
Model for Productive utilization of DPN



By

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INDIAN INSTITUTE OF TECHNOLOGY, MANDI
HIMACHAL PRADESH**



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ACKNOWLEDGEMENT

We would like to thank and acknowledge the following people and organizations for providing the necessary support on the DST sponsored project “Eco-friendly utilization of DPN for social benefits”.

1. DST, Govt of India for funding under CSTRl Scheme
2. SRIC, IIT Mandi for all logistics support
3. Village Pradhanas of Kamand Region, Distt Mandi, H.P for participation
4. Mr S.S. Kashyap, Distt Conservator, Mandi, Distt Mandi, H.P. for helpful discussions
5. ACC Cement, Barmana, Distt. Bilaspur, H.P. for their visit
6. Ochha fuels, Nagrota-Bagwan, Distt Mandi, H.P. for initial studies
7. Project team: Mr Pawan Tiwari (Project Engineer), Mr Rakesh Arya(Project Assiatant), Ms Pooja Thakur (Project Assistant) , who carried out the work

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INTRODUCTION

The Center for Uplifting Himalayan Livelihood (**UHL**) is a DST funded center at IIT Mandi, in Himachal Pradesh working on socio-technical issues of the Himalayan region in general and H.P. state in particular.

- Under the CSTR scheme of DST, Govt of India, a “**Center for Innovative technologies for Himalayan region, called UHL center**” has been established at IIT Mandi.
- The Center aims to identify social challenges in the Himalayan region and address them with the help of solutions developed by local innovators.
- The focus is to promote locally developed solutions and replicate them in the entire Himalayan region.

CHAPTER 1: THE CHALLENGE

1.1 Background

In past few decades, the forest departments of Hilly states such as Himachal Pradesh and Uttarakhand have tried various ways for collection and disposal of pine needles in order to avoid the forest fires caused by them. Further effort has been to somehow utilize pine needles for social good. Despite such efforts bearing great social value, these have not yielded significant results as of now, but have surely highlighted gravity of the situation and motivated numerous organizations (For-profit/Not-for-profit) to look into the possibility to solve the problem. In the meantime, forest departments have taken a safer route of burning pine needles in a controlled manner. The state government departments spend a huge amount of money every year to address the first half of the challenge- to prevent forest fires, while the other half- to make something constructive from pine needles- remains unsolved. For instance, Himachal Government has allocated a budget of Rs 422 Crores in the financial year 2013-14 to protect its forest from fires by cleaning/maintaining its 1000 Kms long fire line [4]. The Government is also looking for alternative ways to address the challenge.

Further, in the Himalayan states, people mostly depend on Agriculture and Animal Husbandry for their livelihood. In Himachal Pradesh alone, about 69% of the main workers are engaged in the associated sectors [6] only. The pine needles dropped from the tree and littered on the ground is known to hinder the growth of grass on the ground by prohibiting air to pass through. The resulting reduction of cattle feed, frustrates people and forces them to set the needles on fire which often turns in to forest fire.

Therefore, it is essential for the wholesome betterment of Himalayan regions that abundance of this natural resource (dry pine needles) be managed along with financial betterment in terms of sustained work wages by developing new and small scale industries fostering on the waste produce of the natural resources like dry pine needles.

1.2 Pine needle biomass in Himachal Pradesh

Himachal Pradesh falls completely inside Himalayan region; It has approx 4.8% of India's total forest cover. Himachal has approx 67% of forest cover. Biomasses are mainly found in the forest. The following data provided by Forest Survey of India (FSI) and Himachal forest department's report gives the total estimate of pine needle in each season:

- Total Geographical Area: 55673 sq Km
- Total Forest Cover: 37,033 sq Km
- Total Pine cover area: 1,25,885 hectare

- Pine availability : 1.2 tons/hectare
Total pine = 1,51,062 ton/year

Our base location Mandi also covers a big area of forest (42% of the total geographical area of Mandi), so the availability of biomass is also in plenty in the base location.

In addition to pine needle, the other mainly available biomasses in Himachal Pradesh are Oak, Pine cone, Lantana, Keekar, Bani, Rice husk, Congress grass, Municipal organic waste etc. [5,7].

1.3 Fire Hotspots in the region

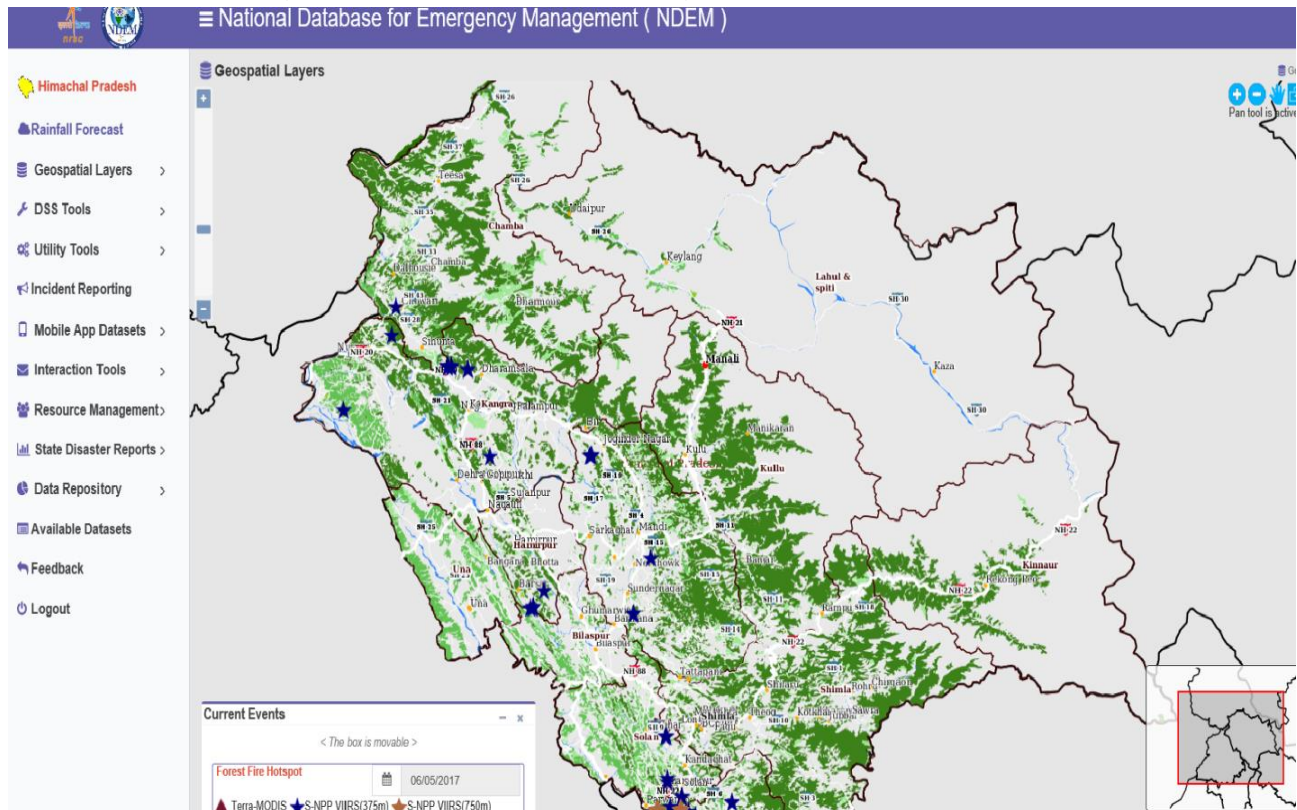
As per the report by Forest Department, Uttarakhand [1], as shown below, the affected area by the forest fire is quite considerable.

Table1: Fire affected area in Uttarakhand Himalayan region [2]

Year	Fire Affected Area (Ha.)
2000	925.00
2001	1393.00
2002	3231.00
2003	4983.00
2004	4850.00
2005	3652.00
2006	562.44
2007	1595.35
2008	2369.00
2009	4115.00
2010	1610.82
2011	231.75
2012	2826.30

National database for emergency management (NDEM) provides the information of the fire hotspots. The location of forest fire hot spots as on 5th June 2017 in Himachal Pradesh from NDEM data base is shown below [3].

Fig- [1] the location of forest fire hot spots as on 5th June 2017 [3]



Considering the huge amount of vulnerable forest area, it is desirable that some effective way for controlling the situation should be developed. With this goal in mind, we here propose a way to dispose of dry pine needles not only in an economically viable way but also with a possibility of generating employment in the region.

CHAPTER 2: IDENTIFIED SOLUTIONS

2.1 Biomass briquetting/Pelletization

Briquetting is a process where raw material is compressed under high pressure to form a round or square briquette, such briquettes of biomasses can be used as fuel. During the compression of the material, temperatures rise sufficiently to make the raw material liberate various adhesive that will assist in keeping the particles together in the compressed shape [7].

2.2 Bio-oil production by pyrolysis of DPN/Lignin extraction

As every biomass contain lignin which shows the amount of oil. Pyrolysis is the simple experimental procedure for oil production. Pyrolysis is high temp low-pressure process mostly used for the production of bio-oil from biomass. Pyrolysis converts lignocellulosic biomass to bio-oil that can be a precursor to fuel and chemicals for industries. Pine needle lignin extraction used to be done earlier but it is now discontinued by the industry because of its economic viability.

2.3 Electricity Generation

Electricity generation with a gasifier that uses pine needles as fuel for generating electricity is another possible utilization. However, this model is not cost effective according to cost benefit analysis of Avani Gasifier Plant, Kumaon Uttarakhand.

After studying various possible ways, we realized that **“Pelletization and briquetting”** of pine needle biomass is the most eco-friendly and economically viable solution. So center decided to address the challenge by working out a solution around pelletization and briquetting of pine needle.

CHAPTER 3: WORK DONE AT IIT MANDI

3.1 Briquettes and pellets produced at center

Interestingly, all previous efforts in this direction either applied controlled burning and then compression or mixing of materials like cow dung/soil etc to make fuel. The product made with these techniques is neither of acceptable quality nor easy to make. Based on our observations and understanding we decided to chop and compress the needles at high pressure. After many trials, we could finalize what kind of set up will work the way we wanted it to work. We succeeded in making very clean, dense and easily manageable briquettes and pellets with pure pine needles and with the mixing of pine needles with many other biomasses. The figure below shows the samples we have made at the center.

Fig-2: [DPN briquette]



Fig-3 : [DPN briquette]



Fig-4: [DPN pellets]



Fig-5: [DPN pellets]



3.2 Briquette Machine set up in Center

Center has its own set up in IIT Mandi campus. The briquetting unit set up in our campus has the **capacity of 150kg/hour** with a connected load of **12 HP**. The cost of the unit is around **six** lacks. Figure below shows the briquette machine.

Fig-6: Briquetting machine



Fig-7: Briquetting machine



Fig 8: Palletization Machine [10]



3.3 Chemical Analysis of DPN briquette

The calorific value of briquettes is the heat liberated when the solid fuel undergoes complete combustion in oxygen. To obtain accurate results, we have to burn our fuel sample in a bomb calorimeter and measure the total heat energy. Biomass briquettes have higher the value of calorific value as compare to wood. Further, we conducted a variety of fundamental ash analysis tests including elemental ash tests, ash fusion tests and coal ash analysis. Following tables lists the calorific value along with moisture and ash content of the various samples made up of pine needles mixed with wood chips.

Table2: Calorific value of DPN briquettes (sample: pine +wood chips)

Pine %	Calorific value (Kcal/kg)	Moisture%
60	6442.58	6.03
40	6186.60	6.98
20	5368.2	7.40

- ✓ DPN briquettes have high bulk density and large heating time.
- ✓ These briquettes are clean and have low sulfur content thereby having positive environmental impact.
- ✓ The use of briquette also reduces CO₂ and CH₄ emission, thus reduces green house gases and associated climate change.
- ✓ **Quantity Required: 3 Kg of pellets will emit eqale heat as 10 Kg of wood emits (according to the heating value)**
- ✓ **We also filed a patent on DPN briquetting “Biomass compact briquette fuel and its preparation method” patent application number 201811000279, dated 03/01/2018**

3.4 Benefits of product

3.4.1 Economic Viability

Based on our cost benefit analysis studies, it seems economically viable product. The following computation gives approximate cost of the product

Machine cost = Rs. 6 lacks (It includes briquette machine and pulveriser cost)

Plant Operating cost = (Power consumption + Labor charges) = Rs. 940 / ton

Material cost = (Collection cost + Transportation cost + Labor charges) = Rs. 3350/ ton

Manufacturing overhead = Rs. 200 / ton (approx)

Total production cost = Rs. 4500 / ton

The production cost of briquette is Rs. 4500/ton or Rs. 4.5/kg.

- From calculation, the production cost of briquette would be Rs 4.5/kg while wood also costs around Rs 4.5/kg.
- Cost of the machine (6 lacks) can be recovered in two to three seasons.

3.4.2 Techno-commercial feasibility of the product

In Himalayan region, more than 70% people depend on wood as fuel for their cooking requirements [4]. Pellets and briquettes have useful heat content. The cost of briquettes comes out to be Rs4.5/kg while wood costs around the same. Owing to high calorific value, consumption of briquettes will be quite less than wood. A household will require only 3kg of briquettes/pellets per day as compared to 10 kg of wood. From the data reported by Himachal government, the total households which depend on using wood for cooking are approx 8 lakhs, which is the half of total population.

3.4.3 Employment generation

It is estimated that the fall of the pine needles is about 1.2 ton per hectare per season. A healthy person can easily collect around 100-150 KG of pine needles in a day, thereby earning around Rs 200-250 on a daily basis depending on the market price of pine needles. The unit is also helping for employment. At least 4 People will work in a single unit. People who have own vehicles will have a chance to earn more by transporting the needles.

3.4.4 Community involvement/Workshop on DPN

The UHL Center organized awareness programs in nearby Gram-Panchayats for Gram Pradhans. The response and acceptance of the product is very good.

Fig-9: Interaction with Gram Pradhan's

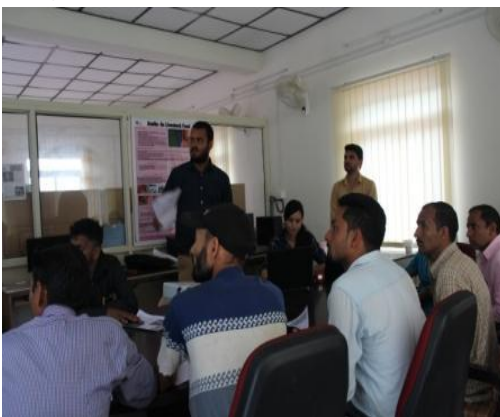


Fig-10: Interaction with Gram Pradhan's



We also organized half day workshop on “eco-frineldy utilization of DPN for social benefits” on 25th Oct 2018.The main goal of the workshop was to make villagers aware about the use of dry pine needle and motivate them to set up pine needle based industry.Over 60 peoples from different backgrounds joined us in workshop. The major participants were forest guards, representative of infinite energy, Gram Pradhan’s, Ward Members, Gram Panchayat Sadasya, Memebtrs from joint Forest management committees(JFMCs), Mahila Mandal, Yovak Mandal etc.

Figure11: workshop on dry pine needle



3.5. Uses of Product:

1. Industrial uses:

- ✓ As a fuel for cement, brick industries, NTPC etc
- ✓ Can be use as a fuel in any other industry where furnace is used
- ✓ In restaurants or Dhaba as food cooking fuel
- ✓ Can be use in a gasifier, for power generation and replacement of LPG

2. Domestic uses:

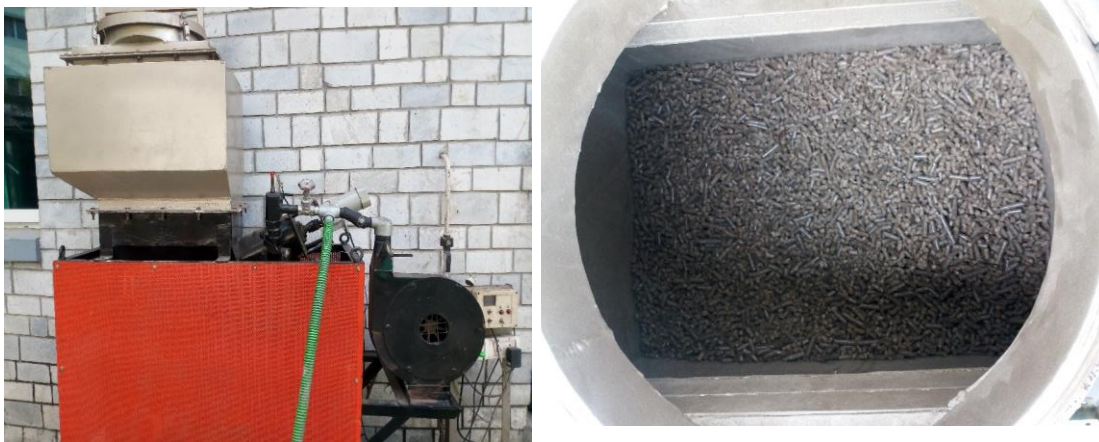
- ✓ Food cooking fuel for household
- ✓ In Hamam for water heating

3. Uses in gasifier:

- ✓ Our centre is also working on the use of briquette in the gasifier, in collaboration with Infinite Energy Pvt. Ltd., Delhi.

- ✓ Gasifier converts organic material into useful gases. Gases can be use as a cooking fuel and cane be a replacement of LPG.
- ✓ Gasifier is a process that heats and decomposes biomass into syngas, a mixture of hydrogen, carbon monoxide, and carbon dioxide, methane in a restricted oxygen condition(partial combustion).
- ✓ It reduces the cost of LPG up to 40%.
- ✓ **The main advantages of using biomass briquette based gasifier over fossil fuels are less cost, renewability/biodegradability of biofuel, it's safer than fossil fuels, and it emits the low toxic gases as compared to fossil fuel.**

Fig12: Pine needle briquette based gasifier

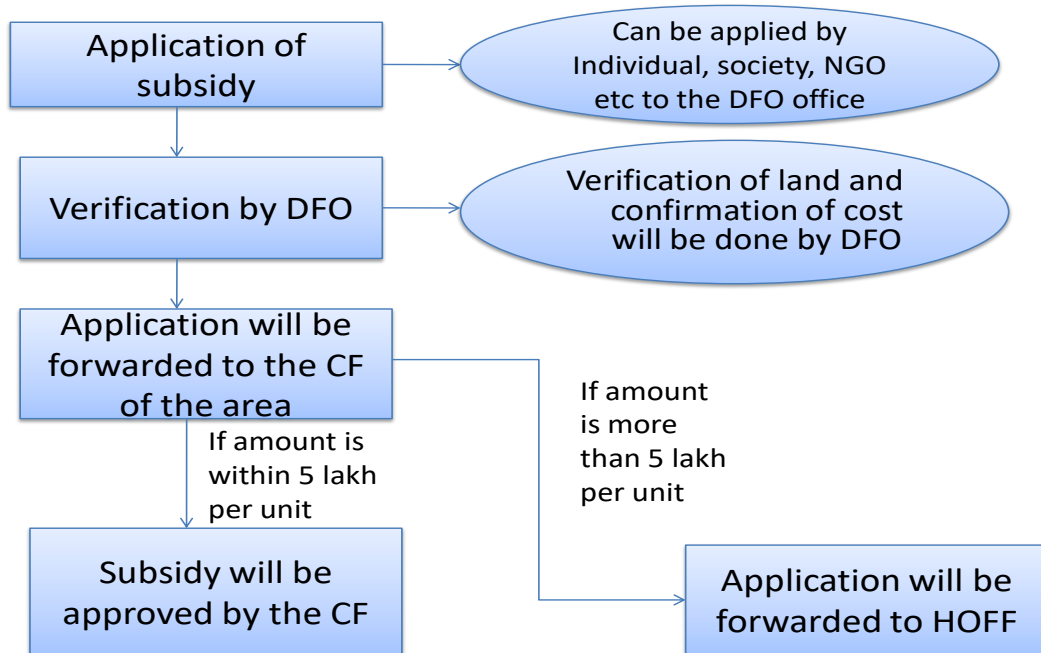


3.6. Government policy on DPN based briquette plant:

On our request, the Government of HP announced a policy for said briquette plants. The important points of the policy are as following:

1. Govt. will provide subsidy of 50% of capital cost upto Rs. Twenty five lakhs per unit (also include shed)
2. No charges will be payable to the forest department for the collection and utilization of dry pine needle
3. Forest department can also help for the collection and transportation of pine needle by providing funds from their forest fire protection scheme fund
4. The collection and transportation can be done by the help of Panchayati Raj bodies, Mahila Mandals, Yuvak clubs, NGOs , right holders or village forest management societies(VFMS) etc.

Procedure for policy:



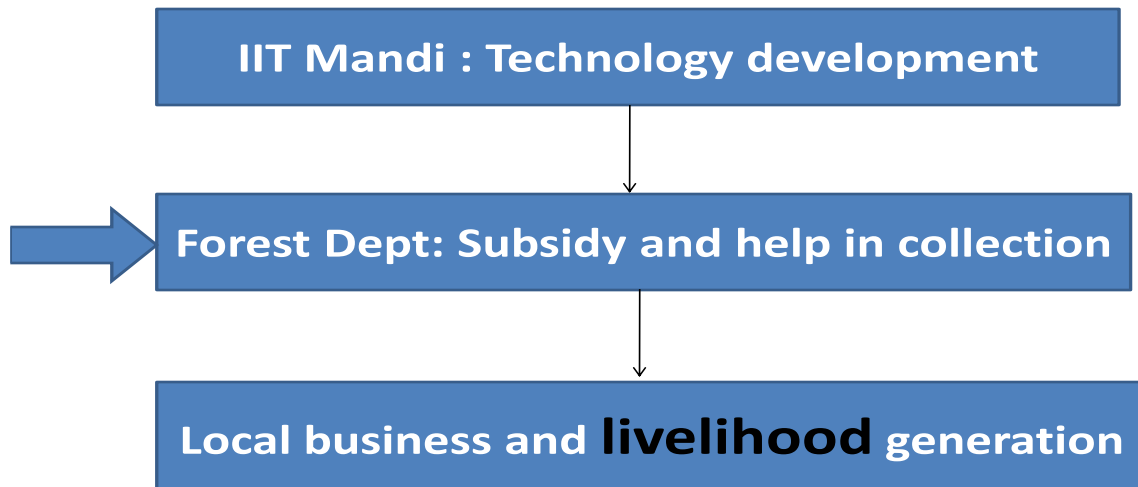
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CHAPTER 4: PROPOSED IMPLEMENTATION

We understand that for the implementation purpose, there has to be the participation of various stakeholders. Following are the concerned stakeholders in this process

- HP State Government through Department of Forest.
- Public through Panchayats, Self Help Groups, Forest Management Committees, Social Entrepreneurs (Small Scale Entrepreneurs)
- Industry like ACC, Ambuja as consumers
- Public as consumers for its domestic use
- Technical partner, IIT Mandi

Proposed Model

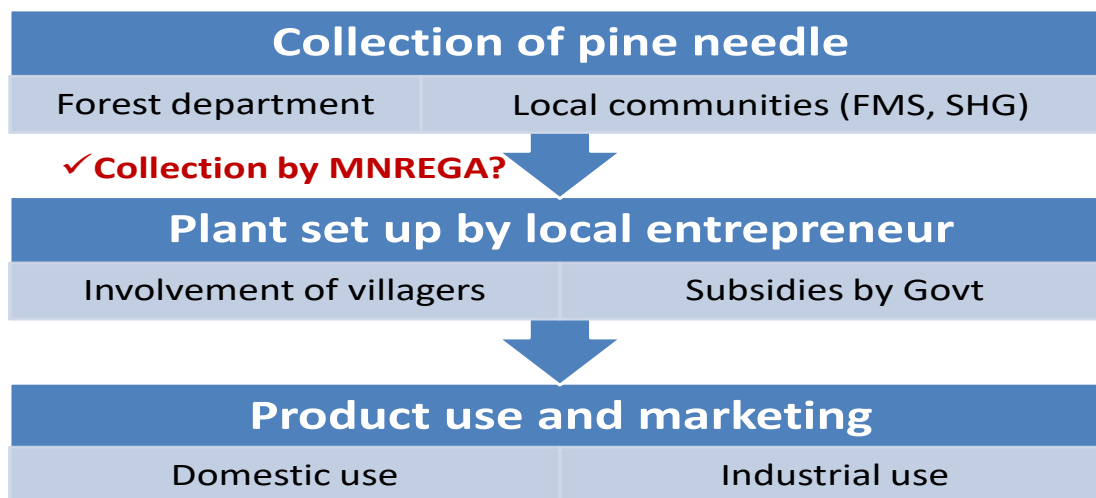


Further, it appears that many small steps taken in right spirit may help. Following points may be worth discussion if the units for briquetting are to be set up for the disposal of dry pine needles:

- a. **Spot identification:** It should be done based on the availability of pine and transportation facilities. Fire hot spots may also be considered even if the transportation is limited to such place.
- b. **Subsidizing plant set up to a local entrepreneur:** Providing subsidy for the set up of the unit may attract villagers to be entrepreneurial.
- c. **Entrusting the community:** Involvement of villagers, self-help groups, forest management committees etc. to run the plant might contribute to better profits to the people involved because of their ownership in the process.
- d. **Subsidizing electricity charges:** Extending subsidy towards electricity consumption will attract the local entrepreneur more for plant establishment and running.

A proper and strong financially viable channel between villagers, small-scale entrepreneur and industry, will help for the plant establishment, marketing and sustainability. Conducting awareness programs for villagers related to the product will help further.

Proposed Model: Implementation (HP Govt)



CONCLUSIONS

- From the experience gained through work done till date and literature survey, UHL Center concludes that briquettes/pellets is a good substitute for industrial and domestic fuel.
- The enhanced usage and ease of availability of briquette for domestic cooking shall help in reducing wood usage for domestic needs in Himalayan region.
- With removal of unwanted biomasses from the forests as a sustained income source, villagers would be able to prevent the occurrences of fires, thereby reducing pollution, saving biodiversity and helping local economy.
- Launching more such units across the Himalayas shall help to create more and more employment opportunities for future.

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