

# The Effect of Climate Change and Drought on Aleppo Pine (*Pinus halepensis*) Forests in the Geopark Mgoun, High Atlas of Morocco

**Youssef Gharnit<sup>1,\*</sup>, Abdelaziz Moujane<sup>1</sup>, Khalid El Haddany<sup>2</sup>, Aziz Hasib<sup>1</sup>, Abdelali Boulli<sup>1</sup>, Aboubakre Outourakhte<sup>1</sup>**

<sup>1</sup>Laboratory for Environmental, Ecological, and Agrindustrial Engineering, Faculty of Science and Technology, Beni Mellal, Morocco

<sup>2</sup>Research Team, Regional Management and Territorial Development, Faculty of Letters and Human Sciences, Marrakech, Morocco

## Email address:

gharnityoussef@gmail.com (gharnit Youssef), moujaneabdelazize@gmail.com (Moujane Abdelaziz), hkaliagegpr@gmail.com (El haddany Khalid El), a.hassib@gmail.com (Aziz Hasib), a.boulli@usms.ma (Abdelali Boulli), outourakhtebakre1991@gmail.com (Outourakhte Aboubakre)

\*Corresponding Author

## Abstract

Climate change in Morocco has led to drought, rising temperatures, and decreased precipitation, profoundly impacting vegetation. Unprecedented dieback has been observed in Aleppo pine (*Pinus halepensis* Mill) forests in the High Atlas, prompting an assessment of climate perturbations' role in this degradation. Climate indicators such as TX90 and TN90 (days with extreme temperatures), P10mm (days with precipitation under 10 mm), Tmin, Tmax (minimum and maximum average temperatures), average temperatures, and the bioclimate index (Q2) were used to evaluate fluctuations. Supervised classification with Sentinel-2 data (10m resolution) on Google Earth Engine calculated the Aleppo pine vegetation area. Results show significant increases in TX90, TN90, Tmin, Tmax, and average temperatures (by 1 °C) from 1960-2020, with P10mm and overall precipitation rates falling by 77.14 mm. Q2 indicates increasing aridification, shifting sub-humid areas to arid and semi-arid climates. Aleppo pine forests lost 22 km<sup>2</sup> (40% of their area) between 2015 and 2022. Statistical analysis reveals a strong correlation between pine dieback and temperatures, while precipitation shows no correlation with vegetation cover behavior in August. Evapotranspiration also shows a severe decrease during the study period, confirming plant stress. As a result, monitoring and conservation policies are highly recommended.

## Keywords

Climate Change, Aleppo Pine, Temperatures, Precipitation, Morocco