

## RESEARCH ARTICLE

# Early onset of aridity in the past millennium: Insights from vegetation dynamics and climate change in the alpine, cold-desert region of Trans Himalaya, India

Ruchika B. Mohanty<sup>1\*</sup>, Amit K. Mishra<sup>2</sup>, Kriti Mishra<sup>3</sup>, Akhilesh K. Yadava<sup>2</sup>, M. Firoze Quamar<sup>2,4</sup>, Iswar C. Barua<sup>1</sup>, Ratan Kar<sup>2,4\*</sup>

**1** Department of Agronomy, Assam Agricultural University, Jorhat, India, **2** Birbal Sahni Institute of Palaeosciences, Lucknow, India, **3** Central Ground Water Board, North Western Region, Chandigarh, India, **4** Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, India

\* [ruchikabajpayee@gmail.com](mailto:ruchikabajpayee@gmail.com) (RBM); [ratan\\_kar@bsip.res.in](mailto:ratan_kar@bsip.res.in) (RK)



## OPEN ACCESS

**Citation:** Mohanty RB, Mishra AK, Mishra K, Yadava AK, Quamar MF, Barua IC, et al. (2024) Early onset of aridity in the past millennium: Insights from vegetation dynamics and climate change in the alpine, cold-desert region of Trans Himalaya, India. *PLoS ONE* 19(1): e0295785. <https://doi.org/10.1371/journal.pone.0295785>

**Editor:** Huasheng Huang, University of Florence: Universita degli Studi di Firenze, ITALY

**Received:** December 5, 2022

**Accepted:** November 29, 2023

**Published:** January 10, 2024

**Peer Review History:** PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: <https://doi.org/10.1371/journal.pone.0295785>

**Copyright:** This is an open access article, free of all copyright, and may be freely reproduced, distributed, transmitted, modified, built upon, or otherwise used by anyone for any lawful purpose. The work is made available under the [Creative Commons CC0](https://creativecommons.org/licenses/by/4.0/) public domain dedication.

**Data Availability Statement:** All relevant data are within the paper and its [Supporting Information](#) files.

## Abstract

Palynological analysis of surface soil and sub-surface sediments from the outwash plain of Hamtah Glacier, Lahaul-Spiti, India, has brought out the vegetation and climatic changes in the area during the last 1580 years. The arboreal and non-arboreal pollen ratio (AP/NAP) has been used to demarcate the different vegetation and climatic zones, complemented by the frequencies of the broad-leaved taxa. Lower values of thermophilous, broad-leaved arboreal taxa, indicate that the region experienced cold-arid conditions between 1580 and 1330 yr BP (AD 370–620); which can be related to the Dark Ages Cold Period (DACP). Thereafter, between 1330 and 950 yr BP (AD 620–1000), a rejuvenation of the broad-leaved elements reflects the initiation of a comparatively warm and moist phase, marking the Medieval Climatic Anomaly (MCA) in the region. The warm-moist phase was, however, short-lived, and from 950 yr BP to the Present (AD 1000 onwards), the region saw a return to cold-arid conditions, as evidenced by a sharp fall in the AP/NAP ratio. This cold-arid phase was, nevertheless, punctuated by a warm-moist period during 790 to 680 yr BP (AD 1160–1270), which marks the terminal phase of the MCA. After the termination of the MCA, the Little Ice Age (LIA) is well-marked in the area. The culmination of the long cold-arid regime is characterized by warmer conditions over the last 160 years, which is the manifestation of the Current Warm Period (CWP). Magnetic susceptibility ( $\chi_{lf}$ ) and sediment geochemistry (Weathering Index of Parker) were also attempted to have a multi-proxy approach, and show a general compatibility with the palynological data. The palaeoclimatic evidences suggest shorter warm periods and extended colder phases during the last 1580 years; in this high-altitude, cold-desert, Trans Himalayan region.