Template/Pro forma for Submission

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research Project Grant

NMHS Reference No.:	NMHS/2015-16/SG11/11

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

PROJECT TITLE

VEGETATIONAL HETEROGENEITY AND IMPACT OF CHANGING CLIMATIC AND LAND USE PATTERND ON TWO CONTRASTING TIMBERLINE ECOTONES OF UPPER CHENAB CATCHMENT, JAMMU AND KASHMIR AND CONSERVATION STRATEGIES THEREOF.

Project Duration: *from* **31.03.2016** *to* **31.03.2019**

***Submitted to*:**

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NMHS-Final Technical Report (FTR)

Demand-Driven Action Research Project

DSL: Date of Sanction Letter

3	1	0	3	2	0	1	6
d	d	m	m	y	y	y	y

DPC: Date of Project Completion

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

Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	NMHS/2015-16/SG11/11									
ii.	Type of Project	Small Grant	✓	Medium Grant		Large Grant					
iii.	Project Title	Vegetational heterogeneity and impacts of changing climatic and land use patterns on two contrasting timberline ecotones of Upper Chenab catchment, J&K and conservation strategies thereof.									
iv.	State under which Project is Sanctioned	Jammu and Kashmir									
v.	Project Sites (IHR States covered) (Maps to be attached)	Site-1 (Kailash Circuit)(Investigated in detail) Site -2 (Paddar-Machail circuit) (Incomplete investigation due to lack of time slot and resources) Jammu and Kashmir State (now a Union Territory)									
vi.	Scale of Project Operation	Local		Regional	✓	Pan-Himalayan					
vii.	Total Budget/ Outlay of the Project	INR 25,21,400.00									
viii.	Lead Agency	University of Jammu									

	Principal Investigator (PI)	Prof. Anil K. Raina Dept. of Environmental Sciences, University of Jammu, Jammu (J&K)-180006
	Co-Principal Investigator (Co-PI)	Dr. Neeraj Sharma Faculty of Life Sciences, Institute of Mountain Environment, University of Jammu
	Project Implementing Partners	Partner 1: Institute of Mountain Environment, University of Jammu Partner 2: Department of Environmental Sciences, University of Jammu Partner 3: Indian Institute of Remote Sensing, Dehradun
	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	Prof. Anil K. Raina Dept. of Environmental Sciences, University of Jammu, Jammu (J&K)-180006 anilkraina@yahoo.com

Part B: Project Detailed Report

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: Timberline is the most conspicuous vegetation limit in the high mountain systems characterized with greater ecology, physiognomy and taxonomic variety. The Himalayan region has the highest and most diverse treeline in the world which is attracting the researchers across the world to explore the complexity and scale dependency that makes tree like dynamics so fascinating and difficult to understand. Our study was on the contrasting tree line landscapes located in Kailash (Site-1), Bhaderwah and Paddar (Site -2), Kishtwar, J&K. However, due to very short working window and also lack of resources (JPF) detailed investigations has been carried out at Site -1 only. Attempts for the detailed investigation at Site -2 were repeatedly hampered due to inclement weather, distance between the two sites, working force etc. therefore the present report includes investigations carried out at Site-1 only.

Aims / Objectives : The main objectives of the study were to : assess the structure, composition and pattern of vegetation in different communities along tree line-rangeland interfaces; assess the biomass and productivity of various interface forest-meadow communities ; study the phenological attributes of important tree line plants and assess the impact of altered climatic conditions on phenology and growth along an altitudinal gradient ; delineate the timberline, landscape dynamics and niche modeling (*Betula utilis*) using Remote Sensing and GIS ; identify and categorize the commercially important plants (MAP, RET and fodder) and their ethno-botanical relevance in the forest interfaces and study the anthropogenic influences (grazing, browsing and fire wood pressures) on the course of tree line and its interfaces.

Methodology: The detailed floristic investigations were carried out in the study area during working periods. 100 m^2 quadrats, twenty each were laid at all five sites (site I to site V) in an elevational range of 1200 m (2800 m to 4000 m). Three vegetation layers, i.e. tree, shrub and herb were analyzed for species richness, diversity and dominance following Misra (1968) and Muller-Dombois and Ellenberg (1974).The Species Importance Value (SIV) was calculated following Curtis (1959). Species richness was simply considered as the number of species per unit area (Whittaker, 1972). The richness was obtained by using the formula SR = S-1/ln (N) given by Margalef (1968) and SR= s/√n (Menhinick, 1964), respectively. The Shannon-Weiner diversity Index (Shannon and Wiener, 1963) was calculated by using formula H'= - ∑ni/n log2 ni/n while

the evenness (equability) was obtained using the formula E1 = H′ / ln (s) (Pielou, 1966). Dominance was calculated using Simpson's index (Simpson, 1949) using D: I-Cd, Where Cd = Simpson's concentration of dominance = (∑ni/n)2.

Results : A total of 238 species of plants among 11 trees, 26 shrubs and 201 herbs contained in 163 genera and 61 families were recorded from the montane forests and upper timberline ecotones of upper Bhaderwah during study period. Of the total, 232 are angiosperms including nine species of orchids and 6 Gymnosperms. Family Asteraceae emerged as the dominant family with highest species richness of 35 belonging in 22 genera followed by Rosaceae (17 species; 10 genera), Lamiaceae (16 species; 11 genera) and Ranunculaceae (15 species; 10 genera). Maximum species richness (178 species) was recorded at Site-II with the dominance of herbs (149 species) followed by Site-II (139 species), Site-III (121 species), Site-IV (82 species) and Site-IV (61 species) exhibiting a characteristic mid elevation peak. The species diversity was recorded maximum for herbs (H'=4.60) at site II, shrubs (H'=2.48) and trees (H'=1.74) at site I, respectively. The value of Simpson's index was recorded maximum for herbs (0.98) at Site II, shrubs (0.89) and trees (0.79) at site I. The phytosociological attributes of trees revealed the dominance of *Quercus semecarpifolia* with highest Importance Value of 163.11 at site-II followed by 100.32 (site-I). In case of shrubs, *Rhododendron companulatum* showed the highest IV of 47.32 at site I followed by IV=68.37 at site-II and *R. anthopogon* (IV=55.08 at Site-III). Beyond this, *Gaultheria trichophylla* takes over the rocky outcrops with importance value of 89.59 and 217.26 recorded for sites-IV and V, respectively. Interestingly in case of herbs, each site is dominated by a single species. *Snecio raphanifolius* (IV=23.08), *Anaphalis nepalensis* (IV=6.33), *Bergenia stracheyi* (IV=13.44), *Pleurospermum brunonis* (IV=9.01), and *Corydalis govaniana* (IV=15.19) have been observed to dominate Sites I, II, III, IV & V, respectively. Phenological characters were also observed for the selective trees and shrubs in the study corridor for two consecutive years. The selected vegetation included three trees (*Betula utilis, Quercus semecarpifolia and Abies pindrow*) and two shrubs (*Rhododendron companulatum* and *Salix denticulata*). The readings observed though did not display any substantial variation in the phenophases on a temporal scale of three consecutive years, but it was observed that different phenophases *viz* flower bud swelling, bursting and flowering (10%, 50% and completion), leafing (bud swelling, bursting, leaf separation and senescence) largely depends on the microclimate, temperature, time of snow fall, duration of snow cover and date of snow melt, etc. Based on the above factors it was felt that the different phenophases occurred earlier during the year 2018 than 2017 as the latter witnessed harsh winters.

In order to understand the vegetational distribution *viz-a-viz* edaphic environment, the soil analysis was performed for all the study sites along the elevational gradient. The analysis revealed no variation in the soil texture as the whole study corridor is characterized by sandy-loam type. The mean soil temperature ranged between 6^{o}C-14^{o}C that showed decreasing trend with the rising elevation with minimum value recorded for site-VII. Soil moisture content varied from 4.00-6.58 with highest values recorded at site-III from where it started falling. The water holding capacity (%) ranged from 19.61-26.75 with maxima recorded at mid elevations. pH (3.97-5.02) showed a declining trend with rising elevation, reaching maximum at site-V and declining further afterwards. The potassium (66.20-493.59 Kg/ha) and organic carbon (2.46-3.10 %) showed higher values along the rising elevation. The available phosphorus (9.72-18.25 Kg/ha) and nitrogen (0.214-0.270 Kg/ha) revealed the higher values near mid elevations with an exception of least phosphorus content observed at site-IV. When correlated with diversity of trees, the results indicate a positive correlation with available potassium and bulk density whereas, shrubs and herbs are hardly influenced by the soil characteristics.

The alpine landscapes beyond treeline are found to be rich repositories of medicinal and aromatic plants currently reeling under myriad of natural and anthropogenic stressors. Twenty-six species figure out in different categories of threat as per IUCN (22 species) and CAMP (4 species) listing. Among these, four are critically endangered, 8 endangered, 9 vulnerable, 1 near threatened, 2 rare and 2 intermittent. The ethno-botanical surveys bring forth 75 plant species being used by the nomads mainly *Gujjars* and *Bakarwals,* the regular summer visitors to the study area. These 75 species belong to 64 genera and 40 families. Ethnobotanical list revealed the presence of maximum herbs (62 species) followed by shrubs (9 species) and trees (2 species). The maximum contribution was made by roots (29 species) followed by leaves (21 species) among the other plant parts used for medicinal purpose.

The spatial extant of treeline was generated on the archive and fresh Google Earth images. No significant shift in treeline was however observed from the data set available except minor changes noted for the density of few forest stands. The land use-landcover map, digital elevation map, slope and aspect maps have been generated archive and fresh satellite images (Resoursesat-II, LISS-IV) in ArcGIS 10 and ERDAS-Imagine 10.1 software. The maps depicted the intact treeline and a steady upward movement of alpine scrub along the elevational gradient.

Recommendations:

- For proper and long-term monitoring of treeline ecotones, we recommend the establishment of permanent plots at treeline and alpine ecosystems. These data on spatial and temporal scales will prove handy in long term species distribution monitoring for climatic / micro-climatic changes besides other abiotic variables.

- Permanent weather monitoring stations and field observatories also need to be setup at the treeline for the better understanding of treeline dynamics and long-term ecological monitoring not restrictive to plants but other biological groups.

- Replication of such studies in other parts of lesser and Great Himalayas across the east-west arc of the state to plug the data gaps and enhance the knowledge base and data availability on treeline ecosystems.

- The excessive and unscientific extraction of medicinal plants and aromatic herbs needs to checked and effectively regulated with stringent provisions.

- Anthropogenic disturbances by migratory pastoral communities are on the rise for past many years. These communities camp near the timberline and use alpine meadows for their livestock (goat, sheep, cow and horse) which affects the vegetation structure and composition. The provision of relocation of nomads, controlled or rotational grazing are suggested besides the provisioning of alternates for their livelihoods.

- The pronounced stressors like pilgrimages, timber extraction, and infrastructure development needs to be executed with rational planning. The anthropogenic disturbances need an effective check.

- Being a rich repository of Biodiversity, the area needs to be declared as protected area.

- The human interferences have lot more alarming effects on the biota and their respective ecosystems than those of natural occurrences. The long-lasting disturbances do not provide enough time to the ecosystem to revive itself naturally and thus can hamper the regeneration process thereby. Hence for boosting the forest health and maintaining high biodiversity, there should be a proper cut in the various anthropogenic activities.

2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1	To assess the structure, composition and pattern of vegetation in different communities along tree line-rangeland interfaces	Different vegetation communities have been studied for their structure, composition and patterns along the rising elevation and across tree line-rangeland interface.
2	To assess the biomass and productivity of various interface forest-meadow communities.	The soil nutrients status has been assessed along the elevational gradient and specific ecotones.
3	To study the phenological attributes of important tree line plants and assesses the impact of altered climatic conditions on phenology and growth along an altitudinal gradient.	The phenological attributes of selected woody species have been recorded for a period of two years. The findings have been correlated with temperature, relative humidity and altitude.
4	Delineation of timberline, landscape dynamics and niche modeling (*Betula utilis*) using Remote Sensing and GIS.	The existing timberline has been delineated on Resourcesat-II, LISS-IV and Google earth images
5	To identify and categorize the commercially important plants (MAP, RET and fodder) and their ethno-botanical relevance in the forest interfaces	The threatened medicinal and aromatic plants have been enumerated on the basis of their ethno-botanical relevance.
6	To study the anthropogenic influences (grazing, browsing and fire wood pressures) on the course of tree line and its interfaces	The secondary information on the anthropogenic influences has been collected in the form of interviews, photographs and video recordings.

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:
	Database on species composition and diversity analysis in J & K, Chenab basin	Assessment report on species composition and diversity along the selected sites (numbers)	Database created on the species composition and diversity along the selected sub-sites (238 plant species) of site-1 provided.	Efforts made to cover all the species in all seasons at site-1 (Kailash-Chattergalla Circuit) However, due to the shortage of staff, short working window due to the long distance between the sites (Site-1 & Site-2) and inclement weather conditions, only the preliminary surveys could be conducted at site-2 (Paddar-Machail circuit).
	Soil nutrient status report of selected sites	Site specific soil nutrient status report and long term analysis of the database compiled for a regional analysis (nos)	Soil nutrient analysis performed for all the sampling sub-sites at site-1 and status report presented.	Efforts made to collect and analyse the soil samples at site-1 (Kailash-Chattergalla Circuit) However, due to the shortage of staff, short working window due to the long distance between the sites (Site-1 & Site-2) and inclement weather conditions, only the preliminary surveys could be conducted at site-2 (Paddar-Machail circuit).
	Digital Herbarium in the University for conservation education	Assessment report on phenological response to climate change (nos)	All the phenophases for the selected tree (3 species) and shrubs (2) species have been recorded for all the	Though a couple of field visits made in the study site-2 and few plant species collected but the phenophases were recorded due to the shortage of staff, short working window due to the long distance between the

			seasons during two years.	sites (Site-1 & Site-2) and inclement weather conditions, only the preliminary surveys could be conducted at site-2 (Paddar-Machail circuit).
		Digital herbarium compiled (no. of species)	The digital database created in the form of high resolution photographs.	A few of the groups (Orchids) from Site-1 have been uploaded on Bhaderwah Campus website. Full digital herbarium for the alpine landscapes of the region under compilation for uploading.
		Community involved	Informal community interactions and few nomads and women folk engaged in pastures were involved in data collection and secondary information generation at Site-1	Due to the availability of small working window only a few informal interactions could be held at site-2. Elaborative interactions were held with the communities at Site-1.

(*) 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/ Brief Details	Remarks/ Enclosures
1.	New Methodology developed	NA	
2.	New Models/ Process/ Strategy developed	NA	
3.	New Species identified	NA	
4.	New Database established		
5.	New Patent, if any	NA	
	I. Filed (Indian/ International)		

S. No.	Particulars	Number/ Brief Details	Remarks/ Enclosures
	II. Granted (Indian/ International)		
	III. Technology Transfer(if any)		
6.	Others (if any) :Plant inventory, phenology, soil nutrients and microclimatic data generated for the first time in any timberline ecotone of the region		

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 Utilisation New data
1.	Baseline data on plant inventory, phenology, soil nutrients and microclimatic data generated for the first time in the region	The baseline information with regard to phenology, soil nutrients and microclimatic data was not available for any treeline ecosystem in the region.	Data being shared with other stakeholders and policy makers

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	1	A local workshop for school children conducted at Kundal, Paddar wherein the children were apprised about the importance of high altitude biodiversity composition, its value and need for conservation	No specific information			50
2.	On Field Trainings		NA				
3.	Skill Development	25	Skill development workshop on parataxonomy with special reference to high altitude plants held	2	1	18	25
4.	Academic Supports		NA				
	Others (if any)		NA				

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	NA		
6.	Others collaborations	NA		

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	NA	
2.	Govt Departments (Agriculture/ Forest)	The ground staff of local forest department was involved and trained during field visits	Helped identification of medicinally and economically important plants, their status and habitat in alpine region for the conservation purpose.
3.	Villagers	Informal interactions	Generated awareness regarding the diversity and distribution of plants and their conservation.
4.	SC Community	-do-	-do-.
5.	ST Community	-do-	-do-.
6.	Women Group	The local women folk and nomads were trained for the scientific extraction of medicinal and aromatic plants for domestic usage.	Theory and hands on the Identification of medicinally and economically important plants, their status and habitat in alpine region for the conservation purpose.
	Others (if any)	All the pilgrims visiting the area during different *Yatras* (pilgrimages) were sensitised for the importance, protection and conservation of the alpine flora and its habitat.	Sensitization about the protection and conservation of economically important and threatened plant species.

8. Financial Summary (Cumulative)

S. No.	Financial Position/Budget Head	Funds Received	Expenditure / Utilized	% of Total cost	Balance unspent
I.	Salaries/Manpower cost	6,81,600.00	5,59,655.00	82%	1,21,945.00
II.	Travel	2,00,000.00	1,99,187.00	99.5%	813.00
III.	Expendables &Consumables	2,50,000.00	2,49,801.00	99.9%	199.00
IV.	Contingencies	1,25,000.00	1,03,318.00	82.6%	21,682.00
V.	Activities & Other Project cost	1,00,000.00	74,166.00	74%	25,834.00
VI.	Institutional Charges	NIL			
VII.	Equipments	4,17,000.00	4,16,919.00	99.9%	81.00
	Total	**17,73,600.00**	**16,03,046.00**	**90.3%**	**1,70,554.00**
	Interest earned	1,439.00			
	Grand Total	**17,75,039.00**			

* 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 Equipments	Cost (INR)	Utilisation of the Equipment after project
1.	Data Logger	18500 x 12 =222000.00	For the determination of Temperature and relative Humidity in research purpose.
2.	Compass with clinometers	4500 x 2 = 9000.00	For the measurement of angles of a slope, elevation or depression in the study sites/sub-sites.
3.	Global Positioning System	35000 x 1= 35000.00	For the measurement of geo-coordinates and elevation.
4.	DSLR Camera	41000 x 1 =41000.00	For photography
5.	Total	307000.00	

10. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States Covered	Jammu and Kashmir	The study area forms the eastern extant mainly comprising the parts of lesser and Great Himalayas bordering Himachal Pradesh
2.	Project Site/ Field Stations Developed	Project sites established	The temporary field stations (tents) were established at Chattri (3400 m) in Kailash-Chattergalla Circuit and Hagyot (3500 m) in Machail-Suncham circuit besides the local camping as per the survey requirements.
3.	New Methods/ Modeling Developed	Standard protocols followed	The standard field protocols and methodologies being followed. The GIS modeling at a little later stage might generate new geo-spatial models for the region
4.	No. of Trainings arranged	Formal 01 Informal 01	A two weeks training program on para-taxonomy with special emphasis on identification of high elevation plants was conducted for the locals of Chenab Valley by IME, Bhaderwah Campus.
5.	No of beneficiaries attended trainings	25	The participants were mostly 10+2 and graduates
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	7-10	01 Junior Project fellow 02 Field Assistants 05-07 Filed helpers / porters per field trip
7.	SC stakeholders benefited	Not specified	05-07 locals are hired as porters / helpers during the field surveys
8.	ST stakeholders benefited	-do-	The local women folk and nomads are trained for the scientific extraction of medicinal and aromatic plants for domestic usage.
9.	Women Empowered	NA	NA
10.	No of Workshops Arranged along with level of participation		A local workshop for school children conducted at Kundal, Paddar wherein the children were apprised about the

			importance of high altitude biodiversity composition, its value and need for conservation
11.	On field Demonstration Models initiated	.... (attach maps about location & photos)	NA
12.	Livelihood Options promoted	Temporary	05 -07 locals are hired as porters / helpers during the field surveys
13.	Technical/ Training Manuals prepared	NA	NA
14.	Processing Units established	.... (attach photos)	NA
15.	No of Species Collected	238	238 species of plants among 11 trees, 26 shrubs and 201 herbs contained in 163 genera and 61 families were recorded.
16.	New Species identified	NA	NA
17.	New Database generated (Types):		Land use land cover maps, Digital elevation maps, slope and aspect type maps and drainage type maps.
	Others (if any)		

11. Knowledge Products and Publications:

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

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

Particulars	Recommendations
Utility of the Project Findings	The baseline data generated, first time for the region will prove handy for line departments and other stakeholders in devising conservation strategies and management plans these eco-sensitive habitats. The study paves the way forward for long term ecological studies with a wider scope and large area coverage in near future.
Replicability of Project	The baseline information on treeline *viz-a-viz* changing climatic scenario is scanty and equivocal for the region. Whatsoever information is available is truncated and unrealistic. The current database and the protocols followed will prove handy in replicating the investigations for other similar ecosystems along the middle and western fringe of the region. It will plug the missing links and data gaps for the region.
Exit Strategy	Since the project does not warrant any financial outlay and being exclusively field based can easily be terminated for the current phase and be efficiently replicated in the similar landscapes with in-house financing in near future. Having established the baseline, similar investigations will be carried forward for other areas in conjunction with the line departments.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

Place: Jammu, **Date:** 24/02/2010