ISSN: 0971-7447 (Print)
ISSN: 2455-6815 (Online)

Volume 28, 2020

Himalayan Ecology and Environment

COVID-19 Impact on Himalayan Ecology and Environment

ENVIS BULLETIN HIMALAYAN ECOLOGY

ENVIS CENTRE ON HIMALAYAN ECOLOGY
G.B. Pant National Institute of Himalayan Environment
An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Government of India)
Kosi-Katarmal, Almora-263 643, Uttarakhand, India

Vol. 28, 2020
ENVIS Bulletin
HIMALAYAN ECOLOGY

Kosi-Katarmal, Almora, Uttarakhand

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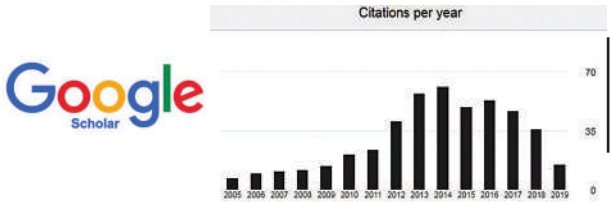
Citation	510	280
h-index	11	7
i10-index	17	4

Global Impact and Quality Factor* : 0543
Research Impact Factor** : 0.091
Sources: *GIF Database (2014)
**ICI Database (2010)

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ISSN: 0971-7447 (Print)
ISSN: 2455-6815 (Online)

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ENVIS Bulletin on Himalayan Ecology is an annual non-priced publication of the ENVIS Centre, which was established at the headquarters of the G.B. Pant National Institute of Himalayan Environment (GBPNIHE) in the financial year 1992-93 with the fiscal support from the Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India, New Delhi. The present volume of the ENVIS Bulletin is 28th in the series of its annual publication and contains papers on Himalayan Ecology and Environment and COVID-19 Impact on Himalayan Ecology and Environment, livelihood options during COVID pandemics etc. The news and views offered in the papers in this publication are the views of the concerned authors. Therefore, they do not necessarily reflect the views of the editors, ENVIS Centre and Institute. The content of the Bulletin may be quoted or reproduced for non-commercial use provided the source is duly acknowledged.

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ISSN: 0971-7447 (Print)
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STUDY OF LAND-USE PATTERN UNDER DIFFERENT AGROFORESTRY SYSTEM IN A PART OF MANIPUR, NORTH- EAST INDIA

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ABSTRACT

The survey regions under this study in part of were inhabited by different communities living in harmony with the surrounding environment. Each village under the studied areas adopted different agroforestry land use system having unique traditional practices. The current land use pattern of the studied areas mainly utilized the existing land by adopting an occupation that generates income and profits which includes fish-cum paddy cultivation along with agroforestry tree plantation on the ring bunds in Khoidumpat wetland, plantation of pineapple on the hillock slopes and water reed cultivation on the plain area in Sharam Tangkhul village, pure agriculture and traditional homegardens in Leitanpokpi village. The existing occupation greatly depends on the monsoon rain, soil type and factors.

Keywords: Agroforestry, Homegardens, Landuse and Plantation.

INTRODUCTION

Agroforestry is seen as an alternative paradigm for rural development world-wide that is central on species-rich, low-input agricultural techniques including a diverse array of new indigenous tree crops, rather than on high-input monocultures with only a small set of staple food crops (Leakey 2001). Agroforestry symbolizes a sustainable land-use system, which integrates growing of agricultural crops and timber or fruit tree together on the same piece of the land for maximum production of food, fodder and wood and other products of economic utility. In agroforestry systems, there are ecological and economic interactions between the different existing components (ICRAF 1993). Agroforestry play an important role in lowering vulnerability, increasing resilience of farming systems and protecting households against the adverse climate related risk in addition to promising livelihood security (NRCAF 2013).

India is particularly notable for ethno-forestry practices and indigenous knowledge systems on tree growing. In terms of household income, Central Indian upland rice fields provide an illuminating economics (Viswanath *et al*., 2000). While most agroforestry systems have great energy for carbon sequestration, home-gardens are unique in this respect. They not only sequester carbon in biomass and soil, but also reduce fossil-fuel burning by promoting wood, fuel production, and conserve agro biodiversity (Kumar *et al*., 2004).

STUDY AREA

The study was executed in two villages and one wetland area which come under Thoubal and Imphal East Districts of Manipur, North East India. The respective villages under Thoubal District were Khoidumpat Wetland and Sharam Tangkhul village, whereas Leitanpokpi village of Imphal East District. Khoidumpat wetland is a big area of Kakching Sub-Division Thoubal District in habitated by more than hundreds of households. This wetland is known for fish cultivation and production area. Majority of the people residing inside this region were engaged in pisciculture and fish cum paddy practices.

METHODOLOGY

In the present study questionnaire for survey were prepared according to the method given by (Shukla *et al*., 2013). To execute the survey an initial research on the suitable area was selected through contact with the local people. Once the area was confirmed, a questionnaire was prepared to extract the required field data and information from the farmers in respective areas. In order to identify the current land use practices and the traditional agroforestry practices of Khoidumpat Wetland, Sharam Tangkhul village and Leitanpokpi village, a specific date was fixed to conduct the study in randomly selected houses of the study regions. The questions were mainly focused on the existing pattern of land use and its components under agroforestry systems (tree species and vegetables, wildlife biodiversity), land holding area (average), annual

investment and income (average), and problems of the studied area.

RESULT & DISCUSSION

Land use pattern under different agroforestry system in Khoidumpat wetland

In the agroforestry system of Khoidumpat wetland, the main occupation was fish-cum-paddy cultivation. The promising source of income was generated from pisciculture activities. Along the ring bunds of the wetlands the timber and fruit tree species were planted and some existed naturally. The different components under agroforestry system are presents in Table 1.

Table 1. Different components of existing agroforestry system in Khoidumpat wetland. Thoubal District.

S. No	Components of agroforestry system			
	Timber	Fruit tree	Vegetables	Wildlife
1.	*Parkia roxburghii*	*Musa paradisiaca*	*Lycopersicon esculentum*	*Nycticorax nycticorax*
2.	*Toona ciliata*	*Mangifera indica*	*Solanum melongena*	*Ardeoda grayii*
3.	*Delonix regia*	*Citrus lemon*	*Brassica napus*	Rodentia
4.	*Gmelina arborea*	*Psidium guajava*	*Solanum tuberosum*	*Ceryle rudis*
5.	*Bauhinia verigata*	*Punica granatum*	*Phaseolus vulgaris*	*Accipiter nisus*
6.	*Ficus religiosa*	*Carica papaya*	*Vicia faba*	*Sambrang*
7.	*Grevillea robusta*	*Elaeocarpus floribunda*	*Allium sativum*	*Dicrurus adsimilis*
8.	*Tectona grandis*	*Ficus racemosa*	*Allium cepa*	Keizanglang
9.	*Callistemon viminalis*	*Citrus medica*	*Raphanus sativus*	*Anas platyrhynchos*
10.	*Lagistromia speciosa*	*Citus grandis*	*Brassica oleracea*	*Anas crecca*
11.	*Albizzia stipulata*	*Spondias mangifera*	*Capsicum annuum*	*Anas acuta*
12.	*Bambusa nana*	*Citrus aurantium*	*Cucumis sativus*	*Anser indicus*
13.	*Areca catechu*	*Citrus paradisi*	*Coriandrum sativum*	*Pycnonotus jocosus*
14.	*Kigalia africana*	*Emblica officinalis*	*Brassica juncea*	*Khasa*

Land use pattern under different agroforestry system in Sharam Tangkhul village

In this village, the hill-top areas were mainly dominated by plantation of Pineapple and some people adopted plantation of pineapple intercroped with China Teak and Groundnut, but it resulted in reduction of soil fertility, production of both pineapple and the intercrops species.

Table 2. Different components of existing agroforestry system in Sharam Tangkhul Village, Thoubal District.

S. No.	Components of agroforestry system			
	Timber	Fruit tree	Vegetables	Wildlife
1.	*Pinus khasya*	*Elaeocarpus floribunda*	*Alocasia indica*	*Erethizon dorsatum*
2.	*Tectona grandis*	*Mangifera indica*	*Nong-mangkha*	*Rodentia*
3.	*Eucalyptus spp.*	*Psidium guajava*	*Melangna*	Herpestes edwardsi
4.	*Dendrocalamus strictus*	*Prunus domestica*	*Coriandrum sativum*	*Rattus rattus*
5.	*Parkia roxburghii*	*Artocarpus heterophyllus*	*Phaseolus vulgaris*	*Funambulus palmarum*
6.	*Bredelia retusa*	*Tamarindus indica*	*Vicia faba*	*Mellisuga helenae*
7.	*Cedrela toona*	*Carica papaya*	*Vigna umbellate*	*Accipiter nisus*
8.	*Quercus serratus*	*Pyrus communis*	*Ipomoea batatas*	Pycnonotus jocosus
9.	*China teak*	*Zigyphus mauritiana*	-	*shendrang*
10.	*Gmelinea arborea*	*Citrus limon*	-	-
11.	*Alnus nepalensis*	*Musa paradisiaca*	-	-
12.	*Erythrina suberosa*	-	-	-
13.	*Areca catechu*	*Citrus paradisi*	*Coriandrum sativum*	*Pycnonotus jocosus*
14.	*Kigalia africana*	*Emblica officinalis*	*Brassica juncea*	*Khasa*

Land use pattern under different agroforestry system in Leitanpokpi village

In this region, majority of the people are government employees and self-employed. The main occupation was agriculture and the harvested rice grains are used for household needs. Moreover, the surplus grains are sold out in market. There was also a well maintained traditional home garden in each of the households by growing seasonal vegetables crops for their daily consumptions which reduces the demand for market vegetables.

Table 3. Different components of existing agroforestry system in Leitanpokpi village, Imphal East District.

S. No.	Components of agroforestry system			
	Timber	Fruit tree	Vegetables	Wildlife
1.	*Toona ciliata*	*Psidium guajava*	*Pisum sativum*	*Accipiter nisus*

2.	*Bambusa tulda*	*Ficus racemosa*	*Coriandrum sativum*	*Corvus macrohynchos*
3.	*Gravillea robusta*	*Syzyzium cumini*	*Allium cepa*	Shandrang
4.	*Parkia roxburghii*	*Punica granatum*	*Brassica napus*	*Pycnonotus jocosus*
5.	*Artocarpus heterophyllus*	*Mangifera indica*	*Brassica juncea*	*Sturnus contra*
6.	*Callistemon viminalis*	*Prunus domestica*	*Vicia faba*	*Anas crecca*
7.	*Delonix regia*	*Musa paradisiaca*	*Solanum melongena*	*Urit*
8.	*Eucalyptus species*	*Cirus maxima*	*Capsicum annuum*	Odocoileus virginiana
9.	*Erythrina suberosa*	*Saccharum officinarum*	*Phaseolus vulgaris*	*Khangbrang*
10.	*Dendrocalamus strictus*	*Artocarpus heterophyllus*	*Zea mays*	*Felis silvestris*
11.	*Wendrandia paniculata*	*Elaeocarpus floribunda*	*Alocasia indica*	*Amaurornis phoenicurus*
12.	*Gmelina arborea*	*Elaegnus pyriformis*	*Allium sativum*	*Maku*
13.	*Jatropha curcas*	*Syzygium cumini*	*Solanum tuberosum*	*Rodentia*
14.	*Morus alba*	*Artocarpus integrifolia*	*Solanum spp*	*Rattus rattus*
15.	*China teak*	-	*Lycopersicon esculentum*	-
16.	*Bischofia javanica*	-	*Hibiscus cannabinus*	-
17.	*Cymbopogon citratus*	-	-	-
18.	*Acacia fernesiana*	-	-	-

Economics importance of existing agroforestry systems

The villages under the studied area generate income from the existing agroforestry practices of home garden and plantation. The people were also having agriculture fields ranging from 3- 13 acre, whereas 1-2 acre was used for growing seasonal vegetables in. homgarden. The annual investment on paddy, plantation of pineapple, fish-cum-paddy cultivation and traditional homegardens, etc. of these studied areas varied according to the acquired land size and other management requirements of the farmers. Some of the people were working as a government employee, carpenter, driver, teacher and businessman. Thus, full time engagement in their respective agricultural field was not seen in majority of the studied areas.

In Sharam Tangkhul village, plantation of Pineapple was their main occupation for livelihood and income generation profit practices. The slopping hillocks had been utilized for Pineapple production having a varied plantation area of 0.6-3 acre approximately. The minimum investment starts from Rs. 15,000 - 20,000 per year with an income of Rs.10,000-12,000 per acre for the first initial year of 5th rotation period under 0.6 - 1acre of land area. Whereas, the maximum input was Rs. 30,000-40,000 per year with an income of Rs. 14,000 -15,000 per acre for the initial year of rotation under 2 - 3 acre of land area. The production of pineapple increases during the second year of rotation, so there was an increase in the income generation.

DISCUSSION

The tree species and horticultural crops in the present study area includes *Parkiarox burghii, Tectona grandis, Eucalyptus species, Elaeocarpus floribunda, Mangifera indica, Bamboo species, Citrus limon,* sugar cane, pomegranate*, Musa pardisiaca* and some vegetables and spices like cabbage, brinjal, beans, raddish, tomato, chilly, onion and garlic etc. In Kuttanad Wetland of Kerala, the dominating agriculture crops of the bund region are coconut, plantain, tubers, vegetables and fruit plants like *Garcinia gummigutta* and *Meristica fragrans* in homesteads (Alexander 2018). (Niyas *et al.*, 2016) reported a total number of 76 tree species with a distribution of 20 fruit tree species, 10 timber species in peri urban home gardens. Whereas, the current studied in the selected areas of Khoidumpat area, Sharam village and Leitanpokpi village, the total number of tree species was founded 38 including timber tree and fruit trees. Comparing with previousstudies, the tree species diversity in the present studied areas was low. The past report by (Sahoo *et al.*, 2010) estimated that there were 58 tree species, reported from the state of Maghalaya was 70 tree species (Tynsong *et al.*, 2010). Whereas, the total number of tree species encountered during the present study was 48 (timber tree and fruit tree), 21 vegetables species and 20 species of wildlife from the selected areas of the survey.

CONCLUSION

The existing traditional land use pattern like homesteads, fish–cum-paddy field and plantation areas were identified, studied, and documented through field visits with the help of interaction with the farmers. The selected villages of two different Districts showed a unique land use system for their livelihood. The respective land use pattern under agroforestry systems adopted in Khoidumpat region was mainly fish–cum-paddy cultivation in each household. The gradual maximization of crop density through plantation of suitable endemic timber and fruit tree species in any available area within the land use practices enhances the overall wealth of the environment and diversity of plants.

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HABITAT PREFERENCE AND AVAILABILITY OF MEDICINAL AND AROMATIC PLANTS IN ALPINE MEADOWS OF KUMAUN HIMALAYA, UTTARAKHAND, INDIA

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ABSTRACT

The study envisages assessing the availability and habitat preference of medicinal plants in the alpine region of Kumaun Himalaya. The availability of medical plants across six major habitats viz., mixed herbaceous meadow, tall forbs, *Danthonia* grassy slope, shrubbies, *Kobresia* sedge and cushinoid were assessed across meadows above 3000m asl. Rapid Mapping Exercise (RME) technique (4 plots of 1×1m at every 50m interval, total 40 plots in one transect) was used to assess the species across habitats. Total 60 transects were laid in above mentioned habitats. The results reveal that mixed herbaceous meadows with maximum density, richness and diversity was the most preferable habitat for most of the alpine medicinal plants. A total 25 species were prioritized for present study. *Picrorhiza kurroa* has most diverse (6) habitat preference followed by *Angelica archangelica, Jurinea dolomiaea* (4 habitats). Due to high habitat specificity, *Rheum australe, Meconopsis aculetea* and *Megacarpa polyandra* were confined to only rocky and shrubberies habitat respectively. *Bergenia stracheyi* recorded the maximum density (2.3 ind/m^2) in rocky/ bouldry habitat while minimum was recorded for *Megacarpa polyandra* (0.3 ind/m^2) in shrubberies habitat. Habitat based studies of medicinal plants would be very important in understanding the ecology of species and formulating the conservation and management plan.

INTRODUCTION

Medicinal plants are essential components of the economy and healthcare for the inhabitants of the Himalaya as they are valuable sources of new drugs (Hamilton 2004). The Himalaya, a global biodiversity hotspot is well-recognized for biophysical diversity and socio-cultural heritage (Rawal *et al*., 2013) and supports more than 10,500 species of flowering plants distributed from subtropical foothills to high alpine zones (Rana *et al.,* 2017). However, owing to the vastness and difficult terrain, the area still exhibits some unrevealed elements of biodiversity. The Himalaya is also a repository of medicinal and aromatic plants (MAPs) reported over 1748 species as medicinal importance (Samant *et al*., 1998). Among the Himalayan states, Uttarakhand is endowed with a high diversity (964 species) of MAPs, where the alpine region has a significant contribution with over 400 species (Rawat 2005). Of the total MAPs of the state, 14 medicinal plants are recognised threatened at global (IUCN) and 40 MAPs at the regional (Uttarakhand) level (Ved *et al*., 2003). Today, about 90% of the plant species used in the herbal industry are extracted from the wild, majority of which comes from the sub-alpine and alpine zones of the Himalaya (Dhar *et al*., 2000). Excessive anthropogenic pressure in terms of unscientific collection, habitat loss and grazing are the main cause of population decline of these medicinal plants (Rikhari *et al*., 1992; Kala *et al*., 1998). Available literature reveals that several aspects of medicinal plants viz., floristic surveys, ethnobotanical aspects, demand and supply of few species are studied extensively, however, quantitative information on the micro-habitat preferences and population status of these species are virtually lacking from the Himalayan region. A little information on phenology of alpine MAPs is available (Negi *et al*.,1992). Studies on these aspects of commercially useful plants would be very vital in understanding the ecology and formulating the conservation plans for the region. Hence, present study intended for the assessment of availability and habitat preferences of some alpine medicinal herbs in alpine region of Kumaun Himalaya.

STUDY AREA

Intensive study was carried out in 30 alpine meadows of Pithoragarh and Bageshwar districts (Kumaun region). It is bounded by Chamoli district on the west, Tibet on the north, Nepal on the east and Almora district on the south. Thus, the total area covered between 3000 to 5300m altitudes is 4617km^2. Generally, these meadows remains under heavy snow cover for four to six months during winter. The climate varies from temperate in lower elevations to cold deserts in

higher elevations. Mean daily temperature ranges between –25°C and 25°C. Annual precipitation varies between 660 and 2200mm, minimum being in January and maximum in July-August. The alpine region of Uttarakhand is mainly categorised into six major vegetation formations viz., tall forbs, short forbs or mixed herbaceous formations, matted shrubs/shrubberies, *Danthonia* grasslands, *Kobresia* sedge meadow, and cushioned vegetation (Rawat 2005). *Danthonia* grass lands mainly dominated by tussock forming grass *D. cachemyriana*, generally form extensive grassy slopes in warmer aspects. Whereas, on the gentler slopes, herbaceous formations are prevalent, while *Kobresia* sedge meadows are found in higher elevations (>4000m) and primarily formed by species of *Kobresia* sp.

MATERIAL AND METHOD

The field work in the alpine region can be executed only from June to September months when most of the area is snow free and plants begin to bloom and make identification easy. Therefore, intensive field surveys were conducted in 30 alpine meadows of Kumaun region during 2016-19. Population assessment was made by using the rapid mapping exercise (RME) technique (Fig. 1) (Rawat *et al*., 2004). A transect of 500m long, having 10 plots (5m circle) at every 50m interval were laid to assess the major habitat type of the species. Within each 5m circular plot, four quadrats of 1×1m in north, east, west and south (NEWS) directions were laid to assess the population of species. About 30 to 40 quadrats were laid in each site where species have been recorded. Within each quadrat (1×1m), total number of species (medicinal and their associates), their number and cover were recorded.

RESULTS

Based on the altitudinal gradient and physiognomy, different habitats were identified. The surveyed MAPs were found within nine different habitats viz., mixed herbaceous meadow, tall forbs, *Danthonia* grassy slope, shrubbies, *Kobresia* sedge, cushinoid, sub alpine forest, Marshy meadows, rocky/bouldry and moist scrub. Species such as *Rheum australe*, *Pleurospermum* and *Nardostachys jatamansi* were found in the higher elevation regions mainly above 4000m whereas *Dactylorhiza hatagirea, Aconitum heterophyllum, Arnebia benthami*i and *Jurinea dolomiaea* were mainly found in the lower alpine zones (<4000m). The population assessment of MAPs reveals that the population of each species varied across the habitats. *Picrorhiza kurroa* was found in six different habitats namely, Mixed herbaceous, *Danthonia* slope, moist scrub, rocky/bouldry, *Kobresia* and sub alpine forest and *Angelica archangelica* (Mixed herbaceous, *Danthonia* slope, tall forbs, moist scrub), *Jurinea dolomiaea* (Mixed herbaceous, *Danthonia* slope, moist scrub and sub-alpine forest, *Kobresia*) were in five habitats. Similarly, *Arnebia benthami* (Mixed herbaceous, *Danthonia* slope, moist scrub) *Dactylorhiza hatagirea* (Mixed herbaceous, *Danthonia* slope, marshy meadow) and *Angelica glauca* (tall forbs, moist scrub, sub alpine forest), *Fritillaria roylei* (Mixed herbaceous, *Danthonia* slope, marshy meaows), *Polygonatum verticillatum* (tall forbs, mixed herbaceous, sub alpine forest) *Allium wallichi* (tall forbs, mixed herbaceous, *Danthonia* slope) were mainly recorded in three habitats and *Aconitum heterophyllum* (mixed herbaceous, *Danthonia* slope), *Aconitum balfourii* (moist scrub, sub alpine forest) *Rheum moorcroftianum* (Rocky/bouldry, cushinoid), *Trillidium govanianum* (moist scrub, rocky/bouldry), *Bergenia strecheyi* (grassy slope, rocky/bouldry), *Malaxis muscifera* (grassy slope. Marshy meadow), *Podophyllum hexandrum* (moist scrub, rocky bouldry) and *Nardostachys jatamansi* (mixed herbaceous and rocky/bouldry) were present in two habitats. Due to high habitat preference, *Rheum austral*, *Meconopsis aculeata* (rocky/bouldry) and *Megacarpa polyandra* (shrubberies) were confined to only in the one habitat.

Among the species *A. archangelica* (1.5 ind/m^2), *P. verticillatum* (1.3 ind/m^2) A. stracheyi (1.2 ind/m^2), *A. wallichi* (1.1 ind/m^2) had higher density in mixed herbaceous meadows and *J. dolomiaea* (2.1 ind/m^2), *A. heterophyllum* (1.5 ind/m^2), *A. benthamii* (1.5 ind/m^2), *Malaxis muscifera* (1.2 ind/m^2) in *Danthonia* grassy slope. *D. hatagirea* showed maximum density (1.1 ind/m^2) in marshy meadows. *Polygonatum verticillatum* had maximum density (1.9 ind/m^2) in tall forbs habitat. *Aconitum balfourii* (1.3 ind/m^2) and *Angelica glauca* (1.6 ind/m^2) had the highest density near the forest fringes. *Bergenia stracheyi* (2.3 ind/m^2), *Ephedra gerardiana* (1.2 ind/m^2), *Rheum austral* (1.5 ind/m^2), *R. moorcroftianum* (2.3ind/m^2) and *Podophyllum hexandrum* (1.3 ind/m^2) in rocky and bouldery areas. *Picrorhiza kurroa* had maximum density (1.9 ind/m^2) in moist scrub habitat (Table 1). *Nardostachys jatamansi* and *Fritillaria roylei* had patchy distribution even in their respective habitat. This reveals that though some species may be present in a variety of habitats, their population would be high in a particular habitat. Previous studies conducted in the alpine region of the state have reported higher density for

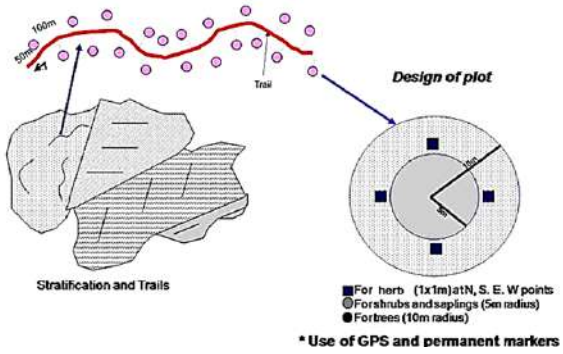

Fig. 1. Rapid mapping technique for plant population (Rawat 2005)

Table 1. Availability of MAPs (ind/m²) in different habitats

S.No	Species name	TF	MH	DGS	MS	R/B	MM	SAF	CV	KSM
1	*Aconitum heterophyllum*	-	0.9	1.5	-	-	-	-	-	-
2.	*Aconitum balfourii*				1.2		-	1.3	-	-
3.	*Allium strecheyi*	-	1.2	-	-	-	-	-	-	-
4.	*Allium wallichi*	0.8	1.1	0.5	-	-	-	-	-	-
5.	*Angelica glauca*	1.5	-	-	1.9		-	1.6	-	-
6	*Angelica archangelica*	0.8	1.5	0.8	0.7	-	-	-		-
7.	*Arnebia benthamii*		0.8	1.5	1.2	-	-	-	-	-
8.	*Bergenia strecheyi*	-	-	1.9	-	2.5		-	-	-
9.	*Dactylorhiza hatagirea*	-	0.6	0.7	-	-	1.1	-	-	-
10.	*Ephedra gerardiana*	-	-	-	-	1.2		-	-	-
11.	*Euphrasia himalaica*	-	1	-	-	-			-	-
12.	*Fritillaria roylei*	-	0.3	0.5	-	-	1.1	-	-	-
13.	*Hyoscynus niger*	-	-	-	0.9	-		-	-	-
14.	*Hyssopus officinalis*	-	-	-	-	0.8		-	-	-
15.	*Jurinea dolomiaea*	-	1.2	2.1	0.5	-		0.9		0.9
16.	*Malaxis muscifera*	-	-	1.2	-	-	0.9	-	-	-
17.	*Meconopsis aculetea*					0.9	-		-	-
18.	*Megacarpa polyandra*	-	-	-	-	0.3	-	-	-	-
19.	*Nardostachys jatamansi*	-	0.6	-	-	0.7	-	-	-	
20.	*Picrorhiza kurroa*	-	1.1	1.2	1.9	1.3	-	1.6	-	0.9
21.	*Podophyllum hexandrum*	-	-	-	0.8	1.3	-	-	-	-
22.	*Polygonatum verticillatum*	1.9	1.3	-	-	-	-	1.8	-	-
23.	*Rheum australe*	-	-	-	-	1.5	-	-	-	-
24.	*Rheum moorcroftianumn*	-	-	-	-	2.2			1.4	-
25.	*Trillidium govanianum*				0.6	0.5				-

*TF= Tall forbs, MH=mixed harbaceous, DGS=Danthonia grassy slope, MS=moist scrub, R/B= rocky and bouldry area, MM= marshy meadows, SAF= sub-alpine forest, CV=cushinoid vegetation, KSM= Kobresia sedge meadow

D. hatagirea (2.3 ind/m²) in a few marshy meadows, *P. kurroa* (12.3 in ind/m²) in moist rocks in upper Gori valley about 20 years ago (Uniyal *et al*., 2002). Higher density was also reported for *A. heterophyllum* (2 ind /m²) and *A. glauca* (1.2 ind /m²) whereas, *D. hatagirea* (0.2 ind/m²), *F. roylei* (0.3 ind/m²), *M. muscifera* (0.5 ind/m²), *M. aculeata* (0.6 ind/m²) had lower availability in Devikund area (Sekhar and Rawat 2011). *A. glauca* had slightly higher density in Napalchunala (1.2 ind/m²) and Palangar (1 ind/m²) sites (Singh *et al*., 2020). (Pandey *et al*., 2018) recorded lowest density for *A. heterophyllum*, *N. jatamanasi* and *R. moorcroftianum* in Johar valley.

SPECIES DIVERSITY AND RICHNESS ACROSS THE MAJOR HABITATS

Among all the habitats, the highest species richness was recorded in herbaceous meadows (45), followed by *Danthonia* grassy slopes (38) and matted scrub. Similarly, diversity, a combined measure of species richness and number of individuals were also observed maximum (4.2) in herbaceous meadows followed by *Danthonia* grassy (3.9) slope. In the region, herbaceous meadows were mainly confined to the undulating flat areas where the slope is less than 200. Such habitats support many herbaceous communities across microhabitats in the region. Alpine dry and moist scrubs habitat showed less variability in terms of the number of species across meadows compared to sedges, grasses and herbaceous habitat types. Cushioned vegetation, Tall forbs, rocky slopes and marsh meadows had relatively low evenness largely due to micro topographic variation and resultant variation in soil moisture. These vegetation types were also characterized by lowest species per site and fewer featured or characteristic species per site.

Table 2. Species richness, diversity and evenness across the habitats types.

Habitat types	Richness	Diversity (H^{l} index)	Evenness
Tall forbs	14	2.51	0.95
Herbaceous meadows	45	4.2	1.1
Danthonia grassy slopes	38	3.9	1
Matted scrub	31	3.1	0.90
Marshy meadows	12	1.2	0.48
Rocky slopes	7	0.9	0.46
Sub alpine forest	12	1.2	0.48

DISCUSSION

Studies on the diversity of high-altitude MAPs in the state is relatively old and researchers at times have listed the MAPs from different alpine meadows. Most of the studies on the richness (list) of MAPs were site specific, covering one or a couple of meadows of the area/valley. The population status (abundance) of a few MAPs eg. *A. glauca, P. kurroa, B. stracheyi, A. hetrophyllum, D. hatagirea* of alpine region are studied, there is relatively little information exists on the availability of a large number of MAPs across the number of meadows. Because of the inaccessibility of high elevation areas in the region and restricted distribution of MAPs, there is hardly any comprehensive record on abundance, extent of distribution, species rich sites of MAPs including rare and endangered species. Among the nine habitat types, mixed herbaceous showed maximum density of species followed by *Danthonia* slopes.

Availability of MAPs across the different habitats was recorded highest for *B. strecheyi* (2.5 ind/m^2), *R. moorcroftianum* (2.2 ind/m^2) and *P. kurrooa* (1.9 ind/m^2). Past study showed *P. kurroa* (3.9 ind/m^2) has maximum density followed by *B. stracheyi* (1.2 ind/m^2), *D. hatagirea* (0.5 ind/m^2) and *P. hexandrum* (0.2 ind/m^2) in nine different habitats of upper Gori valley. The patterns of species richness and diversity in this study reveals that mixed herbaceous formations (MHF) on the south to south-east facing slopes (3600–4200m asl) of the Kumaun Himalaya had the highest number of species per unit area, while rocky slope has lowest species richness and diversity. Previous study also stated that maximum richness was observed in mixed herbaceous formations around tree line gaps and lower alpine areas in the Valley of Flowers NP (35-42 species per site), Kandara Bugyal in Uttarkashi (36–52). *Danthonia* grass lands rank second in terms of species richness with the number of species per site ranged from 20–30. Other physiognomic types in the descending order of mean number of species per site include marsh meadows (18–23 species per site), cushingoid vegetation at higher altitudes (16–22), *Kobresia* meadows (15–21), alpine dry scrub (11–15), and desert steppe of Trans-Himalaya (3–9) (Rawat 2007). Highest species richness and diversity was reported in the moist rocky habitats and undulating meadows (Uniyal *et al*., 2002). Previous work carried out in Valley of Flower National Park by (Kala *et al*., 1998) reported diversity values of up to 3.23 within the tree line gap. (Samant *et al.,* 2004) studied within NDNP revealed that, diversity values ranging between 0.29 to 3.41. The highest values were obtained for MHF. Globally, alpine regions support a high degree of plant richness adapted to extremes of climatic conditions, micro-habitat heterogeneity, and land-use practices. The rough terrain, higher altitudinal limit, and harsh conditions of alpine regions, however, make field monitoring of plant richness expensive and time-consuming (Rawat 2007). During the present investigation, it was found that meadows having mixed herbaceous formation in high rainfall zone had highest number of species per unit area. Also limited information is available on the foraging of these meadows by the livestock during snow free period thus selective use of plant species eaten by them (Negi *et al*., 1993).

CONCLUSION

The present study identified *Danthonia* grassy slope and mixed herbaceous is most preferable habitat for medicinal plant species. Such habitat could be marked as control sites for future monitoring, to provide trends of population status and help in assessing the foreseeable future, keeping in view the present conditions intensive habitat based survey and RME would be required in various alpine meadows/valley to prepare conservation, development and harvesting plan. Besides protecting these plants in their natural habitats, sustainable harvesting of these selected MAPs is required as per the demands of the local people to improve their socio-economic conditions. Establishing Medicinal Plant Conservation Areas (MPCA) could be a step forward in the conservation of medicinal plants including threatened species. Ecological niche modelling could be great help in predicting the potential habitats of threatened species for rehabilitating and reintroduction.

ACKNOWLEDGEMENT

Authors would like to thank Director, Uttarakhand Space Application Centre for providing facilities and encouragement. We duly acknowledge GB Pant National Institute of Himalayan Environment (GBPNIHE), Ministry of Environment, Forest and Climate Change (MoEF&CC) for financial assistance under National Mission for Himalayan Studies (NMHS) program.

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VERTICAL STRUCTURE OF WINTER RAINFALL: A CASE STUDY OF CENTRAL HIMALAYA

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ABSTRACT

This study presents the first time observation of rainfall vertical structure of a Western disturbance induced rainfall event (12 December, 2020 resulting 3.9 mm rain) over a central Himalayan station. Measurements are made using a vertically pointing Micro Rain Radar locatied at Kosi-Katarmal, Almora, Uttarakhand. The rainfall vertical structure is analyzed for two specific rainfall cases (i) a single bright band with no ground rainfall, and (ii) two bright bands with ground rainfall. Due to the presence of bright band signature in the radar reflectivity profile, it is affirmed that the rainfall of 12 December, 2020 is mostly stratiform type. A dominant signature of bright band for both cases is observed around an elevation of 3.5-4.0km above surface indicating that the upper limit of rainfall initiation. The maximum radar reflectivity for both the cases is noted to be less than 19.9 dBz indicating no role of localized convection. The average liquid water content is also found to be below 1.5 gm/m^3 unlike rainfall events of monsoon seasons.

INTRODUCTION

The eastward moving Western disturbances are responsible for the winter precipitation events of central and north-western Himalaya that rejuvenates most of the springs, streams, and spring-fed rivers of the region. The average winter seasonal rainfall in the mid to lower elevation of Uttarakhand and Himachal Pradesh are reported to be 210.0mm and 130.0mm, respectively. The same for the combined union territory of Jammu, Kashmir and Ladakh are reported to be 190.0mm (Nageshwara Rao *et al.*, 2016). The winter precipitations are also known to replenish more than 2000 glaciers, situated above 3000-3500m elevation above sea surface, in the form of snow. Therefore, an elevation dependent change in precipitation type over the north western and central Himalayan region is known to hydrometeorologist. However, knowledge of the detail vertical structure of precipitation (i. e. liquid water content, rainfall rate, droplet fall velocity) and rainfall type (i.e., convective or stratiform) of the winter season remained elusive due to unavailability of in-situ observations, particularly using a vertically pointed Ka-band radar or micro rain radar (MRR). As identification of rainfall type and assessment of vertical structure of precipitation can shed light to convective and cloud microphysical properties (Das *et al*., 2010, Das *et al*., 2011, Das *et al*., 2016), forecasting rainfall intensity and amount could be improved with the better knowledge of such features. Moreover, in-situ observation of rainfall vertical structure could also be used to improve the accuracy of space-borne radar precipitation products as space borne-radars are known to have dissimilarities with in-situ measurements of vertical profiles of radar reflectivity (Peters *et al*., 2005). This study presents the first time observation of rainfall vertical structure of a Western disturbance induced rainfall event over a central Himalayan station. Subsequently, rainfall type is identified based on the detection of bright band signature in the radar reflectivity profile, where bright band is produced through enhanced back scattering due to melting layer having higher reflectivity than the water droplet. As indicated in (Das *et al*., 2010) bright band appears to be the region in the radar reflectivity profile indicating heavy rain at a certain height. Moreover, incidence of more than one bright band is also reported in this study with characteristic features of liquid water content, rainfall rate, and droplet fall velocity. The manuscript is organized as follows: description of the study area is provided in section 2. Section 3 details the instrumentation and data analysis including numerical formulations use for computing characteristic features of liquid water content, rainfall rate, and droplet fall velocity. Results are presented in section 4 and conclusions are made in section 5.

STUDY AREA

The vertical structure of rainfall was observed using the MRR at GBPNIHE campus, Kosi-Katarmal, Almora, Uttarakhand. The measurement site is having an elevation of 1217m above sea level. Climate of the study area is categorized as Cwa as per Koppen climate classification having three dominant seasons: summer, winter and monsoon. The study area is affected by two spells of rainfall, the first one is summer monsoon rainfall during June-September and second one is through Western disturbance in the winter. The annual

average rainfall in Almora is reported to be 1200.0mm.The average monsoon period rainfall is 740.5mm whereas the average winter period rainfall was recorded to be 72mm (Mukherjee *et al*., 2018).

INSTRUMENTATION AND DATA ANALYSIS

Instrumentation

The vertical structure of winter rainfall was observed using a frequency modulated continuous wave (FMCW) micro rain radar (MRR), Metek GmBH Germany, which operates at 24.1GHz frequency, and vertical profiles monitored up to 6.0km above surface. The surface rainfall observations were carried out using a rain gauge (Campbell Sci, Canada). The radar Doppler spectra were used to estimate parameters like drop size distribution (DSD), radar reflectivity (Z), liquid water content (LWC), and rain rates (R). The MRR in Almora, Uttarakhand, was deployed in October 2020. The 01 minaveraged observations of rainfall vertical structure during 12 December 2020 00:00 AM till 12 December 2020 23:59 PM were analyzed in detail in this study.

Data Analysis

MRR provides DSD information by converting measured Doppler spectra into drop diameters by known relationship. Various microphysical parameters can thus be reliably estimated without any assumption to the DSD shape. The retrieval of Doppler spectra, DSD and different vertical rainfall structure parameters are described by Strauch (1976) and (Peter *et al*., 2005). Rain rate (R), liquid water content (LWC), and radar reflectivity (Z) were calculated from the DSD. Mean fall velocity is calculated directly from the measured Doppler spectrum. Using the following formulae, the rainfall integral parameters from the DSD have been estimated (Peter *et al*., 2005).

$$LWC = \frac{\pi}{6}\rho_w \int_0^\infty D^3 n(D)\, dD$$

$$R = \frac{\pi}{6} \int_0^\infty D^3 v(D) n(D)\, dD$$

$$Z = \int_0^\infty n(D) D^6\, dD$$

where LWC is the liquid water content in mg/m^3, R is the rain rate in mm/h, Z is the radar reflectivity in dB, Dn is the mean drop diameter in mm, qw is the density of water, D is the diameter of the drops in mm. n(D) is the number of drops with the size D to D + ΔD in mm^{-1} m^{-3}, m(D) is the fall velocity of drops with the size D to D + ΔD in m/s. Mean fall velocity is obtained as follows.

$$v_m = \frac{\lambda}{2} \frac{\int_0^\infty f \cdot p(f)\, df}{\int_0^\infty p(f)\, df}$$

Where, v_m is the mean fall velocity in m/s, λ is the wave length. p(f) is the spectral power related to Doppler frequency.

RESULTS AND DISCUSSION

The rainfall vertical structure of 12 December, 2020,were analyzed in this study as this event resulted a total rainfall of 3.9 mm at the ground. The surface rainfall duration was 9:30 AM to 2:30 PM as observed using a rain gauge (Fig. 1). The surface rainfall was bimodal in nature wherein the first phase was during 9:30 AM to 10:30AM (a total of 1.6 mm rainfall), and the second phase was during 12:15 PM to 2:30PM (a total of 2.3 mm rainfall).

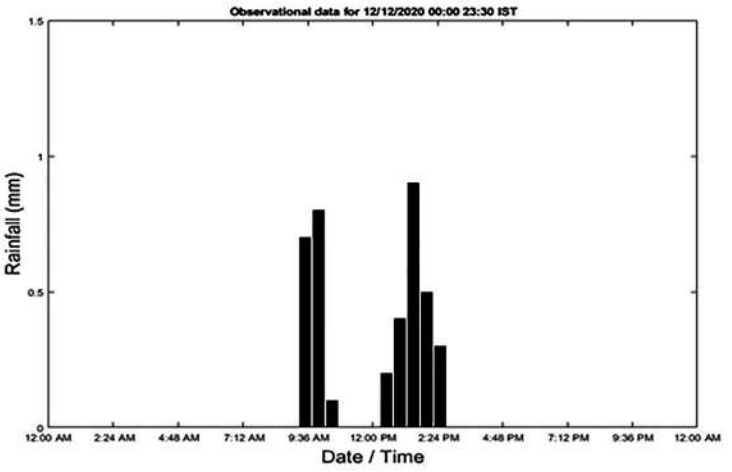

Fig. 1. Rain Gauge data of 12 Dec 2020 00:00 am - 23:59 pm

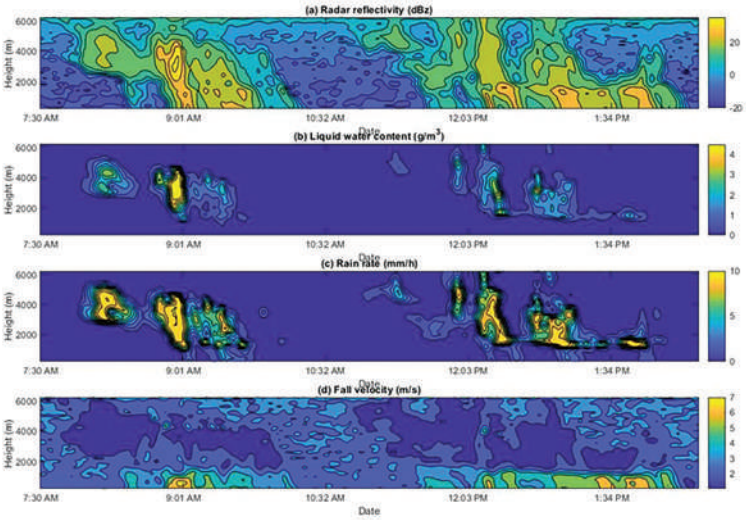

Fig. 2. MRR rain events data of 12 December 2020 00:00 AM - 23:59 PM

The rainfall vertical structure is generally used to classify rainfall types, i. e. convective and stratiform, or a mix of both. Observation of the 'bright band' in the radar reflectivity profile is a signature of stratiform rain and such observation is used for rainfall classification. Therefore, the rainfall vertical structure of 12 December, 2020, was analyzed in terms of observations of various 'bright band' signatures in the vertical profiles of reflectivity. The MRR data of 12 December, 2020, revealed a number of different events with the prominent bright band signatures (Fig. 2). For the entire duration of 9:30am to 2:30pm of 12 December, 2020, the maximum rain rate was about 0.5mm/h at ground but along the 200m to 6000m vertical range above the ground it was 8.00mm/h. One can also note from Fig. 2 that the bright band signatures were actually detectable since 07:40am in the morning which disappeared around 10:30am in the first phase of rainfall. Within the approx. 03 hrs rainfall between 07:40am to 10:30am, two specific rainfall cases associated to (i) a single bright band with no ground rainfall, and (ii) two bright bands with ground rainfall are elaborated below. The bright band signature in the vertical structure of rainfall is associated to the height of melting layer wherein the rainfall process initiates. Moreover, the bright band signature is an indication of stratiform rainfall, and around 20-30% of all stratiform rainfall in India is noted to have a clear bright band signature (Das *et al*., 2011).

A Single Bright Band with No Ground Rainfall

The single bright band with no ground rainfall was observed during 08:20am to 08:25am of 12 Dec, 2020. The vertical profiles of LWC, R, Z, and vm during the event are shown in Fig. 3(A). The vertical profile of Z shows the single bright broad peak between 3.0km and 5.0km. The enhancement of Z around this region (3.0-5.0km) could be attributed to the presence of the melting layer (Das *et al*., 2010). A melting layer is associated to 0°C isotherm wherein the solid hydrometeors start converting to liquid rain droplets. Moreover, the existence of such broad bright band signature can be corroborated to stratiform rainfall initiated through a Western disturbance. The maximum Z during this period was noted to be 19.9dBz at 4.0km above the ground. However, the mean Z within the 3.0-5.0km region during 08:20am to 08:25am was noted to be 16.9 (± 3.2) dBz. Similarly, the mean LWC and R within the 3.0-5.0km region during 08:20am to 08:25am were noted to be 1.2 (± 0.6)g/m^3 and 5.3 (± 2.2)mm/h, respectively. However, no ground rainfall was observed for this upper air rainfall event. The maximum of vm was noted at an elevation of 1.0km above the ground.

Two Bright Bands with Ground Rainfall

The two bright bands with ground rainfall were observed during 09:50am to 09:55am of 12 Dec, 2020. The vertical profiles of LWC, R, Z, and vm during the event are shown in Fig. 3.(B). The vertical profile of Z shows two bright peaks between 200m and 1.0km, and 3.0km and 4.0km above the ground. The enhancement of Z around the 200m to 1.0km and 3.0 – 4.0km region could be contributed to the presence of the melting layer (Das *et al*., 2010). Moreover, the existence of such bright band signature can be corroborated to stratiform rainfall. The maximum Z during this period for both bright bands was noted to be 16.5dBz at 400m above the ground.

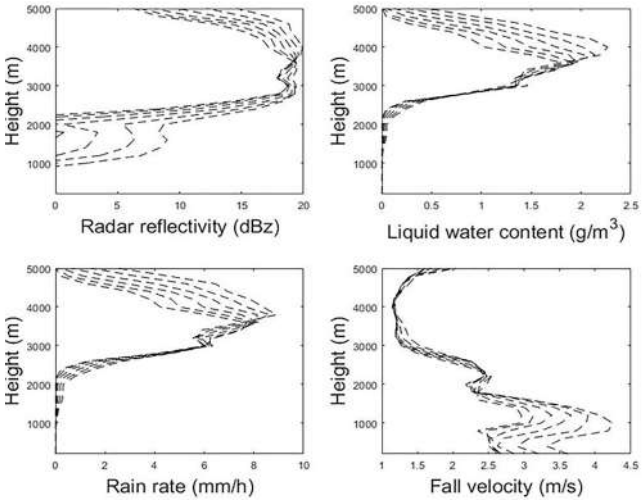

Fig. 3. (A). 12 December 2020 08:20am - 08:25am

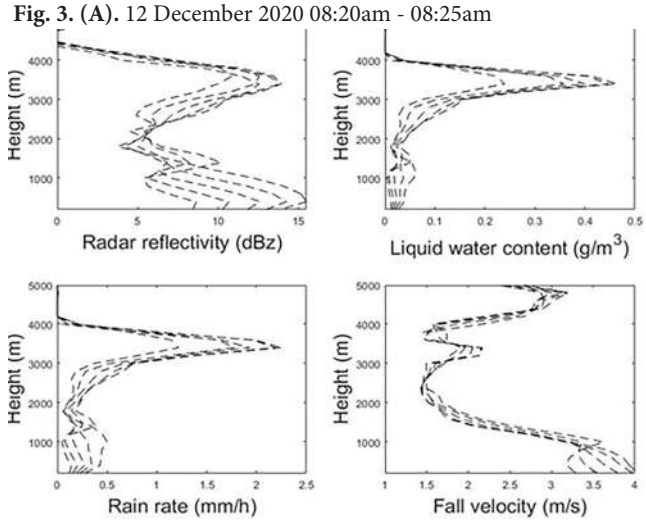

Fig. 3. (B). 12 December 2020 09:50am - 09:55am

Fig. 3. Subplot (A) represents vertical profile of MRR rain event on 12 December 2020 08:20am - 08:25am; and subplot (B) represents vertical profile of MRR rain event on 12 December 2020 09:50am - 09:55am.

However, the mean Z within the 3.0-4.0km region was noted to be 9.9 (± 2.4) dBz. The same for 200m to 1.0km region was noted to be 9.8 (± 1.5) dBz. Similarly, the mean LWC and R within the 3.0 - 4.0km region were noted to be 0.2 (± 0.1) g/m^3 and 1.0 (± 0.6)mm/h. The same for the vertical profile

200m - 1km were noted to be 0.01 (± 0.002)g/m^3 and 0.21 (± 0.03)mm/h, respectively. The maxima vm for both bright bands was noted at an elevation of 400m above the ground. Identification of the original melting layer amongst the two layers is difficult as measured elevation of 0^{o}C isotherm was unavailable over the site.

SUMMARY AND CONCLUSION

The characteristics of the rainfall vertical structure during the winter season of central Himalaya are reported in this study. Measurements from a vertically pointing MRR are used for characterization of the winter precipitation event of 12 December, 2020, at the location of Kosi-Katarmal, Almora, Uttarakhand. A total of 3.9mm rainfall was noted at the ground on 12 December during the 7:30am to 2:30pm. The rainfall vertical structure was analyzed in detail for two specific rainfall cases (i) a single bright band with no ground rainfall, and (ii) two bright bands with ground rainfall. Subsequently, different microphysical parameters like radar reflectivity, rain rate, liquid water content and fall velocity were studied. It could be confirmed that the rainfall event of 12 December, 2020 was mostly stratiform type as bright band signature in the radar reflectivity profile was present. A dominant signature of bright band for both cases was observed around an elevation of 3.5-4.0km above surface indicating that the upper limit of rainfall. Similarly, the maximum radar reflectivity for both the cases never exceeded 19.9dBz indicating no or limited role of localized convection wherein typical reflectivity range is more than 30dBz for with no bright band. Moreover, as the winter precipitations of central Himalaya are due to Western disturbances, the average liquid water content was mostly below 1.5gm/m^3 unlike rainfall events of monsoon seasons. This study suggests that the winter period rainfall type could also be identified using bright band signatures. Further, this study improves the understanding of rain microphysics that may be helpful for simulation of rainfall intensity and types during winter season of central Himalaya.

ACKNOWLEDGMENTS

Authors thankfully acknowledge the financial support received under Science & Engineering Research Board (SERB), DST, GOI sponsored research project ECR/2018/0000629.

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SPECIES DIVERSITY, FOREST STRUCTURE AND REGENERATION POTENTIAL OF SHISHAM (*DALBERGIA SISSOO*) FORESTS IN RAJAJI TIGER RESERVE, UTTARAKHAND, INDIA

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ABSTRACT
The structure, diversity and regeneration potential of Shisham forest was investigated in Chilla range of Rajaji tiger reserve. The enumeration of 12 plots of 20m×20m was randomly laid down to cover the entire tree species of the Shisham forest. *Dalbergia sissoo* was the main dominating species due to the high importance value index followed by the co-dominant species *Holoptelea integrifolia, Mallotus philippensis, Cassia fistula* etc. The maximum stand density was recorded for seedlings (504-1) as compared to sapling and seedlings, whereas the maximum basal area was recorded for tree species 1.19m/ha. The maximum Shannon-Weiner diversity index (2.33) was recorded for tree's seedlings due to greater species richness. It was also observed that *Dalbergia* has sufficient number of seedlings, saplings and tree, which showed good regeneration potential whereas other associated species had poor regeneration.

Keywords: Shisham stand, Rajaji Tiger Reserve, Chilla and Diversity.

INTRODUCTION
Shisham *(Dalbergia sissoo)* is one of the important commercial timber yielding trees of the family Papilionaceae. It is generally found in tropical and sub-tropical regions in Uttarakhand including the foothills areas. Shisham is of the most important species of *Acacia- Dalbergia sissoo* community (Champion *et al.*, 1968), but sometime found the pure forest stand. *Dalbergia sissoo* function as a pioneer species in the riverain succession of the Gangetic alluvial plains in India. Shisham produces best quality of timber with hard wood. It attains the height of 30m, which generally shed its leaves from October-February whereas new leaves appear between February and April. Shisham is also used as an ethno medicinal species in treating various ailments (Akash *et al.*, 2020). It is propagated both by seed and stumps (about 5cm of stem and 20cm of root) and further it is drought resistant species and has great potential for reforestation in different parts of Uttarakhand. It also has great adaptability and produces large organic matter due to its huge canopy resulting into maximum releases of nutrients in soil. It is also used as for fuel wood production and water conservation.

STUDY AREA
Rajaji Tiger reserve is located in Northern India at 29°51'N to 30°15'N, 077°52'E to 078°22'E at an elevations from 250–1100 above mean sea level. It falls within the Gangetic plains biogeographic zone and upper Gangetic plains province (Rodgers *et al.*, 2002, Akash *et al.*, 2019). The whole area of the Tiger reserve cover 820.42km^2 of the forest within the three districts Pauri, Tehri and Dehradun. Rajaji Tiger Reserve (RTR) is one of the most important repositories of Shiwalik biodiversity in Northern India. The tiger reserve covers a total of nine ranges including the Chilla and Gohri, which are just close to the Haridwar- Pauri forest division. Chilla and Motichur are the two forest ranges which has great potential of tourism. The study area comes under Chilla forest range of RTR which is an essential part of tropical forest under Shivalik hills. The Chilla range of the reserve is one of the great centres of attractions for tourists (Akash *et al.*, 2018). The entire area of the tiger reserve comes under Terai part of Shivalik landscape between Sharda and Yamuna River. The Chilla forest of RTR comes under the protected area network but undergoing rapid changes in fauna and vegetation pattern due to the large scale anthropogenic interferences in form of lopping, grazing by Gujjars, trampling and extraction of timber and non-timber forest products along with hydro-power project (Akash *et al.*, 2019)

MATERIAL AND METHODS
The quantitative enumeration of the species was done by random nested quadrate sampling method between 2016-2019. All the species were enumerated as tree, saplings and

seedlings within the quadrats of 20×20m (total 12 plots) in the study area Quantitatively analysis of field data was done for density, abundance, frequency and relative parameters (Curtis *et al*., 1950). The Importance Value Index (IVI) for each tree, herb and shrubs species was calculated following (Curtis 1959).

Table. 1. Tree species composition of Shisham forest along with ecological parameters

Species	Family	Density/ha	TBC (m^2/ha)	IVI
Dalbergia sissoo	Fabaceae	87.50	1.18	103.87
Mallotus philippensis	Euphorbiaceae	14.50	0.19	23.05
Ehretia laevis	Ehretiaceae	10.41	0.32	22.5
Trewia nudiflora	Euphorbiaceae	10.41	0.25	20.67
Lagerstroemia indica	Lythraceae	8.33	0.20	16.30
Phyllanthus emblica	Phyllanthaeae	10.41	0.15	15.89
Adina cordifolia	Rubiaceae	2.08	0.42	14.87
Bombax ceiba	Bombecaceae	6.25	0.18	12.42
Ziziphus oenoplia	Rhamnaceae	6.25	0.16	9.85
Acacia catechu	Fabaceae	2.08	0.02	5.62
Bauhinia variegata	Fabaceae	2.08	0.08	5.37
Ficus religiosa	Moraceae	2.08	0.08	5.37
Cassia fistula	Fabaceae	2.08	0.06	4.77
Ficus glomerata	Moraceae	2.08	0.06	4.77
Psidium guajava	Myrtaceae	2.08	0.04	4.14
Butea monosperma	Fabaceae	2.08	0.04	4.09
Acacia spp.	Fabaceae	2.08	0.03	4.05
Melia azadirachta	Meliaceae	2.08	0.03	4.05
Calliandra haematocephala	Fabaceae	2.08	0.03	3.85
Pterospermum acerifolium	Sterculiaceae	2.08	0.02	3.68
Holoptelea integrifolia	Ulmaceae	2.08	0.02	3.62
Cedrela toona	Meliaceae	2.08	0.02	3.61
Cordia dichotoma	Boraginaceae	2.08	0.07	3.59
Total		185.26	3.65	300.00

D/ha= Density/hectare, TBC= Total basal cover,
IVI= Importance value index

Table. 2. Sapling species composition of Shisham forest along with ecological parameters.

Species	Family	Density/ha	TBC (m^2/ha)	IVI
Dalbergia sissoo	Fabaceae	285.42	0.72	161.98
Mallotus philippensis	Euphorbiaceae	37.5	0.11	35.01
Ficus palmata	Moraceae	2.0	0.14	14.37
Ehretia laevis	Ehretiaceae	8.33	0.04	13.58
Holoptelea integrifolia	Ulmaceae	12.5	0.04	11.61
Listea chinensis	Lauraceae	10.42	0.03	10.49
Holarrhena pubescens	Apocynaceae	16.65	0.04	10.36
Trewia nudiflora	Euphorbiaceae	10.42	0.01	9.13
Ziziphus oenoplia	Rhamnaceae	6.25	0.02	8.70
Azadirachta indica	Meliaceae	6.25	0.01	7.78
Phyllanthus emblica	Phyllanthaeae	4.16	0.02	5.73
Eugenia oogenesis	Myrtaceae	2.08	0.01	4.22
Salix alba	Saliaceae	2.08	0.005	3.64
Syzygium cumini	Myrtaceae	2.08	0.002	3.40
Total		406.14	1.19	300.0

Table .3. Seedlings species composition of Shisham forest along with ecological parameters.

Species	Family	Density/ha	TBC (m^2/ha)	IVI
Dalbergia sissoo	Fabaceae	112.5	320.46	70.14
Holoptelea integrifolia	Ulmaceae	97.92	203.27	47.28
Listea chinensis	Lauraceae	54.17	157.24	37.44
Mallotus philippensis	Euphorbiaceae	56.25	106.10	34.81
Ziziphus oenoplia	Rhamnaceae	41.67	38.35	22.54
Ehretia laevis	Ehretiaceae	29.17	104.69	20.0
Naringi crenulata	Rutaceae	12.5	15.93	10.09
Morus alba	Moraceae	16.67	11.94	9.01

Azadirachta indica	Meliaceae	12.5	33.87	8.66
Melia azadirachta	Meliaceae	12.5	27.43	8.11
Trewia nudiflora	Euphorbiaceae	14.58	18.58	7.67
Delonix regia	Fabaceae	14.58	17.27	7.55
Crateva religiosa	Capparaceae	12.5	13.38	6.78
Cassia fistula	Fabaceae	4.17	11.94	5.00
Putranjiva roxburghii	Putranjivaceae	12.5	9.98	4.93
Total		504.18	1090.43	300.00

Table. 4. Summary of the species inventory in Shisham forest

S.No.	Vegetation Parameters	Trees	Saplings	Seedlings
1	Number of genera	21	14	15
2	Number of families	13	14	11
3	Basal area (m2 ha^{-1})	3.65	1.19	1090.43
4	Stand density (stems ha^{-1})	185.26	406.14	504.18
5	Shannon–Weiner index	2.161	1.256	2.330
6	Simpson index	0.235	0.504	0.122
7	Margalef Richness index	4.900	2.465	2.546
8	Jaccard Evenness index	0.689	0.476	0.860

Seedlings basal cover= cm^2 ha^{-1}, Herb density = D/m^2, Herb basal cover = cm^2 m^{-2}

Table. 5. Chemical parameter of under Shisham forest

Depth	OC (%)	N (%)	P (kg/ha)	K (kg/ha)	pH
0-10	1.39 ±0.005	0.29 ±0.001	15.41 ±0.96	159.4 ±0.52	6.28 ±0.33
15-25	1.36 ± 0.02	0.26 ±0.001	19.33 ±0.88	285.4± 0.58	6.16 ±0.02
30-40	1.23 ± 0.01	0.26 ±0.001	24.1 ±0.88	181.3 ±0.58	6.19 ±0.029

OC= organic carbon, N=nitrogen, P= phosphorus, K=potassium

RESULTS

Althogether 33 species of trees including saplings and seedlings were present in Shisham forest stand of Chilla range of Rajaji tiger reserve. All the 33 species were represented with 32 genera and 19 families. *Dalbergia sissoo* was the main species with dominance in the study area due to its higher importance value index in all the three stages viz. tree, saplings and seedlings. The highest IVIfor tree species was observed for *Dalbergia sissoo* (IVI= 103.87ha^{-1}) followed by *Mallotus philippensis* (IVI= 23.05) and lowest for *Cordia dichotoma* (IVI= 3.59), *Cedrela toona* (IVI= 3.61), *Holoptelea integrifolia* (IVI= 3.62), and *Pterospermum acerifolium* (IVI= 3.68). For saplings species, again *Dalbergia sissoo* (IVI= 161.98ha^{-1}) recorded maximum dominance over other species followed by *Mallotus philippensis* (IVI= 35.01). For seedlings species, *Dalbergia sissoo* and *Holoptelea integrifolia* was observed for highest importance value index whereas lowest for *Putranjiva roxburghii* (4.93ha^{-1}) in the study area. It was also observed that maximum individual density was recorded for *Dalbergia sissoo* trees (87.50ha^{-1}), saplings (285.42ha^{-1}) and seedlings (112.5ha^{-1}) whereas maximum basal area was recorded again for *Dalbergia sissoo* trees (1.18m ha^{-1}) , saplings (0.72m ha^{-1}) and seedlings (320.46cm ha^{-1}).

The maximum Shannon-Weiner was observed for tree's seedlings (2.33), Simposn Index for tree's saplings (0.50) and Margalef index for tree species (4.90) and Jaccard index for seedlings (0.86). A comparison was made for the relative distribution of the total number of individuals in different girth classes. It was observed from that tree girth class-wise density was highest for <10cm diameter in comparison to other diameter classes. The density of seedlings was highest (6100ind/ha) followed by saplings (4875ind/ha) and trees (2225ind/ha). Maximum species (40%) showed no regeneration, followed by 34.28% new, 14.28% fair, 8.57% good and 2.85% showed poor regeneration. The nutrients status of soil was found fair in the study area. The value of organic carbon was recorded maximum in middle layer (15-25cm depth, 1.36 ± 0.02%), whereas total nitrogen was maximum in uppermost layer (0-10cm, 0.29 ±0.001%). On the other hand, maximum potassium was found in middle layer (15-25cm depth, 285.4±0.58kg ha^{-1}), phosphorus in lower depth (30-40cm, 24.1±0.88 kg ha^{-1}) and pH in upper most layer (0-10cm, 6.28 ±0.33). ANOVA showed that pH, Nitrogen, Organic carbon, Phosphorus, and Potassium of soil vary significantly ($P<0.05$) among all the study sites.

DISCUSSION

Tropical forests are rich in species diversity and forest structure (Richards 1952; Paijmans 1970) but at the same time many factors affect the diversity and species richness (Hubbell 1979; Parthasarathy 1999). Rajaji Tiger Reserve

is dominated with *Holoptelea integrifolia, Dalbergia sissoo, Shorea robusta, Mallotus phillipensis, Cassia fistula* and co-dominated with *Naringi crenulata, Ziziphus oenoplia, Z. mauritiana, Ehretia laevi*s, etc. These dominant species in a forest stand sometimes also restrict the light availability to other species in ground flora in the undisturbed and mildly disturbed stands. The absolute total density (ha^{-1}) of the Shisham stand was 185.26 ha^{-1} for tree species, 406.14 ha^{-1} for saplings and 504.18 $cm^2 m^{-2}$ for seedlings. The present results are comparable with earlier study of (Akash *et al*., 2018, 2019) in *Holoptelia integrifolia* (149.99 ha^{-1}) and *Shorea robusta* (318.30 ha^{-1}) forest site in Chilla forest range of Rajaji Tiger Reserve. The recorded absolute density from our study did not vary considerably from values reported by other authors of Garhwal Himalaya by (Singhal *et al*., 1989; Adhikari *et al*., 1991) from Gahrwl Himalaya but the total basal area in our study was more or less similar to the study of other workers in different tropical forests of Northern India. The overall regeneration in the study area was fair but no and poor regeneration of other associated species was also recorded in the study area. Poor and no regeneration might be due to different anthropogenic pressures like lopping, grazing, scraping and trampling. In present study area, maximum species (40%) showed no regeneration followed by 34.28% new, 14.28% fair, 8.57% good and 2.85% showed poor regeneration. Although the regeneration of Shisham was good in the present study area but there was the lack of regeneration for associated species in Shisham stand. This could be due to the destruction of species by elephants and locals from Kodiya-Talla and Kodiya-Malla villages, trying adjacent to the present study area. Overgrazing mainly affects herbs and shrubs as well as some of the under shrubs and small trees. Many workers eg. (Ballabha *et al*., 2013) pointed out factors like lopping, grazing and fire adversely affecting the regeneration pattern of species in Western Himalaya. In Chilla-Pauri, although the forest officials provide protection to the flora and fauna but locals livestock sometime affects the vegetation greatly. The regeneration value of present study resembles to our earlier study in various sites of the Chilla forest division in different forest sites where poor regeneration was also observed for Shorea robusta in Sal forest stand (Akash *et al*., 2020b).

The physico-chemical property of soil always determines the status of nutrients in soil which may change according to the type of vegetation, climatic condition of area (Behari *et al*., 2004).

In present study area, the value of organic carbon was recorded maximum in middle layer (15-25, 1.36 ± 0.02%), whereas total nitrogen was maximum in uppermost layer (0-10, 0.29±0.001%). Potassium in middle layer (15-25, 285.4±0.58kg/ha), phosphorus in lower depth (30-40, 24.1±0.88kg/ha) and pH in uppermost layer (0-10cm, 6.28 ±0.33). Although the overall nutrients status of the Shisham forest was fair but there are some points where the pH value also has crossed above 7.0, which is not favorable for the forest growth (Akash *et al*., 2018). Disturbances like trampling, grazing, scraping and looping are the main pressures which affect the dynamism and upsetting cycling nutrient of in forest, (Amiri *et al*., 2008). The anthropogenic gradients have rendered the system inhospitable for the growth of arious associated plant species and regeneration resulting into a severe loss in plant diversity (Pandey, 2001).

The assessment of diversity and soil nutrient dynamics is important for forest management and conservation as it provides favorable growth for newly regenerating species in the forest. Although the forest structure, diversity, species distribution along with regeneration potential was good for Shisham but there is a need to put more efforts for conservation of other associated species in the Shisham stand. Efforts also need to be done for poor regeneration potential of co-dominant species in present study area. For this purpose closing each compartment, relocation of Gujjars from Gohri forest range and communities residing just adjacent to the Shisham forest should be done properly. Enrichment planting in the closed compartment of Shisham forest with useful species will also favor best regeneration of species in the area.

CONCLUSION

Rajaji Tiger Reserve cover a huge area both in terms of flora and fauna providing the ecosystem services for livelihood. Whole area is dominated with *Dalbergia sissoo, Holoptelia integrifolea, Shorea robusta, Cassia fistula* and *Trewia nudiflora* and co-dominated with *Mallotus philippensis, Holarrhaena pubescens, Trewia nudiflora, Adina cordifolia, Phyllanthus emblica* whose canopy provide great amount of leaf litter which releases nutrients in the soil which further support the growth of ground flora. It was also observed that soil parameters like pH, organic carbon, total nitrogen, available potassium, available phosphorous favouring the growth of various species in Shisham forest. The regeneration of Shisham in the present study area is good for the main dominating species but overall regeneration was not good, which could be due to the various pressures on forest by local and destruction by elephant as there were the lack of seedlings of the co-dominated species of Shisham. So management of Shisham through regeneration could be an important point for improving the overall diversity status of *Dalbergia sissoo* in the present study area.

ACKNOWLEDGEMENTS

The authors are grateful to the Director and Forest guards of the Rajaji Tiger Reserve for their help during the field work.

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DISTRIBUTION AND POPULATION STRUCTURE OF *QUERCUS SEMECARPIFOLIA* SMITH. IN HIGH ALTITUDE FORESTS OF WESTERN HIMALAYA

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ABSTRACT

Quercus semecarpifolia is one among the few tree species, which dominate the upper temperate and subalpine zone of high altitude Himalayan forests. In the present study an attempt was made to analyze the distribution and population structure of *Q. semecarpifolia* in a high altitude forested landscape of western Himalaya. Standard phytosociological methods were followed to carry out the study along three representative transects of the target landscape. The study revealed that the tree and sapling density did not exhibit any uniform pattern, while the seedling density decreases with increasing altitude. Low regeneration of the species (zero or less saplings and seedlings) in few locations highlights the influence of micro level factors. The total basal area form a hump shape curve along elevation gradient; it was recorded maximum (58.4 m^2/hectare) at 2700m. Population structure did not follow classic inverse J shape pattern. This indicates removal of trees in various diameter classes may due to anthropogenic activities and environmental perturbations. The study found high risk to *Q. semecarpifolia* in the landscape, and suggested for proper management and conservation planning..

Keywords: High altitude, Timberline, Regeneration and West Himalaya..

INTRODUCTION

The Himalaya, one of the 36 global biodiversity hotspots, is well known for its unique repository of biodiversity. The topographical variations and the three dimensional frame work (i.e., latitudinal: South-North; longitudinal: East-West; altitudinal: Low-High) have resulted in enormous diversity in the region (Palni *et al.,* 2013). Among different topographical parameters, the altitude gradient plays a key role in determining the diversity and distribution of organisms. The altitude provides very effective natural experimental conditions for finding out ecological and evolutionary responses of species to environmental changes (Körner 2007). Himalayan region has the highest and most diverse treeline in the world. Treeline is the most striking, climatically governed and ecologically important vegetation boundary, which is marked by a change, in site conditions and plant communities when crossing the forest limit (Holtmeier 2005). Understanding of ecological and environmental changes associated with the high-altitude limit of forest is of critical importance because of its high sensitivity of temperature changes and human uses. Review of literature reveals that treeline is largely controlled by heat deficiency, however, (Körner 2012) also suggested that local factors (both ecological and social) influence regeneration and growth of tree species, thus play an important role in its elevational position.

Treeline in the Himalaya is not only a significant environmental boundary (Singh 2018), but also the reservoir of unique biodiversity elements (Rawal *et al*., 2018). Globally, Pinaceae and Betulaceae are most common families in treelines (Singh 2018), while treeline vegetation in the Himalaya primarily consists of coniferous (*Abies pindrow*, *Pinus wallichiana, Abies densa*) and birch forests (*Betula utilis*). *Quercus semecarpifolia* Sm. (Kharsu) also forms the dominant tree canopy in many areas of IHR especially in the western Himalaya. Oak (*Quercus* spp.) form climax vegetation in the western Himalaya, and play a vital role in ecosystem function and services (Singh *et al.*, 1986). Five species of oaks i.e., *Quercus glauca* Thunb. (harinj) (900-1800m), *Q. leucotrichophora* A. Camus (banj) (1200-2300m), *Q. floribunda* Rehder (moru) (1800-2400m), *Q. lanata* J.E. Sm. (rianj) (2100-2700m) and *Q. semecarpifolia* Smith (kharsu) (2400-3600m) grow naturally in the western Himalaya (Singh *et al.*, 2016). Among these, *Q. semecarpifolia* forms most extensive forest between 2400 to 3600m altitude, and well known as important timberline species; a timberline formation by an evergreen broadleaved species, *Q. semecarpifolia* as seen in Himalayas, is not found elsewhere in the world (Negi 2018). It was reported that population structure is vital to understand species coexistence and long-term ecological process of a particular forest (Gairola 2008; Negi *et al*., 2018a). The regeneration patterns of species, based on the population structure, can determine

community stability and infer the potential climax vegetation of a particular area. Therefore, the present study is an attempt to analyze the population structure and distribution of *Q. semecarpifolia* along altitude gradient in a high altitude zone of Western Himalaya.

MATERIAL AND METHODS

Study site

The present study was conducted in Chopta-Tungnath (30°30'03.0" to 30°29'23.8" N and 79°09'52.8" to 79°12'42.3" E) region is a part of Kedarnath Wildlife Sanctuary (KWS) Uttarakhand, West Himalaya. An extensive field survey was carried out along an altitude gradient in representative altitude transects, covering forested area in high altitude zone (i.e., 2400-3200m asl.) across three aspects (SW, NE & NW). The forests of the area fall under temperate to sub-alpine, which give way to vast alpine zone beyond the Treeline. The dissected topography and great variations in climatic conditions along altitude range are characteristic features of the area. Four distinct seasons were observed in the study area viz., short summer (May–June), Monsoon (July–mid September) and autumn (mid-September–October) and long winter (November–April). The snow cover lasts long for about 4-5 months, due to this the growth period lasts for only 5-7 months (Rai *et al*., 2012). The average annual temperature within the forests ranged between 5.6-17.6° in North West aspect and 6-17.2° in South East aspect. While the mean annual rain fall (precipitation) ranged between 1715-2953 mm in North West aspect and 2770-2209 mm in South East aspect (Joshi *et al.*, 2018).

Methods

To obtain a broad representation of Kharshu oak (*Quercus semecarpifolia*) forest within the area, three representative altitude transects in three different aspects (NW, NE and SW) were selected. The study transects were investigated by systematically dividing the transects into 100m altitude bands. Within each altitude band, forest vegetation (Kharshu oak) was investigated using systematic random sampling method. In each altitude band, 3 plots (50m × 50m) were marked randomly; a total of 78 plots were assessed within each altitude band. For enumerating vegetation, in each plot 10 (10m x10m) quadrats for trees and saplings and 20 (5 m x5 m) quadrats for seedlings were placed (Negi *et al*., 2018 a,b; Rawal *et al.,* 2018). A total of 780 quadrats for trees and saplings and 1560 quadrats for seedlings were assessed. Circumference at breast height (cbh at 1.37 m height from the ground) was measured for tree species individuals (cbh) was taken as base measurement for determination of tree basal area. Individuals > 31.5cm cbh (above 10 cm diameter) were considered as trees. Individuals between 10.5-31.5cm cbh (3 to 10cm diameters) were considered as saplings. Towards generating demographic profiles, the adult individuals were categorized following 10 cm diameter classes as, C: 10-20; D: 20-30; E: 30-40; F: 40-50; G: 50-60; H: 60-70; I: 70-80; J:80-90; K: 90-100; L: >100 cm or more diameter. Quadrat data was pooled by plots to estimate density, frequency, total basal area (TBA) and their relative values following the standard phytosociological approaches (Muellerb *et al.,* 1974). Importance Value Index (IVI) was calculated following (Curtis 1959). The regeneration status of species was determined based on the proportional distribution of population size of seedlings, saplings and adults (Gebrehiwot *et al.,* 2014). The status was categorized as (i) "Good" regeneration, if seedlings > or < saplings > adults; (ii) "Fair" regeneration, if seedlings > or ≤ saplings ≤ adults; (iii) "Poor" regeneration, if a species survives only in sapling stage, but no seedlings (though saplings may be < or ≥ adults); (iv) "None" or not regenerating, if species is absent in both sapling and seedling stages, but only found in adults; and (v) "New", if a species has no adults, but present in only saplings and/or seedling stages.

RESULTS AND DISCUSSION

Compositional attributes along altitude gradient

The density distribution of tree and sapling of *Q. semecarpifolia* along altitude gradient did not exhibit any uniform pattern with the altitude (Fig. 1a & b). The analyses shows non-significant relation (R^2=0.36, p>0.05 and R^2=0.07, p>0.05) of the species with the altitude. These results indicated the role of micro level factors as well as anthropogenic influences on density patterns. The pattern of density in seedling strata shows significantly (R^2=0.12, p<0.01) decreasing trend with increasing altitude (Fig. 1c). This indicates the influence of environmental factors in the germination and survival process of seed and seedlings, respectively in the higher altitude zones. The sapling density was recorded greater in lower altitudes as compared to the higher altitudes due to habitat suitability, climatic conditions, and relatively less anthropogenic activity. The low regeneration (less/zero sapling and seedling density) of *Q. semecarpifolia* in the forests is reported as major issue for species level conservation and management priorities (Singh *et al.*, 2020). The average density of *Q. semecarpifolia* trees ranged between (4 - 238ind./ha), sapling (0-27 ind./ha) and seedling (0-282 ind./ha) in the present study site, and these ranges are comparable with the earlier reports (Rawal *et al.*, 1994; Gairola *et al.*, 2008; Rawal *et al*., 2018).

The total basal area form a hump shape curve and having no significant (R^2=0.32, p>0.05) relation with the altitude (Fig. 1 d). The basal area values peaked around 2700m followed by 3100m due to presence of large size trees. This indicates that these altitude belts support better forest health and have more favorable conditions for the secondary growth of individual tree

species. The low basal area at lower altitude (2400m) and high altitude belt (3200m) may be due to high mortality rate and human disturbances (lopping and cutting at lower altitudes and harsh climatic conditions and anthropogenic disturbances at higher altitudes (Negi *et al*., 2018b). The total basal area ranged between 3.35-58.43 m^2/ha is comparable with the previous reported range (5-102.7 m^2/ha) for the similar forested zone of Uttarakhand (Singh *et al.,* 1986; Rawal *et al.,* 1994; Rai *et al.*, 2012; Negi 2018; Rawal *et al.*, 2018). The detailed distribution of density (tree, sapling and seedling) and TBA values along altitude gradient is given in Table 1.

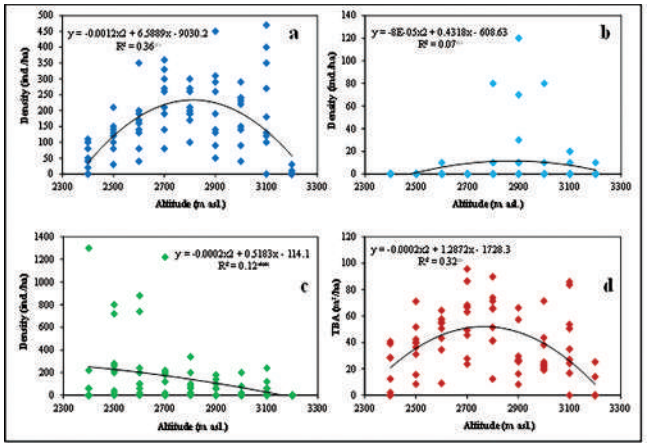

Fig. 1. 1Altitude patterns of density distribution (a, b&c: tree, saplings and seedlings, respectively) and d: TBA along altitude

Table. 1. Distribution of *Q. semecarpifolia* density and TBA along altitude gradient

Altitude belts (m asl.)	Density (ind./ha)			TBA (m2/ha)
	Trees	Saplings	Seedlings	
2400-2500	44	0	182	16.79
2500-2600	120	0	282	37.33
2600-2700	162	1	260	47.37
2700-2800	238	0	218	58.43
2800-2900	210	11	91	56.93
2900-3000	212	27	60	31.31
3000-3100	182	10	33	31.68
3100-3200	157	6	58	30.45
3200-3300	4	1	0	3.35

Regeneration and population structure

The pattern of demographic profile or population structure of tree strata (tree, saplings and seedlings) helps to investigate the regeneration status and future prospects of any plant community (Negi *et al*., 2019). In the present study the *Q. semecarpifolia* fall under "Fair" regeneration category, while it was reported under "Poorly regenerating" category by (Singh *et al.*, 2020). The population structure of *Q. semecarpifolia* in terms of proportional distribution of seedlings, saplings and adults varied across altitude belts along the gradient. The results revealed that the population patterns of *Q. semecarpifolia* did not follow the classic inverse J-shape pattern which is considered stable (Fig. 2). The classic inverse J-shape curve of diameter class distribution of forest population structure is the indication of good regeneration, healthy forest and good proportional conversion rate from seedlings to saplings and adult size classes (Gairola *et al*., 2008; Negi *et al*., 2018a). The variation in inverse J-shape curve of the population structure of a given forest indicates removal of trees in various diameter classes may due to anthropogenic activities and environmental perturbations (Maua *et al*., 2020). In the present study five patterns of population structure of *Q. semecarpifolia* are emerged: (i) greater accumulation of individuals at seedling and initial adult classes with no sapling stage (Fig. 2 a), (ii) greater accumulation of individuals at seedling class with sudden decline at sapling class and moderate individuals at initial to higher adult classes (Fig. 2 b,c&d), (iii) higher accumulation of individuals at seedling and intermediate classes followed by higher adult class (Fig. 2 e), (iv) greater accumulation of individuals in initial and intermediate adult classes (Fig. 2f,h& i), and (v) characteristic budge or greater accumulation of individuals in intermediate class (Fig. 2 g).

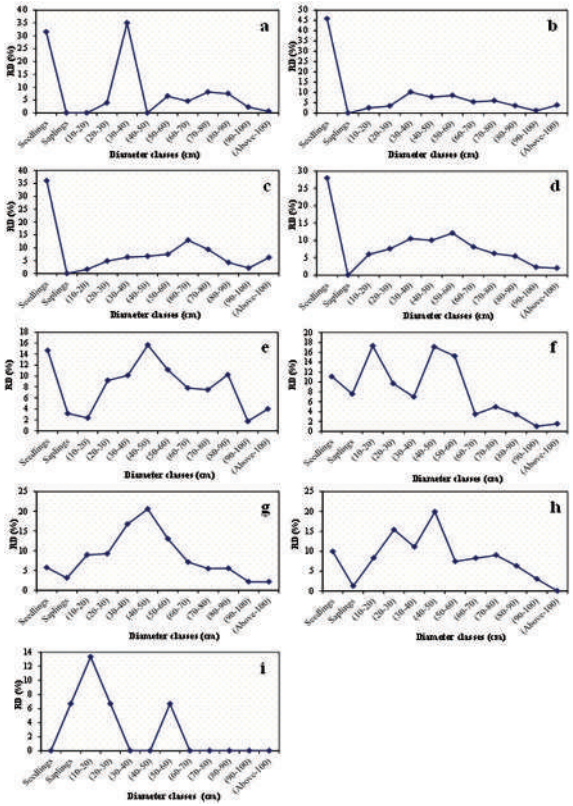

Fig. 2. Population structure of Q. semecarpifolia along altitude gradient (a-2400, b-2500, c-2600, d-2700, e-2800, f-2900, g-3000, h-3100, and i-3200 m

The distribution of a plant species indicates its adaptability to various environments (Wang *et al*., 2004). The composition of forest community mainly depends on the ecological characteristics of sites, species diversity and regeneration status of species (Gairola *et al*., 2008). The pattern of forest population structure is the best way to explain the existing status and future prospectus of individual species and overall forest health of the particular region. A grater accumulation in seedling stage indicates good germination and conversion rate from seed to seedling. The sudden decline towards saplings (no sapling stage) suggests that the conversion of seedling to sapling is not proportional due to high rate of seedling mortality (Khumbongmayum *et al*., 2006). The forests of *Q. semecarpifolia* at 2500, 2600 and 2700m (Fig. 2b,c&d) shows absence of saplings, indicating that conversation of seedling to sapling class is completely absent but the individuals were present in the other adult classes. This trend also indicates that the conversion rate from seedlings to saplings and then towards adult classes was good in past few years, but at present the conversion rate of seedlings to saplings is very poor may be due to climatic and anthropogenic pressure. The greater accumulation of individuals at seedling and initial to higher adult classes (Fig. 2 e) suggests that the environmental conditions are in favor of seed germination and establishment of seedlings but the decline in saplings again indicate the low conversion rate in saplings. Greater accumulation of individuals in initial and intermediate adult classes and characteristic budge or greater accumulation of individuals in intermediate class indicates that environmental conditions was good in the past but become unfavorable due to high anthropogenic pressures in the present. All these patterns of population structure of *Q. semecarpifolia* in the high altitude forests suggests that the conversion of seedling to saplings and then saplings to other adult classes is very low and indicates high risk to *Q. semecarpifolia* in the studied region.

CONCLUSION

Among many tree species growing in the high altitude forested zone of Uttarakhand, *Q. semecarpifolia* has its own unique identity as a major board canopy forest and provides livelihood to the local inhabitants. Knowing this significant role of the species in the high altitude forests, the low regeneration and variation in the classic J shape pattern is the major challenge to the conservationists to develop management and conservation planning for this unique species. The increase in the human interference within these high altitude forests in terms of various anthropogenic activities can hamper the regeneration of oaks and associated native species growing in these forests. Therefore, needs good management plan and its implication to conserve these forests along with particular focus on unique species in the region.

ACKNOWLEDGMENT

The authors are thankful to the Director, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora for facilities and encouragement. We are grateful to Prof. S.P. Singh, Coordinator NMHS-IHTP, for his scholarly advices and encouragement during the study period. Funding support from National Mission on Himalayan Studies (NMHS), MOEF&CC, Government of India (NMHS-IHTP-RSR) is gratefully acknowledged. We would like to extend our gratitude to the Uttarakhand Forest Department for the necessary permissions (latter number: 251 / 5-6- Dehradun, dated 27/07/2016) to conduct study in a protected area.

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CHEMICAL PROPERTIES OF SOILUNDER CONVENTIONALLY AND ORGANICALLY MANAGED SYSTEM DURING PRODUCTION OF BASMATIRICE IN HIMALAYAN FOOTHILLS OF UTTARAKHAND

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ABSTRACT
The present study on soilinvolved a field experiment performed during 2016-17 to assess the changes in soil quality and productivity in ongoing conventional/ organic farming cropping system of rice(variety Pant basmati 1)at Pantnagar. The soil samples were collected from each plot with a screw type auger from 0-15cm and 15-30cm depth after harvest of rice. It was seen that soil pH of both the systems decreased to 7.4 to 7.0 at both the depths. The decrease in pH of organically and conventionally managed soil was attributed to the application of organic amendments (like green manure, green leaf manure), inorganic amendments (urea) etc. Before ploughing, the 'P' content of the soil was low (< 22kg ha^{-1}) at both the depths. After transplanting, it increased from 22-56kg ha^{-1} (medium) for both organically and conventionally managed soil at both the depths. The available 'K' content was higher for conventionally managed soil as compared to organically managed soil. Both organically and conventionally managed soil had no differences in ammoniacal content. The 'NN' content of the soil was extremely low (about 4kg ha^{-1}) before ploughing and after transplantation. Thus, the continuous cropping and joint use of organic / green manure improves chemical condition of soil.

Keywords: Organic farming, Conventional farming, Chemical properties and Soil fertility

INTRODUCTION
Basmati rice is endemic to the Indian subcontinent, where it has been cultivated by farmers for over 250 years. Basmati rice occupies premier place as specialty rice cultivated in the Indian subcontinent; thus, its production and improvement are of interest to the region. Basmati rice plays an important role in the livelihood of people in India.

Demand for organic farming is emerging owing to ill-effects of agro-chemicals on environment as well as human health. It is a unique production management system, which enhances and propagates agro system health including biodiversity, biological cycles and soil biological activity. Conventional agricultural practices like excess use of chemical fertilizers and pesticides negatively affect the soil health. Organic farming is an eco-friendly practice, it involves practicing crop rotation, using biofertilizers and pesticides (Kontopoulou *et al*., 2015) to enhance the product quality and promote environmental safety. As organic manures influence soil productivity through their effect on soil physical, chemical and biological properties (Ramesh *et al*., 2009; Bharose *et al*., 2018).Application of chemical fertilizers depends upon fertility status of the field. Before deciding the fertilizer dose, soil must be tested to know the status of the nitrogen (N), phosphorus (P) and potassium (K) in the soil. After testing the soil, fertilizer dose should be calculated accordingly. The use of fertilizer in transplanted rice field is quite different from upland rice. A progression of responses-physical, chemical and biological happen in transplanted rice fields because of quality of overabundance water in the field. In the root zone anaerobic condition is shaped from high-impact condition because of exhaustion of oxygen in the dirt profile, which is answerable for misty loss of nitrogen compost because of de nitrification process. This anaerobic condition additionally influences the conduct of phosphorus and micronutrients specially iron and manganese.The soil in the transplanted rice fields after puddling develops two zones in water logged conditions. The upper layer of soils (1 to 10mm thick) gets oxygen periodically from fresh supplies of irrigation water and turns to in earthy colored shading called "Oxidized zone" and reacts like an unflooded upland soilDue to variation in soil fertility, rainfall and climatic condition, a typical dose of fertilizer cannot be recommended for all regions. However, in general a level of 30 to 40kg of nitrogen

per hectare in kharif and 60 to 80kg of nitrogen per hectare in rabi appears to be the best dose for the tall indices and double that level for the high yielding varieties on soils of average fertility in the southern and eastern regions. In the northern region, where sunshine is available for longer hours, higher dose of nitrogen is beneficial in the kharif season.Thus, there is a need for better understanding of the various management options for transitioning from conventional to organic production. The reason for this examination was to assess the consequences for the chemical properties of soil during the production of Basmati rice in both conventionally and organically managed system.

EXPERIMENTAL SITES

The experiment was conducted in the Organic Agriculture Technology Block-C of the G.B. Pant University of Agriculture and Technology, Pantnagar. It is situated at an altitude of 243.84 meters above mean sea level at 29.5' N and 79.30'E. This region comes under Tarai and Bhabar agro climatic zone of Uttarakhand. The climate of this region varies from subtropical to temperate, with the annual rainfallranging from 1000-2000mm and temperature ranges between 32°C to 44°C during summer and minimum temperature ranges between 0-9°C in winter. Winter season extends from November to March. The monsoon sets during 2nd or 3rd week of June and continue still September end. Soils of this region are developed from calcareous medium to decently coarse textured potent material under the overwhelming impact of grasses and forest vegetation having moderately to well drained conditions. The soil of the experimental site belongs, to Order– Mollisol; Sub-order– Udoll; Great group– Hapludoll; Subgroup- Typic hapludoll; Family- Fine loamy; Soil series- clay loam (Deshpande *et al*., 1971).

METHODOLOGY

Determine the pH & fertility status, soil samples form 0-15 & 15-30cm depths were collected from the experimental field before commencement of the study to record the first fertility status of soil during 2016-17. Soil samples fromeach site i.e., conventional, and organic fields were collected from different points. All the collected samples from each farming system were quickly transported to laboratory and transferred to sterile zip plastic bags and stored at 4°C for later soil analysis. The chemical analysis of the soil was done with the help of K054 soil testing Kit.

RESULTS & DISCUSSION

The data on soil parameters such as pH, available phosphorus, potassium, ammoniacal and nitrate nitrogen is presented in Table 1 & 2.

Table 1. Chemical properties of soil at 0-15cm depths at distinct stages during kharif crops (2016 and 2017).

Sample collection stages		pH	Soil parameters at 0-15cm depth			
			N (kg/ha)		P (kg/ha)	K (kg/ha)
			Nitrate nitrogen	Ammoniacal nitrogen		
Before ploughing		7.5-7.6	04 (very low)	15.0 (low)	<22.0 (low)	112-280 (medium)
After transplanting	Org	7.5-7.6	04 (very low)	15.0 (low)	22-56 (medium)	112-280 (medium)
	Con	7.5-7.6	04 (very low)	15.0 (low)	22-56 (medium)	112-280 (medium)
30DAT	Org	7.0-7.4	04 (very low)	15.0 (low)	22-56 (medium)	112-280 (medium)
	Con	7.0-7.4	04 (very low)	15.0 (low)	22-56 (medium)	280-392 (high)
60DAT	Org	7.0-7.2	04 (very low)	15.0 (low)	22-56 (medium)	112-280 (medium)
	Con	7.0-7.2	04 (very low)	15.0 (low)	56.0-73.0 (mediumhigh)	280-392 (high)
90DAT	Org	7.0-7.5	10 (low)	15.0 (low)	22-56 (medium)	112-280 (medium)
	Con	7.0-7.5	10 (low)	15.0 (low)	22-56 (medium)	112-280 (medium)

Table 2. Chemical properties of soil at 15-30cm depths at distinct stages during kharif crops (2016 and 2017).

Sample collectionstages		pH	Soil parameters at 15-30 cm depth			
			N (kg/ha)		P (kg/ha)	K (kg/ha)
			Nitrate nitrogen	Ammoniacal nitrogen		
Before ploughing		7.5-7.6	04 (very low)	15.0 (low)	<22.0 (low)	<112.0 (low)
After transplanting	Org	7.5-7.6	04 (very low)	15.0 (low)	22-56 (medium)	112-280 (medium)
	Con	7.5-7.6	04 (very low)	15.0 (low)	22-56 (medium)	<112.0 (low)
30DAT	Org	7.0-7.4	04 (very low)	15.0 (low)	22-56 (medium)	<112.0 (low)
	Con	7.0-7.4	04 (very low)	15.0 (low)	22-56 (medium)	<112.0 (low)
60DAT	Org	7.0-7.4	04 (very low)	15.0 (low)	22-56 (medium)	<112.0 (low)
	Con	7.0-7.2	04 (very low)	15.0 (low)	22-56 (medium)	<112.0 (low)
90DAT	Org	7.0-7.5	10.0 (low)	15.0 (low)	22-56 (medium)	<112.0 (low)
	Con	7.0-7.5	10.0 (low)	15.0 (low)	22-56 (medium)	<112.0 (low)

Soil pH

At both the depths (0-15 & 15-30cm), the soil pH ranged from 7.5 to 7.6. It remained stable in both the systems after transplantation also. But, at later stages i.e., at 30, 60 and 90 days (about 3 months) after transplanting (DAT), it was observed that soil pH of both the systems decreased to 7.4 to 7.0 at both the depths. The decrease in pH of organically and conventionally managed soil was attributed to the application of organic amendments (like green manure, green leaf manure), inorganic amendments (urea) etc. it has been reported that a neutral pH during the crop growing season favors higher microbial diversity particularly in organically managed systems. At both the depths (0-15 & 15-30cm), the soil pH ranged from 7.5 to 7.6. It remained stable in both the systems after transplantation also. But, at later stages i.e., at 30, 60 and 90 days (about 3 months) after transplanting (DAT), it was observed that soil pH of both the systems decreased to 7.4 to 7.0 at both the depths. It has been reported that the reduction in soil pH increases the availability of plant nutrients and results in higher uptake of various nutrients by the plants (Mehdi *et al*., 2011). Reduction in soil pH during the early growing season shows rapid mineralization of added organic inputs which slowed down later due to cessation of humification process (Saikia *et al*., 2015). Organic acids produced during the decomposition of organic manure significantly lower the pH in organic farming. Comparable results have also been reported by workers for organic farming.In both organically and conventionally managed soil there were no differences in ammoniacal-N content. The 'NN' content of the soil was extremely low (about 4 kg ha^{-1}) before ploughing and after transplantation. At maturity 'NN' content of both conventionally managed soil and organically managed soil was increased.

Available Phosphorus and Potassium Content

Before ploughing, the 'P' content of the soil was low (< 22kg ha^{-1}) at both the depths. After transplanting, it increased from 22-56kg ha^{-1} (medium) for both organically and conventionally managed soil at both the depths. Subsequently, at 30, 60 and 90 DAT it remained unchanged. Comparable increases in P through addition of organic materials was also reported (Melero *et al.*, 2008). Potassium content of the soil before ploughing and after transplantation ranged between 112-280kg ha^{-1} (medium) at 0-15cm depth while at 15-30cm depth, it was <112kg ha^{-1}. Thereafter, its content increased to 280 -392kg ha^{-1} at 30 and 60 DAT (within 0-15cm depth) while, at 90 DAT its content varied from 112-280kg ha^{-1}. The overall available 'K' content was higher for conventionally managed soil as compared to organically managed soil.

Nitrogen Content

Nitrogen content of the soil was recorded for both Ammoniacaland Nitrate forms of nitrogen. The ammoniacal forms of nitrogen (about 15kg ha^{-1} at both depths of 0-15cm and 15-30cm depths) in both organically and conventionally

managed soil. At all stages, this form of nitrogen became low at maturity in both the system. The overall results showed that both organically and conventionally managed soil had no differences in ammoniacal content. The 'NN' content of the soil was extremely low (about 4kg ha^{-1}) before ploughing and after transplantation. No general trend was observed for later time intervals of 30, 60 DAT for both the soils. However, at maturity 'NN' content of both conventionally managed soil and organically managed soil was increased (Bansal *et al*., 1980; Tyagi 1989) reported a decline in available soil N with increase in soil depth but it expanded with increment in the dosages of NPK fertilizer in Aquic hapludoll soil at Pantnagar. It is also reported that higher available P and K in organic farming than conventional farming. Similarly, improvement in available N, P and K in soil due to long-term addition of organic manures has been noted (Panwar *et al*., 2010). Before ploughing, the 'P' content of the soil was low (< 22kg ha^{-1}) at both the depths. After transplanting, it increased to 22-56kg ha^{-1} (medium) for both organically and conventionally managed soil at both the depths (Joshi *et al*., 2017). Subsequently, at 30, 60 and 90 DAT it remained unchanged. An experiment conducted at Pantnagar stated that soil available P varied from 6.07 to 30.80kg ha^{-1} in the surface soil and from 5.17 to 30.30kg ha^{-1} in sub-surface soil. Application of phosphatic fertilizers improves available phosphorus in soil. (Yaduvanshi *et al*., 2007) showed that the available P content of the soil increased with the use of organic manures. The available K content of soil showed an increase with the continuous application of fertilizer K and organic manures over the first values (Yaduvanshi 2001). A significant increase in available K in the soil was reported with application of inorganic fertilizer but the difference was non-significant with the use of rice straw in the soil. An application of organic manure resulted in higher build up of available K content over chemical fertilizers alone (Dhaliwal *et al*., 2014). Numerous field studies on fertilizer management in rice and wheat crops have shown an increase in nutrient accumulation and their uptake with increase in level of fertilization through chemical fertilizers. It is also reported that N, P and K up take by wheat increased significantly with increase in the level of fertilizers ascribed to higher grain and straw yields along with higher nutrient contents in the crop with higher levels of fertilizers. (Narang *et al*., 1990) also reported an increase in uptake of N, P, K with increase in fertility levels.

CONCLUSION

Soil pH unaffected by the source of nutrient supply. It was kept around 7.0 to 7.5 in both the rice crop cultivationsystems. Conventionally managed soil had more of both 'Ammonia and 'Nitrate Nitrogen' content as compared to organically managed soil. Similarly, available 'P' and 'K' content were higher for conventionally managed soil as compared to the organic farming system.

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PHYTO-SOCIOLOGICAL CHARACTERISTICS OF PLANT SPECIES IN KEDARNATH WILDLIFE SANCTUARY IN WESTERN HIMALAYA

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ABSTRACT
The present study emphasizes upon the phytosociological and indigenous knowledge of native plants at three forest sites at Kedarnath Wildlife Sanctuary (KWLS) of District Rudraprayag, Uttarakhand. This study is mainly focused on population studies and traditional uses of plants of the area which are utilised by local people. For each species the information was collected through a questionnaire based survey which emphasized the information regarding scientific names, local name, family name, plant part used and medicinal importance of the plant. A total of 29 species which belong to 16 families were studied in the KWLS area. The dominant tree species was Neolitsea pallens with high density ranging between 350 ind./ha. and 555 ind./ha. while the dominant shrub species was *Viburnum mullaha* with the highest density ranging between 405 ind./ha. and 765 ind./ha. across the study area.

Keywords: Phytosociology, Wild edible plants, *Viburnum mullaha*, Conservation and Kedarnath Wildlife Sanctuary (KWLS)

INTRODUCTION
The Indian Himalayan region has total geographical area of about 530,795 km^2 representing 16.16% of the total area of India (Singh 2006). The area is considered very rich in endemic species. The Himalayas cover 18% of the Indian subcontinent and are abode of about 8000 species of angiosperms, of which 1748 species are being used medicinally (Kala 2005). Medicinal plants form a high percentage of non-timber forest products (NTFPs) collected from the Himalayas (Ghimire *et al*., 2005). A completed record of many plant species used by human beings during the past shows their importance in health, economy, shelter, clothing, food and other living necessity for humans (Rizwana *et al*., 2006). Over last two decades, the species area relations, environmental gradient and natural features, distribution pattern of the specific taxa and bio-geographic region are considered the best criteria for declaring importance of area in relation to biodiversity richness its and management across the world (Miller *et al*., 1986). One of the most critical issues on the national and global agenda is need to conserve biodiversity for future generations while trying to understand and document the indigenous knowledge of resource management practices (Farooquee *et al*., 2004). The concern of biodiversity conservation has highlighted the importance to describe vegetation at regional and small scale (Brown *et al*., 1988). The modern concept of ethnobotany deals with the relationship between a given society and environment in general and the plant world in particular (Aumeruddy 1996). Thus, ethnobotany is a multi-disciplinary science of botany, ecology as well as anthropology. However, there is limited information available about the species composition, variation and ecology of many forest communities in Himalaya in general (Maikhuri *et al*., 1998; Dhar *et al*., 1999) and targeting on ethno botanically important species in particular.

The Kedarnath Wildlife Sanctuary, one of the largest protected areas in Western Himalaya, is not only rich in floristic composition and panoramic view but also harbors high diversity of medicinal plants. The local inhabitants have significant and variable reservoir of primitive knowledge about the usage of the plants. They use the folk medicines through different ways, depending on plant species, specific method of preparation, doses and pattern of application (Bhandari 2003). Due to the heavy exploitation, a few species like *Taxus baccata, Cypripedium cordigerum, Dactylorhiza hatagirea, Aconitum heterophyllum* and *Picrorhiza kurrooa* etc have witnessed rapid decline during recent decades (Singh 2008). Above 2800 m oak-conifer association occurs where, *Q. semercarpifolia, Abies pindrow, Rhododendron arboreum, Taxus wallichiana* and species of *Viburnum* are the dominant forms (Bhandari *et al*., 2000). Several studies have been carried out on the use of the medicinal plants in the Indian Himalayan

region in general and Uttarakhand state in particular (Kala 2005). Ethnobotanical information on medicinal plants and their uses by indigenous cultures is useful not only for the conservation of traditional knowledge and biodiversity, but also to promote community health care, and might serve in drug development. The information can provide a guide for drug development assuming that a plant that has been used by indigenous people over a long period of time may well have an allopathic application (Farnsworth 1993).

The knowledge of the floristic composition of a plant community with reference to ethanobotanical significance is a prerequisite to understand the overall structure and function of any ecosystem. Vegetation is the most precious gift, nature bestowed on us, as it is meets all essential requirements of the humans in the form of food, fodder, fuel, medicine, timber, resin, oil, etc. Garhwal Himalaya has been a centre of floristic as well as ecological studies from past several years. However, there are limited studies with reference to a particular species of ethno botanic significance (Kala 2005).

The objective of this study is to assess the phytosociological and structural attributes of three stands in Kedarnath forest range of Garhwal Himalaya particularly to understand the species association with each other. It is expected that information on vegetation will be helpful to solve ecological problems such as, biological conservation and sorting out the site specific management purpose which can act as the input for monitoring the ongoing management practices and to predict possibilities of future bio prospecting of wild species.

MATERIALS AND METHODS

Study Area

The study area was located in Kedarnath Wild Life Sanctuary (KWLS) which was established in 1972. It has total area of 975.20 km^2. It is located in two districts viz., Chamoli and Rudraprayag of Uttarakhand between the coordinates 30°25'– 30°41'N, 78°55'–79°22'E in the Garhwal region of Western Himalayas (Bhandari 2003). The study sites were located in Rudraprayag area and were namely Trijuginarayan (6.65km^2) Sersi (2.18km^2) and Tala (1.24km^2) area of District Rudraprayag, Uttarakhand, and Western Himalaya. The altitude ranges from nearly 800m in the lower part, which experiences sub-montane climate to almost 6000m asl forming the Great Himalayan range including alpine regions. Owing to the wide altitudinal gradient, the area has unique physiognomic, climatic and topographic conditions. The area receives an average annual precipitation of 300cm in which rainy season during June-August contributes approximately 60%. The relative humidity varies from 35 to 85%. There is moderate to heavy snowfall during December–February, even in low-altitude areas. The dominant forest types in the study sites are Temperate Broad leaf and Mixed Conifer forests.

Quantitative Analysis

The phytosociological analysis of woody vegetation was carried out during 2011-2014. The analysis followed 20 randomly placed quadrats of 10x10m size across the sites using the species area curve method (Misra 1968). Each quadrat was subdivided into four 5X5m sample plot for the estimation of shrubs, saplings and seedlings. Species with 31.50cm or more CBH were considered as trees, individuals between 10.5cm to 31.4cm circumference were considered as saplings and upto 10.4cm circumference were considered as seedlings. For each species value of abundance, density and frequency along with their relative parameters such as total basal area and IVI were calculated (Curtis *et al*., 1950).

RESULTS

Tree layer

Total 16 tree species belonging to 10 families were recorded across all three studied sites. Tala site had maximum tree density of 2230indi./ha while Sersi site has minimum tree density of 1605indi./ha. The results showed that the dominant tree species across the study area was *Neolitsea pallens* which have the tree density ranging between 350indi/ha and 555 indi./ha. followed by *Rhododendron arboreum* with the density ranging between 275 indi./ha and 360indi./ha (Table 1). Minimum tree density was recorded for *Persia duthiei* and *Fraxinus micrantha* (25 indi./ha) at Trijuginarayan site, *Acer caesium* (25indi./ha.) at Sersi site and *Aesculus indica* (20indi./ha.) at Tala site (Table 3 and 5). The maximum total basal cover (TBC) was reported for *Neolitsea pallens* which ranged between 1.45m^2 ha^{-1} and 3.14m^2 ha^{-1} while minimum TBC was reported for *Persea duthiei* and *Acer caesium* (0.01 m^2 ha^{-1}) at Sersi site, on Trijuginarayan site minimum TBC (0.09m^2 ha^{-1}) was recorded for *Ilex dipyrena*, whereas, on Tala site the minimum TBC (0.01m^2 ha^{-1}) was recorded for *Aesculus indica* (Table 7).

Table 1. Description of frequency (%), density (indi/ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different tree species at Trijuginarayan forest.

Tree species	Family	F (%)	Density	A/F ratio	IVI	TBC
Neolitsea pallens (D.Don.) Momiyama & Hara ex Hara,	Lauraceae	75	355	0.02	27.46	1.45

Rhododendron arboreum Smith	Ericaceae	70	320	0.02	22.5	0.96
Quercus leucotrichophora A. Camus	Fagaceae	50	205	0.04	13.61	0.45
Betula alnoides Buch.-Ham. ex D. Don.	Betulaceae	35	165	0.08	9.42	0.23
Lyonia ovalifolia (Wall.) Drude	Ericaceae	45	160	0.04	10.96	0.30
Alnus nepalensis D. Don	Betulaceae	45	140	0.04	9.83	0.22
Juglans regia Linn.	Juglandaceae	10	30	1	1.81	0.0045
Aesculus indica Hook.	Hippocastan-aceae	25	95	0.16	5.35	0.052
Pyrus pashia Buch-Ham.	Rosaceae	55	265	0.04	38.17	3.44
Quercus floribunda Lindl. ex Rehder	Fagaceae	25	95	0.16	5.35	0.054
Acer caesium Wall.	Aceraceae	10	30	1	1.79	0.002
Myrica esculenta Buch.-Ham. ex Don	Myricaceae	20	105	0.25	4.86	0.03
Persea duthiei King ex Hook.	Lauraceae	10	25	1	1.69	0.004
Fraxinus micrantha Lingelsheim	Oleaceae	10	25	1	1.66	0.0006
Ilex dipyrena Wallich	Aquifoliaceae	10	30	1	1.80	0.0009
Total/Mean			**2045**	**5.85**	**156.26**	**7.2**

Table 2. Description of frequency (%), density (indi./ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different shrub species at Trijuginarayan forest.

Shrub Species	Family	F (%)	Density	A/F ratio	IVI	TBC
Viburnum mullaha Buch.-Ham. ex D. Don	Caprifoliaceae	80	470	0.01	41.06	2.80
Berberis chitria Edwards	Berberidaceae	30	125	0.11	6.63	0.06
Berberis aristata DC.	Berberidaceae	80	360	0.01	31.29	1.87
Contoneaster bacillaris Wallich	Rosaceae	30	140	0.11	7.57	0.14
Rubus ellipticus Smith	Rosaceae	20	65	0.25	3.88	0.03
Rubus niveus Thunb.	Rosaceae	5	25	4	1.14	0.0008
Prinsepia utilis Royle	Rosaceae	50	210	0.04	13.19	0.37
Pyracantha crenulata (Don) Roem.	Rosaceae	10	45	1	2.16	0.002
Cinnamomum tamala (Buch.-Ham.) Nees ex Ebermaeir	Lauraceae	30	110	0.12	6.45	0.079
Viburnum cotinifolium D. Don	Caprifoliaceae	55	225	0.04	15.61	0.58
Elaeagnus parvifolia Wallich ex Royle	Elaeagnaceae	40	145	0.07	9.05	0.17
Symplocos paniculata Thunb.	Symplocaceae	20	65	0.25	3.72	0.004
Rhamnus virgatus Roxb.	Rhamnaceae	5	20	4	1.01	0.00008
Rubus paniculatus Smith	Rosaceae	5	15	4	0.89	0.0004

Table 3. Description of frequency (%), density (indi./ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different tree species at Sersi forest.

Tree species	Family	F (%)	Density	A/F ratio	IVI	TBC
Neolitsea pallens (D.Don.) Momiyama & Hara ex Hara,	Lauraceae	85	350	0.014	33.61	1.6931
Rhododendron arboreum Smith	Ericaceae	80	275	0.016	26.8	1.2364
Quercus leucotrichophora A. Camus	Fagaceae	40	130	0.063	8.438	0.1009
Betula alnoides Buch.-Ham. ex D. Don.	Betulaceae	35	95	0.082	6.914	0.0957
Lyonia ovalifolia (Wall.) Drude	Ericaceae	60	165	0.028	17.16	0.7351
Alnus nepalensis D. Don	Betulaceae	30	85	0.111	5.967	0.08
Juglans regia Linn.	Juglandaceae	30	85	0.111	6.037	0.08
Aesculus indica Hook.	Hippocastanaceae	15	35	0.444	2.441	0.002
Pyrus pashia Buch-Ham.	Rosaceae	55	165	0.033	12.88	0.32
Quercus floribunda Lindl. ex Rehder	Fagaceae	15	40	0.444	2.62	0.005
Acer caesium Wall.	Aceraceae	10	25	1	1.676	0.001
Myrica esculenta Buch.-Ham. ex D. Don	Myricaceae	10	40	1	2.114	0.002
Persea duthiei King ex Hook.	Lauraceae	10	40	1	2.104	0.001
Fraxinus micrantha Lingelsheim	Oleaceae	10	35	1	1.995	0.005
Ilex dipyrena Wallich	Aquifoliaceae	10	40	1	2.131	0.004
Total/Mean			**1605**	**6.346**	**132.89**	**4.36**

Table 4. Description of frequency (%), density (indi./ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different Shrub species at Sersi forest.

Shrub species	Family	F (%)	Density	A/F ratio	IVI	TBC
Viburnum mullaha Buch.-Ham. ex D. Don	Caprifoliaceae	90	405	0.012	49.65	3.2176
Berberis chitria Edwards	Berberidaceae	65	190	0.024	17.95	0.6925
Berberis aristata DC.	Berberidaceae	75	235	0.018	25.17	1.23
Contoneaster bacillaris Wallich	Rosaceae	35	115	0.082	7.944	0.14
Rubus ellipticus Smith	Rosaceae	40	120	0.063	8.197	0.10
Rubus niveus Thunb.	Rosaceae	20	60	0.25	3.821	0.03
Prinsepia utilis Royle	Rosaceae	40	135	0.063	9.565	0.20
Pyracantha crenulata (Don) Roem.	Rosaceae	40	135	0.063	9.611	0.21
Cinnamomum tamala (Buch.-Ham.) Nees ex Ebermaeir	Lauraceae	35	85	0.082	6.757	0.10
Viburnum cotinifolium D. Don	Caprifoliaceae	50	185	0.04	14.06	0.43
Elaeagnus parvifolia Wallich ex Royle	Elaeagnaceae	30	110	0.111	6.597	0.07
Symplocos paniculata Thunb.	Symplocaceae	30	90	0.111	6.107	0.08
Rhamnus virgatus Roxb.	Rhamnaceae	5	15	4	0.912	0.001
Rubus paniculatus Smith	Rosaceae	5	10	4	0.764	0.0004
Total/Mean			**1890**	**8.916**	**167.1**	**6.50**

Table 5. Description of frequency (%), density (indi./ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different tree species at Tala forest.

Tree species	Family	F (%)	Density	A/F ratio	IVI	TBC
Neolitsea pallens (D.Don.) Momiyama & Hara ex Hara,	Lauraceae	80	555	0.016	38.62	3.14
Rhododendron arboreum Smith	Ericaceae	80	360	0.016	27.41	1.96
Quercus leucotrichophora A. Camus	Fagaceae	35	150	0.082	7.65	0.17
Betula alnoides Buch.-Ham. ex D. Don.	Betulaceae	35	130	0.082	6.99	0.13
Lyonia ovalifolia (Wall.) Drude	Ericaceae	55	225	0.034	11.34	0.20
Alnus nepalensis D. Don	Betulaceae	35	110	0.081	7.10	0.21
Juglans regia Linn.	Juglandaceae	35	155	0.081	7.82	0.20
Aesculus indica Hook.	Hippocastanaceae	5	20	4	0.92	0.001
Pyrus pashia Buch-Ham.	Rosaceae	55	250	0.033	14.23	0.60
Quercus floribunda Lindl. ex Rehder	Fagaceae	10	45	1	1.99	0.009
Acer caesium Wall.	Aceraceae	15	45	0.444	2.49	0.01
Myrica esculenta Buch.-Ham. ex Don	Myricaceae	10	50	1	2.08	0.0072
Persea duthiei King ex Hook.	Lauraceae	10	45	1	1.95	0.004
Fraxinus micrantha Lingelsheim	Oleaceae	10	55	1	2.16	0.004
Ilex dipyrena Wallich	Aquifoliaceae	10	35	1	1.73	0.002
Total/Mean			**2230**	**9.869**	**134.48**	**6.647**

Table 6. Description of frequency (%), density (indi./ha.), A/F ratio, Importance Value Index (IVI) and total basal cover (TBC m^2/ha) of different tree species at Tala forest.

Species	Family	F (%)	Density	A/F ratio	IVI	TBC
Viburnum mullaha Buch.-Ham. ex D. Don	Caprifoliaceae	95	765	0.012	64.73	6.47
Berberis chitria Edwards	Berberidaceae	60	240	0.028	15.95	0.82
Berberis aristata DC.	Berberidaceae	60	240	0.028	16.51	0.92
Contoneaster bacillaris Wallich	Rosaceae	25	105	0.16	5.31	0.12
Rubus ellipticus Smith	Rosaceae	35	145	0.082	7.45	0.16
Rubus niveus Thunb.	Rosaceae	20	65	0.25	3.45	0.02
Prinsepia utilis Royle	Rosaceae	40	185	0.062	10.12	0.40
Pyracantha crenulata (Don) Roem.	Rosaceae	45	195	0.050	10.24	0.30
Cinnamomum tamala (Buch.-Ham.) Nees ex Ebermaeir	Lauraceae	30	125	0.111	6.50	0.15
Viburnum cotinifolium D. Don	Caprifoliaceae	55	255	0.033	13.52	0.46
Elaeagnus parvifolia Wallich ex Royle	Elaeagnaceae	25	135	0.16	5.70	0.06
Symplocos paniculata Thunb.	Symplocaceae	20	75	0.25	3.70	0.02
Rhamnus virgatus Roxb.	Rhamnaceae	10	25	1	1.51	0.0005
Rubus paniculatus Smith	Rosaceae	5	10	4	0.70	0.0001
Total/Mean			**2565**	**6.226**	**165.39**	**9.91**

Table 7. Important vegetational parameters of the study sites

Site	Density (ind./ha)		A/F ratio		IVI		TBC (m^2/ha)	
Trijuginarayan	Tree	Shrub	Tree	Shrub	Tree	Shrub	Tree	Shrub
	2045	2020	5.85	18.01	156.26	143.35	7.2	6.10
					Total	**299.99**		
Sersi	1605	1890	6.346	8.916	132.89	167.1	4.36	6.50
					Total	**299.99**		
Thala	2230	2565	9.869	6.226	134.48	165.39	6.647	9.91
					Total	**299.87**		

Shrub Layer

Shrub species showed the dominance of *V. mullaha* which ranged between 405ind./ha. and 765ind./ha. across the study sites, followed by Berberis species (Table 4-6). Minimum density was reported by Rubus paniculatus which ranged between 10-15 ind./ha.) across the study sites. Shrub density was 2565 ind/ha. at Tala site which was maximum aross the study sites, while shrub density was 1890 ind./ha. at Sersi site which was minimum across the study sites (Table 2). For shrub species, maximum TBC was reported for V. mullaha which ranged between 2.80 m^2 ha^{-1} and 6.47m^2 ha^{-1} across the study sites, while minimum TBC was reported for Rhamnus virgatus and Rubus paniculatus across the study sites (Table 4 and 6). A/F ratio was used to interpret the distribution pattern of individual species. Most of the species were contagiously distributed. However, random distribution was least common.

DISCUSSION

The regeneration potential of tree species in forests depends on the population structure, influenced by the production and germination of seeds, establishment of seedling and saplings in the forests (Rao 1988). Among trees Neolitsea pallens was the dominant species across all three study sites. The present study indicated that the total density of tree species was recorded 1605 ind./ha at Sirsi forest, 2045 ind./ha at Trijuginarayan forest and 2230 ind./ha at Tala forests respectively. The total TBC for tree species was calculated as 4.36m^2 ha^{-1} at Sersi forest 7.2m^2 ha^{-1} at Trijuginarayan forest and 6.64m^2 ha^{-1} at Tala forests, respectively (Table 7).

It is evident from the present study that the density of tree species is highest on Tala forest, whereas, the minimum density of tree species was reported at Sersi forest. The low density of tree species might be due to indiscriminate and unscientific way of lopping of the trees for fodder and fuel wood, collection of medicinal plants and wild edible fruits. This eventually leads to the reduction in the natural forest regeneration on account of poor seedling production in the forests (Singh *et al*., 1986; Samant *et al*., 2001).

Among the shrub species, *V. mullaha* was dominant across all three forest sites. The highest density (765 ind./ha) was recorded for *V. mullaha* on Tala site followed by Trijuginarayan (470 ind./ha) and Sersi (40.50 ind./ha). The total density for shrub stratum was calculated as 2020ind./ha at Trijuginarayan, 1890 ind./ha at Sersi and 2565 ind./ha at Tala sites. Dominance of *V. mullaha* is a positive sign for future planning in bio prospecting of this ethnobotanically significant native species of the Garhwal region. The density of shrub is minimum in Sersi site whereas, the maximum density is shown by Tala site. This indicates intense human interference in the Sersi forest due to close human settlement nearby the forest area and unsustainable harvesting of fruits and other multipurpose use of these species. Presence of sufficient number of seedlings, saplings and young trees in a given population indicate a successful regeneration (Saxena *et al*., 1984). The total TBC (6.10, 6.50 and 9.91 m^2ha^{-1}) for shrub species was recorded on Trijuginarayan, Sersi and Tala sites respectively. The highest TBC for shrub species was observed at Tala site, whereas, minimum was reported at Sersi site. Most of the vegetation layers were distributed contagiously especially in shrubs, saplings and seedlings. However, in tree layers most of the species found distributed randomly and few represented contagious distributions. Contagious distribution has been reported by several workers in different forest ecosystems (Singh *et al*., 1974). It is generally emphasized that contagious distribution is the commonest pattern found in nature (Odum 1971). It has also been reported that contagious distribution pattern is commonly found in the foot-hills forests of Garhwal Himalaya (Kumar *et a*l., 2006). Variation in distribution pattern seems to be associated with multitude of factors, especially the biotic. Studies have shown that strict protection of natural ecosystems and overexploitation lead to changes in vegetation dynamics including structure, species composition, diversity and distribution in an area (Nautiyal *et al*., 2007) besides influencing the productivity and quality of forest resources (Bhandari 2003).

CONCLUSION

The present study shows that the studied forest of the KWLS have a potential to be developed as an important platform for conservation of natural ecosystem and economically important tree and shrub species, which are native to the region and can be sustainably conserved for the ecological and economic potential generation for the dependent communities living in the vicinity. Being the remote area, the sustainable utilization of the species is necessary as the explored species have ethnobotanical value which can be suitable to develop a baseline data for further exploration of the potential of generating ecologically and economically strong management scenario, which will eventually lead to potential capacity development of the dependent community for utilizing the benefits of natural forest in its most sustainable way.

ACKNOWLEDGEMENT

The authors are grateful to the Director, G.B. Pant National Institute of Himalayan Environment. NMSHE Task Force-3 project funded by DST, New Delhi is acknowledged.

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FISH DIVERSITY OF BAIGUL, A SUBTROPICAL RESERVOIR IN UTTARAKHAND

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ABSTRACT

Baigul (sukhi) is a small tributary of the Ganga originating from the foothills of Kumaon Himalaya, which was harnessed in the year 1968 for irrigation purposes to form the Baigul reservoir. A total of 36 species of fish belonging to 13 families were identified in Baigul reservoir. Among 13 families Clupideae, Notopteridae, Cyprinidae, Silurideae, Channideae and Bagrideae were the most common. The fish species such as *Labeo calbasu, L. rohita, L. gonius, Catla catla, Puntius spp., Cirrhinus mrigala, C. reba, Mystus tengara, M. seenghala, Nandus nandus, Gudusia Chapra, Notepterus notopterus, Wallago attu, Xenentodon cancila* and *Mastacembelus armatus* etc. were quantitatively the main components of the fishery of the reservoir. The fish fauna is comprised of major carps, cat fishes, medium carps, minor carps and a large population of trash fishes. Medium sized carps comprised a major share contributing 48.94% to the total fish catch. *Labeo gonius* which contributed 40.83% to the annual catch constitutes the most dominant fishery in the lake, followed by *Gudusia chapra* (29.53%), and *Notopterus notopterus* (7.92%).

Keywords: Baigul, Reservoir, Fish Diversity and Uttarakhand India

INTRODUCTION

Freshwater resources are one of the most precious commodities for the living beings and especially to human beings. Aquatic resources of water should be assessed on the basis of abiotic and biotic parameters in order to provide the complete spectrum of information for the conservation, assessment of fish diversity and better fish management and sustainable utilization. Rapid industrial growth in the post-independent India resulting in deforestation, unscrupulous exploitation of river water for irrigation, siltation of river beds and reservoirs, unattended fish catches by the untrained fisherman, destructive fishing, damming, habitat fragmentation, loss of habitat, predation, diseases, etc. has drastically decreased the fish diversity in the natural waters (Mudgal 2007).

India being the fourth largest producer of fish in the world and second in inland fish production, its share in the world production of fish is about 4.6 %. Fisheries sector has been recognized as a powerful income and employment generator as it stimulates growth of a number of subsidiary industries and is a source of cheap and nutritious food. At the same time, it is an instrument of livelihood for a large section of economically backward population of the country. More than 8.0 million fishers in the country directly depend on fisheries and aquaculture for their livelihood (Chauhan 2004; Ayyappan *et al*., 2006).

Aquaculture in India is almost synonymous to carp culture, since the latter alone contributes to more than 80% of the total aquaculture production of the country. The carp culture mainly involves three Indian major carps viz catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) and three domesticated exotic carps viz silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) (Ayyappan *et. al*. 2006). According to (Chauhan 2004) India is reckoned to be self-sufficient in carp fish seed to meet the demand of aqua farming. The present carp seed production is about 17,000 million fry and it is envisaged to achieve a target of 25,000 million fry by 2009-10. The only alternative is to strengthen and sustain fish farming and culture based capture fisheries by employing better management practices and ensuring enhanced fish production as well as the environmental sustainability. (World Fish Center 2003) has also envisaged major growth in fish farming in Asia particularly in India, where it is expected to increase by 67 % by 2020. The paper discusses fish diversity in this reservoir in relation to physical and chemical environment, stocking of fish and other management practices.

MATERIALS AND METHODS

The Baigul dam is located close to 79° 35' to79° 42' E latitude and 28° 52' to 28° 57' N longitude at an altitude of 211 m and distance of approximately about 45 km South-East of Pantnagar. This reservoir was constructed across the

rivers Sukhi or Baigul near the place Shakti farm, receiving a number of rivulets in the course of their flow from east to west.Commercial fishing in the reservoir is conducted by the contractors throughout the year except during the rainy season. The data on fish landings were recorded weekly during the periods when fishing was carried out in the reservoir. The data on daily and total fish catch were recorded from the landings obtained from the reservoir by the contractor. The total information of the boats and gears used by the contractor was also collected. The data thus obtained were used to analyze the fish population. The fish specimens were obtained, preserved in 5% formalin and systematic identification of fishes was done following (Day 1878; Jayaram 1981; Datta Munshi *et al*., 1988; Talwar *et al*., 1991; Jayaram 2002).

RESULTS AND DISCUSSION

The fish fauna of Baigul reservoir has been studied during the present investigation. Baigul reservoir has a rich assemblage of both naturally occurring and stocked fish species. In addition to the fresh trade, smaller varieties of fish (Puntius spp., Gudusia chapra and Prawns spp.) are also dried and supplied to other places like U.P., Delhi etc. The fish fauna is comprised of major carps, cat fishes, minor carps and a large population of trash fishes. A total of 36 species of fish belonging to 13 families were identified in the reservoir. Among 13 families Clupideae, Notopteridae, Cyprinidae, Siluridae, Channidae and Bagridae were the most common. The fish species such as *Labeo calbasu, L. gonius, L. rohita, Catla catla, Puntius sp., Cirrhinus mrigala, C. reba, Mystus tengara, M. seenghala, Nandus nandus, Gudusia chapra, N. notopterus, Wallago attu, Xenentodon cancila* and *M. armatus* etc. were quantitatively the main components of the fishery of the reservoir. The findings have revealed that the Baigul reservoir harbours a variety of fish fauna. The results of the present study have been presented in two parts. The first part deals with the collection and identification of collected specimen and enlisting of the fish species recorded during the study period; while the second part deals with a comprehensive discussion based on the present fish production data obtained from State Fisheries Department, Uttarakhand.

The fish fauna of Baigul reservoir mainly consists of a rich assemblage of minor carps and forage fishes, residual cat fishes and some amount of major carps. Fish fauna of Baigul reservoir comprised of 36 species of major carps, minor carps, cat fishes, other fishes and weed fishes. (Deorari 1993) reported 35 fish species belonging to 21 genera of major carps, minor carps, cat fishes and weed fishes in Dhaura Reservoir. (Balai 2007) recorded 40 species (28 genera) belonging 13 families representing 5 orders in Jaisamand reservoir. (Pathani *et al*., 2007) identified 39 species of fish belonging to 14 families in Nanak Sagar reservoir. (Deorari 1995) recorded 49 fish species belonging 15 families from Nanak Sagar reservoir. (Rose *et al*. 2006) reported 22 species belonging to 7 families contributing to the commercial fisheries of water bodies of Ajmer, besides the large sized major carps, cat fishes and murrels in substantial members. (Singh *et al*., 2006) recorded 53 different species belonging to 7 orders, 18 families and 34 genera from Mahanadi River. (Mohite 2006) recorded 31 species of fishes belonging to 11 families in reservoirs of Solapur District, Maharashtra. (Sakhare *et al*., 2002) reported the occurrence of 20 fish species belonging to 4 orders in Bori reservoir in Osmanabad district of Maharashtra.

In the Baigul reservoir, the commercial fishing is started in October and continued up to June. Almost immediately after the fish are brought to the shore, these are grouped into three classes viz., class-A, class-B and class-C according to their respective market rates. In the present investigation the monthly data on fish catch from January to December are presented in a systematic manner. The species wise data are divided into 5 groups: The first group (A), major carps which comprises of *Labeo rohita, Catla catla, Cirrhinus mrigala* and *Labeo calbasu*, while the second group (B1) includes cat fishes: *Mystus* sp. and *Channa striatus*. The third group (B2) includes minor carps such as *Labeo gonius* and *Notopterus notopterus*. The fourth group (B3) includes other fishes and the fifth (C) is weed fishes including, *Gudusia chapra* etc.

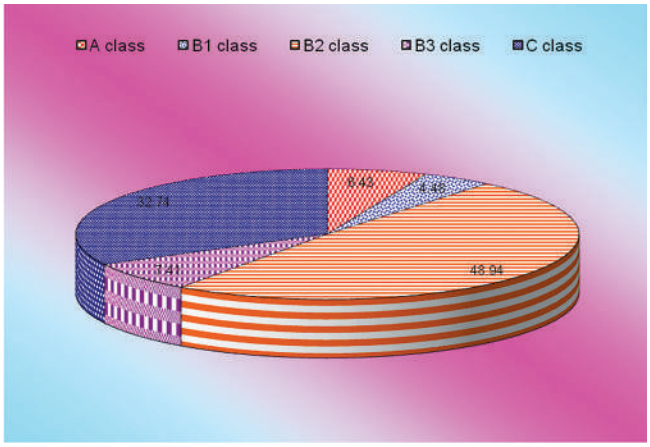

Fig. 1. Classwise per cent contribution of total fish production in Baigul reservoir

The class-A contributed only (6.43 %) to the total fish production of Baigul reservoir (Fig.1). The total production of class-B1 was 8,942.0 kg. This category contributed 4.48 % to the total fish production. It is apparent that the highest production (16288.0 kg) of class–B2 was recorded during June; while the production was least (3818.0 kg) in the month of January. It is obvious from the catch data that

with high share in the total fish catch, this class was most dominant. The class-B3 contributed 7.41 % to the total fish landings. Further class-C contributed (32.74 %) to the total fish production (Fig. 1). (Sultan *et al.*, 2005) reported that the fishes of category A and B representing major carps of all size groups behaved as a sub-population; initially major carps were 10.62 % and 0.89 % for the royalty regime. Category C fishes constituted nearly 38.71 % and category D (49.77 %) in royalty regime. According to (Balai 2007), fishes of category-I contributed only (4.87 %), category-II (36.44 %), category-III (15.92 %), category-IV (5.65 %), category-V (24.73 %) and category-VI contributed (12.38 %) to the total fish production of Jaisamand reservoir. In the present study class-A contributed (6.43%), class-B1 (4.48 %), class-B2 (48.94 %), class B3 (7.41%) and class-C (32.74 %).

Major carps contributed 6.43 % to the total production. *L. rohita* contributed 2.17 % to the total landings from this reservoir (Fig. 2). *C. catla* contributed about 0.58 % to the total landings in Baigul reservoir. The *Cirrhinus mrigala* was contributed about 2.09 % to the total production landing from Baigul reservoir (Fig. 2).

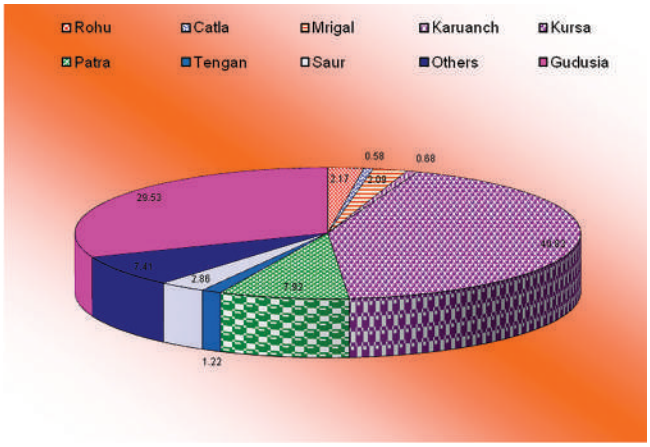

Fig. 2. Per cent contribution of important fishes to total fish production in Baigul reservoir

Labeo calbasu contributed about 0.68 % to the total landings during the present investigation. In the present investigation, the contribution of important fishes/groups to the total fish production was calculated as follows: *Catla catla* (0.58 %), *Cirrhinus mrigala* (2.09 %), *Labeo rohita* (2.17 %), *Channa striatus* (2.86 %) and other fishes (7.41 %). (Balai 2007) recorded monthly fish production of *Catla catla* as 49.59%, *Cirrhinus mrigala* (6.74 %), *Labeo rohita* (1.68 %), *Wallago attu* (1.34 %), *Channa marulius* (0.09 %) and other fishes (36.66 %) in Jaisamand reservoir; major carps contributed 58.01 %, cat fishes 5.33 % and other fishes 36.66 %. In the present study major carps contributed 6.43 %, cat fishes (4.48 %), minor carps (48.94 %) and weed fishes (32.74 %).

The contribution of cat fishes was 4.48 % to the total fish landings of Baigul reservoir. *M. tengara* contributed about 1.22 % to the total fish landings from this reservoir. *Channa striatus* contributed about 2.86 % to the total landings from this reservoir. Minor carps contributed about 48.94 % to the total fish production. *Labeo gonius* dominated the fishery followed by *Notopterus notopterus* in the minor carps group. *L. gonius* contributed about 40.83 % to the total landings from this reservoir (Fig. 2). (Singh *et al.*,1991) have also recorded a large population of weed fishes (40 %) in Nanak sagar reservoir. (Deorari 1993) recorded that the contribution of weed fishes ranged from 42.1 to 56.6 % in Dhaura reservoir in tarai region. Similarly, the weed fishes contributed about 57 % of the total fish catch from Tumaria reservoir in Udham Singh Nagar district (Rawat 1991). The weed fishes were also the most important component of reservoir fishery in Baigul reservoir contributing 32.74 % to the total catch during study period. The highest catch of weed fishes during winters in Baigul may be attributed to low temperature in which these fishes become more sluggish and caught easily. During summer, due to low water level with high temperature, the fish catch was also high. The aquatic weeds present in these reservoirs give better place for the shelter of the weed fishes. *Labeo gonius* is most dominant fishery of this reservoir which contributed 40.83 % in Baigul to the total catch.

Notopterus notopterus contributed about 7.92 % to the total production from Baigul reservoir (Fig. 2). The fishery of Baigul reservoir is mainly comprised by medium sized carp Labeogonius. Weed fishes, catfishes and minor carps comprise the rest of the fishery. Major carps contribute only 6.43 % to the total fish catch. The dominance of weed fishes and the presence of catfishes in reasonable amount are apparently the major factors in preventing the development of major carps in sizeable numbers. It is recommended that *L. gonius* should be stocked in the reservoir to increase its production as it has good recruitment rate. The contribution of weed fishes was 32.74 % to the total fish landings of Baigul reservoir. *Gudusia chapra* contributed 29.53 % to the total annual fish landings (Fig. 2). Other fishes shared 7.41 % to the total fish production in Baigul reservoir. The findings of this study and results of fish stocking in the reservoir are positively related to changes in population.

ACKNOWLEDGEMENT

The author is thankful to the staff members of the laboratory, Fishery Hydrography Department, College of Fisheries, G. B. P. U. A. & T. Pantnagar for providing the necessary facilities to complete this research task.

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*MACROTYLOMA UNIFLOR*UM*:* THE FUTURE PULSE CROP FOR THE TROPICS

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ABSTRACT

Horsegram [*Macrotyloma uniflorum* (Lam.) verdc] is a lesser known member of Fabaceae family. It is mainly cultivated in African and Asian countries and could easily be grown in adverse climatic conditions. In India, it has been used from ancient times as ayurvedic medicine for treating diabetes, bronchitis, asthma, obesity, leucoderma, kidney stones, heart diseases and many more. This crop is rich in proteins, minerals, vitamins and many bioactive compounds such as phenolic acid, phytic acid. Its remarkable ability to grow in harsh conditions like heavy metal stress, dry and drought regions that makes it more demanding pulse crop for future with respect to the era of climate change. Despite of having high nutritional values and medicinal properties this crop has been neglected from a long period. In Uttarakhand Himalayan region it is extensively grown and used as a regular dietery food bylocal people. Looking at the upcoming uncertain climate situations, the attention of scientists towards the under utilized legumes for finding alternate protein sources have increased. Thus, there is an urgent need to study the enormous potential and developing improved varieties of this very old legacy of pulse crop.

Keywords: *Macrotyloma uniflorum*, Horsegram, Therapetic agent, Complete nutritional supplement and Underutilized crop

INTRODUCTION

Since millennia, the second most important group in terms of crop after cereals is legumes (Bhadana *et al*., 2013). They primarily fulfill the huge demand of protein and nutrients in the developing countries still some of the indigenous legumes are underutilized and less explored. Horsegram [*Macrotyloma uniflorum* (Lam.) verdc] also known as gahat in Kumaon/Garhwal, Kulatha in Sanskrit, Kollu in Tamil etc. in different regions of India is among the most protein rich lentils found on earth (Chahota *et al.*, 2013). This crop belongs to the genus *Macrotyloma*, *Phaseoleae* tribe and family Fabaceae. It is grown in the northern, central and southern parts of tropical, sub-tropical and temperate regions of world involving African and Asian countries. This crop is a potent source of protein, carbohydrate and minerals and is resistant to various biotic and abiotic stresses. In present era, the greatest issue on the planet is regarding the food and nutritional security which include the protection of endangered food crops and promoting the production of underutilized food with nutraceutical properties. Instead of depending on few crops and making them adapted according to the climate change scenario, it is better to promote the crop plants that are already adapted to the adverse climate conditions like poor fertile soils, drought and dry seasons (Mabhaudhi *et al*., 2017). For this, Horsegram is the best alternate to be focused which is highly adapted to wide range of temperature regimes that most of the crops fail to sustain.

Fig. 1. (a) Horsegram plant **(b)** Horsegram seeds

Origin and Distribution of Horsegram (*M. uniflorum*)

The members of *M. uniflorum* are extensively grown in both India and Africa. Though as a cultivated plant its centre of origin is reffered as India (Purseglove 1974). The world old tropics are considered as the most genetically diverse regions of this crop especially, the Himalayas and the southern part of India (Zeven *et al*., 1982). While some believe it was native plant to African countries and was domesticated to India since prehistoric times and now has become the part of India's important cultivated crop. It has been distributed to different African and Asian countries like India, Pakistan, Sri Lanka, Malaysia, Myanmar, Bhutan, Somalia, South Africa and Sudan etc. It is grown in many other tropical countries as green manure and forage like Australia, Papua New Guinea.

M. uniflorum Crop Status in India

The major states where Horsegram is grown are the hills of Uttarakhand, Himachal Pradesh, Orissa, Karnataka, Andhra Pradesh, Madhya Pradesh, Jharkhand, Tamil Nadu, Bihar,

West Bengal and Chhattisgarh in India. In India, The total area covered under Horsegram cultivation was approx. 2.32 lakh ha and 1.05 tonnes of production according to Twelfth Plan (2012-2015). Karnataka holds the first rank in terms of contribution towards Horsegram production followed by Orissa and Chhatisgarh. Bihar holds the first rank in terms of yield followed by West Bengal and Jharkhand. The varieties mainly used by farmers in Uttarakhand are VL Gahat-8, VL Gahat-10 and VL Gahat-19.

Importance of Horsegram in Food and Nutrition

Horsegram (*Macrotyloma uniflorum*) is among those very important but less appreciated pulse crop, which is a remarkably rich source of proteins, minerals and vitamins. They have been a very potent food source in India from ancient times. It provides an instant amount of good energy immediately after consumption. They are not only best for the nutritional values but also the medical properties like treating kidney stones, diabeties, edema, menstrual pains, piles, renal stones, healing wounds and many more. Their seeds are widely used now-a-days for reducing obesity and its related problems, which is a very common problem among rich people due to very unhealthy diet. It burns excessive fat by increasing body temperature and are very good to feed on cold regions. The studies have revealed that diet plays a vital role in reducing stone problems in body. In ayurveda, the Horsegram has recommended to be used as a medicine to cure kidney and bladder stones naturally. The horse gram seeds break down the Calcium phosphate crystals that are responsibe for stone formation. The Horsegram seeds are densely packed with lot of nutrients and vitamins; thiamine, niacin, ascorbic acid and carotene. They also contain most of the essential minerals like Calcium, Molybdenum, Phosphorous and Iron; and Polyphenols that possess high antioxidant properties (Sodani *et al*., 2004). They help in increasing muscle strength, fortified bones, regulating red blood cell synthesis and also possess antiurolithiatic activity that prevents the synthesis of stones in kidney, bladder and urethra (Chaitanya *et al*., 2010). Hemagglutinin which is an agent responsible for agglutination of RBCs are abundantely present in Horsegram. Some reports suggested that the lipid extracted from horsegram heals the peptic ulcers in rats (Jayaraj *et al*., 2000). The bioactive compounds like phytic acid and phenolic acid are potent antioxidants that are present in horsegram seeds they provide protection to the body against diabetes mellitus, variety of cancer and coronary heart diseases (Kumar *et al*., 2010). The horsegram seeds also possess many wound healing properties like anti inflammatory, potential analgesic activity and pain relieving properties (Muthukumar *et al*., 2014). Fever and respiratory problems are also cured by this crop. The methanol extract and oil extracted from Horsegram crops exhibit central and peripheral antinociceptive activity and potent analgesic properties (Bharathi *et al*., 2015). The seeds also help in diuretic activity and act as diuretic drugs used to treat high blood pressure and heart failure treatments. They excrete water from the body and lower down the blood pressure. The phytochemicals extracted from the seeds includes tannins, proteins, flavonoids, alkaloids and carbohydrates (Mathew *et al*., 2014). The health benefits of horse gram have gained much popularity from few years its ability to cure various diseases was known by Indian Ayurvedic system but now the western world have understood it too. Still much work is needed to explore this very old legacy by performing pharmacology, biological evaluation, chemoprofile and identifying undenfied phytochemicals to promote and support the programs initiated to promote the underutilized crops for food and nutrition security issues.

***M. uniflorum:* A Potential Food Source for the Future**

M. uniflorum is a complete food source for humans and is a promising food supplement, fulfilling all the demands related to the food, medicine, neutraceutical properties, nutrients and phytochemicals secretions. The Horse gram seed meal is completely non-toxic and safe to feed. Their seeds extract shows significant anti-microbial activity against many pathogenic microbes harmful to humans including *Bacillus subtilis, Escherichia coli, Staphylococcus aureus, Klebsiella* sp and *Pseudomonas aeruginosa* (Gupta *et al*., 2005). It is highly drought resistant pulse crop and could easily be cultivated in adverse climatic conditions. This crop is not only resistant to drought but also to various abiotic stress factors such as salinity, heavy metal and heat stress (Sharma *et al*., 2015a). This remarkable ability of this crop make it vulnerable for future that's why the US National Academy of Sciences has given this crop the status of "Food source for the future" (National Academy of Sciences 1978). It owns an excellent potential of getting the status of a future food legume and contributing to the national and nutrition security (Morris 2008). Currently, it is a minor legume in India as compared to the other pulse crops and grown annually on approx 3.26 lakh ha land area (Directorate of Economics and Statistics 2016–2017), which is only 1-2% of total pulses grown in India (Singh 2013). The traditional mixed cropping in Uttarakhand region involves the farming of twelve food grains also referred as "Barah Anaaja" among which Horse gram is an important member to tackle the drought stress (Zhardhari 2001). Despite of being able to feed the huge masses in drought prone areas and all these medicinal and nutritional values in one crop, this crop has been highly neglected in the global market. India is the only country where horsegram is cultivated on large area and used as a human food. As a result of such negligence a very drastic decline in the production of such a potential crop has been reported from past 2 decades. This is not a good sign towards the protection of food and nutrition security. Currently, it is

widely used as food and forage in malnourished and drought prone areas of the world (Morris 2008). But looking at the current difficult environmental situations regarding climate change, poor soil fertility and less water for agriculture it would not be wrong to say that the exploration of *M. uniflorum* plant related to more phytochemical, therapeutic uses must be done as soon as possible for present and the future struggling time.

CONCLUSION

After assessing so many benefits in one crop it could be undoubtly concluded that Horsegram is an excellent source of nutrients and medicinal properties. It is very much comparable to other crops infact is better in terms of climate adaptation. It is very important pulse crop as food and forage in many developing countries and has possibility to gain attention in developed countries too. It is a complete food full of bioactive compounds thus should be added to the diet on regular basis. These are not only used for feeding but also contain medicinal and neutraceutical properties which are not easy to find in every crop. They have been widely used from ancient times as ayurvedic medicine in our country it is the time to explore and promote it more to make it a worldwide crop so that more phytochemicals and nutrients could be extracted from them and use for mankind. Also the climate change that our world is facing now could become more difficult in upcoming years regarding less water for irrigation and poor soil quality for that we need to find an alternative that could withstand the tough environmental conditions. The innate quality of horsegram to tackle adverse climatic conditions has already proved itself a very potent crop to invest for future.

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LICHENOMETRY IN INDIAN PERSPECTIVE

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Lichenometry is a dating technique that employs the age and size of the lichen thallus to estimate the relative age of any substrate. The use of lichens growth for relative dating of the surfaces was first proposed by the botanist Knut Faegri in 1930s, thereafter Roland E. Beschel further expanded this technique in 1950s and is accredited as '*Father of Lichenometry*'. As part of his doctoral research completed in 1958 at the University of Innsbruck, he studied the ecology of lichens and measured diameters of lichens on dated tombstones in Austrian cemeteries, determining the growth rates of a number of fast-growing species. Beschel published a series of articles on the subject in 1950s (Benedict 2009).

A world wide review of published literature pertaining to lichenometric studies till 2018 revealed 257 publications from 37 countries (Bisht 2018). Maximum numbers of publications were from USA (57) followed by Norway (38) and UK (25) and a few were reported from other countries. However, as far as continents are concerned maximum publications came from Europe (128), followed by North America (80), Asia (21), South America (15), Australia (11) and Africa (2). Most of the studies were focused on application of lichenometry on glaciological studies (124) followed by lichen growth and modifications in practical applications of lichenometry (102). Besides this few publications were focused on application of lichenometry on dating fluvial events (13), landslides (10), archaeology (8), earthquakes (6), volcanoes (1) and anthropology (1).

Lichenometry across the globe and lichenology in India started 7 decades ago in 1950s. In India, although lichenology started in 1950s, but the first publication on lichenometry appeared in 2001 when Srivastava *et al*., (2001) ttempted to date moraines in Gangotri glacier using *Rhizocarpon sublisidum, Rinodina oreina* and *Xanthoria elegans* and estimated the age of three moraines as 1782 AD, 1849 AD and 1865 AD. Thereafter, Awasthi *et al*., (2004) used *Dimelaena oreina* for estimating the age of moraines in Gangotri glacier by monitoring lichen growth for three years and calculated the age of moraines as 1881 AD and 1897 AD. Awasthi *et al.*, (2005) used lichenometry and Schmidt Hammer techniques for relative dating of moraines in Gangotri Glacier. They estimated relative ages of two moraines on the downstream side as 1897 AD and 1881 AD by lichenometry using *Dimelaena oreina* and another moraine on the upstream side as 1970 AD by Schmidt Hammer technique. Gupta (2005) used the percent cover of lichens on slided materials in the Pawari land slide zone located in the Higher Himalaya. This has been correlated with the indicators showing movement of deposits and activity of the slide. He documented that in a slided mass; boulders containing more lichen cover were stable in the present climatic scenario or had moved least compared to the ones showing lesser lichen cover. Chaujar (2006) studied growth rate and colonization delay of *R. geographicum* at four different localities in Himachal Pradesh. He measured the largest sized specimen growing on the well-dated monuments. Correlation of size with age, by plotting the measurements on a graph and finding the best fit line, gave the rate of growth of lichens (per year) and colonization delay. He found that colonization delay and growth rate in the four localities namely Sanjoli, Kanlog, Dharamshala and Dalhousie were 24, 68, 50, 86 years and 0.73, 0.79, 0.56, and 0.54 mm/year respectively. Chaujar (2009) studied impact of climate change on Himalayan glaciers based on the dating of lichens. He showed that the age of the largest lichen on the loop of moraine that indicated the position of maximum advance of the glacier was 258 years. It shows the period when the Chorabari glacier started receding from the point of its maximum advancement. (Joshi *et al*., 2010) used *R. geographicum* with a growth rate of 0.2 mm/year, to estimate the retreat of Pindari Glacier. They calibrated approximate age of the surface exposed at a distance of 1km from the glacier snout ranged from 550 to 600 years. Gupta (2014) estimated the colonization delay of *R. geographicum* on the boulders of granite and gneisses in the Gangotri glacier region. It has been concluded that the colonization delay for the said species is different for both the rock-types. It was about 78 years for granite and between 50 and 78 years for the gneisses. Lichenometric investigations were conducted in Kupup and Thangu area of Sikkim and Thajiwas glacier in Ganderbal district of Jammu and Kashmir with the help of *R. geographicum* (Bajpai *et al.,* 2016). The study revealed that the Thaji was glacier showed vertical retreat of 200m in 279 years, while in Thangu and Kupup area of eastern Himalaya the vertical retreat was estimated 200 m in 100 and 91 years respectively. Bisht *et al*., (2018a) conducted lichenometric studies on Milam glacier in Uttarakhand using the lichen *Dimelaena oreina* and showed that the Milam glacier has receded 1450m in last 70 years with an

average recession rate of about 21 m/year. (Bisht *et al*., 2018b) carried out lichenometry on moraines of Adi Kailash glacier of Uttarakhand with lichen species *Rusavskia elegans* and estimated that the glacier has receded 470 m during the last 41.37 years with an average recession rate of 11.36 m/year. Recently (Bisht *et al*., 2019) studied the issue of cairns on glacial moraines and suggested some methods for minimizing the errors originated due to cairns. India is a country of oceans, glaciers, rivers, mountains, monuments and civilizations. There is vast scope for lichenometry to be used in various aspects of dating. There is an estimate of presence of 9575 glaciers in India (Raina *et al*., 2008) and lichenometry can be useful in estimating recession rates of glaciers. The thousands of kilometers long river system of India is another aspect where lichenometry can be used to date the timing when any river has changed its regular path and to anticipate the causes behind it. Every year there are several incidents of landslides and earthquakes in India. The fragile landscapes and terrains in mountain regions get slided due to heavy rains and large construction activities. Lichenometry can date the slided material and thus can help in understanding the frequency of extreme weather events that have caused the landslide or earthquake. Since ancient times to recent, India has been the land of various cultures and civilizations. Different civilizations left their symbols in forms of monuments that they built thousands of years ago. There are thousands of ancient monuments made up of rocks in various states of India. Lichenometry can estimate the date of their construction and thus can predict the era of a particular civilization Even the date of glacial lake outburst flood (GLOF) can be estimated even after hundreds of years by using lichenometry.

ACKNOWLEDGEMENTS

Author would like to thank Dr. Ranbeer S. Rawal, Director, G B Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora for providing laboratory facilities.

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MICRO PROPAGATION OF ROOTSTOCKS FOR SUSTAINABLE PRODUCTION OF HIGH-QUALITY APPLES IN UTTARAKHAND- A REVIEW

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ABSTRACT

Apple is the chief fruit crop grown in temperate regions of India. Persistent use of seedling rootstocks has lowered fruit quality and demand. Seedling rootstock induces genetic variability, therefore uniformity and suitability required for intense plantations is compromised. Clonal rootstocks on the other hand, have a profound role in shaping orchard efficiency in fruit crops. Combination of desirable traits of two different plants by grafting produce different growth effects. At present the apple productivity of the State is very less, however, with advancements in tissue culture techniques new doors have been opened up for the mass multiplication of clonally propagated apple rootstocks and new varieties of cultivars planting material to meet the State demands. This review focuses at the current situation of apple cultivation in the State and discusses about the new technologies available such as micropropagation and micrografting to uplift apple cultivation and subsequently fruit production. Furthermore, factors affecting apple cultivation and challenges for sustainable, ecological as well as economical state horticulture are discussed.

Keywords: Apple cultivation, Clonal propagation, Micrografting, Rootstocks, Agronomic and Environmental factors

INTRODUCTION

Apple (*Malus x domestica* Borkh.), trees are perhaps amongst the pioneer fruiting trees to be cultivated and improvement in numerous traits such as fruit size, quality, yield, colour etc. have involved selection for over centuries (Potter *et al*., 2007). Necessary traits for production of elite and new cultivars still proves to be a challenge as the climatic conditions have already been pushed with an overall increase in global temperature, stress induced due to multiple factors, changes in the micro environment of temperate regions, etc. Apples are vital pomaceous fruits and are rich organic source of dietary minerals, vitamins, antioxidants, fibre, phytochemicals and carbohydrates (Dubey *et al*., 2007). Apples are cultivated in an estimated 313,040 hectares of land in the Indian Himalayan region that accounts for sixth largest production site globally (FAOSTAT 2014). Apple is the principle horticultural crop produced in Uttarakhand and accounts for more than 13% of overall fruit production and holds 17% of total area utilized for cultivating fruit crops. After Jammu & Kashmir and Himachal Pradesh, Uttarakhand is ranked third in apple production in India with more than 34,000 hectares of land employed for apple cultivation that yields approximately 92,300 metric tonnes (http://nhb.gov.in/area-pro/2014-15 (Final Estimate).xlsx. Moreover, in terms of average yield of apples, the State production is significantly less (2-3 tons/ha) when compared to Himachal Pradesh and Jammu & Kashmir with 5-6 and 7-8 tons/ha respectively (https://data.gov.in/catalog/all-india-and-state-wise-area-and production-fruits). Various factors limits the cultivation of apple in the State such as use of seedling rootstocks, inadequate pollination, old and senile orchards and their poor management, new plantations that are in non-fruit bearing stage, dependence upon rainfed cultivation, poor canopy management and harvesting practices, alterations in climatic conditions such as storms, heavy rainfall, long-dry spell, variations in temperature etc. and postharvest wastages that results in low spur formation, poorly coloured fruits and delayed maturity. Yet, immense scope is present in the State for enhancing apple productivity of apple via technological infusions, implementation of best available global practices (UAPCC 2014). This review acknowledges the limitations of traditional practices and persistent dependence on seedling rootstocks and focus on the adaptation of modern tissue cultured and micrografting raised true-to type, virus-free and disease resistant planting materials to boost fruit production in the State.

Micropropagation of Apple

The emergence of modern technology for production of planting material of horticultural crops is accelerating towards high density plantations in fields and intense growth systems that also include new parent plants in breeding fruits crops and introduction of newer cultivars and modernization of tree habit and pruning (Rehman *et al*., 2015). Such changes require large amount of quality planting material. Orthodox system of propagating the planting material

consumes too much of time and effort, moreover, such raised plants does not carry uniformity. Being saprophytic (self-incompatible), apple trees undergo cross-pollination that leads to heterozygous progenies as a result of chromosome segregation. High degree of variations is observed in plant traits among seedling raised plants therefore, seeds are not considered suitable as true-to-type planting material for propagating plants. An unswerving genome of each cultivar could only be sustained through clonal propagation, necessary for large scale production of genetically stable and uniform rootstocks and scions (Jaime 2019). Clonal propagation plant tissue culture techniques favours exploitation in nurturing whole plants, organs, tissues, or cells under in vitro (controlled and aseptic) conditions. Tissue culture provides all essential nutrients, minerals, vitamins, hormones and water necessary for explant growth through optimized media, light and temperature settings to promote growth. In vitro micro propagation is a well-known tissue culture method extensively utilized for rapid multiplication of numerous disease-free planting material including Malus species (Butiuc-Keul *et al*., 2010). Crop improvement programs are also progressing for a large variety of rootstock and scion cultivars of most fruit trees. Genotypic modifications to make cultivars more resistant to stress, to accelerate growth, to increase tolerance to diseases and to enhance fruit quality, is economically important (Prasad *et al*., 2018).

A grafted plant consists of two parts namely scion that represents the shoot system and is the above part of the graft union that aids in plant metabolism. The rootstock represents the root system that facilitates absorption of soil's nutrients and it is below the graft union. Rootstock have a profound role in growth pattern, size, drought tolerance, adaptation in different soil and climatic conditions, winter hardiness, precocity, fruit quality and yield. In grafting both the rootstock and scion cultivar not only form network with each other but also with the soil and climatic conditions of the region. February-March is best period for grafting success using tongue grafting under hilly regions. In a study conducted in Dehradun district by (Malasi *et al*., 2017), scion wood of three apple cultivars were used namely Vance Delicious, Gold Spur and Oregon Spur, in various combinations were Tung grafted onto three rootstocks (M793, M7 and MM111). Out of various combinations observed, Vance Delicious and M793 combination displayed maximum graft attributes.

Apple cultivation

Amongst the most prevalent planting system present worldwide is high-density planting system (HDP). First established in 1960's in Europe, soon apple orchards of Europe, America, Australia and New Zealand have also undertaken this system where four planting densities have been recognized for apples namely, low-density plantations with less than 250 trees/ha, moderate high-density plantations with 250- 500 tree/ha, high, high-density plantations with 500-1250 trees/ha and ultra-high, high-density plantations with more than 1250 trees/ha. More recently, super high-density apple plantations have also been established in orchards with 20,000 trees/ha. All the above mentioned HDP systems, dwarfing rootstocks are invariably used for raising apple production (Chadha *et al*., 2005).

Apple Rootstocks

Three types of apple rootstocks namely seedling rootstocks that include those from either wild and cultivated apples or from different genera, apomictic seedling rootstocks, and clonal propagated rootstocks. The East Malling Station, U.K., pioneered the apple rootstock breeding and application program during early 20th century. Sixteen distinct rootstocks were identified and sequentially numbered (M1-M16), derived from *M. pumila* var. praecox and *M. pumila* var. paradisiaca. After successful M series rootstocks, East Malling Research Station and John Innes Horticultural Station, Merton, England cooperated together and crossed the M series members with the Northern Spy and introduced the MM series (MM101- MM115) that provide resistance against the woolly apple aphids. The M series were also crossed with native cultivars in foreign lands that have led to the creation of new seriesof rootstocks that include MAC and CG series U.S.A., O3 in Canada, B series in Russia, P series in Poland, Japanese JM series, and GM256 of China. The Agricultural Research Service of the Department of Agriculture in their Apple Rootstock Breeding and Evaluation Program (USDAARS) at the Cornell University, N.Y., U.S.A., also introduced the GENEVA series (G 65, G 41, G 213, G 214, G 222, G 202). Achievements in successful rootstock breeding of dwarf rootstocks have revolutionized the apple cultivation system. (Wang *et al*., 2019).

Fig. 1. Apple rootstocks development in climate-controlled nursery.

In vitro Micrografting

In vitro application of tissue culture methods has also been evolved and are widely practised as an alternative technique for mass propagation of fruit trees. Shoot-tip grafting or micrografting, developed in 1980's, places an aseptic meristem tip or shoot-tip explant over an amputated rootstock that has been previously cultured aseptically or micro propagated. These in vitro micrograft plantlets can be allowed to acclimatize in natural environment or utilized for further multiplication in vitro. Certainly, micrografting technique has advantage of rapid multiplication with increased productivity that results by grafting elite and superior combinations of rootstocks and scions. Avoiding the juvenile phase or unproductive phase of apple tree, micrografting scion onto a rootstock, induces early maturity or triggers precocity leading to early fruit production. Shoot tip micrografting also regenerate the plant by getting rid-off endogenous contaminants and viruses in potential with true to type cloning mature plants. Micrografting is also utilized for early screening of graft compatibility in fruit crops as overlapping of different stress response induced by the graft itself at the interphase between the partners hinders credentials of mechanisms underlying localized incompatibility grim. Micrografting has been applied for physiological analysis of rejuvenation of mature phase plants. It is possible that grafting can be performed through out the year when ever required. In vitro grafting has some advantages for bothproduction and research as shoot-tip grafting has been utilized for improvement and rejuvenation of several tree species, elimination of viruses and analysis of physiological connections between rootstock and scion such as compatibility, root-shoot communication or transport (Rehman *et al*., 2015).

FACTORS EFFECTING APPLE PRODUCTION

Environmental Factors

The quality of the fruits is determined by the interaction of cultivar and rootstock combination with the environment. Availability of optimum light, temperature and humidity including soil characteristics, greatly affect fruit quality. A suitable environment is necessary to cultivate high quality fruits, as both the ecological and economic components are included. A high radiation environment favours for superior-coloured large fruits with high dry matter content, however, intense radiations cause sunburns. In high-density plantations few techniques are employed such as pruning or hedgerow training with a thin canopy, reflective fabrics, paper bags and leaf thinning are employed to achieve large red produce. Temperature is another critical control as apples have a two phased growth that consist of an early exponential cell division phase, in cold temperatures, one week to a month, after full bloom and a cell expansion phase during rest of season when warm temperature during early season favours high fruit growth rate (Musacchi *et al*., 2017).

Agronomic Factors

Rootstock- cultivar interaction, density of the canopy, training system, tree height and architecture, layout of orchard, light interception and photosynthetic efficiency of leaf and tree affects the performance of high-density plantation. The optimum fruit quality is reached with a decent canopy-to root equilibrium without undergoing pruning yields better quality fruits. Row orientation, related to light interception by the trees, critically affects fruit thinning as differences in bloom time between two sides of the tree. Typically, rows are oriented in east to west direction however; north-south oriented rows are most suited for cultivators in the northern hemisphere. It has also been observed that fruits are set in largest flowering buds hence, controlled intensity of pruning that screens half buds to boost cropping while elimination of more than 75% buds removes antagonistic effects. Thus, pruning serves as an important factor for controlling fruit size. Thinning is another technique used to confiscate unnecessary fruit lets from trees to enhance fruit size, colour and quality at harvest. Thinning can be manual, mechanical or chemical. All of which can be utilized singly or in combination.

Apart from the above factors pollination and irrigation are most necessary for fruit setting event and further upkeep of quality fruits. Typically, apples are pollinated by bees. As far as irrigation is concerned, the deficit irrigation system where periods are imposed on supply of water to soil leads to physiological and economic benefits. The use of water lesser than the prevailing evapotranspiration during particular times in the growing season is generally utilized for vegetative growth. A modification of deficit system is the partial rootzone drying technique that allows more water saving by subjecting first half of roots to dry soil while other half on wet soil. This leads to ABA induction in dry roots and limits expansion of leaves and conductance of stomate to elevate efficient water use whereas roots in wet section maintain the necessary water status of trees (Musacchi *et al*., 2017).

Major Challenges to focus for Sustainable apple Production in the State

Limited returns on invested time and capital to farmers with the average farm productivity are dependent on multiple factors that includes farmers problems such as small land holdings typically, small and marginal that leads to less productivity, lack of farmers familiarity with emerging and trending rootstock and scion cultivars, little understanding of among farmers on best available practices for production, little exposure with in-depth training of progressive farmers. Other than problems faced by farmers other factors such as dependence upon rainfed cultivation, unavailability of timely access to quality planting materials, climate change responsible for storms, temperature fluctuations, changing rainfall pattern, increasing pest etc., damage by wild animals

wild boars, bears, monkeys also harm the crops. At present, the major challenge of the State yet to draw critical focus on lack of participation of private sector to render extension services, infrastructure for post-harvest practices such as sorting, grading and packing, storage/ ware housing, processing facility etc, as all the mentioned post-harvest activities are manually done by farmers at farmland itself and is depend on sales to distant markets. Besides that, benefits of integrated value chain negotiations are mostly confined among large producers and poor road infrastructure in distinct rural locations increases the transportation cost of produce (UAPCC 2014).

Integration into a Value Chain

Development of an integrated value chain of apple in Uttarakhand is necessary for socio-economic growth of associated farmers as well as securing sustainable apple cultivation in all respectivezones. Presence of scope for promotion and development of secondary and tertiary level processing of apple is adequate for realizing a higher value for the produce, encourage agrobusiness investments, foster backward and forward linkages. In consideration of high market demand, apple as a cash crop have enormous potential for cultivating districts to boost apple production in Uttarakhand. Any plan and its implementation for sustained interventions along the value chain, a thorough understanding is essential that includes, chief features of the farming community and their participation along the value chain, inter-linkages between various stakeholders, marketing channels and constraints (UAPCC 2014).

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GLACIER RETREAT AND CHANGING SNOW COVER IN THE UPPER GORIGANGA RIVER BASIN, CENTRAL HIMALAYA

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ABSTRACT

In the Himalaya is the abode or glaciers Milam Glacier is one of them, which is situated in the Upper Gori Ganga river basin of the Central Himalaya. Milam is a compound basin type of valley glacier and occupies longitudinal 'U' shaped valley. It is the second largest glacier of the Central Himalaya having an area of 37km^2 and 16km length respectively. The main Glacier is fed by the two cirques emerging from the peaks of Trishuli East (7074m) and Hardeol (7151m). There are seven r tributary glaciers also contributing to the main Milam Glacier. Upper Goriganga river basin comprises an area of 891Km^2. Geologically it comprises Higher Himalayan crystalline and Tethyan sedimentary zone divided by Trans Himadri Fault (THF). The main rocks found in the area are gneiss, quartzites, schist calc phyllites and green siltstone. In this work an attempt is made to identify the snow cover change and Milam glacier retreat during last 46 years. Composite and averaged satellite data of Landsat series for the month of October to December (snow accumulation period) are used for analysis. Snow indices (NDSI & NDSII) are produced to identify the snow cover in the area. Melt water appearing through ice cave in the snout area of the glacier is marked on the satellite data from 1972- 2018 to identify the retreat rate. In 1972 the snow cover was recorded as 70% whereas in 2018 it was reduced to 42.7%. Thus, snow cover change for the studied period (1972- 2018) was 27.30%. The average retreat rate of the glacier was computed 37.8m/year. Study shows that in general snow cover is decreasing and glacier retreat rate is increasing. However, during 1992 snow cover increased and glacier retreat rate reduced. The trend of climatic data in nearby study area for this duration indicates that there has been increase in rainfall and decrease in temperature causing the change in snow cover and glacier retreat rate of 1992.

Keywords: Glacier retreat, Snow covers, NSDI and NSDII, Temperature and Rainfall.

INTRODUCTION

Glaciers are very sensitive and identified as one of the important precursors of climate change. In recent past most of the Himalayan glaciers are receding with an increased rate. Hindu-Kush Himalayan (HKH) region, a biggest mountain range comprises largest store house of snow and glaciers outside the polar region and known as the 'Third Pole' (Bajracharya *et al.*, 2011). Ten major rivers originate from this region including the Indus, the Ganga and the Brahmaputra. Therefore, the Himalaya is considered as the fresh water tower of South Asia. Himalayan glaciers have experienced widespread accelerated recession (length and area), thinning (mass loss), detachment and fragmentation over the last century (Raina *et al.*, 2010; Shukla *et al.*, 2016, Mal *et al.*, 2019).

STUDY AREA

It is extending from 30° 12' 59.83" to 30° 35' 52.79" North Latitude and 79° 59' 53.27" to 80° 17' 30.17" East Longitude. It comprises an area of 891 Km^2 and situated in the Pithoragarh district of Uttarakhand state of India. Two cirques and seven tributary glaciers are main feeders of the Milam glacier. It is a debris mantled glacier. Right bank tributary glaciers of Milam emerge from the peaks of Rishi Pahar (6952m), Jaoni (6074m), Mangraon (6568m), Deo Damla (6637m) and Sakram (6254m) and are named as Surajkund glacier (5.62km), Dhulan glacier (5km), Mangroan glacier (5.37km), Pachmi Bamchu glacier (6.86 km) and Sakram

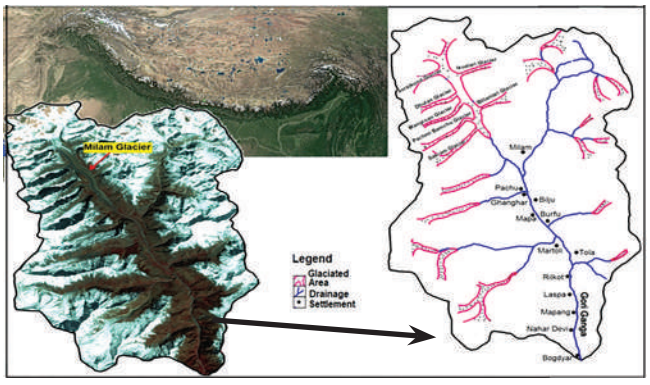

Fig. 1. Study Area

glacier (5.91km) respectively. While on the left bank, the main glacier is fed by Ikualari glacier (4.44km) and Billanlari glacier (2.55km) which originates from the peaks of Nanda Gond (6315m.) and Nanda Pal (6306m) respectively.

Geologically, the study area falls under two geological zones i.e. Higher Himalayan crystalline and Tethyan sedimentary zone separated by Trans Himadri Fault (THF) (Dumka *et al*., 2013). Milam glacier lies in north of the THF in the Tethys Himalayan segment, which is mainly dominated by the rocks of the Tethyan succession. The main rocks types found in the study area are gneiss, quartzites, phyllites, green siltstone, calc phyllite and brick red conglomerate.

METHODOLOGY

Satellite data are used and an analysis is made with the help of Geographic Information System and Digital Image Processing to get the desired information. Satellite data of Landsat series are processed by carrying out the atmospheric correction, filtering, histogram equalization and merging of PAN, MSS and TM data. Snow Indices i.e. NDSI & NDSII are generated by running pre-defined model for the area of interest (AOI) with the help of Erdas14. Composite and averaged satellite data for the month of October to December are used to get the better results. Data base is given in (Table 1).

Table. 1. Year wise Landsat satellite data selected

Year	Landsat Series				
	1	3	5	7	8
1972	✓				
1982		✓			
1992			✓		
2002				✓	
2012			✓		
2018					✓

The Normalised Difference Snow Index (NDSI) method is helpful for snow cover mapping (Hall *et al.*, 1995; Kulkarni *et al*., 2002b, 2006; Gupta *et al.*, 2005). It uses the reflectance value of snow in visible (Green) and shortwave infrared (SWIR) region to delineate and map the snow. A threshold value for NDSI of 0.4 is defined for the pixels that are approximately 50 per cent or greater covered by snow from the imageries of different sensors. Green, MIR and NIR band of satellite data are taken into consideration for calculation. NDSII refers to Normalized Differential Snow and Ice Index and calculated as Green-MIR/Green+MIR. NDSI refers to Normalized Differential Snow Index and is calculated as Green-NIR/Green+NIR. The output values are differentiated using the classification tool to represent different group of features. After identifying the pixel values of snow cover in the imagery the snow cover pixel range extracted separately for snow cover mapping. The rate of retreating glacier is measured by marking the position of snout in satellite image of different years. Climatic information is not available for the area so, the nearby available meteorological station data are used to identify the trend in the rainfall and temperature status during 1971- 2002.

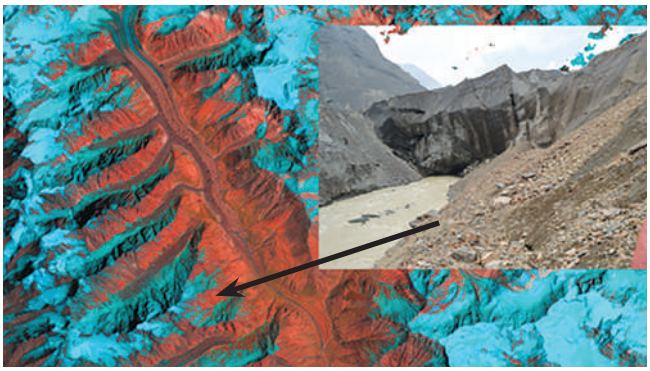

Fig. 2. Position of snout in Satellite Image

RESULT AND DISCUSSION

The ice cave through which melt water is appearing in the snout area of the glacier is identified and marked on the Landsat data series since 1972- 2018 to investigate the retreating rate of Milam Glacier. Glacial retreat carried out by earlier workers is summarised and presented in (Table 2). It shows present retreat rate is very high in comparison to the earlier estimation.

Table. 2. Recession of Milam glacier

S. No.	Observation Period	Total Years	Recession in meters	Average Retreat rate (m/yr)	References
1.	1849-1906	57	732	12.84	Cotter *et al.*, 1907
2.	1957-1966	9	106	11.77	Jangpangi 1975
3.	1966-1997	31	940	30.32	Shukla *et al.*, 2001
4.	1954-2006	52	1328	25.5	Raj 2011
5.	2004-2005	01	9.54	9.54	Dumka *et. al*., 2013
6.	2016-2017	01	24.67	24.67	Bisht *et al.*, 2018
7.	1968-2017	49	1565.4	31.9	Mal *et.al.*, 2019
8.	1972-2018	46	1749	37.8	Present study

Table 3 indicates that during 1972- 1980 glacier retreat rate was 42m/year. For next 12 years i.e. 1980- 1992 it decreased to 36.25m/year. However, during next 10 years (1992 to 2002) it increased to 47.1m/year. From 2002 onward retreat rate is decreasing. Average retreat rate for observed period of 46 years is 37.8m/year.

Table. 3. Retreating pattern (1972- 2018)

Year	Snout position (Distance in m.)	Retreat Rate (m/Yr)
1972	-	-
1982	336	42
1992	435	36.25
2002	471	47.1
2012	322	32.2
2018	186	31
Total (46 Year)	**1740**	**Average 37.8 m/Yr**

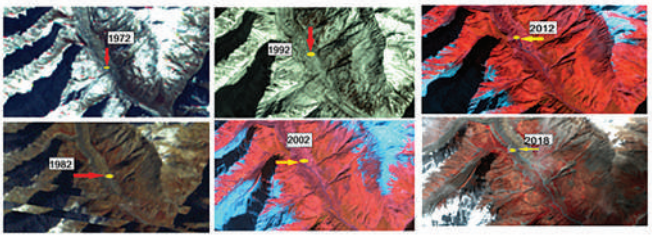

Fig. 3. Changing position of snout

During the period of 1972- 2018 about 30% snow cover reduced. In the year 1972 the snow cover recorded as 72.7% out of total geographical area of Upper Gori Ganga Basin. In the latest satellite data of Landsat 8 for the year 2018 it is reduced to 42.7%. Hence, the total 267.5Km^2 (30%) of snow cover area is lost or melted away. During the period 1972–2018 the maximum snow cover decrease was recorded in the year 2012 to 2018 which is 115Km^2.

Table. 4. Snow Cover Shrink Pattern (1972- 2018)

Year	Snow Cover(Km2)	Snow Cover(%)	Change in Snow cover (%)
1972	648.10	72.7	-
1982	641	72	-1.1 %
1992	821	92.1	+26.7 %
2002	557.1	62.5	-14 %
2012	495.6	55.6	-23.5 %
2018	380.6	42.7	-41.3 %

Satellite data since 1972 of Landsat series has been used in the study to investigate the retreating rate of Milam Glacier. It is

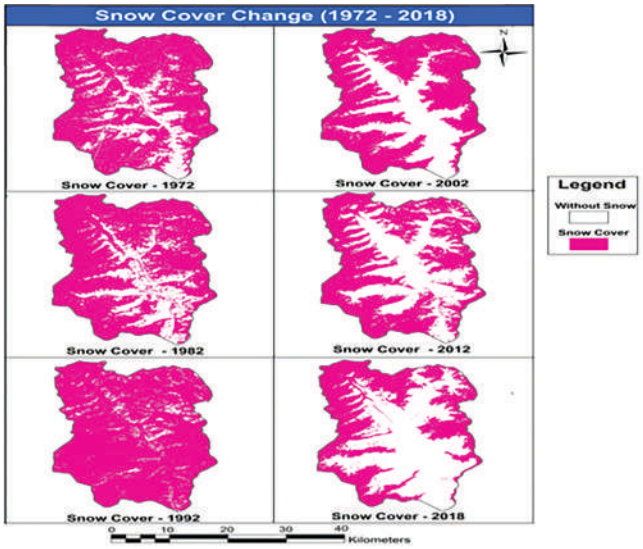

Fig. 4. Snow cover change

observed that the Milam glacier retreats at the rate of 38m/decade, and it is also observed during the study period 1972–2018 that the retreat rate is fluctuating-the lowest decadal retreat rate is 31m/Yr in the year 2012- 2018 and highest rate is 47.1m/Yr in the year 1992- 2002. The total retreat of snout of Milam glacier is 1749m since 1972- 2018. The pattern of retreat is clearly highlighting that in the year 1972 the rate is higher than 2012 and 2018.

Table. 5. Decadal temperature (in °C) of snow accumulation period (Dec, Jan, Feb, Mar, April)

Year	Neighbouring Places of the Study Area			Average
	Pithora-garh	Uttarkashi	Chamoli	
1962-1971	12.4494	11.854	12.46	12.25447
1972-1981	12.0673	11.5259	12.7728	12.122
1982-1991	12.1965	11.6118	12.1449	11.9844
1992-2001	12.9512	12.1239	17.7873	14.28747

Source: https://www.indiawater portal.org

Table. 6. Decadal rainfall (in Cm.) of snow accumulation period (Dec, Jan, Feb, Mar, April)

Year	Neighbouring Places of the Study Area			Average
	Pithora-garh	Uttarkashi	Chamoli	
1962-71	163.5207	143.3799	153.2992	153.3999
1972-81	154.0715	128.1261	139.1892	140.4623
1982-91	200.1023	173.3701	183.6753	185.7159
1991-2001	149.6739	133.7198	134.4107	139.2681

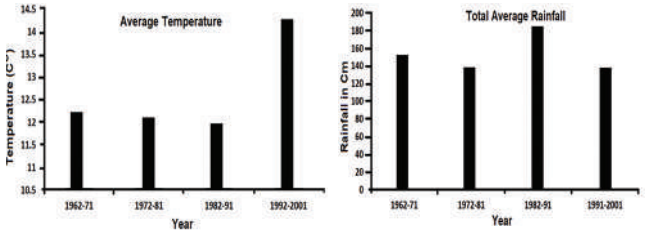

Fig. 5. Temperature and rainfall in the nearby of study sites (*Source: https://www.indiawaterportal.org*)

In 1992 snow cover was found very high otherwise it was decreasing from 1972- 2018. As there is no meteorological station in the area impact of temperature and rainfall on snow cover and glacier retreat is studied using the nearby data available. Table 5 indicates that from 1982- 1991 average temperature was lowest whereas total rainfall for the same period was higher (Table 6). It appears that same trend might have been for the study area also. Low temperature and high precipitation might have been responsible for higher snow cover in the area during 1992. Glacier retreat rate for 1992 was also 36.25m/yr whereas for preceding and succeeding period i.e 1982 and 2002 it was 42m/yr and 47.1m/yr respectively.

CONCLUSION

Milam glacier is having seven tributary glaciers out of which Sakram and Billanlari glaciers are detached from the main glacier. In general snow cover is decreasing and retreat of glacier is increasing. However, decrease in snow cover and retreat rate of glacier is not same over the years from 1972-2018. In 1992 retreat of glacier rate was very low in comparison to 2002 and snow cover for the same year increased very high. The reason for this observation indicates the trend of climatic condition i.e. average temperature was lower and total rainfall was higher in the nearby area of the Milam Glacier

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COMMUNITY FOREST MANAGEMENT IN UTTARAKHAND: A COMPARATIVE CASE STUDY OF WESTERN HIMALAYAN VAN PANCHAYATS

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ABSTRACT
Community forest management is a practice of forestry concerned with generally administrative, legal, economic, and social aspects, as well as scientific and technical aspects of forest management. This practice comprises management of forest resources by regulating collection and distribution of forest products by the user groups. The forests in Indian Himalayan Region (IHR) falls under 3 broad management categories i.e. the Reserve forest managed by the state forest department, Van Panchayat forest managed by local stakeholders and civil soyam forest managed by forest and revenue department. Amongst these, the Van Panchayat (VP) forests arethe people centric category of forests which are being managed by the local communities. The forest produce harvest in the VP forests for subsistence needs depends upon the quality of these forests and the usual harvesting often depends upon the condition of these forests. The conservation and management of these VP forests is often depends upon the active participation of local people. Diverse range of management practices are reported to be carried out by these VPs to distribute equal benefits among the right stakeholders in an equitable manner. The present study focuses on the management of 5 VPs and 4 reserve forests that are located in the Gairsain Block of the Chamoli district inGarhwal division ofUttarakhand. It is interesting to note that the VPs make some of their own rules, so that the forest should be maintained properly and the fund of VPs should be used, in equitable basis to manage the Van Panchayat forest. The management rules of these forests are made applicable through the forest at Van Panchayt committees. There are numerous successful cases of active participation by people in forest resource management especially in the regulated collection and distribution of forest products in the remote villages of Himalayas region. Participatory approaches varies from case to case and people are dependent on decision making and conflict resolution through the interactive of these management committees which focuses a part of elected body through forest department. Present study focuses on the comparative analysis of forest vegetationparameters betweent the reserve forest and community based VPforest andsuggest management practices.

Keywords: Van Panchayat, Community based resource management, Forest produce and Rules regulation.

INTRODUCTION
Forests constitute the largest, complex and most important natural resources, covering 31% geographical area of the planet earth. The importance of forests in relation to two of the most important global environmental threats i.e. climate change and biodiversity loss is hard to overstate (Agrawal 2007).Forests have been long recognized as the reservoir and source of most of the species biodiversity on the planet earth (Wilson 1988). Forests are also important components of global carbon cycle and every year sequesters billions of tons of CO^2 globally (Bonan 2008; Canadell *et al.,* 2008). These statistics about forests are important to convey their immense significance for the survival of humanity as a species. In addition to this, the variety of forest trees and shrubs play a pivotal role in the daily life of rural communities in the developing countries, as sources of wood and non-wood products, as contributors to soil and water conservation, and as repositories of aesthetic, ethical, cultural and religious values. It has been estimated that globally around 800 million rural people depend on forest resources for their sustenance (Chhatre *et al.,* 2009). Due to these diverse claims i.e. environmental conservation and local livelihoods, managing these resources in a sustainable manner has always been a challenge. Until the late 1980s, forests in most developing countries have been managed largely through a centralized governance system. Under this approach, forests rights were held exclusively by the central governments and human use of the resource was either prohibited or severely limited

by means of acts and laws (Barrett *et al.,* 2001). However, given the dependence of a huge population on these forests for sustenance, these kind of exclusionary policies were found ineffective in conserving forests while simultaneously contributing to the marginalization of rural communities (Brandon *et al.,* 1998).

With over 90% geographical area under mountain category, Uttarakhand is predominantly a mountainous state. The recorded forest area of the state is 38000km^2, which constitutes 71.05% of its geographical area (ISFR 2019).Admintratively, forests of the state broadly classified into 3 different category i.e. Reserve forests, Civil andSoyam forests and Van Panchayat forests. The reserve forests are managed exclusively by the forest department and covers 26547km^2 area (49.63%) and villagers have limited rights on these forests. Villagers can enter into the reserves, or have access rights based on permission, but the withdrawal rights are limited to dry and fallen leave and wood. These forests have more commercial species under strict monitoring and enforcement of legal process. Despite a clear understanding of management rules, villagers, however, regularly violate them and withdraw fuel, fodder and timber from the reserves forests(Gururani 2000). In contrast, the Civil andSoyam forests are legally under the control of revenue department are open access and villagers have unlimited rights on these forests therefore these forests are in highly degraded state (Saxena 1987).

The VPs forest, are managed by village communities in participation with state forest and revenue department and covers 7326.8km^2 of the Uttarakhand geographical Region. Significant powers have been given to the villagers to regulate forest produce use and extraction in these forests. Although there have been a great wealth of information on different aspects of these Reserve, Civil and Soyam and Van Panchayat forests, the information on the relative contribution of these forests to local livelihoods and conservation is least investigated. Furthermore, the information on the impact of government policies on conservation and local livelihoods is also limited. The government policies and changes therein affecting these forest ecosystems in general and resource use and management strategies in particular need to be estimated. The present study is focused on the assessment of these issues, through the assessment of forest density status across both of the management regimes.

METHODOLOGY

The present study is based on primary data collected through rapid survey in 5 Van Panchayat and 4 Reserve forest which have been randomly across the Garhwal region of the Uttarakhand.All the five Van Panchayat villages and reserve forests are situated in Gairsain developmental Block of Chamoli District of Uttatakhand. A general description of the investigated VP village's forests and RF is given in Table 1 and Table 2. The selected villages, while vary considerably with respect to altitude, human and livestock population, represent the typical environmental setup of the Himalayan region.

Table1. Details of study sites comprising Van Panchayatin Gairsain,Chamoli District (Uttarakhand)

S. No	Character of study sites.	Site 1	Site 2	Site 3	Site 4	Site 5
1	Location	Pajyana	Marora	Farkandey Talli	Ghindiyal	Saregwar
2	Formation year	1981	1944	1947	1949	1946
3	Altitude(m)	1750	1820	1950	2170	1750
4	Latitude	N 29° 08'.10	N29°. 20.81	N29° 22.46'	N 29°30'	N 29°30'
5	Longitude	E79° 39.4'.6"	E79°. 26.46'	E79 °. 28.62'	E79°44'	E79°54'
6	Dominant species	*Pinus roxburghii*	*Pinus roxburghii*	*Quercus leucotrichophora*	*Quercus floribunda*	*Alnus nepalensis*

Table2. Details of study sites comprising reserve Forest in Gairsain, District Chamoli,(Uttrarkhand)

S.No	Character of study sites.	Site 1	Site 2	Site 3	Site 4
1	Location	Dudhatoli	Kundhon	Purey	Silakot
2	Altitude	3000	2800	2850	1820
3	Latitude	N29° 08'.10	N29°. 20.851	N29° 22.46'	N 29°30'
4	Longitude	E79°39. 4'.6"	E79°. 26.46'	E79 °.28.62'	E79°44'
5	Dominant species	*Quercus semecarpifolia*	*Quercus leucotrichophora*	*Quercus leucotrichophora*	*Alnus nepalensis*

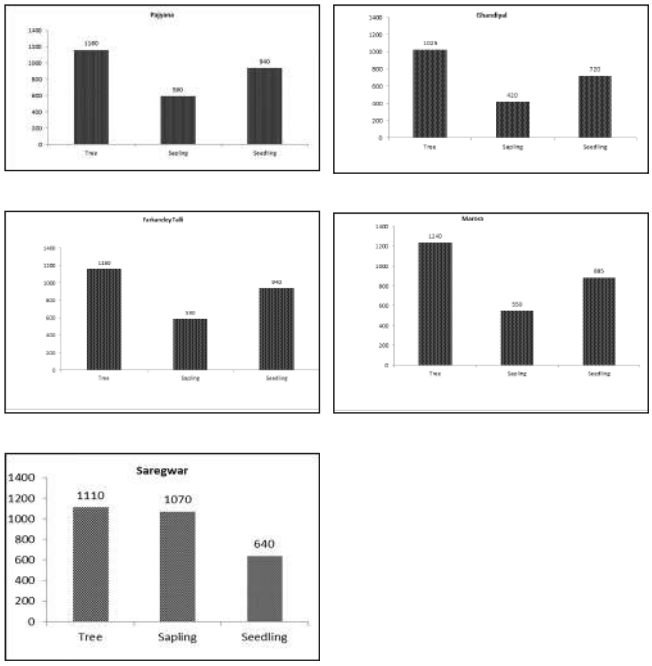

Fig.1. Regeneration pattern of different VPs forest stands (Density ind./ha)

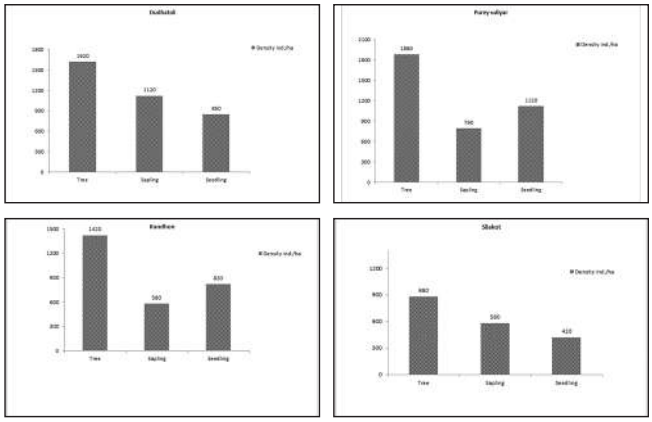

Fig. 2. Regeneration pattern of different Reserve forest stands (Density ind./ha)

MATERIALS AND METHODS

Vegetation analysis of all the selected VP forest and Reserve forest patches was done by non-destructive method (Quadrate method)following regression equations(Rawat 1988). To assess availability of species, vegetation parameter were calculated in 1 ha plots marked at interval of 100m using 10 x 10m quadrates(Mishra 1968; Ambasht 2004).Saplings (10.4 - 31.4cmCBH) and seedlings (<30cm height and 10.4cm CBH) at each forest site were recorded through plotting twenty (total 9 study site) randomly placed 10×10m and 5×5m sampling plots, respectively for trees and sampling. The field data were quantitatively analyzed for density, frequency and basal area and IVI (Important value index) following (Curtis *et al.,* 1950).

Reserve forest sites are dominated by *Quercus semecarpifolia, Q. floribunda* and VPs forest sitesare dominated by *Quercus leucotrichophora.*

Forest species composition and structure was studied for Total 5 VPs forest where the density ranged between 1015-1240ind./ha in table 3 , while in 4 Reserve Forest (Dudhatoli, Kundhon, Purey- Udiyar, Silakot) the density ranged between 880-1880ind./ha in table 4.Random distribution wasrecorded for most of the tree species in both of the forest stands. In VPs forest *Quercus leucotrichophora,Pinus roxburghii,Alnus nepalensis, Abies pindrow* were the dominant *species following Lyonia ovalifolia, Myrica esculenta, Quercus floribunda and Rhododendron arboreum* etc.as under story tree species. While in the Reserve forest *Quercus floribunda, Quercus leucotrichophora, Alnus nepalensis* where the dominance tree species following by *Rhododendron arboreum, Myrica esculenta,* etc as under story species.

RESULTS AND DISCUSSION

General structural characteristics of studied VP forests and Reserve forests are given in Table 3 and Table 4. In Banj-oak VP forests, tree density ranged from 1015-1240 ind.ha^{-1} (Table 3) and maximum tree density was found inMarora VP followed by Farkendey Talli and Saregwar VPs, whereas minimum tree density was recorded in Pajyana VP

Table 3. Forest structure of different VPs stands

Sites	No. of tree species	Dominant/ Co-Dominant Species	Density (ind/ha)	T.B.A (m^2/ha)
Ghandiyal	11	*Q. leucotrichophora* *Q. floribunda* Other spp.	205 165 655 (Total= 1025)	3.94 3.49 12.94 (20.08)
Farkandey Talli	7	*Pinus roxburghii* *Q. leucotrichophora* Other spp.	405 305 450 (Total= 1160)	8.01 7.76 9.39 (25.16)
Saregwar	10	*Q. leucotrichophora* *Alnus nepalensis* Other spp.	400 14 615 (Total= 1029)	10.42 4.03 6.39 (20.84)
Pajyana	11	*Q. leucotrichophora* *Pinus roxburghii* Other spp.	280 185 550 (Total= 1015)	9.34 4.8 13.838 (27.98)
Marora	11	*Q. leucotrichophora* *P. roxburghii* Other spp.	510 245 485 (Total= 1240)	18.43 9.2 15.12 (42.75)

Table 4. Forest structure of different Reserve forest stands

Sites	No. of tree species	Dominant/ Co- Dominant Species	Density (ind/ ha)	T.B.A (m^2/ ha)
Dudhatoli	18	*Abies pindrow* *Q. semecarpifolia* *Q. floribunda* Other spp.	245 180 170 1025 (Total= 1620)	21.65 12.06 5.08 19.48 (Total=58.2)
Kundhon	9	*Q. floribunda* *Q. leucotrichophora* *Myrica esculenta* Other spp.	395 180 155 690 (Total=1420)	15.05 9.25 5.75 12.35 (Total=42.4)
Purey Udiyar	13	*Q. floribunda* *Q. lecotrichophora* *Cedrus deodara* Other spp.	480 465 195 740 (Total=1880)	15.65 12.55 5.75 17.55 (Total=51.5)
Silakot	10	*Q. leucotrichophora* *Alnus nepalensis* Other spp.	195 145 540 (Total=880)	9.5 5.5 4.05 (Total=18.55)

followed by Ghandiyal VPs. Tree density in Chir-pine VP forests ranged from 245-405 ind.ha^{-1} (Table 3). Among the Chir-pine VP forests, maximum tree density was found in Farkendey Talli VP followed by Marora and Pajyana VPs, whereas minimum tree density was recorded in Ghandiyal VP followed by Saregwar VPs. The total tree basal area (TBA) of Banj-oak and Chir-pine (Table 3 and Table4) across VP forests ranged from 20.05-42.75m^2 ha^{-1} and in RF 18.55-58.2m^2 ha^{-1} respectively. Maximum tree density was recorded inPurey- Udiyar(RF) followed by Dudhatoli and Kundhon(RF), whereas, minimum tree density recorded in for Silakot (880ind.ha^{-1}) RF. Tree density in Chir-pine VP forests ranged from 185-405 individuals ha^{-1} (Table 3).

Van Panchayats (VPs) of the Uttarakhand state of India are known to be one of the oldest and best examples of decentralized forest governance in the world (Agrawal *et al*., 2001).Most of the VPs forests are situated near the villages and the local community can extract resources such as (fodder, fuel wood, litter etc.) for their livestock and daily needs easily from these forests

The local people follow the rules and regulations to manage their panchayat forest through VPs Niymawali with the help of local management committee (1 Sarpanch, 8 Panch), and with the help of subordinate employees of the Forest and Revenue departments which have substantial control over local management. VP committees also manage the VP fund and land use under VP forest, along with the interaction with government officials to secure benefits for their forests.

The forest health is dependent upon the regeneration capacity and richness of native tree species and their subsequent management. The forest health shows the management status of the forest and the dependency of nearby community for resources.In this study, an effort was made to study forest vegetative status and its comparison between the forest management scenarios. The study shows thatthe RF (Dudhatoli, Purey Udiyar and Kundhon) are in very good condition because all the three RF are located in reasonable distance (15-20km) from the villages, so the local communities are not highly dependent on these forests for their routine resource extraction. In comparison to the RFs the resource dependency of villagers is higher on VP forests and it isexpected that the removal pressure of resources on VPs was more than that of theproduction capability (Table 3 and Table 4). These results shows that the stability, health status of forests and the sustainability of their management can only be achieved if management responsibilities are clearly identified and the community is capable to manage their forest resources through participatory approach.

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LIVELIHOOD IMPROVEMENT THROUGH INDUSTRIAL HEMP (*CANNABIS SATIVA* L.): A MULTIPURPOSE PLANT OF UTTARAKHAND

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ABSTRACT

Industrial hemp (*Cannabis sativa* L., family: Cannabaceae) is a multi purpose crop valued for its fiber, food, and medicinal uses. Due to the similarities between fibre type and drug type of *Cannabis*, the production of industrial hemp was prohibited in most countries. The northen part of India are legalized for the hemp cultivation for promoting the fibre production that subsequently, strengthen the livelihood option in rural areas. The high protein content of hemp seed can be used as value added fuctional food, supplements and neturaceuticals. More then 500 natural compounds along with 100 phytocannabinoids have been reported from the Cannabis exract. These compounds have been reported for various biological activites including antimicrobial, antiviral, antioxidant, anti-inflammatory, antitumour, etc. The phytocannabinoids like Cannabidiol (CBD) and cannabigerol (CBG) is emerging as an adjunctive treatment in COVID-19. Many research and clinical trials are ongoing on the phytocannabinoids potential in particular to physiological, metabolic and immunomodulatory effect countered by SARC-CoV-2. With this multipupose importance, hemp needs improvement in good quality traits for both the purposes as a fiber and medication. Implication of environment- friendly molecular techniques like CRISPR/Cas system might be beneficial for mass production of desirable hemp chemical like CBD and CBG with the elimination of psychoactive compound like tetrahydrocannabinol (THC).

Keywords: Industrial hamp, Livelihood, Phytocannabinoids, Biological activites and COVID-19.

INTRODUCTION

Cannabis sativa L. is an annual, diploid (2n=20), dioecious (male and female flower on different plant) herb belongs to family cannabaceae. It is widely distributed all over the world and commonly known as marijuana in English and bhang in Hindi (Pellati *et al*., 2018). The taxonomic classification of Cannabis plant is quite difficult due to its genetic variability and chemical constituents. It was believed that cannabis is originated from Central Asia about 500 BC (McPartland *et al*., 2000). The species is considered as most controversial plant in the human history due to its drug abuse. However, industrial hemp is a multi purpose crop for local farmers because all parts can be utilized in one or another way. More than 30,000 hemp products are manufactured globally (Singh 2018). The species is used as anaesthetic medicine to treat many diseases. Hemp cultivated easily on barren land that enrich poor soil and can flourish in limited resources like water. Due to good growth in both temperate and tropical climate, hemp is being traditionaly used in making variety of items like rope, paper, clothing, sails, food etc. Commercilly hemp is being used as a fiber in textile industry, paper industry and alternative to plastic (Singh 2018). Hemp posseses many bioactive compounds like cannabidiol (CBD) and cannabigerol (CBG) which have tremendous potential as antibacterial, antifungal, antioxidant, anti-inflammatory, and antiviral activities. The species is also a topic of concern for the recent Covid-19 pendamic. Two major compound like cannabidiol (CBD) and cannabigerol (CBG) extracted fom *C. sativa* have potential to regulate, the severaity of the SARS-CoV2 (Deguchi *et a*l., 2020). In consideration of the importance in traditional as well as industrial application, this species should be promoted for cultivation in the local regions. The cultivation may be helpful in large scale production of desirable hemp phytochemicals like cannabidiol (CBD) and cannabigerol (CBG) compounds further useful for mankind for various purposes. The large sacle cultivation of hemp in legalized regions can be a good livelihood option with simultaneous benefits in the economy of the country.

Psychoactive potential in *C. sativa*

The resin of *C. sativa* contains 150 different terpenes and approximately 100 different cannabinoids (Booth *et al*., 2019). The female plant of *Cannabis* is preferred for the production of cannabinoid and secondary metabolites. Tetra hydrocannabinol (THC) is the main psychoactive constituent present in *Cannabis* which was discovered by Gaoni *et al*. (1971). THC content in different parts of *C. sativa* is presented in Table 1.

Table 1. The psychoactive content (THC) in a different part of *C. sativa*

Plant parts	THC content (%)
Inflorescence	10–12
Leaves	1–2
Stems	0.1–0.3
Roots	0.03

Legalization of *Cannabis* in India

In India, the government took initiation for the industrial production of hemp in July 2018, and issued a licence for commercial cultivation of hemp in northern part of India. Uttarakhand is the first state that reframed the industrial hemp policies and issued licence for the cultivation of hemp for high-quality fibre. The cultivation of non narcotic hemp for creating seed bank has been initiated in some villages of Pauri Garwal region (http://indianhemp.co.in). Hemp cultivation may be a source of livelihood for local people. It is estimated that the hemp industry in Uttarakhand will sphere around 240 crore rupee while farmers who cultivate hemp will earn around 1 lakh rupee annually for the sale of hemp (Singh 2018).

TRADITIONAL APPLICATION OF HEMP

Cannabis as a source of livelihood

For the state like Uttarakhand, hemp is a valuable crop where the land topology and the severe water scarcity come in the way of growing crops, and the destruction of plant by wild

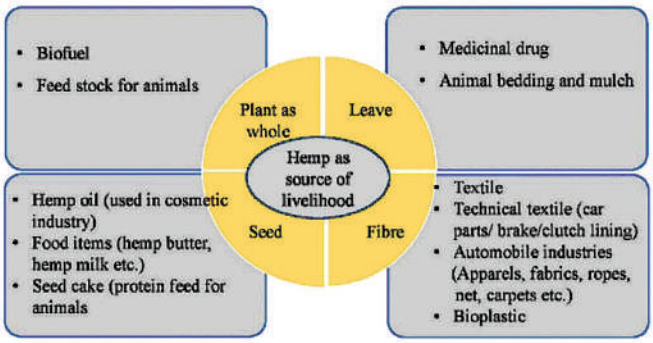

Fig. 1. Various livelihood options of industrial hemp

animal is unrestrained. Hemp can be grown in barren land and do not requires much water to flourish and even can be grown as mixed crops. Fibers in textile industry, seeds and flowers can used for medicinal and food-processing industry may lead to source of livelihood. Cannabis cultivation is an important land use for rural people and they can improve their income. Various ways as livelihood source of industial hemp are presented in (Fig. 1).

Table 2. Nutrient contents present in hemp seeds (Callaway 2004)

Nutrient Content	Whole Seed (%)	Seed Meal Oil (%)
Oil	35.5	11.1
Protein	24.8	33.5
Carbohydrates	27.6	42.6
Moisture	6.5	5.6
Energy (KJ/100g)	2200	1700
Total dietary fibre	27.6	42.6
Digestable fiber	5.4	16.4
Non digestable fiber	22.2	26.2

Hemp as food source

Hemp seed has the highest amount of protein in the entire plant kingdom. It is also rich source of healthy fat particularly alpha-linoleic acid (Abedi *et al.*, 2014). The hemp seed also contains phytosterols that help in reducing the cholesterol and fat build-up in artreis. Due to high nutitional content (Table 2) various hemp products alike hemp seed butter, hemp seed oil, hemp milk, and hemp flour are used. Hemp seed flour can be used to produce baked goods such as pasta, cookies, and breads (Karche 2019).

Hemp used for construction

The hemp fibre is non-toxic, fire resistant, good insulator, water proof and regulate moisture content. For the first time the Hemp Crete technology (mixing of hemp hurd in clay or lime plaster for construction) was introduced by ancient Indian technician. This technology played an role in the preservation of the precious artwork in the ancient cave of Ellora and in the plaster work of massive Daulatabad Fort (Joshi 2020).

Commercial application of Hemp

In India, hemp is an integral part of society and played in many ceremonial activites. Rediscovering the hemp can foster many industries and lead to strengthen the green economy of the country.

Paper Industry

Hemp is the cheapest and efficient source of paper production. One acre land of hemp is eqivalent to four acres of trees in term of paper production. There are various reseaons for using hemp in paper industries including high cellulose content, less maturation time as compatred to tree, high durability, less yellowing and craking of paper with age, and easy to harvest (https://canex.co.uk). The paper made up of hemp can recycle 8 times than paper made from wood that recycle only 3 times. Therefore, hemp cultivation could be a potential alternative for saving trees.

Hemp fibre in textile industry

In Uttarakhand, hemp fibers were called Bhangela. Bhangeli cloth form fibre was manufactured by Koli craftsmen. This fabric was cheaper than other fabrics, strong and durable. The demand for material made from hemp fiber was available in the market of Ramnagar and local fairs (Bageshwar and Jauljeevi) of Uttarakhand. Hemp industry plays an important role to increase the village economy by manufacturing goods such as canvas. Canvas manufactured from hemp is also used in armed foreces due to its ability to protect against ultraviolet radiation, heat, mildew and also repels insects. Advance technologies are required for the manufactureing of ideal fibre (Joshi 2020). The research organizations should develop R&D programme in particular to refining processes.

Hemp as a alternative to plastic

The plastic waste is the major subject of concern globally. Centarl Pollution Control Board estimated the daily production of plastic around 26,000 tonnes in India. The bioplastic made up of industrial hemp is 100% recyclable and biodegradable. Cellulase is the major component of hemp bioplastic that is converted to cellophane, rayon, and celluloids. The high strength and rigidity of hemp based plastic are used in automobile textile for the manufacturing of spare parts of cars, boats, and musical instruments (Singh 2018).

Hemp as source of pharmaceutical bioactive compound

Till date, total of 540 natural compounds are reported but only 100 have been identified as pytocannabinoids. *Cannabis* is divided into two phenotypes that are fibre type and drug type *cannabis*. The fibre type, also known as hemp and used for textile and oil purposes which is low in THC (generally <0.2%) and high cannabidiol (CBD) content. On the other hand, the drug type *cannabis*, known as marijuana and used to produce hashish, has high THC content. Two drugs are obtained from *Cannabis* i.e. hashish and marijuana. Hashish produced from the flowering top (inflorescence) of the plant and marijuana produced by dried unfertilized inflorescences, dried leaves and flowers of female *Cannabis* plant. The biogenetic origin of cannabinoid occurs from phenol, terpene, and geranyl pyrophosphate (Fattore 2015). Cannabinoids such as cannabidiol (CBD), tetra hydocannabinol (THC), cannabigerol (CBG), cannabicyclol (CBC), and cannabinol (CBN) (Appendino *et al*., 2008), terpenoids, flavonoids, alkaloids and lignins are the major identified secondary metabolites from *C. sativa* (Flores *et al*., 2009). Various biological activities are reported from the phytocannabinoid and non-cannabinoid compounds (terpenes, flavonoids, alkaloids, and lignans) like anti-inflammatory potential, antimicrobial (Asati *et al*., 2017), anticancer (Appendino *et al*., 2011), and antioxidant (Esposito *et al*., 2020). The phytocannabinoid compound are also effective in treatment of Epilepsy, Alzheimer's disease, Multiple sclerosis disease (Amin *et al*., 2019).

***Cannabis* and COVID-19**

(Esposito *et al*., 2020) hypothesized that CBD might be a potential bioactive compound to control the severity and progression of new coronavirus disease 2019 (COVID-19). The important role of CBD as in various processes are presented in Fig. 2. It has a potential to play crucial role in down regulating of two key recepotrs for the expression of SARS-CoV2 in human epithelia. The immunomodulatory and anti-inflammatroy effects of CBD can mititgate the uncontrolled cytokinin production during acute lung injury. CBD have antiviral potential that act as an agonists of peroxisome proliferator-activated receptor gamma (PPAR) and can regulate the fibroblast/mycofibroblast activation and inhibit development of pulmonary fibrosis.

(Wang *et al*., (2020) worked on the above proposed hypothesis and identified 13 CBD that decrease ACE2 protein level and downregulate the serine protease TMPRSS2, required

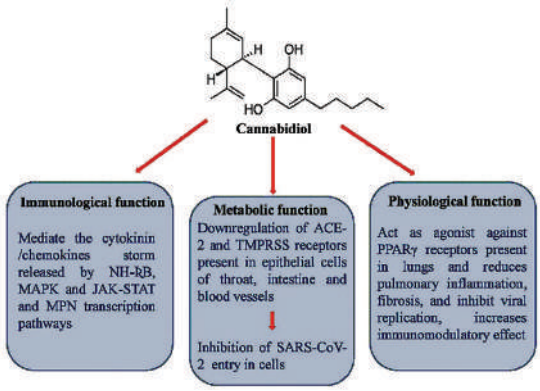

Fig. 2. Potential of cannabidiol in controling the severerity and progression of SARS-CoV2

for SARS-CoV-2 entry into the host cells. There are various cannabinoid receptors (CB1R, CB2R etc.) present in human endocannabinoid system (ECS) that mediated metabolic, immunological, and physiological fuctions in human (Wang *et al*., 2020). The inflammatory cytokine storm activated by SARS-CoV2 infection leading to the cytopathogenic effects cuases the mortality of critical COVID-19 patient. Many authors suggested that the activation of ECS by endocannabinoids and phytocannabinoids may modulate the inflammatory cytokine storm relased by SARS- CoV2 infection. (Deguchi *et al*., 2020) suggetsed some advance environment-friendly techniques including the CRISPR/Cas systems must be implicated to increase the production of desirable hemp phytochemicals like cannabidiol (CBD) and cannabigerol (CBG). These advance techniques may also helpful in elimination of the psychoactive compounds such as THC.

CONCLUSION AND FUTURE PROSPECTIVE

The legalization of hemp cultivation in northern part of India has made an opportunity to the scientific community to acquire the benefits of hemp in various ways. The species is still unexplored for scientific research community. The multipurpose value makes the species self efficient to create green economy. The hemp cultivation in rural areas can generate the livelihood options in rural areas and can, thus, be a mitigation option against the migration towards the urban areas. Advanced technologies are required for refining and manufacturing of ideal fibre. Good quality of hemp species should be devloped for the large scale production of phytochemical like CBD, that may contribute to the prevention/ treatment of COVID-19 diseases.

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TEJ PAAT CHAI: A TRADITIONAL FOLK DRINK OF TRIBAL COMMUNITY OF CENTRAL HIMALAYA

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ABSTRACT

Tej paat chai is a medicated folk drink prepared from the dry leaves of *Cinnamomum tamala* Nees. This article describes the method of preparation of this medicinal folk drink and its applications along with an objective to conserve the practices of traditional knowledge of plant and plant's products. Semi-structured questionnaire and direct interview methods were used to collect the information. This folk drink is frequently used by the tribal community 'Gujjar' of Uttarakhand state which is highly effective in the treatment and control of high blood pressure, heart diseases, blood sugar, anxiety, cold and coughs. It is highly effective in cardiac disorders and control hypertension. This folk drink is cheap but effective, wild but curative and highly effective to control the various diseases. This remedy is simply called 'medicine from the kitchen'. This article will give broad prospects for utilization of plant and plant's products in the field of drug development and pharmaceutical industries.

Keywords: *Cinnamomum tamala*, Folk Drink, Diseases, Tribes and Heart disease.

INTRODUCTION

Tej paat chai is a folk drink of Gujjar community, which is full of health in a single cup of tea. Tej paat chai (bay leaves tea) is prepared from the dried leaves of *Cinnamomum tamala* Nees. *C. tamala*, belongs to family Lauraceae, is also known as Indian Cassia and the leaves usually called as bay leaves. The genus is native to South-east Asia, some Pacific Islands and Australia, represented by nearly 350 species in worldwide (Chakraborty *et al*., 2010). Plant flourish (cultivated/wild) mainly in tropical rain forests at diverse altitudes (900-2500m). In India, it found in Sub-Himalayan tracts to West Bengal, from Central to South India (Dhar *et al*., 2010; Sharma *et al*., 2011). The plant is up to 3-9m tall evergreen tree, bark is dark brown or blackish, rough in texture. Leaves are opposite, sub-opposite, alternate, ovate lanceolate or oblong, entire, new leaves slightly pinkish in colour. Flowers are pale yellowish, axillary, terminal and puberculous panicles. The plant has been used in traditional medicines from the very beginning as an astringent, stimulant, diuretic, carminative properties and effective in the treatment of cardiac disorders, diarrhea, dryness of mouth, bladder disorders, nausea, vomiting and rheumatism. The plant is frequently mentioned in Indian Ayurvedic literature for its various medicinal ethics. Ancient literature has revealed that in the first century A.D., dried leaves and bark were prescribed for fever and anemia. Crushed seeds along with honey administered orally to cure dysentery and cough in children. Recently some researchers explore and proved clinically its hypoglycemic activity, acaricidal, hepatoprotective, anti-inflammatory, anti-hyperlipidemic, antidiabetic, antioxidant, anti-bacterial and anti microbialactivity (Dhulasavant *et al*., 2011; Murugesh *et al*., 2006; Parekh *et al*., 2007). Leaves are the most utilized part of the plant. Other than the medicinal value, the Gujjar community utilizes it in a various way in their daily life such as a spice or flavoring agent, control bad mouth /body odor and as a natural insect repellent due to its strong aroma.

In the same sequence, a report on the preparation of a folk drink prepared from the leaves of *C. tamala* by Gujjar community and its traditional medicinal values were documented with an aim to documentation of preparation of folk medicine by the tribal community (Gujjar) settled in this region. The tradition method of preparation of folk drink (Tej paat chai) and its uses as followed by local people has been described in this article.

MATERIALS AND METHODS

Semi-structured questionnaire methods, personal observation and direct interview methods with the Gujjar community were used to collect the information about the preparation of folk drink and its applications during 2017-2018 while conducting the ethnobotanical survey in Bhabhar belt (Foothill of the Himalayas, where the Himalayan streams descend on to the plains) of Kumaun Himalaya (Padalia *et al*., 2015). The voucher specimen of plant has been deposited in the Herbarium of D.S.B. Campus, Nainital (Uttarakhand). For the preparation of folk drink, dried leaves of *C. tamala* are collected from the well grown mature tree. The collected leaves must be free from the diseases and insects attack, were cleaned and washed thoroughly in tap water to remove

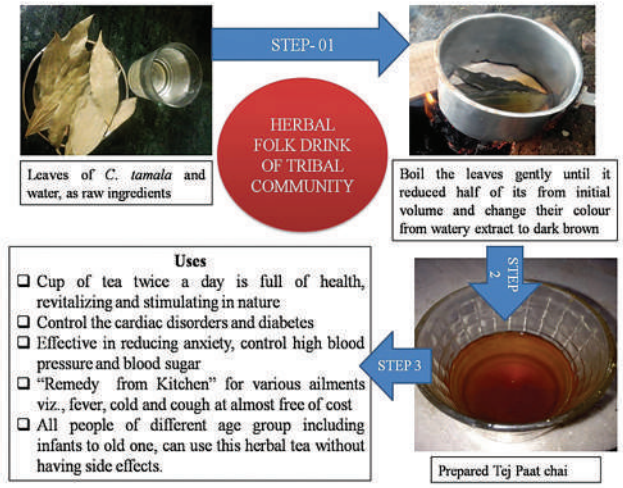

Fig. 2. The step by step method of preparing folk drink along with its curative properties.

dust, soil particles and other surface microbes. The collected leaves (4-6 matured leave) were boiled with water (2 cup) in analuminum utensil under low temperature. While boiling care should be taken to boil the leaves extract over low temperature with continuous stirring to avoid the burning of leaves. The drink would be prepared and ready to consume when it became half of its initial volume and change their colour from watery extract to dark brown (Fig. 1).

Then, the extract is filtered to remove the leaves debris and other impurities. Now, the decoction is ready to consume. It is recommended that it cannot be stored and prepared freshly in every time and prescribes twice a day at morning (empty stomach) and evening for better results. Although pure leaves extract of *C. tamala* is preferred by almost all the Gujjars but some of them add 2-3 seeds of cardamom in it for pleasant fragrance and a pinch of black pepper for better taste.

RESULTS AND DISCUSSION

Although the Tej paat chai is pungent in taste but a couple of cup of tea in a day is full of health, revitalizing and stimulant in nature. The Gujjar community prescribes it particularly to control the cardiac disorders and diabetes in old aged person as well as for adults also. It is very effective in reducing anxiousness, control high blood pressure and blood sugar. It is one of the very effective household remedy for the various ailments viz., fever, cold and cough at almost free of cost with high efficiency and having no side effects. An interesting fact is also emerged from the present study that all the persons from different age groups including infants to old one can use this herbal tea without having side effects. The old age persons use it to control high blood sugar, hypertension and heart diseases, adults ones use it as a replacement of ordinary tea, which gives instant freshness, strengthen nervous system and control anxiousness. Gently warm decoction (1-2 tablespoon) prevents the infants/children from fever and common cold. The gargle of the tea is beneficial in the ailments of the throat and control bad mouth odor. Even the Tej paat chai can be consumed by a healthy person in place of regular tea.

CONCLUSION

This remedy is simply called 'medicine from the kitchen'. Plant and plant's products can give broad prospects in the field of drug development and pharmaceutical industries. Traditional healers have strong faith in ethnomedicines although they were less aware about the documentation and preservation of their ethno-medicinal legends and medicinal plants (Padalia 2015). Although the plant *C. tamala* is not facing any threats or chance of extinction at the study area but the traditional uses of the plants and plant products are really facing the threats of extinction in study area as well as worldwide in near future. This study is therefore an attempt to conserve the traditional practice of ethnobotanical knowledge in this era of modernization. Other than this the governments, policy makers and various agencies should come up with the policies to conserve this precious heritage of knowledge belongs to the plant and plant products, globally.

ACKNOWLEDGMENTS

The author is thankful to the Gujjar community for sharing their traditional knowledge.

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LEAF AND SHOOT GROWTH CHARACTERISTICS OF MAJOR TREELINE SPECIES OF WESTERN HIMALAYA

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ABSTRACT

Leaf and shoot growth characteristics were studied in five treeline species (viz., *A. spectabilis, B. utilis, Q. semecarpifolia, R. arboreum* and *R. campanulatum*) of Tungnath (Uttarakhand), West Himalaya (altitude, 2955–3334m asl). At the time of leaf maturity leaf area ranged from 0.29 (*A. spectabilis*; a conifer) to 55.4 (cm^2 $leaf^{-1}$) (*R. campanulatum*). In all these species shoot extension growth continued for 4-5 months during May-September. The peak shoot length attained by these species was lowest in *R. campanulatum* (mean= 4.6 cm), and highest for *B. utilis* (mean= 14.0 cm). Diameter growth of mature shoot was recorded lowest for B. utilis (2.9 mm) and highest for *A. spectabilis* (6.8 mm). It is expected that with the increasing rate of warming in Tungnath the phenological behaviour of treeline species would change markedly in future leading to changes in ecosystem structure and functioning. In this site, considering the wet and warm months (July–September) as active growing season when the foliage is fully developed, the mean air temperature in 2017 (i.e., 11.2 °C) was much higher than seasonal mean ground temperature of 6.7 °C (± 0.8SD). Thus, it may be pointed out that growing season length at Tungnath is much longer than the climatic treelines, which may have several eco-physiological implications on the treeline vegetation and warrants further studies.

Keywords: Treeline species, Shoot growth, Leaf area, Climate Change and Garhwal Himalaya

INTRODUCTION

Demographic studies of leaf populations is important to understand leaf emergence patterns, life spans, and survivorship of leaves of woody plants that may have ecological and phylogenetic significance. To explain patterns of leaf longevity in different forests and groups of species, a number of climatic, ecological, eco-physiological, bio-geographical and evolutionary hypotheses have been proposed (Chabot *et al*., 1982). Differences in leaf longevity have been evaluated in terms of nutrient use-efficiency, carbon balance and the ratio of cost to carbon gain, successional stage of the plant, micro-environmental conditions in which leaves grow, as well as the emergence time and types of survivorship curves of different leaf cohorts (e.g., Chapin 1980; Chabot *et al*., 1982; Kikuzawa 1995). Several studies have reported that leaf life-span and specific leaf area (SLA) are related to net photosynthetic capacity, and leaf nitrogen concentration (e.g., Kitajima *et al*., 1997; Diemer 1998). Forests containing mixture of deciduous and broadleaved evergreen tree species are of particular interest to understand the interrelations between leaf longevities and SLA, leaf area, leaf nutrient concentration and other leaf traits.

Leaf characteristics such as leaf area and leaf mass are two important leaf traits of the vast majority of vascular plants (Pan *et al*., 2013). For evergreen tree species of the lower altitudes of Central Himalaya, loss of leaf mass begins in autumn and often continues until summer, when new leaves are formed. The decrease in leaf dry mass during this period was reported 12.3-34.1% of the maximum leaf mass (Ralhan *et al*., 1987). (Negi *et al*., 1992) investigated leaf growth patterns in 11 evergreen (with leaf life-spans of just more than 1 year) and 15 deciduous species, occurring along an elevational gradient of 600–2200m elevation in the Central Himalaya. Species of both the groups had approximately fully developed foliage during the warm and wet monsoon period (mid-June to mid-September) of the monsoon. However, significant differences were found at group level in other characters: shoot length (19.5 cm shoot-1 for deciduous and 11.7 cm shoot-1 for evergreen species); leaf population per 10 cm shoot length (4.7 vs. 15.0); leaf area (107.9 vs. 41.4cm^2 $leaf^{-1}$); specific leaf mass (106.9 vs. 191.3g m^{-2}); and leaf mass loss after the monsoon period, being rapid and higher (31.6%) in deciduous species and slow and limited in the evergreens (26.2%). (Athokpam *et al*., 2014) reported that average leaf dry mass loss before leaf shedding was greater ($P<0.01$) for deciduous species (30.3%) than for evergreen species (18.3%) in the forests of Southern Assam. The evergreens seem to outcompete deciduous species by producing annually a greater mass of leaves of low-carbon cost (per unit leaf mass), which is capable of conducting photosynthesis year-round.

Most of the studies have found that deciduous woody species show higher potential growth rates, higher SLA

and specific leaf mass (SLM) and higher photosynthetic rates than evergreen species (Reich *et al*., 1992; Reich *et al*., 1997). (Antunez *et al*., 2001) recorded a wide range of relative growth rates (RLGR) from 8 - 81.7 mg g^{-1} day^{-1} for 16 woody species. Similar results were reported in many woody species (Reich *et al*., 1992; Huante *et al*., 1995; Lusk *et al*., 1996). In trees of Kumaun Himalayan forests the RLGR of leaves following bud break was markedly higher (Dhaila *et al*., 1995), and a positive relationship existed between SLM at initial growth stage and leaf longevity (Dhaila 1991). (Reich *et al*., 1992) considered SLA and SLM as a useful index of construction cost of leaves on area basis (SLM is positively related and SLA is inversely related to construction cost of leaf). Several authors (e.g., Reich *et al*., 1997; Antunez *et al*., 2001) reported that SLA is associated with a number of morphological, physiological and biochemical traits. (Dhaila *et al*., 1995) studies on the dominant evergreen and deciduous trees of Kumaun Himalaya co-existing at the same site in the study area revealed that growth initiation occurred earlier in evergreens, while deciduous species completed their growth earlier. Mature leaf area, shoot growth rate and shoot length and diameter was significantly greater ($P<0.01$) for deciduous trees than evergreen trees. Leaf packing (number of leaves per shoot) was significantly more dense in evergreen trees ($P<0.01$) than in deciduous tree species. Hitherto there is a little understanding about the leaf and shoot growth characteristics of forest forming tree line species of Central Himalayan region. This study was undertaken to determine differences in leaf and shoot growth phenology between high altitude and low altitude forest forming tree species as an adaptive phenomenon to climate change.

Fig. 1. Landscape of Chopta-Tungnath tree line ecotone

Table. 1. Study species in Chopta-Tungnath treeline ecotone. All occurred on North-West aspect, except *B. utilis*, which occupied N-E aspect.

Species	Altitudinal range (m asl)	Physiognomy
A. spectabilis	2990–3276	Himalayan Fir; Evergreen with multi-year leaves leaf life-span between 4 and 5 years
B. utilis	3250–3330	Himalayan Birch; Winter deciduous leaf life-span between 7 and 8 months
Q. semecarpifolia	2955–3105	Brown Oak; Evergreen with 1 year leaf life-span
R. arboreum	2965–3233	Tree *Rhododendron*; Evergreen with leaf life-span between 1 and 2 years
R. campanulatum	3250–3334	Simru; Evergreen shrub (krummholz) with leaf life-span between 1 and 2 years

STUDY AREA

The study was carried out at Chopta-Tungnath (Lat. 30.49', Long. 79.21', Alt. 2955–3334m asl), located in Uttarakhand Himalaya (Fig. 1) Table 1.

In the study area forests of *Abies spectabilis* and *Betula utilis* occur on north facing slopes and *Quercus semecarpifolia* and *Rhododendron arboreum* on south facing slopes, with tree associates viz., *Acer caesium, Prunus cornuta, R. barbatum, Sorbus foliolosa* and *Taxus wallichiana*. The *R. campanulatum* krummholz formation is common at the site; its seedlings/saplings grow up to 3,666m asl (Tungnath peak). None of the other tree species had recruited seedlings/saplings beyond the treeline at 3280m asl. at this site except for R. campanulatum (Rai *et al*., 2012 ; Singh *et al*., 2018). This study was carried out for a period of 5 years during 2016-2020, and all the values of leaf and shoot growth characteristics are average of five years duration.

METHODS

Mature stands of four tree line ecotone tree species viz., *A. spectabilis* (Himalayan fir; evergreen conifer with multi-year leaf life-span), *B. utilis* (Himalayan birch; winter deciduous), *Q. semecarpifolia* (brown oak; semi-evergreen), *R. arboreum* (tree *Rhododendron*, evergreen) and *R. campanulatum* (evergreen krummholz species) distributed between 2,955 and 3,334 masl (the upper limit of distribution of these species) were selected for the study (T. Shoot extension and radial growth were measured at monthly interval on 25 marked current year shoots for each of the tree species. Leaf characters (leaf area and leaf mass) were based on 100 randomly plucked current year leaves from the marked forest stands at monthly interval. Leaf area was recorded using a portable leaf area meter (Biovis Leaf Av). Leaves thus collected represented even aged leaf population from the crowns of mature tree stands. Full expansion of leaf population was considered when the leaves had attained ~90% of its peak leaf area of mature stage. To determine leaf mass, the 100 leaves collected for the leaf area measurement were used. Leaves were brought to the laboratory immediately after collection, divided into four sets, each of 25 leaves, and oven dried at 70°C till 10 were averaged to determine mean dry

weight of a leaf. Specific leaf area (SLA) and specific leaf mass (SLM) of the leaves was calculated by following expressions (Evans 1972). Leaf population per current year and old shoot (differentiated by a node), were counted at monthly interval in the 25 marked shoots to determine the leaf population dynamics.

RESULTS

Leaf population

Leaves are born gradually on the shoots during the onset of growth season (March-April) but the leaf recruitment rate rises rapidly during May-June. In these species at the time of peak shoot extension growth mean leaf population (no/shoot) was recorded in the order: *R. campanulatum* (4.7) <B. utilis (5.4) < *Q. semecarpifolia* (5.5) < *R. arboreum* (9.9), except for *A. spectabilis* (145 leaves/shoot; a conifer) (Table 2).

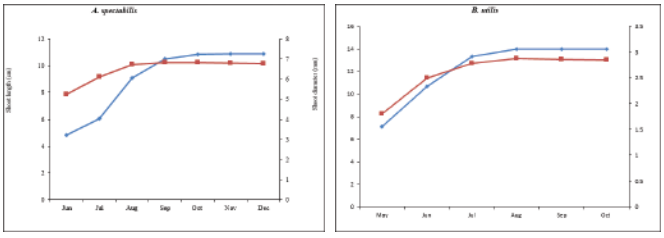
In *R. campanulatum* leaf recruitment in current year shoots continues from June–August, and mean value of peak leaf number per shoot was recorded 4.7. Peak leaf population remains stable from August–March (7 months), and leaf drop starts from next year August, and by November all the old leaf population is dropped. In case of *A. spectabilis* the shoot bears leaves of over three years of age, and the annual growth of shoot is divisible by a node and an internode. Leaves are produced only in the current year terminal shoots. In this species leaf flushing is a brief activity (~3 months), and the peak leaf number in current year shoots was recorded in August (145/shoot). Peak leaf crop in current year shoots remains stable for approximately 13 months. Leaf drop begins in year II in October and continues slowly, but concentrated leaf drop takes place in III rd year December onward, and by the IV year December the leaf population of Ist year is almost dropped. In *B. utilis* peak leaf number across the four years varied from 5.4-5.7 per shoot. Leaf population remains stable only for two months between July and August, and rapidly declines in September, and by October all the trees become leaf less. In *Q. semecarpifolia* peak leaf number per shoot (mean= 5.5) was attained in July-August, and the leaf population remains stable until November (> 4 months), and by the end of next year March-end and early-April, trees become leaf less. In this species the new leaves appear in April- end or early-May, thus the trees remain leafless for 2-3 weeks. In *R. arboreum*, peak leaf population (mean= 9.9/shoot) was attained in July-end to early-August, and the leaf population remain more or less stable for 9 months until next year July, and gradually leaf drop takes place from September, and by next year March all the old leaves are dropped. In *R. campanulatum* leaf recruitment in current year shoots continues from June –August and mean value of peak leaf number per shoot was recorded 4.7. Peak leaf population remains stable from August –March (7 months), and leaf drop starts from next year August and by November all the old leaf population is dropped.

Table 2. Leaf area, Leaf population and shoot growth characteristics in the treeline species at Tungnath.

Species	Leaf and shoot growth parameters						
	Mature leaf area (cm^2 $leaf^{-1}$)	Mature leaf mass (g $leaf^{-1}$)	SLA (cm^2 g^{-1})	SLM (g cm^{-2})	Mature shoot length (cm)	Mature shoot diameter (mm)	Leaf number/ shoot at maturity
A. spectabilis	0.283±0.005	0.008±0.003	35.38	0.0283	10.86±1.65	6.8±0.5	144.61±7.17
B. utilis	23.11±3.65	0.295±0.01	78.34	0.0128	13.97±2.67	2.9±0.19	5.47±1.91
Q. semecarpifolia	24.66±4.41	0.373±0.01	66.11	0.0151	5.78±1.58	3.5±0.3	5.50±1.66
R. arboreum	40.50±5.89	0.803±0.033	50.44	0.0198	5.63±0.65	6.6±0.26	9.91±2.15
R. campanulatum	55.37±9.33	1.051±0.03	52.68	0.0190	4.63±0.67	5.9±0.35	4.68±1.18

Leaf area & leaf mass

Immediately after bud-break and leaf unfolding leaf expansion takes place rapidly in the initial months of leaf formation and attains peak in July (*B. utilis*), and in August-September in rest of the species. Peak leaf area (cm^2 $leaf^{-1}$) computed for these species ranged from 0.29 cm^2 (*A. spectabilis*; a conifer) to 55.4 cm^2 (*R. campanulatum*). Time taken to attain peak leaf area for these species was three to four months (except for two months in *B. utilis*). Corresponding to leaf area, gain in leaf mass was rapid in the initial months of leaf formation. The time when peak leaf mass was attained ranged from July in *B. utilis* and October in *R. arboreum* and *R. campanulatum*. The time when full leaf mass was attained ranged from July in *B. utilis* and October in *R. arboreum* and *R. campanulatum*. At the mature leaf stage the leaf dry weight (g $leaf^{-1}$) was measured lowest for *A. spectabilis* (0.008) and highest for *R. campanulatum* (1.05). Leaf mass remains stable for varying



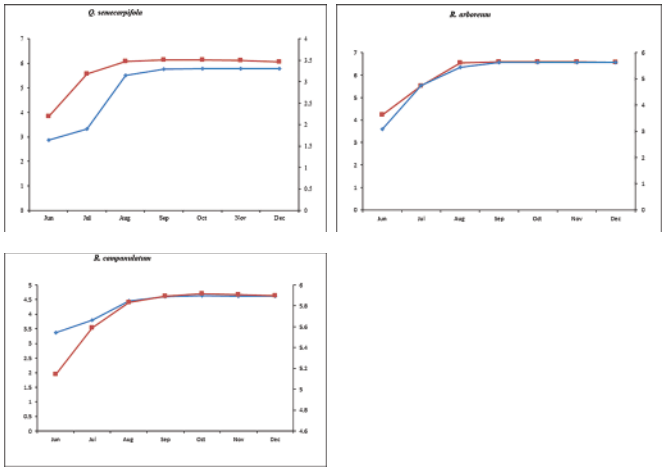


Fig. 2. Shoot length (cm) & shoot diameter (mm) of treeline species at Tungnath forest site.

duration in these species; *B. utilis* (1 month) and A. spectabilis (8-9months). Specific leaf area at mature leaf stage across all the species was computed maximum for *B. utilis* (78.4 cm^2 g^{-1}) and minimum for *A. spectabilis* (35.4 cm^2 g^{-1}).

Shoot length & diameter growth

A majority of the species followed a unimodal pattern of shoot growth, i.e., peak extension being in summer (April end- early August) (Fig. 2).

In these species about two-third of the total shoot elongation was accomplished within one month of bud-break. The minimum shoot elongation within one month of bud-break was accomplished by *A. spectabilis* (43%) and the maximum by B. utilis (68%). Most of the treeline species accomplished over 90% shoot elongation during rainy season (in August). Exceptionally in *B. utilis* shoot elongation was completed in June. Shoot elongation required a minimum of 8 weeks in *R. arboreum*, and *R. campanulatum* and a maximum of 12 weeks in *A. spectabilis*. The amount of shoot elongation ranged between 4.6 cm in *R. campanulatum* and 14.0 cm in *B. utilis*. In all these species the shoot extension growth continued for 3-5 months till September. The shortest shoot growth period was recorded for B. utilis (3 months) and the longest for *A. spectabilis* (5-6 months).

The duration of shoot growth diameter increment varied from three months in *B. utilis* (till August) and five months in *A. spectabilis* (till October). In all these species the shoot extension growth continued for 3-5 months till September. The percentage of the total shoot radial growth realized within one month of shoot extension ranged between 55% in *A. spectabilis* and 85% in *R. campanulatum*. Diameter growth of mature shoot was recorded lowest for *B. utilis* (2.9mm) and highest for *A. spectabilis* (6.8 mm). Shoot grows in thickness in all the species for 4-5 months until October, except for *B. utilis* (August). A marginal shrinkage in shoot diameter was recorded in these species (range= 0.3-1.3%) during November-December due to frost and chilling conditions.

DISCUSSION

Phenological events are constrained at high altitudes by the short growing season characterized by cold temperatures and snow cover. The time of snow melt appears to have an almost universal effect on high-altitude phenology (Inouye *et al.*, 2003), and variations in phenology has been usually linked to variations in the accumulation and melting of snow (Holway *et al.*, 1965; Mark 1970). In the alpine sites of this region it has been reported that because of early availability of snow melt water, majority of the species initiate growth in summer (Negi *et al.*, 1992; Ram *et al.*, 1989), and do not wait for the onset of the monsoon as required for herbaceous plants of the low altitude of this region (Singh *et al.*, 1992). At Tungnath, (Rai *et al.*, 2012) reported that the development of leaves in a shoot and leaf fall at the end of the growth period were highly correlated with soil and air temperature, precipitation and relative humidity. They found that leaf fall was delayed in years with a higher temperature and vice versa, and higher temperatures and delayed monsoon extended the overall growth period of trees. In our study site (Singh *et al.*, 2018), considering the wet and warm months (July–September) as active growing season when the foliage is fully developed, the mean air temperature in 2017 (i.e., 11.2°C) was much higher than seasonal mean ground temperature of 6.7°C (± 0.8; 2.2 K amplitude of means for different climatic zones of the world), reported by (Korner *et al.*, 2004). Thus, it may be pointed out that growing season length at Tungnath is much longer than the climatic treelines, which may have several eco-physiological implications on the treeline vegetation and warrant further studies.

Leaf area of *R. campanulatum* was highest among all the species, and its lower SLA indicated that the leaves were thicker than other species possibly to escape from the stressful conditions of high altitudes (Korner 2012). The krummholz stands were particularly characterized by relatively lower relative humidity and more atmospheric temperature during day time as the stands occurred in open meadows with abundant wind flow. A comparison of leaf and shoot growth characteristics with the *Quercus* spp. and *R. arboreum* of the mid-altitude forests of this region reveals that the bud-break and leafing takes place about four-six weeks earlier than in conspecifics at Tungnath site (Negi 2006). These observations verify the limiting effect of heat deficiency in treelines. Leaf area of *R. arboreum* at these sites was almost equal indicating that the difference of temperature in this species results in delay in phenophases, but not in leaf size. Leaf size depends on several other factors, particularly sunlight (James *et al.*,

2005). Shoot extension period (2–5 months) and low shoot extension growth at the treeline ecotone for *Quercus* spp. and *R. arboreum* was the striking feature of shoot growth phenology. It implies temperature control over the growth of plants in alpine environment (Tranquillini 1979), and warming is expected to increase leaf and shoot growth in treeline ecotone in future.

ACKNOWLEDGEMENTS

Authors thankfully acknowledge Dr. GCS Negi (Scientist 'G'- PI), Director, GBPNIHE, Kosi-Katarmal, Almora for providing necessary facilities to write this research paper. This study was undertaken though NMHS funding of the MoEF&CC.

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INTEGRATED FISH FARMING: A TOOL FOR EMPLOYMENT AND INCOME GENERATION AMONG SMALL AND MARGINAL HILL FARMERS

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ABSTRACT

Integrated fish farming diversifies the farm with various farming system components, which are complementary to each other and facilitate effective recycling of resources within the system. It involves components of fishery, poultry and vegetable production. Composite carp culture viz., silver carp, grass carp and common carp (30,000 fingerlings/ha) raised with chick birds (3000/ha) have yielded 48.7 to 60.3kg of fish (4870-6030 kg/ha/yr), 62 to 75kg of chicken (live weight) and 2646-3028 eggs from 100m2 pond from integrated system. The year round vegetable cultivation on associated fields exploiting overflow of pond and storage tanks for irrigation, 1200-1400kg of different vegetableswere produced annually. Enhanced vegetable production lead to higher remuneration and generated additional income and adequate employment opportunities for the farmer. An average, net gain of Rs. 21,829 and 72,045 was obtained annually from IFF with investment of Rs. 8,109 and Rs 10,150 by the beneficiary family, during 2005-08 and 2018-20, respectively. Besides year-round employment and substantial monitory gain, farmer's family got fresh vegetables and good quality animal protein, which has improved nutritional status of the household.

INTRODUCTION

Integrated Fish Farming (IFF) is a sustainable-agriculture technology practiced widely in Asia and other regions of the world. IFF is a system of producing fish in combination with other agricultural, livestock farming operations centered on the fish pond. The farming subsystems, e.g., fish, crop and livestock are linked to each other in such a way that the byproducts/wastes from one sub-system become valuable inputs to another sub-system and thus ensure total utilization of land and water resources of the farm, resulting in maximum and diversified farm produce with little investment. Although requiring low levels of inputs, it has considerable potential to provide food security, nutritional benefits, employment generation and providing additional income to resource poor small farmers (Shrivastava *et al*., 1999; S; Debnath *et al*., 2013; Singh *et al*., 2014; Dash *et al*., 2015). Various integrated fish farming models have been evolved according to the geography and climate, local agricultural characteristics, socio-economic conditions and traditional practices. Simultaneous production of fish in ponds and livestock and poultry production over or beside the ponds constitute a continuous organic fertilization of the pond by the livestock. This practice increases the efficiency and rent ability of both livestock farming and fish culture through the profitable utilization of animal and feed waste (Edwards *et al*., 1996). Integration of fish farming with pig, ducks and chickens, a widespread technique in Asia has been found most productive (Edwards *et al*., 1986; 1996). In some countries, fish farmers also integrate geese, rabbits, goats, sheep, and cattle with fish culture on small scale. In the hilly region of Uttarakhand livelihood opportunities are limited and livestock supplemented agriculture remains the basic livelihood for majority of rural population, who are living under poverty, food insecurity and undernourished. Small, fragmented land holdings, declining soil fertility absence of irrigation facilities and advance agricultural technologies are important factors accounting for low agriculture production in the region. The traditional rice/millet-wheat cropping system practiced in the region is not profitable. In spite of this, an overwhelming majority of its population, mainly women (85%) are engaged in traditional agricultural merely because lack of alternative sources for employment and income generation. Non-profitable nature of agriculture is the main reason behind low level of education, unemployment, malnutrition and associated health problems particularly among rural women. The application of advance technologies for intensive pond culture, livestock and poultry farming, vegetable production and good water and soil conservation techniques can be helpful to solve some of these problems. Integrated fish farming has been an excellent stimulus to promote rural economic development in less developed areas, especially where fish farming is not popular (4). Further, it could generate employment, increase farmers' income and help to alleviate malnutrition, a serious problem in rural areas of the region (Dutta *et al.,* 2003) by providing additional sources of animal protein and vegetables. To make farming activities economically viable and ecologically sustainable, multi-enterprises farming system models relevant to small and marginal farmers were developed and evaluated.

METHODOLOGY

A quick survey was carried out in seven villages to know agricultural situation, the available resources and farmers need. Village Basoli (1600m amsl) in Takula block of district Almora was selected for demonstration of IFF technology for the first time in the region.

CONSTRUCTION OF IFF UNITS AND STOCKING OF FINGERLINGS AND CHICKS

A fish pond (100m^2), and a low cost of poultry house (2.0m x 2.0m x 2.5m) with locally available resources at the dyke of the pond were constructed. Fingerlings of exotic carp species (5.5-10.0 cm) viz., silver carp (*Hypophthalmichthys molitrix*) (45%), grass carp (*Ctenopharyngodon idella*) (35%) and common carp (*Cyprinus carpio*) (20%) were stocked into the pond at a density of 3 fingerlings/m^2 in March due to their known compatibility with each other, faster growth and hardy nature. Thirty chickens of Kurioler, a coloured hybrid layer species of chick bird, weighing approximately 150gm were kept in poultry house. Stocking ratio of poultry (3000/ha) and also fish species (30,000 fingerlings/ha) have been based on some empirical experiences from overseas or adopted from research done in the country. At initial stages, supplementary feed was provided to the fingerlings. Polished rice bran and mustard oil cake mixed in a ratio of 2:1 is used. Subsequently, after two months of stocking no artificial feeds was given except manure, i.e., cow dung and poultry droppings, grass and vegetable waste to obtain good fish production. Growth and health of fish and chick birds were monitored at a regular interval. Fish were harvested; yield was recorded at each catch and marketed between November and January. Numbers of eggs produced by the chick birds and live weight of chicken sold were also recorded.

VEGETABLE CULTIVATION AROUND THE POND

The agro climatic conditions of the hilly region are favourable for cultivation of off-season vegetables. Year round vegetable cultivation on the fields (600m^2) adjacent to small ponds was practiced, exploiting overflow of pond for irrigation. Composted household waste (vermicompost) and farmyard manure (FYM) was applied to maintain high soil fertility. Vegetable crops were raised, harvested and sold at different times of the year. The typical vegetables of the region, such as French beans (Var. VL bauni bean 1 and Cantender), hybrid tomato (Var. Manisha), bell pepper (Var. California Wonder), okra (Prabhani Kranti) along with local varieties of cucurbits were grown during summer-rainy season, while, pea (Var. Arkel, VL Ageti Matar 7), cauliflower (Var. Snow ball) radish (Var. Japanise white) and Lahi, spinch (local cultivar) were grown during winter, following standard package of practices . Yield and income from vegetable(s) were precisely recorded.

OBSERVATION AND DISCUSSION

Performance of Chinese Carp in Integrated Farming System

Stocking advanced stages fish fingerlings reduced mortality and losses to predators. High survival rates (74.1-91.8%) were recorded for different species. After 7 months period of culture, the weight recorded for silver carp 250-480gm, grass carp (300-650gm) and common carp (285-525gm). From the pond area of 100m^2 (Basoli) under polyculture system the total fish production was 48.7 to 60.3kg corresponding to 4870-6030kg/ha/yr (Table 1). These fish yields are comparable to the fish yields (4323kg/ha/year) reported under fish-duck integration in India (Jhingran *et al.*, 1980) and in Hong Kong (2750-5640kg/ha/year) by (Delmendo 1980). Still higher yields could be achieved through intensive supplementary feeding at initial stages of growth and recycling of manure obtained from integration of poultry and cow thereafter. Fish yield as high as 7300kg/ha has been reported under fish poultry integration (Little *et al.,* 1987).

Performance of Integrated Chick Birds

Kurioler chick birds performed well under mid hill conditions. Besides faster growth rates as compared to local birds, Kurioler exhibited fairly high degree of resistance/ tolerance to various diseases. Chick birds started egg laying after 18 to 20 week. Besides household use, 62 to 75kg of chicken and 2646-3028 eggs from integrated system were sold annually by the farmer (Table 1).

Table 1. Production from different components of integrated fish farming

Produce	2005-06	2006-07	2018-19	2019-20
Fish (kg)	60.3	57.9	48.7	58.5
Eggs	2646	3028	2870	2678
Chicken (kg)	65	62	72	75
Vegetables (kg)	1242	1398	1365	1525

Income Generation through Vegetable Cultivation

Traditionally, local cultivars of few vegetables are grown in kitchen garden without assured irrigation. As a result, the yields are generally very low, which hardy fulfill the household requirements. Integration of livestock-fish-vegetable cultivation as described here has provided substantial yield of different vegetables with improved varieties and application of organic manure in adequate quantity. Altogether, 12.5 to 15.0 Qtl vegetables were produced annually. Yield levels of French beans (8.3-10.5t/ha), tomato (9.5-21.1t/ha), bell pepper (8.8-12.5t/ha) and pea (9.5-10.4t/ha) as green vegetable were obtained at different periods of the years, assuring better returns from the land. Vegetables harvested for household were not taken into account. Off- season cultivation of different vegetables utilizing pond water for irrigation makes the integrated fish farming more profitable (Fig 1).

Annual income generated through Integrated Farming System

In addition to diversified farm output for household use,

Fig. 1. Utilizing pond water for cultivation of different vegetables.

average gross income of Rs 29,938 and Rs 82,195 was generated from different components of integrated livestock-fish-crop farming during 2005-08 and 2018-20, respectively. Fish-poultry unit contributed Rs 15,394 during 2005-08, while Rs 61,695 during 2018-20 towards the gross income. Besides, additional income of Rs 14,544 and 20,500 were generated through vegetable cultivation on the fields around fish ponds during these years. The economics of the system also indicate a good profit. A net annual income of Rs 21,829 and Rs 72,045 was achieved by initial investment of Rs 8,109 and Rs 10,150, respectively (Table.2).

To conclude, IFS is relatively new technology in hilly areas of Uttarakhand. This can increase efficiency of resource utilization, reduces risk through diversified farm output with little investment. It has great potential to generate year round employment opportunities to resource poor small farmers, increase family income and help to alleviate malnutrition by providing additional source of animal protein and fresh vegetables. The findings of the study prove that Integrated Fish Farming is more profitable and ecologically more sustainable than unitary system of farming. Further, the model is self-sustained and adds value to the traditional subsistence based farming system. Established in 2004, the IFF model at Basoli is still running and fetching a substantial income to the beneficiary household. The non-recurring expenditure has reduced in successive years, while demand and selling price of fresh fish, Kuroiler eggs and chicken has increased many fold, thus enhancing net income from the system.

Table 2. Average annual expenditure and income from integrated fish farming

Expenditure/Income (Rs)		2005-07	2018-2020
A	Non Recurring Expenditure		
	Pond and poultry/duck house construction (For 10 Years)	16,100	Nil
	Depreciation @ 10%	1,610	Nil
	Interest @8% on capital investment	1,288	Nil
B	Recurring Expenditure		
	Fish Culture	1,111	2,700
	Poultry rearing	3,350	6,200
	Vegetable cultivation	750	1,250
C	Total expenditure	8,109	10,150
D	Annual income (Rs)		
	Fish	5,910 (100/kg)	16,080 (300/kg)
	Eggs	5,674 (2.00/egg)	27,240 (10.00/egg)
	Chicken (live)	3,810 (60.00/kg)	18,375 (250.00/kg)
	Vegetable	14,544	20,500
Total income		**29,938**	**82,195**
Net gain (Rs) (D-C)		**21,829**	**72,045**

Under COVID-19 pandemic situation the working class has lost their jobs and facing a financial crunch. The economy of the hills have affected more severely, as there are already limited livelihood opportunities in the hills and a large number of migrant workers working with unorganized and private sectors have returned to their villages. The traditional farming is not capable of providing them livelihoods. Under the circumstances, various other complementary enterprises like cultivation of mushrooms, medicinal and aromatic plants, fodder grass; vermicomposting, apiculture may be integrated to generate more income and productive employment. Several migrant youth are willing to adopt integrated fish farming with technical and financial support at initial stage.

ACKNOWLEDGEMENTS

This work was supported by Science & Society Division, Department of Science & Technology, New Delhi. I am thankful to the DST for financial assistance and the Director, GBPNIHED, Kosi- Katarmal, Almora for providing facilities. I am also thankful to Head, CSED, GBPNIHED, Kosi-Katarmal, Almora for support.

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TREE STRUCTURE, SPECIES COMPOSITION AND DIVERSITY OF OAK FOREST STANDS IN THE INDIAN WESTERN HIMALAYA

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ABSTRACT
The present study explores the tree structure, species composition and diversity of selected oak forests stands in the Indian western Himalaya. Two oak dominated forest stands (*Quercus leucotrichophora A. Camus* and *Quercus lanuginosa* Lam.) were investigated between 1850-2250m elevations. The parameter investigated comprised species richness, density, species diversity, regeneration and population structure of species. Tree, sapling and seedling density was reported 652, 208, and 172 ind ha^{-1} at banj-oak stand and 884, 378 and 250 ind ha^{-1} at mixed oak stand. The higher species diversity and richness were recorded in the mixed oak forest stands as compare to banj-oak stand due to less anthropogenic disturbance. Variation in species richness composition and richness of studied forest st ands is related to human interference and the need for forest conservation is emphasized.

Keywords: Species composition, Oak forest, Population structure, Western Himalaya

INTRODUCTION
Himalayan mountain forests are one of the most fascinating and characteristic entities among forests of the world because of their unique ecology, having a temperate climate within a tropical zone. The western Himalaya, offers unique habitats to sustain several endemic and rare plant taxa. It also contributes significantly to environmental sustainability by generating many important ecosystem services i.e., formation of soil, regulate the hydrological cycle, carbon storage and sequestration, and many other provisional and cultural service. In the Himalayan mountains forest composition, tree structure and patterns of diversity are chief ecological features and are notably affected by local environmental conditions and anthropogenic variables (Gairola *et al*., 2008). Forests composition is not only crucial for understanding the forest structure but also important for future prediction, management, and conservation strategies (Malik *et al*., 2015). Differences in vegetation, species richness, diversity, and distribution pattern of species are directly correlated with the strength of other variables such as the topography of the site and man-forest interaction (Criddle *et al*., 2003). The number of species in a certain forest differs distinctly along with the altitudinal range of its growth (Gairola *et al*., 2011), which depends on the complex factors that characterize the habitat of individual species.

The hilly region in the Uttarakhand is varying from sub-tropical to temperate along the gradient from low to high elevation. In lower altitudes (below 1000m asl), *Shorea robusta* forms dominant canopy species, *Pinus roxburghii* occur between 1000 to 1700m asl and *Quercus* spp. occur between 1500 to 2200m asl (Singh *et al*., 1992). The Oak forest of Himalaya represents climax vegetation between 1000 - 3500m asl in the region and plays a vital role in the conservation of soil, water, native flora, and fauna, thereby, providing numerous ecosystem services to mankind (Singh *et al.,* 1992; Upreti *et al*., 1985). The composition and other attributes of the oak forest of Himalaya are significantly varied with the various climatic and anthropogenic variables. Therefore, the present study was undertaken to assess the ecological status, forest stand structure, community composition of two oak-dominated forest stands in the Western Himalayan region.

MATERIAL AND METHOD
Study area The present study was conducted in the two oak-dominated forest stands (i.e., Kailakhan which is dominated by *Quercus leucotrichophora*; and Kilbury dominated by *Quercus lanuginosa* in the temperate zones (1850–2250m asl) of district Nainital, Uttarakhand in the western Himalaya. The descriptions of studied forest stands are presented in Table 1. The climate of the study area is monsoon-temperate type. The year is divisible into three seasons: winter (November-February) and summer (March to mid-June) and rainy (mid-June-September). The soil of this region has been categorized as sandy loam type.

Table 1. Geographical details of studies forests stand.

Parameter	Banj oak forest	Mixed oak forest
Forest location	Kailakhan	Kilbury
Altitude (m)	1850-1950	2050-2250
Latitude	29°22.404'	29°25.43'
Longitude	79°28.58'	79° 26.16'
Dominant canopy species (Tree)	*Q. leucotrichophora*	*Q. lanuginosa*
Soil texture	Sandy loam	Sandy loam
Status of forest	Reserve forest	Reserve forest

Vegetation sampling

Phytosociological studies were carried out during 2017-18 using the quadrat method (10 x 10m for trees and saplings and 5x5m for seedlings) (Mishra 1968). Fifty quadrats were laid randomly in each forest stand for trees, saplings and seedlings. Tree species occurring in each of the quadrats were listed and their circumference was measured. The individuals in the case of tree species were separated into three categories. Individuals having ≥ 30cm girth was considered a tree, 30 to 10 cm was considered as a sapling, and ≤10cm at the base was considered seedling. Field data were analysed for species richness, density, frequency, abundance, basal area, diversity, and concentration of dominance of tree species in different forest stands.

Population structure

To develop the population structure and understand the regeneration of different species.The cbh of individuals was measured. Based on the cbh, trees were randomly classified into 6 classes in addition to seedling and sapling class, A: seedlings < 10cm cbh, B: saplings 10-30cm cbh, C: 31-60cm cbh, D: 61-90cm cbh, E: 91-120cm cbh, F: 121-150cm cbh; G: 151-180cm cbh, H, 181-210cm cbh, and I: 210-240. The relative proportions of seedlings, saplings, and trees of different size classes to the total density of tree species at each site were calculated to develop the population structure (Uma Shankar 2001).

RESULT

Species composition and diversity

The phytosociological attributes andcompositional features of the selected forest stand are presented in Table 2. A total of 27tree species were recorded in studies forest stands. Species richness was recorded 12 and 13 in banj oak and mixed oak stands respectively. Tree density was reported between 652 ind. ha^{-1} (banj oak) and 884 ind. ha^{-1} (Mixed oak stand). The Banj oak stand was dominated by *Q. lecucotrichophora* (412 ind. ha^{-1}) followed by *Cedrus deodara* (74 ind ha^{-1}), *Acer oblongum* (40 ind. ha^{-1}), *Cupressus torulosa*(32 ind. ha^{-1}), *Pinus roxburghii* (20 ind. ha^{-1}) and other associated species, however, themixed oak stand wasdominated by *Q. lanuginosa* (324 ind. ha^{-1}) followed by *Q. floribunda* (260 ind. ha^{-1}), *Cedrus deodara* (94 ind ha^{-1}), *Rhododendron arboreum* (74 ind. ha^{-1}), *Lyonia ovalifolia* (44 ind. ha^{-1}) and other associated species. The total tree basal area was recorded higher at the banj oak stand (51.38 m^2 ha^{-1}) and lower (33. 41m^2 ha^{-1}) at the mixed oak stand. The species diversity (Shannon wiener Index H') was found higher (2.31) in the mixed oak stand and lower (2.04) at the banj-oak stand. Simpson diversity Index (H;) and species evenness (SE) was also reported higher at mixed oak forestas compare to banj-oak forest stands (Table 3).

Table 3. Species diversity indexes of studied forest stands

Parameter	Banj-oak Forest	Mixed-oak Forest
species richness (Tree)	12.00	13.00
Shannon Index (H')	2.04	2.31
Concentration of dominance (CD)	0.42	0.24
Species evenness (SE)	0.82	0.90

Population structure

The comparative proportion of seedling, sapling, small tree, mature tree, and older trees in a forest stand were calculated to develop the population size class and community structure to the predicted future composition helpful for forest management and conservation. A total of 28 species were recorded in all three strata (tree, sapling, and seedling) in studied forest stands. In the present examination of the total number of individuals (seedling+sapling+tree), a total of 17, 20 and 67% individuals at banj oak stand and 17, 24 and 59% individuals at the mixed oak stand were recorded as trees, sapling and seedling stage respectively. Of the recorded species only 20 species were regenerating (present seedling and sapling stages), although at the stand level 9 and 10 species were regenerating at banj oak, and mixed oak stand respectively. The proportion of seedling was lower as compared to mature trees in each forest stand (Fig. 1). The dominant tree (*Q. leucotrichophora* and *Q floribunda*)in each forest stands present all girth class, however the codominant species showed discontinuous distribution in their girth class.

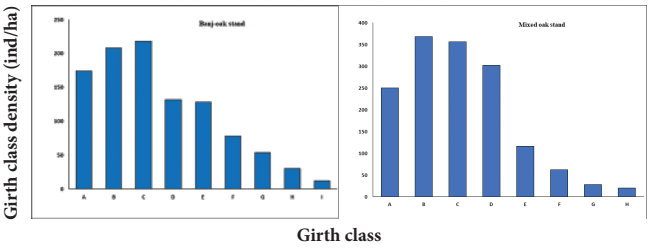

Fig. 1. Population structure of studied oak forest stands

Table 2. Phytosociological attributes (Density, Total basal area and Important Value Index) of studied forests stand

	Species	Tree			Sapling			Seedling
		Density	TBA	IVI	Density	TBA	IVI	Density
BANJ OAK STAND	*Q leucotrichophora*	412.00	41.89	184.39	62.00	0.20	100.55	96.00
	Acer oblongum	40.00	3.51	23.29	20.00	0.05	41.47	12.00
	Cedrus deodara	74.00	2.23	33.16	46.00	0.13	54.82	22.00
	Cupressus torulosa	20.00	0.89	11.94	-	-	-	-
	Pinus roxburghii	32.00	0.64	10.92	26.00	0.06	35.98	8.00
	Lyonia ovalifolia	16.00	0.28	8.56	16.00	0.04	26.77	10.00
	Myrica esculenta	10.00	0.18	5.05	2.00	0.01	18.86	4.00
	Rododendron arboreum	10.00	0.22	5.92	-	-	-	-
	Machilus duthei	2.00	0.06	1.21	4.00	0.01	-	2.00
	Aesculus indica	16.00	1.28	9.72	-	-	-	
	Debregeasia hypoleuca	14.00	0.15	4.03	28.00	0.09	10.79	14.00
	Viburnum cotanifolium	6.00	0.05	1.81	-	-	-	-
	Ficus nemoralis	-	-	-	4.00	0.01	10.75	4.00
	Total	**652.00**	**51.38**	**300.00**	**208**	**0.60**	**300.00**	**172**
MIXED OAK STAND	*Q. lanugnosa*	324.00	13.89	103.50	90.00	0.33	43.79	40.00
	Q. floribunda	260.00	10.20	83.58	84.00	0.38	55.18	44.00
	Cedrus deodara	90.00	3.11	34.32	26.00	0.35	25.53	38.00
	Litsea umbrosa	22.00	0.43	6.51	64.00	0.35	43.79	68.00
	Rododendron arboreum	74.00	2.30	27.35	24.00	0.36	27.47	16.00
	Lyonia ovalifolia	44.00	1.09	16.48	10.00	0.29	16.40	10.00
	Ilex dipyrena	8.00	0.39	3.72	-	-	-	-
	Carpinus viminea	10.00	0.17	3.28	44.00	0.27	29.21	8.00
	V. cotonifolium	18.00	0.23	6.58	-	-	-	-
	M.duthei	14.00	1.10	7.06	16.00	0.29	18.11	10.00
	Q. lecotrichophora	10.00	0.13	3.73	-	-	-	-
	C. torulosa	4.00	0.04	0.89	-	-	-	-
	A. indica	6.00	0.34	2.79	2.00	0.10	4.46	8.00
	M. esculenta	-	-	-	8.00	0.58	23.78	8.00
	Total	**884.00**	**33.41**	**300.00**	**368.00**	**3.29**	**300.00**	**250.00**

Density (ind ha^{-1}), TBA= Total basal area (m^2 ha^{-1}), IVI= Important Value Index

DISCUSSION

The Himalaya is characterizing a diverse and physiognomies of vegetation and show dominance of one or more species (Dhaulkhandi *et al*., 2008). Forest vegetation of this region has been studied with sufficient details (Singh *et al*., 1992). In the present assessment tree species richness was higher (12 and 13) as compare to (Rawat 1983), which reported (6-9) in the Western Himalaya. Mixed oak forests have the higher species richness and diversity as compare to banj oak forest, due to less anthropogenic interference in the mixed oak forest. The variation in species richness among the forest stand among forest stands is likely due to variation in various climatic condition (temperature, rainfall, humidity) and anthropogenic pressure (grazing, resource extraction) and management of forest.

In the present study tree density was recorded range from 652-884 ind. ha^{-1} across the study sites, which is comparable to 473-840 tree ha^{-1} reported by (Saxena *et al*., 1982), (Kumar *et al*., 2005) and (Joshi *et al*., 2020) in the different oak forest stands of Himalayan region.Also, higher tree density (960-1100 ind. ha^{-1}) of oak forest in this region have been reported by (Ralhan *et al*., 1982). Tree diversity value in the present study reported ranged between 1.10-2.31, which is comparable with the reported range between 1.16-3.40 for different Himalayan forest (Sharma *et al*., 2019).

The number of seedlings, saplings, small trees, and large trees in each population may help in prediction the future status of forest (Sundriyal *et al*.,1996). In the present study

dominant species contribute most of the part in regeneration in both the studies forest stands however, the regeneration potential of co-dominant as well as other associate species is significantly varied. The lower number of seedling and sapling than to mature tree in this study showed the poor to fair regeneration potential of species, which directly influenced to future status of forest. In a forest community, domination of trees in mid to lower dimeter class indicates that the forest is still developing stage (Campbell *et al*.,1992) and their domination at mature class show their mature stage. In our study population structure of both oak stands show discontinuous pattern i.e., no definite pattern of population in relation with the girth class. This type of irregular population structure of species has been also reported in some forests in Himalaya (Brokew 1987; Deb *et al*., 2008) tree and mature trees in a given population indicates successful regeneration (Khan *et al*., 1987), and the tree species that are represented by all diameter classes begin continuous regeneration.

CONCLUSION

The present study concluded that the mixed oak forest is slightly richer in terms of tree species richness, density and diversity than banj oak forests because of low anthropogenic pressure. Presence of fewer number of individuals at the lower girth class (seedlings and saplings) shows the poor regeneration capacity of forest stands, it might be due to thick litter accumulation, which reduced seed germination of most canopy species or may be lack of viable seed production, and unfavourable microclimatic conditions as well overgrazing of animal. The presence of dominant species in all girth classes in studies forest stands shows they will dominate in near future.

ACKNOWLEDGEMENT

The authors thank to the Ministry of Environment, Forest and Climate Change (MoEF & CC), Government of India forfinancial support through a project (F. No. 14/222/2014-ERS/RE) and Director, GB Pant National Institute of Himalayan Environment (NIHE) for providing necessary facilities.

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ROLE OF CHIR PINE (*PINUS ROXBURGHII* SARG.) IN THE FOREST FIRE OF UTTARAKHAND HIMALAYA

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ABSTRACT
The Uttarakhand Himalaya has rich and diverse forests; but in the recent decades fire has become a regular phenomenon in Uttarakhand. Every year the Chir Pine forests face forest fire. Research carried out by various authors pointed out that pine needles are highly inflammable and prone to fire due to several anthropogenic factors. This paper presents an overview of forest fire on Uttarakhand with the emphasis on the role of Chir Pine in forest fire. Currently, fire is a very critical disturbance to the vegetation and forests of Uttarakhand Himalaya. Forest fire causes adverse ecological, economic and social impacts. The outcome of the paper concludes that the main reason of forest fire in the Uttarakhand Himalaya is accumulation of inflammable pine needles on forest floor during dry summer and prone to man-made accidental and intentional fire. Suitable strategy to avoid the forest fire by using this resource for bio-energy or other environment-friendly products is emphasized.

Keywords: Chir pine (*Pinus roxburghii*), Uttarakhand Himalaya and Forest fire.

INTRODUCTION
Forests are considered as one of the most important terrestrial ecosystems that provide habitat provisioning for biodiversity and many goods and services to the rural communities. These indispensable resources are prone to constant degradation and exploitation due to anthropogenic activities and changes in the climatic conditions (Pokhriyal *et al*., 2020). The Indian Himalayan Region (IHR) has a rich and diverse forested area and thus globally forests are now considered to be as the major repository of nature and needs to be conserved and managed for posterity, and not to be regarded solely as an important source of revenue (Negi *et al*., 2012). Forest fire is a regular phenomenon in Uttarakhand forest ecosystems depleting most valuable flora and fauna due to frequent incidences of forest fires. More than 50% of mountain forests in Uttarakhand are prone to high incidence of fire, during the months of March to June every year. Forest fire is a major cause of changes in forest structure and function. Fire changes the dynamics of vegetation in the forests. Forest fires are as old as forests themselves. Currently, fire is a very important disturbance to worldwide vegetation cover, affecting terrestrial ecosystems on a large scale (Hussain *et al*., 2018). In terrestrial forest ecosystems, fire can be of natural origin such as lightning, volcanic eruption etc. or man caused (intentional or unintentional), and are further categorized as surface fires, ground fires and crown fires. Due to severe recurrent forest fires, various negative impacts on the environment and ecosystem occur. It destroys flora and fauna, timber wealth of forests and biodiversity, accelerate soil erosion, changes physico-chemical as well as biological characteristics of the soil, cause air pollution and increase air temperature due to emission of green house gases. According to the Forest Survey of India, about 50% of the forest area in the country is fire prone, and about 6% is prone to severe fire annually. Every year, close to 18,000 forest fire incidents are reported in India affecting an area of some 1.14 Mha. So, the effective forest fire management is necessary to mitigate these frequently occurring forest fires in Uttarakhand. Fire activity is strongly influenced by factors such as: air temperature, relative humidity, wind speed, previous day rainfall, dew point temperature, air pressure, potential evapotranspiration, land surface temperature, precipitation rate, forest type, slope, aspect, elevation, normalized difference vegetation index, enhanced vegetation index, albedo, terrain ruggedness index and road network, rail network, human interference (Bargali *et al*., 2017). The man-caused intentional fire has been found to be the major reason behind forest fire in Uttarakhand. Forest fire is one of the major disasters in the forests of Uttarakhand that adversely affects the indigenous and endangered species of flora and fauna (Negi *et al*., 2017). Chir Pine forests are mainly responsible for the spread of forest fires. Chir pine covers an area of 8900 km^2 in India and is regarded as one of the most important timber tree in forestry plantations (Tiwari 1994). The chir pine tree is rich in resin content that makes it economically important species. However, the same property makes its needle litter highly inflammable and vulnerable to forest fires. Pine forests face fire every year to remove the needle litter, which becomes

slippery for humans and cattle to go around in the forests (Chandran *et al*., 2016). Chir pine, scientifically known as *Pinus roxburghii*, also known as three-needled Indian pine, a native of the Himalayas is spread across India, Nepal, Pakistan and Afghanistan. This is a large evergreen tree with elongated crown and attains a height of up to 50 meters, with about 3.5 meters in girth, and forms a straight cylindrical bole. It grows between a lower elevation of 500 meters to higher elevation of 2,200 meters and forms a pure forest. About 16.36% of forest area is occupied by Chir Pine forests between 1000 and 1800 m above sea level in Uttarakhand (Fig. 1).

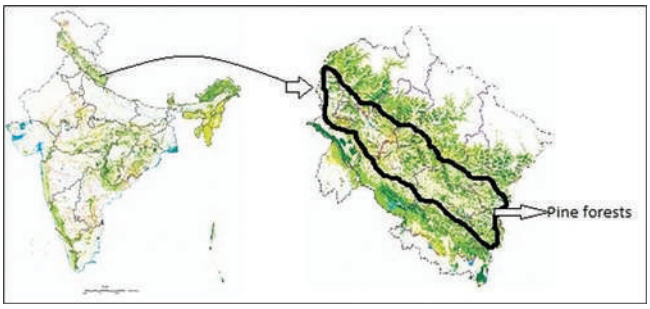

Fig. 1. Map showing the forest are covered by Pinus roxburghii prone to forest fire in Uttarakhand (Source: Chandran *et al*., 2016)

Chir pine is used for timber, fuel wood, torch wood, funeral wood and furniture. Its leaves are used for livestock bedding and field mulching. The bark of chir pine is a source of charcoal, resin and coal tar. The leaves of coniferous tree of pine catches fire easily and thus accelerates the forest fire in Uttarakhand.

METHODS

Based on an extensive review of literature, research articles, reports from numerous databases, such as Google scholar, Research gate, Taylor and Francis online, Springer-link, the present communication has been divided into three sections: (1) history of forest fires in Uttarakhand Himalaya, (2) the role of Chir Pine in forest fire of Uttarakhand Himalaya, and (3) analysis of research along with preventive measures. The online search was carried out using keywords such as "forest fire", "fire history", "role of chir pine in forest fires, "tree mortality due to forest fires" along with the name of Uttarakhand Himalaya.

RESULTS

History of forest fires in Uttarakhand Himalaya

In India, forest fires were considered as the significant and prominent contributory factors in the degradation process altering ecological balance of nature. The most susceptible stretches of the world to fire are the youngest mountain ranges of Himalayas. Human induced forest fires in Uttarakhand have been a regular and historic feature. Major forest fires have been recorded in Uttarakhand in 1911, 1921, 1930, 1931, 1939, 1945, 1953, 1954, 1957, 1958, 1959, 1961, 1964, 1966, 1968, 1970, 1972, 1995, 1999, 2012, 2016, 2019 and 2020. Forest fires are an annual occurrence in Uttarakhand but from past few years it is proving devastating for local people and causing irreparable damage to valuable natural resources of the state (Dobriyal *et al*., 2017). First time, fire protection was initiated in the chir pine forests by the Forest Department in 1912. In Uttarakhand, the periodicity, spatial coverage and severity of forest fire vary temporally and these fires are associated with heavy accumulation of chir pine needles on the forest floor. These mostly man-made forest fires in Uttarakhand are also a potent source of pollutants especially black carbon, being a major cause of glacier melt in the Himalaya, and also alter the regional climate (Singh *et al.,* 2016). In 2016, a total of 1327 forest fire incidents took place with total area affected 4423 ha. Forest fire also causes air pollution and leads to rise in temperature in hilly areas of Uttarakhand and destroys a large amount of flora, fauna and wealth of forests.

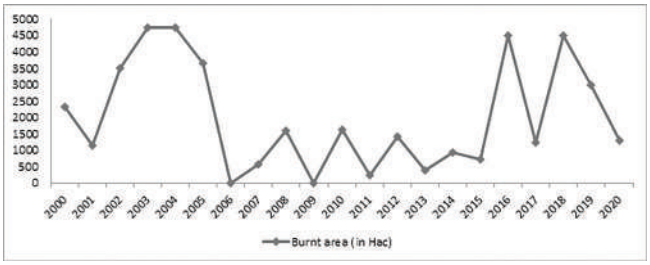

Fig. 2. Yearly trend of area burnt (in hac.) of Uttarakhand Himalaya due to fire (2000-2020); (Source: State Forest Department, Uttarakhand)

Role of Chir Pine in the forest fire

The major causes of forest fire in Uttarakhand are: continued dry weather and lack of moisture in the forests, traditional practice of burning of forests by the local villagers to remove Chir Pine needles accumulated on forest floor to allow growth of herbage and unsustainable forest conservation policy (Dalei 2016). In Uttarakhand, about 4 lakh ton Pine needles are dropped annually in the forests, accelerating the inflammability of the forest floor due to rise in ambient temperature during summer (Negi 2019). Fire incidents mostly take place between 12-4PM and 4-8PM. The major reasons for forest fires in Himalayas are the highly inflammable material of dry chir pine needles and the dry-leaf litter of broad-leaved trees on the forest floor associated with chir pine. The man-caused intentional fire has been found to be the major reason behind forest fire in Uttarakhand. People also ignite fire to remove unwanted grass and to obtain better forage for livestock, extraction of honey from the bee hives and wild edibles among several other reasons (Negi 2019). Fire behavior changes with weather, topography and fuel

of particular landscape and its movement is controlled by conduction, convention and radiation factors (Bhatia *et al*., 2020). Human activities on agricultural land are the most common causes of fires. Today, 95% of all cases of forest fires are caused due to anthropogenic activities. Natural factors that influence the occurrence and spread of forest fires are climatic elements, combustible material, geological characteristics of the terrain and the type of vegetation (Siljkovi *et al*., 2016).

Effects of forest fire in Uttarakhand Himalaya

Forest fire is a potential hazard that leads to physical, biological, environmental and ecological consequences. Forest fire does not depend on any single factor. Due to forest fire many ecological and socio-economic impacts occur (Savita *et al*., 2017). Forest fire alters the ecology of forests, reduces biodiversity and changes plant community composition of the forests. The major impact of forest fire on flora are reduction of the productivity, alteration of regeneration rate that detoriatres the physico-chemical characteristics of soil, thus making the soil infertile. Along with flora, a large number of endemic and endangered species of fauna also get affected. Uttarakhand state has abundant forest resources, and is regarded to have high potential for the economic development of the state, but due to forest fire a large impact occurs on socio-economic aspects of the people (Sati *et al*., 2018). Forest fires destroy not only flora (tree, herbs, grassland etc.), but also creates long term negative impact on fauna including wild endangered species. Due to forest fire, air pollution, various pollutants like NOx, SOx, CO and black carbon increase leading to various air borne diseases. Forest fire reduces the abundance, density and distribution of many species from microbes to mammalia (Dennis *et al*., 2001). Reduction in the level of regional biomass stock occurs and hydrological cycle gets disturbed. The photosynthetic activity is reduced due to the increased concentration of smoke and various pollutants in the environment thus deteriorate the health of human being and animals (Turvey 1994).

CONCLUSION

The chir pine forests are the major forest type in Uttarakhand Himalayas as it covers about 16% forest area. Due to resin rich leaves, it becomes a main contributor to forest fire in Uttarakhand. Therefore, regular elimination of pine leaves and proper looping of the lower branches of pine trees from roads and fire sensitive areas can be performed both by forest department as well as by local people. Plantation of fire resistant and adapted species such as *Carissa spinarum* and *Pyrus pashia* need to be done. Pine needles accumulated on the forest floor during extreme summer season can be utilized for industrial purposes (e.g., making paper to prepare file covers, file folders, note pads, carry bags, greeting cards, envelops, smokeless bio-briquettes etc.), electricity generation, oil extraction etc. for gainful employment in the region (Arya *et al*., 2020). The forest department of Uttarakhand utilizes the pine needles for making check dams in the forest for conserving soil and water, that ultimately moisten the forest floor and reduces the spread of forest fire (Chandran *et al*., 2016). Activities of local people of burning agricultural lands or other actions promoting wildland fires should be regulated. Regular patrolling of forests should be done, as maximum forest fire is incidents are human induced and for better management of forest fire, research in the field of fire detection and fire ecology need to be initiated. Strong collaboration between the forest department and local people needs to be established to reduce the incidents of forest fire and save our forests and biodiversity.

ACKNOWLEDGEMENTS

Authors thankfully acknowledge Dr. G.C.S. Negi, Scientist, GBPNIHE for guidance and encouragement and Director of the Institute for providing facilities to write this ms.

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USE OF FLORA AND FAUNA IN STATE SYMOBLS OF INDIAN HIMALAYAN REGION

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ABSTRACT

Sustainable development of a nation is directly related to the conservation and sustainable utilization of biodiversity. Unfortunately, in recent times a severe decline in biodiversity has been witnessed in several parts of the world with an alarming rate. Now a day's currency bills, coins, and postage stamps have been specifically designed and released to address the flora and fauna hallmark of different nations and their states. The reason behind this is to conserve the threatened, vulnerable, endangered, critically endangered flora and fauna around the globe through such iconic and socio-cultural bonding. The Indian Himalayan Region (IHR) is well-known as a store house of diverse flora and fauna, and is endowed with nearly 18,440 floral species as well as 3948 invertebrate and 959 vertebrate fauna species. Present study aims to find out current status of flora and fauna in state symbols of HIR towards conservation of biodiversity and their current status as per CITES, IUCN and CMS list.

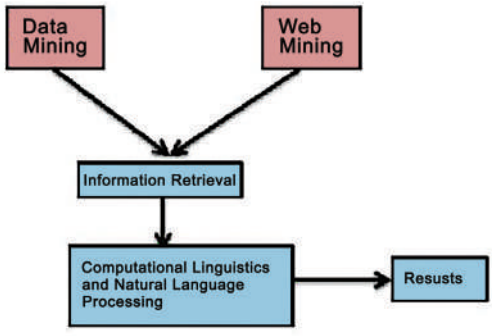
Keywords: Conservation, Biodiversity, Indian Himalayan region and Threatened species.

INTRODUCTION

The Indian Himalayan Region (IHR) serves as a water reservoir for the large part of the Indian subcontinent and comprises of diverse flora and fauna that includes several rare and threatened species (Barry 2016). A The floral diversity in IHR comprises of 18,440 species of plants including 8000 sp. of Angiosperms, 44 sp. of Gymnosperm, 1736 sp. of Bryophytes, 1159 sp. Lichens, 600 sp. of Pteridophytes and 6900 sp. of Fungi, and out of them about 45% are reported to have medicinal properties (Chatterjee 2016). In the case of faunal diversity, a total of 4907 faunal species has been reported which include 3948 invertebrate fauna and 959 vertebrate fauna (Uniyal 2011). Currency bills, coins, and postage stamps all considerably contribute towards the national heritage of any nation (Fig. 1). They carry the glimpses of a nation in their own right and often serve as an important window to peep through the steps of history to study, appreciate and understand the socio-cultural context of any nation or a country, both young and old. The practice of the systematic study of currency is known as numismatics and the collection of coins is now considered to be a part of numismatics. The collection of stamps is known as philately. Globally several flora and fauna species are being threatened with several natural as well as anthropogenic factors with the risks of extinction (http://www.birds.com/blog/category/features). Hence it is important to utilize every possible opportunity for portraying the need for their conservation. The iconographic presentation of different species of flora and fauna through currency bills, coins, and postage stamps is an important, innovative and interesting avenue in popularizing their conservation. This could be considered as a new and important approach in capturing flora and fauna conservation through national heritage and iconography. The present article deals with an account of the state symbols of the IHR states.

METHODOLOGY

In present work, text mining approach was used to create a detailed account of the flora and fauna of IHR that are used as state symbols. Text mining is referred as the discovery of new, previously unknown information, by automatically extracting information from a usually large amount of different unstructured textual resources (Hall 2009). The following text mining strategy is used in present study.



RESULTS AND DISSCUSSION

The tactic of using flora and fauna in stamps/ currencies is beneficial for communicating the message of conservation of flora and fauna of national, regional and local importance among local/ national/ international community. Total 12 animals, 12 birds, 12 flowering plants (Table 2) and 12 trees

Table 1. Total number of plant species (including virus, bacteria, algae, fungi and lichens) and their status in World and India.

S. No.	Type	Number of known Species		Percentage of Occurrence in India	Number of Endemic Species	Number of Threatened Species
		World	India			
I. Flowering Plants						
1.	Gymnosperms	1021	74	7.35%	8	7
2.	Angiosperms	268600	18043	6.72%	ca. 4036	1700
II. Non-flowering Plants						
1.	Bryophytes	16236	2523	15.54%	629	ca. 80
2.	Pteridophytes	12000	1267	10.57%	47	414
III. Others						
1.	Virus and Bacteria	11813	986	8.77%	Not Known	Not known
2.	Algae	40000	7284	18.21%	1924	Not known
3.	Fungi	98998	14883	15.09%	ca. 4100	ca. 580
4.	Lichens	17000	2401	14.12%	ca. 520	Not known
	Total	465668	47513	–	11273	2781

(Source: Chapman 2009; Singh *et al.,* 2014 and http://www.bsienvis.nic.in)

Table 2. State symbols of Indian Himalayan Region

Name of State Flower	JK	HP	UK	SKM	WB	MEG	AS	TP	MZ	MNP	NLD	AR
Rhododendron (*Rhododendron ponticum*)	✓	X	X	X	X	X	X	X	X	X	X	X
Pink Rhododendron (*Rhododendron campanulatum*)	X	✓	X	X	X	X	X	X	X	X	X	X
Brahma Kamal (*Saussurea obvallata*)	X	X	✓	X	X	X	X	X	X	X	X	X
Dendrobium (*Dendrobium nobile*)	X	X	X	✓	X	X	X	X	X	X	X	X
Night-flowering jasmine (*Nyctanthes arbor-tristis*)	X	X	X	X	✓	X	X	X	X	X	X	X
Lady's slipper Orchid (*Paphiopedilum insigne*)	X	X	X	X	X	✓	X	X	X	X	X	X
Foxtail orchid (*Rhynchostylis retusa*)	X	X	X	X	X	X	✓	X	X	X	X	X
Indian rose (*Mesua ferre*)	X	X	X	X	X	X	X	✓	X	X	X	X
Red Vanda (*Renanthera imschootiana*)	X	X	X	X	X	X	X	X	✓	X	X	X
Shiroylily (*Lilium mackliniae*)	X	X	X	X	X	X	X	X	X	✓	X	X
Rhododendron (*Rhododendron arboreum*)	X	X	X	X	X	X	X	X	X	X	✓	X
Lady slipper orchid (*Cypripedium calceolus*)	X	X	X	X	X	X	X	X	X	X	X	✓
Name of State Bird												
Black-Necked Crane (*Grus Nigricollis*)	✓	X	X	X	X	X	X	X	X	X	X	X
Western Tragopan (*Tragopan melanocephalus*)	X	✓	X	X	X	X	X	X	X	X	X	X
Himalayan Monal (*Lophophorus impejanus*)	X	X	✓	X	X	X	X	X	X	X	X	X
Blood Pheasant (*Ithaginis cruentus*)	X	X	X	✓	X	X	X	X	X	X	X	X
White-throated kingfisher (*Halcyon smyrnensis*)	X	X	X	X	✓	X	X	X	X	X	X	X
Common Hill Myna (*Gracula religiosa*)	X	X	X	X	X	✓	X	X	X	X	X	X
White-Winged Duck (*Asarcornis scutulata*)	X	X	X	X	X	X	✓	X	X	X	X	X
Green Imperial Pigeon (*Ducula aenea*)	X	X	X	X	X	X	X	✓	X	X	X	X

Hume's Pheasant (*Syrmaticus humiae*)	X	X	X	X	X	X	X	X	✓	✓	X	X
Blyth's Tragopan (*Tragopan blythii*)	X	X	X	X	X	X	X	X	X	X	✓	X
X	X	X	X	X	X	X	X	X	X	X	X	✓
Name of State Animal Name of State Animal												
Kashmir Stag (*Cervus canadensis hanglu*)	✓	X	X	X	X	X	X	X	X	X	X	X
Snow Leopard (*Panthera uncia*)	X	✓	X	X	X	X	X	X	X	X	X	X
Alpine Musk Deer (*Moschus chrysogaster*)	X	X	✓	X	X	X	X	X	X	X	X	X
Red Panda (*Ailurus fulgens*)	X	X	X	✓	X	X	X	X	X	X	X	X
Fishing cat (*Prionailurus viverrinus*)	X	X	X	X	✓	X	X	X	X	X	X	X
Clouded Leopard (*Neofelis nebulosa*)	X	X	X	X	X	✓	X	X	X	X	X	X
Indian Rhinoceros (*Rhinoceros unicornis*)	X	X	X	X	X	X	X	X	X	X	X	X
Phayre's leaf monkey (*Trachypithecus Phayrei*)	X	X	X	X	X	X	X	✓	X	X	X	X
Sumatran Serow (*Capricornis sumatraensis*)	X	X	X	X	X	X	X	X	✓	X	X	X
Sangai (*Rucervus eldii eldii*)	X	X	X	X	X	X	X	X	X	✓	X	X
Gayal (*Bos frontalis*)	X	X	X	X	X	X	X	X	X	X	✓	✓
Name of State Tree												
Oriental Plane Tree (*Platanus orientalis*)	✓	X	X	X	X	X	X	X	X	X	X	X
Deodar (*Cedrus deodara*)	X	✓	X	X	X	X	X	X	X	X	X	X
Burans (*Rhododendron arboreum*)	X	X	✓	X	X	X	X	X	X	X	X	X
Niveum Rhododendron (*Rhododendron ferrugineum*)	X	X	X	✓	X	X	X	X	X	X	X	X
Blackboard tree (*Alstonia scholaris*)	X	X	X	X	✓	X	X	X	X	X	X	X
Candahar Tree (*Gmelina arborea*)	X	X	X	X	X	✓	X	X	X	X	X	X
Hollong (*Dipterocarpus retusus*)	X	X	X	X	X	X	X	X	X	X	X	X
Eaglewood (*Aquilaria malaccensis*)	X	X	X	X	X	X	X	✓	X	X	X	X
Ceylon Ironwood (*Mesua ferrea*)	X	X	X	X	X	X	X	X	✓	X	X	X
Uningthou (*Phoebe hainesiana*)	X	X	X	X	X	X	X	X	X	✓	X	X
Alder (*Alnus nepalensis*)	X	X	X	X	X	X	X	X	X	X	✓	X
Hollong (*Dipterocarpus retusus*)	X	X	X	X	X	X	X	X	X	X	X	✓

J&K= Jammu & Kashmir, HP= Himachal Pradesh, UK= Uttarakhand, SKM= Sikkim, WB= West Bengal, MEG= Meghalaya, AS= Assam, MZ= Mizoram, MNP= Manipur, NLD= Nagaland, AR= Arunachal Pradesh

are symbolized as state symbols in IHR states to conserve them. A brief account of these state heritages is given below (Table 1).

State Flowers

In case of flowers the species of *Rhododendron* are well-known for their aesthetic values which make them state flower of Himachal (*Rhododendron campanulatum*, colour-Pink) and Nagaland (*Rhododendron arboreum*, colour-Red). *Rhododendron arboreum* is the national flower of Nepal *R. arboretum* is the state tree of Uttarakhand and state flower of Nagaland. According to the reports of International Union for Conservation of Nature (USGS 2014), Pink *Rhododendron* comes under the endangered species of flower. The most highly coveted of ornamental plants; the delicate, exotic and graceful orchid represents love, luxury, beauty and strength. Four orchid species namely Lady slipper orchid (*Paphiopedilum insigne*), Foxtail orchids, Noble orchid (Noble *Dendrobium*), Red Vanda (*Renanthera imschootiana*) holds the state flower position in five Indian states namely Arunachal Pradesh, Meghalaya, Assam, Sikkim and Mizoram, respectively. Lady slipper orchid is common for Arunachal Pradesh and Meghalaya and it is classified as critically endangered in the Red List of Great Britain, Listed under Appendix II of the Bern Convention and Annexes II and IV of the habitats. Schedule 4 of the conservation regulations, 1994 (Mcleod *et al*., 2005, www.jncc.gov.uk/SAC). Red Vanda is considered rare and endangered and is listed on CITES Appendix 1 for which no international trade is allowed except for nursery-flasked and/or raised plants. Lotus (*Nelumbo nucifera*) is the state flower of Jammu & Kashmir. It is one of two extant species of aquatic plants in the family Nelumbonaceae.

Brahma Kamal (The Lotus of Brahma, *Saussurea obvallata*), the state flower of Uttarakhand in India is one of the most famous flowers seen in the Himalayas. *Nyctanthes arbor-tristis* (Night-flowering Jasmine) is the state flower of West Bengal. The tree is sometimes called the "tree of sorrow", because the flowers lose their brightness during daytime. *Mesua ferrea* (Sri Lankan ironwood, Indian rose chestnut, or cobra's saffron) is the state flower of Tripura. It is widely cultivated as an ornamental due to its graceful shape, grayish-green foliage with a beautiful pink to red flush of drooping young leaves, and large, fragrant white flowers. Shiroylily (*Lilium mackliniae*) is the state flower of Manipur. It is truly endemic. but unfortunately it has become an endangered species in India..

State Trees

Chinar tree is a large, deciduous tree of the Platanaceae family. The leaves and bark of the plant are used medicinally. A fabric dye has been made from the twigs and roots. *Deodar* plant is also the national tree of Pakistan. *Deodar* refers to "wood of the gods", in the Sanskrit language and it is derived from deva (i.e. god) and daru (which means wood, etym). The inner wood is aromatic and used to make incense. *Rhododendron arboreum* is a gracious and impressive species of *Rhododendrons* commonly known as Burans. It is a spectacular red flower that makes it the national flower of Nepal and the state flower of Himachal Pradesh (*Rhododendron campanulatum*) and Nagaland. *Rhododendron arboreum* is also state tree of Uttarakhand. In Uttarakhand, it is popular for the processed juice of its flowers under the trade name *Rhodo* juice/ Sharbat. *Rhododendron niveum* is a *Rhododendron* species native to northeastern India (including Sikkim), Bhutan, and southern Tibet in China. The plants are having aesthetic value and are being cultivated in gardens through Europe and America. *Alstonia scholaris* is an evergreen tropical tree in the family Apocynaceae. In Sri Lanka, its light wood is used for coffins. In Theravada Buddhism, Bodhi by first Lord Buddha is said to have used *Alstonia scholari*s as the tree for achieving enlightenment. *Gmelina arborea* scientifically claimed to be very useful in stomachic, anathematic, laxative, improve appetite, piles, hallucination, abdominal pains, fevers, burning sensations and urinary discharge. Moreover, leaf paste of *Gmelina arborea* can be applied to get relief from a headache. The Hollong *Dipterocarpus* timber is used in the construction of the houses, especially for planking. It is a very fire-sensitive plant. The wood used for plywood, internal construction work and also used as railway sleepers veneer, plywood, paper pulp and charcoal. Agar tree is now rarely found in the wild state. It is considered one of the costliest perfumery raw materials used in high-class perfumery and as a fixative, imparting a lasting balsamic odour to the product. Indian rose chestnut is a species in the family of Calophyllaceae widely cultivated as an ornamental due to its graceful shape, grayish-green foliage with a beautiful pink to the red flush of drooping young leaves, and large, fragrant white flowers. It is native to wet; tropical parts of Sri Lanka, India, southern Nepal, Burma, Thailand, Philippines, Malaysia, and Sumatra. Phoebe hainesiana or Uningthou is the state tree of Manipur. It is also an important timber tree. It provides a valuable hardwood used for furniture, ornamental panelling, shipbuilding, and musical instruments like the sitar, rudraveena, and drums. Alder tree is called utis in Nepali and Nepalese alder in English. It is used in land reclamation, as firewood and for making charcoal. It is occasionally used for making boxes and in light construction but is mainly used as firewood.

State Animals

Kashmir stag, Snow leopard, Red panda, Phayre's langur and Clouded leopard is a Schedule–I animal, according to wildlife (Protection) act, 1972 and classified as Endangered (EN) by the IUCN red list. It is protected by law in Bhutan, Nepal, and India. Kashmir stag prefers deciduous and coniferous forests for living and found on the trees. The red panda is an omnivorous animal. Red panda feed on small mammals, birds, eggs, insects, leaves, bark, fruits, flowers and berries. They mainly feed on bamboos. It also feeds on mushrooms, roots, acorns, lichen, and grasses. Musk deer is a Schedule- I animal, according to wildlife (Protection) act, 1972 and classified as Endangered (EN) by the IUCN. They prefer meadows, shrub lands and fir forests on high altitude plateaus above 2000 meters. They are very well adapted for high altitudes. They have well-developed dew claws, broad toes that provide increased stability on steep slopes. *Neofelis nebulosa*, Clouded leopard, Indian rhinoceros, Sangai and Mithun are Vulnerable on the IUCN red list and all these are Schedule–I animal, according to wildlife (Protection) act, 1972 and classified as Endangered (EN) by the IUCN. They prefer dense forested regions and wetland areas. They also found in scrub areas, reed beds, tidal creek areas, vegetated areas near water, marshes, mangroves, rivers, and streams. The Sangai State Government has taken serious and positive measures for the protection of this rare and endangered species. They prefer open scrub jungle, or undulating land between rivers and hill ranges. They inhabit area of floating vegetation known as phumdi. Himalayan serow is a threatened animal, listed in Appendix I by CITES and classed as "Vulnerable" by IUCN Red data IUCN 2004. Mithun (*Bos frontalis*) is the state animal of Nagaland and Arunachal Pradesh. Gayal is a social animal; they found in small groups and usually contain one adult male and several females and juveniles. The gestation period is between 9 to 10 month. Calves are nursed for up to nine months. The average lifespan of Gayal is between 18 to 26 years. Gayal has been classified as Vulnerable by the IUCN. The fishing cat (*Prionailurus viverrinus, Neofelis nebulosa*), Indian rhinoceros (*Rhinoceros*

unicornis) and Himalayan serow (*Capricornis thar*) are classified as Vulnerable by the IUCN where as clouded leopard is been classified very vulnerable by IUCN in the year of 2008. The Kashmir stag (*Cervus canadensis hanglu*), is a subspecies of elk native to India. The state of Jammu & Kashmir, along with the IUCN and the WWF prepared a project for the protection of these animals, known as Project Hangul. Snow leopard (*Panthera uncia*) a rare, beautiful gray leopards live in the mountains of Central Asia. In October 2012, WWF began a four-year project to conserve snow leopard habitat, promote water security, and help communities prepare for climate change impacts in central Asia. WWF developed and launched Third Pole Geo Lab, an interactive web-based tool, and database for snow leopard conservation, climate change, and water security issues in Asia's high mountains, as part of our USAID-funded project, conservation and adaptation in Asia's high mountain communities and landscapes. Musk deer (*Moschus leucogaster*), Red panda (*Ailurus fulgens*), Phayre's langur (*Trachypithecus phayrei*), Sangai (*Rucervus eldi*) are classified as Endangered (EN) on the IUCN red list. Musk deer is perhaps most famous for the waxy substance called musk that the male deer secretes from a gland in the abdomen used in perfumes and traditional medicines.

State Birds

Birds are a group of endothermic vertebrates, characterized by feathers, toothless beaked jaws, the laying of hard-shelled eggs, a high metabolic rate, a four-chambered heart, and a strong yet lightweight skeleton. Black-necked crane, western tragopan, white-winged duck, Mrs. Hume's pheasant, and great hornbill are categorized as Vulnerable (Vu) in the IUCN Red List of threatened species maintained by the International Union for Conservation of Nature (IUCN) under Appendix I and II of CITES. The conservation area or habitat in the Phobhjikha Valley (Bhutan), established in 2003 whereas Himalayan monal and white-throated kingfisher threatened classified as Least Concern (LC) on the IUCN Red List 2006. It lives in upper temperate oak-conifer forests interspersed with open grassy slopes, cliffs and alpine meadows between 2400 and 4500 meters, where it is most common between 2700-3700 meters. It is listed on Appendix I of the convention on international trade in endangered species of fauna and flora which prevents the unlicensed export of the species or its body parts. Blood Pheasant population appears to be slowly decreasing; the species is Schedule– I, according to Wildlife Protection act, 1972 and classified as Least Concern (LC) by the IUCN in 2009. The males are significantly larger than females and eggs 5 to 14, pink or yellowish white with dark brown or rufous speckles. Incubation of the eggs is mostly done by the female. The incubation period is between 27 to 30 days. *Gracula religiosa* is a known fact that Hill Myna live in isolated areas or dense forest especially in the countries of India, Bangladesh, and southern Asia. On a worldwide scale, the IUCN thus considers the common hill myna a Species of Least Concern. In 1992, Thailand had the common Hill Myna put on CITES Appendix III, to safeguard its stocks against collapsing. In 1997, at the request of the Netherlands and the Philippines, the species was uplisted to CITES Appendix II. Eggs 2 to 3, deep-blue, sparsely spotted and blotched with reddish-brown or chocolate. The incubation period often lasts between 14 to 18 days. Both sexes incubate eggs, but female spends more time incubating than the male, however, both parents tend the young equally when they hatch. Green imperial pigeon is a Schedule–IV bird, according to wildlife (Protection) act, 1972 and classified as Least Concern (LC) by the IUCN. Females lay a single white egg, sometimes 2 eggs. The incubation period is between 15 to 19 days. Both the sexes share parental duties. Hume's pheasant name commemorates Mary Ann Grindall Hume, wife of the British naturalist in India Allan Octavian Hume. It is the state bird of Manipur and Mizoram. Hume's pheasant is a Schedule– I bird, according to wildlife Protection act, 1972 and classified as Near Threatened (NT) by the IUCN. They prefer open

Fig. 1. State symbols in currency for conservation of Biodiversity

areas, forest habitats and the forested mountain areas at 1000 to 2500 meter elevation. Eggs 6 to 12, creamy white in color. Incubated by female only. The incubation period is between 26 to 28. Blyth's tragopan common name commemorates Edward Blyth (1810–1873), English zoologist and curator of the museum of the Asiatic Society of Bengal. The Blue Mountain National park in Mizoram, India is currently taking surveys of how many different Blyth's tragopan can be heard and seen in the area. The population was considered to be about 500 and 5000. Great hornbill is classified as critically endangered on the red list of Great Britain, listed under Appendix II of the Bern Convention and Annexes II and IV of the Habitats Directive 1 and Appendix II of CITES. It is fully protected under Schedule-8 of the wildlife and countryside Act 1984 and listed on Schedule-4 of the conservation regulations, 1994.

CONCLUSION

The Indian Himalayan Region (IHR) is well-known as a store house of diverse flora and fauna, and is endowed with flora, invertebrate, vertebrate fauna species. Present study successfully document the current status of flora and fauna in state symbols of HIR towards conservation of biodiversity and their current status as per CITES, IUCN and CMS list.

ACKNOWLEDGMENT

The authors are thankful to the director, G.B. Pant National Institute of Himalayan Environment (GBPNIHE) and Head Department of Botany, SSJ Campus, Kumaun University, Almora and for providing necessary facility to carry out this work.

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DESTRUCTION TO HIMALAYAN WILDLIFE INCLUDING ELEPHANTS AND LEOPARDS IN UTTARAKHAND BY HUMAN INTERFERENCE

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ABSTRACT

Human population explosion has escalated the needs for procuring more foods, clothing, houses etc. and eventually mounted the invasive and detrimental effects and rapid loss of natural habitats and wildlife. The damage by human interferences have reduced the wildlife habitats causing Human wildlife conflicts. This research article presents an overview of losses of wildlife like elephants, tigers, leopards etc. mainly in Himalayan state of Uttarakhand. The people residing nearby wildlife habitats suffer massive losses of crops, lives and properties due to fatal struggles. It was documented that from 1980 to 2003 nearly 1,150 human beings and 370 elephants were killed because of human- wildlife conflicts. During the last seven years, in Uttarakhand, 350 human beings have been brutally killed by wild animals mainly by elephants, tigers and leopards approximately 1886 injured further 32294 domestic animals succumbed to death in this fight, however, about 1715 elephants, tigers and leopards have been killed by human beings during the last 18 years in Uttarakhand. Considering the killings of both human beings and the wild animals, we have tried, through this research article, to portray and crystallize the concept of human disturbances caused fatal consequences of human-wildlife conflicts mainly in Uttarakhand with special reference to elephants, tigers and leopards.

Keywords: Human wildlife conflicts, Anthropogenic interventions, Habitat fragmentation and losses, Elephant, Tiger and Leopard and Wildlife conservation.

INTRODUCTION

Wildlife is the untamed flora and fauna of living world. With the ever increasing growth and developmental activities, human beings are interfering the spheres of wildlife causing worldwide grave concern to human- wildlife conflict. This conflict is defined as "any interaction between human being and wildlife that negatively impacts the human social, economic and cultural life, on the conservation of wildlife populations or the environment". Nearly 24% of world's land area is made by the mountains. These mountains provide house for approximately 20% of world's population and ensure 60–80% availability of world's fresh water. Besides, 50% of the world's biodiversity hotspots are being harbored in this region. The global wildlife population has decreased nearly 52% between 1970 to 2014 (Mann *et al*., 2013). These numbers are still decreasing due to both natural and anthropogenic reasons culminating in the huge biodiversity loss. In Uttarakhand approximately 12 % of total geographical area belong to protected areas including six national parks, seven wildlife sanctuaries, four conservation reserves and one biosphere reserve. Still depletion of wildlife habitats and scarcity of food and water have compelled the wild animals for movement in human settlement areas resulting in the intensified cause of human-wildlife conflicts in this Himalayan state. Table 1 present faunal groups in India and Himalayan region.

Table 1. Showing the diversified prevalence of several faunal groups in India and Himalayan regions Source (Singh 2013).

Faunal Group	No. of species in India	No. of species in Himalaya	%age Prevalence of Himalayan Fauna in Indian Context
Mammals	434	300	69.12
Birds	1232	977	79.30
Reptiles	462	176	38.10
Amphibians	312	105	33.65
Fishes	2641	269	10.19

Human- wildlife conflicts

History has witnessed various incidences of human-wildlife conflicts since prehistoric times where number of predators like tigers, crocodiles, leopards, eagles, elephants, etc. attacked on human beings. Many records of crocodile the largest predator of the time, bites have been noticed since long in the past. (Ogra 2008) extensively studied the various reasons accountable for human–wildlife conflict and made an assessment on perceptions and vulnerabilities from Uttarakhand. The revolution of agricultural farming and animal husbandry have caused a consistent increase in the incidences of conflicts between human and the wildlife.

Since the establishment of Uttarakhand state, there have been many cases of conflicts between human beings and elephants mounting injuries on both the sides. Besides it, the cause of death of many elephants in Uttarakhand is due to accidents on the railway tracks mainly passing across the forest.

So far approximately 123 elephants have been killed in the lethal fights, accidents and poaching activities of human beings in Uttarakhand . The encounters of humans with elephants, however, killed nearly 100 people. The invasions of tigers and leopards are consistently increasing every day amounting to serious injuries, casualties and death of the people. Historical records show killing of tigers/ leopards by human beings. Jim Corbett, a famous naturalist, considered man killing and eating by leopards as noxious incidence after two ultimate human leopard conflicts cases which had happened during British period in India.

Causes of human- wildlife conflicts

Any competition or conflict precipitates upon increased sharing of common resources for procurement of food, land, shelter and greed. Scarcity of any of such requirements ultimately leads to the aggressive conflicts. There may be natural or anthropogenic causes for the scarcity of food and land. With the developmental activities of human and increased population pressure of both human beings and the wildlife, there are frequent encounters and confrontations for obvious reasons between human beings and the wildlife. Some of the leading causes are discussed here (Fig.1).

Fig. 1. Various causes of human- wildlife conflicts

Population increase

The continuous rapid increase in population is a reality and can not be overlooked. An increase in human population was recorded to about 10.39 million in present year in Uttarakhand and so of tigers to about 442 (Jhala *et al.*, 2020) and more than 703 leopards. This rise in population leads to the overlapping of geographical areas and accordingly increasing the retaliatory interactions of human beings with the wild animals.

Habitat fragmentation

The habitats become fragmented generally like the patches or fragments due to the natural causes such as forest fires, drought, floods, etc. and the anthropogenic causes like construction in the forest areas, human caused forest fires, cutting of forests, etc. It has led to the isolation of wildlife species wandering and eventually entering the human settlement areas.The habitat degradation was one of the main reasons for leopard-human conflict (Goyal *et al.*, 2007). The ever increasing lust for luxury, materialistic mindset and greed of human has transformed many forest areas into barren areas. Deforestation has made wildlife deprived of their food, water, shelters and security resulting in the frequent encroachment and aggressions in human localities.

Food scarcity

Besides encroachment of forest and the habitat of wildlife, man has interrupted with the food and feeding habits of wildlife by depriving them from natural prey and food. Hence, the wildlife is compelled to behave aggressively by invading and damaging the human communities. These conflicts mount serious consequences on both human beings and wild animals causing danger to their lives. Further, menace like forest fire troubles the life and safety of wild animals and causes huge loss to natural biodiversity.

Fatal consequences of human- wildlife conflicts

The human-wildlife conflicts amount to serious damages and losses of lives of human beings as well as the wildlife including wild animals. Injury and loss of lives, habitat destruction, human property destruction, depredation of livestock, damage to agricultural fields and farms are issues of immense concern. Behavioral changes are also noticed as the expression of retaliatory responses and wild animals become more ferocious and cruel (Table 2).

Table 2. SKilling of wild animals by human beings in Rajaji National Park, Uttarakhand

Elephant	27%
Sambar	37%
Cheetal	27%
Wild boar	4%
Leopard	3%

(Source : Singh *et al.*, 2001)

Human encounters with elephants

In Uttarakhand, human communities are settled along the side of forest and wildlife habitats. Elephants are frequently seen entering the agricultural fields for food and destructing the vegetation and associated surroundings. These invasive activities have caused major loss to the property and lives of

human beings and elephants are also being killed by human beings as a consequence of retaliatory response. The crops damaged by elephants amount to an average loss of 14 percent of total annual production (Madhusudan 2003). The elephants are known killing more than one person every day in India (Rangarajan *et al*., 2010). Nearly 180 people have been killed by elephants and more than 100 elephants have also been killed brutally by human beings in protest and poaching activities Table 3. Another cause of elephant death in Uttarakhand is accidents along the railway tracks. This is also a part of human-wildlife conflict as development and construction are hindering the wild lives and their regular activities. As per the forest department between 2016-17 and 2018-19 69,39 and 60 lives were loat to elephant encounters in Uttarakhand Table 3.

Table 3. Human deaths in elephant encounters during 2016 to 2019 (report by forest department of Uttarakhand)

Years	Human lives lost
2016-17	69
2017-18	39
2018-19	60

Human, leopard and tiger conflicts

Habitat loss, fragmentation, deforestation, forest fire and hunting and poaching activities of human have resulted in the depredation and extinction of the wealth of Himalayan biodiversity and targeted mostly the prey of big cats causing difficulty for them to sustain their survival. It has forced leopards and tigers to enter the human areas and prey their domesticated animals, livestock and even the human beings. With the killing and preying humans, leopards and tigers are declared as man eaters and then killed. So, these conflicts cause loss to both humans and big cats leading to the loss of biodiversity. During the last few years, more than 28 leopards have lost their lives. It is the highest in Uttarakhand (WPSI 1994).

Mitigation of conflicts by effective management

Ever increasing number of conflicts and fatalities have forced us for strategizing several ways and means to mitigate this crisis looming large over to both the wildlife and human beings. It will bring normalcy in our relations by restoring peace and harmony. The harmonious co-existence between human beings and the wild animals is of supreme priority for ensuring normalcy and healthy relations thereby strengthening and enriching the wildlife (Aiyadurai *et al*., 2010). Translocations do impact positively in mitigating the human-wildlife conflicts (Massei 2010). The MoEF&CC, Govt. of India (2011) has issued effective guidelines for mitigation of human-leopard conflicts. Management is generally aimed at reducing the human- wildlife conflicts to protect life of human and animals, property, habitat and biodiversity. Electric fencing between human and wildlife habitats, proper and rational management of utilizing natural resources, effective land use management, well planed and lesser construction across forest areas, successful management of wildlife corridors, construction of flyovers on national highways and railway tracks for safe passage and avoiding outings and picnic/ tourism activities in wildlife prone areas mainly during night hours are some relevant steps and solutions to minimize these conflicts of invasive, detrimental and altered behavioral incidences.

FUTURE ASPECTS

Advancement related developmental activities have raised serious concerns to co-existence and overlapping of human and wildlife habitats. Advancement is a compulsory step but never ever at the cost of biodiversity. Every single species has a special value and role in an ecosystem. Steps should be taken to diversity the habitat of both the communities so that little impact or loss can be managed. Natural methods like bio-fencing, digging of wells, less developmental activities in wildlife habitats and proper development of wildlife corridors can be used. Bio-fencing is fencing with the natural plants and their products repel wildlife whereas digging of wells is generally done between the habitats of wildlife and human beings to isolate their communities. Wildlife corridors are the passage between two wild habitats usually build to accommodate the passing of wild animals and can be over bridged or under-bridged. All these methods can somehow control the human -wildlife conflicts and mitigate their impacts.

ACKNOWLEDGEMENT

I, Deo Mani Tripathi, Sr. Associate Professor of Zoology, duly thank all researchers, data providers and people involved in such researches for ensuring human beings and the wildlife including wild animals a better and healthy life.

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COVID-19 CAUSED IMPACTS ON HUMAN BEINGS AND THE ENVIRONMENT WITH A PARTICULAR FOCUS ON HIMALAYAN ENVIRONMENT AND WILDLIFE

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ABSTRACT
Corona virus disease (COVID-19), due to the infection of highly contagious and fatal corona virus, massively and adversely affected the human life worldwide. Consequential events caused huge impacts mainly on social, economical and environmental aspects of life. The biodiversity and wildlife were accordingly affected. Severity and fatality of COVID-19 have been discussed globally. This research article reviews the eventual effects of COVID-19 on various aspects of life and environment particularly on Himalayan environment and wildlife. We have considered all the aspects of COVID-19 including its impact on human life and environment worldwide. This research paper is aimed to evaluate the impact of COVID-19 on Himalayan ecosystem. Apart from the huge losses caused by COVID-19, it has also influenced positively some hot issues of environment working as a vaccine for the environment.

Keywords: Corona virus, COVID-19, Human life, Himalayan environment and Wildlife, Environmental vaccine.

INTRODUCTION
Corona viruses, the large family of crown like viruses, affect human beings through zoonotic transmission (Lokhandwala *et al*., 2020). COVID-19, a new disease due to infection of corona virus, is the abbreviated form of corona virus disease. It has affected all the aspects of human life drastically throughout the world. The outburst of COVID-19 pandemic first occurred from human sea food market in Wuhan city of China during December 2019 (Xu *et al*., 2020). Its severity and fatality to human beings forced World Health Organization (WHO) to announce this disease as an international public health emergency in a couple of weeks (WHO 2020). This virus is a single stranded RNA virus comprising of 29,891 nucleotides with a diameter ranging from 80 to 120 nm (Lai *et al*., 2007). Genomic study revealed that COVID -19 is derived from severe acute respiratory syndrome (SARS) bat virus. It is, henceforth, believed that bats could be the primary source of this virus (Chakraborty *et al*., 2020).

Symptoms of COVID-19
The COVID -19 infected persons develop a wide range of symptoms from mild to severe illness. Fever, dry cough, trouble in breathing, tiredness, body aches and chills are the symptoms of early stage after infection. Severe pathological complications like acute respiratory problem, kidney failure and cardiac injury appeared as the leading causes of mortality (Zhou *et al.*, 2020). The symptoms are varying from person to person and recently new symptoms like loss of smell and taste, rashes on skin or fingers have been noticed. Transmission of this disease occurs primarily between people through direct or close contact to infected person. The coughing, sneezing, saliva and respiratory secretions from infected person are known to infect a healthy person (Wang *et al*., 2020).

Global perspective of COVID-19
According to the World Health Organization (WHO 2021) report, till February 2021, this virus has grabbed nearly 224 countries with the death toll of 23, 81, 877 human beings from 10, 81, 53,741 infected cases. The regions of America, Africa and Europe were considered under community transmission whereas South East Asian region showed the cluster of cases (WHO 2021). COVID-19 is a highly transmissible and communicable disease causing massive human distress and damage than any other contagious disease globally. The high infection rate and death toll was uncontrolled initially in the most developed countries like USA, Italy, UK, Spain, France, Germany etc. (Paital *et al*., 2020). COVID-19 pandemic made a greater impact on health, socio-economic and environmental sectors all over the world (Owusu *et al*., 2020).

Strategies to control and clinically treat COVID-19
The clinical treatment related inability, due to unavailability of clinically efficacious drugs, menace of death was heart breaking across the globe. Thousands of people were dying of this disease every day. The death reports from the whole world were

horrifying and Milan city of Italy was one of the worst affected cities. Further, nations including America despite of the best efforts, found it difficult to contain this infection and combating the disease.

For effective control and mitigation of this highly contagious corona virus spreading, people were asked to stay home isolated. It was one of the most meaningful strategies to protect the human beings from getting infected. To control the spread of the virus and reduce the death rate, Governments of most of the affected countries imposed complete or partial lockdown. Further, lockdown completely altered the living standard of millions of people globally due to complete shutdown of industries. The means of transportation were stopped globally. The social lockdown was followed to reduce the transmission of COVID-19. To prevent the direct contact from contaminated surface and person, the use of gloves, masks, hand sanitizers, gowns, PPE kits and other safety measures proved necessary and valuable for human survival. Eventually, it resulted in the excessive use of these masks and sanitizers and generated enormous medical wastes as well as household wastes in the atmosphere (Ma *et al*., 2020). It has been reported that about 200 tons of medical waste was generated within a single day on 24 Feb., 2020 in Wuhan city of China (Luan *et al*., 2020). Inappropriate management of these wastes also resulted in the spreading of COVID-19. These wastes, upon exposure to the environment, interfered in the natural surroundings of the organisms both in terrestrial as well as in aquatic habitats.

Due to lockdown, there occurred a phenomenal decrease in the consumption of diesel, petrol and other petroleum combustions. It subsequently resulted in lowering down the air pollution in many folds. Further, the partial or complete lockdown imposed countries experienced temporary fall in the concentration of CO_2 and NO_2 (Paital *et al*., 2020). During lockdown period, the reduction in Nitrogen dioxide concentration was determined by the satellite image of NASA and European Space Agency and stated that the average NO_2 level was reduced around 40–50% in the major cities of India like Mumbai, Pune, Ahmedabad and Delhi (Wright 2020).

Table 1. Summarizing COVID-19 related research studies and their global impacts on various aspects of environment

Study	Findings	Country	References
Analysis ofthe effects of COVID-19 on environment and society	COVID-19 pandemic positivelyaffected the environment and helped in self regeneration of Nature	Global	Chakraborty *et al*., 2020
Aassessment of COVID-19 impact on several environmental factors	COVID-19 pandemic reduced the environmental pollution and improved its quality	Global	Shakil *et al*., 2020
Study the effect of COVID-19 on various environmental parameters	COVID-19 pandemic reduced the emission of nitrogen oxide, carbon monoxide, sulphur oxide and particulate matter	India	Gupta *et al*., 2020
Evaluation of lockdown impact on air and water quality Baseline study for analyzing the health impact due to reduction in air pollution	Air pollutant PM_{10}, NO_2 and CO_2 reduced Air quality index (AQI) improved in all states of India	India	Lokhandwala *et al*., 2020.
	Indian rivers like Ganga, Yamuna and Cauveri etc. became clean, clear and marine life was visible	India	
Study the impact of COVID-19 on environmental pollution	Visible reduction in air pollution and greenhouse gases due to complete and partial lockdown	Chaina	Wang *et al*., 2020
To explore the pre and post lockdown impacts on air pollution level.	Air pollution decreased up to 30% during COVID-19 pandemic	Chaina, Spain, France, Italy, USA	Muhammad *et al*., 2020
Study the lockdown impact on environment.	Air quality improved. River pollution reduced, positive effectswere noticed on various other fields.	India	Jadhav *et al*., 2020
Exploring positive and negative impacts of COVID-19 pandemic on the environment.	Reduction in greenhouse gases, air and noise pollution and improvement in water quality were observed. Ecological restoration was visible. Increase in hazardous medical waste, PPE disposal and plastic wastes was noted	India	Rume *et al*., 2020
Study of COVID-19 impact on various aspects of environment	Reduction in air and noise pollution, restoration of wildlife and biodiversity and nature rejuvenation were recorded	India	Paital 2020
Study on the impact of COVID-19 on environment	Air quality improved and wildlife was restored	Global	Rupani *et al*., 2020

Anthropogenic interventions, COVID-19 and Himalayan ecosystem and wildlife

The biodiversity of India rapidly degraded in the last two decades due to exponential industrialization, urbanization and economic growth. Himalayan ecosystem and wildlife are also facing severe anthropogenic pressure due to hydropower plant construction, developmental activities, widening and construction of roads and railways and industrialization. Detrimental consequences of pollution on river Ganga in Himalayan regions have been frequently highlighted. COVID-19 provided good chance to nature for nurturing, rejuvenating and restoring itself during the period of lockdown imposition. Apart from the positive effects, however, some negative effects also appeared like how to deal with large quantity of medical wastes and how to recycle and decompose these wastes? These all are again the anthropogenic factors. Overall, this pandemic massively disrupted the socio-economic fabrics of human beings. The GDP of almost all the countries across the world was drastically lowered down. The pandemic directly and indirectly affected the global environment like improvement of air, water and soil quality. The reduction of noise pollution and restoration of ecological relations were also reported (Chakraborty *et al*., 2020). Till date, various investigations have been made on the impact of COVID-19 on environment. These scientific studies are summarized in Table1.

Impact of COVID-19 on air and noise pollution

The studies on air pollution have shown that various air (gaseous) pollutants i.e. SO_2, NO_2 and particulate matter PM_{10} and $PM_{2.5}$ started declining in various parts of Himalayan region. In Dehradun, before lockdown in January, NO2 concentration was recorded 28.43 μg/m^3 while, during lockdown, it was reduced to 8.92 μg/m^3 (Bahukhandi *et al*., 2020). The noise pollution was reduced, during strict and effective lockdown period, because of the massive decline in commercial activities, industries and movement of vehicles. Further, the level of noise pollution was reduced up to 20-30 % in different areas of Himalaya. The average level of noise pollution was 59.55 db in pre lockdown period and it was 43.3 db in different region of Himalaya during lockdown period.

Impact of COVID-19 on forest fire

The anthropogenic factors are largely accountable for forest fires in Himalayan region. COVID-19 provided an opportunity to analyze the role of anthropogenic activities in forest fire initiation and spread in western Himalaya. Uttarakhand and Himachal Pradesh are among the worst affected states due to forest fires in recent years. Important to mention is that, due to lockdown, no human movement took place in hills of Uttarakhand and Himachal Pradesh and eventually, the anthropogenic activities of forest fire incidences in western Himalaya were minimized. Due to continued lockdown imposition, the number of forest fire incidences significantly reduced to about 80% in Indian Himalaya as compared to the previous years incidences of fire ignitions in this region (Gupta *et al*., 2020).

Impact of COVID-19 on rivers

The water quality of river Alkanada, Bhagirathi, Yamuna and other tributaries of river Ganga improved during lockdown period (Bahukhandi *et al*., 2020). BOD, COD, TDS, alkalinity and hardness were found improved and concentrations of Cl, Ca, Mg were reduced during lockdown as compared to pre lockdown period (Bahukhandi *et al*., 2020).

Impact of COVID-19 on wildlife

During COVID-19 pandemic, animals showed uncommon behavior of roaming freely on roads and in human settlement areas. According to the Times of India report, the river Ganges Dolphins were again seen at Kolkata after about three decades. It shows the reduction in Ganga river pollution. Further, the carrying capacity of hill ecosystem was found immensely influenced, both directly and indirectly, due to decline in the number of pilgrims and other kind of tourism related activities. Thus, COVID-19 provided an opportunity to wildlife and Himalayan ecosystem for effective rejuvenation and restoration. It may rationally be stated that corona virus served as an environmental vaccine to empower and improve the strength of environment.

CONCLUSION AND FUTURE PROSPECTS

It is, through this research article, attempted to evaluate and determine the impacts of COVID-19 on human life, environment and other related several aspects. The horrifying global panic of corona virus infection, its disease caused fatalities, treatment related strategies including preventive measures, impact on socioeconomic fabrics of human beings etc. have been summarized. COVID-19 related consequential effects on environment and wildlife support the view that it also servedas an environmental vaccine for effective rejuvenation and restoration of environment itself. Further, this review article specially describes COVID-19 caused impacts on wildlife and Himalayan environment and warns us of the danger ahead in life.

The future prospect of this pandemic disease is a serious threat to human beings and requires an urgent attention. A little carelessness may be far more detrimental to the entire globe including our survival. Vaccines against COVID-19 are better hopes for tomorrow but entire satisfaction may be enjoyed only after discovering clinically efficacious anti corona virus drug.

ACKNOWLEDGEMENT

Priyanka Negi expresses deep sense of gratitude to her teacher Dr. D.M. Tripathi, Sr. Associate Professor of Zoology, for his entire support and guidance and contribution in shaping this manuscript. The researchers, data providers and others involved in such research studies are duly thanked. We very sincerely express our gratitude to corona patients, corona warriors and those who lost their lives during this fatal pandemic crisis.

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RECENT SITUATION OF COVID-19 PANDEMIC AND ITS EFFECTS ON ECOLOGY AND ENVIRONMENT

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ABSTRACT

Currently, the universe is facing Coronavirus disease (COVID-19) pandemic, and the rapid transmission rates of infection have created a lot of suffering over times mainly to the humans. Slow down in industrial practices has negatively affected the economy but positively affected biodiversity. As a result, rivers are cleaner, air pollution has decreased and wild life has been nurtured. In this study the effects of COVID-19 pandemic on biodiversity, food chain, along with steps taken by various health organizations across the world have been discussed.

Keywords: Biodiversity; Biologists, COVID-19, Ecosystem and Pandemic.

INTRODUCTION

The COVID-19 is a prominent example of a viral infection that has grown as the global pandemic. The Coronavirus is a member of order Nidovirales. The genomic organization of Coronavirus consists of the positive RNA genome of 30kb. A 5' cap feature and 3' poly (A) tail that allows it to perform functions of mRNA translations in case of replicase polyproteins. The nonstructural proteins lodge 66% of the genome, which is around 20kb in the case of replicase gene encoding. The multiple loop structures which are required during replication and transcription of the RNA consists of leader sequence along with untranslated region (UTR). The 3'UTR also includes RNA, which is quite obligatory for the synthesis and replication of viral RNA. Here, the association of virus genome includes 5'-leader-UTR-replicase-S (Spike)–E (Envelope)-M (Membrane)-N (Nucleocapsid)-3'UTR-poly (A) tail while other addition genes scattered inside the structural genes on the 3' end (Sohrabi *et al*., 2020; Peeri *et al*., 2020). According to WHO the Coronaviruses are conveyed in between humans and animals, i.e. Zoonotic. The concept of Zoonotic disease first came into existence in early 1900. However, now it is globally well recognized as every new disease has 71% chances of spreading its infections via the zoonotic pathway. Such spread has many reasons, some of them are the growth of the human population and accelerating density of humans globally, rapid urbanization, the loss of biodiversity, changes of climate etc. The chances of transfer of various disease from animal to human have increased tremendously, because of the excessive damage and destruction of animal's habitats, ecology, and biodiversity by different activities of humans. For conservation biologists, the primary concern is to look at the worldwide ecological effects of COVID-19 pandemics, especially on humans, animals, plants and also on the research, training and jobs. The present study describes the implications of Covid-19 on pre and post socio-economic conditions with regard to biodiversity and its detailed analysis. Similarly, the composite effects of Covid-19 pandemic on biodiversity conservation, networking, research, education, along with job opportunities and trainings have been discussed thoroughly.

METHODOLOGY

The relevant information on recent socio-economic situation of COVID-19 Pandemic and its effects on Himalayan ecology and environment was collected from the literature survey including relevant research papers, reviews, commentaries, books and available scientific database such as Google Scholar, Research gate, Web of Science. The keyword Covid and Biodiversity along with various combination were used to obtain the search results. The abstract of suitable article were carefully retrieved. Full length articles were received from direct link or from journal websites. The literature search was limited to English language.

RESULT AND DISCUSSION

Effects of Covid-19 on Biodiversity

The establishment and enhancement of universal civilisation, increasing needs of the global population have tremendously affected the environment and forced the global biodiversity towards its decrement. At the larger scale, it includes air pollution, depletion of many plants and animals species, climatic changes, greenhouse gases production, decrement of universal drinking water level, melting of glaciers, plastic pollution, ocean pollution etc.(Imam *et al*., 2016; Gessese 2018). In April 2020, almost the commercial activities in the whole world were locked fully or partially. These precautions

were taken as necessary steps in order to prevent further spread of disease. Thus, in most of the countries across the world, the administration had put some ban on physical movement of citizens, special group movements etc. In order to do that, administrations had put a clear ban over major mass gathering events and especially the travelling industry was on the almost full ban or a total cancellation of their travels. Such restrictions on movements at the global scale is now showing tremendous positive effects on biodiversity and the environment. Lockdown has improved the water quality of Rivers all across India, including river Ganga, the life line of North India. According to the Central Pollution Control Board (CPCB), from 36 different points of the Ganga River, 27 points are considered ideal for the spread of wildlife and fisheries. Dissolved oxygen (DO) values were found to have increased 6.8 mg/ml from 3.8 mg/ml, reflecting a 79 percent increase. The value of dissolved oxygen (DO) and biological oxygen demand (BOD) levels are also up to 30% higher. According to the CPCB evaluation survey, Ganga water at Haridwar and Rishikesh in India was tested fit for drinking due to a 500 percent reduction in sewage and industrial waste. There was a decline in domestic sewage, industrial waste, cloth washing near ghats, swimming, fairs and tourism activities. Air pollution already causes illnesses such as hypertension, heart attack, cognitive and mental illness, because of COVID-19 Air pollution is decreased by up to 44%. It has been identified that CO_2 emissions increased by 1 percent per year over the previous decade before COVID-19. By 7 April 2020, the positive outcome of the lockdown was to minimize CO_2 emissions by -17 percent (-11 to -25 percent) relative to the mean emission level in 2019(Arora *et al*, 2020). In addition, the pandemic is strongly impacting not only the transport market, but also the industrial and manufacturing industries. As the manufacturing and transport industries worldwide came to a halt, global oil demand fell rapidly down and prices dropped sharply. Lockdown due to decreased transport operations because of COVID-19, resulted in less or resources consumption and reduced demand for gasoline. Such improvements in transport activities and the market for oil have a direct effect on the quality of the environment. NASA (National Space Aeronautics and Administration) and ESA (European Space Agency) have reported new data showing that environmental quality has improved and that NO_2 emissions have decreased by up to 30 percent (Arora *et al*., 2020). The negligible emission of toxins, greenhouse gases and other polluting substances have made low pollution levels across the world which is a very crucial factor for the remarkable growth and development of most of the plant species. Younger generations of metropolis cities are now experiencing a clear sky and fresh air probably for the first time in their life time. Related results are shown by reviving of ozone layer. Thus, it can be outlined that the COVID-19 pandemic had its consequences mostly for humans, but it has worked beautifully to restore the natural environmental balance and biodiversity.

The World Wildlife Fund (WWF), stated that 30% of earth's surface is covered by forests, but the global human population burst leads aggressive deforestations including lands grazing for industries and agriculture. This, ultimately has caused an enhancement in global temperature from season to season, and directly affects the universal biodiversity and ecosystem to a huge extent (Ruscio *et al*., 2015; Cuyler *et al*., 2020). Several, different pandemics and diseases also have a crucial connection with deforestation and COVID-19 can be outlined as the most recent example (Nabi *et al*., 2020; Brunda *et al*., 2020). Global ban on the trading of wildlife is needed, as the origin story of COVID-19 from the Hunan seafood market, of Wuhan China is now evident to all. A report of WHO, says the newly found members of recent zoonotic pandemics have 70% chances to originate from wild animals. So, there are possible chances of getting some new disease or viruses as zoonotic infection. Such universal ban on wildlife trading will insure the 70% reduction in zoonotic infection based pandemics worldwide (Chakraborty *et al*., 2020). Along with this, recently a survey has been conducted to evaluate the impacts of COVID-19 on food chain and security. Where as the international committee quoted that the COVID-19 is disturbing universal supply, trading and demands of food and thus, in several countries unemployed and needy persons are facing enormous difficulties to get their one-time meal (Singhal 2020; Hepburn *et al*., 2020).

Post Pandemic Analysis of Biodiversity

Some listed zoonotic microbes or pathogens which caused the different deadly diseases to the humans and other animals are H_5N_1, H_5N_2, H_1N_1, H_1N_2, Hepatitis E, Ebola, Nipah virus, Q fever, Campylobacter, *Salmonella enteritidis*, COVID-19 etc. When it comes to COVID-19, the bats are reported as the most liked reservoir for SARS COVID-2 as it is similar to bat Coronavirus. SARS-CoV already caused SARS (in 2003), MERS-CoV(in 2012) those were found to have similar zoonotic pathways and transferred from bats. When it comes to wildlife, this can be a huge problem for the world if any other animal species get affected by this pandemic. Recently lions from Bronx Zoo, USA were tested positive, which might be through zoo-worker. A new study says cats are incredibly vulnerable to Coronavirus, thus such transmission of disease from human to animal is a next level threat for biodiversity and globe, as the forests provide almost all the goods to humans stating from non-wood to wood and serve the human economy to greatest affairs. About 80% of universal biodiversity resides in the forests, and they absorb most of the CO_2 emissions, i.e., about 40%. It is estimated that almost 1.6 billion people's livelihood options depend upon forests. According to the UN report on global warming,

the deforestation causes almost 1.5°C increasement in global temperature. According to one of 2019th UN's report, human has destroyed 1/8th of the total species, which is almost one million and overall, 18% of animals are affected by wildlife traders. This scenario needs to be replaced by healthy conservation practices otherwise it can cause many pandemics like COVID-19, again and again.

Motivating prospect for conservation biologists

Human beings are responsible for the degradation of natural resources, and as a counter, we are getting affected by such pandemics like COVID-19. Thus, the conservation of biodiversity and ecosystem is not only our fundamental duty but also becomes our topmost priority if we want to have better safety of humanbeings. Stopping wildlife trades, putting complete ban on live animal markets, stopping deforestation, enhancing and taking up the research with regard to biodiversity conservation etc can address the issue to a great extent. As or now, human have not learnt from their mistakes which is resulting various universal pandemics such as SARS, Swine Flu, H_1N_1, Ebola, Malaria, COVID-19. If all countries across the world, learn from this current situation, we will be able to restrict any futuristic possibility of pandemic (Poudel 2020; MacFarlane *et al*., 2020).Useful evaluations can be made in terms of, how, when and what are the potential areas of improvements in biodiversity, how can we process ecofriendly pathways for conservation and development or biodiversity simultaneously.

CONCLUSION

The universal pandemic situation due to COVID-19 crisis with rapidly increasing rates of transmittance is a massive problem across the globe. The four modes of transmission of COVID-19 have been already mentioned by WHO which is itself an advisory to get protected from getting affected by such pandemic. As per WHO and other groups have worked very hard to create a safer environment for humans during this pandemic. Some suggestions that can be followed to find out the best possible criteria to avoid the possibility of any such futuristic pandemics situations are as under. To stop further spreading of COVID-19 pandemic everyone across the world need to follow all the guidelines provided by WHO carefully. To avoid any futuristic pandemic situation WHO and other world health organization need more efficient monitoring of the regional evaluations of disease so that it can be contained to that specific area or province before it becomes any universal pandemic. The wildlife trading and marketing needs to be stopped or needs to be done under complete government surveillance following strict rules and regulations. If it is allowed to some extent, all the necessary scientific protocols should be followed .We need to find a unique way, which can work as the modulator in between development and conservation of biodiversity.

To avoid any futuristic possibility of such economic slowdown, we need to find a unique way possible to evaluate the exact measures and parameters that can prevent such possibility of financial destruction in future. Different ayurvedic and medicinal plants have played a crucial role in combating the disease and increasing immunity during the spread of the corona virus. Therefore, cultivation of plants such as Tinospora (Giloy) should be increased so that the local people can be provided proper employment as well as biodiversity protection can be achieved.

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IMPACTS OF COVID-19 PANDEMIC ON RURAL LIVELIHOODS AND POSSIBLE SOLUTIONS – REFLECTIONS FROM ARUNACHAL PRADESH

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INTRODUCTION

The North-East Regional Centre (NERC) of G.B. Pant National Institute of Himalayan Environment (NIHE) organised a Webinar on "Impacts of COVID-19 pandemic on Rural Livelihoods in North-East India and possible solutions" on the 3rd September, 2020. The aim of the Webinar was to identify and discuss on the issues and impacts the local communities are facing in north-east India, particularly in Arunachal Pradesh. The senior officials from organizations/departments like NABARD, Arunachal State Rural Livelihood Mission (ArSRLM), Dept. of Finance, Planning & Investment, North Eastern Regional Institute of Science and Technology (NERIST) etc. participated in the webinar. During the discussions it was found that there are few sectors which has been directly affected due to COVID-19 in Arunachal Pradesh. These major sectors and impacts can be listed as:

1. Arunachal Pradesh has a great potential for agriculture, horticulture and animal husbandry sectors. However, the state has not been able to fully exploit these sectors for economic benefits due to lack of facilities for cold storage, processing facilities which led to wastage of produce particularly when the COVID-19 lockdown was imposed.

2. Marketing of the rural produce was affected a lot during the COVID-19. The major challenge in marketing sector of the produce is transportation facilities. There is no farming model for farmers & produce like large cardamom, agar and kiwi. Lack of the continuous inflow has also affected the marketing chain and absence of institutional buyer has affected the value chain due to which the primary producer has affected.

3. There is no intrastate road connectivity available in some parts of Arunachal Pradesh and therefore, transportation usually carried out through interstate roads (via Assam) to connect these parts. During the COVID-19, the Interstate transportation facilities were restricted which have badly affected the transportation of produce from one place to others within the state.

4. The state still largely depends on migrant labourers from the neighbouring state of Assam. During COVID-19 most of these labourers left the state which has affected various farm related activities.

5. The pandemic also slowed down the business of the locals due to which many of locals running their businesses in the capital (Itanagar) were also forced to move to their native places.

6. At the peak time of sowing, the COVID-19 lockdown started which has badly impacted the agricultural activities and production.

7. Transportation cost is very high because of the poor road connectivity which has resulted a negligible benefit and sometimes loss to the farmers. The loss or no benefit has discouraged the farmers for continuing their farm activities.

8. Due to COVID-19, the Self-Help Groups (SHGs) could not carry out their usual functions including SHG meetings and conducting training to farmers.

After identification of the impacts due to COVID-19 pandemic in Arunachal Pradesh, the discussions on possible solutions and future strategies were held. During the discussion the following points emerged out:

1. Government as well as private stakeholders needs to come forward for developing such facilities so that farmers can get benefited for their market produce.

2. Various challenges of Livelihood in Arunachal Pradesh due to lack of farm equipment, extension service in Rural areas, credit design for the poor/marginal farmers. He further said the complicated credit design needs to be simplified and leveraged by the respective agencies.

3. Persistent efforts are required to continue the market value chain and all the stakeholders needs to be responsible

to take the collective responsibility. There is a need for developing a model that is based on social capital. All the Government, Academic and financial Institutions needs to come forward and make a suitable model powered by social capital.

4. For future or post COVID-19, change of mindset, development of network & communication facilities is important. We need to be self-dependent for market produce.

5. To become self-sustainable, the service part was missing during COVID-19. Productivity was high irrespective of the demand but due to restriction in movement, the wastages was higher so food processing unit is important to minimize the wastages of horticulture produce.

6. Co-operative farming is necessary to assure the farmers for consumptions of their farm produce and marginal farmers should be put into more focus. Mixed cropping may be encouraged and cluster wise agricultural practices can be built up.

7. We also need to have the data on demand, supply, transportation facilities and cold storage facilities for better coordination between supplier & buyer is required.

8. Continuity of the produce flow is also important, therefore, the technological interventions in farming is important and we need to think about the long-term goals & green products. Awareness & capacity building on environmental impacts of different practices is important.

The key message on future strategies emerged out of the discussions is that all the stakeholders (including government departments) in the state needs to jointly develop a model powered by social capital for proper marketing of the local produce by establishing a proper value-chain between producers and users. This can only be achieved by first developing the capacity of farmers, development of proper storage, transportation value addition facilities within the state. There is an immediate need to gather real time data/information on local production and market demands so as to identify gaps. There is also a need for promotion of advance agriculture techniques to deal with such situations again in future and make the state self-reliant in food supply and livelihood.

AIR QUALITY INDEX (AQI) IN PRE- AND DURING LOCKDOWN PERIOD DUE TO COVID-19 AT ALMORA, UTTARAKHAND, INDIA

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ABSTRACT

The Himalayan ecosystem is one of the most complex and diversified regions of the world. The present study provides an overall status of air pollutants in the rural area (Kosi-Katarmal) near to Almora city. The results show the concentration of particulate matter and gaseous pollutants within its permissible limit as per the standards of National Ambient Air Quality (2009), and found satisfactory for human health. During lockdown period, human activities restricted to their homes and results in reduced pollution or particulate matter emissions. The highest reduction rate found in TSP, NO2, followed by BC was 55%, 50%, 48%, respectively in Almora. By using Air Quality Index (AQI) the air found to be light polluted in pre- lockdown and clean air during lockdown period.The study also recommends maintaining the current status of good environmental condition of the area through proper policies and implementation.

Keywords: Himalayan ecosystem, Air pollutants, Particulate matter, Gaseous pollutants and Air Quality Index (AQI).

INTRODUCTION

The concentration of particulate matter and gaseous pollutants in the atmosphere shows steady increase due to various anthropogenic activities. Particulate matters (PM) are inhalable particles with diameter generally less than 10 micron. PM are generated from different sources like vehicle combustion engines, residential/industrial fuel burning and leads to the secondary aerosol formation (Guo *et al*. 2019; Hama *et al*., 2020). In India, studies related to air quality associated with COVID-19 are limited but recent studies show an appreciable reduction in air pollutants (e.g., PM_{10}, $PM_{2.5}$, CO, NO_2, O_3, SO_2 and NH_3). In addition, this occurred mainly due to the decreased on-road vehicles activities and closure of non-essential industries (Mahato *et al*., 2020; Sharma *et al*., 2020). In future, climate warming may enhance the occurrence and impact of forest fires on regional air quality (Schar *et al*., 2004).The pollutants of wildfire can travel thousands of kilometres or to a long distance and can affect wide range of areas, including the pristine one, far away from the source (Damoah *et al*., 2004).

STUDY AREA AND METHODOLOGY

Almora is located on a ridge at the southern edge of the Kumaon Hills of the Himalayan range. The present study site- NIHE is located at Katarmal (29.64°N, 79.62°E and 1225m amsl). This site is 14.3 km away from Almora, and 31.6km away from Ranikhet. Generally, this region remains affected due to forest fire and experience acute problem of gaseous pollutants, particulate matter and black carbon in the surrounding environment. The present study was carried out for pre- lockdown (01 January 2020 to 20 March 2020) and during lockdown (21 March to 31 May 2020) due to COVID-19. Respirable Dust Sampler, and Fine Particulate Sampler were used to monitor PM_{10}, and $PM_{2.5}$ respectively. Air quality monitoring was based on filtration-gravimetric method and samples were exposed on 24 hourly basis. The gaseous pollutants such as SO_2, NO_2, and NH_3 were also monitored simultaneously and analyzed with modified methods of (West *et al.,*Gaeke 1956; Jacobs *et al.,* 1958), Nesseler's Regeant methods, respectively. Further, the results

Table 1. AQI Index values with remarks of different categories

Index values	Remarks
0 - 25	Clean Air (CA)
26 – 50	Light Air Pollution (LAP)
51 – 75	Moderate Air Pollution (MAP)
76 - 100	Heavy Air Pollution (HAP)
> 100	Severe Air Pollution (SAP)

Air quality of a place can be calculated by a formula which includes different parameters. The AQI was measured modifying the formula used by (Bhaskar *et al*., 2010) as follows:

AQI = 1/6 x (IPM_{10}/ SPM_{10} + $IPM_{2.5}$/ $SPM_{2.5}$ + ISO_2/ SSO_2 + INO_2/ SNO_2 + ISPM/ SSPM +IRSPM/ SRSPM) x 100

Where; I = Individual values, S = Standard value

were compared with National Ambient Air Quality Standards (2009). Air Quality Index (AQI) was also computed to know the overall pollution status. According to Environmental Protection Agency (EPA), it is divided into five different index values for dividing air quality in different categories (Table 1).

RESULTS AND DISCUSSION

Lockdown due to COVID-19 showed positive impact on the environment of Kosi-Katarmal, Almora. The current study gave us information about many aspects during pre-lockdown months (01 Jan- 20 March, 2020), maximum concentration of TSP stood to be 109.6 ± 16 µg m^{-3}, PM_{10} 73.2 ± 12 µg m^{-3}

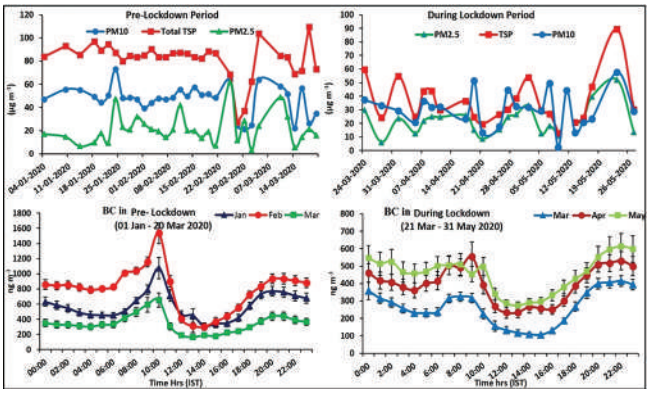

Fig. 1. Air Pollutants (a &b) PM_{10}, TSP, $PM_{2.5}$ and (c&d) Black carbon (BC) during pre- and during lockdown period at Katarmal, Almora

and $PM_{2.5}$ 62.0 ± 13 µg m^{-3}. While during lockdown period (21 March- 31 May, 2020), maximum concentration of TSP stood to be 89.4 ± 17 µg m^{-3}, PM_{10} 57.6 ± 14 µg m^{-3} and $PM_{2.5}$ 52.2 ± 11 µg m^{-3}. During pre-lockdown months (01 Jan- 20 March, 2020), maximum concentration of black carbon stood to be 4615.4 ± 91.2 ng m^{-3}. While during lockdown period (21 March-31 May, 2020) and maximum concentration of black carbon stood to be 2347 ± 43.2 ng m^{-3} (Fig.1).

Table 2. Table showing the rate and % change from pre- & during lockdown period

Parameters	Rate of change from pre- & during lockdown period	% Change
TSP	- 0.5823	- 58%
PM10	- 0.3141	- 31%
PM2.5	- 0.2606	- 26%
BC	- 0.4780	- 48%
NO2	- 0.4997	- 50%
SO2	- 0.3692	- 37%
NH3	- 0.2285	- 23%

In lockdown and pre-lockdown period, the rate and the percentage change from the pre- and during lockdown period are given in Table 2. The highest change occurred in TSP with 58% followed by NO_2 about 50% and lowest change in NH_3 decreased about 23%. Air quality index (AQI)

Table 2. Table showing the rate and % change from pre- & during lockdown period

Parameters	Time (hrs)	CPCB Standards	Pre lockdown	During lockdown
PM10	24	100	47.1	32.3
PM2.5	24	40	29.7	21.9
SO2	24	80	1.6	1.0
NO2	24	80	4.5	2.2
SPM	24	200	81.6	34.1
RSPM	24	100	37.4	14.6
Overall AQI			34.5	20.5

The AQI is one of the most important tools which is used to report the overall air quality status and trend based on specific standards. This Index gives an idea about the environmental status as air quality and also tells the general public to understand how pristine or pollute is the air they breathe daily. Table 3 shows that pre- lockdown period having AQI with 34.5 and the index values fall under 26–50 (Light Air Pollution) and during lockdown the AQI was found to be 20.5 and the index values fall under 0 –25 (Clean Air).

CONCLUSION

Air Quality Index found to be light polluted for pre-lockdown period. The main reasons of pollution were transport activities, forest fires, and number of human population and their activities in the region. Due to COVID-19, the restrictions in all these activities led to overall clean air in atmosphere

ACKNOWLEDGEMENTS

The authors are thankful to the Director, GBP-NIHE for providing facilities and Indian Space Research Organization–Geosphere Biosphere Programme (ISRO-GBP) under Atmospheric Chemistry, Transport and Modelling (AT-CTM) Environmental Observatory Scheme as well as Aerosol Radiative Forcing over India (ARFI), Government of India for financial support to this study.

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सामाजिक एवं आर्थिक विकास केन्द्र, गो.ब.प.रा.हि.प. संस्थान, कोसी–कटारमल, अल्मोड़ा)

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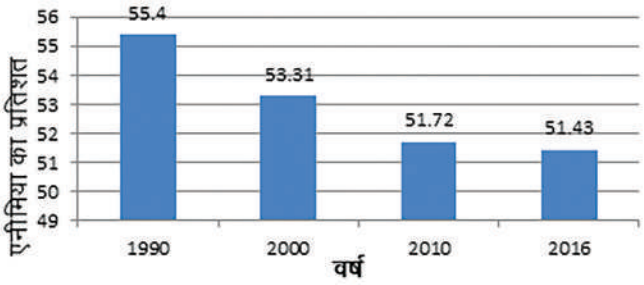
किसी भी देश की अर्थव्यवस्था में महिलाओं का महत्वपूर्ण योगदान होता है, यदि महिला शारीरिक व मानसिक रूप से स्वस्थ नहीं होगी तो उस देश की अर्थव्यवस्था भी सुदृढ़ नहीं हो सकती है, क्योंकि महिलाएं समाज का अभूतपूर्व हिस्सा होने के साथ ही सामाजिक एवं आर्थिक रूप से अर्थव्यवस्था में भागीदार होती है। आज 21वीं सदी में भी पूरा विश्व एनीमिया की मार झेल रहा है। भारत भी इससे अछूता नहीं रहा है। विश्व स्वास्थ्य संगठन 2017 के अनुसार जहां भारत में 51.43 प्रतिशत महिलाओं में एनीमिया है वहीं भारत के पड़ोसी देश पाकिस्तान में 52.1 प्रतिशत महिलाएं एनीमिक है, जो औसतन भारत से कुछ ही आगे है और नेपाल जैसे छोटे देश में 35.14 प्रतिशत महिलाएं एनीमिक हैं। वहीं विश्व में सबसे अधिक एनीमिया गाबोन व गाम्बिया देशों में क्रमशः 59.06 व 57.51 प्रतिशत है। विश्व में सबसे कम एनीमिया वाला देश ऑस्ट्रेलिया है। जहां मात्र 9.09 प्रतिशत महिलाएं ही एनीमिक हैं। भारत में जनसंख्या के आधे से अधिक महिलाएं एनीमिया की शिकार है। यह रोग नहीं बल्कि रोगों की जड़ है, इसे हिन्दी में रक्ताल्पता, यानी कि रक्त की अल्पता अर्थात कमी कहते है। यह खून में पायी जाने वाली लाल रक्त कोशिकाओं में पाये जाने वाले रक्त कणों (हिमोग्लोबिन) की संख्या कम होने से तथा लौह तत्वों की कमी से होती है। लाल रक्त कणिकायें पूरे शरीर में ऑक्सीजन पहुँचाने का काम करती हैं, यदि इन कणिकाओं की संख्या कम हो जाती है तो शरीर में ऑक्सीजन की कमी हो जाती है। जिससे कई प्रकार के रोग उत्पन्न हो जाते हैं तथा शारीरिक शक्ति में कमी आती है।

विश्व स्वास्थ्य संगठन 2017 के अनुसार यदि भारत में 10 वर्षो के अंतराल में देखे तो एनीमिया दर में कमी तो आयी है, लेकिन यह कमी नाकाफी है, जिसमें 1990 से 2016 तक मात्र 3.97 प्रतिशत की ही कमी दर्ज हुई है। जो इस प्रकार है। चित्र : 1



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एनीमिया में देश के राज्यों की स्थिति देखें तो राष्ट्रीय परिवार स्वास्थ्य सर्वेक्षण 2016 के अनुसार ज्यादा एनीमिया प्रतिशत वाले केन्द्र शासित तथा अन्य राज्यों में दादरा एवं नगर हवेली में 79.5, चंड़ीगढ में 75.9, अंडमान निकोबार में 65.7, झारखंड में 65.2, हरियाणा में 62.7, पश्चिम बंगाल में 62.5 एवं आंध्र प्रदेश में 60 प्रतिशत है। सबसे कम एनीमिया प्रतिशत वाले राज्य क्रमशः मिजोरम में 24.8, मणिपुर में 26.4, नागालैण्ड में 27.9, गोवा में 31.3 एवं केरल में 34.3 है। वहीं देश में गर्भवती महिलाओं का एनीमिया प्रतिशत में सबसे अधिक वाले केन्द्र शासित व अन्य राज्यों में भी दादरा एवं नगर हवेली में 67 प्रतिशत, झारखंड में 62.6 प्रतिशत, अंडमान निकोबार में 61.4 प्रतिशत, हरियाणा में 55 प्रतिशत, पश्चिम बंगाल में 53.6 प्रतिशत तथा आंध्र प्रदेश में 52.9 प्रतिशत गर्भवती महिलाओं में एनीमिया है, जो कि एक भयावह स्थिति को प्रदर्शित करता है।

उत्तराखण्ड राज्य में एनीमिया की स्थिति में राष्ट्रीय परिवार स्वास्थ्य सर्वेक्षण–2016 के अनुसार यह ज्ञात होता है कि 42 प्रतिशत महिलाओं में एनीमिया तथा 46.5 प्रतिशत गर्भवती महिलाओं में एनीमिया है। 6–59 माह के बच्चों में 55 प्रतिशत एनीमिया है। वहीं 42 प्रतिशत एनीमिक महिलाओं में से 31 प्रतिशत महिलाओं में मंद/कम तीव्र प्रकार का एनीमिया, 10 प्रतिशत में मध्यम एनीमिया तथा 1 प्रतिशत में अति गंभीर एनीमिया है। जो यह दर्शाता हैं कि उत्तराखण्ड में संसाधनों की अधिकता व जैव विवधता के कारण भी यहां की महिलाओं में एनीमिया स्थिति बेहद खराब है। यह स्थिति मैदानी जिलों में और भी ज्यादा चुनौतीपूर्ण है, जिसमें हरिद्वार में 55.2, उधमसिंह नगर में 52.3 एवं देहरादून में 41.5 प्रतिशत है। यही कमोवेश स्थिति गर्भवती महिलाओं में भी है, जिसमें हरिद्वार में 61.7 प्रतिशत, उधमसिंह नगर में 53 प्रतिशत गर्भवती महिलाएं एनीमिक हैं। वहीं उत्तराखण्ड के अल्मोड़ा जिला में गर्भवती महिलाओं में 40.49 प्रतिशत तथा ग्रामीण क्षेत्र की गर्भवती महिलाओं में 43.2 प्रतिशत एनीमिक है। जो राज्य के आंकड़ो की तुलना से थोड़ा बेहतर दिखती है।

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उत्तराखण्ड के अल्मोड़ा जिला के ताकुला विकासखण्ड के ताकुला–बसौली घाटी में लोक प्रबंध विकास संस्था, सुनोली द्वारा क्षेत्र में 12 गांवों में गर्भवती महिलाओं में एनीमिया की स्थिति का अध्ययन किया गया। यह क्षेत्र बिनसर वन्य जीव विहार की तलहटी में बसा है। क्षेत्र की ऊँचाई समुद्र तल से 1600–1800 मी0 तक है। अध्ययन में ए.एन.एम. तथा आशा कार्यकर्ताओं के साथ अध्ययन तथा प्राथमिक स्वास्थ्य केन्द्र में पंजीकृत गर्भवती महिलाओं की जानकारी ली गयी तथा अध्ययन हेतु सर्वेक्षण/अध्ययन किया गया। गर्भवती महिलाओं में एनीमिया के अध्ययन हेतु निम्न स्तरों पर काम किया गया।

LokLF; foHkkx ds Lrj ij& स्वास्थ्य विभाग से साथ लगातार संपर्क बनाया गया तथा नियमित रूप से अनुश्रवण किया गया। जिससे अध्ययन क्षेत्र में आने वाली सभी गर्भवती महिलाओं का स्वास्थ्य विभाग में पंजीकरण करवाना, उनको टीका लगवाना, हिमोग्लोबिन की जांच करवाना, पहला वजन लेना व अन्य आवश्यक जांचे करवा सकें।

ग्रामीण व गर्भवती महिलाओं के स्तर पर– अध्ययन क्षेत्र में जाकर सभी महिलाओं से लगातार संपर्क बनाया गया और एनीमिक महिलाओं से बैठकों, वार्तालाप व व्यक्तिगत संपर्को से उनको गर्भावस्था में खान–पान सही रखने, गर्भावस्था के समय होने वाले बदलाव पर जानकारी दी गयी तथा उनके वर्तमान स्थिति का अध्ययन किया गया। साथ ही किशोरी व अविवाहित बालिकाओं से इस पर लगातार वार्तालाप किया गया तथा आवश्यक जानकारी दी गयी, जिससे आने वाले समय में वे एनीमिया की शिकार होने से बच सके।

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vkdMk dk ,d=k.k& अध्ययन में शामिल महिलाओं के गर्भावस्था के दौरान सभी आवश्यक जांचों का आंकड़ा एकत्र किया गया, जिसे गर्भवती महिला को स्वास्थ्य विभाग द्वारा प्राप्त जच्चा–बच्चा कार्ड से लिया गया। उसके अलावा अन्य स्थिति जैसे– पारिवारिक स्थिति, बच्चों में अंतर, शादी की उम्र इत्यादि पर सर्वेक्षण का कार्य किया गया, जिससे गर्भवती महिलाओं का एनीमिक होने के कारणों को पता लगाया जा सके।

vkdMk dk fo'y"k.k& सर्वेक्षण के पश्चात निकलकर आये आंकड़ों के विश्लेषण करने का कार्य किया गया।

cky ,oa efgyk fodkl foHkkx dk Lrj ij& गर्भवती महिलाओं को बाल एवं महिला विकास विभाग में पंजीकृत करवाना, विभाग द्वारा गर्भवती महिलाओं को दी जाने वाली सुविधाओं में मिलने टेक होम राशन के वितरण व मॉनीटरिंग करना, पोषण दिवस में ए.एन.एम. को ले जाकर पोषण संबंधी जानकारी महिलाओं तक पहुँचायी गयी। जिससे वे अपने स्वास्थ्य के स्तर को स्वयं सुधारने का जिम्मा ले सकें।

ftyk o jkT; Lrj ij& गर्भवती महिलाओं की स्थिति व गर्भावस्था के दौरान मिलने वाली सुविधा न मिलने पर जिला व राज्य स्तर पर पैरवी करने का कार्य किया गया। साथ ही आंकड़ों के विश्लेषण की रिपोर्ट को जिला स्तर के अधिकारियों व जनप्रतिधियों के सामने रखा गया, ताकि राज्य सहित देश में महिलाओं की एनीमिया की स्थिति में सुधार हो सके।

ifj.kke

अध्ययन क्षेत्र में शामिल 86 गर्भवती महिलाओं में से 53 गर्भवती महिलाएं एनीमिक पायी गयी। (इन 53 महिलाओं में 16 सामान्य जाति व 37 अनुसूचित जाति की महिलाएं हैं) कुल रूप से अध्ययन क्षेत्र में 61.62 प्रतिशत महिलाएं एनीमिक पायी गयी। तालिका–1 में स्पष्ट होता है कि इन 53 एनीमिक महिलाओं में से 40 प्रतिशत महिलाएं मंद/कम तीव्र श्रेणी, 52 प्रतिशत महिलाएं मध्यम श्रेणी व 2 प्रतिशत महिला गंभीर श्रेणी की एनीमिया से ग्रस्त पायी गयी। यह अध्ययन अल्मोड़ा जिले के साथ ही उत्तराखण्ड में महिलाओं में एनीमिया की काफी खराब स्थिति को प्रद.र्शित करता है, साथ ही यह भी साबित करता है कि यह सामान्य जाति के बजाय अनुसूचित जाति में एनीमिया का प्रतिशत अधिक पाया जाता है। इन परिणामों से यह भी ज्ञात होता है कि स्वास्थ्य संबंधित सुविधाओं के होने के बावजूद भी आर्थिक रूप से कमजोर तबके की महिलाओं तक स्वास्थ्य संबंधित जानकारी पूर्ण रूप से नहीं पहुँच पाती, साथ ही वर्तमान समय में कोविड–19 जैसी महामारी के समय में यह स्थिति और भी भयावह रूप ले सकती है। कोरोना महामारी में जहां पर स्वास्थ्य संबंधित सुविधायें, कोरोना के उचार हेतु ही केन्द्रित हो जाने से गर्भवती महिलाओं हेतु अन्य आवश्यक स्वास्थ्य जांचों तथा उपचार के कारको में कमी आ रही है और स्वास्थ्य संबंधित अन्य जांचे समय पर नहीं हो पा रही हैं।

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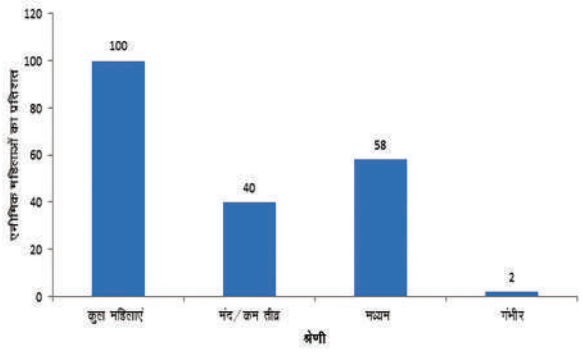
एनीमिया के कारणों से ज्ञात होता है कि आज भी ग्रामीण समाज में गरीबी, अशिक्षा, अधिक कार्य बोझ व कम समय अंतराल में बच्चों का पैदा होने के साथ ही स्वास्थ्य संबंधी जानकारियों की कमी है। साथ ही अध्ययन से यह भी स्पष्ट हुआ है कि अनुसूचित जाति में स्वास्थ्य संबंधित जानकारियों का अभाव, परिवार नियोजन की कमी के कारण भी प्रजनन दर ज्यादा होती है। वर्तमान समय में कोरोना महामारी के चलते स्वास्थ्य संबंधित अन्य कारको पर ज्यादा ध्यान नहीं दिया जा रहा है। अतः यह अति आवश्यक है कि कमजोर तबके व आर्थिक रूप से निशक्त बी.पी.एल., अनुसूचित जाति आदि वर्ग तक ए.एन.एम. तथा स्वास्थ्य विभाग की पहुँच सुनिश्चित की जाये तथा स्वास्थ्य विभाग के साथ मिलकर जागरूकता तथा मुफ्त दवा/उपचार के साधनों को सुनिश्चित किया जा सके। एक स्वस्थ महिला ही देश के स्वस्थ भविष्य को जन्म देती है।

rkfydk1 अध्ययन क्षेत्र में जातिवार गर्भवती एनीमिक महिलाओं का प्रतिशत (संख्या–53)

एनीमिक महिलाएं	कुल महिलाएं			सामान्य			अनुसूचित		
	मंद/कम तीव्र (10–10.9g/dl)	मध्यम (10–10.9g/dl)	गंभीर (10–10.9g/dl)	मंद/कम तीव्र(10–10.9g/dl)	मध्यम (10–10.g/dl)	गंभीर (10–10.9g/dl)	मंद/कम तीव्र (10–10.9g/dl)	मध्यम (10–10.9g/dl)	गंभीर (10–10.9g/dl)
100	40	58	2	13	17	0	26	42	2

स्रोत : लोक प्रबंध विकास संस्था अध्ययन रिपोर्ट



चित्रः 2 अध्ययन क्षेत्र में कुल गर्भवती एनीमिक महिलाओं का श्रेणीवार प्रतिशत (संख्या–53)

अतः यह अति आवश्यक है कि महिलाओं के स्वास्थ्य संबंधी कार्यक्रमों को बढ़ावा दिया जाये तथा स्वास्थ्य विभाग एवं गैर सरकारी संगठनों के साथ मिलकर काम किया जाय।

lanHkZ lwph

अध्ययन रिपोर्ट लोक प्रबंध विकास संस्था सुनोली ''अल्मोड़ा जिले के ताकुला विकासखण्ड में गर्भवती महिला एवं शिशु स्वास्थ्य के संदर्भ में एक अध्ययन– 2016

विश्व स्वास्थ्य संगठन रिपोर्ट – 2017

राष्ट्रीय परिवार स्वास्थ्य सर्वेक्षण – 2016

jk"Vªh; ifjokj LokLF; lo{k.k& 2016, "Fact sheet Uttarakhand, Chandigar, Haryana, West Bengal, Dadra & Nagar Have-li, Andhra Pradesh, Andaman & Nicobar, Jharkhand, Manipur, Goa, Mizoram, Nagaland, Kerala"

Kishor Surekha, Singh Mahendra, Jain Bhavana, Verma Neha, Gauande Kanchan, Kishor Sanjeev, Aggarwal Pradee, Varma Shikhar "A Study to assess prevalence of anaemia among beneficiaries of Amaemia Mukt Bharat Compaign in Uttarakhand" 2020 March.

ENVIS Centre on Himalayan Ecology
G.B. Pant National Institute of Himalayan Environment

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Following sections must appear in sequence –

Introduction (including the objectives)

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List of Tables followed by **Tables** (each in separate pages),
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Singh PA, Yadav G, Pandey A (1947). Farm Forestry in India. Indian Journal of Forestry, 74 (3): 84-88.

Book

Kumar D (1941). Ecology and control of the forest insect pests of India and neighboring countries. Vasant Press, Dehradun. 1007.

Chapter in Edited Book

Rawat RR, Wilkins DE, Negi OC, Joshi DJ (1998). Agricultural technology and adoption of practices. In: Advances in soil and water conservation (FJ Firce and WW Frye, Eds.), Chelsea. 99-158.

Unpublished Thesis and Dissertation

Mehra MS (1984). Litter fall and nutrient return in certain forest ecosystems of Kumaun Himalaya. Ph.D. thesis, Kumaun University, Nainital, 274.

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ENVIS BULLETIN
HIMALAYAN ECOLOGY

G.B. Pant National Institute of Himalayan Environment
(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Government of India)
Kosi-Katarmal, Almora-263 643, Uttarakhand, India

ENVIS Centre on Himalayan Ecology at the G.B. Pant National Institute of Himalayan Environment (GBPNIHE) was established in 1992-93 with the financial support from the Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India, New Delhi. The Centre is collecting, collating, compiling and building quantitative and qualitative databases of information related to various aspects of Himalayan Ecology. Through print/ electronic media, the Centre is regularly disseminating all available information, free of cost, to various stakeholders/users, which include all District Information Centres (working in the Himalayan states of the country), ENVIS Centres of the MoEF&CC, Universities, Research Centers, Engineering Colleges, Govt. Institutions, NGOs and experts/individuals working in the Indian Himalayan region (IHR). The main mandate of the Centre is to spread environmental awareness and help research and development in areas related to Himalayan Ecology.

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