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Spatiotemporal changes in timberline of Sikkim Himalaya: Challenges and recommendations for generating timberline geo-database

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ABSTRACT

Himalaya and its high-altitude vegetation are generally considered as prominent indicator of climate change. Field based observations are rare owing to harsh climatic condition and rough terrain. Moreover, this method is low in precision to understand regional patterns and to be used as inputs to models for generalization (e.g. extent and geo-spatial attributes of climatically sensitive timberline vegetation of Himalaya). Recently, various automated methods/Algorithms have been employed on remotely sensed data to extract vegetation cover and classification. However, each methodology has some serious limitation and cannot considered as robust method. At regional scale such deviations are minor where entire range of timberline varied between 2600m and 4200m. The mean upward shift in the timberline is 100m ± 89 m approximately 26 m per decade and downward shift is 56m ± 54 m approximately 15 m per decade between the year of 1977 and 2015.

STUDY AREA AND METHODOLOGY

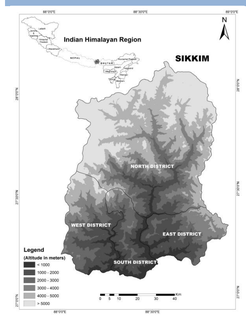

Fig. 1. Study area Map

The Study area include Sikkim state as test case to compare products and develop methodological framework. It is a small state in the north-eastern part of Indian Himalayan Region (IHR) which lies between 27º04'46" to 28º07'48" N latitudes and 88º00'58" to 88º55'25" E longitudes and covering an area of 7096 km2 (Fig.1). The state has four districts with simple nomenclature, viz., East district, West district, North district and South district (Fig. 1), having district headquarters at Gangtok, Geyzing, Mangan and Namchi, respectively.

Remote sensing is of utmost importance in order to delineate timberline and demonstrate changes occurring in Himalayan landscape. In order to map the longest spatio-temporal dynamics of timberline in Sikkim Himalaya Landsat 8 (2015) and Landsat-2 (1977) were used. Different images were co-registered with latest image of 2015 to do change analysis of timberline. The satellite images were then subjected to knowledge-based interpretation technique and timberline was delineated by applying visual interpretation. Change in timberline was recorded as a function of shift in altitude from the past (1977) to the current (2015) position. Thirty-meter spatial resolution of points was in tune to resolution of ASTER DEM (30m) which was used to extract altitudinal information. Points at every 30m were generated over the entire timberlines to match the spatial attributes of DEM, and differences (elevation and distance) were recorded. Temporal changes were marked as 'shift' (upward/downward in timberline position with respect to the base year (1977).

OBJECTIVES

- To develop methodological framework for remote sensing approach in heterogeneous Himalayan landscape thus comparable timberline geospatial database along the Himalayan arc.
- Determine Changes in timberline elevations between 1977 & 2015 and find timberline elevations (lowest and highest).

RESULTS

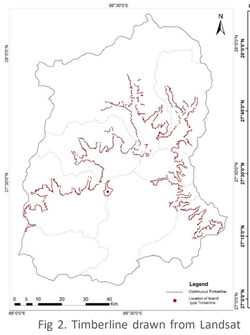

Fig 2. Timberline drawn from Landsat image of 2015. Dot shows an isolated presence of timberline which is away from the main snow peaks.

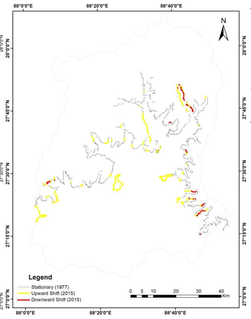

Fig 3. The position of timberline in 1977 and 2015 in the state of Sikkim Himalaya

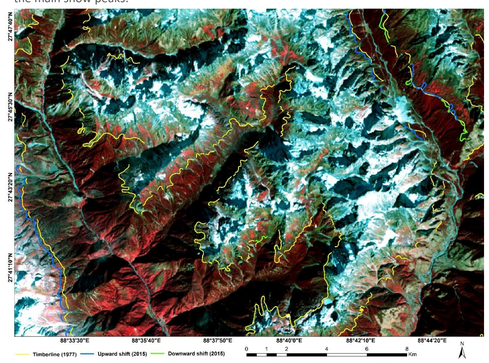

Fig. 4. The shift of Timberline position from 1977 (yellow line) to 2015 (blue line) location draped over FCC of Landsat-8

The gain (32.7 km; increase) and loss (8.56 km; decrease) in different elevation bands were recorded since 1977(Fig. 3), absolute increase in total length of timberline was about 23 km during the studied period. These changes occurred in less than one-fourth of the timberline length of 1977 (23.5% of total; 142.43 km upward and 23.8 km downward) while majority of the timberline (76.5%) remained stationary (i.e., no change) since 1977.

Mean elevation of the entire timberline in 2015 was moved upward by 18m since 1977, however, maximum elevation of occurrence remained same. Minimum elevation (lowest occurrence) increased by 79m which indicates disappearance of lower end of timberline from unusual sites of occurrence.

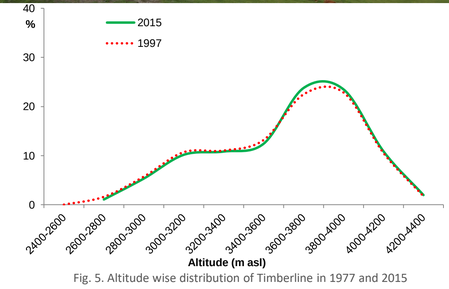

Fig. 5. Altitude wise distribution of Timberline in 1977 and 2015

It was realized that above 3600m elevations (Fig. 5) there is gain in timberline length and below that elevation timberline is shrinking (save 3200-3400m elevation).

CONCLUSION: Regional modelling of change detection, future prediction, and geographical explanations of diverse mountain timberline along the 2000 km long Himalayan arc. Satellite imagery analysis of about three and half a decade reveals two perspectives of the treeline dynamics in Sikkim Himalaya. On one hand, there is an upward shift of timberline position and on another hand downward shift of the timberline. The upward shift in the timberline is about 26 m decade-1 and downward shift is about 15m decade-1.