Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Grant Ref. No.:	GBPNI/NMHS-2019-20/MG

Date of Submission:	2	0	1	1	2	0	2	3
	d	**d**	**m**	**m**	**y**	**y**	**y**	**y**

PROJECT TITLE (IN CAPITAL)

PROMOTING CONSERVATION OF DECLINING LIFE SUPPORT FOREST TREE SPECIES IN HIMACHAL PRADESH

Project Duration: *10/19 to 10/2022*

***Submitted to*:**
Er. Kireet Kumar
Scientist 'G' and Nodal Officer, NMHS-PMU
National Mission on Himalayan Studies, GBP NIHE HQs
Ministry of Environment, Forest & Climate Change (MoEF&CC), New Delhi
E-mail: nmhspmu2016@gmail.com; kireet@gbpihed.nic.in; kodali.rk@gov.in

***Submitted by*:**
[Sanjay Kr. Uniyal, on behalf of Director CSIR-IHBT]
[CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP)]
[*Contact No.: 91 1894 233339*]
[*E-mail: director@ihbt.res.in; suniyal@ihbt.res.in*]

GENERAL INSTRUCTIONS:

1. The Final Technical Report (FTR) has to commence from the start date of the Project (as mentioned in the Sanction Order issued by NMHS-PMU) till completion of the project duration. Each detail has to comply with the NMHS Sanction Order.
2. The FTR should be neatly typed (in Arial with font size 11 with 1.5 spacing between the lines) with all details as per the enclosed format for direct reproduction by photo-offset printing. Colored Photographs (high resolution photographs), tables and graphs should be accommodated within the report or annexed with captions. Sketches and diagrammatic illustrations may also be given detailing about the step-by-step methodology adopted for technology development/ transfer and/ or dissemination. Any correction or rewriting should be avoided. Please provide all information under each head in serial order.
3. Any supporting materials like Training/ Capacity Building Manuals (with detailed contents about training programme, technical details and techniques involved) or any such display material related to project activities along with slides, charts, photographs should be brought at the venue of the Annual Monitoring & Evaluation (M&E) Workshop and submitted to the NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora 263643, Uttarakhand. In all Knowledge Products, the Grant/ Fund support of the NMHS should be duly acknowledged.
4. The FTR Format is in sync with many other essential requirements and norms desired by the Govt. of India time-to-time, so each section of the NMHS-FTR needs to be duly filled by the proponent and verified by the Head of the Lead Implementing Organization/ Institution/ University.
5. Five (5) hard-bound copies of the Project Final Technical Report (FTR) and a soft copy of the same should be submitted to the **Nodal Officer, NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora, Uttarakhand**.

The FTR is to be submitted into following two (02) parts:

Part A – Project Summary Report

Part B –Detailed Project Report

In addition, the Financial and other necessary documents/certificates need to be submitted along with the Final Technical Report (FTR) as follows:

Annexure I	**Consolidated and Audited Utilization Certificate (UC) & Statement of Expenditure (SE)**, including the interest earned for the last Fiscal year and the duly filled GFR-19A (with year-wise break-up).
Annexure II	**Consolidated Interest Earned Certificate**
Annexure III	**Consolidated Assets Certificate** showing the cost of the equipment in Foreign/ Indian currency, Date of Purchase, etc. (with break-up as per the NMHS Sanction Order and year wise).
Annexure IV	**List of all the equipment, assets and peripherals** purchased through the NMHS grant with current status of use, including location of deployment.
Annexure V	**Transfer of Equipment** through Letter of Head of Institution/Department confirming the final status of equipment purchased under the Project.
Annexure VI	**Details, Declaration and Refund of any Unspent Balance transferred through Real-Time Gross System (RTGS)/ PFMS in favor of NMHS GIA General**

DSL: Date of Sanction Letter

1	1	1	0	**2**	**0**	**1**	**9**
d	d	m	m	y	y	y	y

DPC: Date of Project Completion

		1	0	**2**	**0**	**2**	**2**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Grant Ref. No.:	GBPNI/NMHS-2019-20/MG						
ii.	Project Category:	Small Grant		Medium Grant	√	Large Grant		
iii.	Project Title:	**Promoting Conservation of Declining Life Support Forest Tree Species in Himachal Pradesh**						
iv.	Project Sites (IHR States/ UTs covered) (*Location Maps attached*):	Himachal Pradesh						
v.	Scale of Project Operation:	Local		Regional	√	Pan-Himalayan		
vi.	Total Budget:	1.47 (in Cr)						
vii.	Lead Agency:	CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP)						
	Lead PI/ Proponent:	Dr. Sanjay Kumar, Director CSIR-IHBT						
	Co-PI/ Proponent:							
viii.	Implementing Partners:	-Himachal Pradesh State Forest Department, Sundernagar -Himalayan Forest Research Institute, Shimla -YS Parmar University of Horticulture & Forestry, Solan						
	Key Persons (Contact Details, Ph. No., E-mail):	1. Addl Pr.CCF (Research & Training) Sundernagar, Mandi-175019 (HP). apccfntfp-hp@nic.in, 01907-264113 2. Dr. Sandeep Sharma, Scientist G, Himalayan Forest Research Institute, Panthaghati, Shimla (HP) sharmas@icfre.org, 9418129759 3. Dr. YP Sharma, Principal Scientist, YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) yashuhf@gmail.com, 9418148114						

2. Project Outcomes

2.1. Abstract/ Summary (not more than 250-300 words)

***Background*:** Himalaya represents a global biodiversity hotspot with unparalleled species assemblages (Myers et al. 2000). The human communities use these varied species in their day-to-day life and thus provide goods and services critical for livelihood (Xu et al. 2009). However, the deterioration of the Himalayan ecosystem is not only leading to species loss but also affecting the flow of provisioning, cultural, and regulating services (Pandey et al. 2018, Shrestha et al. 2012). The changing climatic conditions further aggravate this. A majority of the multipurpose tree species, including *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina* (NMHS 16/01/2019) occurring in HP not only provide basic amenities to the inhabitants but also sustain the fauna and perform ecological functions that results in a cohesive ecosystem (Uniyal and Singh 2012). However, land use changes, species loss, and lack of regeneration is now a matter of concern as it disrupts ecosystem sustainability and the bio-geo cycle. To check this, initiatives that focus on greening the landscape and enhancing carbon sequestration vis-à-vis meeting the day-to-day requirements of local communities are desired (UN 2017). As a part of its international commitment, India is to increase the carbon sequestration potential by 20-30% (MoEF&CC 2018, http://envfor.nic.in/) and meet the local communities' requirements. Thus, suitable multipurpose tree species are identified and prioritized for plantation. This will not only lead to the rejuvenation of degraded habitats but also resource availability and enhanced carbon capture such that Himalayan forests serve as carbon sinks.

Recognizing this, a brainstorming session was organized by the Ministry of Environment, Forest and Climate Change (MoEF&CC) at New Delhi on 16 January 2019 wherein concentrated efforts on multipurpose Himalayan tree species were advocated. Based on the same proceedings, the CSIR-IHBT has been invited to submit a co-ordinated project proposal on the multi-purpose life support tree species.

Objectives/ Aim: With this background that the project targets- 1). Identification and prioritization of multipurpose tree species, 2). Documenting the current status of the prioritized species, 3). Establishing nurseries and carrying out plantations, 4). Awareness creation and outreach.

Methodology/Approach: For meeting these objectives, based on primary information, secondary information, and expert advice, four species, namely *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina* (NMHS 15/02/2019) species have been prioritized. Field surveys and sampling was done to estimate their status and population characteristics. In order to promote their conservation, nurseries of the species were raised, and plantations were carried out by involving local communities. Further, awareness programmes targeted school students and village communities regarding the importance and significance of these species.

***Results/ Outcomes*:** Eight nurseries were established, and twenty-three thousand one hundred fifty plants were raised. Distribution maps were generated, and reviews on three species were prepared.

Recommendations/ Way Forward with Exit Strategy: Habitat suitability and niche modelling of the species to be targeted. The nurseries developed will not only cater to multiplication but also conservation and restoration.

2.2. Objective-wise Major Achievements

S#	Objectives	Major achievements (***in bullets points***)
1	Documenting current status of the prioritized multipurpose tree species namely *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina*	Distribution maps of *Corylus jacquemontii*, *Taxus wallichiana* and *Ulmus wallichina* prepared. Population estimation was also carried out.
2	Establishing nurseries of the prioritized species	Eight (08) nurseries were developed
3	Greening of landscape through plantations	Twenty-three thousand one hundred and fifty (23150) plants were raised
4	Awareness creation and outreach	Five (05) schools and three (03) villages (n=500 persons)

Note: Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

2.3. Outputs in terms of Quantifiable Deliverables*

S#	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations, if any, & Remarks thereof:
1	Database on current status of four prioritized multipurpose tree species *Corylus jacquemontii, Juglans regia, Taxus wallichiana* and *Ulmus wallichina* in whole HP state.	Database of the current status of identified species area wise	For 03 (*Corylus jacquemontii*, *Taxus wallichiana* and *Ulmus wallichina)* species prepared	Juglans remaining
2	Nursery set up in 4	Number of	08 Nurseries	Done

	districts to raise required seedlings for plantation.	nurseries developed	established *Corylus jacquemontii*, *Taxus wallichiana* and *Ulmus wallichina* [Shilaru (Shimla), Bhrundhar (Manali), Sundernagar (Mandi), Shilli (Solan)]	
3	Human Resource Development (At least in 8 villages and schools)	Number of programmes	Total 500 participants from 8 programmes (05 schools + 03 villages)	Done
4	Knowledge resources	Journal, Book, Manual, publication (06)	03 three reviews prepared	One published

*As stated in the Sanction Letter issued by the NMHS-PMU.

2.4. Strategic Steps with respect to Outcomes (in bullets)

S#	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology/ Technology developed, *if any*:	None	
2.	New Ground Models/ Process/ Strategy developed, *if any*:	None	
3.	New Species identified, *if any*:	None	
4.	New Database established, *if any:*	None	
5.	New Patent, *if any*:	None	
	I. Filed (Indian/ International)	None	
	II. Technology Transfer, *if any*:	None	
6.	Others, *if any*	None	

Note: Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

3. New Data Generated over the Baseline Data

S#	New Data Details	Status of Existing Baseline	Addition and Utilisation New data

1.	Maps of *Corylus jacquemontii*, *Taxus wallichiana* and *Ulmus wallichina* species prepared	Not available	Conservation and effective management
2.	Folk uses species	New uses *Ulmus wallichaiana* reported	Livelihood development and bio-economy generation
3.	Compiled information on phytochemicals and biological activities of the species	Scattered literature	Organized and structured at one place

Note: Further details may be summarized in DPR Part-B. Database files in the requisite formats (Excel) may be enclosed as annexure/ appendix separately to the soft copy of FTR.

4. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S#	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	**ST**	**Women**	**Total**
1.	Workshops						
2.	On-Field Trainings	03 (150 participants)	Villagers				150
3.	Skill Development						
4.	Academic Supports	05 schools (350)	School children				350
	Others (if any)						

Note: Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

5. Linkages with Regional & National Priorities (SDGs, INDC, etc.)/ Collaborations

S#	Linkages /collaborations	Detail of activities (No. of Events Held)*	No. of Beneficiaries
1.	Sustainable Development Goals (SDGs)/ Climate Change/INDC targets addressed	05 schools	350 school children
2.	Any other:		

Note: Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

6. Project Stakeholders/ Beneficiaries and Impacts

S#	Stakeholders	Support Activities	Impacts in terms of income generated/green skills built
1.	Line Agencies/ Gram		

	Panchayats:		
2.	Govt Departments (Agriculture/ Forest/ Water):	Forest Department	Plant sampling and propagation
3.	Villagers/ Farmers:	150 villagers	Awareness
4.	SC Community:		
5.	ST Community:		
6.	Women Group:		
	Others, *if any*:		

Note: Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

7. Financial Summary (Cumulative)

Please attach the consolidated and audited Utilization Certificate (UC) and Year-wise Statement of Expenditure (SE) separately, *ref*. **Annexure I.**

8. Major Equipment/ Peripherals Procured under the Project** (*if any*)

S#	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
1.	DSLR	03	186699	For R&D work
2.	GPS	02	60200	For R&D work
3	Video camera	01	18199	For R&D work
4.	Computer	01	71247	For R&D work

Details should be provided in details **(*ref.* **Annexure III &IV).**

9. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States/ UTs covered:	01	
2.	Project Sites/ Field Stations Developed:	04	
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	04	
4.	Livelihood Options promoted	-	
5.	Technical/ Training Manuals prepared	-	
6.	Processing Units established, if any	.... (attach photos)	
7.	No. of Species Collected, if any	-	
8.	No. of New Species identified, if any	-	
9.	New Database generated (Types):	04	

	Others (if any)		

Note: Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

11. Knowledge Products and Publications:

S#	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal – Research Articles/ Special Issue:	02*	01*	2.0	One published paper anclosed
2.	Book – Chapter(s)/ Monograph/ Contributed:				
3.	Technical Reports:				
4.	Training Manual (Skill Development/ Capacity Building):				
5.	Papers presented in Conferences/Seminars:				
6.	Policy Drafts/Papers:				
7.	Others, if any:				

Note: Please append the list of KPs/ publications (with impact factor, DOI, and further details) with due Acknowledgement to NMHS. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.

12. Recommendation on Utility of Project Findings, Replicability and Exit Strategy

Particulars	Recommendations
Utility of the Project Findings:	Raised nurseries for conservation and plantations
Replicability of Project/ Way Forward:	Identified
Exit Strategy:	The nurseries developed will serve the mandate of the state's Forest department and will provide planting material to the interested parties. Also, the survey and documentation work falls under the mandate of the participating institutes and will be furthered by them.

डॉ. संजय कुमार उनियाल
वरिष्ठ प्रधान वैज्ञानिक
पर्यावरण प्रौद्योगिकी [illegible]
सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर-176061 (हि.प्र.)

(Sanjay Kr. Uniyal)

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: Palampur
Date: 20/11/2023

PART B: DETAILED PROJECT REPORT

The Detailed report should include an Executive Summary and it should have separate chapters on (i) **Introduction**, (ii) **Methodologies/Strategy/Approach**, (iii) **Key Findings and Results**, (iv) **Overall Achievements**, (v) **Project's Impacts in IHR** (vi) **Exit Strategy** and Sustainability, (vii) **References**, and (viii) **Acknowledgements** (acknowledging the financial grant from the NMHS, MoEF&CC, GoI).

Other necessary details/ Supporting Documents/ Dissemination Materials (*New Products/ Manuals/ Standard Operating Procedures (SOPs)/ Technology developed/Transferred, etc., if any*) may be attached as Appendix(ces).

1 EXECUTIVE SUMMARY

2 INTRODUCTION

2.1 Background

Himalaya represents a global biodiversity hotspot with unparalleled species assemblages (Myers et al. 2000). Almost 33% of the total 10,000 flowering plant species occurring here are not found elsewhere (Dhar 2002). These varied species are used by the human communities in their day-to-day life and thus they provide goods and services so critical for livelihood (Xu et al 2009). However, deterioration of Himalayan ecosystem is not only leading to species loss but also affecting the flow of provisioning, cultural, and regulating services (Pandey et al. 2018, Shrestha et al. 2012). The changing climatic conditions, whose impacts are believed to be more pronounced in the Himalaya, further aggravate the problem (Macchi et al. 2012,). Recent studies report that temperature here is rising at a rate double that of the global average which has serious implications (Xu and Grumbine 2014).

Himachal Pradesh (HP), a west Himalayan state that lies between 30°22′ N to 33°12′ N and 75°47′ E to 79°04′ E has a geographical area of 55,673 sq km of which, ~27% is covered by forests (FSI 2017). A majority of the multipurpose tree species namely *Quercus spp., Rhododendron spp., Ulmus wallichiana, Carpinus viminea, Myrica esculenta, Corylus jacquemontii, Juglans regia, Betula utilis* occurring in HP not only provide basic amenities to the inhabitants but also sustain the fauna and perform ecological functions that results in a cohesive ecosystem (Uniyal and Singh 2012). However, habitat degradation and lack of recruitment is now a matter of grave concern (Kumar et al. 2014) as it not only disrupts the ecosystem processes but also raises alarms in terms of sustainability and carbon emissions.

To check this, initiatives that not only focus on greening the landscape but also on enhanced carbon sequestration vis-à-vis meeting the day-to-day requirements of local communities are desired (UN 2017). This emanates from the fact that India is committed to increase its carbon sequestration potential by 20-30% and fulfil the requirements of communities residing close to the forests (MoEF&CC 2018, http://envfor.nic.in/).

Recognizing this, a brainstorming session was organized by the Ministry of Environment, Forest and Climate Change (MoEF&CC) at New Delhi on 16 January 2019 wherein concentrated efforts on

multipurpose Himalayan tree species were advocated. It is with this background the present co-ordinated multi-institutional proposal has been drafted.

2.2 Overview of the major issues addressed

Degradation of forests specially the highly preferred multipurpose species is leading to their decline. This has implications for species conservation, regeneration and carbon sink capacity. Maintaining the flow of ecosystem services, biodiversity and health of the ecosystem are of utmost importance and much desired. In order to create a win-win situation, suitable multipurpose tree species must be identified and prioritized for plantation. This will not lead to rejuvenation of degraded habitats but also in resource availability and enhanced carbon capture such that Himalayan forests serve as carbon sinks.

2.3 Baseline Data and Project Scope (max. 500 words)

Lack of field data and planting material are major limitations towards conservation and management of species, especially tree species of multiple utility. *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina* are amongst the species that are of high local utility and at the same time under severe pressure. The extant information on their distribution and uses is limited.

Also, a dearth of planting material is pertinent to promote their conservation and management. The occurrence of these species is known in Himachal Pradesh and is mentioned in the Floras but their spatial information and maps are lacking. Also, nurseries targeting propagules are scare.

It is thus proposed to generate distribution information on the species and establish nurseries for them in the state of Himachal Pradesh.

2.4 Project Objectives and Target Deliverables (as per the NMHS-Sanction Order)

The proposal targets the following objectives-

- Documenting current status of the prioritized multipurpose tree species namely *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina*
- Establishing nurseries of the prioritized species
- Greening of landscape through plantations
- Awareness creation and outreach

3 METHODOLOGIES/STARTEGY/ APPROACH – *supporting documents to be attached.*

Methodologies used

Identification and prioritization of multipurpose tree species: A total of 19 species were classified and presented in the brainstorming workshop on multipurpose tree species held at the Ministry of Environment, Forest and Climate Change on 16 January 2019. These species were selected based on our erstwhile primary surveys and secondary information. Out of these 19, the expert committee recommended *Corylus jacquemontii*, *Juglans regia*, *Taxus wallichiana* and *Ulmus wallichina* for further exploration and prioritization. Recognizing their conservation status, human use, ecological characteristics, nativity, and

associated secondary benefits (such as mushroom), etc. these four species have been prioritized for the present study. Abatement of human wildlife conflict especially the monkey menace has also been one of the prime criteria for prioritizing these species. Further, noting that a pan Himalaya programme is in pipe line for Oaks (Quercus spp.) and Rhodendrons (Rhododendron spp.) where the Institute would also be interested in participating, they have deliberately been excluded.

Documenting current status of the prioritized species: Consequent to prioritization of the species, their status would be assessed through field surveys and sampling using standard protocols (Kent and Coker 1992, Singh and Singh 2002). Girth, height, and regeneration of the species would be recorded along with habitat characteristics such as altitude, aspect, terrain. Co-ordinates of all the sampling sites would be recorded for temporal recordings of growth characteristics.

Establishing nurseries and carrying out plantation: For generating planting material and carrying out plantations, nurseries would be raised from mature and healthy-looking individuals cuttings. It is proposed to raise nurseries in climatic zones suitable for the prioritized species. Multiple nurseries would be established in the state. Using the nursery raised plants along with the ones already available with different nurseries, greening would be carried out during the growing season. Sites for establishing nurseries and carrying plantations will be finalized with stakeholders' active involvement, especially the state forest department. Following this pits would be dug across contours and at suitable distances prior to plantation. In order to avoid grazing and browsing, at few sites fencing is proposed.

Awareness creation and outreach: Awareness creation would be carried out by involving local communities and school children. Popular talks will be delivered in schools and villages around the planation/ nursery sites. Additionally, brochures highlighting the importance and role of the planted species will be prepared in local language and distributed. Further, it is proposed to organize special programmes such as drawing, quiz, etc. during Van Mahotasva, World Environment Day, etc. Plantation exercises will also involve local communities and other stakeholders**.**

4 KEY FINDINGS AND RESULTS – *supporting documents to be attached.*

4.1 Major Activities/ Findings

- The selected plant species supply humans and wildlife with various ecosystem services, from provisioning to regulating. Thus, they are of high utility.
- Primary and secondary surveys were conducted. Locational information of the species recorded. Identification of areas for setting nurseries. Interactions with the local communities, and awareness programmes.
- Information on three species was compiled.

4.2 Key Results

- Compilation of information on three multipurpose tree species (*Corylus jacquemontii, Taxus wallichiana and Ulmus wallichina*).
- Species mapped and documented.
- Nurseries developed.
- Plants raised

4.3 Conclusion of the study

The species have been propagated through seeds and in the districts- Kangra, Shimla, Kullu, Mandi, and Solan. Close to thirty-five thousand seedlings were generated.

5 OVERALL ACHIEVEMENTS – *supporting documents to be attached.*

- Eight nurseries were established.
- Thirty-four thousand one hundred fifty plants were raised.
- Eleven awareness programmes catering to 500 individuals.
- The first nursery catering to the *Ulmus wallichiana* propagation was established.

5.1 Interventions

5.2 On-field Demonstration and Value-addition of Products, if any

- Nurseries at: Kangra, Shimla, Kullu, Mandi, and Solan

5.3 Green Skills developed in State/ UT

- Identification of species
- Propagation of species

5.4 Addressing Cross-cutting Issues

- Enhancement of green cover
- Conservation of species
- Resource augmentation and livelihood are the cross-cutting issues of direct relevance.

6 PROJECT'S IMPACTS IN IHR – *supporting documents to be attached.*

6.1 Socio-Economic impact: Nil

6.2 Impact on Natural Resources/ Environment (max. 500 words)

- Propagules for conservation and population augmentation

6.3 Conservation of Biodiversity/ Land Rehabilitation in IHR (max. 500 words)

- The targeted species are threatened; compiled data on the species provides information on their status and uses. Further, the developed nurseries will aid in their conservation and management.

6.4 Developing Mountain Infrastructures (max. 200 words)

- Conservatories for propagules

6.5 Strengthening Networking in State/ UT (max. 200 words)

- The project is a collaboration between four Government organizations with the active involvement of villagers and school children.

7 EXIT STRATEGY AND SUSTAINABILITY – *supporting documents to be attached.*

7.1 Utility of project findings (max. 500 words)

- Nurseries for providing propagules
- A compendium of information on threatened species (03)

7.2 Other Gap Areas (max. 200 words)

- Work on *Juglans regia* could not be completed and also of the plantations of the targeted species.

7.3 Major Recommendations/ Way Forward (max. 200 words)

- Niche modelling and habitat suitability for effective conservation and management of individual species

7.4 Replication/ Upscaling/ Post-Project Sustainability of Interventions (max. 500 words)

- Since the Institutes involved in the project have a mandate for bioresources conservation and management, replication of the study and its sustainability are expected.

8 REFERENCES/BIBLIOGRAPHY

Chandrasekhar, M.B., Singh, S., & Roy, P. S. 2003. Geospatial modeling techniques for rapid assessment of phytodiversity at landscape level in western Himalayas, Himachal Pradesh. *Current Science* 84: 663–670.

Dhar, U. 2002. Conservation implications of plant endemism in high-altitude Himalaya. *Current Science* 82: 141-148.

FSI. 2017. *State of Forest Report 2017*, Dehradun.

Kent, M. & Coker, P. 1992. *Vegetation description and analysis. A practical approach*. John Wiley and Sons, Chichester.

Kumar A, Singh KN, Brijlal, Chawla A, Uniyal SK, Kaushal R, Singh RD, Ahuja PS (2014). Regeneration Pattern of Tree Species in Forested Landscapes of Himachal Pradesh, Western Himalayan Region, India. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci*. 84(3): 695-707.

Macchi, M., Gurung, A.M., and B. Hoermann. 2015. Community perceptions and responses to climate variability and change in the Himalayas. *Climate and Development* 7(5): 414-425.

MoEF&CC 2018, http://envfor.nic.in/

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. Da Fonseca, J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403 (6772): 853.

Pandey, R., P. Kumar, K.M. Archie, A.K. Gupta, P.K. Joshi, D. Valente, and I. Petrosillo. 2018. Climate change adaptation in the western-Himalayas: Household level perspectives on impacts and barriers. *Ecological Indicators* 84: 27-37.

Shrestha, U.B., S. Gautam, and K.S. Bawa. 2012. Widespread climate change in the Himalayas and associated changes in local ecosystems. *PLoS One* 7(5): e36741.

Singh, J.S. and Singh, S.P. 1992. *Forests of Himalaya*, Gyanodaya Prakashan, Nainital, India.

UN. 2017. *The Sustainable Development Goals Report*, New York.

Uniyal, S.K., and Singh, R.D. 2012. Natural resources assessment and their utilization: Analyses from a Himalayan state. *Environ. Monit. Assess.* 184: 4903–4919.

Uniyal, S.K., and Singh, R.D. 2014. Biodiversity Information: the need and importance of floral surveys. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* 84(3): 439-446.

Xu, J., and Grumbine, R.E. 2014. Building ecosystem resilience for climate change adaptation in the Asian highlands. *Wiley Interdisciplinary Reviews: Climate Change* 5(6): 709-718.

Xu, J., Grumbine, R.E., A. Shrestha, M. Eriksson, X. Yang, Y.U.N. Wang, A. Wilkes. 2009. The melting Himalayas: cascading effects of climate change on water, biodiversity, and livelihoods. *Conservation Biodiversity* 23: 520–530.

9 ACKNOWLEDGEMENTS

The Ministry of Environment, Forest and Climate Change is acknowledged for the funds through the NMHS.

Annexure-I

Consolidated and Audited
Utilization Certificate (UC) and Statement of Expenditure (SE)

For the Period: 01-11-2019 to 31-10-2022

1.	Title of the project/Scheme/Programme:	GAP-0250 (Promoting Conservation of Declining Life support Forest Tree Species in Himachal Pradesh)
2.	Name of the Principle Investigator & Organization:	Dr. Sanjay Kr. Uniyal CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, HP
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	GBPNI/NMHS-2019-20/MG, Dated: 11-10-2019
4.	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	**₹5630000.00**
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	**₹5805884.00** (Including Bank Interest ₹175884)
6.	Actual expenditure (excluding commitments) incurred during the project period:	**₹ 3284978.00**
7.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	**Nil**
8.	Balance amount available at the end of the project:	**₹ 2520906.00** (Including Bank Interest ₹1,75,884)
9.	Balance Amount:	**₹ 2520906.00** (Including Bank Interest ₹1,75,884)
10.	Accrued bank Interest:	**₹1,75,884.00**

Certified that the expenditure of **Rs. 3284978.00 (Rupees: Thirty two lakhs eighty four thousand nine hundred and seventy eight only)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator)

डॉ. सुजय कुमार उनियाल
वरिष्ठ प्रधान वैज्ञानिक
पर्यावरण प्रौद्योगिकी विभाग
सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर-176061 (हि.प्र.)

Finance & Accounts Officer
CSIR-Institute of HImalayan
Bioresource Technology
Palampur-176061 (H.P.)
16/05/2023

(Signature of Registrar/ Finance Officer)

16/11/2023

(Signature of Head of the Institution)

निदेशक / Director
सी.एस.आई.आर.-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-IHBT
Palampur(H.P.) 176061 INDIA

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Statement of Consolidated Expenditure

[CSIR-Institute of Himalayan Bioresource Technology, Palampur, H.P.]

Statement showing the expenditure of the period from Sanction No. and Date : GBPNI/NMHS-2019-20/MG, Dated: 11-10-2019

1. Total outlay of the project : **₹14700000.00**

2. Date of Start of the Project : **01-11-2019**

3. Duration : **Three Years**

4. Date of Completion : **30-10-2022**

a) Amount received during the project period : **₹58,05,884.00** (including Bank interest ₹175884)

b) Total amount available for Expenditure : **₹58,05,884.00** (including Bank interest ₹175884)

S. No.	Budget head	Amount received	Expenditure	Amount Balance/ excess expenditure
1	Salaries	1500000.00	1463378.00	36622.00
2	Consumable	1350000.00	764521.00	585479.00
3	Contingency	280000.00	252608.00	27392.00
4	Travel	1650000.00	258675.00	1391325.00
5	Minor Field Equipment	700000.00	425796.00	274204.00
6	Institutional Charges	150000.00	120000.00	30000.00
7	Accrued bank Interest	175884.00	0.00	175884.00
8	**Total**	**5805884.00**	**3284978.00**	**2520906.00**

Certified that the expenditure of **Rs. 3284978.00 (Rupees: Thirty two lakhs eighty four thousand nine hundred and seventy eight only)** mentioned against Sr. No. 8 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

Finance & Accounts Officer
CSIR-Institute of HImalayan
Bioresource Technology
Palampur-176061 (H.P.)
16/11/2023

(Signature of Principal Investigator)

डॉ. संजय कुमार अग्निहोत्री
वरिष्ठ प्रधान वैज्ञानिक
पर्यावरण प्रौद्योगिकी विभाग
सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर-176061 (हि.प्र.)

(Signature of Registrar/ Finance Officer)

16/11/2023

(Signature of Head of the Institution)

निदेशक / Director
सी.एस.आई.आर.-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-IHBT
Palampur(H.P.) 176061 INDIA

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

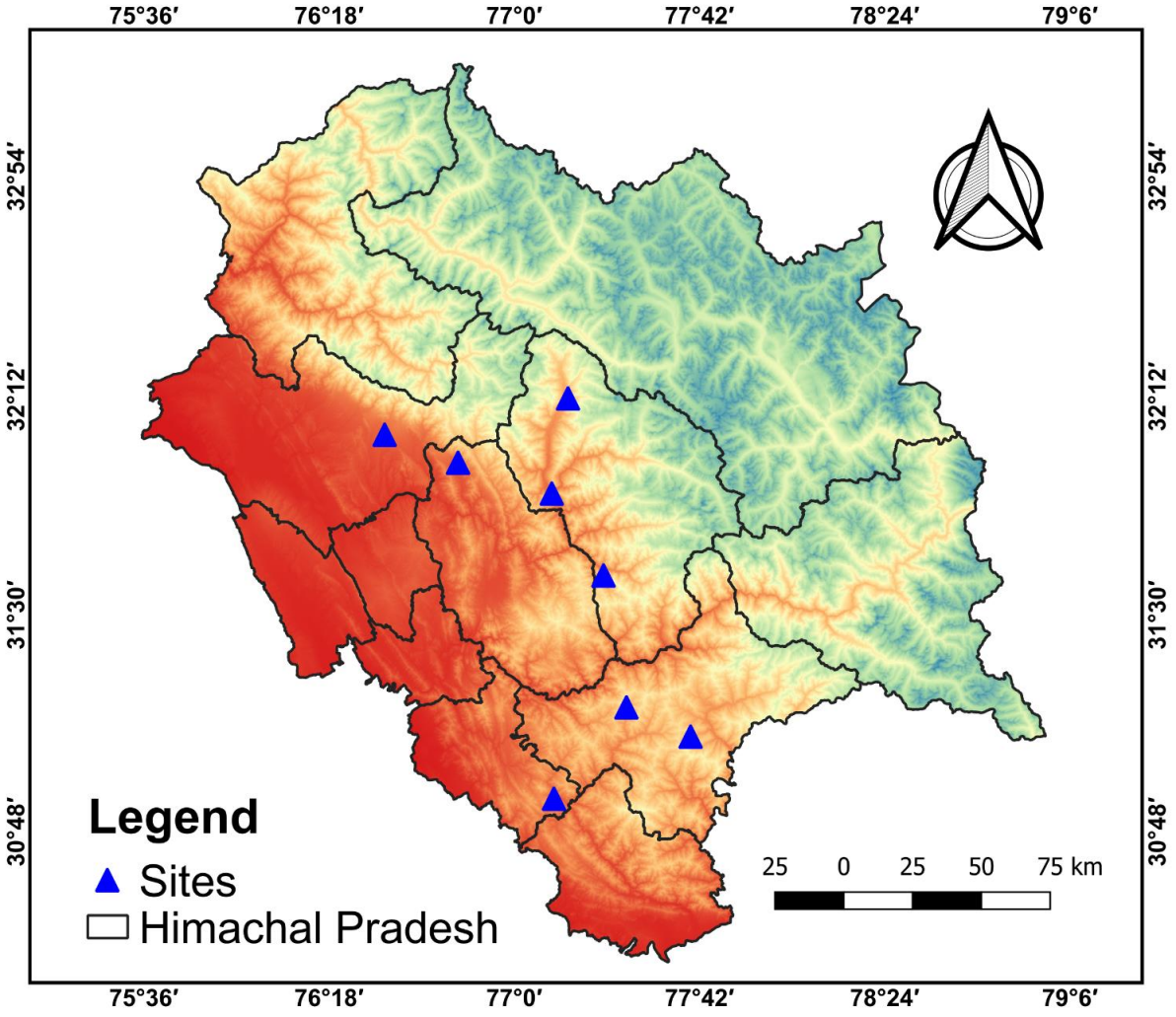
COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

APPENDICES

Appendix 1 – Details of Technical Activities
Appendix 2 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS
Appendix 3 – List of Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings
Appendix 4 – List of New Products (utilizing the local resources like NTFPs, wild edibles, bamboo, etc.)
Appendix 5 – Copies of the Supporting Materials like Manual of Standard Operating Procedures (SOPs) developed under the project
Appendix 6 – Details of Technology Developed/ Patents filled, if any
Appendix 7 – Any other

******

Nurseries: 08 established



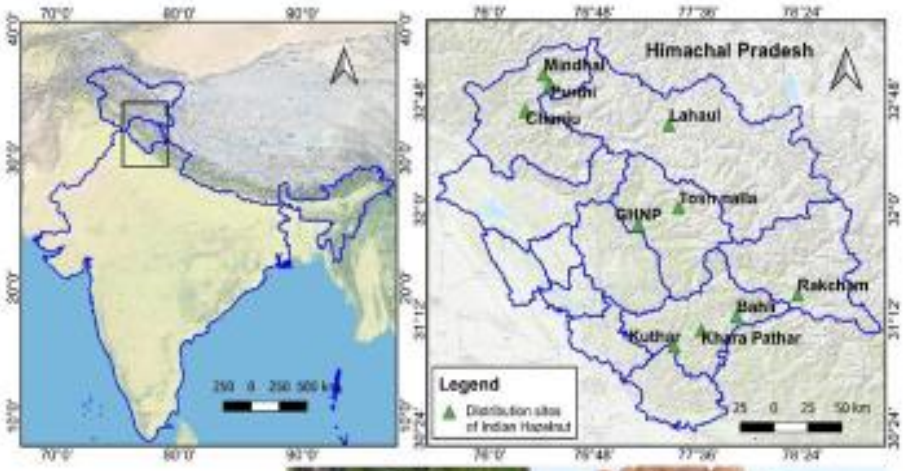
Ulmus wallichiana: First nursery catering to the species

Juglans nursery

Taxus nurseries

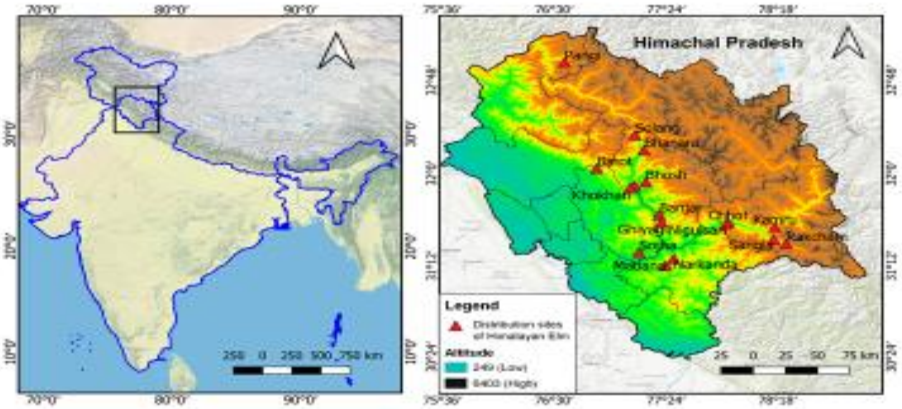
Corylus jacquemontii

Distribution maps



Corylus jacquemontii

Ulmus wallichiana



Awareness and out reach

Corylus jacquemontii Decne.: A traditionally used multipurpose tree species of the Himalayan region

Abstract

The article presents an overview of the Indian Hazelnut (*Corylus jacquemontii*)- a multipurpose threatened species of the Himalayan region of high traditional importance. The species is used as medicine, fuelwood, fodder, and timber by the resident communities of Himalaya. The edible nuts of the species are nutrient-rich and have a high market value, they are collected and sold by the local people to earn hard cash. Further, a wide range of pharmacological properties that aid in the prevention of cardiovascular diseases, diabetes, and other oxidative stress-related disorders add to the importance of the species. Limited information and overexploitation have threatened the survival of the Indian Hazelnut which calls for multidisciplinary efforts toward its conservation.

Keywords: Conservation; Indian Hazelnut, Phytochemicals, Traditional uses

Introduction

Corylus jacquemontii Decne., commonly referred to as the Indian Hazelnut, is a lesser-known yet highly valued taxon of the family Betulaceae. It is a medium-sized deciduous tree that can reach a height of 20-30 m[1] and is distinguishable by its thin, dark grey bark. The bark scales detach at the base and exfoliate upwards[2, 3]. Buds are hemispherical and relatively short while the leaves are alternate, 15-24 cm long, ovate or obovate, acuminate, irregularly lobed, with a cordate base and sharply serrate margins, and a 2-2.5 cm long petiole [3, 4]. The inflorescence is an elongated catkin. Male bracts are obovate and acute with 8 one-celled anthers on short filaments along the midrib. Female flowers are small and in short spikes comprising of numerous imbricate bracts [3, 5]. Flowers grow in clusters and the involucre is coriaceous, much longer than the nuts, and supported by laciniate bracts [3, 6]. Nuts are compressed, hard, and globose, with 1-5 involucres clustered around them and sheathed by lobed, deep brown bracteoles. The nuts mature from August to September (Figure 1).

Distribution

The Indian Hazelnut is a threatened species that has its distribution in Northeast Afghanistan, Northern Pakistan, Northern India, West Nepal, and West Asia at elevations ranging from 1800 to 3300 m asl [3, 7]. In the temperate Indian Himalaya, the species is reported from the western Himalayan states of Uttarakhand and Himachal Pradesh, and the recently carved union territory Jammu & Kashmir. The species is particularly noted in Shimla, Kullu, Lahaul & Spiti, Chamba, and Kinnaur in Himachal Pradesh (**Figure 2)**, where it is locally referred to as Thangi, Bhotiya Badam, Urmani, Sharoli, and Sharod (Paul et al., 2019). It grows in shady moist areas in association with *Pinus wallichiana, Abies* sp*., Picea smithiana, Cedrus*

deodara, Betula utilis, Acer sp*., Juglans regia, Fraxinus xanthoxyloids, Salix daphnoides,* and occasionally with *Parrotia* [1, 3, 8].

Importance

Corylus jacquemontii is an important species of the western Himalayan region that supplies humans and wildlife with various ecosystem services, from provisioning to regulating (**Fig. 3)**. The fruits of the species that are highly sought after in the market are reported to be rich in proteins, carbohydrates, vitamins, polyunsaturated fatty acids and minerals including iron, calcium and potassium, etc.[1]. Nut paste is a common ingredient in a wide range of processed dairy and bakery foods and is also used in the manufacture of cosmetics and pharmaceuticals [7, 9]. In addition to humans, the nuts are also consumed by small rodents such as pica, flying squirrels, rats, and even Himalayan brown bears [1]. Also, the leaf litter of the Indian hazelnut harbours certain fungi such as *Cortinarius* sp. and *Lactarius* sp., thereby supporting macrofungal diversity, nutrient cycling and ecosystem growth [10].

Traditional uses

The indigenous people of the higher Himalayan ranges have been using the species for various domestic, edible and medicinal purposes and thus *Corylus jacquemontii* is of high traditional utility **(Table 1).** The species provides fuel for household energy needs and timber for construction purposes; the foliage is lopped for fodder[11] while the fruit rind is used to make camel dye [4, 12]. Medicinally, the fruit and leaves are used for treating diabetes in humans. At the same time, oil extracted from the seeds is used for relieving muscle pain [11, 13]. The nuts are edible and are primarily collected by the local people from forests for earning hard cash. They are sold in the market with prices ranging between Rs. 1200/- per kg in Killar (Chamba) to Rs. 1500/- per kg in Manali (Kullu). In Udaipur (Lahaul & Spiti), they are noted to be sold for Rs. 1300/- per kg [4, 14]. Hazelnuts are usually consumed whole, either raw or roasted and also can be added to a variety of dishes [15, 16]. A popular saying "*Pangi ki Thangi*," highlights the importance of the species in the Pangi region of Chamba district, Himachal Pradesh [17] where it is locally called *Thangi* and is highly used by *Pangwals* and *Bhots* (resident communities of Pangi) for food and other household purposes [18,19].

Phytochemicals and activities

The species abounds in phytochemicals and phenolics having anti-oxidant, anti-carcinogenic, anti-mutagenic, and anti-proliferative properties [1, 9]. The diversity of chemical compounds in the hazelnut includes Apigenin, Catechins, Dimethylellagic acid, Epicatechin, Gallic acid, Kaempferol rhamnoside, Myricetin, p-Coumaric acid, Proanthocyanidin B dimer, Proanthocyanidin B trimer, Quercetin hexoside, Quercetin rhamnoside, Syringic acid [9]. These can lower the incidence of some malignancies, cardiovascular disease (CVD), coronary heart disease (CHD), stroke, atherosclerosis, osteoporosis, inflammation, and other oxidative stress-related diseases [9]. The plant is used against diabetes wherein the high phenolic content makes it an effective anti-diabetic agent by contributing toward free radical scavenging capabilities [9].

The different parts of Hazelnut are rich in polyphenols and food-derived flavonoids that have antimutagenic, anticarcinogenic, antimicrobial, anti-allergic, and anti-inflammatory properties [9, 13]. In an experimental study by Kumar et al. [9], the highest phenolic concentration was found in 80 percent ethanolic skin extract, followed by hard shells and kernels and accordingly the maximum antioxidant potential was found in hazelnut skin extract followed by hard-shell and kernel. The findings suggest that hazelnut kernels and their by-products have potential free-radical scavenging capability. Proanthocyanidins found in hazelnut are known to improve lipid homeostasis thereby having the potential to lower the risk of cardiovascular diseases. Studies have noted that regular consumption of food rich in procyanidin can improve endothelial dysfunction and reduce vascular oxidative stress, both of which are related to cardiovascular risk factors such as hypertension [9]. The intake of nuts is related to a reduced risk of cardiovascular diseases and cancer.

Conservation Issues

Reports indicate that the species is being lost at an alarming rate due to heavy extraction pressures (fuel, fodder, timber) that limit its growth and reproduction[1, 20]. *Corylus jacquemontii* is a self-incompatible species that grows in isolated patches and detailed population information on the species is yet not available. In Himachal Pradesh, 25 populations of the species have been reported from Lahaul & Spiti, Kinnaur, Chamba, and Kullu[4]. The nuts which are routinely collected for self-consumption and sale in the local market adversely affect its regeneration. Due to the scarcity of seeds, regeneration is poor and only a small percentage of seeds can germinate into seedlings which too face severe trampling on account of nut collection and grazing by animals. Since only a few nuts germinate, their percentage conversion to saplings is limited. Also, the heavyweight of the nuts limits their wider distribution and spread. This has serious conservation implications that are further aggravated by the recent environmental changes. Thus, limited distribution coupled with heavy pressures on the species is threatening its survival. It is, therefore, important that the conservation of the species is prioritized.

Measures and prospects

Recognizing the importance of the species, its inclusion into the agroforestry system as a horticultural crop must be seriously looked into. There is potential for hazelnut production in temperate regions of India, and with concrete and concentrated efforts, the crop can be commercialized. As the starting, this calls for surveying and identifying Corylus populations in the Himalaya so that potential hazelnut production sites may be identified based on ecology and environment. This will require simulation and modern mapping techniques.

There is a need to develop protocols for mass multiplication, and the establishment and maintenance of nurseries for high-quality planting material [4]. Generating high-quality planting material rests on the characterization and identification of population(s) with best-desired traits (nuts, kernel quality, vigour, cropping potential, disease resistance, etc.). This may include grafting with superior Turkish varieties (*Corylus colurna*) for increasing nut yield [21, 22].

Noting that the species occurs in higher altitudes and in limited areas, niche-based afforestation and reforestation programmes are expected to benefit it [22]. The mass planting of the species around habitation and in wild will not only aid in rejuvenation but also in ensuring the flow of ecosystem services [7, 23]. Furthermore, active participation of stakeholders that includes local people, the Forest Department, non-governmental organizations (NGOs) is required for effective, conservation, management and value addition of the species.

Conclusion

The article addressed the issues and potential of *Corylus jacquemontii* as an important multipurpose tree species of high traditional importance. Recognizing its traditional uses (medicine, fuel, fodder, dye, timber, edible) amongst the resident Himalayan communities, the species has the potential to improve the livelihood of the people along with the greening of the area. The promising findings of various studies suggest that the species should be pharmacologically investigated for active ingredients and associated health benefits. Because the plant has a high concentration of catechins and other phenolic compounds, it has the potential for developing novel products that promote human health. The pertinent threats to the species identified in the article call for multidisciplinary efforts including social, cultural, institutional, and scientific for the conservation of this important lesser-known multipurpose tree species.

References

1. Gupta, D., Tiwari, C., Rajput, B. S., Kumar, S. and Sharma, D., Natural regeneration status of Indian Hazelnut (Corylus jacquemontii-Decne.) in Western Himalaya of Himachal Pradesh. *J. Pharmacog. phytochem.,* 2019, 327-331
2. Osmaston, A. E., Forest flora for Kumaon, 1978.
3. Molnar, T. J., Corylus. In *Wild Crop Relatives: Genomics and Breeding Resources.* 15-48. Springer, Berlin, Heidelberg, 2011; doi: http://doi.org/10.1007/978-3-642-21250-5
4. Paul, S., Samant, S. S., Lal, M. and Ram, J., Population assessment and Habitat Distribution Modelling of high value Corylus jacquemontii for in-situ conservation in the state of Himachal Pradesh, India. *Proc. Indian. Natn. Sci. Acad.*, 2019, **85**, 275-289; doi: http://doi.org/10.16493/ptinsa/2018/49507.
5. Brandis, D., Indian trees: an account of trees, shrubs, woody climbers, bamboos and palms indigenous or commonly cultivated in the British Indian empire. *Archibald Constable and Co. Ltd, London,* 1906.
6. Sharma, S. D. and Kumar, K., Preliminary evaluation of hazelnut seedling trees native to India. In *V International Congress on Hazelnut,* 2000, **556**, 29-36; doi: http://doi.org/ 10.17660/ActaHortic.2001.556.3
7. Joshi, S. K., Ballabh, B., Negi, P. S. and Dwivedi, S. K., Diversity, distribution, use pattern and evaluation of wild edible plants of Uttarakhand, India. *Def. Life Sci. J.*, 2018, **3**, 126-135; doi: http://doi.org/10.14429/dlsj.3.12579.
8. Singh, A. and Samant, S. S., Conservation prioritization of habitats and forest communities in the Lahaul Valley of proposed cold desert biosphere reserve, north western Himalaya, India. *Appl. Ecol. Environ. Res.*, 2010, **8**, 101-117; doi: http://dx.doi.org/10.15666/aeer/0802_101117.
9. Kumar, A., Kumar, P., Koundal, R. and Agnihotri, V. K., Antioxidant properties and UPLC–MS/MS profiling of phenolics in jacquemont's hazelnut kernels (Corylus jacquemontii) and its byproducts from western Himalaya. *J. Food Sci. Technol.*, 2016, **53**, 3522-3531; doi: https://doi.org/10.1007/s13197-016-2329-2.

10. Semwal, K. C., Bhatt, V. K. and Stephenson, S. L., A survey of macrofungal diversity in the Bharsar region, Uttarakhand Himalaya, India. *J. Asia Pac. Biodivers.*, 2018, **11**, 560-565. doi: https://doi.org/10.1016/j.japb.2018.09.006.
11. Chauhan, P. P., Nigam, A. and Santvan, V. K., Ethnobotanical study of wild fruits in Pabbar valley, district Shimla, Himachal Pradesh. *J. Med. Plants Stud.*, 2016, **4**, 216-220.
12. Gaur, R. D., Traditional dye yielding plants of Uttarakhand, India. *Nat. Prod. Radiance,* 2008, **7**, 154-165.
13. Rana, D., Bhatt, A., Lal, B., Parkash, O., Kumar, A. and Uniyal, S. K., Use of medicinal plants for treating different ailments by the indigenous people of Churah subdivision of district Chamba, Himachal Pradesh, India. *Environ. Dev. Sustain.*, 2021, **23**, 1162-1241; doi: https://doi.org/10.1007/s10668-020-00617-0.
14. Rana, J. C., Pradheep, K., Chaurasia, O. P., Sood, S., Sharma, R. M., Singh, A. and Negi, R., Genetic resources of wild edible plants and their uses among tribal communities of cold arid region of India. *Genet. Resour. Crop Evol.*, 2012, **59**, 135-149; doi: http://dx.doi.org/ 10.1007/s10722-011-9765-7.
15. Adnan, S. M., Khan, A. A., Latif, A. and Shinwari, Z. K., Threats to the sustainability of Ethno-Medicinal uses in Northern Pakistan (a case study of Miandam Valley, district Swat, NWFP Province, Pakistan). *Lyonia*, 2006, **11**, 91-100.
16. Kumar, P., Singh, H. and Ambrish, K., Traditional knowledge of medicinal and threatened plants used by the inhabitants dwelling in and around Sechu-tuan nalla: a high-altitude wildlife sanctuary in Himachal Pradesh, northwest Himalaya. In *Perspective on Biodiversity of India,* 2018, 329-333.
17. Singh, H. and Kumar, P., A brief overview of vegetation of Pangi valley (Chamba, Himachal Pradesh): A high altitude region of northwest Himalaya, India. *Biosci. Biotechnol. Res. Asia*, 2017, **14**, 625-630; doi: http://dx.doi.org/10.13005/bbra/2487
18. Shaw, K., Stritch, L., Rivers, M., Roy, S., Wilson, B. and Govaerts, R., The red list of Betulaceae. In Botanic Gardens Conservation International, 2014.
19. Subramani, S. P., Kapoor, K. S. and Goraya, G. S. Additions to the floral wealth of Sirmaur District, Himachal Pradesh from Churdhar Wildlife Sanctuary. *J. Threat. Taxa*, 2014, **6**, 6427-6452; doi: http://dx.doi.org/10.11609/JoTT.o2845.6427-52.
20. Mehlenbacher, S. A., Hazelnuts (Corylus). In *Genetic Resources of Temperate Fruit and Nut Crops,* 1991, **290**, 791-838; doi: http://doi.org/10.17660/actahortic.1991.290.18.
21. Rana, J. C., Pradheep, K. and Verma, V. D., Naturally occurring wild relatives of temperate fruits in Western Himalayan region of India: an analysis. *Biodivers. Conserv.*, 2007, **16**, 3963-3991; doi: http://doi.org/10.1007/s10531-007-9201-7.
22. Sharma, O. P., Threatened plants of Jammu region, North-West Himalaya and strategies for their conservation. In *Special Habitats and Threatened Plants of India. Envis. Bulletin. Dehradun: Wildlife Institute of India*, 2008, **11,** 37-40.
23. Samant, Pant, S., Singh, M., Lal, M., Singh, A., Sharma, A. and Bhandari, S., Medicinal plants in Himachal Pradesh, north western Himalaya, India. *Int. J. Biodivers. Sci. Manag.*, 2007, **3**, 234-251; doi: http://dx.doi.org/ 10.1080/17451590709618177.

Table.1: Traditional uses of the species and the parts used

Plant Part(s)	Traditional uses	References
Leaves and fruits	The juice extracted after grinding the fruits and leaves is orally administered to treat diabetes in humans.	Rana et al., 2021
Leaves and young shoots	As a fodder.	Chauhan et al., 2016
Stem/bole	As a fuel and timber.	Gupta et al., 2019
Seeds	The oil is massaged to cure muscle pain.	Paul et al., 2019
Nut	Consumed. Nut paste is used in a range of processed dairy and bakery products. Also, nuts are used in cosmetics and pharmaceuticals.	Kumar et al., 2016; Joshi et al., 2018
Nuts	As a brain tonic.	Adnan et al., 2006; Samant et al., 2007; Kumar et al., 2018;
Fruit rind	To make camel dye.	Gaur, 2008; Paul et al., 2019

Fig. 1 a. Photographs showing plant *Corylus jacquemontii* Decne. **b.** Seed **c.** Leaf **d.** Nuts

Fig. 2. Distribution of *Corylus jacquemontii* in the Indian Himalayan State of Himachal Pradesh

Fig. 3 Traditional use, phytochemistry and biological activities of *Corylus jacquemontii* Decne.

Fig. 1

a.

b.

c.

d.

Fig. 2

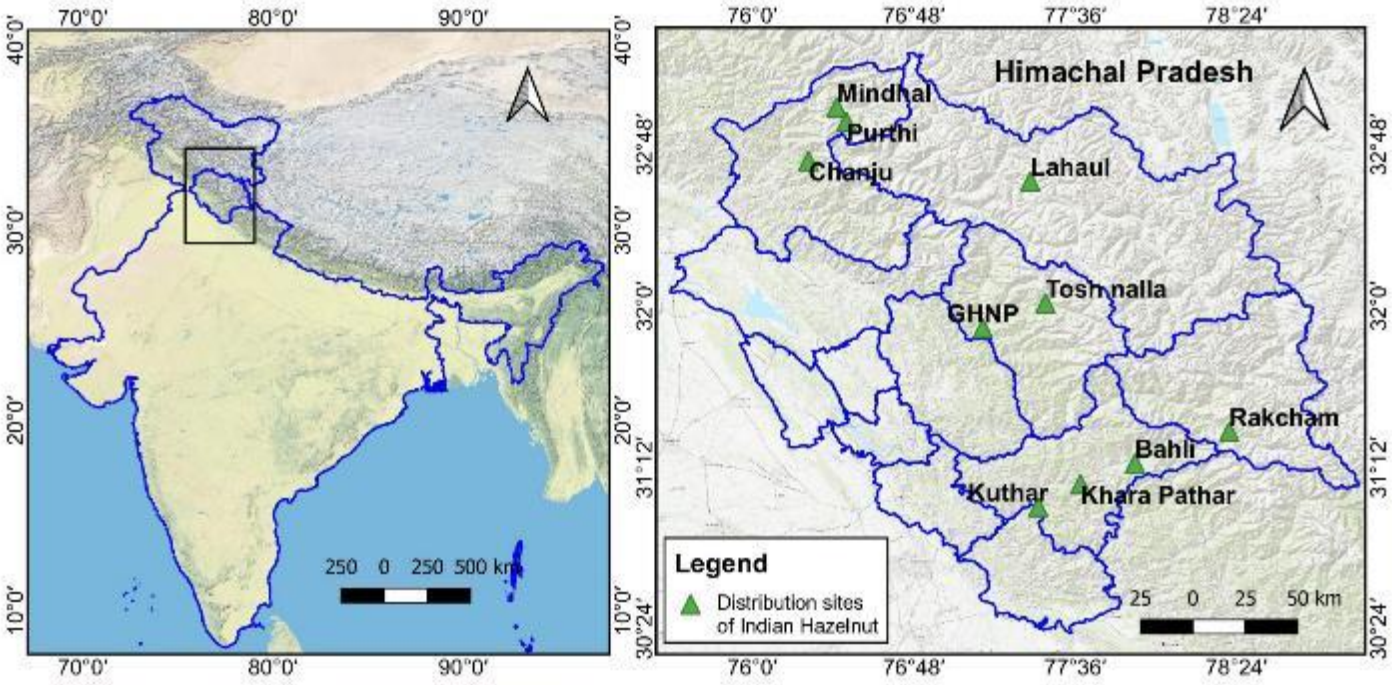

70°0'
80°0'
90°0'
40°0'
30°0'
20°0'
10°0'
250 0 250 500 km
76°0'
76°48'
77°36'
78°24'
32°48'
32°0'
31°12'
30°24'
Himachal Pradesh
Mindhal
Purthi
Chanju
Lahaul
Toshnalla
GHNP
Rakcham
Bahli
Kuthar
Khara Pathar
Legend
Distribution sites of Indian Hazelnut
25 0 25 50 km

Fig. 3

Traditional Uses

- Ethnomedicine
- Fodder
- Food
- Fuel
- Timber

Biological Activities

- Anticarcinogenic
- Antidiabetic
- Antioxidant
- Cardioprotective

Phytochemicals

- Carotenoids
- Polyphenol
- Tannins

Economic potential

- Bakery products
- Cosmetics
- Pharmaceuticals
- Nuts (Phindak or Findak) ranged in cost from Rs. 1500 to 3000 per Kg

Ecological potential

- Promotes macrofungal diversity (*Cortinarius* sp. and *Lactarius* sp.)
- Enhance nutrient cycling

Ulmus wallichiana Planch.: a synthesis of its Phytochemical constituents, pharmacology, and Traditional uses

Abstract

Ulmus wallichiana, commonly referred to as Himalayan Elm, is a vulnerable tree species of the Himalayan region that belongs to the family Ulmaceae. From being used as fuelwood and fodder to treating various diseases, the species is rich in Phyto-constituents of high medicinal value. At the same time, the importance of the species in supporting and improving rural livelihoods is fast catching up. Therefore, recognizing the conservation status of the species and its vast uses, a synthesis of the information on this mountain tree and its usage by the hill people, including its phytochemicals as well as biological activities, is presented. Also, the possible role of the species in generating the economy and livelihood in the Himalayas through a first-hand example is shared.

Keywords: Conservation, Elm, Himalaya, Livelihood, Phytochemicals, Traditional

1. INTRODUCTION

Ulmus wallichiana Planch., known as the Himalayan Elm, is a native Himalayan deciduous tree belonging to the family Ulmaceae **(Fig. 1)**. The tree may attain a height of up to 30 m and is characterized by greyish brown bark that is longitudinally furrowed or reticulate with ridges (Batool et al., 2014). The species has a wide crown with ascending branches, while the branchlets are 1.5-2.7 mm in diameter, pale brown to yellowish-brown, pubescent, and with spherical lenticels (Melville and Heybroek, 1971). The leaves of the species are elliptic-acuminate with a mature leaf reaching dimensions of around 13 cm in length and 6 cm in breadth. The margin of the leaf is roughly biserrate and the serration has 2-4 secondary teeth (Maunder, 1988). On the other hand, the inflorescence axis is elongated with pedicels more than 5 mm long that are uniformly pilose and articulated. Flowers are borne in clusters on leafless branches (Bhat et al., 2017). The perianth is narrow and obtuse while the stamens (5-6) have long filaments and red anthers. The ovary is pubescent (Batool et al., 2014; Bhat et al., 2017; Singh et al., 2021). The diaspore is flat, while the samara (fruit) is stipitate, 1.52-1.78 cm long, orbicular-obovate with a reticulate and membranous wing. Seeds are hairy to subglabrous and surrounded by wings (Phartyal et al., 2002). Flowering and fruiting of the Elm occur between March and April (Bhat et al., 2017).

The species primarily occurs between 1000-3000 m asl in the Himalayas and is usually associated with *Celtis tetrandra, Juglans regia,* and *Betula alnoides* (Batool et al., 2014; Singh et al., 2021). In India, the plant is found in Jammu & Kashmir, Himachal Pradesh, and Uttarakhand **(Fig. 2)** (Bhat et al., 2017; Singh et al., 2021). A small population of it has also been reported from Uttar Pradesh, where it is locally referred to as Maira (Melville and Heybroek, 1971). In Jammu, the species is locally called Mannu while in Kashmir it is known as Brenn. It is commonly referred to as Maraal in Himachal Pradesh and Emrhoi in Uttarakhand (Singh et al., 2021).

The species is of high utility, it is used as fuelwood, fodder, timber and has medicinal importance (Rashid and Sharma 2012; Reddy et al., 2012; Ajaib & Khan 2014; Bora, 2016). It plays an important role in the livelihood of rural people (Down to Earth, 2021). The phytochemicals extracted from the species possess pharmacological activities that have application against bone disorders, obesity, diabetes, hypertension, cancer, heart disorders etc. **(Fig. 3)** (Swarnkar et al., 2011; Kumar et al., 2015; Arya and Sharma, 2016). The bark of the plant is also employed as an astringent, diaphoretic, purgative, stimulent, and emollient (Khare, 2008).

2. PHYTOCHEMISTRY

The Himalayan Elm is a source of phytoconstituents that have primarily been isolated from the stem, bark, and leaf. The antioxidant activity and fatty acid content of the seed extraction of *Ulmus wallichiana* have also been investigated by using Gas Chromatography and Mass Spectrometry. The petroleum ether extract of the seeds contains unsaturated fatty acids, primarily oleic (29%) and linoleic (31.6 %) acids. Seed extract have also been shown to have a considerable quantity of saturated fatty acids, mainly palmitic acid (16.7%). These fatty acids have useful applications in cosmetic, nutraceutical, and food industries (Nengroo and Rauf, 2019).

The species contains flavonoids, phenolics, triterpenes, and some amounts of coumarins (Rawat et al., 2009; Masoodi et al., 2014). The stem bark of the plant is the main source of flavonoid C-glycosides, while some of the flavonoids and triterpenes are isolated from the leaves. A variety of compounds present in the plant have been identified and analyzed using chromatographic, spectrometric, and spectroscopic techniques.

3. BIOLOGICAL ACTIVITY

3.1 Osteogenic activity

Ulmus wallichiana is traditionally used for the treatment of fractured bones of human beings and animals in the folklore of the Indian Himalaya (Arya and Sharma, 2016). Scientific validation of some of the traditional uses of this plant has also been carried out (Arya et al., 2013). Arya et al. (2013) reported that Ulmoside A and Ulmoside B (rich in C-glycosylated flavonoids) and Naringenin 6-C-β-D-glucopyranoside showed therapeutic potential for the treatment of postmenopausal osteoporosis in ovariectomized rats and promoted osteoblast function while inhibiting adipogenesis.

Sharan et al. (2010b) studied that the total ethanol extract of the bark of *U. wallichiana* contains various C-glycosylated flavonoids that have an effect on peak bone achievement in ovariectomized rats. The oral treatment of total ethanol extracts (750 mg kg^{-1} day^{-1}) and butanol fraction (50 mg kg^{-1} day^{-1}) showed enhanced bone mineral density, and having bone conserving properties against bone loss. Another study found that 6-C-β-D- glucopyranosyl-(2S,3S)- (+) -5,7, 3′,4′-tetrahydroxydihydroflavonol (GTDF) isolated from the species reduced the glucocorticoid induced bone loss. It was found that GTDF enhances osteoblast survival through the inhibition of p53 and AKT activation (Khan et al., 2013).

3.2 Anti-oxidative and Anti-apoptotic Activity

Gupta et al. (2019) investigated the impact of Ulmoside A on neurons treated with lipopolysaccharide (LPS). They observed that LPS treated neuronal cells have decreased viability and distorted morphology, resulting in cytotoxicity. Ulmoside A administration restored cell viability and cell toxicity as revealed by MTT and LDH assays, respectively. This showed that the LPS induced mitochondrial membrane potential was restored with Ulmoside A treatment which in turn restored the cellular morphology. Ulmoside A has the capability to act via mitochondria and exhibits anti-oxidant and anti-apoptotic properties in neurons.

3.3 Anti-obesity Activity

Flavonoids play an important role in anti-obesity activities by inducing apoptosis (Zhang and Huang, 2012). These compounds triggers apoptosis in 3T3-L1 adipocytes by the stimulation of the mitochondrial pathway. Swarnkar et al. (2011) reported the isolation of (2S, 3S) – aromadendrin -6-C-β-D - glucopyranoside (AG) from the stem bark of Himalayan Elm and found that AG is a novel compound belonging to flavanol class which at nanomolar concentration inhibits the differentiation of 3T3-L1 adipocytes.

3.4 Cardioprotective Activity

Cardiac hypertrophy refers to the abnormal thickness and growth of the heart muscles. This occurs as a result of persistent hypertension, which gradually leads to heart failure. Quercetin and its analogues present in the species have been highlighted as therapeutic agents for curing cardiac hypertrophy. The study suggested that the above compound led to a reduction in the heart rate, renin release, and angiotensin Ⅱ level while plasma Nitrite / Nitrate (NO) and cyclic Guanosine Monophosphate (cGMP) levels rise (Syed et al., 2016b).

3.5 Anti-hyperglycaemic Activity

In an experimental study by Rawat et al. (2011), Ulmoside A was examined for its effect on glucose uptake by rat muscle cell lines and low dosed-streptozotocin-induced diabetic rats. The results showed the significant reduction in the blood glucose levels, with better in-vivo antihyperglycemic activity in the rat cell lines ranging from 19.9% to 34.9%.

3.6 Anti-hypertensive Activity

Flavonoids such as procyanidin, which is mainly composed of oligomers of catechin, have a variety of physiological effects including antihypertensive effects (Syed et al., 2016a). The antihypertensive activity of the Ethanol extraction and Butanolic Fraction of the species was examined using spontaneously hypertensive rats (SHR), DOCA-Salt, and L-NAME induced hypertension models. According to the study, the oral administration of Ethanol extract and Butanolic fraction shown significant pharmacological activity for the treatment of hypertension at effective doses of 500 mg/kg and 50 mg/kg, respectively. The Ethanol extraction dose of 500 mg/kg is very high to be transferred from rats to human, however the Butanolic

Fraction dose is 50 mg/kg, which is enriched with a high concentration of flavonoid including four C-glycosides that can moderate the blood pressure.

3.7 Antimicrobial Activities

The phyto-constituents in the Himalayan Elm, are having antimicrobial activities (Bora et al., 2018). In an experimental study, the bark extracts of the plant found to have antibacterial properties against *Escherichia coli, Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa*, and *Klebsiella pnuemoniae* (Bora et al., 2018; Mehmood et al., 2019). It has also been evaluated for antifungal activity against *Aspergillus fumigatus,* and *Aspergillus flavus* (Bora et al., 2018). The Ethyl extract showed better inhibition then the other extracts analysed, while the chloroform extract exhibited moderate inhibition. The Agar Well Diffusion technique was used to evaluate the antibacterial activity. The ethyl acetate extract of *U. wallichiana* exhibited the highest percentage of phenolic and flavonoid compounds, which showed the highest antimicrobial activity (Bora et al., 2018).

In another experiment, Mehmood et al., (2019) studied how the leaf extracts of the Himalayan Elm can be used to produce eco-friendly silver nanoparticles (SNPs) when treated with $AgNO_3$. Using the disc diffusion method, these SNPs exhibited antibacterial efficiency against gram positive and gram-negative bacteria. These biosynthesized SNPs show the highest inhibitory activity (1 mg/mL) against *P. aeruginosa* (17.63 mm) following *E. coli* (17.60 mm), *S. aureus* (17.00 mm) and *K. pneumoniae* (14.67 mm) when compared to another antibacterial agent such as ampicillin (Mehmood et al., 2019).

4.8 Anti-cancer Activity

Kumar et al., (2015) studied the cytotoxic and apoptotic activity of Quercetin-6-C-β-D-glucopyranoside (QCG) against prostate cancer cells by MTT assay. The natural analogue of quercetin, quercetin - 6-C-β-D - glucopyranoside was isolated from the ethanolic extract of the bark of *U. wallichiana*. The study suggested that QCG treatment arrests the G_0/G_1 phase of the cell cycle by lowering PCNA, cyclin D, cyclin E, and CDk-2 expression while increasing CDK inhibitor p21 and p27 expression. QCG also triggered apoptosis as evidenced by the release of cytochrome C, cleavage of caspase 3 and poly (ADP-ribose) polymerase. Quercetin has been found to stimulate the expression of Aryl hydrocarbon receptor (AhR), which is a key mediator of QCG activity, because increased AhR expression is required for apoptosis and inhibition of the Akt/mTOR pathway in prostate cancer cells. According to the findings, QCG inhibits prostate cancer cells by supressing the Akt/mTOR pathway in prostatic carcinoma or PC-3 cells via AhR-mediated downregulation.

4. TRADITIONAL USES

Ulmus wallichiana is traditionally been used for fodder, fuelwood, fibre, and timber, among other things. The detail of traditional uses is provided in table 2.

Table 2: Traditional uses

Traditional use	Plant part	Method	References
Bone fracture	Bark	Fresh bark is crushed, boiled in water and left to cool. The semisolid substrate is then poured and wrapped around the fractured part. It is tightened with clean cloth and a support is provided with a hard cardboard to fractured part.	Arya and Agarwal., 2008; Batool et al., 2014; Arya and Sharma., 2016; Syed et al., 2016a; Arya and Sahu, 2017
Wound healing	Inner bark	Bark paste is applied locally on the wounds and cuts.	Phartyal et al., 1997; Singh and Chaurasia, 1998; Alam et al., 2011
Digestive tract disorders	Bark	Decoction of the bark is taken 2-3 times per day to cure digestive problems such as ulcers, gastritis, colitis, and diarrhoea.	Jamal et al.,2012; Khan et al., 2013; Ajaib and Khan, 2014
Skin disorders	Bark	Bark is ground into a paste and is applied to cure skin infections. Also, abscesses and ringworm infections are treated with dried and powdered bark.	Rao et al., 2015; Kumari et al., 2018
Dislocation of joints	Bark	The dislocated joint is aligned, then bark is applied and tied firmly.	Samant et al., 2007
Fibre	Bark, Stalk	Bark yields strong fibre that is used to make ropes, strings, and cordage. A traditional footwear known as "*Pule*" is made fibre. Also, the fibre is boiled along with wool to make extra-soft clothes.	Phartyal.et al.,1997; Rana et al., 2014
Fodder	Leaves	Used as fodder.	Rana et al., 2014: Islam et al., 2017
Fuel wood	Stem	Used as fuel wood for cooking and heating.	Negi and Todaria., 1993; Batool et al.,

			2014; Rana et al., 2014
Timber	Bole/Stem	For light construction, planking, and packing boxes. Also, suitable for furniture.	Phartyal et al., 1997; Batool et al.,2014
Tools and storage structure	Stem	For making stone carrying tool "*Pithu"*, *"Rach"* for woollen weaving, and grinding tool called *Ukhal and Mool*. A storage structure named as "Pedu" (for storage of grains) is also made.	Sharma et al., 2019

5. LIVELIHOOD

The plant is indirectly of high nutritional importance and of direct economic value to the resident communities of Himalaya. The mushroom growing on the tree is believed to be non-poisonous and highly relished. The same fetches a handsome price in the market. The wood of *Ulmus wallichiana* has traditionally been used by the rural people for the cultivation of the oyster mushrooms (*Pleurotus* sp*.)* (Stamets & Chilton, 1983). Oyster mushrooms are generally the easiest and low-cost to grow. In the rainy season, the snags and logs of the species can be seen covered by oyster bloom **(Fig. 5)**. In the Barot area of Himachal Pradesh, an inhabitant was seen earning well from it by gathering Elm logs in their kitchen garden and harvesting and selling these mushrooms in the market for Rs 60-80 per kg (Down to Earth, 2021). Additionally, the plant is employed in traditional agroforestry systems, where it provides significant ecosystem services as well as a source of income for local inhabitants. The plant is considered adaptable to climate change and serves as an excellent carbon sink (Islam et al., 2017). Hence, the plant plays an important role in revitalising the economy of the farmers of the rural area (Down to Earth, 2021).

Fig. 5 (a) *Ulmus wallchiana* tree with *Pleurotus* sp.(b) A women collecting the mushroom for sale

6. CONSERVATION ISSUES

The species is highly vulnerable. Use of the species for medicinal, fodder, fuelwood, etc. adds to the pressures (Haq et al., 2011; Batool et al., 2014). While habitat degradation continues to be a major problem (Khan et al, 2021), lopping shoots and leaves for fodder, fuelwood, and the removal of fibrous bark for making ropes hampers flowering and leads to premature death (Heybroek,1963; Maunder, 1988).

Naturally, the Himalayan elm is propagated through seeds. However, seeds have short viability period and high incidences of empty seeds further hamper the status (Bhat et al., 2007; Nazir et al., 2020). Though the seeds can be stored for several years under controlled conditions (-5- 15° c), under natural conditions, the seeds lose their viability within few months (Phartyal et al 2003a, b). Also, vegetative propagation is difficult, and stem cuttings are hard to root (Mughal and Mugloo, 2016). The hardwood cuttings treated with the various concentrations of IBA (Indole 3-butyric acid) indicated that the IBA formulation at 2000ppm has a significant difference and hence found to be the best rooting hormone (Tomar and Kumar, 2018; Nazir et al., 2020).

7. STRATEGIES FOR CONSERVATION

The status of the species calls for prioritizing conservation strategies. Recognizing that empty seeds and their low viability are a major issue, studies on reproductive biology and vegetative reproductions have become important. Measures for *ex-situ* conservation that include botanical gardens and developing protocols for tissue culture become important.

As the plant species is highly used by the local people, public participation and mass awareness programs should be promoted, wherein training and outreach should form an important component both at the level of government and community. Massive afforestation and reforestation programmes involving the local communities will help in the revival of its population.

Also, extensive and intensive surveys for its population estimation and mapping should be conducted. Preservation plots should be marked and established for understanding the ecology of the species and its long-term monitoring.

8. CONCLUSION

Ulmus wallichiana is a lesser-known yet vulnerable Himalayan species. It has significant traditional, therapeutic, and economic value. The tree is rich in phyto-constituents and the presence of the mushroom (*Pleurotus* sp.) on the logs further adds to the value of the plant. The species provides a viable option for supporting the livelihood of the local people. With the exception of its significance, a reduction in the population of the plant has been observed. Unsustainable bioresource use, overexploitation for a variety of purposes, coupled with the environmental conditions as well as regeneration challenges, put pressure on

the plant population. As a result, there is a need for multidisciplinary efforts including social, institutional, and scientific for the conservation of this important multipurpose tree species. Studies on the species, particularly population and regeneration, are important.

References:

Ajaib, M., & Khan, Z. (2014). Ethnobotanical studies of useful trees of District Kotli, Azad Jammu and Kashmir. Biologia Pakistan, 60, 63-71.

Alam, G., Singh, M. P., & Singh, A. (2011). Wound healing potential of some medicinal plants. International Journal of Pharmaceutical Sciences Review and Research, 9(1),136-145.

Ali, N., Tantray, M. A., Shawl, A. S. (2007). Pentacyclic triterpenoid friedlan-7-one from ulmus wallichiana. Oriental Science, 12, 87-88.

Arya, KR, Sharma, D., & Kumar, B. (2011). Validation and quality determination of an ethnobotanical lead for osteogenic activity isolated from Ulmus wallichiana Planch.: a traditional plant for healing fractured bones. Journal of Scientific and Industrial Research, 70, 360- 364.

Arya, K. R., & Agarwal, S. C. (2008). Folk therapy for eczema, bone fracture, boils, sores and gingivitis in Taragtal province of Uttaranchal. Indian Journal of Traditional Knowledge, 7(3), 443- 445.

Arya, K. R., & Sahu, N. (2017). Ethnopharmacological Developments in Traditional Bone Healing Plants: Ulmus wallichiana, Coelogyne cristata and Pholidota articulata for Osteoporosis Management. Int J Pharma Res Health Sci, 5(4), 1750-54.

Arya, K. R., & Sharma, C. (2016). Folklore driven osteogenic compounds for modern therapeutics from fracture healing plants of Uttarakhand Himalaya. Indian Ethnobotany: Emerging Trends, 51.

Arya, K. R., Khatoon, S., & Kumar, B. (2013). Development of quality control markers for Ulmus wallichiana Planchon: An Indian traditional plant for osteogenic activity. Indian Journal of Traditional Knowledge, 12(4), 664- 669.

Batool, N., Bibi, Y., & Ilyas, N. (2014). Current status of *Ulmus wallichiana*: Himalayan endangered Elm. Pure and Applied Biology, 3(2), 60.

Bhat, G. M., Islam, M. A., Rather, T. A., & Sofi, F. M. (2017). *Ulmus wallichiana* Planch.: An endangered species of north west Himalaya, India. 4. 30-33.

Bhat, G. M., Khan, M. A., & Mughal, A. H. (2007). Seed maturity indices in Elm *(Ulmus wallichiana* Planch): A multipurpose tree species of Kashmir valley. Ecology Environment and Conservation, 13(3), 473.

Bora, K. S. (2016). Pharmacognostic evaluation and physico-chemical analysis of *Ulmus wallichiana* Planch. Journal of Applied Pharmaceutical Research, *4*(3), 01-07.

Bora, K. S., Kumar, A., & Bisht, G. (2018). Evaluation of antimicrobial potential of successive extracts of *Ulmus wallichiana* Planch. Journal of Ayurveda and Integrative Medicine, *9*(3), 190-194.

Down to Earth: https://www.downtoearth.org.in/blog/agriculture/mushroom-growing-elm-trees-can-empower-barot-village-communities-62787

Gupta, P., Singh, A., Tiwari, S., Mishra, A., Maurya, R., & Singh, S. (2019). Ulmosides A: flavonoid 6-C-glycosides from *Ulmus wallichiana* attenuates lipopolysaccharide induced oxidative stress, apoptosis and neuronal death. Neurotoxicology, 73, 100-111.

Haq, F. U. (2011). Conservation status of the critically endangered and endangered species in the Nandiar Khuwar catchment District Battagram, Pakistan. International Journal of Biodiversity and Conservation, 3(2), 27-35.

Heybroek, H. M. (1963). Diseases and lopping for fodder as possible causes of a prehistoric decline of Ulmus. Acta botanica neerlandica, 12(1), 1-11

Islam, M. A., Qaisar, K. N., & Bhat, G. M. (2017). Indigenous knowledge in traditional agroforestry systems of Kashmir valley: current challenges and future opportunities. International Journal of Forestry and Crop Improvement, 8(1), 68-77.

Jamal, Z., Ahmad, M., Zafar, M., Sultana, S., Khan, M. A., & Shah, G. M. (2012). Medicinal plants used in traditional folk recipes by the local communities of Kaghan valley, Mansehra, Pakistan, 11(4), 634-639.

Khan, M. P., Mishra, J. S., Sharan, K., Yadav, M., Singh, A. K., Srivastava, A., ... & Chattopadhyay, N. (2013). A novel flavonoid C-glucoside from *Ulmus wallichiana* preserves bone mineral density, microarchitecture and biomechanical properties in the presence of glucocorticoid by promoting osteoblast survival: a comparative study with human parathyroid hormone. Phytomedicine, 20(14), 1256-1266.

Khan, R., Ali, N., Hussain, M., Rahman, I. U., Majid, A., Romman, M., Ahmed, T., & Shah, AH. (2021). Evaluation of the conservation status of *Ulmus wallichiana* and *U. vilosa* in Pakistan. Pak. J. Bot., 53(6)

Khan, S. M., Page, S., Ahmad, H., Shaheen, H., Ullah, Z., Ahmad, M., & Harper, D. M. (2013). Medicinal flora and ethnoecological knowledge in the Naran Valley, Western Himalaya, Pakistan. *Journal of ethnobiology and ethnomedicine*, *9*(1), 1-13.

Khare, C.P. 2008. Indian Medicinal Plants: An Illustrated Dictionary. Springer Science & Business Media, New York, USA.

Kumar, R., Saini, K. S., Kumar, A., Kumar, S., Ramakrishna, E., Maurya, R., ... & Chattopadhyay, N. (2015). Quercetin-6-C-β-D-glucopyranoside, natural analog of quercetin exhibits anti-prostate cancer activity by inhibiting Akt-mTOR pathway via aryl hydrocarbon receptor. Biochimie, 119, 68-79.

Kumari, P., Samant, S. S., & Puri, S. (2018). Diversity, distribution, indigenous uses and conservation of medicinal plants in central Himachal Pradesh, North Western Himalaya. *J Med Plants*, *6*, 45-68.

Kumari, T., Sharma, C., Bajpai, V., Kumar, B., Srivastava, M., & Arya, K. R. (2015). Qualitative determination of bioactive metabolites through Q-TOF LC/MS in different parts and undifferentiated cultures of Ulmus wallichiana Planchon. Plant Growth Regulation, 75(1), 331-340s

Masoodi, T. H., Islam, M. A., Wani, M. A., Mir, S. A., & Gangoo, S. A. (2014). Allelopathic effect of Populus deltoides and *Ulmus wallichiana* on biochemical constituents of maize, bean and sunflower. Karnataka Journal of Agricultural Sciences, 26(2).

Maunder, M. (1988). Plants in peril, 13. The Kew Magazine, 5(3), 137-140.

Maurya, R., Rawat, P., Sharan, K., Siddiqui, J. A., Swarnkar, G., Mishra, G., ... & Chattopadhyay, N. (2014). *U.S. Patent No. 8,669,232*. Washington, DC: U.S. Patent and Trademark Office.

Mehmood, A., Shabir, S., Hussain, S., & SHAFIQUE, K. (2019). Antibacterial and antioxidant activity of biosynthesized silver nanoparticles from *Ulmus Wallichiana* planch. Leaf extract. Farmacia, 67(4), 662-669.

Melville, R., & Heybroek, H. M. (1971). The elms of the Himalaya. Kew Bulletin, 5-28.

Mughal, A. H., & Mugloo, J. A. (2016). Elm (*Ulmus wallichiana*): a vulnerable lesser-known multipurpose tree species of Kashmir valley. SKUAST Journal of Research, 18(2), 73-79.

National Canter for Biotechnology Information (2021). Retrieved July 16, 2021 from https://pubchem.ncbi.nlm.nih.gov.

Nazir, I., Dutt, V., Raj, A., Bhat, G. M., Bhat, B. A., & Wani, A. A. (2020). Effect of IBA concentrations on rooting and growth of Ulmus wallichiana Planchon stem cuttings under temperate conditions of Kashmir. Journal of Pharmacognosy and Phytochemistry, 9(5), 2446-2449.

Negi, A. K., & Todaria, N. P. (1993). Fuelwood evaluation of some Himalayan trees and shrubs. Energy, 18(8), 799-801.

Nengroo, Z. R., & Rauf, A. (2019). Fatty acid composition and antioxidant activities of five medicinal plants from Kashmir. Industrial Crops and Products, 140, 111596.

Phartyal, S. S., Thapliyal, R. C., Nayal, J. S., & Joshi, G. (2002). Processing of seed to improve seed lot quality of rare and endangered tree species of Himalayan maple (Acer caesium Wall Ex. Brandis) and Elm (Ulmus wallichiana Planchon). Seed Science and Technology, 30(2), 371-382.

Phartyal, S. S., Thapliyal, R. C., Nayal, J. S., & Joshi, G. (2003b). Seed storage physiology of Himalayan elm (*Ulmus wallichiana*): an endangered tree species of tropical highlands. Seed Science and Technology, 31(3), 651-658.

Phartyal, S. S., Thapliyal, R. C., Nayal, J. S., Rawat, M. M. S., & Joshi, G. (2003a). The influences of temperatures on seed germination rate in Himalayan elm (*Ulmus wallichiana*). Seed Science and Technology, 31(1), 83-93.

Phartyal, S.S., & Thapliyal, Rc & Nayal, J. (1997). *Ulmus wallichiana* (Elm) - An engendered tree of economic value. MFP NEWS. VII, 18-19.

Rana, P. K., Kumar, P., Singhal, V. K., & Rana, J. C. (2014). Uses of local plant biodiversity among the tribal communities of Pangi Valley of district Chamba in cold desert Himalaya, India. The Scientific World Journal, 2014.

Rao, P. K., Hasan, S. S., Bhellum, B. L., & Manhas, R. K. (2015). Ethnomedicinal plants of Kathua district, J&K, India. *Journal of ethnopharmacology*, *171*, 12-27.

Rashid, A., & Sharma, A. (2012). Exploration of economically important fodder plants of district Rajouri-Jammu and Kashmir State. International Journal of Life science & Pharma Research, 2(4), 142-149.

Rawat, P., Kumar, M., Rahuja, N., Srivastava, D. S. L., Srivastava, A. K., & Maurya, R. (2011). Synthesis and antihyperglycemic activity of phenolic C-glycosides. Bioorganic & Medicinal Chemistry Letters, 21(1), 228-233.

Rawat, P., Kumar, M., Sharan, K., Chattopadhyay, N., & Maurya, R. (2009). Ulmosides A and B: flavonoid 6-C-glycosides from Ulmus wallichiana, stimulating osteoblast differentiation assessed by alkaline phosphatase. Bioorganic & Medicinal Chemistry Letters, 19(16), 4684-4687.

Reddy, G.A.K., Priyanka, B., Saranya, C.S., & Kumar, C.K.A. (2012). Wound healing potential of Indian medicinal plants. International Journal of Pharmacy Review and Research*, 2* (2), 75-87.

Sahu, N., Tripathi, K., Kanojia, S., & Arya, K. R. (2018). Vegetative propagation and Liquid Chromatography Mass Spectrometry (LCMS) analysis of Indian traditional and endangered plant Ulmus wallichiana using air layering technology. Indian Forester, *144*(8), 723-729.

Samant, Pant, S., Singh, M., Lal, M., Singh, A., Sharma, A., & Bhandari, S. (2007). Medicinal plants in Himachal Pradesh, north western Himalaya, India. The International Journal of Biodiversity Science and Management, 3(4), 234-251.

Sharan, K., Siddiqui, J. A., Swarnkar, G., Tyagi, A. M., Kumar, A., Rawat, P., ... & Chattopadhyay, N. (2010a). Extract and fraction from *Ulmus wallichiana* Planchon promote peak bone achievement and have a nonestrogenic osteoprotective effect. Menopause, 17(2), 393-402.

Sharan, K., Swarnkar, G., Siddiqui, J. A., Kumar, A., Rawat, P., Kumar, M., ... & Chattopadhyay, N. (2010b). A novel flavonoid, 6-C-β-d-glucopyranosyl-(2S, 3S) -(+)-3′, 4′, 5, 7-tetrahydroxyflavanone, isolated from *Ulmus wallichiana* Planchon mitigates ovariectomy-induced osteoporosis in rats. Menopause, 17(3), 577-586.

Sharma, C., Rajendar, K., Kumari, T., & Arya, K. R. (2014). Indian traditional therapies and bio-prospecting: their role in drug development research. International Journal of Pharmacy & Life Sciences, *5*(3).

Sharma, A., Thakur, D., & Uniyal, S. K. (2019). Plant-derived utility products: knowledge comparison across gender, age and education from a tribal landscape of western Himalaya. Journal of Ethnobiology and Ethnomedicine, 15(1), 1-14.

Singh, A., Majeed, A., & Bhardwaj, P. (2021). Transcriptome characterization and generation of marker resource for Himalayan vulnerable species, *Ulmus wallichiana*. Molecular Biology Reports, 48(1), 721-729.

Singh, B., & Chaurasia, O. P. (1998). Medicinal flora of Indian cold desert. In *XXV International Horticultural Congress, Part 13: New and Specialized Crops and Products, Botanic Gardens and 523* (pp. 65-74).

Stamets, P., & Chilton, J. S. (1983). The mushroom cultivator. *First Washington*.

Swarnkar, G., Sharan, K., Siddiqui, J. A., Chakravarti, B., Rawat, P., Kumar, M., ... & Chattopadhyay, N. (2011). A novel flavonoid isolated from the steam-bark of Ulmus Wallichiana Planchon stimulates osteoblast function and inhibits osteoclast and adipocyte differentiation. European Journal of Pharmacology, 658(2-3), 65-73.

Syed, A. A., Lahiri, S., Mohan, D., Valicherla, G. R., Gupta, A. P., Riyazuddin, M., ... & Gayen, J. R. (2016a). Evaluation of anti-hypertensive activity of *Ulmus wallichiana* extract and fraction in SHR, DOCA-salt-and L-NAME-induced hypertensive rats. Journal of Ethnopharmacology, 193, 555-565.

Syed, A. A., Lahiri, S., Mohan, D., Valicherla, G. R., Gupta, A. P., Kumar, S., ... & Gayen, J. R. (2016b). Cardioprotective effect of *Ulmus wallichiana* planchon in β-adrenergic agonist induced cardiac hypertrophy. Frontiers in Pharmacology, 7, 510.

Tomar, A., & Kumar, D. (2018). Propagation of *Ulmus wallichiana* from divergent sources of north India. Indian Forester, *144*(12), 1162-1165.

Xiao, J., Capanoglu, E., Jassbi, A. R., & Miron, A. (2016). Advance on the flavonoid C-glycosides and health benefits. Critical Rreviews in Food Science and Nutrition, *56*(sup1), S29-S45.

Zhang, Y., & Huang, C. (2012). Targeting adipocyte apoptosis: a novel strategy for obesity therapy. Biochemical and Biophysical Research Communications, 417(1), 1-4.

Annexure-I

Consolidated and Audited
Utilization Certificate (UC) and Statement of Expenditure (SE)

For the Period: 01-11-2019 to 31-10-2022

1.	Title of the project/Scheme/Programme:	GAP-0250 (Promoting Conservation of Declining Life support Forest Tree Species in Himachal Pradesh)
2.	Name of the Principle Investigator & Organization:	Dr. Sanjay Kr. Uniyal CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, HP
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	GBPNI/NMHS-2019-20/MG, Dated: 11-10-2019
4.	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	**₹5630000.00**
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	**₹5805884.00** (Including Bank Interest ₹175884)
6.	Actual expenditure (excluding commitments) incurred during the project period:	**₹ 3284978.00**
7.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	**Nil**
8.	Balance amount available at the end of the project:	**₹ 2520906.00** (Including Bank Interest ₹1,75,884)
9.	Balance Amount:	**₹ 2520906.00** (Including Bank Interest ₹1,75,884)
10.	Accrued bank Interest:	**₹1,75,884.00**

Certified that the expenditure of **Rs. 3284978.00 (Rupees: Thirty two lakhs eighty four thousand nine hundred and seventy eight only)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator)

डॉ. संजय कुमार उनियाल
वरिष्ठ प्रधान वैज्ञानिक
पर्यावरण प्रौद्योगिकी विभाग
सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर-176061 (हि.प्र.)

Finance & Accounts Officer
CSIR-Institute of Himalayan
Bioresource Technology
Palampur-176061 (H.P.)
16/11/2023

(Signature of Registrar/ Finance Officer)

16/11/2023

(Signature of Head of the Institution)

निदेशक / Director
सी.एस.आई.आर.-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-IHBT
Palampur(H.P.) 176061 INDIA

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

[CSIR-Institute of Himalayan Bioresource Technology, Palampur, H.P.]

Statement showing the expenditure of the period from Sanction No. and Date : GBPNI/NMHS-2019-20/MG, Dated: 11-10-2019

1. Total outlay of the project : **₹14700000.00**

2. Date of Start of the Project : **01-11-2019**

3. Duration : **Three Years**

4. Date of Completion : **30-10-2022**

a) Amount received during the project period : **₹58,05,884.00** (including Bank interest ₹175884)

b) Total amount available for Expenditure : **₹58,05,884.00** (including Bank interest ₹175884)

S. No.	Budget head	Amount received	Expenditure	Amount Balance/ excess expenditure
1	Salaries	1500000.00	1463378.00	36622.00
2	Consumable	1350000.00	764521.00	585479.00
3	Contingency	280000.00	252608.00	27392.00
4	Travel	1650000.00	258675.00	1391325.00
5	Minor Field Equipment	700000.00	425796.00	274204.00
6	Institutional Charges	150000.00	120000.00	30000.00
7	Accrued bank Interest	175884.00	0.00	175884.00
8	**Total**	**5805884.00**	**3284978.00**	**2520906.00**

Certified that the expenditure of **Rs. 3284978.00 (Rupees: Thirty two lakhs eighty four thousand nine hundred and seventy eight only)** mentioned against Sr. No. 8 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator)

डॉ. संजय कुमार अग्रवाल
वरिष्ठ प्रधान वैज्ञानिक
पर्यावरण प्रौद्योगिकी विभाग
सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर-176061 (हि.प्र.)

Finance & Accounts Officer
CSIR-Institute of HImalayan
Bioresource Technology
Palampur-176061 (H.P.)
16/11/2023

(Signature of Registrar/ Finance Officer)

16/11/2023

(Signature of Head of the Institution)

निदेशक / Director
सी.एस.आई.आर.-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-IHBT
Palampur(H.P.) 176061 INDIA

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

Annexure-III

Consolidated Assets Certificate

Assets Acquired Wholly/ Substantially out of Government Grants
(Register to be maintained by Grantee Institution)

Name of the Sanctioning Authority: NATIONAL MISSION ON HIMALAYAN STUDIES (NMHS), GBPNIHE, Kosi-Katarmal, Almora - 263643, Uttarakhand, India.

1. Sl. No.
2. Name of Grantee Institution: CSIR-Institute of Himalaya Bioresource Technology
3. No. & Date of sanction order: GBPNI/NMHS-2019-20/MG
4. Amount of the Sanctioned Grant: INR 700000/-
5. Brief Purpose of the Grant: Procurement of equipment for pursuing the project objectives.
6. Whether any condition regarding the right of ownership of Govt. in the property or other assets acquired out of the grant was incorporated in the grant-in-aid Sanction Order: NA
7. Particulars of assets actually credited or acquired: GPS, Camera, SD card,
8. Value of the assets as on 08/08/23: 4,25,796/-
9. Purpose for which utilized at present: For project work (field surveys, data analysis, on-site awareness, capacity building, popularization, and dissemination)
10. Encumbered or not: Not
11. Reasons, if encumbered: N/A
12. Disposed of or not: Not
13. Reasons and authority, if any, for disposal: N/A
14. Amount realized on disposal: N/A

Any Other Remarks:

(PROJECT INVESTIGATOR)

(Signed and Stamped)

(FINANCE OFFICER)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Actual Purchased Cost	Purchase Details (Indent No.)
1.	Global Positioning System , Garmin eTrax 10	2	60200.00	Bill No. ANIPL/21-22/1796 DATED 09-11-2021; Bill No. 256 DATED 18-03-2021
2.	SD Card	1	3570.00	Bill No. ANIPL/21-22/1645 DATED 18-10-2021
3.	Camera, Nikon camera D-7500 18-140 VR Kit, Nikon Camera 24 MP DSLR	3	186699.00	Bill No. ANIPL/21-22/1643 DATED 18-10-2021; Bill No. 257 DATED 18-03-2021, Bill No. IHBT 2020/ 26767/ 1 DATED 28-01-2021
4.	Ravi Multimeter	3	9000.00	Bill No. 256 DATED 18-03-2021
5.	Rangefinder Clinometer	2	39255.00	Bill No. 256 DATED 18-03-2021; Bill No. PO/IHBT/2020/27485/ DATED 18-11-2020
6.	Tree Calipers	3	13500.00	Bill No. 256 DATED 18-03-2021
7.	Vanguard Bag	1	2500.00	Bill No. 267 DATED 18-03-2021
8.	Dell laptop (IHBT)	1	71247.00	Bill No. IHBT 2021/252/1 DATED 28-01-2021
9.	Video Camera	1	18199	Bill No. IHBT/2020/26769 DATED 03-11-2020
10.	Lux meter	1	10000	Bill No. GEMC-511687784636048 DATED 09-03-2021

11.	Voice recorder	1	5787	Bill No. GEMC 11687717064144 DATED 24-03-2021
12.	Beetal telephone	1	1349	Bill No. PO/2021/30867/1 DATED 13-10-2021
13.	Kettle	3	4490	Through GEM DATED 31-03-2021

(PROJECT INVESTIGATOR)

(Signed and Stamped)

(FINANCE OFFICER)

(Signed and Stamped)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Annexure-V

Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department

To,

The Convener, Mountain Division
Ministry of Environment, Forest & Climate Change (MoEF&CC)
Indira Paryavaran Bhawan
Jor Bagh, New Delhi-110003

Sub.: Transfer of Permanent Equipment purchased under Research Project titled "Bringing back the real green: eradicating invasive species and restoring ecosystems through community participation." funded under the NMHS Scheme of MoEF&CC – reg.

Sir/ Madam,

This is hereby certified that the following permanent equipment purchased under the aforesaid project have been transferred to the Implementing Organization/ Nodal Institute after completion of the project:

1. Global Positioning System
2. DDR (RAM)
3. LCD Projector
4. Display Screen
5. Camera

Head of Implementing Organization: Director
Name of the Implementing Organization: CSIR-IHBT
Stamp/ Seal:
Date: 11/07/23

Copy to:

1. The Nodal Officer, NMHS-PMU, National Mission on Himalayan Studies (NMHS), G.B. Pant National Institute of Himalayan Environment (NIHE), Kosi-Katarmal, Almora, Uttarakhand-263643

Annexure-VI

Details, Declaration and Refund of Any Unspent Balance

Please provide the details of refund of any unspent balance and transfer the balance amount through RTGS (Real-Time Gross System) in favor of **NMHS GIA General** and declaration on the official letterhead duly signed by the Head of the Institution.

Kindly note the further Bank A/c Details as follows:

Name of NMHS A/c:	NMHS GIA General
Bank Name & Branch:	Central Bank of India (CBI), Kosi Bazar, Almora, Uttarakhand 263643
IFSC Code:	CBIN0281528
Account No.:	3530505520 (Saving A/c)

In case of any queries/ clarifications, please contact the NMHS-PMU at e-mail: nmhspmu2016@gmail.com

Advances in Traditional Medicine
https://doi.org/10.1007/s13596-023-00729-8

SHORT COMUNICATIONS

Corylus jacquemontii Decne.: a promising lesser-known multipurpose tree species of the Himalayan region

Aradhna Bharti[1] · **Sanjay Kr. Uniyal**[1]

Received: 1 May 2023 / Accepted: 7 November 2023

Abstract
The article presents an overview of Indian hazelnut (*Corylus jacquemontii*)- a multipurpose threatened species of the Himalayan region of high traditional importance. The species is used as a medicine, fuelwood, fodder, and timber by the resident communities of Himalaya. The edible nuts of the species are nutrient-rich and have a high market value; they are collected and sold by the local people to earn hard cash. Further, a wide range of pharmacological properties that aid in the prevention of cardiovascular diseases, diabetes, and other oxidative stress-related disorders add to the importance of the species. The recent overexploitation for diverse purposes has threatened its survival and calls for multidisciplinary efforts for the conservation of the traditionally important Indian hazelnut.

Keywords Conservation · Indian hazelnut · Phytochemicals · Traditional uses

Introduction

Corylus jacquemontii Decne., commonly referred to as the Indian hazelnut, is a lesser-known yet highly valued taxon of the family Betulaceae. It is a medium-sized deciduous tree that can reach a height of 20–30 m (Gupta et al. 2019) and is distinguishable by its thin, dark grey bark. The bark scales detach at the base and exfoliate upwards (Osmaston 1978; Molnar 2011). Buds are hemispherical and relatively short while the leaves are alternate, 15–24 cm long, ovate or obovate, acuminate, irregularly lobed, with a cordate base and sharply serrate margins, and a 2–2.5 cm long petiole (Molnar 2011; Paul et al. 2019). The inflorescence is an elongated catkin. Male bracts are obovate and acute with 8 one-celled anthers on short filaments along the midrib. Female flowers are small and in short spikes comprising of numerous imbricate bracts (Brandis 1906; Osmaston 1978). Flowers grow in clusters and the involucre is coriaceous, much longer than the nuts, and supported by laciniate bracts (Brandis 1906; Sharma and Kumar 2000). Nuts are compressed, hard, and globose, with 1–5 involucres clustered around them and sheathed by lobed, deep brown bracteoles. The nuts mature during August to September (Fig. 1).

Distribution

The Indian hazelnut is endemic to the Himalaya and is distributed in Northeast Afghanistan, Northern Pakistan, Northern India, West Nepal, West Asia at elevations ranging from 1800 to 3300 m asl (Molnar 2011; Joshi et al. 2018). In the temperate Indian Himalaya, the species is reported from western Himalayan states of Uttarakhand and Himachal Pradesh, and the recently carved union territory Jammu & Kashmir. The species is particularly noted in Shimla, Kullu, Lahaul & Spiti, Chamba, and Kinnaur in Himachal Pradesh (Fig. 2), where it is locally referred to as Thangi, Bhotiya Badam, Urmani, Sharoli, and Sharod (Paul et al. 2019). It grows in shady moist areas in association with *Pinus wallichiana, Abies* sp., *Picea smithiana, Cedrus deodara, Betula utilis, Acer* sp., *Juglans regia, Fraxinus xanthoxyloids, Salix daphnoides*, and occasionally with *Parrotia* (Brandis 1906: Singh and Samant 2010).

✉ Sanjay Kr. Uniyal
suniyal@ihbt.res.in

[1] Environmental Technology Division, CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh 176061, India

Published online: 30 November 2023

Importance

Corylus jacquemontii is an important species of the western Himalayan region that supplies humans and wildlife with various ecosystem services from provisioning to regulating (Fig. 3). The fruits of the species that are highly sought after in the market are reported to be rich in proteins, carbohydrates, vitamins, polyunsaturated fatty acids and minerals including iron, calcium and potassium, etc. (Gupta et al. 2019). The nut paste is a common ingredient in a wide range of processed dairy and bakery foods and is also used in the manufacture of cosmetics and pharmaceuticals (Kumar et al. 2016; Joshi et al. 2018). In addition to humans, the nuts are also consumed by small rodents such as pika, flying squirrels, rats, and even Himalayan brown bears (Gupta et al. 2019). Also, the leaf litter of the Indian hazelnut harbours certain fungi such as *Cortinarius* sp. and *Lactarius* sp., thereby supporting macrofungal diversity, nutrient cycling and ecosystem growth (Semwal et al. 2018).

Traditional uses

The resident communities of the higher Himalayan ranges have been using the species for various domestic, edible and medicinal purposes and thus *Corylus jacquemontii* is of high traditional utility (Table 1). The species provides fuel for household energy needs and timber for construction purposes; the foliage is lopped for fodder (Chauhan et al. 2016) while the fruit rind is used to make camel dye (Gaur 2008; Paul et al. 2019). Medicinally, the fruit and leaves are used for treating diabetes in humans. At the same time, oil extracted from the seeds is used for relieving muscle pain (Chauhan et al. 2016; Rana et al. 2021). The nuts are edible and are primarily collected by the local people from forests for earning hard cash. They are sold in the market with prices ranging between Rs. 1200/- per kg in Killar (Chamba) to Rs. 1500/- per kg in Manali (Kullu). In Udaipur (Lahaul & Spiti), they are noted to be sold for Rs. 1300/- per kg (Rana et al. 2012; Paul et al. 2019). Hazelnuts are usually consumed whole, either raw or roasted and can also be added to a variety of dishes (Adnan et al. 2006; Kumar et al. 2018). A popular saying "*Pangi ki Thangi*," highlights the importance of the species in the Pangi region of Chamba district, Himachal Pradesh (Singh and Kumar 2017) where it is locally called *Thangi* and is highly used by *Pangwals* and *Bhots* (resident communities of Pangi) for food and other household purposes (Shaw et al. 2014; Subramani et al. 2014).

Phytochemistry

The species is less explored than other Himalayan plants of high utility. However, it is stated to contain various phytochemicals that are reported to have health benefits. The species abounds in phytochemicals and phenolic compounds having anti-oxidant, anti-carcinogenic, anti-mutagenic, and anti-proliferative properties (Kumar et al. 2016; Gupta et al. 2019).

Phenolic compounds

Phenolic compounds exhibit an array of biological activities and can be categorized into several subgroups, encompassing flavonoids, phenolic acids, tannins, and lignans. These compounds are known for their antioxidant properties and play a significant role in plant defence mechanisms (Kumar et al. 2016). They are also of interest for their potential health benefits when consumed through dietary sources rich in phenolic compounds. The diversity of chemical compounds in hazelnut includes apigenin, catechin, dimethylellagic acid, epicatechin, gallic acid, kaempferol rhamnoside, myricetin, *p*-coumaric acid, proanthocyanidin B (dimer), proanthocyanidin B (trimer), quercetin hexoside, quercetin rhamnoside, and syringic acid (Fig. 4). These compounds can lower the incidence of some malignancies, cardiovascular disease (CVD), coronary heart disease (CHD), stroke, atherosclerosis, osteoporosis, inflammation, and other oxidative

Table 1 Traditional uses of the species and the parts used

Plant Part(s)	Traditional uses	References
Leaves and fruits	The juice extracted after grinding the fruits and leaves is orally administered to treat diabetes in humans.	Rana et al. (2021)
Leaves and young shoots	As a fodder.	Chauhan et al. (2016)
Stem/bole	As a fuel and timber.	Gupta et al. (2019)
Seeds	The oil is massaged to cure muscle pain.	Paul et al. (2019)
Nuts	Consumed. Nut paste is used in a range of processed dairy and bakery products. Also, nuts are used in cosmetics and pharmaceuticals.	Kumar et al. (2016), Joshi et al. (2018)
Nuts	As a brain tonic.	Adnan et al. (2006), Samant et al. (2007), Kumar et al. (2018)
Fruit rind	To make camel dye.	Gaur (2008), Paul et al. (2019)

Table 2 Reported DPPH radical scavenging capacities of ethanolic extract of hazelnut
Source: Kumar et el. 2016

Conc. (µg/mL)	Hazelnut skin	Hazelnut hard shell	Hazelnut kernel	Ascorbic acid
20.0	40.06 ± 3.9	22.16 ± 1.9	7.50 ± 0.7	55.82 ± 1.4
40.0	77.87 ± 2.1	36.66 ± 3.7	17.76 ± 2.6	83.75 ± 1.4
60.0	92.95 ± 0.7	56.65 ± 3.4	24.79 ± 0.4	95.76 ± 1.
80.0	97.12 ± 0.9	79.10 ± 1.6	30.73 ± 1.6	97.17 ± 0.9
100	97.78 ± 0.5	92.57 ± 0.6	35.79 ± 0.5	99.45 ± 0.3
IC50	23.12 ± 1.4	51.32 ± 1.2	136.46. ± 0.9	11.18 ± 0.5.

stress-related diseases (Kumar et al. 2016). The plant is used against diabetes wherein the high phenolic content makes it an effective anti-diabetic agent by contributing toward free radical scavenging capabilities (Kumar et al. 2016).

Fatty acid

Corylus jacquemontii comprises of fatty acids containing carbon chains ranging from 14 to 22 carbons. In a study by Nengroo et al. (2022), it was reported that the predominant fatty acids were primarily unsaturated, constituting 91.86% of the total fatty acid composition. Among the unsaturated fatty acids, oleic acid was the most abundant, comprising 79.33% of the total fatty acids. Following oleic acid, the most prevalent fatty acids were linoleic acid, palmitic acid, and stearic acid, contributing 12.21%, 4.95%, and 2.10% to the overall fat content, respectively. Additionally, there were trace amounts of several other fatty acids such as myristic acid, pentadecanoic acid, heptadecanoic acid etc., each accounting for less than 1% of the total fat content. The seed oil of *C. jacquemontii* which is used in the pharmaceutical and cosmetic industry has an average of 60–80% oleic acid, 7–30% linoleic acid, 0.1–1% linolenic acid, 4–9% palmitic acid, 2.5% max stearic acid and 0.6% palmitoleic acid (Nengroo et al. 2022).

Pharmacological activities

The different parts of hazelnut are rich in polyphenols and flavonoids that have antimutagenic, anticarcinogenic, antimicrobial, and anti-allergic properties (Kumar et al. 2016; Rana et al. 2021). Catechin, present in hazelnuts, has been associated with safeguarding against various chronic diseases. Its potential mechanisms of action include antioxidant, anti-inflammatory, and vasoactive effects (Scalbert et al. 2005).

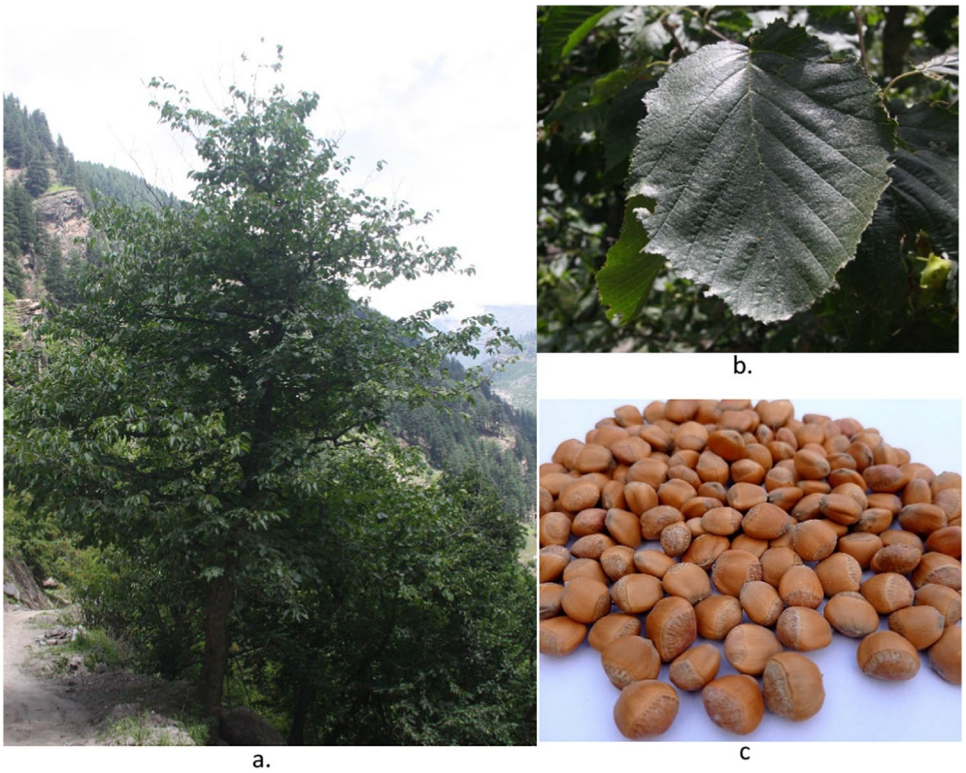


Fig. 1 Photographs showing *Corylus jacquemontii* **a** Tree **b** Leaf **c** Nuts

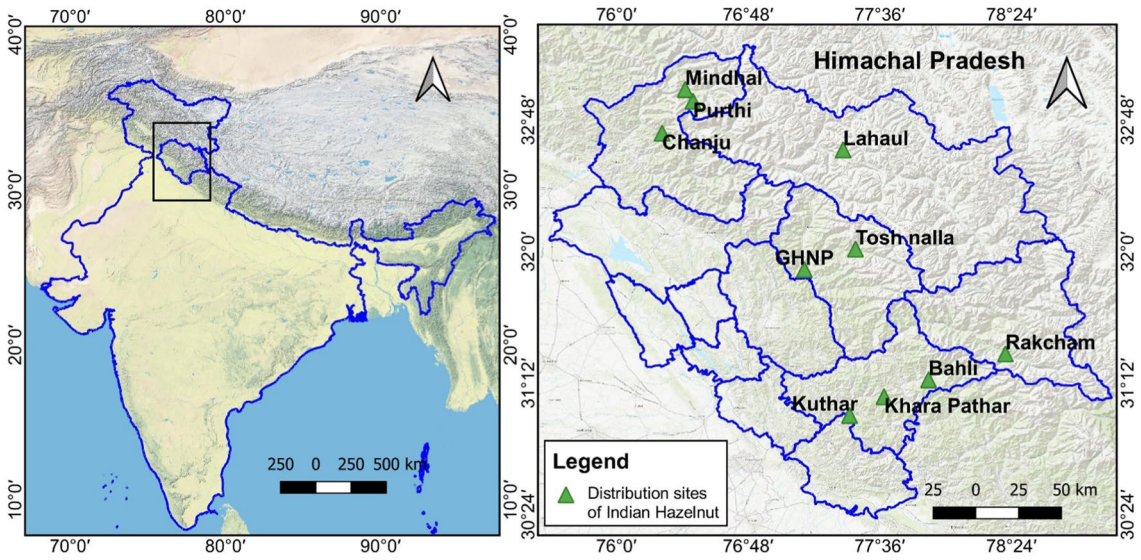


Fig. 2 Distribution of *Corylus jacquemontii* in the Indian Himalayan State of Himachal Pradesh

Anti-oxidative property

In an experimental study by Kumar et al. (2016), the highest phenolic concentration was found in 80% ethanolic skin extract, followed by hard shells and kernels. Accordingly, the maximum antioxidant potential was found in hazelnut skin extract (23.12 ± 1.4 µg/mL), followed by hard-shell (51.32 ± 1.2 µg/ mL), and kernel (136.46 ± 0.9 µg/ mL). The findings suggest that hazelnut kernels and their by-products have potential free-radical scavenging capability (Table 2).

Another study by Nengroo et al. (2022), reported the anti-oxidant potential of the seed extracts. At a concentration

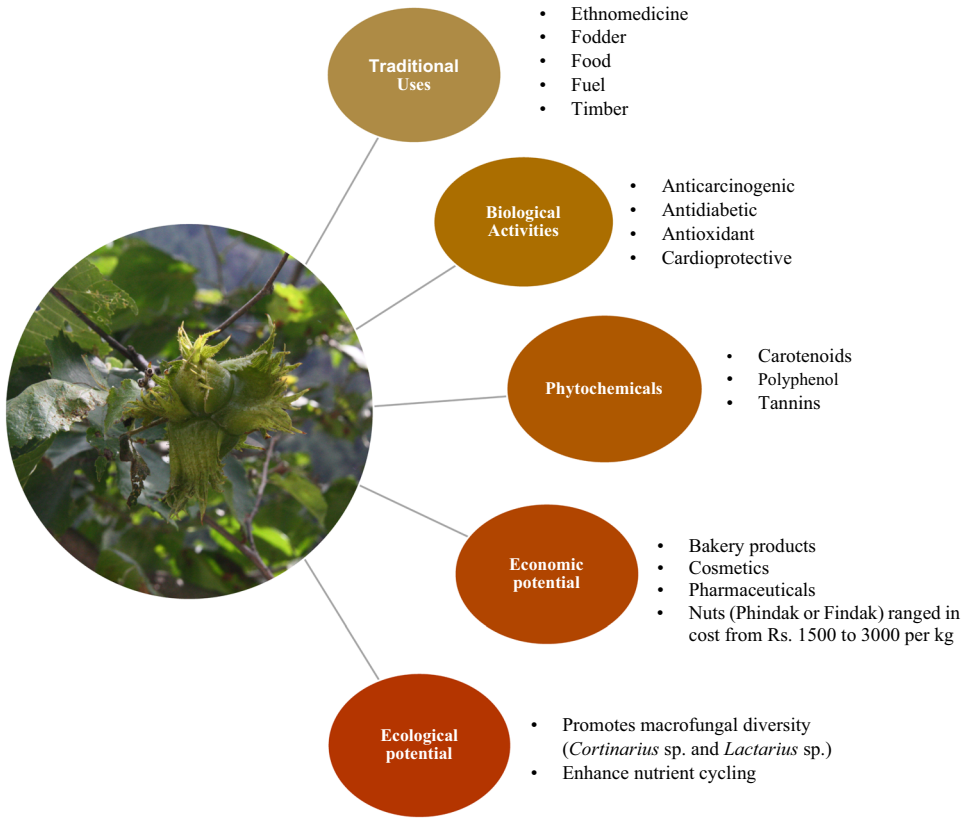


Fig. 3 Traditional uses, phytochemistry, and biological activities of *Corylus jacquemontii*

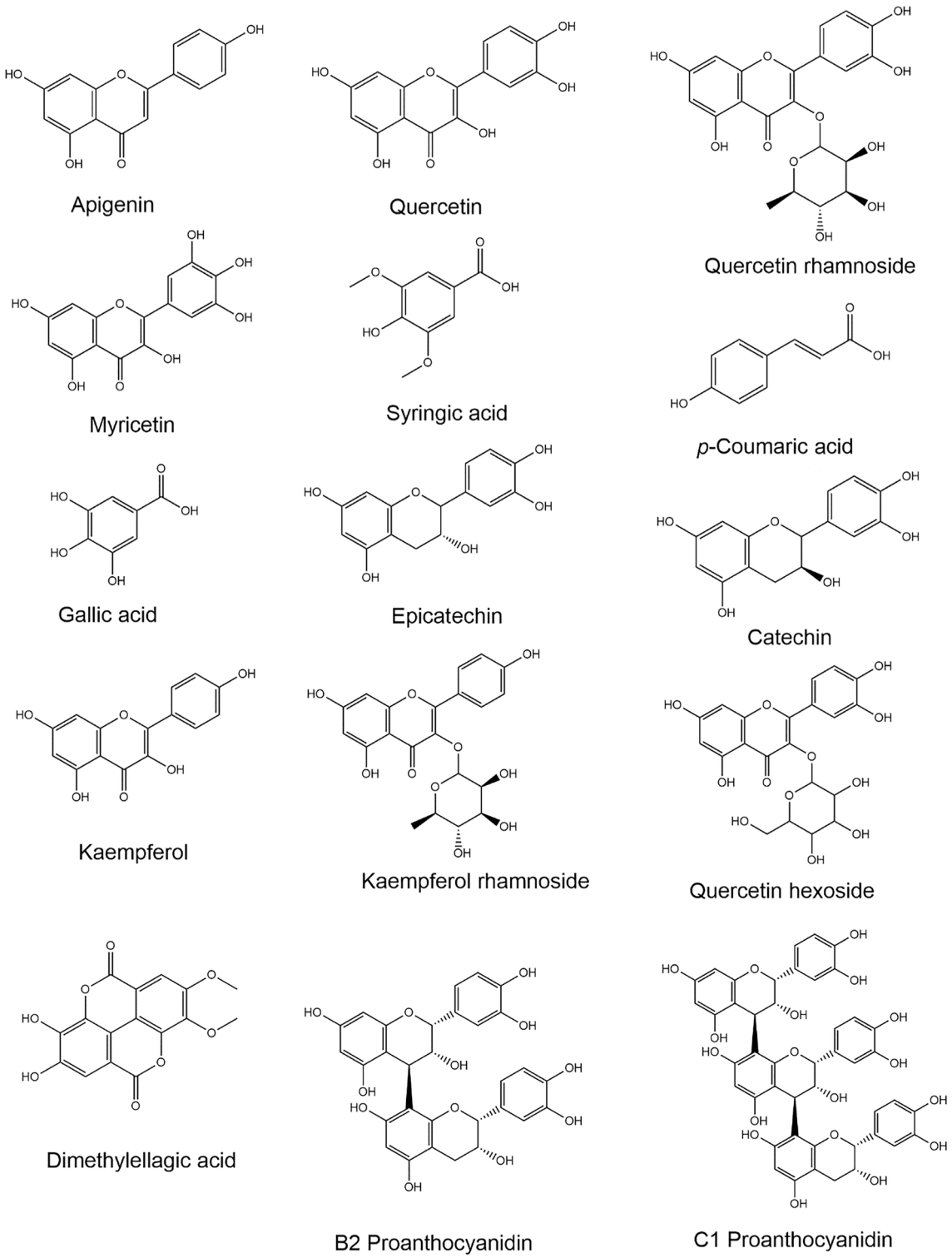


Fig. 4 Chemical structures of important phytochemicals present in *Corylus jacquemontii*

of 50 µg/ mL, the methanolic extract exhibited the strongest radical scavenging activity, with a value of 64.98%. The same was followed by the acetone extract (62.75%) and ethyl acetate extract (61.29%), when compared to butylated hydroxytoluene (BHT), which had an inhibition rate of 68.09%. Whereas, at a higher concentration of 100 µg/ mL, the methanol extract displayed the highest scavenging activity at 80.44%, followed by the acetone extract at

79.36%. In contrast, the ethyl acetate extract exhibited the lowest scavenging activity at 70.98%, as compared to BHT, which showed a scavenging activity of 83.63% (Nengroo et al. 2022). Further, the highest CAT (Activity of catalase) was observed in the case of methanol and acetone extracts while the highest APx (Activity of ascorbate peroxidase) was shown by the acetone extract (530 Ug-1 FM).

At the same time, the quantitative assessment of the antioxidant activity of the methanolic fraction extracted from leaves of *C. jacquemontii* revealed a dose-dependent colour change phenomenon. Essentially, the higher the quantity of plant extract used, the more pronounced the colour change, indicating greater antioxidant activity. Notably, when DPPH (2,2-diphenyl-1-picrylhydrazyl) was employed at a concentration of 150 µg/ mL and the extract was applied at 250 µg/ mL, a substantial colour shift towards dark black was observed. This observation underscores the significant impact of the extract's quantity on its antioxidant activity (Ur Rahman et al. 2023).

Cardioprotective activity

Cardiovascular disease (CVD) encompasses heart and blood vessel conditions, including coronary artery disease, heart failure, stroke, and hypertension with serious health implications. Cardiovascular diseases are a leading cause of morbidity and mortality worldwide (WHO 2023). Proanthocyanidins found in hazelnut are known to improve lipid homeostasis thereby having the potential to lower the risk of cardiovascular diseases. Studies have noted that regular consumption of food rich in procyanidin can improve endothelial dysfunction and reduce vascular oxidative stress, both of which are related to cardiovascular risk factors such as hypertension (Kumar et al. 2016). The intake of nuts is related to a reduced risk of cardiovascular diseases and cancer.

Antifungal activity

The antifungal activity of petroleum ether, ethyl acetate, acetone, and methanol seed extracts of *C. jacquemontii* against three fungal strains; *Aspergillus fumigatus, A. niger*, and *Penicillium marneffi* has recently been evaluated (Nengroo et al. 2022). A significant inhibitory effect was observed at a concentration of 20 µL of the extracts. When tested against *A. niger*, the methanol extract exhibited 16.78 mm (inhibition zone diameter), followed by the acetone extract at 16.12 mm, in comparison to the standard nystatin at 17.47 mm ($p < 0.05$). In case of *A. fumigatus*, the methanol extract demonstrated the highest inhibition of 19.23 mm, followed by the acetone extract at 18.40 mm. The petroleum ether extract yielded a 16.01 mm inhibition zone, and the ethyl acetate extract had a 15.76 mm zone while the standard nystatin had a larger 21.77 mm zone. Additionally, the inhibitory effect against *P. marneffei*, both methanol and acetone extracts displayed similar fungal inhibition, measuring 20.98 mm and 20.27 mm, respectively, while the petroleum ether extract showed an inhibition zone of 18.27 mm. In contrast, nystatin exhibited a larger inhibition zone diameter of 22.53 mm (Nengroo et al. 2022).

Antibacterial activity

The phytochemicals present in the species exhibit antibacterial activities (Ur Rahman et al. 2023). In a study, the methanolic leaf extract of *C. jacquemontii* was evaluated for its antibacterial potential at a concentration of 100 µg/ mL against *Escherichia coli*, *Salmonella typhi*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. The assessment was carried out by determining the percentage of Microbial Growth Inhibition (% MGI) and comparing it to the well-known antibiotic vancomycin. The findings indicated that the methanolic extract from the leaves displayed significant *in-vitro* antibacterial properties. The extract exhibited its highest inhibitory activity against bacteria in the order: *Pseudomonas aeruginosa* > *Escherichia coli* > *Salmonella typhi* > *Staphylococcus aureus* (Methicillin resistant) (Ur Rahman et al. 2023).

Conservation status

Reports indicate that the species is being lost at an alarming rate due to heavy extraction pressures (fuel, fodder, timber) that limit its growth and reproduction (Mehlenbacher 1991; Gupta et al. 2019). *Corylus jacquemontii* is a self-incompatible species that grows in isolated patches (Paul et al. 2019) and detailed population information on the species is yet not available. In Himachal Pradesh, 25 populations of the species have been reported from Lahaul & Spiti, Kinnaur, Chamba, and Kullu (Paul et al. 2019). The nuts that are routinely collected for self-consumption and sale in the local market adversely affect its regeneration. Due to the scarcity of seeds, regeneration is poor and only a small percentage of seeds can germinate into seedlings which too face severe trampling on account of nut collection and grazing by animals. Since only a few nuts germinate, their percentage conversion to saplings is limited. Also, the heavy weight of the nuts limits their wider distribution and spread. This has serious conservation implications that are further aggravated by the recent environmental changes. Thus, limited distribution coupled with heavy pressures on the species is threatening its survival. It is, therefore, important that conservation of the species is prioritized.

Measures and prospects

Recognizing the importance of the species, its inclusion into the agroforestry system as a horticultural crop must be seriously looked into. There is potential for hazelnut production in temperate regions of India, and with concrete and concentrated efforts, the crop can be commercialized. As the start, this calls for surveying and identifying Corylus populations in the Himalaya so that potential hazelnut production sites may be identified based on ecology and environment. This will require simulation and modern mapping techniques.

Considering the importance, there is a need to develop protocols for mass multiplication and the establishment and maintenance of nurseries for high-quality planting material of the species (Paul et al. 2019). Generating high-quality planting material rests on the characterization and identification of population(s) with best-desired traits (nuts, kernel quality, vigour, cropping potential, disease resistance, etc.). This may include grafting with superior Turkish varieties (*Corylus colurna*) for increasing nut yield (Rana et al. 2007, Sharma 2008).

Noting that the species occurs in higher altitudes and in limited area, afforestation and reforestation programmes are expected to benefit it (Sharma 2008). The mass planting of the species around habitation and in wild will not only aid in rejuvenation but also in ensuring the flow of ecosystem services (Joshi et al. 2018; Samant et al. 2007). Furthermore, active participation of stakeholders that includes local people, the Forest Department, Non-governmental Organizations (NGOs) is required for effective conservation, management and value addition of the species. Owing to its traditional medicinal uses, detailed quantitative chemical characterization and activity assessment become important.

Conclusion

The article addressed the issues and potential of *Corylus jacquemontii* as an important multipurpose tree species of high traditional and medicinal importance. Recognizing its traditional uses (medicine, fuel, fodder, dye, timber, edible) amongst the resident Himalayan communities, the species has the potential to improve the livelihood of the people along with the greening of the area. The promising findings of various studies suggest that the species should be pharmacologically investigated for active ingredients and associated health benefits. Because the plant has a high concentration of catechins and other phenolic compounds, it has the potential for developing novel products that promote human health. The pertinent threats to the species call for multidisciplinary efforts including social, cultural, institutional, and scientific for the conservation of this important lesser-known multipurpose tree species.

Acknowledgements The authors thank the Director CSIR-IHBT for the facilities and encouragement. Members of the Environmental Technology Division are acknowledged for their support. The Ministry of Environment, Forest and Climate Change is acknowledged for the funds through the NMHS.

Authors' contribution AB carried out literature survey, compilation, and draft preparation; SKU proposed the idea, guided the work, and prepared the manuscript.

Declarations

Ethical statement This article does not contain any studies involving animals performed by any of the authors. This article does not contain any studies involving human participants performed by any of the authors.

Conflict of interest Aradhna Bharti has no conflict of interest. Sanjay Kr. Uniyal has no conflict of interest.

References

Adnan SM, Khan AA, Latif A, Shinwari ZK (2006) Threats to the sustainability of Ethno-Medicinal uses in Northern Pakistan (a case study of Miandam Valley, district swat, NWFP Province, Pakistan). Lyonia 11:91–100

Brandis D (1906) Indian trees: an account of trees, shrubs, woody climbers, bamboos and palms indigenous or commonly cultivated in the British Indian empire. Archibald Constable and Co. Ltd, London

Chauhan PP, Nigam A, Santvan VK (2016) Ethnobotanical study of wild fruits in Pabbar valley, district Shimla, Himachal Pradesh. J Med Plants Stud 4:216–220

Gaur RD (2008) Traditional dye yielding plants of Uttarakhand, India. Nat Prod Radiance 7:154–165

Gupta D, Tiwari C, Rajput BS, Kumar S, Sharma D (2019) Natural regeneration status of Indian hazelnut (*Corylus jacquemontii*-Decne.) In Western Himalaya of Himachal Pradesh. J Pharmacogn Phytochem 8:327–331

Joshi SK, Ballabh B, Negi PS, Dwivedi SK (2018) Diversity, distribution, use pattern and evaluation of wild edible plants of Uttarakhand, India. Def Life Sci J 3:126–135. https://doi.org/10.14429/dlsj.3.12579

Kumar A, Kumar P, Koundal R, Agnihotri VK (2016) Antioxidant properties and UPLC–MS/MS profiling of phenolics in jacquemont's hazelnut kernels (*Corylus jacquemontii*) and its byproducts from western Himalaya. J Food Sci Technol 53:3522–3531. https://doi.org/10.1007/s13197-016-2329-2

Kumar P, Singh H, Ambrish K (2018) Traditional knowledge of medicinal and threatened plants used by the inhabitants dwelling in and around Sechu-Tuan nalla: a high-altitude wildlife sanctuary in Himachal Pradesh, Northwest Himalaya. Prospective on Biodiversity of India, pp 329–333

Mehlenbacher SA (1991) Hazelnuts (Corylus). Genet Resour Temp Fruit Nut Crops 290:791–838. https://doi.org/10.17660/ActaHortic.1991.290.18

Molnar TJ (2011) Corylus. Wild crop relatives: genomics and breeding resources. Springer, Berlin, pp 15–48. https://doi.org/10.1007/978-3-642-21250-5_2

Nengroo ZR, Azeem M, Parveen M (2022) Fatty acid composition, antioxidant, antifungal activities and functional group analysis of

Corylus jacquemontii seeds grown in Kashmir. Int J Plant Based Pharm 2(1):89–97

Osmaston AE (1978) Forest flora for Kumaon

Paul S, Samant SS, Lal M, Ram J (2019) Population assessment and habitat distribution modelling of high value *Corylus jacquemontii* for in-situ conservation in the state of Himachal Pradesh India. Proc Indian Natl Sci Acad 85:275–289. https://doi.org/10.16493/ptinsa/2018/49507

Rana D, Bhatt A, Lal B, Parkash O, Kumar A, Uniyal SK (2021) Use of medicinal plants for treating different ailments by the indigenous people of Churah subdivision of district Chamba, Himachal Pradesh, India. Environ Dev Sustain 23:1162–1241. https://doi.org/10.1007/s10668-020-00617-0

Rana JC, Pradheep K, Chaurasia OP, Sood S, Sharma RM, Singh A, Negi R (2012) Genetic resources of wild edible plants and their uses among tribal communities of cold arid region of India. Genet Resour Crop Evol 59:135–149. https://doi.org/10.1007/s10722-011-9765-7

Rana JC, Pradheep K, Verma VD (2007) Naturally occurring wild relatives of temperate fruits in Western Himalayan region of India: an analysis. Biodivers Conserv 16:3963–3991. https://doi.org/10.1007/s10531-007-9201-7

Samant SS, Pant S, Singh M, Lal M, Singh A, Sharma A, Bhandari S (2007) Medicinal plants in Himachal Pradesh, north western Himalaya, India. Int J Biodivers Sci Manage 3:234–251. https://doi.org/10.1080/17451590709618177

Scalbert A, Johnson IT, Saltmarsh M (2005) Polyphenols: antioxidants and beyond. Am J Clin Nutr 81:S215–S217

Semwal KC, Bhatt VK, Stephenson SL (2018) A survey of macrofungal diversity in the Bharsar region, Uttarakhand Himalaya, India. J Asia Pac Biodivers 11:560–565. https://doi.org/10.1016/j.japb.2018.09.006

Sharma OP (2008) Threatened plants of Jammu region, North-West Himalaya and strategies for their conservation. In: Special habitats and threatened plants of India. Envis Bulletin. Wildlife Institute of India, Dehradun, pp 37–40

Sharma SD, Kumar K (2000) Preliminary evaluation of hazelnut seedling trees native to India. In: International Congress on Hazelnut, vol 556, pp 29–36. https://doi.org/10.17660/ActaHortic.2001.556.3

Shaw K, Stritch L, Rivers M, Roy S, Wilson B, Govaerts R (2014) The red list of Betulaceae. Botanic Gardens Conservation International.

Singh H, Kumar P (2017) A brief overview of vegetation of Pangi valley (Chamba, Himachal Pradesh): a high altitude region of northwest Himalaya, India. Biosci Biotechnol Res Asia 14:625–630. https://doi.org/10.13005/bbra/2487

Singh A, Samant SS (2010) Conservation prioritization of habitats and forest communities in the Lahaul Valley of proposed cold desert biosphere reserve, north western Himalaya, India. Appl Ecol Environ Res 8:101–117. https://doi.org/10.15666/aeer/0802_101117

Subramani SP, Kapoor KS, Goraya GS (2014) Additions to the floral wealth of Sirmaur district, Himachal Pradesh from Churdhar wildlife sanctuary. J Threat Taxa 6:6427–6452. https://doi.org/10.11609/JoTT.o2845.6427-52

Ur Rahman A, Khan MA, Hazrat A, Farid A, Yahya M, Ullah I (2023) Phytochemical analysis and biological evaluation of methanolic leaf extract of *Corylus jacquemontii* decne. Sarhad J Agric 39(2):564–572

World Health Organization (2023) Cardiovascular diseases (CVDs). https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1