Exploring Third Pole shrub rings: Linking the Arctic and Himalayan regions for delineating Climate change dynamics

Understanding global patterns of diversity and the effects of climate change on vegetation dynamics in arctic-alpine regions is crucial for addressing pressing challenges in biogeography and macroecology. Rapid warming in these high-latitude ecosystems is surpassing the global average, leading to significant changes in plant composition, biomass, and coverage, widely known as "Arctic greening." However, our understanding of vegetation dynamics and responses to climate change in cold and dry biomes, particularly in the Indian Himalayas, remains inadequate.

The Himalayas, functioning as the third pole with substantial snow cover, play a pivotal role in the monsoon climate dynamics of the Indian subcontinent and surrounding areas. These high mountain ecosystems offer ideal settings to study climate variability and vegetation responses, as high-elevation plant taxa in subalpine and alpine zones exhibit rapid responses to temperature changes. However, limited long-spanned instrumental climate data in the Himalayas necessitate the use of proxy records such as tree-rings and shrub-rings to study past climate variability. While dendrochronological studies using trees have been extensively conducted, the application of shrub-ring-based dendroclimatology beyond the upper tree limit in alpine ecosystems, especially in the Himalayas, remains limited. High-resolution data obtained from these natural archives can provide valuable insights into past climate influences on plant growth and recruitment, facilitating the detection of climate change signals. Given the high rates of warming in mountainous regions, surpassing the global average, urgent research is needed to understand the sensitivity of alpine plants adapted to low temperatures to these changes.

To address these knowledge gaps, **this research project aims** to investigate vegetation dynamics and responses to climate change in high-elevation ecosystems, with a specific focus on the Himalayas. By employing dendrochronological methods, including shrub-ring analysis, we will reconstruct past climate variability and examine its impact on plant growth, regeneration, and species composition. Through the study of different elevational gradients and contrasting distributional limits within species ranges, we aim to comprehend the spatiotemporal variability of plant responses to climate change.

By adopting a multi-site approach within the Indian Himalaya and comparing plant responses across different habitats and distributional limits with the Arctic, this project will enhance our understanding of how plants with broad distribution ranges cope with climate change. It will shed light on the spatiotemporal variability of climate change impacts and responses within and across species. The primary objective of our research is to delineate the similarities and differences in shrub growth patterns between the Arctic and Himalayan regions, aiming to identify potential linkages and teleconnections in climate dynamics. Our **specific study aims** include, 1) investigating the growth limitations and potential of globally widespread shrub species, 2) assessing the responses of anatomical traits to climate change in Salix and Juniper species, 3) examining the major dominating environmental factors for the growth and expansion of high-altitudinal shrubs in the Himalayas, and 4)conducting a comparative study to evaluate the response of the same genus of plants in different regions worldwide to contemporary environmental changes and determine if they exhibit similar changes in growth behavior at comparable rates.

The **expected results** of this research are as follows – Firstly, it will provide insights into the growth limitations and potential of *Salix* and *Juniperus* species at the Himalayan shrubline under changing climates. Secondly, understanding the anatomical trait responses of these species to climate change including with the root diameter variation and overall growth patterns of plants. It will contribute to predicting future distribution patterns and dynamics of these shrubs. Thirdly, a comparative analysis across different geographical locations will determine if similar growth behavior changes occur at comparable rates, enhancing our understanding of global vegetation dynamics. These findings will have significant implications for policymakers, conservationists, and researchers dedicated to mitigating climate change effects and preserving biodiversity. The research will provide valuable insights into shrub growth patterns, identifying potential linkages in climate dynamics between the Arctic and Himalayan regions. Additionally, it will support the development of sustainable management practices.