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244-year long tree-ring based drought records from Uttarakhand, western Himalaya, India

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ABSTRACT

Droughts in the orography dominated mid-to-high elevation Himalaya have serious impact on the agrarian economy and biodiversity of the region. Temporally and spatially limited weather records from the Himalaya restrict our understanding on the socioeconomic impact of droughts in long-term perspective. In view of this, high-resolution proxies are required to develop long-term drought records from the data scarce Himalayan region. To fill this void, we developed February–May (FMAM) 4-month standardized precipitation-evapotranspiration index (SPEI4-May), a metric of drought, extending back to AD 1773 using ring-width chronology of Himalayan cedar (*Cedrus deodara* (Roxb.) G. Don) from Chakrata region of Garhwal, Uttarakhand, western Himalaya. The calibration model (1969–2016) captured 43% of the variance in the observed SPEI series. The SPEI reconstruction revealed high year-to-year and inter-decadal variation with 1774 (SPEI -3.11) and 1787 (SPEI +2.13) being the driest and the wettest years, respectively. The five year mean of reconstructed SPEI revealed droughts in 1818–1822, 1798–1802, 1813–1817, 1793–1797, 1958–1962 and pluvials in 1783–1787, 1838–1842, 1788–1792, 1933–1937, 1808–1812. A comparison of present SPEI reconstruction with other available tree-ring based precipitation and drought records from the western Himalayan region revealed synoptic scale features represented in our data. The findings underscore that a wide network of such large tree-ring based drought records from the data scarce Himalayan region should be very useful to understand the spatial distribution of droughts.

1. Introduction

Drought, a natural hazard that may persist for a particular season or month or year or multiple years, sternly affects plant growth hence agricultural production (Mishra and Singh, 2010; Zhang et al., 2017) and also the wellbeing of people associated with farming in affected areas (Wilhite, 2000). Frequent droughts in many regions of India are known to badly affect the livelihood of the low-income population whose sustenance is dependent on agriculture. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are expected to increase with the projected global warming of 1.5 °C (IPCC, 2018). In India, more than 55% of the cultivated area is rain-fed having no proper irrigation facility (NRAA, 2014), hence under drought conditions people are bound to live under precarious conditions as their sustenance to great extent depends on agriculture (Gupta et al., 2011). According to the national commission report on agriculture, the government of India (GOI, 1976) categorised the droughts in three groups; meteorological, hydrological and agricultural. The agricultural droughts affect plant growth due to increasing dryness in soil moisture and high evapotranspiration (Wilhite, 1993). The orography of the Himalayan region restricts the development of additional irrigation facilities and in this condition; farming is totally dependent on natural rainfall. Therefore in such ecologically sensitive Himalayan region understanding the drought variability in a long-term context is important to develop appropriate mitigation measures for minimising the socio-economic loss due to reduced agricultural productivity under extreme drought conditions.

The available instrumental data and proxy records, though very limited from the western Himalayan region revealed the state of climate change in terms of increasing temperature and fluctuating precipitation

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