DENDROCLIMATIC POTENTIAL OF CONIFERS FROM KARAKORAM-HIMALAYAS OF PAKISTAN AND BORDERLANDS: A COMPREHENSIVE REVIEW

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Abstract

In the vibrant realm of dendrochronology, a varied tapestry of research activities explains across the globe. The key sources of data for this review are several published research publications and review articles published before March 2022. More published data in the field of dendroclimatology and dendrochronology can be found by searching on Google Scholar and Research Gate. The data we gathered came from the tree's scientific name, dendrochronology-related literature, and the name of the pioneer dendrochronologist. References for all the collected articles were also reviewed to gather more information. Here we are focusing on Pakistan and the border areas (countries) such as Afghanistan, India (Himalayan), Iran, Tajikistan, and China (only Tibet region).

In Afghanistan, only one study was carried out in the field of dendrochronology, which has great potential in this area. Dendrochronologists may have more focus because Afghanistan has been at war for a long time and the climate and/or the growth of trees/forests may be highly effected due to war. In Pakistan, two reconstructions of temperature and one precipitation were performed. An earlier temperature reconstruction was based on the out-of-phase temperature hypothesis, while another reconstruction was based on the in-phase hemispheric trends. Here we suggest regional chronologies of tree-ring width to understand the out-of-phase temperature trend hypothesis for the stability of Karakorum glaciers. For India, 20 research publications were documented in the field of dendrochronology with a very concise and accurate method. In Nepal, a total of 16 research publications were carried out on dendrochronology. For Tajikistan, 06 research publications were published in the field of dendrochronology, whereas dendrochronologists mostly focused on juniper species. In Iran, 07 research publications were studied in the field of dendrochronology, and the most studied species was Juniper. For China (Tibet region), 44 research publications were selected on dendrochronology, with very detailed information along with a concise and precise method. Our trek across this terrain of dendrochronological miracles is more than just a scientific undertaking; it is a monument to

human curiosity, tenacity, and the unwavering pursuit of understanding. By analysing the rings of these old trees, we may learn about their history, present, and possibly even future, providing us with significant insights into the workings of our planet.

Keywords; Paleoclimate, Climate change, Tree rings, Karakoram-Himalayan conifers

Afghanistan

Khan et al. (1) studied *Picea smithiana* (Wall.) Boiss. in Afghanistan District Dangam using dendrochronological methods. The sample was taken at a height of 2529 meters above sea level. He collected 28 cores from 15 tree trees (Table 1). Despite the fact that forest climate sensitivity had not been documented, they created a Tree Ring width (TRW) chronology and revealed that all cores were highly correlated, indicating comparable climatic signals.

Pakistan

In this area, most dendrochronological studies were conducted on Karakoram region, whereas little study was performed for the Hindu-kush and South area of Pakistan despite of high potential. In the Karakoram region, several studies revealed tree rings to be sensitive indicators of changing temperatures [2-8]. Work by et al. (5) showed a rigorously calibrated summer temperature reconstruction extending over the past five centuries based on the tree ring of *Picea smithiana* and *Pinus gerardiana Wall. ex D. Don*growth. This reconstruction indicated that temperature variations in the Karakoram were out-of-phase compared to the hemispheric trends. However, the prior reconstruction [5] based on a negative association between the tree growth and summer temperature variations, indicating that moisture stress to be the key driver of tree growth. Asad et al. (6) compared their summer temperature reconstruction estimated using a ring-width record of *Pinus wallichiana* in the Karakoram region of Pakistan with some hemispheric scale reconstructions. Because their reconstruction like other hemispheric reconstructions showed warming since the mid-19th century, he asserts that the out-in-phase temperature trend hypothesis does not hold for the stability of Karakorum glaciers.

Himalayan (India)

In an article published in 1989, Bhattacharya and Yadav studied *Cedrus deodara* (Roxb.) G. Don from Joshimath, Uttar Pradesh (India). The elevation ranges from 1800 to 2400 meters in the mentioned region. They conducted climatic growth response function analysis, finding that the tree's growth was inversely sensitive to the previous summer's maximum temperature (Jul, Aug, and Sept) and the present summer, but directly responsive to the present year's precipitation.

At a height of 2700 to 3000 m in the Himalayan area of India, Yadav et al. (9) studied three species of *Cedrus deodara* (Roxb.) G. Don, *Pinus wallichiana* A. B. Jacks, and *Picea smithiana* (Wall.) Boiss. They determined the tree ring chronology as well as reconstructed the temperature, which corresponds strongly (r = +0.62, 1876–1988) with the mean April-May temperature.

Pinus wallichiana A. B. Jacks from Kanasar and Gangotri in the western Himalayan area were studied by Yadav et al. (10). The study sites were 2400m and 3000m above sea level. They extracted 11 cores from 8 trees of Kanasar area and 10 cores from 9 trees of Gangotri region, respectively. They developed a TRW chronology and investigated the climate-growth relationship, whereas temperature of winter season plays a positive effect on *Pinus wallichiana* A. B. Jacks.

Taxus baccata L. was studied by Yadav and Singh (11) in the Western Himalayan, India. The species was found at a height of 2910 meters. They constructed a tree ring chronology and accomplished a Climate Growth Response analysis, finding that tree growth was associated to the pre-monsoon (March-June) season.

Abies densa Griff from India's eastern Himalayan area was discussed by Bhattacharyya and Chaudhary (12). The species' elevation in the examined region range from 3300 to 3900 meters. The documented that the annual to multiyear oscillations, interspersed by chilly and warm intervals, may be seen in the reconstructed temperature record over the previous 237 years. 1978–1987 (+0.258C) and 1801–1810 (-0.318C), respectively, were the warmest and coldest 10-year periods in the whole reconstruction.

Singh and Yadav (13) investigated *Cedrus deodara* (Roxb.) G. Don from Uttarkashi and Chamoli, respectively. The study area's average elevation ranges from 2720 to 3250 metres. They developed tree ring chronology and reconstructed precipitation with the twentieth century having the driest and wettest years in the whole reconstruction.

Yadav et al. (14) published an article in which they discussed *Juniperus macropoda* Kom. from Lahul, Himachal Pradesh (India). The elevation of the studied area is 2600 to 3300m. They developed TRW chronology that limited to from prior year's growth Sep to present May. The strong relationship between the current Himalayan pencil cedar chronology and two Himalayan cedar ring width chronologies prepared earlier from stands adjacent to the current site illustrates the versatility of tree ring data networks of these species in developing reliable reconstructions

needed for a good understanding into climate changes in the trans Himalayan area's precipitation-deficient environment.

Borgaonkar et al. (15) published an article in which they discussed about the 5 species i.e. *Pinus, picea, Cedrus, Abies* and *Tectona grandis* from Himachal Pradesh and Central and Peninsular India. The elevation of the area is from 2900 to 3450m. They developed tree ring chronology and reconstructed the pre-monsoon (Mar-Apr-May) precipitation, whereas the high elevation tree-rings chronology sensitive to winter temperature. *Tectona grandis* from central and Peninsular India shows that the growth was sensitive to premonsoon and monsoon climate.

In their publication, Laxton and Smith (16) discussed *Cedrus deodara* (Roxb.) G. Don, *Pinus wallichiana* A. B. Jacks, *Abies pindrow* (Royle ex D.Don) Royle, *Betula utilis* D. Don and *Picea smithiana* (Wall.) Boiss from Lahul Himalayan (Northern India). The studied species occurred at an elevation of 3016m above sea level. They reconstructed snow avalanche activity.

From the Western Himalayan, Yadav (17) examined *Juniperus polycarpos* K. Koch, *Cedrus deodara* (Roxb.) G. Don, and *Pinus gerardiana Wall. ex D. Don*Wall. ex D. Don. The studied species' altitudes range from 1500 to 4300 meters, 1200 to 3300 meters, and 1800 to 3000 meters, respectively. They established tree ring chronology and reconstructed the precipitation and temperature from Kinnaur, Himachal Pradesh, indicating a decrease in precipitation in the last few decades of the twentieth century, and temperature reconstructions from various Himalayan regions demonstrating strong consistency with other regions.

Deepak et al. (18) analysed teak (*Tectona grandis L.f*) tree rings from two different locations in India's Western Ghats (Dandeli and Shimoga). They used tree ring chronology and dendroclimatic analyses, and found that *Tectona grandis* L.f had a lot of potential for reconstructing historical rainfall and drought years.

Yadav and Bhutiyani (19) investigated two species from the 06 moisture stress area in Lahaul, Himachal Pradesh, India: *Cedrus deodara* (Roxb.) G. Don and *Pinus gerardiana Wall. ex D. Don*Wall. ex D. Don. The study area's elevation extends from 2640 to 3016 meters. They reconstructed the snow water equivalent (SWE) from November to April, dating back to 1460 A.D. They reported severe droughts in the 1780s, 1480s, as well as droughts of lower size in the 1540s–1560s, 1740s, and early 20th century.

Yadav (20) examined *Cedrus deodara* (Roxb.) G. Don and *Pinus gerardiana Wall. ex D. Don*Wall. ex D. Don in the Kinnaur area, Western Himalaya, India. The study area is 1587 meters above sea level. From 1310 A.D. until May, the Palmer Drought Severity Index (PDSI)

was established. In comparison to the severe droughts of 1617–1640 A.D. and 1491–1526 A.D., the twentieth century had dominating decadal-scale pluvial episodes (1981–1995, 1952–1968, and 1918–1934 A.D.).

Cedrus deodara (Roxb.) G. Don was studied by Yadav et al. (21) in two locations: Gangolihat and Jageshwar. The locations are 1760m and 1851m above sea level, respectively. For the first time, they established a yearly resolved February-May (FM) rainfall history dating back to AD 1730 using Himalayan cedar tree-ring width data from the Kumaon area, India's eastern sector of the western Himalaya. Droughts on a decadal scale occurred in the 1920s, 1960s, and early 1970s, as well as pluvials in the 1910s and 1980s. The droughts of 1920–1924, on the other hand, were the worst of any similar era in the past three centuries.

Shah et al. (22) discussed nine different potential species i.e *Abies densa, Juniperus indica, Larix griffithiana, Pinus roxburghii Sarg., P. wallichiana, Taxus baccata L.*and *Tsuga dumosa* (D. Don) Eichler (conifers species), *Toona ciliata* and *Magnolia cathcartii (broad-leaved taxa)* of Eastern Himalaya. They reported that the climate records beyond the existing instrumental data, tree-ring data provides valuable proxy due to its annual resolution. A large number of trees from the eastern Himalaya produce annual rings and found promising to reconstruct past climate data. This paper provides prospects and challenges of tree-ring studies from the eastern Himalaya in connection with climate, stream sow and other geological events.

Abies densa, *Juniperus indica*, *Larix griffithiana*, *Pinus roxburghii* Sarg., *Pinus wallichiana*, T*axus baccata* L., and *Tsuga dumosa* (D. Don) Eichler (conifer species), *Toona ciliata*, and *Magnolia cathcartii* (broad-leaved taxa) are potential species of the Eastern Himalaya [22, 23]. They claimed that, in addition to current meteorological data, tree-ring data provides a useful proxy because of its yearly resolution. Annual rings were discovered to be interesting for reconstructing previous climatic data in a significant number of plants from the eastern Himalayas. The opportunities and problems of tree-ring investigations in the eastern Himalayas in relation to climate, stream flow, and other geologic events are discussed in this article.

The dendrochronological potential of *Tectona grandis* L. f., *Pinus kesiya* Royle ex Gordon, and *Quercus serrata* Murray species from Mizoram, Northeast India, was investigated by Upadhyay et al. (24). The chosen place is located at a high height of 500 to 2000 meters. They constructed tree ring chronology and discovered the species' dendrochronological potential.

Pinus kesiya Royle ex Gordon was investigated by Thomte et al. (25) in Sielmat, Manipur, Northeast India, at an altitude of 855 meters. They created a tree ring chronology and used response function analysis to examine growth rate.

Yadava et al. (26) documented a report in the dendrochronological field on Cedrus deodara (Roxb.) G. Don from the Chakrata area of Garhwal, Uttarakhand. The study region is between 2715 and 2815 meters above sea level. They examined at the SPIE reconstruction, which revealed a lot of year-to-year and inter-decadal variance, with the driest and wettest years being 1774 (SPEI-3.11) and 1787 (SPEI +2.13), respectively. They further stated that the data from the western Indian Himalayas revealed synoptic scale features.

Nepal

Suzuki (27) *studied Abies spectabilis (D.Don) Spach, Pinus wallichiana A. B. Jacks, and Picea smithiana (Wall.) Boiss*(Wall.) Boiss from Lake Rara Jumrat Distt, Karnali zone (western Nepal), at a height of 2980 meters. They constructed a TRW chronology and studied the climatic growth relationship.

Bhattacharyya, LaMarche Jr (28) and Bhattacharyya and Yadav (1989) studied *Abies spectabilis* (D.Don) Spach, *Pinus roxburghii* Sarg., *Tsuga dumosa* (D. Don) Eichler, *Cedrus deodara* (Roxb.) G. Don, *Picea smithiana* (Wall.) Boiss., *Juniperus recurve* Buch. -Ham. ex D.Don, *Pinus wallichiana* A. B. Jacks. and *Larix potaninii* Batalin from 5 sites for AS and at the elevation of 1320m to 3720m. They documented that the *P. wallichiana* and *C. dumosa* were found to be difficult to cross date. Individual site chronologies of *C. deodora*, *P. roxburghii*, and *P. wallichiana*, as well as high elevation A. *spectabilis*, were particularly promising. For this species, densitometric data is likely to be more valuable for dendroclimatic analysis.

Romagnoli and Lo Monaco (29) discussed *Abies spectabilis* (D.Don) Spach and *Pinus wallichiana* A. B. Jacks from Western Nepal at the elevation of 3450m. They developed tree ring chronology.

Bhattacharyya et al. (30) examined for *Abies pindrow* (Royle ex D.Don), Royle, from the Din Gad Valley (seven locations), but they didn't mention the elevation. They established a tree ring chronology and analysed tree development in relation to temperature and glacial activity.

Cook et al. (31) investigated at *Tsuga dumosa* (D. Don) Eichler, *Pinus wallichiana* A. B. Jacks, *Picea smithiana* (Wall.) Boiss, *Abies spectabilis* (D. Don) Spach, *Juniperus recurve* Buch. -

Ham. ex D. Don, and *Ulmus wallichiana* Planch collected from seven 3000m elevation in Nepal. They constructed TRW chronology and performed climatic-growth analysis.

Sano et al. (32) used the ring width and wood density of *Abies spectabilis* (D. Don) Spach from western Nepal at a height of 3850m to reconstruct the climate over the last 249 years. They revealed that the pre-monsoon temperature and precipitation regulate the ring width and minimum density, whereas the latewood density was regulated by the late monsoon temperature. They rebuilt March–September temperatures over the previous 249 years, revealing a rising tendency from the 1750s to around 1790, a cooling period until 1810, a moderate warming trend until 1950, and a significant cold spell from 1950 to the current time.

Chhetri and Thapa (33) discussed *Abies spectabilis* (D.Don) Spach from Langtang National Park (Two areas) at the elevations of 3309m and 3444m. They discuss and developed TRW chronology.

Dawadi (34) studied Betula utilis D. Don in Langtang National Park (NP), central Nepal, at an altitude of 3780 meters. They also did climatic growth analyses and established the TRW chronology.

Thapa et al. (35) investigated for *Abies pindrow* (Royle ex D.Don), Royle, which was found in Khaptad NP, Nepal, at a height of 3000 meters. They constructed a TRW chronology, which was then correlated with climatic variables such as temperatures and precipitation. Temperature had a substantial negative relationship with tree growth while precipitation had a strong positive correlation.

Kharal et al. (36) investigated *Abies spectabilis* (D.Don) Spach from the Mustang area of Nepal, where it grows at elevations ranging from 2700 to 3300 meters. They created the TRW chronology and conducted climate growth association analysis.

Picea smithiana (Wall.) Boiss from the Lokhada area in the northern side of Khaptad NP was investigated by Thapa, Shah (37). The sampling region was 2700 meters above sea level. From 1640 to 2012 AD, they built a TRW chronology and reconstructed the March to May average temperature. The major cooling pattern during the LIA was not captured by this model.

Gaire et al. (38) examined *Abies spectabilis* (D.Don) Spach, which was found in Rara National Park in western Nepal. The appropriate species' elevation was not specified. They created the TRW chronology, which has been used to reconstruct March–June (Spring) precipitation since 1840 AD.

Pinus roxburghii Sarg. was studied by Aryal et al. (39) from Bicharichautara village in Syangja, Nepal, at a height of 1450 to 2517m. They also constructed a TRW chronology and conducted a Climate Growth study.

Pinus wallichiana A. B. Jacks from Shey Phoksundo NP was described by Gaire et al. (40). The study area's elevation ranges from 2130 to 6885 meters. They constructed a long TRW chronology from 1611 to 2015 and reconstructed the Feb–Aug Palmer drought severity index (scPDSI) from 1697 to 2015 AD.

Tsuga dumosa (D. Don) Eichler was studied by Bhandari et al. (41) from Chhetti and Ranghadi (western Himalayan) at elevations of 2700 to 2800m. TRW chronology was created from 1657 to 2013 AD, and the Mar-May (spring) self-calibrating Palmer drought severity index (scPDSI) was rebuilt from AD 1707 to 2013 AD.

Abies spectabilis (D. Don) Spach, *Pinus wallichiana* A. B. Jacks, *Picea smithiana* (Wall.) Boiss, and *Tsuga dumosa* (D. Don) Eichler were studied by Aryal et al. (42) from Timang village at a height of 2700m. They conducted on tree ring chronology and climatic growth analyses, respectively.

Tajikistan

Ephedra equisetina Bunge from the Zaravshan Mountains was investigated by Opała, Niedźwiedź (43). The study region was 2200–2250 meters above sea level. They constructed a TRW chronology and demonstrated the investigated species' dendrochronological potential. According to them, the temperature in July was the species' growth limiting factor.

Opała et al. (44) studied *Juniperus semiglobosa* Regel and *Juniperus seravschanica* Kom from western Pamir-Alay Mountains. These two species were elevated at an altitude of 2700 to 3500m and 1200 to 2400m, respectively. They developed TRW chronology and performed Climate Growth analysis (CGA). The CGA showed that radial growth of the Himalayan pencil juniper was positively correlated with the winter precipitation and spring temperature.

Opała-Owczarek et al. (45) discussed *Juniperus semiglobosa* Regel trees from Artuch village (Pamir-Alay region) at an elevation of 2000m and 3000m. They developed an 1108-year TRW chronology and also performed dendroclimatological analysis and reconstructed the region's drought history over the period AD 908–2015.

Bakhtiyorov et al. (46) discussed *Juniperus pseudosabina* Fisch. & C.A. Mey from Taboshar, Sogd Province Northern Tajikistan. The elevation of the studied area is from 1485 to 1585 m.

They developed TRW chronology and reconstructed summer (June-Sep) minimum temperature from 1840–2016 AD.

Opała-Owczarek and Niedźwiedź (47) discussed *Juniperus semiglobosa* Regel from Pamir-Alay Mountains at the elevation ranging from 1016 to 3373m. They developed tree ring chronology and reconstructed Palmer Drought Severity Index (PDSI).

Juniperus excelsa subsp. polycarpos (K. Koch) Takht. and *Juniperus pseudosabina* Fisch. & C.A. Mey from the Pamir-Alay (NWPA) Mountains were discussed by Fan et al. (48). The examined species were found at elevations ranging from 1175 to 2149 meters and 3249 meters. In their research, they constructed a tree ring width chronology and investigated tree ring carbon isotopes, while dendroclimatological analysis shows that precipitation has a substantial impact on tree development and isotope richness.

Iran

Pourtahmasi et al. (49) discussed *Juniperus polycarpos* K.Koch species from Goochan, Mashhad and Zanjan (Elburz Mountain and koppeh Dagh) at different elevations of 1287m, 990m and 1663m. They discuss the negative (1913, 1917, 1951,1961, 1975 and 1991) and positive (1940 and 1981) pointer years in the TRW chronology.

Mazandaran (50) collected 13 cores from 4 trees of *Acer velutinum* from Khanican forests (Now-shahr province in north of Iran) at the elevation of 100m asl. They developed a TRW chronology and climate growth analysis, whereas the tree growth was limited to precipitation.

Fagus orientalis Lipsky from the Caspian forest in the Alborz Mountains, northern Iran, was studied by Pourtahmasi et al. (51). The study region was between 1260 and 2200 meters above sea level. They constructed a time series of tree ring width as well as a number of vessel factors. According to their findings, mean ring width and average vessel-lumen area declined as altitude climbed, although total vessel-lumen area was unaffected by altitude and vessel density increased.

Gholami et al. (52) discussed *Quercus castaneifolia* C. A. Mey in his work. The study area was Guilan province, Caspian southern coasts, Iran. They studied two wells in the Fomanat plain. In their work they evaluated the Groundwater Level Fluctuations.

Juniperus polycarpos K. Koch and *Quercus macranthera* Fisch. & C.A.Mey. ex Hohen were studied by Foroozan et al. (53) at heights of 2540 m and 2250 m in the Chaharbagh (Alborz Mountain range). They developed latewood oxygen isotope analysis, and the association of tree-ring $\delta^{18}O$ with local and predicted climatic data indicated that temperature had a positive

influence on $\delta^{18}O$ levels in *J. polycarpus* from January to June, with substantial correlations in January and May. In addition, winter precipitation has an effect on juniper $\delta^{18}O$.

Fagus orientalis Lipsky was studied by Haghshenas et al. (54) in Caspian woods at elevations ranging from 1038 to 1152 m. They constructed a TRW chronology and investigated at how climatic conditions affected the species' development rate. The relationship between mean annual air temperature and radial growth was found to be significant. Within the growth season, August temperatures revealed a significant association with tree rings, with the largest correlation found in December and the lowest in February, while there was no significant correlation observed in March.

Juniperus polycarpos K. Koch from the Alborz Mountains was discussed by et al. (55) at an elevation of 2200–2900 meters above sea level. They constructed a long TRW chronology from 1134 to 2015 CE and reconstructed the past 700 years of mean temperature reconstruction, which failed to capture the twentieth century warming tendency of northern Iran.

China (Tibet Region)

Cathaya argyrophylla Chun & Kuang, *Cinnamomum camphora* (L.) J. Presl, *Gordonia acuminata*, *Pinus massoniana* Lamb, and *Schefflera delavayi* were investigated by Xiong et al. (56) in the Gorges reservoir region. The study region ranged in elevation from 271 to 1420 meters. They constructed maximum latewood density chronologies and examined the subject species' dendrochronological potential. Some substantial relationships between tree-ring data and temperature, precipitation, and river flow have been discovered by preliminary climate modelling.

Zhang et al. (57) collected tree ring samples of *Sabina przewalskii* Kom from Dulan, northeastern Qinghai-TP at 3100-3800m elevation. They constructed a 2326 yrs TRW chronology and reconstructed regional precipitation.

Sabina przewalskii (Kom.) W. C. Cheng & L. K. Fu from the Dulan area was discussed by Liu et al. (58). The considered region was 3673–4140 meters above sea level. They established a tree ring chronology and conducted a climate growth study, finding that climate variance impacted tree growth more strongly there, whereas precipitation in spring and summer months regulated *S. przewalskii* growth on a regional scale.

Liu et al. (59) studied *Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu from Dulan (Qurigang, Yangchang and Kecuo). The elevation of these three areas were 3800 to 4200 m, they constructed the TRW chronology and reconstructed the precipitation.

Sabina przewalskii (Kom.) W.C.Cheng & L.K.Fu and *Picea crassifolia* Kom. were discussed by Liang et al. (60). The Qaidam Basin was the subject of the study. At an elevation of 2800 meters above sea level, the species was found. They constructed a TRW chronology and analyzed the rate of growth of the selected species in relation to climatic change, indicating that tree growth was constrained by moisture availability.

Juniperus przewalskii Kom was studied by Gou et al. (61) in the Yellow River Headwaters of the northeastern Tibetan Plateau at a height of 3500 to 3600 m. They established a TRW chronology and used it to reconstruct the minimum winter (October–April) temperature over the previous 425 years.

Huang and Zhang (62) constructed a 680-year-old TRW chronology of *Sabina przewalskii* Kom. The elevation range was 3100 to 3800 meters above sea level. After climate growth analysis, they found spring precipitation (May–June) was the primary limiting factor for tree growth, temperature in November may also have a role in impacting tree-ring growth.

Tree ring cores were obtained from *Juniperus przewalski* Kom species at heights ranging from 3,550–3,700 m asl. at the headwaters of the Yellow River, Animaqin Mountains, in the northeastern Tibetan Plateau [63]. They constructed a TRW chronology that was inversely associated with the highest temperature in the summer. The highest summer temperature (Apr-Sep) was reconstructed for the past 700 years based on the greater correlation.

In their publication, Wang et al. (64) discussed *Juniperus tibetica* Kom. Their study area was Sogxian and Lhari counties (Tibet Nakqu Region). The species are found at an elevation ranging from 3854m to 4233m. They developed the TRW chronology and reconstructed the Palmer drought severity index (PDSI).

Fan, Bräuning (65) discussed *Picea likiangensis* (Franch.) E.Pritz., *Tsuga dumosa* (D. Don) Eichler and *Abies ernestii* Rehder, J. Arnold Arbor from Hengduan Mountain at the elevation of 3100 to 3240 m. They developed TRW chronology and performed drought reconstruction since AD 1655.

Based on tree-ring data of *Picea likiangensis* var. balfouriana (Rehd. et Wils.) Hillier ex Slavin in the Yangtze River's source region, Liang et al. (66) reconstruct the mean June–August Tmin temperature during the prior 379 years. On a decadal timeframe, the model successfully captures recent dramatic climate shifts and corresponds with earlier temperature reconstructions for the TP. The cold and warm periods correspond to documented glacier advances and retreats on the TP east and southeast sides.

Shao et al. (67) published a paper in which they discussed *Juniperus przewalskii* Kom. from Qaidam Basin at elevation 3450-4230m. They developed the longest 3585 years TRW Chronology and suggested that Qilian juniper have a great potential for dendrochronological work.

Liang and Eckstein (68) discussed *Rhododendron nivale*. The study area was Zuoqiupu Glacier in Southeast Tibet. The elevation of the studied area was 4250 to 4500 m. They developed 1st shrub TRW chronology for Southeast Tibet and observed that the growth rate of the selected species with respect to climate response. The influence of mean monthly minimum temperatures in Nov. of the prior year and July of the ring-forming year.

At the timberline in the Sygera, southeast Tibet, Liang et al. (69) constructed four Georgei fir (*Abies georgei* var. smithii) tree-ring width chronologies. They used a composite chronology and reconstructed the average summer temperature from 1765 to the present.

Liu et al. (70) collected *Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu live tree cores from Wulan and Dulan, as well as archaeological wood samples from Dulan. The location of the study was 3300 meters above sea level. They constructed a 2485-year chronology (484 BC–2000 AD) and reconstructed the mean yearly temperature for that time period.

Yang et al. (71) discussed *Cupressus gigantean* species. Their studied areas were the Deep gorge of the Yarlung Tsangbo River in southeast Tibet at an elevation of 2992m. They also developed a TRW chronology from AD 1377 to 1998 and reconstructed the past 622-yrs of Jan–June temperature.

At 4500–4750m elevation, Yang et al. (72) collected tree cores from *Juniperus tibetica* Kom. They developed two TRW standardized chronology as well as a Regional Curve Standardization chronology. They reconstructed the mean (annual) temperature from July to June.

Yang et al. (73) discussed *Sabina przewalskii* (Kom.) W. C. Cheng & L.K.Fu from Qilian Shan, Xiqing Shan, and Anemaqin Shan. The selected studied species were elevated at an altitude of between 3000 and 4000 m. They developed a TRW chronology and observed variations in tree growth over the period AD 1450–2001.

Zhang and Wilmking (74) published an article in which they studied *Picea crassfolia*. Their studied area was Qinghainan Mountains. The elevation of the species at the studied area was 3777 to 3495 m. They constructed TRW chronology and performed climate growth relationship analysis.

Liu et al. (75) discussed *Sabina tibetica* from LKZ from Zangqu Village at the elevation ranging from 4460 to 4678 m. They constructed a 442-yrs TRW chronology and performed climate growth relationship analysis.

Liang et al. (76) a published two articles in a row in which they discussed *Abies georgei* var. smithii. Their study area was the Sygera mountains, southeastern Tibetan Plateau, and they collected the tree ring cores at an elevation of 3550 to 4390m. They also developed a TRW Chronology of 9 sites and discuss the variation of tree growth.

Juniperus pingii var. wilsonii from the Nam Co (Heavenly Lake) area was discussed by Liang et al. (76) b. At an elevation of 4740–4780 meters, increment tree ring cores were obtained. Above-average temperatures during the growing season encouraged the growth of the mentioned species. *Juniperus pingii* var. wilsonii's development was limited by the lack of moisture.

Fang et al. (77) studied *Abies forrestii* from the Hengduan Mountains, which are located between 3040 and 3320 meters above sea level. They recreated a PDSI for the southeastern Tibetan Plateau during the previous 568 years. When we compared our data to those found in other moisture-related reconstructions for surrounding locations, they discovered that the reconstructed droughts were very similar to those observed in other parts of China.

Zhu et al. (78) studied *Sabina tibetica* (Kom.) W. C. Cheng & L. K. Fu study plant species. Their study area was the Leiwuqi-Qamdo area of the Eastern TP. The elevation of the studied area was 3967–4042 m. They developed a tree ring chronology and performed a May to June temperature reconstruction.

Based on a tree-ring width chronology of *Picea likiangensis* var. balfouriana on the southern TP constructed RCS chorology, Zhu et al. (79) present a summer (August) temperature reconstruction for the period 1385–2002. They recreated August temperature fluctuations in the southeastern TP using RCS chronology dating back to AD 1385.

In their work, Xu et al. (80) discussed *Populus pseudoglauca* and *Picea likiangensis* var. balfouriana. They worked out in the area of the Midui glacier in China. The elevation of the studied species at the site was 3772–3952 m. They reconstructed Glacier fluctuations of the Midui glacier.

Liu et al. (81) investigated two *Cypress Cupressus* Gigantean sites, ZXT and LGX, in the Langxian area of western China. Tree rings cores were taken at elevations ranging from 3080

to 3420 meters and 3127 to 3139 meters, respectively. They built a TRW chronology and reconstructed annual precipitation (July-June) for southern Tibet from A.D. 1300 to 2010.

Liang et al. (82) in their publication discuss about dwarf shrub of *Juniperus pingii*, which were found in the area of Nam Co at the elevation of 4725 m. They developed a 245-yrs TRW chronology and observed the dendrochronological potential of the species.

Yang et al. (83) discussed *Sabina przewalskii (Kom.) W.C.Cheng & L.K.Fu* from Qilian mountains at the elevation of 3000 to 3520m. They developed TRW chronology and observed growth rate of the selected species with respect to climate response.

He et al. (84), He, Yang (85) and He, Yang (86) published their papers in the field of dendrochronology discussed about the same species (*Juniperus tibetica* Kom) at three different sites. That three different sites that are Suoxian and Jiali counties, Naqu region (elevation: 4000-4500m), Linzhou County, north of Lhasa (elevation: 4200-4575m) and Qumalai and Zhiduo (elevation: 4175 m). They discussed the same species in the two articles i.e. *Juniperus tibetica.* They developed TRW chronologies and reconstructed millennial precipitation, and annual minimum-temperature in their work.

Wang et al. (87) discussed *Sabina tibetica* from Zhujiao mountains. The elevation of the studied area was 4350 to 4500m. They developed TRW chronology and reconstructed mean yearly temperature for the period of 984–2009 AD.

Lu et al. (88) worked on *Rhododendron aganniphum var. schizopeplum* from Sygera mountains at the elevation of 4000 and 4500 m. They developed 6 TRW chronologies of 400 yrs old which positively associated with temperature of July.

Shi et al. (89) studied *Abies squamata* and *Sabina squamat* species from seven different areas; Batang (BT), Derong (DR), Baiyu (BY), Seda (SD), Xinlong (XL), Daofu (DF) and Miyaluo (MYL). The average elevation of the selected species was 3522 to 4221 m. They developed TRW chronologies and reconstructed Tmin for the past 212-yrs.

Zhang et al. (90) reconstructed the May–June PDSI using a network of 23 moisture-sensitive TRW chronologies from key juniper woods along a north–south transect on the eastern TP.

Chen et al. (91) discussed *Juniperus przewalskii* in the area of the Animaqin Mountains on the eastern TP. The elevation of the species in the area was 3950 to 4100m. They developed a TRW chronology and reconstructed the past 2000yrs of temperature.

Hou et al. (92) discussed *Picea crassifolia* from Lenglongling mountains at the elevation of 2511 to 3049m. They developed tree ring chronology and also reconstructed PDSI since 1786 AD.

Hochreuther et al. (93) discussed *Larix griffithii* from the area of for the southeastern TP. The elevation of the studied area was 4500m. They developed tree-ring cellulose $\delta^{18}O$ chronology.

Lu et al. (94) discussed *Salix oritrepha* from Northeastern TP. The elevation of the discussed species was 4270m. They studied TRW chronology and also Basal Area Increment (BAI) standard chronologies.

Lu et al. (95) discussed *Salix oritrepha* from four different sites i.e. Zhangye, Wulan, Dulan and Huashixia. The elevations of the sites are 3400m, 3828m, 4270m and 4257m, respectively. They developed TRW chronology and performed climate response analysis.

Han et al. (96) discussed *Salix oritrepha* from the area of Nangqian and Leiwuqi County. The elevation of the studied area was 4200-4600m. They performed climate growth response function analysis.

Wang et al. (97) discussed *Pinus tabuliformis* from the area of northern China at elevation of 966m). They developed TRW chronology and from August of the prior year to current year February was reconstructed for the past period of 1903–2012 AD.

Feng et al. (98) presented a research in which they discussed *Picea schrenkiana* species from the Kunlun Mountains region. The species were found at elevations of 3100m and 3200m in the research region. In this research, they constructed tree ring oxygen isotope chronology.

Conclusion

A thorough examination of scientific literature published before March 2022 was carried out to explore dendrochronology in Afghanistan, Pakistan, India, Nepal, Tajikistan, and China's Tibet region. Despite facing challenges due to conflicts, particularly in Afghanistan, dendrochronologists have demonstrated their resilience. Pakistan's research focused on temperature and precipitation reconstructions and emphasized the importance of regional tree-ring width chronologies for the stability of Karakorum glaciers. India had 20 publications that highlighted precision, while Nepal, Tajikistan, Iran, and China (Tibet region) made significant contributions by studying juniper species and employing detailed methodologies. This journey represents not only scientific pursuit but also the unwavering determination of humans to satisfy their curiosity. By interpreting the ancient record of tree rings, we gain profound insights

into the history, current state, and potentially the future of Earth, which is a remarkable accomplishment in our quest for knowledge.

Table 1: List of the dendrochronological related researches of Pakistan and in Border area (countries).

Reference	Study area	Elevation	Species	Research Domain
Afghanistan				
Khan *et al*., 2008	Dangam, Afghanistan	2529m	*Picea smithiana* (Wall.) Boiss	Chronology development (CD)
Pakistan				
Ahmad *et al*. (1989)	Murree and Ayubia	2000 to 3000m	*Abies pindrow* (Royle ex D.Don) Royle	CD and Climate Growth Response
Amad *et al*. (1991)	Takht-e-suleiman, Ayubia, Khansupr and Murree	7200 to 10000 feet (2194-3048m)	*Juniperus excelsa* M. Bieb., *Pinus wallichiana* A. B. Jacks., *Pinus gerardiana* Wall. ex D. Don., *Pistacia khinjuk* Stocks., Olea *ferruginea* Royale., *Ephedra gerardiana*., *Abies pindrow* (Royle ex D.Don) Royle., *Pinus roxburghii* Sarg. and *Cedrus deodara* (Roxb.) Loud	CD and CGR
Esper, 2000	Karagui, Bagrot, Caprot, Morkun, Satpara and Hunza	2500-3200m, 3100-3750m, 3500-3900m, 3900m, and 3300-3900m	*J. turkestanica* Kom., *J. seravchanica*., Komarov., and *J. semiglobosa* Regel., *Pinus wallichiana* A. B. Jacks., and *Picea smithiana* (Wall.) Boiss.	CD, CGR and Pointer years
Treydte, Schleser (99)	Bagrot and Morkun	Above the 3,700m	*Juniperus excelsa* M. Bieb and J*uniperus turkestanica* Kom	Developed $\delta^{18}O$ chronologies and PR
Esper et al, 2007	Pakistan low and Pakistan high	2,700-3,900m	J*uniperus turkestanica* Kom., *Juniperus seravchanica* Komarov., and *Juniperus semiglobosa* Regel.	RCS-CD and performed Growth trend analysis
Ahmed et al. 2011	Chitral Gol National Park, Astore-Rama, Mushkin (Shalguatum), Chera (Gilgit), Naltar (Gilgit) Bagrot, Murree-Ayubia, Bumburet (Kalash), Islam Baiky (Dir), Mushfar (Gilgit), Zairat (Chitral), Joti (Chilas), Bagrot, Caprot, and Morkun	2550- 3450m	*Abies pindrow* (Royle ex D. Don) Royle., *Cedrus deodara* (Roxb.) Loud., *Juniperus excelsa*., *Picea smithiana*., *Pinus gerardiana* Wall. ex D. Don. and *Pinus wallichiana* A. B. Jacks.	CD and CGR
Zafar et al. 2016	Kargah, Jutial, Harmosh, Bagrot, Chera and Chaprot	2850- 3250m	*Picea smithiana* (Wall.) Boiss, and *Pinus gerardiana* Wall. ex D. Don	CD and Temperature Reconstruction (TR)
Asad et al. 2017	Bagrot (Karakoram)	3550–3710	*Pinus wallichiana* A. B. Jacks	CD and TR
India				
Bhattacharyya and Yadav (1989)	Joshimath, Uttar Pradesh (India)	1800 to 2400 m	*Cedrus deodara* (Roxb.) G. Don	CGR
Yadav *et al*., 1997	Himalayan region, India	2700 to 3000 m	*Cedrus deodara (Roxb.) G. Don, Pinus wallichiana A. B. Jacks* and Picea smithiana (Wall.) Boiss.	CD and TR
Yadav and Amalava (1997)	Kanasar and Gangotri	2400 m and 3000 m	*Pinus wallichiana* A. B. Jacks	CD and CGR
Yadav *et al*., 2002	Western Himalayan	2910 m	*Taxus baccata* L.	CD and CGR
Amalava Bhattacharyya, 2003	Eastern Himalayan	3300 to 3900 m	*Abies densa* Griff.	CD and TR
Singh and Yadav, 2005	Uttarkashi and Chamoli	2720 to 3250m	*Cedrus deodara* (Roxb.) G. Don	CD and Precipitation Reconstruction (PR)
Yadav *et al*., 2006	Lahul, Himachal Pradesh (india)	2600 to 3300 m	*Juniperus macropoda*	CD
Borgaokar *et al*., 2007	Himachal Pradesh and Central and peninsular India	2900 to 3450m	*Pinus wallichiana* A. B. Jacks., Picea *smithiana* (Wall.) Boiss., Cedrus *deodara* (Roxb.) G. Don., *Abies pindrow* (Royle ex D.Don) Royle, and *Tectona grandis* L.f.	CD and TR
Laxton *et al*., 2009	Lahul Himalayan (Northern India)	3016 m	*Cedrus deodara* (Roxb.) G. Don., *Pinus wallichiana* A. B. Jacks., *Abies pindrow* (Royle ex D.Don) Royle., *Betula utilis* D. Don, and *Picea smithiana* (Wall.) Boiss.	Snow avalanche activity reconstruction
Yadav *et al*., 2009	Western Himalayan	1500 to 4300m, 1200 to 3300m and 1800 to 3000m	*Juniperus polycarpos K. Koch, Cedrus deodara (Roxb.) G. Don* and Pinus gerardiana Wall. ex D. Don	CD and TR and PR
Deepak *et al*., 2010	Dandeli and Shimoga (India)	Not mentioned	*Tectona grandis* L.f	Dendroclimatic analysis
Yadav *et al*., 2013a	(Lahaul, Himachal Pradesh) western Himalaya, India	2640 to 3016m	*Cedrus deodara* (Roxb.) G. Don and *Pinus gerardiana* Wall. ex D. Don	Snow Water Equivalent reconstruction
Yadav *et al*., 2013b	Kinnaur region (Western Himalayan)	1587 m	*Cedrus deodara* (Roxb.) G. Don and *Pinus gerardiana* Wall. ex D. Don.	CGR and PDSI-reconstruction
Yadav *et al*., 2014	Gangolihat and Jageshwar	1760m and 1851m	*Cedrus deodara* (Roxb.) G. Don	CD and PR

Shah *et al*., 2014	Eastern Himalayan	1209 to 2914m	*Abies densa, Juniperus indica, Larix griffithiana, Pinus roxburghii* Sarg., *P. wallichiana, Taxus baccata* L. and *Tsuga dumosa* (D. Don) Eichler (conifers species). *Toona ciliata* and *Magnolia* cathcartii (broad-leaved taxa)	CD and TR
Singh *et al*., 2016	Imphal, Manipur, northeast India	1200 to 1400 m	*Pinus kesiya* Royle ex Gordon	CD
Bhattacharyya and Chaudhary, 2018	Yumthang (YUM), and T-Gompa (TGA), India	3300 to 3900 m	*Abies densa* Griff.	CD and TR
Shah *et al*., 2019	Mizoram, Northeast India	500 to 2000 m	*Tectona grandis* L.f., *Pinus kesiya* Royle ex Gordon, and *Quercus serrata* Murray.	CD and Dendrochronological potential
Yadava *et al*., 2021	Chakrata region of Garhwal, Uttarakhand, western Himalayan	2715 to 2815m	*Cedrus deodara* (Roxb.) G. Don	Drought Index Reconstruction
Shah *et al*., 2021	Sielmat, Manipur, Northeast India	855 m	*Pinus kesiya* Royle ex Gordon	CD and Growth rate (GR)
Nepal				
Suzuki et al., 1990	Lake Rara Jumrat Distt, Karnali zone (western Nepal)	2980m	*Abies spectabilis* (D.Don) Spach., *Pinus wallichiana* A. B. Jacks, and *Picea smithiana* (Wall.) Boiss.	CD and CGR
Bhattacharyya et al., 1992	5 sites for AS	1320 to 3720m	*Abies spectabilis* (D.Don) Spach., *Pinus roxburghii* Sarg., *Tsuga dumosa* (D. Don) Eichler., *Cedrus deodara* (Roxb.) G. Don., *Picee smithiana, Juniperus recurve* Buch.-Ham. ex D. Don., *Pinus wallichiana* A. B. Jacks. and *Larix potanini.*	CD
Romagnoli and Monaco, 1995	Western Nepal	3450m	*Abies spectabilis* (D.Don) Spach and *Pinus wallichiana* A. B. Jacks	CD
Bhattacharyya et al., 2001	Din Gad Valley (Seven sites)	Not mentioned	*Abies pindrow* (Royle ex D.Don) Royle	CD and Climate and Glacial behavior
Cook et al., 2003	7 sites in Nepal	3000m	*Tsuga dumosa* (D. Don) Eichler., *Pinus wallichiana* A. B. Jacks., *Picea smithiana* (Wall.) Boiss., *Abies spectabilis* (D.Don) Spach., *Juniperus recurve* Buch.-Ham. ex D.Don and *Ulmus wallichiana* Planch	CD and CGR
Sano et al., 2005	Humla District, western Nepal	3850m	*Abies spectabilis* (D.Don) Spach	CR & Densities
Chhetri et al., 2010	Langtang National Park (Two areas)	3309m and 3444m	*Abies spectabilis* (D.Don) Spach	CD and RW
Dawadi et al., 2013	Langtang National park, Nepal	3780 m	*Betula utilis* D.Don	CD and CGR
Tapa et al., 2013	Khaptad NP Nepal	3000m	*Abies pindrow* (Royle ex D.Don) Royle	CD and Climate reconstruction
Kharal et al., 2014	Mustang district	2700 to 3300 m	*Abies spectabilis* (D.Don) Spach	CD and CGR
Thapa, Shah (2015)	Lokhada region	2700m	*Picea smithiana* (Wall.) Boiss.	CD and Climate reconstruction
Gaire et al., 2017	Rara National Park (RNP), western Nepal	Not mentioned	*Abies spectabilis* (D.Don) Spach	CD and CR
Aryal et al., 2018	Bicharichautara village of Syangja in Western Nepal	1450 to 2517 m	*Pinus roxburghii* Sarg.	CD and CGR
Gaire et al., 2019	Shey Phoksundo National Park (SPNP)	2130 to 6885 m	*Pinus wallichiana* A. B. Jacks	PDSI reconstruction
Bhandari et al., 2019	Chhetti and Ranghadi (western Himalayan)	2700 to 2800 m	*Tsuga dumosa* (D. Don) Eichler	CD
Aryal et al., 2020	Timang village	2700 m	*Abies spectabilis* (D.Don) Spach., *Pinus wallichiana* A. B. Jacks., *Picea smithiana* (Wall.) Boiss and *T. dumosa.*	CD and CGR
Tajikistan				
Opała et al., 2013	Fann Mountains	2200 to 2250 m	*Ephedra equisetina* L.	CD and Dendrochronological potential
Opala et al., 2017	western Pamir-Alay mountains	2700 to 3500 m and 1200 to 2400 m	*Juniperus semiglobosa* Regel and *Juniperus seravschanica* Kom.	CD and CGR
Opała et al., 2018	Artuch village (Pamir-Alay region)	2000m and 3000m	*Juniperus trees*	CD and Dendroarchaeological development
Yu et al., 2018	Taboshar, Sogd Province, northern Tajikistan	1485 to 1585 m	*Juniperus Turkestanica* Kom.	CD and TR
Opala et al., 2019	Pamir-Alay Mountains	1016 to 3373 m	*Juniperus semiglobosa* Regel	CD and PDSI reconstruction
Fan et al., 2021	Pamir-Alay (NWPA) Mountains	1175 to 2149 m and 3249 m	*Juniperus seravschanica* and *Juniperus Turkestanica* Kom.	CD and Tree Ring Carbon Isotopes.
Iran				

Pourtahmasi et al., 2007	Goochan, Mashhad and Zanjan (Elburz mountain and koppeh Dagh)	1287m, 990m and 1663m	*Juniperus polycarpus* K. Koch	CD
Kiaei et al., 2011	Khanican forests (Now-shahr province in north of Iran)	100m	*Acer velutinum* Boiss.	CD
Pourtahmasi et al., 2011	Caspian forest in the Alborz Mountains, northern Iran	1260 to 2200 m	*Fagus orientalis* Lipsky	RW and Vessel variability
Gholami et al., 2015	Guilan province, Caspian southern coasts, Iran	Two wells (20 m and 21 m)	*Quercus Castaneifolia* C.A.Mey	Groundwater Level Fluctuations
Foroozan et al., 2015	Chaharbagh (Alborz Mountain range)	2540 m and 2250 m	*Juniperus polycarpus* K.Koch and *Quercus macranthera* Fisch. & C.A.Mey. ex Hohen	Latewood Oxygen Isotope Chronology
Haghshenas et al., 2016	Caspian forests	1038 to 1152 m	*Fagus orientalis* Lipsky	CD and GR
China (Tibet region)				
Xiong et al., 2000	Gorges Reservoir region	271 to 1420 m	*Cathaya argyrophylla* Chun & Kuang Chun and Kuang, *Cinnamomum camphora* (L.) J.Presl, *Gordonia acuminata, Pinus massoniana* Lamb and *Schefflera delavayi.*	CD and Dendrochronological potential
Zhang, Cheng (57)	Dulan, northeastern Qinghai-TP	3100m and 3800m	*Sabina przewalskii* Kom.	CD and PR
Liu et al., 2006a	Dulan region	3673 to 4140 m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu.	CD and CR
Liu et al., 2006b	Dulan (Qurigang, Yangchang and Kecuo)	3800 to 4200 m, 3800 to 4000 m and 4000 to 4200 m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu.	CD and PR
Liang et al., 2006	Qaidam Basin	2800 m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu and *Picea crassifolia*	CD and GR
Gou et al., 2007	Headwaters of the Yellow River	3500 to 3600 m	*Juniperus przewalskii* Kom.	CD and TR
Huang and Zhang (2007)	Wulan	3100 to 3800 m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu	CD and CR
Gou et al., 2008	Headwaters of the Yellow River	3550 to 3700 m	*Juniperus przewalskii* Kom.	CD and TR
Wang et al., 2008	Sogxian and Lhari counties (Tibet Nakqu Region)	3854 m and 4233 m	*Sabina tibetica* Kom.	CD and PDSI Reconstruction
Fan et al., 2008	Hengduan Mountain	3100 to 3240 m	*Picea likiangensis, Tsuga dumosa* (D. Don) Eichler and *Abies ernestii*	CD
Liang et al. (2008)	Yushu region, TP	4010-4330m	*Picea likiangensis* var. balfouriana (Rehd. et Wils.) Hillier ex Slavin	CD and TR
Shao et al., 2009	Qaidam Basin	3450 and 4230 m	*Juniperus przewalskii* Kom.	CD
Liang and Eckstein (2009)	Zuoqiupu Glacier in south-east Tibet	4250 to 4500 m	*Rhododendron nivale*	CD and GR
Liang et al. (2009)	Sygera, southeast Tibet, China	4,280-4,370m	*Abies georgei* var. smithii	CD and GR
Liu et al. (2009)	Wulan and Dulan	3300m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu	CD and TR
Yang et al., 2010a	Deep gorge of the Yarlung Tsangbo River of southeast Tibet	2992 m	*Cupressus gigantea* W.C.Cheng & L.K.Fu	CD
Yang et al., 2010b	Yarlung Zangbo River in the southern part of the TP	4500 to 4750 m	*Tibetan juniper (Juniperus tibetica)*	CD and CGR
Yang et al., 2010c	Qilian Shan, Xiqing Shan, and Anemaqin Shan	3300-4000m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu	CD and CGR
Zhang and Wilmking (2010)	Qinghainan mountains	3777 to 3495 m	*Picea crassfolia* (Willd.) Blume.	CD and CGR
Liu et al., 2010	LKZ from Zangqu Village	4460 to 4678 m	*Sabina tibetica* (Kom.) W.C.Cheng & L.K.Fu	CD
Liang et al., 2010a	Sygera Mountains	3550 to 4390 m	*Abies georgei*	CD
Liang et al., 2010b	Qilian mountains	2005 to 3556 m	*Picea crassifolia* and *Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu.	CD
Fang et al., 2010	Hengduan Mountains	3040 to 3320 m	*Abies forrestii*	PDSI Reconstruction
Zhu et al., 2011a	Leiwuqi, Qamdo area of the eastern TP	3967 to 4042 m	*Sabina tibetica* Kom.	CD and TR
Zhu et al., 2011b	Ranwu Lake and Midui Glacier	3982- 4329m	*Picea likiangensis* var. balfouriana	CD and TR
Peng et al., 2012	Midui glacier	3772 to 3952 m	*Populus pseudoglauca* and *Picea likiangensis var.balfouriana.*	Little Ice Age (LIA) reconstruction
Liu et al. (2012)	Langxian	3127-3139m	*Cypress Cupressus*	CD and PR
Liang et al., 2012	Nam Co	4725 m	*Dwarf shrub Wilson juniper (Juniperus pingii).*	CD and Dendrochronological potential

Yang et al., 2013	Qilian Mountains	3000 to 3520 m	*Sabina przewalskii* (Kom.) W.C.Cheng & L.K.Fu.	CD and GR
He et al., 2013a	Suoxian and Jiali counties, Naqu region	4000 to 4500 m	*Juniperus tibetica* Kom.	CD
He et al., 2013b	Linzhou County, north of Lhasa	4200 to 4575 m	*Juniperus tibetica*.	CD
He et al., 2014	Qumalai and Zhiduo	4175 m	*Juniperus tibetica* Kom.	CD
Wang et al., 2014	Zhujiao Mountains	4350 to 4500 m	*Sabina tibetica* (Kom.) W.C.Cheng & L.K.Fu	CD and TR
Lu et al., 2015	Sygera Mountains	4000 and 4500 m	*Rhododendron aganniphum* var. schizopeplum	CD
Shi et al., 2015	Batang (BT), Derong (DR), Baiyu (BY), Seda (SD), Xinlong (XL), and Daofu (DF)	3522 to 4221 m	*A. squamata*	CD and CR
Zhang et al. (2015)	TP	3,200 and 4,700 m.	*junipers (Juniperus* spp.*).*	PDSI reconstruction
Chen et al., 2016	Wenquan in Qinghai Province	3950 to 4100 m	*Juniperus przewalskii*	CD and TR
Hou *et al*., 2016	Lenglongling Mountains	2511 to 3049 m	*Picea crassifolia* var. crassifolia (Komarov)	CD and PDSI reconstruction
Hochreuther *et al*., 2016	Xizang Autonomous Region	4500 m	*Larix griffithii* Hook.f.	Tree-ring cellulose δ18O chronology
Lu *et al*., 2016	Northeastern TP	4270 m	*Salix oritrepha* C. K. Schneider in Sargent, Pl. Wilson	RW and Basal Area Increment (BAI) standard chronology development
Lu *et al*., 2019	Zhangye, Wulan, Dulan and Huashixia	3400 m, 3828 m, 4270 m and 4257 m	*Salix oritrepha* C. K. Schneider in Sargent, Pl. Wilson	CD and CR
Han *et al*., 2022	Nangqian County and Leiwuqi County	4200 to 4600 m	*Salix oritrepha* C. K. Schneider in Sargent, Pl. Wilson	CGR
Wang *et al.*, 2022	Mengluan Forest Farm	966 m	*Pinus tabuliformis* Carr.	CD and SPEI reconstruction
Feng et al. (2022)	Kunlun mountains	3100 m and 3200 m	*Picea schrenkiana* Frisch. & C.A.Mey	CD and Tree ring Oxygen isotope analysis

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