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HARNESSING NATURE

World Environment Day 2020
Special Issue

IUCN CEM

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Managing Editors: Deepu Sivadas, Shalini Dhyani, Oindrila Basu, Madhav Karki

Cover photo: Grassland Shola Matrix and associated species in the Western Ghats, India (Photo: Deepu Sivadas)

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World Environment Day 2020 Special Issue

Contents

Paphiopedilum druryi (Bedd.) Stein

Scan
&
learn more

05 JUNE 2020

WORLD ENVIRONMENT DAY

TIME FOR NATURE

TIME FOR NATURE

WORLD ENVIRONMENT DAY

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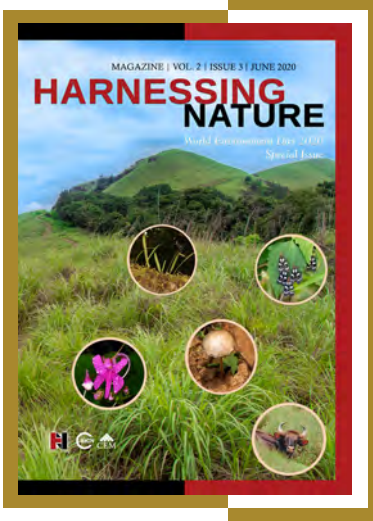
From the desk of Chair

I should like to use this foreword to draw the reader's attention on the themes compiled in this special issue of Harnessing Nature (Volume 2, Issue 3) dedicated to the World Environment Day 2020 during these challenging global times. This is the official magazine of the South Asia regional network of members of the Commission on Ecosystem Management - International Union for the Conservation of Nature (IUCN CEM). CEM South Asia is a regional platform of global significance comprising experts, professionals and emerging leaders (young professionals) for contributing and sharing knowledge that is helping the enhancement and development of existing knowledge related to the concerns, challenges and prospects of ecosystem management and trans-boundary conservation efforts in the region.

This special issue focuses on the themes "Time for nature" and "celebrate biodiversity". The magazine presents insights into diverse ecosystem services and the importance of nature and biodiversity of the region. As per approved IUCN programme 2017–2020 South Asia has been considered as a region that requires greatest conservation need among IUCN's eight Statutory Regions. South Asia region is home to diverse ecosystems under diverse protection categories such as Protected Areas; Trans-boundary Sacred & Biodiversity Landscapes and seascapes; Biosphere Reserves; Key Biodiversity Areas (KBAs). The region has many mega biodiversity hotspots, key wetlands and shares several hydro-geological features in important topographic regions and ecosystems. South Asia is home to many traditional and indigenous communities dwelling in remote as well as sensitive and fragile ecosystems. These communities have helped in shaping the conservation and management of natural resources of these sensitive and fragile ecosystems. Many of these sustainable practices are still relevant in this changing world.

I am delighted that my colleagues in South Asia have mobilized the vast and diverse knowledge, experience, and insights of CEM members in the region for putting together this magazine issue which is coming to your hands from the CEM South Asia Region. I congratulate Shalini, Madhav and Deepu along with the contributors of the magazine and editorial board for their efforts in bringing out this special issue.

Angela Andrade
Chair, IUCN Commission on Ecosystem Management



Commission on Ecosystem Management

A network of professionals whose mission is to act as a source of advice on the environmental, economic, social and cultural factors that affect natural resources and biological diversity.

Angela Andrade
Chair,
IUCN CEM

Madhav Karki
Deputy Chair,
IUCN CEM

Shalini Dhyani
Regional Chair,
IUCN CEM (South Asia)

Foreword

The theme for this year's World Environment Day is "Time for nature" and "celebrate biodiversity". The Global Assessment Report of the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services, IPBES released in June 2019 warned the global community that unprecedented "biodiversity loss presents an existential threat to human life". It said, "nearly a million species face extinction if we do not fundamentally change our relationship with the natural world". I am very pleased that WED, 2020 theme implies that time has come to take urgent action to save biodiversity at local, national, regional and global levels. The GA also reported "Virtually all indicators of biomes, ecosystems, species, varieties and breeds are negative"and that "most of the assessed categories of nature's vital contributions to people" are losing their ability to continue supplying vital ecosystem goods and services. Similarly, the Asia-Pacific Regional Report that I had the opportunity to co-chair found that "22% of all species and 25% of endemic species in the IUCN Red List are either extinct, extinct in the wild, critically endangered, or vulnerable". The largest number of species at risk was found in South Asia (19% of all and 45% of endemic). Roughly 1 in 3 species of freshwater fish species is threatened. The report also pointed out that countries were making good progress only in 4 out of 20 Aichi Biodiversity Targets (2011–20), moderate progress in 7 and poor progress in 6. So the countries will miss achieving most of the targets and goals.

So what actions we can start taking. We do realise that among the policymakers as well as in general public discourse, there is more awareness of climate change than biodiversity. We need to make the public and policy and decision-makers aware that most critical impact of climate change on humanity will be through the impact on or loss of biodiversity since biodiversity provides the bread and butter or livelihoods to human beings. This will help the public to understand the value of biodiversity and policymakers in mainstreaming biodiversity targets into development targets. The IPBES reports also pointed out that biodiversity is decreasing more slowly in areas managed by indigenous peoples and local communities that tell us the importance of documenting, understanding and using indigenous and local knowledge and practices (ILKP) in promoting community-based conservation and management. There is also a role in how we value nature. The indigenous peoples in the Himalayan Mountains, especially in Nepal, Bhutan, NE India and the Western Ghats have preserved biocultural diversity not driven by financial incentives or legal requirements but by their high intrinsic values towards nature. This multiple conceptualisations of nature's value to humans should inspire and guide all us in our biodiversity conservation efforts. High cultural value is the key to sustainable biodiversity conservation. There is also a misconception that by increasing the protected areas, we minimise the loss of biodiversity. The reports found out that although countries are achieving 15% PA target on terrestrial biodiversity, biodiversity at species and ecosystem levels are still declining. So we need to conserve critical biodiversity areas and important bird areas. Let's hope that the post-2020 Biodiversity targets are more meaningful and achievable based on the lessons learned

from the 2011–20 targets.

In closing, I want to say that countries in the Asia-Pacific region, including South Asia, have made significant economic progress but at a high cost on biodiversity. The COVID 19 crisis is a stark reminder to all of us that poor understanding of the fundamental relationship between human and nature can create an existential challenge to human beings. Our region's biodiversity faces unprecedented threats, from rapid climate change and associated extreme events, unwise socio-economic change, glacial melting, sea-level rise, invasive alien species and increasing waste and pollution. Let's pledge on this Day that we all commit ourselves to protect, conserve, increase and sustainably use biodiversity and inspire others to do so. I wish you all a very stimulating, inspiring and motivating World Environment Day, 2020.

I hope the readers will enjoy and benefit from the information the Magazine provides. I urge you to please share your comments, suggestions, feelings and contribution for the next issue.

Madhav Karki
Deputy Chair, IUCN CEM & SA Focal Point

From the Editor's Desk

Time for Nature: Let's acknowledge Nature's benefits to support our survival

By Shalini Dhyani

2020 is a year for urgency, ambition and action to address the crisis facing nature; it is also an opportunity to more fully incorporate nature-based solutions into global climate action—Inger Andersen

It gives me immense pleasure and sense of gratitude to our all contributors, reviewers and editorial board who have helped us to compile and share the World Environment Day, 2020 special issue of IUCN Magazine cum Newsletter "Harnessing Nature" with all of you in IUCN, CEM S. Asia and beyond. In these tough times, it is very tough to put up such significant issues, and with the support of our CEM members, we have been able to keep showcasing good work that was possible. The special issue highlights the theme of World Environment Day, 2020 "Time for nature" and "celebrate biodiversity". The theme is very well aligned to the fact that all countries and people have recognized in last few months more seriously that there is no other alternative or substitute to Nature, the biodiversity, that can ensure human wellbeing. I am happy that many regional members have participated to share the stories from their countries. We showcase the work carried out by our members in Nepal, India and Bhutan in this special issue.

We cannot assign only a day to Nature. It is our every day without Nature and biodiversity we cannot think of human survival. From food, fibre, energy to medicine our entire day and life revolves around the benefits of Nature. S. Asia region with diverse countries of Bangladesh, Bhutan, India, Maldives, Nepal, Sri Lanka, in the last few months had experienced some of the very dark days and ever-increasing pandemic risks. As if it was not enough, the recent attack by locusts. Clouds of locusts invaded vast areas and distant states of India from the second week of April. After destroying millions of hectares of crop areas initially in Rajasthan, they further entered many states in India. This fast-growing locust swarm is now threatening and is expected to amplify into an agrarian disaster for the subcontinent. After cyclone Amphan hitting east coast in May, the cyclone Nisarg (or Nature as translated) hit west coast especially targeting Mumbai. Here it is imperative to mention the expected intensity of Amphan was reduced by the mangroves of Sunderbans after landfall, and the damage was not very severe, though, many local villages in the delta were devastated. While the loss of sparrow population and habitats were indicated towards increased risks of locusts, as sparrows may have fed on them and have reduced the loss; the loss of mangroves are related with

increasing damage to coastal areas.

It is high time we start integrating and mainstreaming conservation, protection and restoration of Nature not only in policies but also in practice and implementation. We should celebrate the importance of biodiversity and try to protect the remaining patches in natural as well as urban areas. It is indeed time for Nature, and if we are unable to reduce degradation, deforestation, species loss, illegal wild trade, maybe we will not be able to reduce the impacts of such severe pandemics. Nature has shown a great way to humanity. While people are trying to build immunity using traditional herbal medicines across the world, be it Ayurveda or Chinese medicine. The respect and acknowledgement to Nature for ensuring human health and wellbeing cannot be avoided or ignored. Increased wild foraging during lockdown provided food, medicine and other provisioning services to many. The psychological benefits to grow our food in our backyards and forage our food gave us a sense of belongingness and peace in these distressing times. Free movement and wildlife sightings were surprising and pleasant, and we hope we would be able to learn to live in harmony with Nature in the new normal. At the same time, there was much depressing news about increasing man-animal conflicts from the region, increased poaching and hunting. This pandemic has shared one big lesson to humanity, to leave wild animals in their habitats and let them live in peace with less and no transmission risks of zoonotic. I hope we will be able to give that due respect and acknowledgment to all living beings and by making sure that our generation next learn the benefits of living in the eco civilization.

Human civilization is facing wide-ranging challenges, from pressures on ecosystems to human wellbeing and rapid depletion of natural capital, resulting in an increased risk of disasters and compromised food, water and energy security. Countries across the world are increasingly exposed to growing disaster risks due to loss of ecosystem services and emerging climate vulnerability. There has been tremendous advancement around the world in terms of conceptualization, research, implementation and policy uptake for Nature-based Solutions (NbS) to address and reduce the severity of disaster risk and climate vulnerability. There has been growing momentum in ongoing international policy dialogues to understand, include and facilitate the implementation of NbS and even for realizing the theme of World Environment Day 2020. Inger Andersen, Executive Director of the UNEP, stressed on the requirement of mainstreaming and localizing NbS for achieving the SDG and post 2020 biodiversity targets. Commission on Ecosystem Management being the pioneer in NbS can facilitate the way ahead for restoring the degraded and red-listed ecosystems (another pioneering effort of CEM to move ahead from species to ecosystem approach). There will be no superior time for all of us to come together to ensure our efforts in nature conservation. Be it climate action, disaster risk reduction or pandemic control none of them can be achieved without conserving biodiversity. There is a growing need to develop policies that stop the deforestation, degradation, fragmentation, unsustainable use and extinction of plant and animal species. Post-2020 biodiversity targets will revolve around biodiversity as it is the only cross-cutting theme for protecting the planet.

I thank our global Chair Dr Angela Andrade and Deputy Chair Dr Madhav Karki, our focal point to CEM global steering committee for their continual support.

While I wish you all very happy readings, I wish you all to stay safe..!!

Shalini Dhyani, Ph. D, is Senior Scientist with CSIR – National Environmental Engineering Research Institute (NEERI), Nagpur, India and South Asia Regional Chair of IUCN Commission on Ecosystem Management

Revisit the limits, Green the Grey and leave the Governance on Commons

By **Oindrila Basu and Deepu Sivadas**

The limitless resources of the Earth, today we know, are not unlimited. Only a few decades back scientists had pointed out how limitless growth is harmful to human society[1]. Today standing still in a pandemic, we humans globally realise how intertwined our health is with our Nature, our biodiversity, and our socio-ecological system[2]. As we emerge out of the crisis, it becomes our duty to revisit these not so long-ago forecasts and embrace the changes needed to transform the horizon.

The term 'feedback loop' from the Biological Sciences[3] that refer to that information in a system which are provided by the outputs of the system in it's various stages to direct the system back to homeostasis, the tendency towards stability, equilibrium. The feedback loops are both positive and negative. While positive feedback loops enhance and amplify the reaction to make the products more quickly, the negative feedback loop slows the reaction, brings the system back to stability. For a system to sustain, the feedback mechanism of self-regulation is indispensable. A faulty feedback system in the human body leads to lifestyle diseases like Diabetes. In case of a fall in blood glucose level, alpha cells of pancreas release glucagon to raise the blood glucose and positive feedback releases more glucagon whereas once homeostasis achieved the beta cells release insulin as negative feedback to signal the formation of glucagon. Similarly, in the natural ecosystem[4,5], an example of a positive feedback loop would be pole ice melting under global warming, causing lack of albedo resulting in further ocean warming. In socio-economic systems too, these feedback loops are present in the form of conflict resolution, reducing, recycling industrial wastes, increasing efficiency of the system. The feedback loops act as guards of systems, preventing the system from going beyond any extremes, protecting from crossing the tipping points[6].

Coming back to the limits, at the beginning of the twentieth century, global population was a little more than 1.5 billion people and today into the third decade of the twenty-first century the global population is about 7.5 billion people and increasing. Estimates suggest that the global population is expected to rise over 10 billion by the end of this century[7]. Economic growth to meet the consumption demand of the growing population may exceed the material supply and carrying capacity of the Earth[8]. Today humankind uses the equivalent of 1.75 Earths

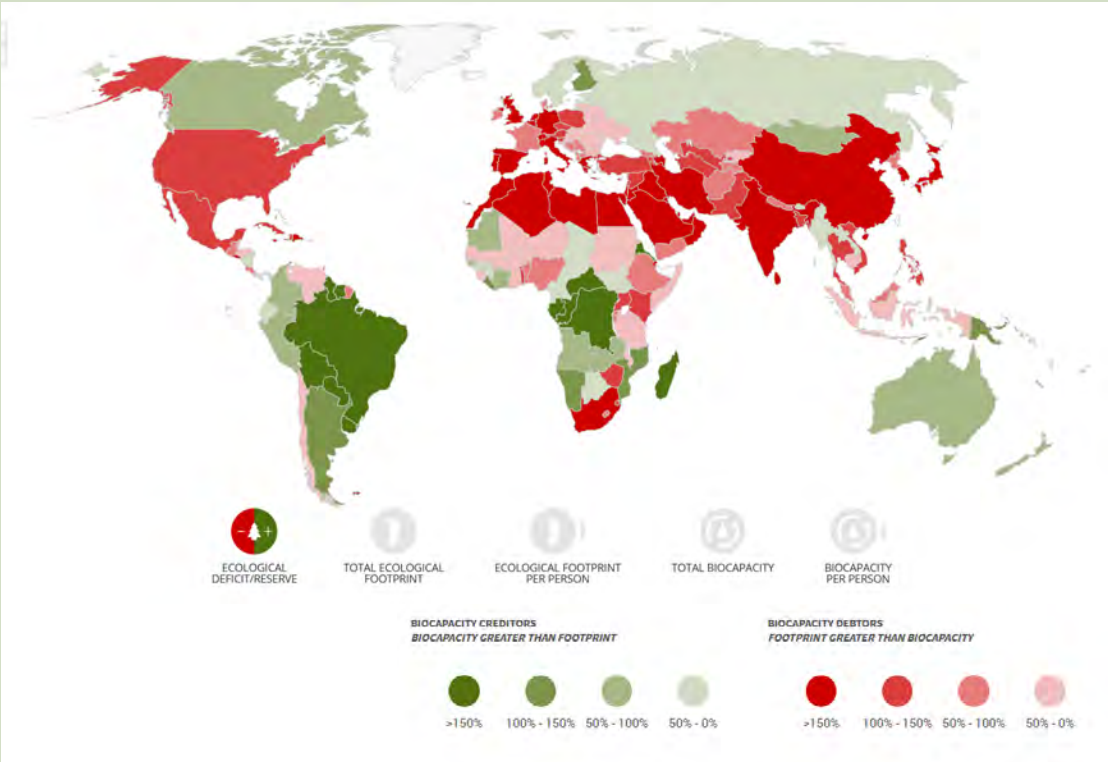
[1]https://clubofrome.org/publication/the-limits-to-growth/. Accessed on 30 May 2020.
[2]https://www.weforum.org/agenda/2020/04/on-earth-day-heres-what-covid-19-can-teach-us-about-improving-our-planetary-health/. Accessed on 30 May 2020
[3]https://www.albert.io/blog/positive-negative-feedback-loops-biology/. Accessed on 30 May 2020.
[4]https://eco-intelligent.com/2016/12/04/feedback-loops-regulating-natural-processes/. Accessed on 30 May 2020.
[5]https://systemsinnovation.io/ecological-feedback-loops/. Accessed on 30 May 2020.
[6]Wu, J., Guo, Y., Zhou, J. 2020. Nexus between Ecological Conservation and Socio-Economic Development and its Dynamics: Insights from a Case in China. Water 12: 663.
[7]https://www.bbvaopenmind.com/en/articles/the-challenges-of-the-end-of-the-demographic-transition/. Accessed on 30 May 2020.
[8]Bloom, D.E. 2020. Population 2020. https://www.imf.org/external/pubs/ft/fandd/2020/03/pdf/changing-demographics-and-economic-growth-bloom.pdf. Accessed on 30 May 2020.

to provide the resources we use and absorb our waste. This means the Earth now takes one year and eight months to regenerate what we use in a year[9]. Generation of wastes disrupting Nature's balance is becoming a significant problem and managing it the greatest challenge in present and incoming future[10].

Climate change, accelerating in an unprecedented rate, is hovering above us, giving us only ten years to combat and keep the globe from heating up the maximum 1.5 degrees, as scientists suggest. With more than 75% of Earth's land area is degraded today, our valuable biodiversity and ecosystem services are at stake [12]. Biodiversity loss in the latter half of last century and the beginning of this (1970–2006) has wiped out more than 31%, nearly one-third of world's wild vertebrate populations, more severe in the tropics (59%) and in freshwater ecosystems (41%) [13]. Although initiatives like IPBES are working in mainstreaming biodiversity and ecosystem services, the global consumption and economic growth in current trajectory demands for material inputs far exceeding Earth's capacity. A major issue arises from the huge global inequality as the limit nears rendering the poorest, depended on ecosystem and biodiversity, more vulnerable once the threshold of global

Ecological Deficit/Reserve

An ecological deficit occurs when the Ecological Footprint of a population exceeds the biocapacity of the area available to that population. A national ecological deficit means that the nation is importing biocapacity through trade, liquidating national ecological assets or emitting carbon dioxide waste into the atmosphere. An ecological reserve exists when the biocapacity of a region exceeds its population's Ecological Footprint.



Source: Global Footprint Network[11]

[9]Network GF. Ecological Footprint - Global Footprint Network 2020 [Available from: https://www.footprintnetwork.org/our-work/ecological-footprint/. Accessed on 30 May 2020.
[10]Eberstadt, N. 2010. The Demographic Future: What Population Growth—and Decline—Means for the Global Economy. Foreign Affairs 89(6): 54-64.
[11]Network GF. National Footprint Accounts 2019 [Available from: http://data.footprintnetwork.org/#/abouttheData. Accessed on 30 May 2020.

tipping points exceeded[12]. The values of scarce ecosystem services and goods are to soar skies inducing more inequality.

Sixty-one individuals today own as much as the entire poorer half of the globe. Although wealth worth billions are created every year, capable of ending global poverty more than once, end up making the top 1% richer while inequality and poverty remain unaddressed, clearly depicting the fallacy in trickle-down economies in a deregulated global market[12]. Around half a century back the Club of Rome released their years' long work—Limits to growth, highlighting how our consumption, unidirectional industrial growth and governance are bringing Earth's as well as human's limits sooner and the dramatic need of change in vision and trajectory to sustain[13,14]. But it seems although they were correct, we failed, as even today 80% of our energy demands are met from fossil fuels, same as was in the 1980s, and are subsidised at a rate of trillions of US dollars[15], and we don't have enough to believe that their prediction, 'Nature probably cannot support present rates of economic and population growth much beyond the year 2100', will go wrong. Today's global pandemic with their link to biodiversity and a cleaner climate under global lockdown again shows us glimpses of the feedback loop of Nature lying in plain sight in front of us while we continue to deny to see them.

To change the discourse of the future, embracing the dramatic transition from grey to the green economy is essential globally today. Green reforms in measuring wealth, financial systems, economic sectors are an urgent need. While the tragedy of commons and mainstream economics led us here as we stand today, it is again the Nobel scholarships in mainstream economics, which can save us. In her pathbreaking work Governing The Commons, way back in 1990, Nobel laureate Ellinor Ostrom paved the way to ecological governance of decentralised Nature[16,17]. Her analysis of social-ecological systems in a multitiered approach is needed urgently to support our global future economics and governance[18]. A global transition to green governance coupled with a green circular economy learning from the social-ecological feedback loops internalising social and ecological costs in the economic systems might pose as the solution we need. Green growth seems prospective as researches to show the vision of a better future. UNCTAD findings show that in achieving SDGs by 2030, we need US $5-7 trillion of annual investments, we can gain US $9 trillion in ecosystem services by restoring 350 million hectares of degraded land by 2030. Further bold climate action holds the potential to deliver at least US $26 trillion in economic benefits and more than 65 million new low-carbon jobs by the end of this decade[15].

As the IPBES report suggests, transformative changes are needed to protect and restore Nature. What we are facing now in the forms of pandemics, natural disasters are due to the five drivers (all rather caused by one species)— (1) changes in land and sea use; (2) direct exploitation of organisms; (3) climate change; (4) pollution and (5) invasive alien species. The report cautions us of degradation and/or reduction in the Nature's capacity to contribute to people. Turn around and look into your surroundings; you can actually feel it.

We are talking of the next-generation technologies, but are they aligned a way to reduce the stress on Nature. We all are aware of what Nature had suffered over the past centuries due to the materialistic relation we had with her, to revert this we are thinking and talking more about 'Sustainable Development', it is also high time to redefine the term 'progress' out of its materialistic context. Last but not least, it is extremely crucial for us to understand that

[12]Green Economy Coalition. 2020. 10 -YEAR STRATEGY 2020 – 2030 Economic reform within a generation. [Available from: https://www.greeneconomycoalition.org/assets/reports/GEC-Reports/gec-report-template-v1.5-FINAL-34pp.pdf. Accessed on 30 May 2020.
[13]https://www.cbd.int/gbo3/?pub=6667&section=6711. Accessed on 30 May 2020.
[14]https://www.theguardian.com/commentisfree/2014/sep/02/limits-to-growth-was-right-new-research-shows-were-nearing-collapse
[15]Green Economy Coalition. 2020. The global trasition to green and fair economies. [Available from: https://www.greeneconomycoalition.org/assets/reports/GEC-Reports/1037-GEC-Barometer-Phase2-A4-V8j-WEB.pdf. Accessed on 30 May 2020.
[16]http://www.bollier.org/blog/commons-model-ecological-governance. Accessed on 30 May 2020.
[17]https://www.onthecommons.org/magazine/elinor-ostroms-8-principles-managing-commmons. Accessed on 30 May 2020.
[18]Ostrom, E. and Cox, M. 2010. Moving beyond panaceas: A multi-tiered diagnostic approach for social-ecological analysis. Environmental Conservation, 37(4): 451-463. doi:10.1017/S0376892910000834

for humanity to sustain, it is essential to value Nature and her resources as assets much beyond their marketed services, as restoring them in their current capacity is beyond the capacity of humanity even in a century.

Man can create a society in which he can live indefinitely on earth if he imposes limits on himself and his production of material goods to achieve a state of global equilibrium with population and production in carefully selected balance—The limits to growth.

Oindrila Basu, is Junior Research Fellow with School of Oceanographic Studies Jadavpur University, Kolkata, India and a member of the IUCN Commission on Ecosystems Management

Deepu Sivadas, Ph. D, is Post Doctoral Fellow with Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala, India and member of IUCN Commission on Ecosystem Management

Makalu Barun Valley Biomeridian Study—Songs of Adaptation

By **Future Generations University BBT team/Sushila C. Nepali**

Nature is constantly communicating with us. It is showing and demonstrating how it is feeling, developing, and changing. It is our job to listen and to care. Climate change is causing dramatic changes in the natural world. One phenomenon we are seeing is that ecosystems are shifting uphill. Warmer temperatures are pushing species to higher elevations.

The Makalu Barun Valley in Nepal is one of the most remote and pristine places on Earth. The people there live with the land. Visitors are compelled to bend to the will of the natural forces there. It is an important ecological area that is telling us about what is happening to the Earth. It is no stranger to these dramatic changes.

Future Generations University has a long history working in the Makalu Barun working in the sectors of land conservation, the people, and help protect ecosystems. Future Generations in partnership with Department of National Parks and Wildlife Conservation (DNPW) and the East Foundation, continues to engage with the people of the Makalu Barun and with conservation efforts of those who wish to protect it.

Our Team at Makalu Barun Valley

Over the last 3 years, one Future Generations University project has been working on listening to the Makalu Barun: Songs of Adaptation. Songs of Adaptation is a bioacoustics project that studies the sounds of nature to understand it better and respond to how it is changing. Consistent and powerful voices in the natural landscape are those of birds. Songs of Adaptation is focusing on bird sounds as they can tell us about ecosystems. The project installs bioacoustics research stations, which record sound, temperature, and humidity, at multiple elevations in an area. With the data, local experts identify the birds recorded (and any other animals they might recognize) and share that information with the rest of the team. When a species is found enough times within the data, Songs of Adaptation trains an Artificial Intelligence model to recognize the bird.

Setting up camera and acoustic

The implications for this work are many. First, consistent scientific data in places allow for informed conservation and climate adaptation efforts. Second, indigenous knowledge is being heard, engaged, and preserved through the use of bioacoustics technology and artificial intelligence. Third, it is possible to track ecosystem changes as the birds migrate. This is key, as the climate warms, and plant species are growing at

higher elevations, birds are moving with them, and they are telling us about it. The Songs of Adaptation team has preliminary evidence that they have found one bird species at a higher elevation in the Makalu Barun than ever before recorded. This data is valuable and leads to another important possibility for this work. Communities will be empowered to make the changes they see fit as the impacts of climate change realize. Evidence that an ecosystem is moving could be key in securing support for conservation efforts and supporting community needs in a changing world.

Bird songs are consistent indicators as to their presence, and the presence of other species in their food webs. Bird songs can tell us about local changes in climate change. The Future Generations University project, Songs of Adaptation is seeing to it that in the Makalu Barun Valley, communities can listen to, learn from, and act upon what the birds are trying to say.

Sushila C. Nepali, Ph. D, is Assistant Professor with Future Generations University, and Nepal Country Focal Point of the IUCN Commission on Ecosystems Management

Invasive species and their impacts to forest biodiversity in the Southern Western Ghats

By **Davidson Sargunam**

Sustainable forest management and conservation management concepts include the activities to safeguard forests from biodiversity loss, natural calamities as fire, landslides and enhance the economic, social and environmental values of all types of forests for the betterment of humans. One of the recent severe threats to the forest sector has been a perennial challenge at the global level is the dominance of invasive alien species. Invasive species are non-native species to a particular ecosystem and whose introduction and proliferation cause or are likely to cause, socio-cultural, economic or environmental impact to the invaded ecosystem.

A pertinent challenge to forest resource management is the intentional introduction of non-native species into the forest ecosystem to provide economic, environmental or social benefits. Some species initially introduced with a positive intention have turned later to be a bane to the ecosystem. There is a considerable concern in the forest segment since many of the tree species used for agroforestry, commercial forestry and desertification control have turned to be invasive to the area.

A study conducted along with K. Mohan Raj, a senior expert in forest conservation, Arun Sankar of Tamil Nadu Green Movement and Santhi Vasantha Malar of Tribal Foundation in the protected areas in the Southern Western Ghats namely Mudumalai Tiger Reserve, Bandipur Tiger Reserve, Wayanad Wildlife Sanctuary, Palani Hills Wildlife Sanctuary and Kanyakumari Wildlife Sanctuary revealed that a host of invasive alien species had made a bio-invasion in the forests, which are destructive, detrimental with devastating results to the forest and water resources.

These Reserves are abundant with herbivores as elephant, Indian gaur, spotted deer, sambar, wild boar, barking deer, Nilgiri tahr, four species of monkeys and predators as tiger, leopard, wild dog, hyena, fox and unique reptiles as cobra, king cobra and vipers.

The invasive plant *Lantana camara* L. forms a dense growth competing with other species and shows allelopathic effect in the surrounding soil that prevents seed germination, dominates over natural growth of grass and bushes. *L. camara* thrives well as an invasive species, due to seed dispersal by birds, substantial tolerance to dry environmental conditions to survive, high level of seed production and inhibits the survival of

Invasive Eucalyptus plantation & Lantana © Davidson

other species.

Parthenium hysterophorus L. is an American tropical species of flowering plant, that invades disturbed land and infests forest lands with prolific growth and drastically reduces the growth of grass and dominates the survival of other undergrowth species. Its pollen is known to create skin allergies and skin rashes in humans.

Prosopis juliflora (Sw.) DC., native to Mexico, South America and the Caribbean was introduced in the 1960s to meet the fuel energy in rural areas and expanded tremendously. Wild animals disperse Prosopis seeds through skat. The invasive wattle (*Acacia*) tree was raised as a plantation that is a threat to biodiversity, reduces surface water flow and affects grazing areas.

In the Western Ghats, vast plantations of Eucalyptus and wattle (Acacia) were raised by converting grasslands and shola forests. The Karnataka government has banned the planting of Eucalyptus and Acacia as both have caused a severe dip in the water table. Wattle trees introduced to extract tannin in the Nilgiris have colonized the grasslands extensively and encroached upon the adjoining shola forests. Planting of these species has been banned from 1987 onwards in the Nilgiris and environmentalists are opposing culturing such species by the forest department or by wood-based industries.

The study revealed that invasive species like Eucalyptus, wattle and pine trees are proliferating across the Nilgiris upper slopes interspersed with *L. camara* while Prosopis and Parthenium are seen in the lower reaches. Wattle, Eucalyptus and pine have become an insurmountable ecological challenge in Kodaikanal Wildlife Sanctuary and Meghamalai Wildlife Sanctuary and adjoining forests in the Western Ghats by affecting the survival and blocking the regeneration of Shola and montane grasslands, mostly preferred by herbivores for foraging.

A mass felling exercise of invasive trees was undertaken in Kodaikanal, which was later stopped due to many reasons, and abandoned following the formation of Kodaikanal Wildlife Sanctuary due to the restrictions.

Eucalyptus was planted extensively surrounding Udhagamandalam and across the Nilgiris district. The leaves are gathered and used to produce eucalyptus oil through oil distilleries.

Opuntia stricta Haw. (Prickly Pear), native to

Invasive *Senna spectabilis* in Wayanad WLS © Davidson

America and the Caribbean Islands is regarded as a weed in many parts of the world, and it has a deleterious impact on the forest and grasslands. Birds and rodents eat it's fruits, and the seeds spread through their droppings. It is listed among the 100 of the world's worst invasive alien species. This cactus is widely found in the Masinagudi forest area in Nilgiris district in the Western Ghats.

Senna spectabilis (DC.) H.S.Irwin & Barneby, a tree species was found in nearly 10 km^2 area of of the Wayanad Wildlife Sanctuary (344.44 km^2), Kerala in the late 2010s. Presently it has covered more than 50 km^2 of the sanctuary within a short span of time. The thick foliage of the tree, which is not edible to herbivores, prohibits the survival of other indigenous species of trees and grasses and causes food shortage for the herbivore population.

The Kanyakumari Forest Division in Tamil Nadu leased about 5,000 hectares of reserve forests to the Arasu Rubber Corporation Limited. Initially, when rubber was raised, *Pueraria javanica* Benth.—a very popular cover crop in plantations, a native species of Thailand was introduced as to prevent soil erosion and for the enrichment of the soil. In due course, the cover crop was changed to *Mucuna bracteata* DC., a creeping vine. It has now become an unmanageable threat to forest biodiversity. It registers a fast growth in rubber plantations, prevents soil erosion, enriches organic matter and helps in retaining moisture. As it is a perennial climbing vine, it chokes and dominates native trees by its gregarious growth and fast climbing behaviour on the tall trees in forests and reduces photosynthetic activity and eventually, the trees face mortality.

The study has generated many insights into the footprint of invasive species that have become threats to biodiversity with an adverse impact on forest ecology. The observations of the study are that the invasive species dominate the native ground flora and choke the survival of native and endemic herbaceous species. There are reports of mixing of toxic resins from some of the invasive species during monsoon with water polluting the soil quality and water streams, and consequently, hill stream fishes, crabs and other organisms are affected.

The spread of invasive species, lead to a scarcity of herbaceous fodder, forcing the herbivores to modify their foraging behaviour and seeking new pastures. Consequently, elephants, Indian gaur, spotted deer, sambar and wild boar raid crops in indigenous people settlements, and fringe villages for food that lead to a chain of human versus animal conflict. Seeking and following their prey, big cats as tiger and leopard follow the herbivore trails and enter into human settlements, which escalate into additional conflicts. All these are due to the sheer anthropogenic activities, the primary driver of forest ecosystem modifications.

Bio-invasions by invasive species are among the top drivers of biodiversity loss and species extinctions. Bio-security measures to prevent the introduction, prevention and eradication are vital to check the invasive species. The governments should address the impact of invasive alien species to balance the biodiversity and conserve the forest ecosystem by mitigation measures and make the forests resilient.

S. S. Davidson, is one of the pioneer educators of the environmental movement based at Tamil Nadu, India and member of IUCN Commission on Ecosystem Management

Hitchhiking plant invaders in urban environments

By **Neha Goyal and Gyan Prakash Sharma***

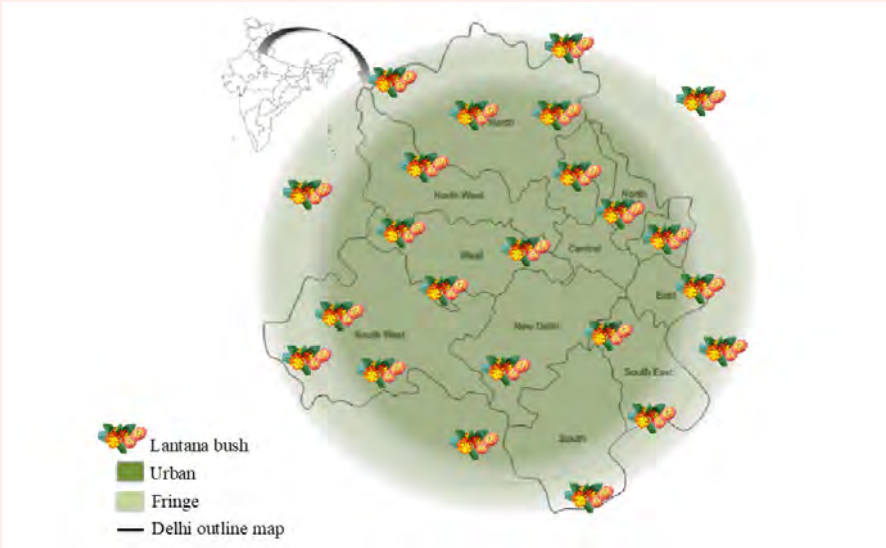
A rapid increase in development and the concomitant growth in global trade and travel has come along with an exponential rise in the introduction of species to regions where they do not naturally occur, i.e., outside their native range. Biologists call such species as invasive species or invaders. Invasive species are the organisms introduced into places out of their natural range of distribution by human intervention, wherein they establish, disperse, and significantly impact environment, economies and human health[1]. Invasion by the alien, introduced species may significantly impact global biodiversity, alter ecosystem services and processes, reduce native species abundance and richness, and cause substantial economic losses.

As urbanization accelerates globally, a better understanding of how urban environments may threaten or contribute to biodiversity conservation is important. Cities, being hubs of anthropogenic activities, with both profoundly transformed and disturbed habitats, are usually the primary sites of the introduction of alien species. Alien species are intentionally or unintentionally introduced to urban environments, wherein they inadvertently spread or escape from confinement to heterogeneous urban landscapes. In times of cosmopolitan citizenship, boundaries (fringe) between rural and urban landscapes are blurring. Rapid land-use changes are driving unsustainable rural to urban transformation. Such transformations make agro-ecosystems and fringe landscapes vulnerable to alien plant species invasion. The intensification of agriculture has also led to a tremendous increase in the introduction of alien plant species outside the native range[2]. Augmenting episodes of dispersal and escape of potential colonizers from the cultivated croplands to fringe landscapes also form an issue of significant concern in the current developmental scenario. Urban green spaces, including green belts, which ought to be covered by native vegetation, are even invaded by a plethora of invasive plant species (*personal observation*). Of concern, the invaded heterogeneous landscapes in urban environments act as breeding areas and/or launching sites for plant invasions in adjacent natural areas.

L. camara bush in full bloom along roadside in Civil Lines, Delhi © G.P.Sharma

[1]CBD. 2018. What are Invasive Alien Species? Convention on Biological Diversity. Retrieved from URL: https://www.cbd.int/idb/2009/about/what. Accessed 12 March 2020.
[2]Ellstrand, N.C., Heredia, S.M., Leak-Garcia, J.A. et al. Crops gone wild: evolution of weeds and invasives from domesticated ancestors. Evolutionary Applications, 2010, 3, 494-504.
[3]Goyal, N. and Sharma, G.P. Unveiling cryptic ecological functions: prospects in plant invasions. Tropical Ecology, 2018, 60, 1-5.

Numbers of introduced alien species are rapidly increasing in India; including all, it grew from 197 in 2005 to 244 in 2019[3]. Recognizing the pace of economic development in India, the problem of plant invasions is pressing. The fast-emerging economy of India has triggered intensive land-use alterations and high levels of habitat destruction, providing favourable habitats and ample recruitment windows for the establishment and spread of invaders. Ongoing construction and infrastructural development, e.g., construction of bridges, flyovers, road and railway networks, buildings, excavations for laying pipelines, electricity, and telephone cables etc. further mobilize movements of alien propagules.



Box 1. Illustration of an urbanized setup with potential urban core and fringe landscapes depicting how invaders take advantage of urban habitat heterogeneity to establish and proliferate into self-perpetuating populations. In the present context, urban habitat heterogeneity refers to spatial environmental heterogeneity, i.e. variation in the physical environment at a particular spatial scale. Human-dominated establishments in urban centres characterized by intensive land-use and high levels of habitat destruction result in heterogeneous habitat mosaics, which provide windows for the establishment of plant invaders. Such populations may act as breeding areas and/or launching sites for further dispersal. The illustration is based on the insights of *Lantana camara* expanse as a pernicious invader in and out of an urban setup, Delhi (personal observation). *L. camara* bush located on the map is arbitrary and indicative of its expanse in urban environments. *Map-not to scale*.

More than half of the world's population live and work in an urban environment. Humans are increasingly reliant on urban nature and associated ecosystem services. Ecosystem services are closely related to land-use changes, thus ensuring their sustainable provision becomes more challenging with increasing episodes of invasions worldwide. Studies till date on prominent terrestrial plant invaders viz. *Ageratum conyzoides* L., *Calotropis procera* (Aiton) Dryand., *Chromolaena odorata* (L.) R.M. King & H. Rob., *Hyptis suaveolens* (L.) Poit., *Lantana camara* L., *Mikania micrantha* Kunth, *Parthenium hysterophorus* L., *Prosopis juliflora* (Sw.) DC., etc. and aquatic plant invaders viz. *Alternanthera philoxeroides* (Mart.) Griseb., *Eichhornia crassipes* (Mart.) Solms, *Pistia stratiotes* L., etc. highlight that these species invade and proliferate well in heterogeneous urban landscapes in addition to natural areas in India.

Not all alien species respond the same to the urban environment; some fit, colonize, naturalize, and subsequently invade, while others may fail. Of special interest, *L. camara*, known

ubiquitous invader, has established well in India across urban and natural environments. *L. camara* was introduced to India as an ornamental plant, wherein, the invader has invaded more than 13 million hectares, established itself in almost every available ecosystem and continues to expand. The species inhabits a wide range of habitats; generally, grows best in open, well-lit degraded lands, disturbed urban landscapes, pastures, edges of tropical and subtropical forests, warm temperate forests, beachfront, and forests recovering from fire or logging. It also grows well under the canopy of neighbouring invaders such as *Prosopis juliflora* (*personal observation*). Of recent, the expanse of *L. camara* reported in unfavourable shaded habitats hints towards species' expansion in newer, unoccupied habitats in urban environments[4]. The local ingress of the species in heterogeneous urban environments facilitates further dispersal from urban centres to fringe landscapes and, *vice versa* (see Box 1). There is a need for the dedicated management strategy, focusing on regular monitoring and removal of the bush, especially before seed production[3].

Interestingly, *Ricinus communis* L., a classic case of crop plant has possibly escaped the cultivation lands and is rapidly expanding its range in India[4]. *R. communis* colonizes heterogeneous urban landscapes viz. railway tracks, road verges, garbage dumps, wastelands, etc. As of now, the species exhibits boom and bust cycles, which subsequently affect species' persistence, collapse, and/or resurgence as an aggressive colonizer in contrasting urban environments. However, the species beholds immense invasion potential in future scenarios of global change. Extensive monitoring of *R. communis* colonizing populations in urban landscapes is warranted to arrest the inadvertent spillover to farther locations[3].

Despite existing detailed inventories of alien plant species, naturalizing or invading across India, information on factors and processes, facilitating their invasion ability is known for a few. Out of a total of 244 alien, introduced species, 225 plant species have been reported to be invasive in India[1]. However, invasion-related researches have focused on a few and explicitly attempted to identify the attributes and mechanisms which contribute to enlisted species' colonization and/or invasive success in newer environments. Nevertheless, other than reported 225, there are species which are increasingly becoming naturalized and/or invasive, but they receive no mention in official national inventories, for instance, *Ricinus communis*[3]. Why a few species proliferate rapidly while a few others exhibit abrupt, transient population explosions and/or declines in the introduced range also deserves dedicated research.

Despite the knowledge that alien species are abundant in urban environments, which tend to be the foci for further spread, our understanding of invasion dynamics in urban ecosystems remains limited. The recognition that human activities both cause and are affected by the ecological change brings with it an awareness of the value of urban nature and of natural systems on which cities depend. Land use in cities and towns are made to the detriment of urban green spaces. There is a need to manage these green spaces to arrest the spread of invasive species and ensure native vegetation in urban landscapes, the supply of ecosystem services, sustained human health, and well-being. Environmental stewardship in urban setups can help to deal with urban green space development and restoration through multi-stakeholder dialogue and trans-disciplinary approaches on land-use change.

Neha Goyal, Ph. D, is Assistant Professor with Sri Guru Gobind Singh College of Commerce, New Delhi, India

Gyan Prakash Sharma, Ph. D, is Assistant Professor with Department of Environmental Studies, University of Delhi, New Delhi, India and member of IUCN Commission on Ecosystem Management

[4]Global Invasive Species Database. 2015. Version 2015.1. Retrieved from URL: http://www.iucngisd.org/gisd/. Accessed 10 May 2020.

Field reflections: Yarsagumba (caterpillar fungus) complex in Pupal pasture, in Dhorpatan Hunting Reserve, Nepal

By **Sanjeev Poudel**

In 2019, as a part of the field survey to study of economics and governance mechanism of *Yarsagumba* (English: caterpillar fungus), I had visited Pupal pasture where thousands of *Yarsagumba* harvesters gathered annually. While I reached the pasture, I only met inhabitants from Maikot (a small village of eastern Rukum district Nepal)—also referred as 'Maikoti' harvesting the Yarsagumba before allowing distant harvesters (harvesters from other villages than Maikot) to collect in the Pupal. So to say, community-based management of the valuable natural resource in the high altitude pasture of Dhorpatan Hunting Reserve, the only hunting reserve of Nepal. A question might strike, why only Maikoti were allowed before other harvesters? The reason is associated with the Yarsa Festival in Pupal on 2016 Biodiversity Day.

In May 2016, coinciding with International Biodiversity Day, *Pupal Yarsa festival* was hosted by the local committee and youth club of the Maikot village. The festival had two motives: a) advertise the quality of Pupal's Yarsagumba and b) promote tourism for a sustained revenue

Entry point to Pupal Pasture. Putha Himalaya in the background © Sanjeev Poudel

flow in the region. The festival was held at 4500 metres above sea level in the base of Putha Himalaya. High profile political representatives such as the speaker of the parliament, forest minister and other key stakeholders, including media, attended the event. The event turns out to be an expensive enterprise.

This festival became a turning point to the local management committee, which adopted a new governance mechanism next year onwards, named as *Ek Ghar Ek Surakshhya* (One Home One Security) to provide an opportunity to Maikot villagers to head to pasture before allowing distant collectors.

Usually, the local management committee decides the pre-departure date of Yarsagumba collection during May normally a week or fortnight before opening the pasture to the public. The rationale of the strategy is to stop illegal pickings of *Yarsagumba*, to check the status and level of snow in the pasture before collection. After the recent elections in 2017, the local government requested the local committee to hand over the rights to govern the *Yarsagumba* collection, which they agreed, provided the local government would pay their debt incurred during the Pupal Yarsa festival, which the rural municipality refused to take responsibility. Then,

Maikoti in the Pupal pasture © Sanjeev Poudel

The *Yarsagumba* collection system has changed since *Pupal Yarsa festival* in 2016. There was no system of 'one home, one security' earlier. All collectors used to go at once in the pasture. But it's different now. Before all other distant collectors head towards the pasture, collectors of Maikot have a special privilege to go and collect *Yarsagumba* from the pasture—Former chair of Pupal Yarsa festival and President of the season management committee (May/June 2019), Maikot.

Ek Ghar Ek Surakshhya strategy was adopted by the committee of Maikot to repay the loan by collecting *Yarsagumba* through this mechanism.

While discussing with former President of the resource management committee, who is also an influencer leader of Maikot, he shared concerns regarding the jurisdiction and access rights of Dhorpatan Hunting reserve and District Forest Office, Rukum on revenue sharing from *Yarsagumba* collection. The jurisdiction of Pupal pasture lies within hunting reserve. But the *Gaun Palikas* (rural municipality) has an interest in

revenue sharing originated from Yarsagumba collection. The *Gaun Palikas* are empowered by the constitution to govern the natural resource management within their jurisdiction. Also, locals do not agree to share the revenue as they have traditional rights on the pasture since they have been doing inter-generational grazing in the pasture, which is now their established culture. These ownership and rights to revenue collection will need to be dealt with sooner as new *Gaun Palikas* are provided rights by the newly promulgated constitution 2018. At the moment, the *Gaun Palikas* have started a dialogue with the committee about this issue. However, due to jurisdiction confusion and loan that Maikoti has, they are not able to fully take over the rights to govern *Yarsagumba* collection sites.

Maikot remains outside the jurisdiction of hunting reserve; however, the pasture lies within the hunting reserve. The reserve official does not have an idea about their borderline, even though the District Forest Office wants to govern the area. After the local elections of 2017, the rural municipality has started to discuss the revenue sharing issue. The governing rights of the pasture lie with the reserve officials, not even with the rural municipality; hence they cannot claim revenue sharing. Nepal has signed Indigenous, and Tribal Peoples Convention 1989 (No.169) of International Labour Organization that states the locals living there for ages should consume three 'Ja' (Jungle (forest), Jamin (land) and Jal (water). Hence, neither hunting reserve nor District Forest Office should claim Pupal pastures under their jurisdictional rights as we have been traditionally using the land for grazing and picking *Yarsagumba*. The local committee does not agree to share the revenue from Yarsagumba as they have incurred losses from Pupal Yarsa festival. Nevertheless, we are ready to move ahead with an agreement with stakeholders—Former President of the season management committee and local influencer leader, Maikot.

The harvesters '*Maikoti*' were in the perception that the one home one security strategy has two benefits for them from the perspective of income and less anthropogenic pressure in the pasture. By allowing, *Maikoti* to harvest before distant collectors, they had the chance to pick the *Yarsagumba* with additional margin. Secondly, the perception of distant collectors is that *Maikoti* would already pick high-quality *Yarsagumba* before they reach in the pasture; hence they head to different pasture to collect the *Yarsagumba*. However, as the local government will start to govern the pasture, a revenue-sharing mechanism will be the top priority of the local season management committee.

This year, unfortunately, due to COVID-19 pandemic, the government had issued collection restrictions to avoid the possibility of community transmission among the harvesters, forcing the *Maikoti*'s to rely on the income of last year. The *Maikoti* source their major (75%) cash income from Yarsagumba collection, i.e. environmental income, which acts as a safety net to harvesters dependent on it. COVID-19 pandemic has bought time from the harvesters to conserve the *Yarsagumba* (caterpillar fungus). The year of the pandemic has provided *Maikoti* time to rethink their livelihood strategy and also sustainable management of *Yarsagumba* in the future. Some of the harvesters during the survey were wishing for rotational harvesting, and the pandemic has provided the right time and space to practice.

Sanjeev Poudel, is associated with Centre for Green Economy Development Nepal and member of IUCN Commission on Ecosystem Management

Traditional Ecological Knowledge and Biodiversity: Emerging Issues

By **Bindia Gupta**

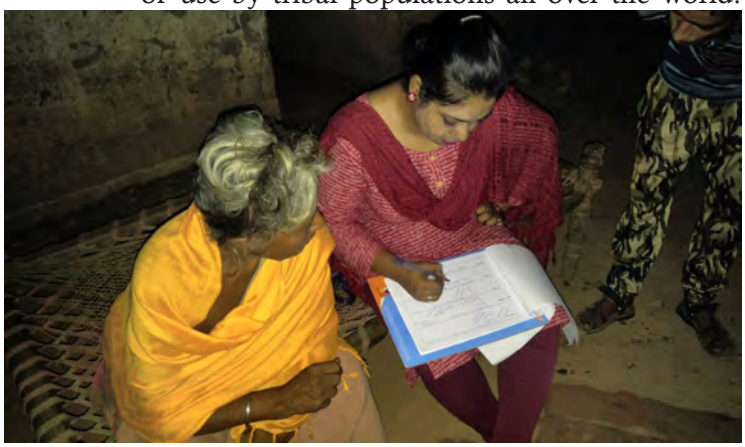
Traditional Ecological Knowledge (TEK) refers to the knowledge and practices acquired by indigenous and local communities over hundreds of years through direct interaction with the environment. It comprehends close and holistic knowledge of plants, animals, ecosystem services, the development and use of suitable technologies for hunting, agriculture, forestry etc. and environmental management. Following the guidelines laid down by the Biological Diversity Act (2002) and Rules (2004) in India, measures were taken for adequate documentation of such knowledge in the form of People's Biodiversity Registers, the participation of indigenous communities in decision-making, equal sharing of benefits and sustainable use of biological resources, as keys to the successful conservation of local biodiversity. However, there are a few relevant issues to be addressed that encompass problems and prospects related to TEK vital for the sustainability of natural resources of our planet.

Younger generations disconnected from Nature

As traditional knowledge about ecosystems is to be culturally transmitted and subsequently preserved through generations, the younger people are expected to nurture concern in the knowledge of the elders. The younger generations, at many places, in the process of modernisation, are losing interest in the protection of local biological resources, owing to lack of prospects in the utilisation of Traditional Ecological Knowledge in improving socio-economic conditions and creating promising livelihoods. Hence, in this way, TEK is rapidly disappearing from indigenous populations[1,2,3].

Less Research on Identification of "Resource Persons"

There have been lots of literature identifying the different biological species and their patterns of use by tribal populations all over the world. However, there has been less research on quantifying the TEK of the tribal individual



During an interview with the only eldest traditional healer of a Lodha village in Jhargram district, West Bengal, India.

[1]Reyes-García V et al. Evidence of traditional knowledge loss among a contemporary indigenous society, Evolution and Human Behavior. 2013. http://dx.doi.org/10.1016/j.evolhumbehav.2013.03.002
[2]Balick M. Traditional knowledge: Lessons from the past, lessons for the future. In Charles McManis (Ed.), Biodiversity & the law: Intellectual property, biotechnology & traditional knowledge. London: Earthscan. 2007. 280-296.
[3]Negi VS et al. Traditional knowledge and biodiversity conservation: a case study from Byans Valley in Kailash Sacred Landscape, India. Journal of Environmental Planning and Management.2017. 61(10), 1722-1743. doi:10.1080/09640568.2017.1371006

using suitable psychometric scales based on ethnoecological indices. Such practices of knowledge quantification will help the researchers to identify knowledgeable individuals within populations who can act as resource persons in future.

Need for Scientific Validation

TEK, which works efficiently in curing ailments, healing or solving environmental problems, is believed to have scientific reasoning. Scientists have identified bioactive compounds from several plant species and tested successfully to validate the claims of cure. Thus there is a definite necessity of widespread scientific testing of such claims to make traditional medicine an acceptable alternative for curing a large number of existing and emerging diseases.

Displacement of Indigenous Tribes from their Homes

We often come across incidences of displacement of indigenous tribes from their homelands due to developmental projects or activities. Subsequently, the precious knowledge they gained through long-term interaction with the local ecosystems lies on the verge of extinction[4]. We should remain grateful to the dedicated environmental activists and legal practitioners often associated with non-governmental organisations who come forward to assist the tribals in the fight for their lands and natural resources.

Protection of Traditional Knowledge from Biopiracy by Intellectual Property Rights

While biopiracy continues to be a threat to the endemic and indigenous species of both flora and fauna, traditional knowledge databases like India's database on traditional medicine plays a dual role where indigenous communities gain Intellectual Property rights over TEK and also attain rights to promote their knowledge, manage its uses and benefits from its commercialisation. Tribal communities are custodians of native seeds that are drought, flood, salt and pest resistant and possess nutritional properties[5]. To ensure food security, their indigenous simple preservations strategies and breeding techniques are precious. All of their practices should be protected under IPR.

Rethink "Hunting Rituals": Hunters-Turned-Naturalists

As we all witness the rapidly vanishing biodiversity and are in the middle of sixth mass extinction, the hunting rituals of indigenous populations are often being questioned. Poverty, illegal bush-meat trade and traditional Chinese medicine (condemned for no therapeutic value) sometimes drive indigenous tribals into poaching activities. It means hunting fauna in excess of what a tribal population actually needs for living. A traditional hunter has a fair knowledge of feeding, breeding and nesting territories, breeding seasons, favourable habitat conditions and behaviour of a diversity of species. With the Wildlife Protection Act (1972) banning on all kinds of hunting of scheduled animals in India, the indigenous hunters in some locations of the country are engaged as efficient naturalists in eco-tourism activities or conservationists in special task force units aimed for protecting endangered species[6]. The conversion process requires long-term teamwork from biologists, social scientists,

Heads of the Hunted. The Angami tribe of NE India gave up hunting to save forests and its wildlife.
(Photo Courtesy: Sayan Hazra; Source: BBC News)

[4]Ramirez CR. Ethnobotany and the Loss of Traditional Knowledge in the 21st Century .Ethnobotany Research & Applications. 2007. 5:245-247.
[5]McCune LM. The Protection of Indigenous Peoples' Seed Rights during Ethnobotanical Research. Ethnobiology Letters. 2018. 9(1):67–75

foresters, veterinarians and counsellors.

Call for sustainable financial incentives and collaborations and inclusion of Traditional Healers in healthcare systems

The knowledge holders irrespective of age and gender can contribute to collaborative efforts like field training of researchers, army personnel, foresters and others as well as supervise ex-situ conservation of biological resources like medicinal plants. Participation of knowledgeable locals have proved to be helpful in rearing and reintroducing orphaned and rescued animals in African countries and animal husbandry practices in India. The TEK becomes a valuable tool for individuals living in remote field stations with limited resources. The suggestion of including the traditional healers in medical research and health-care systems after a formal training also looks promising[7]. Such examples of partnership can be sustainable with long-term financial incentives from local biodiversity funds.

Linking TEK and Biodiversity Conservation

A study in south-west Bengal has revealed that the use-value of a species is positively correlated with the relative frequency of the species in wild conditions. Hence, with the rise in the essential uses of a species, there is a larger probability of that species to be conserved by the local people living in the fringes of dry forests[8].

Because TEK is highly adaptive in nature and provides practical solutions to rising environmental problems, its preservation is essential in the context of biodiversity conservation as well as combating the damaging impacts of global warming and climate change.

Bindia Gupta, is doing her Ph.D at Department of Environmental Science, University of Calcutta, Kolkata, India and member of IUCN Commission on Ecosystem Management

[6]Bolingbroke-Kent A. 'I swapped my guns into binoculars': India's hunters turn into conservation. The Guardian. 10th March 2020. https://www.theguardian.com/environment/2020/mar/10/i-swapped-my-gun-for-binoculars-indias-hunters-turn-to-conservation-aoe
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[8]Gupta B, Mishra TK. Ethnoecology of Different Plant Species in use by Tribal Communities of the Lateritic Region of West Bengal, India. Ambient Science. 2019. 06(2): 38-42. DOI:10.21276/ambi.2019.06.2.aa01

Plantation with exotics: A Green Compulsion

By **Anil Kumar**

The world has lost around 178 million ha of forest since 1990, which is an area about the size of Libya[1] and is the major cause of climate change and global warming. Various studies have shown that forest and trees through Carbon sequestration could provide relatively low cost net emission reduction. Therefore, Carbon management through woody vegetation of forests and tree plantations is one of the foremost agenda in India for the 21st century in the context of greenhouse gases effect and mitigation of global climate changes[2].

In India forestry sector, which includes natural forest and plantations is the second-largest land use after agriculture. Despite Government's ambitious UJJWALA YOGANA, most of the rural population still prefer fuelwood to meet its domestic need. About 300 million of tribal communities depend on forests for their subsistence and livelihood[3]. With four biodiversity hot spots, the country is home for several endemic species. However, overexploitation of forest resources to meet the ever-increasing demand of the society for their lively hood has led to a situation of an unbalanced environment. Dwindling forest resources, disturbed water cycle, deforestation, global warming, and climate changes are the familiar terms discussed and felt by normal human beings.

Poplar Plantation under agroforestry system
(Photo courtesy: Ramesh C. Dhiman, WIMCO Ltd.)

India's forest cover has been dwindling between 21–25% (as against 33% as per National Forest Policy, 1952) for the last thirty years or so. India is among the ten countries with the largest forest coverage in the world, currently having around

[1]FAO. 2020. Global Forest Assessment. Key Findings. 16p.
[2]Khurana, P. 2012. A study on carbon sequestration in natural forests of India. JANS 4(1): 132-136.
[3]Biswas, P. K. Forest People and Livelihood: The Need for Participatory Management. fao.org/3/XII/0586-C1

7.12 lakh sq km forest cover, of which 52,000 sq km is plantations[4].

Massive tree plantation programs were launched in India during the late 70s to increase the forest cover and arrest dependency over natural forest resources. The social objective associated with tree plantations is generally oriented explicitly towards more significant social equity, and increasing the resources and assets of the poor. Farmers were persuaded to grow fuelwood and fodder crops on their lands, community lands, village commons, along roadsides, canals, etc. A similar trend was felt worldwide where about 44% of plantation forests are composed of mainly exotic species[1] consequently, the area of naturally regenerating forests has decreased since 1990 (at a declining rate of loss), but the area of planted forests has increased by 123 million ha[5]. State governments have started massive plantation drives be it Uttar Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, etc., even Uttar Pradesh Government enters Guinness World Records for planting 22 crore saplings as part of "Vriksharopan Mahakumbh". Most of these Plantation drives are aimed at fast-growing natural and economically marketable tree species, so that tree cover of the country increased at a faster rate, and the farmers and the governments can earn monetary benefits in a short period of 7–8 years.

Women plant saplings on the outskirts of Prayagraj, UP, India
(Photo courtesy: Rajesh Kumar Singh/AP)

Exotics like Eucalyptus (*Eucalyptus tereticornis* Sm.), Poplar (*Populus deltoides* W. Bartram ex Marshall), Kikar (*Prosopis juliflora* (Sw.) DC.), *Leucaena leucocephala* (Lam.) de Wit, etc. that was planted by farmers on barren lands, agricultural bunds, roadsides, and in village commons, around many railway tracks. It also became the popular choice of governmental agencies in plantation drives. The repercussions are that in India indigenous multipurpose tree species like Mahua (*Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr.), jamun (*Syzygium cumini* (L.) Skeels), Imli (*Tamarindus indica* L.), bel (*Aegle marmelos* (L.) Corrêa), kaitha (*Limonia acidissima* L.), Jangal Jalebi (*Pithecellobium dulce* (Roxb.) Benth.), Sal (*Shorea robusta* Gaertn.), Peepal (*Ficus religiosa* L.), Bargad (*Ficus benghalensis* L.), and Chilbil (*Holoptelea integrifolia* Planch.) were ignored over various exotic species in the process.

Much of the government forests in the plains were originally Sal or mixed species that were felled in the 1960's and replaced by Eucalyptus to improve productivity. Though these monoculture plantations provide economic relief to the farmers and increase green cover at a faster growth rate, at the same time they also adversely affect the water table, soil quality, crop productivity, biodiversity, and ecological services. Their life span is short of about 7–8 years, then they are harvested for monetary benefits again leaving a void in places to regenerate, or new plantations are required. Monoculture plantations of Eucalyptus and Poplar specifically in Indo-Gangetic Plains became very popular. Poplar was promoted by WIMCO whereas Eucalyptus

[4]FSI 2019. http://www.fsi.nic.in/forest-report-2019
[5]FAO 2016. Global Forest Resources Assessment 2015. How are the World's Forests Changing?. 54p.

Eucalyptus plantation (Source: sabrangindia.in; https://bit.ly/2X0BweD)

was in demand for paper industries. This shift of choosing tree species from local to exotics, monoculture over mixed plantations has created a lot of debate on its suitability in the country.

Plantation drives organized twice every year, involving millions of tree plantations mostly with Eucalyptus and Poplar. The trend has changed a bit presently, and now both indigenous and exotic tree species are distributed for plantations. But there is random selection and distribution of species for plantations without giving any consideration of local climatic conditions and sociological implications. Besides, there is no mechanism in place that can assess the survival of these plantations, and no liability is fixed on anyone to check the survival rate of these plantations. The government and industries also encouraged the farmers to plant Eucalyptus or Poplar as it gives better economic returns in a short time. Eucalyptus being fast-growing species has been widely accepted by poor farmers as once planted, the maintenance cost is low, and the trees later provide income[6]. Eucalyptus has been planted in all the districts of the Uttar Pradesh, both by farmers as well as the Forest Department. In fact, within a short time, Eucalyptus became popular and most prominent species in the region replacing the local species grown traditionally.

As these plantations progress (aged), various conflicting observations have been made by the farmers as well as environmentalists. Foresters maintained that Eucalyptus could help to meet the increasing demands for wood- supplying local communities and industries, Environmentalists on the other, hand oppose the introduction of Eucalyptus plantations due to their perceived ecological hazards and emphasizing that Eucalyptus plantation alone cannot meet the diverse product demand for community use. Not only this, on biodiversity front Eucalyptus and Poplar again failed to provide as much ecological niche as other traditional trees provide, causing loss of birds diversity they can harbour dilute complex food chain that a mixed plantation can provide.

Various studies have been made on the effect of eucalyptus plantations on the yield of crops, especially wheat and paddy. It has been

[6]Kumar, A.,Sinha, A. K. & Singh, D. 2003. Studies of Eucalyptus Plantations under the Farm Forestry and Agroforestry systems of U.P. in Northern India. Forests,Trees and Livelihoods.13: 2003. https://doi.org/10.1080/14728028.2003.9752468

estimated that crop yield is reduced up to 15 m distance from the Eucalyptus line; however, the intensity of crop losses varied in indifferent agro-climatic regions. These yield losses are sensed only after the 3rd year of the plantations. Losses are more severe when theses plantations are maintained for more than eight years, which hardly any farmer maintains. Similarly, income generated from the sale of eucalyptus wood also varied from time to time. The involvement of middlemen in wood marketing also deprived the farmer of getting reasonable wood price. Almost similar is the case with Poplar. Since Eucalyptus is a fast-growing tree, it requires more water and nutrient to sustain their growth and thus affected the yield of the surrounding crops. The leaves are difficult to degrade as their leaves contain oil and take a longer time to decompose. Though there is no significant effect on soil nutrient quality, farmer's perception is that these plantations are affecting crop yield because they are deteriorating soil nutrient quality also absorbing more water causing fall in the groundwater table. Poplars being deciduous nature, better suited for bund of agricultural field, their leaves are easily decomposed as compared to Eucalyptus leaves. Economic returns of these plantations were also fluctuating on-demand availability basis. Under these complex conditions, farmers get confused, whether to plant eucalyptus further or to stop. On the social front, Eucalyptus or Poplar neither provide adequate shade like traditional indigenous broad-leaved trees of Mahua, mango, Jamun or Peepal under which several recreation village activities, village meetings, community programs used to be held nor it provides fruits or fodder even timber/fuelwood is not very promising, then why these exotics become so popular?.

Perhaps the answer to this is even more complex. You cannot fully ignore Eucalyptus or Poplar, as they are fast-growing trees with commercial implications. Exotic species are not always harmful; they have many benefits as well. They are easily adapted to the local environment, works as a windbreak, check soil erosion, improve the organic matter in the soil, involve in carbon sequestration, and provide fodder and timbers as well. Through careful planning and proper field selection, exotic species can be planted with locally suited indigenous species to extract maximum benefits without affecting the natural ecosystems. These patterns of plantations not only restore the glory of our traditional trees but also increase the farmer's income and restore a sustainable environment.

Anil Kumar, Ph.D, is Associate Professor and Head with Department of Botany, Feroze Gandhi College, Uttar Pradesh, India and member of IUCN Commission on Ecosystem Management

From an allergen to the carrier of COVID 19: A bizarre mystery of Populus deltoides in Kashmir

By **Peerzada Ishtiyak Ahmad* and Aatiqa Ashraf**

Poplars are principally distributed in temperate regions of the world amid few types found in tropical regions and Africa[1]. In India, poplar is a significant tree species of choice for different agroforestry systems and is grown on 317,800 hectares. Among which a large share (270,000 ha) is of *Populus deltoides* W.Bartram ex Marshall with 20–25 m^3/ha/yr growth rate in block plantations[2]. Besides six indigenous species around 13 exotic species of poplars have been introduced to India and their cultivation has been extended to the states of Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Uttarakhand, West Bengal and Bihar[3,4]. However, due to short rotation, better adaptation and yield *Populus deltoides* are considered as the most significant exotic species for commercial cultivation[3].

Populus deltoides green tunnel on Srinagar-Anantnag (Kashmir) National Highway © Peerzada Ishtiyak

Poplars in Kashmir

Although, the traditional cultivation of poplars has been practised in Kashmir since the 15th century when *Mughal* rulers introduced *Populus nigra* L. "Italica"[5] in this region. *Populus deltoides* locally called as "Rousii Phras" an Eastern cottonwood species of American origin was introduced to Kashmir during the 1980s under the World Bank aided Social Forestry Project by State Forest Department[6]. Since then this fast-growing short-rotation tree species has been extensively planted by the social forestry department, private landowners and farmers of Kashmir for immediate returns. Forest Survey of India (FSI) estimated that Kashmir has around 15.22 million trees of poplars under different diameter classes having a volume of 5.179 million cubic meters, about 90% of which is realized from *Populus deltoides* alone[7].

[1]Klasa A. and Karlen D. 2014. Poplar: publication from USDA-ARS/UNL Faculty. 1663. Retrieved from http://digitalcommons.unl.edu/usdssrsfacpub/1663.
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[3]Kumar D. and Singh N.B. 2012. Status of poplar introduction in India. Forestry Bulletin, 12 (1): 9-14.
[4]Naithani H.B. and Nautiyal S. 2012. Indian poplars with special reference to indigenous species. Forestry Bulletin, 12 (1): 1-8.
[5]Fotidar A.N. 1979. Some observations on poplars in Jammu and Kashmir state. In: Symposium on Silviculture, Management and Utilization of Poplars, Srinagar, 15-18 October 1979. Proceedings. Shimla, The Manager Government of India Press.
[6]Masoodi T.H., Khan P.A., Mugloo J.A., Wani A.A., Sofi P.A., Peerzada I.A. 2019. Proceedings of brainstorming session on poplar cultivation in Kashmir: A boon or menace. Faculty of Forestry, SKUAST Kashmir.

Populus deltoides: an ecolonomical marvel

- *P. deltoides* cultivation is significant for livelihood generation, economic prosperity and environmental stability in Kashmir[6,7]. Fruit industry with a requirement of 1 to 1.5 million fruit boxes per annum, plywood, veneer, sawmills and construction industries are principally dependent on this species[6], thus significantly reduce pressure on natural forests.
- In Kashmir, poplars and other trees growing outside forests are spread over an area of 4,76,000 ha, with 107.45 million m^3 growing stock, producing 21.13 million cft^3 of timber and 2.66 lakh tons of firewood annually[6].
- Poplar plantations are important for maintaining microclimatic conditions; help in carbon mitigation[6], phytoremediation[9], stream-bank stabilization, and as bioindicators for ozone in the environment[10].
- One-hectare poplar trees transpire about 300 gallons of water in a year; thus, 15.22 million trees have the potential to purify about 14 million gallons of water in a growing season[9].
- Balm of Gilead extracts made from fresh floral buds of *Populus deltoides* has been found effective for antiseptic and healing properties.

The mystery of Poplars in Kashmir

The main purpose of large scale cultivation of *P. deltoides* in Kashmir is timber production; hence this species is retained for extended rotation age of 18–22 years[7]. Consequently, these trees attain reproductive stage and produce a large number of seeds embedded in cottony tufts. As a natural mechanism of seed dispersal, these cottony tufts float in the air, therefore are assumed to affect people suffering from respiratory problems. This led to a vicious media campaign against the alleged ill effects of *P. deltoides* on human health[6]. Consequently, the arguments were taken to courts, where different verdicts on the issue were passed from time to time. In compliance with these court verdicts, administration chopped off thousands of poplar trees irrespective of their location, gender and age. Ironically, some district magistrates while issuing orders for removal cited *P. deltoides* as a threat for spreading COVID 19[11]. However, the Hon'ble High Court stayed its own 2015 order and asked Govt. to constitute a committee to look into the issue. Accordingly, the Government constituted a committee on April 2020 to examine all the aspects relating to "Russian" poplar trees in Kashmir.

Myth Busters

- *Populus deltoides* is locally misquoted as "Rusii-phrass—Russian poplar", it has nothing to do with Russia, it is an American cottonwood species[7].
- Poplars are dioecious, male produce pollen and after pollination females produce seeds[7] embedded in cottony tufts for dispersal by wind, therefore, female trees of the species are wrongly being associated with pollen allergies.
- Only *P. deltoides* is not releasing cottony tufts during April–June, other species like *P. alba* L. and *P. ciliata* Wall. ex Royle also produce a huge amount of cottony tufts during the same period[9].
- Cottony tufts shed by poplars are not an allergen, even though some studies suggest that they may carry pollen of other species[12]. Therefore, Pollen from other species like conifers, fruit trees, Rubinia etc. pollinating at the same time may be causative of allergy to people.

[7]Mir A., Masoodi T.H., Mir N.A., Rather T.A., Sofi P.A. 2017. Nursery performance of male clones of poplar (Populus deltoides Bartr.) under temperate conditions of Kashmir valley. British Journal of Applied Sciences & Technology, 21 (1): 1-8.
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- A report based on 'skin prick tests' compiled by Government Medicinal College Srinagar on common allergens in Kashmir has revealed that among plant pollen, common grass pollen triggered allergic reactions in 73.5% tested population, followed by 62.7% by pollen from pine species, 59.3% by pollen from Chinar (*Platanus orientalis* L.) and 18.2% by pollen from poplar trees. The report further states that house dust mite, a common insect that dwells in dust caused allergy in 92.6% tested population of Kashmir. A similar study[13] conducted in Kashmir found that pollen (54%) of *Parthenium hysterophorus* L., *Amaranthus spinosus* L. and *Cynodon dactylon* (L.) Pers. is the most common allergen followed by house dust mites (44%).
- The aeroallergens that trigger allergy vary in different geographical regions[14]. Once sensitized human can become allergic to homologous proteins of other pollens or present in food via cross-reactivity[15,16].
- The aggravating factors of allergic disorders may also be due to environmental pollution and urbanization influenced microbial load associated with pollen[17]. Pollution caused by cement factories, brick kilns, infrastructural development, and military activities like use of PAVA (Pelargonic Acid Vanillylamide also called Nonivamide) shells for crowd control and daily movement of heavy military vehicles in hundreds of convoys affects the physical environment of Kashmir[18].
- COVID 19 is an infectious disease caused by corona-virus. The disease spreads primarily from person to person through direct contact or small droplets released from the nose or mouth of an infected person while coughing, sneezing or talking. These droplets are relatively heavy, don't travel far and quickly sink to the ground. As of now, no scientific evidence is available to prove that viral disease like COVID 19 can spread through cottony tufts released by female *P. deltoides*.

Recommendations

- Have a clear policy and regulatory mechanism for managing such resources.
- Harvesting before flowering stage must be incentivized or subsidized by Government.
- Adaption of judicious pruning of branches of Poplars. Keeping the bole devoid of branches up to 50–75% of its height, right from 3rd year of planting, will reduce the number of catkins by 81%.
- Certification of registered poplar nurseries and a complete ban on unauthorized nurseries.
- Comprehensive Research and Development for genetic improvement of the species and development of less cotton-producing clones.
- Maintenance of clonal identity.
- Adaptation of short rotation coppice forestry (4–6 year cycle) particularly near inhabited areas.
- Establishment of wood-based industries in Kashmir for consumption of juvenile trees i.e. paper and pulp, plywood, food container, pallet, pharmaceutical and biomass based energy industries.

Peerzada Ishtiyak Ahmad, Ph. D. is Scientist, Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India and member of IUCN Commission on Ecosystem Management

Aatiqa Ashraf, is Former Director, Temperate Institute of Sustainable Innovations, Srinagar, Kashmir

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Biodiversity in Harmony with Livelihoods: An Option for Viable Model of Conservation and Development in Mountains of Uttarakhand

By **Pankaj Tewari**

The Himalayas are one of the global assets. Hindu Kush Himalayas (Himalayas and Hindu Kush mountains) are the source of 10 river basins where live over 1.3 billion people. Stretched over an area of more than four million square kilometres, the HKH region is a dynamic landscape endowed with a high species richness and gene pool. In the Himalayas, forest ecosystems and their surrounding communities are among the most ecologically and economically threatened. Because of that, the residents of hilly regions remained marginalised in the context of the larger development process. Communities in forest ecosystems are dependent on natural resources and biodiversity for food security and livelihoods through fuelwood, fodder, and non-timber forest products (NTFPs) collection.

Aarohi is working with around 1,385 villagers as CBOs and individuals from 182 villages in Uttarakhand, who together facilitate the Livelihood Unit of Aarohi based at Satoli, Nainital as a small enterprise under Livelihood Promotion Program (LPP). The product development from all above bioresources is taken up by a team of professionals and local communities in harmony.

Arohi has an initiative to generate supplementary options for income for mountainous communities in the form of Cold-pressed Apricot oil, extracted from the kernel (the part of the fruit which is considered as waste). The organisation is attempting to provide crop buyback to subsistence farmers. The extracted oil formed the base of an extensive body care range products such as body scrubs, creams and soaps. Alongside this, dried culinary herbs, herb teas

and local niche agro-products are also providing alternate livelihood options for the communities of Kumaun and Garhwal in Uttarakhand. Besides the use of chuyra ghee (extracted from *Diploknema butyracea* Roxb., one such under-explored and lesser-known multipurpose tree species), in manufacturing handmade soaps.

The targeted herb species are Rosemary (*Salvia rosmarinus* Schleid.), Parsley (*Petroselinum crispum* (Mill.) Fuss), Thyme (*Thymus serpyllum* L.), Mint (*Mentha arvensis* L.), Peppermint (*Mentha balsamea* Willd.), Sage (*Salvia officinalis* L.), Basil (*Ocimum basilicum* L.), Oregano (*Origanum vulgare* L.), Marjoram (*Origanum majorana* L.), Lemon Balm (*Melissa officinalis* L.), Caraway (*Carum carvi* L.), etc. An additional annual income of INR 15 lakhs is generated for ~1,300

households only through procurement and processing of apricot seeds, nuts and culinary herbs by Aarohi's Livelihood unit. On average,

there is an increase of INR 2,500 in the annual income of the beneficiaries on an individual basis, for the last four years. ~6.17 quintals of apricot seeds were processed to extract apricot oil and scrub, and a total of ~3.86 quintals of culinary herbs were cultivated, processed and marketed during 2019–20. The average annual revenue generated by Aarohi's Livelihood unit through the aforesaid activities is approx. INR 49.45 lakhs. Around 18 local community members (25% females) are continuously employed at this unit since the last 10–25 years round the year.

To meet the requirement and supplement biodiversity, Aarohi is following the approaches for cultivation, sustainable harvesting, and protection against existing threats through livelihood enhancement of local communities in the Indian Himalayan region. As a result, the organisation is involved in the plantation of around 1,400 Apricot and Peach seedlings in last three years with an average survival rate of ~75% and ~2.5 ha area is under herb cultivation. Aarohi endeavours to create awareness for the sustainable harvesting of the aforesaid and other herbs found in the region, skill development and capacity building of the subsistence farmers and strengthening indigenous techniques of cultivation through promoting cost-effective and appropriate climate-resilient rural technologies.

The practices such as collection, production, management, and marketing have changed significantly in the region after Aarohi's initiatives. The concept of utilising the barren and fallow land for agrobiodiversity conservation is the focus area inclusive of organic farming, cultivation of niche traditional millets and pulses, spices, herbs, etc. along with efficient supply chain that is well established and this need to be replicated as a micro-enterprise to ensure both (i) conservation and management of land and bioresources, and (ii) creating livelihoods and providing employment to producers, collectors, skilled people involved in value addition and marketing.

The aim of this case was to assess the impact of Aarohi's initiatives concerning the promotion of bio-resource based livelihood options in Central Himalayas. The locally available and commercially valuable natural resources, including NTFPs, herbs and agro-based products have a huge potential to improve the livelihoods of the mountain communities and biodiversity conservation as well and have immense scope to maintain the ecosystems as well as in reducing the stress migration which is in support of the previous studies conducted in other Himalayan regions[1-3]. This study also provides essential insights for mountain development practitioners and policy-makers concerning livelihood improvement and poverty reduction for communities that depend on available natural resources for livelihoods. There is a need to develop a framework in terms of conservation and sustainable development, particularly for the Indian Himalayan region; however, future initiatives aiming at the commercialisation of bioresources must need to take an integrated approach of skill development in production, processing, marketing, and value chain development.

Pankaj Tewari, Ph. D, is Executive Director of Arohi, Nainital, India and member of IUCN Commission on Ecosystem Management

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Exploring Bhimbetka rock shelters from an ecological perspective: A World Heritage Site

By **Tarun Kumar Thakur and Joystu Dutta**

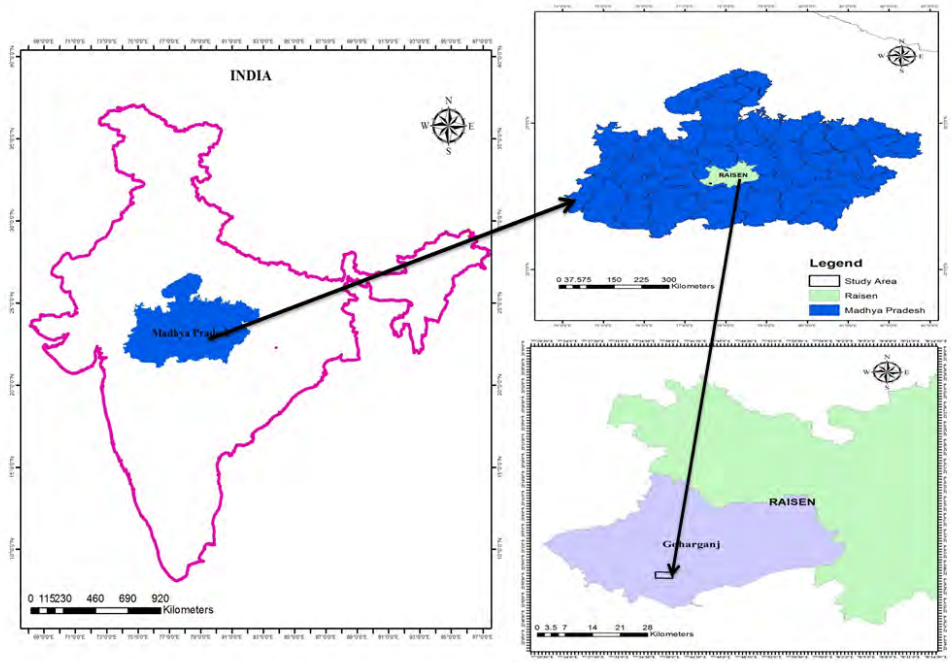
The Bhimbetka rock shelters are located in the Raisen district of Madhya Pradesh, India; within the Ratapani Wildlife Sanctuary. They are surrounded with sandstone rocks, in the foothills of the Vindhya Range. Ratapani Wildlife Sanctuary has recently been declared by National Tiger Conservation Authority (NTCA) as a Tiger reserve. It has a population of ca. 40 tigers, with an additional 12 individuals on the move. The area is of about 3500 sq.kms of Raisen, Sehore and Bhopal districts. The core area is about 15000 km^2, with a buffer zone of 2000 km^2. This area being a transition zone made by Vindhya and Satpura hill ranges becomes ecologically significant. The site has been home to varied flora and fauna. The rock shelters of Bhimbetka display charismatic socio-cultural significance through exquisite rock paintings and is established in global historical map. Here we make a quick roundup on the ecological significance, a lesser explored aspect of Bhimbetka apart from its' globally renowned historical splendour.

The main forest types of Bhimbetka comprises of dry deciduous tropical forests (Southern tropical dry deciduous Teak forest (5 A/C_{1b}), Northern tropical dry peninsular deciduous Sal forest (5 B/C_{1c}), Northern tropical mixed deciduous Sal forest (5 B/C_2), Dry bamboo brakes (5/E9) (the classification follows Champion and Seth[1]) These are comparable to moist deciduous forests which shed their leaves in dry season. The major difference is that the species of dry deciduous forests can grow in areas of moderate precipitation ranges from 90–140 cm per year. The dominant species of the region include *Tectona grandis* L.f., *Madhuca indica* J.F.Gmel., *Boswellia serrata* Roxb. ex Colebr., *Buchanania*

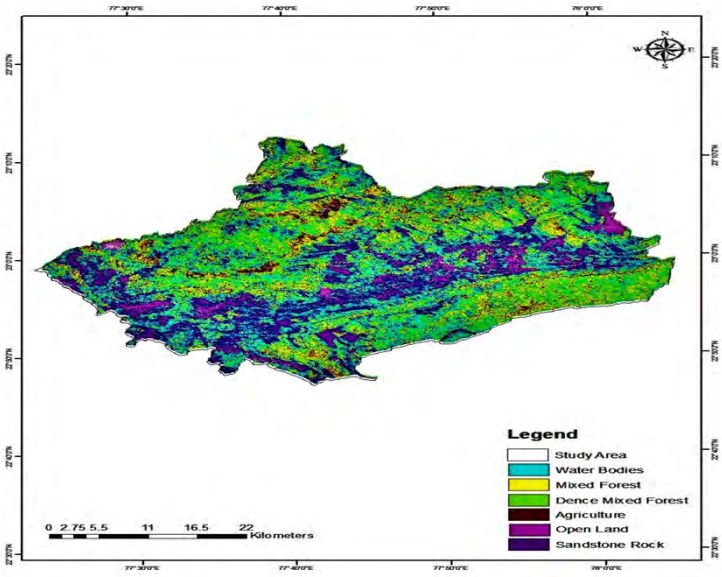
Bhimbetka Rock Shelters: A World Heritage Site (Photo courtesy: Sandeep Rathore)

[1]Champion, H.G. and Seth, S.K. (1968) A Revised Forest Types of India. Manager of Publications, Government of India, Delhi.

lanzan Spreng., *Lagerstroemia parviflora* Roxb., *Phyllanthus emblica* L., *Diospyros melanoxylon* Roxb., *Dalbergia latifolia* Roxb. etc. In open forests *Butea monosperma* (Lam.) Taub., *Lagerstroemia lanceolata* Wall., *Cleistanthus* sp., *Bauhinia* sp., etc. were observed. Shrubs such as *Grewia* sp., *Ziziphus mauritiana* Lamk., *Casearia* sp., *Prosopis* sp., *Capparis* sp., *Woodfordia* sp., *Phyllanthus* sp., *Carissa* sp., *Justicia adhatoda* L., *Carissa carandas* L., *Grewia hirsuta* Vahl, *Holarrhena pubescens* Wall. ex G.Don, *Lantana camara* L., *Nyctanthes arbor-tristis* L., *Zizyphus* sp., *Phoenix acaulis* Roxb., etc. were observed in the site. *Dendrocalamus strictus* (Roxb.) Nees is the most predominant bamboo species, while *Bambusa bambos* (L.) Voss also occasionally occur in these forests. The important herbaceous species include *Achyranthes aspera* L., *Aristida funiculata* Trin. & Rupr., *Euphorbia hirta* L., *Cynodon dactylon* (L.) Pers., *Cyperus rotundus* L., *Mimosa pudica* L., *Tephrosia purpurea* (L.) Pers. and *Tridax procumbens* L. The important faunal species observed during our study period include Indian bison, spotted deer, sambhars and birds (sparrows, crows, peacocks, pigeons, ducks, jungle fowls, etc.) and reptiles (like cobras, kraits, vipers, etc.). and a large number amphibians like toads, frogs and salamanders are also occur in these forests. Primary consumers are sambhar, rabbit, hare, spotted deer, Indian bison, cheetal, langur, rhesus monkey, porcupine, antelope, while secondary consumers include leopard, hyena, fox wild bear etc. (secondary information about animals were collected from forest department).



The LULC classified map of Raisen district showed that the sandstone rock occupies a dominant portion of the landscape followed by open land, dense mixed forest, mixed forest, water bodies and agricultural areas. With increase in anthropogenic stress factors, recent years have seen rampant decrease in forest areas. Increase in agriculture with habitation in and around the rock shelters is responsible for forest exploitation. Open grasslands are majorly exploited due to uncontrolled grazing of stray bovines. Invasive species is a stress factor too.



LULC classified map of Raisen district

Bhimbetka Rock Shelters stands at the

crossroads of historical and ecological significance. Though, the cultural heritage and historical significance of Bhimbetka is admired by connoisseurs globally, ecological values of the rock site seems to be a forgotten aspect. The natural bounties of the historical landscapes calls for urgent conservation measures from concerned authorities of Madhya Pradesh Forest Department including a faunal and floristic survey. It is the time we carry management of a particular site of significance from a holistic perspective highlighting both socio-cultural as well as environmental values.

Tarun Kumar Thakur, Ph. D, is Professor with Department of Environmental Science, IGNTU Amarkantak, Madhya Pradesh, India and member of IUCN Commission on Ecosystem Management

Joystu Dutta, Ph. D, is Assistant Professor with Department of Environmental Science, Sant Gahira Guru University, Chhattisgarh, India and member of IUCN Commission on Ecosystem Management

White-bellied Heron new habitat inventory

By **RSPN**

Punatsangchu and Mangdechhu river basins and their tributaries are the two confirmed habitats of the critically endangered White-bellied Heron (*Ardea insignis* Hume) in Bhutan. According to WBH International meeting 2015, there were occurrence records of White-bellied Heron (WBH) in Chowki, in Indian side bordering to Deorichhu and adjacent areas as recent as 2011. Although the regions towards the Indian side is highly disturbed today, the stretch of the river towards Bhutan remains intact and unexplored.

At times, it found crucial to prioritize and conduct habitat inventory in new and potential areas to understand the habitat preferences with increasing threats and disturbances in the existing habitats. Royal Society for Protection of Nature (RSPN) in 2016 conducted a brief inventory along the upper catchment of Deorichhu and found the area suitable, although no herons were sighted. Considering the high probability of WBH presence in the area, and the past occurrence records in adjacent sites, RSPN in collaboration with Samdrup Jongkhar Territorial Forest Division conducted another rapid habitat inventory along Khalatsho and Deorichhu basin from March 4–10, 2020.

The team surveyed more than 6 kilometres along Khalatshochhu, and 18 kilometres along Deorichhu catchment. Alth-ough no WBH sighted during the survey, significant evidence; droppings, track marks, footprints resembling White-bellied Heron were encountered. The topography, vegetation and river flow were also very similar to most of currently occupied WBH habitats, and the area was found still intact and less disturbed, at least in Bhutan side. The team also recorded commonly associated species like little egret, little cormorant and other water birds in the area. Although no detailed assessment was done during the survey, past assessment by STFD found a healthy thriving fish population in the river.


White-bellied Heron © RSPN

Deorichhu has high potential to harbour WBH, and there was also information on sighting of WBH along Deorichhu in the border areas with Assam, India in the past. Comparatively, the Deorichhu basin was found more suitable for WBH to Khalathso River, which has more deep gorges and narrow valleys.

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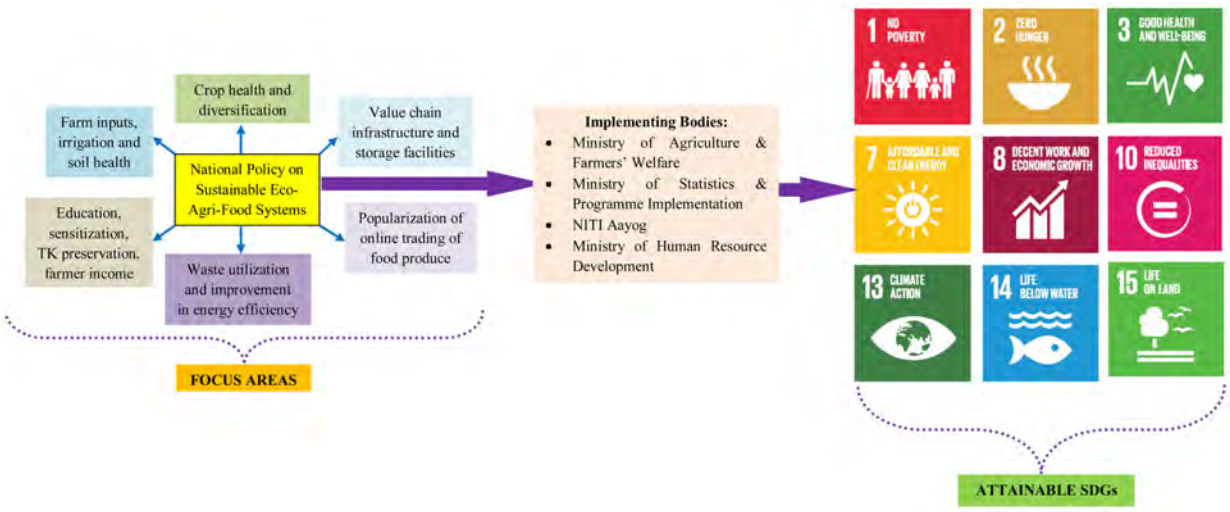
Policy recommendations for enabling transition towards sustainable agriculture in India

By **Priya Priyadarshini and P. C. Abhilash**

Aligning existing agricultural polices with UN-Sustainable Development Goals is imperative for the transition towards a cleaner and planet friendly food production, especially for a geographically and demographically diverse country like India. In this context, a study focusing on ascertaining the major social and environmental challenges affecting agriculture in India, while evaluating the potential of efficient policy restructure in boosting growth within this sector was undertaken. The methodology incorporates a quantitative assessment of social, ecological and economic indicators of agricultural sustainability in India, coupled with a co-relation analysis between several nutrition and land-based indicators for leading agriculture states across the country. The results highlight that despite attaining sufficiency in terms of food production, access to food by all in the country remains a major challenge along with incoherence between certain Sustainable Development Goals (SDGs) indicators and their corresponding data values. Furthermore, a critical analysis of operational as well as recommended agriculture and farmer welfare policies indicate that formulation of an overarching policy influencing sustainable management of agricultural systems, combined with proper implementation of social welfare schemes, would lead to the timely realisation of SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 3 (good health and well-being) in India.



Schematic representation of an umbrella policy (National Policy on Sustainable Eco-Agri-Food Systems) proposed by authors for transition towards a sustainable agricultural value chain in India.

Consequently, an umbrella policy (National Policy on Eco-Agri-Food Systems) has been proposed by authors for sustainable management of the country's entire agricultural value chain. Recommendations related to agricultural waste management and adoption of planetary healthy diets have also been suggested for enabling the smooth transition of agriculture as a sustainable enterprise in India.

Priya Priyadarshini, is Research Scholar with Institute of Environment & Sustainable Development, Banaras Hindu University, India

Abhilash P. C., Ph. D. is Assistant Professor with Institute of Environment & Sustainable Development. Banaras Hindu University, India and Chair Agroecosystem Specialist Group, IUCN-Commission on Ecosystem Management

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Land-Use Transformation from Muck to Eco-Park: An Initiative of Tata Steel to align with COP14 UNCCD Delhi Declaration

By **Hishmi Jamil Husain**

Tata Steel operations constantly address environmental sustainability, and its developmental activities have focused on improving the green cover in the area and better water management. In recognition of this fact, Tata Steel has always adopted effective measures in improving its processes, invested in break-through technology and developed products and services that diminish negative consequences in the environmental performance of the product cycle. In line with its environmental responsibility, Tata Steel has rehabilitated Jugsalai Muck Dump (JMD), Jamshedpur, an artificial mound of coal cinders, spread loosely packed over an area of 2,50,000 sq m. to an environmentally acceptable state. The dump is approx. 133–180 m above MSL, having varied slopes, terraces. The dumping has yielded a high level of undulation, and the site is devoid of organic matters sustainable for vegetative growth. This dump has posed environmental, safety and health hazards to the people of Jamshedpur.

The overall objective of the eco-restoration was to convert the Jugsalai Muck Dump (JMD) into a landscape that is safe, sustainable and compatible with any other natural hillocks in the vicinity of Jamshedpur. Other objectives were to check the possible atmospheric pollution due to mixing of fine dust particles in the atmosphere during summer and developing effective drainage system in the Muck Dump area for harvesting rainwater and store in a lined water reservoir to prevent the leaching of the coal cinder into the natural groundwater aquifers.

The Jugsalai Muck Dump was formed over the years by dumping of cinder and slag mainly consisting of iron & coal residues from the steel plant and power plant generated from Tata Steel Plant at Jamshedpur. The composition of the dump is predominantly 64.24% of sand content and 35.76% of silt content. The above characteristics reveal that the site is devoid of any organic matter and therefore, cannot support any sustainable biological growth in normal conditions.

Due to sandy soil texture, there was a high probability of ash and cinder being washed off from the dump slope into nearby water bodies during heavy rains. Fire hazard was also anticipated as the dump was formed with the stacking of ash and cinders of unburnt coal which when exposed to air could result in

JMD before rehabilitation on April 2004

JMD after rehabilitation on October 2018

Rehabilitated Jugsalai Muck Dump © H. J. Husain

spontaneous combustion, especially in the peak summer. This posed severe health and safety hazards, especially for those who engaged in illegal collection of unburnt coal particles from the dump. The temperature of the majority of the dump area due to the burning of the half-burned coal was around 50–70oC, which was a huge challenge for growing plants.

Considering the soil conditions and characteristics of the JMD, a comprehensive rehabilitation plan has been implemented for slope stabilization and vegetative growth for biological reclamation of the muck dump.

To have a sustainable green cover, a soil texture was created to enhance water retention, provide better aeration, improve physical and biological conditions of soil, and promote the development of root system which also gave strength to dump soil stabilization. Ameliorated conditions cannot be achieved by simple conventional means of good earth and manure. For this, a growing media in the slurry form of minimum 5 cm thickness, with a ratio of neo-peat (50%), topsoil (30%) and manure with micronutrients (20%) before and after laying of the geotextile coir mat was adopted which was followed by plantation of grass and shrubs.

The whole objective was to create environmentally safe and sustainable 'Green Cover' and suitable 'Geo Green Blanketing' to protect side slopes, prevent soil erosion and resulted dust generation while adding aesthetic value to the Steel City of Jamshedpur has achieved only through the concept of a sustainable environment-friendly methodology for eco-restoration of the Jugsalai Muck Dump area for biological reclamation with vegetative plantation.

JMD is helping in achieving the objective of UNCCD to achieve Land Degradation Neutrality by arresting the soil erosion. Solar

Water Body to contain Rain Water © H. J. Husain

Energy is also being harnessed at the Park for irrigation and lighting. JMD is now developed as an eco-park and has enhanced the biodiversity in the area, minimizing the environmental impact of a dump area.

Hishmi Jamil Husain, Ph. D, is Head, Biodiversity with Tata Steel Limited, Jamshedpur, India and member of IUCN Commission on Ecosystem Management

Reclaiming Spaces: Lockdown Lessons in Human-Animal Coexistence

By **Samir Kumar Sinha**

Around the globe, the news is flooded with stories of wild animals reclaiming space, mainly in and around cities, as a result of the lockdown and human confinement precipitated by the Covid-19 pandemic. The *Washington Post* reported on 15th April 2020 that, "As humans stay indoors, wild animals take back what was once theirs". The story chronicles how wild boars are roaming the streets of Barcelona, Spain, mountain goats are doing the same in Wales, UK, and Brazilian beaches have witnessed record numbers of hawksbill sea turtle hatchlings on deserted beaches. Similarly, Indian media has highlighted the spotting of nilgai, sambar, spotted deer, small Indian civet, leopards, and elephants on city roads. The coronavirus lockdown in India has also been perceived as a blessing in disguise for the Ganges river dolphin which have been spotted in several places due to a drastic reduction in river pollution.

Undoubtedly, the lockdown has made our air cleaner and river water clearer. It is the tranquil ambience and clean environment that has changed the behaviour of wild animals. Previously hesitant to explore spaces humans occupy, animals are now coming back to these places that were colonised from them decades or even centuries ago. In these altered spaces, until now, most humans had not seen wild animals; they were strangers to them. The result was wild species lost in the mists of time in urban and semi-urban areas. Fortunately, the patches of a natural environment that humans have created, in the shape of gardens, orchards, ponds, garbage dumps, or farms, provide animals with suboptimal refuge. Many generalist species that could adapt to these suboptimal spaces have modified their behaviour and survived alongside human beings.

Human dominated landscapes support a variety of animal species—birds being the most common. Snakes and small mammals like jackals, mongooses, squirrels, bats, macaques are all common to urban areas, though the diversity around rural areas is greater. Agricultural, horticultural, and fallow areas provide enough food and cover to many species of rodents, like porcupines and rats, as also hares, jungle cats, jackals, foxes, hyenas etc. Wild pigs, nilgais, and macaques thrive in many parts of rural India.

Sarus crane and people using the same wetland © Samir

Wildlife sanctuaries and forests are the true storehouses of wild fauna, including predators like leopard and tigers, and large-bodied animals such as elephants, though they too show up in cities and villages on occasion.

By and large wild animals were not frequently detected in cities and towns before the forced silence generated by the spread of COVID–19. The key reason we are seeing more of

them reclaiming human spaces is that animals are withdrawing the avoidance response to human beings. The response compels them to avoid human presence either by living away (spatial avoidance) or by staying away at certain times (temporal avoidance). These are risk minimising strategies of animals which let them coexist with humans. These adaptive strategies allow them to reduce the threat of predation or the risk of being in conflict with humans. A 2018 study, by Kaitlyn M. Gaynor and associates published in the journal *Science* refers to humans as the diurnal apex "super-predator", driving animals to temporal avoidance. Based on the observations on 62 mammal species, the study established a strong effect humans have on the daily patterns and activities of wildlife.

For instance, human disturbance causes an increase in nocturnality of animals; this is highest in urban areas. Wild animals living close to human beings change their behaviour patterns and become more active at night, in order to maintain a safe distance from people.

The COVID-19 pandemic has drastically curtailed anthropogenic disturbance, creating much silence for animals in and around cities. This has allowed them to explore new spaces and look for resources for their survival, such as food, water, breeding sites, and protection. This has resulted in the sighting of more birds and mammals in cities. At the same time, people now have more time to observe their surroundings, which has also contributed to increased animal sightings. People of all age groups seem to be enjoying the viewings or news of the presence of wild animals in their vicinity. This reaction is positive and a must for the continued coexistence between humans and wildlife.

The silence and low disturbance levels in the countryside, especially adjoining wildlife-rich areas, has created a different situation. Cases of wild animals like leopards, elephants, and bears coming out to human-occupied areas have increased. These animals often venture into areas of human habitation in search of food, but now, with very little activity on, they are increasingly being noticed. As per media reports, the wild animal-human conflict has gone up in Central India in April 2020. In Bihar's Valmiki Tiger Reserve, authorities rescued four leopards sheltering in houses in villages close to the forest. One leopard from the same area travelled over 250 km along the river Gandak and was captured successfully. These are cases where the tranquillity has caused negative interactions between human and wildlife.

The key questions we must now ask are: How permanent are these events? Is it really going to help wildlife in the long-run? Clearly, the events are not going to be long-lasting, due to one obvious fact, that the situation will get back to square one once the ongoing crisis is over. And most importantly, animals will not find resources, especially in urban areas, to sustain their needs. For example: if a nilgai comes to Noida from the adjoining Yamuna floodplain, what will it eat in the concrete jungle? Ultimately it will have to go back.

There is another matter to consider. Wildlife sanctuaries and forest areas will also bear the brunt of the pandemic-driven economic slowdown. With the increased loss of jobs, particularly among poor and vulnerable communities, people will turn to illegal extraction of forest resources to counter their livelihood challenges. This is sure to have a major impact on the quality of wildlife habitats and forest managers foresee a challenging situation.

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Samir Kumar Sinha, Ph. D, Head – Species Recovery and Protected Area Recovery at Wildlife Trust of India, Uttar Pradesh, India and member of IUCN Commission on Ecosystem Management

Member Event Note

Rural Transformation through Science & Technology Intervention will make India Prosperous

By **Ranbeer S. Rawal, Indra D. Bhatt* and Vikram S. Negi**

The 107th Indian Science Congress (3–7 January 2020), organised at the University of Agricultural Sciences, Bangalore under the aegis of Indian Science Congress Association (ISCA), aimed to advance the role of Science & Technology in Rural Development. Shri Narendra Modi, Hon'ble Prime Minister of India, while inaugurating the Congress stressed on the need to revolutionise the landscape of Indian Science Technology and innovations. He mentioned that the growth of India much depends on progress in Science and Technology. While giving the motto of ''Innovate, Patent, Produce and Prosper'' he hoped the new generation of scientists and technocrats would lead rural India towards prosperity. Prime Minister Modi launched the I-STEM portal (Indian Science, Technology and Engineering Facilities Map) that will help the researchers to find specific facilities required for their Research & Development work. Dr Harsh Vardhan, Minister of Science & Technology, Govt. of India, spoke on the progress of Indian Science in relation to the world. He was of the opinion that academic and lab facilities must be further strengthened for Science and society to flourish and bring innovations. Shri B.S. Yediyurappa, Hon'ble Chief Minister, Government of Karnataka mentioned that the Karnataka state is the first state to establish Science and Technology Council to cater to the needs of the rural farming community. Prof. K.S. Rangappa, General President of ISCA, informed about the progression of Indian Science Congress. Among major events of 107th ISC, Children Science Congress - 2020 and Women Science congress 2020 was of special attraction. In the Valedictory session of ISC-2020, Shri M. Venkaiah Naidu, Hon'ble Vice-President of India, presented different awards. In his valedictory speech, he emphasised on the need for technology from the lab to land so as to benefit the larger society.

The congress was attended by over 15,000 delegates/ participants ranging from including students to academicians, young researchers to domain experts, farmers to policymakers. Among others, two Nobel Laureates also attended the Science Congress. Besides four public lectures and 26 plenary sessions, a total of 14 thematic sessions remain a major attraction.

Environmental Sciences, was one of the major session, wherein a total of 227 papers presented. The Sectional President of the Environmental Sciences, Dr. Ranbeer Singh Rawal, Director, G.B. Pant National Institute of Himalayan Environment (GBP-NIHE), Uttarakhand while delivering a presidential lecture on 'Integrating Science & Technology in Rural Transformation', he mentioned that India with a large population and rapid urbanisation is blamed as a major contributor for the urban explosion in Asia, thereby affecting Asian Development in 21st century. This calls for rural transformation across the country through Science & Technology innovation and interventions in most prominent sector of rural employment (i.e. agriculture) and bringing alternative opportunities of livelihoods through non-farm activities. He was of the opinion that opportunities of rural transformation through S&T intervention are immense one

needs to identify appropriate interventions by way of contextualising them to specificities and needs at different locations, and making efforts for engaging people. Dr Hitendra Padalia, IIRS, ISRO, Dehradun in his Platinum Jubilee Lecture on 'Novel satellite remote sensing techniques for the understanding forest carbon cycle, focused on global efforts to balance carbon cycle, and the role of IIRS-ISRO to measure the spatial distribution of forest biomass carbon in India. A keynote address delivered online by Prof. Rattan Lal, The Ohio State University, Columbus, USA on 'Advancing sustainable development goals by restoring soil health of India's agroecosystems', emphasised on the need for a paradigm shift in managing soil of agriculture systems so that human demands can be met while restoring the environment. He further stressed on soil management to make the part of Sustainable Development Goals and underlined the fact that restoration of soil and ecosystems is essential for a proper society.

The proceeding of the Environmental Science section further progressed with various invited talk, oral and poster presentation covering diverse aspects of environmental Science under two different symposia. Dr M.G. Tewari, the senior-most past sectional president present during the session chaired the inaugural session and informed the house that the Environmental Science section had got wide popularity among the researchers and scientists over last 18 years of its existence. He highlighted that the number of taxonomist in most of the universities and institutes declining, and this posses the challenge for research in environmental sciences. Sectional Secretary, Dr K.T. Prasanna, Professor & University Head, Dept. of Forestry and Environmental Science, GKVK Bangalore, indicated that the Science and Technology should go hand to hand for development and find solutions of burning issues of society. The young scientist presentation focused on 'Bioherbicidal optimisation studies on fungal enzymes for water hyacinth control'.

Day two (5.1.2020), two parallel symposia, i.e., (i) Balancing environmental conservation and sustainable development in India, and (ii) Promoting Environmental Consciousness in developing India' were organised. Oral presentation covering diverse areas, ranging from the potential of satellite remote sensing in monitoring plant diversity to livelihood enhancement and biodiversity conservation through promoting the cultivation of medicinal plants in rural areas; modern approaches on vegetation/faunal assessment to eco-friendly technologies. These presentations besides the context highlighted (i) the need to standardise the approaches for threat assessment and sustainable use of biodiversity, (ii) promote field-based research that has relevance to society (iii) research problems must be aligned with SDGs and Aichi Biodiversity Targets, etc. A special session was organised for the 'Best Poster Award' presentation on the second-day session (5.1.2020). A total of six researchers presented their research work for the award.

Proceeding of the third day (6.1.2020) continued with two parallel sessions on the same themes. Among others, the problem of water recharge and invasion over the years in rural and remote villages of Himachal Pradesh; the importance of exploring prospect for delineation

of field margin vegetation using RS and GIS; carbon dioxide fluxes from the temperate mountainous ecosystem of Nilgiris and their implications on global warming remained a major attraction. A parallel session on poster presentation (second and third day) yielded a poster by a total of 108 researchers from different university and institutes of India. Overall a total of 94 oral presentations and 173 posters were presented in the session. While analysing these presentations by subject focus, the maximum number of oral presentations were made under environmental science general (40), followed by metal science (11), biodiversity (9), chemical ecology and ecology (8 each), microbiology (6), GIS (5) and waste management (3). Under poster category also dominance of general environment science (82) was prevalent followed by ecology (23), heavy metal studies (20), biodiversity (7), soil science (6), GIS/remote sensing (4), and chemical ecology (3).

A total of 146 organisations representing 27 states of India and 03 foreign countries (i.e. USA, South Africa and China) participated in the Environmental Science section. During the concluding session, the following recommendations were drawn for improving and strengthening research in Environmental Science in India:

- India is facing an acute problem of land degradation, including deteriorating soil health of agroecosystem; this call for urgent attention towards restoring the degraded land, especially the soil health of agriculture landscapes, in mission mode and effective science & technology-based interventions.
- The rapid urbanisation in the country is causing various environmental problems, including land abandonments in the rural landscape and related ecological and economic consequences. Therefore, greater attention is required to transform predominantly rural landscape such as the Indian Himalaya, with implementing the concept of 'smart villages' with effective use of science & technology.
- Various R&D based agencies have developed and demonstrated pilot level success towards addressing issues of environmental deterioration in the country (i.e., air and water pollution, degradation of land, contamination of food, etc.). However, achieving scale remains an issue for all these success stories. This requires a concerted effort for scaling up all such pilots to benefit masses and bring impact on the ground.
- Despite the availability of advance technology and know-how, the benefits of space technology are yet to be realised fully. Therefore, more intensive use of available space-based technology in assessment and monitoring of natural resources, designing and planning developmental projects, implementation and monitoring of the success of programmes, etc. needs to be promoted across the country. This would require developing adequate skilled manpower.

Ranbeer S. Rawal, Ph. D, is the Director, GBPNIHESD, Uttarakhand, India

Indra D. Bhatt, Ph. D, is the Centre Head, Centre for Biodiversity Conservation and Management (CBCM), GBPNIHESD, Uttarakhand, India and member of IUCN Commission on Ecosystem Management

Vikram S. Negi, Ph. D, is Scientist at GBPNIHESD, Uttarakhand, India

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