A Case Study of Electricity Generation from Pine Needles in Rural Uttarakhand, India

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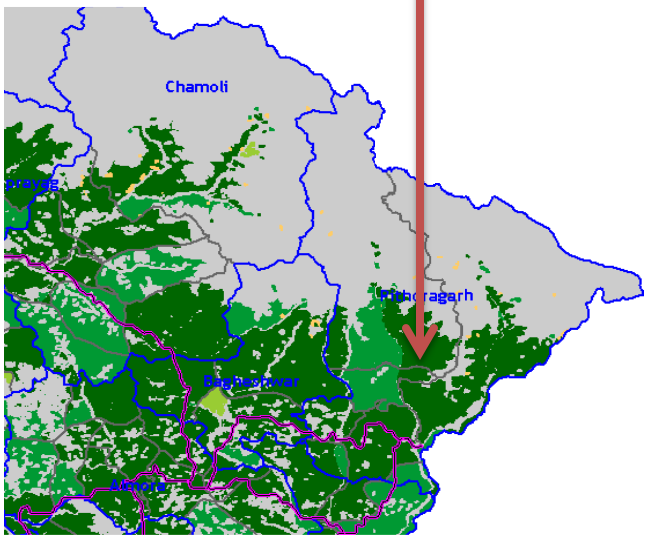
Wood-based Energy Goes Global
7 October, 2015

2015 DUBROVNIK ADRIATIC WOOD DAYS

Study Area: Pithoragarh, Uttarakhand, India



Villages: Munsiari,Dharchula,Gangolihaat,Didihat

Socio-economic details of the study area

- The population of Pithoragarh is diverse and includes two tribes: *Van Rawats* and *Bhotiyas*, the former being hunter gatherers and the latter practicing transhumance.
- A substantial number of males from the area work outside the district. Indian armed forces employs large number of males from the area. A good number of people are engaged in tourism related enterprises.
- 62% of the households reported being Below the Poverty Line (BPL), a higher incidence of poverty among scheduled caste households and, surprisingly, male headed households.
- 85% of the households were male headed and the remaining 15% of the households were female headed.
- Median per capita annual income of Uttarakhand is ~ 55,000 rupees (US$ 860)

Socio-economic details of the study area

$1US= 60 Rupees

n=155

Education	
High School or less	42
Intermediate	67
Graduate	40
Post Graduate	6

Primary Source of Household Income	
Agriculture	20
Business (other than livestock)	16
Livestock	26
Employment	40
Labor	12
Remittance	41

Household Size	
Members in Household	Frequency
3	22
4	16
5	23
6	18
7	27
8	21
9	17
10	3
11	8

Annual Household Income (Rupees)	
25,000-39,999	46
40,000-54,999	60
55,000-69999	28
70,000-84,999	15
85,000-100,000	6

Annual Household Income(Sample)	
Mean	50133
Median	48300

Fodder Consumption by Livestock (kg/month)	
425-499	24
500-574	32
575-649	45
650-724	52
725-799	2

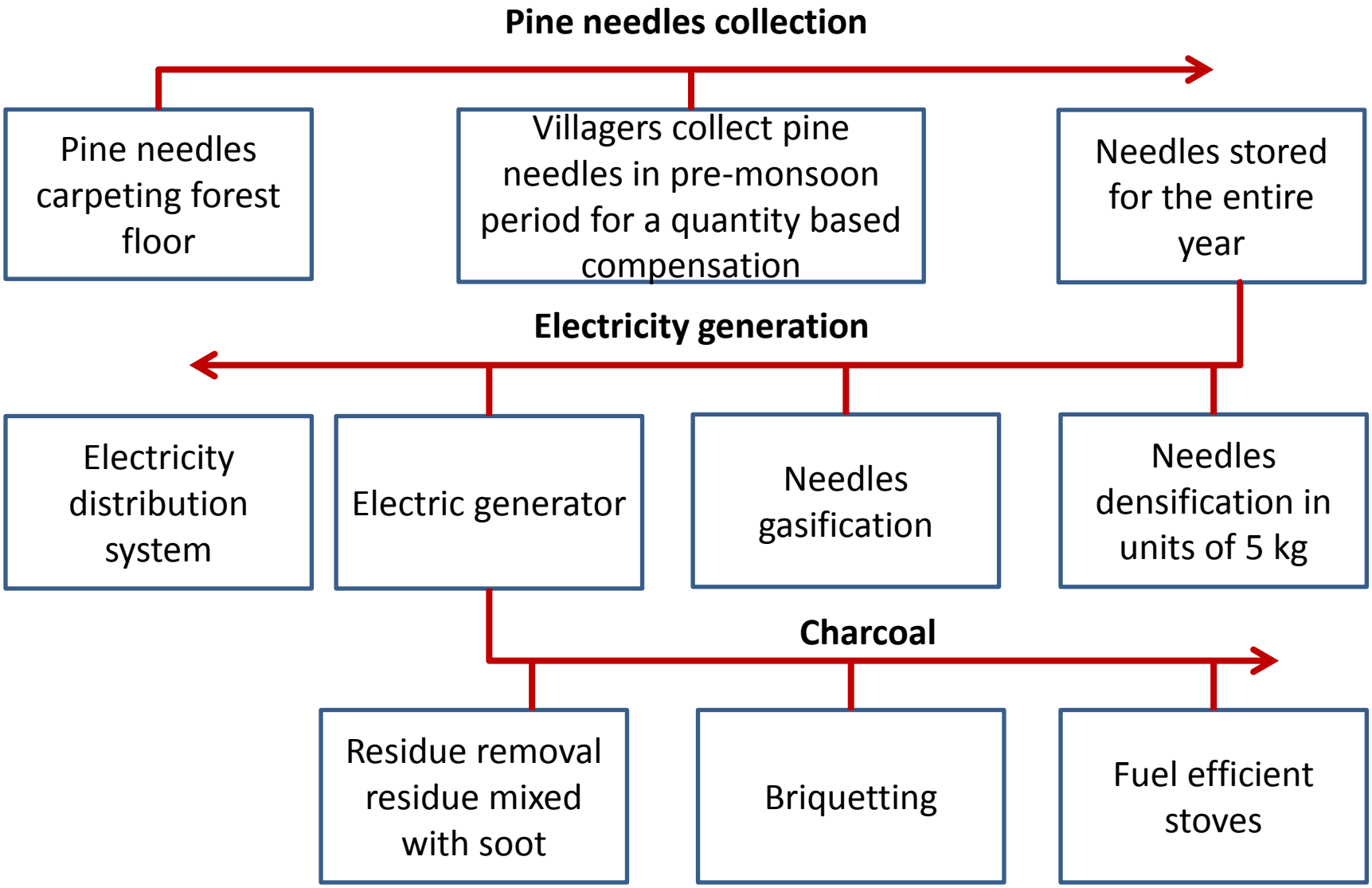
Overview

- Avani, a non-profit organization, has been successfully running a 9kW pine needles based electricity generation facility for the last four years in Gangolihaat village in the study area.
- Pine forests cover large parts of the central Himalayan region in North-India, hence there is potential for scaling up electricity generation from pine needles.
- Prima-facie, pine needles collection activity could be an income enhancing opportunity for the villagers, however, factors determining their willingness to participate in pine needle collection program are unclear.
- Financial sensitivity analysis of the pine needles based gasifier project shows that viability of the project is highly sensitivity to pine needles collection cost and availability, therefore ascertaining the willingness of the villagers to participate in the program is critical.

Pine needle collection

- A 120 kW pine needle based gasifier power unit requires 5,400 Kg (including storage and moisture loss) of pine needle per day or 1620 Tons per year.
- 700 hectares of pine forest can support a 120kW gasifier unit.
- The gasifier unit has to secure rights from Van Panchayat (Village Forest Administrative Body) to collect pine needles.
- Pine needles have to be collected from February till June (before Monsoon) and stored to be used as feedstock for the entire year.
- Individuals from the nearby villages can collect and manually bring the needle stacks as headloads.
- Village population in the region has traditionally been extracting and carrying fuel-wood and cattle fodder as headloads over longer distances from the adjacent forests.

Electricity generation from pine needles

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Research objectives & methodology

Objective:

Ascertain determinants of willingness of villagers to collect and supply pine needles to a electricity generating entity (gasifier)

Methodology:

Sample: random sampling from the list provided by Van Panchayat (village administration unit).

Village	Number of Households
Munsiari	35
Dharchula	37
Gangolihaat	51
Didihat	32
Total	**155**

Survey : door-to-door interview with the questionnaire in Hindi

Two-part Study

1) Willingness to Collect Pine Needles vs. Economic, Environmental, and Social Perceptions; Statistical analysis: Principal Component Analysis

2) Willingness to Collect Pine Needles vs. Socio-Economic Indicators; Statistical analysis: Multinomial–logit model

Study Part I

Willingness to collect pine needles: Economic, Environmental, and Social Perceptions

Willingness to collect pine needles: Economic Perceptions

"In this section, we are going to ask you about your perception related with the economic potential of pine needles collection and supply to the electricity generation company."

Economic Impact	Loadings
Pine needles collection is a good income enhancing opportunity for my family.	0.52
My village will economically benefit from having a electricity generating company nearby.	0.87
My family will economically benefit from having a electricity generating company nearby.	0.89
Price offered by the electricity company for pine needles collection is fair.	0.78
Factor Score	**2.53***

*Average summated score: Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

Willingness to collect pine needles: Environmental Perceptions

"In this section, we are going to ask you about your perception related with environmental impact of an electricity plant near your village."

Environmental Impact	Loadings
Commercial collection of pine needles will negatively impact the forest near my village.	0.89
The electricity plant will negatively impact the air quality around my village.	0.95
Commercial activity within the village forest will lead to over-extraction from the forest.	0.90
Factor Score	**3.43***

*Average summated score: Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

Willingness to collect pine needles: Fairness Perceptions (Social)

"In this section, we are going to ask you about your perception related with fairness of electricity generation company's dealings with you. "

Fair Deal	Loadings
A privately owned company is/will be fairer than a government entity in its dealings with the villagers.	0.86
The electricity company is/will be fair in dealing with the villagers.	0.75
Employees of electricity generation company are/will be courteous to me.	0.68
Employees of the company are/will be helpful.	0.76
Factor Score	**2.48***

*Average summated score: Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

Willingness to collect pine needles: Reliability Perception (Social)

"In this section, we are going to ask you about your perception related with the reliability of an electricity generation project near your village "

Reliability	Loadings
Electricity from pine needles is a reliable energy alternative to fossil fuels.	0.91
Economically viable technologies exist for converting pine needle too electricity.	0.75
The company will be able to collect sufficient amount of pine needles for its operation.	0.78
My village will be able to supply sufficient pine needles to the company for its operation.	0.75
The company will remain in operation for at least 5 years.	0.66
Factor Score	**2.41***

*Average summated score: Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

Willingness to collect pine needle : Operational Ease Perception (Social)

The section begins with the following statement : “In this section, we are going to ask you about your perception related with the ease of pine needles collection activity. “

Operational Ease	Loadings
I have necessary tools to collect pine needles	0.93
I understand the process of collecting pine needles	0.80
It will be easy for my family to collect pine needles	0.89
Factor Score	**3.37**

*Average summated score: Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

Dependent Variable: Willingness to collect pine needles

Questionnaire also includes a direct question on a five point scale:

Scale: 1=Strongly Disagree; 2=Somewhat Disagree; 3=Neutral; 4=Somewhat Agree; 5=Strongly Agree

"Will your household be willing to participate in the program for Rupee 1 per Kg of pine needles?"

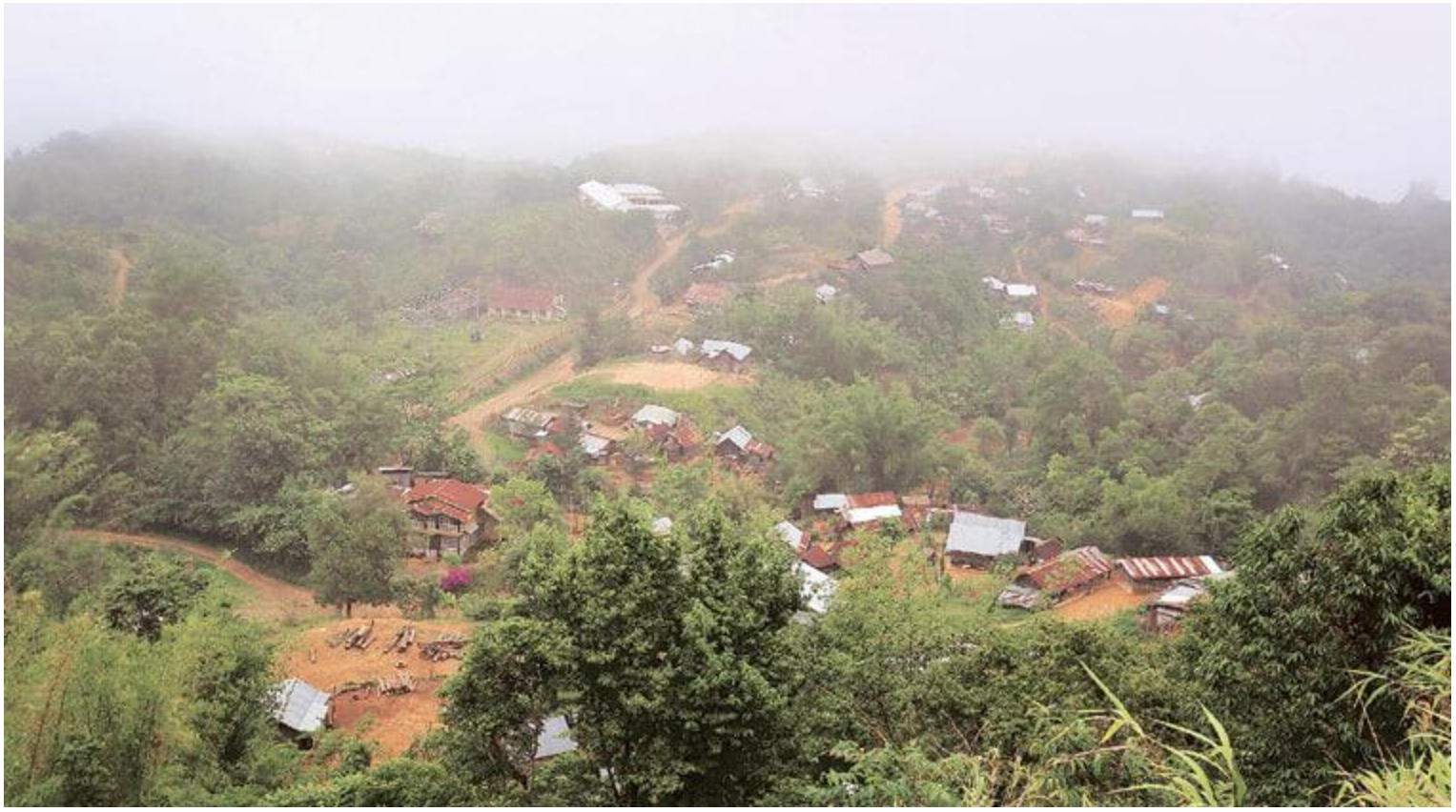
Correlation: Perception vs. Willingness to Collect

	Environmental Impact	Economic Impact	Fairness	Reliability	Operational Ease
Willingness	-0.21*	0.66*	0.19*	0.39*	0.18*

* Statistically significant at p=0.05

Study Part II

Willingness to collect pine needles:
Related to Socio-economic-demographic factors



Multinomial-logit model

$$Logit\{\pi(x)\} = \propto + \beta_1 MHI_1 + \beta_2 \ MHI_2 + \beta_3 \ HHSIZE + \ \beta_4 \ \text{FODDER}$$

X= Willingness to collect pine needles

MHI= Monthly household income

HHSIZE= Number of members in a household

Fodder= Fodder collection for livestock in a household

MHI	0	<46,000 Low Income
	1	>45,999 High Income

HHSIZE	Quantitative

Fodder	0 < 570 Kg per month Low
	1 > 569 Kg per month High

Results

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	1.05	0.55	3.66	0.06
MHI	1	0.44	0.18	5.89	0.02
Fodder	1	-0.72	0.19	14.19	0.00
HSIZE	1	0.19	0.09	4.89	0.03

Goodness-of-Fit Statistics

Criterion	Value	DF	Value/DF	Pr > ChiSq
Deviance	32.29	28.00	1.15	0.26
Pearson	25.08	28.00	0.90	0.62

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
5.42	7.00	0.61

Inferences

- **Household Size**: Odds of Willingness goes up by 20% ($e^{0.19}$) with a 1 unit increase in household size.
- **Fodder**: Odds of willingness goes down by 51% ($e^{-.72}$) as fodder collection moves from a high level to a low level.
- **Household Monthly Income**: Odds of willingness goes up by 56% ($e^{.44}$) as we move from high income to low income group.

Conclusion

- High income group in the area tends to be predominantly upper caste households which may look down upon pine needles collection activity.
- Most lower income group are Scheduled Caste households which regard pine needles collection activity as income enhancing opportunity.
- Households that already collect high amount of fodder from the forest display higher willingness to collect pine needles.
- Larger households higher likelihood of having at least one member who could be willing to collect pine needles.

Implications for Households

- Recall, median per capita income in is ~ 55,000 rupees (US$ 860).
- A 100-120 Kw system can support 80 to 100 households for 3 to 4 kg charcoal consumption /family/day, substituting charcoal for fuel-wood.
- Pine needle collection April to July pre-monsoon period (120 days)
- An individual can collect 300kg pine needles, at $ 0.02/kg ($6 per day) s/he can make $720 in 120 days.
- Women in Uttarakhand household spend 4 hours per day in collecting fuel wood and feeding the family. By participating in pine needles collection program they can earn money with which they can buy charcoal.
- Reduced forest fire due to removal of pine needle from the forest resulting in preservation of biodiversity.

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Thank You

Questions???

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