Template/Pro forma for Submission

NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Reference No.:	NMHS/2017-18/MG44/28

Date of Submission:	2	4	1	1	2	0	2	2
	d	**d**	**m**	**m**	**y**	**y**	**y**	**y**

PROJECT TITLE

UNDERSTANDING THE IMPACT OF FOREST FIRE ON FAUNAL RESOURCES OF NORTH EASTERN STATES FOR CONSERVATION AND MANAGEMENT

Project Duration:*from23.02.2018 to 23.11.2021*

***Submitted to*:**
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***Submitted by*:**
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GENERAL INSTRUCTIONS:

1. The Final Technical Report (FTR) has to commence from the date of start of the Project (as per the Sanction Order issued at the start of the project) till its completion. 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 process. Colored Photographs (4-5 good action photographs), tables and graphs should be accommodated within the report or should be annexed with captions. Sketches and diagrammatic illustrations may also be given giving step-by-step details about the methodology followed in technology development/modulation, transfer and training. Any correction or rewriting should be avoided. Please give information under each head in serial order.
3. Training/ Capacity Building Manuals (with details contents of 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 sent at 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 duly filled by the proponent and verified by the Head of the Lead Implementing Organization/ Institution/ University.
5. Five (5) bound hard copies of the Project Final Technical Report (FTR) and a soft copy 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 parts:

Part A – Project Summary Report

Part B – Project Detailed Report

Following Financial and other necessary documents/certificates need to be submitted along with Final Technical Report (FTR):

Annexure I	**Consolidated and Audited Utilization Certificate (UC) & Statement of Expenditure (SE)**, including interest earned for the last Fiscal year including 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 and 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	Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department
Annexure VI	**Details, Declaration and Refund of any Unspent Balance transferred through Real-Time Gross System (RTGS) in favor of NMHS GIA General**

NMHS-Final Technical Report (FTR) *template*

Demand-Driven Action Research Project

DSL: Date of Sanction Letter

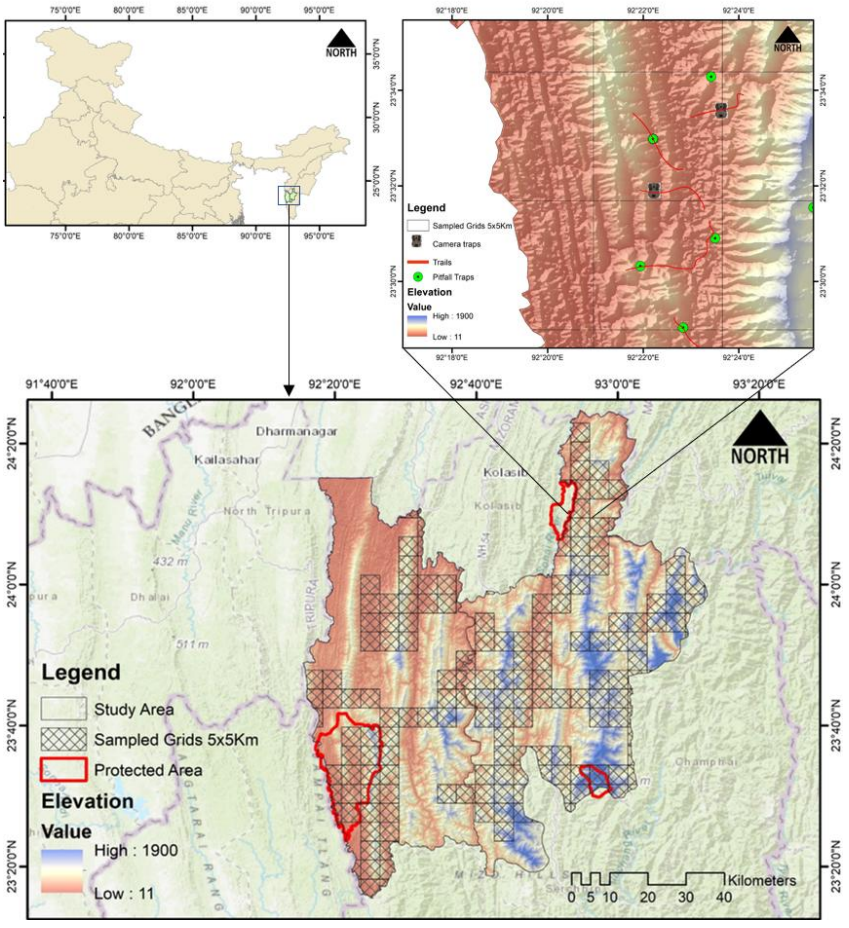
2	3	0	2	2	0	1	8
d	d	m	m	y	y	y	y

DPC:Date ofProject Completion

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

Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	NMHS/2017-18/MG44/28						
ii.	Type of Project	Small Grant		**Medium Grant**	**Yes**	Large Grant		
iii.	Project Title	**Understanding the impact of forest fire on faunal resources of Northeastern States for Conservation and Management**						
iv.	State under which Project is Sanctioned	Mizoram						
v.	Project Sites (IHR States covered) (Maps to be attached)	Aizawl and Mamit districts of Mizoram 							
vi.	Scale of Project Operation	**Local**	**Yes**	Regional		Pan-Himalayan		

vii.	Total Budget/ Outlay of the Project	Rs. 99,68,200/- (Ninety-nine lakhs sixty-eight thousand and two hundred only)
viii.	Lead Agency	Zoological Survey of India
	Principal Investigator (PI)	Dr. Lalit Kumar Sharma ScientistD& O/C Wild life& GIS Section, Zoological Survey of India, PraniVigyanBhawan M-Block, New Alipore, Kolkata-700053, West Bengal
	Co-Principal Investigator (Co-PI)	Dr G. Maheswaran Scientist E &O/C Bird Section, Zoological Survey of India, Prani Vigyan Bhawan, M-block, New Alipore, Kolkata 700053, West Bengal.
ix.	Project Implementing Partners	NA
	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	Dr Lalit Kumar Sharma Scientist D& O/C Wildlife & GIS Section, Zoological Survey of India, Prani Vigyan Bhawan, M-block, New Alipore, Kolkata 700053, West Bengal E-mail id- lalitganga@gmail.com Phone no.- 9756605304

2. Project Outcome

2.1. Abstract (not more than 500 words) [it should include background of the study, aim, objectives, methodology, approach, results, conclusion and recommendations).

Background: - Forest fires are one of the significant environmental problems in the North East Region (NER) and has become a major threat to the forest ecosystems, leading to loss of timber, biodiversity, wildlife habitat and deterioration of other natural resources. Mizoram is situated in NER of our country, where slash and burn or shifting cultivation, also known as "Jhum," is the source of sustenance of the remote communities, labeled to be the primary cause of widespread forest fires. It ordinarily upsets natural cycles, changes the region's microclimate, destroys native plant communities, and encourages the growth of fire-tolerant vegetation and non-native weeds. The forest fire leads to local extirpation of rare species and can greatly influence to community structure which is detrimental for the ecosystems.

Objective/Aim: - The objectives of the proposed study aimed to understand the impact of forest fire on faunal resources, change in species composition of major vertebrate groups/indicator taxon, identification of sites for the establishment of long-term monitoring plots, to enhance capacity building and awareness among of different stakeholders including frontline staff of forest department and building network of people and development of knowledge products for effective management.

Methodology: - Literature survey and geospatial analysis has been done to identify the knowledge gap

and study the entire landscape based on topographic, forest cover, climate and other satellite imagery data. We implemented multiple conventional methods and field survey techniques such as camera trapping, sign survey, trail sampling, questionnaire survey, variable radius point count, acoustic survey, pitfall traps, soil sampling, visual encounter surveys, opportunistic records and non-invasive sampling.

Approach: - We have used different analytical methods to understand species composition in unburnt and burnt areas and interacted with locals to understand the socio-economic vulnerability. Further statistical analysis was performed to understand the role of fire disturbance on habitat structure and faunal species in the study landscape.

Results & Conclusions: - We walked a total of 131trails of various length covering an effort of 1133 km, installed 62 camera trapping and interviewed 178 respondents representing 31 villages in the study landscape. The forest fire is a recurring phenomenon in the study landscape, with maximum instances recorded in March. The forest fire season (January to April) coincides with jhum practice; most of them are close to forests, making them most vulnerable to fires, aided by the warmest temperature. Such fires have impacted the faunal composition negatively as well as positively for few taxons. The eDNA based metagenomic analysis suggested significant change in the composition of soil fauna as well as microbes under different fire intensity regimes in the study landscape. Our analysis indicates that the recurring fires in a same micro-watershed has greatly changes the community structure of animal species. Further we observed that the jhum cultivation is leading to transformation of forest communities predominantly into bamboo patches during the cultivation period. We developed a methodology to quantify the impacts of fire on fauna which can be adopted anywhere to understand the impacts.

Recommendations: - The fire impact composit equation developed under the project can be used to]quantify the impacts of fire on fauna can be used anywhere. Our analysis indicates that there were gainers and losers animals species and taxons of forest fire, most of them get wiped away, leave the area and move to other areas for shelter but some of the taxons are gainers because they have evolved with a mechanism to safe guard them during fires like they move inside the soil burrows, escape and comeback again. These species includes largely scavengers and birds of prey as they get easy food after fire. The metagenomic analysis of the soil samples collected indicates changes in composition of soil fauna in different fire regimes indicates decrease in diversity of soil insects mostly belonging to collembola and also the microbial diversity varied but not signiticantly.Hence, we advocatelong term successional studies to understand the impacts of fire using advance techniques such asbio-acoustic survey; camera trapping and sign survey. The fire management calendars should be adopted and the strategies suggested in the calendar must be followed as per the schedules to control and mitigate ramped forest fires in the landscape. A network of agencies identified and established through the present study can be used by the forest management to deal with fire instances. Furthermore, we recommend socio-economic studies in jhum areas to understand the natural resource utilization and

dependence so that effective alternative livelihood strategy can be developed.

2.2 Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1.	To accesses the impacts of forest fire on faunal resources and diversity	• Prepared the fire risk map to identify the areas at risk and to understand the factors enhancing the breakout of forest fire for management and planning at a regional level. • Prepared the Geo-spatial data of the faunal species of both the study site and the key information on conservation status and significant action required. • The faunal diversity data were collected for various taxonomic groups using different robust methods and recorded about 116 species of bird, 28 species of mammals, 28 species of reptiles, 21 species of amphibians and a total of 418 species of insect identified belonging to 10 different orders from the field survey of 3 years. • Bio-acoustics survey and soundscape analysis were performed for the first time in forest fire impact assessment. The prime objective was to explore the biotic community using different patterns of acoustic complexity, evenness and diversity in burnt and unburnt areas, respectively. • Camera traps study reveals that the capture rates were highest for Rhesus macaque and lowest for Golden cat and Greater hog badger in burned areas. • A total of 114 tree species belonging to 89 genera and 43 families were recorded from the study area during the habitat analysis. • The eDNA based metagenomic was used on pilot basis to understand the variability in the soil fauna composition under the different fire intensity regimes.

2	To identify the sites for the establishment of long-term monitoring plots and to develop adaptive management strategies for the long-term conservation of those faunal resources	• The long-term monitoring plots for forest fire impacts on the faunal resources have been established in consultation with the forest department of the study districts. • A total of 10 permanent plots were finalized (1 ha size each based on the topographic features, cover different elevation and habitat types, species abundance, diversity and richness in the study landscape. • These plots provided all the baseline information such as the fine-scale land use land cover, forest fire frequency, species diversity and anthropogenic pressure for long-term monitoring. • In consultation with the forest department officials and different stakeholders, the forest fire management Calendar was curated for preparedness and early forest fire mitigation. • The questionnaire surveys were conducted to gather information on the people's perceptions of forest fire and conservation status.
3	To enhance capacities for the frontline staff of the forest department and other stakeholders (like local Institutions/colleges, local NGOs and local communities) for greater awareness creation and effective management of forest fire incidences and conservation of faunal resources	• To enhance the capacities of different stakeholders and frontline staff, we conducted workshops in different forest fire hotspot sites with regard to effective management of forest fire incidences and conservation of faunal resources with the helpof various stakeholders, frontline staff of forest departments and different beneficiaries identified in the study sites(organized at Aizawl Club, Aizawl on 27th and 28th April 2019 and in Mamit on 27th and 28th February 2020). • We have trained more than 150 participants from different stakeholders including forest department staff, line departments, collage students, villagers, NGOs and law enforcement agencies during the last 3 years through the training programmes. • Participants were trained in different capacities like combating forest fire, faunal monitoring, sample collection, basics of species identification, wildlife forensics and knowledge of different wildlife conservation related regulations & acts. • The training program also includes awareness through small videos, small talks, demonstrations, and knowledge products like pamphlets and brochures among the local communities regarding the negative impacts of forest fire and to quit jhum

		cultivation and deviate to other forms of income like NTFP collection, Apiculture, Greenhouse agriculture, Integrated farming etc. Also, it motivated them to take the initiative to start compulsory plantations in 30% of their allotted land. • We also tested the participants' pre and post-training understanding and knowledge about the impact of forest fire and its impact on faunal resources for understanding the success of our training programmes. • Further, we have also identified the training needs of different stakeholders in the study landscape for long-term conservation.
4	To build a network and development of knowledge products for creating awareness about the negative impact of forest fire and management and conservation of faunal resources in the North Eastern region	• To develop a network of stakeholders for forest fire management, consultative sessions were organized with different stakeholders, frontline forest staff, academic institutions etc. • A training manual and information flyers have been prepared and distributed to the various stakeholders. GIS maps have also been prepared for the Stakeholders. • To build a network of different organizations working in the study site like Young Mizo Association(YMA), Young Chakma Association (YCA) members, Village council members (VC), forest officials and many various stakeholders, local colleges and local farmers are assembled to define and share responsibilities during combating forest fire incidences and also prepare standard action plans. The same was shared with the local forest managers to deal with the forest fires in their management units.

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, and Reason thereof:
1.	Geo-spatial database of faunal resources with respect to different fire regimes and established long-term monitoring plots in two districts of Mizoram, namely	• No. of new database/ datasets generated. • Long-term Fire Monitoring Plots established. • Baseline survey report prepared.	• Forest fire risk mapwas prepared to identify the risk areas. • Spatial distribution of the faunal	No deviation of any type. Deliverable achieved 100% as per the proposal.

	Aizawl and Mamit.		resources is created. • Various ecological indices such as relative abundance, acoustics indices and diversity were generated for both study sites to know the impact of the forest fire. • The impact of fire disturbance on habitat structures was analysed. • 10 monitoring plots for forest fire impacts on the faunal resources have been established for long-term monitoring. • A total of 178 questionnaire surveys were conducted in 31 villages in the study area. (A baseline information/ reports on both the sites were generated and compiled in the technical report of the Project; Appendix-1)	
2.	Development of forest fire management site-specific calendar at each forest management unit.	• Temporal Pattern of Fire Incidence analysed. • Documented the activities performed by the forest department before and after the fire season.	• Temporal pattern of forest fire incidences was analysed for the last one decade using the fire incidence data in designated forest lands. • Forest fire management calendar in consultation with the forest	No deviation of any type. Deliverable achieved 100% as per the proposal.

			department officials and different stakeholders prepared.	
3.	Capacity building and enhancement of forest department officials in Aizawl and Mamit.	• Two Capacity Building Programmes/Training were conducted. • 157 participants, including stakeholders, frontline forest staff, academic institutions, NGOs etc. were, benefitted.	• Completely achieved. In these training programmes, we have trained 157 participants (54-from Aizawl and 93-Mamit) from district during the last 3 years in both the study sites. • 15 persons were specifically trained during thefield workin forest fire mitigation, collecting the data on forest fires and species presence recording. These 15 persons were also hired as field assistants during the study period. • The training programme's pre and post evaluationwere achieved based on the knowledge gaps and understanding of the forest fire and its impact on faunal resources.	Deliverable achieved 100% as per the proposal.

4.	Building a network of professionals and different stakeholders to combat forest fire in two districts of Mizoram, namely Aizawl and Mamit		• A training manual and information flyers have been prepared and distributed to the various stakeholders. GISmaps have also been prepared for the Stakeholders. • We build a networkof the different organizations working in the study site like YMA, YCA members, forest officials and other stakeholders like Village council members (VC), local colleges and farmers are assembled to define and share responsibilities to combat forest fire incidences and also prepare common action plans. • Further, we also prepared the data of different groups of institutions with the role can contribute to the protection and conservation offaunal resources and forest fire management in Mizoram	Deliverable achieved 100% as per the proposal

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

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

S. No.	Particulars	Number and Brief Details	Details of Attachment/ Supporting Document
1.	New Methodology developed:	NA	

S. No.	Particulars	Number and Brief Details	Details of Attachment/ Supporting Document
2.	New Models/ Process/ Strategy developed:	Two (2), The use of Bioacoustics survey for the first time in order to assess the impact of forest fire on avian abundance,diversity and developed forest fire management calendar for long-term monitoring and forest fire management.	Report attached inAppendix-1
3.	New Species identified:	Two (2),A species of Semi slug *Austeniaresplendens*(Nevill, 1877) and a land operculate snail *Cyclophoruspfeifferi* (Reeve, 1861)	(Paper attached with Appendix-4)
4.	New Database established:	A Geospatial database of the faunal speciesof the study landscape wasdeveloped.	(Details of the Geospatial database are provided in the Appendix-1)
5.	New Patent, if any:	NA	NA
	I. Filed (Indian/ International)	NA	NA
	II. Granted (Indian/ International)	NA	NA
	III. Technology Transfer(if any)	NA	NA
6.	Others (if any):	NA	NA

3. Technological Intervention

S. No.	Type of Intervention	Brief Narration on the interventions	Unit Details (No. of villagers benefited / Area Developed)
1.	Development and deployment of indigenous technology	NA	
2.	Diffusion of High-end Technology in the region	NA	
3.	Induction of New Technology in the region	NA	
4.	Publication of Technological / Process Manuals	NA	
	Others (if any)	NA	

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilization New data
1.	Fire risk map prepared	Not available before the present study.	The spatial database generated under the Project to understand the factors enhancing and identifying the fire risk areas for conservation and management planning.
2.	The spatial database of faunal species in the Mizoram (Aizawl and Mamit district).	Not available, for the first time, a consented effort was made to compile distribution data with specific point locations.	The spatial database generated under the Project is fine-scale and can be used for conservation and management planning.
3	A database of the acoustic index with respect to time since fire	Not available, an innovative effort was made to compile different acoustic indices patterns (complexity, evenness, diversity, bio-acoustic index and normalized difference soundscape index) in separate areas for burnt and unburnt habitats.	The generated data under the Project can be further used for wildlife monitoring, biodiversity conservation and management.

5. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	**ST**	**Woman**	**Total**
1.	Workshops	A total of 2 workshops were conducted in two different study sites in Mizoram	To enhance the knowledge of forest fire and its detrimental impact on wildlife of all the possiblestakeholders, frontline forest staff of the study sites.These include Forest Department officials, NGOs (like YMAand YCA), Academic institutions, Village council membersas well as elected members of the region.	(Categories not defined)	(Categories not defined)	42	157

2.	On Field Trainings	Two trainings were held with field demonstration sessions	To develop knowledge and quick responsiveness toward forest fire, faunal monitoring, basics of species identifications and creating awareness toward conservation and sustainable development.	(Categories not defined)	(Categories not defined)	42	157
3.	Skill Development	The skill developed in using monitoring equipment and methods for forest fire monitoring and faunal species conservation.	The activity was intended for all stakeholders of the study districts. Moreover, enhanced skills of tracking porters and field guides will openup new avenues for fetching good remunerations from tracking tourists because these sites have some of the best tracking trails in North Eastern regions.	(Categories not defined)	(Categories not defined)	4	15
4.	Academic Supports			(Categories not defined	(Categories not defined	17	33 students
	Others (if any)						

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

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
1.	Sustainable Development Goal (SDG)	NA		
2.	Climate Change/INDC targets	NA		
3.	International Commitments	NA		
4.	Bilateral engagements	NA		

5.	National Policies	Data generated under the Project will directly contribute towards achieving the national biodiversity targets, the Indian Wildlife Action Plan. The information will be useful in developing the working plans of territorial forest divisions and action plans for Protected areas falling under the study districts. The data generated under the Project can also be used for making Peoples Biodiversity Registers (PBRs)	Technical reports are provided to Forest Departments on an annual basis as well as the final technical report along with all the research papers, books, and flyers published under the Project.	MoEFCC, Ministry of statistics, NMHS, NAPCC, UNCCD reporting, State Forest Departments, Agencies such as UNDP, WB, GEF, GIZ etc. The Biodiversity Management Committees of the states can utilize the data for making PRBs.
6.	Other collaborations	Collaborations with Symbiosis InternationalUniversity	2 MSc and dissertations published based on the project data.	The degrees published by the universities of the students who worked under the Project will be of great use in reporting academic excellence and national reporting and grading of universities.

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	64 Village council members, trained for biodiversity monitoring, awareness creation related to the ecological importance of species in the areas, and sustainable forest resource extraction.	• Local peoples involve awareness creation regarding active participation in combating and fire mitigating techniques. • Local peoples were concerned about the negative impact of forest fire and the jhum cultivation, and they are now slowly shifting to other sustainable agricultural practices like apiculture, greenhouse farming, sloping agriculture land technology (SALT), commercial plantation and quit jhum cultivation.

2.	Govt Departments (Forest)	The frontline staff of the forest department were trained in the different monitoring methods, and research manuals and toolkits were shared for effective monitoring and conservation plan. The training will be helpful in forest fire management.	• Teaching, handling, demonstrating and trainingwith firefighting equipment and developing effective management strategies for combating forest fire incidences like creating control lines separating forest and nearby agricultural land and clearingoff-dry fuel in the forest at regular intervals.
3.	Villagers	76 Villagers were trainedand encouraged to create awareness about the importance of wildlife conservation,the negative impact of forest fire, the impact of jhum cultivation, and minimizing the use of forestproducts. Use of other agricultural practices other than jhum cultivation. They wereencouraged about the alternate agricultural practices and involvement in the compulsory plantation in fallow jhum lands.	Awareness program and outreach regarding negative impacts of forest fire mainly caused due uncontrolled fire spread because of jhum cultivation.
4.	SC Community	**(Categories were not defined) same as in villagers**	**(Categories were not defined) same as in villagers**
5.	ST Community	**(Categories were not defined) same as in villagers**	**(Categories were not defined) same as in villagers**
6.	Women Group	Capacity building	Women were involved in creating awareness for forest fire and its impact on wildlife species.
7.	Others (Forest department, Tourism department, State Public Works Department)	Data generated under the Project will be useful in making informed decisions for sustainable development activities.	The data generated under the Project will be shared with all these frontline departments in the form of a report, which they can utilize for planning development activities, forest fire management and sustainable and true nature-based eco-tourism.

8. Financial Summary (Cumulative)

S. No.	Financial Position/Budget Head	Funds Received	Expenditure/ Utilized	% of Total cost
I.	Salaries/Manpower cost	2298726	2004336	87.19
II.	Travel	1521127	1151512	75.70
III.	Expendables &Consumables	1295527	1171953	90.46
IV.	Contingencies	451127	435361	96.51
V.	Activities & Other Project cost	3162864	3050075	96.43
VI.	Institutional Charges	0	0	0
VII.	Equipment	828627	562210	67.85
	Total	9557998	8375447	87.63
	Interest earned	0		
	Grand Total	9557998		

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

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

S. No.	Name of Equipment	Cost (INR)	Utilization of the Equipment after Project
1	Suunto KB 20 Precision compass (5 no.)	36030	Will be utilized in ZSI Wildlife section for further research work in Himalayan landscape and elsewhere.
2	Garmin GPS (3 no.)	108000	
3	Laptop (1 no.)	61580	
4	Camera traps (15)	277500	
5	Sound Recorder devices (8 nos.)	79100	

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

10. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Details of Attachments/ Supporting Documents
1.	IHR States Covered	1	Mizoram
2.	Project Site/ Field Stations Developed	2	Mamit & Aizawl districts
3.	New Methods/ Modeling Developed	1	Jhum fire Risk Map developed
4.	No. of Trainings arranged	2 training programs and workshops	A total of 150 persons participated in thetraining programs representing different stakeholders including the forest department, police,

			agriculture, local communities, local collages, schools, NGOs (YMA) and media.
5.	No of beneficiaries attended trainings	150	Differentstakeholders including the forest department, police, agriculture, local communities, local collages, schools, NGOs (YMA) and media.
6.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA):	7 JRFs	Excel file 1(with Annexure)
7.	SC stakeholders benefited	Not Categorized	
8.	ST stakeholders benefited	Not Categorized	
9.	Women Empowered	5	
10.	No of Workshops Arranged along with level of participation	2	150 Participants
11.	On-field Demonstration Models initiated	*NA*	
12.	Livelihood Options promoted	*NA*	
13.	Technical/ Training Manuals prepared	One field manual was developed and circulated.	Field manuals for understanding the impact of forest fire on faunal resources was developed for different stakeholders.
14.	Processing Units established	NA	NA
15.	No of Species Collected		611 species recorded
16.	New Species identified	2	• Semi slug *Austeniaresplendens* (Nevill, 1877) • Land operculate snail *Cyclophoruspfeifferi* (Reeve, 1861).
17.	New Database generated (Types):	3	• Fire Risk map prepared • An spatial database of faunal species in the Mizoram(Aizawl and Mamit). • A database of the acoustic index with respect to time since fire
	Others (if any)		

11. Knowledge Products (KPs) and Publications

S. No.	Knowledge Products (KPs)/ Publication	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal Research Articles/ Special Issue:	2	3 under submission		
2.	Book Chapter(s)/ Books:				
3.	Technical Reports				
4.	Training Manual (Skill Development/ Capacity Building)	2			
5.	Papers presented in Conferences/Seminars	NA			
6.	Policy Drafts/Papers				
7.	Others:				

*Please append the list of KPs/ publications (with impact factor and further details) with due Acknowledgement to NMHS.

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

Particulars	***Recommendations***
Utility of the Project Findings:	The current study addresses the different issues on the conservation of faunal resources in Mizoram due to recurrent forest fires. The Project has utility in designing management strategies for combating forest fire incidences. The significant uses of the project outputs are provided below:- 1.The methods standardized under the Project will be helpful inbiodiversity monitoring and conservation in North Easternregions. 2. Geospatial database generated for the faunal resources of Mizoram will be helpful in the evaluation of climate change impacts and trends in loss or gain in the habitat of species. 3. Establishment of long-termmonitoring plots in the study landscapewill help in achieving the monitoring goals and further assessment of the status of faunal composition due to forest fire. 4. Capacity building of different stakeholders will help in knowledge sharing, awareness creation, effective monitoring,and forest fire management. 5. Building a network of people, including stakeholders and forest fringe populations, would facilitate early prevention, preparedness, and mitigation in case of any widespread fire.

Replicability of Project:	The methodologies, study design, and data generated in the present study are reproducible. They can be replicated in the survey for other North Easternstates facing the same types of problems. The respective data obtained from the camera traps, sign survey, and acoustic survey are provided with the abundance information in the form of captures and encounter rates, and this information can be used at temporal and spatial scale to determine how the occurrence of the species change with reference to any change in the habitat structuredue to forest fire. GPS locations of the species are available and can be further used. Manuals developed for the capacity building programs and other procedures are standard and have the reproducibility for the wildlife monitoring.
Exit Strategy:	The project's outcomes will be of great help in developing conservation and management strategy in forest areas where forest fire is a recurring issue. Activities envisaged in the project can be sustained by the funding support of state and central governments or the international donor agencies such as the World Bank, UNDP, etc. As per the existing mechanism in states, forest departments have funds for the management of forested areas under the working plans and protected area management plan from which required funds can easily be allocated as a forest fire is a very serious issue in the North Eastern region of the country.

(PROJECT PROPONENT/COORDINATOR)

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PART-B: DETAILED PROJECT REPORT

1. EXECUTIVE SUMMARY:

The Executive Summary of the project should not be more than 3–5 pages, covering all essential features in precise and concise manner as stated in Part A (Project Summary Report) and Part B (Comprehensive Report).

Background:

Forests are major natural resource and they play an important role in maintaining environmental balance. The health of a forest in any given area is a true indicator of the ecological conditions prevailing in that area. Globally forest fire has been recognized as the major driver of the degradation of forests. Forest fires are considered to be a potential hazard with physical, biological, ecological and environmental consequences. Fire has been a major influencing factor in developing and managing many of the world's forests. Some forest ecosystems have evolved in response to frequent fires from natural causes, but most others are susceptible to the effects of wildfire. Each year millions of hectares of the world's forests are consumed by fire, which results in enormous economic losses because of burnt timber, degraded real estate, high costs of suppression, damage to environmental, recreational and amnesty values, and loss of life.

Forest fires are one of the major environmental problems in the North East Region (NER) with large tracts of forest areas are affected every season. It has become a major threat to the forest ecosystems in the region, leading to the loss of timber, biodiversity, wildlife habitat and loss to other natural resources. Studies on forest fire have reported that about 50% of forest fire in the country takes place in the NER region. As per the FSI, the main reasons for the change in the forest cover have been summarized to be due to the shortening of the cycle or fallow period of shifting cultivation. Most of the forest fire in NER is anthropogenic in nature. Communities use it to prepare lands for shifting cultivation, clear forest floors for NTFP collection, and promote grass growth for grazing. Poachers use it to force wild animals to come out of safe hiding places. At the same time, unintentional fires caused by careless throwing of burning matchsticks and escape of cooking fire from temporary shelters for road workers also account for many forest fires. Traditional shifting cultivation is believed to have an adverse effect on soil arthropods. A recent study on the diversity of soil marcoarthropods in shifting cultivation leads to a decrease in species composition compared to the natural forest (Zodinpuii et al. 2019).

Increased incidences of forest fire have prompted government intervention and schemes to prevent and control forest fire in Mizoram (Darlong, 2001). But the cause of failure is the piecemeal approach to the problem. Both the national focus and the technical resources required for sustaining a systematic forest fire management program are lacking in the country. The losses due to forest fires range widely from

ecological to socioeconomic impacts on society. Important forest fire management elements like strategic fire centers, coordination among Ministries funding, human resource development, fire research, fire management, and extension programs are missing. It is a serious problem, and it is necessary to make some major improvements in the forest fire management strategy for the country. The Ministry of Environment and Forests, Government of India, has prepared a National Master Plan for Forest Fire Control. This plan proposes to introduce a well-coordinated and integrated fire-management programme.

Therefore, the present study aimed to understand the impact of forest fire on faunal resources and the change in species composition of major vertebrate groups/indicator taxon by comparing pre and post-fire conditions in the selected study area. To establish long-term monitoring to understand the impacts of forest fire and change in species composition. Long-term monitoring of biodiversity has a greater implication in understanding the changing biodiversity trends and providing useful information for management and developing effective conservation strategies. To enhance capacities and awareness among of different stakeholders for effective conservation and management. Furthermore, we also built a network of people working in the area that will be created for the effective management of forest fire in the study sites.

Methodology:

The study was conducted in two districts of Mizoram, namely Aizawl and Mamit, located in northeast India. Aizawl is the largest city as well as the capital of the state of Mizoram in India. According to the 2011 census, the Aizawl district is the most populated district of Mizoram, with a population of about 400,309. It is the most urbanized among all the other eight districts of the states. The population density of Mamit was reported to be the lowest density at 28 persons per sq. km among all other eight districts of the state. Both the study areas were classified under the different grids based on their forest types and elevation gradient feasibility of sampling location. The field surveys were conducted from October 2018 to November 2021 in different months in both the study sites. We also undertook a reconnaissance survey and interacted with the locals, and gathered information. We have identified the fire risk area fire by preparing the fire hotspot using the fire instance data of MODIS. Based on MODIS active fire products, fire occurrence frequency at various spatiotemporal grids were identified based on the time since fire and classified into three broad categories: unburnt or control sites (no fire record), single-fire and repetitive-fire. In single-fire sites, a fire occurred once in the last 20 years, while in repeated fire sites, fires have occurred at least 3 times in the last 20 years. Further, the single and repetitive fires are categorized into five types from 2yr to 20yrs of time since fire.

For all direct or indirect signs (direct sighting, fecal matter, hair, footprint, scraps) of vertebrate names of the locality, GPS coordinates, altitude, sign type, terrain, forest type, canopy cover, distance from the nearest village, distance from nearest water source along with photographs were recorded. Camera traps were deployed in the selected micro-watershed, for which remote Camera traps. Pitfall traps were installed in a $100m^2$ plot for invertebrate sampling. Light traps (For light attracting insects) and a Sweep

net were also used to sample ground vegetation or to target aerial insects, like wasps and butterflies, selectively. We also conducted a questionnaire survey in the selected forest fringe villages based on the fire hotspot zones. The avifauna of the landscape was documented through the point count methods and acoustic survey during the trail walk in the selected grids. We collected surface soil samples from different depths, viz. 0–10 (Top), 10–20 (Middle), and 20–30 cm (Bottom)from all the risk zones. Soil samples were immediately transported to the lab to analyze for total nitrogen and available nitrogen. All the samples were air-dried at room temperature, sieved through 2 mm sieve and stored in zip-lock plastic bags. Soil samples were homogenized (i.e., using a clean spatula to dissociate large clumps of material) and further processed for DNA extraction.

Results:

Cumulatively, a total of about 131 trails were walked, covering with a team effort of 1133 km in both the study sites of Mizoram. We placed about 62 camera traps with a total effort of 1670 camera trap night effort was made from October 2018 to November 2021 in both the study sites.

A total of 935 non-invasive samples were collected. Information on the socio-economic condition of forest-dependent fringe people was collected through questionnaire surveys of n=178 respondents of n=31 villages at both sites.

A total of 9,236 and 12,528 forest fires incidence were recorded in the Mamit and Aizwal districts of Mizoram from 2001 to 2020, respectively. Most of the forest fire incidents in the study site were documented in the month of March, about 78.41 % in the period of 2001-2020. About 46.5 % of the total study area is under ahigh fire risk zone and 16.62 % area is under a very high-risk zone, which calls for higher priority for fire prevention. This study confirmed that forest fire probability has a strong correlation with anthropogenic variables like distance from human settlement and distance from the road, especially in lower elevations below 1000, with about 96% of fire incidence.

We gathered the data of around 611 faunal species from entire study sites and spatial data were prepared for all these species with all information on the habitat, conservation action and threats. In the study area, we documented 28 species of mammals. The overall encounter rate was highest for Rhesus macaque(0.023± 0.012), followed by Wild boar (0.015±0.009) and they were more or less uniformly distributed in most of the sampling trails walked. Other species like the Indian bison, Indian flying fox, Himalayan Crestless Porcupine, Barking deer, Yellow-throated Martin, Indian grey mongoose, Large Indian civet etc, also recorded. Moreover, 28 species of Reptiles are also observed during the sign survey. From the Aizwal district, Mizoram, we documented 9 species of mammals. The encounter ratewas highest for Wildboar (0.010±0.006) followed by Barking deer (0.006 ± 0.002) and Rhesus macaque(0.006± 0.003) in Aizwal.

In the Mamit district, sign survey resulted in recording of 21 mammalian species with a high encounter rate of Rhesus macaque(0.017± 0.005) followed by Indian bison (0.011±0.006) and least was found for

Asiatic Golden cat (0.001±0.001). We also observed human disturbances in the other sites, where livestock, domestic dogs, and other species were caught in the wildlife habitats

A total of 418 Invertebrate species were identified from a total of 43,833 individuals belonging to ten different orders of insects were collected from the study sites.The most abundant orders were: Hymenoptera (42.7%), Coleoptera (38.8%). The remaining specimens belonged to other orders, such as Lepidoptera (7.9%), Hemiptera (3.1%), Orthoptera (2.4%), Diptera (2%), Odonata (1.1%), Blattodea (1%), Phasmida (0.51%) and Arachnida (0.45%).The overall mean number of species per trap site was higher at Unburnt or control site, significantly lower in single burn and repetitive burn sites respectively, However, the overall mean number of individuals tend to increase in in single burn site but decrease with increase in fire frequency in repetitive burn sites significantly (Appendix 1). The mean number of individuals is low compare to other sites significantly.

We identified and established 10 plots for the long-term monitoring in our study sites. These plots were selected based on the survey. 150 participants were trained, which represent about departments, Forest Department, line Departments, NGOs, CBOs, paramilitary forces, frontier forces, local police, schools and colleges. We developed a network of people with local administrative bodies like Village council members of the Young Mizo Association (YMA) and Young Chakma Association (YCA), teachers from the academic institutions, forest department staff and many other stakeholders. We prepared a Forest fire calendar that will help the local managers in utmost preparedness and help in prevention, control, and mitigation of fire.

Conclusion:

The species richness decreased drastically with time since fire in repetitive fire sites compared to single and unburn sites. After repeated fires, the sites had recovered only partially, even till the late-successional stages of 20years. Hemiptera, Lepidoptera, and Odonata showed the lowest resilience to fire and recovered only after 5-10 years after the first fire.. Diversity Index of birds reveals unburn or control fire sites were the most diverse zones with high species richness of birds encountered in both point count and recorded in acoustic devices. ADI (Acoustic Diversity Index) also supports the Shannon diversity index, with the highest mean value in control fire zones. NDSI (Normalized Difference Soundscape Index) in turn, provided the ratio of biophony and anthrophony, explaining which component is dominant in the study landscape. Repetitive and single fire sites were dominated by anthrophonic components, which is quite real as we observed many anthropogenic activities in these areas.

We also analyzed historical forest data to identify the spatial and seasonal distribution of forest fires in both the district of Mizoram. The analysis provides a reasonable estimate of the occurrence of the fires in various land covers, topographic and near different settlement features. The district-level forest fire risk maps with spatial faunal composition data will be advantageous for forest managers at the national and regional levels to allocate resources among the districts based on their relative risks. Permanent

monitoring plots will help in the continuous monitoring of faunal species with respect to change in any catastrophic event and other anthropogenic activities.

Here the forest fires have been a local issue with global impact, which may happen more frequently than the recent past due to the impact of rising temperature and global warming. The forest fire in NER is anthropogenic in nature. Communities use it to prepare lands for shifting cultivation, clear forest floor for NTFP collection, and promote grass growth for grazing. Poachers use it to force wild animals to come out of safe hiding places, while unintentional fires caused by careless throwing of burning matchsticks and escape of cooking fire from temporary shelters for road workers also account for many forest fires. Changes in the attitude and action of individuals, stakeholder groups, the private sector, and governments are required for action and implementation of sustainable forest fire prevention policies. But before any conservation plans, we need to consider the ongoing practices of shifting cultivation by the local communities for their sustenance and the interval between successive jhuming cycle or fallow period have declined from around 20 years to about 3-6 years now in most parts of both the study sites, creating large areas of arrested successional bamboo forests (Tewari 1991; Ramkrishnan 1992). In our study, we clearly show that the decrease in the jhum cycle or fallow period of our study, the greater the impact on the faunal species. It is therefore very essential to demarcate and protect areas of primary and late-successional forest in order to achieve conservation goals.

Recommendations:

We recommended that Geo-spatial analysis of forest fire and Camera trapping will be useful for understanding the forest fire pattern and its impact on fauna in North Eastern Region. Long-term monitoring of Faunal species is required, especially in the selected permanent plots in both the study sites. There is also the immense need to implement various government schemes related to livelihood to reduce the dependency of Villagers on traditional shifting cultivation. Different methods for cultivation should be adopted by the villagers with properly government-funded thus to change their traditional way of cultivation with more upgrades and advanced methods for better yield. Strengthening emergency communication systems for early warning and quick response by increasing linkages among institutional capacity will effectively lower further risks of widespread forest fire in the State and improve productivity. Thus more quick-fire response teams should be built under government support with fully equipped advanced tools for necessary action during a forest fire. Education is the best means to literate people regarding the awareness of climate change and its impact on our daily life. Thus, we would recommend having more workshops with ground site local people to create awareness and educate them for better livelihood. Community participation and different adaptive management strategies will be key to achieving successful conservation goals.

2. INTRODUCTION:

2.1 Background of the Project *(max. 500 words)*

Forests are major natural resources, and they play an important role in maintaining ecological balance. The health of a forest is an indicator of the prevailing conditions that thrive in the ecosystem. Globally forest fires are recognized as one of the significant drivers of forest degradation. It is, therefore, considered to be a potential hazard with physical, biological, ecological and environmental consequences. Forest fires are a major environmental problem in the North Eastern Region, where large tracts of forests are affected every year. It has become a major threat in the region leading to the loss of biodiversity, timber, habitat fragmentation and degradation of other natural resources. Mizoram, situated in the North Eastern region of the country, is famous for practicing slash and burn shifting cultivation or locally known as jhum, the predominant form of agriculture, the prime reason for forest fire in the area. It covers a total geographic area of 21,081 sq.km, out of which 80% of the area is under the state's recorded forests. Increased incidences of widespread forest fire have resulted in detrimental consequences. Forest fire causes drastic structural change and local extirpation of all faunal elements that depend on the unburnt forest habitat. It destroys all forms of life and different levels of an organization, including organic matter, saplings, seedlings, insects, micro invertebrates and fully grown trees. Altogether, these have varied impacts on the country's economy, environmental well-being, human safety and wildlife. The major change in the micro climate of the region in terms of soil moisture balance and increased evaporation is also attributed to the fire. Previous studies have documented floral and faunal composition of the state's protected areas; however, no study is made to assess the impact and monitor the effect of forest fire on the faunal resources. As a silviculture practice controlling fire though may help in managing the ecosystem, but uncontrolled fires contribute heavy loss to the biodiversity, soil fertility and sustainable forest base production. Therefore, understanding its repercussions on biodiversity richness, wildlife habitat, vegetation and landscape properties remains an imperative task. Mitigating the threats and challenges requires a series of diverse and interdisciplinary studies, which will gather information on spatial distribution, demography, evolutionary history and landscape features.

2.2Overview of the major issue to be addressed: *(max. 1000 words)*

The Indian Himalayan Region is experiencing rapid land-use changes to meet the growing needs of the human population, such as the expansion of agricultural lands in the hilly tracts, conversion of forest land into the commercial plantation, forest encroachment, and other developmental activities (Pandit et al. 2007). In the recent past, the unorganized developmental activities within the North Eastern region have led to biodiversity loss, degradation of natural resources, uncontrolled forest fire incidents, agricultural expansion, forest degradation, and deforestation. Consequently, mountain ecosystems are meeting with species extinction and natural landscape elements. Wildfires are steadily augmenting factors in the degradation process in India, yet the extent and biological quantification of the total damage is widely

disputed. Climate change is another globally recognized threat to intensify the damages, disrupting the flow of ecosystem services. It is evaluated that the proportion of forest areas prone to fire annually ranges from 33% in some states to over 90% in others. The Forest Survey of India (FSI) estimated that about 50% of the forest area of the country is prone to forest fire. It is estimated that about 3.73 million ha. of forest area is annually affected by forest fires, where hefty, heavy and frequent forest fire damages are noticed in over 0.87%, 0.14% and 5.16% of forest areas. Forest fire destroys all forms of life at different levels of organizations, damaging forest wealth and ecosystem, thus, impacting regeneration processes and successional stages. It upsets natural cycles, destroys native plant communities and encourages the growth of fire-resistant vegetation and invasive weeds. The phenomenon also results in the generation of ash, decaying of organic nutrients, increased water run-off and soil erosion. The change in precipitation patterns, global temperature increases and climatic isotherms adversely affects plant phenology and range shift of vegetation pattern, which dramatically impacts the adaptability of faunal resources. The forest fire is identified as an accidental disaster that is predominantly anthropogenic, recurring throughout the spatial coverage of forests in the country. So far, concerted efforts have mainly focused on saving the threatened species of protected areas of mainland Himalayas, but non-protected areas are also undergoing undue pressure from communities located inside and outside the fringe areas (Sharma and Yonzon, 2005), causing threat levels to animals and birds partly or whole. The Eastern Himalayan or the North Eastern hills, in particular, is a complex region where tribal populations have used wildlife resources and adapted to shifting cultivation to meet their livelihood needs. Since the communities have evolved in such a way that forests, wildlife hunting, exploitation and over utilization of natural resources, timber extraction and illegal trade have become so integral to their lifestyle, leading to the unsustainable ecosystem, that more intensive interdisciplinary understanding is required for strengthening conservation and management initiatives (Aiyadurai et al. 2010). The indigenous institutions play an important role in forest management. As per the Forest Survey of India, the main reasons for the change in the forest cover in Mizoram have been summarized due to shortening periodicity of shifting cultivation, encroachment and illicit felling (SFR, 2011). Increased incidences of forest fire have prompted the government to formulate schemes aiming at prevention and control. The effect of fire on the forest ecosystem depends on fire regime, fuel availability and burn severity. The direct and indirect effects of fire vary among different taxonomic groups. Soil is an effective insulator, so many animals survive in crevices and cracks or in burrows of the soil. Reptiles and slow-moving invertebrates can suffer higher mortalities, also true in the case of large mobile vertebrates in severe fire incidences. A large crown of a forest fire causes drastic changes in habitat attributes and local extirpation of all faunal elements. The size and configuration of burnt and unburnt patches influence animal meta-populational structure and composition through local extinction and patch recolonization of animal species (Pons and Clavero, 2010). Many species are threatened with extinction because changes in the fire regime no longer produce the right mix of mature and immature populations of food plants that are necessary for their survival. Several studies have attributed the decline of bird species to the development of homogeneous landscapes through the

systematic burning of large tracts of land. Moreover, in North Eastern regions where wildfires are caused by humans, impacting the forest structure, have already devastated and disturbed the faunal resources. Moreover, many primary forest specialists, including squirrels, hornbills, and other fruit-eating and frugivorous birds and primate species, will disappear altogether from burnt and adjacent areas. In addition, during post-fire, wildlife populations can suffer substantial losses due to habitat alteration and destruction. Wildlife species get displaced and hence spend more time searching for food, water and shelter. Such displacements sometimes encourage the animals to travel to other areas, leading to increased competition for available food, water, and shelter and sometimes leading to man-animal conflict. The forest fire can potentially destroy the local natural resources completely and disrupt the ongoing ecological succession. Hence, the present study has been proposed by keeping the above in view to understand the impact of forest fire in sites that experience recurring forest fire instances. In the present scenario, the information on the impact of forest fire on faunal resources is not available from any ecosystem in India. Till now, no forest fire impact assessment has been carried out in the North Eastern hills, so such impact assessments will be helpful in developing effective conservation and management strategy for ensuring the long-term sustainability of ecosystem services.

2.3 Baseline Data and Project Scope: *(max. 1000 words)*

The biodiversity on the earth is unevenly distributed, and hence it is imperative to generate information on the distribution patterns of species for conservation and management planning. Forests of different regions have unique structures and species compositions. A lot of ecosystems in the Indian Himalayan Region are under significant threat due to various developmental activities leading to habitat fragmentation, deforestation and forest degradation. Anthropogenic pressure from the local inhabitants and unsustainable use of natural resources also lead to species extirpation from their habitat causing environmental deterioration. Forest fire is an example of a major environmental problem in the North Eastern landscape. Large forest tracts are destroyed annually, leading to the loss of timber, biodiversity, ambient atmosphere, and other natural resources. Forest fire analysis has revealed that 50% of fire incidences are occurring in the North Eastern region, reason accounting to be anthropogenic in nature. The slash and burn or shifting cultivation is a predominant form of agriculture in the hill tracts of Mizoram, causing major fire accidents. The place is a meeting region of temperate east Himalayan flora, paleo-arctic flora of Tibetan highland, wet evergreen flora of southeast Asia, and Yunnan forming bowl of biodiversity. The altitudinal variation and rainfall patterns of southwest and northeast monsoon play a significant role in the development of ecological niches in this region of India. Increased incidences have prompted government interventions and schemes aimed at preventing and controlling forest fires in Mizoram as the phenomenon is responsible for changing the landscape extensively and breaking down the whole ecosystem. Forest management has suffered in the recent past due to land pressure, shifting cultivation cycle, exploitation of forests for timber and lack of scientific management strategy. Knowledge of fire is important to the local managers to carry out ecosystem conservation, management

and restoration processes. The direct effects of fire on animals vary among the different taxonomic groups. Agile animals can flee to refugia within the fire such as termite mounts, or move across the fire line to places of safety. Soil is an effective insulator so that many animals survive in crevices and cracks or in burrows in the soil. Reptiles and slow-moving invertebrates can suffer higher mortalities and mortalities of large mobile vertebrates, including humans, occur only in the most severe fires. But the indirect effects of fires are generally far more important than fire line mortality, especially changes in habitat attributes as vegetation recovers from a fire. A large crown fire in a forest causes drastic structural changes and local extirpation of all faunal elements that depend on un-burnt forest habitat. Post-burn stages are colonized by a new suite of species. Even frequently burnt grasslands have distinct bird assemblages which turn over with successive years of re-growth after burning. The pattern of fires across a landscape imposes a mosaic of patches of different succession ages. The size and configuration of patches influence animal meta-populational structure and composition through local extinction and patch recolonization of animal species (Pons and Clavero, 2010). For example, nectar-feeding birds in shrublands will lose its food source after a burn and have to seek un-burnt stands for food. Hence, the landscape configuration of old stands with flowering, and young stands with immature shrubs, necessitates a highly mobile bird assemblage. Many primary forest specialists, including squirrels, hornbills, and other fruit-eating and frugivorous birds and primate species, will disappear from burnt and adjacent forests. In addition, during post-fire, wildlife populations suffer substantial losses due to habitat alteration and destruction. The wildlife species get displaced and hence spend more time searching for food, water and shelter. Such displacements sometimes encourage the animals to travel to other areas, leading to increased competition for available food, water, and shelter and sometimes leading to a man-animal conflict situation. A forest fire has the potential to completely destroy the local natural resources and can disrupt the ongoing ecological succession. Hence, considering all these facts, the present study was proposed to understand the impact of forest fire on wildlife, particularly in sites that experience recurring instances. The Government of India Parliamentary Committee on Science and Technology 2016 have visited fire affected areas in Western and North-Western Himalayas and stated the need of studying impact assessment of fire on local biodiversity. In the present scenario, there is not a single study available in India where forest fire impact assessment has been carried out especially in the Himalayan region and North Eastern hill states. So, the information on the impact of forest fire on faunal resources is not available from any ecosystem in India. Thus, the information generated from the proposed study will be helpful for the restoration of ecological balance in Himalayan regions, protection of forests from fires and conservation

2.4Project Objectives and Target Deliverables

SerialNo.	Chief Objectives	Target Deliverables
	Assessing the impacts of forest fire on faunal resources and diversity: Estimating losses to faunal resources, changes in species composition of in lower taxon and major vertebrate groups in different fire regime.	Baseline knowledge about the faunal resources and forest fire hotspot identification for long-term monitoring in two districts of Mizoram, namely Aizawl and Mamit.
	Identification of sites for the establishment of long-term monitoring plots: Identification of plots in the study area with an aim to carry out long-term monitoring of the impacts of forest fire and changes in species composition.	A spatial database of Faunal species in both the district of Mizoram and their permanent plot has been established. Forest fire management site-specific calendar prepared.
	Capacity building of the frontline staff of forest department and other stakeholders: A number of training and workshops will be conducted to create awareness about forest fire incidences, effective management and conservation of faunal resources with the help of different stakeholders and beneficiaries identified.	No. of training programs and workshops conducted focusing on effective and well-structured training with the latest techniques and skills on forest fire monitoring, generating awareness among the locals for understanding the importance and sustainable use of forest resources.
	Building network and development of knowledge products: A network of organizations such as locals, NGOs, college and university departments, and forest officials will be created for handling forest fire issues in the study sites.	Building a network of professionals and different stakeholders to combat forest fire in two districts of Mizoram, namely Aizawl and Mamit.

3. METHODOLOGIES, STRATEGY AND APPROACHES:

3.1 Methodologies used for the study: *(max. 1000 words)*

a) Literature Survey: The existing documented studies across Mizoram were surveyed for assessment and identification of the knowledge gap in order to carry out the proposed study. **b) Geo-spatial analysis**

for the selection of study sites: The geo-spatial analysis was carried out in the ArcGIS software program to identify the forest fire hotspots. **c)Questionnaire Survey:** The information on forest fire frequency, incidences, peak season, periodicity, ethno-zoological facets, human-wildlife conflict and local's perception of wildlife conservation were systematically collected during the study period using semi-structured questionnaire surveys. We covered villages from different forest fringes across different forest divisions in both the study sites. Efforts were made to sample a minimum 30% of the total number of households.

Field sampling techniques to study the impact of fire on faunal resources during pre and post-fire situations: Various methods opted for data collection **For Mammals: a) Sign Survey:** A sign survey was carried out on the forest trails along the ridges of small rivers or streams (2-6 km) covering elevation gradients of the proposed study site. Pug marks of carnivores (felids, canids and ursids) and herbivore's hoof marks (ungulates) were observed and recorded. Similarly, pellets, scats, scratch marks on trees and scrap marks on trails were recorded along with GPS locations. Direct sighting during sign survey was also recorded along with geo-referencing locations, habitat types and any other observations if any. **b) Trail Sampling:** At least three in each 500 m elevation difference covering each aspect trails were selected for repeated survey in proposed study sites. Direct sightings of mammals including (number of individuals, sighting distance and angle and the adjacent habitat features) and encounters with pellets or scats, were also recorded. **c) Camera Trapping:** Camera Trapping for mammals (ungulates and carnivores) was performed in the selected grids of the selected study sites in Mizoram. The cameras were installed in the animal's trails, resting sites and in opportunistic sites. Each camera was placed one meter above the ground to ensure the maximum area and trail was covered. The information regarding habitat and climatic variables was collected for each grid. **For Birds: a) Variable radius point count:** Along the elevation gradient variable radius point count was carried out. Birds were counted for 10 minutes duration and the sighting distance was recorded using a range finder. **b)Trail sampling:** It was specifically carried out to detect the presence of Galliformes on the trail of 1 to 1.5 km length. **c)Acoustic survey:** In unburn, single burn and repetitive fire burn sites, 60 acoustic monitoring units using automated recorders were installed, each of them separated by a distance of a minimum of 3000 m. These were located at the center of each survey site and configured to continuously capture biotic vocalizations for 10 days. The recorders were programmed to collect 1 h data in *.wav* format. **d)Opportunistic records:** The presence of bird species was recorded before and after the sampling period; documented and daily logs were maintained with necessary information. **For Insects and another taxon: a) Pitfall traps:** Pitfall traps were composed of two plastic containers placed together, each of 19 cm diameter (250 ml volume) and were inserted into the ground together. The cups were partially filled with an odorless soapy solution adding one drop of detergent to reduce surface tension. The traps were emptied every 7^{th}day. All collected specimens were sorted to order level and kept in 70% ethanol for preservation. A plastic roof of roughly 10 cm size was provided above the traps to protect

them from rain. **b) Light Traps:** Light trapping is appropriate for monitoring phototactic (i.e., light-attracted) night-flying insects used for surveying a wide range of insect taxa including flies (Diptera), true bugs (Hemiptera), beetles (Coleoptera), caddisflies (Trichoptera), wasps (Hymenoptera, and moths (Lepidoptera) etc. Light traps provide an opportunity to gather standardized and comparable data, but many factors influence the abundance and composition of light trapped insects, including trap type, season, time of day, lunar phase, duration of sampling, and light attractant (Jonason et al., 2014). Here we have carried out a Field collection of the specimens using fluorescent bulbs on a white cloth sheet hanging. **For Herpetofauna:** Nocturnal stream Visual Encounter Surveys (NVES) involving three one-hour Visual Encounter Surveys (VES) (Scott et al., 1994). We performed 20 transect in each sites. Each site is a 100 m marked segment along with stream courses. All the sampling effort for amphibians has been concentrated along with the stream courses. The sampling method involved two people walking abreast with night searcher and head lamp along the stream course looking for amphibians. Most of the these surveys were carried out on post-sunset between 18:30 – 21:00 hrs. In day time transect in forest and near streams covering the different elevation gradients of the study areas for amphibians and reptiles by raking the leaf litter, turning logs and rocks, peeling bark and by opening fallen logs. This technique targeted litter dwelling herpetofauna. The microhabitat features were recorded at every locations from where the species were observed. **Soil sampling:** In order to determine soil fertility levels in burnt and unburnt landscapes of the study area, soil sampling was conducted using soil cores. We collected surface soil samples from different depths viz. 0–10 (Top), 10–20 (Middle), and 20–30 cm (Bottom)from all the risk zones. Soil samples were immediately transported to the lab to analyze for nitrogen content and for meta-barcoding analysis to identify the different groups of species. All the samples were air-dried at room temperature, sieved through 2 mm sieve and stored in zip-lock plastic bags. Soil samples were homogenized (i.e., using a clean spatula to dissociate large clumps of material) and further processed for DNA extraction. We used 16 rRNA for the bacterial community, COI and ITS region for invertebrates and vertebrates. The physio-chemical properties of soil were estimated to understand the influence of soil micro habitat characteristics with reference to the forest fire in the study landscape.

3.2 Preparatory Actions and Agencies Involved: *(max. 1000 words):*

The present study aimed to understand the impact of forest fires in sites that experience recurring fire incidences. There is very limited information on the impact of fire on faunal resources from the study site. Above all, there isn't a single study where pre and post-fire impact assessment has been carried out especially in the Himalayan and North Eastern Region. The High-Powered Committee constituted by the Government of India on disaster management has highly recommended the need to study damage assessment caused by fire. As the Himalayan ecosystem is getting destroyed, the proposed project is in coherence with the objectives of the National Mission on Himalayan Studies because information on the impacts of forest fire on the biological diversity of the Himalayas will play a vital role in the sustenance

and enhancement of the ecological, natural, cultural and socio-economic capital assets and values of the Indian Himalayan Regions. The information generated in this will be helpful for the restoration of ecological balance in the study site forest fire management calendar prepared in this study will help in planning and preparatory management of forest fire seasons.

Furthermore, we established 10 long-term monitoring based on our survey. These will help us to understand the change in the species diversity, abundance and other associating threats. Furthermore, long-term monitoring will not only provide information on population change but also help in understanding the impacts of unplanned or uncontrolled events such as Forest fire and climatic patterns on the wildlife populations. We developed a team of a network of people with local administrative bodies like Village council members of the Young Mizo Association (YMA) and Young Chakma Association (YCA), Teachers from the academic institutions, forest department staff and many other stakeholders. Consultative sessions were organized and shared printed knowledge products like Flyers, pamphlets and Monitoring manuals/ booklets. These team members will work with Forest frontline staff for forest fire management and prevention on the ground level.

The implementing partners of this project are Farmers, Local administrative bodies like Gram Panchayats, NGOs, Universities, Forest departments, GBPNIHESD, National Biodiversity Authority, IUCN, CBD, UN, Agricultural departments, State Medicinal Board Plants and Ministry of Earth Sciences and Ministry of Environment, Forest and Climate Change. The goal of the proposed study cannot be achieved without the active participation of project stakeholders such as the state forest department, village-level institutions, and local NGOs like YMA (Young Mizo Association) and YCA (Young Chakma Association). The state forest department has undergone detailed capacity-building programs along with the research scholars on forest fire impacts on faunal resources and combating and mitigating the disaster in their specific localities. The lead agency, the Zoological Survey of India, has played a pivotal role in disseminating ideas and implementing project plans at each study site. The state or local NGO would support the research team, ensuring active participation of the local communities in the project. Engagement of women, youth and village councils are also welcomed for curating mitigating measures from forest fire with the aim of biodiversity conservation in the region.

3.3 Details of Scientific data collected and Equipment used: *(max 500 words)*

The field survey was conducted during 2018-2019 and 2021 in different months in both study sites. Because of restrictions imposed by the Government due to COVID-19 and corresponding complications, research scholars resigned and field work was disrupted. A 9-month extension was given to the project in 2021 for continuing the work by new team and fulfillment of the project objectives. A team of researchers systematically visited the selected grids to detect or non-detection of mammals following different monitoring methods. For the sign survey, all selected grids were covered using about 2-6 km length trails for documenting mammalian diversity from October 2018 to December 2019 and again from

April 2021 to May 2021. As per the project objectives, ZSI has to collect data in non-invasive manner for mammals, birds, and specimens for threatened fishes, amphibians and reptiles. However, permission was only obtained for non-invasive sampling of vertebrates and thus, we focused on collecting mammalian sampling only. Whenever possible, information on birds was gathered by collecting feathers also. For all direct or indirect signs (direct sighting, fecal matter, hair) of vertebrates' local name, GPS coordinates, altitude, sign type, terrain, forest type, and photographs were recorded. Camera traps were deployed in selected grids for which we used three types of camera traps *viz.*, SPYPOINT FORCE-11D (SPYPOINT, GG Telecome, Canada, QC), Boly Trail Game Camera (Boly Media Communications (Shenzhen) Co., Ltd., China) and Browning trail camera (Prometheus Group, LLC Birmingham, Alabama, (https://browningtrailcameras.com) in the study ranges. We placed 62 camera traps in different locations with an overall of 1670 trap nights. During the study period, birds were observed using Cannon (10 x 42) binoculars and photographs were taken with a Cannon 700D DSLR camera equipped with Canon EF-S 50- 250mm lens.

Bioacoustic Sampling at 60 different locations was performed in the Mamit district of Mizoram in three different micro-watersheds using Song Meter SM4 and Audiomoth. Bioacoustic studies differ from traditional field surveys are often more visual and require work in the daytime. A sampling of acoustic signals is possible to explore the diurnal variation of three different sites on time since fire. The non-invasive samples such as scat, pallets, feathers and hairs were collected systematically from the study landscape. Soil sampling was also performed from burnt and unburnt areas for meta-barcoding to identify the soil faunal composition and bacterial community with respect to forest fires. We have used equipment such as handheld GPS, Compass, range finders, binoculars, canopy densitometer, digital cameras, remote camera traps for conducting the field survey. For insect sampling, the methodology mainly utilized was pitfall trapping in each sampling location by placing 3 traps, partially filled with an odorless soapy solution and adding one drop of detergent to reduce surface tension. All collected specimens were kept in 70% ethanol for preservation. We also interviewed 178 respondents in 31 villages to collect information on wildlife presence, human-wildlife conflict, ethnological facets, forest fire regimes, peak and periodicity of shifting cultivation and other necessary details.

3.4 Primary Data Collected: *(max 500 words)*

We used camera trapping, sign survey, questionnaire-based information, acoustic sampling, pitfall trapping and soil sampling to obtain information on species composition, diversity and abundance. In this study, we used MODIS active fire products MCD14DL The whole study area was classified into 2 X 2 km grids.

Cumulatively, a total of 131 trails were walked of 2-6 km in length covering a distance of 1133 km in the grids for documenting faunal data. We placed a total of 62 camera traps in different locations with an overall of 1670 trap nights. Camera trapping revealed 15 mammalian species with the highest capture

rate of rhesus macaque and wild boar. A single capture of the Sun bear, Golden cat and Greater hog badger were obtained. We also interviewed 178 respondents in 31 villages to collect information on wildlife presence, human-wildlife conflict, ethnological facets, forest fire regimes, peak and periodicity of shifting cultivation and other necessary details to prepare the fire calendar. The soil samples exhibited 50 taxonomic groups of bacterial species, identified using the GenBank's nucleotide database, BLASTN (https://blast.ncbi.nlm.nih.gov/Blast.cgi). A total of 114 tree species belonging to 89 genera and 43 families were recorded from the two study districts. A total of 118 birds were identified from the acoustic recordings belonging to 45 families. A total of 418 species were identified belonging to 10 different order were collected from the field in the span of three years with 175 species of Lepidoptera, 59 species of Coleoptera, 32 species of Hymenoptera, 32 species of Diptera, 44 species of orthoptera, 25 species of Hemiptera, 9 species of Blattodea, 11 species of Phasmida and 9 species of arachnids.

3.5 Details of Survey Sites of the proposed Study:

This study was conducted in two districts of Mizoram state (Aizawl and Mamit) of the North Eastern region.

Mamit District: Mamit is situated in the western part of the Mizoram covering 3025 sq. km area out of which 90% is covered with forest. The region falls under the sub-tropical rain forest, and vegetation has three different categories namely tropical wet evergreen vegetation, tropical semi-evergreen vegetation and mountain sub-tropical pine forest. Mamit is also comprised of the important river of the state like Tlawng, Tut, Langkaih, Khathlangtuipui and Marr covering hilly terrain which are crisscrossed by the valleys and deep gorges where rivers wend their ways to constitute its river system. The district is bounded by Tripura on the west, assam on the north, Kolasib and Aizawl on the east and lunglei on the south. With its fertile soil and plentiful rain, the vegetation is an admixture of species which ranges from bamboos and canes to fuel woods and timber species. Besides, there are several mammal species that occur such as Asiatic black bear, elephant, barking deer, serow and many species of primates etc. Raising plantation commercially viable species such as Teak and Gamari are of vital importance; Pine and Eucalyptus are also adopted on a smaller scale. In 1985 Mamit district became home to Dampa Tiger Reserve, with a total area of 988 sq. km (core area with 500 sq. km and buffer area 488 sq. km). Reserve habitats consist of a variety of habitats characterized by diverse biota, with a rich floral and faunal diversity in three different forest types: comprises of Tropical evergreen and Semi-Evergreen Forest, Tropical moist deciduous forests and Sub-montane type forests.

Aizawl District: Aizawl, the main capital of the state of Mizoram, covers a geographical area of the districtcovering 3577 square kilometers and is located north of the Tropic of Cancer in the northernpart of Mizoram. It is situated on a ridge 1132 meters (3715 ft) above sea level, with theTlawng river valley to its west and the Tuirial river valley to its east. Aizawl comprises lessamount of dense forest but has 57% of open forest and 32% of moderately dense forest.Aizawl is 89% covered by the forest of the total geographical area of the district. It has one protected area, i.e., Tawi Wildlife Sanctuary (TWS), it is

Mizoram's first sanctuary, established in 1978. TWS is located at a distance of about 101 Km. from Aizawl. It is spread in an area of 35.75 sq. km at an altitude range between 400 m to 1458 m above sea level. Tawi Wildlife Sanctuary hosts a variety of rare and endangered species of flora and fauna. The vegetation of Tawi Wildlife Sanctuary mainly comprises of Sub-Tropical evergreen forest, Semi-Evergreen Forest and Scrubland. The species commonly found include *Gmelina arborea, Schima wallichi, Micheliachampaca* and a variety of Bamboos and Canes.

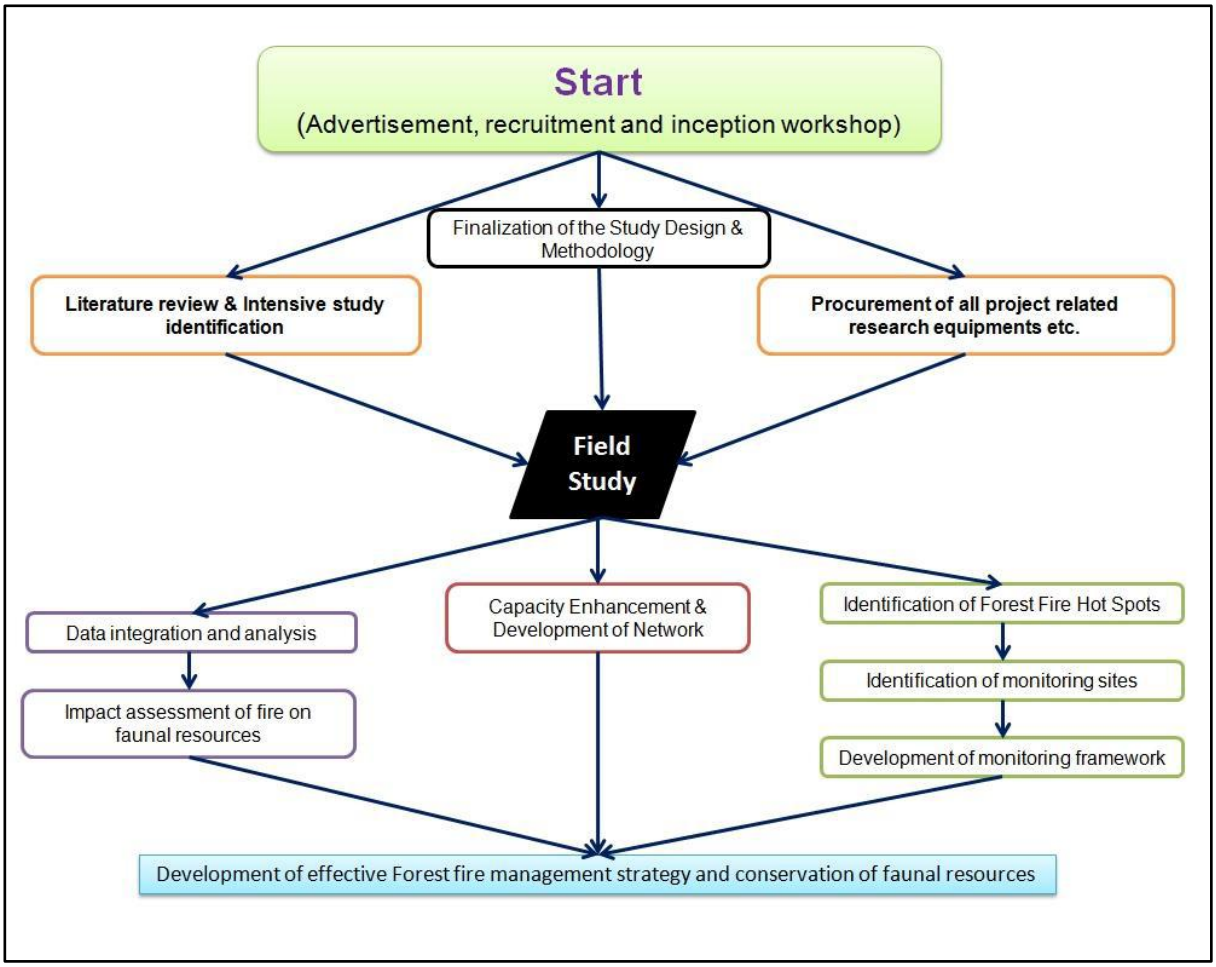
3.6 Strategic Planning for each Activities: (max. 1000 words).

The planning activity for implementing the project has been defined using a flowchart below.

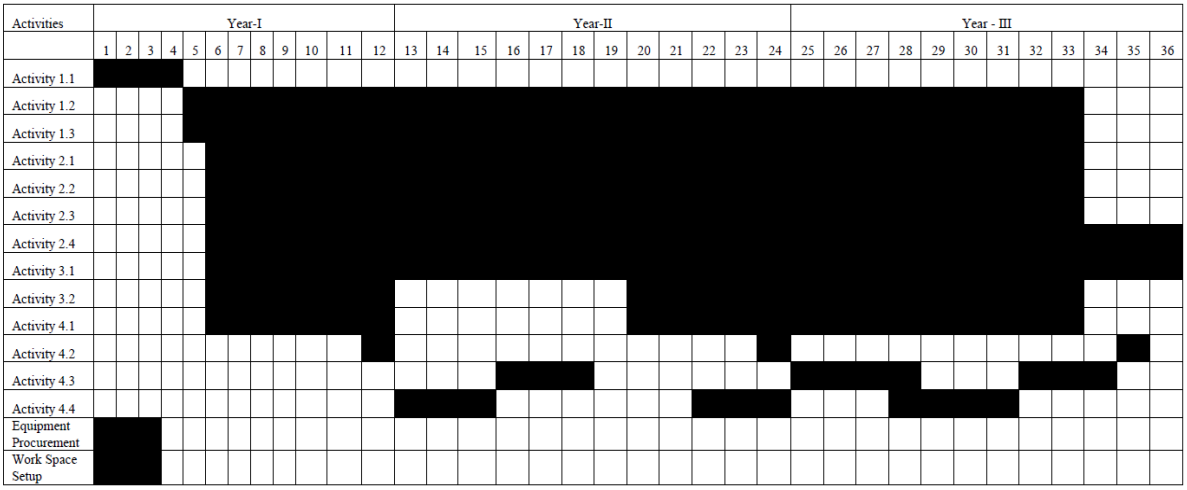
We have divided each of the study area viz. Mamit and Aizwal in 5x5km and further 2x2 km grids for systematically covering all the habitats, and also those which are logistically and physiologically possible. The second level of stratification was done using the forest types in the two districts. Final grids were systematically selected to show maximum representation. Based on MODIS active fire products, fire occurrence frequency at various spatiotemporal grids was identified based on the time since fire and classified into three broad categories: unburnt or control sites (no fire record), single and repetitive fire. In single-fire sites, a fire occurred once in the last 20 years, while in sites of repeated fires, fires have occurred at least 3 times in the last 20 years. Further, the single and repetitive fire are categorized into four types from 2yr to 20yrs of time since fire (Appendix 1). The sampling grids were equipped with camera traps and pitfall traps and were surveyed using line-transect, sign survey or animal use trails to document the landscapes' fauna. We also conducted an acoustic survey. For all direct or indirect signs (direct sighting, fecal matter, hair, footprint, scraps) of vertebrate names of the locality, GPS coordinates, altitude, sign type, terrain, forest type, canopy cover, distance from nearest village, distance from nearest water source along with photographs were recorded. Camera traps were deployed in the selected micro-watershed, for which we use the SPYPOINT FORCE-11D trail camera and Boly Trail Game Camera SG562-C. Pitfall traps were installed in $100m^2$ plot for invertebrate sampling. Light traps (For light attracting insect) and Sweep net were also used to sample ground vegetation or selectively target aerial insects, like wasps and butterflies. We also conducted a questionnaire survey in the selected forest fringe villages based on the fire hotspot zones. The avifauna of the landscape was documented through the point count methods and acoustic survey during the trail walk in the selected grids. We collected surface soil samples from different depths viz. 0–10 (Top), 10–20 (Middle), and 20–30 cm (Bottom)from all the risk zones. Soil samples were immediately transported to the lab to analyze for total nitrogen and available nitrogen. All the samples were air-dried in room temperature, sieved through 2 mm sieve and stored in zip-lock plastic bags. Soil samples were homogenized (i.e., using a clean spatula to dissociate large clumps of material) and further processed for DNA extraction.

While conducting trails or transect sampling, we also marked plots for documenting avifauna of the study area. Forest fire hotspots were identified through data analysis and more sampling effort was put into

those areas in the 3rd year. Finally, capacity building of the frontline staff member and other stakeholders and building people's network was an imperative task to mitigate forest fire, a number of training workshops were conducted in the main fire hotspots area for effective management and conservation of wildlife resources. A round of consultative sessions with village council members, frontline forest staff, students, locals, farmers, NGOs and other stakeholders was performed to demonstrate the use of firefighting equipment, make them aware and use them in time of emergency. Knowledge-building products like pamphlets and brochures were also distributed to create mass awareness and increase their understanding regarding ill effects of shifting cultivation and its effect on wildlife. After such brainstorming events, a forest fire calendar was generated for both of the landscapes, which would help the local managers in having utmost preparedness and help in the prevention, control and mitigation of fire.



3.7 Activity wise time frame followed using Gantt/PERT Chart:



4. KEY FINDINGS AND RESULTS

4.1 Major Research Findings (max. 1000 words)

Cumulatively, a total of about 131 trails were walked, covering with a team effort of 1133 km in both the study sites of Mizoram. We placed about 62 camera traps with a total effort of 1670 camera trap night effort was made from October 2018 to November 2021. in both the study sites. Most camera traps were placed at the height of 40–60 cm above the ground along animal trails and paths. A total of 935 non-invasive samples were collected. Information on the socio-economic condition of forest-dependent fringe people was collected through questionnaire surveys of n=178 respondents of n=31 villages at both sites.

A total of 9,236 and 12,528 forest fires incidence were recorded in the Mamit and Aizwal districts of Mizoram from 2001 to 2020, respectively. Most of the forest fire incidents in the study site were documented in the month of March, about 78.41 % in the period of 2001-2020. About 46.5 % of the total study area is under ahigh fire risk zone and 16.62 % area is under very high-risk zone.

We gathered the data of around 611 faunal species from the North Eastern States for conservation and management and the spatial data were prepared for all these species with all information on the habitat, conservation action and threats (Appendix 1).

In Mamit district, Mizoram, we walked a total of 67 trails with an average length of 3.2 km covering 224 km (520 km team effort), which resulted in the documentation of 23 species of mammals. The overall ER was highest for Rhesus macaque (0.017± 0.005) followed by Indian bison (0.011±0.006) and they were distributed in most of the forest edges and core areas of Dampa Tiger reserve respectively.Other species like the Wild boar, Indian flying fox, Barking deer, Indian grey mongoose also shown that the higher encounter rates range from 0.015–0.007. Moreover, some 19 species of Reptiles are also observed once during the sign survey.

In Aizawl district we walked a total of 64 trails with an average length of 4.5 km covering 234 km (613 km team effort), which resulted in the documentation of 9 species of mammals. The overall ER was highest for Wild boar (0.010± 0.006) followed by barking deer (0.006±0.002) and Rhesus macaque(0.006± 0.003).In Mamit district, 34 cameras with an effort of 910 trap night were installed and 28 cameras with an effort of 760 traps night resulted in capturing of 15 mammalian species. We also observed human disturbances in the other sites, where livestock, domestic dogs, and other species were caught in the wildlife habitats.

At each sampling point, insects were trapped using nine pitfall traps, which were set up inside a square plot of 100sq m (100m×100 m), consisting of 5 traps. These traps are arranged inside square with its four corner pattern with 20 m apart and one traps at centre (Appendix 1). Each trap was filled with an odorless soapy solution, adding one drop of detergent to reduce surface tension, and its catches were emptied within one week since first setting day. The biodiversity of insects was assessed by species richness observed "S_{obs}," which correspondsto the total number of identified insects up to species level at each site. In addition, Shannon's index ($H' = -\sum pi \times \log_2 pi$) and evenness ($\text{Evenness} = H'/\log_2 S_{obs}$) were calculated. We then analyzed the mean number of species and of individuals (± SD) per sampling plot with regard to three categories of fire sites using ANOVA with subsequent Scheffe´ post-hoc tests. When the homogeneity of variances was not achieved even after log-transformation of the data, non-parametric Kruskal-Wallis ANOVA by ranks and Mann-Whitney U-test withBonferroni correction between two groups was applied(Zar 1984). All analyses were performed using SPSS Version 21, Past and R studio.

A total of 1800 h of acoustic data was processed to assess our study objectives. We scanned recordings in Kaleidoscope Pro and Audacity software for data processing and analysis. The spectrograms generated using Kaleidoscope Pro to identify the vocalization records in acoustic devices as mentioned in workflow (Appendix 1). Further we also verified the raw audio data using Xeno-canto and BirdNET which is a novel machine learning algorithm use for identifying bird species (Kahl et al. 2021). Each species was identified by a song or call for that species. Here we assume the maximum detection of species is 20 as its abundance in each sites (unburn, single fire and repeated fire sites). Few species which are confusing in raw audio data or crowded calls and songs are avoided for identification. Further we classified bird species in six food guilds (as binary traits): (Ne) nectarivores, (Gr) granivores, (Fr) frugivores, (In) insectivores, (Ca) carnivores, and (Om) omnivores. We consider a species as omnivore when it is simultaneously included in two or more guilds.

We calculated different soundscape indices values in every five of every fifteen minutes in each hour recording and pooled the data for each sites. We used packages *seewave* (ver 2.1.0; Sueur, Aubin, & Simonis, 2008) and *soundecology*(ver 1.3.3; Villanueva- Rivera & Pijanowski, 2018), the following six indices were calculated: ACI, Acoustic Diversity Index (ADI), Acoustic Evenness (AEve), Bioacoustic Index (Bio) and the Normalized Difference Soundscape Index (NSDI). Further to determine which indices were most important in separating habitat specific soundscape, we took a random forest

classification using the random forest package. RF was built using mean hourly indices values, fire zone, season, forest type and diel phase. 70% of data was kept for training and the remaining 30% was applied for testing purposes. Decision Trees were also constructed zone wise to support the output of RF Classification. We built separate models with time since fire (log-transformed) as the independent variable and individual variables and habitat structure and bird community as dependent variables, to test the hypotheses related to the influence of disturbance frequency on plant/habitat and bird community taxonomic and functional descriptors, respectively.

We identified and established 10 long-term monitoring in both the study sites. These plots were selected based on the survey. These will help us understand the change in species diversity, abundance, and other associating threats with forest fire. We also developed forest fire management calendar in consultation with the forest department officials and different stakeholders was curated for preparedness and early mitigation.

4.2 Key Results (max 1000 words in bullets covering all activities)

a. We generated the spatial database of 611 faunal species from the study site. A total of 28 species were of mammals, 116 species of birds, 28 species of reptiles, 21 species of Amphibia, 175 species of Lepidoptera, 59 species of Coleoptera, 32 species of Hymenoptera, 32 species of Diptera, 44 species of Orthoptera, 25 species of Hemiptera,23 species of Odonata, 11 species of Phasmida and9 species of Arachnids.

b. A total of 21,764 forest fire incidents were recorded in both the district of Mizoram over in last 20 years (2001 to 2020). The majority of the fire incidents were documented in the month of March (78.41%). About 46.5 % of the total study area is under ahigh fire risk zone and 16.62 % area is under a very high-risk zone.

c. A total of 418 insect species were identified from a total of 44040 individuals belonging to 10 different orders of insects trapped. The most abundant orders were: Hymenoptera (42.7%), Coleoptera (38.8%). The remaining specimens belonged to other orders, such as Lepidoptera (7.9%), Hemiptera (3.1%), Orthoptera (2.4%), Diptera (2%), Odonata (1.1%), Blattodea (1%), Phasmida (0.51%) and Arachnida (0.45%).The eDNA based metagenomic analysis suggested significant change in the composition of soil fauna as well as microbes under different fire intensity regimes in the study landscape.

d. We identified and established 10 plots for the long-term monitoring in our study sites. These plots were selected based on the survey. These will help us to understand the change in the species diversity, abundance and other associating threats. Furthermore, long-term monitoring will provide information on population change and help in understanding the impacts of unplanned or uncontrolled events such as Forest fires and climatic patterns on the wildlife populations.

e. 150 participants were trained, representing departments, Forest Department, line Departments, NGOs, CBOs, paramilitary forces, frontier forces, local police, school, and collages. They receive an effective training manual kit with hands-on training for firefighting the latest techniques and skills covering various aspects of forest fire management.

f. The Unburn sites in our study area estimates high positive values NDSI as compared to both single fire and repetitive fire sites. The matrix gives information about dominant properties of the site in the form of anthrophony or bio-phony. The average value of the all 20 installed devices comes out to be a positive 0.812, indicating supremacy of bio-phony. +1 values indicate pure bio-phony. The 2nd station in unburn site depicts the maximum NDSI, reaching up to 0.943525, almost +1 representing pure bio-phony(Appendix-1). The values considerably reduce in case of both single fire sites and repetitive fire sites. Both of the sites together exhibit an average positive value of 0.70, expressing reduction of pure biophonic characters. This is also supported by our field observation as most of the repetitive fire sites were jhum land, permanent agricultural lands, with continuous use of the landscape by humans and the single fire sites include most of the commercial agricultural lands, Oil palm plantations, forests edges and timber cutting activities also has been witnessed during field survey.

g. We developed a network of people with local administrative bodies like Village council members of the Young Mizo Association (YMA) and Young Chakma Association (YCA), Teachers from the academic institutions, forest department staff and many other stakeholders. Consultative sessions were organized and shared printed knowledge products like Flyers, pamphlets and Monitoring manuals/ booklets. These team members will work with Forest frontline staff for forest fire management and prevention on the ground level.

h. A Forest fire calendar was generated, which will help the local managers in having utmost preparedness and help in the prevention, control and mitigation of fire.

4.3 Conclusion of the study (maximum 500 words in bullets)

a. The generated spatial database of faunal species in this study was assessed for their IUCN and WPA and provided information on taxonomic keys, distribution, conservation action etc.For Effective conservation various ecological aspects of the species such as abundance, habitat ecology and diversity for majority of the species and the existing knowledge is largely confined to few species in selected Protected Areas. Therefore, the present study holds important as it covers several species found in the study sites.

b. Species composition after the fire is highly guided by the frequency of the fire. Certain faunal orders like Lepidoptera displayed higher resilience to a single fire as compared to repeated fires. This temporary increase in number between single and repeated fire regimes is most likely due to the high mobility of such faunal orders. For certain nesting species like Hemiptera, Arachnida, etc, it was observed that initial burns caused a sharp decline in their abundance; however, they started recovering and recovered back to its initial state with the increase in the period to time since fire.

c. Shannon Diversity Index for Birds survey reveals unburn or control fire sites were the most diverse zones with high species richness of birds encountered in both point count and recorded in acoustic devices. ADI (Acoustic Diversity Index) also supports the Shannon diversity index, with the highest mean value in low or control fire zones. NDSI (Normalized Difference Soundscape Index) provided the ratio of biophony and anthrophony, explaining which component is dominant in the study landscape. Repetitive and single fire sites were dominated by anthrophonic components, which is quite real as we observed many anthropogenic activities in these areas. NDSI has dominant biophonic components in unburn fire sites due to low disturbance and most diverse vegetation supporting high avian diversity as ACI (Acoustic Complexity Index) revealed in our study.

d. The long-term monitoring plots were selected based on the survey. These long-term fire monitoring plots in the both the study site will help us in documenting the changes in population, species diversity, abundance, facts impacting the biodiversity. The monitoring information on species composition and diversity is vital for making informed conservation and management decision.

e. The Forest fire management calendar was generated which will help the local managers in having utmost preparedness and help in the prevention, control and mitigation of fire. The calendar contains the detailed activities need to perform during the fire and non-seasons for minimizing the risk of forest fire.

f. Further Conducted Capacity building of the frontline staff of forest department and other stakeholders trained 150 participants, representing about departments, Forest Department, line Departments, NGOs, CBOs, paramilitary forces, frontier forces, local police, schools, and collages. They receive an effective training manual kit with hands-on training for firefighting latest techniques and skills covering various aspects for forest fire management.

g. We developed a network of people with local administrative bodies like Village council members of the Young Mizo Association (YMA) and Young Chakma Association (YCA), Teachers from the academic institutions, forest department staff and many other stakeholders. Consultative sessions were organized and shared printed knowledge products like Flyers, pamphlets and Monitoring manuals/ booklets. These team members will work with Forest frontline staff for forest fire management and prevention on the ground level.

5. OVERALL ACHIEVEMENTS:

5.1 Achievement on Project Objectives [Defining contribution of deliverables in overall Mission (max. 1000 words)]

Under the first deliverable, we develop the spatial database of the 611 Faunal Species found in the Mizoram.

a) **Assessing the impacts of forest fire on faunal resources and diversity:** *Baseline knowledge about the faunal resources and forest fire hotspot identification for long-term monitoring in two districts of Mizoram, namely Aizawl and Mamit.* We have prepared a spatial database of population abundance and occupancy of all the major taxa with the most robust and standard method available. Forest fires are the major environmental problem in the northeast region with large tracts of forest being affected in every season. It has become a significant threat to the forest ecosystems in the region, leading to the loss of timber, biodiversity, and wildlife habitat. The knowledge on forest fire is available in short-term assessments and covers the very small area. However, there is no detailed study available that provides an assessment of the impacts of forest fires on faunal resources. Moreover, no information is available how recurrent fire shapes the community structure of different faunal groups. Hence, the present study has been conceptualized to enhance the scientific understanding of the impacts of forest fire on the faunal element of the North Eastern states of Mizoram. We investigated the resilience of the varied faunal orders to forest fire, analyzing community similarity, the number of families and individuals, and the shifts in the dominance of species within communities at different time intervals following single or successive fires. Probability distribution map showing forest fire vulnerability and hot spots across the two districts of Mizoram, namely Aizawl and Mamit, established.

b) **Identification of sites for the establishment of long-term monitoring plots:** *Spatial database of Faunal species in both the district of Mizoram and their permanent plot have been established. Forest fire management site-specific Calendar prepared.* The spatial data on different Faunal species will be useful in screening the biodiversity risks because of Forest fire and other anthropogenic impacts. The biodiversity in the Mizoram is mainly threatened by illegal poaching, jhum cultivation, extension of agricultural land, fire wood collection, encroachment, and infrastructural development. Considering these threats, long–term monitoring is important for quantitative and qualitative assessment on the abundance of the different species. Therefore, to achieve long-term conservation goals, we aimed to set the long-term permanent monitoring plots in both the selected districts (Aizawl and Mamit, Mizoram) representing all different habitats, biotic provinces and landscapes of that region for monitoring the biological diversity of the site. These long-term monitoring plots help us in documenting the changes in population, species diversity, abundance, and facts impacting the biodiversity. The monitoring plots were selected based on the surveys conducted in the present

study. We collected the data through intensive camera trapping, insect sampling through pitfall traps and other standard methods, acoustic survey, sign survey, questionnaire survey, and non-invasive DNA-based analysis. We used FCI (Faunal composition index and its trend across the faunal orders to calculate the faunal loss in terms of order with basic inputs data (Heterogeneity + Relative Abundance + Relative Density + Mean no. of threatened species) with successive stages after fire. The monitoring plots will help us to understand the change in the impact of management regimes on the forest and faunal resources for the long-term monitoring.

c) **Capacity building of the frontline staff of the forest department and other stakeholders:** *No. of training programs and workshops conducted focusing on effective and well-structured training with latest techniques and skills on forest fire monitoring, generating awareness among the locals for understanding the importance and sustainable use of forest resources.*One of the major factors causing the destruction of the forests is the erratic use of forest resources by the poor village people living in the forest fringes that depend on it. Therefore, it is very important to promote awareness of the importance of forest management among the local villagers and provide assistance to improve the livelihoods of the poor and their sustainable use of forest resources. It is essential to receive effective training with the latest techniques and skills covering various aspects on forest management for frontline staff of the forest department and other stakeholders as they are in daily contact with local villagers. Thus, we have conducted workshops that are focused on forest fire monitoring, awareness creation, understanding the importance and sustainable use of forest resources, and believing the harmonic coexistence with natural resources. Hence 150 participants were trained which represent about departments, Forest Department, line Departments, NGOs, CBOs, paramilitary forces, frontier forces, local police, school and collages.

d) **Building network and development of knowledge products:***Building a network of professionals and different stakeholders to combat forest fire in two districts of Mizoram, namely Aizawl and Mamit.* To develop a network, a team with local administrative bodies like Village council members of Young Mizo Association (YMA) and Young Chakma Association (YCA), Mizo HmeichheInsuihkhawm Pawl (MHIP), Mizoram Upa Pawl (MUP), Mizo Student's Association, Teachers from the academic institutions, forest department staffs and many other stakeholders, consultative sessions were organized and shared printed knowledge products likes Flyers, pamphlets and Monitoring manual/ booklets. A training manual and information flyers has prepared for the various stakeholders. Different stakeholders have been identified and consulted for their role in the network in their respective landscapes for forest fire management. A Forest fire calendar was generated which will help the local managers in having utmost preparedness and help in the prevention, control and mitigation of fire.

5.2 Establishing New Database/Appending new data over the Baseline Data (max. 1500 words, in bullet points)

The present study has resulted in the development of three major databases which will be imperative for the conservation and management of forest fire on faunal resources of Mizoram.

a. Geo-spatial database of all the 611 faunal species of Mizoram: This database is based on the primary as well as secondary data collected during the study. We have used the IUCN range boundaries along with the present study's primary data for creating a geo-spatial database. This database can be used for screening the biodiversity risks because of developmental projects and anthropogenic impacts.

b. Jhum Fire Risk Mapping using Weight model approach.: In this study, GIS techniques were applied to develop the Jhum fire risk map for the study area. Also, the risk map was evaluated to check the accuracy by comparing it with the jhum locations data gathered from primary and secondary data collected during the field. In this study, we used Active fire data from the MODIS instrument on NASA's Terra and Aqua satellites dating from 2001 to 2020 was used. This study confirmed that jhum fire probability has a strong correlation with variables like distance from the road and settlement and elevation, explaining the factors responsible.

c. The Role of Fire Disturbance on habitat structure and bird communities: Biodiversity assessment is an increasingly immediate task in the face of global environmental change. Ecoacoustics, the study of environmental sound, offer a more rapid and economical means of terrestrial biodiversity appraisal than traditional approaches. Passive acoustic monitoring (PAM) typically involves recording equipment devices that now enable us to record a large volume of acoustic data in the field for weeks or months.Monitoring environmental sound may offer a novel method for rapid biodiversity assessment. Changes in species assemblages at a given location are reflected in the site's acoustic energy, termed the soundscape. Soundscapes can be readily described using acoustic indices, metrics based on objective features of recordings such as pitch and amplitude. We found that species richness significantly decreased in the repeated burned sites compared to single burned and unburned sites with time since fire. The unburned site provides more heterogeneity and species diversity for supporting bird diversity than others.

d. Faunal diversity data base through eDNA of soil using metagenomics of both the study sites: exploring complete biodiversity profile of soil (16s RNA (Bacteria) + ITS (fungi) + COI (Invertebrates & Vertebrates) in both Unburned and Burned sites with time since fire.)

5.3 Generating Model Predictions for different variables (if any) (max 1000 words in bullets)

Not Applicable

5.4 Technological Intervention (max 1000 words)

Not Applicable Since the project was a wildlife ecology project where we have not done technological interventions.

5.5 On field Demonstration and Value-addition of Products (max. 1000 words, in bullet points)

Not Applicable

5.6 Promoting Entrepreneurship in IHR

Not Applicable

5.7 Developing Green Skills in IHR

Under the project training and workshops, we have imparted several stakeholders towards monitoring and conserving wildlife populations, combating forest fire, knowledge regarding wildlife forensics, and different legislation and regulations. The local NGOs (Young Mizo Association and Young Chakma Association), hired field assistants, and Self-Help Groups benefited from these training and improved their skills. The local tour guides in the area also attended the programs and by following this training, their wildlife monitoring skills were developed and enhanced. Village council members and local farmers were assembled to define and share knowledge and responsibilities for the prevention, preparedness and mitigation of forest fire incidences. Teaching, handling, demonstration and training of fire-fighting equipment, the importance of the creation of fire control lines and clearing off dry fuel load inside forests at regular intervals were taught. All of these will be useful in incorporating locals for curating conservation and management plans and enhanced skills of tracking porters, and field guides will open up new avenues for fetching good remunerations from tracking tourists because these sites have some of the best tracking trails of Himalayas.

5.8 Addressing Cross-cutting Issues (max. 500 words, in bullet points)

The project implementation has resulted in addressing following cross cutting issues:

a. **Women empowerment:** The project team is composed of more than 50% female researchers indicating gender equality in project implementation. 42 women from 64 village council members attended the training and workshop, indicating their presence in large proportions. Female field assistants were also hired during field data collection and sampling study. We have tried to maintain gender equity at the organizational level by attracting more women to sport their interests in ecology and wildlife conservation. Skilled researchers provided the organization with a talent pool, which may pass on as coaching to others, gaining mainstream benefits. This helped in changing the image of women in wildlife conservation and management. In turn, taking the lead in promoting women and more women getting attached to organizations increases prestige and value to the organization. We have ensured women in leadership roles, involving them in decision making and determining

budgetary allocations to carry out research activities. The participatory rate of women in capacity-building programs for forest fire combating activities was also very impressive.

b. **Communication:** Capacity building and networking of professional peoples were one of the important and indigenous parts of this study for creating mass awareness regarding the ill effects of shifting cultivation, forest fire, and wildlife conservation, thus focusing on effective communication. The chief goal of 3rd and 4th objectives of this project was fulfilled by involving the local communities, village council members, farmers, frontline staff and other prominent members of the forest department, NGOs, Self-Help Groups, and students from Colleges and Universities. We directly engaged local forest guards in training and handling of fire-fighting equipment, teaching monitoring methods of threatened faunal groups, using different electronic devices like camera traps, GPS, and range finders to prevent illegal wildlife crimes like hunting and poaching and share responsibilities in order to prevent, prepare and mitigate incidences of forest fire and formulate area-specific management planning. People also actively participated in sharing knowledge in demonstration sessions to develop responsiveness towards wildfires and the basics of species identification.

c. **Climate change:** Forest fires have swept into public policy and awareness over the recent years due to its increase in frequency throughout the spatial extent of the country. The season of the year in which fire occurs is one of the determinants of successional trajectories on which ecosystem embark after the fire. Temporal patterns may also affect fire intensity through differences in surface and crown fuel moisture contents. A number of studies conducted previously indicate forest fire contributes to climate change. The critical aspect of climate change's impact on forest fires with respect to its influence on vegetation is that fire may be more important than the direct effects of climate change with to species distribution, migration, substitution and extinction. As per some models, fire activity is expected to increase in the next century and hence, it is going to accelerate changes in species composition and structure. So, the present study was undertaken to study on the impact of forest fire on faunal resources, which will be of great significance in combating the climate-related extremities and building adaptation strategies for the long-term conservation and management.

6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development:

Not Applicable

6.2 Scientific Management of Natural Resources in Indian Himalayan Region:

Since the project is related to biodiversity conservation and environmental protection, the outcomes of the project will pave the way for scientific management of natural resources in IHR in the following ways:

1. Scientific monitoring of threatened mammals and avifauna in the North Eastern region and in a broader scale, the Himalayan region for species conservation and management planning.
2. The establishment of baseline information on the faunal diversity of the two study sites will help document changes in species composition, abundance and richness in fire scenarios, climate change, developmental activities, or other anthropogenic changes.
3. A new approach in preparing geodatabase comprising all species present in Mizoram detected through sign survey, camera trapping, trail sampling, and insect sampling will be essential in curating working plans for both protected and non-protected areas of the landscape in the future for long term monitoring purposes.
4. Information collected on native herbs, shrubs and trees present in the study sites through vegetation sampling will be crucial in carrying out plantation strategies or performing compensatory afforestation programs in post-fire scenarios that would facilitate maintaining the natural foliage and habitat of the landscape.
5. A questionnaire survey and key informant interviews conducted from villages near the forested habitats helped gather ethno-zoological knowledge. More participatory efforts from NGOs and forest departments will probe deeper into discovering local's dependency on natural resources and how these can be sustainably extracted in the long run.
6. Using the MODIS decadal fire point data, ten permanent monitoring plots were identified and established and thus, vulnerable fire areas were detected based on probability distribution mapping and hazard reduction modeling for conservation, protection and management planning in the study landscape.
7. A forest fire hotspot modeling was also performed to classify low, medium and high fire risk zones, which helps make adaptive management strategies by carrying out systematic research programs at specific intervals to check how species composition is being affected by categorized fire zones.
8. The fire calendar prepared in consultation with the forest department and training workshops and capacity building programs demonstrating the handling and usage of firefighting equipment to frontline forest staff, students from state university and colleges, NGO members and locals would ensure utmost preparedness and prevention towards any havoc incident.
9. Creating people's network in the study area consisting of farmers, locals, forest staff members, village council members, hired field assistants, students, NGOs and other important stakeholders was achieved which would aid in generating hazard reduction opportunities and protection of landscape resources.
10. Mass awareness programs were also conducted by disseminating knowledge products, printed materials and news articles at strategic fire hotspot locations regarding wildlife conservation and ill

effects of shifting cultivation. People were persuaded to reduce their dependence on jhum and change to other agricultural practices like integrated farming, contour farming, oil palm plantations, etc. to secure long-term sustainability.

6.3Conservation of Biodiversity in Indian Himalayan Region:

Since the project is related to biodiversity conservation and environmental protection, the outcomes of theproject will pave the way for scientific management of natural resources in IHR in the following ways:

1. The establishment of monitoring plots will help in the scientific monitoring of threatened species in the North Eastern region. It will help document changes in species composition, abundance and richness in fire scenarios, climate change, developmental activities, or other anthropogenic changes.
2. A new approach in preparing geodatabase comprising all species present in Mizoram detected through sign survey, camera trapping, trail sampling, and insect sampling will be essential in curating working plans for both protected and non-protected areas of the landscape in the future for long term monitoring purposes.
3. Using the MODIS decadal fire point data, ten permanent monitoring plots were identified and established and thus, vulnerable fire areas were detected based on probability distribution mapping and hazard reduction modeling for conservation, protection and management planning in the study landscape.
4. A forest fire hotspot modeling was also performed to classify low, medium and high fire risk zones, which is useful in making adaptive management strategies by carrying out systematic research programs at specific intervals to keep a check how species composition is being affected in categorized fire zones.
5. The fire calendar prepared in consultation with the forest department and training workshops and capacity building programs demonstrating the handling and usage of firefighting equipment to frontline forest staff, students from state universities and colleges, NGO members and locals would ensure utmost preparedness and prevention towards any havoc incident.
6. Creating a people's network in the study area consisting of farmers, locals, forest staff members, village council members, hired field assistants, students, NGOs and other important stakeholders was achieved, which would aid in generating hazard reduction opportunities and protect landscape resources.
7. Mass awareness programs were also conducted by disseminating knowledge products, printed materials and news articles at strategic fire hotspot locations regarding wildlife conservation and ill effects of shifting cultivation. People were persuaded to reduce the dependency over jhum and shift to other forms of agriculture practices like integrated farming, contour farming, oil palm plantations etc. for achieving long-term sustainability.

6.4 Protection of Environment:

Forest fires are considered as one of the most widespread hazards in a landscape. Unplanned and abrupt forest fire are a major cause of forest degradation, habitat fragmentation and pollution. Since the project is related to biodiversity conservation and environmental protection, the project's outcomes will also result in the improvement of the environment in the study landscapes in various ways. The same is explained in the above points 6.3 and 6.4 also provide related information on biodiversity, and natural resources, which are integral parts on the environment and are mutually related.

6.5 Developing Mountain Infrastructures:

Mountain ecosystems are essential for economic growth and human well-being, providing us with numerous public goods and services like freshwater, food, medicinal products, energy, biodiversity and associated traditional knowledge and cultural diversity. Certain states stretching from Jammu and Kashmir to North East in the Himalayan Region are at a disadvantageous situation in difficult terrain, topography, severe weather conditions, dispersed habitations, large forest lands, and small and small and underdeveloped market, long international borders, poor connectivity and inadequate general infrastructures. It is well known that Himalayan and North Eastern States should adopt a developmental path that does not require disturbing the ecological balance of the region yet continue to prosper and grow. The tragic disastrous events in Uttarakhand have highlighted how Nature’s fury can be unleashed in these mountainous regions. Conservation of natural resources and environment along with measures to enhance productivity for improved livelihood and human development is vital in the long run which can be achieved by adopting scientifically and technically appropriate, economically viable and environmentally sustainable methods and approaches that are acceptable to local people. The information generated on species composition and abundance, their geolocations and components of habitat ecology under the project can be used as a baseline source for planning infrastructure in the state. It can be also used for mapping biologically rich corridors for the conservation priority of species so that large scale road and railway networking projects can be systematically planned, however, they have to be protected by suitable legislation. Training, workshops and capacity building sessions conducted involving the locals and forest frontline members would facilitate disaster risk reduction and fire mitigation in the fragile ecosystem of North-East. Promotion of sustainable development spawned through mass awareness programs will also be carried out by bringing changes in their existing agricultural practices and thus, will enhance the economic and revenue opportunities of the inhabitants. It will also promote social forestry with indigenous vegetation cover for carbon credits and soil conservation. Planning and regulating construction activities based on a scientific approach is essential to prevent or reduce the recurrence of disaster losses in the future. Therefore, identifying safer and environmentally sustainable places for research and developmental activities is a prime requirement. So, the permanent monitoring plots will aid in multi-hazard risk zoning of the area for delineating safer zones so that exposure of society to natural hazards can be reduced. Strengthening emergency communication systems for early

warning and quick response by increasing linkages among institutional capacity will effectively lower further risks of widespread forest fire in the State and improve productivity. The outcomes of the project will substantially help in green development, creating eco-friendly jobs and planning new protected areas. Further, the geodatabase created will be of great significance with regard to monitoring the impacts of big developmental projects where large-scale landscape modification is required.

6.6 Strengthening Networking In IHR:

The outcomes of the study will markedly help in strengthening the network in Indian Himalayan Region in the following ways:

1. The training workshops will increase institutional capacity and linkages among various departments of the State to utilize the scientific inputs.
2. The trained human resources and village council members can be hired by the State government or their affiliated agencies to build locally available skilled persons in fire-fighting, wildlife monitoring, and green jobs.
3. The species composition information will help in conservation priority programs that can be shared among other North Eastern states and transboundary landscapes for risk assessment, evaluation, planning and monitoring.
4. The project outcomes will also strengthen the international transboundary network for strategic planning of natural resources.
5. Capacity building of community and local bodies of governance (Village Council) is vital for sustainable management of natural resources, enhancing opportunities for livelihood and preparing a disaster (fire) resilient community.

7 EXIT STRATEGY AND SUSTAINABILITY:

7.1. How effectively the project findings could be utilized for the sustainable development of IHR (max. 1000 words)

Fire is still used as a tool to clear forest lands, scrublands, and meadows to establish agricultural fields. Being a part of the geological cycle, it also plays an important role in rural culture in the study landscape and its key role in the hydrological, erosional, and biological cycle. Fire is a key to flora and fauna diversity, soil properties and carbon and nitrogen cycles. Air and water pollution in the area are sometimes ephemeral and the risk associated with fire necessitates careful planning. Although the project is not related to technological interventions for sustainable development, however, the outcomes can be used in several ways for sustainable development in IHR:

1. The government of India can use the information generated under the project for reporting purposes in many accredited international commitments like UNCCD, CBD, UNFCCC etc., and address sustainable development goals. Activities undertaken in the project can also be sustained by the

funding support of state and central governments, as per existing mechanisms in states, forest departments have funds for forest and protected area management. So, for long-term monitoring purposes, funds can be drawn as forest fire is a serious issue in the country's North Eastern region.

2. The capacity enhancement and training workshops for the stakeholders will result in the creation of skilled and semi-skilled personals in the landscape who can be involved in various green projects, engage in eco-tourism activities, and work as nature guides to generate more livelihood options. The frontline forest guards hired as field assistants were given hands-on training on handling gadgets and equipment used for field surveys. This knowledge can be shared and passed on to future generations (school and college students) upon whom the future conditions of our ecosystem rely.
3. The project outcomes will help develop conservation and management strategies in areas where a forest fire is a recurring phenomenon. A Forest fire calendar prepared in consultation with the forest department of Mizoram will be of great use in the prevention and preparedness from any forthcoming fire incident.
4. Using 20years of MODIS active fire points, fire instances in the study landscape, probability distribution map depicting categorical fire vulnerable zones and forest fire hotspots were classified that aided the identification of long-term monitoring plots under the project, which will help in hazard reduction facilitating forest fire mitigation and management.
5. Awareness programs were created regarding the negative impacts of shifting cultivation; farmers were motivated to adopt other forms of agriculture such as slope agriculture land technology, apiculture, greenhouse farming, integrated crop farming across the slopes of the agricultural lands and persuaded to gradually reduce the practice of jhum cultivation. This would help in restoring the ecosystem from future stress, which may increase further for practicing jhum. Prescribed and controlled fire is a part of the solution; however, there is a need to educate citizens on the role that fire plays.

7.2. Other Gap Areas (max 1000 words)

Due to COVID-19 restriction, field work and lab work was disrupted. So, there remained a few areas of research that should be given priority in the future concerning Mizoram as well as the entire North Eastern region, reproducible to IHR:

1. To assess the impact of fire on animals, other parameters like occupancy, habitat suitability, population viability, genetic evaluations and ethno-zoological studies need to be studied for conservation planning.
2. As animals tend to migrate in case of a fire outburst, large-scale biological corridors studies are required in the North Eastern region. Also, the Government of India is developing its road and railway networks, it would be imperative to suggest biological corridors for the species, connecting critical habitats for their viable population and protection.

3. Research programs focused on herpetofauna should also be given priority since poor information is available on this taxon. As specimen collection was prohibited by the state forest department, the state's active involvement and participation is required to undertake studies on herpetofauna.
4. A non-invasive DNA-based evaluation of threatened species and their population viability analysis should be carried out for long-term monitoring and conservation planning.
5. As hunting practices are quite prominent in these areas, data on ethno-zoological information must be collected from the entire region, reproducible to IHR.
6. The amount of vegetation loss or deforestation due to jhuming operations is clearly visible from remote sensing imageries. The rate of deforestation can be estimated from representative relationships between population density and the percentage of forest cover for formulating mitigation plans.
7. Remote sensing tools can also be utilized to estimate carbon stock and growing stock mapping for forest management purposes. As forest fire releases a great deal of ash and other toxic pollutants into the atmosphere, air, water and soil pollution estimations and their impact on biodiversity can also be undertaken.
8. As time and season are essential determinants of forest fire, causing drastic structural changes, studies related to vegetation dynamics and habitat attributes in pre and post fire scenarios can be assessed to identify fire-resistant and resilient species necessary for carrying out forest restoration and plantation strategies.
9. Economic quantification of damage caused by forest fire has not been covered in the study landscape, so this could be an essential aspect of enhancing policy-making and other loss recovery decisions.
10. There is a need to study the aquatic fauna from the region's wetlands and rivers, which are threatened by unsustainable utilization.
11. Finally, an evaluation of the timberline with respect to climate medicated uphill movement of vertebrates which is resulting in crowding of generalist species is required as they are out-competing the native specialist species of this narrow landscape of IHR.

7.3. Major recommendations for sustaining the outcome of the projects in future (500 words in bullets)

A successful scientific project cannot disregard any of the three bottom line pillars of sustainability: economic, social, and environmental. Stakeholders representing each of these pillars have to be satisfied to a certain degree in each successful project, even if the way of balancing the pillars varies differently on the project type. Systematic analysis and modification of project definition in practice can increase project sustainability and, thus, project success. According to the objectives formulated in this project, the goal cannot be achieved without the engagement of stakeholders. So, active participation, involvement and networking of locals, farmers, frontline forest staff members, state and local NGOs,

women association and students from colleges and universities is utmost for successfully sustaining the project outcomes. The above-mentioned project partners can utilize the funds from the state forest department, working in collaboration to carry out regular capacity building programs on forest fire impacts and combating methodologies to ensure execution and adaptive management. The lead agency Zoological survey of India can provide access to their database, records and reports, test action research methods, and play a pivotal role in disseminating ideas through electronic media to enhance understanding the problems of forest fire and implementation of mitigation strategies and biodiversity monitoring and conservation. Research on faunal resources in pre and post-fire scenarios at a suitable time interval is vital for protecting the native species and sustainable management of natural resources. Training and workshop programs in the fire hotspot areas will help understand the knowledge gaps with respect to preparedness and mitigation activities. The training module developed by the researchers will help in risk reduction and spreading awareness. The forest fire calendar prepared under the project will immensely contribute in taking preventive precautionary measures so that fire outbreaks can be reduced. The long-term monitoring plots established through probability distribution mapping for hazard reduction and forest fire mitigation would facilitate observation and tracking in the fire-prone landscape. Regular clearing off forest lands to eliminate dry fuel accumulation, the early creation of fire lines and keeping in hand firefighting equipment will give more emphasis to early prevention strategies. The network linkages of stakeholders need to be maintained in the long run through effective coordination to improve the study area's project outcomes. This would accelerate prompt detection of fire incidences along with efficient ground patrolling and communication networks. Lastly, human-caused fires can be prevented through proper education, environmental modification, and greater awareness regarding the ill effects of shifting cultivation and promoting other sustainable agricultural practices.

7.4. Efficient ways to replicate the outcomes of the project in other parts of IHR (Max 1000 words)

The project's outcomes should be replicated and up-scaled to other areas of the Himalayan and North Eastern region where forest fire impact assessments have not been conducted. Some of the most pertinent ways are given below:

1. The field-tested training kit prepared can be used by forest departments of the entire Himalayan Region.
2. The database generated under the project can be used by future researchers from different institutions and forest officials for developing action-oriented working and planning documents for non-protected areas, and other untouched portions of large protected areas as well. Temporal scale studies can be performed to see how an abundance of species increases or decrease with any reference to changes in habitat quality and disturbance level.
3. The present study was implemented only in two districts of Mizoram. The approach can be replicated to other districts and other states of the North Eastern region as well, where a forest fire is a recurrent phenomenon. This can be used as a sample study, while the approach can be taken up for

other IHR states so that comparative data can be generated, which will be useful for curating region-specific management and conservation strategies.

4. The forest fire calendar prepared for Mizoram can be recreated with modifications in consultation with the forest departments of other states of the North Eastern region for fire preparedness, prevention and mitigation activities.
5. The long-term monitoring plots established through probability distribution mapping for hazard reduction and forest fire mitigation should be monitored long-term to understand the changes in species community and structure because of anthropogenic and climate change impacts.
6. The training and workshop programs conducted for stakeholders, frontline forest staff, and other ground-level personals throughout the project can be used as trainers for building a new set of trained workers to conserve and monitor wildlife species in the IHR.
7. As per the existing mechanisms for state forest department, funds can be drawn to organize more awareness programs in order to penetrate into the grassroots level to take up other sustainable livelihood options like greenhouse farming, apiculture, oil palm commercial farming and permanently quit jhum. This would also help generate other jobs like nature guides or take up eco-tourism projects.

8. Reference

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Annexure-I

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

For the Period: - 01.06.2021-30.11.2021

1.	Title of the project/Scheme/Programme:	**Understanding the impact of forest fire on faunal resources of North Eastern States for conservation and management**
2.	Name of the Principle Investigator & Organization:	**Dr. Lalit Kumar Sharma** Zoological Survey of India
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. And Sanction Date of the Project:	**GBPNI/NMHS-2017/MG- 28/08/158/282 Dated 24.05.2019**
4.	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	**1st Year Grant: INR 22,30,400/-** **Letter No.:** GBPNI/NMHS-2017/MG-28 Dated 23.02.2018 **2nd Year Grant : INR 38,70,400/-** **Letter No.:** GBPNI/NMHS-2017/MG-28/08/158/282 Dated 19.09.2019 **3rd Year Grant: INR 34,57,198/-** **Letter No.:** GBPNI/NMHS-2017/MG-28/08/158/282/85/84 Dated 29.07.2021 **Total Amount Received = INR 95,57,998/-**
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	**INR 95,57,998/-**
6.	Actual expenditure (excluding commitments) incurred during the project period:	**Total 3 year Expenditure : INR 8375447/-** (1st Year INR 1897471/- 2nd Year INR 4203141/- 3rd Year INR 2274835/-)

7.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	**0**
8.	Balance amount available at the end of the project:	**0**
9.	Balance Amount:	**1182551**
10.	Accrued bank Interest:	**0**

Certified that the expenditure of **Rs.83,75,447/- (Rupees Eighty Three Thousand Seventy Five Thousand Four Hundred and Forty Seven Only)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned.

Date: 24/11/22

(Signature of Principal Investigator)

Dr. Lalit Kumar Sharma
Scientist-D
Zoological Survey of India
M-Block, New Alipore
Kolkata-700 053

29/11/22

(Signature of Finance Officer)

Drawing & Disbursing Officer
Zoological Survey of India
Kolkata-53

(Signature of Head Institution)

Dr. Dhriti Banerjee
Director
Zoological Survey of India
MoEF&CC, Govt. of India
Kolkata-700053

OUR REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

Zoological Survey of India, Kolkata

Statement showing the expenditure of the period from **01.06.2021-30.11.2021**
Sanction No. and Date : **GBPNI/NMHS-2017/MG- 28/08/158/282 Dated 24.05.2019**

1. Total outlay of the project : **99,68,200/-**

2. Date of Start of the Project : **23.02.2018**

3. Duration : 3 Years

4. Date of Completion : 30.11.2021

a) Amount received during the project period : **95,57,998/-**

b) Total amount available for Expenditure :**95,57,998/-**

S. No.	Budget head	Amount received	Expenditure	Amount Balance/ excess expenditure
1	**Salaries/Manpower cost**	2298726	2004336	294390
2	**Travel**	1521127	1151512	369615
3	**Expendables &Consumables**	1295527	1171953	123574
4	**Contingencies**	451127	435361	15766
5	**Activities & Other Project cost**	3162864	3050075	112789
6		0	0	0
7		0	0	0
8		0	0	0
9	**Institutional Charges**	0	0	0
10	**Equipments**	828627	562210	266417
11	**Interest earned**	0	0	0
12	**Grand Total**	**9557998**	**8375447**	**1182551**

Certified that the expenditure of **Rs.83,75,447/- (Rupees Eighty Three Thousand Seventy Five Thousand Four Hundred and Forty Seven Only)** mentioned against Sr. No.12 was actually incurred on the project/ scheme for the purpose it was sanctioned.

Date: 24/11/22

(Signature of Principal Investigator)

Dr. Lalit Kumar Sharma
Scientist-D
Zoological Survey of India
M-Block, New Alipore
Kolkata-700 053

(Signature of Registrar/ Finance Officer)

Drawing & Disbursing Officer
Zoological Survey of India
Kolkata-53

(Signature of Head of the Institution)

Dr. Dhriti Banerjee
Director
Zoological Survey of India
MoEF&CC, Govt. of India
Kolkata-700053

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.

NOT APPLICABLE

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: **Dr. Dhriti Banerjee**

1. Sl.No.**01**
2. Name of Grantee Institution: **Zoological Survey of India, Kolkata**
3. No. & Date of sanction order: **GBPNI/NMHS-2017/MG- 28/08/158/282 Dated 24.05.2019**
4. Amount of the Sanctioned Grant: **Rs. 828627**
5. Brief Purpose of the Grant: **For meeting the sanctioned project objectives.**
6. Whether any condition regarding the right of ownership of Govt. in the property or other assets acquired out of the grant was incorporated in the grant-in-aid Sanction Order: **NO**
7. Particulars of assets actually acquired: **Details provided on Annexure-IV**
8. Value of the assets as on: **Not valued as on date (Rs. 562210/- purchase cost)**
9. Purpose for which utilized at present: **For research studies**
10. Encumbered or not: **Not encumbered**
11. Reasons, if encumbered_NA
12. Disposed of _NA
13. Reasons and authority, if any, for disposal_
14. Amount realized on disposal _NA

Any Other Remarks:

(PROJECT INVESTIGATOR)

(Signed and Stamped)

Dr. Lalit Kumar Sharma
Scientist-D
Zoological Survey of India
M-Block, New Alipore
Kolkata-700 053

(FINANCE OFFICER)

29/11/21

(Signed and Stamped)

Drawing & Disbursing Officer
Zoological Survey of India
Kolkata-53

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Dr. Dhriti Banerjee
Director
Zoological Survey of India
MoEF&CC, Govt. of India
Kolkata-700053

Annexure-IV

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Sanctioned Cost	Actual Purchased Cost	Purchase Details
1	Suunto KB 20 Precision compass (5 no.)	5		36030	2019
2	Garmin GPS (3 no.)	3		108000	2019
4	Laptop (1 no.)	1		61580	2020
5	Camera traps (15)	15		277500	2020
6	Sound Recorder devices (8 nos.)	8		79100	2021

(PROJECT INVESTIGATOR)

(Signed and Stamped)

Dr. Lalit Kumar Sharma
Scientist-D
Zoological Survey of India
M-Block, New Alipore
Kolkata-700 053

(FINANCE OFFICER)

(Signed and Stamped)

Drawing & Disbursing Officer
Zoological Survey of India
Kolkata-53

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

Dr. Dhriti Banerjee
Director
Zoological Survey of India
MoEF&CC, Govt. of India
Kolkata-700053

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:

S. No.	Name of Equipment	Quantity
1	Suunto KB 20 Precision compass (5 no.)	5
2	Garmin GPS (3 no.)	3
4	Laptop (1 no.)	1
5	Camera traps (15)	15
6	Sound Recorder devices (8 nos.)	8

Head of Implementing Organization: Dr. Dhriti Banerjee
Name of the Implementing Organization: Zoological Survey of India, Kolkata

Stamp/ Seal:
Date: 5/12/2022

Dr. Dhriti Banerjee
Director
Zoological Survey of India
MoEF&CC, Govt. of India
Kolkata-700053

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 throughRTGS (Real-Time Gross System) in favour 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

The refund of unutilized will be done once the UC is approved by the PAO, ZSI, Kolkata