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Apple Tree Line Shifting in Himalayas as Evidence of Climate Change

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Apples are not native to the Himalayan region. While wild apple species (*Malus*) evolved naturally across Central Asia, the Tian Shan mountains, and parts of Asia Minor and Western China, the British colonial era introduced cultivated commercial apples to the Himalayan region, and early 20th-century agricultural pioneers expanded their cultivation. Over the past century, the apple industry has evolved since an American missionary introduced it. This has created a lifestyle around apple production (Chandrashekhar, 2013). In addition, the market peaked then. However, there has been a decrease in productivity due to upward movement of tree lines in areas where the apple belt used to be located (1200-1500m) in the 1980s. The cultivation belt moved to areas of 1500- 2500 m in the 2000s. However, in 2014, apples started to grow above 3500m, such as in Leo village (Upper Kinnaur) and the Keylong area (Lahaul and Spiti) (Sahu *et al*., 2020).

The shifting apple tree line

As the apple belt in the Himalayas has begun to move up, this has been noticed by farmers and researchers. This happened only because of accelerated global warming and subsequent climate change.

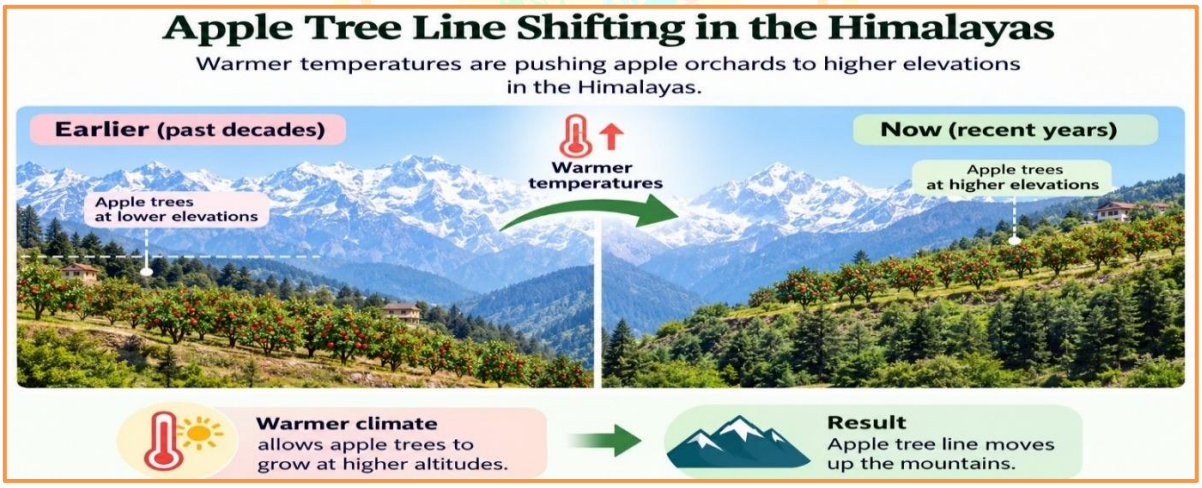


Fig 1. Apple tree line shifting

Cold Requirements

Apple trees require cold winter weather to grow, bloom, and bear fruit. This requires a long period of cold weather. This is known as the chilling hours. Standard apple varieties require between 800-1100 chilling hours (Chand *et al*., 2016). However, if the apple tree experiences warm weather (temperatures of 70 °F for 4 hours or more), it reduces chilling hours (Chand *et al*., 2016). The winters in the hill areas are no longer as cold as before. Research has shown that over the past 30 years (1986–2015), the chilling units in Kullu (the heartland of the apple

belt) have been decreasing by approximately 6.4 every year. Between 2011 and 2015, it decreased by approximately 15 every year (Chand *et al*., 2016). However, productivity was not straightforward.

The Tree Line is Moving Upwards

Research on temperature, precipitation, and chilling hours data over the past few decades has shown that the apple belt in Himachal Pradesh is moving upward because of the decrease in chilling hours in low-altitude areas, changing annual precipitation, and warmer growing season. These are directly linked to global warming and are causing problems for apple production in lower areas (Sahu *et al*., 2020). For example, research has been conducted in the Manaslu area, central Nepal (around 3750–4000 m). The trees in the tree line were mapped. They found that there was increased density in the ecotone and a definite upward trend. Most of the fir trees were young, indicating that the forest was expanding upward (Gaire *et al*., 2014). Furthermore, East in Langtang National Park, which has remained relatively untouched for centuries. This was chosen as it would remove the issues of grazing and logging. The young rhododendrons were thriving up to 200m above the tree line. However, the fir trees had barely moved up for 25m. However, not all species will move up at the same rate. The tree line in this area showed that the birch trees stayed in place, whereas the fir trees moved (Mainali *et al*., 2020).

The affected species

Table No 1. The affected species

Species	Description	Evidence
Abies spectabilis (East Himalayan fir)	Conifer at the treeline	Upward shift with many young plants in Manaslu, Nepal (Gaire *et al*., 2014); only about 25 m above the old treeline in Langtang (Mainali *et al*., 2020)
Betula utilis (Himalayan birch)	Broadleaf treeline tree	Upper limit largely stagnant in Manaslu, held back by dry pre-monsoon spells (Gaire *et al*., 2014)
Rhododendron campanulatum	Shrubby rhododendron	Young plants up to 200 m above the treeline, dying less often there than below (Mainali *et al*., 2020)

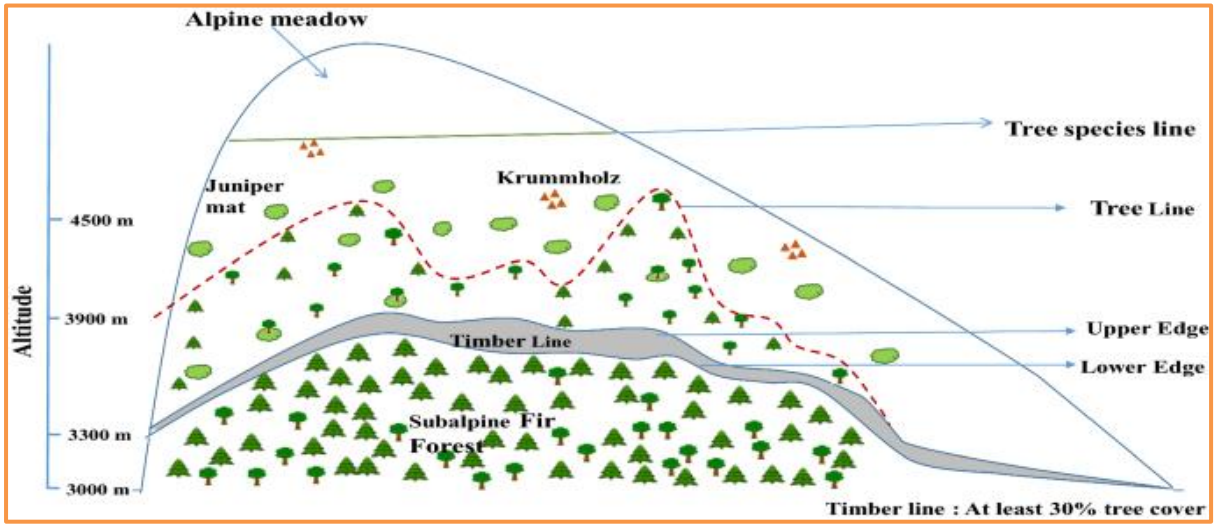


Fig 3. Species in Himalayas (source: https://link.springer.com/article/10.1007/s42965-020-00093-7)

Benefits and Problems

At the same time, higher-altitude areas are becoming more suitable for apple farming. Kinnaur has experienced an increase in wealth due to the booming apple industry. However, Rahimzadeh (2017) stated that without climate change, the industry may not have expanded as quickly. Ethnographic research shows that so far, the effects have been positive overall. However, this is a short-term opportunity. Markets can change, and so can the climate. In the meantime, the tree line in the forest could be devastated. Research has shown that the unique flora, such as fir and birch, in the region is at risk due to the upward movement of the tree

line (Kumar & Khanduri, 2024). However, tree lines can be influenced by grazing, roads, land use, and other anthropogenic activities. The tree line does not move very rapidly. Only a few metres every decade.

Control measures

Introduce alternative varieties: Apples such as Anna (300 chilling hours) and Dorsett Golden (150 chilling hours) can still fruit in Solan, even though Royal Delicious cannot be due to it requiring 900–1000 chilling hours. These varieties can fruit one month earlier in June in areas with mild winters and therefore can be sold at a higher price. Hariman (Parmar, 2021).

Mitigation and Adaptation: Researchers have suggested that mitigation and adaptation should be used to protect vulnerable alpine ecosystems (Kumar & Khanduri, 2024). Tree lines are affected by land use, grazing, and road (Mainali *et al*., 2020). This means that less pressure can be exerted on grazing and building in sensitive areas, which can control the microclimate in sensitive areas.

Conclusion

The upward shift in apple cultivation in the Himalayan region reflects the growing impact of climate change on mountain ecosystems. Rising temperatures and reduced winter chilling hours are challenging traditional apple-growing areas, while creating opportunities at higher elevations. Although some farmers benefit economically, others face livelihood losses, and the alpine ecosystems may be disturbed. Adopting suitable apple varieties, diversifying crops, and protecting tree-line habitats are essential for balancing agricultural development with ecosystem conservation.

References

1. Chand, H., Verma, S. C., Bhardwaj, S. K., Sharma, S. D., Mahajan, P. K., & Sharma, R. (2016). Effect of changing climatic conditions on chill units' accumulation and productivity of apple in mid hill sub humid zone of Western Himalayas, India. *Current World Environment*, 11(1). https://doi.org/10.12944/CWE.11.1.18
2. Chandrashekhar, V. (2013, April 22). Climate change sends India's apple farmers up the Himalayas. The Christian Science Monitor. https://www.csmonitor.com/World/Asia-South-Central/2013/0422/Climate-change-sends-India-s-apple-farmers-up-the-Himalayas
3. Gaire, N. P., Koirala, M., Bhuju, D. R., & Borgaonkar, H. P. (2014). Treeline dynamics with climate change at the central Nepal Himalaya. *Climate of the Past*, 10(4), 1277–1290. https://doi.org/10.5194/cp-10-1277-2014
4. Kumar, S., & Khanduri, V. P. (2024). Impact of climate change on the Himalayan alpine treeline vegetation. *Heliyon*, 10(23), Article e40797. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11652899/
5. Mainali, K., Shrestha, B. B., Sharma, R. K., Adhikari, A., Gurarie, E., Singer, M., & Parmesan, C. (2020). Contrasting responses to climate change at Himalayan treelines revealed by population demographics of two dominant species. *Ecology and Evolution*, 10(3), 1209–1222. https://doi.org/10.1002/ece3.5968
6. Parmar, C. (2019). Extending apple cultivation to lesser cold areas. *Indian Horticulture*, 64(1). https://epubs.icar.org.in/index.php/IndHort/article/view/87801
7. Rahimzadeh, A. (2017). Political ecology of climate change: Shifting orchards and a temporary landscape of opportunity. *World Development Perspectives*, 6, 25–31. https://doi.org/10.1016/j.wdp.2017.03.004
8. Sahu, N., Saini, A., Behera, S. K., Sayama, T., Sahu, L., & Nguyen, V.-T.-V. (2020). Why apple orchards are shifting to the higher altitudes of the Himalayas? PLOS ONE, 15(7), Article e0235041. https://doi.org/10.1371/journal.pone.0235041
9. Tribune Web Desk. (2021, January 11). Not just a temperate fruit, apple is going places. The Tribune. https://www.tribuneindia.com/news/features/not-just-a-temperate-fruit-apple-is-going-places-196708/