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HIMA PARYAVARAN

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From Director's Desk

The Indian Himalayan Region (IHR) is very rich in biodiversity, cultural diversity, traditional knowledge and all kind of natural resources. However, at the same time IHR is vulnerable to anthropogenic pressures and climate change. The G.B. Pant National Institute of Himalayan Environment (NIHE) has been working for the wellbeing of Himalayan environment and for the people since more than last three decades. NIHE in the capacity of a research organization is trying to bridge the science, policy and practice gaps through action research and knowledge dissemination.

Hima Paryavaran is one of the valuable publications of the Institute and a significant means of knowledge dissemination. This particular volume of **Hima Paryavaran** has come after an undesired gap. During this period (2018-2023), the institute has made significant stride towards toning up the concepts of sustainable development in IHR. Institute's work for water security, sustainable tourism, skill development, biodiversity conservation, etc. has been greatly appreciated at regional and national level. The institute works in a decentralized set-up in IHR through its Headquarters (HQ) located at Almora (Uttarakhand) and 5 Regional Centers (RCs) located in different states of IHR. To cater the local and regional needs of diverse Himalaya, in the Year 2019 the NIHE has established its 5th Regional Center at Leh which is strategically important and expanding the horizon of the institute. The LRC of the institute is now implementing R&D activities under various innovative research programs. During the reporting period, NIHE has completed some of the landmark assignments like landscape programs (03) in collaboration with ICIMOD, NMSHE-Task Forece-3 Program, Himalayan Knowledge Network, etc.

The present volume of Hima Paryavaran addresses some of very important and relevant issues of sustainable development in IHR which will empower the reader to take responsible actions for biodiversity conservation, socio-economic development and environmental stewardship. This publication comes at a time of heightened global interest in efforts to address sustainable development agenda (eg. G20) wherein India is leading from the front.

I am personally very grateful to the authors who has contributed to this important volume. I also extend my sincere appreciation to the reviewers and editorial team for their kind efforts.

Prof. Sunil Nautiyal
Director

HIMA-PARYAVARAN
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HIMA PARYAVARAN

(Bi-Annual Newsletter)

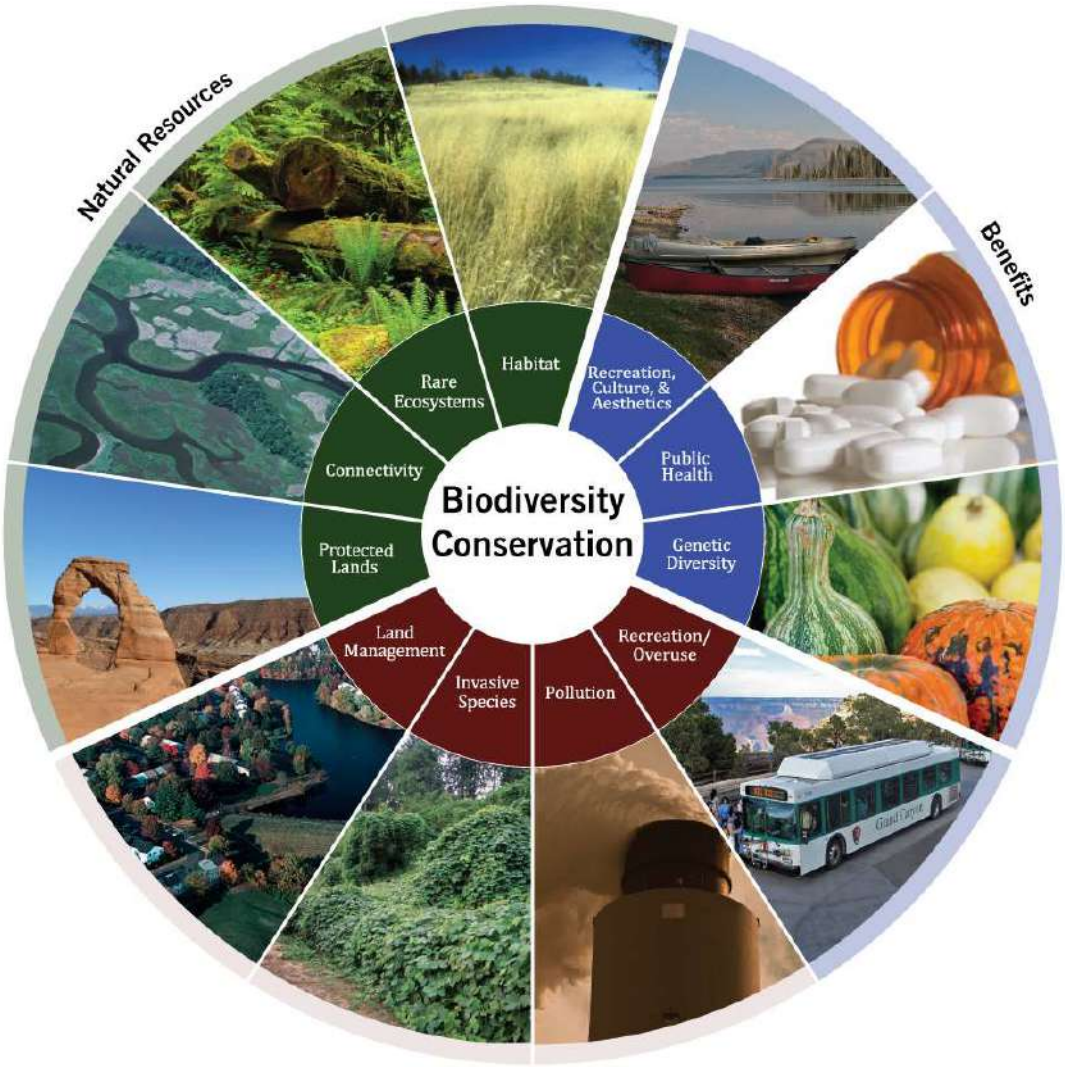
About the Institute

The G.B Pant National Institute of Himalayan Environment (GBP-NIHE) was established in 1988. It is mandated to devise suitable R&D strategies to maintain a balance of intricate linkages between socio-cultural, ecological, economic and physical systems that could lead to sustainability of the Indian Himalayan Region (IHR). The scope of Institute's R&D activities is broad and covers various facets of environment and development in the twelve Himalayan states of India. It executes its mandate through the Headquarters located at Kosi-Katarmal, Almora (Uttarakhand), and Five Regional Centres known as Himachal Regional Centre (HRC) located at Kullu (Himachal Pradesh), Garhwal Regional Center (GRC) at Srinagar-Garhwal (Uttarakhand), Sikkim Regional Centre (SRC) at Pangthang Gangtok (Sikkim), North-East Regional Centre (NERC) at Itanagar (Arunachal Pradesh), Ladakh Regional Center (LRC) at Leh and a Mountain Division at MoEFCC, New Delhi. The R&D activities of the Institute at HQs are operated through four Thematic Centres, namely - i) Centre for Land and Water Resource Management (CLWRM), ii) Centre for Biodiversity Conservation and Management (CBCM), iii) Centre for Socio-Economic Development (CSED), and iv) Centre for Environmental Assessment and Climate Change (CEA&CC), whereas the R&D at Regional Centres focus on issues of regional relevance. The Institute strives to achieve its mandate by following inter/multi-disciplinarity and integration as guiding principles, and a balanced approach with equal emphasis on research, demonstration, and dissemination activities. The emphasis on interlinking of natural and social sciences is the major thrust of all R&D programmes of the Institute. In this effort, special attention is placed on the intricate linkages between fragility of mountains, indigenous knowledge and sustainable use of natural resources, and transboundary collaborative studies on biodiversity conservation. Design and implementation of R&D activities on priority environmental problems, development and demonstration of best practices, technology packages and delivery systems for improved livelihood of the people are amongst the core issues covered under most of the Institutional projects/programmes.

Contents

Section-I

Biodiversity and Conservation



ASSESSMENT OF THE DIVERSITY OF INSECT POLLINATORS ASSOCIATED WITH *Pittosporum eriocarpum*an ENDANGERED AND ENDEMIC HIMALAYAN TREE

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Introduction

Honeybees and associated insect pollinators are the most important component of the ecosystem to ensure pollination. Pollination is one of the most essential ecological processes to ensure fertilization, fruit, and seed formation in majority of the flowering plants. Pollinators are the connecting link between wild and agroecosystems to maintain biodiversity and ecosystem health. Himalaya is the home of native and endemic plant diversity and supports the most valuable wild and domesticated bioresources that are directly and indirectly dependent on native bees and other insect pollinators for their pollination success, and crop production. Native pollinators help to keep the plant communities healthy and able to reproduce. The fruits and seeds produced by pollinated plants form an important part of the diet of birds and mammals. Many insects, including butterflies, use flowering plants as egg-laying and nesting places. The populations of native pollinators including honeybees are reported to decline due to habitat degradations and fragmentations, lack of pollen, nectar, and nesting resources, shortage of pollinator-friendly flora, use of chemicals, pesticides, herbicides, and climate change. As a result of the declining pollinator population affected the productivity of wild and agroecosystems. Himalayan native and endemic plants are important pollen and nectar resources for native insect pollinators to sustain their population. The*Pittosporum eriocarpum* is endemic to certain pockets of Uttarakhand, Himachal Pradesh and Jammu and Kashmir. Its flowers are bi-sexual and pollinated by insect pollinators. Many mature trees of *P. epirarpum* are well established in the arboretum of GBPNIHE, HRC, Mohal, Kullu, Himachal Pradesh. Realizing the importance of the Himalayan wild flowering plants in the conservation and management of native pollinators as well as ensuring pollination of native and endemic plant diversity present study "Assessment of the diversity of Insect pollinators associated with *Pittosporum eriocarpum* an endangered and endemic Himalayan tree" has been carried out.

Study Area

The study was conducted in the arboretum of the GB Pant National Institute of Himalayan Environment, Himachal Regional Center, Mohal, Kullu, Himachal Pradesh during April - May 2019. An Arboretum is an area devoted to specimen plantings of trees and shrubs It is a place where many varieties of trees are grown for research, educational, and ornamental purposes; where trees and shrubs are cultivated for exhibition. Himachal Regional Centre has initiated the establishment of Arboretum in November 2006 at Mohal (31°54.840' N Latitude and 77°07.316' E Longitude). It is spread approximately over in 2 ha land and located at 1155m, amsl in the Mohal Khad watershed. Over 50 species of trees and shrubs have been established and maintained in the Arboretum and Nursery. Majority of the species are native to the Himalaya and used for various purposes. The notable tree and shrub species are *Cedrus deodara*, *Pittosporum eriocarpum*, *Fraxinus micrantha,Platanus orientalis, Aesculus india, Cornus capitata, Quercus glauca, Q. floribunda, Q. leucotrichophora, Cornus capitata, C.*

macrophylla, Carpinus viminea, Alangium salviifolium, Ulmus wallichiana, Toona serrata, T. ciliata, Pistacia integerrima, Salix babylonica, S. tetrasperma, Acer oblongum, Pinus gerardiana, Morus alba, Pyrus pashia, Alnus nitida, Celtis australis, Buxus wallichiana, Grewia oppositifolia, Robinia pseudoacasia, Melia azedarach, Ginkgo biloba, Albizia chinensis, Bauhinia variegata, Olea ferrugenia, Alnus nitida, Pyrus pashia, Sapindus mukorossi, Dalbergia sissoo, Ficus palmata, Juglans regia, Callistemon viminalis, Berberis lyceum, Isodon rugosus, Justicia adhatoda, Opuntia monacantha, Prinsepia utilis, Roylea cinerea, Plectranthus rugosus, Zanthoxylum armatum, etc.The arboretum attracts a large number of birds, bees, and butterflies. The bird visitors are Red-headed Bullfinch, Rusty tailed Flycatcher, Wallcreeper, Spotted Forktail, Green-backed Tit, Grey Bushchat, Himalayan Bulbul, Greenish Warbler, Himalayan Black Bulbul, Red-vented Bulbul, Himalayan Blue Whistling thrush, Rock Pigeon, Common Myna, Hoope, Red-billed Magpie, Drongo, Fire breasted Sunbird, White-eye, Turtle Dove, Himalayan Spotted Dove, Paradise Flycatcher, Purple Sunbird, etc. Among the butterflies are Indian Tortoiseshell, Painted Lady, Indian Red Admiral, Chocolate Pansy, Blue Pansy Common Sailor, Common Leopard, Common Grass Yellow, Large Cabbage White, White Bordered Copper, Golden Sapphire Green Sapphire Sorrel Sapphire, Wind Mill, Hill Jezebel, Common Mormon, and Common Yellow Swallowtail, etc.

Methods

Visual /Scan sampling of the flower visitors

The main flowering season of the *Pittosporum eriocarpum* is in April and May, and flowers are full of sweet scents and attract a diverse group of insect pollinators. To assess the diversity and flower-visiting frequency of insect pollinators associated with *P. eriocarpum* tree, a scan/visual sampling was carried out.The observations were concentrated during the period (approximately 8-10 days) of maximum blooming of the selected species (Photo 1). A total of 28 observation of 15) minute each were carried out. Each day, the Observation periods were uniformly distributed according to the climatic conditions. During each 15-minute sampling unit/ period, a single selected species was viewed from a fixed point by observer, and each pollinator visit to open flowers were recorded (Ramirez et al., 2005).

Objectives

- To assess the diversity of the insect pollinators associated with *Pittosporum eriocarpum*
- To determine the flower visiting frequency of insect pollinators

Results

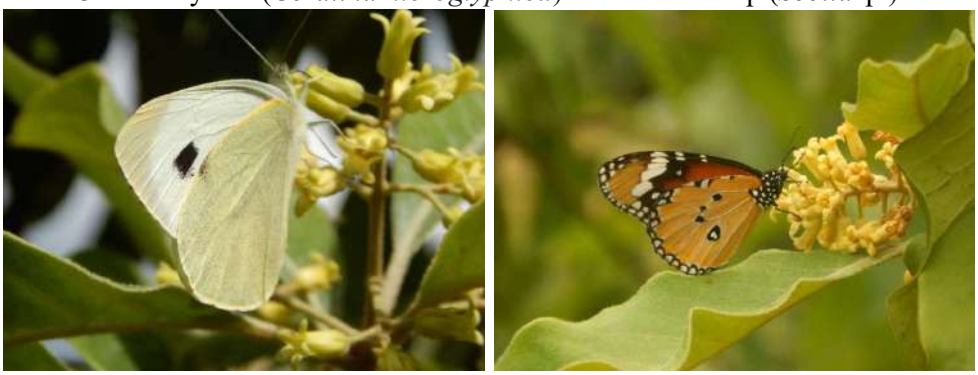
An association of 34 species of insect flower visitors representing 03 orders of 15 families and 30 genera of different groups of insect pollinators were recorded from the blooms of *Pittosporumeriocarpum* during the study period (Table 1). The P. *eriocarpum* flower visitor represented by different groups of insect pollinators i.e., Honey Bees, Bumble bees, Carpenter bees, Solitary bees, Drone flies, Syrphid flies, and Butterflies. Out of 34 species of insect visitors of *P. eriocarpum* bloom, a maximum of 16 species represented by order Lepidoptera (Nymphalidae 07 species, Pieridae 04 species, Hesperidae, Sphingidae 2 species each and Lycaenidae 01 species) followed by Hymenoptera 12 species (Apidae 5 spp., Vespidae 02 spp., Bombydae, Andrenidae, Megachilidae, Formicidae and Scolidae1 species each), Diptera 6 species (Syrphidae 04 species, Callihoridae, Muscidae 01 species. each). Among the observed flower visitors, the Indian honeybee was the most frequent visitor of the *P. epicarpum*bloom followed by Solitary bees, Butterflies, Western honeybee, Syrphid and Droneflies (Fig.1). Among the potential flower visitors are *Apis cerana, Ceratina hieroglyphica, Crocisa ramose, Apis mellifera, Vanessa cardui, Danus chrysippus, Junonia*

iphiata iphiataPieris brassicae, Episyrphus balteatu, Eristalis tenax, Eristalis arvorum. Some of the insect pollinators of the selected plant species aregiven in photo plate 2.

Photo plate 1 & 2. Full bloomstree of *Pittosporum epicarpum*

1. Indian Honeybee (*Apis cerana*) 2. Western Honeybee (*Apis mellifea*)

3. Solitary bee (*Ceratina hieroglyphica*) 4. Scolid wasp (*Scolia*sp.)



5. White cabbage Butterfly (*Pieris brassicae*) 6. Plain Tiger (*Danus chrysippus*)

Photo plate (1-6). Insect pollinators associated with *Pittosporum eriocarpum*

Table 1. Diversity of Insect pollinators associated with (*Pittosporum eriocarpum*)

Taxon	**Scientific name**	**Common name**
Hymenoptera: Apidae	*Apis indica*	Indian Honey bee
	Apis mellifera	Italian Honeybee
	Ceratina hieroglyphica	Solitary bee
	Crocisa ramosa	Solitary bee
	Xylocopa fenestrata	Carpenter bee
Bombydiae	*Bombus haemorrhoidalis*	Bumble bee
Andrenidae	*Andrena leaena*	Solitary bee
Megachilidae	*Megachile rodunta.*	Solitary bee
Vepidae	*Vespa velutina*	Wasp
	Polistes maculipenis	Wasp
Formicidae	*Camponotus* sp.	Ants
Scolidae	*Scolia* sp.	Scolid Wasp
Lepidoptera: Nymphalidae	*Agalis caschmirensis*	Indian Tortoiseshell
	Vanessa cardui	Painted Lady Butterfly
	Danus chrysippus	Plain Tiger Butterfly
	Athyma opalina	Hill Sargent
	Athyma inara inara	Himalayan Color Sergeant
	Danus genutia	Common Tiger
	Hipparchia parisatis	Himalayan Five Ring
Pieridae	*Delias belladona*	Hill Jezbel
	Junonia iphiata iphiata	Chocklate Pansy
	Precis orithaya	Blue Pansy
	Pieris brassicae	White cabbage
Lycaenidae	*Hypolcaena erylas*	Common Tit
	Schizuyaozephyrus ziha	White spotted Haristreak
Hesperidae	*Pelopidas mathias*	Small branded swift
	Oriens goloides	Common Dartlet
Sphingidae	*Macroglossum belis*	Hawk Moth
	Cephonodes hylas	Pellucid Hawk Moth
Diptera: Syrphidae	*Episyrphus balteatus*	Syrphid fly
	Eristalis tenax	Drone fly
	Eristalis himalayensis	Drone fly
	Eristalis arbustorum	Drone fly
Calliphoridae	*Calliphora vicina*	Blue bottle fly
Muscidae	*Fannia canicularis*	Lesser house fly

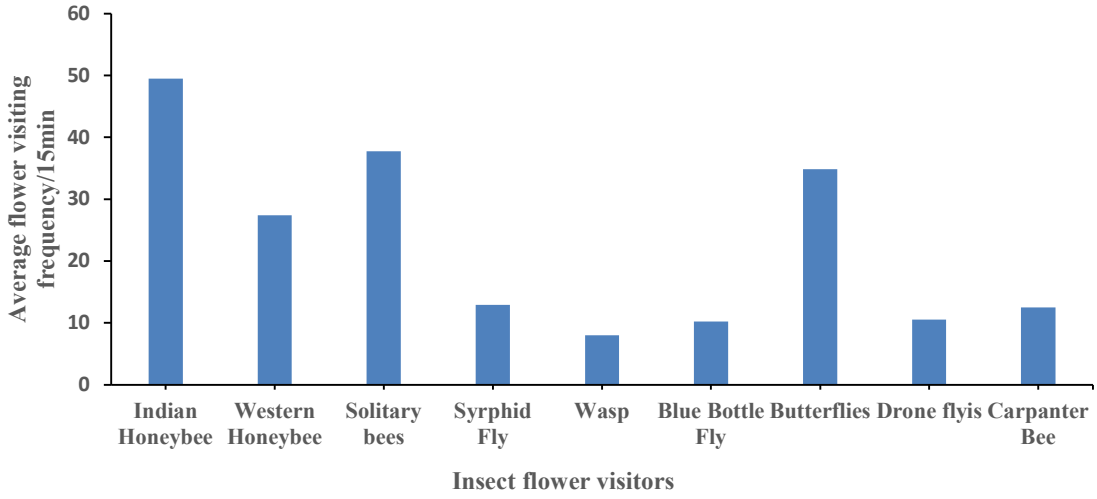


Fig. 1. *Pittosporum epicarpum* flower visiting frequency of the insect pollinators

Conclusion and future prospects

The *Pittosporum eriocarpum* is an endemic and endangered Himalayan plant. The present assessment study of insect flower visitors' diversity of this species revealed an association of 34 insect pollinators represented by Honeybees, Bumblebee, Solitary bees, Butterflies, Syrphid flies, and Drone flies. The notable insect pollinator associated with *P. eriocarpum flowers* i.e., *Apis cerana, Ceratina hieroglyphica, Megachile rodunta, Crocisa ramose, Apis mellifera, Vanessa cardui, Danus chrysippus, Junonia iphiata iphiata, Pieris brassicae, Episyrphus balteatus, Eristalis tenax*, and *Eristalis arvoru*m. The flowers of this species also attract specialist pollinator species i.e., *Xylocopa fenestrate, Macroglossum belis*, and *Cephonodes hylas*. Among the reported 34 species of insect flower visitors, the Indian honeybee was recorded as the most frequent flower visitor of this species. The flowers of this species are bisexual and cross-pollinated by honeybees and other insect pollinators. The diverse group of associated Insect pollinators with the flowers of this species may play an important role in pollination success, seed production, natural regeneration, and population restoration of this Himalayan endemic Plant. As the study indicates that the flowers of this species are highly preferred by Indian honeybees and other insect pollinators and it may be beneficial for the conservation and management of the Indian honeybee and other valuable insect pollinators. Mass multiplication and plantation of this species may be one of the important sources of bee forage to sustain the Indian Honeybee population as well as promotion of beekeeping in hilly areas for sustainable livelihood. Since this is a case study confined in the arboretum with limited information so far, multi-locational studies are required to assess the diversity of associated insect pollinators of *P. eriocarpum* species.

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AVI-FAUNAL DIVERSITY OF LADAKH AS A KEY TO UNLOCKING WILDLIFE TOURISM POTENTIAL

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Birds are distinct, omnipresent, and among the most extensively studied vertebrates on the planet. Their unique behaviors, melodious songs, and vibrant colors pique people's curiosity about these fascinating creatures. Birdwatchers, numbering in the millions, passionately observe avian species all across the globe. Among these enthusiasts, Ladakh holds a special place, located in the Trans-Himalayas of the Himalayan Mountain system. Ladakh is flanked by the Karakoram range to the north and the Great Himalayas to the south. Due to its strategic location on the border between the Palaearctic and Indo Malayan Zoogeographic Zones, Ladakh boasts a distinctive avifauna representative of both regions. In this article, the author and a group of nature enthusiast friends have meticulously documented the avian fauna of Ladakh over a period of seven years. Their journey involved extensive travels across Ladakh, with the primary objective of discovering new bird species and identifying rare avian sightings. To aid in the process of bird identification, a comprehensive range of resources was utilized, including photographs, field guide books, traditional knowledge, online bird databases and websites, journals, articles, and personal experiences. With technology becoming accessible to all, bird enthusiasts in Ladakh are also utilizing the eBird app to upload their checklists and maintain their observations. The eBird app, developed by Cornell Lab of Ornithology, serves as an online database for bird sightings. According to the data provided by the eBird app, there have been 430 bird species recorded in Ladakh to date (eBird, 2023). This includes areas of Gilgit-Baltistan under the Pakistan-occupied Jammu and Kashmir region. However, when considering the bird species reported specifically from the Ladakh region under Indian administration, the total number comes to 425. These birds are categorized into 19 Orders and 61 Families. The availability of such comprehensive data allows for a better understanding of the avian diversity in the region and aids in conservation efforts.

The bird species found in Ladakh can be broadly categorized into two main groups: resident birds and migratory birds. To ensure an organized and precise study of each species, additional subdivisions have been created within these categories. These subdivisions aim to streamline the analysis and examination of every avian species, making the study more accessible and comprehensive. By implementing these divisions, a more systematic approach can be taken towards the analysis and understanding of the diverse bird population in Ladakh.

1. Resident Birds

Resident Birds are observed and documented throughout the year, with the majority of them breeding in the same area. Some notable examples of these avian species include the Eurasian Magpie (Pica pica), Ibisbill (*Ibidorhynchastruthersii*), Carrion Crow (*Corvus corone*), Chukar (*Alectoris chukar*), Little Owl (*Athene noctua*), Tibetan Sandgrouse (*Syrrhaptestibetanus*), Bearded Vulture (*Gypaetus barbatus*), Mongolian Finch (*Bucanetesmongolicus*), Tibetan Snowcock (*Tetraogallustibetanus*), Eurasian Eagle Owl (*Bubo bubo*), and Golden Eagle (*Aquila chrysaetos*). Some resident birds can be classified as

Altitudinal Migrants, indicating their inclination to move across various altitude ranges during the spring season for breeding and raising their young. During the winter months, they descend to lower valley bottoms. A few examples of these birds include the Streaked Rosefinch (*Carpodacus rubicilliodes*), White-winged Redstart (*Phoenicuruserythrogastrus*), Eurasian Wren (*Troglodytes troglodytes*), and White-browed Tit Warbler (*Leptopoecilesophiae*). Some selected Resident Birds are shown in Fig 1.

Fig. 1. Resident Birds (a) Tibetan Snowcock (b) Tibetan Sandgrouse (c) Bearded Vulture (d) Eurasian Eagle Owl (e) Ibisbill (f) Chukar

Migratory Birds

Migratory birds comprise the majority of bird species reported in Ladakh, with approximately 65 percent of the total recorded birds being migrants. These birds can be further classified as follows:

(a) Passage Migrants

Passage Migrants are a distinct group of birds that can be observed in Ladakh for only a brief period of time. They utilize a few key stopover sites in order to feed and refuel before continuing their journey to their primary breeding areas outside of Ladakh during the spring season. Additionally, these birds can also be seen during the autumn season as they migrate back towards their wintering grounds. Examples of passage migrants include the Northern Wheatear (*Oenanthe oenanthe*), Red-tailed Shrike (*Lanius phoenicuroides*), Osprey (*Pandion haliaetus*), Barred Warbler (*Currucanisoria*), Goldcrest (*Regulus regulus*), Demoiselle Crane (*Grus virgo*), Eurasian Curlew (*Numenius arcuata*), Greylag Goose (*Anseranser*), as well as rare species such as the Lesser Grey Shrike (*Lanius minor*), Rustic Bunting (*Emberiza rustica*), Meadow Pipit (*Anthus pratensis*), and Wood Warbler (*Phylloscopussibilatrix*). Notably, both the Meadow Pipit and Wood Warbler have only been photographed in the Ladakh region within India.Some selected Passage Migrantsare shown in Fig 2.

Fig 2. Passage Migrants (a) Wood Warbler (b) Osprey (c) Greylag Goose (d) Goldcrest (e) Demoiselle Crane

(b) Summer Visitors

Summer Visitors are migratory species that are recorded in the Ladakh region from mid-March until mid-October. They utilize the Ladakh range as their breeding site. Among the well-known summer visitor species in the region are the Black-necked Crane (*Grus nigricollis*), which is also the state bird of UT Ladakh, the Bar-headed Goose (*Anser indicus*), known as the world's highest-flying bird, and the Endangered Saker Falcon (*Falco cherrug*). Other noteworthy species include the Eurasian Hobby (*Falco subbuteo*), Tibetan Lark (*Melanocorypha maxima*), Upland Buzzard (*Buteo hemilasius*), Eurasian Hoopoe (*Upupa epops*), Great Crested Grebe (*Podiceps tristatus*), Common Cuckoo (*Cuculuscanorus*), and Mountain Chiffchaff (*Phylloscopussindianus*), among others.Some selected Summer Visitorsare shown in Fig 3.

Fig 3. Summer Visitors (a) Upland Buzzard (b) Eurasian Hobby (c) Black-necked Crane (e) Bar-headed Goose

(c) Winter Visitors

Winter Visitors are species that can be observed during the winter months in Ladakh, from mid-October until mid-April. During this time, the average temperature remains below -10º Celsius, and in certain areas, it even dips below -30 º Celsius. Despite the harsh winters, some bird species bravely survive these extreme temperatures. Noteworthy species in this category include Naumann's Thrush (*Turdus naumanni*), Dusky Thrush (*Turdus eunomus*), Brambling (*Fringilla montifringilla*), Eurasian Woodcock (*Scolopaxrusticola*), Hen Harrier (*Circus cyaneus*), Merlin (*Falco columbarius*), Himalayan Buzzard (*Buteo refectus*), Northern Goshawk (*Accipiter gentilis*), Himalayan White Browed Rosefinch (*Carpodacus thura*),

Buff-bellied Pipit (*Anthusrubescens*), and Common Snipe (*Gallinagogallinago*).Some selected Winter Visitorsare shown in Fig 4.

Fig 4. Winter Visitors (a) Naumann's Thrush (b) Himalayan Buzzard (c) Eurasian Woodcock (d) Dusky Thrush (e) Brambling

(c) Vagrant/Straggler

During the migration season, a few bird species may deviate from their main migratory routes due to adverse weather conditions and the lack of food at their regular stopover sites across the trans-Himalayan range. These species, when sighted in Ladakh outside of their typical migratory paths, are referred to as vagrants or stragglers and are generally observed individually. Some examples of these vagrants/stragglers include the Common Shelduck (*Tadornatadorna*), Amur Falcon (*Falco amurensis*), Red Crossbill (*Loxiacurvirostra*), Shikra (*Accipiter badius*), Rufous-bellied Niltava (*Niltavasundara*), Paddyfield Pipit (Anthusrufulus), Bohemian Waxwing (*Bombycillagarrulus*), Whistler's Warbler (*Phylloscopuswhistleri*), Sedge Warbler (*Acrocephalusschoenobaenus*), Garden Warbler (*Sylvia borin*), Common Wood Pigeon (*Columba palumbus*), Trumpeter Finch (*Bucanetesgithagineus*), Oriental Dollarbird (*Eurystomusorientalis*), Daurian Starling (*Agropsarsturninus*), Rough-legged Buzzard (*Buteo lagopus*), and Sharp-tailed Sandpiper (*Calidris acuminata*). Some selected vagrant/straggler are shown in Fig 5.

Fig. 5. Vagrant/Straggler (a) Trumpeter Finch (b) Red Crossbill (c) Paddyfield Pipit (d) Common Shelduck

In conclusion, the avian faunal diversity of Ladakh holds immense potential for unlocking wildlife tourism in the region. Ladakh's unique geographical features, including its high-

altitude desert environment and varied habitats, have contributed to the presence of a rich birdlife. Through the use of technology, such as the eBird app, bird enthusiasts in Ladakh are actively documenting their observations and contributing to the growing database of avian species. The recorded data reveals a remarkable diversity of bird species, with 430 recorded in Ladakh, including areas of Gilgit-Baltistan under Pakistan's administration. For the Indian-administered Ladakh region specifically, there have been 425 bird species documented across 19 Orders and 61 Families. This wealth of avian biodiversity presents a valuable opportunity for wildlife tourism development in the region. By leveraging the avi- faunal diversity of Ladakh, tourism initiatives can be designed to cater to birdwatchers and nature enthusiasts. Wildlife tourism can be a sustainable form of economic growth, providing local communities with livelihood opportunities while fostering conservation efforts. Efforts to promote and protect the avian diversity of Ladakh should focus on sustainable tourism practices, conservation education, and the preservation of natural habitats. Collaboration between local communities, governmental agencies, and conservation organizations is crucial for ensuring the long-term success of wildlife tourism in Ladakh. Overall, Ladakh's avi-faunal diversity stands as a key asset that, when properly harnessed, can unlock the full potential of wildlife tourism, bringing economic benefits and conservation outcomes to the region.

COMPOSITION AND DISTRIBUTION OF SHRUBS AND TREES IN GLACIATED AND NON-GLACIATED TREELINE ECOTONES OF THE INDIAN HIMALAYAN REGION

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Abstract
High-altitude regions offer valuable opportunities for the study of diverse flora and floral communities. This research specifically focuses on the ecotones found at treeline, which represent the transition zone between subalpine forests and alpine regions, within glaciated and non-glaciated valleys of the Indian Himalayan Region. Through the implementation of transect-based surveys, this study aims to document the variety of shrubs and trees present along the elevation gradient in treeline ecotones. Within the study area, a total of 21 species, encompassing both shrubs and trees, have been identified. The significant abundance of plant species in a relatively small geographical area underscores the importance of conserving treeline ecotone ecosystems to preserve Himalayan plant biodiversity. Notably, certain species demonstrating higher tolerance to cold conditions were discovered within the cooler environments of the glaciated valley. Differences in species composition and occurrence shed light on community-level processes and the dynamics of treeline ecosystems. The study emphasizes the role of topography in creating microclimatic conditions that influence species compositions and create favorable environments for survival and growth. By enhancing our understanding of these relationships, this research contributes to the development of effective management and preservation strategies for these ecologically significant areas.
Key words: Alpine, Treeline ecotones,Glaciated valley, non-Glaciated valley, Floral diversity.

Introduction

High-altitude regions offer unique and intriguing opportunities for the study of diverse flora and floral communities, primarily due to the rapid transformations that occur within short distances (Testolin et al., 2021). Among these regions, the treeline serves as a critical ecological boundary, marking the transition from subalpine forests to the vast expanse of alpine tundra, making it an invaluable setting to observe and understand these remarkable transformations (Montesano et al., 2020).In high-altitude ecosystems, treeline ecotones are shaped by various topographic conditions, including elevation, aspect, and slope, resulting in the creation of distinct local climates and microclimates that play a crucial role in shaping species interactions and the dynamic relationships between vegetation and the surrounding environment. These treeline ecotones harbor highly endemic flora, with the Indian Himalayan Region alone boasting an impressive 30% endemism rate, highlighting its significance as a reservoir of unique plant species (Bargali et al., 2022).Despite their ecological importance, treeline ecotones have historically received relatively less research attention. However, in recent years, there has been a growing interest in studying these ecologically sensitive areas,

driven in part by concerns about climate change and its potential impacts on treeline dynamics (Gulzar et al., 2022). The need for a more comprehensive understanding of these ecosystems has become increasingly apparent.It is important to acknowledge that treeline ecotones exhibit considerable global variation, influenced by a complex interplay of factors such as plant species composition, climate patterns, topography, soil conditions, and historical land-use practices (Bader *et al*., 2021). These unique combinations give rise to distinct ecological processes and dynamics, underscoring the necessity for region-specific investigations.

Materials and Methods

The study focused on the treeline ecotones of Nan Pakhwa (NPK) and Pakhwa (PKW) summits in the Bageshwar district, which separate the Pinder and Saryu valleys. The Pinder River originates from the Pindari glacier, while the Saryu River is monsoon-fed and originates from Sarmool (Kothyari, 2014). These valleys exhibit distinct environmental and microclimatic conditions influenced by topography, including the presence of a glacier in the Pindari valley, contributing to variations in floral diversity. The elevations of the NPK and PKW sites ranged from 3060 to 3440 m asl. The study employed transect-based surveys, one in a non-glaciated valley with a southern treeline aspect, and another in a glaciated valley with a northern treeline aspect (Figure 1). The NPK summit is located at 30°07′22.1′′N, 79°58′33.0′′E (3365 m asl), while the PKW summit is located at 30°07′35.7′′N, 79°58′44.4′′E (3465 m asl).

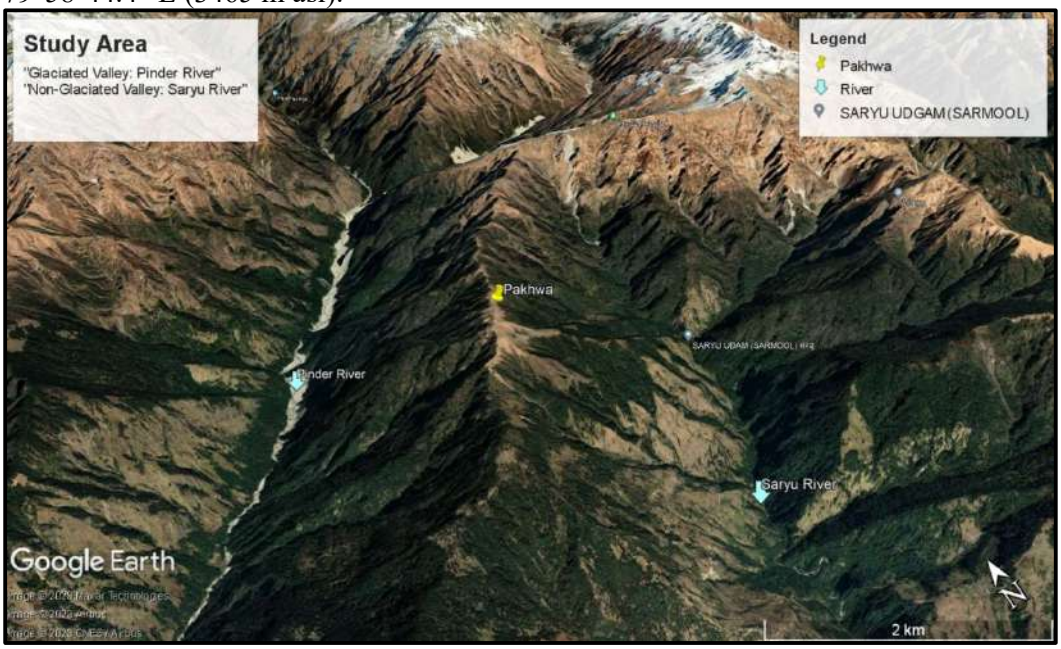

Fig. 1. Glaciated and non-Glaciated valley types along Pinder River and Saryu River

Results & Discussion

A total of 21 species, including shrubs and trees, were identified in the treeline ecotones of glaciated and non-glaciated valleys around Nan Pakhwa and Pakhwa summits. These species belonged to 16 genera and 12 families. Specifically, the treeline ecotone of the glaciated valley had 16 species from 13 genera and 9 families, while the treeline ecotone of the non-glaciated valley had 14 species from 11 genera and 10 families. The taxonomic inventory of shrubs and trees found in the study area is presented in Table 1. The largest family was

Rosaceae, comprising 7 species, accounting for approximately 33% of the overall species richness, followed by Ericaceae with 3 species. The percentage distribution of species among different families is shown in Fig. 2. In total, 14 shrub species from 7 families were reported across all study sites. Only one family, Polygonaceae, was exclusively found in the treeline ecotone of the non-glaciated valley. Seven tree species from 6 families were recorded, with Aceraceae and Ericaceae being common to both valleys. Our findings indicate higher species richness of treeline-forming trees (7 species) and shrubs (14 species) compared to a study conducted in the treeline ecotone of the Kashmir Himalayas, which reported 3 tree species and 8 shrub species (Gulzar *et al*., 2022). This difference can be attributed to the greater topographical variance, represented by the presence of both glaciated and non-glaciated valleys in our study area.

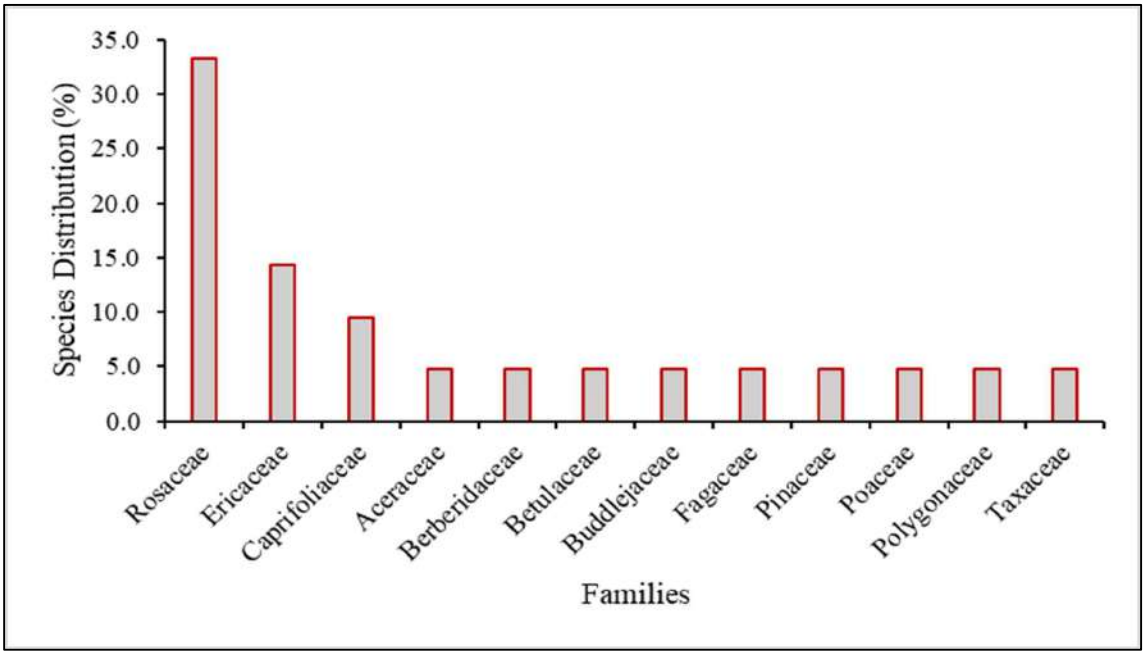

Fig. 2. Percent distribution of Species in different families

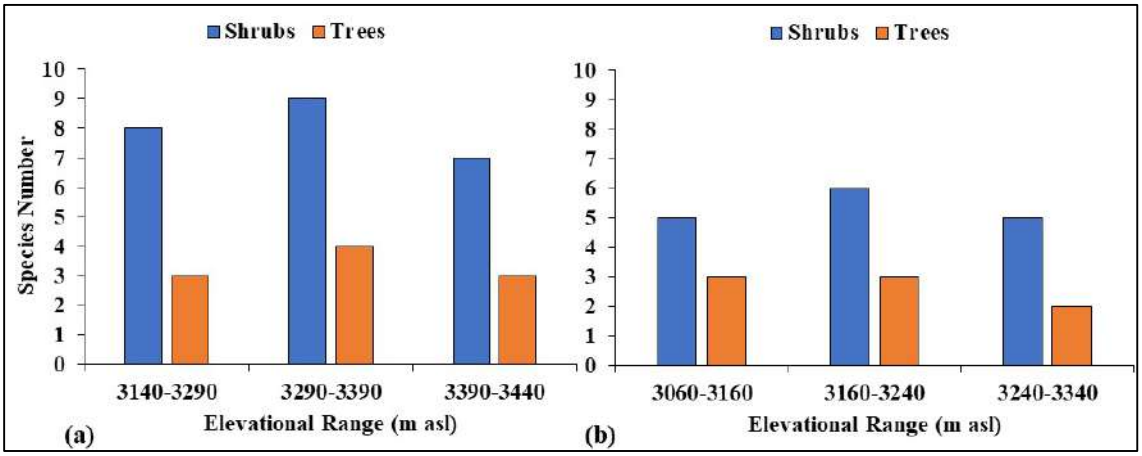

Fig. 3. Distribution of Species in different Elevational range in the studied treeline ecotone of (a) Glaciated valley, and (b) non-Glaciated valley

Table 1. Taxonomic inventory of Shrub and Tree species reported from studied Treeline Ecotones of Glaciated and non-glaciated valleys

S. No.	Species name	Life-form	Family	Glaciated Valley	Non-Glaciated Valley
1	*Berberis kumaonensis*Schneid.	Shrub	Berberidaceae	+	+
2	*Buddlejapaniculata* Wall.	Shrub	Buddlejaceae	+	+
3	*Cotoneaster acuminatus*Lindl.	Shrub	Rosaceae	+	+
4	*Cotoneaster microphyllus* Wall. ex Lindl.	Shrub	Rosaceae	+	+
5	*Lonicera myrtillus* Hook. f. & Thoms.	Shrub	Caprifoliaceae	+	-
6	*Polygonum paniculatum* L.	Shrub	Polygonaceae	-	+
7	*Rhododendron campanulatum*D.Don	Shrub	Ericaceae	+	-
8	*Rosa macrophylla*Lindl.	Shrub	Rosaceae	+	+
9	*Rosa sericea*Lindl.	Shrub	Rosaceae	-	+
10	*Rubus foliolosus* var. *racemosus* (Hook. f.) B.D.Naithani	Shrub	Rosaceae	+	-
11	*Rubus nepalensis* (Hook. f.) Kuntz.	Shrub	Rosaceae	-	+
12	*Sorbus foliolosa* (Wall.) Spach	Shrub	Rosaceae	+	-
13	*Viburnum grandiflorum* Wall. ex DC.	Shrub	Caprifoliaceae	+	+
14	*Yushania anceps* (Mitford) W.C.Lin	Shrub	Poaceae	+	+
15	*Acer acuminatum* Wall. ex D.Don	Tree	Aceraceae	+	+
16	*Abies spectabilis* (D.Don) Mirb.	Tree	Pinaceae	+	-
17	*Betula utilis*D.Don	Tree	Betulaceae	+	-
18	*Quercus semecarpifolia* Sm.	Tree	Fagaceae	-	+
19	*Rhododendron arboreum* Sm.	Tree	Ericaceae	+	+
20	*Rhododendron barbatum* Wall. ex G.Don	Tree	Ericaceae	+	-
21	*Taxus wallichiana*Zucc.	Tree	Taxaceae	-	+

Note: + = Presence; - = Absence

Comparing the species composition between the treeline ecotones of glaciated and non-glaciated valleys, we found 11 and 10 shrub species, and 5 and 4 tree species, respectively. Seven shrub species (50%) were common to both valleys. *Lonicera myrtillus, Rhododendron campanulatum, Rubus foliolosus,* and *Sorbus foliolosa*were unique to the glaciated valley, while *Polygonum paniculatum, Rosa serica,* and *Rubus nepalensis*were exclusive to the non-glaciated valley. Regarding trees, *Acer acuminatum* and *Rhododendron arboreum were* found in both valleys. *Abies spectablis, Betula utilis,* and *Rhododendron barbatum* were reported in the treeline ecotone of the glaciated valley, while *Querecussemecarpifolia*and *Taxus wallichiana* were reported in the treeline ecotone of the non-glaciated valley. This distribution pattern may be influenced by species' tolerance levels to low temperatures in the glaciated valley, resulting in specific environmental conditions favoured by particular species. The distribution of shrub and tree species along three different elevational gradient classes are presented in Figure 3. The highest richness of shrub species was observed in the middle elevational zone of both valleys, possibly due to overlapping vegetation from lower and higher elevational zones. Within the treeline ecotone transects of the glaciated valley, three tree species were recorded in the lower elevational range (3140-3290 m asl) and the higher elevational range (3390-3440 m asl) with different species compositions. Similarly, in

the treeline ecotone of the non-glaciated valley, three tree species were reported in the lower (3060-3160 m asl) and middle elevational range (3160-3240 m asl). Some species showed restricted distribution within a small elevational zone within the treeline ecotone.For example, *Taxus wallichiana* was limited to the lower elevational transects of the non-glaciated valley, while *Betula utilis* and *Abies spectabilis* were restricted to the middle and upper elevational zones of the glaciated valley. This specific distribution of species in a small geographical area demonstrates how topography creates microclimatic conditions that support particular species compositions and provide favourable conditions for their survival, growth, and local dispersal (Chandra et al., 2018).

Conclusion

This study presents valuable findings regarding the makeup and distribution of shrubs and trees in glaciated and non-glaciated valleys within treeline ecotones. The significant abundance of plant species within a confined geographic area underscores the vital importance of conserving these treeline ecotone ecosystems to safeguard Himalayan plant biodiversity. Notably, the occurrence of specific species such as *A. spectabilis, B. utilis, R. barbatum, L. myrtillus, R. campanulatum, R. foliolosus,* and *S. foliolosa* in the colder environments of the glaciated valley highlights their exceptional ability to tolerate cold conditions compared to species limited to the treeline ecotone of the non-glaciated valley. The disparities observed in species composition and occurrence yield valuable insights into community-level processes and the dynamics of treeline ecosystems. The specific distribution of species within a limited geographical area showcases how topography influences the creation of unique microclimatic conditions that facilitate distinctive species compositions and provide favourable circumstances for their survival, growth, and local dispersal. Through documenting species diversity across various topographic settings, this study advances our understanding of the intricate relationships between topography, microclimates, and species dynamics within high-altitude ecosystems.

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CARBON SEQUESTRATION: A CRUCIAL COMPONENT IN BIODIVERSITY CONSERVATION

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Abstract

This paper explores the significance of carbon sequestration as a crucial component in biodiversity conservation. Carbon sequestration, the process of capturing and storing carbon dioxide (CO_2) from the atmosphere, plays a vital role in mitigating climate change and preserving global biodiversity. By examining the interconnections between carbon sequestration and biodiversity conservation, this paper highlights the various ways in which carbon sequestration initiatives contribute to the protection and enhancement of biodiversity. The paper emphasizes the importance of habitat preservation, ecosystem services, climate regulation, adaptation and resilience, and co-benefits for local communities. It further highlights the potential of carbon sequestration projects to achieve synergistic outcomes by integrating biodiversity conservation goals. Through this comprehensive review, the paper aims to shed light on the critical role of carbon sequestration in maintaining ecological balance and safeguarding our planet's natural heritage.

Introduction

Carbon sequestration is indeed a crucial component in biodiversity conservation. It refers to the process of capturing and storing carbon dioxide (CO_2) from the atmosphere, preventing it from contributing to climate change (Lewis et al., 2019). Carbon sequestration plays a significant role in mitigating the effects of greenhouse gas emissions and stabilizing global climate patterns(Yoro and Daramola, 2020). By reducing the concentration of CO_2 in the atmosphere, carbon sequestration helps to limit global warming, which in turn supports biodiversity conservation in several ways?

Biodiversity conservation and climate change mitigation are two pressing global challenges that require urgent attention and integrated solutions. In this context, carbon sequestration has emerged as a crucial component in biodiversity conservation efforts (Portner *et al*., 2021). Carbon sequestration refers to the process of capturing and storing carbon dioxide (CO_2) from the atmosphere, effectively reducing greenhouse gas emissions and combating climate change (Shahbazi and Nasab, 2016*).* However, the significance of carbon sequestration goes beyond its role in climate change mitigation. It is intricately linked to biodiversity conservation, as it supports habitat preservation, ecosystem services, climate regulation, adaptation and resilience, and co-benefits for local communities. This introduction sets the stage for understanding the importance of carbon sequestration as a multifaceted approach that not only addresses climate change but also contributes significantly to the preservation and enhancement of global biodiversity.

This study is important because it addresses the critical need to understand the interconnections between carbon sequestration and biodiversity conservation. By examining the relationship between these two domains, the study can provide valuable insights into how carbon sequestration initiatives can simultaneously contribute to climate change mitigation and the preservation of biodiversity (Lamba *et al*., 2023). Understanding the synergies and potential co-benefits of integrating these approaches is essential for developing effective

strategies and policies that address both global challenges. Moreover, this study can inform decision-making processes by highlighting the importance of habitat preservation, ecosystem services, and the well-being of local communities. Ultimately, the findings of this study can contribute to more holistic and sustainable approaches to conservation and climate change mitigation efforts, thereby fostering a healthier and more resilient planet.

Habitat Preservation

Many carbon sequestration methods, such as afforestation and reforestation, involve planting trees and restoring forests. Trees provide essential habitats for numerous plant and animal species, promoting biodiversity by providing food, shelter, and breeding grounds. Increased forest cover helps preserve the biodiversity of ecosystems and supports a wide array of species (Cunningham *et al*., 2015).

Interconnections between Carbon Sequestration and Biodiversity Conservation

The interconnections between carbon sequestration and biodiversity conservation are multifaceted and mutually reinforcing. Carbon sequestration initiatives, such as afforestation, reforestation, and the restoration of degraded ecosystems, contribute directly to the preservation and enhancement of biodiversity (Sahoo *et al*., 2022). These involve planting trees and restoring habitats, which provide essential shelter, food, and breeding grounds for numerous plant and animal species. Moreover, healthy ecosystems, including forests, wetlands, and grasslands, have the capacity to store significant amounts of carbon and regulate local and regional climate patterns (Salimi *et al*., 2021*)*. This climate regulation supports the survival of diverse species that rely on specific climatic conditions. Conversely, biodiversity conservation efforts play a crucial role in supporting carbon sequestration by maintaining the health and functionality of ecosystems. By protecting habitats, preserving ecosystem services, and enhancing the resilience of species and ecosystems, the conservation of biodiversity contributes to the success and sustainability of carbon sequestration initiatives. Together, carbon sequestration and biodiversity conservation create a positive feedback loop, fostering the preservation of our planet's natural heritage while mitigating climate change (Malhi *et al*., 2020).

Ecosystem Services

Biodiversity is closely linked to the provision of ecosystem services, including nutrient cycling, water purification, and pollination. Carbon sequestration initiatives that focus on restoring degraded ecosystems or protecting natural habitats contribute to the maintenance of these services. Healthy ecosystems, in turn, support a diverse range of species and help sustain the overall biodiversity of an area (Brockerhoff *et al*., 2017).

Climate Regulation

Biodiversity conservation and carbon sequestration are interconnected through their influence on climate regulation. Healthy ecosystems, including forests, wetlands, and grasslands, have the capacity to store large amounts of carbon and regulate local and regional climate patterns. This stability is crucial for the survival of various plant and animal species that rely on specific climatic conditions (Malhi *et al*., 2020).

Carbon sequestration importance in climate change mitigation

Carbon sequestration plays a critical role in climate change mitigation by reducing the concentration of carbon dioxide (CO_2) in the atmosphere. As one of the primary greenhouse gases contributing to global warming, CO_2 emissions are a major driver of climate change. Carbon sequestration helps counterbalance these emissions by capturing and storing CO_2,

preventing it from entering the atmosphere and exacerbating the greenhouse effect (Lynch *et al.,* 2021). By removing CO_2 from the air, carbon sequestration initiatives help to stabilize global climate patterns, reduce the rate of global warming, and mitigate the impacts of climate change on ecosystems, communities, and economies worldwide. It serves as a vital tool in efforts to transition towards a more sustainable and low-carbon future, making carbon sequestration of utmost importance in climate change mitigation strategies.

Adaptation and Resilience

Biodiversity conservation is essential for enhancing the resilience of ecosystems and species to environmental changes, including those caused by climate change. Carbon sequestration efforts can contribute to this by protecting and restoring habitats that provide refuge for species vulnerable to the impacts of global warming. By creating more resilient ecosystems, carbon sequestration helps safeguard biodiversity in the face of changing climatic conditions (Weiskopf *et al*., 2020).

Conclusion

Carbon sequestration is a vital tool for mitigating climate change and plays a crucial role in biodiversity conservation. By preserving habitats, supporting ecosystem services, regulating climate, enhancing adaptation and resilience, and providing co-benefits to local communities, carbon sequestration contributes significantly to the conservation of biodiversity and the protection of our planet's natural heritage.

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ASSESSING QUANTITATIVE VEGETATION CHARACTERISTICS AND BIODIVERSITY PATTERNS IN THE FORESTS OF MAHARAJA VALLEY, HIMACHAL PRADESH

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Abstract

The Indian Himalayan Region is renowned as a biodiversity hotspot due to its diverse forest ecosystems. Himachal Pradesh is one of the Indian Himalayan states, which has a diverse forest type and plays an important role in maintaining the region's ecological integrity. However, these forests face numerous threats that endanger their sustainability and the entire Himalayan ecosystem. Therefore, present study has been carried out in the forest vegetation of villages in Maharaja Valley.Our study's main objectiveis collection of baseline data on the structure and composition of the village's forest communityin relation to the species diversity, density, frequency and abundance. Total of 17 species of trees have been recorded. The Important Index Value (IVI) ranged7.39-120 (Site-1), 5.85-157 (Site-II), 6.218-151.9 (Site-III) and 8.3-197 (Site-IV). These IVI values would provide insights into the relative significance and contributions of different tree species in the overall ecosystem. The most dominating species were *Pinus roxburghii*, *Quercus floribunda*, *Alnus nitida* followed by *Pinus Wallichiana* and *Toona Ciliata*. Current study will provide baseline information on the forest vegetation of these villages which can be used for the development of tree species database of the region.

Introduction

Forests are vital components of our planet's ecosystems, providing numerous ecological, economic, and social benefits. They serve as essential habitats for a diverse array of floral and faunal species, contribute to global carbon sequestration and climate regulation, support local livelihoods, and offer recreational opportunities. IHR, with its majestic landscapes and rich biodiversity, is home to significant forest cover. The forests have always been an essential source of livelihood for the local communities, which have evolved traditional ways of utilising the forests in order to meet various needs ranging from food, fodder, and fuel-wood to medicine and timber. As per the current data, IHR is facing several threats which will affect their viability in the run-in near future. These threats include anthropogenic disturbances, commercial utilization of forests and alienation of the local population from their traditional forest's rights. Himachal Pradesh's biodiversity is rapidly diminishing due to human-caused stresses and climate change. Therefore, conducting both qualitative and quantitative assessments of vegetation is imperative (Sharma and Samant, 2013). Forest vegetation assessment will provide insights into the overall health and resilience of the forests. Our study aims to investigate the structural characteristics and species composition of the village forest, providing valuable insights into its ecological dynamics and biodiversity.

Methods

Field survey and quadrate sampling was performed during the winter season at the forest communities of the cluster villages under Khadiyar and Balh-2 Gram Panchayat under Kullu

district. At each site, random sample was takenby laying ten 10*10m quadrates. Standard ecological techniques were implemented to collect data from these quadrates(Khanduri *et al*., 2017; Sharma and Samant, 2013). For each species, the circumference at breast height (cbh at 1.37m) of each tree in each quadrat was measured and recorded individually (Khanduri *et al*., 2017; Sharma and Samant, 2013). Only trees with a CBH greater than 31.5cm were selected for this study (Sharma and Samant, 2013). The data were quantitatively assessed for frequency, density, and dominance (Curtis and Mcintosh, 1950). The relative values were obtained and added together to generate the Important Value Index.

Results and Discussion

A total of 17 tree species were identified in the selected study area. At site II and III, highest number of trees species was recorded. Fig.1 depicts the percentage frequency of the species with highest detection range across all sites. The Important Index Value (IVI) ranged from 5.85-197. IVI is measurement of the species with ecological importance in the community. It takes into consideration, both the relative abundance and relative frequency of the species. Based on the IVI values, the following dominant tree species were identified at the study sites: *Pinus roxburghii* (120), *Quercus floribunda* (157), *Alnus nitida* (151.9) and *Pinus wallichiana* (66.2). Having the highest IVI suggests that these species are an important component of the forest community and has a significant impact on the overall biodiversity of the community. These dominant species are likely to have a substantial impact on ecological processes such as nutrient cycling, biomass production, and species interactions.It may also provide serives like carbon sequestration, water regulation and conservation and management efforts also.

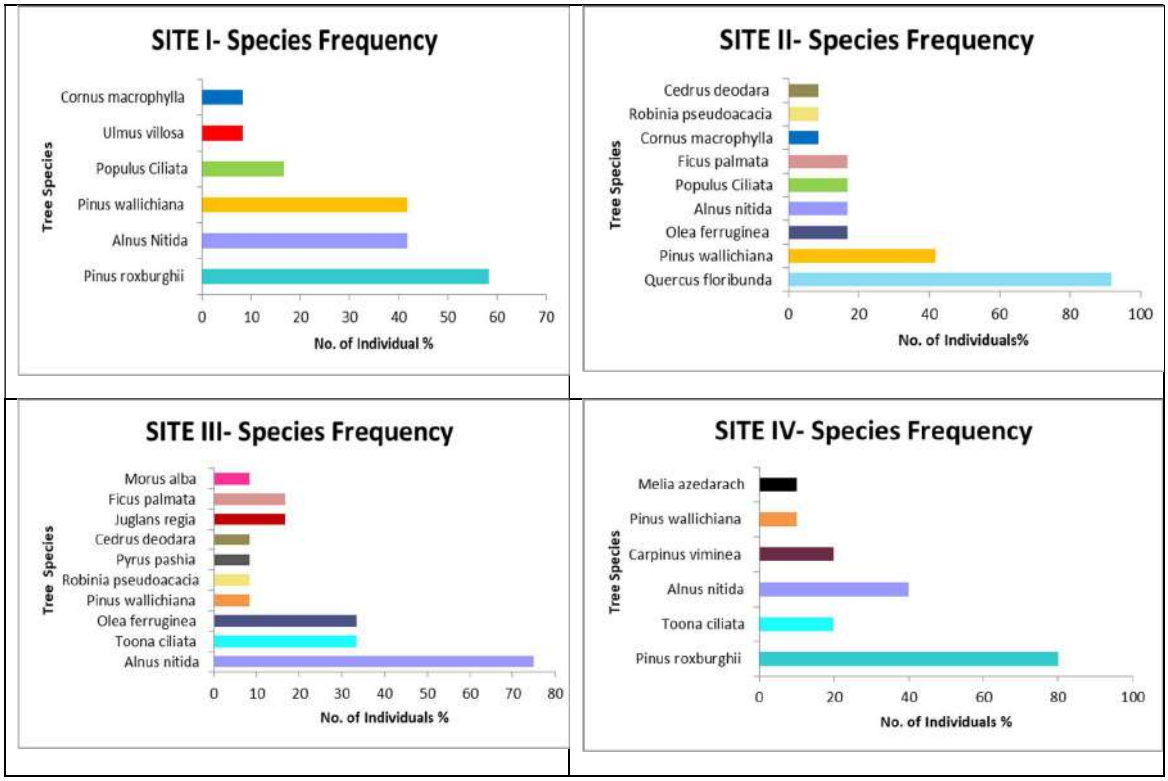


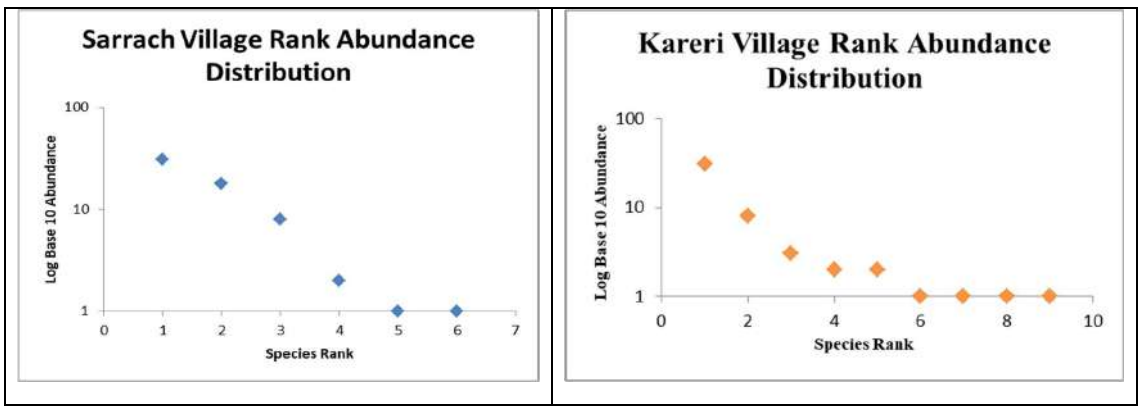
Fig. 1. Site-wise tree species percentage frequency distribution

In determining the species diversity and dominance of the forest community in the four villages, the Shannon-Wiener Information Index (Spellerberg and Fedor, 2003)and Simpson's Index were used(Simpson, 1949). The Simpson index (cd) values recorded in Table 1 ranged from 0.23-0.64, which was within the reported range across these categories of forests. The evenness index has a value of 0.49 -0.77, indicating that the distribution of individuals within the different species is not very uniform, with some species being more abundant than others. As for the species diversity, the values suggest that the biodiversity of the four sites is different, with Site III having the highest Shannon's index (1.77) and Site IV having the lowest Shannon's index (0.88). Higher Shannon's index value indicates a more diverse ecosystem with a greater number of species and a more even distribution.

Table 1. Site Wise Species Diversity, Dominance and Evenness

Study Site	Number of Trees	Shannon Weiner Index (H′)	Simpson's Index (Cd)	Evenness Index (Eq)
Site-I Sarrach	6	1.21	0.64	0.68
Site-II Kareri	9	1.32	0.40	0.60
Site-III Pachahli	10	1.77	0.23	0.77
Site-IV Buragran	6	0.88	0.59	0.49

To visualize the distribution of species abundances in a community, rank abundance distribution curve was plotted for sites. The curve can provide insights into the structure and diversity of the community (Foster and Dunstan, 2010). A log scale can be used to plot the abundance rank curve as this will help in revealing the patterns in the distribution of species abundance that might not be apparent on a linear scale. The slope of the curve indicates the evenness of the distribution of individuals among the different species in the community. In Fig. 2. The species ranks are in descending order. Site I have a steep slope, followed by Site IV and Site-II. However, Site-III has a shallow slope which indicates that the distribution of individuals among the different species in the community. Therefore, the rank abundance distribution curve can be used to complement the information provided by Shannon's index and Simpson's index and to gain a more complete understanding of the biodiversity and ecological health of an ecosystem (Avolio *et al*., 2019).



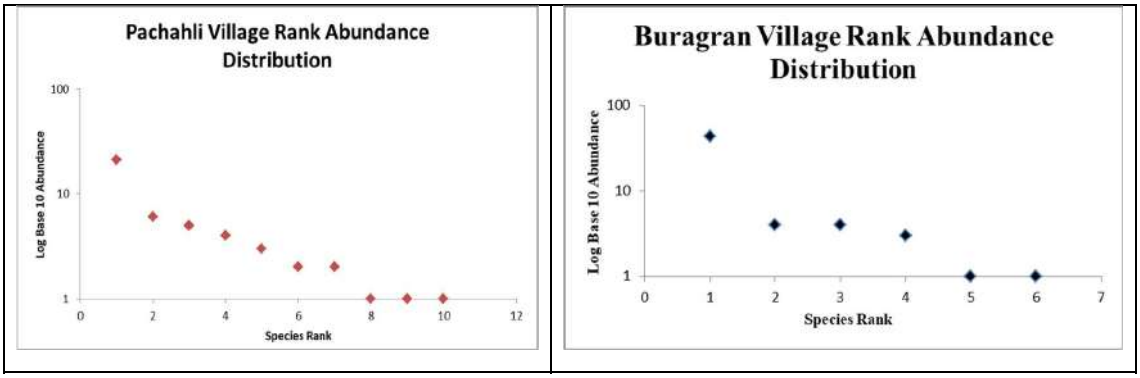


Fig. 2. Site wise rank abundance distribution curve

Conclusion

Results can be used for developing tree species database and information for future research. It can also be helpful for the locals in order to develop sustainable practices, promote biodiversity conservation, and maintain ecosystem services and long term health and productivity of forest community. However, it is important to acknowledge the limitations of the data as it has been recorded for the first time. Further research and data collection may be needed to confirm the results. Increase in sample size is recommended for future studies for its accuracy.

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BOTANICAL CARNIVORY IN NORTH-EAST INDIA: PHYLOGENETIC INSIGHTS FROM CHLOROPLAST GENOMES

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Abstract

Carnivorous plants (CPs) have unique mechanisms for attracting, capturing, and killing animal prey and obtaining sustenance through the absorption of their biomass. CPs have highly specialised features tothrive in quite sensitive ecologies, as they are often constrained to nutrient-depleted habitats where carnivory provides a competitive advantage. These plants are severely affected by habitat degradation, land use change, and changes to natural ecological processes, and are particularly vulnerable to processes such as eutrophication and weed invasion, as well as poorly understood impacts such as airborne nitrogen inputs.Nepenthes khasiana, India's sole Nepenthes representative, is a rare and endangered dioecious carnivorous plant native to North-east India. Despite being a well-known insectivorous plant in the Nepenthaceae family, genomic resources are sparse, making genomic breeding and understanding the genetic basis of key characteristics difficult. As a result, the full mitochondrial and chloroplast genomes of N. khasiana were identified for the first time using next generation sequencing technologies, in order to better understand their evolutionary ties with other carnivorous plants.

Introduction

Many of the world's 860 Carnivorous Plant (CP) species are found in wetland habitats, which are among the most destroyed and degraded ecosystems on the planet. Utricularia (38 species), Drosera (3), Nepenthes (1), Pinguicula (1), and Aldrovanda (1) are the five genera with 44 species identified in India (Santapau & Henry 1976; Singh and Sanjappa 2011; Kamble *et al*., 2012). North-eastern India is home to a total of 21 of these species. We report the first comprehensive analysis of the five lineages and all major families of carnivorous plants' chloroplast genome phylogeny. Nepenthes sp., sometimes known as tropical pitcher plants or monkey cups, is a carnivorous plant genus. Hundreds of different species of insects can be found in the plant species. *Nepenthes khasiana*, the only representative of the genus Nepenthes in India, is a rare, endangered, dioecious member of the carnivorous plants found in Northeast Indiaand is included in the Botanical Garden List of Rare and Threatened Species of India compiled by the International Union for Conservation of Nature and Natural Resources.Among the various medicinal properties, the digestive juice of the unopened pitcher plant is used as an eye- drop to treat cataract and night blindness.Though *N. khasiana* is a well-known insectivorous plant, there is a scarcity of genomic resources, which impedes genomic breeding and comprehension of the genetic basis of important traits. Multiplication of this ecologically and economically important wild plant through seeds and cuttings (micropropagation) is difficult. In spite of this an effort has been made for its ex-situ conservation. We generated the full organelle genomes of *N. khasiana* with NCBI refseq accessions. This reference genome could provide essential genomic resources for N. khasiana evolution, breeding, and research into its unique evolutionary biological features.

Methodology

High quality gDNA was isolated from the *N. khasiana* leaf sample using Qiagen Genomic-tip 100/G; quality and quantity ensured by Agarose gel electrophoresis and Nanodrop/Qubit

Fluorometer. The shotgun and mate pair libraries were sequenced on NextSeq 500 using 2 x 150 bp chemistry. The adapter trimmed reads were used for assembling. The chloroplast genome was assembled using adapter trimmed shotgun reads in NOVOplasty. The chloroplast genome was pulled from a whole genome sequencing initiative. Reads from shotgun library with insert size 45011 bp was used for assembling the organelle genomes. The cp genome was assembled using NOVOplasty [Dierckxsens et al., 2017). The Cp genome was annotated using DOGMA (Wyman *et al*., 2004), CpGAVAS (Liu *et al*., 2012) and BLAST (blastn, blastp and tblastx) (Altschul, 1990) (Fig.1). All other CP genomes for other insectivorous families were retrieved from GenBank as outlined in Table 1.

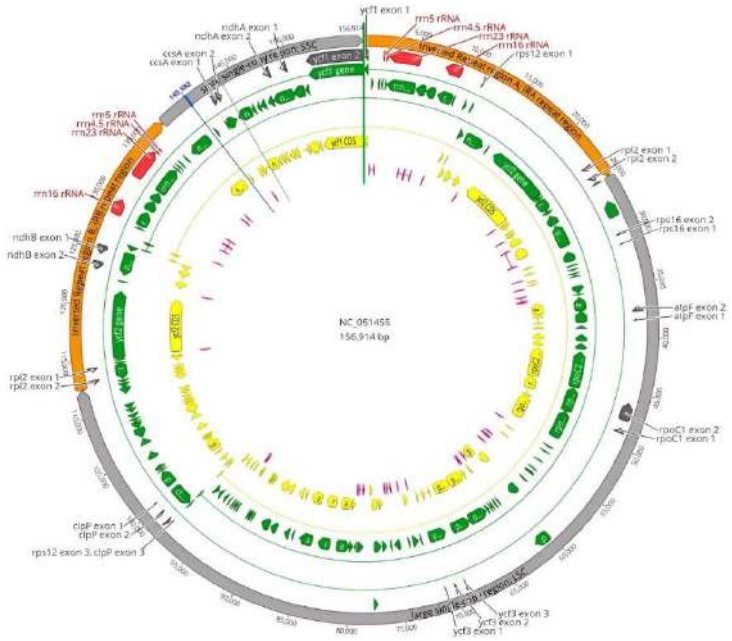

Fig. 1. Annotated chloroplast genome of *Nepenthes khasiana*

Table 1. List of carnivorous plant species whose chloroplast genomes are used in this study

Family	Species	GenBank ACCESSION
Cephalotaceae	Cephalotusfollicularis	NC_042597
Drosophyllaceae	Drosophyllumlusitanicum	NC_040939
Dioncophyllaceae	Triphyophyllumpeltatum	NC_069067
Droseraceae	Aldrovandavesiculosa	NC_035416
	Dionaeamuscipula	NC_035417
	Droseracapensis	NC_073004
	Droserarotundifolia	NC_029770
	Droseraregia	NC_035415
	Droseraerythrorhiza	NC_035241
	Droserapeltata	MZ297473
Nepenthaceae	Nepentheskhasiana	NC_051455
	Nepenthesmirabilis	NC_041271
	NepenthesventricosaxNepenthesalata	NC_044185
Lentibulariaceae	Genliseaaurea	NC_037078
	Genliseafiliformis	NC_037079
	Genliseamargaretae	NC_025652
	Genliseapygmaea	NC_037080

	Genliserepens	NC_037081
	Genliseatuberosa	NC_037082
	Genliseaviolacea	NC_037083
	Pinguiculaehlersiae	NC_023463
	Pinguiculaalpina	NC_056190
	Pinguiculajackii	NC_068629
	Utricularia macrorhiza	NC_025653
	Utricularia gibba	NC_021449
	Utricularia foliosa	KY025562
	Utricularia reniformis	NC_029719
	Utricularia amethystina	MN223720
	Utricularia adpressa	NC_071362
	Utricularia tenuicaulis	NC_058517
Roridulaceae	Roridula gorgonias	NC_069066
Sarraceniaceae	Heliamphora minor	NC_069063
	Sarracenia alata	NC_069062
Bromeliaceae	Brocchinia acuminata Brocchinia hechtioides	NC_069195 NC_069197

Results and Discussion

Carnivorous plants can be found in four of the major angiosperm lineages (the Monocots, Core Eudicots, Rosids, and Asterids), and in five orders: Poales, Caryophyllales, Oxalidales, Ericales, and Lamiales (Fig. 2). Convergence of CPs and their traps is most apparent at the ordinal level, whereas gene sequences have distinguished between convergence and homology within orders, families, and genera. Within the Caryophyllales, relationships between carnivorous families have been elucidated through chloroplast genome phylogeny (k-mer analysis). The sundews (Drosera) with their sticky leaves are related to this lineage of snap-trappers, as are Aldrovanda vesiculosa and Dionaea muscipula (Fig. 2). Three further carnivorous families with a clear relationship to the Caryophyllales are Nepenthaceae, Drosophyllaceae, and Dioncophylaceae (Fig. 2). All three of these families are part of a large clade that is related to the Droseraceae by a common ancestor, most likely one that had flypaper traps. Nepenthes, or more specifically, its monogeneric family, the Nepenthaceae, defies Darwin's assertion that it is "not at all related to the Droseraceae" (Fig. 2). Nepenthes is the sister group of the Droseraceae.

The flypaper-producing *Triphyophyllumpeltatum* appears to have re-derived carnivory in the Dioncophyllaceae, while the *Drosophyllumlusitanicum* Link is now well established in its own family (Drosophyllaceae). Carnivory had multiple independent origins in the Lamiales (Fig. 2). As in the Caryophyllales, the trap structure of carnivorous Lamiales evolved from flypaper traps in *Pinguicula* to more complicated, unidirectionally twisted 'eel' traps in *Genlisea* and bladder traps with its unique suction mechanism in *Utricularia*. The three remaining carnivorous dicot families—Roridulaceae, Sarraceniaceae, and Cephalotaceae—showcase different takes on the convergent theme of trap evolution.

Within the monocots, carnivory has also evolved at least twice in the Bromeliaceae genera *Brocchinia.* If this identification is correct, it would be the first instance in carnivorous plant lineages of morphologically more complicated traps (in this case, pitchers) being ancestral to simpler sticky traps. Similarly, there is no obvious sticky-leaved ancestor in the Australian endemic *Cephalotus follicularis* (Cephalotaceae) (Fig. 2).

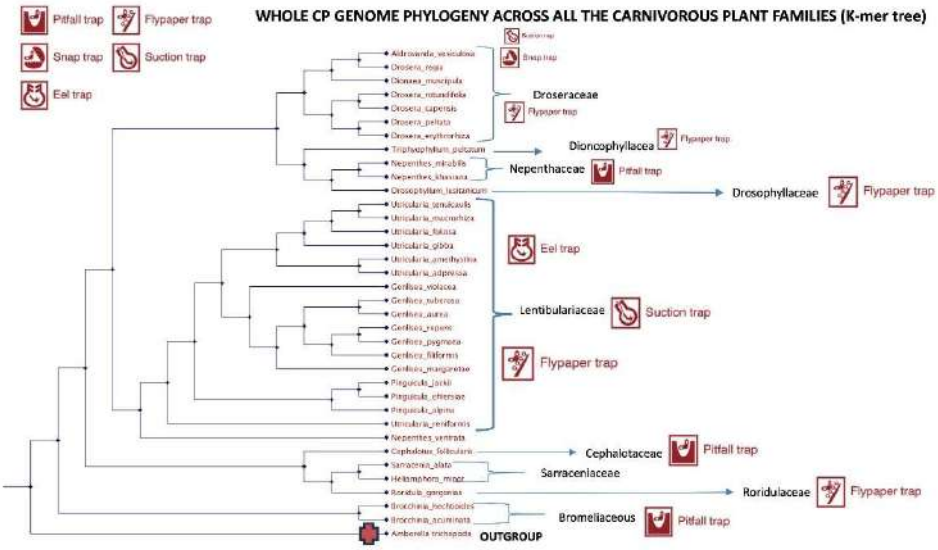

Fig. 2. Overall chloroplast genome phylogeny of carnivorous plant families along with their trapping mechanism

As the ordinal placement and systematics of CP families have become more stable, focus has shifted to resolving relationships among genera and subgeneric relationships in the most speciose carnivorous genera—*Drosera, Nepenthes, Pinguicula, Genlisea, Utricularia, and Sarracenia*. Thus, when morphological and genomic data are integrated, unexpected insights into the history and biogeography of these carnivorous plant taxa will emerge with a scope for further barcoding and pan genomic analyses of these carnivorous plants in the region.

Acknowledgement
We acknowledge RuchishreeKonhar, SRF, CSIR-IGIB for her contributions in annotating the chloroplast genome with GenBank accessions.

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MYMENSINGH NARROW- MOUTHED FROG *MICROHYLAMY MENSINGHENSIS* HASAN, ISLAM, KURAMOTO, KURABAYASHI, AND SUMIDA, 2014 FORM WESTERN ASSAM-A PHOTOGRAPHIC RECORD

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Abstract
Based on the incidental encounter and photography, here we report Mymensingh Narrow-mouthed Frog *Microhylamy mensinghensis* from the Bongaigaon district of Lower Assam. Brief morphological characteristics and diagnostic features are also provided.This report reflects the presence of such creatures at the regional level.

Introduction

Family Microhylidae is one of the richest among the families with 12 sub-families and 744 valid species globally and is distributed in America, Sub-Saharan Africa, Indian Sub-continent and Southeast Asia (Frost, 2023). The narrow-mouthed frog genus *Microhyla* tschudi, 1838 has 51 valid species in the world (Frost, 2023), of which14 species are known to distribute in India.After the description of *Microhylamy mensinghensis from M. mensingh*, Bangladesh (Hasan *et al.,* 2014), it has been reported from Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura in India (Frost, 2023; Decemson *et al*., 2021; Pratihar and Deuti, 2021). Recently, Wangyal *et al*., (2020) extended its distribution range to the Kingdom of Bhutan, after they confirmed its occurrence. Garg *et al.,* (2018) revealed that most of the Northeast Indian population of previously reported *Microhylaornata* is actually *M. mymensinghensis*. Based on incidental encountered, here we are reportingMymensingh Narrow-mouthed Frog at Dhalgaon area of Bongaigaon District, Assam. The Bongaigoan district is situated in the western part of the State of Assam. The district harbours Kakoijana reserve forest, Nakkati Reserve Forest and Bhumeswar Reserve Forest with high biodiversity. The forest cover in the district is sub-tropical broadleaf forest. It is a faunal gateway between the Hills of Bhutan to Kakoijana Reserve forest and Chakrashila Wildlife Sanctuary, Kokrajhar.

Materials and Methods

The amphibian survey was done by visual encounter method through active search. The encountered specimens were caught, photographed and released back to their natural habitat. The photographs of the specimens and observed key features were matched with Hasan *et al*. (2014) and Pratihar and Deuti (2021) for identification of the specimens.

Fig.1 *Microhylamy mensinghensis* from Dhalagaon, Bongaigaon, Assam.

Result and Discussion

During the evening walk at 07.12 pm, 1st author encountered two individuals of Microhylid frogs at the water edges. Both the individuals were caught and photographed. It is clearly observed a crescent-shaped black mark present above the anus, which is the diagnostic character of *M. mymensinghensis* (Hasan *et al*., 2014; Pratihar and Deuti, 2021). Besides this, the inner metacarpal tubercle of the specimens was rounded. The dorsum of this frog is brownish with an X-shaped marking and it is smooth; vomerine teeth are absent; the tympanum is also hidden. Tibito tarsal articulation of the observed frog is extended in between eye to tip of the snout. Based on these morphological characteristics, we confirmed both specimens as *Microhylamy mensinghensis* (Fig.1).This report confirms the occurrence of this narrow mouthed frog at the regional level and also extends its range 186 km (approx) from its type locality and 122 km (approx) from the nearest known population in Rani-GarbhangaReserve Forest in Kamrup District, Assam (source Google Earth Pro). Since frogs are an eco-sensitive species or ecological indicator, so itsneed to be conserved their habitat.

Acknowledgements

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PRUNUS CERASOIDES: AN AUTUMN FLOWERING WILD CHERRY OF HIMALAYAN REGION

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Abstract
Prunus cerasoides, commonly known as the wild Himalayan cherry or sour cherry, is a species of deciduous cherry tree in the family rosaceae and grows primarily in the temperate biome at an altitude ranging from 1,000- 2,500 mts. It is one of the important multipurpose tree species of Himalayan region, as it is used for consumption of food, medicine, fuel, fodder, timber, dyes, tannins etc. The plant is acclaimed for significant medicinal importance in the traditional system of medicines and used in several ayurvedic formulations. The tree also occupies a sacred place in Hindu mythology, as its branches and twigs are used in many Hindu rituals. The tree is also cultivated for its ornamental value because of its beautiful appearance with flowering during winter. Because of its multifarious uses, this tree can be considered as a suitable source for the upliftment of local people of Himalayan region.

Introduction

The genus *Prunus* from the family rosaceae symbolise perseverance and hope, as well as, beauty thriving in adverse circumstances. *P. cerasoides*, commonly known as Padam or, Pajja or Wild Himalayan Cherry is a sacred plant in Hindu mythology. It is popularly known as Padmakha – a Sanskrit word meaning "Similar to a lotus flower" due to the aroma from its wood. It is found in southern and eastern Asia. *P. cerasoides* grows in the temperate forests and its distribution range extends in the Himalayas from Himachal Pradesh in North-central India to Sikkim, Nepal, Bhutan, Myanmar, West China and Thailand. In India the plant is restricted to sub-montane and montane Himalaya ranging from 1,000–2,500 meters elevation. It prefers moderate light conditions and grows in shady locations of hills and along the fields.

Description

Bark is smooth and brownish-grey in colour, peels off in thin shining horizontal stripes, and gives a shining reddish-brown color that resembles the metal copper on exposure. Leaves are ovate, acuminate, doubly serrate and glabrous. The petiole has 2-4 glands at its base. The stipules are feathery. The tree flowers in autumn or early winter October-December. Flowers are of rose-red colour, which gradually fade to nearly white, occur in fascicles. Pollination is mainly through insects. Fruiting occurs between December and February. The fruits are produced in abundance and ripen from March - April. Sapwood is whitish and lustrous whereas heartwood is reddish brown, closely grained and moderately hard.

Mythological importance

It is considered as a sacred tree in many parts of Western Himalayas and its flowering twigs and branches are used in various religious ceremonies. The whole tree is never cut down by local dwellers as the wood is forbidden to be used as fuel. During the Shivratri festival in

upper areas of Himachal Pradesh, leaves of the tree along with barley (Jau) and Kemtu (Citrus species) are worked together to prepare the chodoh, which is hung at the main alter of the sanctum podium at Shivratri in each home.

Chemical Constituents

The key chemical components comprise of beta-sitosterol, stigmasterol, uroslic acid, prunetinoside and neosakuranin. The plant contains flavone glucoside-puddumin A. While the seeds contain flavonoid glycosides and their leaves, twigs, bark, and kernels contain a cyanogenetic compound.

Medicinal uses

It is an incredible ayurvedic plant used since times immemorial for its indispensable therapeutic and medicinal qualities. Right from its seeds, fruit, bark, and gums are used largely in traditional medicine for preparing several herbal formulations. The kernel is used as a remedy for stone and gravel in urinary bladder. The leaves, twigs and bark contain a cyanogenetic substance. The bark is used for plastering fractured bones. The smaller branches are crushed and soaked in water and taken internally to stop abortion. Its stem is antipyretic, refrigerant and useful in treating vomiting, leprosy and leucoderma.

Economic uses

Wild populations of *P. ceresoides* are a source of timber. The heartwood is red with a pretty silver grain and the sapwood is white in colour. The attractively coloured wood is moderately hard, strong, durable, aromatic and resistant to termites. It is used in carpentry and for ornamental furniture. The branches, suckers and saplings are used to make walking sticks and for preparation of handles for agricultural tools.

Pajja is a multipurpose tree for local people and is an excellent source of food, medicine, fuel, fodder, etc. Ripe fruits, seeds, bark and gum are edible and eaten to harness their rich medicinal values. Deseeded fruits are cooked to make jam, chutney etc for pleasant taste and sometime fermented for making local alcoholic drink. The fruits and the leaves yield a dark green dye. The seeds are used as beads in necklaces and rosaries. Roasted seeds are also eaten and powdered bark infusion is served as a cleansing drinking water. The tree being a relative of the sweet cherry (*Prunus avium*), is often used as rootstock for propagating its good cultivars, so it has the potential for use as a gene donor for crop improvement. This species is a significant source of nectar for bees. All the four species of *Apis* visit the flowers of *P.cerasoides* for its rich nectar and pollen. Gum exuding from trunk and branches is used by honeybees as honeydew. The gum is chewed and can be employed as a substitute for gum tragacanth.

Conclusion

Pajja tree, which is unquestionably one of the most majestic naturally growing flowering trees of the Himalayan region and is consumed for food, medicine, fuel, fodder, timber, dyes, tannins etc. Besides its natural habitat, *Prunus cerasoides* is also cultivated as an ornamental tree. Due to its multifarious uses, the tree can be also introduced in farm land in various agroforestry systems /road side avenue plantation, which would be very beneficial for the upliftment of local people from the Himalayan region.

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MICROBIAL DIVERSITY OF HIMALAYAN MEDICINAL PLANTS AND THEIR POTENTIAL USES

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Abstract
Himalaya harbours a diverse array of medicinal plants. These plants within their tissues and surroundings harbours a vast variety of microbiota termed as plant microbiome or plant associated microbiota. They possess numerous functions which involves promotion of plant growth and development, abiotic and biotic stress tolerance, and secondary metabolite production andantioxidants to mitigate ROS produced under environmental extremes. They also have important role in nitrogen and carbon metabolism. Current article discusses its different properties associated with Himalayan medicinal plants and its potential uses.
Keywords: Himalaya, medicinal plants, microbes, growth promotion, secondary metabolites

Introduction

The Indian Himalayan region harbours a diverse array of medicinal plants with approximately 8000 species of angiosperms, 44 species of gymnosperms and 600 species of pteridophytes that have been reported of having high medicinal potential (Singh et al. 1996). Medicinal plants belonging to Himalayan region have a long history of applications, these plants have been mentioned in Ayurveda as proving effective against various ailments. Peoples of the Himalayas are highly dependent on these plants for remedies against various diseases and ailments, these plants also provide income to these people resulting in economic growth of the area. These plants are good source of important secondary metabolites which have industrial applications and used in pharmaceuticals, dyes manufacturing, and cosmetic industries to name a few, and provides a plethora of other applications. The tissues and environment of Himalayan medicinal plants include a variety of microorganisms. These microbes are referred to as the plant microbiome since they populate the soil around plants as well as their inside tissues (Schaeppi and Bulgarelli, 2015). These microbiotas assist these plants in germination, growth, and development, induce production of various secondary metabolites, provide tolerance against biotic as well as abiotic stresses and perform other copious functions which play a prominent role throughout the life cycle of the plant. The plant-associated microbiota persists at the plant's internal tissues, known as the endosphere, the air-plant contact known as the phyllosphere, and the interface between the plant's roots and the soil(Compant *et.al*., 2019), stem colonization called caulosphere, association with flower is called anthosphere, seed associated microbiota termed as carposphere, and seed associated microbiota is termed as spermosphere.The plant-associated microbiota greatly influence the microbial diversity of the soil, they are known to secrete various allelochemicals which attract and repel the microorganisms thus modulating the rhizosphere microbial diversity, both plants and microbes communicate with each other by secreting various molecules involved in two-component signalling pathway which modulate the bacterial movements towards or away from plant surroundings, plants also secrete various root exudates which attracts the microbial pool within the soil. Microbiota associated with Himalayan medicinal plants is of great significance as they stimulate the productions of

various important secondary metabolites in plants that are responsible for their medicinal properties, they are a source of industrially important enzymes, produce various coloured pigments used as dyes, and have various plant growth promotion (PGP) activities.

Plant growth promoting (PGP) properties of plants associated microbiota

PGP properties of the microorganisms include phosphate solubilization, IAA production, siderophore production, nitrogen metabolism, phosphate/nitrogen metabolism, ACC deaminase and have various other properties which make them extremely important for a plant during growth and development and Himalayan medicinal plants are important source to isolate these microbes. Siderophore is an important secondary metabolite which provides plants better tolerance against various biotic stress conditions and chelate metals, IAA (Indole-3-Acetic Acid) an important plant phytohormone which is responsible for lateral root growth in plants, cell elongation and promotes plant growth and development. Under stress plants produce excessive ethylene which results in cell death, the endophyticmicrobiota of plants has microbes that can produce an important enzyme termed ACC deaminase which blocks the synthesis of ethylene. ACC,1-aminocyclopropane-1-carboxylic acid is the immediate precursor of ethylene, the microbes producing ACC deaminase degrade ACC to ammonia and α-ketobutyrate, ultimately resulting in less ethylene biosynthesis within plants. The endophyticmicrobiota has a significant role in carbon assimilation in plants. They play prominent role in carbon metabolism and photosynthesis regulation within plants directly or indirectly affecting both Dark and Light reactions. Phosphate solubilization is the property which is generally associated with rhizosphere microorganisms. Phosphate is present in the soil but in a form which cannot be uptaken by plants (Inorganic form). Plant-associated microbes convert the insoluble form of phosphate into soluble form, plants uptake this soluble form of phosphate which promotes growth and development of plants. The phosphate solubilizing microorganisms are widely used in agriculture as biofertilizers providing soluble phosphorous to plants.

Abiotic and Biotic stress tolerance

The plant-associated microbiota of Himalayan medicinal plants produces antioxidants that mitigate the effect of various Reactive oxygen species (ROS). Under various abiotic stress conditions plants produce ROSs that includes superoxide radicals, hydrogen peroxide, singlet oxygen and hydroxyl radical. These microbes produce various antioxidants like SOD, catalase and various secondary metabolites which have a potent antioxidant activity and thus provide protection to plants under various abiotic stress conditions. This Himalayan plant-associated microbiota has shown to have antibiotic properties and provides tolerance against various plant pathogens.

Enzymes and secondary metabolites production

Microorganisms also produce a variety of secondary metabolites that have numerous potential uses in the agriculture, healthcare, food, and cosmetics industries. They also produce a variety of enzymes that are significant for industry (Shukla *et al*., 2014; Jalgaonwala *et al*., 2011; Strobel and Daisy, 2003) Various functional groups, including alkaloids, saponins, steroids, chinones, benzopyranones, tannins, flavonoids, quinones, phenolic acids, xanthones, terpenoids, tetralonesand many others, can be used to classify the secondary metabolites produced by these microbial communities. (Jalgaonwala *et al*., 2011; Strobel and Daisy, 2003; Pimentel., 2011; Schulz *et al*., 2002; Joseph and Priya, 2011). Novel secondary metabolites found in endophytic bacteria are a rich source of medications with beneficial anti-arthritic, anti-microbial, anti-cancer, antidiabetic, anti-insect, and immunosuppressive properties (Jalgaonwala *et al*., 2011). The production of numerous

commercially significant secondary metabolites of diverse medicinal plants can be increased by using the microbes*in-vitro* as well as *in-vivo*.

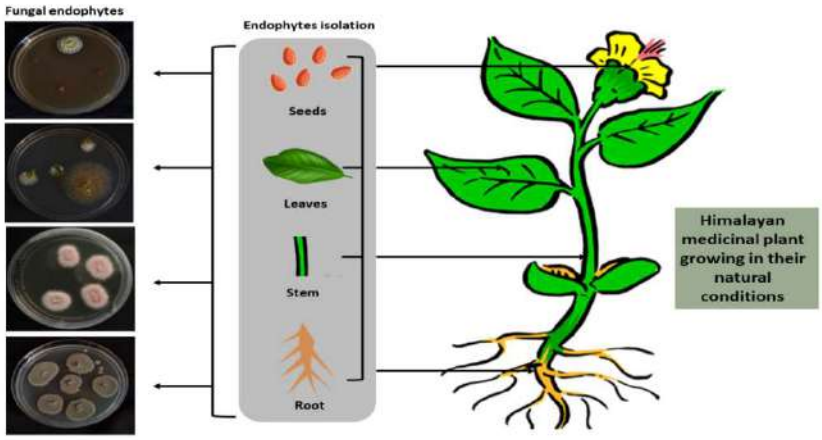

Fig. 1. Isolation of endophytes from different parts of the Himalayan medicinal plants.

Biosynthesis of therapeutically important secondary metabolites in Himalayan medicinal plants is tissue specific. Therefore, different parts of plants should be used for isolation of potential endophytes to produce desired bioactive compounds. Picture represents emergence of fungal endophytes on potato dextrose agar from surface sterilized parts of plants.

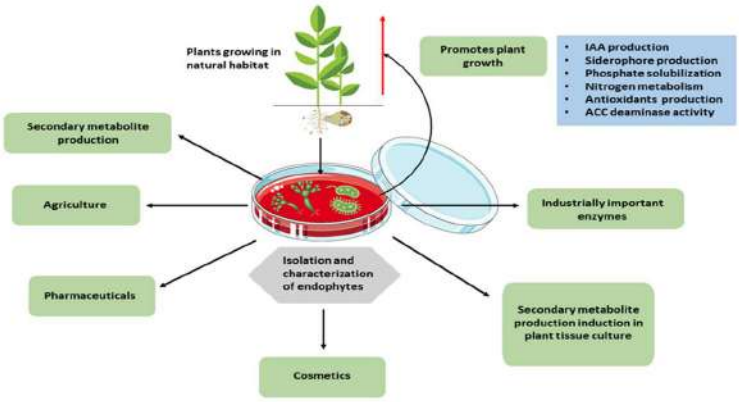

Fig. 2. Various functions and applications of plant-associated microbiota.

Conclusion

Himalayan medicinal plants are important source of these microbial communities having a long list of above-mentioned PGPR activities. We can isolate, these microbes and can use them in agriculture as biofertilizers to increase crop productivity, can provide tolerance to crops under various abiotic stress conditions, and induce tolerance/resistance against various harmful pathogens. We can use them for industrial applications such as secondary metabolite production, indue secondary metabolites production in plants *in-vivo* as well as *in-vitro*, extact enzymes and use these compounds for manufacturing medicines, cosmetics, and other diverse arrays of products.They are unique in terms of their natural habitat as they reside within tissues of medicinal plants growing at high altitudes. Therefore, these microbial diversity needs to be explored as these are a perfect mirror to investigate the past as they bear ancient DNA sequences. This further makes the isolation and identification of these plant-associated microbiota extremely important as they are a prominent Himalayan bioresource.

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Rhododendron campanulatum D.Don: STATE FLOWER OF HIMACHAL PRADESH

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Abstract

Rhododendron campanulatum D.Don is ecologically and socio-economically important deciduous shrub species which is known for its spectacular flowers. Currently it is state flower of north western Himalayan state of Himachal Pradesh. It is also listed as an endangered species in International Union for Conservation of Nature's (IUCN) Red Data Book. It is commonly known as Pink Buransh and Simru and it belongs to family Ericaceae. Current article discusses the local uses of the plant species, challenges faced in recent scenario and its future conservation efforts.

Introduction

Identification, conservation, and exploration of wild ornamental plants are one of the emerging areas of research that accounts for a wide range of applications in environmental management. The epithet 'Rhododendron' is derived from the Greek words "Rhodo" and "Dendron," which indicate "Rose-tree," and was first described by Carl Linnaeus in 1753. Species of Rhododendron are valuable component of forest biodiversity and their conservation is essential for the well being of people. Rhododendron genus a member of Ericaceae family has approximately 1025 species worldwide, with the majority of them situated in temperate regions of the Northern hemisphere, particularly in the Sino-Himalayas region. In the wild they are mainly associated with centres of diversity in the Himalayas and in South East Asia, where they form important components of montane ecosystems. There are around 80 species (with 10 subspecies and 14 variations) in India, the majority of which are widely spread in diverse regions and altitudes in the Himalayas ranging from 1500 to 5500 m mainly found in states Arunachal Pradesh, Sikkim, Manipur, Nagaland, Himachal Pradesh, Uttarakhand and Jammu and Kashmir UT (Bhattacharyya, 2011). Out of 80 species in India only 4 species namely, *Rhododendron arboreum* (Buransh Phool), *Rhododendron campanulatum* (Gulabi Buransh), *Rhododendron anthopogon* (Talispatra), and *Rhododendron lepidotum* (Kashmiri patta) are all known to grow in North werstern Himalayan states of India (Sharma and Kala, 2016). *R. campanulatum* commonly known as Pink buransh, Simru, Chimura (in Garhwal), Cherailu (Hindi), Nichnai (Kashmir), Chimul (Kumaon) in different parts of Indian Himalaya. This species is entitled Least Concern (LC) in the Red Data Book of IUCN (Gibbs *et al*., 2001). Due to its greater

indigenous importance, it is enunciated as State flower of Himachal Pradesh (ENVIS Centre: H.P Centre of Environment & related issues, 2007). It is one of the few Rhododendron species that forms thick, pure stands in the Central and Western Himalaya's timberline zone. *R. campanulatum* can grow as an evergreen gregarious shrub or small tree, 0.5- 4.5 meters in height. The shrub produces flowers which are bell-shaped, pink to mauve in colour with various variants; they are practically purple when in bud, turning progressively white as they age. The leaves of this plant are said to possess several medicinal and poisonous properties. *R. campanulatum* is well-known for its traditional therapeutic efficacy for a variety of maladies such as body aches, sore throats, digestion, skin problems, rheumatism, syphilis, cold and fever, and so on. *R. campanulatum* is not grazed because it is an unpalatable species; therefore its regeneration status is predicted to be mostly decided by warming.

Distribution

This species is distributed mainly in Himalayan alpine regions of Northern India, Bhutan and Nepal. In India it is found mainly in the moist temperate and alpine regions of Northern India from Kashmir to Nagaland at 2400-5200 m elevations. In Himachal Pradesh, it is found in Kullu, Kinnaur, Lahaul & Spiti, Chamba, Mandi, Kangra, Sirmaur and Shimla districts of Himachal Pradesh between 3000-4200 m elevations.

Silvicultural Characteristics and Phenology

The plant is dwarf shrub to a small tree, 0.5–4.5 m, can reach a height of 6 m. It avoids being shaded by huge trees and can withstand harsh weather conditions. The leaves are normally eight to fourteen centimetres long, ovate to broadly elliptic in shape, and flexible, with a bright green upper surface with a dense fulvous lanate tomentum composed of capitellate to ramiform hairs and a yellowish-brown, thick, very soft indumentum on the underside. The leaves of this Rhododendron are the smoothest among other Rhododendrons. The bark is cinnamon or grey in colour, and it peels off in thin papery flakes. Flowers grow in clusters, 8–15 in a truss, shaped like a small bell, white to pale mauve/pink or deep plum purple, with purple flecks, open-campanulate, nectar pouches lacking, 30–50 mm; ovary and style glabrous. Inflorescence is racemose-umbellate; pedicel: about 1.5-3.5 cm; calyx: about 1-2mm; corolla broadly campanulate; stamens: about 10. The flowers bloom during period April–May and above that height in June, followed by fruiting in June- July and seed dispersal subsequently. Fruits are cylindrical, straight to curved, green, turning brown and many black seeded.

Regeneration Status

The main factors responsible for adequate regeneration of *R. campanulatum* were ample amount of snowfall, soil moisture, available N, P, K, solar influx, aspect and elevation (Kapoor et al. 2023). Because of its combustible nature, migratory graziers are removing its adult sticks for fuelwood, causing disruption in its natural growth and succession. Furthermore, intensive grazing at this site has been observed to result in the dominance of less palatable herb and grass species such as *Anemone* spp., *Poa alpina, Polygonum* spp., *Ranunculus hirtellus*, and others, which may influence *R. campanulatum* regeneration.

Uses

R. campanulatum is located in higher elevations so only a few collectors harvest its components. Collectors collect only leaves on demand for business use. The average price of *R. campanulatum* leaves is 30.28 INR per kilogramme. According to locals, wood is used for cooking and heating as its wood is an excellent fuel but the smoke it produces is an irritant. The traditional method of using this plant is to mix the leaves and stem with tobacco and sniff

this to cure hemicranias and colds. The research carried out in this study by (Prakash *et al*., 2016; Kathmandu, 2011) showed that the plant exhibits significant antibacterial activity against Gram-positive bacteria, it may therefore, be concluded, that the plant has antimicrobial activity, which may be helpful in generating lead molecules for the development of new and novel antibacterial agents. Leaves are poisonous to livestock due to the presence of a toxic substance called romedotoxin. The wood and dried twigs after crushing mixed with tea and used by the people of areas of Darjeeling hills in treating chronic fevers. The flowers yield an essential oil. A study also demonstrates the usage of *R. campanulatum* wood for drying medicinal plants gathered from the wild in the same location.

Conclusion

The uncontrolled usage of *R. campanulatum* by transient inhabitants in high altitude places may result in its low population in the future. The involvement of various entities in the value chain is utilising the fundamental assets. As a result, it is critical to monitor each stage of the value chain and educate locals about it so, the management and conservation of these species, as well as their sustainable use, is critical. General habitat clearance is a major threat as is increasingly the impact of climate change. Clearly action must be taken to conserve the threatened species as a matter of urgency.

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संरक्षित पर्यावरण के तहत कीट प्रबंधन

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संरक्षित खेती नियंत्रित पर्यावरण कृषि है जो अत्यधिक उत्पादक, जल और भूमि के संरक्षक और पर्यावरण की सुरक्षात्मक भी है। ग्रीनहाउस में नियंत्रित पर्यावरणीय परिस्थितियों के कारण खाद्य वस्तुओं को मौसमी और गैर–मौसमी दोनों के रूप में उगाया जा सकता है। ये आम तौर पर 3 मिमी (⅛″) बागवानी कांच या पॉलीथीन प्लास्टिक से बने होते हैं। इष्टतम तापमान, आर्द्रता, वेंटिलेशन और बिजली को नियंत्रित करने के लिए ग्रीनहाउस में विभिन्न तकनीकों का उपयोग किया जाता है। आमतौर पर ग्रीनहाउस में उगाई जाने वाली सब्जियां टमाटर, शिमला मिर्च, खीरा और बैंगन के अलावा प्याज, साग, सलाद, गाजर, पालक, गोभी की फसल, मिर्च आदि हैं। कीट दुनिया भर में ग्रीनहाउस फसलों के उत्पादन और उत्पादकता के लिए प्रमुख खतरा हैं। ग्रीनहाउस में गर्म, नम स्थितियों और प्रचुर मात्रा में भोजन की उपस्थिति कीट विकास के लिए एक स्थिर वातावरण और आवास प्रदान करती है। प्रायः जो प्राकृतिक शत्रु बाहर कीटों को नियंत्रण में रखते हैं, संरक्षित वातावरण में उनका अभाव होता है। कुछ ग्रीनहाउस कीट पौधों में रोग संचारित कर सकते हैं जो कि कीट के कारण होने वाली क्षति की तुलना में अक्सर अधिक गंभीर होते हैं जैसे कि कुछ एफिड्स, लीफहॉपर्स, थ्रिप्स और सफेद मक्खी शामिलहैं। ऐसे मामलों में, प्रारंभिक कीट नियंत्रण के माध्यम से रोगों का प्रबंधन किया जाना चाहिए।

ग्रीनहाउस में उगाई जाने वाली सब्जियों में महत्वपूर्ण नाशी कीट

संरक्षित खेती के लिए एकीकृत कीटप्रबंधन रणनीतियाँ

1 निवारक उपाय
2 प्रारंभिक पहचान
3 उपचारात्मक उपाय
4 निवारक उपाय

कीट प्रबंधन में स्वच्छता पहला कदम है। फसल काटने से पहले और बाद में हमेशा सफाई करें। साफ जूते, कपड़े और दस्ताने के साथ उपकरण, डिस्पोजेबल कवर ऑल सभी कीटों और बीमारियों के फैलने के जोखिम को कम करने में मदद करेंगे। ग्रीन हाउस का नेटफटा हुआ नहीं होना चाहिए जिससे कीट ग्रीनहाउस में ना प्रवेश कर सकें दोहरे दरवाजे का प्रावधान अनिवार्य है संक्रमित ग्रीनहाउस फसलों को साफ फसल में न ले जाएँ उड़ने वाले कीड़ों को फँसाने के लिए दरवाजे पर पीला चिपचिपा जाल लगा

देना चाहिए रोपण सामग्री कीट संक्रमण से मुक्त होनी चाहिए पॉलीहाउस के बाहर साफ सफाई रखनी चाहिए ओरवह खरपतवार मुक्त होनी चाहिए संक्रमित सामग्रियों और संक्रमण के संभावित स्रोतों दोनों को हटाना आवश्यक है

खरपतवारों को नियंत्रित करें और आस पास के खरपतवारों को नियंत्रित करने के लिए पड़ोसियों के साथ काम करें। ग्रीनहाउस में एक नई फसल शुरू करने से पहले, पिछली फसल के अवशेष और खरपतवार को हटाना बेहद जरूरी है

प्रारंभिक पहचान

कीट संक्रमण को सफलता पूर्वक प्रबंधित करने के लिए स्काउटिंग और शुरुआती पहचान महत्वपूर्ण हैकीट समस्याओं की पहचान और आकलन करने के लिए पौधों और बाहरी हिस्सों का नियमित, व्यवस्थित निरीक्षण आवश्यक है वयस्क आबादी की निगरानी के लिए पीले चिपचिपे ट्रैप(/ 1 ट्रैप/100 वर्ग मीटर) का उपयोग फसल से 10 सेमी ऊपर रखकर करें। बड़े पैमाने पर वयस्क आबादी को फंसाने के लिए पीले चिपचिपे ट्रैप / 1 ट्रैपप्रति 10 वर्ग मीटर का उपयोग करें।

उपचारात्मक उपाय

ग्रीनहाउस में उपयोग के लिए जैव नियंत्रण में एनकार्सियाय एंटोमोपैथोजेनिक नेमाटोडय ग्रीनलेस विंगय प्रीडेटरी थ्रिप्स और स्पाइडर माइट प्रीडेटर उपयोगी हैं। कीटनाशक कीट प्रबंधन में उपयोग के लिए उपलब्ध सबसे शक्तिशाली उपकरणहैं।वे अत्यधिक प्रभावी हैं, तेजी से उपचारात्मक कार्रवाई करतेहैं, अधिकांश स्थितियों के लिए अपनाने योग्य हैं। सीआईबीआरसी द्वारा अनुशंसित कीटनाशकों का उपयोग उचित मात्रा में किया जाना चाहिए। मित्र कीट की उपस्थिति में कीटनाशक का उपयोग नहीं किया जाना चाहिए. ऐसे में जैव कीटनाशकों और नीम आधारित कीटनाशकों का प्रयोग करें

Section –II
Climate Change

TRENDS IN AEROSOL OPTICAL DEPTH IN MOHAL KULLU VALLEY OF NORTHWESTERN HIMALAYA REGION

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Abstract

Aerosol influences the climate through both direct and indirect effects. Aerosol Optical Depth was measured at Mohal (31.90◦N, 77.11◦E, 1154 m amsl) in the Kullu valley using multi-wavelength radiometer (MWR) for the period 2018 to 2022. This study objective of the study is to shows the spectral variation of aerosol optical depth and seasonal variation of AOD at 500 nm at the site. The result revealed that the observed mean AOD_{500nm} was 0.33± 0.01which is due to increased anthropogenic activities in the valley. Higher AOD value were record during summers (Apr-June) because of the dominance of coarser particles, moderate during monsoons (July- Sept) because of the wash out effect of rain and low during winters shows dominance of fine particles at the site. Mean AOD for clear days for the study period 2018 to 2022 was 0.47 in summers, 0.38 in Monsoons and 0.27 in winters.

Introduction

Aerosol is a suspension of the fine solid particles or liquid droplets, in air or liquid droplets, in air or another gas. Aerosol range in size from a few tens of nanometres (nm) to several tens of micrometres (μm), yet their impact on climate, weather, health is significant.Aerosols produce a variety of atmospheric effects such as formation of fog, mist and brown clouds, thereby reducing visibility in the troposphere (Kaufman and Fraser 1997; Moorthy and Pillai 2004). The trends in the spectral variation of aerosol optical depth (AOD) reveal the significance of anthropogenic activities on the increasing trend in AOD. The variation in AOD is important for study of climate and atmospheric science and it also has implications to human health and agriculture as well.

Methodology

Observations were carried out at Mohal (31.90◦N, 77.11◦E, 1154 m AMSL), Mohal (Kullu) in Himachal Pradesh state of India using an MWR. Experimental site at Mohal is located in the lesser Himalayan region of the north-western Indian Himalaya. Mohal is a semi urban experimental location in the Kullu valley and Beas River flows through the middle of valley. The valley which earlier was famous as 'the Valley of apples' has nowadays become a jungle of concrete, in terms of construction of large numbers of hotels, business establishments, hydropower colonies and a large number of tourism-related activities (Sharma *et al.*, 2011). In this study we analysed the AOD data of years 2018 to 2022 and for that we used Multi Wavelength Radiometer (MWR) at experimental site. The ground-based MWR developed and designed by the Space Physics Laboratory (SPL), VikramSarabai Space Centre, and Trivandrum is used to retrieve AODs. The MWR contains 10 filters of wavelengths 380, 400, 450, 500, 600, 650,750, 850, 935 and 1025 (in nm) allowing light from ultraviolet to near-infrared region to pass through it in steps with the help of automatic filter wheel motion. The radiation passes through a field of view (FOV) limited to ∼2◦ using lens pin-hole detector optics, so that the effect of diffuse radiation entering into the FOV on the retrieved optical depths may be insignificant (Moorthy *et al*., 1998). The instrument is semi-automatic in

nature. Before tracking the Sun, the optical unit is mechanically adjusted on an equatorial mount and is allowed to move at every 12 s around the orthogonal axis with an angular speed equal to the Earth (i.e., 0.05◦ in 12 s) in order to keep the MWR always aligned towards the Sun. It works on the principle of measuring solar extinction using Lambert–Beer law (Shaw *et al*.,1973).

Results and Discussion

The value of AOD is decrease exponentially with increasing in wavelength. Higher value of AOD is at 380nm and at 400nm which indicates large presence of fine particles in our atmosphere. At experimental site mean AOD_{500nm} was observed to be 0.33± 0.01 in year 2018 to 2022. The value of AOD has increased as there is increase in anthropogenic activities in the valley. The spectral variation in AODs in 2018 to 2022 at wavelength 500nm is shown in (Figure1). The value of AOD also vary with seasons, high in summer (Apr-June), moderate in monsoon (July-Sept) and low in winter (Dec-March). The mean AOD_{500nm} was 0.47 in summer, 0.38 in Monsoon and 0.27 in winters for the clear days between 2018 to 2022 (Figure 2). Bimodal nature of mass size distribution indicates two important sources contributing in total aerosols-fine practical, primarily due to anthropogenic activities and the coarse mode aerosols, mainly due to natural sources (Kuniyal *et al*., 2005). Long range transportation of the mineral dust and peak tourist season during summer months are the major concern for the dominance of coarser particles. During winter season the aerosols were originated from biomass/biofuel burning and due to vehicular pollution over the experimental site.

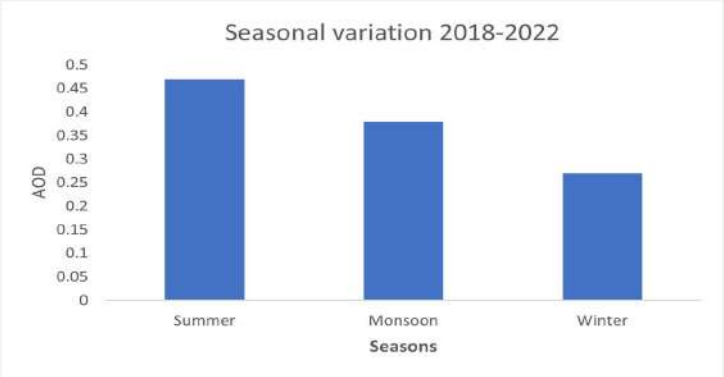

Fig.1. Spectral variation in AOD at Mohal in the Kullu Valley

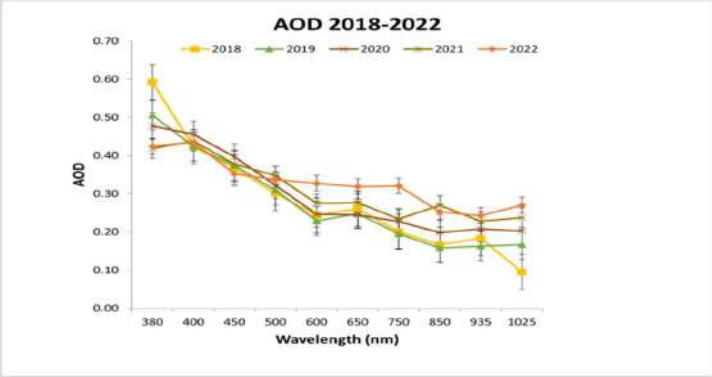

Fig. 2. Seasonal Variation AOD Values

With increase in anthropogenic activities around the experimental site the value of AOD has increased. Spectral dependence of AOD showed higher values at shorter wavelengths which decreases gradually towards longer wavelengths for summer monsoon and winter suggesting fine to coarse particle loading on clear days.

Conclusion

With increase in anthropogenic activities around the experimental site the value of AOD has increased. In summer monsoon and winter, the spectral dependence of AOD revealed larger values at shorter wavelengths which gradually declines towards longer wavelengths, indicating fine to coarse particle loading on clear days. Meteorological parameters also plays a crucial role during observation of aerosol particles at study area.

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UNCERTAINTIES AND ASSUMPTIONS OF BIOCLIMATIC ENVELOPE MODEL WHILE MONITORING NICHE OF SIGNIFICANT SPECIES IN THE INDIAN HIMALAYAN FOREST ECOSYSTEM

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Abstract

Climate change is a long-lasting change in statistical distribution of weather. This is also responsible for the shifting and shrinking of vegetation in Himalayan regions. Current article discusses the uncertainties and assumptions of Bioclimatic Envelop Model on monitoring the niche species in Himalayan regions.

Introduction

The vegetation cover is consistentlyshrinking throughout the world (Richards and Belcher, 2020), dueto the intertwined and cascading effect of multiple human activities (Harte and Shaw, 1995). These humans made perturbations are the profound cause behind shrinking of biodiversityon the earth, which directly and indirectly diminishespopulation size of endemic plant species at the pace of climate change (Singh, 2006). Climate change is the long-lasting change in the statistical distribution of weather parameters like air, temperature, wind patterns andprecipitations etc. These indicators play a crucial role in the heat budget of the earth. Althoughsuch indicators in an ecosystem are influenced anthropogenically. Central legacies behind ecosystem manipulation are deforestation, conversion of land shift, harvesting of endemic plant species, grazing, burning of fossils fuel coal; ultimately leading to declining of biodiversity in term count of species genetic variability as well as a variety of species including the phenology and behaviour change(Adhikari *et al*., 2019). The climate changetrends is responsible for the vegetation shiftingand shrinking of vegetation was also monitored in the IHR by various researchers in the past (Paul and Samant, 2023). The previous study speculated that the mean temperature of the Asian landmass, including the Indian Himalayan region, will escalate by 3°C thresholds by 2050 and 5°C by 2080 if appropriate action is not taken seriously (Hanifehlou *et al*., 2023). Nevertheless, with such an intense, the climate interferences trend will continue, then most plants' species will be extinct, and many will be on the verge of extinction. The conservation and management of vegetation dynamic in the present scenario is an immense challenge to ecologists, globaldelegates and policy planners (Carroll and Ray, 2021). However, natural selection of the species is based on the carrying capacity of the environmental gradient in spans of biological interaction in which species reside and survival through speciation (Wessel *et al*., 2022). If such an unpretending ecozone consistently influences anthropogenically, it will affect the ecological habitat and the niche of the individual species in terms ofa biotic and a biotic interaction; ultimately, it will lead to vegetation decline. However, In ecological science the foundation and definition of ecological niche were explained by various ecologists in their study like, Grinnell viewed an ecological niche is a kind of subpart of habitat in which species occur with abundance and distribution and containing the environmental condition to reproduce and survive.

The bioclimatic envelope model, well known as the ENM model, is an indispensable machine learning tool in ecological science to predict potential geographic species distribution relations to climatic variables. In recent circumstances, it has been considered *fascinating* as the essential machine learning tool employed for species distribution mapping (Fig. 1). It

shows the current environmental niche of the species in association with the future distribution model derived from the given climate variable and it project where the requirement of the species may be satisfied in the future. Since prehistoric times the various medicinal plants such as Dactylorhiza *hatagirea* (D.Don) Soo, *Fritillaria roylei* Hook. *Angelica glauca* Edgew, *Arnebiaeuchroma* (Royle ex Benth.) I.M.Johnst *Podophyllum hexandrum royle* T.S.Ying, *Trillium govanianum* Wall. exD.Don, and *Aconitum heterophyllum* DC have been used in various curative properties (Kumar *et al*., 2021). These plants herb has remarkable biological and chemical significance considerable remedial properties for the Autonomic nervous system (ANS) and cardiovascular system (Rohlf 1991). Due to indiscriminate usages, this species faces significant threats and shortlisted in IUCN Red list as critically endangered species and lies under vulnerable species as well. It may be extinct if appropriate conservation action is not taken seriously. The intent of the this highlight is, (a) to find out the influential climatic variables responsible for the accuracy of specieshabitat prediction, (b) The potential habitat distribution of significant speciesin terms of present and future climatic conditions, and uncertainties and assumptions and suggest preservation strategies and managing possibilities for habitat conservation under different scenarios.

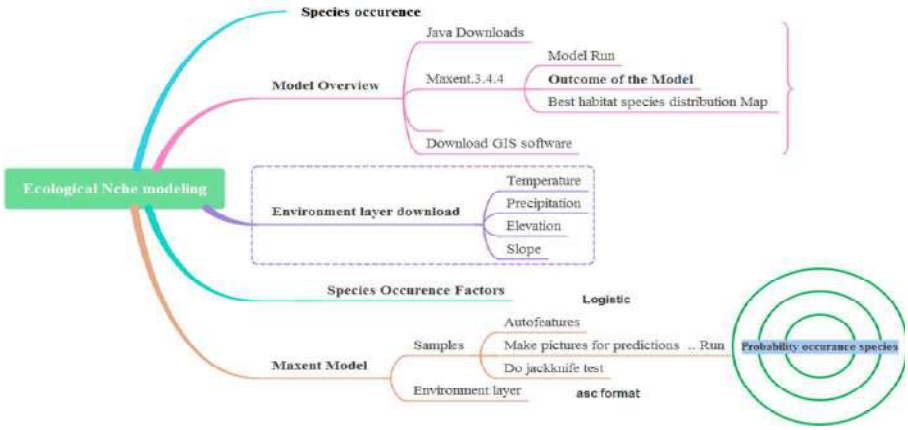

Fig.1. Species distribution patterns through Bioclimatic envelope model

Method for the Species distribution modelling

For species distribution modeling, the fundamental natural habitat of multiple species is considered from primary or secondary sources. The precise secondary location and distribution patterns of the species are collected from significant sources such as the Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/occurrence/maptaxon_key=4095989), the IUCN Red List data, Google Scholar, and published and unpublished data records etc.

Model calibration

Several software options are available for species niche modelling; however, the MaxEnt version (https://biodiversityinformatics.amnh.org) (Phillips et al., 2006) is widespread. Additionally, R, a programming language, is often used for habitat prediction. In this strategy, it is vital to acquire data on 19 bioclimatic parameters with a spatial resolution from the WorldClim data portal (http://worldclim.org). Moreover, topographical data, such as altitude and aspect, can be derived from the Shuttle Radar Topographic Mission (SRTM). Furthermore, elevation data for a Digital Elevation Model (DEM) with a corresponding

resolution is obtainable from the United States Geological Survey (USGS) portal (https://earthexplorer.usgs.gov).

Uncertainties and assumptions

Species distribution modelling is an extensively employed method in the ecological dimension, but it is subject to the indecisiveness and speculations intrinsic to species distribution. These elements play a vital role in comprehending the limitations and dependability of the modelling approach and the consequent projections. The considerable anticipation derives from data limitations, including spatial coverage, precision, and species habitats occurrence data resolution. These constraints can encourage inclinations and influence the dependability of the models. Nevertheless, discrepancies in ecological processes and environmental gradients can determine the transferability of models. Recognizing and managing these elements will improve the reliability and relevance of the species distribution models in ecological Science.

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DECODING THE DYNAMIC SHIFT OF GLACIERS IN THE WESTERN HIMALAYA

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Himalayan region (including Karakoram) amasses one of the largest glacier covers on Earth (Bolch *et al*., 2019) and have great socioeconomic importance as it supports large irrigation (~577,000 km2 area), hydropower generation (26,432 MW), megacities development (5 in number) and domestic water needs of about one billion people(Azam *et al*., 2021), warranting their regular monitoring. Rigorous research during the last two decades confirms a continuous glacier decline in the Himalaya(Shean *et al*., 2020)which is primarily been ascribed to human-induced warming(Marzeion *et al*., 2014). However, the rate of glacier change is not uniform in the different Himalayan regions namely western, central and eastern Himalaya- as they are well distinguishable in terms of climate and hydrology. River flow in the western Himalaya has the highest contribution from meltwater as compared to central and eastern Himalaya(Lutz *et al*., 2014) making this region more vulnerable to water security issues originating from depleting glaciers.

Glaciers in the western Himalaya have experienced highly heterogeneous recession trend. For example, Azam *et al*., (2012)proposed a hypothesis that Chhota Shigri Glacier, a well-studied benchmark glacier, in the Lahaul-Spiti, western Himalaya was in balanced conditions or experienced slightly positive mass balance over 1990s based on glacier velocity results of 1988/89 and 2003/04. Later, Vincent *et al*., (2013) and Mukherjee *et al*., (2018) confirmed this balanced condition. Mukherjee et al.(2018)even noticed the balanced conditions over eight selected glaciers of the Lahaul-Spiti followed by a rapid glacier reduction after the year 2000.Thus, it is possible that there has been a shift in dynamics from balance to imbalance conditions in the Chhota Shigri as well as other glaciers in the Lahaul-Spiti basin since the beginning of the 21st century. We hypothesize that this shift may not be limited to only the Lahaul-Spiti basin and may also be extended to other basins of the western Himalaya, which are not yet explored.

The present study aims at assessing selected glaciers from different basins of the western Himalaya to agnise whether the shift in glacier dynamics also prevailed in the other regions. A total number of 25 glaciers (labelled as G1 to G25) from the western Himalaya,spread across the region, wereselected as a representative sample (Fig. 1). These glaciers were selected carefully based on multiple criteria such as size, altitude range, slope, orientation, percentage of debris cover, geographical location etc. At least one glacier is included deliberately from all the major glacierized sub-basins of the Western Himalaya. To assess the dynamic shift, glacier velocity for each selected glacier was monitored for three periods 1990/91, 2000/01 and 2015/16 and the changes were assessed for the entire study period (1990/91-2015/16) and separately for pre-2000 (1990/91-2000/01) and post-2000 period (2000/01-2015/16).

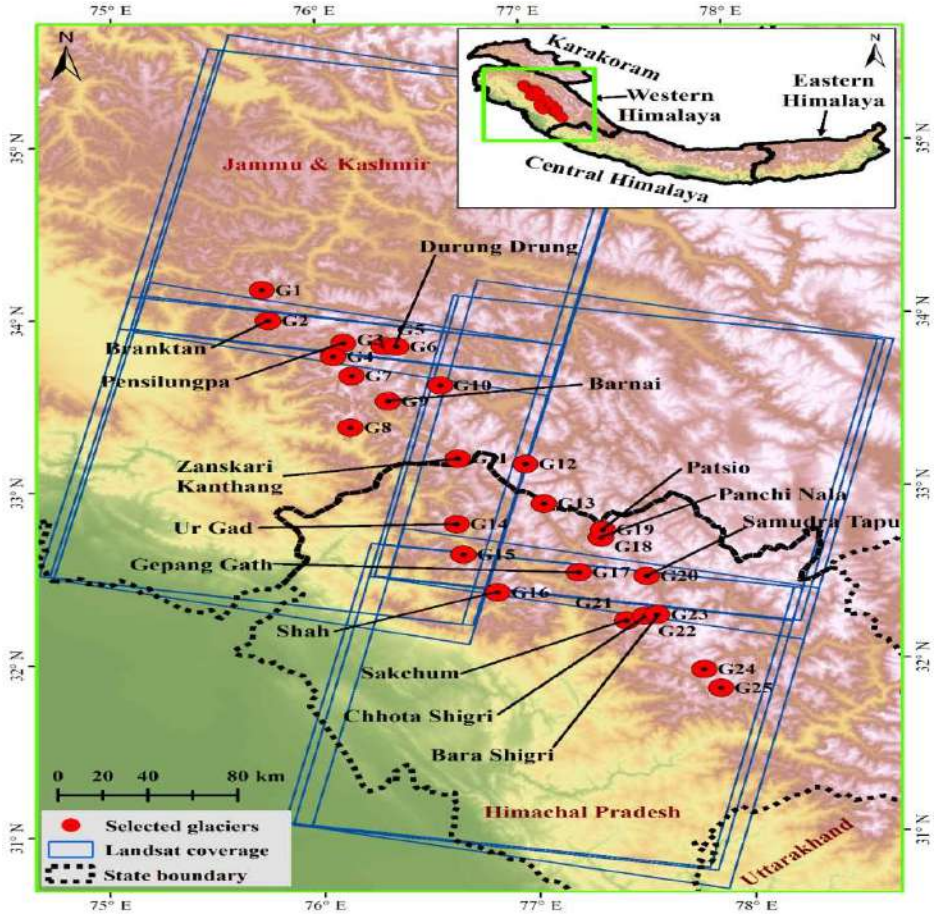

Fig. 1. Location map of the selected 25 western Himalayan glaciers, labelled from G1 to G25.

The map also displays the spatial extents of Landsat images utilized to cover the chosen glaciers. The background is a shaded relief map generated from the SRTM DEM. The inset shows the whole Himalayan-Karakoram range (source: Bolch *et al*., 2012) Glaciers' velocity is one of the important parameters for ascertaining their dynamicsas it is directly linked with the glacier mass. Thus, changing glacier velocities are a reliable manifestation of changing mass in the glacier system(Heid and Kääb, 2012). Here the glacier velocity was delineated using the Co-registration of Optically Sensed Images and Correlation (COSI-Corr) method (Leprince *et al*., 2007)applied on the Landsat- Thematic Mapper (TM for 1990/91) Enhanced Thematic Mapper Plus (ETM+ for 2000/01) and Operational Land Imager (OLI for 2015/16). The correlation in COSI-Corr yields North-South (NS) and East-West (EW) displacement images along with corresponding signal-to-noise ratio (SNR). After applying several filters (e.g. discarding low SNR values, excluding outliers and non-local mean filter), the absolute glacier velocity was determined as the square root of the sum of squares of NS and EW displacements and all the velocity products were normalized for 365 days interval (i.e. m/y). The uncertainties in the glacier velocity were quantified by adding the mean displacements and standard deviation over the non-glaciated stable terrain.

Results show an average velocity of the studied glaciers to be 27.3 ± 4.7 m/y during 1990/91 which reduced to 21.7 ± 3.3 m/y during 2015/16 exhibiting a reduction of 21% or 0.9%/y (Fig. 2). Decadal observations further reveal very interesting patterns. During pre-2000

(1990/91-2000/01) the average velocity increased (by 7% or 0.9%/y) from 27.3 ± 4.7 m/y to 29.3 ± 3.6 m/y. About half (12 glaciers) of the studied glaciers experienced an acceleration in their velocity whereas about 4 glaciers showed only trivial velocity decrease during 1990/91-2000/01 (Fig. 2). Velocity for 4 glaciers could not be deduced and only 5 glaciers experienced slowdown ranging from 14% to 38% (Fig. 2). However, during post-2000 (2000/01-2015/16,) all the glaciers experienced velocity slowdown with a significant average velocity reduction of 25% (2%/y). Thus, the overall results clearly indicate that the average velocity of the studied glaciers first increased during pre-2000 and then decreased substantially during post-2000. Since the increasing glacier velocity denotes an increase in ice mass within the glacier system, it can be interpreted that the balanced condition of glaciers in the western Himalaya was not only limited to Lahaul-Spiti, rather it was widespread.

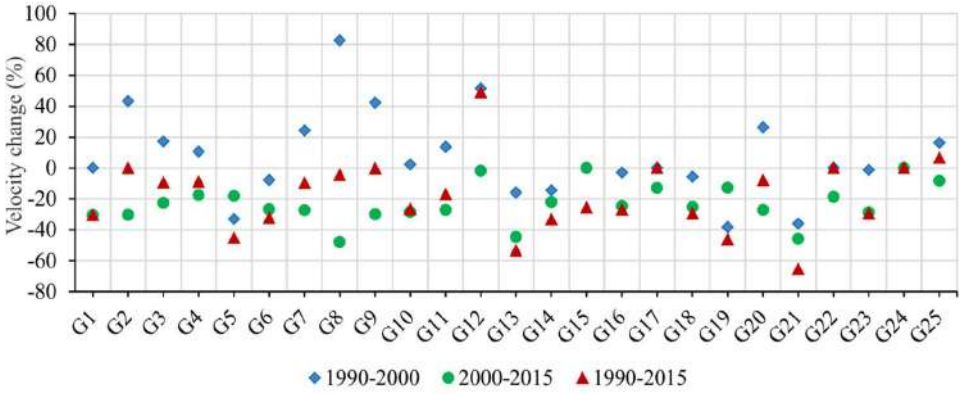

Fig. 2. Temporal changes in the velocity over the studied 25 glaciers (G1-G25) of the western Himalaya

Earlier studies ascribed this balanced condition to the climate dynamicsin the western Himalaya. Mukherjee *et al*., (2018)noticed that the temperature in the Lahaul Spiti region started increasing since 1995 and that is too with significant rate after 2000. The winter precipitation also started decreasing after 2000. Mukherjee *et al*., (2018)attributed these climatic trends for the balanced conditions of glaciers during pre-2000 and accelerated mass loss during post-2000 in the Lahaul-Spiti. Recently,Srivastava *et al*., (2022)noted the highest winter mass balance over the Chhota Shigiri Glacier during 1990s(1991-2000) in the last six decades i.e. since 1961. This is substantiated by the fact that during 1990s, the annual precipitation (highest in last three decades i.e. during 1981-2020) and winter precipitation (highest since 1961) were higher. The higher supply of mass in the glacier system through higher precipitation possibly explains the balanced condition of glaciers during 1990s. Nevertheless, Srivastava *et al*., (2022)found that the glacier mass wastage was almost doubled since 2000 and related it to the negative summer mass balance caused by increased temperature.

Overall, this study presents the dynamics of 25 glaciers spread over different basins of the western Himalaya for the 25 years period of 1990/91-2015/2016, and assesses the shift in their dynamics during pre-2000 and post-2000 periods. Velocity results clearly indicate a widespread balanced condition during pre-2000 followed by an accelerated mass loss. The changing glacier velocitiesalso have severe implications in modifying supraglacial

morphology and in regulating the development of supraglacial ponds and ice cliffs (Fig. 3). In view of these findings, the present study is expected to be helpful in understanding the past, present and future glacier evolution over the western Himalaya. Yellow ellipse marked on the photograph shows the human scale

Fig. 3. Field photograph showing supraglacial debris cover, undulating topography and presence of mounds and ice cliffs over G18 (one of the studied glaciers from the western Himalaya).

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Importance and Method for Green Infrastructure Prioritization against Climate-Induced Risks in the North Eastern Indian Himalayan Region.

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Introduction

Climate change has become a major threat to different ecosystems, including Socio-Ecological Systems (SES). SES is a complex and interconnected system of bio-geophysical units with the social actor of a particular region(Redman *et al*., 2004). Assessing the scale of multi-hazard risk and vulnerability in terms of present and future threats of climate change of the SES is important for designing sustainable adaptation strategies for green infrastructure development. Green infrastructure is the type of intervention with minimal ecological disturbance in the present and long-term future, in the region or country that promotes livelihood options for the locals. These types of infrastructure are being planned with considering proper hazard, risk, and vulnerability of the SES in the regions. Green infrastructure development planning in mountains can be one of the probable adaptation practices to reduce the negative effect of climate change. Multi-hazard risk assessments for prioritizing green infrastructure development are essential adaptation and mitigation strategies known for their capacity to increase resilience and reduce the risk and vulnerability of socio-ecological systems to climate change effects, especially in the mountains(Sekhri *et al*., 2020).

Therefore, inclusive Green Infrastructure development in a region should incorporate all of the dimensions of socio-ecological systems and concerns (Ou *et al*., 2022). Thus, the identification of green infrastructure areas in eco-sensitive zones can minimize ecosystem degradation which will ensure climate adaptation has become a research hotspot. Nowadays these types of interventions are also called Ecosystem-based Adaptation (EbS). These types of actives are more cost effetives as compared to pure engineering based intervetions (seddon *et al*., 2020) Green Infrastructure area planning is a successfully tested tool to provide socio-ecological benefits through nature-based solutions in developed counties. Several Green Infrastructure development mechanisms can be adopted by local inhabitants to improve the overall financial strength of their farmlands and households in the mountains of different altitudinal zones, including increasing off-farm income-earning by adjusting the livelihood options, planting high-yielding and climate-resilient crop varieties, intensifying agriculture, modernizing farm cultivation, adoption of agroforestry, and protecting soils. All these adaptation strategies can be applied only after carrying out the multi-hazard risk and vulnerability assessment in different altitudinal zones of the particular region (Negi *et al*., 2022; Sekhri *et al*., 2020). However, as per the knowledge of authors, no such framework has been developed for the Himalayan region.

Nonetheless, in the Eastern Himalaya, socio-ecological systems are facing many challenges in terms of increasing extreme events such as heavy rains, floods, heat waves, and biotic stresses. Further, several studies have listed issues related to the social vulnerability and flood vulnerability at the district level in the Eastern Himalaya but the level of the multi-

hazard risk and vulnerability of the socio-ecological system are not well understood due to a lack of scientific evaluation. Considering the specificity of the geographical region of the Northeast Himalaya, and the special focus of government for development activities, the present methodology tries to providea robust framework for the identification of Green Infrastructure zone at different altitudes and to prioritize Green Infrastructure zones, by linking multi-hazard risk and vulnerability of the Socio-ecological system of the region.

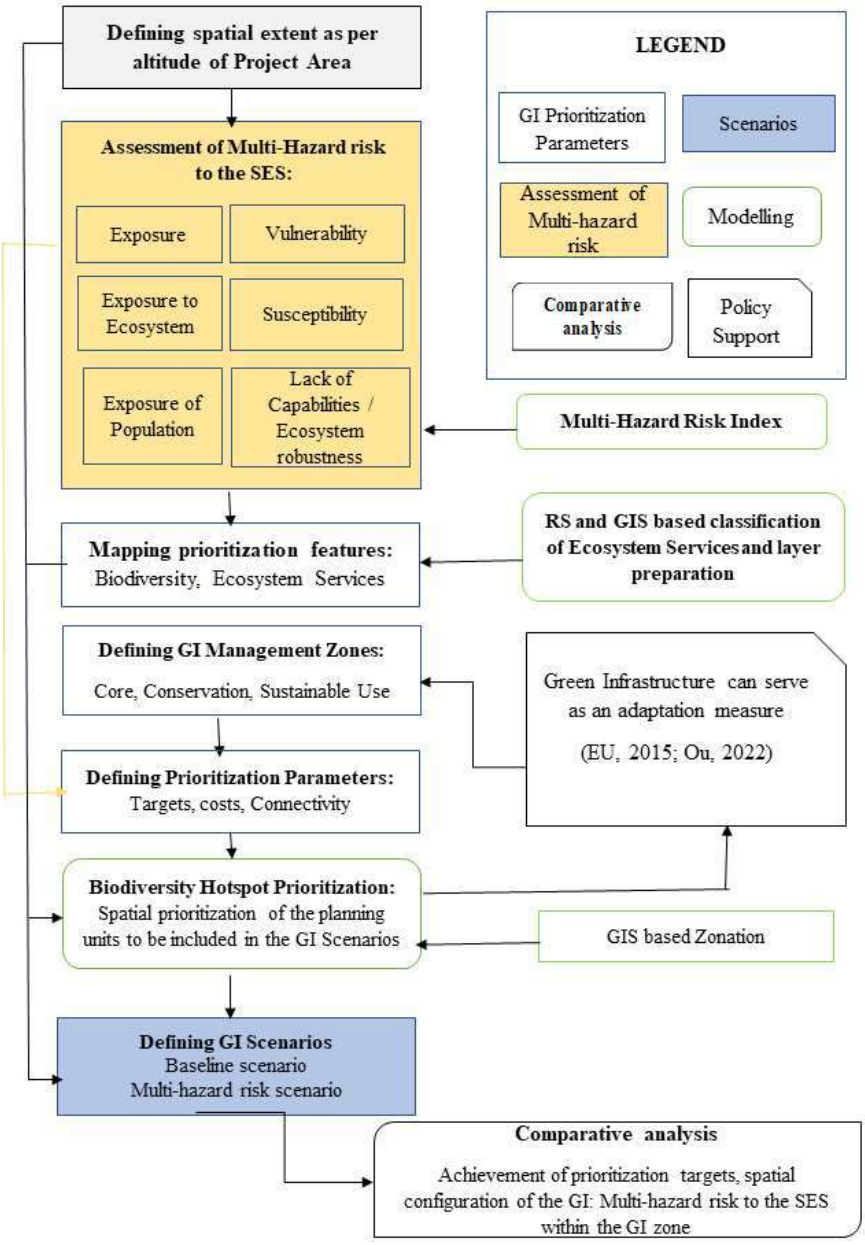

Fig. 1. A mountain-specific methodological framework for Green Infrastructure Prioritization

Methodological Framework for Green Infrastructure Prioritization

To Identify the Green Infrastructure prioritization zone in different altitudes, spatial analysis should be performedusing different layers such (land use land cover, biodiversity, forest types, Ecosystem service layer geographic and multi-hazard risk vulnerability assessment layers) with the help of Geographical Information System (GIS) andother application such

asMarxan with Zones software. This software is a spatial conservation prioritization tool which has been extensively used for spatial planning focused on minimizing the conflict between ecological conservation and exploitation activities of natural resources (Watts *et al*., 2009). The field-level biodiversity assessment should be carried out and the information may be verified from IUCN dataset for this purpose. Finally, it may betransferdin a GIS environment for further assessment and analysis (Fig. 1).

Green Infrastructure Management Zones

These types ofactivityshould try to specify three types of management zone for GI prioritization. The two zones with conservation aimsshould include a core zone for biodiversity conservation and a conservation zone in connection with the core zone should be for sustainable utilization of services from the region. Third zone may be used for development activities.

Environmental and societal benefits from use of present framework

The overarching aim of developing framework for prioritization of green infrastructure in North East India that will help in achieving the socio-ecological resiliency of the region that can be applied in the entire IHR. This framework and the SERVI will help inbuilding the capacity of the stakeholders including line departments, Central Government agencies and local NGO. Furthermore, it will also help in creating awareness at the household levelrelated to the impact of climate change on their livelihood and natural ecosystem, conservation of the socio-ecological systemalong with the best adaptation and mitigation practices.

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भारतीय हिमालयी क्षेत्र में अपशिष्ट का बढ़ता संकट एवं उपाय

पर्णिका गुप्ता एवं वसुधा अग्निहोत्री

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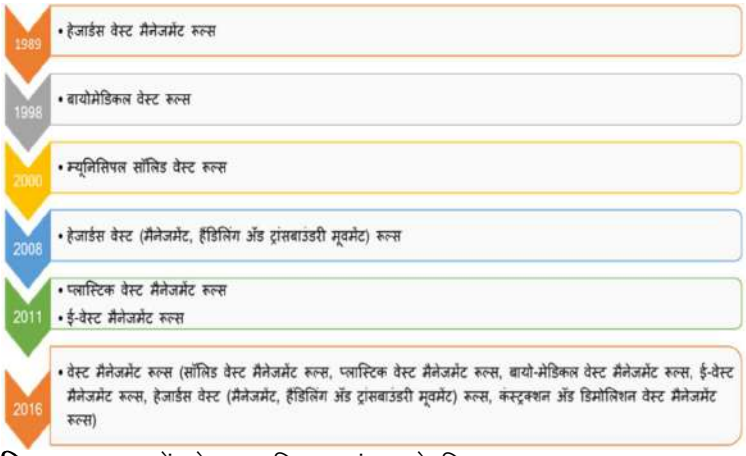
दुनिया का सबसे अधिक आबादी वाला देश, भारत, तेजी से शहरीकरण की ओर अग्रसर है। जनसंख्या का शहरी हिस्सा 1971 में 18 प्रतिशत से बढ़कर 2020 में लगभग 34 प्रतिशत हो गया है और इसकी 2030 तक 40 प्रतिशत तक पहुंचने की संभावना है। यह बढ़ता शहरीकरण, और उपभोक्तावाद के बढ़ने के साथ–साथ ठोस अपशिष्ट पदार्थ की मात्रा भी बढ़ती जा रही है। पारम्परिक कचरा निपटान तंत्र के टूटने और उचित प्रबंधन प्रणाली की कमी के कारण बढ़ता कचरा प्राकृतिक संसाधनों और पर्यावरण को प्रदूषित कर रहा है। बढ़ती आय, तेजी से बढ़ रहा अनियोजित शहरी करण और बदलती जीवनशैली के परिणामस्वरूप भारत में नगरपालिका की कचरा प्रबंधन इकाई में कचरे की मात्रा में वृद्धि और कचरे के प्रकार में परिवर्तन हुआ है (चित्र 1)। भारत, जो एक औद्योगीकृत राष्ट्र का दर्जा प्राप्त करने की लक्ष्य रखता है, में पिछले कुछ दशकों के दौरान तेजी से औद्योगीकरण में वृद्धि हुई है। भारतीय शहरों से अनौपचारिक कचरा महीनों और वर्षों तक निस्तारण क्षेत्र में पड़ा रहता है जहाँ मूल रूप् से केवल अवशिष्ट कचरे के सुरक्षित निपटान के लिए लैंडफिल क्षेत्र विकसित करने के लिए भूमि आवंटित की गई थी।

भारत में नगरपालिका कचरा प्रबंधन की (एम.एस.डब्ल्यू.एम.) की दयनीय स्थिति और चुनौतियां इस लेख की प्रेरणा है। अन्य विकासशील देशों की तरह, भारत में भी ठोस अपशिष्ट प्रबंधन के बारे में आम आदमी की धारणा ''मेरे आंगन में नहीं'' सिंड्रोम से ग्रस्त है और कचरे को केवल शहरी स्थानीय नगर निकायों द्वारा देखभाल के लिए छोड़ दिया जाता है। ठोस कचरे का स्रोत पर पृथ्करण और प्रबंधन का पूर्ण अभाव है। इस प्रकार लोगों की सक्रिय भागीदारी के बिना बढ़ते कचरे का प्रबंधन करना वास्तव में कठिन हो जाता है। लागत प्रभावी और टिकाऊ प्रबंधन के लिए मौजूदा असंगठित क्षेत्र (रैग पिकर्स) का लाभ उठाते हुए एकीकृत ठोस अपशिष्ट प्रबंधन दृष्टिकोण को विकसित और कार्यान्वित करना भी महत्वपूर्ण है। ऐसी निपटान तकनीकों को बढ़ावा देने की तत्काल आवश्यकता है, जिसमें संसाधन वसूली के साथ–साथ ऊर्जा उत्पादन का विकल्प हो। कचरे के सुरक्षित निपटान के प्रति जागरूकता, सार्वजनिक–निजी भागीदारी और कचरे की विशेषताओं के अनुसार उपयुक्त तकनीक का चयन महत्वपूर्ण है(चित्र 1)।

चित्र 1. विभिन्न प्रकार की अपशिष्ट श्रेणियाँ

नगरपालिका ठोस कचरे के प्रबंधन और हैंडलिंग नियम, 2000 के दिशा–निर्देशों के लागू होने तक नगरपालिका अपशिष्ट भारत भर में एक उपेक्षित मुद्दा था। ठोस अपशिष्ट प्रबंधन में कटौती, पुर्नचक्रण और संसाधन पुनप्राप्ति के सिद्धांतो का पालन करने के बाद अवशिष्ट कचरे को सुरक्षित रूप से जमा करने की आवश्यकताहोती है ताकि गैर वसूली योग्य और अन्य ऐसे कचरे को अलग किया जा सके और इसे पर्यावरण पर प्रतिकूल प्रभाव डालने से रोका जा सके। इन नियमों के बावजूद भारत में केवल हानिकारक कचरे के लिए ही वैज्ञानिक रूप् से विकसित लैंडफिल है। ठोस कचरा प्रबंधन 2016 नियमों के अनुसार केवल प्रयोग में न आने वाले, गैर–पुर्नचक्रण योग्य, गैर– जैव अपघटित, गैर दहनशील और गैर–प्रतिक्रियाशील अक्रिय अपशिष्ट और अपशिष्ट प्रसंस्करण सुविधाओं के अवशेष ही एक सैनिटरी लैंडफिल में जायेंगे। इन नियमों के बावजूद कचरा इधर–उधर फैला हुआ देखा जा सकता है। भारत में अपशिष्ट प्रबंधन के लिए प्रशासन और विनियमन पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय (एमओईएफसीई), शहरी विकास मंत्रालय (एमओयूडी), राष्ट्रीय पर्यावरण इंजीनियरिंग अनुसंधान संस्थान (एनईईआरआई), केन्द्रीय अथवा राज्य प्रदूषण नियंत्रण बोर्ड (सीपीसीबी, एसपीसीबी) और जमीनी स्तर पर कार्यान्वयन की जिम्मेदारी शहरी स्थानीय निकाय द्वारा शासित है। पिछले लगभग ढ़ाई दशकों के दौरान भारत में अपशिष्ट प्रबंधन के लिए सरकार द्वारा बनाए गए नियम निम्नलिखित है (चित्र 2)।



चित्र 2. भारत में ठोस अपशिष्ट प्रबंधन के लिए सरकार द्वारा उठाए कदम

भारत विविध स्थलाकृति का देश है जिसके उत्तरी भाग में हिमालय स्थित है। हालांकि हिमालयी क्षेत्र में आबादी अधिक नहीं है परंतु यह क्षेत्र अपनी प्राकृतिक सुंदरता एवं धार्मिक स्थानों क कारण दुनिया भर से आगंतुकों और तीर्थ यात्रियों को आकर्षित करते है। नीति आयोग की 2018 की रिपोर्ट के हिसाब से सालाना 10 करोड़ पर्यटक का आगमन होता है। पिछले कुछ दशकों में हिमालयी क्षेत्र में पर्यटन, भारत में सबसे तेजी से बढ़ते आर्थिक क्षेत्रों में से एक बन गया है और 2025 तक पर्यटकों की संख्या 24 करोड़ तक बढ़ने का अनुमान है। तेजी से हो रहे आर्थिक परिवर्तन ने उचित अपशिष्ट प्रबंधन प्रौद्योगिकियों की कमी के कारण कचरे के उत्पादन और उसके कुप्रंबधन की समस्या को बढ़ा दिया है।

पर्वतीय क्षेत्रों में विभिन्न जलवायु परिस्थितियां होती है जैसे कम तापमान, विविध स्थलाकृति और प्राकृतिक आपदाओं की प्रवृत्ति जिनके मिलने से अपशिष्ट प्रबंधन में अतिरिक्त चुनौती मिलने से अपशिष्ट प्रबंधन में अतिरिक्त चुनौती पैदा होती है। हिमालय में होने वाले शहरी विकास प्रक्रिया काफी हद तक अनियोजित और अनियमित है जिसने इसका प्रबंधन करने के लिए नगर पालिका की क्षमता को बढ़ाने की आवश्यकता है। अपशिष्ट प्रंबधन में जगह की कमी के कारण कूदे को खुले में जलाना, एवं निस्तारण और गैर–इंजीनियरड लैंडफिल जैसे अनुचित निपटान के तरीके सामने आये हैं। इसके अलावा कूड़ा–कचरा घाटियों और नदियों में फेंका जाता है, जिससे मीठे पानी की धारायें और स्रोत प्रदूषित होते हैं।
भारतीय हिमालयी क्षेत्र में लगभग 1.1 करोड़ शहरी आबादी लगभग 1.905 मैट्रिक टन प्रतिवर्ष ठोस अपशिष्ट पैदा करती है। उत्पन्न कचरे में से 1.688 मैट्रिक टन एकत्रित किया जाता है, 0.413 मैट्रिक टन का उपचार किया जाता है और केवल 0.263 मैट्रिक टन कचरे का उचित तरीके से निस्तारण किया जाता है। दूसरी ओर यहाँ की ग्रामीण आबादी के पास कचरे को कुशलपूर्वक निपटाने का कोई विकल्प नहीं है जिसके परिणामस्वरूप इस स्थलाकृतिक रूप् से नाजुक पहाड़ों पर संचयी बोझ पड़ता है। जमा हुए ठोस कचरे को खत्म करने के लिए क्षेत्र के लोगों ने अनौपचारिक तरीकों को अपनाया है जो पर्यावरण और सार्वजनिक स्वास्थ्य को प्रभावित करता है। भारतीय हिमालयी क्षेत्र में हो रहे आर्थिक बदलाव का नकारात्मक पक्ष गैर–निगरानी वाली गतिविधियाँ जैसे ट्रैकिंग, अभियान आदि हैं जिसके परिणामस्वरूप अनियंत्रित ठोस अपशिष्ट उत्पादन होता है जो की लगभग 0.839 करोड़ टन प्रतिवर्ष है। एक कारण यह भी है जिससे पारिस्थितिक रूप से संवदेनशील क्षेत्रों की ओर चिंता बढ़ जाती है। उत्पन्न कचरे की संरचना मुख्य रूप से निवासी आबादी की स्थानीय खपत पैटर्न और खाने की आदतों पर निर्भर करती है। हिमालयी क्षेत्रों में उत्पन्न अपशिष्ट पूरे वर्ष असंगत होता है क्योंकि गर्मियों और सर्दियों में पर्यटक प्रवाह भिन्न होता है जो अपशिष्ट संग्रह, परिवहन, उपचार और निपटान सुविधाओं पर बोझ डालता है। कचरा प्रबंधन शिक्षा और जागरूकता कार्यक्रम की कमी और कचरे के उचित संग्रह के लिए किसी औपचारिक प्रबंधन प्रणाली की अनुपस्थिति के कारण पर्यटकों द्वारा उत्पन्न कचरा नाजुक व संवदेनशील स्थानों में पीछे रह जाता है। पदार्थ अपशिष्ट, हिमालय में वन्य जीवों की स्थिति को भी प्रभावित कर रहा है क्योंकि भारी मात्रा में फैले हुए कचरे ने कई गम्भीर रूप से लुप्तप्राय प्रजातियों की शिकार क्षमताओं को बदल दिया है। इस गंभीर समस्या के बावजूद भारतीय हिमालयी क्षेत्र पर केन्द्रित अपशिष्ट संरचना के आँकड़े दुर्लभ है। कुमाल एट. आल, 2016 के एक अध्ययन में पूर्वोत्तर भारत के आठ राज्यों के 10 शहरों एवं उत्तराखण्ड और हिमालय प्रदेश के 2 शहरों के अपशिष्ट कूड़े में विभिन्न प्रकार के पदार्थो की मात्रा को चित्र संख्या 3 में दर्शाया गया है (Kumar *et al.*,2016)। मुख्य रूप से जैव निम्नीय कचरा घरों से उत्पन्न होता है और अक्रिय कचरा सड़क की सफाई और रख–रखाव निर्माण, उत्खनन सामाग्री और विध्वंस से उत्पन्न होता है हालांकि विकास में वृद्धि, प्रतिव्यक्ति आय और पर्यटकों की बढ़ती संख्या के कारण हिमालयी क्षेत्र में गैर जैविक कचरों में लगातार वृद्धि देखी गयी है। अपशिष्ट पुर्नचक्रण खाद्य अवायवीय पाचन, रेफ्यूज व्युत्पन्न ईधन और लैंडफिल गैस का उपयोग जैसा दृष्टिकोण अपशिष्ट के मूल्यवान उत्पादों में परिवर्तन के लिए उपयोगी है। ''एकल उपयोग वाले प्लास्टिक पर प्रतिबंध'' और ''प्रदूषकों द्वारा भुगतान'' जैसी पहलों की अपशिष्ट प्रबंधन में संभावित भूमिका है। विशिष्ट अपशिष्ट प्रौद्योगिकी का चयन, क्षमता निर्माण और कई पर्यावरण करों की शुरूआत, अपशिष्ट प्रबंधन के निर्वाह और विकास के लिए आवश्यक राजस्व प्रदान कर

सकती है। मुख्य रूप से सरंक्षण अथवा सामाजिक आर्थिक विकास पर ध्यान केंद्रित करते हुए हिमालयी राज्य विशिष्ट रणनीतियों को लागू किया जाना चाहिए। जब तक इन चुनौतियों को पूरा नहीं किया जाता। भारतीय हिमालयी क्षेत्र में हो रहे आर्थिक परिवर्तन अथवा मानवजनित समस्याओं का पर्यावरण पर बोझ बना रहेगा।

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जलवायु अनुकूल खेती के लिए जंगली खाद्य सक्यूलेंटस (वाइल्ड एडिबल सक्यूलेंटस) को उगाने की आवश्यकता

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सार

तापमान में लगातार वृद्धि और बदलाव के कारण आने वाले वर्षों में सूखा, पानी की कमी, गंभीर सामाजिक एवं आर्थिक नुकसान और भोजन संकट होने की भारी संभावना है। इंटरनेशनल पैनल ऑन क्लाइमेट चेंज ने पहले से ही रिपोर्ट प्रकाशित की है कि आने वाले वर्षों में खाद्य सुरक्षा के सभी पहलू जैसे कि उत्पादन, मांग,पहुंच,खपत और मूल्य स्थिरता जलवायु परिवर्तन से संभावित रूप से प्रभावित होंगे। वर्तमान में ही हमारी कृषि लगातार जलवायु परिवर्तन की चुनौतियों का सामना कर रही है,जो निकट भविष्य में और अधिक गंभीर होने वाली है। इस अध्ययन मेंभोजन संकट से निपटने के लिए और सतत विकास सुनिश्चित करने के लिए जलवायु अनुकूल भविष्य की फसलों के रूप में उगाने की आवश्यकता पर जोर दिया गया है ।

परिचय

सक्यूलेंटस रसीले या गूदेदार पौधे होते हैं जिनका कोई हिस्सा (पते,ताना या टहनियां) साधारण से अधिक मोटा होता हैं। इन हिस्सों में पानी भंडारण की क्षमता होती है। काटने पर इनसे रस, जल या गोंदनिकलती देखी जा सकती है। इसलिए ये शुष्क या पानी की कमी वाले स्थानों में आसानी से उगते हैं, तथा वातावरण से अधिक मात्रा में कार्बन डाइऑक्साइड अवशोषित करने में कुशल होते हैं। सक्यूलेंटस का रसीलापन,जो नियमित सूखे और उच्च तापमान के लिए एक रूपात्मक अनुकूलन है, को बदलते वातावरण से आने वाली चुनौतियों (जैसे कि सूखा, पानी की कमी और भोजन संकट आदि) के समाधान के लिए भविष्य की खाद्य फसलों में वरीयता दी जा सकती है। पश्चिमी हिमालय के विभिन्न हिस्सों में कुछ जंगली खाद्य सक्यूलेंटस जैसे कि रामबाण, छूहीं, नागफनी और पथरचट्ट का उपयोग स्थानीय लोगों द्वारा आपातकालीन भोजन या मौसमी व्यंजनों के रूप में किया जाता है। सूखे और भोजन की कमी के समय ये पौधे उनके लिए भोजन के महत्वपूर्ण स्रोत हैं। चूंकि इनके जल–भंडारण ऊतक वनस्पति परिवार में सबसे सफल सूखा अनुकूलन है और सूखे स्थानों में उगने में अधिक सक्षम है । ये शुष्क स्थानों में भी ऊर्जा आपूर्ति को बनाए रख सकते हैं। इस प्रकार,ये पौधे हमारी वर्तमान खाद्य फसलों को अधिक पौष्टिक, किफायती,जलवायु लचीला और टिकाऊ बनाने की जबरदस्त क्षमता रखते हैं ये पौधे न केवल पोषक तत्वों के बहुमूल्य स्रोत हैं बल्कि स्थानीय लोगों के लिए इनके कई अन्य उपयोग भी हैं। अपने औषधीय मूल्यों के कारण उनकी फार्मास्युटिकल उद्योग में भी भारी मांग हैं। इसलिए इनको जलवायु परिवर्तन के प्रतिकूल प्रभावों को कम करने के लिए एक संसाधन के रूप में पहचानने की सख्त जरूरत है। आइये इस लेख में जानते हैं ऐसे ही कुछके बारे में।

1– ओपोंसीयाः (नागफनी या दराबडछूहीं) की दो प्रजातियाँ (ओपोंसीया दिल्लेनी और ओपोंसीया फिकस इंडिका) बारहमासी पौधे हैं जो 2000 मीटर की ऊंचाई तक मिलती हैं। वे वनस्पति परिवार कैक्टैसी से संबंधित हैं और अपने स्थानीय नामों नागफनी या द्राभड छूहीं से जानी जाती है। सक्यूलेंटस होने के कारण ये सूखे और अनिश्चित वर्षा की स्थितियों में भी अच्छे से पनपते हैं। आमतौर पर इन्हें सड़कों के किनारे, रास्तों, पहाड़ी ढलानों और खुले जंगल में उगते देखा जाता है। हालांकि, दिल्लेनी, फिकस –इंडिका की तुलना में अधिक सामान्य है। इनके कोमल पैड (तना व् शाखाएं)और फलों को स्वादिष्ट सब्जी में पकाया जा सकता है और पके फलों को कच्चा खाया जाता है। विन्स की तरह कटे हुए पैड पुलाव, पोहा, पास्ता आदि में पकाए जा सकते हैं। पके हुए फलों का उपयोग देसी शराब बनाने में भी किया जाता है। इन पौधों पर कांटे मिलते हैं जो दिल्लेनी में अधिक तेज और दर्दनाक होते हैं। फलों पर मौजूद काँटों को पत्थरों पर या किसी गीले मोटे कपड़े से रगड़ कर हटाया जा सकता है। ये पौधे फाइबर, वसा, राख, अम्लीय, एस्कॉर्बिक एसिड, कुल फेनोलिक, ग्लूकोज, फ्रुक्टोज और खनिजों Na] Ca] Mg] Mn] K] Fe] Zn] छप का समृद्ध स्रोत है। इनका सेवन इम्युनिटी बढ़ाने और कैंसर को ठीक करने में भी मददगार है। इन पौधों को हेज (बाड) या सजावटी पौधे के रूप में भी उगाया जाता है। फिकस–इंडिका के कोमल अंकुरों को चारे के रूप में भी इस्तेमाल किया जा सकता है।

2– अगेव कैनटलाः यह वनस्पति परिवार अस्पेरेगेसी से संबंधित एक बारहमासी सक्यूलेंटहै । इसका सथानीय नाम रामबाण है तथा इंग्लिश में इसे बॉम्बे एलो कहा जाता है। यह 1500 मीटर की ऊंचाई तक बंजर भूमि, खेत की सीमाओं

और पहाड़ी ढलानों में उगता हुआ पाया जाता है। इसकी युवा कलिया खाने योग्य होती हैं और सब्जी के रूप में पकाई जाती हैं। कलियों में फाइबर 1 ग्रमय शर्कराः12 ग्रामय विटामिन एः0.02 ग्राम और विटामिन सीः0.04 ग्राम तथा पोषक तत्व होते हैं। कलियों को ऑफ सीजन के लिए संरक्षित करने के लिए अचार भी बनाया जा सकता है। पत्तियां फाइबर का अच्छा स्रोत हैं। एगेव को आवास और बगीचों के पास हेज या सजावटी पौधे के रूप में उगाया जा सकता है।

3– यूफोरबिया रोयलेयानाः यह वानस्पतिक परिवार यूफोर्बियेसी का सदस्य है। इसका स्थानीय नाम छूहीं है यह देखने में बंजर भूमि पर उगने वाला एक बेकार सा पौधा लगता है जिसमें खंडों वाली हरी शाखाएँ होती हैं। पोधे में एक सफेद दूध जैसा तरल पदार्थ भरा रहता हैं जिसको लेटेक्स कहते हैं। यदि पौधे में कोई छोटी सी भी चोट लग जाये तो लेटेक्स की बूंदें टपक कर गिरने लगती हैं। कहा जाता है कि छूहीं का दूध आंखों के लिए बहुत हानिकारक होता है। इसलिए छूहीं के आसदृपास होने पर आंखों के बचाव की विशेष आवश्यकता होती है। इसका कोमल तना और शाखाएं पका कर खाने योग्य होते हैं और इनसे सब्जी के अलावा, एक बहुत ही विशिष्ट व्यंजन मिट्ठा भी तैयार किया जा सकता है। बस ध्यान रहे कि छूहीं को प्रयोग में लाते समय इसका दूध आपकी आँखों या त्वचा को न लगे। इसलिए छूहीं को निकालने और काटने से पहले गाँववासी अपने हाथों में सरसों का तेल लगा लेते हैं। इससे अंगों का दूध से बचाव हो जाता है। पकाने के लिए छूहीं की कोमल शाखाएं छोटे टुकड़ों में काटी जाती हैं। फिर इन टुकड़ों को बहते पानी में या नल के नीचे अच्छी तरह से धोया जाता है ताकि ये लेटेक्स से पूरी तरह मुक्त हो जाएं। अब ये मनचाहे तरीके से पकाने के लिए तैयार हैं। हिमाचल के बहुत से क्षेत्रों में शादी ब्याह तथा अन्य अवसरों में परोसी जाने वाली धामों की शुरुआत मिट्ठे से ही होती है। इसके लेटेक्स को यदि सरसों के तेल के साथ मिला कर जोड़ों पर लगाएँ तो दर्द से आराम भी मिलता है। छूहीं में मेथनॉल, हैक्सेन ,एंटीओक्सीडेंट और एंटीटुमर गूण होने के कारण इसका सेवन कैंसर और बवासीर जैसे रोगों की रोकथाम में लाभकारी है। गांवों में महिलाएं छूहीं के दूध से काजल भी बनाती हैं। यह माना जाता है कि यह काजल नवजात शिशुओं तथा छोटे बच्चों की आँखों की ज्योति बढ़ाता है। यह भी मान्यता है कि प्रसव से पहले प्रेगनेंसी के अंतिम महीनों में काजल बनाने की प्रक्रिया होने वाले बच्चे का लिंग जानने का एक सरल सा तरीका है। काजल बनाते समय दिये के ऊपर काजल एकत्रित करने के लिए रखे गए वर्तन में बनने वाले लिंग की आकृति शिशु के लड़का या लड़की होने के बारे मैं संकेत देती है। इसलिए लोग लिंग जांच के लिए यह तरीका अपनाते थे। सूखी हुई छूहीं को इंधन के रूप मं प्रयोग किया जा सकता है।

4– पोरटूलेका ओलेरकाः यह वनस्पति परिवार पोरटूलेसी से संबंधित एक जड़ी–बूटी है। इसका सामान्य नाम पर्सलेन तथा स्थानीय नाम कूलफा या नयार है। यह आमतौर पर धूप वाली नम जगह,धान व् मक्की के खेतों और अन्य खाली स्थानों में 1800 मीटर की ऊंचाई तक उगता हुआ पाया जाता है। इसकी कोमल टहनियां, पत्ते और बीज खाने योग्य होते हैं। यह पत्तेदार सब्जी साग के रूप में पकाया जाता है। इनमें ऊर्जा–16 Kcal; कार्बोहाइड्रेट–3.4 gm; प्रोटीन–1. 30 ग्राम कुल फैट–0.1ग्रम विटामिन **।–1320**IU; विटामिन सी –21 मिलीग्रामः कैल्शिय्म –65 मिलीग्रामः ताम्बा –0.113 मिलीग्रामः आयरन–1.99 मिलीग्रामः मैग्नीशियम –68 मिलीग्रामः मेगनीज –0.303 मिलीग्राम होता है। इन्हें स्थानीय बाजार में भी बेचा जाता है और चारे या सजावटी पौधे के रूप में भी उपयोग किया जाता है।

5– कलांचो पिनाटाः यह 1000 मीटर तक की ऊंचाई तक मिलने वाला एक बारहमासी पौधा है जो कि वानस्पतिक परिवार क्रएसुलएसी से आता है।यह अपने जीवाणुरोधी, एंटीवायरल, रोगाणुरोधी, एंटिफंगल, एंटीहिस्टामाइन गुणों के कारण विभिन्न प्रकार की बीमारियों को ठीक करने के लिए उपयोग किया जाता है। इसका विशेष उपयोग गुर्दे की पथरी को गलाने के लिए किया जाता है। यही कारण है कि यह पथरख।र, पथरचट् या पत्थरचूर आदि स्थानीय नामों से जाना जाता है। यह पत्तियों से प्रजनन करता है तथा आसानी से आसपास के क्षेत्रों में फैल जाता है। पथरचट् के इस अद्वितीय प्रजनन और विभिन्न प्रकार के रोगों को ठीक करने की प्रवृत्ति के कारण इसे कई दिव्य सामान्य नामों जेसे कि मदर ऑफ मिलियन, एयर प्लांट, लाइफ प्लांट, लाइव लीफ, लाइव लीफ प्लांट इत्यादि से जाना जाता है। इसकी पत्तियां, तना और जड़ सभी खाने योग्य होते हैं। इनको मसालों, पोषक तत्वों की खुराक या हर्बल चाय के रूप में लिया जा सकता है। इसकी पत्तियां थोड़ी मात्रा में परांठा, ओट्स, पास्ता, पकोड़े, पकोड़ा करी, चटनी, कचरू (बेसन के साथ प्याज, पथरचट की पत्तियों एवं मसालों से चीला की तरह पकाया जाने वाला स्नैक) आदि में आहार पूरक के रूप में उपयोग की जा सकती है। पथरचट की 100 ग्राम पत्तियों में ऐश क्रमश 1–21 और 0–8% कार्बोहाइड्रेट, 72-92 और 4-46% बसा, 1–38% और 1–15% रेशे, 6–02 और 0–95% प्रोटीन, 5–38 और 1–61% और नमी, 13–01 और 91–03% विटामिन के, 3–49 और 3–74% तथा कैल्सियम, 4–99 और 6–28% होता है।

निष्कर्ष

इस लेख में वर्णित स्थानीय लोगों के लिए बहुउद्देशीय (6 से अधिक उपयोग) पौधे हैं वर्तमान में इनका भोजन या भोजन पूरक के रूप में उपयोग बहुत ही कम है। अद्वितीय और असामान्य बनावट होने के कारण ये अत्यंत शुष्क वातावरण के लिए भी अच्छी तरह से अनुकूलित हैं और जल संरक्षण उत्तम तरीके से करते हैं। वे आसानी से प्रजनन कर सकते हैं और रासायनिक उर्वरकों के किसी भी उपयोग के बिना सूखे, गर्म और अधिक परिवर्तनशील जलवायु

परिस्थितियों में अच्छी तरह से उगाए जा सकते हैं। इसलिए,ये भविष्य की खाद्य फसल होने की पूरी क्षमता है। इनको जलवायु के अनुकूल खाद्य फसलों के रूप में उगाना समय की जरूरत है ताकि हम अपनी आने वाली पीढ़ी को कई जानलेवा बीमारियों से बचा सके।

Section- III
Culture and Literature

THE SOCIO-CULTURAL AND LITERARY ACTIVITIES OF THE TRIBALS OF TRIPURA REFLECTED IN THE NOVEL "HACHUKKHURIO"

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Abstract

The culture of Tripura is similar to that of the ethno-tribal people. Similar to the cultures of Tripura, Assam, Manipur, Burma and Southeast Asia, small parts of the plains are influenced by mainstream Indian cultural influences, especially by tribal traditions from Bengal culture, especially in the plains which are not extensively mountainous. Tripura is a state in northeastern India. In the 2001 census of India, Bengalis represented about 70% of the Tripura population and 30% of the Tripura population belonged to the indigenous population. Indigenous populations belong to different tribes and ethnic groups with different languages and cultures. The largest indigenous group was the Kokborak-speaking tribe of Tripura.There are linguistic groups in different ethnic groups in Tripura, which has given rise to a composite culture. The influential cultures are Bengali, Bishnupriya Manipuri, Manipuri, Tripura, Jamatia, Riang, Noatia, Kolai, Murajing, Chakma, Halam, Garo, Kuki, Mizo, Mug, Munda, Aron, Sanhal and Uchai.Tripura is notable for its bamboo and cane handicrafts. Hindus believe that Tripureshwati is the patron goddess of Tripura and the people of Tripura. Several deities are worshiped by the tribes, such as Lam-prera (dual gods of sky and sea), Melu-ma (goddess Lakshmi), Khulu-ma (goddess of cotton plants), and Burha-cha (god of healing). Several festivals are associated with different tribal traditions such as Ganga Puja, Giaria Puja, Kherchi Puja, Ker Puja etc.

Introduction

The chief novelist SudhanyaDebbarma of the Kakbarak language of Tripura and the writer of the novel, 'HachukKhurio', was born in the village of Sutaramura under the Bishalgarh police station in West Tripura in Shakabda (1918). Sudhannya Debbarma is a renowned writer in the field of Kakbarak literature in Tripura. Sudhanya Debbarma is one of the best writers in the history of kakbarak literature, her novel '**HachukKhurio'** being the first novel published in kakbarak. The novel **'HachukKhurio'** i.e. '**in the lap of the hill,**'in Bengali language ends in four volumes. He wrote the first volume of the novel while imprisoned in the Hazaribagh jail in Bihar during the Sino-Indian conflict in 1962. He wrote three more volumes after his release from jail. SudhannyaDebbarma has introduced her mother tongue, kakbarak, to the readers of the world by writing an epic novel based on the life story of her kakbarak-speaking people. The kakbarak language is a living language of a large branch of the Tibetanlanguage family. At present, Kakbarak-speaking people are more than ten lacs though the government of Tripura recognized this language as an official language in 1979.

Life and culture in the Novel Hachukkhurio: -

SudhannyaDebbarma is one of the brightest names in the genre of indigenous life and culture and literature of Tripura in the novel 'HachukKhurio'. His novel 'HachukKhurio' (English translation: In the lap of the hill) is one of the documents in the Mirror of Tribal life. In this novel, as he paints a picture of the disintegration of the tribal society and the Tripuri society, he also depicts the unprecedented changes that have taken place in the lives of these tribal

people as a result of the mass education movement. In literature, the image of society finds a place in the writings of every writer. Therefore, SudhannyaDebbarman's novel, 'HachukKhurio' gives a detailed account of the life and culture of the tribes and the Tripuris. The people of the Tripura tribal community have been living in the forest for a long time. As a result, they have never been able to keep pace with the world's progress for a long time. In fact, such a situation did not arise. Just as time did not stand still, so did people's thoughts in the life journey. At one time, he had to be caught in the whirlpool of time. So the changing situation of the Tripura is indigenous people over time— they have a desire to move forward with the culture and culture of the world. So, this changed culture and culture is captured in SudhannyDebbarma's novel **'HachukKhurio'**. This Culture can be further divided into two parts: the first part is directly related to daily life, and the second part is related to the means and means of subsistence. Culture is the strategy of survival and man is the only cultured animal in the world.

Adornments and Dressing

Tribal people have their own dresses. For example, men used to wear the dhoti of American clothing. In ancient times, towels and barakwere also used. However, with the change of era, the circulation of this dhoti almost went up.

Scholarship Equipment

The main source of income for the residents is farming. They used to make a living by cultivating jum. But later, he left Jum and started farming. Tribal peoples live in the hills or in the mountains. It is also called 'Shifting Cultivation'.

Belief of the People:

The inhabitants believe in various supernatural things. They believe in ghosts, demons, gods, sorcerers, witches, etc. According to the beliefs of the inhabitants, if someone is ill, the patient should be called to ojha or ojha at home.

Custom of the People: -

There are various customs of the people in the society of Tripura. In this novel also, there is a mention of some customs. For Examples –

House Son-In-Law or Son-In-Law Working Style:

In the Tripuri society at one time the practice of house son-in-law was prevalent. In the novel, it can be seen that the novelist speaks of the practice of this house son-in-law through the devotees. In the month of Bhadra, Ashwin, the young boys go to the house of the father-in-law when the son-in-law wakes up. The boys had to go to the daughter's house for a month or two before marriage to work.

Dowry System

Kanyapana was prevalent in Tripuri society. At the time of marriage, the bridegroom would dowry for the bride. But with the passage of time, the practice of barpanwas introduced. Dowry practice is not only rampant in Tribal society. Dowry exists in all societies.

Popular Custom

There are several kinds of popular custom in the Tripura community. There are also several kinds of popular customary system in the society of Tripura.

The Funeral Obsequies

In Tripura society, when someone dies, the boys of the neighborhood cut wood and bamboo and go to the crematorium. The dead body is decorated with flowers and taken to the crematorium in new clothes.

Funeral Ceremony:

There are also rules of funeral ceremony in Tripuri society after death. On the occasion of this funeral ceremony, the people of the village are fed according to their ability. Therefore, in the novel, it is seen that even in the funeral ceremony of the old devotee.

Conclusion

Tripuri religion is based on Hinduism. The habitants of the intention through perform their traditional ritual according to their customs, many of their god and goddesses are akin to the Hindu gods and goddesses particularly in the nature of belief. Only the mode of worship is completely different. Besides, the neighbouring Hindu Bangalees have a distinct shape of their deities which is absolutely found absent among the Tripuries. In Sudhannya Debbarma's novel, 'HachukKhurio', there are many characters. He has beautifully presented the activities of each character. This Novel has nicely presented the indigenous people's life and characters. And in this way, SudhannyaDebbarma has painted the social and financial life of the people through his novel. All the characters are beautifully set in such a way that seems very significant and important.

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चीखती- बिलखती नदियाँ

चीखती- बिलखती नदियाँ
जोर- जोर से मचलती लहरें
दर्द सुनाई नहीं देता है प्रकृति का
क्यूँ बन बैठे हो तुम बहरे?

गिरते डंगे रास्तों के
और दरकते रहे पहाड़
किसने और क्यूँ? शरू किया है
प्रकृति के साथ खिलवाड़
समय है बचाव भी होगा
यूँ ना मनोरम हिमालय को उजाड़

सभी विद्वान है यहाँ पर
पर प्रकृति सा ज्ञानी नहीं
पट्टे पर मिली है वसीयतें यहाँ रहने की हमें
प्रकृति के संसाधनों पर हक हमारा खानदानी नहीं
यूँ ना लूटो इनको तुम दिखावे के चक्कर में
समझदार है इंसान तू
पर इतना भी अज्ञानी नहीं

नदी- नालों पर तुम्हारा कोई अधिकार नहीं
जो मिला है जीवन ये चंद दशकों की साँसों का
ये इतना भी बेकार नहीं
बीमार हो गयी तेरी गलतियों से, ये वादियाँ
स्वच्छ जल, वायु, अन्न से लहलाते खेत
क्या मर हम वाला कोई उपचार नहीं?

किसके लिए ये हम सबकी दौड़ है
आने वालों के लिए कमा रहे हैं इतना सारा
पीछे क्या छुटा मालूम नहीं, आगे भी कुछ बेहतर ऐसे और नहीं
बचालो जितना बचा सकते हो इस धरा को
छलक जाए भरने से, ये कोई घड़ा नहीं

चोट गहरी और जोर से लगी है इसे
तुझे दिखता अपनी आकांक्षाओं का ताड़ नहीं

अभी भी वक़्त है बेहतर से बेहतरीन नजारे ला सकते हैं
ज़मीं पे आसमां से चाँद- सितारे ला सकते हैं
ये जो फ़ैला है मंजर आज कल बर्बादी का यहाँ
इसको सूझ बूझ से किनारे ला सकते हैं
जब ये प्रकृति है तभी हम सभी है यहाँ
इसका सरंक्षण ज़रूरी है सबके लिए
दिन फिर से यहाँ सुनहरा ला सकते हैं

क्यूँ निचोड़ना है तुम्हें इसे
क्या कोई कल रहने के लिए यहाँ दुबारा आ सकता है ?

ना कोई वर्तमान, ना कोई भविष्य और ना ही भूतकाल

क्या देहावसान के बाद हमारा- तुम्हारा आ सकता कोई यहाँ ?

वक़्त जवाब देना जानता है

याद रखना इन सब बातों को

वक़्त और प्रकृति से यहाँ कोई बड़ा नहीं

ये तत्पर रहे हमारे लिए, उपस्थित रहे यहीं के यहीं

जब- जब जरुरत थी इन पहाड़ों कोहमारी

इनके हक के लिए कोई इन के जैसा अटल, अडिग खड़ान हीं

पहाड़ों की सम्पदाओं के दोहन के लिए

फिर कोई इन नदी- नालों में बहते उफान की तरह इन के हक के लिए लड़ा नहीं

खेमचंद
क्षेत्र- अन्वेषक(इसरो- जीबीपी)
गोविंद बल्लभ पंत राष्ट्रीय हिमालयी पर्यावरण संस्थान
हिमाचल क्षेत्रीय केंद्र, मौहल- कुल्लू
हिमाचल प्रदेश

अतीत के बेहतर दौरों ने

“बिन वृक्ष वीरान होगी धरती
याद रखना पैसों से कभी
शरीर में शुद्ध वायु नहीं है भरती.....
तुम डरा रहे हो इसे अपने विज्ञान के लाभ से
याद रखना इसने हम जैसे करोड़ों पाले है युगों- युगों से
ये धरती, ये प्रकृति येपर्यावरण एक माँ है
और ये उगाही करने से कभी डरती नहीं “

अतीत के बेहतर दौरों ने
जंगल वीरान किया औरों ने ?
आने वाली पीढ़ी तुम्हारे दिखावे की भूखी होगी नहीं
याद रखना आठों प्रहरों में
घरवार, ऊँची इमारतें सब बना लेना
वक़्त देख रहा है वक़्त की दीवारों में
कभी यहाँ मिट्ठे पानी की बावड़ी थी
कभी यहाँ ऊँचें देवदार, कैल, रौई,तोष
खरशु, मोहरू, बान, खनोर, रखाल
के थे वन

बस! पढ़ेंगें अब वो सिर्फ किताब- अखबारों में
ये कैसी भाग- दौड़, ये कैसी इर्ष्या
इंसान की इंसान से
ये कैसी लड़ाई अपने अंदर के हैवान से
सब बढ़े जा रहे हैं बस लम्बी- लम्बी कतारों में

भू-कटाव, भू- धंसावदरकती पर्वत मालाओं ने
नदी- नालों के रास्ते रोके
घोल दिया है ज़हर हमने शांत वादियों की फिजाओं में
वातानुकूलित, फ्रीज़, कूड़े- कचरे के ढेरों ने
बना लिया होटल अपना दरिया इन्हीं किनारों में
भूख इतनी मिटे ना नोट हजारों से
क्या- क्या नहीं बेचा हमने झूठे इन बाज़ारों में ?

जंगल जलाए, पेड़ कटाए अंधाधुंध इन मशीनों से
धरा का रोना सूनान हींरो रही है महीनों से
देखना तुम एक दिन जवाब इसका
बेदखल कर देगी प्रकृति हमें हमारी जमीनों से
जंगल लगाओ- जंगल बचाओ बात होगी हर सरकारों में
लूट लिया है प्रकृति को, आश्रय में रहकर इन्हीं ढोंगी दरबारों ने
अतीत कितना सुंदर, खुबसुरत, मनोरम, दर्शनीय छोड़कर चला गया था हमारे लिए
इस प्रकृतिको, तरक्की आज की कहनों वालों
भरोसा नहीं है ना दान कलम के लिखे पर

चाहे!
पूछ लो इन वादियों, पहाड़ों इन मुरझाई बहारों से
लड़ो खुद से बचाओ और बचाना होगा इस प्रकृति को
भविष्य के लिए, आने वाली पीढ़ी के लिए
हमारे तुम्हारे ही वंशज होंगें ना वो अगर मानते हैं
तो छोड़ो लूटना इसे इतना
अपनी तरक्की की झूठी तलवारों से
जंगल बचाओ, धरा को बचाव, आने वाली पीढ़ियों के लिए
सवाल यही जवाब यही है हर बार हमारा
लोक हितैषी सभी सरकारों से

खेमचंद
क्षेत्र- अन्वेषक(इसरो- जीबीपी)
गोविंद बल्लभ पंत राष्ट्रीय हिमालयी पर्यावरण संस्थान
हिमाचल क्षेत्रीय केंद्र, मौहल- कुल्लू
हिमाचल प्रदेश

संकल्प पर्यावरण संरक्षण का

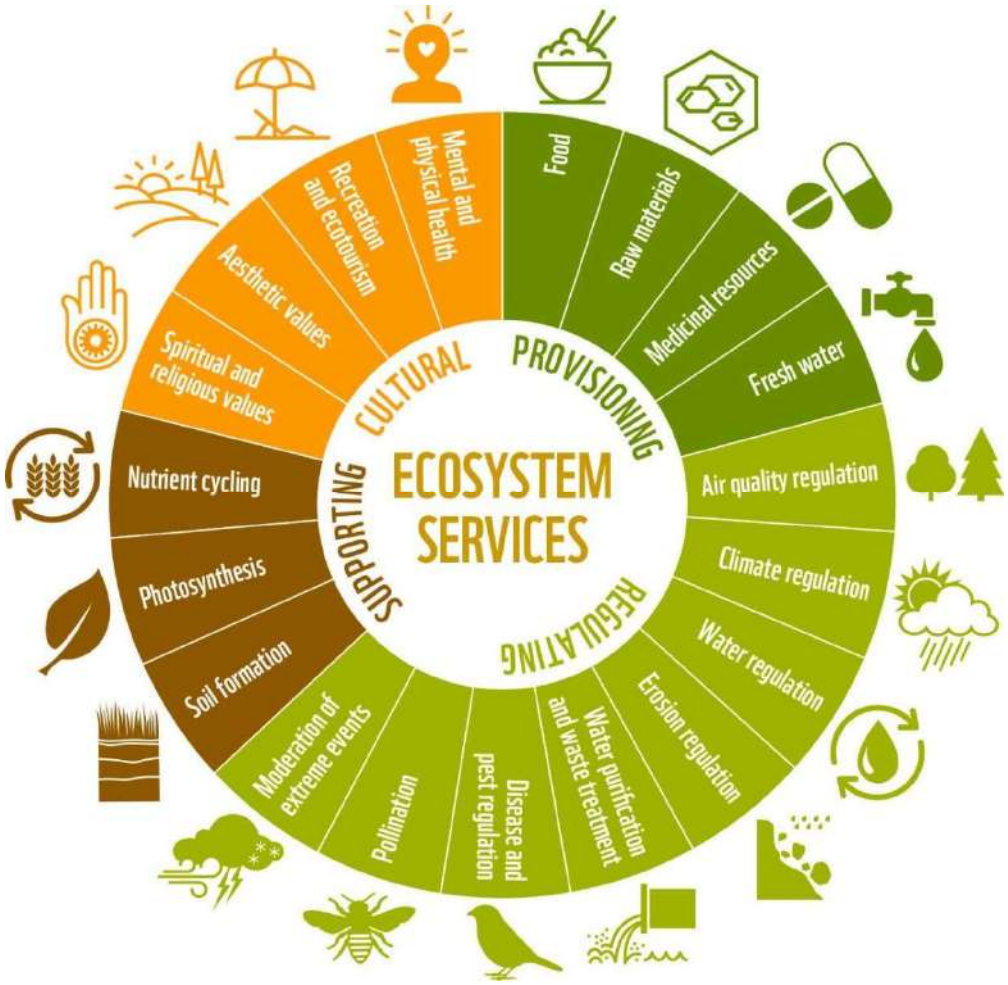
बहुत सुंदर है हमारी पृथ्वी और ये पर्यावरण और ये प्रकृति।

कल-कल नदियाँ बहती हैं,
पवन के झोंकों से हरे-भरे खेत लहराते हैं।
सात रंग के इंद्रधनुष भी हमें दिखाई पड़ते हैं।
मिट्टी की खुशबू भी आती है,
पक्षी भी गाना गाते हैं।
हर रोज़ सूरज भी एक नया सवेरा लाता है।
प्रकृति माँ ने हमें सब कुछ दिया है,
फिर भी हमने पर्यावरण को प्रदूषित किया है।
चलो आज हम ये कसम खाते हैं,
पर्यावरण को और भी स्वच्छ बनाते हैं।
वातावरण से प्रदूषण को दूर भगाते हैं,
धरती से कूड़ा-कचरा हटाते हैं।
बहुत सारे पेड़ लगाते हैं।

पर्यावरण के साथ मानव जीवन को भी संकटमुक्त करते हैं।
पिछली पीढ़ी आनेवाली पीढ़ी को ये सौगात देते हैं।
चलो आज हम ये कसम खाते हैं,
इस सुंदर पृथ्वी को और भी सुंदर बनाते हैं।।

त्रिदीपा बिस्वास
वैज्ञानिक-C
उत्तर-पूर्व क्षेत्रीय केंद्र, गोविन्द बल्लभ पंत राष्ट्रीय हिमालय पर्यावरण संस्थान

Section-IV
Ecosystem Services and Agriculture



AGRO-BIODIVERSITY OF UTTARAKHAND HIMALAYA: NURTURING NATURE'S BOUNTY

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Abstract
The agro-biodiversity of Uttarakhand is a captivating subject that highlights the rich variety of flora, fauna and genetic resources. The present article emphasizes the farming practices, conservation and promoting the agro-biodiversity of Uttarakhand Himalaya.

Key words: Agroforestry; cropping pattern; Himalaya

Introduction
Uttarakhand is a stunning area abounding with rich biodiversity, cuddled in the majesty of the Himalayan Mountain range. Himalayan agro-biodiversity demonstrates the fundamental interdependence between humans and nature through the use of traditional agricultural methods that have been passed down through the generations and an astounding variety of crops that are grown. We shall examine the exceptional agro-biodiversity of the Uttarakhand Himalaya in this article, highlighting its diversity, significance, difficulties encountered and actions made to protect this natural legacy.

Agricultural practices
Agriculture of Uttarakhandcan be divided into different agro-climate zone along the altitudinal gradients viz., (i) lower (up to 1200m) (ii) middle (between 1200-2300 m) and (iii) higher altitudes (above 2300 m). ***Shifting cultivation*** (practiced in past but not seen anywhere in recent), ***crop rotations***and ***mixedcropping*** (sowing a mixture of many traditional crops into a single plot of land) are the common practices. Cropping pattern of this region is mainly based on traditional type. Crops can be categorized according to the growing season as: ***Kharif crop*** (April-October: grown during the rainy season. e.g., Paddy, soyabean, sugarcane etc); ***Intermediate crop*** (May-August: maize etc); ***Ravi crop*** (November-April: grown during winter. e.g., wheat, barley etc);***Jayad crop*** (April-October: kitchen garden, seasonal vegetablesetc).

Agrodiversity
The great agro-climatic heterogeneity, local socio-cultural variety and preponderance of locally generated traditional crop varieties in the Himalayan highlands make them the repository for a significant number of crop genetic resources. Many researchers have documented the agro-biodiversity of the Himalayan region of Uttarakhand. Bargali *et al*., (2022) extensively worked on the energy and monetary efficiencies of agroecosystemsat the different altitudes of Uttarakhand Himalaya. Vibhuti *et al*., (2022) worked on the homegarden agroforestry system of Himalaya and concluded that management practices and conventional activity could show a higher effect on species composition and their utilization

pattern to improve food security and conserving plant genetic diversity.Pandey *et al*., (2019) state that agriculture was fully traditionalin earlier, but now-a-days farmers have started using chemical fertilizers, new crop varieties along with a shift from mixed cropping towards monocropping. They further claim that the main reasons for this shift is attributed to low productivity, ingression of wild animals and shortage of agricultural labours have also digressed the agriculture.

Pandey *et al*., (2018) documented overall 78 species in Kumaun Himalaya including cereals, pulses, millets, vegetables, fruits, medicinal purposes, agro-forestry trees etc. In their study 14 plants having sacred values which justifies the protection of these species because of their use in rituals and festivals of local people. Padalia *et al*., (2018) recorded total 114 plant species in agroecosystem of Kumaun Himalaya. In their study, tree (17 species), shrub (8 species), herb (77 species) and climber (12 species) constitute the agrodiversity. Padalia *et al*., (2017) were also reported that the agricultural diversity is immense and the farmers are very progressive. They are engaged in agriculture and its allied occupations including cultivation of medicinal plants, horticulture, bee keeping, floriculture and mushroom cultivation.
Pandey *et al*., (2017) proclaimed that an agro-biodiversity system of Kumaun Himalaya is responsible for maintaining soil fertility, as well as a series of varied socio-cultural and religious rituals. In their study they reported total 78 species all having food and nutritional value in which 49 species representing medicinal, 23 species fodder, 18 species spices, 17 species sacred, 12 species as oil yielding and 11 species as fuel. Pande *et al*., (2016) reported 161 plants belonging to 117 genera in agroforestry system of Kumaun Himalaya. Based on their uses vegetables (23.12%) formed the most frequent mode of uses followed by multipurpose trees.

Sati (2009) worked on Barahnaja (a cropping pattern, involving 12 or more food crops grown in synergetic combinations), a traditional system of cultivating (literally, '12 seeds') together in cropped land is a centuries-old practice. Nautiyal *et al*., (2008) emphasised on a traditional festival called “Harela”, is one the festivals in Uttarakhand which encourages people to conserve and manage their traditional crop diversity. Mehta *et al*., (2008) state that traditional crop diversity play key role in diversifying the agriculture as well as ensuring food security.

Preserving Farming Practices:
The farming methods used in the Himalayan region of Uttarakhand are steeped in tradition and influenced by the local environment. In the mountainous region, local communities have created innovative systems like terrace farming that not only prevent soil erosion but also maximise water use. The usage of synthetic inputs has been reduced and the ecological balance has been preserved because of farmers' adoption of organic farming practises. The long-term survival of the agricultural systems is guaranteed by these sustainable practises, which also preserve the delicate balance between human activity and the environment.

Challenges and conservation efforts
Despite its importance, the Uttarakhand Himalaya's agro-biodiversity confronts a number of difficulties. Younger generations are increasingly moving away from conventional farming methods as a result of modernization, changing lifestyles, and the attractiveness of urban regions. The preservation of indigenous knowledge and agricultural diversity is at jeopardy as a result of this shift. Climate change, water scarcity, and the introduction of alien species all contribute to the situation's worsening.

Numerous conservation programmes have been launched in the area to address these issues. Government and non-profit organisations in the area are aggressively supporting sustainable agriculture, educating farmers on organic farming methods, and building seed banks to protect historic crop varieties. Additionally, initiatives are being undertaken to encourage young people to engage in farming activities and to increase their understanding of the value of agro-biodiversity.

Conclusion

This agro-biodiversity must be preserved not just for the benefit of the neighbourhood communities, but also for environmental sustainability and global food security. The Agro-biodiversity of Kumaun Himalaya can continue to grow, motivating future generations to preserve and protect our natural heritage, if we acknowledge its importance, address the issues, and support conservation initiatives.

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APITOURISM IN KULLU VALLEY OF NORTH WESTERN HIMALAYAN REGION

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Abstract

Apitourism, commonly referred to as bee tourism, describes tourist activities focused on traditional beekeeping and the discovery of sites connected to honeybees. It gives visitors the chance to learn about beekeeping procedures, bees ecological as well as economic importance, the making of honey and other bee-related goods. There is a chance for the northern Himalayan Region specially Kullu district of Himachal Pradesh to grow dynamically as a result of the various functions it can perform. Beekeeping in Kullu valley is being traditionally for long time. Bee activities in their natural habitat, as well as the plants and their significance to the ecosystem, are displayed through apitourism. Apitourism advances public knowledge, including that of students and scientists in particular, as well as knowledge of rural areas, the relationship between beekeeping and agriculture, and the role of bees in the conservation of biodiversity. This article shows the future of apitourism in Kullu Valley of Himachal Pradesh

Introduction

According to the UNWTO, tourism is a social, cultural, and economic phenomenon which involves people traveling for pleasure, business, or both to locations outside of their normal environment. Interest in pro-environmental travel, including eco- and Agri-tourism, nature-based travel, and cultural travel, has been seen as a recent trend in the tourist industry. Ecotourism is a type of resource-based tourism that largely focuses on experiencing and learning about nature. Ecotourism is also supporting conservation and providingincome for local communities in protected areas (Das & Chatterjee, 2015). It frequently happens in natural environments, thus it ought to help protect or conserve those regions. Apitourism, a form of ecotourism associated with traditional beekeeping and honeybees. Beekeeping is an agricultural activity defined as the art, science, and/or business of keeping bees for the purpose of producing honey, wax, and other bee products for personal consumption, pollination of cash crops and industrial use (Masuku 2013). Apitourism, also referred to as bee tourism, offers a novel way to travel responsibly. It encourages person to embark on a trip into the fascinating world of bees presenting the rich cultural history and natural majesty of the Indian Himalayan Region. Apitourism can help to improve the beekeepers' financial well-being by encouraging local ecotourism. One of the biggest aspect of beekeeping is pollination which is a common good and a universal right, which consists of valuing the environmental services/externalities generated by honey bees. The diversity in the houses (bee hivs) of honeybeesespecially **Indian Honeybee** (*Apiscerana*) attracts the tourists. In Himachal Pradesh there are four types of bee houses or bee hives namely Wall Hive (*Madhi* in Kullu locality), Log hive (*Tultha* in Kullu locality), Mud Hive and Modern ISI hive. There are many activities associated with apitourism, including visits to apiaries, outdoor museums, bee museums where visitors can see how beekeepers harvest honey, learn about other bee products, observe how bee colonies live, and apitherapy. Apitherapy is a method of treatment

and also a part of health tourism in which beeproducts (honey, wax, propolis, bee venom etc.) are usedto improve health or prevent disease (Suna, 2018).

Methods of Apitourism

Methods are based on the primary data as well as secondary data. In primary data hands on experience has been given to students, farmers and tourists. In secondary data westudied the literature on tourism, apiculture, ecotourism. After reviewing the literature, it is found that Apitourism is in developingstage in this region. There are various functions given below that promote the apitourism in Kullu Valley, Himachal Pradesh

Results and Discussions

Educational Tours: Conduct educational tours that give guests information about the world of bees and beekeeping. Visitors can see bee colonies, learn about bee behaviour, and comprehend the various facets of beekeeping by visiting apiaries, bee farms, or other beekeeping facilities. Apitourism educates visitors about the significant contribution bees make to the wellness of various ecosystems. The majority of goods consumed by a man both directly and indirectly depend on insect pollination. Educational toursoffer classes on biology, ecology, and the history of beekeeping. Workshops on beekeeping, which mix theory and practice and offer several extracurricular activities (trips to apiaries, donning protective gear, participating in beekeeping-themed games and plays, and tasting honey straight from a honeycomb), are a particularly intriguing proposition for schools and kindergartens.

Introduction with bee products: Offer public the chance to taste and sample many kinds of honey and bee-related goods, such as beeswax candles, royal jelly, propolis, and pollen. Honey Tasting and Product Sampling. This enables travellers to taste the various flavours and applications of bee products and develop a deeper understanding of their significance.

Hands-on Experiences: Give visitors the opportunity to engage directly in beekeeping activities while being supervised by seasoned beekeepers. This may entail donning safety gear, managing beehives, and performing duties like gathering honey, removing honeycombs, or even helping to look after bee colonies.

Seminars, Workshopsand demonstrations: Organize workshops and demonstrations to educate visitors about beekeeping methods, hive maintenance, and honey production procedures. Topics like hive construction, beekeeping tools, honey extraction techniques, and the processing of bee products may be covered in these interactive seminars.

Involve Local Communities: To assist regional development and local economies, involve regional communities in apitourism efforts. This can be accomplished by working with potential beekeepers, hiring local guides, buying bee products from local producers, and spreading the awareness regarding the value of bees in locality.


Picture: Traditional bee hives; Modern hive Inspection (*Apis cerana)*

Environmental Sustainability: Throughout the apitourism experience, emphasize sustainable methods with an emphasis on the conservation and management of bee habitats, biodiversity, and ethical beekeeping. Stress the value of pesticide-free settings and advocate for organic beekeeping practices that put the health and welfare of the bees first.

Conclusion

This tourism can help people of KulluValley as well entire Indian Himalayan Region by generating new jobs in the tourism industry, advancing the growth of regional infrastructure, and promoting rural tourism. The uniqueness of apitourism, which was developed on the foundation of existing bee farms and allows for the gradual extension of an offer based on the financial, residential, and human resources of each farm, enables the preparation of an offer in every apiary without the need for significant initial investments. Education about healthy living and the promotion of an ecologically conscious mind-set grounded in knowledge and respect for nature seem to merit support. Exposure visits to local beekeeper apiariesthat draw consumers' attention to the unbreakable bonds between man and nature are an excellent method to promote regional culture and tradition.According to the research, it can be concluded that local community, government and other organizations in charge of rural development must also promote Apitourism for it to flourish.

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INTRODUCTION OF COLE CROPS AND THEIR OFF-SEASON PRODUCTION IN HIMACHAL PRADESH, NORTH WESTERN HIMALAYAS "-A PROMISING SOURCE OF INCOME FOR FARMERS AT SMALL SCALE

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Abstract

The state Himachal Pradesh is the core of Indian Himalayan Region and with diverse agro climatic geography which further support the production of cole crops The Cole crops are a great source of income for farmers as they are cultivated globally. Himachal Pradesh have regional advantage as compared to plains in terms of growing off seasonal vegetable crops and cole crops are best suitable for such conditions. This article elaborates the cole crops and its uses as livelihood option with increase in demand throughout the year. It also discussed the need to build the capacities of locals, farmers on the various technical details of the cole crop production for sustainable livelihood generation.

Keywords: Cole crops, Indian Himalayan Region, Himachal Pradesh, Farmer, Off season, cash crops

Introduction

The Indian Himalayan region support rich biodiversity and is best known for diverse socio-economic biodiversity. It covers three biogeographic zones- the Trans Himalayas, the Himalayas and the north east India. The state Himachal Pradesh covers the parts of Trans and North-western Himalayas Physio geographically, it is divide in three conspicuous zones, namely outer Himalayas (Shivaliks), inner Himalayas (mid mountains) and the greater Himalayas (alpine zone) and four agro-ecological zones i.e. Sub-tropical low hills (240-1000m); Sub humid mid hills (1001-1500m); Wet temperate high hills (1500-3250m) and dry temperate high hills (3251-4250 m and above). All of these agro- ecological zones, except dry temperate high hills are suitable for the production of cole crops and their seeds.

The centre of origin of cabbage and kale is believed to be the Western Europe and the cauliflower and broccoli came from Mediterranean region. Cole crops are biennials but are generally grown as annuals. A cold period is required for flowerings in these crops that is why they are grown in the Rabi season and are cold resistant. The crop requires regular water supply during the growing season. Shortage of water can affect the rate of growth and head development. There is a variation in required temperature for seed germination in cole crops. Cabbage can germinate in temperature ranges as high as 37ºC and low up to 5ºC while cauliflower and broccoli will not stand temperature variation as in cabbage. High temperatures can delay maturity and increase vegetative growth while cool temperature may induce early bolting. Cole crops are a great source of income for farmers as they are cultivated globally. In state like Himachal Pradesh, with the development in the field of agriculture and tourism, chinese dishes have become more popular and they have created a huge market and there is a rapid demand of cabbage throughout the year.

General description of various colecrops

The word cole crop originated from the latin word "*caulis"* which means stem or stalk of a plant. These crops have been mainly originated by mutation and introgression from wild species during evolution, human selection and adaptation. Prior to cultivation, the cole crops were mainly used for medicinal purposes. It was descended through mutation and selection from a common ancestor *Brassica oleracea* var.*sylvestris*, the leafy kale like structure, leafy wild cabbage. Cole crops are members of mustard family i.e. *cruciferae* or *brassicaeae*which includes cabbage (*Brassica oleracea* var.*capitata*) also known as white cabbage is one of the most popular vegetables in the world, Cauliflower (*Brassica oleracea* var.*botrytis*), Broccoli (*Brassica oleracea* var.*italica*), Brussel sprouts (*Brassica oleracea* var.*gemmifera*), Kale (*Brassica oleracea* var.*acephala*), and Kohlrabi (*Brassica oleracea* var.*gongylodes*). These are commonly known as stem brassicas.

Cabbage : The edible part of cabbage is formed by thickening of apical bud and is generally called as 'head'.Cabbage is generally used as cooked vegetable, stewed or boiled items in continental form. It is also eaten raw as salad or as cole slaw, which is generally prepared after shredding cabbage in small pieces, is mixed with different vegetable oils or vinegar, spices, creams and is taken as salad or pickle.

Broccoli: Broccoli is well known not only for its delicate taste but also for its high nutritive, anti-oxidants and cancer prevention properties. Among the cole crops, broccoli is the richest source of nutrients. It has more vitamin A contents than cauliflowers andcabbage. Broccoli is a good source of vitamin C, iron, fibre, potassium, vitamin A, carotene and vitamin B.

Kale: Kale was the first cole crop to be selected and adapted by man. The cultivated species selected by man had biennial habit and is a kind of super food that is generally grown for their edible leaves. It is the only cole crop which don't form any head or curd. Source of vitamin C, iron, fibre, potassium, vitamin A and Calcium.

Brussels sprout: The Brussels sprout is a recent development in cole crops. It was initially grown around Brussels, the capital of Belgium. In recent years, it has become very popular around big cities to meet the demand of foreign tourists in five star hotels. This is the least used cole crop by farmers of Himachal Pradesh. The edible part of Brussels sprout is swollen auxiliary buds called sprouts or buttons or mini cabbage. The sprouts are round, white or green coloured which borne on lower side of the lengthy stem.

Cauliflower: Cauliflower is the most popular vegetable among cole crops, particularly in Asia. The name cauliflower has originated from the Latin word "*Caulis*" meaning stem and "*Floris*" meaning flower. The edible part of cauliflower is curd which is botanically the pre-floral fleshy apical meristem.

Fig.1. Maintanance of cole crop in field farm (IARI Naggar Farm)

Knol- Khol : Kohlrabi is a type of cabbage which appears to be like turnip and is known as ganthgobhi. It is often used as replacement for turnip due to similarity in their taste and is great source of vitamin C, iron and fibre.

Table.1. Cole crops, their type, centre of origin and their edible parts and uses

Sr. no.	Crop	Centre of origin	Market	Edible part	Uses
1	**Cabbage**	Europe	Commercial	Head	Vegetable/ Cole slaw/ Salad
2	**Cauliflower**	Mediterranean region	Commercial	Curd	Vegetable/ Cole slaw/ Salad
3	**Broccoli**	Mediterranean region	Commercial	Curd	Vegetable/ Salad
4	**Brussel Sprouts**	Brussels, the capital of Belgium	Specialty	Sprouts	Vegetable/ Cole slaw/ Salad
5	**Kale**	Europe	Specialty	Leaf	Vegetable/ Salad
6	**Kohlrabi**	Europe	Specialty	Knob	Vegetable/ Salad

Table. 2. Cole crops, their recommended hybrids, varieties, soil type, sowing and transplanting for Himachal Pradesh

Crop	Soil type	Seed rate per hectare (gram)	Sowing	Trans plant	Spacing (cm)	Recommended (IARI) hybrids and varieties
Cabbage	Sandy loam and clay loam	500	July-August	Sep.	60×45	**Red-** Pusa Red Cabbage Hybrid-1 **White-** Golden Acre, Pusa Cabbage Hybrid-81,82
Cauli flower	Sandy loam and clay loam	500	July-August	Sep.	60×45	**White-**Pusa Snowball K-1, Pusa Snowball Hybrid-1,2 **Purple-**Pusa Purple Cauliflower-1
Broccoli	Loamy	350	July-August	Sep.	60×45	KTS-1
Brussel sprouts	Sandy loam	400-450	August-September	Sep.-Oct.	75×60	Hild's Ideal
Kale	Sandy loam	400	August-September	Sep.-Oct.	45×45	Pusa Kale-64
Kohlrabi	Sandy loam	400	July-August	Sep.	60×45	PusaVirat, White Vianna

Conclusion and Recommendations

The state Himachal Pradesh has made significant development in the field of agriculture and commercialization of vegetables has become the focus of agricultural development planning process. Himachal Pradesh have regional advantage as compared to plainsin terms of

growing off seasonal vegetable crops and cole crops are best suitable for such conditions to generate more income. The farmers have accepted mainly cabbage, cauliflower and broccoli for large-scale production and cultivation. Other cole crops like Kale, Brussel Sprouts and Kohlrabi also have high commercial value and their production and management is similar to cabbage, broccoli and cauliflower. There is a need to organize meeting with farmers and villagers to make them aware about production and management of cole crops so that they can cultivate other marketable cole crops for commercial purpose and for self-use as well. To improve the skills of local inhabitant and rural farmers, there is a need to provide them some on field trainings and make them technically aware of farming and latest technologies used by farmers of other states. Table 1 and 2 represents suggestions regarding, recommended varieties, soil conditions, sowing and transplanting of cole crops.

PRINCIPLES AND BENEFITS OF NATURAL FARMING

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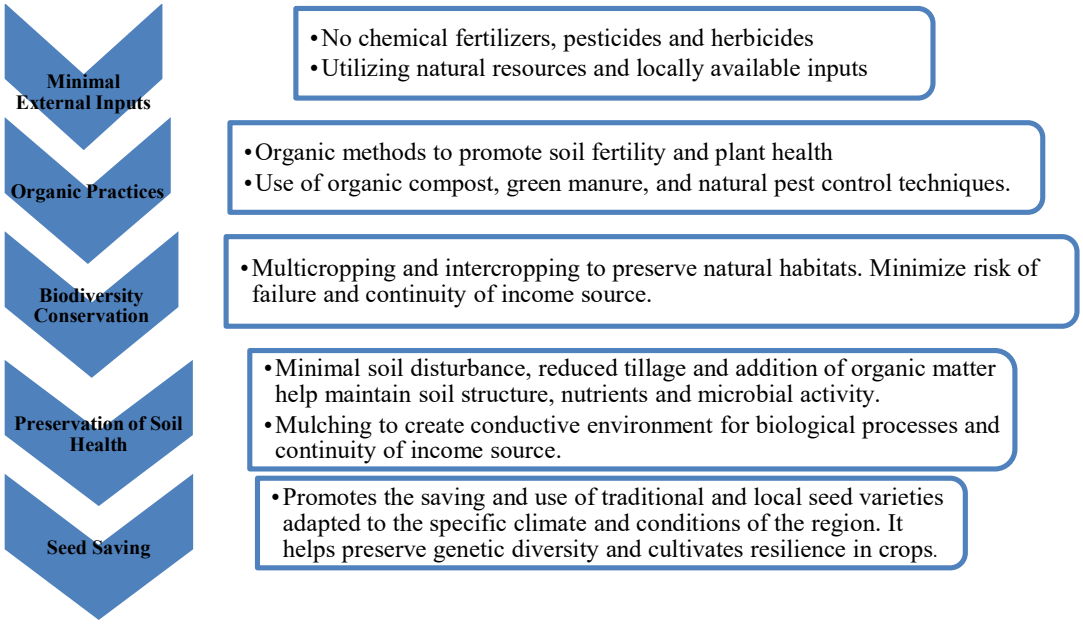
Abstract

Natural Farming is a chemical-free alias traditional chemical free and livestock-based farming method. It is considered as an agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity. This system of was re-evolved and developed in the 1980s by Indian farmer, agricultural scientist and extension agent Subhash Palekar who established Zero budget natural farming (ZBNF) after a period of self- study of vedas, organic farming and conventional agricultural science, testing methods on his own farm. In India, Natural farming is promoted as Bharatiya Prakritik Krishi Paddhati Programme (BPKP) under centrally sponsored scheme- Paramparagat Krishi Vikas Yojana (PKVY). It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulations; periodic soil aeration and exclusion of all synthetic chemical inputs. Use of natural farming will reduce dependency on purchased inputs and will help to ease smallholder farmers from credits burden. In 1657 Gram panchayat of Uttrakhand, Uttar Pradesh, Bihar proposed the concept of natural farming along the river Gangaunder NamamiGangeProgramme 6,282 clusters and 1,23,620 ha area was covered. Indiscriminate use of synthetic pesticides has caused adverse effect of environmentas well as on livingorganisms.

Introduction

Natural farming is based on several principles that are rooted in sustainability, ecological balance and harmonious coexistence with nature.



Techniques and Practices in Natural Farming

Natural farming employs a range of techniques and practices that promote sustainable and ecological farming systems. These techniques prioritize the use of natural resources, minimize external inputs, and foster a harmonious relationship with the environment.

Agroecology: Natural farming adopts an agroecological approach, considering the interactions between crops, soil, water, and organisms in the farm ecosystem. It aims to mimic natural processes and enhance ecological balance.

Non-chemical Pest Control: Natural farming employs various methods to control pests without relying on synthetic pesticides. These include

- Biological controls: Encouraging the presence of beneficial insects, birds, and predators to naturally control pests.
- Crop rotation: Rotating crops to disrupt pest life cycles and reduce pest buildup.
- Companion planting: Growing mutually beneficial plant combinations that deter pests or attract beneficial insects.
- Physical barriers: Using nets, fences, or traps to protect crops from pests.

Soil Conservation and Management:

- Minimal soil disturbance: Reducing or eliminating tillage to prevent soil erosion and preserve soil structure.
- Cover cropping: Planting cover crops between main crops to protect the soil, suppress weeds, and add organic matter.
- Mulching: Applying organic materials such as straw, leaves, or compost on the soil surface to conserve moisture, suppress weeds, and improve soil health.
- Composting: Recycling organic waste into nutrient-rich compost that improves soil fertility, structure, and microbial activity.

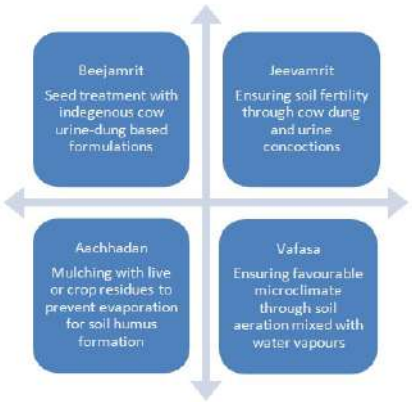
Crop Rotation and Diversification:

- Rotating crops: Alternating the planting of different crop species in a particular field to prevent soil nutrient depletion, suppress diseases, and manage pests.
- Polyculture: Growing a variety of crops together to enhance biodiversity, maximize resource utilization, and reduce the risk of crop failure.

Water Conservation:

- Drip irrigation: Using localized irrigation systems that deliver water directly to the plant roots, minimizing water wastage.
- Rainwater harvesting: Collecting and storing rainwater for irrigation purposes, reducing reliance on external water sources.
- Water-efficient practices: Implementing measures like mulching, soil moisture monitoring, and proper timing of irrigation to optimize water use efficiency.

Wheels of Natural farming



Benefits of Natural farming:

Environmental Benefits

- **Soil Conservation**: Natural farming preserve soil structure, minimizes erosion, prevents soil degradation in order to maintain soil health, fertility and long-term productivity of
- **Biodiversity Preservation**: Natural farming practices often incorporate crop rotation, intercropping, and mixed farming methods, which help enhance biodiversity. It promotes the presence of beneficial insects, birds, and microorganisms, creating a balanced ecosystem within farmland.
- **Water Conservation**: Practices such as mulching, cover cropping, and water-efficient irrigation systems help retain soil moisture and minimize water loss through evaporation and thereby lead to water conservation by reducing the need for irrigation.
- **Reduced Chemical Pollution:** By avoiding or limiting the use of harmful chemicals, natural farming reduces the pollution of soil, water bodies, and the overall environment along with the reduction of residues in edible commodities.

Health benefits

- **Nutrient-Rich Food**: This approach enhances the nutrient content of the soil, resulting in crops that are generally richer in essential vitamins, minerals, and antioxidants. Consuming nutrient-dense organic produce can contribute to improved overall nutrition and well-being.
- **Improved Cardiovascular Health**: Organic farming practices, which avoid the use of synthetic fertilizers and pesticides, have been associated with lower levels of certain chemicals in the environment.
- **Lower Risk of Allergies and Sensitivities**: Some studies indicate that individuals who consume organic food may have a lower risk of developing allergies or sensitivities.

Social benefits

- **Environmental Conservation:** Natural farming practices prioritize the health and preservation of the environment. By avoiding synthetic pesticides, herbicides, and genetically modified organisms, natural farming helps reduce chemical pollution in soil, water, and air.
- **Community Empowerment**: Natural farming often involves community-based initiatives and farmer cooperatives. By encouraging local participation and knowledge sharing, natural farming empowers communities and promotes self-sufficiency in food production.
- P**reservation of Traditional Farming Practices**: Natural farming methods often draw upon traditional and indigenous knowledge systems. By incorporating these practices, natural farming helps preserve traditional farming techniques, cultural heritage, and local wisdom. This not only safeguards traditional knowledge but also provides opportunities for intergenerational learning, fostering community cohesion and cultural identity.

Economical benefits

- **Reduced input costs:** It emphasizes the use of organic and locally available resources, such as compost, animal manure, and cover crops. By reducing the reliance on expensive inputs, natural farmers can significantly lower their production costs.

- **Enhanced biodiversity and ecosystem services:** This farming technique encourages biodiversity by avoiding the use of synthetic chemicals that can harm beneficial insects, birds, and other wildlife. A diverse ecosystem can provide natural pest control, pollination services, and nutrient recycling, reducing the need for costly interventions. It also contributes to the overall health and resilience of the agricultural system.

Conclusion

Natural farming offers a range of benefits that extend beyond the boundaries of individual farms. By adopting these practices, we can protect the environment, promote human health, and build resilient and sustainable food systems. Embracing natural farming is not just a choice for farmers but a collective responsibility to safeguard our planet and secure a better future for generations to come. Let us join hands and support the transition to natural farming for the benefit of all.

HIDDEN HARVEST OF RURAL AREAS: SOME IMPORTANT WILD EDIBLE FOOD PLANTS OF SERAJ VALLEY IN THE WET TEMPERATE REGION OF HIMACHAL PRADESH

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Introduction

Wild or naturalized plants have provided social security to millions of people globally, in theformoffuel, food, fodder, supplements, raw materials for industries, medicines, and especially a source of additional income. People of rural and hilly regions of the country largely depend on wild plants for medicine and food supplements. Seraj valley is one of the most beautiful valleys of the middle Himalayas situated in wet temperate zone of Himachal Pradesh. This valley is situated in district Mandi at an altitude of 2052 m (31.5892°N, 76.9182°E) with annual rainfall around 1240 mm. It covers approximately 313.57 Km ² areas and comprises 22 Panchayats and 171 villages. Valley is fed by fresh water lakes and streams from the mountains. The climatic conditions favour the growth of many important wild edible food plants. Some of them are *Diplazium esculentum* (fiddleleaf fern, lingad), *Morchella esculenta* (Honey combed mushroom/ Guchhi), *Nasturtium officinale* (watercess, chucch), *Cyclanthera pedate* (meetha karela) and *Urtica dioica* (stinging neetleleaf, Koogas) which are consumed by people of the valley as local delicacy. *Morchella esculenta* commonly known as 'growing gold of mountains' because it fetches good price in national and international markets. Some food plant sare known for their rich nutritive value and excellent source of antioxidants. *Diplazium esculentum* is known as seasonal delicacies and eaten for their unique flavour or taste. *Nasturtium officinale* and *Urtica dioica* are consumed as a green leafy vegetable (saag), cooked along with potato by local people of Seraj valley.

Common Name: Guchhi, Morel mushroom, Scientific Name: *Morchella esculenta*, Vernacular Name: Gucchi, Dunglu, Family: Morchellaceae

Morchella esculenta naturally grows in forest habitat, as a mycorrhizal or saprobic relationship with hardwood and coniferous trees. In Himachal Pradesh it is found mainly in two districts Mandi and Kullu. Its growing season is from March to July. It contains carbohydrates, proteins, fibres, all important vitamins (A, **B**, C & D), minerals (calcium, iron, copper, zinc, magnesium, manganese, sodium, phosphorus, selenium, and potassium) and aromatic compounds (phenol, alcohol, esterand carbamicacid). It contains a wide range of pharmacological properties which includes antioxidant (contains beta carotene, lycopene, tocopherol and lenoleic acid), antitumor, antibacterial (due to methanol, ethanol and chloroform) and anti-inflammatory properties (due to methanol), it also acts as an immune stimulant due to the presence of Galactomannan. It may be used as purgative, laxative, body tonic, emollient and also used for stomach problems, heal the wound and for generalweakness.

Conventional uses: People of hilly areas have immense traditional knowledge about this mushroom and use the fruiting bodies of Guchhi in the prevention and treatment of various diseases like stomach pain, pneumonia, dehydration, respiratory problems, fever, cough andcold, healing of wounds andasthma.

Collection of mushroom and economic value: In this valley, mostly women and children are engaged in collection of guchhi. They haunted difficult terrain in search of these valuable herbs and mostly collected from nearby lakes, streams, nullaha and forest floor during the rainyseason. The people these mushrooms either under the sun or hang them with a wire over the traditional "chulhas" in their kitchens. This method of drying is helpful in long-term preservation and to protect fruiting bodies from insects and molds. One of the traditional methods of drying these morelsis making a gar land off ruiting bodies and hangsiton the wall or house afters. The drying process, under favorable climatic conditions, take saround ten to fifteen days.

A freshly harvested 1 kg of guchhi is reduced to 80 -100 grams after drying under natural conditions. In terms of economic returns, 1 kg of dried guchhi is selling from Rs 8,000 to Rs 12,000 in the wholesale domesticmarket, depending upon the quality and size.

Almost 90 per cent of the produce in the hill state is heading offshore. Britain, Germany, Italy, France and the Netherlands offer good prices. The morels sell for upwards of $500 per kg in the international market.

Fig.1. Freshly harvested *Morchella esculenta* (Gucchi) and Dried Gucchi women in to garland by local women

Common Name: Stinging nettle, stinging nettle or nettle leaf, Scientific Name: *Urtica dioica,* Vernacular Name: Bichubuti, Koogas, Family: *Urticaceae*

Stinging nettle plants (Koogas, Bichubuti) are one of the most frequently consumed wild plants as a cooked vegetable and herbal medicine in different parts of the world. This plant is one of the most important and popular herbs of Himachal Pradesh growing upto an altitude of 3000m. People of Seraj valley use leaves and shoot terminals of koogas in the form of Saag (Cooked leaves). As older leaves can be laxative, so relatively younger leaves and tender terminals are preferred for cooking. But sometimes local delicacy like *chutney* and *kachru or masoru* are also prepared. Local people mainly eat *koogas* saag along with maize *ROTI* for its warming effect on body. Addition of souring agent in chutney neutralize its warming effect. People also intake koo gas leaves as tea forweight reduction program. Some researchers reported the use of stem and bark of *Urtica dioica* in outer Seraj areas (Kullu, Manali) in making ropes, mats andthreads.

Ethnobotanical uses and economic value: In recent years, it has been used as a nutritionaltonic and for many other preparations, such as dried leaves for herbal tea, or in combination with other herbs. But traditionally hilly people consider fresh leaves juice of this herb as haemostatic, diuretic, anti arthritic, anti rheumatic, anti- itchand anti-inflammatory. In some part of theare as, the roots are used as a di uretic, a stringent, emmenagogue, and anthelminticagent. Roots are alsoused for the treatment of cough, cold,

jaundice, and asthma. The decoction of the leaves if given to women after child birth to gain energy, as well as for the treatment of menstrual disorders and jaundice. The paste of leaves isused for the treatment of diarrhea and dysentery. Boiled leaves are used of the treatment of cough and cold. In India, leaf juice is used to treat epilepsy, and it is also used locally to treat boils and blisters. It is also used traditionally in Uttarakhand as a vegetable. The roots of this herb contain plant lectins, known as *Urtica Dioica* Agglutinin (UDA). in immunology as a superantigen, a lectin that induces cell growth and division (clonal activation). When these lectins induce the multiplication of specific white blood cells, they are known as mitogens. UDA lectin has properties that may make it worthy of being considered as an anti- coronavirus agent. The young shoots/leaves of the nettles are highly marketable almost all year, with April-September being the peak season for quality and quantity. Growing markets have encouraged people to harvest nettles perennially. Villagers in Himachal Pradesh sell the shoots/leaves in bunches of 300-500 gm for Rs. 8-15/bunch. During the season, a vendor may earn Rs. 200-500/day.

Fig. 2. Stinging nettle leaf plant, Local women collecting leaves for 'saag' preparation, Cooked leaves (Saag), Stinging nettleleaf tea, Nettleleaf plant fibre extraction and utilization training to women self-help group of H.P.

Common Name: Fiddlehead fern, Scientific Name: *Diplazium esculentum,* Vernacular Name: Lingad, Lungdu, Family: Athyriaceae

Diplazium esculentum (Lingad) is one of the topher baceus edible ferns of theHimalayas. It is among the popular wild growing food edible plants of district Mandi of Himachal Pradesh mostly along water stream sand springs in hill forests between an altitudinal range of 1300 to1900 m above the sea level. The local people of Seraj valley start harvesting the young hairy, blackish green fronds of lingad having height of 15-20 cm, as soon as the weather starts warming up after winter. The fronds are supposed to fit for cooking only at this stage (1cm thick at base, 6-9 inches long, erect but coiled at the apex).

Traditional and edible uses: Lingad is popular seasonal delicacy of Seraj valley. It is known for its characteristic pleasant flavour which is liked by many people. Fronds of this ferns can be pickled and made in to delicious vegetable which is eaten alone with chapatis or rice during the main course. Special curries like '*dum*' and '*madhara*' with exclusive recipes are made from Lingad in many areas of Mandi and served as special dishes on many special occasions like festivals, marriages, and birthday ceremonies.

Ethnobotanical uses: Available literature indicates that the edible fronds of this fern are rich in iron, phosphorus, potassium, and protein, richer than that of many conventional vegetables and many wild edibles. The mineral content has also been reported to be several times greater than that present in many commercial fruits. Traditionally it is used in prevention or treatment of several diseases such as diabetes, smallpox, asthma, diarrhoea, rheumatism, dysentery, headache, fever, wounds, pain, measles, hypertension, constipation, oligospermia, bone fracture, and glandular swellings. Various extracts of this fern were evaluated to elucidate their phytochemical and pharmacological activities. A wide array of

pharmacological properties such as antioxidant, antimicrobial, antidiabetic, immunomodulatory, CNS stimulant, and anti-anaphylactic activities have been recognized in different parts of *D.esculentum*.

Role of *Diplazium esculentum* in prosperity of rural people: A per the report by one of the researchers working on this aspect, revealed that on an average about 100 kg of lingad was sold daily at Mandi town only in a season spanning 80 days. This quantity is worth of Rs. 3,20,000 at an average price of rupees 40 per kg. Lingad is sold in all the big and small towns of District Mandi like Sundernagar, Nerchowk, Kotli, Rewalsar, Chalchowk, Sarkaghat, Mandi sadar, Joginder nagar, Karsog, Padhar etc. So, the total annual trade in lingad must be worth several llakh rupees, whereas, lingad cost significantly increases after value addition like'pickle'which is sold at the cost of Rs 400 to 450/kg. Many self-help groups of the district are involved in value addition and selling of lingad pickle in local markets and various traditional fairs.

Fig.3. Fiddle leaf fern (Lingad), Lingad ki sabzi, Rural people selling Lingad in Mandi town, Value addition of Lingad(Pickle)

Common Name: Watercress, Scientific Name: *Nasturtium officinale,* Vernacular Name: Chucch, chunali, Family: Brassicaceae

Nasturtium officinale is semi-aquatic or aquatic perennial herb found in cold shallow, gently moving fresh water. Seraj valley is fed by fresh water lakes and streams from the mountains so *water cress* is present in abundant in this region. Local people of Seraj valley called water cress by the name of *rayata* or *chucch*. Traditionally it is consumed as a gre en leafy vegetable (saag), cooked along with potato, sarson leaves or consumed raw as salads, soups and other recipes.

Patrode (Chopped tender leaves mixed with gram flour and spices, wrapped with in the leaf of *Bergenia cilliata* and steam cooked), Sosre (finally chopped water cress mixed with gram flour, rice flour and spices.)are also made from this plant.Water cressis important source of vitamins and a good detoxifying herb. High content of vitamin C and minerals makes this herb as a potential remedy for chronicillness.

Ethnobotanical uses: Water cress contains glucosinolates specifically gluconasturtin, which has been traditionally used for treatment of diabetes. The leaves of this plant are antiscorbutic, depurative, diuretic, expectorant, purgative, hypoglycaemic, odontalgic, stimulant and stomachic. The freshly pressed juice has been used internally and externally in the treatment of chest and kidney complaints, chronic irritations, and inflammations of the skinetc.

Fig. 4. Water cress (Chucch growing near water stream), Local women of Seraj Valley picking chucch for cooking, Women selling chucch in Mandi town, Cooked leaves (saag)

Common Name: Van karela, Ram karela, Scientific Name: *Cyclkanthera pedata,*
Vernacular Name: Pahadi karela, meetha karela Family: Cucurbitaceae
Cyclanthera pedata is an herbaceous plant of Cucurbitaceae family native of the Andean territories of South America.It is common cucurbit crop foundin Seraj valley. This plant is called with different names like metha karela, van karela and ram karela. This non-conventional vegetable is cultivated by the rural people of valley who utilized its fruits as food. It is an annual climbing plant provided with tendrils, palmate leaves, and small unisexual fowers (monoecious species) at the leaf axilla. The fruit is a green-pale/green ovoid pepo with grooves smooth orwith softspines. Theme so carpis thin and succulent while the endocarp is white and fluffy when mature, the inside of the ripe fruit is hollow, and contains dark-brown seed sroughly quadrangular attached to a placenta. It bears well extreme temperatures (hot and cold).

Ethnobotanical uses: Some traditional uses of this plant as herbal remedy are also known. The fruit juice or infusion is recommended as a treatment for people who have high blood cholesterol levels, hypertension, arteriosclerosis, circulatory problems, and diabetes. Fruit and leaves boiled in oil are used externally as a topical anti-inflammatory and analgesic. Dried and powdered seeds shall be taken as remedy for intestinal parasites. Leaves are considered hypoglycaemic and are prepared in a decoction for the treatment of diabetes.

Fig. 5. *Cyclanthera pedate* (Van karela) vine growing in backyard of local people, harvested fruits, Seeds of van karela from mature fruit

Fig. 6. Freshly harvested plant of Brassica spp. (Jood plant), Dried roots, overnight soaked meaty roots ready for cooking, Local delicacy 'jood ka saag'

Common Name: Sarson, Scientific Name: *Brassica spp.,* Vernacular Name: chood ka saag, jood ka saag, Family: Brassicaceae

Jood plant (*Brassica spp.*) is main brassica crop of higher region of Seraj valley. This plant is mainly grown by local people for its fresh leaves as well as for roots (Dried roots). This plant resembles with other species named *Brassica napus.* Word 'Jood' is derived from Hindi name 'Jad' meaning roots. This plant is grown in valley mainly for its meaty roots. At the time of harvesting, the roots are cut and separated from shoots and then sun dried forits further use in lean periods (winters). 'Jood ka Saag' is famous delicacy of this region which is prepared bywashing, dipping of dried roots overnight and steam cook to make famous 'jood ka saag'. The dried roots are also sold by local people at Mandi town market which fetch great returns.

HYDROPONIC TECHNOLOGIES: AN OPPORTUNITY IN TRANS HIMALAYA FOR LIVELIHOOD IMPROVEMENT AND YEAR-ROUND AVAILABILITY OF VEGETABLES

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Hydroponics offers several advantages for the Trans Himalaya region, some of which are elaborated below:

Water Efficiency: Hydroponic systems offer a compelling advantage in regions like Trans Himalaya, where water scarcity is a significant challenge. Compared to traditional soil-based farming methods, hydroponic reduces water consumption by approximately 90%. This remarkable reduction in water consumption makes hydroponics an exceptionally appealing option for sustainable agriculture in Trans Himalaya.

Climate Control:
The region of Trans Himalayawitnesses' extreme temperature fluctuations, ranging from blistering hot summers to freezing winters. However, hydroponic systems provide a remarkable solution by offering precise climate control through potential cultivation. This allows crops to thrive and reach their optimal growth potential regardless of the external weather conditions. By leveraging hydroponics, Trans Himalaya can ensure year-round cultivation and overcome the challenges posed by its harsh and unpredictable climate.

Land Optimization: Hydroponics eliminates the need for fertile soil, making it possible to set up farms in unconventional locations such as rooftops, unused buildings, or even underground spaces. This opens up new opportunities for urban farming and maximizes land utilization.

Higher Yields: Hydroponics accelerates growth rates and boosts yields significantly when compared to traditional farming methods. This advantage becomes especially crucial in Trans Himalaya, where it can help address food shortages by generating a higher volume of crops within the constraints of limited available space. By implementing hydroponics, Trans Himalaya can enhance its agricultural productivity, alleviate food scarcity concerns, and ensure a more sustainable and abundant food supply for its residents.

Reduced Dependency: Currently, Trans Himalaya relies heavily on importing fresh produce from other regions, which increases costs and carbon emissions. Embracing hydroponics will reduce dependency on external sources, leading to greater self-sufficiency and resilience in the face of logistical challenges.

Environmental Sustainability: Hydroponics is an environmentally friendly farming method that reduces the need for chemical fertilizers and pesticides. Additionally, the controlled environment of hydroponic systems prevents soil erosion and nutrient leaching, minimizing the negative impact on the fragile Trans Himalayan ecosystem.
The arid region of Trans Himalaya is renowned for its challenging landscape, extreme temperatures, and limited water resources. Agriculture in this area encounters numerous

obstacles due to the harsh climate and lack of fertile land. Nevertheless, the advent of hydroponic technologies provides a ray of hope for sustainable food production in Trans Himalaya. By leveraging its unique environmental conditions and implementing creative approaches, Trans Himalaya has the opportunity to pioneer the adoption of hydroponic systems, revolutionizing regional agriculture and ensuring food security for its residents. Hydroponics, an inventive cultivation method, allows plants to thrive in nutrient-rich water, eliminating the reliance on conventional soil-based systems. This soilless approach provides a controlled environment where crucial growth factors such as temperature, pH levels, and nutrient composition can be precisely regulated. By optimizing the growing conditions, hydroponics greatly improves plant growth rates and yields, establishing it as an efficient and sustainable agricultural practice.

The Ladakh Regional Centre of GB Pant National Institute of Himalayan Environment has made significant strides in the development of a cost-effective hydroponic technology under protected cultivation. Their primary goal is to promote widespread adoption of this technology in rural areas of Trans Himalaya for agricultural purposes. Currently, the centre is actively engaged in refining cultivation methods using this innovative technology for a diverse range of crops, including Tomatoes, Cucumbers, Pak choi, Mangol, Mint, and various others. These efforts are aimed at revolutionizing farming practices and enhancing agricultural productivity. Till date, Ladakh Regional Centre has developed hydroponic protocol for tomato, cucumber, lettuce, and mint under protected cultivation and results can be depicted in the Figures.

Fig. 1. Hydroponic (Deep Water Culture) growth of Tomato under protected cultivation

Fig. 2. Hydroponic (Deep Water Culture) growth of Cucumber under protected cultivation

Recently, the Ladakh Regional Centre has been granted a new project as part of the National Mission on Himalayan Studies "Exploring the use of treated wastewater for vegetable cultivation through hydroponic in Ladakh UT" in collaboration with Municipal Committee Leh (MCL). The primary goals of this project are to employ treated wastewater from sewage treatment plants of MCL in a hydroponic system for vegetable growth. Once successful, the significant technological progress achieved in this project presents vast opportunities for the

broad implementation of hydroponic systems across diverse regions of the Indian Himalayan Region (IHR). This replication would enable the adoption of sustainable agricultural practices and play a pivotal role in improving food production and security in these areas. Furthermore, the incorporation of treated wastewater in the hydroponic systems would enhance their environmental sustainability by promoting efficient water management and reducing waste.

Fig. 3. Hydroponic (Nutrient Film Technique) growth of Lettuce under protected cultivation

Fig. 4. Hydroponic (Deep Water Culture) growth of Mint under protected cultivation

Hydroponic technology offers a transformative solution to the agricultural challenges faced by Trans Himalaya. By adopting this sustainable agricultural method, Trans Himalaya can position itself as a pioneer in high-altitude hydroponics, guaranteeing food security, diminishing reliance on external sources, and fostering economic development. With the necessary assistance and dedication from all parties involved, Trans Himalaya can harness the vast capabilities of hydroponic technologies to ensure a thriving and sustainable future for its inhabitants.

AGARWOOD: A SCENT OF STRESS FROM WOOD OF GOD

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Abstract
Agarwood is a resin-impregnated heartwood obtained from the plants belongs to the genera, *Aquilaria.* It is traditionally used to produce perfume and incense stick, and pharmaceutical applications. Agarwood usually induced by the natural (traditional), conventional, and non-conventional methods. The major groups of phytochemicals identified in agarwood extracts are sesquiterpenes, 2-(2-phenylethyl)-4H-chromen- 4-one derivatives (PECs), and aromatic compounds. India is home to two *Aquilaria* species, *A. khasiana*and *A. malaccensis*. North east India is considered as cradle of Agarwood aromatics.

Introduction

Agarwood also known as "Wood of God" is highly valuable aromatic dark resinous heartwood of *Aquilaria* species belongs to the family Thymelaeaceae.This is also known as **agar** in India, **Gaharu** in the South East Asia, **Oud** in the Middle East, **Chen xiang** in China and **Jinkoh** in Japan. The formation of agarwood is generally associated with the wounding and fungal infection of the *Aquilaria* trees. The resin is secreted by the trees as defence reaction and deposited around the wounds over the years following the injury, where the accumulation of the volatile compounds eventually forms agarwood. There is a total of 31 *Aquilaria* species have been documented worldwide, among which, about 19 of them are recognized to be agarwood-producing. Species like *A. malaccensis*, *A. sinensis*, *A. rugosa*, *A. filaria*, *A. subintegra*, and *A. beccariana*are reported to produce fragrant resin include (Afzal *et al*., 2021).

Medicinal value of Agarwood

Agarwood is reported as a main component of many traditional Ayurvedic remedies in India as well as being used in Tibetan, Chinese, Malayan and Vietnamese medicine. In the traditional Chinese medicines, it is used as an aphrodisiac, sedative, cardiotonic and carminative, to treat gastric problems, coughs, rheumatism and high fever, in traditional Arabian medicine, its essential oil is used for aromatherapy.

Economical value

Agarwood has high demand throughout the world as a raw material for incense, perfume and medicine purposes, with Middle East and East Asia as the two major regions of consumption (Antonopoulou *et al*., 2010). Depending on its quality, global prices of agarwood may range from 2000 to 10,000 USD per kilogram for the wood itself, or 6000 USD per kilogram for the wood chips. Agarwood oil is by far one of the most precious essential oils in the world, with its value reported to be as high as 30,000 USD per kilogram, or up to 80,000 USD per litre. The annual global agarwood essential oil market for the year 2021 has been estimated to be in the range of US$ 132.5 million and is expected to reach USD 172.2 million by the end of 2028, growing at a CAGR of 3.4% between 2022 and 2028 (Adhikari *et al*., 2021).

1. Perfume

Agarwood resin is a key ingredient in old and new Arabic perfume products, and used as an element within high-quality perfumes in Arabic, Japanese and Indian cultures. Agarwood resin is mainly composed of the mixtures of sesquiterpenes and 2-(2-phenylethyl) chromones (PECs). Together all of these major compounds and some low abundant volatile aromatic metabolites form the unique and fragrant-smelling property of agarwood. Its oil is a yellow to dark amber, viscous liquid with a characteristic balsamic and woody odour. (Adhikari *et al*., 2021)

2. Pharmaceutical use

Agarwood plays a vital role in the field of medicine, contains various chemical components, including several sesquiterpenes, 2-(2-phenylethyl) chromens (PECs), and aromatic compounds, etc (Li *et al*., 2021). These compounds display various biological properties such as anticancer, anti-inflammatory, antioxidant, antibacterial, antifungal, anti diabetic.

Fig. 1. A) Agarwood seedlings B) Agarwood tree plantation in Assam, India C) Agarwood tree plantation in Veitnam D) Mechanical injury (iron nails) inflicted E) Infestation of tree by insect borer *Zeuzera conferta* F) Process of holes making in tree trunk for artifical induction G) Artificial induction of agrwood resin by fungus and/or chemical stimulant in *Aquilaria* trees H) Resin impregnated heartwood I) Worker chipping agarwood into small pieces J) High quality agarwood chips with high resin content extracted from *Aquilaria* trees K) Scanning electron micrograph showing a transverse section of *Aquilaria* wood and agarwood resin L) Fragrant agrwood oil

Due to the scarcity of agarwood resources in the wild and its increasing demand, theneed for producing sustainable agarwood becomes eminent, leading to the cultivation of*Aquilaria* trees in various agarwood-producing countries (Adam et al., 2017). Nevertheless, the frequency of natural infection remains low, approximately 7 to 10% of the treesform resin in plantations. Several artificial agarwood-inducing methodshave also been introduced and they can be generally classified into two different groups, namely, the conventional and non-conventional methods (Table 1).

Table 1. Summary of various agarwood-inducing methods

Sr. No.	Type	Examples	Concept
1	Natural	Thunder strike, animal grazing, pest and disease, broken branches, microbial invasion	Wounds are created which then triggers the activation of the tree's defence system, therebyproducing resin

2	Artificial conventional	Cauterizing, nailing, holing, bark removal, trunk pruning, burning chisel drilling	Mimics natural factors by creating physical wounds on the trees which will then trigger the formation of agarwood via tree's defence mechanism
3	Artificial biological	Fungal strains such as *Melanotusflavolivens*, *Penicillium* spp., *Phytium* spp., *Lasiodiplodis* spp., *Botryodyplodis* spp., *Fusarium* spp.	Introduction of microbial cultures into Aquilaria trees to mimic its pathological infection, thereby triggering the tree's defence mechanism
4	Artificial chemical	Chemicals or Signalling molecules such as ferric chloride, ferrous chloride, salicylic acid, sodium methyl bisulfide, hydrogen peroxide, formic acid, cellobiose, and methyl jasmonate	Direct induction of tree's defence mechanism for the secretion of resin

Status and distribution of agarwood in India

India is home to two *Aquilaria* species, *A. khasiana*and *A. malaccensis*. North east India is considered as cradle of Agarwood aromatics. Species *A. khasiana*is found mainly in the Khasi Hills of Meghalaya.*A. malaccensis*is native to nine north-eastern States: Arunachal Pradesh, Assam, West Bengal, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Assam is called as 'Agarwood Capital' of India. The species is typically found growing at altitudes of up to 1000 m, being localized mainly in the foothills and undulating slopes of evergreen and semi-evergreen forests.

Conclusion

Agarwood is highly sought after due to its economic value and cultural and medicinal uses around the world. The quality of artificially induced agarwood is close to wild agarwood, and its production in Aquilaria plantations may be able to meet the ever-increasing demand for this unique fragrance.

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FROM PLANT TO HEALTH: THE SCIENCE BEHIND PHYTOCHEMICALS

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Abstract

Phytochemicals, also referred to as phytonutrients, are bioactive compounds naturally occurring in plants. These compounds contribute to the vibrant colors, flavors, and aromas found in numerous fruits, vegetables, herbs, and spices. This abstract aims to explore the diverse applications of phytochemicals across various scientific disciplines. In the realm of cancer research, phytochemicals have exhibited considerable potential in impeding tumor growth and triggering apoptosis (cell death) in cancerous cells. Moreover, their immunomodulatory properties render them invaluable for enhancing immune function and promoting overall health. Phytochemical compounds play a pivotal role in plant growth, defending against diseases, and safeguarding against environmental stressors.

Keywords: Phytochemicals, Medicinal Plants, Health, Bio-prospection

Introduction

Nature has long been a treasure trove of solutions to various health challenges. Since ancient times, civilizations have turned to plants for their medicinal properties, harnessing their healing potential to combat ailments and promote well-being. At the forefront of this scientific exploration are phytochemicals, the diverse array of compounds found in plants that hold great promise for human health. (Willianson, 2013). Flavonoids, carotenoids, alkaloids, phenolic acids, and terpenoids are just a few examples of the many phytochemical groups that have been extensively studied. (Liu, 2004). Through their potent antioxidant properties, these compounds actively combat oxidative stress and effectively shield our cells from potential damage. Furthermore, they demonstrate remarkable anti-inflammatory effects, which play a pivotal role in the prevention of various chronic diseases, including cardiovascular disorders, cancer, and neurodegenerative conditions (Benavente-García *et al*., 1997). Phytochemicals are natural bioactive compounds derived from plants, have gained considerable attention in recent years due to their potential health-promoting properties. These compounds encompass a wide range a wide range of chemical classes, including flavonoids, (Harborne *et al*., 1999). Carotenoids and phenolic acids (Heim *et al*., 2002). and alkaloids among others. Beyond their sensory appeal, these compounds have been extensively studied for their diverse applications in promoting human health. Phytochemicals are found in various plant families and contribute to their unique properties and potential health benefits. Phytochemicals are a diverse group of natural compounds synthesized by plants, primarily serving as defence mechanisms against environmental stressors such as pest, pathogens, and ultraviolet radiation (Beckman, 2000).

Table 1. Details of Family, Phytochemical compounds and Health benefits

Family	Phytochemical Compounds	Health Benefits
Asteraceae (Compositae)	Quercetin, Apigenin, Luteolin, Parthenolide, Helenalin,	Antioxidant, anti-inflammatory, cardiovascular protection, analgesic,

	Caffeic acid, Chicoric acid	cancer, and immune modulation(Ghantous *et al*., 2010)
Lamiaceae (Mint)	Rosmarinic acid, Menthol, Thymol, Eugenol, Limonene, Carvacrol	Anti-inflammatory, antioxidant, (Lu *et al.*, 2010) neuroprotective, analgesic, respiratory support
Solanaceae (Nightshade)	Capsaicin, dihydrocapsaicin, solanine, cyanidin, delphinidin, pelargonidin	Analgesic, anti-inflammatory, anticancer,anti-diabetic, neuroprotective, antioxidant, cardiovascular health (Wiczkowski *et al*., 2016)
Brassiaceae (Cruciferous vegetables)	Sulforaphane, indole-3 carbinol, phenethylisothiocynate, allylisothiocynate, quercetin, kaempferol, sinapic acid	Anticancer, antioxidant, detoxification, anti-inflammatory, cardiovascular support (Verkerk, *et al*., 2009).
Rosaceae	Cyanidin, pelargonidin, punicalagins, ellagic acid,	Antioxidant, anti-inflammatory, cardiovascular protection, antioxidant, anticancer, quercetin, kaempferol, catechins (Bondonno *et al*., 2018)
Zingiberaceae (Ginger)	Gingerol, curcumin, demethoxycurcumin, bisdemethoxycurcumin, zingiberene	Anti- inflammatory, anti- nausea, antioxidant anticancer, digestive support (Mahboubi, 2019)
Fabaceae (legume)	Genistein, daidzein, glycitein, soyasaponins, glycyrrhizin, falvinoids, tannins	Hormone regulation, cardiovascular health, anticancer, cholelestrol management, immune modulation, anti-inflammatory, cardiovascular protection(Yao *et al*., 2004).

Phytochemicals in drug discovery: exploring nature pharmacopeia.

The Himalayan region isrenowned for its unique flora, characterized by a wide range of medicinal plants. These plants have been traditionally used in Ayurveda, Tibetan medicine, and other indigenous systems for their therapeutic properties. Berberine and vincristine are found in various Himalayan plants, and they demonstrated antimicrobial, anti-inflammatory and anticancer activities making them valuable in modern science. These compounds have demonstrated cardio protective and ant-diabetic properties, making them valuable for maintaining overall health.(Joshi *et al*., 2016)

Phytochemicals have valuable resources show unique chemical scaffolds and diverse biological activities that can be further optimized medicinal chemistry approaches. (Kumar *et al.,* 2011). Discovery of paclitaxel from *Taxus brevifolia*, a potent anticancer drug and artemisinin from *Artemisia annuna* a key antimalarial compound. Phytochemicals often undergo synthetic modifications to enhance their potency, selectively pharmacokinetic properties, and stability (Newman and Cragg, 2020)They lead the development of novel analogs with improved drug like properties like morphine such as oxycodone and hydrocodone which improved analgesic properties (Koehn and Carter, 2005). The exploration of nature's pharmacopeia through phytochemical research holds immense potential for the discovery of new drugs to combat various diseases.

Conclusion

The study of phytochemicals and their impact on human health has gained attention in health science. Phytochemicalsbridge traditional wisdom and modern scientific advancements. They

are naturally occurring plant compounds with diverse biological activities. Their antioxidant properties help reduce oxidative stress, protecting against chronic diseases like cardiovascular disorders and cancer. They also possess anti-inflammatory properties, alleviating conditions such as arthritis and asthma. Furthermore, these compounds exhibit antimicrobial activity, offering alternatives to conventional treatments. They have been investigated for their anticancer potential, inhibiting tumourgrowth, and inducing cell death. They can also enhance immune function, aiding in disease resistance. The study of phytochemicals connects traditional medicine systems with scientific research. Traditional practices, like Ayurveda have long utilized phytochemical-rich botanicals for therapeutic purposes. Understanding their mechanisms contributes to evidence-based healthcare.

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Exploring Livelihood Opportunities and Off-Farm Employment in Ladakh's Rural Landscape through Natural Resources

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Introduction

Ladakh, which became a Union Territory in October 2019, is renowned for its remote mountain beauty, unique culture, and distinct climate. Due to its high altitudes and cold climate, the growing season for plants is limited mainly to summer months (i.e. April to September), resulting in a significant period without agricultural activities. Although Ladakh is primarily a cold desert region with limited natural vegetation, some plants like Seabuckthorn, Fescue grass, Salix, Poplar, Apple, and Apricot are cultivated in certain conducive areas. Despite the presence of various plant-based natural resources in the local environment, opportunities for their optimum utilization and up-scaling have seldom been explored for sustainable development. While some local products have been used for self-consumption and on a small-scale commercialization, potential for nature-based entrepreneurship remain largely untapped.

The role and skills of women in managing their families and communities are often underappreciated in Ladakh, with limited participation in capacity building programs and decision-making processes. Additionally, rural youth migrating to urban areas for education and employment further burden women with increased workloads. Addressing the above issues, Ladakh Regional Centre (LRC) of GB Pant National Institute of Himalayan Environment (NIHE), Leh, Ladakh conducted various livelihood improvement programsfor the local people with targeting the following objectives, (i) to develop local plant resource-based entrepreneurship through capacity building, and (ii) to create off-farm livelihood employment opportunities using local resources.

Study Area

The various livelihood improvement programs were implemented in the Union territory of Ladakh, extending between latitude 32.5°N and 35.5°N, and longitude 75.5°E and 79°E, situated in the northernmost part of India. It is characterized by high altitudes (3000 m asl or more), a dry climate (annual precipitation 300 mm or less), and long cold winters (October to March). During winter months ambient temperature may drop to -40°C in many places, and usually remains sub-zero for a few months. Thus, living conditions are difficult for the resident population or others who works during winter. With the objective of enhancing capacity and fostering skill development, a total of four (4) training programs were organized in 25 villages across two districts: Leh (including Stok, Matho, Changa, Shang, Martselang, Stakna, Youlkham, Summor, Chamshen, and Charasa) and Kargil (Khumbathang, Minnjee, and Kanoor) since 2020. These programs were tailored to the availability of natural resources in each village.

Results and Discussion

Over the course of the reporting period spanning from 2020 to 2023, LRC primary focused was on executing non-farm employment activities through comprehensive skill development programs. These programs specifically targeted village clusters reliant on natural resources for their livelihoods. Our principal aim was to empower participants with the necessary expertise to effectively solve local issues related to livelihoods, and sustainable use of the natural resources. To achieve this goal, we placed a strong emphasis on capacity building and on-site training programs. Our intention was to impart a sufficient level of knowledge and skills to each participant, enabling them to tackle challenges independently. We strived to equip them with the tools and insights required to address local livelihood and natural resource-related problems effectively. An overview of the various skill building programs organized during 2020-2023 is given in Table 1, which provides detailed insights on location and nature/theme of trainings as well as the number of participants.

Table 1. Details of training and awareness programme conducted by Ladakh Regional Centre, GB Pant National Institute of Himalayan Environment, Lehduring 2020-2023

S.N.	Hands on Trainings	Villages	Total Participant (no.)
1	Introduction of new products and Value Addition to existing products from locally available Aprico	Wanla, Chamshen and Matho	112
2	Plant based utility Products (Basket, etc.)	Matho and Martselang	58
3	Value addition to food-based products from Seabuckthorn and introduction of new products	Matho and Chamshen	82
4	Integrated Mushroom Cultivation	Skara, Shanam, Sumoor, Chamshen, Stok, Saspol, Ursi, Taru, Khatpoo, Tarchit, Himya, Gonpa, Ganglas, Sankar, Katpa,Khumbathang, Minnjee, and Kanoor	331
	Total	25	583

The implementation of above skill development programs and capacity building initiatives in Ladakh has yielded remarkable progress and positive outcomes. A total of 583 participants from 25villages actively engaged in the training programs, acquiring valuable skills in their respective domains. Their training encompassed diverse areas such as basket product creation, value addition to apricot-based goods, and development of seabuckthorn products. Efforts were made to establish market linkages for some products, enabling the trained participants to connect with potential buyers and consumers. This facilitated the development of market-ready items and the implementation of marketing strategies to promote the unique features and benefits of these locally made products. The outcomes of these initiatives extend beyond economic empowerment. They have fostered entrepreneurship, encouraged sustainable resource utilization, and promoted the preservation of local traditions and cultural heritage. The trained individuals have become catalysts for positive change in their communities, driving innovation and contributing to the overall well-being of Ladakh's rural landscape.

Among these training programs, one of the most notable trainings was on ‘Integrated Mushroom Cultivation’. After achieving very encouraging outcomes in mushroom cultivation, LRC has developed and received an externally funded project "Developing New and Improved Agriculture Techniques (Mushroom Cultivation)" funded by GoI-UNDP-GEF SECURE Himalaya Project to facilitate its upscaling. This project particularly aims to further advance agricultural practices by focusing on commercialization of mushroom cultivation. To accomplish this, LRC has established a total of 25 integrated mushroom units across three villages situated in the picturesque Changthang Valley of Leh. These villages include Tarchit, Khatpoo, and Hemya. The purpose of setting up these units is to promote sustainable mushroom cultivation techniques that integrate various components of the agricultural ecosystem. Through this initiative, LRC aims to enhance the agricultural landscape of Ladakh and empower the local communities with improved techniques for mushroom cultivation. By leveraging the expertise gained from the successful demonstration in Ladakh, LRC aims to bring about positive changes in agricultural practices and contribute to the overall development of the region.

Conclusion

In conclusion, the skill development programs and market linkage initiatives undertaken by Ladakh Regional Centre have not only provided participants with opportunities to enhance their livelihoods and generate income but have also contributed to the broader goals of sustainable development, community resilience, and empowerment in Ladakh. These endeavors have laid a solid foundation for a more prosperous and sustainable future, where the unique talents, resources, and cultural richness of Ladakh can thrive.

PRODUCTION AND VALUE ADDITION OF HAZELNUT

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Abstract
Hazelnut (*Corylusavellana* L.) is typically a temperate zone nut crop and mostly grown in Turkey, Italy, Spain, Germany, France and England. The common hazel (*Corylusavellana*) is native to Europe and Western Asia. Common hazel is cultivated for its nuts. The plants are sprawling shrubs and nut is roughly spherical to oval, about 15-25 mm long and 10-15 mm in diameter, with an outer fibrous husk surrounding a smooth shell. Hazelnut is also known as cobnut and filbert. In Himachal Pradesh, it is found growing wild in Pangi region of Chamba district and locally known as Thangi. In Kullu area of Himachal Pradesh wild species of hazelnut locally known as Rasoli and the local people of Kullu valley generally use this species as a green fodder and hardly collect the nuts for human consumption. In UK, a distinction is made between filbert and cobnut.

Introduction

Different types of nuts like almonds, brazil nuts, hazelnuts, peanuts, pine nuts, walnuts and cashews are present all over the world. Hazelnuts are rich in monounsaturated fatty acids, antioxidant bioactive substances & rich source of oleic acid (about 80%), which decreased risk of cardiovascular disease. It is used as antioxidant, hypocholesterolemic, cardioprotective, anticancer, anti-inflammatory & in production of biodiesel. Turkey is the biggest market of the hazel nut in the world. Hazelnuts are good source of fats like other nuts i.e. almond, cashew etc. It is good source of monounsaturated fatty acid (MUFA) & polyunsaturated fatty acid (PUFA). It contains predominately palmitic acid, Steracic acid, linoleic acid &linolenic acid. The omega-3 fatty acids are not synthesized by the human body. Hazelnuts are extensively used in confectionary to make praline and also used in combination with chocolate truffles and products such as nutella. Hazelnut oil is strongly flavoured and used as cooking oil. Growing conditions of hazelnuts are best in mild climates without extremes of heat and cold. Temperature of -10 ^{0}C are critical, especially if accompanied by wind, which may kill both pistillate and staminate flowers. Hazelnut is cultivated mainly in regions sheltered from very cold winter, with soft winds to improve the pollination, without spring frosts and with relatively warm weather in the early summer, regular summer rain and high humidity during the vegetative period. Hazels will grow in pH ranging from 4.5 to 8.5, but around pH 7 is ideal. Hazelnut orchards should not be located where the soil is poorly drained, shallow, too heavy or too light.

Varities**:** Tonda Romana, Barcelona, Tonda Giffoni, Tonda Gentile delleLanghe, Negret, Pauetet, Tombul

Planting is usually carried out by hand between October and November. A planting distance of around 860 rees/ha is recommended with rows 4m- 5m apart (to allow machinery access) and 2m- 3m within row spacing. To ensure adequate pollination it is advisable to include a mix of atleast 10% of atleast one other variety, evenly distributed throughout the stand. Organic fertilizers like FYM should be applied at around 30 tonnes/ha if the soil organic

matter is below 2 per cent. Where the soil pH is around 5.5, it should be raised to 6.5 by liming but not more than 5 t/ha should be given in a single dressing. Fertilizer application to mature trees should be based on leaf and soil analysis. The most appropriate fertilizer contributions, with possible variances because of environmental conditions, are 120 to 150 Kg/ha of N, 60 to 70 Kg/ha P and 100 Kg/ha of K, with fragmented N applications in March-April (35%), end of May (50%) and October to November (15%) in case of shallow soils.Potassium application could be increased to assure healthier leaves in the period that follows harvesting, as it is intuited that there exist a lack of this element in the leaves at the moment that the kernel starts growing. Nitrogen is an important nutrient for plant development and consequently for crop yield. Phosphorous acts beneficially in hazelnut during fecundation and fruiting, although response to increased doses of this element are minimum. Potassium acts as a crop quality element, as it facilitates the assimilation of N in the leaf and the increase of kernel size. The traditional training system in hazelnut orchards in the main production areas (Turkey, Italy and Spain) has been a multistem bush, according to its normal tendency of bushing growth. However, the training system used in the new orchards of United States, France, Italy and Spain is in vase with only one stem. In growing single trunk orchard trees, the removal of suckers, which from at the base of the trunk is a very important practice. New suckers are to be removed as soon as they appear. Nowadays several herbicides are used, mainly Paraquat, 2,4-D amine salt, Glyphosate + MCPA, its efficiency depends on the sucker size and number of treatments done during spring and summer. Normally, treatment is advised when suckers have herbaceous consistency (15-20 cm height) and repetition at least 3 or 4 times between May and August. Weeds compete the crop for moisture and nutrition and adversely affect the nut yield and quality, thus planting should be kept free of weeds manually or through the use of herbicides. In the majority of productive areas, except for Turkey, the use of herbicides is very generalized, in both dry and irrigated orchards. Trees generally become commercially viable 5-6 years after planting, and can produce 2.5 tonnes/ha at this stage. When nuts change from green to brown and the abscission start, is the best time of harvesting. Usually, it comes in mid autumn. As autumn comes to a close, the trees drop their nuts and leaves. Most commercial growers wait for the nuts to drop on their own, rather than use equipment to shake them from the tree.

Fig. 1. Hazelnuts value added food products (Hazelnut chocolate truffles, Hazelnut Flour cake, Hazelnut cookies, Hazelnut bread)

Value addition of Hazelnuts

Hazelnuts are used for the preparation of different value-added food products due to its nutritive value and exceptional flavor. They are widely used in dairy products, cookies,

bread, coffee, spreads, Hazelnut chocolate truffles and confectionery. Only a very small fraction (10 %) of hazelnuts is commercialized in shell nuts, while remaining 90% is used for industrial purposes as shelled nuts. Many bioactive molecules present in hazelnuts have been reported as having several benefits for the human health. This fruit is an excellent for richness in lipids, dietary fibre, protein, minerals (especially calcium) and vitamins (in particular vitamin E), with the added advantages of low amounts of sodium and sugars. Hazelnuts can be consumed fresh or toasted in avariety of gastronomic and industrial applications.

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Section – V
Sustainability and Environment

ASSESSMENT OF NORMALIZED DIFFERENCE VEGETATION INDEX USING REMOTE SENSING AND GIS: A CASE STUDY OF SAINJ VALLEY

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Abstract

The evaluation of the vegetation status is important for ensuring the environment's ecological viability.The Normalised Difference Vegetation Index (NDVI) is a remote sensing technique used to measure and categorise vegetation cover over land.The objective of this research is to measure the amount of healthy vegetation in Sainj Valley. In this study, NDVI analysis for classify vegetation cover and detect change using Landsat 8 annual images for 2016,2017, 2018, 2019, 2020, 2021 was analysed using Arc GIS 10.8. Average, Minimum and Maximum values were calculated for each year to check the trend in NDVI.According to our findings, healthy vegetation cover was lowest in 2018 and 2019, accounting for 23.77% and 25.64% of total area, respectively, and highest in 2021, accounting for 43.35% of total area. The result shows that average Vegetation cover and average Healthy vegetation cover was increased in the study area. The findings of this study provide a thorough picture of the valley's changing vegetation cover, which could further help policymakers plan for the socioeconomic development of the valley.

Keywords: NDVI, Vegetation cover, Landsat, Remotesensing.

Introduction

The most commonly used formula for determining the value of the vegetation index (NDVI) provides information about the primary production of vegetation (Pettorelli *et al., 2011).* NDVI is widely used in agriculture, forest, ecology to monitor the growth and health of vegetation and to identify areas of stress or damage. Many studies include vegetation indices of normalised difference vegetation index (NDVI) in their method of analysis to represent vegetation grade because NDVI is robustly linked with dynamics of surface heat energy, water balance, and the carbon cycle (Chase *et al.,*1996).In Botswana, Nicholson and Farrar (1994) reported that the response of NDVI to rainfall was nearly linear at low rainfall values, but indicated very little further increase with rainfall at relatively high rainfall values (50-100 mm/month) (Nicholson *et al.,* 1994). To determine the density of Greenness on a patch land, NDVI is used. The pigments in plant leaves, chlorophyll, strongly absorb visible light (from 0.4 to0.7 μm) for use in photosynthesis. Multiple investigations have found a global increase in vegetation activity in various ecosystems, demonstrating that variations in rainfall and/or temperatures are the main drivers of changes in vegetation dynamics (Delbart *et al.,* 2008).

Study Area

Sainj valley is an offbeat place located 45 Km from the District Headquarter Kullu. The Sainj valley begins from Larji. The valley is around 528 Km^2. Sainj valley has an average slope of 38.12˚ and a mean elevation of 3510 m amsl. The valley lies along the Sainj river which is a tributary of Beas in the lower areas of Great Himalayan National Park.The main river that

crosses the Sainj valley is the Sainj river. From Raktisar Glacier (+5500m) Sainj River originates, and it flows south-west from there to join the Beas River at Larji Village.

Methods

Vegetation index allows us to delineate the distribution of vegetation and soil. The NDVI algorithm is determined by subtracting red reflectance values from near-infrared values and dividing the result by the sum of near-infrared and red bands.

$$NDVI = (NIR-RED) / (NIR+RED)$$

Here

NIR= Near Infra Red band

RED= Red band

The NDVI values fluctuate between -1 to 1. High values represent temperate and tropical rainforests, while moderate values represent grassland.Negative NDVI values are used to represent water bodies, while positive NDVI values are used to represent bare soil (Karaburun, 2010).A very low NDVI value indicates barren areas of rock, sand, snow.NDVI ranges of different classes are given in (Table 1).

Table 1. NDVI Range

NDVI Values	**Classes**
-1	Water
0	Barren land, Snow
0.2-0.3	Grassland
0.3-0.5	Unhealthy Forest
>0.5	**Healthy Forest**

Results and Discussions

NDVI Variation

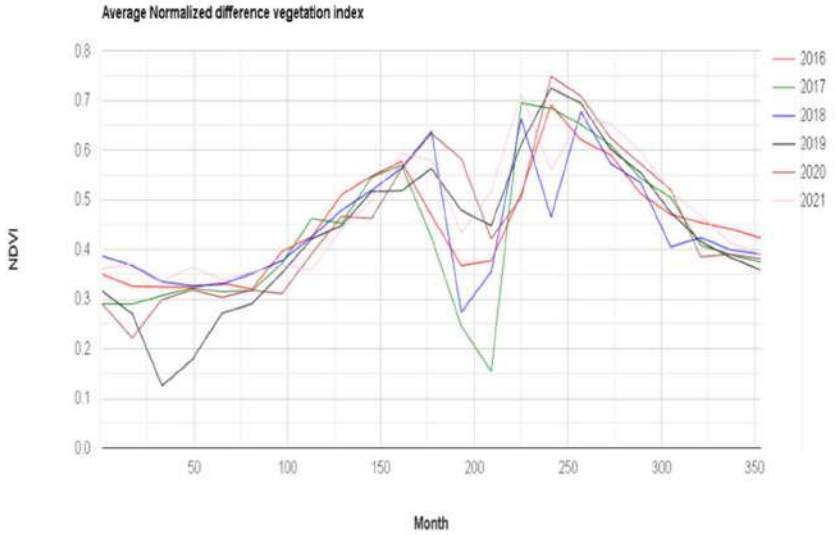

Fig. 1: Average Annual NDVI from 2016 to 2021

Remote sensing data is extensively utilised for large- scale vegetation cover change monitoring. Positive or negative vegetation changes are primarily caused by the intense

pressure of the human population, various economic activities, or anthropogenic activities. The statistics based on NDVI values are categorised as Minimum, Maximum, Mean, Grassland (%), Unhealthy vegetation (%), Healthy Vegetation (%) and these NDVI values vary significantly from 2016 to 2021 (Table 2).The NDVI was examined annually basis from 2016 to 2022. The dataset depicted that the year 2017 has the least value which means that this year had the least foliage. Comparative to the year 2021 which had the Highest mean values of 0.47 depicted the maximum vegetation. The dataset also illustrated that for the year 2018 and 2020 there was no significant change in the mean values which was 0.45. The mean NDVI values in 2016 are 0.45, whereas they were 0.47 in 2021, demonstrating the increase in biomass values over the previous six years (Table 2). Sainj valley's south-western side had the highest NDVI reading. The Present analysis has shown that an average area percentage of Healthy vegetation as 31.97, 30.54, 23.77, 25.64, 32.98, 43.35 during the period 2016, 2017, 2018, 2019, 2020, 2021. As per our results, the year 2021 had the highest Percentage of Healthy Vegetation cover of 43.35%where as year 2018 show the least amount of percentage healthy vegetation cover in Sainj valley with 23.77% coverage. In the year 2017 average NDVI values ranges from -0.34 to 0.76 while in year 2018 these values ranges between -0.16 to 0.74. This increase in the lower limits of NDVI from -0.34 to -0.16 which indicates depletion in the water resources and increases in barren land, whereas decrease in the upper limits if average annual NDVI from 0.76 to 0.74 which indicates a slight degradation in the healthy vegetation in the study area from 2017 to 2018.

Table 2. Descriptive statistics of Vegetation Index from 2016 to 2021

Year	Min	Max	Mean	Grassland (%)	Unhealthy Vegetation (%)	Healthy vegetation (%)
2016	-0.23	0.73	0.45	33.28	28.57	31.97
2017	-0.34	0.76	0.43	32.86	26.60	30.54
2018	-0.16	0.74	0.45	34.86	33.94	23.77
2019	-0.18	0.77	0.44	41.62	21.93	25.64
2020	-0.34	0.77	0.45	34.56	20.73	32.98
2021	-0.26	0.77	0.47	26.72	19.56	43.35

Conclusion

In our country, degradation of forests has become an enormous problem. NDVI is a significant method for assessing land use and land cover (LULC), particularly for identifying shifts in vegetation pattern and area. In this study, Landsat 8 data sets covering Sainj's valley were processed using GIS. This study analyses the vegetation index in Sainj Valley over a six-year period from 2016 to 2021. Since 2016, the average annual vegetation index has been greater in four out of six years, where as in 2017 and 2019 having less vegetation index than the average. From 2016 to 2021, the average Healthy vegetation cover in Sainj valley was 31.37%. According to the results, there was an overall increase in Healthy vegetation and a decrease in Unhealthy vegetation and Grassland. The findings indicate an increase in NDVI values overall for the study area between 2016 and 2022. The calculated NDVI indicated biomass and can also be used to determine the "greenness" of the vegetation.

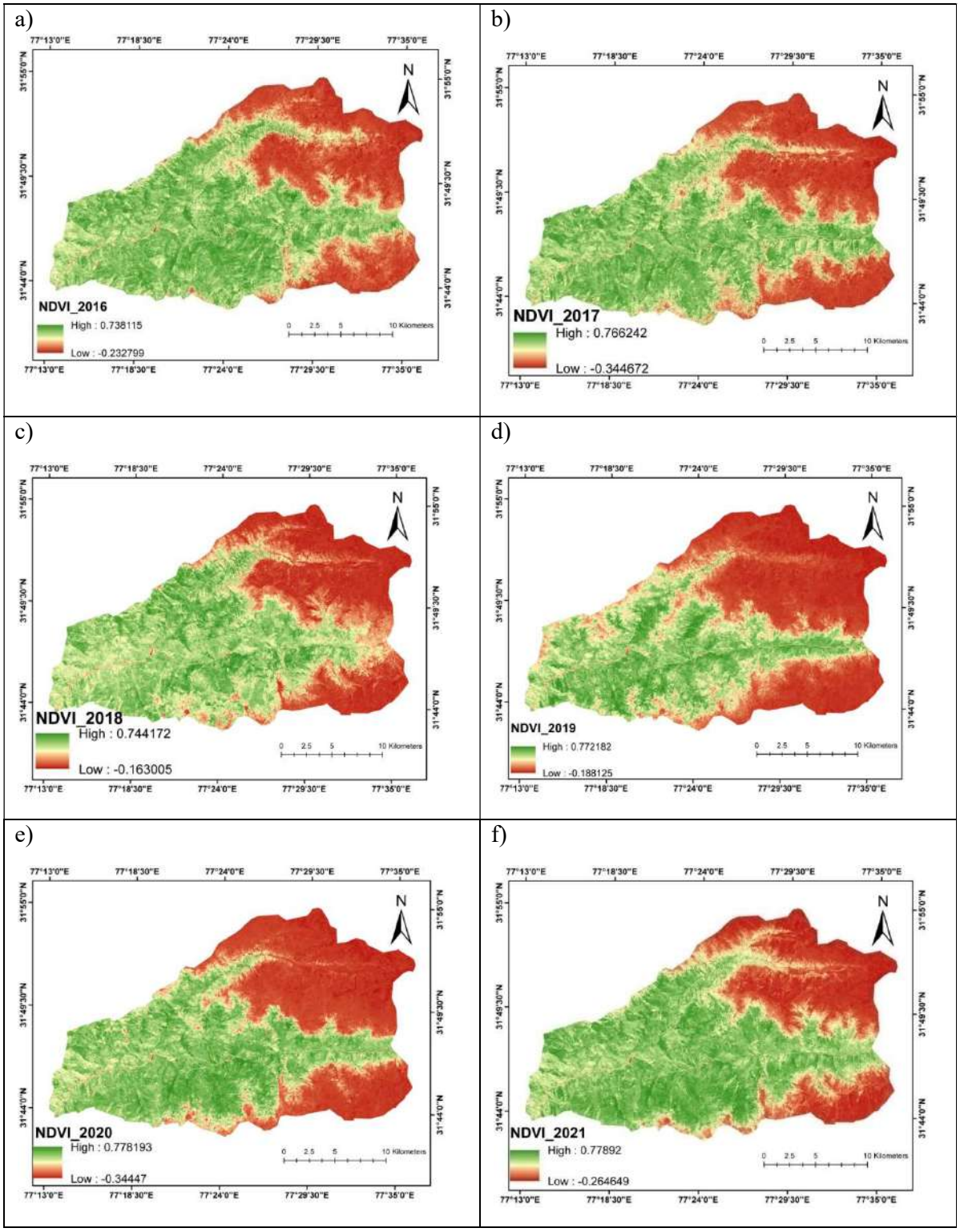

Fig. 2 (a-f). Year wise change in NDVI of Sainj Valley

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INITIATIVES FOR PLASTIC WASTE MANAGEMENT IN HIMACHAL PRADESH

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Abstract
Himachal Pradesh is a constant tourist destination which leads to more generations of plastic waste littered around the state. About 60% of plastic waste is disposedof in landfills, which leads to uncontrolled emissions of methane. Therefore, there is a need for improvements to current plastic waste management procedures that can be made by raising awareness at the elementary level with the cooperation of educational institutions, establishing town-based disposal units on a larger scale, and researching ways to manufacture biodegradable plastics in order to eliminate problems at the manufacturing level itself. Thus, the present study is focused on various steps and initiatives taken by the Government of Himachal Pradesh along with various other departments.
Keywords: Plastic waste, government policy, emissions, management**,** disposesin landfills.

Introduction

Rapid growth in population, urbanization, and industrialization has resulted in serious waste management issues in a number of cities around the world.According to the annual report of the Central Pollution Control Board (CPCB) for the year 2018-19, plastic production in India exceeded 3.3 million metric tonnes, indicating a significant rise of over 1 million metric tonnes compared to the previous year, 2017-18.During 2019-20, around 3.46 million tonnes per annum (TPA) of plastic waste was generated (Times of India, 2023). Improper disposal and a lack of recycling facilities worsen the situation (Down To Earth, 2022).When compared to other countries; India has the highest percentage of plastic waste recycling (60%) (China 10%, Europe 7%, Japan 12%, South Africa 16%, and the United States 10%)(Sikka, 2007).Polythene bags for disposal, when burned carelessly, emit highly harmful gases such as phosgene, carbon monoxide, chlorine, sulfur dioxide, nitrogen oxide, and fatal dioxin(Sikka, 2007) (Da Costa., *et al.*, 2020).

Plastic waste includes various effects on the human body such as oxidative stress, inflammatory lesions, cellular damage, immune reaction, etc. Thus, proper management of plastic is necessary to avoid long-term impacts on the environment and biodiversity (Da Costa, *et al.,*2020).A significant portion of plastic waste ends up in landfills, rivers, and other natural environments.Additionally, the burning of plastic waste releases toxic pollutants into the air, contributing to air pollution and health problems for nearby communities. In 2018, Government of India launched the "Plastic Waste Management Rules" to regulate and promote responsible plastic usage and waste management. Additionally, campaigns like "Swachh Bharat Abhiyan" (Clean India Mission) aim to create a cleaner and more sustainable environment by encouraging proper waste segregation and management. Non-governmental organizations (NGOs), environmental activists, and citizens are actively involved in raising awareness about the plastic waste and advocating for sustainable alternatives. Despite these

efforts, challenges persist in addressing India's plastic waste scenario. Inadequate waste collection and segregation systems, limited recycling infrastructure, and a lack of public awareness hinder effective waste management. However, with increasing awareness, policy interventions, and collaborative efforts, there is hope for a more sustainable and plastic-free future in India.

Results and Discussion

Generation of waste in Himachal Pradesh

Himachal Pradesh has a per capita waste generation rate of about 0.413 kg/day (TERI. 2015). Furthermore, it is estimated that 60% of waste generated ends up in land fills (Pandey *et al.,* 2015). Unscientific waste disposal generates anaerobic conditions at the disposal site, resulting in uncontrolled emissions of methane. Himachal Pradesh's total GHG emissions from the garbage sector are estimated at 6.129 tonnes of equivalent CO_2 (Department of Science and Technology, GoHP, 2012). Himachal Pradesh's daily waste generation is expected to climb by over 133% by 2041 (Table 1).

Table 1. Estimated waste generation in Himachal Pradesh

Year	Per capita waste generated(kg/day	Urban Population (x1000)	Waste generated (T/day)
2011	0.413	736.3369	304.3
2021	0.472	883.3212	416.6
2031	0.538	1023.429	550.9
2041	0.614	1155.249	709.6

Source: *T E R I.* 2015

Policy strategies for waste management in Himachal Pradesh

- Year 1999- First state of the country to ban use of colored recycled polythene carry bags.
- Year 2004- Ban imposed on use of polythene with thickness less than 70 micron (DEST 2010).
- Year 2009- The state launched '*Polythene HataoParyavaranBachao*
- Year 2018- '*Polythene HataoParyavaranBachaoAbhiyan'*the entire campaign was again reviewed in this year. It was found that there were economic, social, and technological factors that contributed greatly to not sustenance program.
- Collection of Waste by Rag Pickers: The rag pickers and recyclers are not earning excellent returns from selecting plastic garbage since it is mixed with other waste and requires a lot of effort to isolate it, in addition to harming their health and wellbeing. The cost of collecting plastic wasteis not handsome, discouraging them from collecting waste, and resulting in a non-collection of waste.
- The Solid Waste Management Rule, 2016: According to Rule 17 of Solid Waste Management (SWM) 2016, all makers of disposable items such as tin, glass, plastics packaging, and so on, or the owners of brands who bring such items to the market, must offer the required financial support to local governments for the construction of a waste management system.

Steps taken by Himachal Pradesh Government and other Departments

I. The Department of Environment Science and Technology (DEST)/Urban Development Department (UDD) have taken efforts to make plastic waste collection centres available to the PWD for road building.
II. DEST partnered with the Central Road Research Institute (CRRI) to give technical assistance to the government
III. The Pollution Control Board issued an order that the Cement Industries to use at least 0.1%of their yearly fuel consumption from the combustible material from MSW or Refuse Derived Fuel (RDF) derived from MSW and biomass-basedfuel.]

Conclusion

The current state of plastic waste management is inflicting irrevocable harm to the ecosystem, prompting individuals to completely ban the use of plastic waste.Thus, proper management of plastic is necessary to avoid long-term impacts on the environment and biodiversity. Since Himachal Pradesh is an eco-sensitive area, therefore improper management of waste may lead to great impacts not only in the area but in the surrounding states too. Various initiatives for the proper disposal of plastic waste, such as '*Polythene HataoParyavaranBachao Abhiyan', 'Plastic Waste Buy-Back Policy',* etc. were taken by Government.In this regard, Central Ministries of the Indian Government, such as the Ministry of Environment, Forest, and climate change (MoEF&CC) can collaborate to develop a strategy and action plan to work with state ministries to enhance their capacity to implement traditional plastic waste processing.

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COPPER BASED ANTIMICROBIALS IN PLANT PROTECTION

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Introduction

Copper is generally known as an oligo-element that is essential for life. This element plays important role in cellular physiological processes, such as iron absorption and transport, synthesis of phospholipids and haemoglobin, energy production, and ribonucleic acid production. Copper is present in the ecosystem as well as inagricultural soils. The soil copper inputs from agrarian sourcesare essentially from manure, sewage sludge, fertilizers and pesticides. Bordeaux mixture was the first copper-based antimicrobial compound (CBAC) used in agriculture and was accidentally discovered in 1885 by the French scientist Pierre-Marie Alexis Millardet. Since that time, copperhas been continuously used in agriculture as a fungicide, bactericide andpesticide.Copper pesticides are copper compounds used as bactericides, algaecides, or fungicides. They can kill bacteria, oomycetes and algae, and prevent fungal spores from germinating. Common forms of fixed copper fungicides include copper sulfate, copper sulfate pentahydrate, copper hydroxide, copper oxychloride sulfate, cuprous oxide, and copper octanoate. The spectrum of activity of copper compoundstargets many phytopathogenic microorganismsn, making this metal one of the major componentsof fungicide and bactericide formulations throughoutthe world. While copper continues to play key rolesin integrated pest management, it is essential for organicfarming, since disease management in this systemdepends almost exclusively on its use.The discovery of Bordeaux mixture has revolutionized the twentieth century agriculture following the rapid development of copper based antimicrobial compounds. These compounds are relatively toxic to plant pathogens, cost is low, mammalian toxicity is also low and are chemically stable. These properties prevent them from being readily washed from plantsurfaces and long residual periods, are among the mostimportant advantages of these compounds. Consequently, these compoundshave become an important component of integrated pestmanagement (IPM) system seeking to provide long-termsolutions for pathogen management.The active ingredient is the cupric ion (Cu^{++}) and these ions act non-specifically (multisite) at the cell membrane level, leading to the denaturation of proteins and altering membrane semipermeability.The copper ions dissolved in water layerson plant surface can enter the cell protoplasm oftrue fungi, oomycetes, and bacteria. Onceinside the cells, copper ions interfere with numerousenzymatic reactions, blocking respiratory activitywith consequent inhibition of spore germination. Copper is used as protectant, which means copperions must be present on plant surfaces before pathogen infection.

It is well known that Cu based antimicrobials are effective tools for crop disease management both in conventional and organic farming. However, reliance on these compounds, as the sole means of disease management, poses serious threats to sustainable agricultural production. The high level of Cu accumulation in the soil and the risk of surface and subsurface water contamination and potential public health problems due to Cu entering the food chain have raised concerns on the use of these compounds in agriculture. As a consequence, there is a

worldwide communityand regulatory pressure on agriculture in general, andin organic farming systems in particular, to restrict the use ofthese compounds.

Copper biocides used for plant protection

Cu acts as a broadspectrum biocide at higher concentrations due to its interaction with nucleic acids, disruption of enzyme active sites, and interference with energy transport system and finally the disruption of membrane integrity. A number of inorganic Cu formulations have been developed and used as biocides against plant pathogenic bacteria, fungi, oomycetes and in some instances, invertebrates and algae. Copper pesticides can be effective in preventing several bacteria, fungal pathogens including *Botrytis*, *Plasmoparaviticola*, *Pseudoperonosporahumuli*, *inaequalis*, *Bremialactucae*, *Peronosporadestructor*, *Taphrinadeformans*, *Stemphyliumvesicarium*, *Cercosporabeticola*, *Phytophthorainfestans*, *Pucciniatriticina*, *Puccinia striiformis* and *Alternariasolani* etc. Wide availability of these Cu compounds has facilitated foliar disease management of a number of annual and perennial crops. Unlike a wide range of fungicides available to manage cropdiseases caused by plant pathogenic fungi, there are only a few known bactericides available to protect crops. Consequently, Cu based compounds are the only means available for growers both in conventionaland organic farming to manage diseases caused byplant pathogenic bacteria both of annual and perennial cropsincluding tomato spot, citrus canker, fireblight of pome fruits, walnut blight, stone fruit canker, mango apical necrosis and oliveknot.

Risks due to excessive use of inorganic copper

Copper based antimicrobial compounds have been intensively used in plant protection for more than one century. This continuous use has led to a number of impacts related to human health and the biodiversity. High levels of Cu in agricultural soil may cause plant stress and reduce soil fertility having adverse effects on crop quality and yield. Copper compounds release Cu ions when they are dissolved in water and thus an excessive uptake of Cu ions by plants at any time may lead to phytotoxicity. Many factors might lead to Cu phytotoxicity on plants, including the application of highly soluble Cu formulations (e.g., copper sulfate, copper nitrate) or excessive amounts, use of acidic spray solution (pH below 5.5) which results in excess soluble Cu, tank mixing of Cu with other products, application of Cu athigh temperatures, dry weather and presence of impurities in the product. Overall, many perennial fruit tree crops express frequent symptoms of Cu phytotoxicity, especially when they are at the blooming phase, compared to annual crops. For instance, phytotoxic effects of Cu have been observed on tomato, apple, pear, cherry and citrus. In addition to the aboveground parts, Cu in high concentration is toxic to plant roots as it interferes with the uptake of iron and other nutrients, especially in acidic soils where pH is not well-controlled. Typical symptoms of Cu phytotoxicity on leaves consist of chlorosis, darkening of axial and abaxial surfaces, necrotic spots, and leaf margin burn. On fruit, Cu may cause value depreciating blemishes such as corky, dark, and star-shaped lesions. Overall, plants may show loss of vigor and/or stunted growth. These compounds have multisite activity with a low risk of pathogens developing resistance; several cases of resistance developed by plant pathogenic bacteria are reported worldwide. Bacterial pathogens such as *Pseudomonassyringae*, *Erwinia amylovora* and *Xanthomonas campestris pv. vesicatoria* have developed resistance to some copper compounds. Instead, elevated levels of Cu may pose public health problems if soil Cu enters the food chain. Prolonged application of these compounds for more than over a century has resulted in accumulation of this heavy metal in the soil in general and in the topsoil in particular as Cu extract residues typically accumulate in the upper 15 cm of soil. It may cause the contamination of surface and subsurface waters. However, agricultural goods with levels of Cu residues exceeding this legal threshold are reported by different researchers worldwide.

These copper spray residues may have adverse effects on agricultural products, on both external and internal quality parameters including appearance and taste.

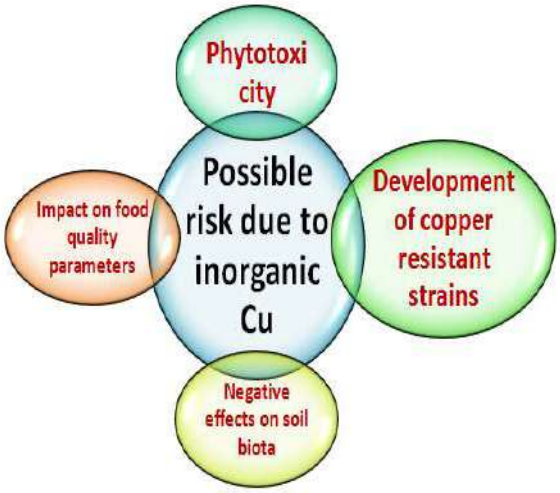

Fig 1. Possible risk due to continuous use of Cu based antimicrobials

Alternatives to copper compounds

Replacement of Cu based antimicrobials with other known less harmful products is a major challenge faced by researchers. This is mainly due to the many positive aforementioned attributes of these compounds, especially their broad-spectrum activity, as well as the paucity of robust and scientifically proven alternatives. To date, a number of non-Cu-based products and biological control agents showed some effectiveness against many plant diseases. Several biocontrol fungi, bacteria, actinomycetes and endophytes have been exploited against many pathogenic organisms. Most of the commercialized biocontrol products have shown successful control over the past several years. In particular, biologicalcontrol agents including resistance inducers andnanoparticle-based metallic formulations are the mostpromising alternatives to Cu compounds in a short term. The systemic acquired resistance inducers such as Jasmonic acid, ethylene, beta amino butyric acid, Acibenzolar-S-methyl etc are also one of the options to confer protection against plant pathogens. Application of nanoparticles in agriculture is anothernnovel approach that has been proving very effective control. Current trends in advancement and use of natural bioactive compounds are becoming more popular around the globe due to their environment friendly nature. These bioactive compounds are isolated from plant sources, algal sources, microbial sources and marine sources. They act as elicitors for plant defence and thereby activating resistance in plants against pathogens. Majority of them are salicylic acid (SA), benzoic acid, chitosan, benzothiadiazole, alkaloids, flavonoids, terpenes, proteins, peptides, blasticidin, mildiomycin, polyoxins, phenolic compounds, etc., that works as antimicrobial agents. Similarly, bacteriohages are more environmentally friendly, can be easily tailored against specific phytopathogenic bacteria, and their reformulation is also easily if resistance develops. Infection of bacteria by virulent bacteriophage results in viral replication, lysis of the bacterial cells and release of abundant progeny phages. The resulting progeny phages then infect the bacteria in the vicinity. In this way the numbers of phage will exponentially expand when target bacteria are encountered and the phage therapy will essentially be amplified in response to the bacterial infection.

These biocontrol phages have certainly proved the proverb -'The enemy of my enemy is my friend'. In any successful example of biocontrol with bacteriophage the main deciding factor is whether a phage is lytic (virulent) or temperate in nature.

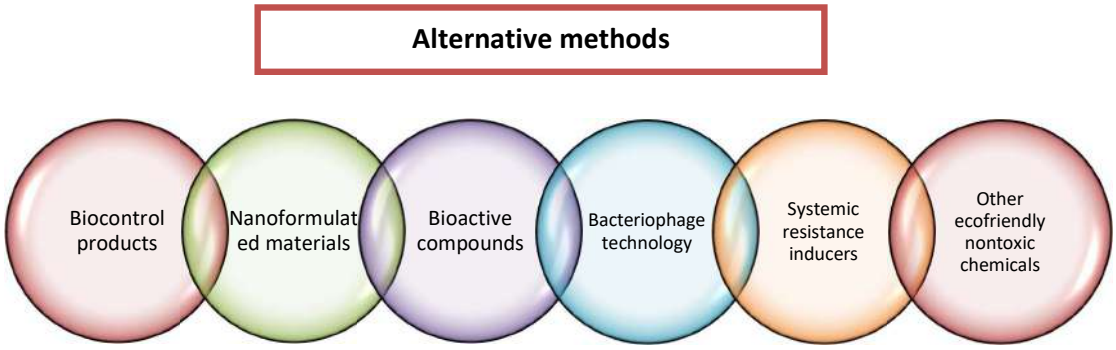

Fig 2. Alternative strategies to replace use of Cu compound

STRENGTHENING OF SUSTAINABLE LIVELIHOOD THROUGH *DIPLAZIUM ESCULENTUM* (RTEZ.) SW.: AN ENDEMIC & ECONOMICALLY IMPORTANT FERN OF HIMACHAL PRADESH, NORTH WESTERN HIMALAYAS

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Abstract
Lingad is a terrestrial, endemic and most commonly consumed fern of sub-temperate to temperate Himalayan region of Himachal Pradesh. Every year tons of lingad worth sold inthe markets of Himachal Pradesh in lakhs of rupees. Several preparations are made, some are served as special dishes to VIPs on special occasions. The entire supply of this plant directly harvested from forests as this fern has still not been brought under cultivation. Besides Himachal, lingad also occurs in the other states of NorthIndia like Jammu & Kashmir, Uttrakhand*etc.*

Introduction
Botanically lingad is known as *Diplazium esculentum* (Retz.) Sw. a pteridophyte which belongs to the family *Athyriaceae*. The genus *Diplazium* comprises approximately 350 species out of which few are edible. Lingadis commonly known as a 'janglisabji'among the Himalayan and sub-Himalayan communities. In Himachal it is locally known as Lingad; in India: kasrot, kukari-sag, mairungshai, linguda, kathura and Lingad; in Japan: Kuware-shida; Malay: paku, paku-tanjong; in Nepal: paninyuro, piraunli; and in Bangladesh: DhekiShak.Leaves of ferns are called fronds so tender circinatefronds of *D. esculentum*are edible, used as vegetable (Fig. 1a) and is also recommended for good digestive system. Mature fronds are used as fodder for cattle. The young emerging, hairy, blackish green fronds of this plant considered to be best for human consumption. These fronds are around 1 cm thick at base, 6 – 9 inches long, erect but circinate at the apex. Rhizome of lingadproduces numerous fronds which are mostly tri-pinnate, covered with shortrufous scales of about 1 cm long. Uppermost pinnae are simple. When fully developed, the pinnae can be 0.6 to 1.8 m long and 30-60 cm wide. They are fit for eating during the earlier stages when these are tender. After this stage, the leaves open up, increase in size and the succulent stem turns woody. It is does not remain fit for cooking at that stage. So lingad has therefore to be picked up at a particular stage of development. Therefore, it has a limited season mainly rainy season.

Distribution
D. esculentum is distributed through different parts of the globe including Cambodia, China, India, Indonesia, Japan, Malaysia, Papua New Guinea, Pakistan, Philippines, Singapore, Taiwan, Thailand, Vietnam, and Bangladesh. It grows on the banks of rivers and streams, canals, marshy areas, and hills with an altitudinal range up to 1300 to 2,300 meters above the sea level.

Edible uses
Tender fronds are harvested when it is 15 to 20 cm long for edible purpose. Special Himachali dishes like dum, madhra, raitaetc are made as special preparations in several

occasions. Young fronds are also stir-fried and used as a salad. Lingad salad is also served in hotels and restaurants. These young fronds are also used for pickle making.

Medicinal and Ethnobotanical Uses

Literature survey revealed that *D. esculentum* was traditionally used for the prevention or treatment of several diseases such as diabetes, smallpox, asthma, diarrhea, rheumatism, dysentery, headache, fever, wounds, pain, measles, hypertension, constipation, bone fracture and glandular swellings. Various pharmacological properties such as antioxidant, antimicrobial, antidiabetic, immune modulatory and anti-anaphylactic have been recognized in different parts of *D. esculentum*. The Mishingcommunity of Assam (State of the Indian republic) use lingad as one of the essential items in the religious ceremony of a dead person. Paste of rhizome and stipe is found to be effective over cuts, wounds and burns. Root is boiled and is taken in empty stomach twice a day to cure spermatorrhoea. Decoction prepared from rhizome and young leaves are used for haemophtysis and cough in Philippines.A decoction of lingdu leaves is recommended as a tonic for women after child birth in different communities.

Economic value

In Himachal Pradesh, local venders collect fronds of lingad and make their bundles. The price for one bundle (*i.e.* 1 kg) is varied fromINR 50-100.Lingad is sold in all big and small markets of HP. So the total annual trade in lingad must be worth several lakh rupees. Also, lingad is a good source of income for poor women of Western Himalayan region. The fronds are also used to make pickle. Its pickle (Fig. 1b) fetch good price in the market *i.e.* 300-350 Rs/Kg. Women of Himachal Pradesh prepare lingad pickle and sell it through various SHGs. Lingad pickle is in great demand and is a good source of earning for the stakeholders of different region of Himachal Pradesh.

Nutritive value

The tender fronds are mucilaginous. One hundred grams of fresh fronds contain 91.3 g moisture, 1.0 g protein, 100 mg fat, 1.4 g fiber, 600 mg of mineral matter. They also contain 0.98 mg/100 g of beta carotene.

Fig 1. (a) Tender fronds of Lingad; (**b)** Pickle of Lingad

Livelihood improvement

Lingad is a good source of earning for villagers; particularly women. The income generated by villagers is used to meet their basic needs especially for women. The lingad has to be collected from odd and difficult places located deep inside the forests. Some youngstersalso collect lingadduring weekends for additional income. Students use this in come to purchase stationary products, eatables and to fulfill other needs. While women used to utilize the

money in household's requirements and thus supporting their family. So, in nutshell this fern has been improving some aspects of living, yet its cultivation has not been initiated as it takes a month or two to grow completely after being plucked.

Conclusion and Future prospects

This species is collected in huge amount entirely from wild resources and marketed by the rural and tribal communities of India for their livelihood enhancement. *D. esculentum* has proved to a source of strengthening the livelihood condition of local people in sub-temperate region of Himachal Pradesh. It has been helping to generate income among women and youngsters. Therefore, it is essential to take necessary steps for its proper cultivation and to provide appropriate market for supply of their produce. Training, lectures, awareness camps etc. can be organized for the different communities so that they can adopt this plant for cultivation and thus strengthen their livelihood in the Himalayan region.

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BASIC FLOW PROPERTIES OF SARYU AND GORIGANGA RIVERS OF UTTARAKHAND, INDIA

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River flow can be envisaged as the amalgamation of the multiple climatological and geomorphological factors of a basin. Subsequently, river flow is characterized as one of the major components of the hydrological cycle. Quantification and understanding of the basic river flow characteristics is imperative for long-term evaluation of water resources, their planning and management. A thorough assessment of river flow behavior further assists in mitigating impacts of extreme climatic fluctuations on flows such as floods, droughts, etc.(Meresa, 2020).The sciences of hydrometry and hydraulics are applied for quantifying the basic flow characteristics of a river. In general, the river flow is quantified as volume of water passing through a river channel at unit time and measured at a given point; hence, river flow is often termed as river discharge. The most common method for quantification of river flow/ discharge is the area-velocity approach wherein river cross-section information is required under the assumption that the river channel is stable. The area-velocity method is applied by segmenting the channel into multiple components, and velocity and stage height is measured in the stream cross-section. Subsequently, the flow/discharge is computed by integrating the area and velocity at each point of segment. Therefore, the basic principle of measuring flow/discharge using area-velocity method is the representation of flow/discharge as the product of area of channel and velocity of the flow.

Once the flow data are collected over a significant duration for a channel, additional important flow-characteristics can be deducted primarily through timeseries analysis, base flow separation, and flow duration curve (FDC) analysis. A time series analysis of flow data is likely to provide information on flow seasonality, high and low-flow, and retardation time if additional rainfall data is available for the basin. Here, the low-flow dynamics of river needs a special mention as it plays vital role in water supply, irrigation, and, hydroelectric power plants, as well as evaluating groundwater resources (Curran, 1990;Griffiths & Clausen, 1997). Base flow separation from the observed discharges of a river is required to quantify contribution of ground water, seasonal low flow, short-term run off behavior, and instream ecology(Duncan, 2019); however, base flow separation is non-trivial and a number of methods are available for its quantification. Similar to base flow separation, production of flow duration curve of discharge data, that provides the percentage exceedance of flow rate, is used for extracting basin and flow characteristics(Le Boutillier & Waylen, 1993). Hence, a primary analysis of flow variability, base flow separation and computation of FDC would provide many important information of a river discharge.

In view of the accelerated responses of the Indian Himalayan region to climate change(Mukherjee *et al.,* 2019;Sabin *et al.,* 2020;Ballav *et al.,* 2021;Mukherjee, 2021), glacier and stream-fed rivers of the region warrants special attention for better flow

management. However, except for few major rivers originating in the Himalayas, a large number of rivers remained ungauged and their flow characteristics are unknown. Therefore, this brief report is an attempt to quantify flow characteristics of two glacier-fed rivers of the Kumaon Himalaya, Uttarakhand, and confluencing with the Kali River that separates India and Nepal.

The two rivers considered in this study are Saryu and Goriganga, and part of the Kali watershed of Upper Ganga basin. The respective watershed areas of Saryu and Goriganga rivers are 2252 km^2 and 2141 km^2 area (Fig. 1). The region has several hydropower schemes including the proposed Pancheswar Dam, which would be the largest Dam in India in terms of hydro power development after construction. Both Saryu and Goriganga rivers are tributaries of the Kali River wherein many other glacier-fed rivers confluence.

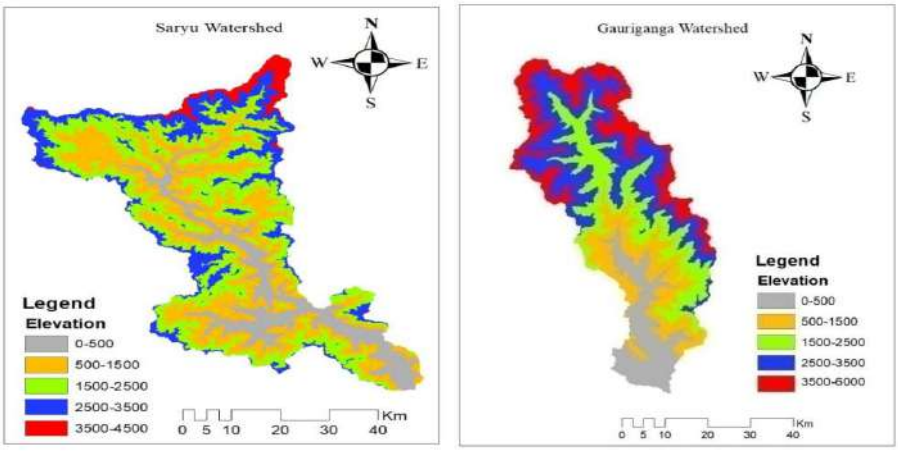


Fig. 1. The water sheds of Saryu and Goriganga rivers.

In order to assess the basic flow properties of the Saryu and Goriganga rivers, daily discharge data were collected from the Central Water Commission (CWC), India, for the period of 01/01/2018 to 31/12/2018. The discharge data was computed using the area-velocity method, and gauging stations were located just before the confluence of both rivers with Kali River. Before further analyses of discharge data, basic data quality assessment was made by removing any data having value greater than $\mu_d + 3.5\sigma_d$, whereμ_d and σ_d are the mean and standard deviation of the daily discharges, respectively. The data gaps were filled with linear interpolation. The flow seasonality was examined by producing monthly box plots. Base flow separation of the daily discharge data for both rivers were carried out using recursive digital filter technique following Arnold et al. (1995). Finally, the flow duration curves were produced and flow variability of both rivers was investigated using (Q_{10}/Q_{90}) and (Q_{10}/Q_{50}) values where $Q_{10....90}$ values were extracted from the FDCs of Saryu and Goriganga rivers.

The monthly flow variability of Goriganga and Saryu rivers are provided in Fig 2. The mean daily discharges of Saryu and Goriganga during 2018 were noted to be 174.6 and 160.8 m^3/s, respectively. The daily discharges are marginally smaller than the Chandra River of Himachal Pradesh (260.7 m^3/s) which is also a glacier-fed river of western Himalaya (Singh et al., 2020). The average maximum discharges for Saryu and Goriganga rivers were noted for the month of August and were 645.1 (±323.2) and 530.5 (±89.5) m^3/s, respectively. The lowest monthly discharges were noted for January-2018, and were 46.5 (±1.1) and 29.0 (±1.6), respectively. The maximum daily discharges of Saryu and Goriganga rivers were 1384.6 and 716.9 m^3/s, respectively, observed for the month of August as a result to accelerated glacier melting due to summer.

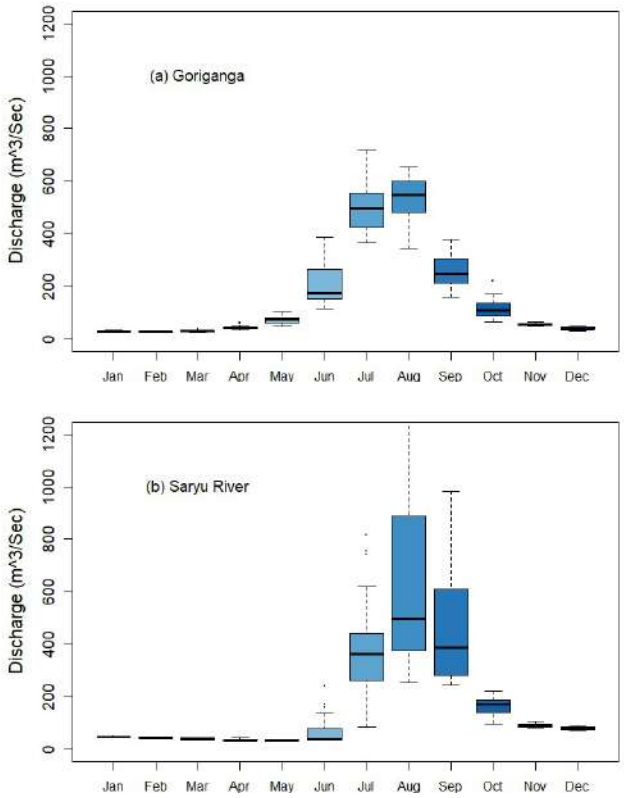


Fig 2. Monthly distribution of discharge and base flow of saryu and Goriganga rives**.**

Similarly, the baseflows of Saryu and Goriganga rivers were computed using a recursive digital filter. The comparative diagrams of daily discharge and baseflow of Saryu and Goriganga rivers are provided in Fig 3. The annual averages of baseflow for 2018 were 85.9 and 90.9 m3/s, respectively for the Saryu and Goriganga rivers, consequently, the base flow indices were noted to be 0.18 and 0.16, respectively, indicating Saryu has higher and continuous contribution of groundwater to river flow than Goriganga.

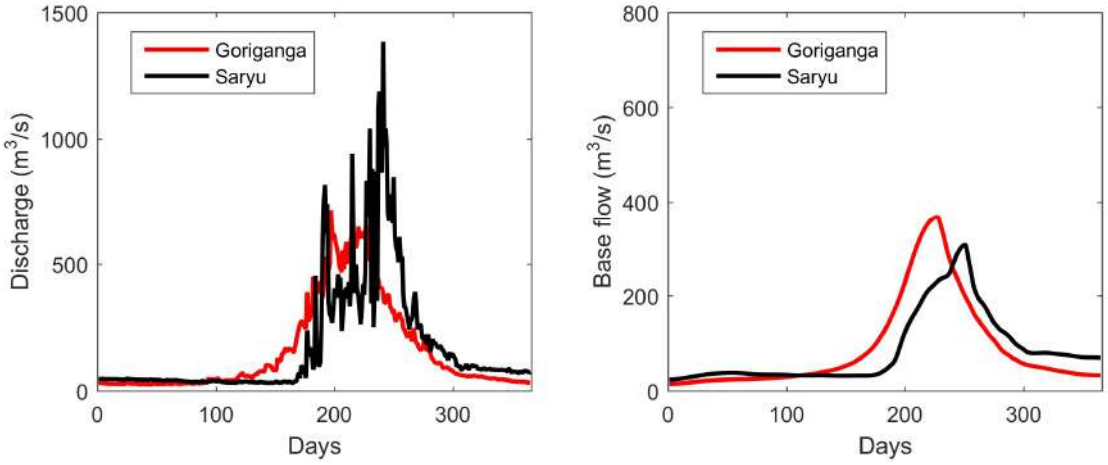
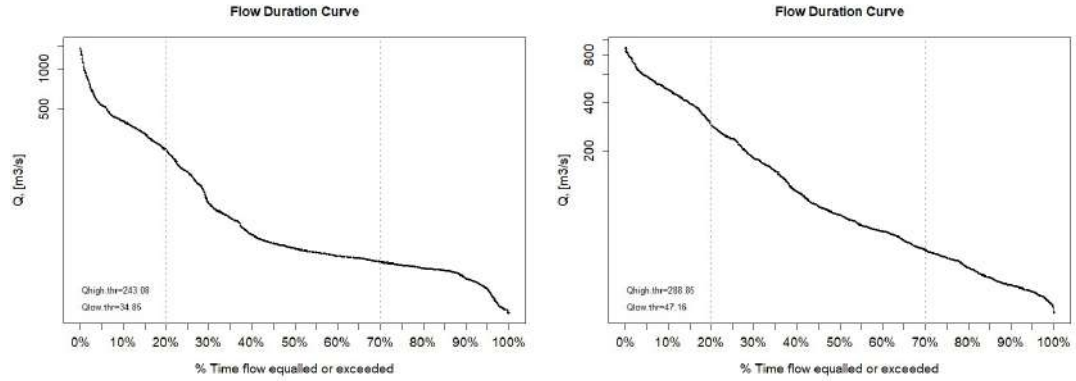


Fig 3. Daily discharge and base flow for (a) Saryu and (b) Goriganga rivers during 2018**.**

Finally the FDCs were produced for the Saryu and Goriganga rivers (Fig 4). Particular characteristics of the FDCs are reported with respect to slope characteristics and flow

variability. Since the general slopes of both the FDCs are gradual, it can be inferred that aquifer storage for both rivers had gradual discharge. The Q_{10}/Q_{90} values for Saryu and Goriganga rivers were noted to be 13.4 and 18.2, respectively, indicating higher flow variability for the Goriganga river. Similarly, Q_{10}/Q_{50} values for Saryu and Gorigangarivers were noted to be 6.0 and 8.4, respectively, indicating probability of higher flood peaks for Goriganga.



(a) Saryu River(b) Goriganga River

Fig 4. FDCs of (a) Saryu and (b) Goriganga rivers using observations of 2018

This brief report is an attempt to identify the basic flow characteristics of two glacier-fed rivers of Uttarakhand. Since, water in the Himalaya is also used for non-consumptive purposes like hydropower and tourism, and both Saryu and Goriganga rivers have substantial prospects for hydropower and tourism, this initial assessment of flow properties of these rivers are anticipated to be beneficial for a detail assessment of discharge characteristics for river-based developmental issues.

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LICHENS: NATURE'S BIO-INDICATORS OF ENVIRONMENTAL HEALTH

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Abstract
Lichens are fascinating organisms that serve as valuable bio-indicators, providing insights into environmental conditions and changes. This article explores their unique characteristics and significant role in assessing air quality and habitat health. Lichens' sensitivity to environmental shifts makes them effective tools for monitoring the impacts of human activities. Technological advancements have enhanced their monitoring capabilities, but challenges remain in standardization and data interpretation. By understanding and utilizing lichens as bio-indicators, we can make informed decisions to protect and restore our environment for a sustainable future.

Introduction
Our planet's environmental health is of utmost importance as it directly impacts the well-being and survival of all living organisms. As humans continue to engage in various activities that affect ecosystems, it becomes imperative to understand and monitor the consequences of our actions. In this pursuit, bio-indicators emerge as indispensable tools for assessing and evaluating environmental conditions. These remarkable natural indicators offer crucial insights into the effects of human activities on ecosystems. Among the diverse array of bio-indicators, lichens stand out as fascinating organisms that possess the unique ability to provide valuable information about environmental conditions and changes. In this article, we will explore the world of lichens and their significant role as bio-indicators.

Understanding Lichens
Lichens, often overlooked and misunderstood, are a unique form of life. They are not single organisms but rather a symbiotic partnership between fungi and algae or cyanobacteria. This symbiosis allows lichens to thrive in diverse habitats worldwide, from lush forests to barren deserts. Lichens come in various forms, including crustose (crusty), foliose (leafy), and fruticose (branching) types, each displaying a stunning array of colours and textures. Their intricate structures and astonishing diversity make them a captivating subject of study.

The Role of Lichens as Bio-indicators
Bio-indicators are organisms that reflect the quality of their environment. An easy example of what bio-indicators would be the use of Canary bird by the coal miners to detect the breathable air inside the mines. They used to bring a caged canary with them into the mines and observe the activity of the bird. A caged canary's activity, such as singing, assured miners of relatively good air quality, as the birds were highly sensitive to noxious gases like methane. If a canary perished, it served as an immediate sign for miners to evacuate.

Lichens possess many morecharacteristics than canary birds to be a better bio-indicator that make them excellent bio-indicators. Firstly, they are highly sensitive to environmental

changes, responding rapidly to variations in air quality, habitat disturbances, and climate. Their reliance on the surrounding atmosphere for nutrients and water makes them particularly vulnerable to pollution and changes in environmental conditions. Additionally, lichens have long lifespans, enabling the assessment of environmental conditions over extended periods.

Lichens as Indicators of Air Quality

One of the most well-known applications of lichens as bio-indicators is in monitoring air quality. Due to their unique physiology, lichens are particularly sensitive to air pollution. By observing changes in lichen species composition, abundance, and overall health, scientists and researchers can assess air pollution levels in different regions. Lichen monitoring has provided valuable data for understanding the impacts of industrial activities, urbanization, and vehicular emissions on air quality. For example, in urban areas with high pollution levels, lichens may exhibit reduced diversity and unhealthy appearances, whereas in cleaner environments, a greater variety of lichen species thrive.

Lichens as Indicators of Habitat Quality

Beyond air quality, lichens also serve as indicators of overall habitat health. Their presence or absence, as well as their species diversity and abundance, can indicate the impact of habitat disturbances such as deforestation, pollution, or climate change. By studying lichens within a given ecosystem, scientists can gain insights into the impacts of human activities and assess the restoration and conservation needs of habitats. For instance, in areas affected by pollution or habitat degradation, lichens may decline or disappear, highlighting the urgent need for conservation efforts. Conversely, the presence of a diverse and thriving lichen community indicates a healthy and well-preserved habitat.

Advancements and Challenges in Lichen Bio-indication

Technological advancements have improved our ability to monitor and analyse lichen data. Digital imaging, molecular techniques, and data mapping have enhanced the precision and efficiency of lichen bio-indication. Researchers can now use high-resolution photography and image analysis software to document and compare lichen communities over time. Molecular techniques allow for DNA analysis, enabling a deeper understanding of lichen species and their responses to specific environmental factors. Furthermore, data mapping and geographical information systems (GIS) help visualize lichen distributions and identify areas of concern.

However, challenges remain in the field of lichen bio-indication. Firstly, the need for standardized monitoring protocols is crucial to ensure consistency and comparability across studies and regions. Establishing a common framework would facilitate data sharing and collaboration among researchers and organizations. Secondly, natural variations in lichen populations and responses to environmental factors can complicate data interpretation. It requires careful consideration and statistical analysis to distinguish between human-induced changes and natural fluctuations. Lastly, there is still much to learn about the responses of certain lichen species to specific environmental conditions. Further research is necessary to better understand these species and expand the scope of lichen bio-indication.

Conclusion

Lichens, with their unique ecological characteristics and sensitivity to environmental changes, have proven to be invaluable bio-indicators of environmental health. They provide us with crucial information about air quality, habitat conditions, and ecosystem well-being. By understanding the messages conveyed by lichens, we can make informed decisions and take necessary actions to protect and restore our environment. Let us appreciate the

remarkable role of lichens as nature's bio-indicators and strive to preserve the delicate balance of our planet's ecosystems for generations to come. Through continued research, standardized monitoring protocols, and collaborative efforts, we can harness the power of lichens to monitor environmental health and ensure a sustainable future.

पानी के चश्मों को पुनः प्रवर्तनकी आवश्कयता तथा कार्यविधि

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परिचय

जल जीवन का आधार है । पानी के चश्मों ऐसे स्थान हैं जहां भू जल उजागर होता है और पृथ्वी की सतह से बहता है, यह जल भूमिगत जल पर निर्भर हैं। यह वैश्विक जलवायु परिवर्तन के सबसे संवेदनशील संकेत कभी हैं । इसके अलावा यह सांस्कृतिक महत्व भी रखते है, हिमालयन क्षेत्र म ंपीने के पानी के मुख्य स्त्रो तभी है विशेषकर हिमाचल प्रदेश का शीत मरुस्थल क्षेत्र लाहौल तथा स्पीतिमेंपय जलमुख्य स्त्रोत यह पानी के चश्मे ही है (छयाचित्र 1) ।

चित्र 1. पानी के चश्मे लाहौल (क एवं ख) तथा कुल्लू (ग)

चश्मों का पुनः प्रवर्तन की आवश्यकता

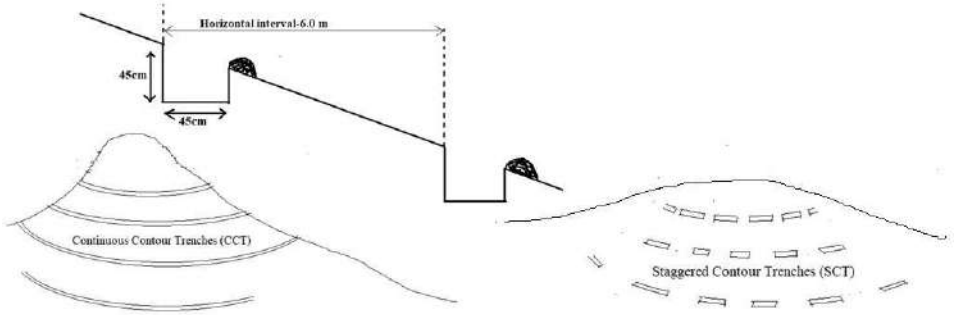
प्राकृतिक चश्मों, जलीय और स्थलीय आवासों के बीच महत्वपूर्ण सम्बन्ध हैं भू जल पर निर्भर पारिस्थितिकतंत्रों की गिरावट ने पुनः प्रवर्तन की आवश्यकता को बढ़ा दिया है, लेकिन पुनः प्रवर्तन के लिए पारिस्थितिकी प्रतिक्रियाएं काफीहद तक अज्ञात हैं (वार्ड तथा टॉकनर , 2000,कैंटोनाटी एट अल 2012). नीति आयोग के अनुसार, इसबात के प्रमाण बढ़ रहे हैं कि पूरे भारतीय हिमालयी क्षेत्र में प्राकृतिक चश्मे सूख रहे हैं या उनका डिस्चार्ज घट रहा है । अनुमान है कि भारतीय हिमालय में आधे चश्मे सूख गए हैं, हिमाचल प्रदेश विज्ञान, प्रौद्योगिकी और पर्यावरण परिषद के अनुसार हिमाचल के गांवों में लगभग 10,000 पारंपरिक जल स्रोत हैं। जिनमे केवल 3041 जल स्रोत ठीक से रिचार्ज कर रहे हैं, जबकि 6959 स्रोत निकट भविष्य में लगभग सूखने वाले हैं। इससे बड़े पैमाने पर पानी की कमी होगी, जिसने हिमालय के पारिस्थितिकतंत्र, फसल उत्पादन और पशुधन पर प्रतिकूल प्रभाव पड़ेगा। मानव की अवैज्ञानिक तरीके से जल विद्युत परियोजनाओ के निर्माण तथा विकास की अंधी दौड़ के कारण पानी के इन प्राकृतिक स्त्रोतों के पारिस्थितिकतंत्र को वहुत बड़ा खतरा पैदा हो गया है । वहुत से स्त्रोत सुख गए है और वहुत से सूखने के कगार पर है। इन स्त्रोतों के पुनः प्रवर्तन वहुत

आवश्यकता है इन स्त्रोतों के पुनः प्रवर्तन के लिए गोविन्द वलभपंत पर्यावरण संस्थान महत्वपूर्ण कार्य कर रहा है ।

पुनः प्रवर्तन पुनः प्रवर्तन में ऐसी कार्रवाइयाँ शामिल होती हैंजो किसी स्थल पर भौतिक विशेषताओं के आधार पर, इन स्त्रोतों के कम हो रहे डिस्चार्ज में सुधार करती हैं। मोटे तौर पर गतिविधियों के निम्नलिखित कार्य शामिल हैंः

कंटूरट्रेंचेस का निर्माण

कंटूरट्रेंचेस एक पहाड़ी के साथ इस तरह से खोदी गई नालियाँ हैं जो एक समोच्चका अनुसरण करती हैं और पानी के प्रवाह के लंबवत चलती हैं। इन ट्रेंचेस से खो दी गई मिट्टी का उपयोग ट्रेंचेस के निचले किनारे पर मुँडेर बनाने के लिए किया जाता है जिन पर पेड़, झाड़ियां या घास उगाई जाती है (साम्रा एट अल, 2004) । कंटूरट्रेंचेस मुख्य दो प्रकार की होती है एक कंटीन्यूअस कंटूरट्रेंचेस तथा दूसरी स्टैगर्ड कंटूरट्रेंचेस किसी भी क्षेत्र में इनका चुनाव उस क्षेत्र की जलवायु तथा स्थलाकृति के आधार पर किया जाता है अर्ध शुष्क तथा तीव्र ढलान वाले क्षेत्र में कंटीन्यूअस कंटूरट्रेंचेस तथा अधिक वर्षा एवं कम ढलान वाले क्षेत्र में स्टैगर्ड कंटूरट्रेंचेस का चयन किया जाता है (चित्र 1)



चित्र 1. कंटीन्यूअस कंटूरट्रें चेस तथा स्टैगर्ड कंटूरट्रें चेस

वनस्पति आवरण को बढ़ाना जलग्रहण क्षेत्र में स्वच्छता बनाए रखना उपयुक्त स्थानों पर नालों और सहायक नदियों पर छोटे चेक डैम का निर्माण करना । भू जल को रिचार्ज करने के लिए छोटे तालाबों और पर को लेशन पिट्स का निर्माण करना । पानी की गुणवत्ता की निरंतर निगरानी पुनः प्रवर्तन के कार्यो में स्थानीय लोगो की सक्रिय भागीदारी सुनिश्चित करना अतः आज के परिपेक्ष मेंजल के प्राकृ तिक स्त्रोतों का सरंक्षण एवं पुन प्रवर्तन करना वहुत आवश्यक हो गया है उपरोक्त विधियों के क्रियान्वन द्वारा सूखने के कगार पर पहूँचे जल के प्राकृतिक स्त्रोतों का सरंक्षण एवं पुन प्रवर्तन किया जा सकता है।

संदर्भ

वार्ड, जे. वी. और के. टॉकनर (2001)। जैवविविधताः नदी पारिस्थितिकी के लिए एक एकीकृत विषय की ओर। मीठे पानी का जीवविज्ञान 46: 807–819

केंटोनाटी, एम., एल. फ्यूरेडर, आर. गेरेके, आई. जटनरऔरई. जे. कॉक्स। (2012)। मीठेपानी की जैवविविधता संरक्षण के लिए क्रेनिक आवास, हॉटस्पॉटः उनकी पारिस्थितिकी की समझ की ओर।मीठे पानी का विज्ञान 31: 463–480

साम्रा , जे .एस., चंद्रप्रकाश , सस्त्री , जी . एंडरायजादा , ए. (2004) । टेक्निकल मैन्युअल ऑन कंटूरट्रेन्चिंग फॉररिहैबिलिटेशन फॉर डिग्रेडिडलैंड्स , पब्लिश्ड वाय डायरेक्टर , सीएसडव्ल्यूसीआरटीआई, देहरादून

हिमाचल प्रदेश के पहाड़ी क्षेत्रों में वर्षा जल संचयन की संभावनाएँ

नेहा ठाकुर' और प्रियंका ठाकुर

डॉ वाई एस परमार औद्यानिकी और वानिकी विश्वविद्यालय , औद्यानिकी और वानिकी महाविद्यालय थुनाग मंडी, हिमाचल प्रदेश

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परिचय

राज्य में जमीन और पानी की उपलब्धता हिमाचल प्रदेश एक पहाड़ी राज्य है जिसे देवभूमि कहा जाता है और राज्य में 70 प्रतिषतलोग जीवनयापन के लिए कृषि पर निर्भर हैं। हिमाचल प्रदेश राज्य का कुल भौगोलिक क्षेत्रफल 55,673वर्ग किलोमीटर, कुल फसल क्षेत्र 9,40,597 हेक्टेयर और नया बोया गया क्षेत्र 5,38,412 हेक्टेयर है। कुल भूमि क्षेत्र में से नए खेती योग्य क्षेत्र के कम प्रतिशत का कारण यह हो सकता है कि कुछ भूमि जंगल के अधीन बसी हुई, शहरीकृत और कम उपयोग वाली बंजर है। हिमाचल में 81प्रतिषतकृषि वर्षा पर आधारित है (जसवाल ए.के, 2015)। अंकुरण के समय फसल को गंभीर मिट्टी की नमी के तनाव का सामना करना पड़ता है । क्षेत्र में औसत वार्षिक वर्षा 1200 मिमी है। 1971 से 2020 की अवधि के लिए जलवायु विज्ञान के अनुसार , हिमाचल प्रदेश राज्य अपनी वार्षिक वर्षा का 15 प्रतिषत सर्दियों (जनवरी–फरवरी) के दौरान , 19.3 प्रतिषत पूर्व–मानसून (मार्च–मई) के दौरान, 19.0 प्रतिषत दक्षिण–पश्चिम मानसून (जून–सितंबर) के दौरान और 6.7 प्रतिषत मानसून के बाद (अक्टूबर–दिसंबर) के दौरान अनुभव करता है। जिनमें से 70 प्रतिशत वर्षा की दर मानसून काल में, 18 प्रतिशत शीत ऋतु में तथा शेष वर्ष के अन्य महीनों के दौरान बिखरी हुई है । कृषि फसल वृद्धि के महत्वपूर्ण चरणों में पानी की अनुपलब्धता के कारण उत्पादकता बुरी तरह प्रभावित होती है उदाहरण के लिए अंकुरण के चरण में मिट्टी में नमी के तनाव का अनुभव होता है। फसल वृद्धि के समय पानी की कमी का कृषि उत्पादकता पर नकारात्मक प्रभाव पड़ता है। गर्मियों के दौरान , हिमाचल प्रदेश की शिवालिक पहाड़ियों में पीने के पानी की गंभीर कमी होती है।

वर्षा जल संचयन की आवश्यकता

राज्य की अर्थव्यवस्था प्रमुख रूप से कृषि पर निर्भर है और पानी इसका एक अनिवार्य हिस्सा है। लेकिन हाल के वर्षों में यह देखा गया है कि फसल उगाने की अवधि के दौरान किसान पानी की कमी की चुनौतियों का सामना कर रहे हैं। राज्य के कृषि विभाग के प्रारंभिक आकलन के अनुसार, अल्प वर्षा के कारण वर्ष 2021–22 में 1.48 लाख हेक्टेयर से अधिक रबी फसल (सर्दियों में बोई गई) नष्ट हो गई है । जिस से लगभग 130 करोड़ रुपये का भारी आर्थिक नुकसान हुआ है। बारिश के पानी की कमी से सबसे ज्यादा प्रभावित क्षेत्र कांगड़ा में 33,520 हेक्टेयर , मंडी में 36,000 हेक्टेयर और हमीरपुर में 30,220 हेक्टेयर पाया गया है। इस तरह की स्थिति जहां फसल के लिए पानी की अनुपलब्धता होती है , किसानों को सिंचाई के पानी के लिए महंगे और गैर–टिकाऊ विकल्पों पर निर्भर रहने के लिए मजबूर करती है , जैसे कि मोटर संचालित पानी के पंप, जो क्षेत्र के भूजल तालिका को भी प्रभावित कर सकते हैं।

विश्व स्तर पर हम जलवायु परिवर्तन का सामना कर रहे हैं जो देश भर में बारिश के प्रतिरुपों में बदलाव का प्रमुख कारण है। जलवायु परिवर्तन के कारण तापमान में वृद्धि होती है जो की वातावरण की नमी धारण करने की क्षमता को बढ़ाता है और वर्षा के प्रतिरुपों में परिवर्तन करता है। आईएमडी में मौसम विज्ञान के महानिदेशक डॉ. मृत्युंजय महापात्र के अनुसार , जलवायु के 1 डिग्री सेल्सियस तापमान में वृद्धि के परिणामस्वरूप वातावरण की नमी धारण करने की क्षमता में 7ः की वृद्धि हुई है। आईएमडी के शिमला केंद्र के प्रमुख सुरेंद्र पॉल का दावा है कि अप्रैल 2023 की वास्तविक बारिश 104.1 मिमी थी , जो औसत (64 मिमी) से 63ः अधिक थी। क्षेत्र को प्रभावित करने वाले चार सक्रिय पश्चिमी विक्षोभों के परिणामस्वरूप अप्रैल

2023 में राज्य में कुछ हद तक व्यापक वर्षा का अनुभव हुआ। ये आँकड़े लोगों के बीच यह संदेश फैलाने का आदेश देते हैं कि पानी की अधिकता होने पर उसे बचाने की परिकल्पना की जाए न कि पानी न होने पर पछताने की। इसीलिए खेतों में फसल न होने की अवधि के दौरान अत्यधिक बारिश से पानी का संचयन फायदेमंद साबित हो सकता है और बदलते मौसम यानी रबी और खरीफ के दौरान सिंचाई के पानी का एक निरंतर स्रोत हो सकता है।

पहाड़ियों में वर्षा जल संचयन के तरीके

पहाड़ियों में वर्षा जल संचयन के कई तरीके है जैसे की पहाड़ियों में खेत तालाब, छत के वर्षा जल का संग्रह ,नौला ,कुल्ह ,खात्रि, जाबो वगैरह । पहाड़ियों में खेत तालाब बनाने के लिए छोटा रिवर्स–पिरामिड आकार का 1.0 से 1.5 मीटर गहराई वाला गड्ढा खोदा जाता है । फिर तालाब की सतह के चारों ओर पत्थर की चिनाई की जाती है। गढ़े के ऊपर सिंगल पीस एलडीपीई शीट (0.25 मिमी मोटी) को ठीक से रख कर कोनों को मोड़कर दबा दिया जाता है । अब यह खेत तालाब बारिश के पानी या प्राकृतिक स्रोत से अतिरिक्त पानी के माध्यम से भरने के लिए तैयार है। हिमाचल प्रदेश की शिवालिक पहाड़ियों में गर्मी के महीनों के दौरान पानी की कमी से निपटने के लिए ये खेत तालाब बहुत लोकप्रिय हैं (शर्मा 2017)। वर्षा जल संचयन का एक और विकल्प है छत पर वर्षा जल संचयन । छत से पानी एकत्र कर पीवीसी पाइप के माध्यम से संग्रह कक्ष में लाया जाता है ।अंत में जल अलग–अलग टैंकों में संग्रहीत करते है जिनकी क्षमता 2.0, 1.2 और 0.4 लाख लीटर तक होती है। घर की छत से जल संचयन के बारे में एक वीडियो है जिसे इस क्यूआर कोड को स्कैन करके देखा जा सकता है (संदर्भ के लिए) । 90 के दशक के अंत में राज्य में शहरी क्षेत्रों में इमारतों की छतों से बारिश के पानी के संग्रह को अनिवार्य बनाने का कैबिनेट का निर्णय इस प्राकृतिक संसाधन के संरक्षण के लिए एक स्थायी कदम था। लेकिन इसकी सफलता केवल हमारे विकल्पों पर निर्भर करती है कि यह टिकाऊ है या वांछित है ।

नौला पहाड़ी क्षेत्रों के लिए विशिष्ट सतह–जल संचयन की एक विधि है। ये छोटे कुएँ या तालाब होते हैं जिनमें जलधारा के आर–पार पत्थर की दीवार बनाकर पानी इकट्ठा किया जाता है। कुल्ह, पर्वतीय क्षेत्रों में पाई जाने वाली जलधाराएँ हैं। ये सतही धाराएँ पानी को प्राकृतिक रूप से बहने वाली धाराओं से मोड़ते हैं जिन्हें खड्ड कहा जाता है और यह धारा खड्ड की तुलना में अधिक ऊंचाई पर बहती है । इसका उपयोग नदी के ऊपर की भूमि को सींचने के लिए किया जाता है । हिमाचल प्रदेश की स्पीति घाटी में ग्लेशियरों से पानी को गांवों तक ले जाने के लिए ये जलधाराएँ प्रयोग में आती है। खात्रि लगभग 10•12 फीट आकार की और छह फीट गहरी संरचनाएँ हैं जो कठोर चट्टान के पहाड़ में उकेरी गई हैं। ये पारंपरिक जल संचयन संरचनाएं हिमाचल प्रदेश के हमीरपुर , कांगड़ा और मंडी जिलों में पाई जाती हैं (शर्मा एन. और कंवर पी. 2009)। जाबो– इस शब्द का अर्थ है इम्पाउंडिंग रन–ऑफ, अर्थ पलायन रोकना, ये प्रणाली उत्तर–पूर्वी भारत के नागालैंड राज्य में प्रचलित है। इस तकनीक को रूजा प्रणाली के रूप में भी जाना जाता है , जिस्मे सीढ़ीदार खेतों से अतिरिक्त पानी को रोककर रखा जाता है। यह वानिकी, कृषि और पशु देखभाल के साथ जल संरक्षण को जोड़ती है। सीढ़ीदार खेत वाले हिमाचली किसान भी इस तकनीक को अपना सकते हैं । इसी तरह भूजल संचयन प्रणाली, समोच्च खाई, तलछट और नाला बांध और फिल्टर सिस्टम वाले टैंक वर्षा जल संचयन के कुछ अन्य तरीके हैं।

निष्कर्ष

मानव निर्मित प्रयासों से जल संरक्षण की अनंत संभावनाएं हैं। इसलिए यह इस प्राकृतिक संसाधन को संरक्षित करने के लिए हमारे द्वारा चुने गए हरित विकल्पों पर भी निर्भर करता है। यह सरकार द्वारा हाल ही में लॉन्च किए गए स्थ्म मिशन से भी संबंधित हो सकता है जो पर्यावरण के लिए एक स्वस्थ जीवन शैली को अपनाने के लिए प्रोत्साहित करता है।

संदर्भ

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https://youtu-be/1aZrc1oTbIo

Section VI

Traditional Knowledge and Indigenious Practices

DOLOMIAEA MACROCEPHALA DC. EX ROYLE: AN IMPORTANT MEDICINAL AND SACRED PLANT OF NORTH WESTERN HIMALAYA, INDIA

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Introduction

Dolomiaeamacrocephala DC. Ex Royle is commonly known as Himalayan Dolomiaea. It belongs to family Asteraceae. The genus *Dolomiaea* morphologically resembles with *Jurinea*and *Saussurea*generaof Asteraceae family but is it can be distinguished from these genera by the presence of scabridpappus bristles and naked alveolate receptacles without scales. The genus *Dolomiaea* is represented by 21 species all over the world and to endemic alpine regions of China, Nepal, Myanmar and Pakistan. In India the genus is represented by three species viz.,*D. macrocephala*, *D. baltalensis* and *D. costus*.The species *Dolomiaea macrocephala* is an important endemic plant of the North Western Himalaya, and an indicator species for alpine vegetation.In its distribution areas it is commonly known as Dhoop or Gugul and its roots are collected by Himalayan communitieson a largescale due to its aromatic and medicinal property and commercially sold as dhoop to the incense industry.It also has insect repellent and anti-microbialproperty. It is also considered as major food plant of *Ochotona roylei* (Himalayan Mouse hare).

Synonyms

Jurinea dolomiaea Boiss, *Jurinea macrocephala* DC., *Jurinea salicifolia* Boiss., *Carduus nepalensis* Spreng. ex DC, *Jurineahim alaica* R.R. Stewar

Vernacular Name

Dhup (Kashmir), Dhup, Dhupa, Gugal, Guggal, Zhangar (Punjab), Dhoop Lakkar, Zhangar, Gugal Dhup, JariDhoop, Guglang, Gugal (Himachal Pradesh): Dhup, Gugal (Punjab).

Description

It is a rosette forming stemless perennial herb. Roots are woody. Leaves are radical, spreading, 15-45 x 3.5-17.5 cm, oblong-lanceolate, pinnate or deeply pinnatifid, white lanate above, densely white tomentose beneath; lobes broad, lobulate or pinnatifid, denticulate with acute or mucronate teeth. Heads purple, homogamous, discoid, 1.5-4 cm across, numerous (3-30), rosulate, sessile or shortly peduncled; peduncles stout, tomentose often cottony at base. Involucral bracts many-seriate, imbricate, 1.8-3.5 cm long; outer ovate-lanceolate; inner oblong-lanceolate, long acuminate, scabrid or smooth, erect, scarious. Receptacle flat, densely bristly; bristles united into laciniate cup, bristles much shorter than achenes. Disc Florets purple, all bisexual tubular; tube slender. Corolla 2.5-3 cm long, 5-fid. Stamens 5 or rarely 4, epipetalous, alternating with corolla lobes; filaments free, glabrous; anthers bases sagittate, auricles usually connate, tails lacerate. Ovary inferior, unilocular, terete or compressed; style arms short; ovule solitary. Fruits (Achenes) ca 6-8 mm long, cuneate-obovate, curved, compressed, unequally 4-5 angled, truncate, tubercled. Pappus brown or brownish barbellate, ca 2.5 cm long, copious, cohering. Seeds exalbuminous. It's flowering and fruiting period is July-September.

Distribution
It has very restricted distribution throughout world and found only in countriesIndia, Nepal and China. In India it is found in Western Himalayan states of Himachal Pradesh,Uttarakhand and Jammu & Kashmir UT.In Himachal Pradesh it is found in Chamba (Bharmour, Chansil, Dharwas valley, Pangi, Satrundi), Kangra (Bhangal,Bara Bhangal, Dainasar, LakhaThamsar Jot), Kinnaur (Chitkul, ManjibanKands, Palikchi to Kiari pass, Sanglakanda to Rupin pass), Kullu (Chandrakhani, Hurla, Parvati, Seraj and all the valleys of GHNP), Lahaul&Spiti (Keylong), Mandi (Nargu), Shimla (Chansal, Gorju, Kalgapattan, Muraldanda, Rampur Bushar, Rohru forest Division) districts.

Altitudinal range: 3000-4700 mamsl.

Habitat
It is generally found in open slopes, in rock-crevices and glacial moraines.

Major Associated Species
Trillium govanianum Wall. Ex D.Don, *Meconopsis aculeata* Royle, *Aconitum violaceum* Jacquem. Ex Stapf, *Morina longifolia* Wall. ex DC., *Rheum australe*D.Don, *Sinopodo phyllumhexandrum* (Royle) T.S.Ying*, Dactylorhizahatagirea* (D.Don) Soó*,Bergeniastracheyi* (Hook.f. & Thomson) Engl.*Arnebiabenthamii* (Wall. ex G.Don) I.M.Johnst., *Corydalis govaniana* Wall., *Fritillaria cirrhosa* D.Don, *Delphinium vestitum*Wall. Ex Royle*, Ligularia amplexicaulis* DC., *Potentilla argyrophylla* Wall. Ex Lehm., *Potentilla atrosanguinea* Lodd., G.Lodd. & W. Lodd., *Pedicularis longiflora* Rudolph, *Cremanthodium ellisii* (Hook.f.) Kitam and *Bistortaaffinis* Greene

Indigenous Uses
It is used in Indian traditional system of medicine. Decoction of the roots used to cure colic and fever. The bruised root is used as a poultice to cure skin eruptions. The roots are also considered to be stimulant and given in fever after the child birth.Aromatic oil from the roots is also used to curearthritis and rheumatism. Local consider it sacred and roots are commonly used as incense in temples, monasteries, houses and religious ceremonies. Locals also believe that it keep away evil spirits and negative energies so it is also used in holy rituals. In its distribution areas local people also collectthe root of this plant during the period July-September months for own use and marketing. Flowers and roots are also offered to the deities in the temple especially in Fulaich festivalsthroughout Kinnaur. In Ribba village of Kinnaur district every year two Rajputs known as 'Senapala' (selected by villagers) visits alpine pastures and collects Gugaldoop and they distribute roots of *Dolomiaeamacrocephala* to every household of the village on first day of Fulaich festival before the deity reaches the festival place. Afterwards female folk of the entire village welcomes the local deity '*Kasurajji'*with the incense of *Juniperusindica* (Shur) and *Jurineamacrocephala* (Guglang) along with apricot, bemi, and grape wine.

Major Chemical Constituents
Carbohydrate, proteins, Fats, Glycosides, Alkaloids, Tannins, Flavonoids, Steroids, Saponins, Phenolic compounds, Phytosterols.

Conservation Measures
*Dolomiaeamacrocephala*is one of the most highly exploited medicinal and aromatic plants of North Western Himalayan region of India because it is an important source of raw material forvarious pharmaceutical, perfume and fragrance industries. In India 10.96 MTroots

ofGugalis consumed by rural household and folk healers (Goraya and Ved, 2017). Due to continuously increasing market demand there is overexploitation of this species in its whole distribution range.Apart from this, its natural population is continuously decreasing due to other human interference viz., grazing, construction of roads, fire and tourism activities in its natural habitat.During the last few decades, there has been a drastic decline in the natural numbers of this species, due to which the International Union for Conservation of Nature (IUCN) has placed this species in the category 'Vulnerable'.Hence, population assessment, ecological niche modelling, development of sustainable harvesting methods and cultivation techniques along with awareness programmes is suggested for its conservation.

TRADITIONAL KNOWLEDGE OF WATER MANAGEMENT PRACTICES IN HIMACHAL PRADESH

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Abstract

The study examines the status of traditional water resources and their traditional management system in selected agro-climatic zones of Himachal Pradesh. The analysis of information provided by the residents showed that every selected site in the study region consisted of traditional water sources, which are managed by the local community. These sources are constructed with traditionally inherited technology using locally available natural resources present nearby. These traditional water structures are locally known as *Jairu, Maggru, Churrdu*, *Bawodi, Naun*, and *Khatri* for drinking purposes and irrigation channels are locally known as *Naa, Phil, Shrik, Phizur, Khad/Nalla,* and *Kuhl*; which contributes in water as well as soil conservation with indigenously developed management practices

Keywords: Indigenous structures, Community management, Water conservation, Sustainability.

Introduction

The Indian Himalayan Region is considered the third pole and water tower of Asia, as it covers about 17 percent of the region under permanent snow cover/glaciers. This plays a significant role in feeding many springs and rivers of India that supports the welfare of 2 billion people in the mountain regions and plains by proving them with fresh water for domestic purposes, industries, irrigation purposes, hydropower, and sustaining life (Ansari *et al.,* 2015). There are numerous adverse impacts of population growth and developmental activities on water sources, such as drying-up of springs, reduction in forest cover, increased soil erosion, silting of water bodies, and degradation of water quality as well as increased water demand (Sundriyal*et al*., 2018). The only solution to this problem is the utilization of traditional water harvesting systems. But in recent times, it has been noticed that traditional water sources are deteriorated and poorly maintaineddue to modern facilities such as bore-wells, hand pumps, and electric pumps (Singh *et al*., 2010).So there is a need of conserving and managing these traditional water sources, which can be done by acknowledging the traditional knowledge of the local people transferred from generation to generation.

Methodology

Himachal Pradesh is a hilly-mountainous region in the Indian Himalayan Region, which covers an area of 55,673 sq km and is situated between the latitudes 30°22’40’’ to 33°12’40’’ North and longitudes 75°45’55’’ to 79°40’20’’ East. The climate of the state varies considerably and the season cycle is like that of hot and sub-humid to cold glacial and alpine. Three study sites located in three different districts, *viz*., Lahaul&Spiti, Kullu, and Mandi

representing different agro-climatic conditions were selected for studying the traditional water management practices. The Lahaul&Spiti study sites (3200 m amsl) represents high-hills temperate zone, Kullu district (1200 m amsl) represents mid-hill sub-humid to high-hill sub-temperate-wet zone and Mandi district (776 m amsl) represents mid-hill sub-humid zone of Himachal Pradesh.The information related to the indigenous knowledge system of water sources, their usage, and management was conducted using a pre-tested questionnaire with tribal communities. The whole information in each case was subsequently compiled and has been cross-validated to ascertain the facts about the local use of the practices and presented.

Results and Discussion

On the basis of a questionnaire-based survey conducted with local inhabitants of the study region which mostly included elders, information related to traditional water structures, local names, and their use was gathered. The perusal of Table 1 displays the list of water storage practices and traditional water sources in this selected region of Himachal Pradesh.

Table 1. Water use practices for drinking, irrigation, domestic use and conservation practices

S. No.	Water storage, use & conservation methods	Local Name	Locations	Use
1.	Indigenous water structures	*Jairu, Maggru, Churdu, Bawodi/ Bai, Nau/Panyehar/ Khatri/Khatiya/ Gharat*	Kullu, Mandi	These are used for drinking and domestic use.
2.	Religious conservation	*DeyokiBai, Tirath, Saur*	Kullu, Mandi	These structures are used to protect and conserve water.
3.	Small ponds harvesting/ water storage	*Bouro*	Kullu, Mandi	Spring water is collected in small reservoirs scattered at intervals on the high uplands and then water is drawn from these ponds when required. It is a common practice in cold deserts and temperate wet Himalayas. Water from these ponds is used for irrigation and domestic purposes.
4.	Farm pond for harvesting water	*Talaab*	Mandi	Farm ponds are useful during the period of water scarcity. Rain water during spring season is harvested in farm pond and used for irrigation and other domestic uses.
5.	Water diversion channels	*Kuhls / Nalu*	Kullu, Mandi	This practice is used to irrigate the distant agriculture farms with help of channels

				from main streams.
6.	Harvesting of water from snow melt	*Yon, Naa (Nallah), Phil, Shrik, Phizur*	Lahaul&Spiti	For Livestock, irrigation and other domestic use
7.	Water channels for irrigation	*Khad/Nalla, Kuhl*	Lahaul&Spiti, Kullu, Mandi	These channels bring water from main streams for irrigation as well as washing purposes.

On the basis of interaction with the residents of the agro-climatic region Lahaul&Spiti, it has been noticed that traditional water sources such as *Naa (Nallah), Phil, Shrik*, and *Phizur* (Table 1) fulfil the basic needs of the local communities of the region. In addition, the inhabitants of the study region favourcommunity-based water storage and distribution systems. In this system, they construct a local water tank to store glacier meltwater, which is then further channelized into small streams i.e. *Kuhls*to irrigate crop fields and for daily domestic use. Also, in this community-based system water sharing is done by the residents in a very low maintenance and dispute-less method starting from the collection of water during the evening and night-time in the traditional water storage structures for use in the next day.

Plate 1. (a) Community-based storage of water at Lahaul&Spiti district (b) Drinking water storage called *Bawodi* at Kullu district; (c) Religious water structure called *Saur*at Mandi district

Whereas in the Kullu district, it has been noticed that local communities of the valley rely on traditional water sources such as *Jairu*, *Maggru*, *Churdu*, *Bawodi/Bai*, etc. for drinking purposes, *Khad/Nalla*, *Gharat*, *Kuhl* for livestock, irrigation and other domestic use and *Tirath* and *Saur* for religious purpose (Table 1). These water harvesting structures have been manufactured from the ecological and geological diversity of the region. Some of these have been constructed and handled by the local communities. In addition,the water resources regime depends on specific environmental conditions, which revealed that most of the sources of water are both perennial and seasonal i.e. dependent on glaciers, rainwater, rivers, streams, and springs.Moreover, the local communities of Mandi district with their indigenous knowledge has been observed to utilize traditional water structures and sources such as *Bai*/*Bawodi*/*Panendh*/*Chow*, Naun, *Khatri/Khatiya*, *Khu* for drinking purpose, *Khad*/*Nalla*, *Gharat* and *Kuhl* for livestock, irrigation, and other domestic use. Additionally, during the survey, it was noticed that traditional water structures have been handled by the native community of the region in a sustainable way.

Conclusion

Overall, it has been inferred that the traditional water structures and their indigenous use from generation to generationmake these water supply systems the preferred domestic use as well as irrigation option in mountain areas in a sustainable way. These include the enhancement of natural water storage systems such as glacial-snow melt, mountain springs, soil moisture, and high-altitude wetlands. So, there is a need for integrated linkages between traditional as well as technological approaches to conserve and strengthen these water foundations for the sustainability of the water sources in the IHR.

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SACRED STREAMS: THE SPIRITUAL ESSENCE OF HIMALAYAN SPRINGS

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Abstract

In the Himalayan regions, springs hold significant importance in the context of religious beliefs. They are considered purest form of water and are often associated with various deities, rituals, and mythologies. Some springs are linked with certain gods and goddesses, which makes them sacred places for various religious pilgrimages to seek blessings. These springs find a close relationship with various mythological stories in religious books which attract tourists from around the world to visit such places. Their geographical setup in beautiful mountains and valleys makes them perfect places to meditate and connect with spirituality. They are also believed tohave numerous health benefits as they have certain healing powers to treat various diseases related to skin and bones. The following study was conducted to understand the cultural and religious beliefs of the local community with the natural springs. Extensive field surveyswere conducted in the Kullu valley of Himachal Pradesh to understand the people's perceptions relating to the springs. It was found that these springs were considered sacred as they were closely related to their local deities and certain rituals of worshipping water were being followed by the people from past generations.

Introduction

In Indian Himalayan Region, springs hold immense importance in the Himalayan Region, playing a vital role in the ecological balance and the lives of the local communities. These natural freshwater sources emerge from the mountain slopes and nourish the surrounding ecosystems, providing essential water for both humans and wildlife (Kulkarni *et al.,*2021). The Himalayas, known as the "Water Tower of Asia", heavily rely on springs for their unique hydrological system. These springs contribute to the formation of rivers that sustain agriculture, biodiversity, and livelihoods down stream (Margat *et al.,*2013). They serve as a lifeline for mountain communities, fulfilling their water needs for drinking, cooking, irrigation, and livestock rearing. Springs in the Himalayan Region are not only a symbol of purity and spirituality but also act as natural indicators of climate change and ecological health. Hence, preserving and managing these springs are crucial for the sustainable development and resilience of the entire Himalayan ecosystem. Springs find its close linkage with certain religious beliefs and rituals in the Himalayan regions. In Hindu mythology, *Jal devata* is considered as God of water. Spring water is considered pure by the people and manifestation of God itself as it emerges onto the surface from the earth and is devoid of any kind of impurities (Risko.,2018). People often visit these springs for holy dip during certain auspicious days throughout the year. Hot water springs, which emerge at the surface and gets heated by the geothermal heat beneath the earth finds themselves directly related to the religious beliefs. Some of them finds their mention in mythological stories and epics. These places are considered sacred sites where people visit to seek blessings. Apart from religious

beliefs, they are also believed to be full of health benefits as spring water promotes blood flow in the body and is capable enough to treat various skin related diseases like acne, psoriasis, etc.

Methodology

The methodology is based on primary & secondary data inputs. The literature review was used as secondary data input while the primary data includes discussions with the local stakeholders during field visits to collect spring samplesto assess their dependency on springsfor water demands and the association of their lifestyle with springs. It was found that majority of the springs were associated with some local deities and were worshipped during special occasions. The spring water is considered sacred and is used to offer to the Gods and Goddesses.

Results & discussion

In the Himalayan regions, springs hold significant importance in the context of religious beliefs. Here are some evidenceswhich shows the corelation between springs and religious beliefsof local people:

Purification and Healing: Springs are often believed to possess purifying and healing properties. The pristine water flowing from the mountains is considered pure and free from any impurities. It was found that majority of the people visit springs to bathe, drink the water, or perform rituals to cleanse themselves of impurities, both physical and spiritual.

Deity Manifestations: Springs are often believed to be the abode or manifestation of deities. Local folklore and legends associate some springs with specific gods or goddesses. These springs are considered sacred sites where people can connect with the divine and seek blessings. Pilgrims visit these springs to offer prayers, perform rituals, and seek the favour of the associated deities. Also, majority of the springs have images and sculptures of their deities embarked on the walls to restrict people from polluting its water.

Fig. 1: Images of deities embarked on the walls of a spring in Barshaini, Parbati valley.

Ritual Practices: Springs are integral to various religious rituals and ceremonies in the study area. For example, during festivals or special occasions, devotees gather around springs to perform religious rites, such as ablutions, pouring offerings into the water, or conducting rituals to honour specific deities. The presence of a spring adds sanctity and significance to these rituals. In some areas, people carry their deities on shoulders to a local spring or water body to give them holy dip in the sacred water.

Mythological references and Legends: Many springs in the region have mythological stories associated with them. These stories often involve gods, goddesses, or mythical beings, (e.g., Manikaran and Vashishth). Such legends contribute to the belief in the sacredness of the springs and attract devotees and tourists who are interested in the cultural and religious heritage of the region. People often visits these springs for holy bathe during certain auspicious days such as solar eclipse.

Fig.2: Hot spring in Manikaran

Spiritual Significance: The Himalayan regions are regarded as sacred landscapes, and springs are seen as integral parts of the natural spiritual ecosystem. The awe-inspiring beauty and serenity of these regions, coupled with the presence of springs, are believed to create a conducive environment for meditation, self-reflection, and spiritual practices. People visit these areas to seek solace, enlightenment, and a deeper connection with nature and the divine. E.g., Kheerganga and Kasol hot spring in Parbati valley.

Health benefits: Hot springs have been found very useful in providing health benefits as they are considered closely related to religious beliefs. Water from Hot springs naturally detoxes our body as it is enriched in nutritious elements which increases blood flow into the body and provides relief from pain. It is rich in minerals like calcium, sodium bicarbonate, silica and sulphur. High amount of silica helps in curing dry and rough skin, while higher sulphur content helps in treating skin related issues like psoriasis, acne and eczema.

Conclusion

It's important to note that the significance of springs in religious beliefs can vary across different regions and communities within the Himalayas. Local customs, traditions, and specific religious practices may shape the importance attributed to individual springs.

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SEABUCKTHORN (*Hippophae sp.*): LIVELIHOOD THROUGH TRADITIONAL KNOWLEDGE SYSTEM

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Abstract

Lahaul and Spiti are known for their fragile ecosystems, because of which earning a livelihood is quite difficult. Due to its unique geographical conditions, the place has diversity of high value plants. The local people are dependent on these natural resources because of which the place has diverse ethnobotanical knowledge. *Hippophaerhamnoides* L., also known as seabuckthorn, is a plant that has been mentioned in ancient literature as a medicinal plant.Over hundreds formulations has been mentioned in the ancient pharmacopeia of *Sowa-Rigpa.*The articleexploresthe potential contribution of the traditional knowledge of local people with respect to seabuckthorn,in developing sustainable livelihood in the valley.

Keywords: Seabukcthorn, Traditional Knowledge System, Tribal.

Introduction

There's a global demand of raw material of the plant which can be utilized by pharmaceutical companies, ethno medicinal practitioners, and a variety of the traditional medicine. It has been observed that India plays important role being the world's major exporters of raw herbal drugs. Being one of the extraordinary locations of our country, Lahaul-Spiti provides abundant opportunities in the field of ethnobotanical studies. Since the district is known for its unique geographical condition, it is rich when it comes to ethnic and biological diversity. Local inhabitant still practices traditional medicinal system (Singh *et al.,* 2008). The people of the region depend on the natural resources that are available there. Seabuckthorn (*Hippophaerhamnoides* L.) belongs to the Elaeagnaceae family, has recently gained global recognition due to its medicinal and nutritional properties. The plant has both ecological as well as economicimportance. Due to its nutritional and medicinal properties the demand of the plant has globally increased in many region (Kumar *et al.,* 2011). According to (Stobdan *et al.,* 2017) the genus has seven species. Out of these seven, three species namely *Hippophaerhamnoides*, *Hippophaesalicifolia, and Hippophaetibetana*are present in Lahaul.

Methods and Methodology

A comprehensive search for collecting data from different sources was conducted using keywords such as "Seabuckthorn," "Traditional Knowledge," and "Socio-Economic" to ensure relevant and reliable literature. 9 papers were selected for the following article.

Seabuckthornand Its Traditional Uses

The traditional knowledge of seabuckthorn in the valley is rich since it has been mentioned in many ancient literatures. The ancient Tibetan literature, such as *GyudBzi* (the Four Books of Pharmacopoeia) of Sowa Rigpa, which was written during the time of the Tang Dynasty, i.e., 618–907, reveals the utilisation of seabuckthorn. There are over 200 seabuckthorn

formulation mentioned in Sowa Rigpa.When people travel at altitude, the literature recommends the consumption of seabuckthorn (star-bu) (Gâtlan *et al.,* 2021). As early as the eighth century, the Tibetan medicinal classic rGyudBzi mentioned the medicinal property of seabuckthorn (Stobdan et al., 2013). The plant is an important medicinal plant having lots of properties because of its bioactive compounds. Traditionally the plant in Lahaulhas been used to treat many ailments which includes, treating cancer, throat infection, lung and hepatic related diseases, heart related issues, skin related issues, headache, jaundice, etc. (Singh *et al.,* 2011). These are practiced by local doctors called *"amchi"* The local population of the valley uses the plant as fuel, medicinal and veterinary uses, agriculture tools, and bio-fencing. Therefore, the ethnobotanical knowledge of seabuckthorn of the people in the valley is vast. By exploring these knowledges, the plant can contribute in creating livelihood.

Economic Status of Seabuckthorn

The demand of medicinal plant like seabuckthorn has increased due to its beneficial properties, as mentioned in ancient literatures. According to the World Health Organization (WHO), the annual demand for medicinal plants is about US $14 billion**.** The global trade in seabuckthorn has increased, because of which many countries have started the cultivation of the plant. .Many products of seabuckthorn, especially the oil extracted from the plant, have medicinal and cosmetic properties. In the Indian market, seabuckthorn-based products such as tea from the leaves of the plant, jam from the berries, sauce, wine, vinegar, soap, shampoo, etc. have become popular. The cultivation of seabuckthorn has contributed to improving the environment and promoting economic growth (Husain *et al.,* 2018). Based on the information available, between 2010 and 2011, the export of seabuckthorn products increased significantly, especially in countries like Vietnam, Spain, Thailand, and The Netherlands. The plant has economic potential for third-world countries like India (Pallavee *et al.,* 2017), especially in the tribal area like Lahaul-Spiti where the plant is native. Semi-processed products are also being marketed. To meet the growing demand, farmers from Asia, Europe, and North America are implementing large-scale seabuckthorn cultivation (Raţiand Raducanu, 2018). The plant has the potential to uplift the economic and livelihood through income generation from the products of seabuckthornsuch as juice, jam, tea, medicine and cosmetics as observed in China.

Result and discussion

The current increase in seabuckthorn demand focuses on the plant's commercial potential. The plant is native to Lahaul and Spiti. Seabuckthorn is a prime example of how ancient cultural heritage blends with modern science, producing enormous benefits for modern society. Also, the Government of Himachal Pradesh has decided the plantation of the species in these regions, recognizing the potential of the plant. This will further enhance and promote regional economic development while also assisting in the sustainable management of seabuckthorn resource. The plant can be cultivated as economic plant in the region of Lahaul-Spiti to improve the livelihood of the people. In conclusion, by exploring ancient literature and ethnobotanical knowledge, it can be concluded that the plant has future potential in creating livelihood in the area.

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- Authors should avoid any kind of pilgrims.

Manuscripts Language

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Body of the Text

- Manuscripts should be grammatically correct and properly typed using font Times New Roman, size 12.

Body of the Text

- Abstract must reflect important findings of the paper. It should be accurate, expressive, intelligible and brief within 200 words.
- Brief Introduction,Methodology, Results & Discussion
- Maximum 2 Tables and 2 graphs and 1 photo plate (Maximum 3 illustrations). The pictures/ photographs should be in 'jpg or tiff' format with a minimum of 300 dpi resolution or 3MB size.

Reference Style

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