Template/Pro forma for Submission

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research Project Grant

NMHS Reference No.:	**NMHS/SG-2016/019/382/345**

Date of Submission:	1 0	0 2	2 0	2 0
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PROJECT TITLE (IN CAPITAL)

POST-FIRE MANAGEMENT IN THE PINE FORESTS OF INDIAN HIMALAYAN REGION BY STUDYING, CONSERVING AND DISTRIBUTING CULTURABLE MICROBIAL BIOTA TO INCREASE ECOLOGICAL SUCCESSION AND TO REVIVE FOREST PRODUCTIVITY

Project Duration: *from* (**01.06.2016**) *to* (**30.09.2019**).

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

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NMHS-Final Technical Report (FTR) *template*

Demand-Driven Action Research Project

DSL: Date of Sanction Letter								*DPC: Date of Project Completion*							
0	1	0	6	**2**	**0**	**1**	**6**	3	0	0	9	**2**	**0**	**1**	**9**
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Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	**NMHS/SG-2016/019/382/34**									
ii.	Type of Project	Small Grant	√								
iii.	Project Title	Post-Fire Management in the Pine Forests of Indian Himalayan Region by studying, conserving and distributing culturable microbial biota to increase ecological succession and to revive forest productivity									
iv.	State under which Project is Sanctioned	HIMACHAL PRADESH									
v.	Project Sites (IHR States covered) (Maps to be attached)	Bajhol, Manjholi, Sultanpur, Jabli and Seri villages of Solan Districts Attachment 1: Picture 5-7									
vi.	Scale of Project Operation	Local	√	Regional		Pan-Himalayan					
vii.	Total Budget/ Outlay of the Project	Rs 4026000.00									
viii.	Lead Agency	Center of Research on Himalayan Sustainability and Development, Shoolini University, Solan HP									
	Principal Investigator (PI)	Prof. Adesh K Saini (PI) Prof. Kartar S Verma (PI) Dr Anita Pandey (PI)									
	Co-Principal Investigator (Co-PI)	NA									
ix.	Project Implementing Partners	NA									

	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	**Prof. Adesh K Saini (PI)** Center of Research on Himalayan Sustainability and Development, Shoolini University Post Box No.9, Head Post Office, Solan (HP) – 173212 Mobile: 08988205238, Email: sainiade@gmail.com

2. Project Outcome

2.1. Abstract

***Background*:** Indian Himalayan Region (IHR) represents about one-third of the total forest cover and approximately 45% of the overall good forest cover of the country. One of the prominent tree vegetation of these regions is coniferous forests, which include the subtropical pine trees which very well grow in shallow soil of stress and sloppy areas and wastelands. Pine forest helps the ecosystem and local communities in many ways. The productivity of these forest ecosystem depends on many biotic factors which includes the beneficial symbiotic microbes. The productivity of forest gets severely affected in the event of wildfires which also changes the microbial biodiversity. Forest fires are common in areas where main forest species are pine trees. Pine needles are rich in oil content and so cause great fires which not only cause loss of the trees but also the microbial community at the soil bed. Wildfires burn on an average of 380 million ha/year (range 270–570 million ha/year) globally.

Objectives/Aim: We intended to study the impact of Forest fire on the loss of microbes beneficial to the forest ecosystem. ***Methodology:*** Analyze the change in microbial (bacterial, fungal and mycorrhizal) biodiversity and soil properties (binding capacity and erosion ability) in the Pine forest after fire outbreak as compared to the nearby-unaffected area. Involving the local panchayats and community people in the collection process to make them aware of the losses occurred due to fire. Test different ways to apply consortium from the repositories bank to the fire affected areas. ***Approach:*** We took microbiology approach to understand the loss of microbes, chemistry to understand the changes in soil properties and in plantae experiments to further understand the biological importance of loss.

R*esults*: We found that the bacterial population of burnt region was five times greater than unburnt region of *P. rouxburghii* forest. Surprisingly, bacterial species from the unburnt region exhibited PGP traits. We also found changes in the diversity of fungal and arbuscular mycorrhizal (AM) spores from the burnt and unburnt regions. A deterioration in values of soil nutrients, bulk density and dispersion ratio was also seen owing to the forest fire. We have trained and aware the local communities regarding the severe effects of forest fire.

Conclusion: We were able to gain enormous collection of microbial population which can be used firstly to replenish microbes in the fire affected area. Communities could be benefited by the increase in fodder quality and agriculture productivity.

Recommendations: We recommend that these studies need to be further taken to other regions of Himalayas where Forest fire is very common. The consortia further need to be tested in plantae experiments. We also need to analyze non-cultivable, and viable but non culturable microbes by using preserved soil samples. Various field trials of patents (bacterial plant growth promoting composition) can be study further. We can also use the library to identify bacteria surviving in the forest for isolating economically important enzymes used to degrade the debris (cellulases, laccases etc).

2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1	Analyze the change in microbial biodiversity in the Pine forest after fire outbreak as compared to the nearby unaffected area.	• After 4 weeks post-fire, we found that there is an average 60-70 % more CFUs in case of burnt sample as compare to less burnt and unburnt sample • Gram reaction of bacterial strains isolated from burnt and unburnt region revealed that there was a loss of gram negatives rods, cocci in the burnt region. • We found that mean spore density of AM spores in 50 g unburnt soil sample was ~ 120 and surprisingly in burnt soil sample it was ~360. • Fungal strains isolated from unburnt pine forest were found as strong degraders of lignocellulosic compounds (present in pine needles) confirmed by laccase test. which were lost due to the forest fire in burnt pine forest.

2	Collection, identification and characterization of bio fertilizer and bio control properties of bacterial and fungal microbes and make their repositories based on their geographical location to serve as feeding-bank to revitalize forest soil upon fire.	• Microbes of burnt area are 80% gram positive rods against unburnt area where 60 % are gram negative. • Characterization of fungal and bacterial strains was done by ITS region sequencing • We found that fire reduces available nitrogen and phosphorus from the soil. While values of potassium increases after the forest fire. • We found that PGPR traits (IAA production, phosphate solubilization and siderophore production and anti-fungal activity) were lost in bacteria isolated from burnt soil sample, Indicated increased population of bacteria in burnt region is not beneficial at all.
3	Involving the local panchayats and community people in the collection process to make them aware of the losses occurred due to fire	• Video was showed to local community to aware them about losses due to the forest fire. • Various awareness programs were organised for the involvement of local community.
4	Test different ways to apply consortium from the repositories bank to the fire affected areas and analyze its cost-effectiveness, feasibility and improvement in the forest productivity and soil parameters as compared to untreated fields.	• *In plantae* experiment was done to show that the bacterial strains isolated from unburnt soil sample can improve the plant growth.

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.	Model depicting increased the ecological succession after forest fire and reduction in soil loss.	Livelihood strengthening and promotion practices/ models tested (Nos.);	In Plantae experiment was done to check the productivity of forest. In which Wheat and Pea	We have checked the application of isolated microbes on seedlings which showed improvement in

			seedlings were taken as model to analyse the germination difference.	growth parameters.
2.	Increase in the productivity of forest and nearby agriculture ecosystems.	Variation Assessment Report on changes in microbial biodiversity assessment and soil properties in the pine forest under post-fire management and assessment practices (Nos./ species).	There was reduction in the beneficial microbes due to forest fire and there is nutrition depletion for nitrogen and phosphorus, but no change was observed for potassium. Total nine fungal strains were isolated from ten sites of unburnt and burnt region.	
3.	Improved the livelihood of families dependent on milk production.	Women/ beneficiary participation in awareness and outreach programmes (Nos.);	5 M.Sc. Student were trained Two women were participated during sampling and community interaction i.e. Mrs Reena Bhatia, Mrs Champa Devi	
4.	Guidelines/ manual for field replication in other fire affected forest areas of hilly regions.	Knowledge products developed and published out of the projects (Nos.).	Research Article: 1 Patents: 8	

(*) 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	NA
2.	New Models/ Process/ Strategy developed:	NA	NA

S. No.	Particulars	Number and Brief Details	Details of Attachment/ Supporting Document
3.	New Species identified:	19 – Bacterial strains 9 – Fungal strains 21 – Mycorrhizal strains	**Bacterial strains** MF574402 MF574403 MF574404 MF574405 MF574407 MF574408 MF57449 MF574410 MG051195 MG051196 MG05119 MG051199 MG051200 MG051201 MG051202 MF574411 MF574412 MF574413 MF574414 MF574416 MF574417 MF574418 MF574419 MF574420 **Fungal strains** MH654782 MH654783 MH654784 MH654785 MH654786 MH654787 MH654788 MH654789 MH654790
4.	New Database established:	NA	NA
5.	New Patent, if any:	8	Patents attached

	I. Filed (Indian/ International)	9	Application No. • An ecofriendly *Bacillus* based biofertilizer/biocontrol composition PA. NO. 201911010767 • An ecofriendly *Burkholderia* based biofertilizer/biocontrol composition PA. NO. 201911010768. • An eco-friendly *Enterobacter* based biofertilizer/biocontrol composition PA. NO. 201911011827. • An eco-friendly *Klebsiella* based biofertilizer/biocontrol composition PA. NO. 201911011828. • An eco-friendly *Pantoea* based biofertilizer/biocontrol composition PA. NO. 201911011829. • An eco-friendly *Pseudomonas* based biofertilizer/biocontrol composition PA. NO. 201911011851. • An eco-friendly *Serratia marcescens* based biofertilizer/biocontrol composition PA. NO. 201911011850. • An ecofriendly *Acinetobacter calcoaceticus* based biofertilizer/biocontrol composition PA. NO. 201911010766.

S. No.	Particulars	Number and Brief Details	Details of Attachment/ Supporting Document
			• An eco-friendly natural biofertilizer/ biocontrol agent. PA. NO. 201911005125
	II. Granted (Indian/ International)	None	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	NA
2.	Diffusion of High-end Technology in the region	NA	NA
3.	Induction of New Technology in the region	Use of microbes for crop improvement through videos	~200 villagers
4.	Publication of Technological / Process Manuals	10	1 Publication 9 Patents
5.	Others (if any)	Developed Questionnaire and videos	2

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
1.	From our research we came to know about the status of bacterial, fungal and mycorrhizal population after forest fire.	Information of microbial loss after forest fire of our region was not available before our study	Isolated beneficial bacteria were used to study the *In plantae* experiment.

2.	Deterioration of soil properties i.e. nutrient loss, bulk density and dispersion ratio were reported after forest fire.	Existing data indicated the same result	All the information was shared with local people during awareness interaction.

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	**4**	**Awareness**			**25**	**50**
2.	On Field Trainings	**2**	**Use of technology**			**20**	**65**
3.	Skill Development	**N/A**	**N/A**				**N/A**
4.	Academic Supports	**4**	**PhD Project of M.Sc. /B.Sc students**				**6**
	Others (if any)						

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

S. No.	Linkages /collaborations	Details	No. of Publications/ Events Held	Beneficiaries
1.	Sustainable Development Goal (SDG)	N/A		
2.	Climate Change/INDC targets	N/A		
3.	International Commitments	N/A		
4.	Bilateral engagements	N/A		
5.	National Policies	N/A		
6.	Others collaborations	N/A		

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	Awareness with the help of Questionnaire and video	Noticed less number of forest fire in local region
2.	Govt Departments (Agriculture/ Forest)	NA	

3.	Villagers	Awareness meetings	Noticed less number of forest fire in the local region
4.	SC Community	NA	
5.	ST Community	NA	
6.	Women Group	Awareness meetings	Everyone was aware of the impacts of Forest fire. Noticed less number of forest fire in local region
	Others (if any)		

8. Financial Summary (Cumulative)

S. No.	Financial Position/Budget Head	Funds Received	Expenditure/ Utilized	% of Total cost (40,26,000)
I.	Salaries/Manpower cost	660000.00	624800	15.5
II.	Travel	95,000	104991	2.6
III.	Expendables &Consumables	1513124	1548439	38.46
IV.	Contingencies	30000.00	30000.00	0.745
V.	Activities & Other Project cost	-	-	
VI.	Institutional Charges	259570	259570	6.44
VII.	Equipment	1350000.00	1350000.00	33.53
	Total	39,07,694	39,17,800	97.31
	Interest earned	5446**		
	Grand Total	3913140		

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

****It is shifted to Expendables and Consumables in 2018-19 Funds received.**

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

S. No.	Name of Equipments	Cost (INR)	Utilisation of the Equipment after project
1.	Spectrophotometer (Thermo Fisher Scientific; VL0L00D0)	Rs. 14,72,652 (20450.00 Euros)	The

Details should be provided in details **(*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*	*Himachal Pradesh*
2.	Project Site/ Field Stations Developed	*1*	*At Shoolini University, Solan*
3.	New Methods/ Modeling Developed	*1*	*Publication and 8 patents Appendix 2 and 6*
4.	No. of Trainings arranged	*2*	*Attachment 1 (picture 1 and 2)*
5.	No of beneficiaries attended trainings	*NA*	*65*
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	*1 PhD* *5 M.Sc.*	
7.	SC stakeholders benefited	*NA*	
8.	ST stakeholders benefited	*NA*	
9.	Women Empowered	*NA*	
10.	No of Workshops Arranged along with level of participation	*4*	*(Picture 1)*
11.	On-field Demonstration Models initiated	.... (Maps about location & photos)	Attachment 1 Picture 4-8
12.	Livelihood Options promoted	*N/A*	
13.	Technical/ Training Manuals prepared	*N/A*	
14.	Processing Units established	*N/A*	
15.	No of Species Collected	19 – Bacterial strains 9 – Fungal strains 21 – Mycorrhizal strains	
16.	New Species identified	19 – Bacterial strains 9 – Fungal strains 21 – Mycorrhizal strains	
17.	New Database generated (Types):	*Bacterial strains deposited to NCBI website*	Attachment 1 Picture 9 and 10
	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:	NA	1	3.4	
2.	Book Chapter(s)/ Books:	NA	NA		
3.	Technical Reports	NA	NA		
4.	Training Manual (Skill Development/ Capacity Building)	Questionnaire and video	NA		
5.	Papers presented in Conferences/Seminars	Presentation	NA		
6.	Policy Drafts/Papers	NA	NA		
7.	Others:	Patents - 9	NA		

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

12.1. Success Model(s)/ Best Practice(s) under the Project: N/A

Parameters	***Description***	***Details of Attached supporting documents***
(1) Adaptability of the Technology	We have developed method to study impact of microbes. We have reached out to local communities to discuss the impact of forest fire	Publication Appendix 2
(2) Acceptability (interest of the local people):	Local communities are indeed interested in understanding the impacts of forest fire.	Attachment 1 Picture 1 and 2
(3) Improvement in Ecological Variables:	We envisage that there would be less forest fire in the surrounding region.	More study is required to access this.

(4) Baseline Data and Comparison with the Controlled Data:	Information of biodiversity loss after forest fire of our region was not available before our research. From our study we came to know about the status of bacterial, fungal and mycorrhizal population after forest fire. Isolated beneficial bacteria were used to study the In plantae experiment. Deterioration of soil properties i.e. nutrient loss, bulk density and dispersion ratio were reported after forest fire. Although existing data indicated the same result All the information was shared with local people during awareness interaction.	

(5) Outcomes of the Scientific Publications, Knowledge Products:	Research article entitled: Divya Mittal, Rakesh Shukla, Sudhir Verma, Anand Sagar, Kartar S Verma, Anita Pandey, Yashwant Singh Negi, Reena V Saini, and Adesh K Saini. Fire in pine grown regions of Himalayas depletes cultivable plant growth promoting beneficial microbes in the soil. Applied Soil Ecology. 2019 April. Patents 9: Application No. 1. An ecofriendly *Bacillus* based biofertilizer/biocontrol composition PA. NO. 201911010767 2. An ecofriendly *Burkholderia* based biofertilizer/biocontrol composition PA. NO. 201911010768. 3. An eco-friendly *Enterobacter* based biofertilizer/biocontrol composition PA. NO. 201911011827. 4. An eco-friendly *Klebsiella* based biofertilizer/biocontrol composition PA. NO. 201911011828. 5. An eco-friendly *Pantoea* based biofertilizer/biocontrol composition PA. NO. 201911011829. 6. An eco-friendly *Pseudomonas* based biofertilizer/biocontrol composition PA. NO. 201911011851. 7. An eco-friendly *Serratia marcescens* based biofertilizer/biocontrol composition PA. NO. 201911011850. 8. An ecofriendly *Acinetobacter calcoaceticus* based biofertilizer/biocontrol composition PA. NO. 201911010766. 9. An eco-friendly natural biofertilizer/ biocontrol agent. PA. NO. 201911005125	Appendix 2 and 6

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

Particulars	***Recommendations***
Utility of the Project Findings:	The project produced data on the applicability of microbes on the places where microenvironment is disturbed due to wildfire confirmed by *In plantae* experiment. The results was shared with the local panchayats and with government officials. Our research reported that microbes are essential part in the forest ecosystem which were lost due to forest fire.
Replicability of Project:	After the application of PGP microbes (plant growth promoting) on the fire affected sites of our region. Similar systems can be replicated in other fire affected forest areas of hilly regions of other part of non-Himalayan regions and in the biosphere reserves where vegetation get severely affected upon fire incidents. The strategy will be very fruitful in the places where communities are heavily dependent upon forest ecosystem not only for the livelihood but also for getting health benefits from local medicinal plants.
Exit Strategy:	We have the repository of microbes at Shoolini University. The farmers can get the microbes from here in the form of liquid culture which can be utilized in the fields and in forest.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)
(Signed and Stamped)

Place: Solan ..
Date: …10../…02…/…2020…

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(Signed and Stamped)

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(Signed and Stamped)

Registrar
Shoolini University of Biotechnology
& Management Sciences
Solan (H.P.)

Place: ...Solan.....

Date: 10/.02./..2020