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Interplay between climate, tectonics and sea level changes in shaping the geomorphic landscape of the Mainland Gujarat, western India: A review

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ABSTRACT

The landscape of Mainland Gujarat has experienced processes which are governed by external forcings viz., climate, tectonic and sea level changes. However, the studies carried out so far have been focused on each of these factors in different pockets of this vast region. The Kachchh region has mostly attracted research on tectonic aspect of Quaternary period and the Mainland Gujarat on tectonics as well as palaeoclimatic changes. In this review, we attempt to analyse all the available information pertaining to external forcings and their mechanisms, to evaluate the lacuna in the landscape evolution model and identify pathways for future research, especially in the Mainland Gujarat region. The climatic and tectonic studies have often not been integrated to deconvolute the imprints of each forcing in quantitative aspects. The review highlights the need for more chronologically supported analysis, which would be more quantified in nature rather than qualitative. The term neotectonic activity has been used widely in context of Gujarat, which needs to be supported with chronology for the realistic assessment of tectonic attributes.

Keywords: Gujarat mainland, Climate, Sabarmati River, Geomorphology, Tectonics

INTRODUCTION

The roles of climatic changes and tectonic instability in shaping the landscape have been debated since a long time (Schumm, 1977; Holbrook and Schumm, 1999). Indeed, these factors have together implicated changes in hydrological balance, sediment erosion and topography formation during the Quaternary times. To access this, the fluvial systems are most sensitive to tectonic or climatic perturbations as they archive these signatures in the form of erosion and/or deposition of sediments (Starkel, 2003). River systems respond in varying manner as per varying climatic conditions i.e., during dry conditions, they tend to produce enormous amount of sediments but due to poor discharge they are unable to erode and hence eventually, they lead to aggradation of valley. Contrastingly during wet climatic conditions, rivers will flush out the sediment produced and also lead to incision in the bedrock (Srivastava et al., 2008). However, it is widely believed that the response of 'Dryland Rivers' is quite complex (Tooth, 2000).

Gujarat Mainland, western India shows spectacular signatures of tectonic-climatic-sea level interplay. However, the research over this terrain has remained monotonous with focus only on tectonic or climatic forcings. In comparison, the Gujarat Alluvial Plains (GAP), have been studied well for palaeoclimatic and hydrological changes (Tandon et al., 1997; Jain and Tandon, 2003; Jain et al., 2004; Bhandari et al., 2005; Prasad et al., 2007; Sridhar et al., 2013; Prasad et al., 2014; Raj et al., 2015). The studies on fluvial systems of Mainland Gujarat alluvial plains have shown strong control of tectonic instability and palaeo-environmental changes during the Quaternary period (Srivastava et al., 2001; Chamyal et al., 2002, 2003; Bhandari et al., 2005; Raj 2007; Das and Solanki, 2020). Additionally, some archeological findings have hinted at eustatic-tectonic instability, which had affected the human settlements and led to their migration / collapse (Gaur and Vora, 1999; Khadkikar et al., 2004). However, the picture of climatic and tectonic interplay that led to evolution of this magnificent landscape of Mainland Gujarat, is still not clear. The aim of the present article is (i) to synthesize the available data on climatic and tectonic instabilities which governed the formation of present-day landscape of Mainland Gujarat covered by the fluvial sequences of Sabarmati, Mahi rivers, and (ii) to highlight the gaps in present understanding for future prospects.

STUDY AREA

Climate

The landscape of Mainland Gujarat is bordered by the great Thar desert of western India (Figure 1a, b). The present-day climate is predominantly controlled by the Indian Summer Monsoon (ISM) with periods of precipitation restricted between June–September with annual precipitation varying from 750 - 300 mm (Figure 1) (Chamyal et al., 2003). The landscape hosts semi-arid landforms and geomorphic features.

GEOLOGICAL AND TECTONIC FRAMEWORK

The Cambay basin is NNW-SSE oriented narrow graben that originated during the Mesozoic period during the break up of Gondwana land and the subsidence occurred during the Tertiary (Biswas, 1987). The basin extends from Tharad south-southeast through the alluvial plains of Gujarat, the