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COMMENT

Assessing the influence of watershed characteristics on the flood vulnerability of Jhelum Basin in Kashmir Himalaya by Gowhar et al., 2015

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Abstract This comment raises a number of scientific questions about the research work conducted by Gowhar et al. 2015. It shows that the structural, topographic, and geomorphic architecture of the Kashmir Basin is mainly shaped by an active interaction between the tectonics and climate. This is backed by the historical and geological records, which clearly demonstrate that climate change and unplanned urbanization are NOT the major reasons for flooding. The historical data show that the devastating floods occurred in Jammu and Kashmir before the climate change science came into existence, and this strongly brings into question the climate argument made by the authors and equally challenges the urbanization argument because the population of Kashmir was much less in the past and has increased in the last 24 years, plus urbanization is a recent phenomenon in the history of Kashmir. Therefore, it is an over-exaggeration to claim that unplanned urbanization is the *single-most important factor* causing the flooding in Jhelum in 2014. It equally questions the proposed construction of an alternate flood channel for the Jhelum River because the geological and tectonic history has clearly shown that a number of destructive floods were caused by earthquakes, and significant drainage reversals have also been reported in the KB. Therefore, it is important to reassess the various causes of flooding and offer a balanced alternative.

Keywords Kashmir Basin · KBF · Thrust · Drainage · Jhelum

Gowhar and coworkers have undertaken a crucial study to understand the causes of and vulnerability to floods in the Jhelum Basin. However, there are a number of arguments that conflict with the historical flood data and geological history of the Kashmir Basin (KB). These fundamental scientific concerns are listed below:

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1. The authors evaluated the watershed characteristics (drainage, land cover, and slope), which are said to have made the downstream areas of the watershed prone to flooding. However, a robust evaluation of such data can only be achieved if satellite and rainfall data are compared over a long period of time, e.g., 30 years. Such data can efficiently show us the changes in slope, drainage, and land cover over time, and then one can be sure what drives these changes. Such a comparison is missing, and the authors have claimed that the unique geomorphology and heterogeneous lithology render the basin more vulnerable to natural hazards, particularly flooding; however, nowhere did they mention how these factors cause hazards, which needs clarification.
2. The authors concluded that reckless and unplanned urbanization of the floodplains as well as the conversion of the wetlands in the Jhelum Basin was the "single-most important reason" responsible for the enhanced extreme flooding event in September 2014 in Jhelum. However, a number of previous studies have reported historical floods in the KB (e.g., Lawrence 1895; Bilham et al. 2010; Bilham and Bali 2013; Ahmad et al. 2014). These devastating floods occurred in Jammu and Kashmir before the climate change science came into existence, because most of the observed warming occurred over the last 50 years, which is said to be due to the increase in greenhouse gas concentrations (Oreskes 2004). This strongly brings into question the climate argument made by the authors and equally challenges the urbanization argument, because the population of Kashmir was much lower in the past, and it has increased in the last 24 years (Kundu et al. 2014), plus urbanization is a recent phenomenon in the history of Kashmir (Kundu et al. 2014). The authors have not produced reliable data to argue that urbanization of floodplains is the cause of flooding. There are no data to compare how urbanization has changed over the last 30 or 40 years. Even if there has been change, what caused the historical deadly floods when there was no sign of climate change or unplanned urbanization through anthropogenic action?
3. Another significant historical argument is that a number of earthquakes caused floods in Kashmir (e.g., Lawrence 1895; Bilham et al. 2010; Bilham and Bali 2013; Ahmad et al. 2014). For example, one such earthquake occurred in Kashmir during the reign of King Avantivarman (855–883 AD). It caused a landslide that impounded the Jhelum River and flooded the entire Kashmir Valley. It is said that the "ridge of Khadniyar" above Baramula, Khadniyar (Khadanyar), on present-day maps (Lawrence 1895; Bilham and Bali 2013) was broken down and caused the choking of river. Similarly, the 1885 Baramulla earthquake is considered to have caused severe destruction of houses in Sopore and Baramulla. The overall damage was observed for an area of over 1000 km^2 (Jones 1885) with considerable damage in 12 localities, including Srinagar, Magam, Pattan, Gulmarg, Sopore, Doabgah, Lari Dura, Gohan, Muran, Baangil, Baramulla, Kohala, Naoshera, Uri, and Chikar near Garhi (Jones 1885; Fig. 1). The number of casualties reported varies from 3000 (Bamzai 1962) to 3500 (Lawrence 1895). This earthquake also caused landslides near Baramulla along the PirPanjal Range. Failure along a plateau, about 300 m high, occurred at Muran, Gohan, and Lari Dura (Fig. 1), burying the entire village (Neve 1913, 1928; Ahmad et al. 2014). Flooding was observed in Sopore and Baramulla (Ahmad et al. 2014).
4. Another important aspect that is overlooked in this study is the role of active faults. This cannot be foreseen in the KB, because the tectonic history tells us that it is a classic example of a piggyback basin (Burbank and Johnson 1983; 1982). This means that the basin is riding on faults, and the bedrock geology clearly shows a sequence of rocks and sediments (Fig. 1), where the Upper Carboniferous-Permian Panjal Volcanic Series and Triassic limestone are the foundation rocks on which the Plio-Pleistocene

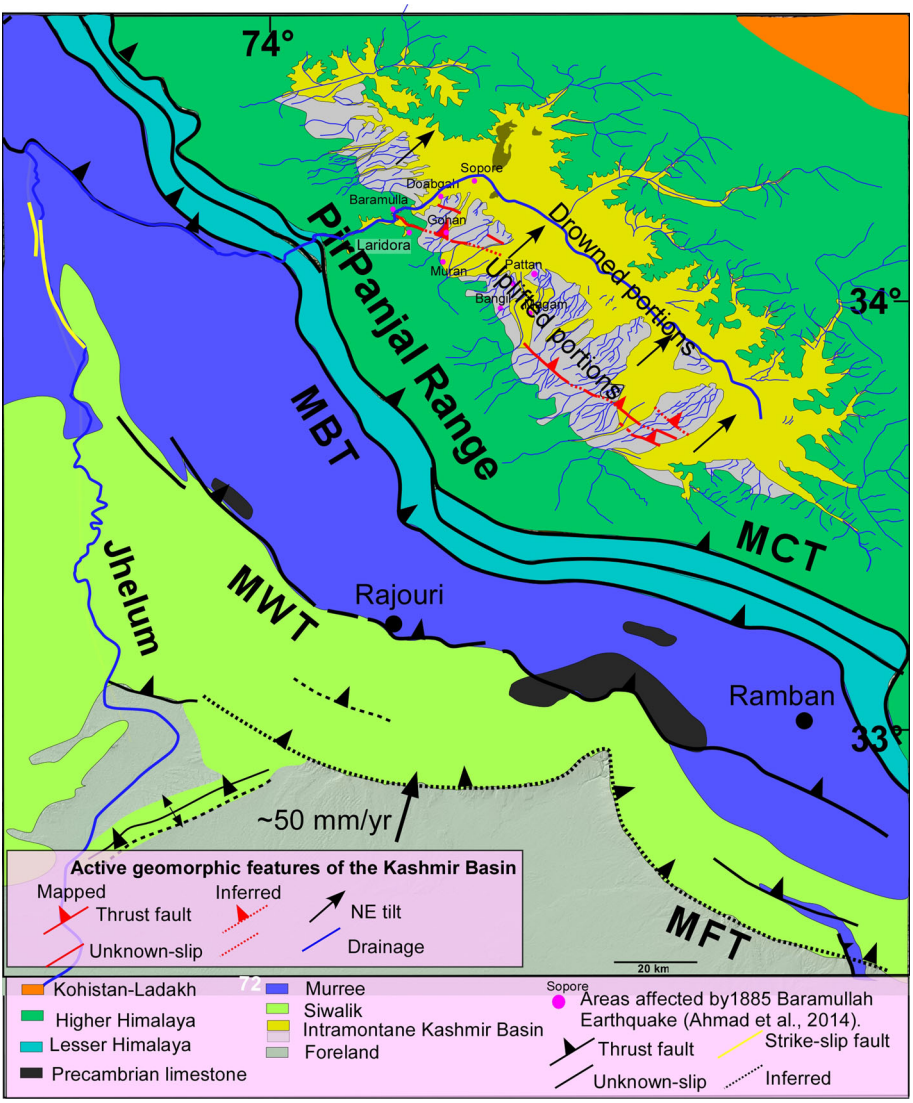

Fig. 1 Regional geological and structural map of a portion of the NW Himalayas (modified from Thakur et al. 2010; Shah 2013; Shah 2015; Vassallo et al. 2015). *MCT* Main Central Thrust, *MBT* Main Boundary Thrust, *MWT* Medlicott-Wadia Thrust, and *MFT* Main Frontal Thrust

fluvio-glacial sediments of KB are deposited (Bhatt 1975; Burbank and Johnson 1982). This means that the whole valley was a huge pool during the geological past when a ~1500-m-thick sequence of sediments was deposited in the KB (Burbank and Johnson 1982). What caused this? Obviously there was no anthropogenic factor or unplanned urbanization in sight.

5. Recent works (e.g., Ahmad and Bhat 2012; Ahmad et al. 2013; Shah 2013; Shah 2015) have demonstrated that a number of active faults are present in the KB, and the active movement on the KBF has tilted the KB toward the SE (Shah 2013; Fig. 1). This

supports the view that the SW side of the KB is climbing a ramp on the Main Himalayan Thrust (MHT), uplifting the SW side and drowning everything to the NE (e.g., Shah 2013; Fig. 1). In addition, the morphology and topography of the KB can only be explained by NE-dipping thrust faults. This clearly suggests that flood waters will easily accumulate on the SE portion, because it has subsided, and the number of lakes on this side testifies to this interpretation. Previous studies have reported a number of drainage reversals in the geological past and impounding of the Jhelum River (Burbank and Johnson 1983), which means there is a potential that such a condition could recur in the KB if a future earthquake occurs on the KBF, because a portion of the fault runs under Jhelum (Shah 2013).

Thus, the KB is mainly shaped by an active interaction between the tectonics and climate. The historical and geological record (shown above) clearly demonstrates that climate change and unplanned urbanization are NOT the major reasons for flooding; thus, it is an over-exaggeration to say that unplanned urbanization is the single-most important factor in the flooding of Jhelum in 2014. In fact, it is clear from the study of the geology, topography, and geomorphology that flooding in the KB is controlled by an interaction between tectonics and climate. Therefore, it will NOT help to make any efficient progress if we only consider climate as the key element in the flooding of rivers. Importantly, the authors proposed the construction of an alternate flood channel for the Jhelum River; however, the geological and tectonic history has shown that a number of destructive floods were caused by earthquakes, plus significant drainage reversals have also been reported in the KB (Burbank and Johnson 1982). Therefore, it is important to reassess the various causes of flooding and offer a balanced alternative.

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