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Emerging Fields in Geomorphology: The Future Challenge

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It is indeed a matter of great honour and privilege to address the learned gathering at the opening of the 24th Conference of Indian Institute of Geomorphologists (IGI). IGI is one of the largest gatherings of geomorphologists in India. I feel proud to be the president of this learned gathering of geomorphologists of India. Shortly we shall enter into the 25th year of the formation of the IGI. The age of adolescence that is bubbling with zeal and enthusiasm. We all as worthy members of the IGI have the responsibility that we not only celebrate the silver jubilee of the formation of IGI with fervor but also make valuable academic contributions to enlarge the activities of IGI in the times to come.

I, as member of IGI and as president have always been of the opinion that field geomorphology in India is on decline. Since the introduction of computers and user friendly software in geomorphology the young geomorphologists have preferred to understand and interpret various processes and mechanisms of landform generation on computers, least realising the interference of multifarious small but significant processes in the landscape evolution. It becomes the valued responsibility of all senior members of IGI to impart education and knowledge to young geomorphologists in the field. This will not only inculcate the practice of conducting field work among young geomorphologists but also introduce them to various complex processes that operate in nature and cannot be otherwise visualised on computers.

It should be the mission of IGI in times to come to undertake studies on some of such fields of geomorphology that have not received much attention in the past. It should be the challenge for young geomorphologists of IGI to undertake research on the topics that have been least attended by the seniors for one or the other reason.

One of the most demanding and challenging subjects is the palaeoclimate studies that need immediate attention. Prof. A.K. Singhvi and Prof. V.S. Kale in one of their publications titled *Palaeoclimate Studies in India: Last Ice Age to Present* have rightly addressed to the applications of palaeoclimate studies. The studies are useful in understanding the durations and conditions under which the landforms are stabilised. Monsoon is the most significant climate factor. Most of the Indian subcontinent is under the effect of monsoon, barring a few regions of high Himalaya. The strengthening and weakening of monsoon is most effective cause for change in landforms (Fig 1). Palaeoclimatic history of Thar desert, Rajasthan for past approximately 200 kyr

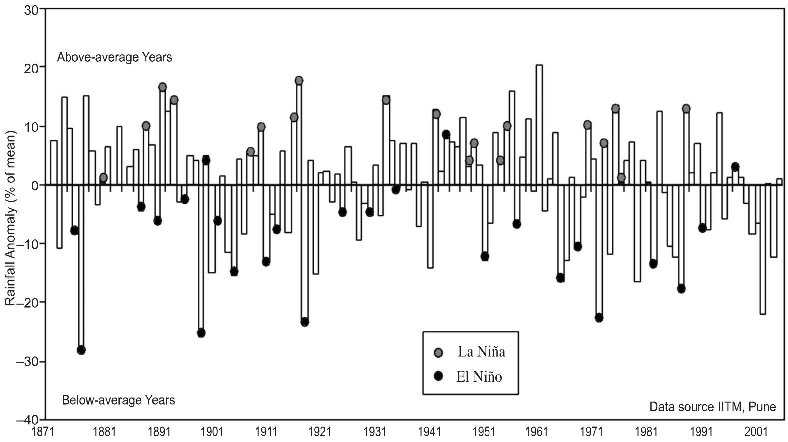

Figure 1. Time series plot showing the interannual deviation in monsoon rainfall over India between 1871 and 2005 (modified from Singhvi and Kale, *undated*).

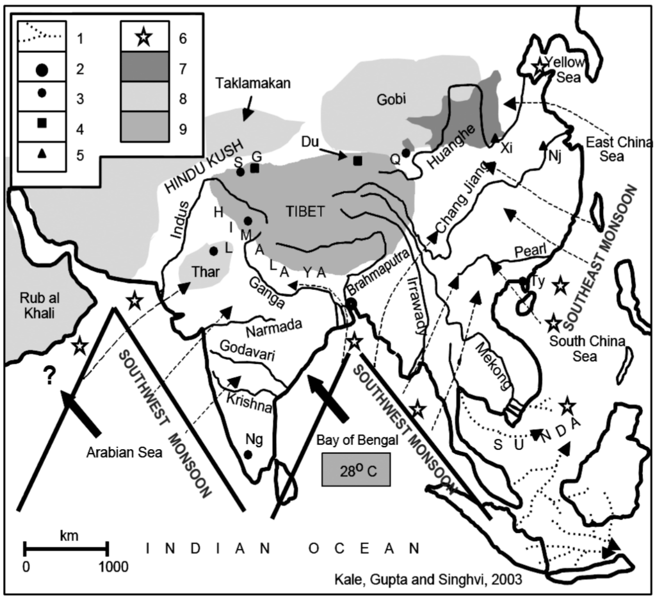

Figure 2. The Bay of Bengal, by virtue of being stratified with high sea surface temperature provides rainfall to India. The Arabian Sea is much cooler and hence does not provide rain to the Arabian desertic region (thick arrows). The monsoon winds of June to September are shown by broken arrows. Key sites where palaeoclimate reconstructions have been done are as follows. 1: Extinct drainage of Sundaland, 2: Borehole sites, 3: Lake/peat sites, 4: Ice core sites, 5: fluvial/flood sites, 6: Deep sea core sites, 7: Loess plateau, 8: Deserts, 9: Qinghai-Tibetan plateau, Du: Dunde ice cap, G: Guliya ice cap, L: Lunkaransar lake, Ng: Nilgiri, Nj: Nanjing flood site, Q: Qinghai Lake, S: Sumxi Co, Ty: Tianyan lake, Xi: Xiaolangdi palaeofloods site, (modified from Kale *et al*., 2003 in Singhvi and Kale, *undated*).

presents a geological record of oscillation in monsoon conditions that has been largely responsible in stabilising sand dunes and forming palaeosols. It is a well known fact that Indian monsoon and Chinese monsoon together are significant in controlling the global hydrologic cycle. The meteorological data of Indian summer monsoon for over one hundred years do show significant spatial and temporal variability in the rainfall.

The rainfall during short span of time may cause floods, resulting in appreciable modification to landforms. On the other hand rainfall if spread over time, may marginally modify the landforms and also be useful to the agrarian economy of the country. Shift in the monsoonal rainfall can be a cause for drought or floods. In either case the landform is subjected to significant change. Understanding the phenomenon of change in the Indian summer monsoonal pattern for a geological time period especially for past 10 kyr through proxy evidences would help in deciphering the changes in landscapes in the past and perhaps build model for the future as well (Fig. 2).

The other recently emerging and challenging field is the integrated research on mountain geomorphology. The globe in future is going to face the consequences of climate change. It is the biggest challenge before the mankind. The mountains are also going to be affected by change in climate. Mountain ecosystems are sensitive to any change in climate. The impact of change in climate can be felt on the mountain biodiversity and hazards, human resources such as water and soil, socio-economic activities namely tourism, trade and transport and health such as spread of diseases. Mountains provide training ground for the understanding of complex interaction among glaciers, atmosphere, tectonics and time. The young geomorphologists armed with new analytical tools can focus on the integrated study of mountains and link various sub-disciplines of earth science systems.

Himalaya and trans-Himalaya is the abode of 9,575 glaciers outside the Polar Region. This earns the name of 'Third Pole' to Himalaya. Glaciers are very sensitive to climate change or global warming. A minuscule change in the temperature affects the glacier in changing it from solid to liquid or back to solid phase. It is this property of snow and ice that makes it very vulnerable to climate change or global warming and hence changes in glacier are a direct measurement to change in atmospheric temperature. The glaciers in Himalaya showed largest extension at around 100 kyr rather than the Last Glacial Maximum at around 25 kyr. Very few glaciated valleys have been studied in detail and with sufficient radiometric dates to establish with certainty the extent of glaciation in Himalaya in geological recent past. It is yet to decipher the causes for significant retreat of glaciers in last about 20 kyr. The change in the glaciers today because of the popularly believed anthropogenic global warming may not have been the cause for change in the glaciers during Marine Isotope Stage 2. Dedicated institutes and scientists outside India have been monitoring change in the glaciers over a century to build atmosphere-ocean coupled Global Climate Model. Unfortunately, it is one such branch of geomorphology that has been least attended to in India. Realising the significance of the study of glaciers and glaciated valleys in unraveling the causes and effects of climate change or global warming, the integrated mountain research is emerging thrust area of field geomorphology. The Ministry of Science & Technology, Government of India, realised the significance of glacier studies and took serious initiatives to set up National Centre for Himalayan Glaciers at Dehra Dun that shall be a dedicated centre for the study of various aspects of glaciers of Himalaya.

The International Open Science Conference *Global Change in Mountain Regions* held at Perth, Scotland, in 2005 has emphasised 'to develop a framework for long-term research on global change that can be implemented in mountain biosphere reserves and other mountain localities'. The close relationship between the climate and environment makes the ecosystems of mountain region sensitive to potential impact of climate change in future. The natural resources, namely biodiversity, human resources, namely water and soil, socio-

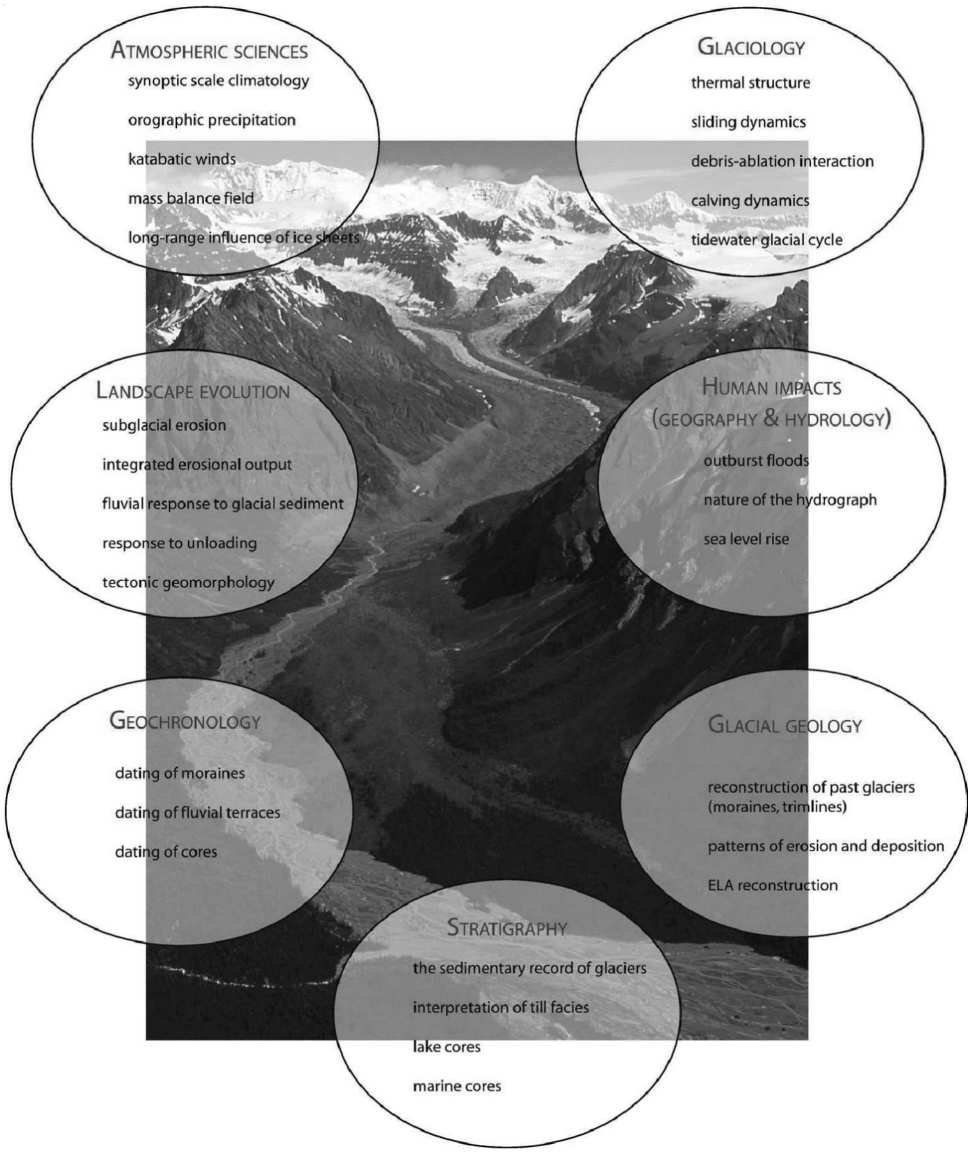

Figure 3. The interdisciplinary nature of glaciology

economic resources, namely trade and tourism and health, namely spread of diseases and frequent hazards in the mountain region are vulnerable to the threat of changing climate (Fig. 3). The workshop titled *Long Term Monitoring and Analysis of Indicators of Environmental Change in Mountain Regions* held at Vienna, Austria, in 2004 under the aegis of Global Change in Mountain Regions (GLOCHAMORE) recommended concerns for (a) cryospheric indicators related to snow cover, glaciers, and permafrost processes, (b) indicators for freshwater ecosystems, their sediment record and for watershed hydrology and (c) indicators for terrestrial ecosystems, particularly plant communities and soil invertebrates.

It has become increasingly important to

have significant and unbiased scientific inputs in framing the policies of a nation. The input should be well reasoned and well argued on the topical issues, such as global warming, climate change, water harvesting, scientific methods of agriculture etc. for the administrators to develop the societal need policies accordingly. I would quote the much hyped Theory of Himalayan Degradation (THED) that was posited as environmental crisis in Himalaya owing to the deforestation that causes increasing floods in Gangetic plains of India and Bangladesh. THED embedded in the public policy of Nepal, India and China for a long period of time unless scientifically proved that it is an iconic example of environmental myth. Scientific studies revealed that Himalaya is a complex landscape, prone to high rates of erosion and sediment transport often produced under extreme conditions and role of deforestation in this complex landscape is difficult to discern.

Issues such as climate change, environmental degradation, and integrated mountain research are the areas where geomorphology can immensely contribute to the society. This nee s a close interaction among science, social science and society. It is rightly pointed out in the *A Draft Vision Document for Indian Science 2010* prepared by Indian National Science Academy, New Delhi, that 'We should specifically identify and support science which impacts our social goals as a country, networking practitioners of such science from different fields, and taking care to explain our efforts to the general public in the interests of social engagement with science and its practice.' It is becoming increasingly difficult to separate the cause and impact in a natural system owing to the fact that the natural systems are increasingly altered by the human activities. There is, therefore, utmost need to develop interdisciplinary approaches to combine social and natural sciences to study the nature-society system and its response to changing climate (Fig. 3).

There shall be an addition of three billion persons in next four decades to the population of the less developed countries. This shall have tremendous impact on the natural resources including the resources from mountains. Unfortunately, there lies a big gap between the knowledge on mountain geomorphology in the less developed countries including India. Efforts have to start in capacity building so that these countries develop their own solutions, outside of the common procedure of supply driven projects which usually leave more economic debts than benefits. I strongly believe that institutions such as Indian Institute of Geomorphologists come forward to support these issues by its strong network of researchers, taking into account the existing global economic resources.

I thank worthy members of IGI for electing me as President and provide an opportunity to present this response.

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