# LAND DEFORMATION IN THE JOSHIMATH REGION, UTTRAKAND

The Himalayas are highly susceptible to various natural disasters, such as land deformation, earthquakes, landslides, and extreme climatic events. Recently, the Joshimath town witnessed extensive land subsidence activity. The phenomenon resulted in the development of large cracks in roads and over 868 civil structures, posing a significant risk to the inhabitants and infrastructure of the area. The investigation was carried out using a time-series synthetic aperture radar (SAR) of the Sential-1 satellite. The interferometry-based PSInSAR approach is used to monitor land deformation. The line of sight (LOS) land deformation velocity for the Joshimath region for 2022–2023 varies from − 89.326 to + 94.46 mm/ year. The + ve sign indicates the LOS velocity/displacement away from the SAR sensor, whereas the −ve sign signifies the earth's movement towards the SAR sensor in the direction of the LOS. The displacement was further validated using multi-temporal high-resolution Planet datasets. The results are consistent.

The study also separately estimated the land deformation for 2016–2017, 2018–2019, and 2020–2021. Our results show that the Joshimath region experienced the highest land deformation during 2022–2023. During this period, the maximum land subsidence was observed in the north-western part of the town. The maximum LOS land deformation velocity +60.45 mm/year to + 94.46 mm/ year (2022–2023), occurred around Singhdwar, whereas the north and central region of the Joshimath town experienced moderate to high subsidence of the order of +10.45 mm/year to + 60.45 mm/year (2022–2023), whereas the south-west part experienced an expansion of the order of 84.65 mm/year to − 13.13 mm/ year (2022–2023). Towards the south-east, the town experienced rapid land subsidence, −13.13 mm/ year to − 5 mm/year (2022–2023).

The study analyzes the causative factors of land deformation. Uncontrolled population growth, unplanned built-up development, and inadequate drainage systems are the leading causes. To mitigate the issue, the government needs to implement a comprehensive approach. This includes establishing a well-designed drainage system, implementing regular maintenance and effective waste management, and preventing water seepage and infiltration. Measures such as constructing retaining walls and employing erosion prevention techniques are essential to address toe erosion and slope instability. The immediate actions should involve minimizing construction activities utilizing lightweight and earthquake-resistant building materials and promoting sustainable development practices. Joshimath's future relies on practical strategies considering the region's

delicate geological and environmental conditions. This entails regulating urban growth, carefully planning and executing large-scale infrastructure projects, and diversifying industries. By doing so, the government can ensure the long-term prosperity and well-being of the region while preserving natural resources and safeguarding the population from natural disasters.

Reference: Awasthi, S., Jain, K., Sahoo, S., Kumar, R., Goswami, A., Joshi, G.C., Kulkarni, A.V., Srivastava ,D.C., Analyzing Joshimath's sinking: Causes, consequences, and future prospects with remote sensing techniques . In: Scientific Reports, 14, 10876, 2024

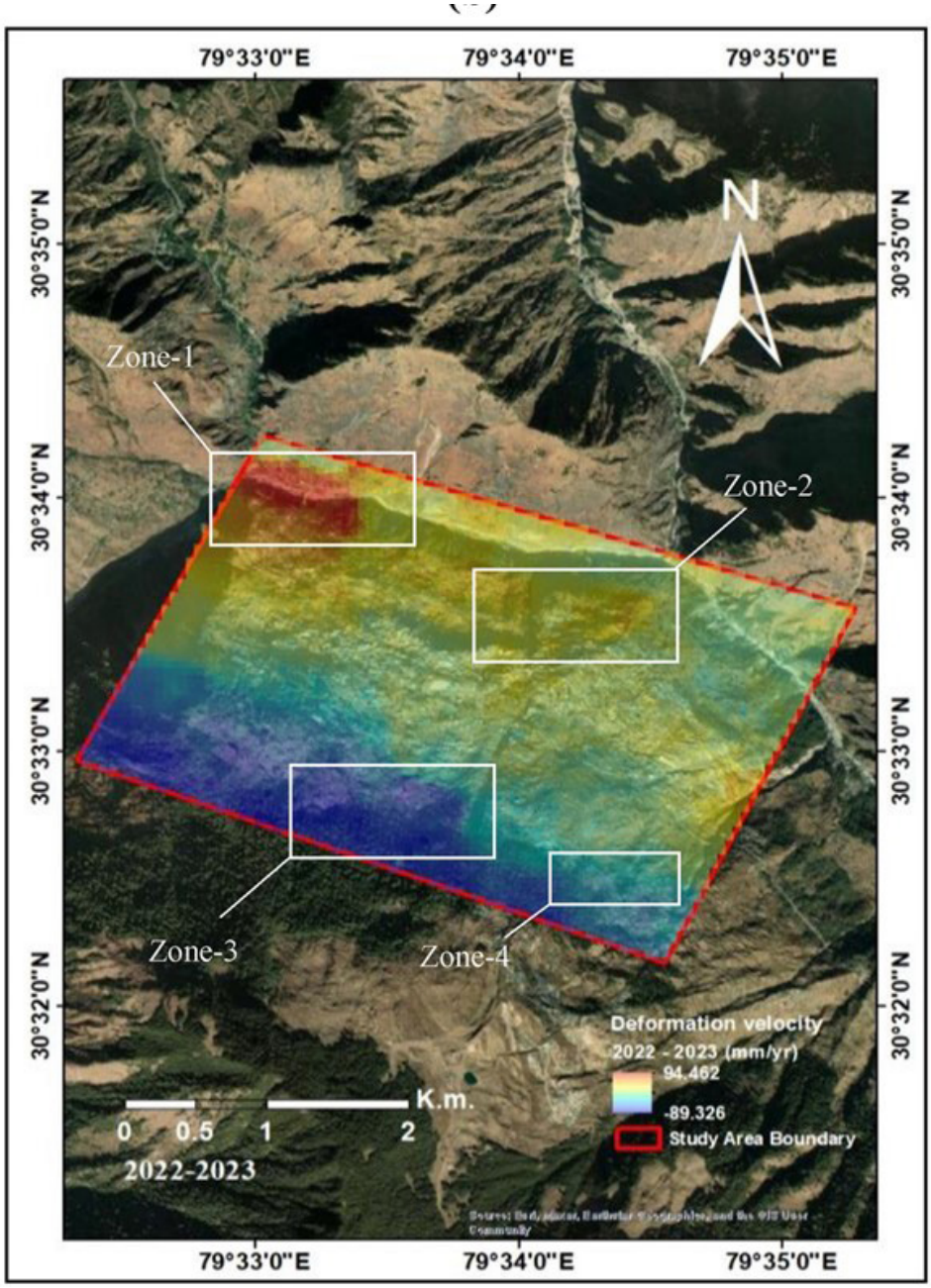


Figure: land deformation in the Joshimath region during 2022–2023. Maximum deformation was observed in Zones 1 and 3.