



Climate change effect on forest in Western Himalayas

BY

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Abstract

During the last few decades, forest in western Himalayas is under serious threat to climate change. It has affected not only trees but also the ecosystem and microbiome system. Pests and diseases are depleting our forest cover for which beetles, nematodes, pathogenic fungi are found responsible. Soil strata were also found to alter the complete plant, microclimate as well as macroclimate thus affecting the microbiome system. Climate hot spots were evident resulting in tree mortality in western Himalayas.

Introduction

Forests are important for absorbing carbon, preserving nutrients, and useful for timber as well as fuel wood. Cedrus or cedar belongs to Pinaceae family and is native to western Himalayas. It occurs at an altitude varying from 1500-3200 m above mean sea level in the Himalayas. There are four groups of *Cedrus* on the basis of phylogeny viz., *C. brevifolia*, *C. deodara* (Deodar), *C. atlantica*, and *C. libani*. *C. deodara* is also called as wood of the Gods and its name is derived from Sanskrit term. It is highly priced item as a construction material because of resistance to insect pest and diseases and other qualities like antifungal properties. In Himachal Pradesh, it is found in Shimla, Kullu, Chamba, Lahul, and Spiti as well as Kinnaur districts.

Pine forests occur in Western Himalayas and grow at an altitude of 2000-4000 m above mean sea level. The tree is economically important as wood is used in the construction and paper products industries. It is also a source of turpentine, rosin, oils, etc. There are three species of pines i.e., *Pinus roxburghii* (Chir pine), *P. wallichiana* (Kail), and *P. gerardiana* (Chilgoza). *Pinus* is the largest group of monoecious and resiniferous evergreen tree. Chir pine is a large tree with spreading crown growing at an altitude of 450-2400 m from Kashmir to Bhutan and Siwalik hills. It covers about 20 percent of the forest trees. This pine tree is one among six pines of India covering maximum area. Uttarakhand has Garhwal and Kumaon areas with highest number of pine trees. Kail grows at an altitude of 2000-3500 m while chilgoza pine is found at an altitude of 1600-3000 m

amsl in district Kinnaur of Himachal Pradesh. Pine tree is used for resin tapping and also for extracting turpentine oil. The wood of tree is mainly used by the people of surrounding areas for making their houses, furniture as well as firewood.

The northern conifer trees contain deodar, Kail, spruce, and silver fir. The needles of pines are susceptible to forest fires. It leads to biodiversity loss as a result of loss of fauna and flora. The tree grows in Marwah valley of Doda in Jammu and Kashmir and Malari and Bampa areas of Garhwal in Uttarakhand. Chilgoza pine is found in Satluj valley in Kinnaur district of Himachal Pradesh and few areas in Pangi as well as Bharmour area in Chamba district of the state.

Climate Change

Climate change and global warming has resulted in drying up of many forest trees in the western Himalayas. The global warming is depleting forests besides community-driven deforestation. A government study during August 2021 by HP Govt. revealed that 23,542 sq. km. area was under snow cover in 2019-20 which dropped to 19,183 sq. km. in 2020-21 i.e., a decline of 3,404 sq. km. amounting to 18.52%. Nearly half of India's forest and tree cover (315,667 sq.km.) can emerge as Climate hot spots as per Forest Survey of India. By 2050, 448, 367 sq. km. of India's forest and tree cover is likely to face high severity of climate change. This is as per report of State of India's Forest Report, 2021. Our forests are under serious pressure due to human activities, global warming, fire, pests, and diseases. The annual deforestation rate in temperate forests has been reported to the extent of 0.31 million hectares during 2015-2020 leading to reduction in the biodiversity.

Temperate forests in India covers 6.74% of the geographical area and consists of 12.84% of Himalayan region. The Himalayan region is rich in natural resources and has unique biodiversity. The paleoecological studies indicate that forest vegetation has the potential to respond within years to a few decades of climate change. Studies also indicate that 20-30% of the plant and animal species would be at increased risk of extinction if the global average temperature increase exceeded 2-3°C above the pre-industrial level. During the 21st century, there will be a large-scale forest and biodiversity loss and trees mortality with decreasing ecological benefits.

Scientists claim that tree infection is due to *Phytophthora* or *Fusarium* or *Ganoderma* resulting in root rot and mortality of trees, especially in Deodar, Kail, salix as well as shisam, kikar, and Saal in high and low hills of Himachal Pradesh especially in adjoining areas of Shimla, Solan, Hamirpur, Kinnaur, Paangi as well as Lahul and Spiti of Himachal Pradesh. Drying and mortality of trees has also been observed in Anantnag, Pahalgam, and other areas of Kashmir. It is thus a serious concern to protect our valuable forest resources which needs immediate attention so as to save our forests in near future from such type of mysterious diseases.

Diseases

The future of Chilgoza and pine forests in Western Himalayas is greatly threatened by the appearance of a mysterious disease. As per records, the Pine trees are affected by different diseases like Annosus root rot where conks are found at the tree base of stumps, brown spot needle blight with lesions on secondary needles, fusiform rust with yellow spots on the leaf surfaces. Hardwood decay or heart rot with rotten wood, cankers, wilt affecting water-conducting cells leading to drooping of foliage with reddish discoloration in crown, little leaf with yellowing of needles which are short and few in number. Annosus root rot causes stunted needle growth and decay. This disease is caused by *Heterobasidion annosum*. The disease can be managed by applying borax powder to the surface of the freshly cut tree stumps so as to prevent further infection to healthy trees.

Brown spot needle blight infects longleaf pine seedlings and trees. In this case, circular grey to green spots on the needle causes them to die and fall off prematurely. The disease is caused by *Mycosphaerella dearnessii*. This disease can be prevented by making use of best-managed fire-burning technique after every two to three years. Cotton root rot symptoms appear as yellow to brown infected tree leaves followed by complete mortality. The disease is caused by *Phymatotrichum omnivorum*. The disease can be managed by ammonium sulphate and sulphur application over the manure and forming a ridge of soil around the tree. Pine wilt is a serious disease caused by a nematode namely *Bursaphelenchus xylophilus*. In this case, the nematode infests the resin canals thus clogging the water transport in a tree. The disease can be managed by removing nematode-infested trees by burning. The nematode is dispersed by a Beetle like *Monochamus*. Biological control of the disease is by the use of *Streptomyces avermitilis*

Diplodia tip blight is caused by *Diplodia sapinea*. In this case, shoot tips are attacked in the spring and a canker is formed at the base of new shoot. Resin is found to ooze out from the cankerous tissue. Lower branches are killed after few years. Needle rust is another disease in which cream-colored pustules are formed on the needle. It is caused by *Coleosporium asterum*. Another rust with a few galls is also reported which is caused by *Cronartium quercuum*. White pine blister rust is caused by *Cronartium ribicola*. In this case, swollen cankers are formed on the branches. Trees are also infected by *Verticillium dactylophorum* root rot. Such infected trees need to be removed.



Results

Our study during survey and surveillance of these areas amply reveal that the drying is due to local inhabitant's interference with soil and microclimate conditions. As far as disease or disorder is concerned, it is due to a beetle carrying nematodes which further make bruises in root system from where *Fusarium* or *Phytophthora* gets their entry through fine roots into the vascular stream of trees thus clogging xylem tissues depending upon the soil conditions resulting in wilting, drying of leaves and ultimately mortality of trees.



Future thrust areas

Digital pathology has an important role in this direction. Remote sensing and use of optical sensors and 3D imaging for tree disease and pest monitoring are of great significance besides use of automatization, mechatronics, sensors, electrical engineering, and artificial intelligence for drones and robotic applications. It warrants study to investigate the real cause of the insect-pest disease complex under different locations and to further explore the reasons of complexity

including soil factors and methods of their control. The management of the disease complex may be by digging of trenches or use of biocontrol agents like *Trichogramma*, *Beauveria*, *Trichoderma*, *Streptomyces* or *Glomus*, or other AM fungi besides *Pseudomonas fluorescens* as well as their consortium drench followed by suitable mulch application for combating the insect-pest disease complexity problem.

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