The sampling design adopted for conducting the inventory in the study area was systematic random sampling. In this method, the starting point of the first transect was selected randomly, GPS locations of each transect was recorded. Quadrates were laid along both the sides of transect with 50m distance between 2 quadrates on opposite sides.

To study the vegetation attributes, quadrates of 10 m × 10 m size for trees, 5 m x 5 m size sub-plot for shrubs and seedlings of tree species less than 1.3 cm dbh (diameter at breast height); and 1m x 1m size for herbs and grasses were laid out at each site at different elevations. The observations on Name of the species, Diameter of the species and the Number of occurrence of each species in each quadrate were recorded. The enumeration of vegetation in each of the quadrate was done by measuring dbh individually in case of woody vegetation and collar diameter in case of shrubs with Verniers digital caliper, whereas, herbs were counted.

Vegetation Analysis

The vegetational data was quantitatively analyzed for frequency, density and abundance. The relative values of frequency, density, and dominance of all the species were summed up

(Mishra, 1968) to signify the Importance Value Index (IVI). The ratio of Abundance to Frequency (A/F) has been used to analyze the distribution of species within each site studied.

Density (D) = (Total Number Of individual in All Quadrat)/ (Total Number of quadrats studied).

Abundance (A) = (Total Number of individuals of Species in all Quadrats) / (Total Number of quadrats in which the Species Occurred).

Frequency (%) = (Total number of quadrats in which species occurred)/
(Total number of quadrats studied) × 100

Relative frequency = (Number of occurrence of the species)/ Number of Occurrence of all species × 100

Relative Density = (Number of Individuals of a species)/ (Number of Individuals of all Species) × 100

Relative Dominance = (Total Basal Area of the Species in all Quadrats)/ (Total Basal area of all species in all the quadrats) × 100

Importance Value Index (IVI) = R. Freq. + R. Den. + R. Dom.

A/F Ratio = (Abundance/ Frequency)

The area was randomly surveyed to understand the vegetation under different microclimatic conditions. An extensive field survey of the area was carried out during June 2014 - October 2015 for collection and identification of various plant habitats along the different altitudinal ranges. The area surveyed includes various forest types like temperate, coniferous, broad leaved and alpine pasture lands. The plant species were identified with the help of available literature (and taxonomists at Centre of Plant Taxonomy, Botany Department, University of Kashmir, Srinagar (J&K) India. The plant species are enlisted alphabetically and each species is provided with its botanical name, author citation, form, habit, habitat, family, altitudinal range, threat category and uses (Table 1).

Results & Discussion

Floristic Diversity:

The present study revealed that the diversity and affinities of the flora of the region has approximately 22 species. The commonly occurring species are *Abies pindrow, Cedrus deodara*, *Pinus wallichiana, Picea smithiana, Taxus buccata* and *Betula utilits.* Prominent medicinal plants include *Sussurea lappa, Dioscoria species, Aconitum heterophylum, Podophyllum hexandrum*, *Trillium govanianum*, and *Berberis Spp.* Major grass species are *Bromus japanics, Cynodon dactylon, Fastuca gigantea, Phalaris anundinacea, Poa pratense* and *Puccinellia kashmiriana* etc.

Floristic diversity and its Socio-economic Importance

Indigenous knowledge about the plant wealth has been passed-on from one generation to next, as a folklore among the village people. This exercise was conducted to know that diversity of plant resources that are being used by local people for various purposes in this area. Several trips were made to the nearby villages (Bhot-Nalla, Atholi and Kirthaie) of the study area for collecting information on the traditional uses of plants. During the field visits number of local inhabitants of different social strata viz; elderly people, women and practicing herbalists were consulted for interaction and discussions. Information about the plants used for various purposes was recorded.

The inhabitants of study area are heavily dependent on the local flora for timber, food, fodder, fuelwood and folk medicines. The present investigation revealed that 22 plant species distributed in 16 families are reported to be used for different purposes by local people. Among which 50% are herbs, 26% are shrubs and 24 % trees (Fig. 2). The plants are listed alphabetically by genus, local name, habit, family, altitudinal range and folk uses of these plant species (Table 4). The deterioration of plant wealth of the area needs immediate attention as most of the species may become rare due to population growth, deforestation, over-exploitation and unscientific harvesting of resources. The information on the folk uses of these plants is not well documented, there is an urgent need for more detailed research to collect the information and preserve it for future necessities.

Resource Assessment

The floristic composition of the Bangus valley was studied at four randomly selected sites (Table 1).

Table 1: Geo-coordinates of Medicinal Plants Resource Assessment Sites

Site	Aspect	Elevation	Latitude	Longitude	Reference Points
I	NW	3140	34.21.04 N	74.02.01 E	Badi bahek-Gujarpati- Right Bank of Nalla
II	ES	2980	34.21.13 N	74.02.02. E	Backside of abandoned army unit
III	NW	2893	34.20.49 N	74.05.03 E	Bangus Ridge upto middle
IV	NE	2971	34.20.50 N	74.05.21 E	Nildari middle & Base

The present study revealed that the diversity and affinities of the flora in the sampled area of the Bangus valley has approximately 51 species. The commonly occurring species are *Abies pindrow, Berberis lyceum, Gerenium pretense, Podophyllum hexandrum, Myosotis arvensi, Ranunculus laetus* and *Adonis aestalivis* among others.

Vegetation Analysis:

The data pertaining to vegetational parameters at Site I, II, III and IV of Bangus valley are presented in Table 2, 3, 4 and 5 respectively. Analysis of recorded data reveals that the tree vegetation at all four surveyed sites was dominated by *Abies pindrow* with IVI of 300 at sites I, II and III, and IVI of 196.195 at site IV. Whereas, *Pinus wallichiana* has very rare distribution with IVI of 103.805at site IV only**.**

The shrubby vegetation was dominated by *Viburnum grandiflorum* with IVI of 217.49 and 300 at site III and IV followed by *Rosa brunie* with IVI of 161.72 and 82.51 at site I and II respectively. Whereas, *Berberis lycium* has less distribution with IVI of 138.28 at site I only.

Among herb species vegetation of the site I was dominated by *Plantago major* with IVI of 44.48 followed by *Ranunculus laetus*, *Nepeta linearis*, *Geranium pratense* with IVI 20.73, 19.03 and 16.09 respectively. At site II, the dominant species was found *Myosotis arvensis* followed by *Plantago major*,*Podophyllum hexandrum*, *and Geranium pretense* with IVI of 45.39, 35.53, 19.26 and 16.12. The dominant species at site III was found *Anemone biflora* followed *by Iris hokeri*,*Myosotis arvensis*, and *Salvia nubicula* with IVI of 41.97, 29.22, 27.10, and 26.09 respectively. At site IV the dominant species was found *Nepeta linearis* followed by *Poa pretense, Myosotis arvensis, Rumex hastatus* with IVI of 27.82, 19.69, 19.42, and 18.18. In

all the four surveyed sites the most dominant species was found *Myosotis arvensis* followed by *Plantago major,Iris hokeri*, and *Geranium pretense*. The higher dominance of *Myosotis arvensis*, *Plantago major, Iris hokeri*, and *Geranium pretense* was attributed to their higher frequency, density and abundance as compared to the rest of the species.

Table 2: Ecological indices of Tree species in Bangus forests.

S. No.	Species	Site 1			Site 2			Site 3			Site 4		
		Density (Ha^{-1})	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**
1	*Abies pindrow*	0.019	0.023	300	0.021	0.042	300	0.012	0.1	300	0.02	0.055	196.195
2	*Pinus wallichiana*	0	0	0	0	0	0	0	0		0.014	0.056	103.805

Table 3: Ecological indices of Shrub species in Bangus forests.

S. No.	Species	Site 1			Site 2			Site 3			Site 4		
		Density (Ha^{-1})	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**
1	*Berberis lycium*	0.01	0.03	138.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	*Rosa brunie*	0.01	0.03	161.72	0.02	0.15	82.51	0.00	0.00	0.00	0.00	0.00	0.00
3	*Viburnum grandiflorum*	0.00	0.00	0.00	0.08	0.53	217.49	0.00	0.00	0.00	0.17	0.05	300.00

Table 4: Ecological indices of herb species in Bangus forests.

S. No.	Species	Site 1			Site 2			Site 3			Site 4		
		Density (Ha^{-1})	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**	**Density (Ha^{-1})**	**A/F**	**IVI**
1	*Aconitum heterophyllum*	0.60	0.15	7.87	1.7	0.07	11.79	0.04	0.10	12.62	0.70	0.08	7.89
2	*Aconitum chasemanthum*	0.50	0.13	8.33	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	*Adonis aestalivis*	0.80	0.20	7.51	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	*Anemone biflora*	0.00	0.00	0.00	0	0.00	0.00	0.63	0.58	41.97	1.30	1.30	6.23
5	*Arisema costatum*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.20	0.05	11.98
6	*Arisemi jacqmontane*	0.50	0.02	15.87	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	*Artemisia absinthium*	0.00	0.00	0.00	2.5	0.28	11.71	0.00	0.00	0.00	0.00	0.00	0.00

8	*Berginia ciliata*	0.60	0.15	9.59	0.6	0.15	10.54	0.02	0.17	9.50	0.60	0.15	7.82
9	*Capsella bursa-pastoris*	0.00	0.00	0.00	0.2	0.20	6.38	0.00	0.00	0.00	0.00	0.00	0.00
10	*Carum carvi*	0.20	0.05	10.25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	*Cirsium arvense*	0.30	0.08	8.53	0	0.00	0.00	0.00	0.00	0.00	1.10	0.28	9.69
12	*Cirsium wallichia*	0.00	0.00	0.00	0.8	0.80	13.22	0.00	0.00	0.00	0.00	0.00	0.00
13	*Epilobium hirsutum*	0.30	0.30	7.40	0.9	0.06	14.46	0.00	0.00	0.00	0.00	0.00	0.00
14	*Euphorbia wallichii*	0.00	0.00	0.00	1.8	1.80	9.28	0.00	0.00	0.00	0.00	0.00	0.00
15	*Fragaria vesca*	0.00	0.00	0.00	0.6	0.60	7.10	0.00	0.00	0.00	4.80	0.30	17.36
16	*Fritillari royleie*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.30	0.08	8.96
17	*Geranium pratense*	1.30	0.02	16.09	2.8	0.08	16.12	0.11	0.11	20.98	1.00	0.11	8.21
18	*Geum elatum*	0.10	0.10	3.91	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	*Impatiens glandulefera*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	1.60	0.10	16.32
20	*Iris hokeri*	0.20	0.20	13.55	2.2	0.55	12.38	0.20	0.33	29.22	0.60	0.60	14.06
21	*Lamium album*	0.60	0.07	6.60	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	*Malva neglecta*	0.60	0.02	8.87	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	*Myosotis arvensis*	2.80	0.18	15.48	16.6	0.20	45.39	0.36	0.51	27.10	5.80	0.36	19.42
24	*Nepeta linearis*	1.60	0.03	19.03	3.3	0.21	14.21	0.00	0.00	0.00	6.10	0.10	27.82
25	*Plantago major*	9.10	0.09	44.48	12.9	0.26	35.53	0.23	0.63	16.67	2.20	0.55	9.39
26	*Poa pretense*	1.70	0.19	10.47	0	0.00	0.00	0.24	0.67	16.28	6.20	0.39	19.69
27	*Podophyllum hexandrum*	0.70	0.18	14.41	0.6	0.04	19.26	0.02	0.10	15.04	0.00	0.00	0.00
28	*Polygonum amphicaule*	0.20	0.20	6.14	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	*Potentilla astrosanguinea*	0.20	0.20	2.92	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	*Primula denticulata*	0.10	0.10	5.79	0	0.00	0.00	0.00	0.00	0.00	0.30	0.08	7.61
31	*Primula eliptica*	0.00	0.00	0.00	1	0.25	6.89	0.14	0.23	16.79	0.00	0.00	0.00
32	*Prunella vulgaris*	0.30	0.30	6.49	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	*Pteris cretica*	0.40	0.04	5.89	0.6	0.04	9.31	0.06	0.18	11.36	0.70	0.18	6.00
34	*Ranunculus laetus*	3.00	0.05	20.73	0	0.00	0.00	0.10	0.42	10.18	1.20	0.13	8.33

35	*Rumex hastatus*	0.00	0.00	0.00	0	0.00	0.00	0.06	0.25	13.31	3.10	0.09	18.18
36	*Salvia nubicula*	0.00	0.00	0.00	0	0.00	0.00	0.07	0.19	26.09	1.20	0.08	16.65
37	*Sambucus wightiana*	0.00	0.00	0.00	0.7	0.18	14.45	0.00	0.00	0.00	0.00	0.00	0.00
38	*Senecio chrysanthemoides*	0.00	0.00	0.00	0.6	0.04	9.31	0.00	0.00	0.00	0.00	0.00	0.00
39	*Taraxicum officinale*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	1.30	0.14	8.54
40	*Thymus linearis*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	3.60	0.40	13.89
41	*Trifolium pratense*	0.20	0.05	4.05	1.8	0.45	8.67	0.31	0.43	25.46	1.00	0.25	6.62
42	*Trilium govanianum*	0.60	0.15	5.46	0.7	0.08	7.15	0.03	0.12	7.42	1.70	0.07	14.83
43	*Urtica dioica*	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.60	0.60	5.42
44	*Valeriana hardwickii*	0.00	0.00	0.00	1.2	1.20	6.18	0.00	0.00	0.00	0.00	0.00	0.00
45	*Verbascum thapsus*	0.90	0.00	14.29	1	0.11	10.65	0.00	0.00	0.00	0.00	0.00	0.00
46	*Viola odourata*	0.00	0.00	0	0	0.00	0.00	0.00	0.00	0.00	1.20	0.08	9.11

Table 5. Floristic diversity and distribution of medicinal plants along altitudinal gradient

S. No.	Species Name	Origin (Native/ Endemic)	Family	Habit	Altitudinal range (m)	Threat Category*	Medicinal system**	Traded 100 million tones/yr
1.	*Abies pindrow* Royle.		Pinaceae	Tree	2100 – 3600		A, F	
2.	*Acer caesium* Wallich ex Brandis.		Aceraceae	Tree	2200 – 3000		F	
3.	*Achillea millefolium* Linn.		Compositae	Herb	1800 – 3600		H, U, S, M, F	
4.	*Aconitum heterophyllum* Wallich ex Royle.		Ranunculaceae	Herb	2400 – 4000	CE	A, U, T, S, F, M	
5.	*Actaea spicata* Linn.		Ranunculaceae	Herb	2900 – 3500		H, F	
6.	*Adiantum capillus-veneris* Linn.		Pteridaceae					
7.	*Adonis aestivalis* Linn.		Ranunculaceae	Herb	1200 – 3000		F	
8.	*Aesculus indica* (Colebr. ex Cambess) Hook.		Sapindaceae	Tree	1800 – 3000		F	
9.	*Agrimonia pilosa* Ledeb.		Rosaceae	Herb	1000 – 3000		U, M, F	
10.	*Ajuga bracteosa* Wallich ex Benth.		Lamiaceae	Herb	1000 – 4000		A, F	
11.	*Allium humile* Kunth		Amaryllidaceae	Herb	3000 – 4000		A, U, F	
12.	*Anemone obtusiloba* D. Don.		Ranunculaceae	Herb	2100 – 4300		U, F	
13.	*Angelica gluca* Edgew.		Apiaceae	Herb	2500 – 3000		A, T	
14.	*Aquilegia fragrans* Benth.		Ranunculaceae	Herb	2500 – 4100		F	
15.	*Arabidopsis himalaica* (Edgew.) O. E.Schulz.		Cruciferae	Herb	2400 – 4300		F	
16.	*Arisaema jacquemontii* Blume.		Araceae	Herb	2400 – 4000		F	
17.	*Arnebia benthamii* (Wallich ex D.Don) I. M. Johnston.		Boraginaceae	Herb	3000 – 4300	CE	A, U, F	
18.	*Artemisia absinthium* Linn.		Asteraceae	Herb	1500 – 2700		A, H, M, F	
19.	*Astragalus grahamianus* Royle ex Benth.		Paplionaceae	Herb	1500 – 3300		F	
20.	*Atropa accuminata* Royle ex. Lindl.		Solanaceae	Herb	1500 – 3000		A, U, F	
21.	*Berberis lycium* Royle.		Berberidaceae		1500 – 3000		A, U, F	

22.	*Berberis pechycanthra*							
23.	*Bergenia ciliata* (Haw.) Sternb.		Saxifragaceae	Herb	1800 – 2400		A, U, S, F	
24.	*Betula utilis* D.Don.		Betulaceae	Tree	2700 – 4300	CE	A, S, F	
25.	*Bupleurum falcatum var. marginatum* Wallich.		Apiaceae	Herb	1500 – 400		F	
26.	*Cannabis sativa* Linn.		Cannabaceae	Herb	1800 – 2800		A, U, H, T, S, M, F	
27.	*Capsella bursa-pastoris* (Linn.) Medikus.		Cruciferae	Herb	1800 – 2200		H, F	
28.	*Cedrus deodara* (Roxb. ex D. Don) G. Don.		Pinaceae	Tree	1800 – 3000		A, U, T, S, F	
29.	*Chenopodium album* Linn.		Chenopodiaceae	Herb	1500 – 3600		A, U, S, F	
30.	*Cichorium intybus* Linn.		Compositae	Herb	1500 – 2400		F	
31.	*Cirsium falconeri* (Hook.f.) Petrak.		Compositae	Herb	2700 – 4300		F	
32.	*Clematis montana* Wallich.		Ranunculaceae	Climber	1800 – 3000		F	
33.	*Colchicum luteum* Baker.		Liliaceae	Herb	1800 – 3500		A, U, S, F	
34.	*Corydalis govaniana* Wallich.		Papaveraceae	Herb	2400 – 4800		A, F	
35.	*Corylus jacquemontii* Decne		Corylaceae	Tree	1800 – 3000		F	
36.	*Cotoneaster nummularia* Fischer & Meyer		Rosaceae	Shrub	600 – 3000		F	
37.	*Cuscuta reflexa* Roxb.		Cuscutaceae	Climber	1800 – 3300		A, S, U, F	
38.	*Cynodon dactylon* (Linn.) Pers.		Poaceae	Herb	1800 – 2500		A, H, T, U, S, F	
39.	*Dactylorhiza hatagirea* (D.Don) Soo		Orchidaceae	Herb	2800 – 4000	CE	F	
40.	*Delphinium roylei* Munz.		Ranunculaceae	Herb	1800 – 2400		F	
41.	*Digitalis lanata* Linn.		Scrophulariaceae	Herb			U, F	
42.	*Dioscorea deltoidea* Wall. ex Griseb		Dioscoreaceae	Climber	1800 – 2600		M, U, F	
43.	*Dipsacus inermis* Wall.		Dipsacaceae	Herb	1800 – 2800		F	
44.	*Epilobium hirsutum* Linn.		Onagraceae	Herb	1000 – 3300		F	

45.	*Equisetum arvense* Linn.		Equisetaceae	Herb	2200 – 3000		A, M, F	
46.	*Euonymus hamiltonianus* Wallich.		Celastraceae	Shrub	700 – 2700		F	
47.	*Euphorbia wallichii* Hook.f.		Euphorbiaceae	Herb	2300 – 3600		F	
48.	*Fragaria nubicola* Lindley ex. Lacaita		Rosaceae	Herb	1800 – 3800		F	
49.	*Fraxinus excelsior* Linn.		Oleaceae	Tree	1000 – 3000		F	
50.	*Fritillaria roylei* Hook. (Shethkhar)		Liliaceae	Herb	2800 – 4000	EN	A, U, F	
51.	*Gagea elegans* Wallich ex D.Don.		Liliaceae	Herb	2000 – 4300		F	
52.	*Galium aparine* Linn.		Rubiaceae	Herb	1800 – 2200		F	
53.	*Gaultheria trichophylla* Royle.		Ericaceae	Shrub	2700 – 4500		F	
54.	*Gentiana carinata (*D.Don) Griseb.		Gentianaceae	Herb	3000 – 4300		F	
55.	*Geranium wallichianum* D. Don ex Sweet.		Geraniaceae	Herb	2200 – 3500		F	
56.	*Geum elatum* Wallich.		Rosaceae	Herb	2700 – 4300		F	
57.	*Hedera nepalensis* K. Koch.		Araliaceae	Climber	1800 – 3000		F	
58.	*Heracleum candicans* Wallich ex DC.		Apiaceae	Herb	1800 – 3000		F	
59.	*Hyoscyamus niger* Linn.		Solanaceae	Herb	2100 – 3300		A, H, U, S, M	
60.	*Hypericum perforatum* Linn.		Hypericaceae	Herb	1800 – 2500		H, M, F	
61.	*Impatiens glandulifera* Royle.		Balsaminaceae	Herb	1800 – 4000		F	
62.	*Indigofera heterantha* Wallich ex Brandis.		Leguminosae	Shrub	1800 – 3000		F	
63.	*Inula royleana* C. B. Clarke.		Compositae	Herb	2800 – 4000	EN	F	
64.	*Iris kemaonensis* D.Don ex Royle.		Iridaceae	Herb	2800 – 4000		F	
65.	*Jasminum humile* Linn.		Oleaceae	Climber	1800 – 3000		A, S, T, F	
66.	*Juglans regia* Linn.		Juglandaceae	Tree	1500 – 3000		A, H, T, U, S, F	
67.	*Jurinea dolomiaea* Boiss.		Asteraceae	Herb	3000 – 4300		A, F	
68.	*Lamium album* Linn.		Lamiaceae	Herb	1800 – 3000		H, S, F	
69.	*Lavatera kashmiriana* Cambess.		Malvaceae	Herb	1800 – 3600		F	

70.	*Leonurus cardiaca* Linn.		Labiateae	Herb	2400 – 3600		F	
71.	*Lepidium latifolium* Linn.		Cruciferae	Shrub	3000 – 3600		F	
72.	*Lonicera quinqueolocularis* Hardw.		Caprifoliaceae	Shrub	1800 – 3000		F	
73.	*Malva neglecta* Wallr.		Malvaceae	Herb	1800 – 2800		F	
74.	*Mentha arvensis* Linn.		Lamiaceae	Herb	1800 – 2200		A, U, S, M, F	
75.	*Myosotis silvatica* Ehrh. ex Hoffm.		Boraginaceae	Herb	1800 – 4000		F	
76.	*Nepeta linearis* Royle ex Benth.		Lamiaceae	Herb	1500 – 4000		F	
77.	*Origanum vulgare* Linn. (wan-babri)		Lamiaceae	Herb	1800 – 3000		A, U, F	
78.	*Oxalis acetosella* Linn.		Oxiladaceae	Herb	2100 – 3000		A, U, T, S, F	
79.	*Oxyria digyna* (Linn.) Hill.		Polygonaceae	Herb	2400 – 4500		F	
80.	*Parrotiopsis jacquemontiana* (Decne.) Rehder.		Hamamelidaceae	Shrub	2000 – 2500		F	
81.	*Pedicularis bicornuta* Klotzsch		Scrophulariaceae	Herb	2800 – 4000		F	
82.	*Phlomis bracteosa* Royle ex Benth.		Lamiaceae	Herb	1200 – 4000		F	
83.	*Phytolacca acinosa* Roxb.		Phytolacaceae	Herb	1500 – 3000		F	
84.	*Picea smithiana* (Wall.) Boiss.		Pinaceae	Tree	2100 – 3600		F	
85.	*Picrorhiza kurrooa* Royle ex Benth.		Scrophulariaceae	Herb	3300 – 4300		A, T, U, S, F	
86.	*Pinus wallichiana* A. B. Jackson.		Pinaceae	Tree	1800 – 3000		F	
87.	*Plantago lanceolata* Linn.		Plantaginaceae	Herb	1800 – 2200		A, U, F	
88.	*Plectranthus rugosus* (Wall.) ex Benth.		Lamiaceae	Shrub	1000 – 2700		F	
89.	*Podophyllum hexandrum* Royle.		Podophyllaceae	Herb	2400 - 4500		A, U, H, M, F	
90.	*Polygonatum verticillatum* (Linn.) All.		Liliaceae	Herb	1500 - 3700		F	
91.	*Polygonum affine* D.Don.		Polygonaceae	Herb	3000 - 4500		F	
92.	*Potentilla nepalensis* Hook.		Rosaceae	Herb	2100 - 3000		F	
93.	*Primula denticulata* Smith.		Primulaceae	Herb	2800 - 3500		F	
94.	*Primula eliptica* Royle		Primulaceae	Herb	3200 - 4300		F	

95.	*Prunella vulgaris* Linn.		Lamiaceae	Herb	2200 - 3500		F	
96.	*Ranunculus arvensis* Linn.		Ranunculaceae	Herb	1800 - 2400		F	
97.	*Rheum webbianum* Royale.		Polygonaceae	Herb	3000 - 4200		A, U, F	
98.	*Rhodiola himalensis* (D.Don.) S. H. Fu.		Crassulaceae	Herb	3000 - 4000		F	
99.	*Rhododendron anthopogon* D. Don		Ericaceae	Shrub	3000 - 3800		A, F	
100.	*Rhus succedanea* Linn.		Anacardiaceae	Tree	1200 - 2400		F	
101.	*Rosa webbiana* Wallich ex Royle.		Rosaceae	Shrub	1500 - 4100		S, F	
102.	*Rubia cordifolia* Linn.		Rubiaceae	Climber or shrub	1200 - 2700		F	
103.	*Rubus niveus* Wallich.		Rosaceae	Shrub	2200 - 3300		F	
104.	*Rumex nepalensis* Sprengel.		Polygonaceae	Herb	1800 - 3000		H, F	
105.	*Salix alba* Linn.		Salicaceae	Shrub	1800 - 2500		M, F	
106.	*Salvia moorcroftiana* Wall. ex Benth.		Lamiaceae	Herb	2400 - 3800		F	
107.	*Sambucus wightiana* Wallich ex Wight & Arn.		Sambucaceae	Shrub	1800 - 3000		U, F	
108.	*Saussurea costus* (Falc.) Lipsch.		Asteraceae	Herb	2800 - 3500	CE	A, U, M, F	
109.	*Senecio chrysanthemoides* DC.		Compositae	Herb	1800 - 4000		F	
110.	*Solidago virga – aurea* Linn.		Compositae	Herb	1800 - 3200		H, F	
111.	*Sorbaria tomentosa* (Lindley) Rehdar.		Rosaceae	Shrub	1800 - 2900		F	
112.	*Sorbus lanata* (D. Don) Schauer.		Rosaceae	Shrub or small tree	2500 - 3400		F	
113.	*Spiranthes sinensis* (Pers.) Ames.		Orchidaceae	Herb	1500 - 4500		F	
114.	*Swertia petiolata* D. Don		Gentianaceae	Herb	3000 - 4500		A, U, F	
115.	*Syringa emodi* Wallich ex Royle.		Oleaceae	Shrub or small tree	2100 - 3600		F	
116.	*Taraxacum officinale* Weber.		Compositae	Herb	1500 - 3800		A, H, U, S, M, F	

117.	*Taxus wallichiana* (Zucc.) Pilger.		Taxaceae	Tree	2500 - 3400	EN	A, U, M, F	
118.	*Thymus linearis* Benth. ex Benth.		Lamiaceae	Herb	2200 - 3200		F	
119.	*Trifolium pratense* Linn.		Leguminosae	Herb	1800 - 2500		U, H, M, F	
120.	*Trillium govanianum* (D.Don.) Kunth.		Liliaceae	Herb	2800 - 4000		M, F	
121.	*Tusilago farfara* Linn.		Compositae	Herb	3800 - 4500		H, U, M, F	
122.	*Urtica dioica* Linn.		Urticaceae	Herb	1800 - 2500		A, H, U, F	
123.	*Valeriana jatamansii* Jones		Valerianaceae	Herb	1500 - 3600		A, U, F	
124.	*Verbascum thapsus* Linn.		Scrophulariaceae	Herb	1800 - 3800		H, U, M, F	
125.	*Viburnum grandiflorum* Wall. ex DC		Sambucaceae	Shrub	2500 - 3600		F	
126.	*Viola biflora* W.Becker.		Violaceae	Herb	2400 - 3600		F	

*** Threat Category:-**CE - Critically Endangered, EN - Endangered, VU - Vulnerable, R - Rare, I- Indiscriminate.

****Medicinal System:-**A - Ayurveda, H - Homeopathy, U - Unani, S - Sidha, Tibetan, F - Folk, M - Modern system of Medicine (Allopathic).

Conclusion

The study of vegetation in bangus valley concluded that the tree vegetation at all four surveyed sites was dominated by *Abies pindrow*. Whereas, *Pinus wallichiana* has very rare distribution**.** The shrubby vegetation was dominated by *Viburnum grandiflorum* followed by *Rosa brunie*. Whereas, *Berberis lycium* has less distribution. Among herb species vegetation of the site was dominated by *Plantago major* followed by *Ranunculus laetus, Nepeta linearis, Geranium pratense* respectively. In the surveyed area the most dominant species was found *Myosotis arvensis* followed by *Plantago major, Iris hokeri,* and *Geranium pretense*. The higher dominance of *Myosotis arvensis*, *Plantago major*, *Iris hokeri*, and *Geranium pretense* was attributed to their higher frequency, density and abundance as compared to the rest of the species.

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