Journal of Forest Research: Open Access

OPEN ACCESS Freely available online

Review Article

A Review on Dendrochronological Potentiality of the Major Tree Species of Nepal

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ABSTRACT

Several researches related to dendrochronological field are carried out in Nepal. Silvicultural characteristics, distribution, associated species, climatic response of the species are very essential to understand the nature of species before conducting dendrochronological research. The objective of this research is to assess the dendrochronological potentiality of the major tree species so far studied in Nepal. For this, we have used Google engine to search published articles through March 2020 and listed out the name of the species used so far for the dendrochronological studies in Nepal. We were able to record the species *Abies pindrow*, *Abies spectabilis*, *Betula utilis*, *Cedrus deodara*, *Cupressus torulosa*, Larix potaninii, *Picea smithiana*, *Pinus roxburghii*, *Pinus wallichiana*, *Rhodendendron campanulatum*, *Tsuga dumusa* and *Ulmus wallichiana* from the published research articles and review articles till March 2020. We have also accessed why the dendrochronologist has chosen these species for their research in Nepal. It was found that most of them are Himalayan conifers and have climatic signals with clear annual tree rings which can be easy to date with each other.

Keywords: Annual rings; Tree species; Silvi-cultural characteristics; Climatic response

INTRODUCTION

The distribution range of tree species is known to better understand the growth-climate relationship for the proper management and conservation against the adverse effects of climate change [1]. In recent years, climate-changing patterns directly influence on the environment and its component significantly. The global average temperature has increased by more than 1.3°F over the last century [2] and has projected to increase worldwide by 2°F to 11.5°F by 2100 [3]. This changing climate affects all the ecosystem and landscape especially, the Himalayas are the most affected ecosystem because of the increasing rate of temperature on these regions are significantly higher than another ecosystem [2,4]. So, Himalayan ecosystem is considered as the indicator of climate change and its impact [5]. Several studies and observations on the Himalayan region have concluded that due to an adverse effect of climatic parameters the different species are shifting towards the higher altitude than that found originally [6,7]. Vegetation found in this region is more sensitive to temperature rather than the availability of moisture and hence they are reflecting the significant response on the global warming phenomenon [8,9].

There are few ways to understand the dynamics of the climatic condition and cite relevant literatures for them. The dendroclimatology is one of the most widely accepted and scientific methods [10,11], various types of plants and trees can be used for such type of study but conifers are the most suitable species to determine the climatic response on high altitude region [7,12].

For such type of study tree ring analysis is the best and easier way to determine the growth and climatic condition in the past. Any tree or shrub species that could meet the requirements of producing the distinguishable rings for most years, the ring features that can be cross-dated dendrochronological and attaining the sufficient age to provide the time control required for particular investigation can be used for the dendrochronological study [13]. Therefore, the objective of this research is to enlist and give brief information on the major dendrochronological potential species so far studied in Nepal.

METHODOLOGY

Various published research articles and review articles published before March 2020 are the major source of data for this study. We search through Google Scholar and Research Gate to collect more published information in the various disciplines of

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Received: April 21, 2020, **Accepted:** May 27, 2020, **Published:** June 03, 2020

Citation: Gautam D, Basnet S, Karki P, Thapa B, Ojha P, Poudel U, et al. (2020) A Review on Dendrochronological Potentiality of the Major Tree Species of Nepal. Fores Res 9:227. doi: 10. 35248/2168-9776.20.9.227

dendrochronology. Information were collected through trees scientific name, dendrochronology related articles and pioneer dendrochronologist name. References of all the collected articles were also reviewed to gather more information.

RESULTS AND DISCUSSION

In this study, we have analyzed the research articles published up to March 2020 from Nepal. Many researchers were involved in development of chronologies. Till now the longest chronology developed was from *T. dumosa* having the chronology length of 1141 years ranging from 856 to 1996. Some of the longest chronologies so far built in Nepal are given in Table 1.

Total of 60 articles for 20 species from 25 districts were studied so far in Nepal for dendro-related studies [7]. In this study, we have analyzed 85 articles published up to March 2020 and found that dendrochronologist of Nepal has done research on 114 sites mainly on the species like *A. spectabilis, P. wallichiana, T. dumusa, P. smithiana, B. utilis, P. roxburghii and J. recurva* (Figure 1). Similarly, species like *A. pindrow, U. wallichiana, C. torulosa, R. Campanulatum, L. potanini and C. deodara* are also studied. The short descriptions of the potential species are given below and details of the list of the species are given in Table-2.

A. spectabilis is the most studied species, which represents 48% (Figure 2) of total dendrochronological research of Nepal. It is a high altitude fir of Pinaceae family found in central Nepal between 2,400-4,400 m elevations at temperate and alpine zones [14]. It extends up to the treeline altitude, and *B. utilis* forest succeeds at upper elevation.

Table 1: Length of the longest ring width chronologies of selected tree species from Nepal.

Species	Chronology length (year)	Duration (AD)	Source
Tsuga dumosa	1141	856-1996	Cook et al., (2003)
Pinus wallichiana	694	1303-1996	Cook et al., (2003)
Abies spectabilis	603	1395-1997	Cook et al., (2003)
Juniperus recurva	582	1717-1998	Cook et al., (2003)
Picea smithiana	556	1498–2013	Panthi et al., (2017)
Betula utilis	458	1552-2009	Dawadi et al., (2012)
Ulmus wallichiana	432	1566-1997	Cook et al., (2003)
Pinus roxburghii	297	1683-1979	Bhattacharyya et al., (1992)
Cedrus deodara	264	1714-1978	Bhattacharyya et al., (1992)
Populus species	171	1824-1994	Cook et al., (2003)

(*Source: Gaire et al., (2013) & Gautam et al., (2020)* and modified).

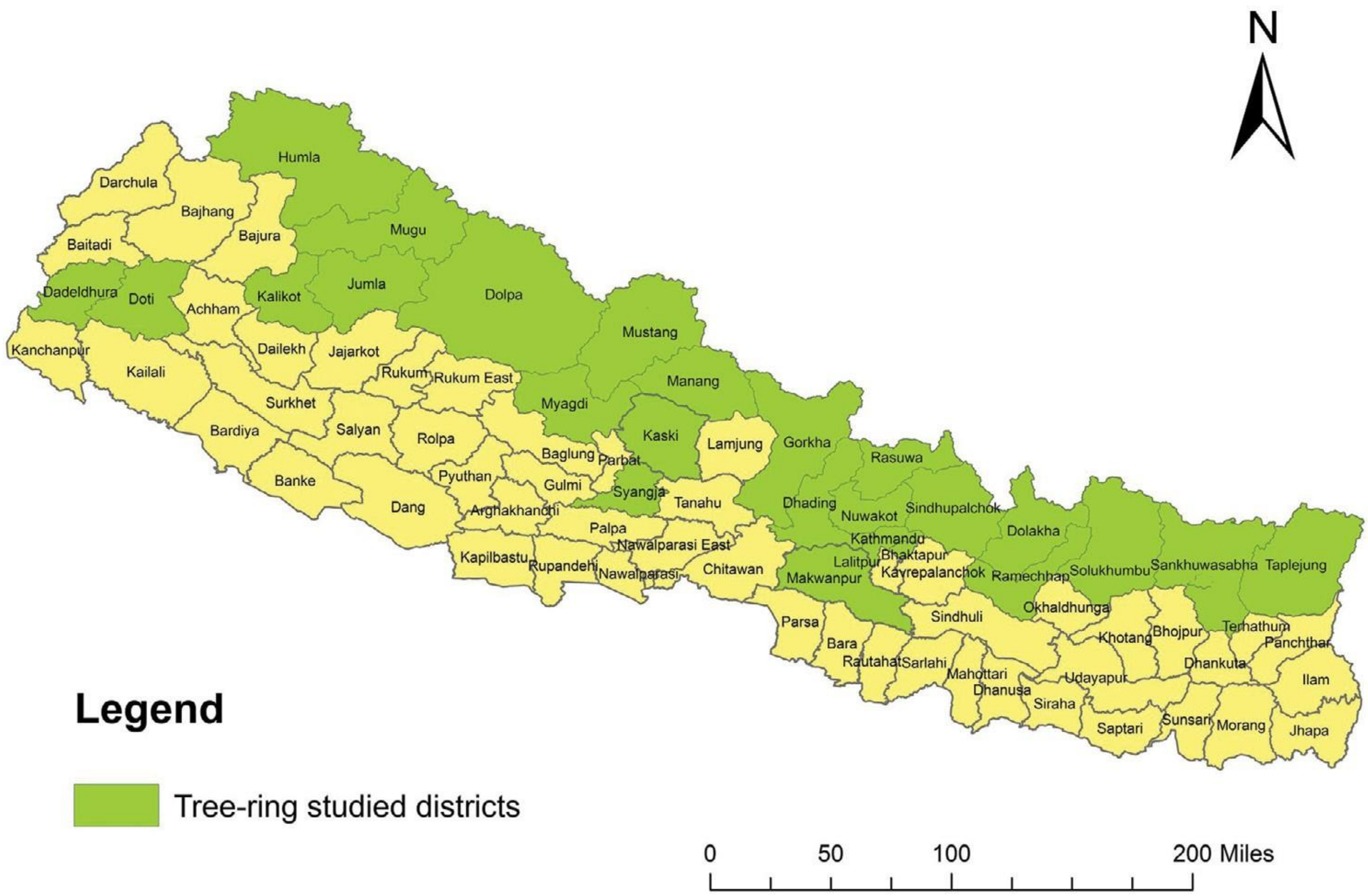

Figure 1: Distribution of sampling site on districts having tree-ring studies in Nepal.

Table 2: List of the dendrochronological related researches in Nepal.

	Abies spectabilis	
Authors	**Study area**	**Research domain/altitude**
Suzuki, (1990)	Jumla district	CB and Climate
Bhattacharyya et al., (1992)	5 sites for AS.	Chronology building (CB)
Romagnoli & Lo Monaco, (1995)	Western Nepal	CB
Schmidt et al., (1999)	Mustang & Khumbu	CB
Yasue et al., (2002)	Central Nepal	CB & CC
Khanal and Rijal (2002)	Ganesh Himal	CB
Cook et al., (2003)	14 sites	Climate Reconstruction (CR)
WDC-Paleo	5 sites	Climate Reconstruction (CR)
Zech et al., (2003)	Gorkha Himal	CR & Glacial history
Brauning (2004)	Mugu & Dolpa	CB & wood Density
Sano et al., (2005)	Humla District	CR & Densities
Chhetri, (2008)	Langtang National Park	CB & CR
Udas, (2009)	Mustang district	CB & CR
Bhuju et al., (2010)	Sagrmatha NP (2 spp.)	Dendroecology
Chhetri & Thapa, (2010)	Langtang NP	CB & CR
Sano et al., (2010)	Humla distict	CB & CR
Suwal, (2010)	Mansalu CA	Dendroecology
Tenca & carrer, (2010)	Khumnhu (2 spp.)	CB & CR
Brauning et al., (2011)	Upper Dolpo	CB with dendroarcheology
Gaire et al., (2011)	Langtang NP	CR & dendroecology
Sano et al., (2012)	Humla district	CR, Densities
Shrestha, (2013)	Manag, Langtang (2 spp.)	CB with dendroarcheology
Gaire et al., (2014)	Manaslu CA (2 spp.)	RW/CR & dendroecology
Kharal et al., (2014 & 2017)	Mustang (4 sites); Manang (3 sites)	RW/CB & CR
Krishna et al., (2015)	Manang and Rasuwa	RW/CB & CR
Gaire et al., (2017a; 2017b)	Sagarmatha NP; Rara NP	CB &CR; CB & Precipitation
Bhattacharyya et al., (1992)	Ghuchilehk	RW/CB /3450
	Pinus wallichiana	
Suzuki, (1990)	Jumla district	CB/RW
Schmidt, (1992)	Mustang (MU)	CB/RW
Gutschow, (19940	Kagbeni/Mustang	CB/RW
Romagnoli & Lo Monaco., (1995)	Western Nepal	CB/RW
Schmidt et al., (1999)	MU/Manang/Khumbu	CB/RW
Schmidt et al., (2001)	Kagbeni/Mustang	CB/RW
Cook et al., (2003)	7 sites for PW	CB/RW
Brauning, (20040	Mugu and Dolpa	CB/RW
Brauning et al., (2011)	Upper Dolpa	CB /RW & ^{14}Cdating
Scharf et al., (2013)	Dolpa	CB/RW & ^{14}Cdating
Sherestha et al., (2013)	Manang, Langtang	CB/RW
Gaire et al., (2019)	Shey Phoksundo NP	CB/RW
Karki et al., (2019)	Manaslu CA	CB/RW
	Tsuga dumosa	
WDC-Paleo	Yalung Khola	CB /3033
Cook et al. (2003)	7 sites in Nepal	CB /1940
Bhandari et al., (2019)	Api Napa	CB
Aryal et al., (2020)	Manang	Temperature reconstruction
	Picea smithiana	
WDC-Paleo	Rara Goan	CB/3000
Schmidt et al., (1999)	Manang,Mustang, Khumbu	CB /500/3000/3300

Cool et al., (2003)	Katya Khola -3	CB/CR/3480
Tapa et al., (2015)	Khaptad	CB/2700
Panthi et al., (2017)	Rara NP	CB/Climate
	Betula utilis	
Brauning, (2004)	Mugu and Dolpa	CB/3500/4020
Buju et al., (2010)	Sagarmatha NP	CB/3850/4050
Tenca & Carrer	Khumbu	CB/3800-4100
Dawadi et al., (2013)	Langtang NP	CB/3780/3950
Gaire et al., (2014 & 2017)	MCA; Sagarmatha NP	(CB/3690-3996); CB
Liang et al., (2014)	SNP, LNP, MCA	CB /3900-4100
	Pinus roxburghii	
WDC-Paleo	Bhakatapur ; Nagarjun	(CB/ 1320); (CB/1420)
Bhattacharyya et al., (1992)	TilaNala	CB /2080
Shrestha et al., (2013)	Dolkha	CB /900-1750
Speer et al., (20160	Bhaktapur	CB
Aryal et al., (2018)	Panchase	CB
References	**Species**	**Sites/Chronology**
Cook et al., (2003)	*Juniper recuva*	(Bhulepokhari; CB /3600) Dhobini danda; CB/3500
WDC-Paleo	*Populus ciliate*	(Bagarchap)CB /2270
Thapa et al., (2013)	*Abies pindrow*	(Khaptad)CB /3000
Cook et al., (20030	*Ulmus wallichiana*	(Katyakhola 2)CB /2760
Schmidt et al., (2001)	*Cupressus torulosa*	Kagbeni/Mustang CB /3000
Rana et al., (2017)	*Rhododendron campanulatum*	(MCA)CB /2500 m
Bhattacharyya et al., (1992)	*Larix potanini*	CB
Bhattacharyya et al., (1992)	*Cedrus deodar*	CB

(*Source: Gautam et al., 2020 and modified*).

Among the several Himalayan conifers, *A. spectabilis* is proved for its dendroclimatic potential along the entire Himalayan range [15,16]. Trees at treeline frequently respond to climatic warming with upward advances in the treeline [16]. Climatic variability with temperature increase is serious concern [17]. So study of the ring of this species will give some ideas about increasing temperature. Sano et al. [11] recreated the past 249 years climate of western Nepal using ring width and wood density of *A. spectabilis*. Sujuki [18] has done first research of this species in Jumla in 1990 and the latest research was conducted by Gaire et al. [1] from Manaslu Conservation Area. The longest chronology so far developed for this species is 603 years from 1395-1997 by Cook et al. [10]. The list of the authors and paper who has done research on *A. spectabilis* is given in Table 2.

P. wallichiana belongs to a Pinaceae family, and is the second highest (18%) studied species so far in the field of dendrochronology (Figure 2). It is a large evergreen tree which is naturally distributed in the South Asia from Afghanistan to Bhutan at altitudes ranging from 1,800 to 3,900 m. In Nepal, it is extended between 1,800 m to 3,600 m and occasionally up to 4,400 m too [14]. It is widely distributed in the midland zone between foothills and the main Himalaya. It usually prefers to grow on deep moist soils, pure or mixed withC. *deodara, A. pindrow, P. smithiana* and *Quercus semecarpifolia*. At higher elevations its associates are *B. utilis* and *J. macropoda.* Past studies have shown the potential of this species for the multiple aspects of dendrochronological studies [10,19] because of its clear annual rings and its wide geographical coverage. The longest so far developed was 694 years ranging from 1303-1996 [10] Similarly, 405 years long tree ring chronology was developed from Dolpa area in the trans-Himalaya region of Nepal in which radial growth is limited mainly by moisture stress during the spring-summer season [20]. False rings and missing ring are the major problem of this species during coss-dating [21]. The list of the authors who have done research on *P. wallichiana* is given in Table 2

T. dumosa is an economically as well as medicinally important conifer belonging to family Pinaceae. It is also known as “Hemlock Spruce” and locally called as “Dhupi” or “Thingre Salla”. In Nepal, it is found in between 2,100 to 3,600 m, is associated with *Quercus semicarpifolia* forest in the lower belt and *P. wallichiana*, Abies and Picea forest in the upper part [22]. Bhattacharaya et al. [19] has studied about this species in the damp and adverse areas of Sagarmatha National Park. Hemlock is a slow-growing, long-living, and shade-tolerant species being sensitive to persistent drought [23].

T. dumosa has well-marked growth rings formed by a sharp change in small-celled darker latewood and large-celled light early-wood [24]. The first tree-ring chronology of *T. dumosa* was recognized by Bhattacharyya et al. [19]. Recently, Aryal et al. has reconstructed temperature using *T. domosa* from Manang. *T. dumosa* showed a negative response to spring temperature and positive relationship of precipitation with the spring season [25]. Cook et al. [10] built the longest chronology of *T. dumosa* in Nepal. Its chronology ranges from 856 to 1996 (1141 years). The longest chronology so far recorded in Nepal in this field. Recently, Bhandari et al. [26] built a tree ring chronology from Api Nampa area.

C. deodar tree rings have a strong potential for dendroclimatic study [27]. Naturally, it occurs in Nepal only in the west, in the Karnali River basin, with some scattered trees in the Thuli Bheri Valley, its eastern-most limits; it typically grows on the northwest and northeast slopes between 1900 and 2600 m. It is commonly planted in the west, especially near temples, and planted in Kathmandu valley before 1820. Most studies believe that the wetting trend in Hindu Kush Himalaya is going to escalation in current decades [28]. However, some extreme drought events in the region are very severe and persistent [29]. Singh et al. [30] reported that the preceding October precipitation limited the growth of *C. deodar*, while Ahmed et al. [31] found no such effect. Bhattacharya et al. [19] carried out the research on chronology building.

C. torulosa belonging to the family Coniferae is a large evergreen tree with a pyramidal crown and drooping branchlets. In Nepal, this species has a local distribution in the western Himalayas between 1800-3550 m elevations. Its eastern limit is kali Gandaki valley. It is moderate light demander, drought tolerant, frost tolerant and widely distributed in limestone soil [22]. In its natural habitat the absolute maximum shade temperature is probably about 90°F, the absolute minimum about 15°F and the normal rainfall varies from 1000 to 2400 mm per annum. Relying on natural succession, it takes hundreds of years to regenerate the degraded forests to climax stage with species like *P. wallichiana Jackson (kail), C. deodara (Roxb.), G. Don (Deodar), A. pindrow Spach, P. smithiana* (Spruce) *and C. torulosa* (Himalayan cypress) which dominate vegetation of our forests. The timber of cypress shapes smoothly; as compared to Teak. Its working quality index is 116 [32]. Schmidt et al. [33] carried out its research in Kagbeni, Mustang at an altitude of 3000 m and tree ring chronology.

R. campanulatum which belongs to the *Ericaceae* family has a wide altitudinal range and is found at the treeline ecotone, timberline and subalpine forest in Nepal [34]. Dendroecological inquiries were carried out to study the age structure and history of establishment of *R. campanulatum*. Gaire et al. [16] reported that *A. spectabilis* was established around 1850s and *B. utilis* in the 1820s in the Manaslu Conservation Area. After, establishment at 3700 m elevation *R. campanulatum* colonized 3600 m and 3800 m elevation about 16 and 13 years later respectively. After reaching 3800 m elevation, it progressively moved-up until it reached the species limit of 4090 m elevation around 2007. *R. campanulatum* is also reported to be poisonous and unpalatable to cattle and wild animals [35,36]. Recently, Rana et al. [37] built a tree ring chronology of this species from Manaslu conservation area at the altitude of 2500 m.

P. smithiana is a native species in the central and western Himalayas from Afghanistan to central Nepal, and mostly grows on lithosol soils within an elevation belt of 2500–3300 m. The species is cold tolerant and either forms pure forest stands on steep slopes or acquaintances with various conifers, e.g. *Abies* sp., *P. wallichiana*, and *Juniperus indica* or broad-leaved trees such as *B. utilis*, *Quercus semecarpifolia*, and *Juglans regia*. Thapa et al. [20] re-constructed spring temperature from *P. smithiana* in the western part of the central Himalaya, Nepal and revealed increasing spring temperature since the 1980s. Gaire et al. [29] reconstructed tree-ring based on March– June precipitation and found decreasing spring precipitation in the north-western part of the Nepal since mid-1970s. Cook et al. [10] has done research on Katya Khola at an elevation 3480 m and developed the tree ring chronology. Similarly, Thapa et al. [20] build the chronology from Khaptad from an elevation 2700 m. Panthi et al. [38] built the longest chronology of this species ranging from 1498-2013 (556 years) from Rara National Park of western Himalaya of Nepal.

P. roxburghii is the three-needled pine tree, belonging to the family Pinaceace and commonly known as Chir pine in English. *P. roxburghii* is an important native pine tree species that cover large geographical areas in the middle and high mountain regions in Nepal with 8.54% coverage of the total forest cover in Nepal. Mainly, *P. roxburghii* is a subtropical conifer inhabiting in dry and steep south facing and well drained slope of the Himalaya. The species covers the greater landscape of China, India, Pakistan, and Bhutan from 400 to 2300 m elevation [39].

Pine is strong light demander, frost hardy and fire-resistant species. It coppices badly and is very sensitive to grazing and browsing. It is slow growing evergreen tree species. It prefers dry or moist soil and tolerate drought. Its associates are *S. robusta, L. monopetala* in lower altitude and *P. wallichiana, R. arboretum, Quercus* sp. in higher altitude. It is economically important species since it offers timber, resins, wood for local people. *P. roxburghii* trees are suitable for their annual growth assessment and monitoring as they produce clear annual rings and internodes [19,40,41]. This species cross dates well and its growth are reasonably well correlated with climate [19].
P. roxburghii has been widely explored for growth response and other climatic studies using dendrochronological approach [40-43].

P. patula is exotic species to Nepal; it grows considerably faster than the indigenous pines in a very poor soil [22] and has been dominating species to rehabilitate the degraded hills of Nepal [44]. They are observed in mid-hills and high hills of Nepal. Establishment of these plantations incurred a huge cost but benefits from these plantations can be maximized only if they are managed adopting the principle of forest management [45] to enhance the biomass on trees. Dendrochronological assessment taking sample cores of 120, 80 and 120 was conducted in 2000, 2005 and 2015, respectively in plantation done between 1975 and 1990. The study found that the growth rate decreased after 12 years and the rate was high in the higher density class. The cumulative increment, which was found to be higher in the lower density class, was found to have retarded faster after 15 to 17 years of age in the higher density class as well as in the conventionally managed plantations [44].

U. wallichiana is a mountain tree ranging from central Nuristan in Afghanistan, through northern Pakistan and northern India to western Nepal at an elevation of 800 to 3000 meters altitude. *U. wallichiana* is heavily chopped for firewood and also for fodder, leaving it in danger of extermination in some areas [46]. Elsewhere however, it has been deliberately planted near villages and farmhouses [47]. It is an endangered species regenerated through seeds, which are characterized by the lack of any dormancy [48]. Efforts have been made in India to conserve the tree by drying the seeds and placing them in refrigerated storage [47]. The physiology of germination, especially the temperature requirement for germination of *U. Wallichiana* was not known. So, Phartyl et al. [47] conducted a research to find out impact of temperature in the absence of some limiting factors. It was revealed that in the absence of other limiting factors (e.g. water, light and media), the germination of *U. wallichiana* seed is influenced by temperature which is consistent with Garcia-Huidobro et al. [49] work on pearl millet. Temperature affects both the maximum fractions of seed germinated after a fixed period of time and the rate of germination.

L. potaninii also called Chinese Larch is a deciduous conifer species in the family Pinaceae which occurs at the mountains of Tibet, Yunnan, Gansu, Sichuan and Shaaxi of China and Nepal at an altitude between 2500-4300 m asl [50], on acidic podzol soils,

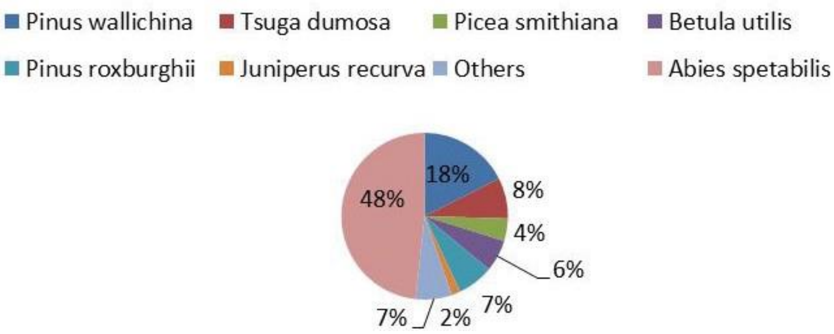

Figure 2: Species-wise dendrological studies in Nepal.

where climate is cold, and annual precipitation ranges from 800 to 2000 mm [51]. The trees are up to 50 m tall with trunk up to 1m dbh and gray and gray-brown colored bark [50]. It is found to be associated mainly conifers including species of *Abies, Picea, Tsuga, Juniperus, Cephalotaxus* and *Taxus* [24]. IUCN had listed it as a least concerned species in its red list. In the previous researches, *L. potaninii* had shown dendroclimatic potential. Rudolf Zuber collected the first tree ring sample of *L. potaninii* from Langtang area in 1979/80 which was later published by Bhattacharya et al. [19]. Bhattacharya et al. [19] mentioned that clear boundary was found between earlywood and latewood in *L. potaninii*. Chinese Larch tree ring width chronology revealed thermic and humid variations for hundreds of years in the Balikun region [52] and in the northern Xinjiang region [52,53] and significantly positively correlated with the precipitation in March and June in the Far East of Tian Mountain [54].

Tiwari [55] found both T-max and T-mean have pronounced influence at Larch treeline, whereas the minimum temperature (T-min) has more positive impact at timberline than treeline. Similar growth climate response was found for Larch in many parts of China [56]. Fan et al. [38] also revealed that radial growth of larch is sensitive to temperature variation in winter season. Lower winter temperatures may reduce root activity and carbon storage, increase the risk of frost desiccation, and thus reduce radial growth during the following year [57]. Radial growth depressions of larch trees, accompanying with reduced latewood density were found synchronously [38].

Abies pindrow has been reported to have dendroclimatic potential in Western Himalaya [58-61]. *A. pindrow* is a low altitude Himalayan fir extending from Afghanistan to Pakistan distributed in the range of 7,000–10,000 ft above sea level, is confined to northern and western aspects of the slopes [62]. In Nepal Himalaya, it is utmost abundant in Humla District found either in a single stand or with other taxa such as *P. smithiana* and *B. utilis* [62]. It has been reported that radial growth of *A. pindrow* in Western Himalayan region are restricted by pre-monsoon climate [59,61]. Tree-ring width chronology of *A. pindrow* spanning over 362 years dating back to 1650 was developed from Western Nepal Himalaya [26]. Similar response has been noted in the ring-width scrutiny of *A. spectabilis* in Nepal Himalaya [11,63].

B. utilis is a hardy perennial plant of moderate size up to 20 m in height, forming the upper limit of forest vegetation. It inhabits along the Himalayan range from Bhutan westwards, ascending to an altitude of 4200 m [64]. The genus Betula, commonly known as Birch, is deciduous tree which belongs to the family Betulaceae. According to the recently published monograph for this species there are approximately 40-50 recognized species of Betula, although the World Checklist of Selected Plant Families recognizes 62 species all of which are essential ecological components of northern temperate and boreal forests in many parts of the world [65]. It is also among a few Himalayan tree species that have been used in dendrochronological research whose chronology length has been recorded to be 458 years 1552-2009 [7]

The Himalayan region has large areas of natural Himalayan Birch (*B. utilis*, *D. Don*) forests. It is long-lived (more than 400 years old) [66] with the promise for developing long tree-ring chronologies. Unfortunately, to date, little is known about its dendrochronological potential [66,67]. As reported, Himalayan birch growth responded positively to the mean temperature of July and September in the previous year in west Nepal [67] and March, April and June precipitation in the western Himalayas [66]. Taking its wide distribution in High Asia into account, further efforts are needed to investigate its potential to develop a long, high-elevation tree-ring chronology, in particular in the central Himalayas.

J. recurva commonly named the Himalayan juniper or drooping juniper, is a juniper native to high-altitude climates of the Himalaya, from northern Indus Valley in Kashmir east to western Yunnan in southwestern China. It is mainly found in Eastern Himalayas of Nepal. It is common in alpine zone between 3,000-4,600 m altitude [68]. It belongs to the family Cupressaceace. Distinguishing character of *J. recurva* from other varieties is it has ultimate twigs pendulous and recurved, leaves with/without appressed and overlapping, glaucous-green, with/without flaccid 4-6- 9 times as long as broad, margins scarious; mature female cone ovoid-elongate [68].

It is conical tree to 18 m in height and dioecious, with male (pollen) and female (seed) cones on separate plants. It is moderate light demander and fire resistant species. It is both frost and drought species. It coppices well and makes good association with Fir (*Abies*). It's an evergreen species which prefers acidic soil and develops a strong tap root system. The wood is burned for incense in Buddhist temples in Eastern Himalayas.

P. ciliata is a large, handsome, deciduous, dioecious and fast-growing tree of temperate and sub temperate regions of the Himalayas. An intolerant tree that grows best on deep moist soils, but can grow on a variety of sites and soils including rocky exposed, land slide areas. It also grows best on alluvium, stream beds and/or sandy loams. It is adapted to a precipitation zone of 750 to 1250 mm/yr or more, in a temperature range of -20 to 35 degree Celsius. It prefers a humid, semi-arid cool, cold temperate, climate. It does not coppice except when young. It is relatively fast growing. Yields of 6 to 13 m³/ha/yr. have been recorded. *P. ciliata* is a handsome large tree, notable for its attractive light grey bark when young, and large cordate leaves with pale undersides. It seems to have been introduced to the Forestry Commission's Research Station at Alice Holt, Surrey in 1959 when material was sent from the Forest Research Institute in Dehradun, India.

CONCLUSION

Himalayan confers are the major studied species to build long tree ring chronology and find out tree climate relationship. Most of the dendrochronologist focused their research on limited species. Till, 2013, 60 articles were published in which 20 species were studied from 25 districts. From 2013 to March 2020 twenty seven more articles were published. Out of these species *A. spectabilis* is the most studied species followed by *P. wallichiana*. Similarly, *T. dumosa, P. smithiana, B. utilis and P. roxburghii* are also studied well. But the species *like J. recurva, P. ciliate, A. pindrow, U. wallichiana, C. torulosa, R. campanulatum, L. potanini and C. deodar* are least studies species. There are many other species which are still not studied in Nepal but studied in China, India and Pakistan. The knowledge derived from the detail study of these species will help the forester and conservationist to manage the forest well and take the necessary action to mitigate the possible impacts that will be derived by the change in climate in the future.

ACKNOWLEDGEMENTS

We are grateful to all the reviewer and editors for their valuable comments and suggestions. We are also grateful IOF, Tribhuvan University and Beijing Forestry University for providing scholarship to the first author. Our special thanks go to Narayan Parsad Gaire and Jyoti Bhandari for their feedbacks.

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