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.:	GBPI/NMHS-2019-20/MG

Date of Submission:	3	1	0	7	2	0	2	3
	d	**d**	**m**	**m**	**y**	**y**	**y**	**y**

PROJECT TITLE (IN CAPITAL)

PINE-OAK SYSTEM OF HIMALAYA: WATER CLIMATE AND PLANT BIODIVERSITY

Project Duration: *from* (**30.09.2019**) *to* (**31.03.2023**).

***Submitted to*:**
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***Submitted by*:**
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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

3	0	0	9	**2**	**0**	**1**	**9**
d	d	m	m	y	y	y	y

DPC: Date of Project Completion

3	1	0	3	**2**	**0**	**2**	**3**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Grant Ref. No.:	NMHS/MG/64						
ii.	Project Category:	Small Grant		Medium Grant	✓	Large Grant		
iii.	Project Title:	Pine - Oak system: Interactions with water, climate and plant biodiversity						
iv.	Project Sites (IHR States/ UTs covered) (*Location Maps attached*):	Uttarakhand and Himachal Pradesh (Location maps are attached as **Annexure –A**)						
v.	Scale of Project Operation:	Local		Regional	✓	Pan-Himalayan		
vi.	Total Budget:	……2.49…. (in Cr), As sanctioned.						
vii.	Lead Agency:	G B Pant National Institute of Himalayan, Environment (GBP-NIHE), Kosi- Katarmal, Almora, Uttarakhand.263643						
	Lead PI/ Proponent:	Dr. Sandipan Mukherjee, Sc-D, NIHE						
	Co-PI/ Proponent:	Dr. K. C. Sekar, Sc-F, NIHE Dr. Subimal Ghosh, Professor, IIT Bombay Dr. Sumit Sen, Associate Professor, IIT Roorkee Dr. Krishna Kishore Osuri, Associate Professor, NIT Rourkela Er. Vaibhav Gosavi, Sc-C, NIHE						
viii.	Implementing Partners:	IIT Bombay; IIT Roorkee; NIT Rourkela						
	Key Persons (Contact Details, Ph. No., E-mail):	Dr. Sandipan Mukherjee, Sc-D Head: Ladkah Regional Centre, NIHE, Leh, UT. Email: sandipan@gbphied.nic.in						

2. Project Outcomes

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

The Pine (*Pinus* Spp.) and Oak (*Quercus* Spp.) systems of central Himalayan are known to provide substantial ecosystem services to the people of hill and near plains. However, sub-daily to annual scale interactions of Pine and Oak ecosystems with microclimatic and environmental parameters are not investigated in detail. Since quantification of ecosystem responses to micro-climatic fluctuation is expected to be beneficial for sustainable management of plant biodiversity, a detail ecosystem level assessment of plant-water-and microclimatic interactions are carried out in this project. With this broad overarching aim, this study also verifies the conjecture that "Oak forests are having higher ecosystem services than the Pine forests and, Pine stands may systematically be replaced with Oak forests, and subsequently the paradigm of water, climate and biodiversity is expected to change significantly from its current state." The conjecture was primarily tested over the Kosi watershed area (~1800 km^2) of Uttarakhand and only biodiversity assessment was carried out in Sainj watershed area (~780 km^2) of Himachal Pradesh. The primary plant species distribution assessment indicates that out of total surveyed area under Kosi and Sainj-watersheds, Oak covers around 240 and 08 km^2 area, whereas Pine occupies around 750 and 44 km^2, respectively. In terms of ecosystem carbon exchange, both Pine (*P. roxburghii*) and Oak (*Q. leucotrichophora*) dominated ecosystems were found to be a sink of carbon (600-1000 gC/m^2 for Pine and 500-800 gC/m^2 for Oak). We have also identified a rainfall amount threshold for Pine and Oak-dominated ecosystems (10 ± 0.7 and 17 ± 1.2 mm, respectively) that resulted in highest ecosystem carbon assimilation in monsoon. Diurnal pattern of sap flux density of *P. roxburghii, Q. leucotrichophora,* and *Q. glauca* trees are calculated along with emphasis on Pine and Oak seasonal pattern of sap flux densities. The initial results indicated *P. roxburghii* has almost 1.5-2.0 times the sap flux densities than the other two *Quercus* species indicating higher water extraction by the *P. roxburghii* stands. When information network theory was used to identify micro-met controls effecting ecosystem carbon assimilation, we find that *P. roxburghii* dominated ecosystem is heat dominating while *Q. leucotrichophora* dominated ecosystem is moisture dominating at sub-daily scale. When plot scale water budget was estimated for *P. roxburghii* and *Q. leucotrichophora* dominated ecosystems, for an annual rainfall of 972 mm over Pine, the canopy interception loss is noted to be 199.9 mm whereas for a same amount rainfall over Oak, the interception loss was 182.9 mm indicating almost same interception loss. The surface run off characteristics of Pine plots indicated runoff under Pine stands is primarily due to lateral subsurface flows whereas due to higher water holding capacity, runoff under Oak is primarily due to infiltration excess. Moreover, numerical simulations of land surface conditions using Noah-MP model for needle leaf trees over the Kosi-watershed could produce better land surface processes close to observations. The overall inference of this study indicates that *P. roxburghii* dominated ecosystems are better sink of carbon at the cost of higher loss of surface and ground water, consequently, *Q. leucotrichophora* dominated ecosystems are better for soil and water conservation as envisaged by the traditional knowledge.

2.2. Objective-wise Major Achievements

S#	Objectives	Major achievements (***in bullets points***)
1.	Assessment of Pine and Oak forest distribution under a warmer climate over Himalaya	• A thorough assessment of plant diversity over Kosi-watershed area is completed. • Similarly, plant diversity over Sainj watershed area is also completed. **Method used and results are presented in Part-B.** • In addition, identification of the species collected during field survey is also completed. **Details are provided in Annexure-B.** • Ecological integrity assessment is under process.
2.	Assessment of hydrological budget of Pine-Oak dominated watersheds and future scenarios under a warmer climate	• A thorough quantification of water yield of Pine and Oak ecosystem is completed. • Alongside, rainfall partitioning into throughfall and stemflow is also quantified to estimate interception loss from both Pine and Oak dominated micro-watershed. • In order to quantify the contributions of different LULCs to runoff generation in the upper Kosi River catchment, SWAT model is used to simulate the runoff in different sub-catchments. • Surface run-off, infiltration and leachate characteristics of Pine and Oak dominated micro-watersheds are compared using storm event based measurements. Associated methodologies and results are presented in **Part-B**. • Field survey for spring geo-tagging and instantaneous discharge measurement is completed at the Oak Forest Site (Shitlakhet). A total of 18 springs are geo-tagged. Details are provided in **Annexure-C.**

3.	Assessment of microclimate variability of Pine-Oak dominated forests and future changes under a warmer climate and its societal implications. 3.1. Comparison of Pine and Oak ecosystem exchange and transpiration using sap flow observations under limiting meteorological conditions for two sites of watersheds. 3.2. Regional scale climate modeling for IHR including three sites of two watersheds including high resolution data assimilation.	• A detailed comparison of daily to seasonal scale ecosystem fluxes is accomplished. Impact of different micro-meteorological parameters on net ecosystem carbon exchange is also identified on daily scale for Pine and Oak. • Impact of varying rainfall spells and amount on ecosystem carbon exchanges of Pine and Oak is also quantified. • Further, a Vegetation Photosynthesis and Respiration (VPRM) model is simulated during the period of 2011–2020 for Pine dominated ecosystem and calibrated with field observations. • Apart from the ecosystem carbon exchange measurement, a detailed assessment of stand level transpiration of *P. roxburghii*, *Q. leucotrichophora*, and *Q. glauca* trees is also completed. Furthermore, relationship between soil CO2 efflux with varying rainfall spell and amount is also established for Pine and Oak dominated sites. Methodologies used and results are presented in **Part-B.** • Numerical simulations of land surface conditions using Noah-MP model for needle leaf trees over the Kosi-watershed could produce better land surface processes close to observations for the duration of 2011-2021. **Detailed results are provided in Part-B.**
4.	Assessment of eco-hydro-climatological processes with information theory-based process network and understanding resilience under shock.	• The networks of eco-hydro-meteorological variables obtained from in-situ flux tower observations of Pine and Oak dominated ecosystems are developed using the information theory-based Temporal Information Partitioning Network (TIPNet) approach. • The micro-meteorological drivers affecting carbon uptake of Oak and Pine ecosystems of the Himalayas with half-hour temporal resolution flux tower data are also identified. **Detailed results are provided in Part-B.**

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:
	Assessment reports on Pine and Oak transpiration rates of Himalaya linking with water balance and recharge of ground water/springs (3 representative sites)	Database on Pine and Oak transpiration rates (Nos.)	Transpiration data for Pine (Particularly, *Pinus roxburghii*) and 2 Oak species (Particularly, *Quercus leucotrichophora* and *Quercus glauca*) is available from Nov, 2020 to 31st, March, 2023.	A manuscript on comparative estimates of transpiration and their links with micro-met parameters is under preparation.

	New hydro-meteorological database of two (02) watersheds in three (03) IHR States in GIS format;	Hydro-meteorological database (No.) Number of spring Geo-tagged (nos.)	• 10 Hz carbon and water flux data is available for the duration of 1-Jan-2014 to dec, 2022 for Pine dominated forest. • 10 Hz carbon and water flux data is available for the duration of 22-April-2016 to till date for Oak dominated forest in Gangolihat, Pithoragarh, Uttarakhand with data gaps. • A total of 18 springs are geo-tagged at Shiltakhet region.	Hydro-met watershed is developed for Kosi and Hat-Kalika watersheds.
	High-resolution land and climate model products (1970 - 2099);	Climate Model products (Nos.)	• Noah-MP, a new generation of LSM, simulations are generated for ST, SM, and energy fluxes and compared with the *in-situ* observations for 2011-2021. • High-resolution land data assimilation system (HRLDAS) derived land surface products, including SM and ST, are prepared, such data are not currently available for the Himalaya region.	NA
	Technical reports on Ecological integrity of two dominant forests;		• Ecological integrity assessment for two dominant forest types is under progress.	NA
	At least 08 Knowledge products: 04 quality research publications including journal articles, 02 book chapters, and 03 policy briefs.	Reports/Research articles/Policy documents prepared and published (Nos.)	**Journal articles:** 03-published; 02-submitted; 02- under preparation. **Book chapters:** 01-published. 01- Conference abstract compendium. **Conference publication:** 07 - National	NA

			04 - International **Policy briefs:** Under preparation.	

*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*:	• 02-watersheds are investigated for current and future plant distribution • 03-tree species investigated for sap flow / ET variability • 02-Himalayan ecosystems investigated for soil CO_2 flux comparisons • 02- Himalayan ecosystems investigated for surface run-off, leachate and infiltration characterization.	NA
2.	New Ground Models/ Process/ Strategy developed, *if any*:	• 02 ground models for measuring surface run-off from Pine and Oak dominated systems are established. • 02 number of 1st order stream monitoring stations established over Pine and Oak dominated ecosystems.	NA
3.	New Species identified, *if any*:	Nil	
4.	New Database established, *if any:*	4	-
5.	New Patent, *if any*:	Nil	-
	I. Filed (Indian/ International)	Nil	-
	II. Technology Transfer, *if any*:	Nil	-
6.	Others, *if any*	-	-

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.	Grid-wise (2 x 2 Km) vegetation and soil data produced for Kosi and Sainj watershed.	Pine-Oak distribution and dynamics over Himalayan region have been carried by targeting individual forest type (Singh and Singh, 1987). Moreover, soil dynamics have also been reported several times (Joshi et al., 1991, Pandey et al., 2018). However, stratified sampling using grid based approach is used for the first time in this study to assess plant diversity of Kosi and Sainj watersheds.	The baseline data on plant diversity and distribution over Kosi and Sainj watershed would work as primary database for further long-term monitoring and conservation of Oak forests under the climate change scenario.
2.	Sap flow derived transpiration data of Pine (*P. roxburghii*) and Oak (*Q. leucotrichophora* and *Q. glauca*)	Apart from the data generated from this project, no data is available on transpiration of Pine and Oak systems in India, as of now. However, a research was carried out in central Himalaya, Nepal where transpiration rate of *P. roxburghii* was reported (Ghimire et al., 2014).	Data on Pine-Oak stand level transpiration would work as baseline data to provide insights of water use pattern of Pine and Oak trees and. are expected to highlight role of environmental conditions on governing the water cycles of Pine and Oak stands of Himalaya.
3.	Hydrological database (02 ground models for measuring surface run-off from Pine and Oak dominated systems are established; and 02 number of 1st order stream monitoring stations established over Pine and Oak dominated ecosystems of Uttarakhand)	Previous studies on natural forested watersheds are many, though these studies fail to provide much insight into hydrological processes (Negi 2002). However, a paired micro-watershed study between Oak-dominated and Pine-dominated forests in Central Himalayas reported the annual water yield of the Pine and Oak watershed (Kumar and Verma 1991). More recently, Qazi (2020) reported a micro-watershed study from a dense Oak watershed and a degraded Oak watershed. But studies comparing specific forest species (Pine and Oak) have not been replicated in recent decades. In this study, run-off plot experiments for understanding runoff generation mechanism and micro-watershed monitoring for hydrological assessment have been conducted in a paired micro watershed dominated by Pine and Oak forests of the upper Kosi river catchment in the Kumaon Himalayas in Uttarakhand.	The baseline data would be helpful in understanding of biophysical linkages between a warming climate and hydrologic regimes by development of a comprehensive data-based mechanistic water balance model. The study of eco-hydrological responses of two dominant land uses (Oak and Pine) would provide aid to decision making and devise state wide mitigation strategies towards soil, water and ecology conservation in the Indian Himalayan region.

4.	Soil efflux data (02-Himalayan ecosystems investigated for soil CO_2 efflux comparisons in Uttarakhand)	Previous studies on soil efflux of Pine and Oak ecosystem are analysed individually. However, long term monitoring and comparison of ecosystem fluxes along with soil efflux are seldom evaluated for Pine and Oak ecosystem.	The generated data would be beneficial for predicting rate of CO_2 emissions and sequestration of two contrasting forest type to suggest effective CO_2 emissions reduction and mitigative measures under a rather warmer scenario.

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	1. A webinar cum consultation meeting was organised with all PI/Co-PIs. The webinar was chaired by Prof. V.K. Gaur, Hon. Scientist, CSIR-4PI, Bengaluru.	The webinar was organised to provide information about the baseline data available and to discuss methodologies for implementation of the project.	**-**	**-**	**02**	**12**
		1. As a part of Azadi ka Amrit Mahotsav, a workshop entitled "Biosphere- atmosphere-hydrosphere interaction. Status, challenges and way forward" was organised at GBP-NIHE in hybrid mode held on 14-Dec-2021.	The workshop was organized with the rationale that the extremely complex topography along with heterogeneously distributed forests of Indian Himalayas results in non-linear interactions amongst biosphere – atmosphere – hydrosphere regimes which are further expected to change under a warmer climate.	**-**	**-**	**05**	**35**
2.	On-Field Trainings	**1.** A training cum demonstration programme was organised at GIS, Hawalbagh for school students on the occasion of world water day, 22 march, 2022.	The training was organised for on-field demonstration of augmented sensors for water budget estimation and transpiration calculation.	**-**	**-**	**25**	**49**
3.	Skill Development	NIL	-	-	-	-	-
4.	Academic Supports	NIL	-	-	-	-	-

	Others (if any)	**1.** A lecture on "land-atmosphere interactions: An application to dynamic modelling" was delivered by Prof. Subimal Ghosh, IIT-Bombay, at GBP-NIHE on 20th May, 2022.	To share the knowledge on land atmosphere interactions and to dicuss how the stress from the global change have impacts on biosphere and affects the future trajectory using information theory based approach.	-	-	10	**35**
		1. A project end national conference entitled ***Land-Atmosphere Interactions Controlling Weather & Climate: Applications of Numerical Models and Observations (LAI-2023)*** was organized in NIT Rourkela during 9-12 January, 2023.	The conference was organised with the aim to bring together experts from various fields to discuss latest research and development in land-atmosphere interactions and their role in controlling weather and climate.			10	Total abstracts received - **70** Number of presentations - **61** Not participated - **9**

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	SDGs – 6 (Clean Water), 13 (Climate Action), and 15 (Life on Land) are addressed through 05 skill development and knowledge dissemination activities.	Total = 192
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:	Shitlakhet and Papoli Gram Panchayat, Almora, Uttarakhand	NA
2.	Govt Departments (Agriculture/ Forest/ Water):	Forest Department of Uttarakhand	NA
3.	Villagers/ Farmers:	-	-
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)

The consolidated and audited Utilization Certificate (UC) and Year-wise Statement of Expenditure (SE) attached as **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.	Sap Flow Analyser (12) with accessories (GBPNIHE)	SF-L type sap flow analyser. (Ekomatic, Germany)	Rs. 25,34,414/- (with GST)	Three sap flow sensors installed in Pine trees at GBP-NIHE got destroyed in forest fire during 2022. Remaining 9 sap flow sensors would be dismantled from the sites and reinstalled in some other tree species.
2.	Soil CO_2 analyser (02) (GBPNIHE)	EOS-FD, Eosense, Canada	Rs. 10,40,371.5/- (with GST)	Both the sensors would be reinstalled in some other location to estimate soil efflux of grassland.
3.	Plot Lysimeter setup Water Level Recorder: 0.5M and flume (IIT-R)	Local Fabricated with Xtreem Capacitance Water Level Recorder	Rs. 1,81,200/- (without GST)	All the instruments installed for estimation of hydrological budget would be remained installed in Pine and Oak site till 2024 to provide support for Ph.D of Mr. Denzil Daniel.
4.	Two river/stream gauging with depth, conductivity and temperature sensors and accessories (IIT-R)	Local Fabricated with Odyssey sensors	Rs. 2,34,200/- (without GST)	
5.	Soil Moisture Sensors (6 sets of 3 sensors each.) with data loggers (IIT-R)	Acclima (TDR310H)	Rs. 9,45,000.00	
6.	Raingauge with logger (2) And PAR sensors(IIT-R)	Rainwise with Hobo pendant logger(Tipping bucket raingauge) and Apogee instruments (Quantum sensor)	Rs. 11,27,000/-	

7.	Throughfall collection system (troughs, supporting frames, tank)(10)(IIT-R)	Fabricated indigenously		
8.	Stemflow collection system (PVC collar, tubing, tank)(6) (IIT-R)	Fabricated indigenously		
9.	Field Laptop (IIT-R)	Lenovo(20RV (Lenovo Think Book 14-IML U))		
10.	One Laptop	Lenovo	Rs. 68500.00 /- (with GST)	Purchased at GBP-NIHE, Kosi-Katarmal Almora and Will be kept with PI.
11.	One PC (NIT-R)	--	Rs. 72,299/- (with GST)	Purchased at NIT, Rourkela for modelling and Will be kept with Co-PI.

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:	*2*	***Details are provided in Annexure-A.***
2.	Project Sites/ Field Stations Developed:	*07*	
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	*05*	
4.	Livelihood Options promoted	-	
5.	Technical/ Training Manuals prepared	*02*	*01 – EC flux analysis manual* *02- EC flux footprint analysis manual*
6.	Processing Units established, if any	*NA*	*NA*
7.	No. of Species Collected, if any	*110*	***Detailed list is attached as Annexure-B.***
8.	No. of New Species identified, if any	*NIL*	*NA*
9.	New Database generated (Types):	*4*	***Under progress***
	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		

S#	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal – Research Articles/ Special Issue:	-	3- Published 2-submitted 2-under preparation	10.23 (Published)	*Copies of the manuscripts are attached as* ***Annexure-D.***
2.	Book – Chapter(s)/ Monograph/ Contributed:	1-Conference abstract compendium	1-Book Chapter	-	*Copy of the book chapter is attached in* ***Annexure-D***.
3.	Technical Reports:	01	NIL	-	Ecological Integrity Assessment under preparation
4.	Training Manual (Skill Development/ Capacity Building):	02	-	-	Under Preparation
5.	Papers presented in Conferences/Seminars:	7	4	-	
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:	The initial findings of the project would be useful in providing scientific basis to the plantation and conservation strategies for Pine-Oak forests of central Himalaya.
Replicability of Project/ Way Forward:	The novel research insights would provide the baseline data to undertake qualitative/quantitative analyses of water-climate-biodiversity dynamics in the Central Himalayan Pine-Oak system. Furthermore, long term monitoring and conservations of identified Oak forests in near future would be useful in combating the climate change impact on carbon and water of the region.

Exit Strategy:.	Dissemination of the knowledge products (Research article and policy brief) generated from the project would be helpful in providing the scientific understanding on water use and carbon sequestration pattern of Himalayan Pine-Oak systems and their responses under changing climate scenario.

21/7/23

(PROJECT PROPONENT/ COORDINATOR)

(Signed and Stamped)

प्रमुख / Head
लद्दाख क्षेत्रीय केन्द्र / Ladakh Regional Centre
गो० ब० पंत राष्ट्रीय हिमालय पर्यावरण संस्थान
G.B. Pant National Institute of Himalayan Environment
लेह, लद्दाख (के०शा०प्र०) / Leh, Ladakh (UT)

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

निदेशक / Director
गो०ब० पन्त राष्ट्रीय हिमालय पर्यावरण संस्थान
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Place: ALMORA
Date: 26/07/2023