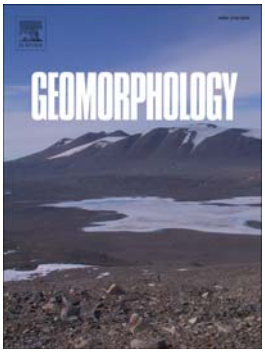

Terrain changes, caused by the 15–17 June 2013 heavy rainfall in the Garhwal Himalaya, India: A case study of Alaknanda and Mandakini basins

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Terrain changes, caused by the 15-17 June 2013 heavy rainfall in the Garhwal Himalaya, India: A case study of Alaknanda and Mandakini basins

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Abstract

Exceptional early high monsoon rains between 15 and 17 June 2013 combined with discharge from snowmelt water caused widespread floods in every major river of the Garhwal Himalaya. This catastrophic event triggered widespread landslides and devastation in the region, affecting the movement of the people that led to stranding of pilgrims in various pilgrimage routes. This event caused many casualties and irreparable damage to the infrastructures and property in the Garhwal Himalaya. A large volume of debris was deposited in Kedarnath town (3.9×10^6 m^3), and a huge amount of debris was removed from Rambara and surrounding areas (2.6×10^8 m^3). The study also found that villages like Lambaghar, Bhyundar (Alaknanda River Valley), and Rambara (Mandakini River Valley) were completely washed away, leaving no trace of earlier settlement. Govindghat and Pulna villages in the Alaknanda River Valley were also badly damaged. Approximately 0.3×10^6 and 0.72×10^6 m^3 of debris was deposited, respectively. Similarly in the Mandakini Valley, Kedarnath and Sonprayag towns were also badly damaged and ~3.9×10^6 and ~1.4×10^6 m^3 of debris was deposited in the area, respectively. Simultaneously, the moraine-dammed Chorabari Lake breached releasing ~6.1×10^5 m^3 of water with an average rate of ~1429 m^3/s (discharge of lake). The towns of Pandukeshwar in the Alaknanda Valley and Gaurikund in the Mandakini Valley were partially damaged. However, no evidence of such magnitude of destruction was reported from the Yamuna River Valley during the same period. This catastrophic event changed the landscape in many parts of Uttarakhand, making the whole region more fragile and vulnerable. A disaster of such magnitude was perhaps not witnessed by the region for at least the last 100 years.

Key words: disaster; Uttarakhand; Himalaya; extreme events; rainfall