Mountain Conservation through Accelerated Climate Change

Vinod K. Gaur, Distinguished Professor, Indian Institute of Astrophysics, Bangalore, India,vgaur@iiap.res.in

J. Ramonette Pacia

The Himalayas viewed from Rasuwa district, Nepal

The mountain fastnesses of the Himalayas, stretching over 2400 km from the Hindu Kush in the west to Arunachal in the east, together with Tibet, constitute some of the most dramatic geomorphic features on earth. A kaleidoscope of spectacular landscapes forever forming from the arid west to the lush east are the most eloquent expressions of its internal vibrancy.

These landscapes have fashioned an equally fascinating array of human cultures sensitive to the interplay of the intrinsic rhythms of Nature: the inexorable pulsations of the earth below, tempered by the elements above. By a sensible response to their perennially transforming landscapes – often paroxysmal – people have created flourishing cultures while conserving the many unique endowments of its extraordinary habitats – a gift, though sadly remaining unacknowledged, to the wider global community. The natural processes of change, always mercifully slow enough in the past to enable a creative reordering of human activities have, over the past decades of radically new techno-economic structures, acquired a speed that threatens to destabilise many critical subsystems of this complex environment. The changes are too rapid and daunting for most local people to respond in a constructive manner. The most serious result is an almost irreversible erosion of the regenerative capacity of vital ecological niches crucial for the sustenance of local communities, and the survival of the planet.

The heritage value of Himalayan biodiversity lies in its subtle role in securing greater stability for the global ecological system, and herein lies the heart of our concern to sustain its integrity.

Herein lies the heart of our modern concern about the sustained integrity of this global heritage. By virtue of its extraordinary world eminence, the Himalaya-Tibet region is at once the driver of atmospheric circulation of the Northern Hemisphere – a vast reservoir of steady release freshwater, a rich basket of unique flora (some of them forming the core of rare pharmaceutical products in the world markets), and home to some of the most beautiful, if threatened, creatures: the black-necked crane, the curiously agile wild ass of Ladakh, the musk deer of the Central Himalaya, to name a few.

Only an incisive analysis of the consequential issues and thoughtful, knowledge-based interventions can arrest this one-way attrition of our global heritage. And all our recent experiences in disaster mitigation point to empowering local communities with knowledge and skills as the most effective means of accomplishing the desired goals. Sustaining a vibrant organic culture among diverse Himalayan people in their natural habitat, in a way that makes life meaningful for them, is the most enduring insurance for the health of the Himalaya-Tibet region.

Fora and meetings in countries of the region and elsewhere have brainstormed the critical issues which, addressed effectively, could achieve the desired goals. My own articulation of a desired goal is the gestalt view of landscape conservation, inspired by the expectation that in optimising a dynamic balance between the subsistence requirements of a dignified indigenous human culture and the wider biological ambience on the one hand, and the changeful forces of nature and the demands of the international community on the other, these fragile ecological niches could be sustained for a long time. Its realisation would call for the availability of insightful and periodically refined, user-friendly knowledge products and current information, systems design, technology availability for implementation, and most pre-eminently, the realisation of a shared perception of goals through participatory processes. Assuming that a **healthy human culture-landscape synergy** could be an effective safeguard against the runaway processes of degeneration in the Himalaya-Tibet region, and that an agreed clarity on critical issues may be a promising start for constructive intervention, it may be instructive to explore some of the implicated issues.

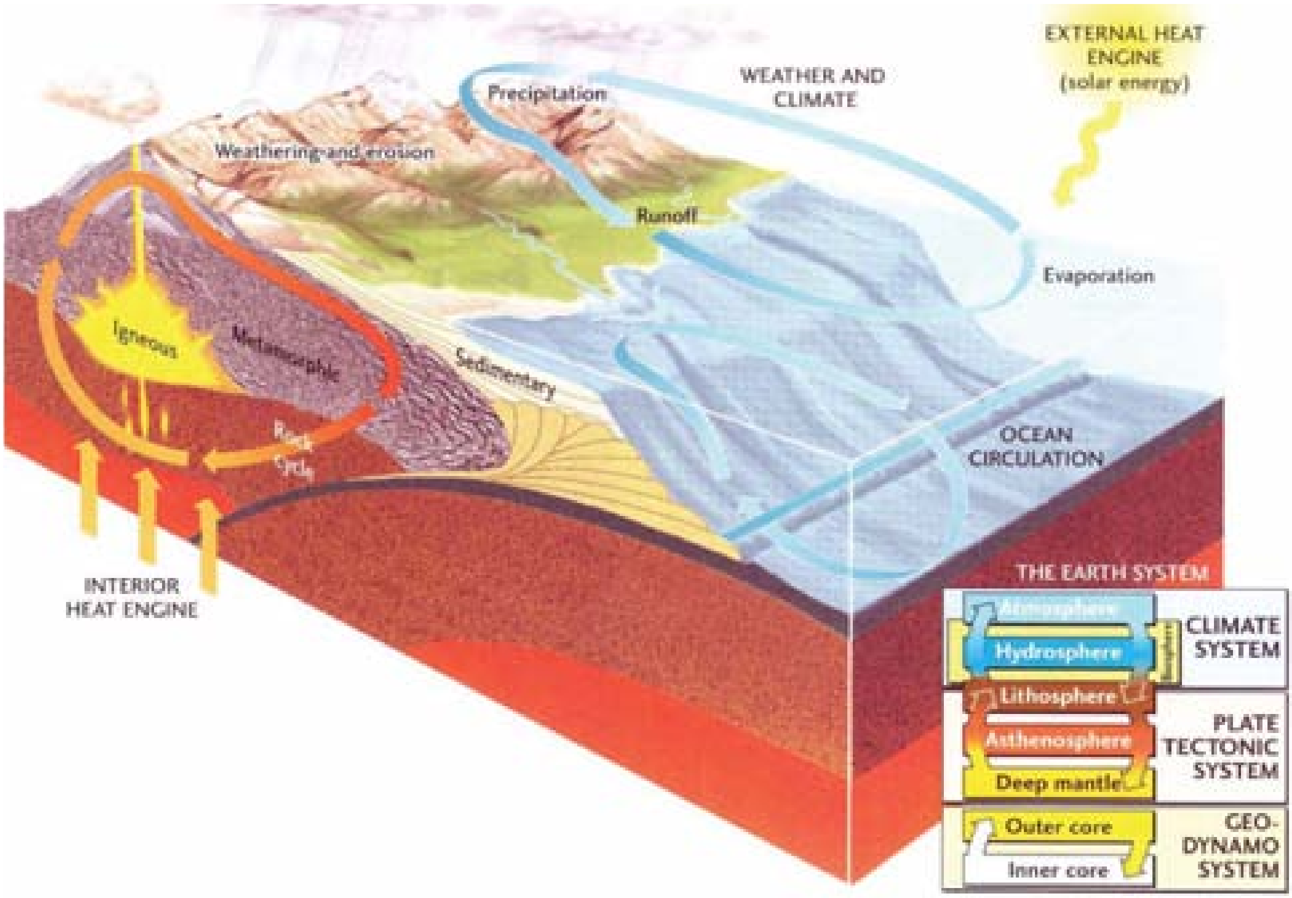
One can begin with the subsistence needs of local communities for **a modicum of dignified existence** – easy availability of water, food, energy resources, health care, education, protection from natural hazards, and grazing lands for livestock that do not outstrip the regenerative capacity of the ecosystems. Without recounting the serious erosion of the sources of water, food, and energy resources suffered by the Himalayan region in the wake of pressure from a growing human family and livestock, and the rapid changes in the global climate during the past half century, it is worth considering how much, may yet be done by conservation measures in catchment areas and monitoring-based stabilisation of hill slopes. Further, the realisation that by optimising the outreach of income through knowledge and understanding, the educational enterprise, implemented with initial investments, is a self-generating capital with enormous possibilities for empowering local communities. Knowledge and understanding can unleash the local communities' imaginative potential to identify productive ecological niches for value addition, to create wholesome habitats for a healthy life, and to build effective safeguards against preventable diseases and hazards.

Another larger issue is that of landscape conservation in the Himalaya-Tibet region, with implications for the long-term interest of humanity. Its significance to climate and the indicators of climate change as well as to freshwater storage and responses to climate change, biodiversity, particularly for those who have invented exotic biochemical mechanisms for survival in extreme environments and, are thereby, valuable in designing special purpose drugs or efficient biochemical pathways for industrial processes. The heritage value of Himalayan biodiversity lies in its subtle role in securing greater stability for the global ecological system whose biodiversity, with few exceptions (after being enriched steadily over the past 500 million years), is suddenly registering a worrisome attrition. That the stability of any interconnected system of energy and materials flow, such as the biological world, is determined by the varietal richness of the network, of which a telling example is the precariousness of mono-culture, is now well appreciated.

Fortunately, these issues are amenable to acceptable solutions, although they may require some relocation or redesign, or both, of extant systems. More important, since these are both knowledge- and technology-intensive, they would require massive inputs. Here are a few examples.

Climate Change. The earth's climate has been changing, after being warm through much of history over the last 130 million years. During the last 1.8 million years, it was periodically covered with large sheets of continental ice, 3-4 km thick, separated by briefer periods (20,000 years) and warmer interglacials such as we have today. Its climate at any time, represented by the mean global temperature, is determined by the balance of incoming solar radiation and that radiated back by the earth, except that the atmospheric constituents of certain long-lived gas molecules (notably carbon dioxide and methane) increase its opacity to the outgoing radiation thereby increasing the thermal budget (the total amount of thermal energy transferred to the water during the given elevated temperature operation of the earth's atmosphere). Increasing CO_2 emissions in the atmosphere generated by human activities since the Industrial Revolution, and particularly since the 1960s, have thus led to increases in the earth's mean global temperature. There is little doubt that this trend will continue until the end of the 21st century unless corrective regulatory measures are put in place in the interim to contain our runaway dependence on fossil fuels for energy. Another source of increased atmospheric CO_2 resides in degraded lands. Here, the Himalaya-Tibet region contributes to climate change by a variety of human activities such as denudation of the alpine rhododendrons for fuelwood. Discontinuing such practices by creating alternative solutions for the energy requirements of mountain communities, and creating awareness of what could be their enlightened self-interest in preserving these habitats, is achievable through well-formulated activities engendered among local communities. Measures to constrain the adverse impact of global warming on the fresh water storage capacity of mountains, or sudden glacial outburst flows, would need high cost technological solutions. Governments of the region must be made aware of the potential threats so that mitigative solutions are implemented. A persuasive approach would require illuminating knowledge products illustrating the geographical characteristics of this mountain region: the geomorphic ambience, particularly of downstream habitats potentially at risk, and most importantly, the rates of activity. For example, in order to create a model of the glacier response function needed to reliably predict a glacier's future behaviour in the wake of climate change, there is a need to constrain the changing ablation rates of glaciers, among other characteristics of their spatial ambience. These can be determined by carefully designed experiments to measure glacier advance rates using the millimetre precision of GPS geodesy and its cross-section with the help of a ground-probing radar – high technology solutions that are now within reach.

Extreme events. A particularly intriguing aspect of climate change is the increasing frequency of extreme events such as heavy rainfall over a short period. One such extreme event took place in the 500-year old



town of Almora in the Central Himalaya. The town is situated on a rocky ridge which is considered the safest foundation, yet an unanticipated water seepage beneath the ridge destabilised dwellings in the area. A basic fact to appreciate here is that mountain systems which are subject to a steady supply of ground deforming energy from the ongoing mountain building processes are forever poised in a meta-stable state – susceptible to destabilisation by the slightest addition of energy that may be contributed by any of a myriad of factors, much like the classic case of a sand pile. Built slowly by a constant supply of sand, it moves inexorably towards a critical state poised to drive an avalanche that may be triggered by the next arriving grain. This condition applies to all critically stressed mountain environments: landslides, avalanches, and debris flows, as well as the regions stressed by the unabated penetration of the Indian plate into the belly of Tibet – the prime source of energy that powers earth movements in the entire Indo-Tibetan region and drives devastating earthquakes in various segments of the Himalaya once every few hundred years.

Earthquakes. The Himalaya and Tibet have been formed and are sustained by the continued underthrusting of the Indian plate (a fragment of the earth's outer brittle rind) into Tibet powered by material flows welling up from its hot interior. Despite the steady stress this imposes, the outer, colder brittle material cannot slide steadily into Tibet because of the frictional bond at their shared interface – usually tens of thousands of square kilometres in area. Only when this frictional bond is exceeded by the steadily accumulating stresses do materials on each side of the interface slip in a sudden displacement of a few metres, causing a devastating earthquake. Between great earthquakes, minor slips at localised asperities of their interface occur at shorter intervals. The Himalayan people are therefore no strangers to the risk posed by earthquakes and have, traditionally, built dwellings with local materials such as timber and bamboo. Unlike concrete, these organic materials do not fail catastrophically during such extreme events. However, modern construction style has proliferated the use of concrete for multi-storey buildings. These materials are not designed to withstand the strong ground shaking that great earthquakes such as the 2005 Kashmir earthquake caused, burying over 70,000 people under falling building debris within minutes. This catastrophe could have been altered dramatically or prevented had there been an estimate of the probable ground shaking that a future earthquake in a given region could cause based on the probabilities of various earthquake scenarios. This can now be estimated scientifically using high precision GPS geodesy and computer simulation of fault-induced ground motion. Structures designed on the basis of this knowledge would be able to withstand the fury of earthquakes, or at least not fail catastrophically, thereby reducing the risk posed to life and property.

Summing up, the global setting of the Himalaya-Tibet region, beyond dispute, marks it as a fundamental element of the global ecosystem and, by this token, a unique heritage of mankind worthy of a collective global initiative to preserve it against the processes of global change and the intrinsic instabilities of the mountain building process. Fortunately, this challenge can be met effectively by bringing to bear the illuminations offered by modern instrumentation and information systems. Sophisticated modelling and computer visualisation of probable future scenarios in advance of a hazardous event can give people and communities lead time to prepare for disaster. For example, a dynamic analysis of mass and energy balance of a meta-stable system has the power to show how the various subsystems such as lakes, streams, glaciers, and avalanches, function. The same models can be exploited to design and test cost-effective implementation solutions for mitigative social, administrative, and engineering systems to minimise the potentially adverse impacts of possible hazards. Their effectiveness would depend on how local communities perceive these programmes and are prepared to support them, which underlines the desirability that the prime focus be on helping to generate a human culture capable of being sustained locally with **a modicum of dignity, in harmony with its landscape**. The challenge is a persuasive one, and the attendant tasks perfectly feasible, albeit not trivial, given our global capital of knowledge and expertise. The major effort would need to be contributed by local and regional governments and communities, but the possibility of catalysing their purpose would be heightened by generating innovative knowledge products that help delineate policy options and a hierarchy of possible technological solutions that can be implemented at various levels: individual, community, local, and regional. ICIMOD could provide such a catalyst by creating, jointly with its strategic partners, insightful knowledge about the system characteristics of mountain regions and the critical environmental processes and their rates, with a bearing on the quality of human culture, its biospheric ambience and landscape. This may form the bases for policy initiatives and dialogue to mitigate the impacts of and design adaptation to climate and environmental change.

The prime focus of interventions should be on helping to generate a human culture capable of being sustained locally with a modicum of dignity, in harmony with its landscape.