NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Reference No.:	**NMHS/2018-19/MG58/58**	**Date of Submission:**	2	3	0	4	2	0	2	1
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PROJECT TITLE

HARNESSING THE DESTRUCTIVE ENERGY IN PINE NEEDLES – DEMONSTRATION UNITS OF ELECTRICITY AND CHARCOAL GENERATION FROM PINE NEEDLES AND STUDY THEIR SOCIO-ECONOMIC ENVIRONMENTAL IMPACT ON COMMUNITY IN SELECTED VILLAGES AND ECONOMIC VIABILITY FOR SCALING IN THE HIMALAYAN ECOSYSTEM

Project Duration: *from* (**1.04.2019**) *to* (**1.04.2021)**

***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

DPC: Date of Project Completion

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Part A: Project Summary Report

1. Project Description

i.	Project Reference No.	NMHS/2018-19/MG58/58					
ii.	Type of Project	Small Grant		Medium Grant	x	Large Grant	
iii.	Project Title	**Harnessing the destructive energy in pine needles – demonstration units of electricity and charcoal generation from pine needles and study their socio-economic environmental impact on community in selected villages and economic viability for scaling in the Himalayan ecosystem.**					
iv.	State under which Project is Sanctioned	**Uttarakhand**					

v.	Project Sites (IHR States covered) (Maps to be attached)	Site no.1: Balta Khasra no. 543, Village Balta, Block Hawalbag, District Almora, Uttrakhand, Pin code: 263601 Site no. 2: Nigrar Khasra no. 1816, Village Nigrar, Block Ramgarh, District Nainital, Uttrakhand, Pin code: 263138					
vi.	Scale of Project Operation	Local		Regional	X	Pan-Himalayan	
vii.	Total Budget/ Outlay of the Project	0.99 (in Cr)					
viii.	Lead Agency	Avani					
	Principal Investigator (PI)	Rajnish Jain, Avani					
	Co-Principal Investigator (Co-PI)						
ix.	Project Implementing Partners	Implementation partner: Avani Technology partner: Avani Bio Energy					
	Key Persons / Point of Contacts with Contact Details, Ph. No, E-mail	Rajnish Jain, 94120 92982, Rajnish@avani-kumaon.org					

2. Project Outcomes

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

Background:

Recurrent forest fires are spread by pine needles, which fall during dry summer months in large tracts of pine forests in the ecologically fragile Himalayan region. These fires not only destroy biodiversity stressing the already fragile Himalayan eco-system, but also diminish the forest resources that are available for the local people.

This project employs people in the villages to collect these fallen pine needles before they burn and converts this destructive biomass in to clean and affordable energy for rural needs, thus reducing carbon emissions, regenerating biodiversity and above all creating jobs in the villages.

Electricity is generated through gasification of pine needles. The residual charcoal is briquetted. While these briquettes meet cooking energy needs in the villages, reliable supply of electricity will create facilities for an entrepreneurial ecosystem in rural areas, creating a positive impact at every stage of the value chain. The project aims to set up a self-sustaining renewable energy micro-business based on the diversion of pine needles from forest floors to support rural economy, generate conservation-based livelihoods, prevent forest fires, and reduce deforestation, fostering the regeneration of biodiversity and improving quality of life for rural communities in the target geography.

Objectives: Facilitating an entrepreneurial ecosystem to harness the destructive energy of pine needles for rural development in the central Indian Himalayas.

Methodology:

- Site identification
- Baseline survey
- Identification and Finalization of the sites
- Village feasibility tests

- Finalization of Village Implementation Partner
- Approval from Nodal Agency
- Ordering, Manufacturing, and Installation of the equipment and training
- Community mobilization for pine needle collection
- Technical and managerial training for the plant operators
- Stable plant operations

Approach:

Develop micro-entrepreneurs to set up these power plants at the selected sites, which could be a model for generating large scale employment while conserving biodiversity and meet cooking and electrical energy needs of rural population.

Results:

- **Electricity generation:** A total of 19,456 units generated at the power plants, out of which 19,380.5 units have been synced into the grid. The net revenue, from generation over a period of 9 months for the Balta site and over 6 months for the Nigrar site (excluding periods of downtime during technical R&D), is Rs 1,37,742.

- Plant operators trained in charcoal production. A total of 368 kg charcoal has been produced until March 2021. The buyers include local hotel owners and villagers.

- **Income generated:**

Through pine-needle collection: An amount of Rs. 2,39,259 earned by a total of 70 pine-needle collectors across Balta and Nigrar. The highest individual earning from Pirul collection was Rs. 19,321, by collecting as per their convenience.

Through salaries: An amount of Rs. 3,56,000 has been earned by a total of 6 operators and 2 plant managers cum operators.

Local labour and supporting ecosystem: Locals employed as labor in plant setup and installation have earned more than Rs. 3,80,000. Additional income was also earned by the locals in terms of boarding and lodging charges levied for the visiting

technical team and transportation service remunerations. The positive side of such revenue is that the money is returned to the local economy and has a great multiplier effect as it is spent repeatedly.

- 120 Ton of pirul cleared off of the forest floor, preventing forest fires in the forest ranges where the collection took place and aiding vegetation regeneration & biodiversity conservation.

- Multiple training workshops conducted for plant operators/managers. Locals without any formal qualification, trained on the job to develop technical expertise and managerial skills to operate power stations. The plant staff continue to undergo training and handholding on proper maintenance management.

- Facilitated multiple site visits and orientation sessions for locals interested in setting up these plants. They are planning to apply in the upcoming phase of applications.

- ***Recommendation***: The project has been crucial in studying how decentralized power production and distribution systems can help bring social and environmental benefits for the rural communities along with financial benefits for the entrepreneurs and other stakeholders.

In order for the project to scale, it is important to look for ways to raise patient capital as bridge funding for the rural entrepreneurs, providing them an alternative to the complicated and often demoralizing process of seeking bank loans. It is also crucial to take forward the dialogue with policymakers & bureaucrats to streamline the process of application and plant set up.

It can be useful for the esteemed G.B. Pant National Institute of Himalayan Environment to assign a dedicated researcher for the study to observe the socio-economic and ecological impact over a long-term period.

2.2. Objective-wise Major Achievements

S. No.	Objectives	Major achievements (in bullets points)
1.	• To set up a small scale, village based, and grid connected power plant (25 kW) at an appropriate site.	• Identification of the village implementation partners. • Site preparation and working shed construction for setting up of the plant. • Signing of the power purchase agreement. • Installation and commissioning of plant. • Conducting test runs and setting up operations procedures. • Local plant operators successfully managing the operations of the entire power plant.
2.	• To generate conservation-based livelihood opportunities by employing people in the villages to collect pine needles during summer season before they burn.	• Mobilization of the community into self-help groups consisting of pine-needle collectors: ‘Palayan Roko Samuh’ at Balta and ‘Maiti Mahila Mangal Dal’ at Nigrar. • Organized collection of more than 120 Ton of pine-needles. • An amount of Rs. 2,39,259 earned by a total of 70 pine-needle collectors across Balta and Nigrar. The highest individual earning from Pirul collection was Rs. 19,321.

3.	• Build local capacities for plant operations and maintenance by training local youth and employing them.	• Identification and training of 8 power plant operators and 2 plant managers. • A novel arrangement of plant ownership devised for the Balta Village. Equitable profit distribution arrangement devised between all stakeholders. • Regularly conducting entrepreneur orientation and capacity building workshops to cover business as well as technical training, with comprehensive focus on plant operation and maintenance procedures.
	• Oversee regular operations to utilize the destructive pine needle biomass for generation of clean electricity and cooking charcoal, providing affordable energy for rural community households saving fuel wood and deforestation.	• Community mobilizers handheld the local stakeholders in managing the revolving fund for pine needle collection and ensuring that the collectors are remunerated on time. • Increasing the participation of the local community members in the pine-needle collection through one-on-one interactions and group meetings. • Helping the plant owners in marketing and selling the briquetted charcoal to the people.

• Prevent forest fires in pine forests surrounding the plant, enabling biodiversity regeneration, increased soil moisture retention, and restoration of ecosystem services.	Emissions reduction from electricity generation 0.89 kg of CO_2 emissions reduction is attributed to each kWh generated through biomass gasification. So far, estimated 19456 units of electricity have been generated by both the plants; reducing 17,315.84 kg (17 tonnes) of CO_2 emissions. Forest area affected Average pine-needle yield per hectare= 7 tonnes. With a total pine-needle collection of 120 tonnes, forest area cleared of pine-needle biomass (120/7) =17.14 hectares Emissions saved by avoiding forest fires Estimated emissions for woody biomass=1.74 Kg CO_2 /kg. Assuming the same for pine needles, 120*1.74= 208.8 tonnes of CO_2 emissions saved, that would otherwise be released by pine needles alone during forest fires. Not accounting for all other trees and shrubs that have been saved by this intervention. Emissions reduction through bio-charcoal Trials show that 1.5 kg of pine-charcoal briquettes are sufficient to prepare 3 meals a day for a family of 4 people. This would substitute for average 10 kg fuel wood per family per day. So far, 368 kg of cooking charcoal has been produced, potentially saving (368/1.5) *10= 2,453 kg of forest wood annually, reducing 4269 kg of CO_2.

		It is important to note that the CO_2 *reduction will be higher as our calculation here does not factor in the carbon sequestered by the biodiversity conserved and the forests protected from the wildfire)*
	• To develop systems, identifying potential future sites and entrepreneurs in the area to develop a cluster of plants and understand how these systems can be scaled up for a larger impact	• Site visits and presentations to more than 100 prospective entrepreneurs • Fostering entrepreneurship through our role as pine-needle energy incubator, including helping the locals develop their business & operational acumen, navigating bureaucratic procedures and accessing MSME subsidy. • Linking 4 entrepreneurs to bank finance while 8 are in the offing, helping them leverage debt financing for their power plants. • Arranging bridge funding for entrepreneurs on a need-by-need basis through grants and public funding. • Performing impact assessment studies to effectively measure the socio-economic-environmental impact of the systems.

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations made, if any, & Reason thereof:
1	• Establishment of 2 power plants of 25 kW in each district to have a 56-kW gross capacity	• Number of power plant established (Nos.)/power produced (kWh	2 25 kW power plants successfully commissioned.	
	• Employment generation for 70 people, 10 permanent plant operators, and 60 people for collection.	• Employment generated (Nos.)	Employment generated for 80 people- 70 collectors and 10 permanent plant operators.	
3.	• Identify and train the 10 local entrepreneurs to independently run the decentralized supply chain system for storing the pine needles. • Improved biodiversity in 100 hectares of forest land • Generate employment and cooking charcoal for 70 families, and reduce 910 units	Person trained (Nos.)	10 local entrepreneurs trained to run the collection and storage of pine needles.	
		No. of region-specific best practices/ models/ technologies developed (Nos.)	• Plant ownership and operation model by a women only SHG at Balta • Equitable profit distribution arrangement between all stakeholders. • Developed an integrated automatic system for feeding the pine-needles into the system, thereby enhancing ease of plant	

	carbon reduction annually		operations.	
		Number of beneficiaries village/ SC/ST community/ local people (Nos.)	Total no. of local beneficiaries > 100 (collectors:70, local entrepreneurs: 10, local labour> 22)	
		Policy/ strategic framework/research article developed (Nos.)	• Baseline survey and follow-up studies on the socio-economic state of the selected sites.	

(*) 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/ Attachment
1.	New Methodology developed	1	Appendix 7
2.	New Models/ Process/ Strategy developed	1	
3.	New Species identified	-	
4.	New Database established	1	Appendix 12
5.	New Patent, if any		
	I. Filed (Indian/ International)	-	
	II. Granted (Indian/ International)	-	
	III. Technology Transfer(if any)	-	
6.	Others (if any)	-	

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	2	2 sites developed (Appendix 7)
2.	Diffusion of High-end Technology in the region		
3.	Induction of New Technology in the region	1	Successful trial and deployment of the automatic feeder system at 1 site (Appendix 6)
4.	Publication of Technological / Process Manuals	1	Training Manual for plant staff (Appendix 5)
	Others (if any)		

4. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Additionality and Utilisation New data
1	3 Follow-up studies on the Ecological baseline study	Authorised	• Affirm the changes in perceptions and expectations of the project's impact
2	3 Follow-up studies on the socio-economic baseline study	Authorised	

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**	**Man**	**Total**

1.	Workshops	**7**	**Local community members**	**30**		**60**	**17**	**77**
2.	On Field Trainings	**39**	**Power station operators**	**5**		**6**	**4**	**10**
3.	Skill Development	**11**		**5**		**6**	**4**	**10**
4.	Academic Supports	**2**	**Ecological Interns**			**2**	**0**	**2**
	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)	Address the cross-cutting issues of gender equity, climate change, affordable and clean energy, industry innovation and communication for change. (SDG Goal 5, 7,9,13,17) .	Consistent on-ground interactions by the community mobilizers to engage with community leaders, prospective entrepreneurs, youth, self-help groups, women's' groups and village level governance bodies.	Local women are employed for pine needles collection, thus giving them equitable employment for their work. All the benefits of carbon emission reduction, local livelihood and forest fire reduction are accessed by the local community.
2.	Climate Change/INDC targets	Pine needles gasification project fundamentally challenges the notion of anthropocentric climate change by using pine needles for clean energy generation and biodiversity conservation.	On an ongoing basis	Immediate community and the overall region

3.	International Commitments	Involving students and volunteers in technical and community sides of implementation.	4 students from the University of Waterloo and 2 students from Azim Premji University were engaged.	Academic research, Student community
4.	Bilateral engagements			
5.	National Policies			
6.	Others collaborations	Recognizing the technology's potential in helping check both the exponentially detrimental impact of pine on the fragile Himalayan ecosystem and the lack of appropriate livelihood opportunities in the region, the Uttarakhand government released a major policy in 2018.	Under this policy, we are currently incubating rural entrepreneurs to set up self-sustaining renewable and village-based energy enterprises.	Local community, state entrepreneur, Local community, SHG, Forests

7. Project Stakeholders/ Beneficiaries and Impacts

S. No.	Stakeholders	Support Activities	Impacts
1.	Gram Panchayats	Open meetings where the entire village was encouraged to be a part of the project and a participatory approach to	All the benefits of economic activity, reduced pressure on forests for fuel and biodiversity regeneration are brought to the source, which are the villages.

		activity implementation.	
2.	Govt Departments (Agriculture/ Forest)	Granted exclusive rights to the collectors' group to utilize the pine needles for power generation.	This innovation gives pine needles an economic value, giving villagers a reason to remove the pine needles from forest floor for economic activity instead of burning the same. The resulting interests of the community in safeguarding the forests directly compliments the forest department's conservation efforts. This is crucial as burning pine needles have biodiversity and eco-system services as collateral damages.
3.	Villagers	•Providing local livelihood opportunities •Meeting rural energy needs	• Local youth is a major beneficiary as they now have livelihood options in proximity. • Locals have a cleaner fuel option in the form of charcoals from the residue of the gasification process. • Hectares of biodiversity protected and regenerated around the setup area.
4.	SC Community	• Providing local livelihood opportunities • Meeting rural energy needs	The benefits are equitably distributed amongst all segments of the community. For the Balta plant, the SC community members constitute a major

			percentage of the beneficiaries.
5.	ST Community	NA	NA
6.	Women Group	• Engaging the women group members in pine needle collection • Providing accessible funding to the women groups for compensation for the pine needle collection • Providing managerial and financial training to the women SHGs	Women are the major providers of cooking energy as well as the main users of other services that forests provide to rural poor. Women are employed to collect pine needles and empowered to buy the charcoal and live a smoke free life. By restoring the natural ecosystem, women can make use of the forest services. They are now paid for their labour, collecting pine needles, where previously, they collected fuel wood for no pay.
	Others (if any)		
	Uttarakhand Power Corporation Limited UPCL	Power purchase agreement has been signed with UPCL. They are also looking after grid connectivity, interconnection point and metering arrangements.	UPCL has benefitted from collaboration, with small capsules of power injected by the distributed plants making the grid more robust and thus, more reliable.
	Uttarakhand Renewable Energy Development Agency UREDA	Assisting UREDA in facilitating and helping potential pine-energy entrepreneurs.	In our role as technology partners, we have so far worked with more than 100 locals who are interested in setting up.

8. Financial Summary (Cumulative)

S. No.	Financial Position/Budget Head	Funds Received	Expenditure/ Utilized	% of Total cost
I.	Salaries/Manpower cost	27,77,632	29,76,000	100
II.	Travel	4,05,912	4,34,000	100
III.	Expendables &Consumables	7,61,449	8,00,000	100
IV.	Contingencies	-	-	100
V.	Activities & Other Project cost	11,19,849	11,76,000	100
VI.	Institutional Charges	4,75,327	5,00,000	100
VII.	Equipments	41,00,000	41,00,000	100
	Total	96,40,169	99,86,000	100
	Interest earned	1,75,252		
	Grand Total	98,15,421		

* 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.	25 kW Pine needle power station for Balta (includes biomass gasifier with manual feeding, total gas cleaning system, 25 kW 100% producer gas based genset with three phase, brushless alternator, basic control panel with battery, suitable biomass wood dryer and pine needle cutter, synchronizer panel, meter and metering panel)	20,50,000	Both the power plants are under the ownership of the local implementation partner. (Annexure-III)

2.	25 kW Pine needle power station for Nigrar (includes biomass gasifier with manual feeding, total gas cleaning system, 25 kW 100% producer gas based genset with three phase, brushless alternator, basic control panel with battery, suitable biomass wood dryer and pine needle cutter, synchronizer panel, meter and metering panel)	20,50,000	

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

10. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States Covered	*1*	*Appendix 6*
2.	Project Site/ Field Stations Developed	*2*	
3.	New Methods/ Modeling Developed	*1*	*Appendix 7*
4.	No. of Trainings arranged	*39*	*Appendix 3*
5.	No of beneficiaries attended trainings	*12*	
6.	Scientific Manpower Developed (Phd/M.Sc./JRF/SRF/ RA):	*NA*	*NA*
7.	SC stakeholders benefited	*43*	
8.	ST stakeholders benefited	*-*	
9.	Women Empowered	*75*	*Appendix 8*
10.	No of Workshops Arranged along with level of participation	*7, 77*	*Appendix 3*
11.	On field Demonstration Models initiated	*2*	*Appendix 6*
12.	Livelihood Options promoted	*6*	
13.	Technical/ Training Manuals prepared	*1*	*Appendix 4*
14.	Processing Units established	*NA*	
15.	No of Species Collected	*NA*	
16.	New Species identified	*NA*	
17.	New Database generated (Types):	*4 (Socio-economic data)* *4 (Ecological data)*	• *1 Baseline data and 3 follow-up studies* • *1 Baseline data and 3 follow-up socio-economic studies (Appendix 2)*
	Others (if any)	*Informative document/brochures for entrepreneurs*	*Appendix 3*

11. Knowledge Products and Publications:

S. No.	Publication/ Knowledge Products	*Number*		*Total Impact Factor*	*Remarks/* Enclosures
		National	International		
1.	Journal Research Articles/ Special Issue:				
2.	Book Chapter(s)/ Books:				
3.	Technical Reports				
4.	Training Manual (Skill Development/ Capacity Building)	1		NA	Training Manual *(Appendix 4)*
5.	Papers presented in Conferences/Seminars				
6.	Policy Drafts/Papers				
7.	Others: Poster presentation by Gabrielle McMullan, School of Environment, Resources and Sustainability, University of Waterloo during her university's innovation showcase at Energy Day 2019. Gabrielle supported us in the study design in her capacity as an ecological intern with Avani.		1	NA	

* 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 results, as described in section 2,3,4 and 6, build the case for the transformative impact of these power plants on the following: • Developing an alternate model of entrepreneurship based on generating clean, renewable, and distributed energy from a locally abundant & destructive biomass. • Deploying a business model that balances both economy and ecology, while creating livelihood opportunities in an area otherwise considered opportunity dead ends. • Developing local talents in the village for both technical and management work. • Highly relevant impact on biodiversity restoration and CO_2 emission reduction. • Achieving direct impact in SDGs 5, 7,9,13,17. • Despite the ecosystem in place, the need for mentorship and support for these early stages, innovation based for-profit enterprises has never been higher. Providing an enabling environment to these micro-energy pine entrepreneurs is imperative for scale and thus impact.
Replicability of Project	With a payback period of about 3 years (solely from the income on selling electricity to the grid and sale of charcoal at Rs.15/kg), the entrepreneur can multiply his/her revenue by utilizing generated energy to fuel local enterprises. While micropreneurs make their revenue from sale of charcoal and electricity, we make our revenue by selling the technology & giving support to them with a completely homegrown team.

Exit Strategy	The process of handing over the plants to the local implementation partners is underway. Both Avani and Avani Bio Energy will remain available for support on managerial and technical issues during lifetime of the power stations.

(**PROJECT PROPONENT/ COORDINATOR**)

(Signed and Stamped)

(**HEAD OF THE INSTITUTION**)

(Signed and Stamped)

Place: ……..

Date: …../……/……

PART B: PROJECT DETAILED REPORT

The Detailed report should include an Executive Summary and it should have separate chapters on (i) Introduction (ii) Methodologies, Strategy and Approach (iii) Key Findings and Results (iv) Overall Achievements (v) Project's Impacts in IHR (vi) Exit Strategy and Sustainability (vii) References and (viii) Acknowledgement (It should have a mention of financial grant from the NMHS, MoEF&CC)

Further, description of Technical Activities, List of Trainings/ Workshops/ Seminars with details of trained resources, list of New Products developed under the project, Manual of Standard Operating Procedures (SOPs) developed, Technology developed/Transferred etc should be enclosed as Appendix.

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).

1.1 Background of the Project (max. 500 words)

Recurrent forest fires are spread by pine needles, which fall during dry summer months in large tracts of pine forests in the ecologically fragile Himalayan region. These fires not only destroy biodiversity but also stress the already fragile Himalayan eco-system. This project employs people in the villages to collect these fallen pine needles before they burn and converts this destructive biomass in to clean and affordable energy for rural needs, thus reducing carbon emissions, regenerating biodiversity and above all creating jobs in the villages. Electricity is generated through gasification of pine needles and the residual charcoal is briquetted. While these briquettes meet cooking energy needs in the villages, reliable supply of electricity will create facilities for an entrepreneurial ecosystem in rural areas, creating a positive impact at every stage of the value chain.

The technology can be replicated in geographies with pine forests across the globe. With scaling up in subsequent years, our vision is, apart from setting up a sustainable clean energy business, to establish a platform for policy makers, service providers and

stakeholders to encourage harvesting of pine needles for renewable energy generation, which will lead to accessible funding and permission for scaling up.

1.2 Overview of the Major Issues to be Addressed (max. 1000 words)

Sub-Central Indian Himalayan Region has a highly fragile ecosystem with the native tree species giving way to monoculture pine forests. The area is mostly rural having 50-100 households each having around 4.5 people on average.

Most of the people are literate, yet unemployed. Rural communities used to depend on forest resources and services for their daily existence find themselves alienated from their habitat due to over exploitation of natural resources, diminishing eco-services provided by the forests, a burgeoning population, disappearing traditional livelihood base with no new opportunities in sight, and lack of access to modern amenities. The problem is further compounded by the forest fires spread by carpet of pine needles shed over forest floor during dry summer months. These forest fires burn any new saplings of native trees, that are trying to regenerate, saves pine, a hardy, xerophytic species that resists fire and drought. A diminishing water recharge cycle due to the carpet of pine needles, massive soil erosion due to exposed soils after fires, and diminishing biodiversity is taking away the most precious resource from people, water.

In accordance with our organization's purpose and vision, our work seeks to reverse this vicious cycle, by providing a host of appropriate technologies for developing amenities and livelihood opportunities in the area. The idea originated as a response to the devastating impact of seasonal forest fires in the region. The evidence of pine needles' energy potential is apparent every year during forest fires. Various research papers on the invasive nature of pine, and technology research into small scale generation of biomass energy using gasification formed the initial basis for the project idea.

Extensive efforts have been made over the last decade by Avani to adapt gasification technology to the low-density pine needle biomass. This has led to the creation of an attractive entrepreneurial solution to harness the destructive energy of pine needles for sustainable rural development.

This project addresses the three broad themes of clean energy, biodiversity conservation and management, livelihoods options and employment generation. The cross-cutting themes are gender equity, climate change, and communications.

1.3 Baseline Data and Project Scope (max. 1000 words)

In order for the impact assessment study to be effective in its measure of desired socio-economic-environmental impact, a baseline survey was conducted to collect the data on those fronts. This baseline data has been useful in measuring the efficacy of this action research project and will further help in the scaling up of this system to other villages also. The project focused on setting up 2 25 kW grid connected generation capacity by setting up pine-needle based power plants in the villages.

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

Project Objectives	Target Deliverables
• To set up a small scale, village based, and grid connected power plant (25 kW) at an appropriate site. • To generate conservation-based livelihood opportunities by employing people in the villages to collect pine needles during summer season before they burn. • Build local capacities for plant operations and maintenance by training local youth and employing them. • Oversee regular operations to utilize the destructive pine needle biomass for generation of clean electricity and cooking charcoal, providing affordable energy for rural community households saving fuel wood and deforestation. • Prevent forest fires in pine forests surrounding the plant, enabling biodiversity regeneration, increased soil moisture retention, and restoration of ecosystem services. • To develop systems, identifying potential	• Establishment of 2 power plants of 25 kW in each district to have a 50-kW gross capacity. • Employment generation for 70 people, 10 permanent plant operators, and 60 people for collection. • Identify and train the 10 local entrepreneurs to independently run the decentralized supply chain system for storing the pine needles. • Improve biodiversity in 100 hectares of forest land. • Generate employment and cooking charcoal for 70 families, and reduce 910 units carbon reduction annually

future sites and entrepreneurs in the area to develop a cluster of plants and understand how these systems can be scaled up for impact.	

2 METHODOLOGIES, STARTEGY AND APPROACH

2.1 Methodologies used for the study (max. 1000 words)

We deployed an Agile project management methodology, deploying an iterative and people-centric approach to project management that focused on responding to change over following detailed planning.

The 2 standing pillars of our methodology makes it novel:

1. Investment made in building community systems

Teamwork- It takes a village. Community participation was crucial to ensuring that the project proceeds the way we envisioned. From day 1, building equity with the locals for increased ownership of these projects was of paramount importance. We have successfully developed a system that brings ownership stake to collectors and operators. Training programs conducted to educate the villagers. This will incentivize the villagers to be a part of the project and work for its growth.

For example; While discussing the construction of the working shed with the villagers, we had floated around the idea of everyone voluntarily contributing in the form of labor, or 'Shramdan'. This was to help reaffirm the community's self-sufficiency, helping them believe, "As long as we work together, we can fix anything." It is important for us to sustain this community involvement and keep them motivated about the project through the times when there is patience involved too.

Given the underlying currents of class and caste in the villages, it was also quite a balancing task to ensure no one was left out. For example; when the members of the pine-needle collectors' group and the operators were asked to choose between two candidates for the Balta power station's manager position, they forthrightly pointed the inherent predictability of the decision. They confessed that their vote would go for the candidate from their caste; regardless of their ability! That is the reason it took us longer than usual to select the plant staff at the Balta site. We sensitively navigated these dynamics as the project proceeded further.

As expected, a large part of our work involved working with fixed mindsets. During our field visit to Balta in April, we were confronted with a curious situation. For the first time ever, 2 women, completely on their own accord, had volunteered to become operators. We were quite excited at the possibility of something like this happening but at the same time unsure about how they would balance their work and domestic responsibilities.

What followed were a strong opposition from the land lessor and other men from the village-they were of the opinion that it was simply not possible for the women to do this. In the end, we convinced them to let the women be given a chance to opt for the training. This is a risk that we had the moral duty to take!

Grassroots, bottom-up social projects are just as essential as high-level policy development. Over and over what has been noticed during our interactions is: this project is capable of far-reaching impact, provided we do not underestimate the importance of changing mindsets in the rural communities. Our methodology emphasized on investing in these very interactions with the community.

2. Equitable profit distribution between all stakeholders

Developing an equitable model for plant ownership and profit-sharing arrangements amongst the stakeholders was crucial to our approach. This was especially more important in the case of Balta, given the novel plant operations arrangements in its case, with the SHG consisting of the female pine needle collectors also being the plant owners.

If this meant that we had to read out the agreements word-by-word, so be it. None of the discussions were to be rushed or to be dismissed off as irrelevant. Every query was addressed and the members, especially the women were categorically encouraged to ask more questions.

To develop a sense of ownership, each stakeholder was assigned a share in the profits (on top of their salaries).

At Balta:

- The manager-cum-operator of the plant will receive 20% of the total profits for his contribution.
- 10% of the profits will be given to each operator as per participation in the plant.

- 10% of the total profit will be shared with the collectors, where it will be directly added to their self-help group monthly savings money / overall fund. It will be the responsibility of the members of the SHG to ensure proper utilization of this amount.

At Nigrar:

- Bhupendra Singh Negi will receive 50% of the total profits for giving his land for setting up the plant and for his contribution as the manager-cum-operator of the plant.
- 10% of the total profit will be shared with the collectors, where it will be directly added to SHG's monthly savings corpus.
- 10% of the total profit will be given to each operator as per participation.

These arrangements are open to modifications by Avani, and key stakeholders based on performance review after 2 years of plant operations. These agreements can be found in Appendix 10.

3. Resilience in the face of new challenges

The entire second year of the project was executed under the shadow of the COVID-19 (Novel Coronavirus) spreading across India.

The travel restrictions placed in face of the COVID-19 coronavirus severely restricted the team's ability to travel for project work, chiefly including plant installation, grid integration etc. Despite later securing permission from the government to perform the required work-lack of accommodation and the overall sense of fear in the villages towards outsiders remained a major obstacle. Policies put in place to flatten the coronavirus curve also disrupted the availability of labor, materials, and equipment, and continues doing so even today.

Yet, irrespective of the pandemic, we were aware of the performance bar—and our team faced an uphill battle. Although we looked to governments for initial guidance, the burden of leadership at the work site fell squarely on the shoulders of our team. As we successfully achieve the intended outcomes of the project, we acknowledge our focus on three core priorities: protecting people, the project, and performance for passing this test.

Given that this is a novel project, the system was found ill prepared to provide swift on-ground support. Bureaucratic delays were faced, and it took repeated calling and consistent follow up to make progress.

The colder than usual weather this year and early rains also led to delayed shedding of the pine needles, affecting the overall pine needle collection. This was offset to a certain extent by putting in extra efforts in engaging the community in collection.

2.2 Preparatory Actions and Agencies Involved (max. 1000 words)

A three partners strategy was implemented. The three partners were Avani (NGO), Avani Bio Energy Private Limited and the village implementation partner. The village implementation partner in case of the Balta site was a Self Help Group of local pine needles collectors and in case of Nigrar, a local entrepreneur.

Avani set up the power stations, helped build the village level entrepreneurial ecosystem, identified local entrepreneurs, and trained them to manage the supply chain of pine needles and the sale of charcoal. All stakeholders were trained in business management, financial planning, and operations. Avani provided support in taking clearances from regulatory bodies, signing of PPA, conducting impact assessment studies and monitoring of operations. Avani also mobilized the community to generate awareness about environmental issues, use of charcoal instead of wood, etc. Avani Bio Energy is the technology partner. It provided equipment, technical training and installation support, maintenance support. The implementation partner recruited plant personnel.

Figure 1 Project organization chart

Details of Scientific data collected and Equipments Used (max 500 words)

2.3 Primary Data Collected (max 500 words)

Ecological Data

- Building a vegetation inventory for selected transects within the larger plot.
- Analyzing vegetation sampling data to determine species richness.
- Assessing ground cover to observe the trend of pine-needle/plant/biotic soil crust domination on the soil and nutrient resources on a site.
- Studying the characteristic differences between plots.
- Collection and testing of soil samples.
- Equipment used: Fundamental field tools such as Crosshair point frame, plant database, measuring tape etc.

Socio-Economic Data

- Socio-economic classification of the households of potential beneficiaries.
- Baseline and follow-up study on household demographics, assets and socio-economic classification and income & consumption.
- Measuring women's involvement in the project activities and the consequent effect on social capital.
- Analyzing the impact of the project on the socio-economic stability of the local community members.
- Equipment used: Interview methodology (The Reality Check Approach)

2.4 Details of Field Survey arranged (max 500 words)

The data mentioned in section 2.3 was collected over periodic assessments. The details of the same can be found in the respective reports.

The data for field visits for technical activities, trainings and workshops can be found in the respective appendices.

2.5 Activity wise Time frame followed [using Gantt/ PERT Chart (max. 1000 words)]

		Months																						
	Activities																							
1	Site Identification																							
2	Baseline survey																							
3	Identification and finalisation of village implementation partner																							
3.1	Survey of Village Feasibility Tests																							
3.2	Finalization of Village Implementation Partner																							
3.3	Approval from Nodal Agency																							
3.4	Agreement Signature																							
3.5	Group formation for collection																							
4	Order, Manufacture, Installation																							
4.1	Preparing land and order																							

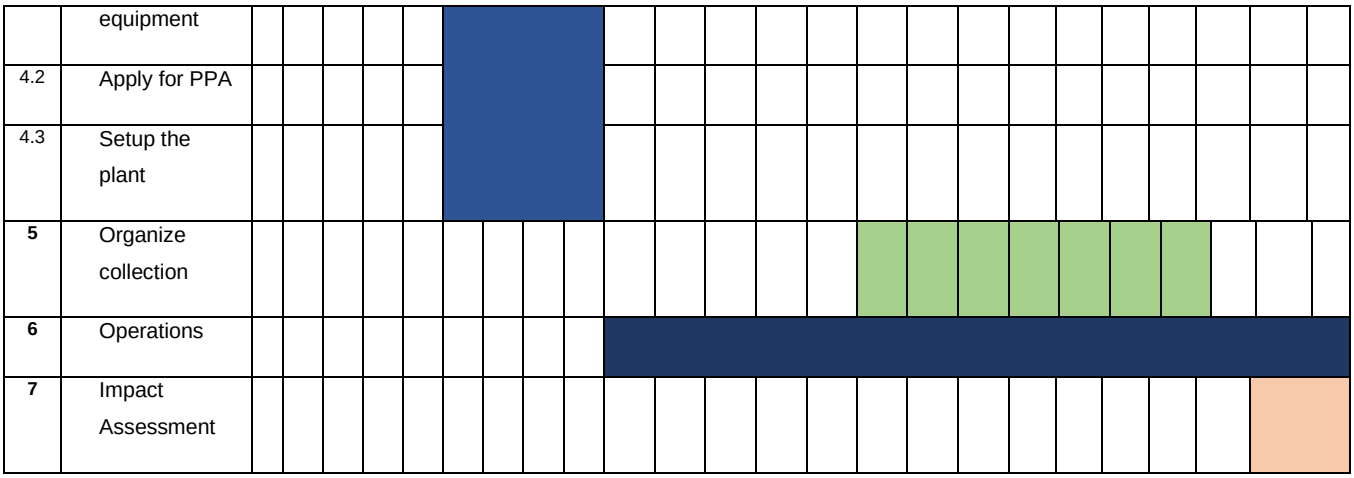


Figure 2 Gantt chart

3 KEY FINDINGS AND RESULTS

3.1 Major Research Findings (max. 1000 words)

NA

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

4.1 Socio-economic Impact assessment

An analysis of the socio-economic impact of Avani's project on the communities studied, at the baseline level. The same categories are used in the analysis as mentioned above in Section 4.0.

4.1.1 Assets and Socio-Economic Classification

The socio-economic classification system has been used to analyze households across India, both rural and urban populations.

This is consistent with this study, as we found most households in Balta and Nigrar village to be classed as D1, D2, or E1. As per the baseline, the distribution of both villages and the respondents' socio-economic class is expressed in Figure 2 below.

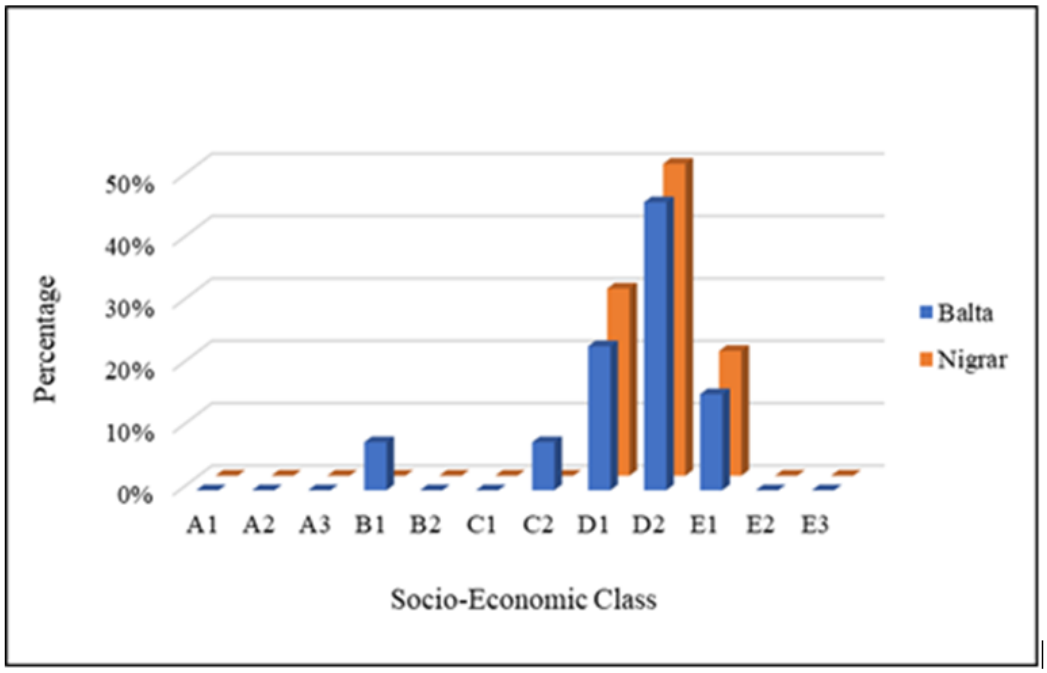


Figure 3 Distribution of households in Balta and Nigrar villages by socio-economic class. Distributions are expressed in percentages.

All household's primary earners were skilled workers or shop owners in occupations. This can be seen in Figure 3 below.

Skilled Workers	E2	E1	D	C	C	B2	B2
Petty traders	E2	D	D	C	C	B1	B2
Shop Owners	D	D	C	B2	B1	A2	A2
Businessmen with No employees	D	C	B2	B1	A2	A2	A1
Businessmen with 1-9 employees	C	B2	B2	B1	A2	A1	A1
Businessmen with 10+ employees	B1	B1	A2	A	A1	A1	A1
Self Employed professional	D	D	D	B	B	A	A
Clerical/Salesman	D	D	D	C	B2	B	B
Supervisory Level	D	D	C	C	B2	B1	A2
Officers/Executives-Junior	C	C	C	B2	B1	A2	A2
Officers/Executives-Mid/Senior	B1	B1	B1	B1	A2	A1	A1

Figure 4 Occupation in accordance with socio-economic class (Broadcast Audience Research Council India, 2015).

This pattern remained unchanged in the assessment period.

4.1.2 Income and Consumption

The baseline average daily income for households sampled in Balta was 350 INR. On earning employment as pine needle collectors, they went on to earn an additional income of Rs. 2000 to Rs. 8000. This is a significant increase to overall household income, increasing access to resources, food, education and raising standard of living.

At the beginning, there was a general disinterest in switching to charcoal. However, interest has now piqued with charcoal readily available and affordable, especially when compared to the amount of time spent collecting fuelwood. As regular charcoal productions have begun in the last quarter, the adaptation can be quantified in the coming months.

Members of Sund Nigrar cross the gasifier site daily on route to the closest main road to sell milk. They collect on their way back through the forest towards the site, optimizing their time to best be able to participate in the project. Undertaking work as a pine needle collector has been a smooth transition, and these individuals were able to earn additional income based on their availability and desire to contribute.

Similar to Balta, there was a general disinterest in Nigrar over switching to charcoal. However, there has also been an increase in interest and wide-spread adaptation is expected in the coming months.

4.1.3 Social Capital: Women's Involvement

The majority of households sampled in Balta and Nigrar had male primary earners. Of all 23 women interviewed, 83% had expressed an interest in working as a pine needle collector for the gasifier project. Over the project duration, employment was generated for upto 70 as pine needle collectors, earning a total income of ~ Rs. 2.4 Lakh.

Additionally, Avani guided the Balta community in forming a self-help group called "Palayan Roko Samuh" and 'Maiti Mangal Dal' in Nigrar, run by women who work as pine needle collectors. The self-help groups have opened their own bank accounts to manage the funds

and income of the project. Both the SHGs received a fund of Rs. 4,00,000 to pay for the pine needle collection.

4.1.4 Ecological Observations

The ecological observations shared during respondent interviews for the baseline survey gave insightful information on local forest health, resource access, traditional understanding of the ecosystem and the villager's ecological concerns. Their interest has been piqued by the pine-needle clearing aspect of the project, as the villagers also believe that clearing the needles will reduce fire damage, increase grass coverage in their forests and increase water percolation.

This is consistent with the ethos of Avani's projects, as it aims to sustainably manage and conserve resources, reduce carbon emissions, and provide green employment opportunities.

4.2 Ecological Impact assessment

4.2.1 Characteristic Differences in Studied Plots

As noticed before, there was a visible difference between the Sariya Pani and Kabhada Tok forests in species richness, species diversity, ground vegetation coverage and forest strata. However, the exhibited characteristics were consistent with literature regarding mixed Chir pine forests.

Compared to the initial survey, the species richness value decreased as while the number of samples increased, the number of unique species reduced marginally from the initial surveys. The relative abundances of different species also remained skewed in favor of certain species.

Given the reduced pine needle collection from the forest in this quarter and the dry season, the vegetative ground cover did not show major improvement in favor of more plant/biotic soil crust coverage over pine litter coverage.

4.2.2 Data Comparison

Data summary for the Balta plot

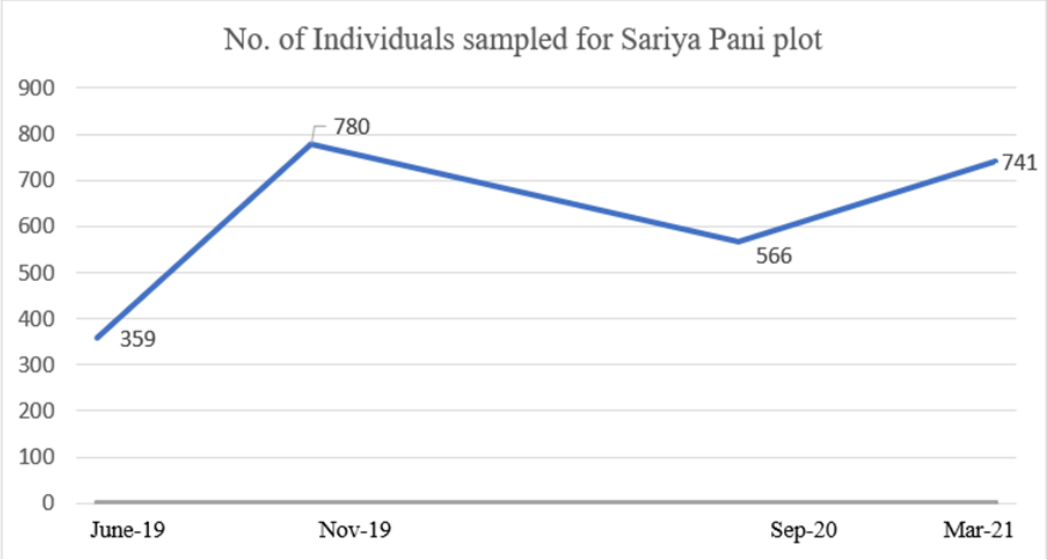


Figure 5 No. of Individuals sampled for Sariya Pani plot

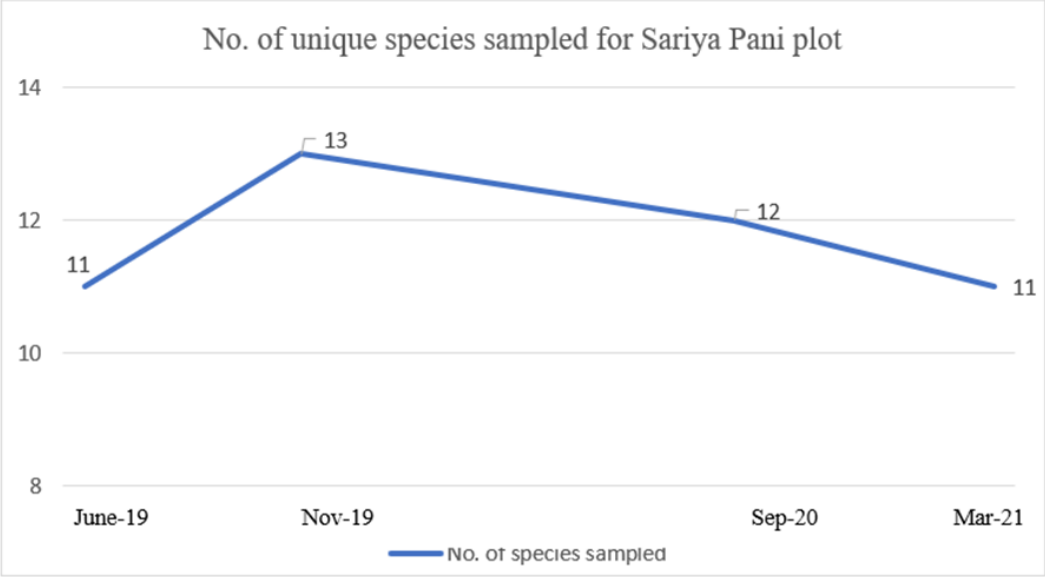


Figure 6 No. of species sampled for Sariya Pani plot

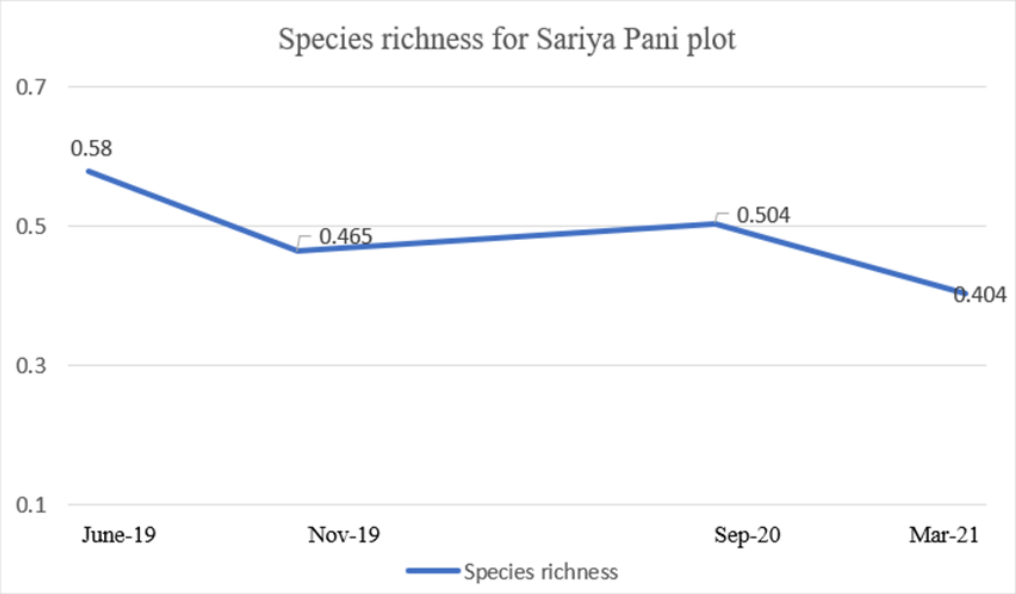


Figure 7 Species richness for Sariya Pani plot

Species richness in vegetation sampling is relevant as it expresses the richness of species in the same 400 m^2 area across different location. An area with 100 plant species (richness = 100) will be considered more diverse than an area with only 10 species (richness = 100). But an area with 100 species where each species is reasonably well-represented would also be considered more diverse than an area where 99% percent of the plants are a single species, and the other species are all very rare (M. Beals, L. Gross, and S. Harrell). The ability of the species richness factor to quantify diversity in terms of both species diversity and evenness is an important tool to understand community structure.

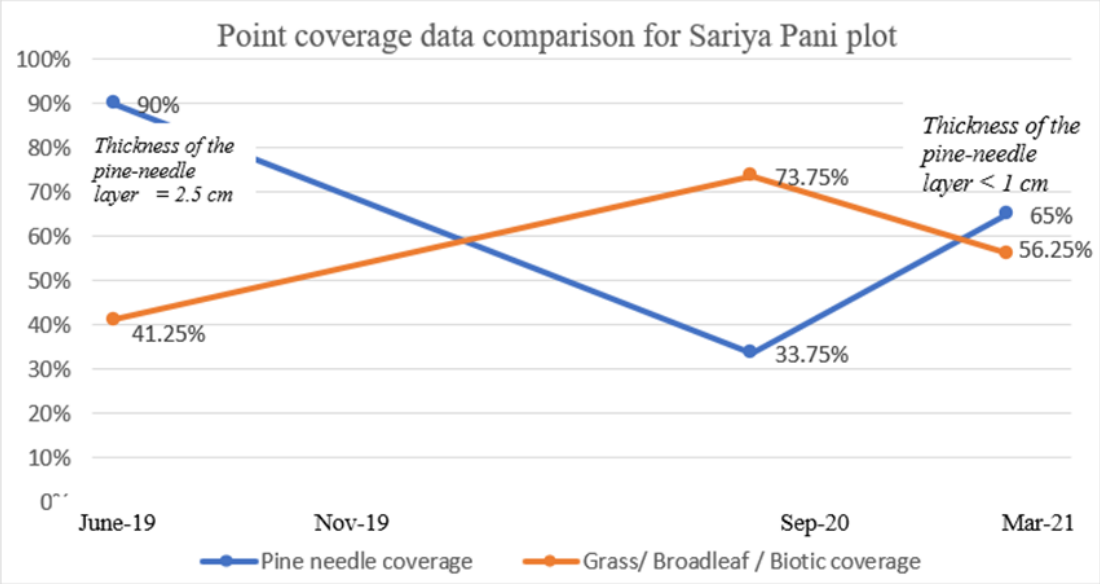


Figure 8 Point coverage for Sariya Pani plot

The plots witnessed regular pine-needle collection before the data collection for Sep-20, which might have contributed to the reduced pine-needle coverage and higher vegetation cover for the specific time-period.

	Pine tree	**Kaphal Tree**
Jun-19	34.75 cm	44 cm
Nov-19	34.8 cm	44.02 cm
Sep-20	34.84 cm	44.03 cm
Mar-21	34.85 cm	44.04 cm

Table 1 Tree diameter for the Sariya Pani plot

It is important to note that the plots are uncontrolled.

Data Summary for the Kabhada Tok plot

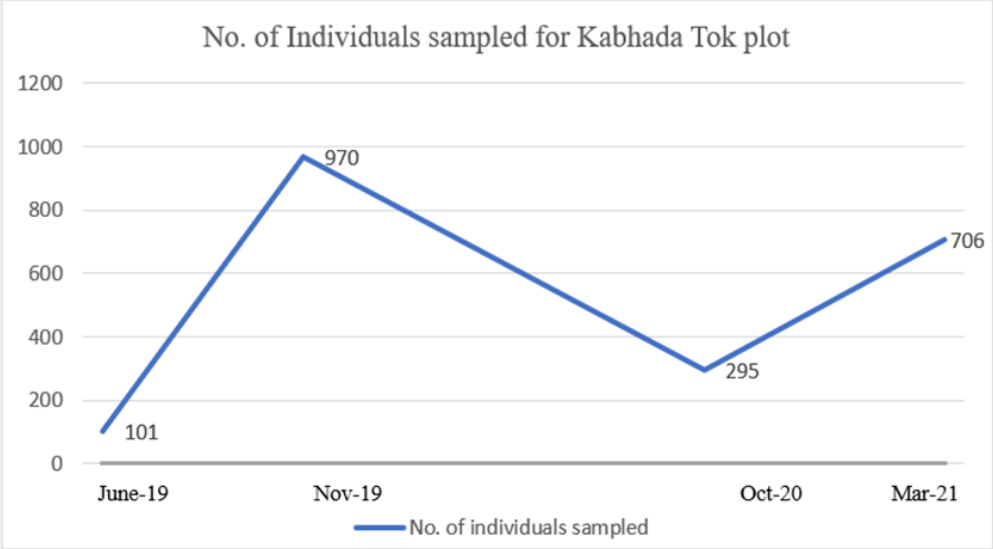


Figure 9 No. of individuals sampled for Kabhada Tok plot

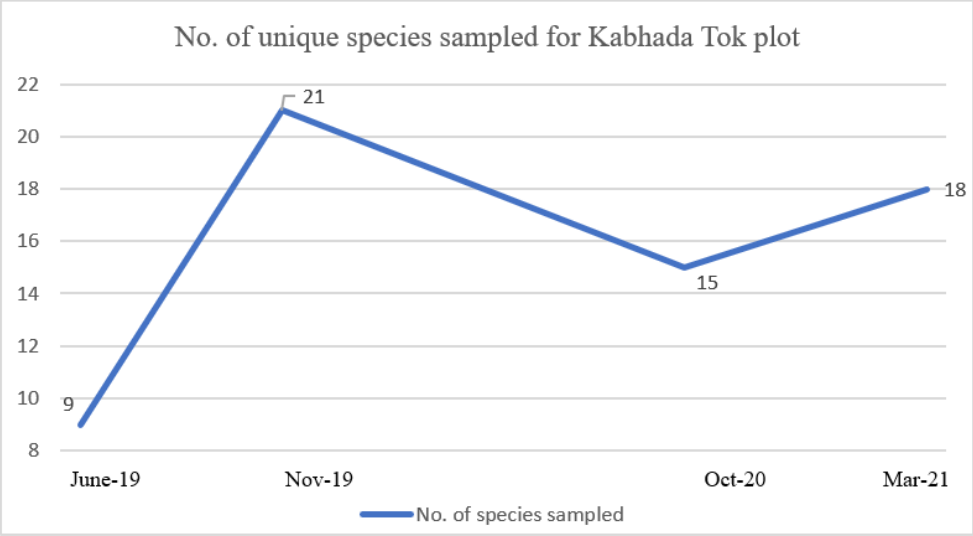


Figure 10 No. of species sampled for Kabhada Tok Plot

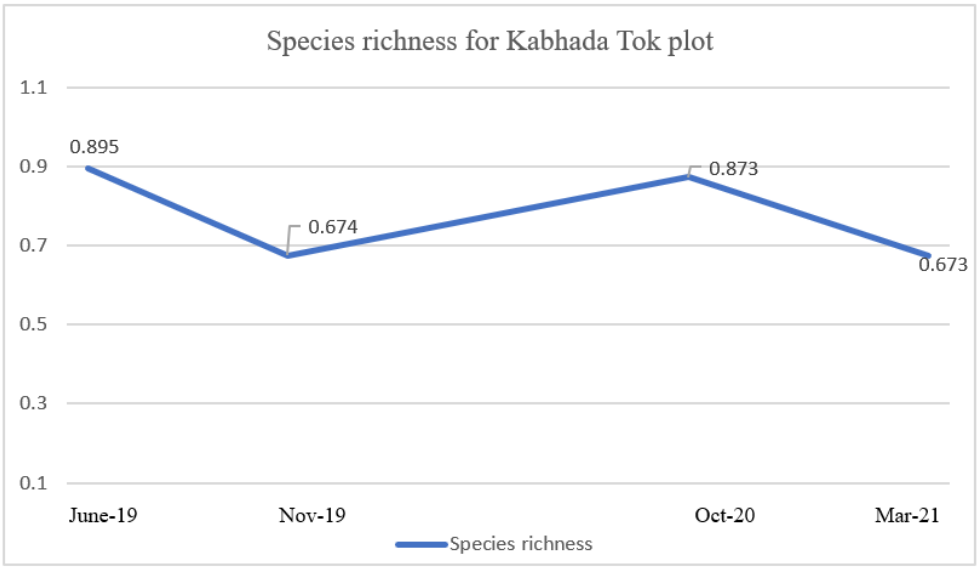


Figure 11 Species richness for Kabhada Tok Plot

As the increase in the no. of species was steeper than the increase in the no. of individuals sampled, the species richness factor did not increase that much.

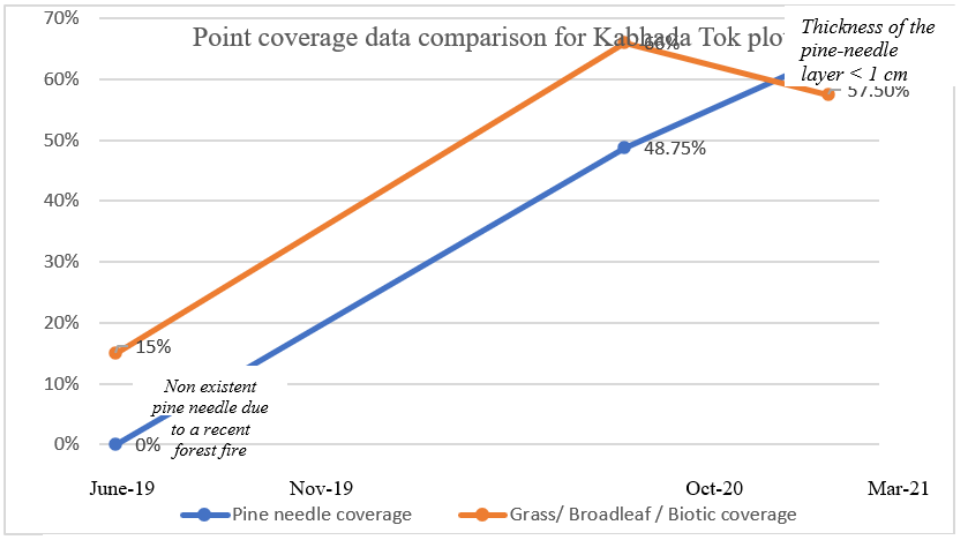


Figure 12 Point coverage data for Kabhada Tok plot

While the grass and pine-needle coverage remain consistent with the characteristics of the seasons, it is important to note the reduced thickness of the pine-needle layer for both the shortlisted plots.

	Pine tree	The other varieties, Kaphal, plum, Hiptage, mehal, kilmora, Ghingaru were in the sapling stage and hence, their diameters were not measured.
Jun-19	36 cm	
Nov-19	36.03 cm	
Sep-20	36.06 cm	
Mar-21	36.05 cm	

Table 2 Tree Diameter for the Kabhada Tok Plot

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

- Using the results and analysis acquired from the socio-economic study, the survey has largely proven the hypotheses stated on the socio-economic impacts of the gasifier plants on these villages. Avani made it a priority to directly correspond with the respective villagers to empower and enhance the socio-economic stability that will come alongside this project.
- With regards to the ecological survey, any changes to Uttarakhand's forests from pine needle litter removal will only become apparent through dedication to consistent monitoring over the next several years. Regular collection and critical evaluation of the data will be important going forward to establish evidence that will support a conclusion. Uttarakhand's rural communities will continue to clear pine needle litter from the forest floor to protect themselves, their livestock and their homes from fires by constructing fire lines that reduce the amount of burnable biomass.
- The potential for Avani to enhance communities through education on the dynamics of the ecosystems they live in and rely on, has potential. Regular ecological impact assessments can aid Avani in establishing studies and frameworks that not only contribute to our scientific understanding of these ecosystem dynamics but can empower villagers to effectively conserve and care for these ecological communities that are so integral to their health and survival.

- The results gathered from the studies will be a valuable resource to further enhance the socio-economic characteristics of numerous villages in the Central Himalayan Region.

5 OVERALL ACHIEVEMENTS

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

- Established 2 power plants of 25 kW in each district to have 50-kW gross capacity.
- Employment generation for 80 people, 10 permanent plant operators, and 70 people for collection.
- Identified and trained 10 local entrepreneurs to independently run the decentralized supply chain system for storing the pine needles.
- Improved biodiversity in 120 hectares of forest land.
- Reduced 228 tons of CO_2 emissions. It is important to note that the CO_2 reduction will be higher as our calculation does not factor in the carbon sequestered by the biodiversity conserved and the forests protected from the wildfire.

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

3 Follow-up studies to the ecological baseline data (including the vegetation inventory) and 1 Follow-up study to the socio-economic baseline data has been submitted. The same are available in the appendix 2.

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

5.3 Technological Intervention (max 1000 words)

The feeding rate of pine-needles into a gasifier system is a cumbersome activity. To make it easier, we developed a feeding system that picks the raw material from the ground.

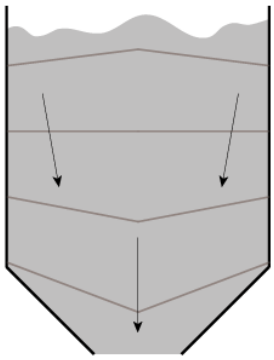
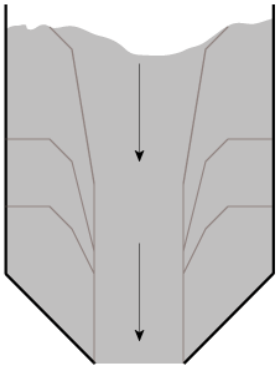
	**Mass flow**: Mass flow occurs when all areas of the hopper have a constant flow. Mass flow is generally preferred.
	**Funnel Flow**: In funnel flow, the center material moves fastest, and the outside walls do not move at all (stagnant).

Figure 13 Flow patterns of raw material

The details on the work done for this system's installation are as follows:

1. Conveyor design specifications

1. Dust containment system

- The hotspots on a conveyor line that are typically subject to excessive levels of dust accumulation from the pine needle are usually the bearings. This was addressed by fabricating custom built gaskets, several layers of which now securely cover the bearings.

2. Raw material conveying and handling system

- The construction of the screw conveyor needed to be in relation to the load it had to carry. This in turn influenced our size of bearings, angle of incline, conveyor speed and other items like timing the sensor.

3. Motor and gearbox specifications

- The conveyor transporting pirul was to experience additional friction forces between the belt and the load. All of this had to be considered for calculating the conveyor system's motor and gearbox specifications.

4. Loading the raw material

- An additional hopper was installed at the loading end of the conveyor system for the raw material.

5. A sensor to monitor raw material in the system

- An ultrasonic distance sensor has been installed at the unloading end of the conveyor system. The sensor sounds an alarm to intimate the operator and ensures that there is always enough pirul in the system.

6. Integration of the feeder system with the existing gasifier setup

- The reactor's top had to be modified to accommodate the screw feeder system in place of the earlier hopper design. The opening of the reactor was made conical, and a new cap system was designed.
- The vibrator's position was adjusted to adequately disturb the redesigned reactor bed.
- Replacement of the reactor's grate and other auxiliary instruments such as gearbox, shaft, pin, bearing etc.
- The grate shaft's seal, for ash removal, was changed.

7. Improving the air nozzle system design

- The height of the inlet air nozzle and the placement of its opening in the gasifier reactor vessel has been optimized to improve the overall performance of the air distribution system.

8. Addition of a second cyclone

- The presence of dust in the gas gave us the idea to install a smaller second cyclone, next to the already existing cyclone. This setup has been effective in further reducing the presence of finer particulates in the syn gas.
- The ducting was replaced to accommodate the new cyclone.

9. Adding a water-gas segregator at the scrubber stage

- By installing a water-gas segregator, the water no longer reaches the fan plates and is now directed instead to the tar box. This has substantially reduced the regular maintenance requirements.

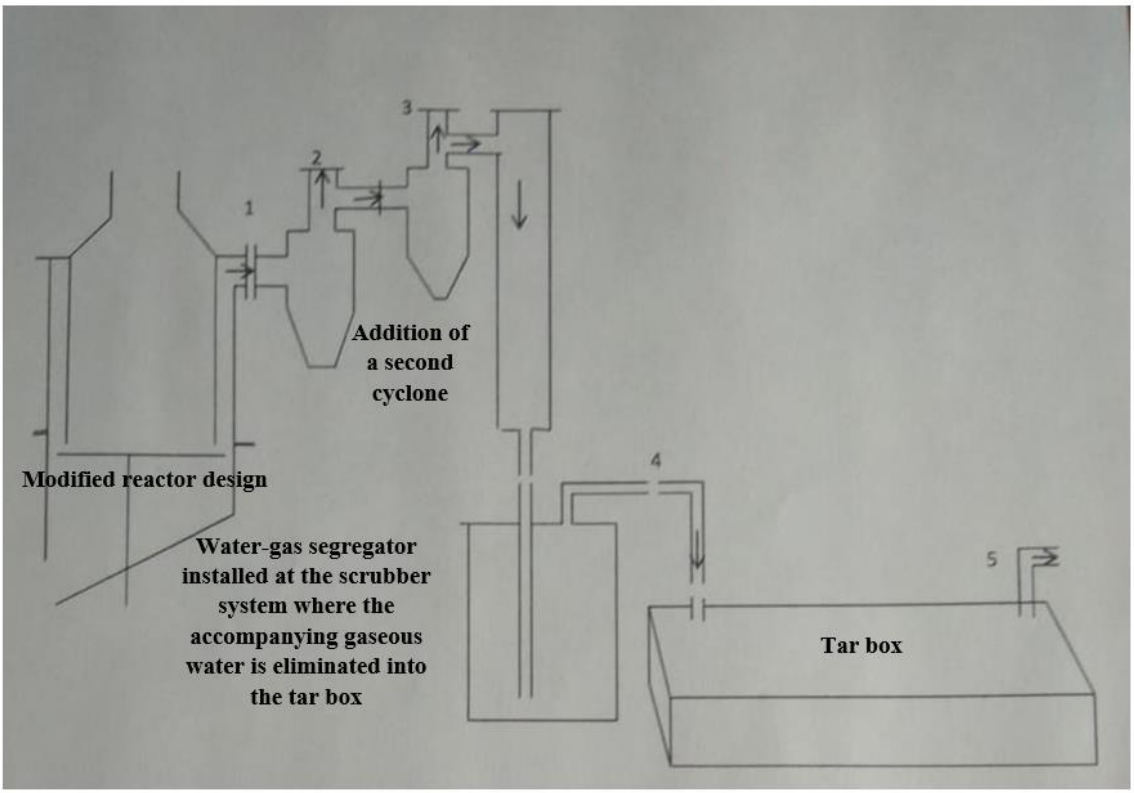


Figure 14 Sketch of the updated system

Results

A trial of this system was carried out at the Balta plant.

The trials have been successful. It has increased the ease of operations, enabling 1-2 people to conveniently manage in a shift. In case of availability of cut pine needles, even 1 person can manage the entire process on their own!

The timelines are as follows:

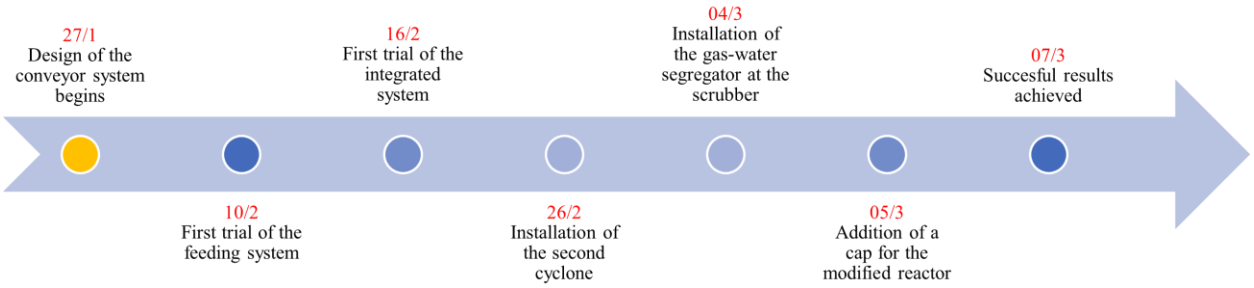


Figure 15 Timeline of the successful trial of the new feeder system

Line of action

The successful trial makes this a milestone in our efforts to scale the pine-needle based power plants across Uttarakhand. This will dramatically reduce the machine downtime and increase the entrepreneur's revenue. We have also filed a patent for our technology to generate electricity from pine needles. The patent approval is pending.

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

- Successful operations of 2 25 kW plants at the shortlisted sites.
- Regular charcoal production at both the power plant locations.

5.5 Promoting Entrepreneurship in IHR

For more than the last 2 years, Avani has been identifying and supporting aspiring pine-energy entrepreneurs across the region and providing them with the advice, resources, and access they need to successfully set up pine-needle based energy enterprises.

Through our dedicated incubation center for the pine-energy entrepreneurs, we not only provide the essential mentorship but also facilitate a favorable ecosystem for them. We have linked 4 entrepreneurs to bank finance while 8 are in the offing, helping them leverage debt financing for their power plants.

The beneficiaries include the power station owners, commercial users, machine operators and the pine-needle collectors. The details of the potential entrepreneurs that were guided during the NMHS project duration is included in the appendix 3.

Here is a map of the 25 kW power plants set up by us since 2006:

Figure 16 25 kW Plants set up by us since 2006

5.6 Developing Green Skills in IHR

Given that the power stations generate clean and renewable energy from an otherwise destructive biomass, every single job created around this enterprise contribute to preserve or restore the fragile Himalayan environment. Be in power plant operations, pine-needle collection and supporting jobs generated such as the supplier of our machinery, technical trainers- all of them are crucial in responding to the challenges of forest fires and local employment.

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

This project seeks to ensure access to affordable and sustainable energy for the under-represented communities. Harnessing the destructive energy of pine needles in a decentralised manner is a one stop solution to a range of interconnected problems.

- The project explicitly relies on mobilizing local communities (*social drive*) for the removal of pine needles from large tracts of forest floors before they burn, and use these for producing clean, affordable energy for rural households and industry.
- This removes the primary cause of forest fires, enabling native flora to regenerate, gradually leading to better water recharge cycles, also increasing availability of herbs, fruits, and other essential ecosystem services *(environmental sustainability).*
- Collection of raw material generates significant seasonal employment for rural communities, making the energy from this resource more equitable and affordable. Availability of cooking charcoal has convenience, reduction in drudgery, cleaner indoor air and better health for more people, especially women and children. Simultaneously, large scale adaptation of charcoal creates significant reduction *(energy access and reliability*) in deforestation for fuel wood, enabling this project to set new benchmarks in the environmental sustainability of energy use.
- The direct beneficiaries are typically the most *economically vulnerable* members of remote rural settlements in the central Himalayan region. Our work seeks to create large number of conservation based livelihoods based on appropriate technology, for these remote communities with access to pine forests, and helping to reduce *migration* of youth to urban industrial areas.
- Our approach is to develop small scale power plants driven by rural *micro-entrepreneurs*. This project impacts people who benefit from access to renewable electricity and cooking charcoal energy from the 2 pilot plants currently operational. Over 100 people have benefited with direct income from pine needle collection and from skill development as plant operators.

6 PROJECT'S IMPACTS IN IHR

6.1 Socio-Economic Development (max. 500 words, in bullet points)

- The increase in household incomes from participating in the pine-needle collection varied from Rs. 2,000 to Rs. 19,000. The highest individual earning from Pirul collection was Rs. 19,321- with the woman collecting as per her convenience.
- The total increase in household incomes from participating in gasifier operations as plant staff varied from Rs. 40,000 to Rs. 48,000 per member. The total salaries earned by the local staff is Rs. 3,56,000. For majority of the plant staff, they are the only breadwinner of their family.
- While the profession of the male head of the family remained unchanged, a greater percentage of their earnings are now earmarked as savings as the women contribute to the immediate household spends with their earnings from pine needle collection/salaries.
- The financial empowerment of women is in motion to create a ripple effect that yields multiple benefits, not only for individual women, but also for families, communities, and countries. Increasing women's control over household income is improving their children's access to school and healthcare; along with the long-run effects such as women gaining greater control over their reproductive health and improvement in their status within families and communities.
- Since the charcoal production only began this quarter, we do not have data to quantify the transition of the respondents from firewood to charcoal as their primary fuel resource.
- When asked how they spent additional income earned from working as a pine needle collector/operator:
- 70% spent it on their children's education,
- 31% spent it on household expenses,
- 9% spent it on health/wellbeing of their family and livestock
- Locals without any formal qualification, trained on the job to develop technical expertise and managerial skills to operate power stations. This becomes an even greater feat given that

the all-women team of operators has taken up a historically male-dominated role in a highly conservative setup.

- Through this training, they have gained the confidence to not only successfully operate the plant but also to field all kinds of queries from locals/media/authorities interested in learning more about the project. They are also on their way to hold their own in front of members from the forest department, electricity department, etc.

- Locals employed as labor in plant setup and installation were provided work closer home, with more than 3-month of work at an average of 4 labor + 2 masons for tasks such as land leveling and preparation, welding for working shed setup, mason for floor construction, etc. The compensation was based on the daily wage rate of Rs. 500/labor and Rs.700/mason. The welders mostly took the job on contract. For example, for the Balta site, a total of more than Rs. 2,50,000 has been earned so far by the locals for the site-related tasks.

- Additional income was also earned by the locals in terms of boarding and lodging charges levied for the visiting technical team and transportation service remunerations. The positive side of such revenue is that the money is returned to the local economy and has a great multiplier effect as it is spent over and over again.
More details can be found in the final socio-economic survey that is a part of the appendix.

6.2 Scientific Management of Natural Resources In IHR (max. 500 words)

Our solution enhances both economy and the ecology. The project works with locals to collect pine needles, while also helping protect natural resources by using negligible energy and reduced water in plant operations. The collectors practise caution and only rake pine needles off the forest floor, without damaging the other grass/plants.
A functional rainwater harvesting system has also been installed at every site, with multiple tanks for the collection and storage of rain.

6.3 Conservation of Biodiversity in IHR (max. 500 words, in bullet points)

- Forest fires destroy native species while pine trunk is fire resistant, causing a gradual conversion of mixed species forests to pine monoculture.

- Greater the density of pine trees, higher the incidence of forest fires; leading to an even higher density of pine trees.
- Loss of biodiversity has weaned people away from traditional livelihood practices such as cattle rearing, fibre production and processing for making wool textiles, housing with local material, and rendered farming less remunerative due to lack of irrigation and manure from cattle.
- Economic value given by our technology incentivized people at these sites to collect the fallen pine needles instead of burning them for removal, thus eliminating root cause of the forest fires and breaking this vicious cycle. The forest ranges around the finalized sites have seen negligible instances of fires.

6.4 Protection of Environment (max. 500 words, in bullet points)

- Lack of vegetation resulting from the forest fires and reduced percolation in pine litter leads to diminished ground water recharge, causing floods during rains and prolonged water shortage during summers.
- Many endangered animal species struggle to survive and often get decimated by forest fires.
- Smoke from the multiple forest fires negatively affect the health of people, especially the elderly and the children, in the affected areas.
- The main activity of pine needle collection at the sites cleared them off the forest floor before they caught fire, allowing for preservation of the natural assets.

6.5 Developing Mountain Infrastructures (max. 500 words, in bullet points)

- With reliable electricity available from the pine-needle based power stations, there will be greater opportunities for rural micro-enterprises to build upon existing ventures and embark upon new enterprises that were hitherto unviable because of the dearth of stable electricity.

- This technology offers the hill villages of Uttarakhand a clean energy source for revenue generation, job creation and overall development, while allowing the preservation of its rich ecological heritage.
- Entrepreneurs from villages across Uttarakhand are undergoing training to manage plant operations and learn the required business skills, especially crucial given that this is also being executed at the heart of a place which is otherwise considered as an opportunity dead end.

6.6 Strengthening Networking in IHR (max. 700 words, in bullet points)

- Potential entrepreneurs are being introduced to the current plant owners, creating a network where provide they can exchange reliable information pertaining to technical concerns, business models, best practices etc.
- The network also provides contacts and introductions to businesses, funders and other important officials in the broader technology/government ecosystem.
- We have also made it possible to share relevant beyond the physical space by making it accessible virtually. Virtual access is both mobile or online, including the use of WhatsApp as a medium of sharing resources, expertise, or training material.

7 EXIT STRATEGY AND SUSTAINABILITY

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

We are incubating several entrepreneurs who are interested in setting up these plants in their villages. The technical and managerial learnings from the NMHS-funded power stations at Balta and Nigrar are being keenly followed by the pine-needle energy entrepreneurs across the state. The entrepreneurs of Balta and Nigrar have also developed a certain functional expertise which is being sought after by other aspiring entrepreneurs. The learnings of the Balta and Nigrar Plant team are highly valued and are being leveraged by the budding entrepreneurs to guide their business strategies and thought process. The

technical R&D being performed at these sites is also eagerly looked forward to and being replicated at other sites.

The project findings will go a long way towards solving many of the socio-economic problems that the IHR has traditionally grappled with such as out-migration, under-employment, and human-wildlife conflict, apart from meeting urgent commitments towards climate change mitigation.

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

It is important to work with communities, policymakers, and other stakeholders to establish several clusters of these small-scale bio energy plants. Local entrepreneurs will have to be identified and trained to independently manage the operations and selling the briquetted charcoal & generated power.

A small 25 kW unit can easily be run by a single family in the villages. It is also the most optimum scale of operation for collecting sufficient pine needles given the difficult nature of the Himalayan terrain. We will be able to replicate similar units in the villages and develop an entrepreneurial ecosystem, fostering employment and biodiversity in the villages.

With the operations starting within one year of securing funds, revenues will start rolling in for the entrepreneur and the power station will be financially sustainable by supporting the operational expenses through income from sale of electricity and charcoal. Avani will remain available for support on managerial and technical issues during lifetime of the project.

7.3 Identify other important areas not covered under this study needs further attention (max 1000 words)

NA

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

In order for the project to scale, it is important to look for ways to raise patient capital as bridge funding for the rural entrepreneurs, providing them an alternative to the complicated and often demoralizing process of seeking bank loans. It is also crucial to take forward the

dialogue with policymakers & bureaucrats to streamline the process of application and plant set up.

It is important that a synergy be established between the government departments so that the MSME subsidy and bill payments are released on time.

It can be useful for theesteemed G.B. Pant National Institute of Himalayan Environment to assign a dedicated researcher for the study to observe the socio-economic and ecological impact over a long-term period.

A certain amount of funding for the machinery, initial set-up and capacity building for the local team can also prove useful.

8 REFERENCES/BIBLIOGRAPHY

9 ACKNOWLEDGEMENT

The financial support from the National Mission on Himalayan Studies, under the aegis of the Ministry of Environment, Forest, and Climate Change has been pivotal in helping us execute this project successfully. The combined experience and wisdom of a seasoned grantmaker such as NMHS is a powerful resource for grassroots initiatives to maintain the ecosystem health of the Himalayan region and it was extremely useful for us to be able to use this funding support to scale pine-needle-fuelled power stations across Uttarakhand. We thank NMHS, MoEF&CC for the funding support and we very much welcome a future opportunity to join forces again.

We wish to express our sincere gratitude to the local community at Balta and Nigrar for their unwavering support to the project.

APPENDICES

Appendix 1 – Details of Technical Activities

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

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

Appendix 4 – Copies of the Manual of Standard Operating Procedures (SOPs) developed

Appendix 5 – Details of Technology Developed/ Patents filled

Appendix 6 – Demonstration sites

Appendix 7- Project Methodology

Appendix 8- Details of the collectors' self-help group (SHG) and the women beneficiaries

Appendix 9- Ecological Plant Identification database

Appendix 10- Agreements signed with the village implementation partners

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Exit Strategy	The process of handing over the plants to the local implementation partners is underway. Both Avani and Avani Bio Energy will remain available for support on managerial and technical issues during lifetime of the power stations.

AVANI
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(PROJECT PROPONENT/ COORDINATOR)

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Place: ...Tripuradevi

Date: 23/04/2021