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Assessment of Climate Hazards in the Garhwal Himalayan Region using Geospatial Techniques

Major Findings:

An assessment of climate hazards in the Garhwal Himalayan Region (GHR) has been undertaken in this research work. The study showed that the Garhwal Himalayan Region is a multi-hazard prone region. The flood and landslide events in Indian Himalayan Region are correlated on an annual with r = 0.53, and monthly basis with r = 0.92. The states recorded highest floods also recorded maximum landslides with r = 0.64. This trend is also evident in Garhwal Himalayan Region with r = 0.82, r = 0.92 and district recorded floods also recorded maximum number of landslides with r = 0.74. The findings of the present study led to the confirmation of climate change in GHR due to anthropogenic activities of increasing population, urbanization, industrialization, and deforestation. Between 1803-2021, 63 major floods were identified in GHR of the total 650 in IHR and the highest frequency was observed in 2010-2021. In GHR, only 6 flood events were recorded before 1980 which increased to 16 in 2000s and 27 in 2010-2021 with an annual average of 2.7 events. Maximum events were reported in Chamoli followed by Rudraprayag and least in Haridwar. The flood hazard zonation map of the region, divided into 5 classes (very low to very high), revealed that 41.1% of the geographical area lies within moderate to very high flood hazard zone. The flood risk mapping showed that 43.34% of the area lies in a very high to moderate risk zone. The morphometric analysis of the region revealed its vulnerability to floods and landslides.

In GHR 3037 landslide events occurred of the total 17906 events induced by rainfall in IHR. The distributional trend depicts a rising trend up to 2021. The landslide frequency increased from 1 in 1980s to 101 in 2010s and 264 in 2020s, contributing to an annual average of 26.4 events. Most of the DAMS and HEPs were found to be located in high to very high hazard zone indicating the destructive influence of these developmental activities in the region leading to frequent landslide events. 1208 villages and towns identified were affected by landslides in the region (519 by DAMS, and 564 by HEPs). And not surprisingly 68.9% of the total geographical area is within moderate to high landslide hazard zone. The landslide susceptibility map has shown a positive association with landslide inventory and the area under the curve (ROC) contributes to 0.87 or 87%. The landslide risk index mapping also showed high consistency with landslide hazard zones with r=65 or 65% (Table 5.11). The reason behind increasing climate hazards in the region

are population,industrialization,urbanization, deforestation,mining, LULC changes, Global GHGs, temperature, Air pollution, and climate variability.

Although most heads of settlements in the region had significant theoretical knowledge of the relationship between climatic variability and climate-induced disasters, their comprehension of expected trends in climate variability's repercussions in the region was limited. The findings also indicated a number of other elements that either contribute to the region's growing number of events or act as roadblocks to its development and expansion. Poor living conditions, insufficient health care infrastructure, health professionals, a lack of climate variability training, as well as insecurity, poor administration, and a lack of all-weather roads and communication, are other factors.