Developing resilience against emerging climate change normal of the hydro-geological hazards in Western Himalaya, India

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A chain of unprecedented floods and landslides beginning in early July of 2023 in the Western Himalaya and its adjoining plains of Punjab, Haryana and western Uttar Pradesh, India, shook the entire nation due to large-scale destruction in terms of human lives, properties, landscape and environment. It began with the extreme rain episodes across the width of the Himalaya, leading to high-velocity water flowing from the steep hill slopes along low-order streams into the main rivers. In the stepwise process, it initially filled the river channels and was followed by extensive flooding in the alluvial plains, inundating extensive areas of Punjab and Haryana along River Ghagghar and Delhi–Uttar Pradesh along River Yamuna. In Himachal and Uttarakhand, rainfall also triggered a sequence of landslides of different scales in the urban areas and roadsides. These disasters have annihilated almost all our landslide-preventing measures and flood-taming capacity and exposed the fragility and hollowness of our habitational planning, especially in the hilly regions.

The myopic planning was evident in all physiographic domains of India, i.e. from the Himalaya to the Indo-Gangatic Plains to the peninsula. The oft-repeated public excuse of abnormally high rainfall events is only a partial explanation that fails to hide that we allowed people to occupy known flood-prone areas and vulnerable slopes of the mountains, made roads on poor-quality rock surfaces without due protective care and due diligence in road-alignment studies, and failed to control the rush of 'ill-informed' tourists to the fragile landscape of the Himalaya. This is essential because short-term economic benefits and socio-political considerations trump the scientific component of sustainable development.

Are these disasters natural or human-made? In fact, these are the product of both. We cannot blame nature alone because global warming induces unpredictable changes in the intensity and distribution of summer monsoons and westerlies every year at unbelievable scales. We have high-intensity rainfall in short durations, more rainfall in the dry regions and long summers, though the normal rainfall may not deviate much. There are more cloud bursts, less snowfall and more rainfall at high altitudes. In the climate change and global warming context, the uncertainties in prediction are greater and more difficult. We have no control over natural uncertainties, but we can certainly strengthen our resilience to adjust, combat and adapt to the adverse effects to a great degree.

Large-scale destruction by floods and landslides in the Himachal and Uttarakhand Himalaya indicates long-term, faulty developmental planning. The most important lacuna in the process is the grossly ignored geological-cum-geomorphological milieu of the areas, especially in the context of urbanization[1]. The second important error is building civil structures on vulnerable areas over and above the bearing capacity of the land surface, which stems from ignoring terrain-specific care during development planning. Urban or industrial development in the Himalaya cannot be on similar lines as in a metropolitan city in India.

There are inherent characteristics of the natural setting of the Himalayan terrain, which are unique in their own way. The Himalaya region is tectonically unstable and neo-tectonically active, where rocks are compressed, folded, thrusted and prone to erosion and sliding by a slight stimulation induced by rainfall, shock and overloading. By fluvial and glacial actions, the hill and valley topography has created steeply sloping hazardous surfaces. The only flat surfaces are the river terraces made of loose to slightly consolidated, unsorted boulders and clay-sized sediments. The land is limited to suitable habitation and associated infrastructure, and is generally restricted to the terraces and hill slopes. The latter may not be suitable (or partially suitable on slopes based on angle and other considerations) because these are either palaeo-landslides, alluvial fans, debris or hill-wash material. Such domains often comprise loose, cohesionless, unsorted sediments of low shear and compressive strength. The terraces are comparatively stable surfaces but are liable to lateral erosion by rivers when in flood. Some hill slopes are rocky but dangerous if their dip and joints are along the slope. Clay and shale beds in the sedimentary terrain are extremely poor-strength rocks, while phyllite, schist, gneisses and other hard rocks may also be prone to sliding due to structural disposition and weathering[2]. Despite all this, we have opted for heavy construction in known high-landslide probability zones[3]. This is on the lines of increased urbanization, which appears to be a global trend in the mountainous regions[4].

In Himachal Pradesh, two modes of landslides are observed during monsoon: (1) a top-driven, progressive sliding and (2) a toe-driven, retrogressive failure. The former is predominant in Simla, Mandi and Kula urban areas, while the latter is common in Manali area. Top-driven failure occurs where hill slopes are full of buildings and hilltops are covered with heavy trees. When pore pressure increases during rainfall, the failure of the slopes begins at the top, progressively triggering further failures downward. The washing away of a temple, the toy train bridge near Summer Hills in Shimla, and a six-storey building in Mandi market are a few examples. Toe-driven slides are caused by lateral erosion of the base of the slope by the rivers. It begins from the base and triggers more slide upslope.

Was the ongoing devastation of landslides and floods fully or partially avoidable? The answer is 'yes', if not fully, at least substantially. We have erred in allowing the haphazard expansion of townships by housing and road building on unsuitable sites, ignoring the essentials of geological conditions. We have also failed to enforce the standards of civil construction vis-à-vis land capability and hazards. The market forces of excessive tourism prevailed over safety norms.

In just a couple of months, we have lost thousands of crores of properties and hundreds of lives. Reconstruction and rehabilitation will take several years. This unfortunate set of events is an opportunity to rethink the sustainability of planning and development for the future. There is a need to proceed scientifically by integrating all essential inputs on the area-specific land capabilities on geology, climate, vegetation, seismicity and pattern of population growth.

The natural follow-up question is – can the present staffing of Government departments handle these specialized responsibilities? The answer is possibly 'yes', but with additional strengthening of specialization

in planning for sustainable development from a geoscientific perspective. Tenant and Gilmore[5], in a study on governance and mortality in cyclone-affected nations for the period 1996–2016, showed that countries with more effective governance have lower mortality rates. This is well exemplified in the case of India, post-enactment of the Disaster Management Act in 2005 and subsequent formation of the National Disaster Management Authority (NDMA) and State Disaster Management Authorities. Though our post-disaster management is excellent, as exemplified by an active NDMA, the prevention part requires attention. It is important to note that the cost of protective measures is likely to be a fraction of the scale of losses witnessed in recent climate-change-induced disasters, and this is the need of the hour in the present context. Despite decades-long valuable inputs from organizations such as the Geological Survey of India, Indian Space Research Organisation and many others, the accelerated climate change appears to render these inputs inadequate. Thus, we need to have qualified and trained specialists in each district of hill states who must be entrusted with the task of studying, planning, and monitoring land characteristics, natural processes and anthropogenic interference to bring out a unified approach to multiple development activities, be it large infrastructure projects or urbanization within specific areas. These basic inputs are large-scale thematic maps on geology, geomorphology, neotectonics and probability of natural hazards. Use of India's enhanced remote sensing capabilities, as well as modern tools such as artificial intelligence and machine learning, which are being applied in various geoscientific domains[6], can be effectively utilized. This will necessitate an expertise-based administration, and such planning will be robust, cost-effective and people-friendly in the long run. This can also be a significant step in the right direction for fulfilling the ambitious goal of India becoming a developed nation in a few decades.

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COMMENTARY

Opportunities of 'Make in India': a path towards 'Aatmanirbhar Bharat' or Self-Reliant, India

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Globally, science, technology and innovation are gaining prominence. Research and development (R&D) is India's main driving force for sustainable economic growth. The 'Make in India' (MII) initiative by the Government of India (GoI) motivates the Indian manufacturing sector with aim to make India a global centre for manufacturing via foreign investors. In this regard, India became a hub for foreign investors with a 76% rise in the foreign direct investment (FDI) equity inflow of the manufacturing sector from financial year (FY) 2020–21 (USD 12.09 billion) to FY 2021–22. One of the key objectives of MII is job creation and skill enhancement in the country. In this context, the Department of Science and Technology, GoI, continuously contributes to improving the science and technology infrastructure through several funding programmes. This note provides a brief overview of the achievements of MII and its scope in scientific R&D.

The Indian economy is rising day by day, with an estimation of 7% gross domestic product (GDP) during the year 2022–23 (ref. 1). This development has been guided by a fusion of key features like good domestic utilization, funding and a young workforce. Research and development (R&D) is one of the areas contributing to Indian economic output. According to the 2021 data of World Development Indicators, World Bank, India holds fifth position in the world economy[2,3]. The Department of Industrial Policy and Promotion was renamed Promotion of Industry and Internal Trade (DPIIT) in January 2019 under the umbrella of the Ministry of Commerce and Industry, Government of India (GoI). The major initiative of DPIIT is to reinforce the manufacturing and financing domain of the country. In this regard, the DPIIT launched the 'Make in India' (MII) initiative on 25 September 2014. MII aims to expand the manufacturing sector at the rate of 12%/annum by 2022 to generate 100 million jobs and assure a 25% contribution to the GDP[4]. MII is the first 'Vocal for Local' initiative that aims to promote India's manufacturing sector at global level. It helps attract foreign investors to India for the manufacturing domain. The main aim of MII is to manufacture goods with zero defects without compromising on environmental standards. MII was initiated in two phases, viz. MII-I and MII-II were launched in 2014 and 2020 respectively. The objectives of MII-I are to attract to draw interest of