Journal of Bioresources 7(1): 11-21 (2020)
Print: ISSN 2394-4315
Online: ISSN 2582-2276

Original Research Article

Tapping of Resin from *Pinus roxburghii* Sargent in West Kameng District of Arunachal Pradesh (India)

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Received: December 2, 2019; revised: February 12, 2020; accepted: February 15, 2020

DOI: 10.17605/OSF.IO/UQ46J

Abstract: India has been tapping resin from chir pines since many years. However, the production has declined since 1975-76 due to increased frequency of extraction and impact on the health of the trees. Presently, there is deficit in the market demand of resin leading to import from the neighboring countries. Large-scale tapping of resin was reported from West Kameng district before the ban imposed by the Supreme Court of India in 1996. Since then the cases of resin extraction has slowed down but not completely stopped in the district. The present study has been carried out with the objective to understand the status of chir pine trees in the natural condition as well as the impact of resin tapping on health of the trees if any. A phytogeographic survey with handheld Global Positioning System was carried out and 173 chir pine trees were recorded from the study area. The interactions and interviews with the villagers revealed that almost all the matured trees have been used for tapping of resin during the past. It was observed that most of the trees bear the footprints of resin extraction process and are unhealthy compared to the other trees. Moreover, extraction of timber, house building materials and furniture works by the local inhabitants are also posing threats to the tree. Hence, the study suggests imparting awareness and training to the local people for standard procedures of resin tapping. Also keeping in view the multiple utility of the tree its conservation is of utmost importance.

Key words: Chir pine, Conservation, Habitat characteristics, Ethnic uses, Resin

Introduction

Pinus is the most common genus of the family Pinaceae and the largest family within the coniferales. It is a large genus with over 110 species worldwide (Richardson and Rundel, 1998). According to Little and Critchfield (1969) the genus is divided into two subgenera: Strobus (Haploxylon, soft pines) and Pinus (Diploxylon, hard pines). Pines occupy a wide range of habitats from the arid plateaus of western North America, the mountains of Mexico and Central America, to the tropical lowlands of the Caribbean. They also cover large areas across Eurasia into the mountains and tropical lowlands of eastern Asia (Mirov, 1967). Pines are the primary source of resin although other conifers and some broadleaf trees are also commercial resin sources. As per records, more than 80 species of pine trees are tapped for the production of resin throughout the world. About 90% of the resin is produced from five pine species namely *P. massoniana*, *P. yunanensis*, *P. elliottii*, *P. caribaea* and *P. merkussii*. However, *P. kesiya*, *P. oocarpa*, *P. pinaster*, *P. roxburghii* and *P. tabuleiformis*, are also tapped for the production of resin. China, Brazil and Indonesia together produce more than 90% of the pine resin in the world. The other producers includes India, Argentina, Mexico, Nepal, Russian Federation, Portugal, Spain, Cuba, Vietnam,

Madagascar, Fiji, Honduras, South Africa, Colombia, Malaysia and Uruguay. Pierre Hugues (around 1850) developed the first pine resin tapping technique in France. Afterwards, Steele (1869) was granted US patent for fish bone tapping technique. Later, this technique was modified by Mazek (1950) which came to be known as Rill Method. Presently there are four tapping techniques applied for the production of pine resin. The "Chinese method" applied in China and South East Asia. The "American method" used in South America and Europe. The "Hugues method" used in Indonesia and Mexico and the "Mazek or Rill method", mainly used in India.

In the sub-tropical parts of Indian sub-continent, pine forests are found in Bhutan, North India, Kashmir, Nepal, Pakistan, Sikkim, and southern parts of Tibet with altitudes ranging between 400 and 2500 m (Naithani, 1984; Tiwari, 1994). According to Gamble (1902) five species of pines are indigenous to India viz. *P. roxburghii* (Chir pine), *P. wallichiana* (Blue pine), *P. kesiya* (Khasi pine), *P. gerardiana* (Chilgoza pine) and *P. merkussi* (Teriasserian pine).

Pinus roxburghii Sargent (family: Pinaceae) commonly known as chir pine, is a tall tree with a spreading crown which yields the highest amount of oleoresin in India. The chir pine forests are found in Jammu and Kashmir, Haryana, Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh, West Bengal and parts of Sikkim with an estimated total area of 8, 90,000 hectares. Uttarakhand, Himachal Pradesh and Jammu and Kashmir are major resin producing states of India (Coppen and Hone, 1995). It is found at the height of 500 to 2,500 m above sea level and grows gregariously (Khan *et al.,* 2012). Most Pinus species bleed when the stem wood (xylem) is cut or otherwise injured. Crude resin obtained by tapping living chir pine trees is a thick, sticky, but usually, still fluid material. Resin is obtained from the tree in a manner analogous to rubber tapping. The resin is tapped commercially for rosin and turpentine production. Rosin is the major product obtained from pine resin. It is graded and sold on the basis of colour, the palest shades of yellow-brown is the better quality. It is used in paper manufacturing and sizing, chemicals and pharmaceuticals, synthesis of ester gums, synthetic resins, paint, varnishes, printing inks, soap, rubber, surface coatings, floor coverings, adhesives, plastics, etc. Turpentine is a clear, flammable liquid, with a pungent odour and bitter taste. It is a mixture of organic compounds, mainly terpenes and its composition can vary considerably according to the species of pine from which it was derived. Turpentine oil is mainly used as a solvent in industries and has medicinal qualities as well (Coppen and Hone, 1995).

Pine trees naturally grow in Arunachal Pradesh and the local inhabitants use different parts of the plant for various purposes. The houses are mostly constructed with the help of the timber extracted from the plant. Besides, the resin is also ethnically used in different socio-cultural occasions by the people. Nafra Chemical Private Limited (NCPL) played a central role in storing and supplying the extracted resin from the peripheral areas of the district. The extraction of resin was mostly concentrated in Nafra and Bichom areas. In other circles like Bomdila and Rupa, the local people use pine trees for timber, firewood, floor, roof (the leaves), and to tie the Holy flags. The extraction of oil continued for many years resulting into loss of forest cover in general and deep impact on the chir pines in particular. Therefore, the paper attempts to understand the extraction process of resin and its impact on chir pine trees. It also seeks to suggest conservative measures for sustainability of this important plant.

Materials and methods

Study area

West Kameng district is approximately located in between 91° 30' to 92° 40' east longitudes and 26° 54' to 28° 01' north latitudes. The district shares a long international boundary with Bhutan in the West, state boundary with Assam in the south and district boundary with Tawang in the northwest and East Kameng in the east (Fig. 1). It covers a total geographical area of 7,422 km^2 accounting to 8.86% of the total geographical area of the state of Arunachal Pradesh. Five major tribes constitute the population of the study area viz. the Monpas, Miji (Sajolang), Sherdukpen, Aka (Hrusso), and Khowa (Bugun). The altitude ranges in between 198 to

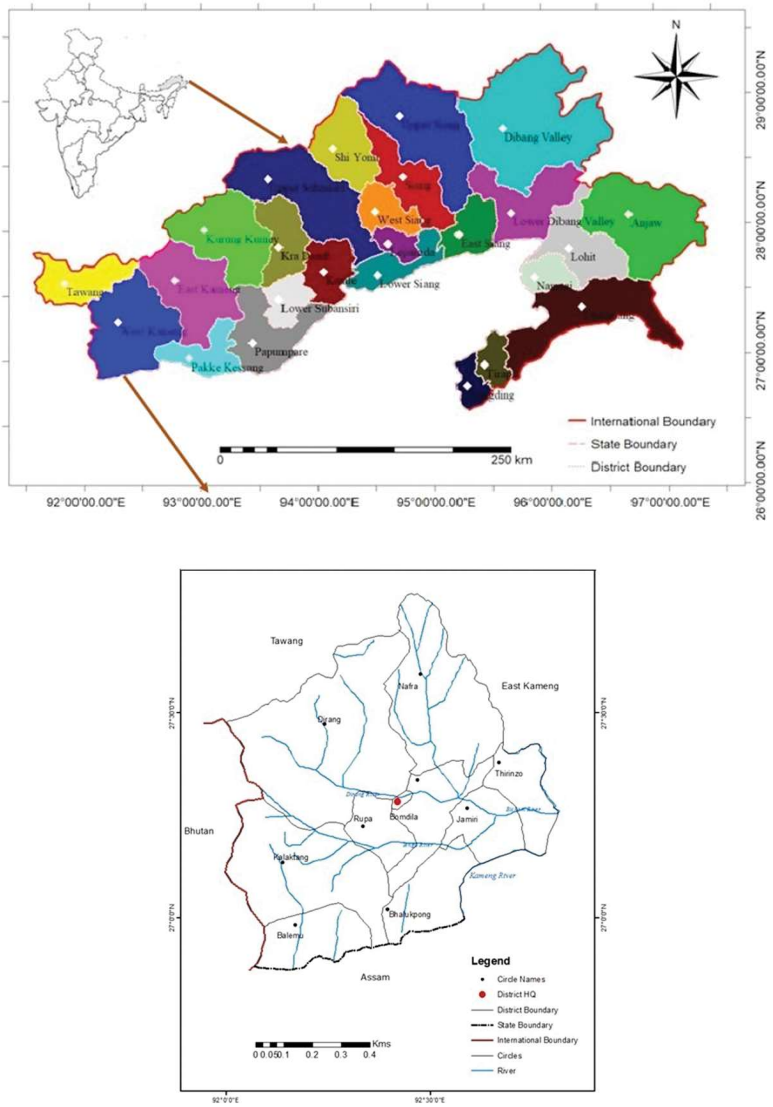

Fig. 1. Location map of the study area.

4,180 m. Three principle mountain ranges are Sela range, Bomdila range and Chaku range or the foothill range. The Kameng river, a tributary of the mighty Brahmaputra flows through the district. Tenga, Bichom and Dirang Chu are other major rivers that flow through the district. The area experiences tropical monsoon climate in general but climatic variations are visible within short distances due to the topographical variation. Climatic condition varies from mesothermal climate to alpine climate with the varying elevation. The study area receives most of its rainfall in the months of June and July, which are also recorded as the warmest months. The winter is generally cold and dry. The central and northern parts of the district experiences snowfall in the months of December and January. The district is home to wide variety of flora and fauna with vast potential of tourism industry.

Data sources

The study has been carried out using both primary and secondary data. Primary data has been collected through field survey, observations, interviews and interaction with the local people. The information on tapping of pine resin has been collected from the office of the Principal Chief Conservator of

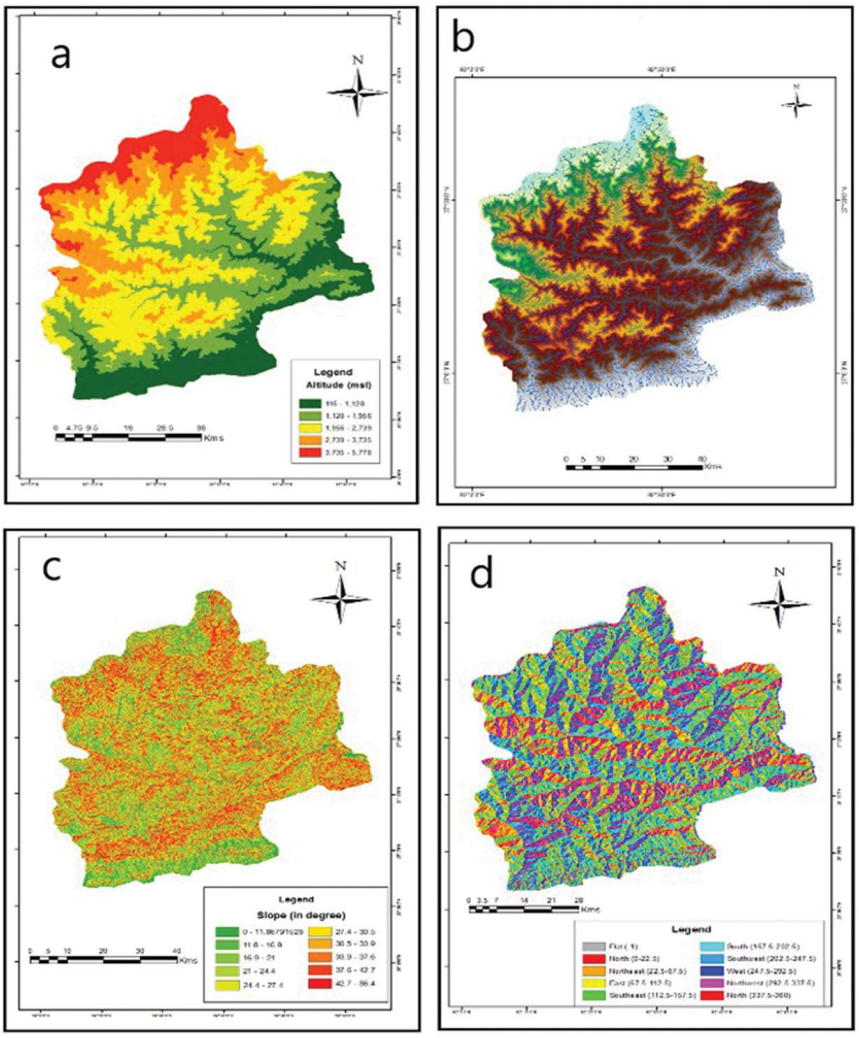

Fig. 2(a-d). a. Altitude map of the study area. b. Drainage map of the study area. c. Slope map of the study area. d. Aspect map of the study area.

Forest (PCCF), Dept. of Environment and Forests, Govt. of Arunachal Pradesh, Itanagar and Office of Divisional Forest Officers (DFO), Bomdila, Shergaon and Khellong Forest Divisions. The secondary data sources include research papers of journals, books, and state / district reports. Moreover, data from Meteorological Department of India and Geological Survey of India were also used in appropriate places. Advanced Spaceborne Thermal Emission and Reflection Global Digital Elevation Model from Earth Explorer has been used for deriving various thematic maps.

Field survey

A detailed Phytogeographic survey was carried out to locate the chir pine trees of the study area. Random line transacts were laid in selected sites with handheld Global Positioning System (GPS). On each plant location, the soil temperature, moisture and pH were recorded and soil samples were collected for texture analysis (Fig. 3). Relevant information was also collected through personal and open interview. The soil samples collected from the field were analyzed for texture following standard procedures in the laboratory. The collected GPS points from the field were entered into the MS Excel in Degree Minute Second format and converted into Degree Decimal format and saved in CSV format for the generation of point map. Meteorological data were also collected and appropriate diagrams were prepared for climatic information. Various thematic maps were generated using the ArcGIS software. The downloaded ASTER_GLOBAL_DEM has been

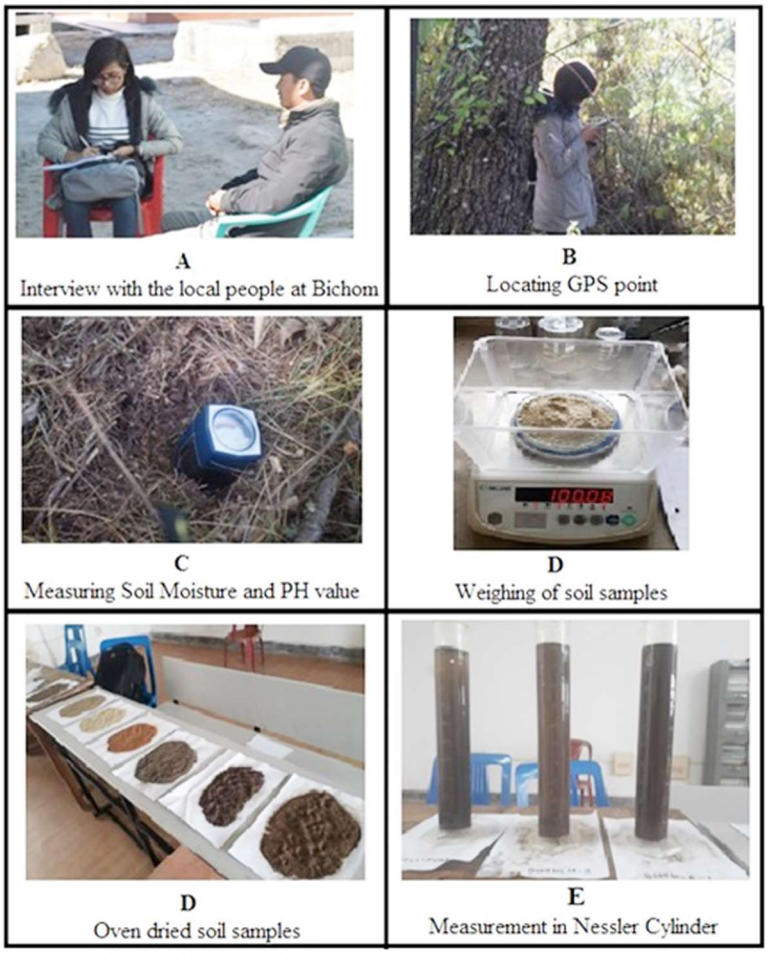

Fig. 3(A-E) Field activities and soil texture analysis.

used to create altitude, slope and aspect map. Further, the GPS points collected from the field were overlaid on top of the map of study area to show the routes undertaken for the field survey.

Results

A phytogeographic survey was conducted in the selected sites of the study area during the month of November, 2018. Line transact survey covering hundreds of kilometers in the deep jungles with handheld GPS in the selected sites recorded a total of 173 *Pinus roxburghii* (chir pine) trees.

Habitat characteristics

The distribution of chir pine trees is largely affected by various environmental factors such as physiography (altitude, slope, aspect, drainage etc.), climate (temperature, rainfall and humidity), soil (soil texture, pH, moisture content, etc.), anthropogenic factors (land use, deforestation, grazing, burning, clearing of land for agriculture, etc.). The altitude of the study area ranges in between 115 to 5,778 m asl (Table 1 & Fig. 2a). Altitude has direct impact on plant distribution. The density of chir pine was found high in the altitudinal range of 1000-2000 m whereas it was sparse in the altitude above 3,000 m. The trees were also healthy and large in girth size in the altitudinal range of 1000-2000 m. The trees were found both in steep and gentle slopes. Although, slope steepness and gentleness have considerable effect on distribution of trees, the trees were also located in these extremes (Table 1 & Fig. 2c). The trees grow well even in steep slopes despite of having huge girth due to its strong roots that can go down below up

Table. 1. Habitat characteristics of West Kameng district

Parameters	Category	Area (km^2)	Area (%)	Source
Altitude (m)	<600	357.83	7.14	DEM Processing
	600-1200	529.47	10.57	
	1200-1800	874.23	17.45	
	1800-2400	1144.35	22.84	
	2400-3000	1012.84	20.21	
	3000-3600	480.09	9.58	
	3600-4200	337.72	6.74	
	4200-4800	229.67	4.58	
	4800-5400	42.92	0.86	
	>5400	1.36	0.03	
	Total	5010.47	100.00	
Slope (degree)	<10	306.29	6.11	DEM Processing
	10-20	981.07	19.58	
	20-30	1786.73	35.66	
	30-40	1491.70	29.77	
	40-50	388.78	7.76	
	>50	55.90	1.12	
	Total	5010.47	100.00	
Slope aspect	N	607.29	12.12	DEM Processing
	NE	601.48	12.00	
	E	615.93	12.29	
	SE	764.84	15.26	
	S	730.53	14.58	
	SW	645.84	12.89	
	W	517.51	10.33	
	NW	527.03	10.52	
	Total	5010.47	100.00	
Land use / Land cover	Agriculture	326.28	6.51	Image Processing
	Alpine Forest	353.08	7.05	
	Brok / Grassland	170.87	3.41	
	Built-up area	32.59	0.65	
	Cloud	38.44	0.77	
	Deciduous Forest	1045.64	20.87	
	Degraded Forest	675.91	13.49	
	Sand	3.82	0.08	
	Shadow	371.62	7.42	
	Snow	122.57	2.45	
	Sub-Tropical Forest	421.14	8.41	
	Temperate Forest	1126.28	22.48	
	Tropical Forest	315.26	6.29	
	Water Body	6.98	0.14	
	Total	5010.47	100.00	
Rainfall (mm)	<2000	81.10	1.62	Point Interpolations
	2000-2200	1953.80	38.99	
	2200-2400	1648.96	32.91	
	2400-2600	1062.72	21.21	
	>2600	263.89	5.27	
	Total	5010.47	100.00	

Temperature (° C)	<12	18.16	0.36	Point Interpolations
	12-14	518.10	10.34	
	14-16	3284.19	65.55	
	16-18	1035.51	20.67	
	18-20	154.51	3.08	
		5010.47	100.00	

Table. 2. Soil moisture, pH and texture of sample sites

Sites	Clay (%)	Sand (%)	Silt (%)	pH	Moisture	Texture
Chillipam	16.67	33.33	50	6.8	1	Loamy Soil
Bomdila 1	46.15	23.07	30.77	7.1	1	Clay
Bomdila 2	23.07	46.15	30.77	6.7	4.4	Loamy Soil
Bichom 1	66.67	0	33.33	6.9	1	Clay
Bichom 2	16.67	55.55	27.78	6.9	1	Sandy Loam
Nafra	25	37.5	37.5	7	1	Loamy Soil
Champaching	10	70	20	6.9	1.5	Sandy Loam

Source: Field survey, 2018.

to 10 meters. Because of its strong roots it is planted in many sites to prevent soil erosion. Being situated in the northern hemisphere, the south and south-east facing slopes receive more sunlight than the north facing slopes. The north-east facing slopes receives slight amount of sunlight but for short duration. Majority of the trees were found in the south-east slopes (Table 1 & Fig. 2d). Maximum temperature and precipitation occurs in the month of July while the lowest is recorded in the month of December and January. July and August are the warmest months. The temperature starts rising from the month of March and begins to fall from the month of October. The recorded annual precipitation is comparatively low. The southern part of the district receives more than 60% of the rainfall in the months of June to September. The district experiences winter precipitation during October to December. The precipitation pattern changes from south to north with decreasing rainfall as altitude increases. From the month of November to January precipitation (mostly snowfall) occurs in the northern parts. The humidity is high throughout the year except the winter months. The soil type of the district varies from place to place. Generally, Pine trees prefer moderate to strong acidic soil where the moisture content is low. The collected soil samples of the study sites show different pH, moisture and texture. However, the collected soil samples show neutral pH ranging in between 6.8 to 7.1 The moisture content was low i.e. 10 to 44%. Most of the soil samples show loamy and sandy loamy texture (Table 2). Hence, the habitat characteristics of the area were found suitable for the natural growth of the plant.

Tapping of pine resin

Pine trees are common source of economic value for the local people. They are dependent on the extraction and selling of the products of pine trees thereby it is associated with their livelihood. About 70 % of the villagers are dependent on the business of pine trees. The resin extracted from the tree has commercial value in the market. Hence, extraction of resin is in full fashion thereby affecting the status of the trees in the wild. The resin is extracted by rill method. The trunks of the trees are carved into a pattern of arrow and acid is applied for early release of the resin. A small cup is attached on the lower side for collection of the oil. NCPL is the main buyer of the oil that is extracted from the tree. Many people are engaged in extraction of resin from chir pine which is supplied to NCPL and further to Assam for making of turpentine. According to the villagers, the best season for extraction of resin is June and July. They also revealed that the amount of oil extraction from a tree is very low and involves more time. The NCPL

buys the oil in Rs. 1150 per 100 kg whereas for extraction of 100 kg of resin at least 30 pine trees are needed because a tree gives ½ liter of resin in a week. As per reports large-scale tapping of pine was carried out in West Kameng district from 1993-94 to 2006-07. The mean average harvest was 232855.6 blazes with mean revenue of Rs. 31.50 lakhs. However, the temporal pattern of harvest of the species has shown a declining trend for quantity harvested over the years. The Nafra area reported maximum extraction of Pine trees. Almost all the Pine trees in the forests reflect the imprints of resin extraction during the past. Some trees have more than two imprints of resin extraction. Consequently, some of the trees have dried up and died in the process. Also application of over dose of acid on the barks and improper size of blaze resulted into death of trees in many places. In the absence of standard guidelines for recommended dose of acid and size of blaze and also lack of training and ignorance of the people such an erratic tapping of pine trees had taken place in the study area.

Ethnic uses of pine trees

The local people are dependent on the forest resources in terms of many aspects like food, timber, wood etc. The interviews and interaction with the villagers reveal a strong linkage of the people with the utilization of pine trees. They have developed an intricate relationship with the pine trees and their socio-cultural life deeply reflects the imprints of such relationship. According to the villagers, the pine forest and the pine trees remain untouched by them during the olden days. The tree or the leaf is only used when it falls or some natural factors cause to bring it down. However, during the field survey large-scale extraction of timber was observed. They consume the seeds and widely use it in making planks for house construction. Pine woods are used for different purposes such as carpentry, furniture, wall paneling and fuel wood. The heartwood of pine tree is used for lighting of the street at night and ignition of firewood at home. Besides, they also use the tree for tying holy flags during religious festivals and dead of a person. The villagers expressed that conservation of pine trees is essential because their culture and tradition are linked to it.

Conservation

The increasing population and developmental activities like construction of roads and logging are increasing day by day in the study area. Besides, settlements in and around the pine forest are increasing which is causing increasing clearing of forests and felling of pine trees to meet their requirements. As pine trees are used for different purposes like food, timber, fuel wood, resin etc. the extraction rate of the trees is touching the skies. Hence, the future of pine trees in the study area is bleak and there is an urgent need of evolving strategies for conservation and regeneration. The continuous extraction of resin for more than 20 years from a particular tree has largely affected the health of the trees. Notable differences have been observed between the extracted and non-extracted trees. At the present rate of extraction the pine forests of the area may diminish within few decades. The local people lately realized the effects of such extraction on the health of the trees and informed that due to such effects some of the extraction sites have been closed down now. The younger generations of the area are also planning for closing down of all such extraction process for some years, so that the tree can be conserved and regenerated for future use.

The study area is inhabited by diverse ethnic people with diverse socio-cultural practices. The utilization pattern of pine trees is varied among the various ethnic groups. In some areas, the belief systems are associated with the minimal utilization of the trees whereas in some areas such systems are lacking. Moreover, there is lack of concrete policies and planning for conservation of pine trees. The observations during the field survey and interaction with the villagers revealed the prevalence of some good practices by the villagers. For example, in some villages people do not fell pine trees and use only the fallen trees. People are restricted from cutting of pine trees and prior permission from the village council is mandatory before cutting of trees. Therefore, the sound practices of the local people coupled with concerted efforts through awareness

and community participation are essential for conservation of such an important plant species. The local people who are dependent on such practices need to be encouraged for adopting alternative way of earnings like cultivation of fruits and vegetables.

Discussion

Chir pine generally occurs at lower altitudes than other pines in the Himalaya from 500 to 2000 m, occasionally up to 2300 m (Kaushik *et al.,* 2010), 500 to 2,500 m (Khan *et al.,* 2012), 450-2300 m (Sharma and Lekha, 2013). However, occurrence of the tree above the upper limit of altitude has been reported. In the present study also some sparse distribution of the tree has been located at 3000 m of altitude. The concentration of the tree does not depend upon the angle of the slope; it can grow even in very steep slopes due to its strong and noticeably long roots. Due to the hardness and resistance of the tree it prevents soil erosion processes in steeper areas. Chir pine prefers light (sandy) and medium (loamy) soils and can grow easily in nutritionally poor and unfertile land. It can grow in soils with acid, neutral and basic and even has adaptability to very alkaline conditions. It requires dry or moist soil and has tendency to tolerate prolonged drought conditions and can grow in both low as well as high light intensity landscape (Aeri, 2008). It prefers dry climate with mean annual temperature of 12-17° C and mean rainfall range between 25-200 mm. During the past 30 years similar climatic conditions have been observed in the study area. The dominance of the pine trees is strong as almost negligible associations of other plants were found in the chir pine forests.

In Pakistan, India and Nepal human intervention, mainly overgrazing, road construction, overexploitation for fuel wood and fodder, shifting cultivation and quarrying has resulted in significant reductions, up to 50% of the total area. The few larger blocks of remaining habitat are now found in Bhutan (Wikramanayake *et al.,* 2001). Resin has traditionally been foremost source of revenue for the government. A ripen tree of Chir pine produces about 4.30 kg resin in a year. Areas of natural and, more recently, plantation chir pine have been used in the northern states of Jammu and Kashmir, Uttar Pradesh and Himachal Pradesh. Crude resin production peaked at about 75, 000 tonnes in 1975-76 and has since fallen steadily. The main reason for the decline has been the loss of trees for tapping, either because many of them have reached the end of their productive lives and there are no new areas of pine with which to replace them, or because the damage done to trees by the use of inefficient, incorrectly applied methods of tapping has led to Forest Department bans on tapping (Coppen and Hone, 1995). A total of 7, 25,949.37 kg of pine resin were tapped from West Kameng district during 1993-94 to 2006-07 and a total of Rs. 394.54 lakhs was realized by the Forest Department by selling of pine resin during the same period (Saha, 2009). Apart from tapping of resin pine trees have been deforested for meeting the daily needs of the people. For instance, every year more than 4 million pine trees are deforested by villagers in Uttarakhand for the purpose of hays and tendril poles (Silori *et al.,* 2013).

The tree has multiple utility for human beings. The tree is used for various domestic and socio-cultural activities by the local people but they are not aware of the medicinal uses of the plant. The resin is administered orally to combat gastric troubles (Manandhar, 2002). It is also used as an inhaler for nasal and throat ailments and applied to boils, heel cracks and on either side of the eye to reduce swelling (Singh *et al.,* 1990; Rajbhandari, 2001). In soldering process, it is used to get rid of oxide compounds in the surface of metal, synthetic rubber and chewing gums (Wiyono *et al.,* 2006). Different parts of the plant are prescribed to treat cough, colds, influenza, tuberculosis, bronchitis, as antiseptic, diaphoretic, diuretic, rubefacient, stimulant and febrifuge (Chopra *et al.,* 1986; Puri, *et al.,* 2011). It is used as food (the seed); medicine (the turpentine) basically antiseptic used for kidney and bladder complaints (Orwa *et al.,* 2009). However, the local people are unaware of such medicinal importance of the tree.

The study recorded a good number of pine trees in the study area but, proper utilization of the available resources is essential for sustainable future. Owing to the ban on extraction of timber

by the Supreme Court of India in 1996, there has been decline in the rate of pine extraction in the study area. However, the imprints of high rate of resin and timber extraction from the area are still remarkable. The increasing population *vis-a-vis* settlements is also causing depletion of pine trees in the area. The interviews, interactions and observations reveal a strong linkage of the inhabitants with the pine trees. Pine trees are used for different purposes by the people such as food, house construction, rituals, marriage, fuel wood, timber, furniture, etc. The timber of the tree is very strong and good for building houses, due to which great amount of trees are cut down every year. Such multipurpose use and rapid extraction processes are causing threat to the trees.

No conservative measures have been undertaken for saving the pine forests by the people as well as from the Government side. In some areas, the villagers have framed community guidelines for conserving the pine trees. Some extraction sites have been also closed down for the regeneration of pine trees. The villagers have evolved a sustainable way of utilization of pine trees during the past but the introduction of business through timber and resin extraction has changed their attitude. Most importantly, the extraction of resin has caused deep impacts on the species. The extraction process which involves marking on the trunk and application of acid has degraded the health of the trees. Consequently, the trees had dried up and died with the passage of time. Very recently, another form of extraction has been introduced in the area which involves slicing of the pine trunks and collection of the oil bearing slices for supply to companies in Assam. This process has led to felling of thousands of pine trees in the area. Also the regular illegal logging is going on inside the deep forests and there are no regulatory measures to check such activities. Therefore, it is essential that the local people and the government agencies come together and develop strategies for sustainable utilization of pine trees in the area. In the absence of such measures and at the present rate of extraction the pine trees will diminish in very short period of time from now. Conservation of forest resources through community participation is a success story in many countries like Nepal (Maharjam, 2005) which needs to be raplicated in the study area or better future. The revival of traditional practices and indigenous knowledge system like the Aka tribes (Ninachow, *et al.*, 2011) that involves suchtainable way of utilization must be encourged while discouring the timber business. The government needs to take lead role in spreading awareness and suggesting alternatives to the people by inviting their participation. The healthy practices of some societies like Buddhist who attach religious importance to the trees will contribute greatly in conservation of such important resources.

Acknowledgements

Authors are thankful to the Department of Geography, Rajiv Gandhi University for providing necessary infrastructure to carry out the work. Authors are also thankful to the respondents of the study area for cooperating in sharing the information related to tapping of pine resin.

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