INDIAN SUBCONTINENT BIODIVERSITY: EVALUATING THE IMPACT OF CLIMATE CHANGE AND MANAGEMENT METHODS IN THE HIMALAYAN REGION

Author

Dr. Shiv Ji Malviya

Assistant Professor
Department of Zoology
H.N.B. Govt. P.G. College, Naini, Allahabad (U.P)

ABSTRACT

India is a global mega-biodiversity hotspot and has a unique ecological identity that is due to its diverse forests, wetlands and the important Himalayan range. The Himalayas providing the climatic root to the subcontinent are host to crucial glaciers and perennial rivers, both of which are under attack from anthropogenic climate changes. This paper assesses cascading effects of global warming by concentrating in the aspects of glacial shrinkage and the increasing threat to genetic resources in India.

By analysing impacts at multiple biological scales - from individuals to biomes - researcher show that species adapt by shifting in time (phenology), space (range) and self (physiology).". "Whereas researcher estimate for different approaches on global and sub-continental scales and irrespective of the taxonomic group examined, researcher find that the overall arc of evolution is alarming. The worst-case scenarios of the models seem to suggest that we could be facing a sixth mass extinction of Earth's ancestral population.

Ultimately this study develops necessary management frameworks and control mechanism to reduce these risks, especially in the Himalayan ecosystem. By dealing with the shortcoming of the existing research, researcher present part of a plan for future conservation efforts towards the sub-continent's irreplaceable natural riches.

Keywords: **-** Biodiversity, climate change, Himalaya, species, management.

INTRODUCTION

Predicting how biodiversity is going to respond to a rapidly warming planet has become one of the most important and dynamic frontiers of modern biological research. In recent years, like attempts of the contributing group (e.g., Dillon *et al.* 2010; Dawson *et al.* 2011), have stressed that we are no longer observing theoretical shifts but active ecological transformations more or less. For a mega-biodiverse country such as India, these anticipations are not just academic, they are essential instruments of survival. They are an early-warning system to indicate the dangers our unique flora and fauna face, alerting scientist, forest policymakers as well as the Government of India, from the Himalayan foothills to the Western Ghats.

By helping provide a solid framework to attribute biological change directly to anthropogenic climate change these models help the proposition of proactive conservation strategies (Parmesan *et al.* 2011). While, as of 2016, we have yet to see very many examples of out-and-out global extinctions due to climate change alone, the trend bodes badly. Current projections (e.g. Leadley *et al.* 2010) indicate a terrifying change: in the next few decades, climate change is likely to overtake even habitat destruction and land use change as a global biodiversity killer.

However, the way ahead is foggy due to a "multiplicity of approaches." The sheer variety of modelling techniques tend often to give widely different projections, and it is only difficult for decision-makers to have a coherent picture of the ecological future of India on different carbon emission scenarios. There is therefore an urgent need to synthesize what we currently understand.

THE EFFECTS OF CLIMATE CHANGE ON THE FUTURE OF BIODIVERSITY

Defining the Climatic Shift

The term climate is more as a term that refers to the long-term weather fluctuations for a particular geographic location that includes average temperatures, precipitation amounts, and the solar exposure that is measured over decades. However, the modern era is characterised by Climate Change - a deviation from these patterns, which was attributed (directly or indirectly) to man. Since the Industrial Revolution in the 1850s, human burning of fossil fuels has caused carbon dioxide concentrations to rise from a starting point of 280 ppm to excess of 380 ppm today with projections of soaring to 560 ppm before the end of the 21st century.

This anthropogenic influence causes the composition of the global atmosphere to change which results in a change of the annual mean temperatures in such a way that the increase is higher than the natural variability. Climate change is not about averages; it is the crisis of the extremes. It causes volatility of minimum and maximum temperatures and more frequent extreme rainfalls and disastrous storms, which fundamentally cause ineffectiveness in the environmental balance of life needs.

India's Unique Geographic and Climatic Tapestry

India is a country with unsurpassed physiographic and biological diversity. Its climatic regime is characterized by huge contrasts: while the mercury may soar to 55°C in the Great India Desert of Rajasthan, it lurches to minus 45°C in winters in Leh, Jammu and Kashmir. Similarly, India is home to the highest mean rainfall in the world in Mawsynram, Meghalaya (11,873 mm) and overlaps that with dry stretches of Jaisalmer with a measly 10-25 mm.

This enormous variation helps to offer a great variety of natural habitats for a vast list of flora and fauna. The Indian subcontinent is a leading mega-biodiversity centre in the world especially the Himalayan region. Through a system of national parks, sanctuaries and biosphere reserves, there is protection of unique biological resources in India, which now have been placed under direct threat by the expected temperature rise of 3.5-5.5°C by 2100 onwards.

The Himalayan "Water Tower" and the Threat of Glacial Retreat

The Himalayas, which have been described as the "Water Tower of Asia," have more than 5000 glaciers located in the Indian sector alone. These glaciers account for approximately 50-70% to the discharge of Western Himalayan rivers and a bulk of it for the Eastern range. These are the perennial systems - Ganga, Yamuna, Indus, Brahmaputra and more are the lifeblood of the Indo-Gangetic Plains and are the source of water security and power generation of over 500 million people.

However, a rapid melting is changing these mountains. As temperatures rise - with increased temperatures predicted particularly in the Tibetan Plateau - more accelerated runoff first decreases ice reserves below a problematic level, and then eventually causes "mountain tsunamis" or catastrophic flash floods (Bajracharya et al., 2007). In a horrific forecast came out in 2016 in which experts predicted that Himalayan glaciers may shrink from 500,000 km^2 to merely 100,000 km^2 by the 2030s. The melting of natural ice called the Shiva Lingam of the Amarnath cave is one poignant and an early warning of this warming trend.

Ecological Cascades: Forest Dieback and Biome Shifts

On a higher organizational scale, climate induced vegetation changes are forecast to pose a threat to the integrity of biomes. By the year 2000, the Indian Sub-Continent had already lost 15% of its forest covered area as compared to 1970s. Projections for the year 2100 are even worse: half of the region's forests may be gone with less than a third of the thick forests of the Western Himalayas.

These shifts are caused by anthropogenic pressures - industrialisation, urbanisation and deforestation. Warming in the Himalayan region points to the moderate to large-scale shift of vegetation types leading to forest dieback. Because the response time of forest ecosystems to change is long, the present rate of change in climatic conditions is probably likely to exceed their natural ability to be resilient (Ravindranath and Sukumar, 1998).

Socio-Economic Impact: Agriculture, Health, and Livelihoods

The implications for the civilization of man are substantial and complicated.

- Agricultural Crisis: In the northern plains (Punjab, Haryana, Western UP) the climate change is reducing the period of growth, and producing poor vernalization in the cereal crops, with a drastic reduction in the yields. Fruit orchards are already being forced up into higher altitudes for suitable climates.
- Water Scarcity, rising water and also in the end of decreasing water: As glaciers initially swell, and get thinner and thinner to dangerously low levels, it is that the seasonal water budget of the Ganga and Indus is on a decrease. Increased sediment loads are "choking" the minor drainages and silting up the major river systems.
- Public Health: Increasing temperatures are increasing the range of vector-borne diseases like malaria, yellow fever and schistomiasis; while traditional food crops are more vulnerable to new diseases.

BIODIVERSITY OVERVIEW: INDIA VS. THE WORLD

In their seminal work, this fissured land: an ecologic history of india, Madhav Gadgil (2008) argues that a huge segment of the Indian population (which they group under the category of "Ecosystem People") is directly dependent on the health of their immediate environment for their survival. For these communities Biodiversity is not an exception, but a condition for existence. Gadgil and Guha emphasise that India's history conservation ethos is very much embedded in cultural practises such as the maintenance of 'Sacred Groves.' These pockets of protected forests are ancient repositories of biology proving that community-led conservation has been at the heart and finest position of the ecosystem's resilience in the subcontinent going all the way back before there's even modern legislation.

India is home to an overwhelming number of species, many of them endemic (them nowhere else on earth).

- Flora: Approximately 45,000 species, including 15,000 flowering plants. Between 5,000 and 7,500 of these are endemic.
- Fauna: Over 65,000 species, including:
  - Insects: 50,000+
  - Fishes: 2,546
  - Birds: 1,224
  - Mammals: 350
- Hotspots: The Western Ghats, the Eastern Himalayas are well noted as two of the hotspots of biodiversity in the world.

The Himalayan Region: An Exceptional Endowment

The Himalayas are one of the most complicated and important ecosystems on the planet. In The Himalayan Biodiversity: Richness, Representativeness, Uniqueness, and Life-support Values, Rawal et al. (2013) call the range a "Cultural Landscape" where biological diversity and human tradition are closely linked. The area is not only a biodiversity hotspot, but it is also known as "Asia's Water Tower." More than a billion people depend on the glaciers and river systems that start here for fresh water. Rawal et al. also stress that the Himalayas are home to an unmatched collection of medicinal plants and wild edibles, which are essential for the future of global food and health security.

The Himalayas are a transition zone between the Pale-arctic and Indo-Malayan realms, which is why there are so many unique species there.

- **Structure:** The Himadri (Greater), Himachal (Lesser), and Shivalik (Foothills) ranges make up this area.
- **Climate Gradient:** The base is tropical, and the peaks are always covered in ice. There is a lot more rain in the east than in the west.

- **Water Security:** There are almost 1,500 glaciers in this area that provide water to major river systems and support farming and power generation for the whole subcontinent.

Species that are only found in the Himalayas

The Eastern Himalayas are a treasure trove of evolution. In the larger Himalayan hotspot, the level of endemism, or species that only live in this area, is very high:

Taxonomic Group	Total Species	Endemic Species	% Endemic
Plants	10,000	3,160	31.6%
Amphibians	105	42	40.0%
Reptiles	176	48	27.3%
Freshwater Fishes	269	33	12.3%
Mammals	300	12	4.0%
Birds	977	15	1.5%

The mountains are more than just a place for plants and animals to live; they also protect Central Asia from the cold winds from the Arctic. This wall is what keeps the Indian subcontinent from becoming much colder and instead keeps it tropical.

This heritage is under more pressure than ever, even though it is rich. In The Biodiversity of India, Erach Bharucha (2002) says that rapid industrialization and changing land-use patterns are causing habitat fragmentation. Bharucha says that many of the plants and animals that live in India are about to go extinct because of pollution and people taking over their habitats. India is home to about 7% of the world's plants and 6.4% of its animals. The climate crisis makes this vulnerability even worse.

Madhav Gadgil (2005) suggests in Ecological Journeys that conservation needs to move toward a decentralized model in order to reduce these losses. The introduction of "People's Biodiversity Registers," which record local ecological knowledge, is an important step toward giving communities the tools they need to protect their biological resources. To keep the subcontinent's unique plants and animals alive, we need to combine traditional knowledge with modern conservation science to make a framework that works for everyone.

ASSESSING THE FUTURE OF GLOBAL BIODIVERSITY

The Indian subcontinent is one of the world-leading "mega- biodiversity" centres, by virtue of its exorbitant plant and animal life and high endemism. In 2016, scientists estimated that India was home to some 45,000 species of plants and over 91,000 species of animals, which equalled to about 7-8 percent of the total known species on Earth, although India has just 2.4 percent of the total land area on the planet. Across this diversity in the Himalayas is the world's youngest fold mountains, the Himalayan mountain range which constitutes one of the most crucial transition zones between the Palearctic and Indo-Malayan biogeographical realms. Madhav Gadgil and Ramachandra Guha in their book, *This Fissured Land*, (1992), point out that this variety of life, is deeply related to that of the "Ecosystem People" of India whose livelihoods are tied in with these natural resources. The Himalayas extend approximately 2,500 kilometer and are 200-400-kilometre-wide which forms a climatic shield to the harsh arctic winds and facilitates a tropical climate on the subcontinent. The region is particularly well known for the Eastern Himalayan hotspot. Data from Myers et al. 2000, 2000-2008 indicate that it contains approximately 10,000 species of plant of which 31.6% (some 3,160 species) are endemic. Amphibian diversity is also remarkable as of the 105 species known until the mid-2000s, almost 40 percent of them were endemic, indicating powerful evolutionary forces at the local level that exist in the high altitudes.

Erach Bharucha (2002) in The Biodiversity of India states that India accounts for 6.4 per cent of the total faunal diversity in the rest of the world, with 350 species of mammals and more than 1,200 species of birds, but that heritage is under constant threat as a result of loss of habitats due to the change in land use. The

Himalayas act as the "Water Tower of Asia" and about 1500 glaciers covering an area of 33,000 square kilometers provide water to the large river systems. Pachauri (2007) and Rawal half of all 2013 warn that already the health of these glaciers and alpine plants are being weakened by human pressure and early 21st century climate change. By 2016 however, conservationists including Madhav Gadgil (2005) argue that a way to save the 35,000+ Himalayan ecosystem species is to move toward decentralized management, such as through "People's Biodiversity Registers" used to record traditional ecological knowledge. The fine balance of altitude, rainfall and soil in the various areas of the Himadri, Himachal and Shivalik ranges form a mosaic of ecoregions which is one of the greatest natural gifts of this planet. To protect it, comprehensive or community-focused protection is required in the face of approaches to the present day.

CONTROLLING GLOBAL WARMING

- In India climate change action requires a two pronged strategy of mitigation and adaptation that meets the international commitments and local priorities. In the year 2016 as a developing country India mostly focused on adaptation. This means building stronger ecosystems and communities in order to deal with inevitable changes in the environment.
- Reducing emissions of greenhouse gases, planting trees and using low-carbon technologies are ways to slow down the melting of glaciers and habitat loss (Rhys et'al., 2003). Still, due to the inherent lags of the global climate systems, past emissions will continue to have an effect on weather patterns even with strong cuts. Therefore, adaptive measures - climate resilient agriculture or improved flood forecasting and robust infrastructure - too are required to survive.
- Forestry departments are abandoning traditional "Working Plan" because it's not 'right.' They must embrace dynamic management models which take into account socio-economic land early changing pressure and projected climate variables (Pachauri, 2007).
- A good example of this problem is the Himalayas. Mass tourism develops heat-producing infrastructure and upgrades transport, which also further degrades habitats. Effective management also has to be based on soils and croplands including promoting better farming practices and restoring organic soils as carbon sinks.
- Policy instruments in the form of carbon taxes, tradeable permits and renewable energy subsidies are needed to make green processes economically feasible (UNDP, 1998).
- The IPCC identifies that solving problems caused by humans, such as deforestation and burning fossil fuels, is a matter of the change in behavior of consumption patterns and stabilizing the levels of atmospheric greenhouse gases. Such changes facilitate the maintenance of the balance between society and nature.

CONCLUSION

The end of any study on the Himalayan region should realise that climate change is no longer a remote threat, but the present crisis which can impact the economy, ecology, and stability of the entire subcontinent of India. The Himalayas feed most of the big rivers that flow throughout the year and provide protection to nearly 1,500 glaciers. They are an important life support system to high altitude communities and large population downstream. Yet the special ecological zones and the various habitats that contain the world's most precious genetic riches are immediately threatened by their destruction. By 2016 the case was closed: natural disasters had increased, weather patterns were unpredictable, and geophysical changes manifested themselves in a number of altitudinal zones.

The degradation of the region is a combination of climate and human activities. Habitat destruction, forest fires and changes to land use have heavily damaged biological integrity of area. Bharucha (2002) explained that habitat fragmentation has the consequence of irreversible biodiversity loss. As well, the vegetation changes with altitude and the melting of the "Third Pole" glaciers disturb the region's climatic balance. To be able to protect this natural wealth, it is necessary a comprehensive management plan. This plan should focus on ecological restoration through afforestation and reforestation and strict controls of the landscapes and tourism to reduce the "heat island" effects caused by unchecked infrastructure (Pachauri, 2007).

A move to sustainable energy models is just as important. Slowing warming by reducing the amount of greenhouse gases in the global atmosphere requires improving energy efficiency and advancing the use of renewable technologies. Gadgil (2005) reiterated the need that local action has to be scientifically based. This means the development of advanced level of predictive models, continuous environmental monitoring and

focused research on specific vulnerabilities of Himalayan plants and animals. The Himalayas do not have the option of dying out but may only survive if we change the way we perceive and treat the natural resources in our world - changing from exploitation to resilient management. Without these united efforts the most precious of Mother Nature's subcontinent will die on its descent, destroying the ecosystems of the mountains and triggering a socio-economic collapse that will affect billions who rely on its waters.

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