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/SG

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

PROJECT TITLE (IN CAPITAL)

HIGH RESOLUTION SPATIAL MAPPING OF BIRD PHENOLOGY AS AN INDICATOR OF ECOSYSTEM HEALTH IN RELATION TO CLIMATE CHANGE IN HIMALAYA

Project Duration: *from* (**10.10.2019**) *to* (**28.02.2023**).

***Submitted to*:**
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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

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

DPC: Date of Project Completion

2	8	0	2	**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.:	GBPNI/NMHS-2019-20/SG						
ii.	Project Category:	Small Grant	Yes	Medium Grant		Large Grant		
iii.	Project Title:	**High Resolution Spatial Mapping of Bird Phenology as an Indicator of Ecosystem Health in Relation to Climate Change in Himalaya**						
iv.	Project Sites (IHR States/ UTs covered) (*Location Maps attached*):	Himachal Pradesh. The two sites covered within Himachal Pradesh were Bilaspur district and the Great Himalayan National Park Conservation Area (in Kullu district). See Annexure VII for location maps. Bilaspur district - nestled in the Shivalik hills, it is a gateway for migrants to both the plains and the mountains. With an elevational range between 324 - 1773 m, it hosts a variety of habitats, fed by seasonal rains and the Sutlej. Great Himalayan National Park Conservation Area is a protected area network composed of the Great Himalayan National Park, Tirthan Wildlife Sanctuary, Sainj Wildlife Sanctuary, as well an Ecozone, all located within Kullu district. With an elevational range between approx. 1400 - 6000 m, it is largely untouched by human setllements (barring the Ecozone), with four rivers running through it - Jiwa Nal, Sainj, Tirthan and Parvati. See Annexure VIII for site photographs.						
v.	Scale of Project Operation:	Local	Yes	Regional	Yes	Pan-Himalayan		

vi.	Total Budget:	Rs. 0.3990160/- crore (Rupees Point Three Nine Nine Zero One Six Zero Crore)
vii.	Lead Agency:	Government College, Kosrian Sector, Bilaspur-174001, Himachal Pradesh, India
	Lead PI/ Proponent:	Dr. Kuldeep Singh Barwal
	Co-PI/ Proponent:	Dr. Randeep Singh, Dr. Puneet Pandey, Dr. Harminder Pal Singh
viii.	Implementing Partners:	Amity University, Sector 125, Noida (Uttar Pradesh) and Panjab University Chandigarh
	Key Persons (Contact Details, Ph. No., E-mail):	Randeep Singh (Amity Institute of Forestry and Wildlife (AIFW), Amity University, Sector 125, Gautam Buddha Nagar, Noida - 201313, Uttar Pradesh, India, +91 9643210059, rsingh@amity.edu) Puneet Pandey (Conservation Genome Resource Bank for Korean Wildlife (CGRB), Research Institute for Veterinary Science and College of Veterinary Medicine, Seoul National University, Seoul, Republic of Korea, +91 8368702446, puneet.pandey09@gmail.com) Harminder Pal Singh (Department of Environment Studies, Panjab University, Sector 14, Chandigarh - 160014, India, +91 9878942694, hpsingh_01@pu.ac.in)

2. Project Outcomes

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

Background: Flycatchers are behaviourally linked to the availability of invertebrates in an area for aspects like breeding and migration, and phenological changes can affect them.

Objectives/Aim:

1. To map the forest/vegetation phenology traits using satellite remote sensing data.

2. To study synchrony between forest phenology, food abundance and flycatchers breeding timing,

3. To project the broad-scale changes in plants phenology under future climate change using IPCC emission scenarios in Himalayas.

4. To develop a protocol for monitoring of plant phenology and flycatchers breeding timing in the Himalayas and disseminate results with local communities.

Methodology/Approach: Point counts, trail transects, vegetation sampling, camera trapping, audio recording, and data loggers were used for collection of data. Satellite data coupled with this data were used for producing forest phenology/landuse cover map. Preparation of bird phenology maps involved filtering of interactions of between invertebrate, plant and flycatcher species, and species distribution modelling using an iterative process.

Approach: Repeated manual surveys at stratified random sampling sites were done across the landscape, supplemented by arboreal autonomous sensors, and survey of non-survey-sites with potential habitat for Flycatchers. Breeding ecology of Flycatchers were studied in relation to phenology of invertebrates and plant phenology.

Results/Outcomes: A forest phenology map/land-use cover map of the Bilaspur has been prepared. Inventory of flycatchers, plant, and invertebrates were carried out for both sites.

Conclusion: Majority of the objectives were achieved, with some not being achieved due to logistical, time and technical constraints.

Recommendations/ Way Forward with Exit Strategy: Employing citizen science and forest department employees to collect data through the years will help in creating phenology maps with better temporal resolution. Making these sampling sites permanent for continuous monitoring of phenological traits would be helpful for long-term studies on the subject.

Conclusions: Data collection and analysis were successful within project constraints.

2.2. Objective-wise Major Achievements

S#	Objectives	Major achievements (***in bullets points***)

1.	To map the forest phenology traits using satellite remote sensing data.	● A forest phenology map of less than 1:10,000 scale (better than expected since the resolution is higher) has been prepared for Bilaspur district (see annexure IX). ● Javascript codes for supervised classification and accuracy assessment in Google Earth Engine has been compiled, and tested for replication over time and space so that we can get multiple maps of forest phenology in the study sites.
2.	To study synchrony between forest phenology, food abundance and flycatures breeding timing.	● The Inventory on plant and invertebrate biodiversity and abundance, in and outside sampling cells, has been completed for several taxa (such as butterflies) in both the study sites. Inventory and collection of detection data were made for birds in both studies (see annexures X to XVII). ● Species distribution models were developed to understand the synchrony between forest phenology, invertebrate (food) abundance and flycatchers breeding time. Exhaustive review of literature has been made for breeding and feeding ecology of flycatchers in the study sites (see annexures XVIII and XIX) ● The sympatric breeding ecology of two morphs of *Terpsiphone paradisi* (Indian Paradise-flycatcher) has been fully captured in a orchard farm in GHNPCA using manual observations, camera traps, Audiomoths, and data-loggers (see annexure XVIII). These outputs from these autonomous recorders and a manual document has been added as annexures XX and XXI respectively.

3.	To project the broad-scale changes in plants phenology under future climate change using IPCC emission scenarios in Himalayas.	● Distribution modelling (as a proxy for phenological changes such as flowering) of three plant genera/species were carried out as part of species distribution modelling of flycatchers under future climate change IPCC emission scenarios in Himalayas (see annexure IX).
4.	To develop a protocol for monitoring of plant phenology and flycatchers breeding timing in the Himalayas and disseminate results with local communities by conducting stakeholder workshops and training.	● Protocol has been developed, however it needs to be made in the form of a use guide for dissemination and ideally includes inventory of plants and invertebrates with identification keys. ● Two stakeholder workshops were carried out for the forest department in Kullu district (see annexure XXII for images from workshops). ● One paper has been published, one is under review, and another is under revision. Papers related to Flycatcher phenology are under preparation.

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 availability of food resources and their abundance for birds. Database on Flycatchers breeding. Report on tree phenology, insect breeding and flycatchers	Database on forest phenology, food resources, flycatchers breeding	Databases of irruption of insects during breeding season/active season has been compiled along with that of plants. Flycatcher breeding has been studied and a report on the same has been elucidated in this	Although identification of several plant and invertebrate taxa have been completed, we are found it difficult to find suitable experts for some cryptic and understudied taxa. We will seek help at the Zoological Survey of India for such taxa. However, as adviced by a researcher who

	breeding timing.		FTR.	worked in GHNPCA on invertebrates, we may have to travel to the location, in which case we may use a superficial form of classification such as “small-sized grasshopper”, “medium-sized grasshopper”, and “large sized-grasshopper” etc. for analyses since the species themselves may be insignificant compared to body size for the Flycatchers. This is because of constraints of travelling just for identifications. Citizen science platforms and social media groups has aided the process of identification. We did not install nest-boxes, but instead studied the Flycatcher’s natural nests, because 1) preparation and carrying nest boxes to breeding sites is often difficult 2) they don’t

				seem to use artificial nests of any kind, such as abandoned boxes or cavities in artificial structures.
2	A high-resolution map of forest phenology at 1:10,000 scale. Detailed tree phenology change map with respect to different IPCC emission scenarios.	Develop tree phenology change map	A forest phenology/land use map of less than 1:10,000 scale has been prepared for Bilaspur district. Distribution modelling (as a proxy for phenological changes such as flowering) of three plant genera/species were carried out as part of species distribution modelling of flycatchers under future climate change IPCC emission scenarios in Himalayas.	The resolution is better than expected since the resolution is higher. This can be resampled to 1:10,000 scale if necessary without losing much accuracy. The imagery used was Landsat 8 Collection 2 Tier 1 calibrated top-of-atmosphere (TOA) reflectance, with around 15 m resolution. Although MODIS and Sentinal data were downloaded for Bilaspur district, we finally decided to use Google Earth Engine for the process of supervised classification, due to the ease of handling, pre-processing and computation of high resolution imagery online compared to a desktop GIS software.

				Since acquiring very high resolution satellite imagery for the entire Bilaspur district would be prohibitively expensive (it will vastly exceed the allocated 2 lakhs), we did not buy them. We do not require very high resolution imagery of 1m or less for achieving our aim of 1:10,000 and 1:50,000 scale. We did not develop one for GHNPCA due to difficulties in classification of land use/forest type assessment without a botanist assisting on field, as well as terrain, and time constraints. However, data from this study coupled with other studies and data can be used to develop such a map.
3	Conduct stakeholder workshops and training programme (2 No	Number of Training/Awareness Programme Organized (Nos.)	Two sessions of stakeholder workshops were carried out for the forest department	

	100 Beneficiaries)	Number of beneficiaries village/ local people (Nos.)	in Kullu district. 2) In addition, at least 30 locals from the study sites learned about some aspects of the project and befitted from the knowledge.	
4	Develop the knowledge products: 01 Policy, 01 manual document and 2-3 publications in well reputed journal	No. of Reports/Research articles/Policy documents prepared and published (Nos.).	One paper has been published, one is under review and one is under revision. Several more are being written. One brief manual document have been created.	We were unable to create one policy document, per se. However, suggestions for policies have been briefly discussed.

*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*:		

S#	Particulars	Number/ Brief Details	Remarks/ Attachment
2.	New Ground Models/ Process/ Strategy developed, *if any*:	1	A reiterative process of MaxEnt species distribution modelling has been developed to understand the influences of plant and insect species on flycatcher breeding phenology (see annexure IX).
3.	New Species identified, *if any*:		
4.	New Database established, *if any:*	2	1. A database of checklists from both the study sites will be made available to the public once the papers using the data are published. 2. Databases of butterfly and plant species with their date and coordinates of sighting have been compiled.
5.	New Patent, *if any*:		
	I. Filed (Indian/ International)		
	II. Technology Transfer, *if any*:		
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	**Regular checklists of birds in Bilaspur district (Appendix 5a).**	**The amount of checklists previously available for Bilaspur district was scarce.**	**This includes 1140 bird checklists in Bilaspur district (5,830 rows of data)**
2	**Regular checklists of birds in GHNPCA (Appendix 5b).**	**The amount of checklists previously available for GHNPCA was scarce.**	**This includes 1174 checklists in Kullu district (4260 rows of data).**
3	**Inventory/checklist of bird species of Bilaspur district (Annexure XIV).**	**The available checklists are severely incomplete.**	**At least 35 new species were added to existing informal checklist available in eBird**
4	**Inventory/checklist of bird species of GHNPCA (Annexure XV)**	**The available checklists are incomplete.**	**At least four new species have been added to GHNPCA.**
5	**Database of occurrence data of selected invertebrates and plants in Bilaspur district and GHNPCA (Appendices 5c and 5d).**	**No such database in existence prior to the study**	**All of it new data.**

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**	**Himachal Pradesh Forest Dept.**			**7**	**16**
2.	On-Field Trainings						
3.	Skill Development	**3**	**Field assistants**				**3**
4.	Academic Supports	**1**	**Junior/Senior Research Fellow**				**1**
	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		
2.	Any other: Knowledge derived from the project were presented in 5 different online/hybrid events whose scope was national and international level.	1&2) CitSci India conferences by the Biodiversity Collaborative - 2021 and 2022.	A conservative estimate of 100 beneficiaries in 2021 and an additional 75 in 2022 (accounting to repeat attenders). The presentations are available online even after the end dates of conferences/symposiums.
		3) National Seminar on Biodiversity and Sustainable Development (2022) by SGGSJ Govt. College Paonta Sahib, Sirmour, Himachal Pradesh.	A conservative estimate of 30 beneficiaries.

		4&5) Bird monitoring Symposium by Bird Count India, Nature Conservation Foundation, LTEO India, and Azim Premji University - 2022 and 2023.	A conservative estimate of 100 beneficiaries in 2022 and an additional 75 in 2023 (accounting to repeat attenders). The presentations are available online even after the end dates of conferences/symposiums.

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):	Workshops for Forest Dept. officials.	They were taught about tools and techniques in ornithological research we carried out in the GHNPCA landscape, developing some of their technical skills.
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)

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.				
2.				

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:	*1*	*Himachal Pradesh*
2.	Project Sites/ Field Stations Developed:	*2*	*Bilaspur district and GHNPCA (in Kullu district)*
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	*1*	*SRF*
4.	Livelihood Options promoted	*8*	*3 field assistants; 5 cooks/porters*
5.	Technical/ Training Manuals prepared	*1*	*Annexure XXI*
6.	Processing Units established, if any	.... (attach photos)	
7.	No. of Species Collected, if any		
8.	No. of New Species identified, if any	*16 species of Flycatchers seen (of 223 species of birds in Bilaspur district and 156 species in the GHNPCA); 171 species of insects in Bilaspur district and 92 species in GHNPCA; 54 species of plants in Bilaspur district and 179 in GHNPCA*	*Annexures X to XV*
9.	New Database generated (Types):	*See section 3*	
	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/	*Number*	*Total*	*Remarks/* Enclosures

#	Knowledge Products	National	International	*Impact Factor*	
1.	Journal – Research Articles/ Special Issue:		1	0.569 SNIP (Source Normalized Impact per Paper from Scopus)	2022; 'Back after 40 years: a rare sighting of Eurasian Siskin Spinus spinus (Linnaeus, 1758) (Aves: Passeriformes: Fringillidae) in Himachal Pradesh, India' published in the Journal of Threated Taxa https://doi.org/10.11609/jott.7779.14.4.20935-20938 (Appendix 2a).
2.	Book – Chapter(s)/ Monograph/ Contributed:				
3.	Technical Reports:				
4.	Training Manual (Skill Development/ Capacity Building):		1	NA	One manual document have been created (Annexure XXI)
5.	Papers presented in Conferences/Seminars:		5	NA	● 'Range extension, range shift, or vagrancy?: An investigation into the spatio-temporal patterns of the Himalayan Vagrant' at the CitSci conference 2021 ● 'Testing the reliability of 'c-science' data: A case study of *Vagrans egista sinha* (Kollar, 1844)' at the National Seminar on 'Biodiversity and Sustainable Development' 2021 ● 'Citizen science', manual surveys or automated data collection - which is better for ecology?' at the CitSci conference 2022 ● 'Use of arboreal camera traps for bird monitoring in the Western Himalayas' in the Bird Monitoring Symposium 2021 (Annexure XX - initial portion) ● 'Machine learning for automated identification of flycatchers in

S #	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
					Western Himalaya' in the Bird Monitoring Symposium 2022
6.	Policy Drafts/Papers:				
7.	Others, if any:		2	NA	• 2023; 'A preliminary checklist of moths in Bilaspur district (Himachal Pradesh) in the western Himalayan foothills' is under review in Asian Journal of Conservation Biology (appendix 2b). • 2022; 'An investigation into the spatiotemporal patterns of the Nymphalid butterfly *Vagrans egista sinha* (Kollar, [1844]) is under revision, see https://doi.org/10.1101/2022.01.02.474748 for pre-print (appendix 2c). Several more pertaining to the main aspects of the project are being written and reviewed.

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 pure ecological information we have gathered from field work during this project can used utilized for further hypothesis testing or to understand the underlying reason for it. For example, from our study, we found that the incubating, hatching and fledging time for *T. paradisi* within GHNPCA is significantly lower compared to plains and other regions towards the East. From this it can be hypothesized the breeding period for this species higher up in the mountains or in cooler habitats is lesser compared to that of low elevation or warmer locales. The underlying reasons for this can be explored by carrying out a synchronized study between sites at lower altitude and the sites which were studied during the current project (they are known to reuse nesting locations). In terms of methods developed, the iterative method of developing high resolution maps of species from publicly and freely available data, combined with more systematically collected data through field work, is an affordable alternative to those that require very expensive very high resolution satellite imagery. We have described the procedure for this, and will be making all the data publicly available after publication, so that more researchers can utilize the results of our findings. We recommend that this be replicated over time and space. A collaborator has helped develop a model using for automated identification of calls/songs of flycatchers in Himachal Pradesh, whose accuracy was 70% (using Koogu machine learning model). This will be useful for automated identification of birds from data collected from autonomous recording devices. We recommend the use of such hardware for regular data collection. Our study has also identified high biodiversity areas such as Panjel Kalan which requires prioritization for conservation. We recommend that they are given some level of protection soon.

Replicability of Project/ Way Forward:	Researchers can use the same sites we used to replicate the study in a future time. Temporal replication will easier if the plots which are under threat of conversion for road or some other development project, are bought by the Forest Dept., any other governmental or non-governmental agency, and established as permanent long-term ecological sampling plots. Even within those cells which are heavily modified, these circular plots can remain and they can used to understand the impact of anthropogenic impacts on flycatchers or any other species. Our modelling finds significant association between certain plants, butterflies and flycatchers. Since they are common species, regular data collection from Forest Dept. officials on their beats while they are patrolling, will help model them better. This is one way to upscale the scope of the project, with more and ears on the field. This can bettered furthered by making biodiversity assessment and training in use of platforms such as eBird and iNaturalist, parts of the curriculum of courses in schools and colleges, since there are likely to be the most enthusiastic. It can even be gamified with rewards for students who contribute the most good-quality data. For replication of our current study, we will be providing all the raw data, methods, codes etc. after the relevant publications are made. Since MaxEnt modelling is stochastic, to replicate the results, the ‘set seed’ has been used. Through these methods and steps, replication and upscaling is 100% possible.

Exit Strategy:	To self-sustain such a project, we can employ machine-learning for species identification from imagery from camera traps, and audio for Audiomoths. For replicating the study using camera traps and Audiomoths, it would be good to involve locals living near those sites to take care of them, and maybe even do the deployment, data collection and redeployment themself. For this, they will expect some monetary compensation. This however may be cheaper than travelling through the are area, and also has lesser carbon footprint. For creating better and higher resolution models, we need to get more finer level bioclimatic variables in the former of raster layers. For this, we need a gridded network of dataloggers placed within areas such as Bilaspur district and GHNPCA. For this purpose, even just a simple datalogger like the one we used for the project, which primarily measures only relative humidity and temperature will suffice. Although 100 or more is ideal, even 50 of them placed strategically along grid with equal distance between them can be used to interpolate and create high resolution bioclimatic variables for the region. Downscaled bioclimatic variables made from a few weather stations in the region (or even combined with satellite imagery) cannot give as high resolution a map as those prepared using this method since the weather data collected is numerous and ground-adjacent, and therefore better represents the data experienced by the focal species.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: ……..
Date: …../……/……

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 (not more than 2–3 pages)

Avian species of various families such as the Muscicapidae and Monarchidae in the 'Old World' constitute bird known as flycatchers. For this study, we selected those species which engage in the behaviour of hawking (sallying into mid-air to capture prey). We selected some members within the subfamilies Muscicapinae and Niltavinae (Muscicapidae family) and in the Monarchidae (Monarch flycatcher) family since our goal is to study insectivores, specifically those capturing winged insects (subclass Pterygota) so that we can understand how their seasonal phenological changes such as breeding or flying affect. These include the species with common names ending in 'Flycatcher', 'Niltava' and Paradise-flycatcher'.

As global temperatures are rapidly rising and we have most likely passed the point of no return (such as self-sustained thawing of permafrost), it is important to understand its impact on the phenological changes of sensitive species such as insectivores like flycatchers who depend on the spring irruption of invertebrates for their breeding and feeding activities in the Himalayas, where they carry out seasonal altitudinal migration to higher or lower elevation for wintering or for breeding. Given that there are no studies to study the phenology of flycatchers in the Himalayas, and phenological changes in insectivores such as flycatchers can be used as an indicator ecosystem health, we find this study very important and necessary. In the study sites of Bilaspur district and the Great Himalayan National Park Conservation Area, there are limited annual records of flycatcher occurrences available in public datasets like eBird for modelling their phenological changes such as reproductive phenology. And there is none or very little records of plants or invertebrates in these study sites. One of the major issues addressed is the fixing of these fundamental issues through systematic and opportunistic collection of a vast array of data, such as species checklists, geo-referenced occurrence databases with date of sighting, and flycatcher nest observations.

The scope of the project at the time of the inception was to develop high resolution spatial map of flycatcher phenology in addition to invertebrate/insect and plant phenology within the study sites, in

addition to detailed information on flycatcher breeding timing or hatching dates and insects availability. So the scope was not just local, but regional and maybe even extrapolatable to most of Western Himalaya.

Review of literature was done to collect relevant baseline information from the literature and other web resources already existing on the study topic, and identify gaps in that information. After this, field and computer-based methodologies were developed to address the various objectives of the study. Field surveys began with acclimatization to the biodiversity of the area and traits for identification (such as bird calls), simultaneously carrying out reconnaissance surveys to remove sites which are inaccessible or non-ideal for flycatcher presence from the sampling developed using GIS (whenever possible). The actual surveys involved point counts for bird sampling, square sampling for vegetation and visual encounter surveys for invertebrates. The primary data collected were manual and autonomous, the manual data being the ones collected through repeated and systematic or exploratory field surveys/visits. Nikon Monarch 8×40 binoculars was used for surveying birds and Garmin etrex 20x GPS was used to enter coordinate data. Nikon D5600 DSLR with 18-55 mm and 70-300 m lens and a Canon IXUS-190 were used for photography. Reconyx HF2x HyperFire 2 Covert camera traps, Audiomoth audio recording devices and HOBO Pro V2 dataloggers were used for autonomous data collection.

A large amount of baseline data has been collected which amounts to about 511 GB of data collected from manual and autonomous data collection. This includes 1140 bird checklists in Bilaspur district and 1174 checklists in Kullu district. Other survey data collected includes the type and number of plants and invertebrates sampled during the survey as well as data such as average heights of herbs, shrubs and trees within their plots, and their coverage within the plots. Photographs were collected to captured for identification of species and phenological traits such as leaf flush, budding and flowering.

Camera trapping were done for maximization of detection of flycatcher species as well as capturing changes in phenological traits of trees. The data collected from this in Bilaspur were 97,929 media files, over the course of 218 trap nights/227 trap days; and in GHNPCA, 82,041 files totaling, over the course of around 1,472 trap night/1,529 trap days. At least 49 species of birds have observed camera trapping in the GHNPCA, out of which 37 were not recorded by camera traps in Bilaspur district. In total, 73 species were recorded using camera traps only, within Himachal Pradesh, which is 10.6-11.6% of all species found in the state; ~9.6% in Bilaspur district; and ~16.5% in the GHNPCA.

The amount of data by Audiomoth autonomous audio recording devices were 15,198 audio files totaling 22,818 minutes or ~15.8 days of recordings, collected over the course of 439 trap days. A collaborator helped develop a model using for automated identification of calls/songs of flycatchers in Himachal Pradesh, whose accuracy was 70% (using Koogu machine learning model).

We discovered a high density of nests of *T. paradisi* in an orchard/farm in the GHNPCA ecozone with sympatrically breeding white and rufous morph, which haven't been reported before from India, although they have been reported together. Contrary to the findings in the gangetic plains in southern West Bengal and in southern Thailand, where utmost three eggs were reported for a *T. paradisi* nests, the two active nests on the orchard had 4 eggs each. Incubating, hatching and fledging took 14-18 days for the white morph and 23-25 days for the rufous morph. This is much shorter than in the plains, where at least 38 days were reported for the whole process, possibly indicating that the breeding phenological phenomenon changes at an accelerated pace at higher elevation or cooler places. The high resolution habitat suitability maps were created which acts as proxies for overwintering and breeding phenology of flycatchers at Bilaspur district and GHNPCA respectively, shows variable trends in occupancy and relationships between flycatchers and changing changing temperatures in future climates.

2 INTRODUCTION

2.1 Background (max. 500 words)

Flycatchers is a term given to avian species of various families such as the Muscicapidae and Monarchidae in the 'Old World' (with counterparts in the same name in the 'New World'). While Muscicapidae is considered the 'flycatcher family' and therefore all species belonging to this family are called commonly flycatchers, we selected only those species which engage in the behaviour of hawking (sallying into mid-air to capture prey) which is apt given their name, unlike other members who glean from branches or pounce on terrestrial prey from an above perch (Winkler et al, 2020a). Since our goal is to study insectivores, and several members of the Muscicapidae family have berries and seeds as significant portions of their diet; and of the insectivores, we have come to focus on bird species capturing winged insects (subclass Pterygota) so that we can understand how their seasonal phenological changes such as breeding or flying affect, we selected some members within the subfamilies Muscicapinae and Niltavinae (Muscicapidae family) and in the Monarchidae (Monarch flycatcher) family (Sangster et al, 2010, Winkler et al, 2020a, Winkler et al, 2020b). These include the species with common names ending in 'Flycatcher', 'Niltava' and Paradise-flycatcher'.

Since variation in temperature is linked to variation in altitude, and altitude and temperature are among the most important drivers of phenological changes in plants (Zhu et al, 2018), and invertebrates whom flycatchers feed upon depend on floral resources for their breeding and feeding, a study on phenology of flycatchers in relation to phenological changes in plants in the Himalayas is especially important as it will throw light on how climate change can possibly affect the flycatchers' phenological traits such as reproductive timing (such as mating timing, incubation period and hatch date) and their seasonal migration (another phenological trait). The Himalayas is an especially sensitive biome and will be one of the first to show the effects of climate change (Bergengren et al, 2011). The timing of breeding is a life-

history trait that can greatly affect fitness, because successful reproduction depends on the match between the food requirements for raising young and the seasonal peak in food availability. Given that there are no studies to study the phenology of flycatchers in the Himalayas, and phenological changes in insectivores such as flycatchers can be used as an indicator ecosystem health, we find this study very important and necessary.

2.2 Overview of the major issues addressed (max. 500 words)

As global temperatures are rapidly rising and we have most likely passed the point of no return (such as self-sustained thawing of permafrost) (Randers & Goluke, 2020), it is important to understand its impact on the phenological changes of sensitive species such as insectivores like flycatchers who depend on the spring irruption of invertebrates for their breeding and feeding activities in the Himalayas, where they carry out seasonal altitudinal migration to higher or lower elevation for wintering or for breeding. While there are studies which looks into the impact of climate changes on animals such as otters in the Himalayas (Jamwal, 2022), there are very low number of them which specifically looks into that of birds. As spring irruption of invertebrates is linked to the phenology of plants such as leaf unfolding, and emergence, and flowering, as these plants are larval host plants to several vertebrates such as butterflies and sources of floral resources such as nectar, an understanding of spatio-temporal patterns of such phenological traits of invertebates and plants is necessary. However there is little to no baseline data for this, and the most important issue addressed in this study is this.

We have very limited understanding of which specific factors influence the phenology of plants which influences invertebrates and then flycatchers. So, the issues addressed is mainly the dearth of this data, and a establishing a protocol for studying them in the high altitude systems of Western Himalaya. Specifically, there is limited annual records of flycatcher occurrences available in public datasets like eBird for modelling their phenological changes such as reproductive phenology, in the study sites of Bilaspur district and the Great Himalayan National Park Conservation Area. And there is none or very little records of plants or invertebrates in these study sites. There also exist no complete inventory for any of these three taxa in the various trophic levels, so that it is possible to identify them during the field surveys. So, one of the major issues addressed is the fixing of these fundamental issues through systematic and opportunistic collection of a vast array of data, such as species checklists, geo-referenced occurrence databases with date of sighting, and flycatcher nest observations.

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

For this project baseline data was attempted to be collected through search of academic sources such as peer-reviewed papers and online data sources such as those of citizen science projects. This included primarily eBird, iNaturalist, and India Biodiversity Portal. From eBird and Birds of the World by Cornell Lab of Ornithology, the birds likely to occur in the state of Himachal as a state as well as selected potential study sites were discerned, and their habitats, diets and behaviour were learned in detail before starting the field surveys so as to maximize chances of recording them. It was found that many of the published literature on inventories of birds, invertebrates, and plants were either outdated or were published in predatory/parasitic journals with poor or no peer-review. So, these were essentially useless for our study. A baseline information needed for collection of any faunistic or floristic data would be their identification. Easy identification was possible for birds from prior ornithological experience of the research fellow in the Himalayas as well as keys present in the Birds of the Indian Subcontinent (Grimmett et al, 2011), and for butterflies keys from Butterflies of Uttarakhand (Sondhi & Kunte, 2018). For plants and cryptic insects, photos and notes were taken to get them identified with the help of experts.

In terms of satellite data, high resolution weather, climate and vegetation raster layers were available for the analyse, however as we discuss in the methodology, they were foregone due to their cost, and instead free bioclimatic data available from sources such as CHELSA were used instead.

The scope of the project at the time of the inception was to develop high resolution spatial map of flycatcher phenology in addition to invertebrate/insect and plant phenology within the study sites, in addition to detailed information on flycatcher breeding timing or hatching dates and insects availability. So the scope was not just local, but regional and maybe even extrapolatable to most of Western Himalaya. In terms of taxa, the scope of the project covered multiple trophic levels including producers (plants) and primary and secondary consumers (insects and flycatchers). While in the case of flycatchers, the taxonomic resolution was till species level, in case of insects and plants, it was genus or species, within higher taxonomic limit at class for the consumers (class Aves and Insecta) whereas there were no limits to plants except perhaps to the clade Angiospermae (flowering plants).

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

The project objectives of our study:

- To map the forest phenology traits using satellite remote sensing data.
- To study synchrony between forest phenology, food abundance and flycatures breeding timing,
- To project the broad-scale changes in plants phenology under future climate change using IPCC emission scenarios in Himalayas.

- To develop a protocol for monitoring of plant phenology and flycatures breeding timing in the Himalayas and disseminate results with local communities by conducting stakeholder workshops and training.

The target deliverables of our study:

- A high resolution map of forest phenology at 1:10,000 scale
- Database on availability of food resources and their abundance for birds
- Database on Flycatures breeding
- Detailed tree phenology change map with respect to different IPCC emission scenarios
- Report on tree phenology, insect breeding and flycatures breeding timing
- Conduct stakeholder workshops and training programme (2 No 100 Beneficiaries)
- Develop the knowledge products: 01 Policy, 01 manual document and 2-3 publications in well reputed journal

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

3.1 Methodologies used (max. 500 words)

The first methodology employed was a thorough review of literature to collect relevant baseline information from the literature and other web resources already existing on the study topic, and identify gaps in that information. After this, field and computer-based methodologies were developed to address the various objectives of the study. Field surveys began with acclimatization to the biodiversity of the area and traits for identification (such as bird calls), simultaneously carrying out reconnaissance surveys to remove sites which are inaccessible or non-ideal for flycatcher presence from the sampling developed using GIS (whenever possible).

The areas of Bilaspur district and the GHNPCA are nearly equal with 1,167 km² for the former and 1,171 km² for the latter. This was why the entire GHNPCA was selected for comparative analysis between the two study areas. Stratified Random Sampling was done to select sampling sites (hexagonal cells) (see Annexure) where two point counts of 10 minutes in 25 m radius circles (Hutto et al, 1986) separated by at least 100 m and replicated over time with usually at least one month in between, were carried out for bird sampling, and modified visual encounter surveys for invertebrates (Pollard, 1977; Thomas, 1983; Van Swaay et al, 2012). Since much of the area is inaccessible and/or require long-treks in GHNPCA, not much reconnaissance could be done for better stratification for it. After doing surveys at several plots in GHNPCA, it was understood that high elevation plots cannot be covered for logistical and budgetary

constraints, and it has been restricted to ≤ 3,000 m, reducing it to 40% i. e. at least 14 cells since the area above 3,000 m is 709 Km^2 in the GHNPCA (Sahani, 2019). A total of 34 cells (per cell, n 2×33 + 1×2 = 68 plots) in Bilaspur district and 16 cells (per cell, n 2×15 + 1×2 = 32 plots). The two extra cells in GHNPCA was useful since there is much more habitat and altitudinal variability there compared to Bilaspur.

Square sampling grids of one, five and ten square metres were used for herb, shrub and tree sampling. Invertebrate sampling was done for the 25 m radius circle, like that for the birds. In several such cells, camera traps, autonomous audio recording devices and dataloggers were deployed to enhance the chances of detecting Flycatchers and covariate collections. Autonomous sensors were also deployed in other areas with suitable habitats. In areas where Flycatchers were seen, repeated targeted surveys were carried out to check for evidence of breeding and when breeding was detected, it was thoroughly studied. An iterative and largely automated method for development of high resolution spatial mapping of Flycatcher phenology has been employed using software such as R studio, MaxEnt, QGIS, Google Earth and Google Earth Engine (by considering their presence in ideal breeding habitat and season as proxy for breeding phenology). Originally, the plan was create very high resolution maps for the species distribution, but required covariates using remote sensing are not available/accessible at that scale.

3.2 Data collected and Equipments utilized (max. 500 words)

The primary data collected can be broadly classified as manual and autonomous, the manual data being the ones collected through repeated and systematic or exploratory field surveys/visits. Since flycatchers are the main focus of our project, bird checklists were regularly recorded using eBird with accurate geographic coordinates of trails or points from which they were identified and counted, as well as any auxillary data such as weather or terrain added as comments. Nikon Monarch 8×40 binoculars was used for surveying birds and Garmin etrex 20x GPS was used to enter coordinate data. These checklists can be seen in the attached excel files for Bilaspur district and GHNPCA (20% of the each datasets removed for data protection; all data will be made public upon publication). Survey data were directly entered in excel sheets in a phone while in the field and backed up in the cloud regularly to avoid data loss and double data-entry work (same reason for using eBird as well). Photographs and videos were taken using a Canon IXUS-190 while in Bilaspur district (due to delay in arrival of the DSLR) and Nikon D5600 DSLR with 70-300 m lens for capturing birds and invertebrates at a distance, and an 18-55 mm lens for plants, landscape, and nearby invertebrates. A total of ~134.5 GB of data was collected in the form of images and videos from manual photography.

In terms of autonomous data collected, three sources were used: camera traps (Reconyx HF2x HyperFire 2 Covert), audio recording devices (Audiomoth) and relative humidity/temperature dataloggers (HOBO Pro V2). All ten camera traps which were bought for the project were deployed in both Bilaspur

district and GHNPCA - 10 main sites (10 trees) in the former and 11 main sites (14 trees) in the latter. Dynamic decision-based redeployment was done at GHNPCA to maximize the chances of capturing flycatchers. The deployment period was from January to April 2021 in Bilaspur district and March to November 2022 in GHNPCA. The amount of media accrued from camera traps were as follows: Bilaspur - total of 97,929 media files (759 video files of 5 and 10 seconds length, and 97,190 image files) totaling ~77.5 GB, over the course of 218 trap nights or 227 trap days; GHNPCA - total of 82,041 (9530 video files of 5 and 10 seconds length, and 72,511 image files) totaling ~ 164.7 GB, over the course of around 1,472 trap night or 1,529 trap days.

All four functioning Audiomoths (one of the five did not function) and four dataloggers were deployed in six different locations in the GHNPCA (their arrival was delayed during the Bilaspur phase, and therefore could not be deployed there). The amount of data collected by them were 15,198 audio files (of 60, 90 or 120 s duration each, adding upto 22,818 minutes or ~15.8 days of recordings totaling ~131.7 GB), over the course of 439 trap days. See Appendices X to XXI for more extensive details about the data collected and equipment used.

3.3 Details of Field Survey conducted, if any (max 500 words)

Field surveys included reconnaissance surveys for better stratification of the random sampling map in Bilaspur district, exploratory surveys to find suitable habitats and potential nest sites of flycatchers, and then the systematic sampling repeated twice for each cell. In GHNPCA, after doing surveys at several plots, it was understood that high elevation plots cannot be covered for logistics reasons since we would require 3 or more field assistants and more than 4 days of travel for each plot, making it prohibitively expensive. And a lot of the area in the high elevation is covered with snow, requiring more equipment such as snowshoes. One cell in both study sites were not included for second survey due to map boundary issues in Bilaspur district and logistical difficulties in case of GHNPCA. While most of the locations Bilaspur district was accessible via roads and during one-day trips, the travel was long-winded and time-consuming due to presence of the Gobind Sagar lake and tributaries emptying into it. Some areas in Naina Devi side required overnight stay due to the distance from primary basecamp in Bilaspur town. Accessibility to sampling cells in GHNPCA was very limited due to availability of only harsh roads leading to areas near some of the cells in the Ecozone, and narrow walking trails to most of the other sampling cells deep in the National Park of or the Wildlife Sanctuaries. Camping was necessary for many of those plots, and for the rest, accommodation within Forest Dept. rest houses or guard patrol huts were possible.

Since the spring and summer were when the breeding of flycatchers happened in both districts, that was when the most effort was to be put in. This was done in GHNPCA. However due to the covid-19 outbreak, the surveys during the spring and summer of 2020 in Bilaspur was very limited, and actual

surveys only started pre-winter and ended just before spring, thus giving an idea about flycatchers during winter time. It was possible to get data about food sources of flycatchers in Bilaspur district during winters because while many insects became inactive, several were still active throughout the winter, and the overwintering flycatchers were presumably feeding on them. The cold was tolerable to some extent in Bilaspur even during mid-winter in Bilaspur district, so that field work could be carried out. However, it was not possible at all to do the same during mid-winter in GHNPCA due to extreme cold and freezing conditions. Field work was also very limited during monsoon in GHNPCA due to constant threat of landslides.

While carrying out deployment of camera traps, it was clear that without climbing equipment (which the JRF/SRF) had requested for, but not initially included in the project proposal and hence not procured, one aspect of the project — that of studying tree phenology was not entirely possible, as free-hand climbing was not possible for very tall trees, especially conifers with no branches near the base.

3.4 Strategic Planning for each activity with time frame (max. 200 words)

As stated in the project proposal, recruitment of researcher was carried out in the first four months, with few more additional weeks, from October 2019 to February 2020. Due to unforeseen circumstances — Covid-19 outbreak and resulting lockdown just after project initiation in March 2020, and road closures due to landslides during the monsoon of 2021 — the proposed timing strategy for each aspect of the project was not entirely followed through. Much of the review of literature, data structuring and analysis were carried out during these periods where the JRF/SRF was stuck at basecamp (March-May 2020; May-October 2021) as well towards the end of the extended project duration (December 2022-February 2023). Field work was carried out in between these dates (June 2020-April 2021; November 2021-December 2022), with the exception of a several weeks during winter and monsoon in GHNPCA. Final report along with final analyses of phenological and other data writing was carried out between December 2022 and February 2023. Extra months were taken after the end of the project duration to complete the report due the high amount of data collected and time required to perfect a workflow including coding in R, to carry out the analyses.

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

4.1 Major Activities/ Findings (max. 500 words)

We discovered a high density of nests of *Terpsiphone paradisi* (Indian Paradise Flycatcher) in the same area in the GHNPCA ecozone with at least 2 males of the white morph, 1 male of the rufous morph, and 2 females, indicating a communal nesting pattern. Nests/nest hole of other species such *C. ceylonensis* (Grey-headed Canary Flycatcher), *Dicrurus leucophaeus* (Ashy Drongo), *Psilopogon virens* (Great

Barbet), *C. macrorhynchos* (Large-billed Crow) on the same tree or very nearby indicates that predators and prey can nest in the nearby place at the same time in this landscape, as well as the huge availability of prey. Contrary to the findings in the gangetic plains in southern West Bengal and in southern Thailand, where utmost three eggs were reported for a *T. paradisi* nests (Mizuta & Yamagishi, 1998; Das & Adhikari, 2019), the two active nests on the orchard had 4 eggs each. And contrary to the findings in the study by Gokula & Vijayan (2003), where two morphs were reported but only brown morph bred, in the current study, both morphs bred in the same area. For the white morph, incubating, hatching and fledging took 14-18 days and for the rufous morph, the whole process took 23-25 days. This is much shorter than in the plains, where at least 38 days were reported for the whole process (Das & Adhikari, 2019). This may indicate that incubation and hatching and fledging may be faster at a higher elevation or cooler places. For more details, see annexures XVIII and XIX.

The high resolution habitat suitability map which acts as proxies for overwintering and breeding of phenology of flycatchers at Bilaspur district and GHNPCA respectively, shows variable trends in occupancy and relationships between flycatchers and changing changing temperatures in future climates. This has been extensively detailed in annexure IX.

Deployment of autonomous sensors for unsupervised regular collection of data was another major activity, and it was found that they were very helpful for the study, capturing information missed in manual surveys. This was especially true for GHNPCA, since much of the terrain is harsh to travel back and forth (only accessible by foot). At least 49 (with most likely three more) species of birds have observed camera trapping in the GHNPCA, out of which 37 were not recorded by camera traps in Bilaspur district (either visual or audio), and 8 whose observations in camera traps in Bilaspur disrict were audio-only (images were captured in the GHNPCA). That brings it to a total of at least 73 species recorded using camera traps only, within Himachal Pradesh, which is between 10.6 and 11.6% of all species found in the state; ~9.6% in Bilaspur district; and ~16.5% in the GHNPCA. One species of bird recorded in the camera traps - *Urocissa erythrorhycha* (Red-billed Blue Magpie) was only recorded once during manual surveys, and that too after it was picked up camera traps. We also recorded at least 9 arboreal mammals. See annexures XX and XXI for more details.

4.2 Key Results (max. 500 words in bullets covering all activities)

- A large amount of baseline data has been collected. This includes 1140 bird checklists in Bilaspur district (5,830 rows of data) and 1174 checklists in Kullu district (4260 rows of data). Other survey data collected includes the type and number of plants and invertebrates sampled during the survey as well as data such as average heights of herbs, shrubs and trees within their plots, and their coverage within the plots. Photographs were collected to captured for identification of species and

phenological traits such as leaf flush, budding and flowering. A total of ~134.5 GB of data was collected in the form of images and videos from manual photography.

- Camera trapping were done for maximization of detection of flycatcher species as well as capturing changes in phenological traits of trees. The data collected from this in Bilaspur were 97,929 media files totaling ~77.5 GB, over the course of 218 trap nights/227 trap days; and in GHNPCA, 82,041 files totaling ~ 164.7 GB, over the course of around 1,472 trap night/1,529 trap days. At least 49 species of birds have observed camera trapping in the GHNPCA, out of which 37 were not recorded by camera traps in Bilaspur district. In total, 73 species were recorded using camera traps only, within Himachal Pradesh, which is 10.6-11.6% of all species found in the state; ~9.6% in Bilaspur district; and ~16.5% in the GHNPCA.

- The amount of data by Audiomoth autonomous audio recording devices were 15,198 audio files totaling 22,818 minutes or ~15.8 days of recordings, which constitute ~131.7 GB, collected over the course of 439 trap days. A collaborator helped develop a model for automated identification of calls/songs of flycatchers in Himachal Pradesh, whose accuracy was 70% (using Koogu machine learning model).

- We discovered a high density of nests of *T*. *paradisi* in an orchard/farm in the GHNPCA ecozone with sympatrically breeding white and rufous morph, which haven't been reported before from India, although they have been reported together. Contrary to the findings in the gangetic plains in southern West Bengal and in southern Thailand, where utmost three eggs were reported for a *T. paradisi* nests, the two active nests on the orchard had 4 eggs each. Incubating, hatching and fledging took 14-18 days for the white morph and 23-25 days for the rufous morph. This is much shorter than in the plains, where at least 38 days were reported for the whole process, possibly indicating that the breeding phenological phenomenon changes at an accelerated pace at higher elevation or cooler places. For more details, see annexure XVIII and XIX.

- The high resolution habitat suitability maps were created which acts as proxies for overwintering and breeding phenology of flycatchers at Bilaspur district and GHNPCA respectively, shows variable trends in occupancy and relationships between flycatchers and changing changing temperatures in future climates. This has been extensively detailed in annexure IX.

4.3 Conclusion of the study (max. 500 words in bullets)

Phenology can be defined as "the timings of cyclical or seasonal biological events" which can include migrations, flowering, egg laying, and hibernation (Warren et al, 2021). This three year study on the phenology of flycatchers and the species these flycatchers depend upon directly or indirectly has revealed a lot. Given the vulnerability of the Himalayas to climate-change induced biological changes,

phenology of flycatchers and associated species is a great way to determine ecosystem health, since they act as indicator species.

Our most basic finding was that there is huge dearth of even the most basic information, such as which species of plants and invertebrates are found in the two study sites - Bilaspur district and GHNPCA. While birds and butterflies could be fully identifiable due to availability to guide books, there is none for other taxa in Bilaspur district, whereas there are some previously available checklists for lepidoptera and plants for the GHNPCA. We have identified as many plant, insect and bird species as possible within the region, since phenological studies requires understanding which species is dependent on which for which portion of cyclical changes or behaviour. For example, we have found through species distribution/environmental niche modelling that the butterfly *Papilio polytes romulus* (Indian Common Mormon) could be a major limiting factor during overwintering of *Eumyias thalassinus* (Verditer Flycatcher) and *Niltava sundara* (Rufous-bellied Niltava), as they are one of the most common species present in the area, and therefore more likely to consumed by the flycatchers, and since *Murraya koenigii* (Curry Plant) is the butterfly's host plant and they are abundant as well, they likely indirectly influence the phenology of the flycatchers.

This brings us to the second point that there is no data for the feeding habits of flycatchers in the study sites. This study has made available some direct observations of which species is consumed by flycatchers such as the consumption of the abundantly found *Pieris canidia indica* (Himalayan Cabbage White) by *T. paradisi*. This data is difficult to collect due to the quick feeding habits of the flycatchers, and difficulty of photographing species in the mouth of flycatchers at angles sufficient to identify them. Due to these difficulties, modelling of the most abundantly invertebrate/insect species and using them to model flycatchers will give us an idea of which species' phenology is linked to which. This, we were able to carry out for a total of 3 species/genera of plants, 22 species of butterflies, and 4 species of flycatchers in the two study sites combined.

We also tested and established tools, techniques and modelling methods to streamline the efficiency of, and maximizing data collection with minimal human intervention. This includes camera traps, autonomous audio recording devices, dataloggers and automation species-identification from them using machine learning techniques. Since this was the first flycatcher phenology study in Western Himalaya, we were not able to fully achieve some of the objectives as we overestimated what we could achieve with the available time, workforce, and resources.

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

5.1 Achievement on Project Objectives/ Target Deliverables (max. 500 words)]

- Databases of irruption of insects during breeding season/active season has been compiled along with that of plants. Data from this database were used in the preparation of high resolution spatial mapping of flycatcher phenology.
- Flycatcher breeding has been studied, specifically that of the *Terpsiphone paradisi* since we could locate the nests of other species despite intensive searches.
- A forest phenology/land use map of less than 1:10,000 scale has been prepared for Bilaspur district. This land use map represents classes of biotic or human habitats, which can be used as proxy for phenology at a landscape level, for example flowering of deciduous trees during seasons such as spring and summer which may be used as cues by invertebrates for their irruption or by flycatchers for migration.
- Distribution modelling (as a proxy for phenological changes such as flowering) of three plant genera/species were carried out as part of species distribution modelling of flycatchers under future climate change IPCC emission scenarios in Himalayas.
- In addition, high resolution ecological niche maps or species distribution maps have been made for selected butterflies and 4 species of flycatchers. Many interesting associations between these trophic levels, as well as the trends in phenology traits over space and time (for which these maps acts as proxies), have been discovered such as *Eumyias thalassinus* showing decline of breeding suitable areas in GHNPCA by 20% by 2050 and then an increase by 45% as weather stabilizes in 2070 under RCP 4.5. So, anthropogenic climate change is expected to have a negative impact on their breeding range till mid-century.
- Two sessions of stakeholder workshops were carried out for the forest department in Kullu district, which was attended by almost all Forest Dept. employees working in the GHNPCA i.e seventeen individuals. In addition, at least 35 locals from the study sites learned about some aspects of the project and befitted from the knowledge.
- One paper has been published (2022; ‘Back after 40 years: a rare sighting of Eurasian Siskin Spinus spinus (Linnaeus, 1758) (Aves: Passeriformes: Fringillidae) in Himachal Pradesh, India’ published in the Journal of Threated Taxa https://doi.org/10.11609/jott.7779.14.4.20935-20938), one is under review (2023; ‘A preliminary checklist of moths in Bilaspur district (Himachal Pradesh) in the western Himalayan foothills’ in Asian Journal of Conservation Biology), and one is under revision (2022; ‘An investigation into the spatiotemporal patterns of the Nymphalid butterfly *Vagrans egista*

sinha (Kollar, [1844]), see https://doi.org/10.1101/2022.01.02.474748 for pre-print). Several more pertaining to the main aspects of the project are being written and reviewed. One manual document have been created.

5.2 Interventions (max. 500 words)

Our project was an exploratory study and had no component of intervention.

5.3 On-field Demonstration and Value-addition of Products, if any (max. 500 words)

This section is mostly irrelevant to this project as we did not have any commercial aspect to this project. However, we could say that in terms of 'on-field demonstrations', the demonstration of the working principles of hardware such as camera traps, autonomous audio recording devices, and datalogger, as well as softwares such as eBird, to the field assistants would probably qualify. This would help them better guide and maybe even take part in future research in the area using the same tools.

5.4 Green Skills developed in State/ UT (max. 500 words)

In addition to the skills developed by the Junior/Senior Research Fellow, several field assistants were taught skills necessary to be a guide to researchers (with possibility of training to them do the actual research itself). While none of the field assistants showed the necessary aptitude for field or computer-based research, they were nonetheless taught in a variety of field skills. This included the basics of point counts, basic identification of birds, insects and plants (some local knowledge about wildlife they enriched the knowledge of the JRF/SRF too), use of certain software and hardware, and deployment of autonomous sensors.

In terms of identification, they were send pdfs of guide books for identification of birds and other taxa, as well as on-field identification using the book, using identification morphological features and calls/songs. There were shown basics of GIS softwares such as Google Earth, QField and Google MyMaps for use of vector and raster layers for navigation to the survey sites. They were taught how to use eBird for data entry. In terms of autonomous sensors, they were given a brief understanding of what they were used for, and basic parts and functions, including changing settings of camera trap, and inputting data such as geographic coordinates into it. They were taught how to use the GPS. Other things such as removal and placement of batteries, and proper cleaning methods for these devices were also briefly taught. In addition to the three main field assistants (two in Bilaspur district and one in GHNPCA), 5 cooks/porters who accompanied us during treks and camping within GHNPCA also befitted from such knowledge. One aspect which troubled us were that two out of three field assistants hired for the project had the problem

almost consistently becoming late in the mornings which often resulted in late starts of surveys. This problem was rectified to some extent towards the end, but coming early and on time is a necessary skill for a green job such as that field assistants, especially for that of ornithological research.

In addition to this, Forest Dept, officials also gained knowledge of such tools and techniques, as well as knowledge gathered from the study in GHNPCA, during the two workshops held for them at the end of the study.

5.5 Addressing Cross-cutting Issues (max. 200 words)

Lack of systematic data sharing is a cross-cutting issue in both the study sites. One way to do this is to maintain one repository where all the publications from a region such as GHNPCA is stored so that researchers will not have a hard time tracking them down. This includes yet-to-be digitized historical/old cadastral maps and notes written on notepads or paper datasheets. This can prevent them being lost forever through deterioration or any disaster. Free and open datasets will invigorate researchers to do better research.

Another issue is the lack of regular or systematic monitoring of biodiversity so that trends in biodiversity can be assessed over time. Permanent sampling plots would be the best way. The cells we used for our sampling can be surveyed every 3 or 5 or even 10 years to understand changes in phenology and other characteristics of biodiversity. During the gap years, autonomous sensors such as camera traps and Audiomoths can be deployed so that data is collected automatically. Thanks to advancement in battery technology and memory size of SD cards, it is possible to collect it after an year or more after deployment, thus saving time and eliminating constant travel through difficult terrain.

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

6.1 Socio-Economic impact (max. 500 words)

Since our project didn't have a socio-economic aspect, this is largely irrelevant to us. However, this project generated or supported a number of green jobs for locals, that of field assistants (n = 3), and that of cooks/porters during treks through GHNPCA (n = 5). These jobs provided reasonable pay for several people who consistently provided their support. In total, a few lakhs were distributed amongst these individuals, during the course of the study. In addition, specially hired drivers for rough terrain or owners of vehicles received reasonable financial compensation. And of course, since the project was carried out in Himachal Pradesh, many residents of Bilaspur district and Kullu districts, such as shopkeepers, house owners, eateries etc. received money directly from the project for procurement of project equipments or

from the JRF/SRF as part of living expenses, which meant that a lot of the money spent on the project remained in the Himalayas.

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

Without baseline biodiversity inventory through identification, impact on natural resources/environment cannot be quantified. We set the stage for further research on this by collecting baseline information as species present in the are and occurrence data through the years. We would make all or most of the data from this project public for use by other researchers after the project is over, and the relevant articles from the data collected are published. Researchers can request the data even before this, by contacting us. Our own analyses shows which areas need to be prioritized for protection from potential sources of harm (such as Panjel Kalan in Bilaspur district). It also shows which flycatcher species are linked to which butterfly species, and in turn plant species, for their phenological cycles. From this information, one can glean the potential impact of removal or decimation of populations of a species on another, thereby providing a rough idea on what management actions would be prudent.

From auxillary or opportunistic data collected, we have identified more problems which are beyond the scope of the project but important issues nonetheless. One of this is finding of dead fruit bags (Macrochiropterans) on transmission/electric wires in Bilaspur district. One or two dead fruit bats were found hanging in transmission/electric wires at the coordinates 31.3526994, 76.805807; 31.346484, 76.75772; 31.4689, 76.725836; and 31.364229, 76.768591. These multiple sightings warrant further investigation and safety measures to prevent these fruit bats from dying. Another issue is the dumping of non-biodegradable garbage in rivers or their burning in both the study sites, which is a very prevalent practise there due to the lack of a better alternatives. We recommend looking into this matter as well.

The JRF/SRF set up collection projections called ‘Biodiversity of Bilaspur’ (https://www.inaturalist.org/projects/biodiversity-of-bilaspur) and ‘Biodiversity of Kullu district’ (https://www.inaturalist.org/observations?project_id=139650) in iNaturalist so that it will help aggregate biodiversity information for both the district, as well as help the people who post media for identification of species, from these two districts. This will help invigorate the green stewardship in common people. The JRF/SRF is also helping people identify species of birds bu their audio in Xeno Canto for the study sites. Both these will help increase the data for environmental analyses and rapid Environmental Impact Assessments.

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

To conserve biodiversity, we need to find out which area needs to be prioritized for conservation which includes maximum biodiversity as well as abundance of common species which are important prey

species for predator higher up in the food web. Areas with breeding pairs of birds is a great indication of such areas. The Great Himalayan National Park, Tirthan Wildlife Sanctuary, and Sainj Wildlife Sanctuary, which are part of the Great Himalayan National Park Conservation Area are largely safe thanks to its protected area status and UNESCO World Heritage status. However, the ecozone of GHNPCA is under threat in many parts, such as the Tirthan Valley where tourist resorts are being built at a rapid pace, and some of which looks like they violate zoning regulation (such as directly building structures on the riverbed). This sort of haphazard building which inevitably gets damaged, gets carried away and pollutes the river downstream during flooding in monsoons, needs to be stopped.

In addition, the visitor characteristics of the tourists who visit GHNPCA and trails in the ecozone need to be considered. Quite a number of them are unruly and have very little regard for nature, which can seen in their playing of portable subwoofers turned on at full volume in ecologically sensitive areas, as well as littering in the rivers or trail- side. Waste dumping directly into the river by the locals is also an issue. They do this because these areas lack a system for collection and recycling of non-biodegradable wastes. Such issues were raised by us with the tourists, locals as well as Forest Dept. officials, and hopefully it has had a local effect.

Since our study has helped enumerate more number of species, adding many species to checklists within the study sites, this will also help preserve biodiversity as more biodiversity will result in more protection. This is especially true of Bilaspur district, where there are no legitimate peer-reviewed checklists for any taxa. Bilaspur district is undergoing a frightening amount of development; with the recently opened AIIMS Bilaspur, and associated development; as well as the proposed railway network to Bilaspur district, with land acquisition already notified by the government. A large chunk of the prime wildlife habitats is not under protection. This means that they are likely to be razed for development soon, and some it has already happened.

Our study has revealed through field surveys and modelling, one such area with most abundance of flycatchers called Panjel Kalan. It has the most number of bird species in the district with around 1/3rd of all species (n = 90) recorded till date. We are recommending that this area be turned into a community-based conservation area, as it is a rather remote location with few houses, but with farms located in the valley closed off at three sides by hills, providing a very important and unique microhabitat for lifeforms, including birds and insects (we also found some insect species there not found in other parts of Bilaspur district).

6.4 Developing Mountain Infrastructures (max. 200 words)

This is largely beyond the scope of our study. But, we recommend developing field stations with additional charging and technical facilities (such as a solar-powered desktop) so that data from

autonomous recording devices can be downloaded or transferred within those field stations, and redeployed immediately, rather than carry back and forth equipment which are heavy in large numbers. For example, instead of using throw-away alkaline batteries for camera traps (which has lower efficiency too), rechargeable Li-ion batteries can be used instead, eliminating the need to increase the carrying load in a rough terrain. These facilities can be shared with non-forest department researchers, upon the payment of a fee.

Another important infrastructure development that needs to be done is that of data management. It has been noticed that the current data security of Forest Dept. desktop or laptops from corruption and damage is extremely low. The USB we used for workshops using an FD device got corrupted beyond repair and has been rendered unusable. We recommend shift to a Linux-based OS like Ubuntu for maximum protection of data, as Windows OS is easily corruptible. And we recommend regular back-up of any data that is collected as hard-disc is easily physically damaged.

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

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There seems to be good communication between Forest dept. employees, and with researchers. It will however would be a good idea to create a publicly accessible database of names, email IDs, and areas of expertise of researchers who has worked in the same landscape so that it will be easy to network and collaborate.

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

7.1 Utility of project findings (max. 500 words)

The pure ecological information we have gathered from field work during this project can used utilized for further hypothesis testing or to understand the underlying reason for it. For example, from our study, we found that the incubating, hatching and fledging time for *T. paradisi* within GHNPCA is significantly lower compared to plains and other regions towards the East. From this it can be hypothesized the breeding period for this species higher up in the mountains or in cooler habitats is lesser compared to that of low elevation or warmer locales. The underlying reasons for this can be explored by carrying out a synchronized study between sites at lower altitude and the sites which were studied during the current project (they are known to reuse nesting locations).

In terms of methods developed, the iterative method of developing high resolution maps of species from publicly and freely available data (such as CHELSA or WorldClim bioclimatic layers and data from citizen science portals like eBird and iNaturalist), combined with more systematically collected data through field work, is an affordable alternative to those that require very expensive very high resolution satellite

imagery. We have described the procedure for this, and will be making all the data publicly available after publication, so that more researchers can utilize the results of our findings.

Our study was the first to use targeted arboreal camera traps for bird surveys in India (Moore et al, 2021). Method testing for camera trapping found that the false triggers due to wind and other elements in the field can be greatly reduced. Whereas, nearly 99% of media captured in Bilaspur district was due to wind, the ratio of media with animals in them and the total number of media captured in GHNPCA had drastically increased due to method testing in Bilaspur district. These findings are useful for future researchers from making the same mistakes.

A collaborator has helped develop a model using for automated identification of calls/songs of flycatchers in Himachal Pradesh, whose accuracy was 70% (using Koogu machine learning model). This will be useful for automated identification of birds from data collected from autonomous recording devices. The findings from our species distribution/phenology modelling will help government officials, especially Forest Dept. officials to make policies or adopt management practices to protect species and the habitats in which they utilize most. Our study has also identified high biodiversity areas such as Panjel Kalan which requires prioritization for conservation.

7.2 Other Gap Areas (max. 200 words)

For identifying species, which is necessary for any data collected, there is a necessity for identification keys to differentiate between similar species. Unfortunately, this is unavailable for most taxa. In our paper which provides a preliminary checklist of moths in Bilaspur district, we have added identification keys for helping researchers in the future. Like, this people who are doing inventory of taxa is requested to identification keys, especially for the cryptic taxa. This will fill up the gap between data collected for easily identifiable taxa such as birds (Aves) and butterflies (Rhapalocera), when compared to others such as moths (Heterocera) or orthopterans (grasshoppers, locusts, and crickets). While two separate individuals have said that they will help us with identification of the orthoptera group (of which many members were found in Bilaspur district), they haven't. This indicates the difficulty in getting such understudied taxa identified to be used as covariates for understanding the phenology of flycatchers.

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

It is clear that one year in one study site is insufficient to confirm phenological changes. We recommend permanent plots for long-term ecological monitoring, from which we can understand if different phenological traits changes annually with weather, or remain rather the same and only gradually change with climatic changes. For creating better and higher resolution models, we need to get more finer level bioclimatic variables in the former of raster layers. For this, we need a gridded network of dataloggers

placed within areas such as Bilaspur district and GHNPCA. For this purpose, even just a simple datalogger like the one we used for the project, which primarily measures only relative humidity and temperature will suffice. Although 100 or more is ideal, even 50 of them placed strategically along grid with equal distance between them can be used to interpolate and create high resolution bioclimatic variables for the region. Downscaled bioclimatic variables made from a few weather stations in the region (or even combined with satellite imagery) cannot give as high resolution a map as those prepared using this method since the weather data collected is numerous and ground-adjacent, and therefore better represents the data experienced by the focal species.

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

Our surveys were carried out through an initial thorough study of literature and reconnaissance surveys to selected the suitable sites from random stratified cells within the selected study areas. So, researchers can use the same sites to replicate the study in a future time. Temporal replication will easier if the plots which are under threat of conversion for road or some other development project, are bought by the Forest Dept., any other governmental or non-governmental agency, and established as permanent long-term ecological sampling plots. Since the plots within each cell are only 25 m in radius, and there won't be too many of such plots, the cost of it wouldn't be too high. Even within those cells which are heavily modified, these circular plots can remain and they can used to understand the impact of anthropogenic impacts on flycatchers or any other species.

Our modelling finds significant association between certain plants, butterflies and flycatchers. Since they are common species, regular (either systematic or opportunistic) data collection from Forest Dept. officials on their beats while they are patrolling, will help model them better. This is one way to upscale the scope of the project, with more and ears on the field. This can be bettered furthered by making biodiversity assessment and training in use of platforms such as eBird and iNaturalist, parts of the curriculum of courses in schools and colleges, since there are likely to be the most enthusiastic. It can even be gamified with rewards for students who contribute the most good-quality data. For doing this however, guide booklets or books for many taxa whose data needs to be collected needs to prepared and shared. This is one of our next goals, even though the project is officially over.

For replicating the study using camera traps and Audiomoths, it would be good to involve locals living near those sites to take care of them, and maybe even do the deployment, data collection and redeployment themself. Setting them up with a good internet connection (which is available in a large proportion of area in Bilaspur district), the entire data can be uploaded into a repository without anyone even visiting them, except the initial visit(s) to train them in this process. For this, they will expect some monetary compensation. This however may be cheaper than travelling through the are area, and also has lesser carbon footprint.

For replication of our current study, we will be providing all the raw data, methods, codes etc. after the relevant publications are made. Since MaxEnt modelling is stochastic, to replicate the results, the 'set seed' has been used. In addition, while writing the manuscript, the necessary metadata and other details will be given as explained in Feng et al. (2019). All these methods are transferable to any part of the Himalayas, and we are willing to guide any researchers who would like to carry out spatial replication of this current study. Through these methods and steps, replication and upscaling is 100% possible.

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APPENDICES

Appendix 1 – Details of Technical Activities

Annexures VII, IX, XX, XXI, and XXII

Appendix 2 – Copies of Publications duly Acknowledging the Grant/ Fund Support of NMHS

Appendices 2a, 2b, and 2c.

Appendix 3 – List of Trainings/ Workshops/ Seminars with details of trained resources and dissemination material and Proceedings

See annexure XIII for photos of the workshops, Appendices 3.1-3.4 are the main PPTs/material used for workshops. However, PPTs from previous conferences/symposiums (Appendices 3.5-3.8) were also used for training, in addition to the hands-on session with autonomous recording units.

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

Annexure XXI, Appendix 5a (Butterfly occurrence dataset), Appendix 5b (Plant occurrence database)

Appendix 6 – Details of Technology Developed/ Patents filled, if any
Appendix 7 – Any other

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Annexure-I

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

For the Period: ……

1.	Title of the project/Scheme/Programme:	
2.	Name of the Principle Investigator & Organization:	
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	
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):	
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	
6.	Actual expenditure (excluding commitments) incurred during the project period:	
7.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	
8.	Balance amount available at the end of the project:	
9.	Balance Amount:	
10.	Accrued bank Interest:	

Certified that the expenditure of **Rs._____ (Rupees _____)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator)	(Signature of Registrar/ Finance Officer)	(Signature of Head of the Institution)

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

[Institution Name here]

Statement showing the expenditure of the period from
Sanction No. and Date :

1. Total outlay of the project :

2. Date of Start of the Project :

3. Duration :

4. Date of Completion :

a) Amount received during the project period :

b) Total amount available for Expenditure :

S. No.	Budget head	Amount received	Expenditure	Amount Balance/ excess expenditure
1	Salaries			
2	Permanent Equipment Purchased (Item-wise			
3				
4				
5				
6				
7				
8				
9				
10	Institutional charges			
11	Accrued bank Interest			
12	**Total**			

Certified that the expenditure of **Rs._____ (Rupees:_____)** mentioned against Sr. No.12 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date:

(Signature of Principal Investigator)	(Signature of Registrar/ Finance Officer)	(Signature of Head of the Institution)

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

Annexure-II

Consolidated Interest Earned Certificate

Please provide the detailed interest earned certificate on the letterhead of the grantee/ Institution and duly signed.

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: _____

1. Sl. No. _____
2. Name of Grantee Institution: _____
3. No. & Date of sanction order: _____
4. Amount of the Sanctioned Grant: _____
5. Brief Purpose of the Grant: _____
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: _____
7. Particulars of assets actually credited _____ or acquired_____
8. Value of the assets as on _____
9. Purpose for which utilised at present _____
10. Encumbered or not _____
11. Reasons, if encumbered _____
12. Disposed of or not _____
13. Reasons and authority, if any, for disposal_____
14. Amount realised on disposal _____

Any Other Remarks: _____

_____

(PROJECT INVESTIGATOR) **(FINANCE OFFICER)**

(Signed and Stamped) **(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	Sanctioned Cost	Actual Purchased Cost	Purchase Details

(PROJECT INVESTIGATOR) **(FINANCE OFFICER)**

(Signed and Stamped) **(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 "...." 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. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....

Head of Implementing Organization:
Name of the Implementing Organization:
Stamp/ Seal:
Date:

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