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SCIENCE

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Glacial geomorphology of the Kolahoi glacier valley in the northwestern Himalaya

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ABSTRACT

This study presents the first comprehensive glacial geomorphological map of the Kolahoi Glacier valley, northwestern Himalaya, India. Employing high-resolution glacial geomorphological mapping at a 1:1000 scale, we combined satellite data from Sentinel-2 and Google Earth with the ALOS PALSAR digital elevation model, complemented by extensive fieldwork. The mapped glacial geomorphological landforms include mountain sclupting features, bedrock features, ice-marginal, ice-stagnation and subglacial. The discernible presence of these well-preserved glacial geomorphic features suggests that the Kolahoi Glacier advanced approximately 20 km during the Last Glacial Maximum (LGM) relative to its current snout position. The glacio-geomorphological data from this study are of paramount importance and are a valuable resource for chronological investigations, providing insights into the past advances and extent of the Kolahoi Glacier during the LGM. Furthermore, these findings contribute to a deeper understanding of the complex interplay between monsoons and westerlies, the primary moisture sources for the Himalaya.

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1. Introduction

For paleo-glacier reconstructions, geomorphological mapping of glacial features such as frontal moraines, lateral moraines, drumlins, roche moutonnées, trimlines, etc., is essential (Murtaza & Romshoo, 2021; Paul et al., 2022b; Nieuwendam et al., 2016; Benn et al., 2005). Various studies (e.g. Boston et al., 2015; Lukas, 2006) suggest that glacial geomorphic features, especially moraine patterns, can provide vital evidence for differentiating distinct phases of former glaciation. Mapping glaciers and glaciated terrain in the Himalaya using conventional surveys was started by the Survey of India (SOI) in 1767. Others later modified these maps and reported the corrections (Bhambri & Bolch, 2009). However, the actual improvement in mapping glacial geomorphology in the Himalaya started only after 1960 with the advent of remote sensing and GIS techniques (e.g. Amerson et al., 2008; Benn et al., 2005; Fezer, 1971; Graf, 1970; Sugden, 1978). Nevertheless, only a few studies have reported the glacial geomorphology of the Himalaya and its importance for studying Quaternary glaciation and climatic variability (e.g. Dubey et al., 2019; Garg et al., 2019; Mehta et al., 2012; Murtaza & Romshoo, 2021; Nawaz Ali & Juyal, 2013; Singh et al., 2022; Singh et al., 2023; Pankaj et al., 2012).

The rapid uplift, high relief, and continuous mass movements in the Himalaya sometimes build landforms similar to glacial moraines (Alam et al., 2015; Andermann & Gloaguen, 2009; Hewitt, 2009; Seeber & Gornitz, 1983), and thereby confound the mapping and interpretation of glacial geomorphology from remote sensing images. Therefore, field investigations are inevitable to minimise the mapping errors in delineating glacio-geomorphic features from remote sensing platforms. Many studies related to various aspects of glacial geomorphology have been reported from the Kashmir Himalaya (e.g. Dar et al., 2017; Dar et al., 2021; Paul et al., 2022b; Rashid et al., 2017; Murtaza et al., 2021; Kaul, 1990) and a couple of these studies have been done in the Kolahoi valley (Kaul, 1990; Rashid et al., 2017). However, the important small-scale glacial-geomorphic features have not been reported in these studies due to the lack of extensive field investigations and the unavailability of high-resolution satellite data in the past.

Geographically, the Kolahoi valley falls in the Great Himalayan Range, Kashmir, India, with an altitude ranging from about 2100 to 5244 m a.s.l. and is spread over an area of about 450 sq. km (Figure 1). The Lidder river, one of the largest tributaries of the Jhelum river, which is one of the six main tributaries of the Indus, originates from the Kolahoi glacier (Figure 2) (Rashid & Romshoo,

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