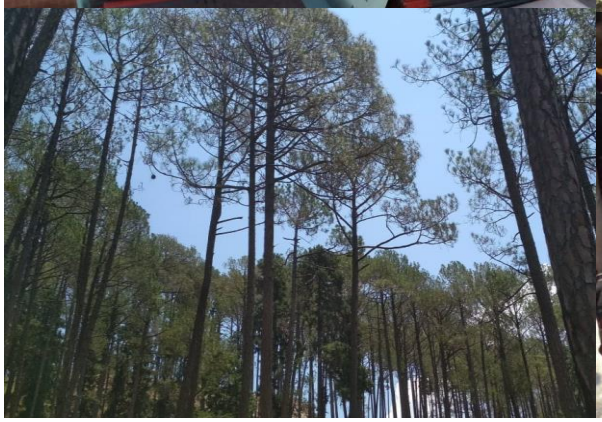
Environment-friendly use of Pine needles (Pirul) for livelihood enhancement and income generation by rural people and avoidance of forest fire

A Technical Manual

Rural Technology Centre, Centre for Socio-economic Development, GBP-NIHE, Kosi-Katarmal, Almora



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Introduction

Fire is one of the major causes of forest degradation in India, and has wide ranging adverse ecological, economic and social impacts. This outrage of forest fire (FF) concerns everyone across the country, and to save the forests large scale efforts are made at various levels both at Government and civil society. Every year, close to 18,000 FF incidents are reported in India affecting an area of some 1.14 Mha (Bahuguna and Singh 2002) with an estimated annual loss close to Rs. 4,400 million. However, this loss does not include a range of intangible services of forests (Parashar and Biswas 2003) (Box-I). In the Indian Himalayan region (IHR), on average 3908 FF events occur annually with average burnt area of 1129 km^2, and black carbon emission of 431 t/yr (Vadreuv et al. 2012).

BOX- I

Negative Impacts of Forest Fire

- *Loss of vegetation, biodiversity, soil biota, seed bank.*
- *Loss of medicinal plants, timber, wild edibles and other NTFPs.*
- *Loss of wildlife, microhabitats of a range of flora & fauna.*
- *Proliferation of weeds (e.g., Lantana and Eupatorium) and loss of native flora.*
- *Loss of carbon sink and soil and water conservation value of forests.*
- *Increase in air pollution (SOx & NOx) and black carbon.*
- *Reduced solar radiation, plant photosynthesis and crop yield.*
- *Increase in rainwater runoff, soil erosion, triggering of small landslides and flash floods due to loss of forest crown cover.*
- *Drying up of water sources, water pollution and aesthetic value of landscape.*

Chir Pine & Forest Fire

In Uttarakhand, Chir Pine (*Pinus roxburghii*) forests spread over appx. 16.4% of total forest area (1000-1800 m asl) are particularly prone to FF due to resin-rich leaf litter (Pirul) accumulation on the forest floor during summer, and also in late winter. Pine being an early successional species and susceptible to fire has also expanded into the socio-ecologically valued Oak forests negatively impacting the forest ecosystem services (Singh et al. 1984; Joshi & Negi, 2011). Since the formation of Uttarakhand in 2000 up to June 2019 a total of 44,518 ha forest area has been burnt due to FF. The colossal loss to the forest wealth remains least accounted in the monetary loss in our GDP. For example, in 2016 the forest area burnt in Uttarakhand was reported to be 4423 ha and the loss was estimated at Rs. 4.62 million as per the scheduled rates (@ Rs. 1500 per ha) of Forest Department, Uttarakhand that was estimated Rs. 4 million to 50 billion by others. In the FY 2020-21, Rs. 16 crores have been allocated for firefighting in Uttarakhand.

An Innovative approach to use Pine for environment-friendly products

This Institute at its Rural Technology Complex (RTC) established a Pine Unit under NMHS Project (Title: A sustainable approach for livelihood improvement by Integrated Natural Resource Management in the Central Himalaya) between 2016-17 and 2020-21. Products such as file covers, meeting folders, carry bags, envelops, diary, weeding cards, decorative items etc. were prepared on pilot scale (total products made = 7650) from the Pirul collected from the Project area (Hawalbagh Block; Distt. Almora) involving women and other beneficiaries (Box-II). These Pirul products were sold for Rs. 79,000.00 to ICAR-VPKAS, District Judge Office, Ajivika in Almora, and also used by our Institute and also sent to MoEF&CC and widely appreciated by various stakeholders including NMHS experts and MoEF&CC. This activity was largely viewed both as employment and income generating and more importantly reducing the likelihood of FF in the vicinity of project area. Now the NMHS Project is over and it was thought prudent to prepare a TECHNICAL MANUAL that could be used by other stakeholders.

BOX - II

Pirul products	*Inputs*	*Input cost (Rs./Unit)*	*Total cost (Rs./ Unit)*	*Benefit/Loss*
File cover / Meeting folder (A4 size)	*Material (Pirul, cotton, starch, soda, chemicals, water, electricity etc.*	*17.00*	*22.00*	*File cover in the local market costs Rs. 15-20. The Pirul items are readily bio-degradable*
	Manpower	*5.00*		
Carry bag (A4 size)	*Material (as above)*	*20.00*	*25.00*	*Its suitable to be used for seminar / workshop kits*
	Manpower	*5.00*		
Bio-briquette	*Material*	*1.25*	*5.45*	*Bio-briquettes were sold @ Rs. 8 -10 /- making a benefit of Rs. 2-4/Unit.*
	Manpower	*4.20*		

Production of Handmade Paper at Pine Processing Unit using Pine needles

Chir Pine needles (Pirul) were utilized for preparation of handmade paper and various finished products at the RTC of the Institute under the NMHS Project. Material used in handmade paper making are: Chir pine needle, cotton, Sodium Hydroxide (caustic soda), starch powder and seizing chemicals. The process of making pulp and paper is given below (Table 1 & 2):

Step 1: Freshly fallen sun dried Pirul is collected from the Pine forests and cleaned off wood pieces etc. and cut into small fine pieces by loading into a Rag Chopper Machine.

Step 2: The fine pieces of pine needle thus obtained are grinded in the Hammering Machine which makes this material further finer, smaller and flexible.

Step 3: This hammered material is now cooked in a Digester (40 kg capacity at RTC) with 10% of caustic soda for 4.5 hours at 100^0 C and high pressure which removes the lignin from pine needles.

Step 4: Cooked material is washed with tap water repeatedly.

Step 5: Pulping process is done in a Beater where cooked material is run for 4-5 hours. Cotton (~15%), starch (~10-12%) and seizing chemicals (Alkyl Ketene Dimer, @2%) are added to pulp to enhance the properties of paper. Sometimes, bleaching of pulp is also done to enhance the quality of products by soaking into a mixture of NaOH and H_2O2 (4% of total material).

Step 6: This pulp is now spread over large trays (Auto vat, using inlet frames) to prepare paper sheets.

Step 7: Paper sheets thus prepared are pressed in a Hydraulic Press to remove water and the sheets are dried in the sun.

Step 8: Dry sheets are smoothed and straightened into Calendaring Machine and cut to desired size to make final products.

Step 9: Making file covers, carry bags etc. then require cloth, islets and finally printing the brand name on these products for ready to de sold.

Various steps in preparation of Handmade Paper from dried Pine needles

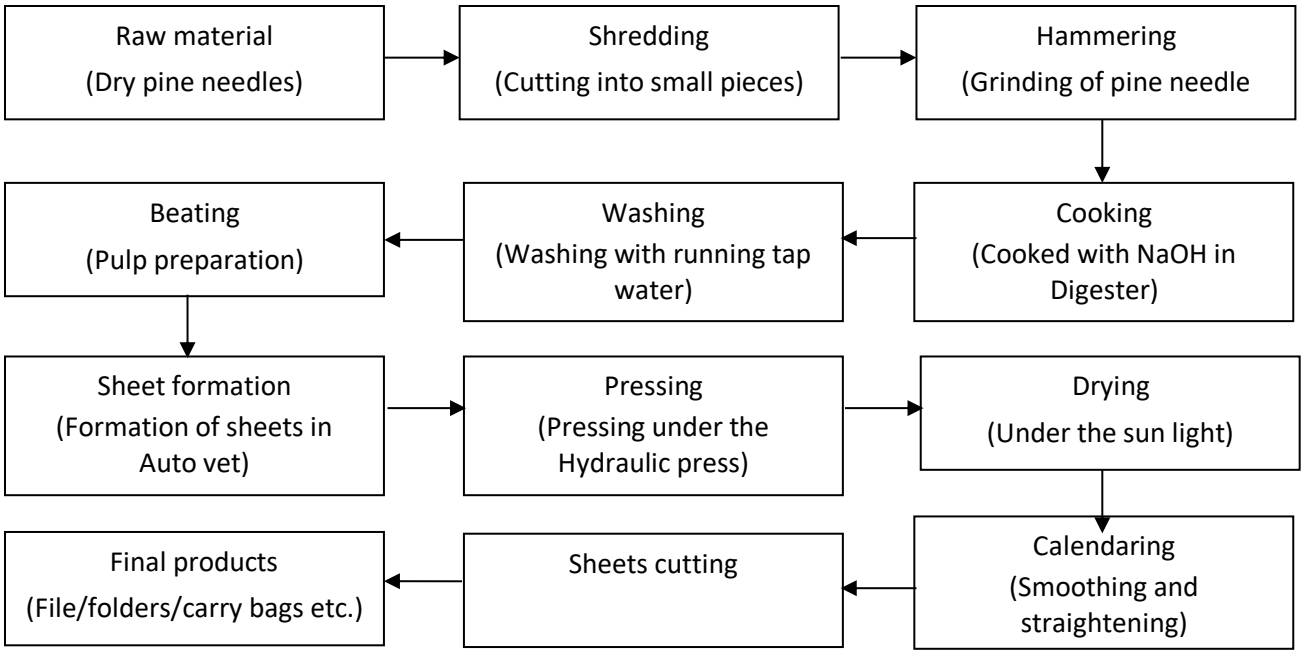


Table 1: Processing cost of 30 kg pine needle at pine processing unit to make paper

Material/man power/others	**Total cost (Rs.)**
a) Material (pine needle, cotton, starch powder, caustic soda, seizing chemicals etc.)	1368.00
b) Manpower	1625.00
c) Electricity consumption	80.00
Total investment (a+b+c)	3073.00
No. of paper sheets produced	90
Estimated cost of a single paper sheet (size...)	34.13

Table 2: Production cost of various products made out of handmade Pirul paper

Products	**Inputs**	**Total cost (Rs.)**
File (Standard size)	a. Material	17
	b. Manpower	5
	Total investment	**22**
Meeting folder (standard size)	a. Material	18
	b. Manpower	5
	Total investment	**23**
Carry bag (a4 size)	Material	20
	Manpower	05
	Total investment	**25**

Properties of handmade paper made at pine processing unit:

The composition and properties tests of handmade paper were conducted by National Handmade Institute, Jaipur in 2019 (Table 3 & 4). The paper obtained is environment-friendly and rapidly bio-degradable. However, there are certain drawbacks which are observed during the processing. The paper is not conveniently writable and do not have water resistance. However, water resistance problem can be fixed by adding seizing chemical (Alkyl Ketene Dimer, @2%). Pine needles contain higher lignin which results into high bleach chemical demand. Thus, instead of bleached variety pine needle can be utilized for production of unbleached craft paper, filler, packing cases and paper board.

Table 3: Composition of handmade paper made at pine processing unit (Test Methods IS: 1060 (Part-I): 1960**)**

S.N.	**Parameters (%)**	**Handmade sheets**
1	Holo-cellulose	68.23
2.	Total lignin	26.50
3.	Moisture	7.65
4	Ash	2.06

Table 4: Physico-chemical properties of handmade paper (Test Methods IS: 1060 (Part-I) 1960**)**

S. No.	**Parameters**	**Pure pine needle sheet**	**Cotton mixed pine needle sheet**
1	Basis weight (gm/m^2)	533.33	498.28
2	pH	7.2	7.50
3	Moisture (%)	7.65	6.52
4	Tear Index ($mN.m^2/gm$)	13.35	5.45
5	Burst Index (kPa.m2/gm)	0.65	0.71
6	Caliper (mm)	0.63	0.6685
7	Ash (%)	7.62	5.61

Rag chopper

Hammering Machine

Boiler

Digester

Beater

Auto Vat

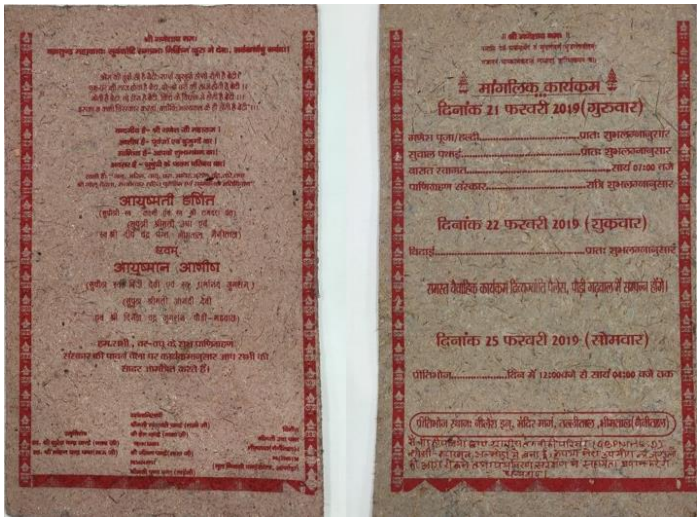
Hydraulic Press

Calendaring Machine

Paper cutter

Various machines used in making paper at Pine Processing Unit

Internal view of Pine Processing Unit



Various products made at Pine Processing Unit

Process of Making Bio-briquettes from Pine tree leaf litter (Pirul)

Briquetting is a process of converting low bulk density mass (dry pine needle) into high density and energy concentrated fuel bio-briquettes.

Step 1: Dry pine needles (Pirul) are collected from the forests during summer (April-June) and air dried for 3-5 days for removing moisture contents.

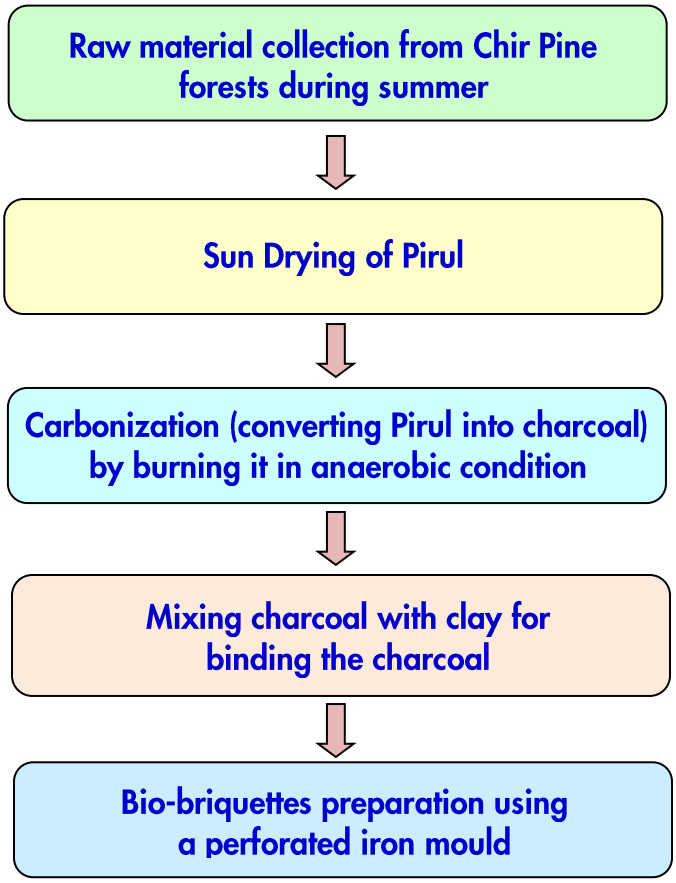
Step 2: The Pirul now undergoes the carbonization process by putting 10 kg dried Pirul in a pit (1.5.m x1mx1m) with arrangement of a tin sheet to cover the pit. Size of the pit can be increased or reduced depending upon the quantity of Pirul.

Step 3: After loading the dry pine needle into the pit, fire is ignited in the pit and the pit is covered with the tin sheet tightly by sealing the air passages with soil and left for burning for 1-2 hour (depending upon quantity of Pirul). Thus, in the absence of air (anaerobic condition) it burns slowly and about 30% carbonized char (by weight of Pirul) is obtained (i.e., 10 kg Pirul will give rise to 3 kg char).

Step 4: Now the carbonized Char is taken out from the pit after it cools down and the Char is mixed with sieved soil (clay as a binding material) by adding water in the ratio of 8 (Char): 2 (clay). The material is mixed well to ensure that every particle of char is coated with binder.

Step 5: The charcoal mixture is made into bio-briquettes using a specially designed iron mould (Plate 1). The mixture is tightly filled directly into the mould by hammering it on a hard surface to form compact and uniform sized briquettes.

Steps in Preparation of Bio-briquettes from Chir Pine leaf litter (Pirul)



Economic analysis of bio-briquetting:

The average weight of chir pine needle collected by a hill woman at a time is about 30 kg. Thus, economic analysis of bio-briquettes has been done on the basis of 30 kg Pirul biomass. The carbonization of 30 kg Pirul yields 7.2 kg charcoal, which is sufficient to make 36 bio-briquettes. Total time taken in preparation of one batch of bio-briquettes (36) is 4.33 hours. The production cost of 36 bio-briquettes is Rs. 195.5. Thus, it gives a net profit of Rs. 200.5 (Tables 5 & 6).

Table 5: Time taken in preparation of one batch of bio-briquettes (using 30 kg pine needle)

Activity	Duration (Time in hrs.)
Collection of pine needle	1
Loading in Carbonizer pit	0.08
Carbonization and cooling	1.5
Unloading	0.25
Briquette formation	1.5
Total time taken	**4.33**

Table 6: Economic analysis of bio-briquette preparation

Activity	Cost (Rs.)
a. Collection of one head load of pine needle (30kg)	45.25
b. Labour cost in preparation of bio- briquettes	150.65
c. Total investment (a+b)	195.9
d. Total bio-briquettes (36) prepared & sold in nearby town (@ Rs. 10/- unit)	360.00
Net profit (d-c)	**200.5**

The proximate analysis test of bio-briquettes was carried out in 2019 at Shri Ram Institute for Industrial Research, New Delhi using standard methods (ASTM D-7348). Water boiling test was carried out to compare the cooking efficiency of bio-briquettes. It measured the time taken for each set of briquettes to boil equal volume of water in similar condition. A bio-briquette takes 12-15 minutes to boil 3 litres of water and produces fuel energy for about 1.5 hours which is enough to cook a onetime meal of small family. Estimated fixed calorific value in pine needle charcoal briquette is 2500 Kcal/kg (Table 7). Although the calorific value of bio-briquette using starch as binder is higher than bio-briquettes made of using clay as binder but we have used clay as binder due to it easy availability and reduce the cost. The bio-briquette is smokeless and the ash is used as fertilizer in kitchen garden strong enough for safe transportation.

Table 7: Proximate analysis of bio-briquette sample

Parameters	Value (%)	Protocol/Test Method
Total moisture, % by mass	25.6	ASTM D 7348 guidelines
Volatile Matter, % by mass	38.5	ASTM D 7348 guidelines
Ash Content, % by mass	60.3	ASTM D 7348 guidelines
Fixed Carbon, % by mass	1.1	ASTM D 7348 guidelines
Gross Calorific Value, Kcal/kg (on dry basis)	2500	IS: 1350 Part -II, 2017

Chir pine needle bio-briquetting process

Rough estimation of environmental cost of avoidance of forest fire:

Although standard methods to estimate the environmental cost of avoidance of FF are yet to be developed under a CAMPA (MoEF&CC) Project funded to our Institute involving an ecological economist, an attempt has been made to account for direct and indirect cost estimation by collecting data from unburnt (control) and burnt patches of Pine forests in the vicinity of our Institute (Table 1).

(i) Plant diversity loss: To determine the loss of plant diversity due to FF inventory of plants (species richness of trees, shrubs and herbs; number of seedlings and saplings as a measure of regeneration and herb layer biomass as a measure of fodder production either grazed by the livestock or stall-fed to them) was prepared on paired-plots approach using unburnt (control) and burnt (treatment) plots during June-July, 2020 in the vicinity of our Institute Campus. It can be safely assumed that the plant diversity was representative as forest vegetation was revived this year in terms of flora and biomass production as summer has been quite favorable for plant growth due to frequent rainfall in June 2020 and suitable temperature. In these study sites a total of 3 tree, 8 shrub and 10 herb species were recorded. In the unburnt plots only one species of shrub was found. In case of herbs at the unburnt Pine forests 10 herb species were found and in the burnt forests only 7 herb species were found (Table 1). Most of these shrubs and herbs species are either wild edibles and has ethnobotanical uses in local traditional healthcare system such as *Rubus ellipticus, Pyracantha crenulata, Berberis spp., Indigofera spp., Discorea spp., Solanum spp., Zizyphus spp.*

BOX- III

GBP-NIHE Campus Produces 54 ton Pine Needles / Year

The quantity of Pirul production in the forests of Institute Campus (June 2020) was estimated placing 25 quadrates (Pine tree density = 610 trees/ha and total 5856 Pine trees in the Institute Campus under Pine forest (i.e., 9.6 ha). Each mature tree of Pine produced about 4.6 kg Pirul /tree that converts to ~ 27 ton/yr. As about 50% of all Pine leaves had not fallen on the forest floor this year due to rains in summer it is assumed that the quantity of Pirul should be twice as much as we estimated. Thus, Pirul production from the Campus can be best put to ~ 54 ton per annum (at 100% collection) that is sufficient to produce the various products for our office use and also to meet the demand locally at District HQs Almora. An estimate based on RS technique on the forests of Uttarakhand estimated Pirul production 12.4 Kg/tree and considering a loss factor of 0.3 this leaves Pirul production at 8.7 Kg/tree (Kala & Subbarao, 2017).

Assuming each of our Institute / Regional Centres faculty, Researchers and office staff uses 15,000 file covers, file folders, carry bags / year (@50 file covers/yr) and to buy them from market we spend appx. Rs. 2.25 lakh (@ Rs. 15 / file cover) and the surplus we sell locally we can run the Pine Unit sustainably. In this endeavor, support from MoEF&CC would be crucial by advising State / Central Govt. offices to purchase these environment-friendly products.

etc. (Table 2) but they are sometimes sold in market thus could not be given monetary value. However, some of these products are rarely sold locally (e.g., *Rubus ellipticus*) or utilized by the local *Vaidyas* who pay to local people for its collection from the wild.

(ii) Forest Regeneration: Regeneration of forests is greatly affected by forest fire. To assess this loss seedlings and saplings of tree species were counted in unburnt and burnt Pine forests. In the unburnt Pine forests seedlings (16200 / ha) and saplings (4200 / ha) were recorded, and the burnt plots were completely devoid of seedlings and saplings. However, more number of such paired sites (burnt vs. unburnt) would give better understanding that could not be pursued due to lockdown situation and very low number of fire events this year.

(iii) Loss of herbs / grasses: The herb layer biomass in the unburnt Pine forest was estimated at (2.9 t/ha) as compared to burnt plots (0.72 t/ha). Taking a minimal value of Rs. 1 per kg of green fodder (as per the local rates in villages) the price of green fodder converts to Rs. 2900/ha for unburnt plots as compared to only Rs. 720/ha for burnt plots thus the loss assessment computes to Rs. 2500/ha due to forest fire.

Chemical analysis of the file covers analyzed by Kumarappa National Handmade Paper Institute, Jaipur revealed: holo-cellulose (68.2%), total lignin (26.5%), moisture (7.65%) and ash (2.06%).

Multiple Uses of Pine Trees Promote its Existence?

Chir Pine is the most important species in India covering an area of 8900 km2 , and has its roots in folklore and mythology (Tiwari 1994). It forms a straight cylindrical bole, and among the most important timber trees in forestry plantations. Though, the Chir Pine was in the Himalayas since time immemorial, its mass-scale regeneration was promoted for resin tapping in the British period (Rawat 1991). Its non-palatability, drought tolerance, fast growth and early-successional nature promotes its preponderance in inhospitable area where other broadleaf species such as Oak (Quercus spp.) does not grow (Singh and Singh 1992). Pine trees are also important as a source of valuable resin extracted from its bole. India ranks 6th position among the top ten resin producing countries of the world (Coppen and Hone 1995). In Uttarakhand about 7-8 Mg resin is collected every year costing @ Rs. 6000-7000 per 100 kg. Resin yields an essential oil on distillation, turpentine, and non-volatile rosin which is used in pharmaceutical preparations, perfume industry, disinfectants, insecticides, denaturants, and in adhesives, paper, rubber, soap, cosmetics, paint, varnish, rubber and polish industries. Resin is used by local people for medicare against boils, swellings and cramps, and mature bole is used as torchwood. The seed is edible and produces edible oil. The thick and soft bark is easily carvable to make useful decorative items. Pine cones are also used as decorative items, and leaves are extensively used to make brooms, thatching roofs and making cattle-bed and FYM. In spite of all these utilities, Pine forests are accused for voracious use of soil water leading to drying up of streams and springs and suppress floral diversity of forest floor (Joshi and Negi 2011).

Table 1: An assessment of economic loss due to forest fire at a few sites in Pine forests of Kosi, Almora.

Forest parameters / products	Quantity / ha		Cost estimate (Rs./ha)	
	Unburnt forest	**Burnt forest**	**Unburnt forest**	**Burnt forest**
Plant species richness Trees Shrubs Herbs	 3 8 10	 1 0 6	 - - -	Rs. 14,400.00 for 9.6 ha (@ Rs. 1500/ha as per Forest Dept. rates)
No. of shrubs / ha No. of herbs/ha	2420 146 x 10^3	0 73x10^3	-	
Tree seedlings / ha Tree saplings / ha	16200 4200	0 0	- -	
Herb / grass biomass (t/ha)	2.9	0.72	2910.0 (Rs. 27936 for 9.6 ha area of Campus)	720.0 (@ Rs. 1/kg of green weight sold locally in the region)
Ethnobotanically important species	6 (Shrubs) 6 (Herbs)	0 4	Many of these species are edible and have medicinal value and used locally for various uses but they are not sold in the market hence cost could not be assigned (Annex. II).	

Utilization of Pirul for making multiple products under NMHS Project

Under the NMHS funded project (2016-17 to 2019-2020) in eight villages of Hawalbagh block of District Almora (Uttarakhand) 216 people (170 men & 46 women) were trained on preparation of bio-briquettes from Pirul. Of these 80 people made bio-briquettes and earned Rs. 35,000/- in the Financial Year 2016-17 by selling these locally in Almora town. To prepare bio-briquettes Pirul is burned in a pit under anaerobic condition by covering the pit with tin sheet and sealing the air passages using soil. The Pirul is left burning overnight in the pit and charcoal is taken out. On an average 1 quintal Pirul produces about 24 Kg. charcoal. This charcoal is now mixed with sieved soil in 8:2 ratio by adding water and this material is now filled in an iron mould and then turned around on cement floor / or wooden base and the bro-briquette is left for sun drying for about 2 days. It is now ready for use in a locally fabricated wood stove. One bio-briquette weighs about 750-800 g and burns for about 90 minutes that is sufficient for cooking one-time meals for an average family and also warms the house during winter. Chemical composition of bio-briquette was determined as 0.62% Nitrogen, 6.77% Hydrogen and 0.031% Sulphur. Also, total moisture (25.6% by mass), volatile matter (38.5% by mass) ash content (60.3% by mass), fixed carbon (1.1% by mass), gross calorific value (2500 kcal/kg on dry basis) were reported in the biobriquettees (Shriram Institute for Industrial Research, Delhi). In addition, various decorative items were made out of Pine tree parts such as bark and cones. Pirul is also utilized for preparing check dam to check rainwater-runoff generated soil erosion and stabilizing the gully erosion on hill slopes.

Conclusion

The foregoing document proves that the Pine Unit established at RTC of GBP-NIHE under the NMHS Project can be continued utilizing the Pirul available in the Institute Campus annually (~ 50 t). This Unit established in 2016-17 so far produced 3950 items (file covers, folders, carry bags, envelopes, marriage cards, bio-briquettes etc.) on demand from ICAR-VPKAS, Ajivika, Distt. Judge Office, Almora and MoEF&CC, New Delhi, and earned Rs. 39,000. In addition, 4000 bio-briquettes and 250 file cover etc. are in our stock now for ready use. This activity has been particularly rewarding in terms of avoiding the likelihood of forest fire in the vicinity of the project area (Hawalbagh Block of Almora Distt.), employment generation and environmental awareness among rural people, particularly women, and appreciated at various levels of stakeholders including MoEF&CC. The Pirul (raw material required for making these products) is annually available in the Campus during summer (April-June) is sufficient for making 1,27,000 file covers or alternatively to make similar quantity of bio-briquettes. At the moment one file cover is costing us Rs. 22 and one bio-briquettes Rs. 5.45. The bio-briquettes were sold @ Rs. 8-10/unit by a partner NGO Mahila Haat at Almora. In the market file covers are available @ Rs. 15/- These environment-friendly products are in much demand in various Govt. offices in Almora and with the advisory of MoEF&CC to State Govt. Offices the file covers can be purchased by these offices. In this endeavor although conventional cost: benefit of this activity may not be beneficial initially but it will be rewarding in terms of reducing the likelihood of forest fire in the nearby Pine forests and within the Institute Campus thus avoiding the loss to forest wealth and biodiversity and contributing to environmental conservation.

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Annexure Table I: List of flora found at unburnt and burnt plots of Pine forests in Almora

S. No.	Tree spp.	Un-burnt	Burnt	Shrub spp.	Un-burnt	Burnt	Herb spp.	Un-burnt	Burnt
1	*Pinus roxburghii*	+	+	*Berberis* sp.	+	-	*Ajuga* sp.	+	+
2	*Pyrus pashia*	+	-	*Discorea* sp.	+	-	*Anaphalis* sp.	+	-
3	*Celtis australis*	+	-	*Lantana camara*	+	-	*Carex* sp.	+	+
4				*Pyracantha crenulata*	+	-	*Cynodon dactylon*	+	-
5				*Rubus ellipticus*	+	-	*Desmodium* sp.	+	+
6				*Solanum torvum*	+	-	*Galium aprine*	+	+
7				*Urena lobata*	+	-	*Geranium* sp.	+	+
8				*Ziziphus jujube*	+	-	*Rumex* sp.	+	-
9							*Tagetes* sp.	+	+
10							*Trifolium* sp.	+	+

Annexure Table - II: Tree, shrub and herb layer characteristics of burnt and unburnt plots in Pine forests of Almora

S. N.	Tree sp. (40 Quadrates)	Un-burnt Density ind. /ha	Burnt Density ind. /ha.	Sapling density ind./ha.		Seedling Density ind./ha		Shrub sp. (80 Quadrates)	Un-burnt Density ind. /ha.	Burnt Density ind. /ha.	Herb sp. (120 Quadrates)	Un-burnt Density ind. /ha.	Burnt Density ind. /ha.
				Un-burnt	Burnt	Un-burnt	Burnt						
1	*Pinus roxburghii*	1120	940	2400	0	11800	0	*Berberis sp.*	320	-	*Ajuga sp.*	11333	14667
2	*Pyrus pashia*	0	0	1800	-	4000	-	*Discorea sp.*	140	-	*Anaphalis sp.*	23000	0
3	*Celtis australis*	0	0	-	-	400	-	*Lantana camara*	1220	-	*Carex sp.*	55333	49000
4								*Pyracantha crenulata*	40	-	*Cynodon dactylon*	17000	0
5								*Rubus ellipticus*	280	-	*Desmodium sp.*	333	667
6								*Solanum torvum*	240	-	*Galium aprine*	3333	2000
7								*Urena lobata*	140	-	*Geranium sp.*	4333	667
8								*Ziziphus jujube*	40	-	*Rumex sp.*	3000	0
9											*Trifolium sp.*	23333	5667
10											*Tagetes sp.*	6000	0
	TOTAL	1120	940	4200	0	15200	0		2420	0		146998	72688

Annexure Table III: List of flora found in Pine forests of GBP-NIHE Campus in June-July, 2020

S. No.	Tree sp.	Shrub	Herb
1	*Alnus nepalensis*	*Agave americana*	*Anaphalis sp.*
2	*Bauhinia sp.*	*Artemisia sp.*	*Barleria sp.*
3	*Bombax ceiba*	*Asparagus sp.*	*Carex sp.*
4	*Celtis australis*	*Berberis sp.*	*Cynodon dactylon*
5	*Cupressus torulosa*	*Discorea sp.*	*Desmodium sp.*
6	*Grevillea robusta*	*Eupatorium adenophorum*	*Galium aprine*
7	*Melia azedarach*	*Indigofera tinctoria*	*Geranium sp.*
8	*Pinus roxburghii*	*Lantana sp.*	*Impatiens sp.*
9	*Pittosporum sp.*	*Pyracantha crenulata*	*Panicum sp.*
10	*Prunus cerasoides*	*Rhus sp.*	
11	*Pyrus pashia*	*Rubus ellipticus*	
12	*Q. glauca*	*Urena lobata*	
13	*Quercus leucotrichophora*		
14	*Toona ciliata*		

Annexure Table IV: Tree, shrub and herb layer characteristics of Pine forests of GBP-NIHE Campus, Kosi-Almora

S. No.	Tree sp. (25 Quadrates)	Tree Density (ind. /ha.)	Sapling Density (ind./ha)	Seedling Density (ind./ha)	Shrub sp. (50 Quadrates)	Density (ind. /ha.)	Herb sp. (75 Quadrates)	Density (ind. /ha.)
1	*Alnus nepalensis*	33	0	0	*Agave americana*	60	*Anaphalis* sp.	5444
2	*Bauhinia* sp.	66	66	233	*Artemisia* sp.	0	*Artemesia* sp.	0
3	*Bombax ceiba*	33	67	0	*Asparagus* sp.	33	*Asparagus* sp.	0
4	*Celtis australis*	200	167	800	*Berberis* sp.	353	*Barleria* sp.	3000
5	*Cupressus torulosa*	133	0	0	*Discorea* sp.	7	*Carex* sp.	19667
6	*Grevillea robusta*	133	133	33	*Eupatorium adenophorum*	153	*Cynodon dactylon*	5333
7	*Melia azedarach*	67	167	233	*Indigofera tinctoria*	0	*Desmodium* sp.	4333
8	*Pinus roxburghii*	5100	133	6367	*Lantana camara*	27	*Galium aprine*	7111
9	*Pittosporum* sp.	0	133	67	*Pyracantha crenulata*	120	*Geranium* sp.	2556
10	*Prunus cerasoides*	0	0	33	*Rhus* sp.	33	*Impatiens* sp.	3000
11	*Pyrus pashia*	733	1167	2100	*Rubus ellipticus*	393	*Indigofera* sp.	1667
12	*Q. glauca*	700	167	100	*Solanum torvum*	0	*Panicum* sp.	4555
13	*Quercus leucotrichophora*	1333	1233	1567	*Triumpfetta* sp.	13		
14	*Toona ciliata*	0	67	67	*Urena lobata*	20		
Total		**8533**	**3533**	**11600**	**Total**	**3640**	**Total**	**56,666**

Annexure Table V: Ethnobotanical uses of shrub and herb species found in the Pine forests of Almora

Species	Medicinal/Ethno botanical uses/ Edible value
Berberis aristata (Indian Barberry or Tree turmeric) - Shrub	Antibacterial, antiperiodic, antidiarrheal & anticancer; also used in treatment of ophthalmic infections. Its root, stem, leaves are used extensively in Aurveda fruits rich source of Vitamin C. Root bark rich in barberine & isoquinoline alkaloids those are anti-fungal, anti-bacterial, anti-oxidant, anti-viral, anti-diabetic, anti-tumor and anti-inflammatory in nature. products such as Madhu mehantak Churna (type 1 & 2 diabetes). Daruhaldi powder 100 g Rs. 400/- Maintains blood glucose level.
Pyracantha crenulata (Indian hawthorn)- Shrub	The leaves are found useful for antioxidant, immuno-modulatory, anti-inflammatory activities and also use to make herbal tea. The fruit has been used in Garhwal folk and traditional medicine in the treatment of heart disorders, hypertension, diabetes, blood pressure and circulation system especially in case of angina. The food substances used as nutraceuticals contain antioxidants, minerals, vitamins, prebiotics, probiotics, polyunsaturated fatty acids certain phytochemical and dietary fibers. The powdered, dried fruit, combined with yoghurt, is used in the treatment of bloody dysentery. A combination of Ginkgo and Pyracantha leaves are a tonic to mind. The stem bark is useful in fevers especially malaria. It is rich is beta-carotene, iron, potassium, and anti-oxidants.
Rubus ellipticus (Yellow Himalayan raspberry) - Shrub	Bark of this plant is mainly used as renal tonic and antidiuretic. Juices used to treat cough, fever, colic and sore throat. Juice of the root is used in treatment of fever, gastric troubles, diarrhea & dysentery, colic. A renal tonic & antidiuretic. Annual yield of plant about 750 g from a plant occupying 2.5 m2 fruit. The fruit contains about 10.9% sugars, 1.1% protein, 0.5% ash, 0.55% pectin fruits good source or micro nutrients such as anthocyanin, phenols, flavonoids & Vitamin C. Fruits also used as natural dye, bush has good soil erosion control valve.
Zizyphus jujube	Delicious fruits increase weight, stamina and improves muscular strength. In Chinese medicine, it is prescribed as a tonic to strengthen liver function. Its functions as antidote, diuretic, emollient and expectorant. The dried fruits are anodyne, anticancer, pectoral, refrigerant, sedative, stomachache, styptic and tonic. Help in purify the blood and aid digestion. They are used internally in the treatment of chronic fatigue, loss of appetite, diarrhea, anemia, irritability and hysteria. It is used internally in the treatment of palpitations, insomnia, nervous exhaustion, night sweats and excessive perspiration. The root is used in the treatment of dyspepsia, fevers, root powder for old wounds and ulcers. The leaves are applied as poultices and are helpful in liver troubles, asthma and fever. The fruit is very nutritious with potassium, phosphorus, calcium and manganese and also is rich source of Vit- C and Vit- B complex and anti-oxidant content of fresh fruits is high.
*Solanum torvum (*Wild Eggplant) - *Shrub*	The green fresh fruits are edible and used in certain Thai curries or raw in certain Thai chili pastes and incorporated into soups and sauces. In Tamil Nadu, the fruit is consumed directly, or as cooked food like Sundaikkai Sambar, Poriyal, Aviyal & Pulikulambu after soaking in curd and drying the fruit is fried in oil. In siddha medicine its Choornam is used to improve digestion. Its berry contains a number of potentially pharmacologically active chemicals including the sapogenin steroid chlorogenin. Extracts of the plant are reported to be useful in the treatment of hyperactivity, colds and cough, pimples, skin diseases, and leprosy. Methyl caffeate, extracted from the fruit of S. torvum, shows an antidiabetic effect in streptozotocin-induced diabetic rats.
Ajuga parviflora (Herb)	Leaf extract is used as a remedy for acne, pimples, stomach disorders, ear and throat infections. It is credited with astringent, febrifugal, stimulant, aperients, tonic, diuretic and depurative properties.
Cynodon dactylon (Couch grass) - Herb	This species is used as a laxative, coolant, expectorant, carminative and as a brain and heart tonic. In homeopathy it is used in treating all types of bleeding and skin troubles. In traditional medicine it is used for indigestion and the treatment of wounds. This grass is very easy to grow and it can be used in erosion control. In the garden as a lawn grass and even for farm pastures. While it does not produce much bulk, its feeding value is high and it grows fast.
Geranium spp.	Many species of the genus are used in the treatment of various ailments such as renal disorders, fever, itching, eczema, wound, toothache, otorrhoea, opthalmia, liver troubles, ulcers, headache, jaundice etc. Some species of Geranium has shown biological activity like hypertensive, mild astringents, diuretics, hepatoprotection, antioxidants, anti-inflammatory and antiviral. Geranium spp. also are used as a remedy for tonsillitis, cough, whooping cough, urticarial, dysentery, kidney pain and gastrointestinal disorders.