# ZOO'S PRINT

## Communicating science for conservation

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# The Ram Hattikudur Advanced Training in Conservation 2025–26 Special Issue

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# RHATC 2025–26 Special Issue



**Lesser Florican *Sypheotides indicus* male in a lush grassland. A water colour reproduction of a photo by P.M. Laad, inspired by Bhagyashri Patwardhan's artwork. Sketch by Shreya Yadav & Srijita Pal and water colours by G. Pannagasri.**

# Ecological Restoration Insights: RHATC Field Trip to Ooty and the Nilgiris Shola-Grasslands with Upstream Ecology

## Introduction

On 3 November 2025, RHATC Fellows embarked on a four-day field trip to Ooty. Since the theme for RHATC this year is ecological restoration, the main aim was to understand the challenges of restoring degraded landscapes in the Nilgiris. One of the characteristic ecosystem type in the Nilgiris are the Shola-grassland mosaics, which are home to many endemic species such as the Nilgiri Tahr, Nilgiri Marten, Nilgiri Salea, plants like Kurinjis, and many other native flora and fauna.

Before the trip, we had attended a session on the different Nilgiri ecosystems by Godwin Vasanth Bosco from Upstream Ecology, an organization based in Ooty, and he explained the characteristic biodiversity of the Nilgiris, the ecological importance of shola-grasslands, the threats they face, and how to restore them. He talked about how unique the shola-grassland ecosystem is and how the grasslands act like biological glaciers by trapping and slowly releasing huge amounts of water, providing a perennial source of water and preventing soil erosion. However, now with human interference in these areas, the once common Shola-grasslands are disappearing as a huge part of the landscape has undergone land use change. Both the forest and grasslands have been replaced by tea and timber plantations, resulting in fragmentation which threatens the biodiversity of this region. Other threats include dam constructions, invasive species, and human-wildlife conflict. The grasslands are the most neglected areas and are in urgent need of restoration, especially as they are reliable carbon sinks, important for mitigation of climate change and are also the habitat and food source for several endemic species, such as the Nilgiri Tahr, and are culturally important for indigenous communities such as the Todas.

## Nursery visit at Upstream Ecology

Upstream Ecology nursery situated in Ooty was set up 12 years ago with the aim of growing plants native to the high altitude Nilgiris region. We started exploring the nursery by walking around, observing and taking

Godwin Vasanth Bosco explaining about *Tripogon bromoides*. © Sanjay Molur.

© Nishigandha

*Cyathea nilgirensis*
Tree fern

© Nishigandha

*Rhododendron arboreum* var. *nilgirica*

© K Gokul

*Psuedoxytenanthera monadelpha*
Shola Dwarf bamboo

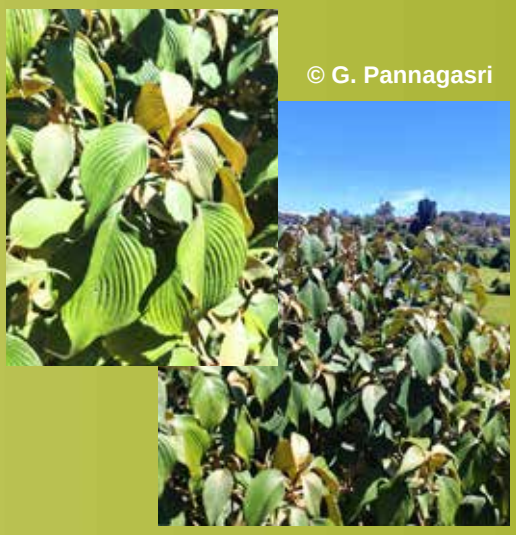
© Srijita Pal

© Nishigandha

*Strobilanthes lanata*
Golden kurinji

© Sanjana Vadakke Kurupath

*S. kunthiana*
Neelakurinji



© G. Pannagasri

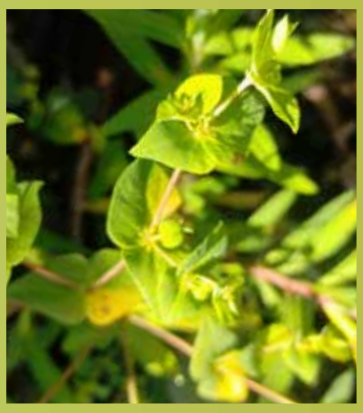
*S. cuspidatus*
Silver kurinji

© Sanjana Vadakke Kurupath

© Nishigandha

*S. lawsonii*
Copper kurinji

© Nishigandha



*Euphorbia platyphyllos*

© Sanjana Vadakke Kurupath

*Impatiens cuspidata*
Balsam

© Nishigandha

Epiphytes
Orchid and Lichens

© Nishigandha

*Mohonia leschenaultii*

© G. Pannagasri

*Rubus ellipticus*
Golden Himalayn Raspberry

© G. Pannagasri

*Rubus niveus*
Mysore Raspberry

© G. Pannagasri

*Sisyrinchium* sp.

© Yadav Shreya

*Bidens pilosa*
Black Jack

© G. Pannagasri

*Calceolaria* sp.
Slipper flower

pictures of invertebrates, plants, flowers, frogs and other elements. There were approximately 95 floral species in the nursery, most of which belonged to the Shola-grassland ecosystem. The office had a huge bush of Golden Kurinji *Strobilanthes lanata*, which gleamed beautifully in the morning sunlight. It is a point-endemic species which blooms once in nine years.

There are currently 28 species of kurinjis found in the Western Ghats and most of them have a similar periodic flowering pattern. Some other species of *Strobilanthes* we observed were Silver Kurinji *S. cuspidatus*, blooms once in 13 years, Purple Kurinji *S. papillosa*, Copper Kurinji *S. lawsonii*, Forest Kurinji *S. heteromalla*, Neelakurinji *S. kunthiana*, and *S. homotropa*, a rare species whose flowering pattern and microclimate are not yet known fully and are under research at their nursery.

Kurinjis are helpful in maintaining microclimates by holding water and maintaining evapo-transpiration in the shola forest. They also act as forest skirts which are well adapted to thrive in ecosystem transitions, i.e., ecotones and are great at stabilizing slopes. Hence, they are often used by Upstream Ecology in an 'ecotone approach' of restoration to help heal the habitat. The tribes of the Nilgiris also have strong cultural ties with the kurinjis. For example, some of them measure their age by how many Kurinji blooms they have witnessed in their lifetime. Growing next to the Golden Kurinji was a lush Shola Dwarf Bamboo *Psuedoxytenanthera monadelpha* whose shoots are consumed by local tribes.

We also discussed how some species are common to both the Himalaya and the Nilgiris, like *Rhododendron arboreum, Rubus ellipticus*, and *R. niveus*. The habitat similarity and suitability has also brought some non-natives and invasives from the Himalaya, like the Himalayan Knotweed *Persicaria wallichii*. There were some invasive plants on the edges of the nursery, not deliberately planted but naturally occurring. Some of those were *Lantana camara, Ageratina adenophora, Bidens pilosa*, slipper flowers, and *Sisyrinchium* sp. Many of these flowers are brightly coloured, aesthetically pleasing, and hardy, which is why people often cultivate them in gardens, making it easy for them to establish themselves widely.

## Shola-grassland

On 4 November, we went to the Upstream Ecology Nursery in the morning, where Vasanth gave us a briefing on the propagation of native grass species, highlighting the ecological significance of *Tripogon bromoides* as a primary food source for the Nilgiri Tahr. We then loaded 300 saplings of *Tripogon bromoides* and headed to the restoration site, an abandoned tea and timber plantation, at Carrington, Thaishola. We carried the 300 saplings uphill to the designated planting area, helped by the on-site workers. We observed the restoration plot to be a cleared area, situated adjacent to an established tea plantation, which had been prepared for planting by the removal of invasive species and tea shrubs. Jeevit, a botanist from Upstream Ecology, guided us regarding how to plant the saplings to maximize survival rates in the high-altitude environment. We then spent the afternoon planting the saplings in a scattered manner, with a distance of approximately 0.5 m between saplings. We also created a raised crescent on the lower slope below each planted sapling to help retain rainwater. The activity provided us with a practical understanding of the multiple components of ecological restoration, particularly the logistical and labor-intensivechallenges of restoration in difficult terrain.

**Jeevith explaining about *Tripogon bromoides* before plantation. © Sanjay Molur**

Plantation of *Tripogon bromoides* saplings. © Sanjay Molur.

## Riverine Bamboo Plantation

On 5 November, we travelled to Vazhaithottam in Mudumalai Tiger Reserve via Gudalur, where we observed the vegetation transition from moist deciduous forests to dry deciduous forest to dry thorn/scrub forest. We learned that this was due to the rainfall gradient, as the Nilgiri Hills have a rain shadow effect on the eastward landscape. In Vazhaithottam Village, which is in the Singara range of Mudumalai Tiger Reserve, we visited another restoration site of Upstream Ecology in riverine habitat. There, we planted bamboo *Bambusa bambos* saplings from the on-site nursery to the riverine area. The saplings had already grown to about 1 m in height and had developed small spines, which would improve survival by reducing the chances of predation by herbivores. In total, we moved around 90 saplings and successfully planted most of them, covering a long patch along the riverbank.

Since the site includes both reserved and private areas, forest department permission was needed to remove invasive species. Also, Vasanth mentioned that invasives (mainly *Lantana camara*) tend to regenerate quickly even after repeated removal efforts. This observation reinforced what we have learnt earlier in the course that ecological restoration is a long-term, continuous process requiring regular monitoring and maintenance. Vasanth also highlighted that for the next four to five years, the team will need to keep checking and maintaining the site to ensure the restoration efforts are successful. For many of us fellows, this was their first hands-on experience in planting and restoring bamboo, offering valuable practical exposure to the challenges and processes involved in restoration work.

During the visit, we also observed elephant dung in the area, but found no visible signs of life within it. Typically, elephant dung supports more than 50 species of invertebrates that depend on it for food and habitat. The absence of these organisms, perhaps, shows a disruption in the food chain. It may be possibly due to changes in the elephant's diet, specifically that the elephants might not be consuming the native plant species that host the invertebrates essential for maintaining ecological balance.

## IISC Field Station visit

Later that afternoon, we met the staff of the IISc Centre for Ecological Sciences field station in Masinagudi, Mr. Bharanaiah, the field station manager, Dr. Nachiketha Sharma who studies elephant acoustics, Mr. Arjunan, and Mr. Albert Suresh who have been working on the long term monitoring of forest dynamics in Mudumalai. On a drive to Moyar Village, Nachiketha introduced us to his work on elephants and, with Albert, helped us understand the landscape, different animal behaviours, invasive plant presence and how it affects elephant movement in the reserve. At Moyar, we observed the south aspect of the Moyar Gorge and the vegetation distribution. Nachiketha then shared his knowledge and observation around the gorge, its dimensions, and the influence these factors have on the distribution, speciation, and movement of animals across the gorge. Albert spoke about the diversity of the invasive species and the cyclic patterns he has observed with respect to their dominance over the years.

We also visited the tree shrine that the Jenukuruba tribe residing in Moyar Village worships. We had multiple sightings of elephants and Spotted Deer on the journey

to and fro. On the way back, we were ecstatic to also see a few herds of Sambar Deer. This part of our field visit was unexpected and yet it was a genuine treat to interact with and learn from the whole team at the field station.

## Kodanad Viewpoint

After leaving Ooty on 6 November, we visited the Kodanad Viewpoint, which is located at an elevation of about 1,800 m in the Western Ghats and faces north. From this viewpoint, we could see the meeting point of the Eastern and Western Ghats, as well as the Moyar River gorge. Ahead of the viewpoint lay the Deccan plateau beyond the hill ranges. We could also see the meeting point of the Mudumalai and Sathyamanagalam tiger reserves. The main purpose of visiting this place was to visualise the biogeography of the Nilgiri landscape that we had been discussing over the past few days. Dr. Sanjay Molur pointed out various features of the landscape as evidence supporting our earlier discussions about the geological and ecological evolution of the region. One major feature was the Moyar gorge, which is one of the oldest gorge in the country at 2.5 billion years. We also observed different vegetation types from the viewpoint, including moist forests of the Western Ghats, riverine vegetation in the valley, and dry grasslands and scrub forests of the Eastern Ghats, which lie in the rain shadow region. We could also see human settlements scattered throughout the area.

## Moyar River

While at the viewpoint, Sanjay discussed the Moyar river with us and we learned that it originates from the catchment area in Mudumalai Tiger Reserve, flows along the Moyar gorge into the Bhavani Sagar reservoir, and acts as a tributary of the river Kaveri. The river and parts of the gorge act as a natural marker for the political boundary between Tamil Nadu and Karnataka, and supports a large population of trees like *Terminalia arjuna*, which are part of riverine vegetation, form a high canopy, and provide optimal nesting conditions for vultures. As the river flows, it collects the nutrition-rich soil from the slopes and deposits it on the banks of rivers on the plains, forming alluvial soil. This rich soil is the reason that humans selected the river sides for agriculture and settlement.

The Moyar River is the habitat of Humpback Mahseer *Tor ramadevii*, but only till the Bhavani Sagar dam. Earlier, the whole stretch of river from the Moyar to the Kaveri river supported a large population of Humpback Mahseer. However, after 1980, the Tata Hydropower bred hybrid Blue-finned Mahseer *Tor khudree* was introduced into Kaveri River, which competed with the native Humpback Mahseer and wiped out its population from its natural range. At present, the dam acts as the barrier for the invasive species to reach the Moyar River, therefore being one of the last homes for the natural population of Humpback Mahseer.

## Climate and Biogeography

We also discussed the formation of the Deccan Plateau, which was caused by volcanic eruptions 65 million years ago. The multiple eruptions produced lava that were contained by the barriers of the Western and Eastern Ghats on either side, forcing them to flow and cool to form multiple layers of basaltic rock on the plains. As an example, some places like Maharashtra have elevated land mass and are found with different layers of volcanic substrate. Below the Ghats, the lack of lava flow left the grassland ecosystems covering most of the Tamil Nadu plains untouched.

Some areas of the windward side of the Western Ghats, such as Agumbe in Karnataka, receive 6,000–7,000 mm of rainfall over a longer duration of eight months. However, the rainfall pattern has changed due to climate change, with the Nilgiris currently receives around 4,000 mm of rainfall for 5–6 months. The soil gets

**Elephants in Mudumalai Tiger Reserve. © Srijita Pal.**


Indian Gaur. © B. Ravichandran.


Nilgiri Salea female. © Shreya Yadav.


Nilgiri Salea male. © Shreya Yadav.

oversaturated with this heavy rainfall as the water cannot percolate fast enough, especially due to the loss of grasslands, leading to soil erosion, landslides, and flooding.

## Restoration learning outcomes and challenges

Overall, we had a broad introduction to the Nilgiri landscape and the practical aspects of carrying out restoration in such an ecologically diverse area. Some of our learnings about restoration include the following:

- ⇨ It requires a substantial investment of time, energy, money, and manual labour. Physical labour is not only important for planting itself, but for removing invasives or planted commercial species, preparing the soil, and spacing out plants appropriately over the given area.
- ⇨ It's important to look at published literature and untouched reference sites to understand the historical habitat and species composition before beginning restoration.
- ⇨ To be successful, it needs to be planned for in the long term (such as planting *Strobilanthes* species to create suitable microclimate for other species to grow over the years, planting bamboo only after it has developed spines to reduce the chances of herbivory, or shaping the soil to break the flow of water near each sapling and improve percolation).
- ⇨ Successful nursery management requires a good manager and enough information about the ecological role, taxonomy, germination, and growing conditions of each species.
- ⇨ Good restoration planning needs a broad foundation of knowledge about the natural ecology, taxonomy across taxa, climate, hydrology, edaphology, topography and geography of the area.
- ⇨ Monitoring should continue well after planting, ideally until the restored area starts to thrive naturally. This is to help improve chances of survival as well as to understand causes of sapling loss.
- ⇨ It requires a multilateral approach, with the involvement of all relevant stakeholders such as the local government, local communities, forest department, and ecologists.
- ⇨ It's a constant learning process, and it's better to be prepared for unforeseen factors to impact the


Moyar River Gorge. © Sanjay Molur.

project outcome from the beginning. In the case of a tea estate restoration site you cannot get water up the hill to water the grasses, you can only monitor. In the case of the riverine bamboos, the saplings could be preyed on by herbivores like elephants, wild boars, etc. or even cattle from the surrounding farm. So it is important to expect a realistic outcome, especially since native trees have a much lower survival rate than non-natives.

- ⇨ The ecotone approach uses vegetation that is adapted to thrive in between two different ecosystem types to support those that require specific microclimates to grow in either of the neighbouring ecosystems. This approach is uniquely suited to the shola-grassland mosaic.

We also learned a lot about the challenges that need to be overcome for successful restoration, both in this landscape as well as for restoration in general, such as: Working in protected areas requires permissions that can be difficult to get.

- ⇨ Invasives are a major obstacle for successful restoration and a strong, committed strategy is required for the removal of the multiple species that colonise areas cyclically. It's also important to recognise that these invasives can alter the chemical composition of the soil and make it even more difficult for native plants to grow.
- ⇨ Lack of published work on certain understudied habitats or species (like grasses) can hamper restoration efforts, making it difficult to plan planting and propagation.
- ⇨ Raising funds for restoration with native plants can be difficult because of the low survival rate compared to non-native fast-growing plants.
- ⇨ Different landscapes have different challenges - for example, working in the thorny riverine habitat versus moving plants and planting equipment up the hillside.
- ⇨ Misconceptions can be hard to work against and require a strong education campaign - for example, the idea that grasslands are nothing but wastelands, or that they have little carbon capture value.
- ⇨ Colonial practices of growing timber like eucalyptus and teak are a problem as some people can argue that it is more beneficial for those trees to remain and continue their carbon capture rather than growing native trees from scratch. However, this ignores the highly reduced biodiversity (and therefore biomass) that non-native trees or monocultures can support.

- ⇨ Restoration should include a strong component of education about waste management and why plastic should not be littered. It was very disheartening to find plastic in soil everywhere we dug in the riverine patch, which was in the middle of a tiger reserve, especially when we still don't know enough about the impacts buried plastic could have on the soil, vegetation, and fauna.

In general, **education** on why restoration is needed and the impacts of monocultures and invasives is very important. It is the only way to gather local support for sustained restoration in the long run.

## Conclusion

The four-day field trip to Ooty and the Nilgiris gave us a comprehensive understanding of ecological restoration within the Shola-grassland landscape. Through visits to Upstream Ecology's nurseries, hands-on planting of native grasses and riverine bamboo, and guided sessions on landscape ecology, we explored how restoration is deeply shaped by hydrology, geology, species interactions, and long-term environmental change. Each site revealed different challenges – from invasive species and altered rainfall patterns, to labour-intensive fieldwork and limited water access – highlighting the complexity of restoring degraded ecosystems.

The landscape-level observations at Kodanad and the interactions with IISc researchers broadened our ecological perspective, showing how restoration is intertwined with animal movement, soil processes, and historical land-use decisions. These experiences helped us connect theory with practice, reinforcing that restoration is not just technical work, but a slow, adaptive, and collaborative process requiring patience, monitoring, and continuous learning. The varied approaches and on-ground realities also raised important questions about sustainability, feasibility, and long-term success. At the same time, they encouraged us to think creatively, experiment with methods, and remain flexible to ecological and social constraints. Ultimately, the field visit deepened our appreciation of the practice of restoration, equipping us with insights crucial for engaging with real-world conservation challenges in the future.

## Acknowledgements

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RHATC team after plantation. © Sanjay Molur.

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# Beginning of Our Restoration Journey

The Ram Hattikudur Advanced Training in Conservation by the Zoo Outreach Organisation focuses on a different theme each year. This year, the theme is ecological restoration. The program emphasizes practical and experiential learning, including field visits to relevant sites.

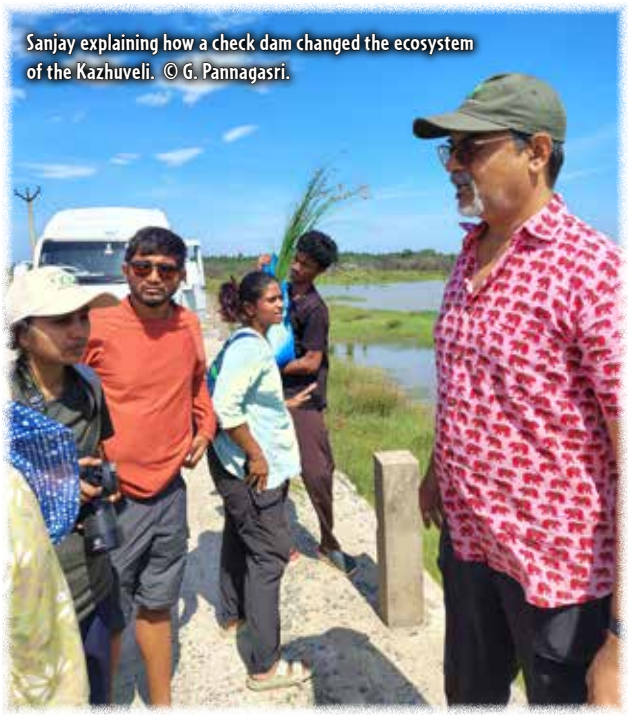
Under the restoration theme, we undertook a four-day journey along the Coromandel Coast, from Auroville to Chennai. During this trip, we visited several places such as Pitchandikulam Forest, Auroville Botanical Garden, Aurovanam, Poorvigam Herbology and Training Centre, the sacred groves in Putthupet and Oorani, Nadukuppam, the Madras Crocodile Bank Trust, and Siruseri Twin Lakes. Along the way, we also stopped at various locations to observe and understand human-centric developments such as the Kazhuveli Bird Sanctuary, salt pans, and artificially planted mangroves.

Throughout the trip, we interacted with experts from various fields, learning about native and non-native species, the importance of tropical dry evergreen forests (TDEF), different reforestation practices and the roles of governments, corporations, and communities in it. We also reflected on the ecological impacts of human-centric development across the region.

## Pitchandikulam Bio-resource Centre:

We visited Pitchandikulam's bio-resource centre with Joss Brooks, the founder, and met other staff including Dr. Shanmugam Mani, a botanist, Gopi, an archaeologist and Aurosylle, who manages operations and consultancy at Pitchandikulam. We first saw a series of pictures of what Pitchandikulam looked like over the years – from barren land in the 1960s to a rich TDEF patch now. The forest as a whole is now around 40 years old. We learned that Pitchandikulam covers about 75 acres and is part of the National Medicinal Plant Conservation Network, run by the Foundation for Revitalisation of Local Health Traditions (FRLHT). It also functions as a plant conservation park for native forest and medicinal species. The bio-resource centre held everything from brass wildlife sculptures and seed samples to faunal skeletons, antique furniture, and other unique artefacts. There were also several posters depicting Pitchandikulam's education and outreach work in nearby villages. It also functions as a consultancy service, with a corporate-funded project in Chennai to restore lakes at the outskirts of the city.

Much of the art we saw in the posters was done or directed by Eric Ramanujan, an incredible wildlife artist who spent much of his life contributing to Pitchandikulam and other wildlife initiatives with his sketches of Indian flora and fauna. He also ran the Pitchandikulam Art Collective, a group of artists who created sculptures, paintings and other creative work to help spread environmental education messages. We saw many more examples of this artwork as we took a walk through the forest outside the bio-resource centre, where art and information on a wide range of taxa and environmental concepts were painted on slabs of stone for display. These were kept side by side with petrified wood fossils and huge traditional pots used for storing rice, creating a beautifully organic blend of history, education and culture in the midst of the quiet forest.



Sanjay explaining how a check dam changed the ecosystem of the Kazhuveli. © G. Pannagasri.

Wall art in Pitchandikulam for education. © G. Pannagasri.

Art by Eric Ramanujan in Patchandikulam Museum. © K. Gokul.

Gopi showing us the archaeological museum at Pitchandikulam. © P. Kritika.

Walk around Pitchandikulam with Aurosylle. © P. Kritika.

Joss's introductory session. © P. Hrishikesh.

## Archaeological Museum:

We were guided by Gopi who showed us around the museum that covers a small part of the area. The museum displays various artefacts such as a bullock-driven cold press for oil extraction, a tool used for bullock shoeing, old terracotta objects, a flour grinder, a jaggery mould made from *Albizia lebbeck* wood (chosen for its heat resistance), a woven coracle, a wooden machine used to extract sugarcane juice, rice storage pots and terracotta stoves. Additionally, the museum features a Kazhuveli Bioregion timeline and a collection of fossils discovered in the area. We also discussed the different types of water sources and their traditional Tamil names.

## Morning walk with Aurosylle:

Our second day began with a morning walk through the Pitchandikulam Forest guided by Aurosylle. In the early years, a wide range of species was planted here, including some non-natives, a few of which still persist today. Currently, they focus entirely on restoring native TDEF species. However, one of the most persistent invasive species is *Mimosa pudica*, commonly known as the "touch-me-not" plant.

We explored both the older forest, which has taken about 40 years to reach its current state, and the newer forest, which is growing at a much faster rate. Some of the plant species we observed included *Lantana*, *Ceiba pentandra*, *Toddalia asiatica*, *Khaya senegalensis*, *Abrus precatorius*, *Hiptage benghalensis*, *Albizia lebbeck*, *Hura crepitans*, *Mimusops elengi*, *Memecylon umbellatum*, *Pongamia amara*, and several species of lianas. Apart from plants, we also observed a few common bird species, along with various butterflies, insects, and fungi, adding to the forest's biodiversity.

Discussion with Joss in Pitchandikulam Library. © G. Pannagasri.

Manjula giving us an overview of Auroville Botanical Garden. © P. Kritika.

## Joss's Journey:

Joss shared his journey, being born in Manchester during World War II and then shifting to live in Tasmania when he was six years old. He told us about his upbringing there and how Australian flora and fauna had been sustainably managed by the Aboriginal people across the continent before the invasion of European settlers. They caused immense damage not only to the native human communities but to the ecology of the continent.

Learning about this and the other atrocities perpetrated by Europeans made him give up his law degree and spend his time first as a lighthouse keeper for a while before leaving to travel the world after the Vietnam War started. He lived in different countries, including Turkey, France, and South Africa, before coming to India. During his travels, he passed through Puducherry and decided to stay and start Pitchandikulam after learning about Auroville. He showed us pictures of their efforts over the years and how the forest slowly grew as they integrated traditional methods of water management. Currently, Pitchandikulam carries out restoration projects for governments as well as corporates, with a major one being the Adyar Poonga. The 358-acre dumping ground was converted into a wetland-cum-forest with walking paths and an environmental education centre.

## Auroville Botanical Garden:

At the Auroville Botanical Garden, Manjula (a staff ecologist) guided us and gave a detailed explanation of each section as we walked through the campus. The Auroville Botanical Garden is made up of several themed sections with a coverage of 50 acres of well-defined planted area with around 310 species of trees. The themes include Japanese Zen garden, cactus, butterfly garden, native species and common species.

Apart from this, they also work in different areas such as education, outreach, research and consultancy for restoration projects, especially with mining companies.

At present, they are involved in three mining site restoration projects across southern India. Their work includes soil testing, studying hydrology, understanding the local ecological region, and developing reference systems for restoration planning. So far, they have worked with around 1,200 plant species.

Manjula also mentioned ABG partnering with the Tamil Nadu government to introduce a restoration policy aimed at preventing "greenwashing" by organizations. They also collaborate with the forest department to train staff and raise awareness about native species planting and maintenance. She added that the organization focuses on ecological, economic, and social aspects to ensure a more holistic approach to restoration.

## Aurovanam:

Our next stop was at Aurovanam, a 5.6 acre estate run jointly by the Sri Aurobindo Society and Pitchandikulam for experimental nature-based research, particularly with native food plant varieties. While there were many TDEF species grown on about half the estate from saplings provided by Pitchandikulam Nursery, much of it was devoted to water reclamation through a series of ponds as well as organic food production. We were shown around by Shiva, who looks after the place and was very knowledgeable about the different plants grown there. For instance, he showed us three different okra varieties and four different chilli varieties. School students often visit Aurovanam to understand kitchen gardening and start their own plots in their schools. Much of the produce goes to the Auroville Ashram. There was also a resource centre where Shiva showed us several seed, fruit and vegetable varieties as well as natural products like honey and placemats woven from invasive *Ipomoea* species.

## Poorvigam Herbology and Training Centre:

Following Aurovanam, we visited Poorvigam Herbology and Training Centre founded by Dr. N. Loganathan, who is an 11$^{th}$ generation medicinal plant researcher and Siddha ophthalmic surgeon located near Puducherry. Dr. Loganathan shared his academic, historical, traditional and mythological knowledge of the plants with us. The centre houses a nursery with 1,350+ plants with medicinal and therapeutic properties from around the world that is used in AYUSH system of medicine; 460 species of these are used for medicine in this bioregion and 126 are used to treat ophthalmic ailments and the centre does give separate attention to the threatened and endangered plants. Some plants are given special conditions to grow based on location of origin. The training centre also hosts educational classes, herbal tours, seed ball making, and home remedy preparation sessions to educate people about traditional herbology. They also facilitate medicinal preparation in the Poorvigam campus.

## Sacred Grove 1: Putthupet

We visited the Manjaneeswarar Ayyanar Temple, situated in Keezh Putthupet, which is surrounded by a sacred grove consisting of TDEF. Earlier, this forest had an area of nearly 28 acres, but now it has reduced to merely 12 acres due to various reasons - expansion of temple infrastructure and activity, agricultural encroachment,

Siva showing us the seed bank at Aurovanam. © P. Kritika.

Dr. Loganathan explaining the uses of various medicinal plants. © P. Kritika.

Human waste in Sacred Grove 1. © K. Gokul.

timber collection by the locals, grazing of cattle and goats, and introduction of non-native species. We saw that there was a lot of plastic litter on the ground throughout the grove.

Dr. Shanmugam Mani explained about the different stratifications of the forest to us. There was little to no vegetation in the understory, the middle layer was the most dominant and top layer consisted of just 6–7 trees. *Acacia caesia* is one of the most destructive and invasive species of this forest. The distance between the forest and the coast is just 1 km which makes it prone to cyclonic devastations. As the sacred grove falls under Panchayat's jurisdiction and not under that of the forest department, it is difficult to undertake restoration efforts. At one point, it served as the seed source for the other restoration initiatives of Pitchandikulum. The temple, which was built by Raja Raja Chola, gets at least 1,000 visitors daily during the peak season which has impacted the forest in different ways:

- The invasive climber Acacia caesia shading all the trees not letting other trees grow and regenerate.
- The understory completely vanishing because of the dark/shaded area.
- Significant reduction in the biomass because of the shaded canopy and death of the native species, making the soil more favourable for invasive species.

## Sacred Grove 2: Oorani:

We visited another sacred grove which was comparatively cleaner and less disturbed. *Combretum albedum*, a native woody climber, had largely dominated the forest and had hooded the forest canopy. The girth of the climber we measured was around 140 cm. We learnt that even when the forest seems undisturbed, one could determine the health of the forest by the size and composition of the flora and fauna in different forest patches. For example, in the Western Ghats, when the Sahyadri Forest Rat *Rattus satarae* is replaced by the Common House Rat *Rattus rattus*.

We discussed whether a degraded forest could revive on its own if left alone, especially since competition with non-native species makes it difficult for native species to regenerate. Additionally, we often think of only plants as habitat engineers, but a healthy forest also needs a good mycelial network to support native flora and fauna and help them thrive. We concluded that too much damage results in the forest not being able to recover on its own if the conditions remain the same (with too many invasives and continuous human presence).

## Kazhuveli Bird Sanctuary:

Next, we stopped at Kazhuveli Bird Sanctuary, which is one of the largest wetlands of peninsular India and was designated as a Ramsar Site in 2024. Many migratory bird species that utilize the Central Asian Flyway for migration use it as a stopover site. It's noteworthy that these areas harboured TDEF in earlier times (Ramsar Information Sheet 2024). We saw a lot of diversity of bird species, with many of us observing "lifers".

However, the construction of the Kazhuveli check dam, which was built to stop seawater from entering the wetland, has resulted in the conversion of a saltwater to a freshwater habitat. As a result, migratory shorebirds that depend on the brackish water have stopped foraging and visiting, and have been replaced entirely by freshwater birds, potentially endangering the ecosystem.

## Salt Pans:

Similar to the bird sanctuary, we saw many waterbirds and shorebirds using salt pans along the East Coast Road as a foraging site. A dam built nearby eventually led to the shrinkage of the creek feeding the area. As a result, we learned that the chemical composition of

Birds fly away seeing the arrival of a raptor at Kazhuveli. © P. Hrishikesh.

## Kazhuveli Bird Sanctuary Bird Count
## 12.1221°N, 79.8640°E
## 25/09/2025, 0945 - 1000 hrs

| Sr. No | Species of Bird | Scientific Name | Count |
|---|---|---|---|
| 1 | Painted Stork | Mycteria leucocephala | 2 |
| 2 | Eurasian Curlew | Numenius arquata | 3 |
| 3 | Western Marsh Harrier | Circus aeruginosus | 1 |
| 4 | Black-headed Ibis | Threskiornis melanocephalus | 4 |
| 5 | Glossy Ibis | Plagadis falcinellus | ~76 |
| 6 | Black-winged Stilt | Himantopus himantopus | 54 |
| 7 | Spot-billed Duck | Anas poecilorhyncha | 5 |
| 8 | Great Egret | Ardea alba | 1 |
| 9 | Pied Kingfisher | Ceryle rudis | 1 |
| 10 | Grey Heron | Ardea Cinerea | 1 |
| 11 | Black Drongo | Dicrurus macrocercus | 1 |
| 12 | Little Cormorant | Microcarbo niger | 1 |

the water changed from brackish water to freshwater, similar to Kazhuveli Bird Sanctuary, which affected the algal and fish composition. This eventually affected birds like swimmers, waders and other creek birds because of habitat unsuitability and fragmentation, gradually changing the bird composition. The salt pans also reduced the flood barriers as they are built in the estuarine ecosystem, increasing the chances of flooding of the nearby residential and agricultural areas. They also result in a high concentration of salts and other heavy metals from the pumped groundwater once the salt is harvested, after which the land is left barren.

Mangroves in saltpan. © G. Pannagasri.

Mangroves in saltpan. © G. Pannagasri.

## Mangrove:

The mangrove we visited were also planted in the estuarine area along the East Coast Road. About seven species were planted by the forest department, out of which only two species adapted and rest died. This was because of two reasons. First, the saplings were planted in a non-mangrove area, where they had never existed before, which adversely affected the survival rate of the plants. Secondly, prawn culture in the surrounding area significantly increased the salinity of the water. *Rhizophora microcarpa* and *Avicennia marina* were the mangrove species that survived. We had a discussion around the need for restoration and what drives it; whether it comes from a social need to restore something, the need for greening, or from a genuine ecological crisis. Since the mangroves were not naturally present there, they stood very little chance of surviving and thriving. So it served more like a plantation site rather than the restoration site in this scenario, with the plants then having no other option except dying or potentially becoming invasive. Hence deciding the ecological need/agenda of restoration is the most crucial step in conservation.

## Nadukuppam School:

In Nadukuppam, another campus run by Pitchandikulam forest, Joss gave us a brief introduction to the area and the work they do there. We then ventured into the government school nearby, where there was another restoration and education project site. The school once consisted of only two mud huts, but environmental education and government cooperation helped take the school infrastructure and students' academic performance to a whole new level. We were introduced

Various native rice varieties in Nadukuppam School. © S. Naufal Nazium.

to two environment education teachers, who take part in plantation initiatives, help the students learn about the importance of the flora and fauna around them, and maintain a minimalist kitchen garden which supports many butterfly species. Most parts of the school were allocated for native trees, but we also saw a few varieties of non-native trees.

We were then guided to the environmental educational centre of the school where they showed us various examples of arts and crafts done by the students. The teachers described how these were used for awareness drives in the nearby village communities in the form of puppet shows, shadow dramas and *Villu Paatu* - an ancient form of musical storytelling. We were amazed to know that with their teachers' guidance, the students had crafted all the costumes and props themselves. The art gallery also featured a seed bank with collections of native rice and seed varieties. Outside the art gallery, there were infographics showcasing an imaginative picture of the bioregion and methods of ancient water harvesting methods in Tamil Nadu, along with a variety of guides showcasing flora and fauna of the region.

Spirulina culture in Nadukuppam. © S. Naufal Nazium.

After leaving the school, we visited the community hall outside the school campus which is used for awareness workshops, medical camps and also functions as a temporary veterinary clinic for the nearby villages. These camps are supported by Pitchandikulam and operate to garner public support for eco-restoration efforts. Nearby, a spirulina farm not only provided training and education for local livelihoods but also facilitated sales of its products.

## Nadukuppam Forest Restoration:

After we returned from the school, we gathered to hear Joss explain how he started the restoration of Nadukuppam. He described how the area was originally barren land with depleted soil and a high rate of soil erosion. In order to fix this, they changed the entire hydrology of the area in order to open the way for restoration. Paths were dug along natural drainage paths for the water to flow gradually into a series of interconnected ponds to support water harvesting and slow soil runoff. Over time, the site was also restored by planting native tree species. We also met Usha, a local community member who has been working at the Pitchandikulam nursery for several years, who explained the entire process of selecting seeds and raising saplings.

In the early stages of the project, she used to collect seeds and saplings from different forests and areas. However, now most of the seeds and saplings are sourced from Pitchandikulam Forest and Nadukuppam. We then took a walk through the campus to understand how natural vegetation has come up around the constructed water bodies.

## Madras Crocodile Bank Trust:

At Madras Crocodile Bank Trust (MCBT) in Chennai, we were met by Ms. Pramila Rajan, the director. Established in 1976 to breed Indian crocodiles in captivity for reintroduction, it currently holds 15 species of crocodiles of the 27 in the world and several turtles and snakes, but only consistently breeds endangered species to exchange with other organisations or to release in the wild. An example is the critically endangered Red-crowned Roofed Turtle *Batagur kachuga*.

Conversation between Zai Whitaker and Sanjay Molur at Madras Crocodile Bank Trust. © S. Naufal Nazium.

As we went around, we met Zai Whitaker, the managing trustee. We also saw how different enclosures were adapted to different species, such as a water spray and basking log for the green iguana, and how staff managed duties like cleaning and feeding the animals. We also met Angeline Samuel, the curator, who explained the process of artificially incubating crocodile eggs, microchipping, and sexing snakes, crocodiles, and turtles. She also showed us examples of eggshells and teeth from different species. In addition to their ex situ breeding work, MCBT runs a snake venom extraction programme that partners with people from the Irula tribe, who have historically captured snakes, to collect venom for the synthesis of antivenom. Involving the Irula in venom extraction helps provide them with a livelihood related to their traditional occupation, saves people from snakebite, and preserves the snake population. We were guided by Gnaneshwar, project leader – snakebite mitigation, who guided us as we saw the venom extraction process and learned about the method, the venomous species used, and how the Irular and MCBT feel about continuing the process.

One particularly interesting fact is that venom is geography-specific; that is, the anti-venom made from a snake in Tamil Nadu will have decreasing efficacy against snakebite as the distance from Tamil Nadu increases, due to the specific proteins in the venom. We left MCBT with a new hoard of knowledge about Indian reptiles and their conservation in captivity.

## Siruseri Twin Lakes:

We then visited Periya lake and Chitteri lake in Siruseri on the outskirts of Chennai - a lake rejuvenation project which began in 2019. The project is supported by a CSR initiative of Tata Consultancy Services and guided by Indian Institute of Technology (IIT Madras). The work was executed by Pitchandikulam Forest consultants with support from SIPCOT for a maintenance part which is approved by PWD and Siruseri Panchayat and Public Cooperation. The site included huts for people to sit in, and there are plans to expand further with 17 additional lakes featuring children's parks, huts, and cafeterias. We were assisted by the manager to show us around. He mentioned that the lake was divided by a small path and later made as a road which then slowly turned out to be a landfill.

The whole lake was restored by removing the waste, and the depth of the lake was increased to 4.5 m by excavation. During the rejuvenation process, desilting was undertaken and the mud extracted from the lake was used to create hillocks around the banks for aesthetic reasons. We were informed that it took almost three years for the water level to appear natural again.

However, we saw that many of the plant species were non-native to India or Indian coastal plains; we also learned that people can fish in the lake and most of the fish species are ornamental. Therefore, there didn't seem to be much attention given to ecology and protecting a natural ecosystem. The project leaned more towards beautification and a 'green' space designed for recreation.

## Conclusion:

The four-day field trip offered an opportunity to explore different approaches to ecological restoration across forests, wetlands, and urban projects. Each site presented unique perspectives on biodiversity, land use, and community involvement. The experience helped us

Siruseri Twin Lakes Restoration Project. © G. Pannagasri.

connect theory with practice and reinforced the idea that restoration is a gradual process that requires ecological understanding, social participation, and long-term commitment.

Overall, the visit broadened our understanding of restoration efforts across diverse ecological and cultural settings, encouraging us to think critically about what truly defines sustainable restoration practices. It also gave us the chance to observe and learn the fundamentals of restoration from multiple perspectives and long-standing practices.

These varied approaches left us with many unanswered questions, but they also inspired us to think differently—to experiment, learn, and refine methods while remaining flexible to real-world challenges, including corporate and institutional collaborations.

Ultimately, the experience provided a deeper understanding not only of restoration itself but also of the social and political contexts that shape it. It left us with insights that are crucial as we prepare to engage with real-world conservation scenarios.

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# Ecology Outside Restoration: RHATC Field Trip to Hunsur and Kodagu

From the 13th to the 18th of November, the RHATC Fellows visited Karnataka, primarily to understand conservation work being done by people outside of restoration projects. We stopped at The Liana Trust in Hunsur, followed by Rainforest Retreat at the Mojo Plantation in Kodagu. We also stopped briefly at a long-term ecological monitoring plot managed by the National Centre for Biological Sciences (NCBS), and finally attended a talk by Dr. Mewa Singh at the University of Mysore. Each place taught us about different aspects of conservation, from mitigating negative human-wildlife interactions to the scope for agricultural practices that support biodiversity.

## The Liana Trust

On the first day of our trip, we travelled to the Liana Trust in Hunsur, Karnataka, accompanied by the Srinivasulu family (Bhargavi, Aditya and Chelmala) who work on bats and are based at Osmania University. The Liana Trust is an NGO committed to snake-related conservation and environmental education, especially in rural and agricultural regions, it was founded by Gerry Martin. The trust focuses on reducing human-snake conflict through scientific research, awareness campaigns, and community-based education initiatives.

Their efforts include snakebite research, rescue and rehabilitation of wildlife, community workshops, and the establishment of a serpentarium to supply venom for anti-venom development. The area was previously degraded farmland, which they altered by mulching for a year, planting trees, and providing boulders for microhabitat. Currently, the area supports much more biodiversity than it did, including birds, herpetofauna, and mammals, and is subjected to minimal management.

## Serpentarium and venom production

We first went to see the serpentarium, guided by the curator, Ms. Lisa. Here, snake venom is extracted using processes that meet WHO standards and the entire venom supply is provided free of cost to Premium Serums and Vaccines for antivenom production. Lisa mentioned that the trust had permission to collect 346 snakes of seven species from conflict situations, but their long-term aim is to maintain 600 or more snakes through captive breeding to ensure a reliable venom supply. At present, the serpentarium houses 31 kraits, 11 adult and 24 young of Malabar pit vipers, 31 Russell's vipers, 12 adult and 6 young spectacled cobras, 32 saw-scaled vipers and 1 king cobra. The venom is extracted once a month only from F1 or F2 generation snakes.

All the snake enclosures were appropriately sized and designed to incorporate elements of the species' natural habitat, like wood stumps, hideouts, and vegetation. Every enclosure was equipped with a data logger to monitor carefully regulated temperature, humidity, and light intensity. They also had QR codes through which caretakers could access each snake's health and breeding records. The enclosures were sanitised daily and routine fecal examinations were conducted to monitor infections and ensure good health of the snakes. All snakes were primarily fed captive-bred rats and mice. Lisa shared a few interesting behaviours she'd observed in the captive snakes, like 'cryptic basking' seen in nocturnal snakes where they expose only a small part of their body at a time to the light to absorb heat.

When a new batch of snakes arrives, they undergo a two-month quarantine. During this time, they are sedated for easy collection of morphometric data and given three rounds of deworming at 14-day intervals. After a health check and PIT tagging, they are introduced to the main enclosures. Overall, the experience highlighted the trust's dedication to the welfare of their captive snakes and to supplying standard quality venom for antivenom production, shaping a safer future for both people and snakes.

The Liana Trust also houses several exotic reptiles rescued from inadequate housing care situations. Accompanied by Lisa, we visited the section where these animals are kept. She explained that they are no longer accepting additional rescued exotics due to limitations in space and manpower, to make sure those they already

Rescued from exotic pet trade: Cherry-headed or Red-footed Tortoise (from South America). © Pathak Hrishikesh.

Endangered African Spurred Tortoise. © Yadav Shreya.

have are well taken care of. Among the animals we saw were a green iguana, dwarf caiman, sail-fin dragons, a red-footed tortoise, an African spurred tortoise, and a green anaconda. Lisa mentioned that each of these animals is cared for according to detailed pet care sheets, ensuring their welfare.

We also learned about their native habitats and interesting aspects of their behaviour. For example,gGreen iguanas can become invasive, as a single female can lay around 60 eggs at a time; at the trust, these eggs are usually fed to other animals to not increase their numbers. The male sailfin dragon displays territorial head-bobbing behaviour, and the species shows almost no parental care—in one case, a female had even eaten her own clutch of eight eggs. Meeting Voldetort, the African Spur-thighed Tortoise, was a highlight; large, calm, and fully herbivorous, it calmly grazed on grass when placed on the ground.

Afterwards, we had a nice activity with Gerry where we tried out very high frequency (VHF) telemetry. After a brief introduction to telemetry and how VHF is used for snakes, we split up into two groups and competed to find the hidden transmitter. It really helped us understand the complexities of tracking an animal on the ground in the wild.

## On Nature Education with Chandini Chhabra

Chandni is a nature educator with over a decade's experience. She and her team work with the government schools in the vicinity and Mysore district. Chandni says she is a believer of "actions lead to action", not just awareness but to bring positive change in behavior is her goal which reflects in her pedagogy. She primarily works with children between 2 to 12 years of age, so the sessions are curated accordingly emphasizing on intuitive activities, tactile experiences, and movement sessions. The sessions are well-researched and designed to instigate curiosity regarding different professions

Our evening session with Chandni on nature-based education. © Sanjay Molur.

related to the natural world such as paleontology and wildlife research by exploring the processes, methods and equipment used to learn about these fields. All the games and activities are highly contextualized according to the topic and whether to be done in the classroom or out in the environment, so significant efforts are invested in planning and preparation. Additionally, request boxes are deployed in the schools where children suggest what they want to learn about, which helps them direct their own educational journeys. She also conducts teacher training workshops to build capacity and develop engaging curricula, while raising awareness about snakebite and snake-human interactions in local schools. In this way, the education wing of the Liana Trust helps amplify their overall impact.

## Gerry Martin on Snakes in India

Gerry Martin's presentation focused on the importance of understanding snakes, reducing human–snake conflict, and improving India's response to snakebite. He began by briefing us about snake biology, such as how snakes sense their surroundings using the Jacobson's organ, a special chemical detection system in the roof of the mouth which helps the snake identify prey, avoid predators, locate mates, and navigate. This explains why snakes rely more on chemical cues than eyesight or sound. We learned that India has around 360 snake species, out of which 60 are venomous, and approximately 17–20 are medically significant, meaning their bites can be dangerous or fatal. However, Gerry clarified an important point: snakes never bite humans intentionally. Snakebite is always a defence mechanism, triggered when a snake feels threatened, cornered, is stepped on or accidentally handled. Most snakebite incidents occur in rural areas, where people walk barefoot in fields, sleep on the floor, or move around without torches at night. These conditions increase accidental encounters with snakes.

He also discussed different categories of snakes. Non-venomous snakes like kukri snakes, wolf snakes, and rat snakes help in controlling pests. Mildly venomous species such as cat snakes and vine snakes cause only mild symptoms. Constrictors like sand boas and pythons kill prey by squeezing. Highly venomous snakes like cobras, kraits, Russell's vipers, and saw-scaled vipers play an important ecological role as predators, especially of rodents.

He also pointed out that snake rescue is not the same as conservation. Many people misunderstand rescue work, assuming rescuers work only for the welfare of snakes. In reality, rescuers help both people and snakes by removing snakes from human spaces and reducing panic, fear, and killing. For long-term conservation, rescuers must engage communities with clear, respectful communication that explains the ecological value of snakes and the importance of coexistence.

Looking at bee boxes with Avinash. © Sanjana VK.

A potential field for owl perch installation. © G. Pannagasri.

Discussing holistic conservation with Gerry. © Sanjay Molur.

A major challenge Gerry discussed was the issue of antivenom production and usage in India. Antivenom must be given only under proper medical guidance; otherwise, it can cause severe reactions or even be fatal. Also, venom composition not only varies between species, but also within a single species from region to region. India has only a few antivenom-production centres and the venom for these centres are collected from a restricted range. The current method of antivenin production followed by most Indian producers is also suboptimal and better protocols would result in higher efficacy of neutralizing venom. Lastly, antivenin is currently only produced for the 'Big Four' (common krait, spectacled cobra, Russel's viper, and saw-scaled viper), while bites from other snakes could also result in near-fatal symptoms. For example, plantation workers in Kerala were hospitalized with symptoms of what seemed to be saw-scaled viper bites, but were later found to be hump-nosed pit viper bites. Together, these aspects explain why antivenom effectiveness varies across regions and why collecting venom from a wider range of species is so important.

He concluded with these Do and Don't guidelines:
Do:

- Wear proper footwear when walking outdoors or in fields.
- Carry a torch at night to avoid stepping on snakes.
- Keep surroundings clean to reduce hiding spots.
- Stay calm and go to the nearest hospital immediately after a bite.
- Allow trained rescuers to handle snake removal.

Don't:

- Don't try to catch or kill snakes.
- Don't apply tourniquets, cut the wound, or suck venom.
- Don't rely on traditional healers or home remedies.
- Don't panic or run after a bite.
- Don't attempt to give antivenom without medical supervision.

On the next day, the 14th of November, Avinash and Karthik from Liana Trust took us to show the owl perches that they have installed in the farm for rodent population control as a potential accessory measure in the snake-bite mitigation plan. This is also an attempt to boost the biodiversity on the farm. The owl perches are poles with a small plank on top, that are fixed in fields to observe if this helps in the management of rodent population in the vicinity. This can potentially reduce human-snake negative interactions by giving snakes more competition for rodent prey. If this pilot succeeds, the Trust plans on deploying these in other farms in the vicinity.

The Trust also supports farmers who have been affected by snake bites. In some of these farms, they lease an acre of land from them to demonstrate the benefits of organic farming, including promoting coexistence between local communities and wildlife and supporting biodiversity. Additionally, they provide bee boxes to promote apiculture as an additional source of income through the sale of honey and wax. We visited an organic farming plot with 10 of these boxes containing *Apis cerana indica* bees with their queens. They also plan to eventually introduce another native species, *Apis dorsata*, in their apiculture initiative. If both pilots of owl perches and bee keeping succeed, they plan to replicate it at other locations in Hunsur. After a thorough discussion with Gerry about his plans with the organic farming and owl perches initiative over breakfast, we headed to the Rainforest Retreat at the Mojo Plantation in Coorg.

## The Coorg Experience

On arrival, we were greeted by a beautiful property that was blanketed in greenery surrounding a running stream meandering its way around the cottages and the dining area. Mojo Plantations is a certified organic farm that Sujatha and Anurag started 31 years ago where they practice sustainable agriculture, now with their daughter Maya. Within the 25 acre plantation, they run an eco-lodge called Rainforest Retreat for long-term stays focusing on education, research and community.

After we'd settled in and had a refreshing meal, we visited a stream ecosystem where we observed many unique freshwater species living in the fast flowing water. This habitat supports *Tor malabaricus*, one of the smallest mahseer species, along with other stream fishes such as *Glyptothorax sp.*(hill-stream catfish), *Schistura sp., Nemacheilus sp., Mesonoemacheilus sp.* (hill-stream loaches), *Davario sp.* and *Garra sp.* These fishes depend

Glimpses of Rainforest Retreat and Mojo Plantation © Srijita Pal.

Glimpses of Rainforest Retreat and Mojo Plantation. © G. Pannagasri.

on clean, cool, highly oxygenated water and have special adaptations like flat bellies and sucker mouths that help them cling to rocks and move against the strong current. The hill streams of Coorg provide the perfect conditions for these fishes with rocky beds, plenty of dissolved oxygen, shade from riparian forests and natural seasonal changes. An exciting find were a few Stream Glory damselflies (*Neurobasis chinensis*) that shimmered green in the evening light. We also noticed a stagnant pool at the edge of the river where tussock grasses held the soil firmly, while other nearby areas without grass were heavily eroded. This clearly showed the importance of grasses and grasslands in preventing soil erosion and maintaining a healthy ecosystem.

Sanjay explained that building check dams in these streams would reduce the flow, change the depth, lower the oxygen levels and severely affect these sensitive species adapted to specific conditions. In the late evening we saw Davario fishes jumping out of the water to catch midge flies while bats were also feeding above the stream, as recorded by the Srinivasulu family. Walking back from the trail we observed rich biodiversity such as damsel flies, spiders, crabs,

Exploring a hill stream at twilight © Sanjay Molur.

earthworms, centipedes, millipedes, snails, slugs and frogs, highlighting the ecological richness of the Coorg hill stream environment.

## The Ridge Walk

On the morning of the 15th of November, we headed out after breakfast for a short trek called the Ridge walk, which took us in a loop around the crown of the hill. On the way, we noted several interesting natural history features of the landscape, such as wild cardamom, Mysore trumpetvine (*Thunbergia mysorensis*), kokum (*Garcenia indica*), a lantern flower species (*Ceropegia* sp.), fishtail/toddy palm (*Caryota urens*), six species of fern, Jerdon's leafbird, a giant golden orb weaver (*Nephila pillipes*) and her impressive web, a white-bellied treepie, a bank where bee-eaters had burrowed into a mud cliff to make their nests, and different structures of moss and lichen. We also saw multiple sites where landslides had been caused by heavy rain a few years ago, and discussed how we would go about restoring them. Sanjay explained that since landslides expose hard rock, restoration cannot be done unless lichens and other habitat-forming organisms have enough time to weather the rock and make it suitable for plants to take root. On our way up, we mostly walked through commercial plantations, with occasional patches of native forest trees.

At the top, we emerged from a large forest patch into a grassland dotted with shrubs and bushes. We sat there to observe the landscape and discuss how restoration should ideally be carried out there, particularly in the

Discussing ecosystem resilience on the ridgeline © G. Pannagasri .

A landslide area with some natural regeneration. © Sanjana VK.

A cliffbank with bee-eater burrows. © Sanjana VK.

Setting off on the trail with Ravi anna. © Trisa Bhattacharjee.

Learning about nature-based agroforestry with Sujata. © K. Gokul.

Malabar Trogon female (*Harpactus fasciatus*). © Pathak Hrishikesh.

Tarantula (*Thigmopoeus* sp.). © Pathak Hrishikesh.

Coorg Yellow Bush Frog (*Raorchestes luteolus*). © G. Pannagasri.

Clear-winged Forest Glory (*Vestalis gracilis*). © Sanjana VK.

context of climate change, since Shola-grasslands are especially threatened by rising global temperatures. We concluded that although high altitude grasslands might be easily lost, it would not be wise to try and engineer a climate resilient ecosystem. This is because 'climate resilient' is only a name for a collection of traits such as drought resistance or high carbon sequestration capacity, and have nothing to do with the ecology of the plant and how it interacts with other biotic and abiotic factors. Therefore, it's best to try to restore the native ecosystem, since all the species it contains have evolved to work with each other over millions of years, making it more likely to be resilient to external stresses. Ultimately, however, we need to focus on stopping climate change if we want to save the world's biodiversity.

With this in mind, it was difficult to watch the clearing of vegetation we encountered on our way down, when passing through commercial plantations again. Other natural history observations included civet scat with coffee beans and a sparrowhawk being harassed by two drongos.

## Nursery Build

In the evening, we pitched in to help plant Arabica seedlings and build a bamboo nursery to store them. With the help of Ravi anna and Lakshmana anna, who work at the plantation, we learned how to tie bamboo shafts together to form a frame open on one side and cover the frame with green netting on the top and three sides for shade. We also planted saplings in small grow bags filled with forest soil and arranged them in rows on raised mud beds in the nursery to prevent waterlogging. Some of us also learnt how to make the raised beds by clearing the area of weeds in which we planted the saplings directly. Afterwards, in the evening, we had an evening discussion about bat detectors and bat conservation with Chelmala, Aditya and Bhargavi.

## The Valleys of Mojo

On the 16th, we started the day with a morning walk led by Sanjay through one of Mojo Plantation's valleys. We learned about the importance of the catchment areas in the Western Ghats, and the formation of the lateritic plateaus over millions of years due to long-term geological events and climatic interactions, which play an important role in the flow of water from its origin in the headwater area (primary system) to the quaternary system. We then climbed up to a hillock administered by the Forest Department, and discussed how the grassland ecosystems were being compromised by tree saplings (including non-natives) which are steadily taking over the grass patches. We identified some of the pioneer species used to start restoration, and learned how climate change is causing the Western Ghats to receive six months' worth of rain (2500-3500mm) in one or two months.

After breakfast, Sujatha took us on a small tour of the plantation, explaining how they try to prioritise ecological complexity over conventional agricultural practices like pest eradication. For example, she told us about how a "clean" plantation is biologically dead and instead, they try to maintain natural undergrowth to protect the soil structure. From a scientific perspective, this allows termites and their gut bacteria to thrive as essential nitrogen fixers, making nutrients available to plants without the need for synthetic fertilizers. In another example, she described how plants communicate, releasing volatile organic compounds when mechanically stressed which activate defense enzymes in neighbouring plants. In order to maintain these ecological relationships, the estate avoids lethal pesticides to control pests like the cardamom stem borer. Instead, they use natural repellents to reduce the number of pests and allow a viable population of predators to remain, ensuring that the predator-prey cycle remains active rather than wiping out the food web. Additionally, they allow all native trees and shrubs to remain as they are, only trimming branches to manage shade when necessary. This is how the plantation manages to support so much native biodiversity. Even invasive weeds, though they should ideally be removed, are managed carefully to stabilize the soil against landslides.

## What Feeds the Plantation

Later in the day, we were shown the other practices the plantation employs. One of these was the use of biochar, which is organic material (usually wood) burnt in the partial absence of oxygen. This is soaked in effective

A top view of all the seedlings. © G. Pannagasri.

Watering stacked seedlings. © G. Pannagasri.

Putting seedlings in bags .© G. Pannagasri.

A diagram of the biogas plant. © G. Pannagasri.

microorganisms (EM) before being added to the compost, which speeds up the process of composting as it has a large surface area for adsorption. We were shown the process of making biochar, which was to burn the wood from the top, as a result of which a controlled burning atmosphere is created providing partial oxygen and this results in the upper layer of the wood to be burnt and traps the carbon inside. While we were told that this helps in carbon sequestration, we were unsure how it does so better than leaving it on the ground, as fallen logs will naturally break down and the carbon will return to the soil. Also, such logs provide habitat for a lot of detritivores and microorganisms, while burning wood in this manner contributes to carbon emissions in the atmosphere.

Another major part of the plantation was the domestic animals kept for manure and animal products. They keep domesticated cows, goats and hens. The weeds cleared from the plantation are used as feed and bedding for the livestock, and the cow dung from the sheds are used to produce biogas. The biogas plant consists of three tanks - cow dung and water are put into the first tank to form the slurry, which then flows to the second tank where it undergoes anaerobic breakdown by microbes for about six weeks (known as the lag phase) producing gases such as methane, carbon dioxide, etc. A pipeline from the second tank takes these gases to the kitchen to be used

Group photo with the Rainforest Retreat team. © Sanjay Molur.

for cooking. The remaining sludge is then transferred to the third tank from where it is extracted to be used in compost, transported through the plantation through pipelines.

We also helped apply compost beneath coffee plants to get practical experience of the daily labour required to run the plantation. We paired up to carry manure in trays and spread it under each coffee plant. Working on the slope was definitely labour intensive, but rewarding as we encountered a Malabar pit viper at close range! In the evening, we watched a film from the early 2000s about Rainforest Retreat and a private sanctuary in Coorg, SAI Sanctuary, which also talked about the impact of agrochemicals on local biodiversity in Kodagu.

## Long term monitoring plot (NCBS) - Thithimati:

We left the next morning for Thithimati, where we visited an 85 acre estate bordering Brahmagiri Wildlife Sanctuary that has been recently leased to NCBS by a family for ecological research. Guided by Mr. Chengappa and Mr. Aiyappa, we learned that the plot held primary forest that has been degraded by lopping and grazing. Nine months ago, NCBS started long-term monitoring of tree dynamics like carbon sequestration, methane production, and litter fall in a one hectare plot. They have also done some camera trapping to document mammal diversity, and are planning to expand to other taxa soon. Mr. Chengappa explained to us how they measure girth at breast height (GBH) using dendrobands and how they tag all tree individuals with unique ID numbers. The monitoring site has 148 species of plants, of which all trees are native but some non-native species of weeds are present.


Learning about long-term monitoring with Mr. Chengappa. © Sanjay Molur.

### Interaction with Dr. Mewa Singh:

After travelling to Mysore to spend the night, we visited the University of Mysore, where we attended a talk by Dr. Mewa Singh. Granted a lifetime professorship for his work, he has been a pioneer of ecology and animal behavior research, particularly focusing on primates. He spoke about 'Perception for wildlife conservation in India', where he used the examples of bonnet macaques, lion-tailed macaques, and slender lorises to show the different conservation needs each species can have.

Bonnet macaques, while generalists, have lost many large roadside trees because of development pressure and highway expansion. They are also actively poisoned and translocated without any attention to their ecology, resulting in more human-macaque negative interaction. As a result, they have been upgraded from least concern to vulnerable category in recent IUCN assessment. Temple groves remain a last stronghold for them, and protecting such groves as well as educating people about their decline is necessary for their conservation.

Lion-tailed macaques, on the other hand, are forest specialists found in the evergreen forests of the Western ghats. While their natural food consists mostly of fruits and insects and they live in populations of low density, human expansion has reduced their habitat. Now, lion-tailed macaques in Valparai have started behaving like bonnet macaques, entering kitchens and scavenging from garbage. Electrocution and highways which lead to canopy fragmentation are some of the biggest threats for the lion-tailed macaque. Their conservation requires linking forest fragments or deploying canopy bridges to help them move, enhancing the quality of habitats, and sensitising local communities to coexist with them.

Lastly, we learned about Dr. Singh's team's discovery of slender lorises in Dindigul district after spotting a local using a captive loris for fortune telling. With the help of the committed officials in charge at that location and dedicated fieldwork to assess the population, they were eventually able to get the area declared as the Kadavur Slender Loris Sanctuary. Overall, we learned that different species need different conservation management plans with multilevel interactions and inputs from researchers, NGOs, government, local leadership and the Forest Department to be successful.

Attending Dr. Mewa Singh's talk. © Sanjay Molur.

## Conclusion

From this trip, we learned that while restoration is the most ideal way to combat biodiversity loss and habitat degradation, it is not possible in areas that humans actively use, as land is still required for agricultural and other uses. Still, we saw how even farms can support an incredible amount of biodiversity with the appropriate nature-friendly practices, such as minimising tree-felling, planting native plants, working with ecological cycles (e.g. prey-predator dynamics), not using harmful agrochemicals, and restoring waterbodies to their natural state. Donating land for ecological research was also a wonderful gesture which could help advance the field as a whole. Thus, even if they are not plant ecologists or active restoration practitioners, anyone can contribute to supporting and safeguarding local wildlife with the right attitude and dedication.

## Acknowledgements

We would like to thank Zoo Outreach Organisation for organising this wonderful trip as part of the RHATC course, particularly Dr. Sanjay Molur, Director, and Trisa Bhattacharjee, Course Coordinator. We are very grateful to Gerry Martin for hosting us at The Liana Trust, and to Sujata, Maya, and Anurag Goel for our stay at the Rainforest Retreat, with comfortable accommodation and amazing food. We thank Mr. Chengappa and Mr. Aiyappa for guiding us at Thithimathi, and Dr. Mewa Singh at the University of Mysore for his talk on primate conservation. Lastly, we deeply appreciate that the Srinivasulu family accompanied us on this trip, came birding with us every morning, answered all of our questions with patience and kindness, and helped us learn about bat conservation.

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# Ecological Restoration in the Anamalai Hills

The Anamalai Hills are a rugged and biodiverse stretch of the Western Ghats. The landscape tells a complex story of fragmentation and resilience. The Nature Conservation Foundation (NCF) has been working since 2001 to heal the scars left on the landscape. As part of the Ram Hattikudur Advanced Training in Conservation we participated in an immersive two-day session on the 4th and 5th of December 2025, focussing on "Ecological Restoration" led by Dr. T.R. Shankar Raman and Dr. Divya Mudappa, who focus on restoring degraded rainforest patches among tea plantations on the Valparai plateau, adjacent to Anamalai and Parambikulam Tiger Reserves. Their work offers a blueprint for how science, patience and dedication can rebuild ecosystems after years of degradation.

**Divya Mudappa & Shankar Raman's classroom session at NCF field station. © B. Ravichandran.**

Restoration, as we learned, is not merely about planting trees. It is an attempt to reconstruct the biological and social values of a landscape. It requires identifying barriers to natural recovery, engaging local communities, and committing to long-term monitoring. The ultimate goal is to conserve biodiversity, revive natural ecosystem functions, and sustain multiple values for the community. However, the overarching philosophy remains clear: conserving existing natural habitats is always superior to attempting to rebuild them from scratch.

## Shankar Raman's Classroom Session

The first day was dedicated to understanding the theoretical framework and the engine room of restoration: the nursery. Restoration is a specific, high-level goal that sits atop a ladder including reclamation, rehabilitation, regeneration, reforestation, and afforestation. True ecological restoration aims to return a site to a state similar to a "reference ecosystem." This reference is typically a site with little to no disturbance, identified through historical evidence and indigenous knowledge. For the NCF team, historical documents like the Flora of the Annamalai hills (1921) serve as vital guides for selecting the correct native species.

A crucial distinction was drawn between "active" and "passive" restoration. Passive restoration involves removing stressors (like grazing or fire) and allowing nature to heal itself. Active restoration requires intervention. However, measuring success requires moving beyond simple metrics like the number of seedlings planted. The team emphasized that better, more ecological metrics include the survival rate of native species, the recovery of forest structure, the return of wildlife and similarity with the reference site, in order to accurately assess the success of the project.

## The Nursery

Our visit to the nursery gave us an insight into the meticulous care required to support this science. The practices here are governed by a strict ethic: never damage a healthy forest to fix a broken one. Seeds and saplings are collected only from roadsides, plantation edges, or disturbed areas.

Nandu, who's in charge of the nursery, explained that once collected, seeds are planted in germination bags within three days to ensure viability. The nursery utilizes

**Srini and Nandakumar explaining to the RHATC team about nursery management. © B. Ravichandran.**

a specific soil mixture of seven parts soil, two parts compost, and one part coco peat to grow the saplings. A layer of rock phosphate is added on top which aids the saplings in proper rooting and soil nutrient absorption. The plants are continuously watered as they germinate, but the frequency is reduced in the months before planting which in turn promotes resilience.

The nursery is a place of constant experimentation where they work with nearly two hundred native species, some of which remain stubborn. Hard-shelled seeds like nutmeg require cracking to sprout, while tiny seeds like Pongamia are spread in trays. As saplings grow, their roots are periodically trimmed which in turn, induces "root shock" in a controlled environment, increasing the plant›s stress tolerance and survival rate once transferred to the field. When planting in the restoration plot, they dig a pit, add compost, and sprinkle rock phosphate to further help saplings root properly and absorb nutrients.

One of the most interesting things that we came across was that the nursery does not arrange species in order; everything is mixed and the same goes while planting as well. This mimics natural diversity and acts as an insurance policy; if one species fails in the field due to disease or pests, others will survive. This stands in stark contrast to monocultures, which are highly vulnerable to pathogens. The nursery also maintains a genetic bank of regionally vital species, including Nageia wallichiana, Cullenia exarillata, Mesua ferrea, and various wild balsams and orchids.

## Day 2

The LEMon (Long-term Ecological MONitoring) Plot: On the second day, we moved from theory to the field, visiting sites that showcased the challenges and triumphs of restoration on the Valparai plateau. Accompanied by K. Srinivasan (Srini), senior project manager of NCF's Western Ghats project, and Ahirbuhnyan, a new project assistant, we traveled to the western side of the plateau, where NCF manages a 120 ha area of abandoned pepper and vanilla plantations. This area has seen heavy agrochemical use, with networks of irrigation pipes buried in the ground. This site, contiguous with the Vazhachal Reserve Forest and Parambikulam Tiger Reserve, is critical for wildlife connectivity.

In 2015, this area was divided into 1 ha grids for systematic study and experimental treatments while

RHATC team at LEMon site. © B. Ravichandran.

RHATC team at NCF Nature interpretation center. © B. Ravichandran.

RHATC team at Kandura Photo monitoring plot. © B. Ravichandran.

planting. For example, dibbling in some plots and regular weeding in others, as opposed to their usual method of active planting followed by minimal interference. One plot, called the «LEMON,» plot (Long-term Ecological MONitoring). Srini explained that this restored one-hectare plot, divided into 100 grids of 10x10 m, serves as a treatment site compared to a control primary forest plot in a protected area to examine the difference in ecosystem functionality between the two.

In the LEMON plot, the intense scientific rigor of the research is evident in the detailed mapping of every tree, using coordinates and correcting elevation errors with a theodolite. Dendrometers, which are metal bands attached to the tree trunks, are used to precisely measure girth growth with millimeter accuracy every quarter. For trees with buttresses, dendrometers are placed above the buttress, or a formula is applied to correct the error. The team also conducts Environmental Gas Monitoring (EGM) to track soil and tree respiration, analyzes leaf litter for nutrient cycling, and estimates carbon sequestration. They also monitor Coarse Woody Debris (CWD) along transects.

The restoration site, being a secondary forest, holds approximately half the amount of carbon compared to the primary control forest. We learned that young restoration sites often act as carbon sources before they become sinks, highlighting that restoration is a generational process. In addition to this, we saw the aggressive invasive herb Sphagneticola trilobita, which is a major challenge on the forest floor. Its dense, yellow-flowered mats prevent native tree seeds from reaching the soil, thus stopping natural regeneration. The key obstacle is clearing these mats without using herbicides, which would harm the catchment area.

## Kandura

At the Kandura site, we witnessed the interaction between restoration and wildlife. Despite three years of effort, this plot showed few tangible gains because elephants frequently move through the patch, often stepping on the saplings. Conventional fences and tree guards proved ineffective against these giants.

However, the monitoring techniques were fascinating. Srini demonstrated the use of "photo-reference" monitoring using an app called FoMo, the team takes a photograph from a fixed point annually. By putting a see-through "ghost image" of last year's photo right on top of the current view, the photographer can line everything up perfectly. This method creates a really accurate visual timeline, showing positive or negative signs of forest recovery over the years.

## Selaliparai and Rottikadai

The Selaliparai plot, planted in 2007, has transformed from a weed-infested patch of Lantana camara and eucalyptus into a thriving young forest (plantations have been leased). This plot was a clear vision into the

**RHATC team at Salaiparai. © B. Ravichandran.**

success of restoration. The success was underlined by the sighting of two Indian Giant Squirrels playing in the canopy, a clear biological indicator that the ecosystem›s function is returning. However, despite community engagement efforts, challenges persist as local people sometimes cut trees for poles used during temple festivals. Srini showed us a video of elephants moving through this small patch of just around one hectare, showing us how no forest is too small to support biodiversity. In contrast, the Rottikadai plot, started in 2024, showed the beginning of the journey. Here, the team used Clerodendrum infortunatum as a pioneer species after clearing invasive Lantana. Interestingly, some Lantana was deliberately left at the edges to act as a natural hedge, which initially seemed contradictory, but the team told that it serves as a natural fence to protect saplings from disturbances.

## Conclusion

Our session concluded at the Anamalai Nature Information Centre. Established in 2007 and revamped in 2019, this space bridges the gap between hard science and public engagement. The centre features art by Rohan Chakravarty, Sartaj Ghuman, and Nirupa Rao, which translates the complex biodiversity of the plateau into accessible narratives. Rohan Chakravarty's Valparai Natural History Map particularly resonated with us. It weaves together diverse stakeholders of the land from tiny balsams and orchids to elephants and humans. It serves as a visual reminder that we are not outside observers of this ecosystem but active participants within it.

As we stepped out of the centre, a double rainbow stretched across the landscape. It was a fitting end to a session that taught us that ecological restoration is not just about soil and seeds. It is about resilience, scientific rigour, and the enduring hope that with enough time and care, we can help the rainforest heal itself.


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**G. Pannagasri, Sanjana Vadakke Kuruppath, Srijita Pal, K. Gokul, Pathak Hrishikesh, S. Naufal Nazium, M. Nishigandha, Ishika Shah & Yadav Shreya.**
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# Starscapes at Pollachi

Post Sriram Murali's session on fireflies in Coimbatore a field visit was planned to see the fireflies. Sriram has been documenting and photographing fireflies for more than five years. He planned our visit to Iyal Thottam at Sethumadai at the foothills of Anamalai hills. This place is located approximately 70 km from Coimbatore. The farm belongs to Sarvanan, an organic farmer for the last 14 years. Saravan has been hosting and facilitating organic farming workshops in that area. Soon after meeting Saravanan we met Bala from 'Attral', an organization that carries out nature camps for environmental education. At his lab we saw different equipment and gadgets they use to demonstrate fundamental concepts in physics to people.

Most of the day was spent in and around the farm with Sriram and Chandrasekhar, firefly conservationists, Dr. Anusha Shankar from TIFR Hyderabad, and her post-doc Harsha. There we learned about their ongoing study on how they test out acoustic monitors at the farm, check their performance, and deploying them for monitoring during the light retrofitting project.

It was great to learn about fireflies and stars and other celestial bodies from Sriram and Chandrasekhar. Their love and passion for the species and the landscape is clearly palpable. We also visited a stream nearby that runs through Iyal Thottam to see the firefly habitat, fireflies, and their larvae. While we were embracing the beauty of the area at dusk, the fireflies became active slowly enthralling all of us. The Zooreach team accompanying us collected a few native grass species and other aquatic plants for the nursery back in Coimbatore.

**Fireflies sparkling around the Iyal farm. © Gokul K.**

Once it started getting dark we could see a few larvae sparkling at the edges of the stream. Sriram and Chandradhekar told us that the fireflies live in moist soil and leaf litter undergoing complete metamorphosis through egg, larval, pupal, and adult stages. They also spoke about the phenomenon of firefly bioluminescence which takes place between luciferin and oxygen, catalyzed by enzyme luciferase creating an unstable, high-energy product (oxyluciferin). This reaction is devoid of thermal components and entire energy is converted into light. They shared many more such interesting insights about the firefly ecology from the experience over the years of working on them.

The night sky was dark and we noticed much less light pollution. There was light spills from Coimbatore and Pollachi city. This instigated a long conversation about light pollution and light spills from urban areas and what all ways it can affect the wildlife even at the distance. The team has been working with TN government on changing the lightings in the core wildlife areas making it wildlife friendly.

It was 14 December, the last day of Geminid Meteor Shower. Sriram being an astrophotographer shared his knowledge about stars, Geminid shower, and star photography. He and Chandrasekhar taught us the adjustment of aperture and shutter speed while taking the star/fireflies pictures at night. We attempted to capture the fireflies and stars and shooting meteors but barely succeeded.

A wonderful homely dinner was arranged at Sarvanan's farm. Post dinner we again sat for some time watching meteor showers. In the darkness, sitting at the foothills of Anamalai, we could hear the crackers bursting in the distance reminding us of the elephants in the area and the negative interactions in or near human habitations.

We all enjoyed our time at the farm, learnt about stars, fireflies, photography, enjoyed a delicious dinner, and witnessed beautiful star scape & fireflies.

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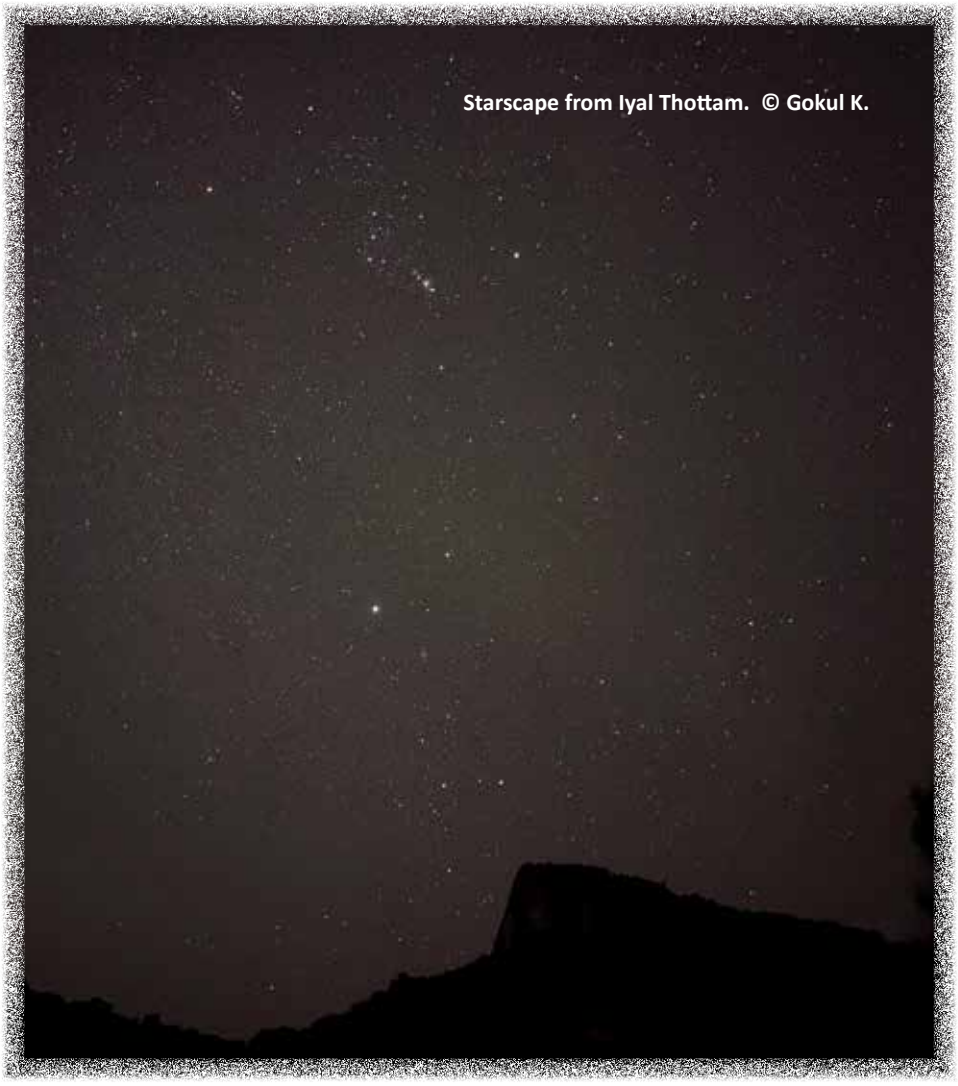

Starscape from Iyal Thottam. © Gokul K.

# Indian Corals and the 30% by 2030 Kunming-Montreal Target: Assessing the State of Coral Restoration in India

## Introduction

Corals are small invertebrates from the phylum Cnidaria that form colonies of many polyps. As most species excrete a hard exoskeleton formed of calcium ions from seawater, these colonies often create large, structurally diverse, calcified formations on the seabed, called reefs, over time. Coral reefs are formed primarily in warm, shallow waters (Goreau et al. 1979) and may be of four main types: fringing reefs, which border coasts close to the shore; barrier reefs, which also run parallel to coasts but are further away from land and are continuous for longer distances; atolls, which are rings of coral islands that form on inactive volcanoes to surround a lagoon (Goreau et al. 1979); and patch reefs, consisting of small isolated reef clusters. Most corals have a symbiotic relationship with unicellular dinoflagellates called zooxanthellae, which photosynthesize to provide the corals with energy, while the corals provide them with structural protection (Goreau et al. 1979). The zooxanthellae also give these corals their characteristic variety of colour.

Corals (particularly reef-building species) are also notable for the immense diversity of other species that they support by providing habitat and forage for shallow-living species. Estimates vary widely, between one to nine million, and they have earned the moniker 'rainforests of the sea' (Knowlton 2001). However, this very diversity means that if corals are affected, millions of other species will also be affected. Additionally, the dependence of most coral on zooxanthellae makes them especially vulnerable to climate change, as coral first digest, then expel them when under thermal stress (Brown 1997; Fujise et al. 2014). When this occurs, coral becomes 'bleached' as they lose the colour the zooxanthellae provided, and the coral die, leaving behind only the exoskeleton.

Coral reefs have seen four global bleaching events so far, in 1998, 2010, 2014–2017, and 2023–2024, that coincided with El Niño heat oscillations (Reimer et al. 2024). However, the last two occurred before El Niño onset began, indicating that the underlying factor driving coral bleaching is global climate change rather than the El Niño pattern alone (Reimer et al. 2024). Bleaching also occurs repeatedly at regional sites depending on local environmental variables, which include changing salinity, sea water temperature, and solar radiation (Brown 1997) as well as the availability of inorganic nutrients (Suggett & Smith 2020). Additionally, coral reefs are widely negatively affected by overfishing, coral trade (Harriott 2003), pollution (van Dam et al. 2011), and disease outbreaks (Pollock et al. 2011). The worldwide decline in coral cover over the last several decades has been so drastic that it was labelled a global crisis as early as 2004 (Bellwood et al. 2004).

## Coral Reefs in India

While India's coral reefs are not extensive or widely distributed, covering only about 2,380 km2 (less than 1% of global coral cover) (Venkataraman 2011), they hold a notable diversity of corals and are a vital reserve of diversity in the Indian Ocean (Muley et al. 2002). They also represent all the major reef types (atoll, fringing, barrier, and patch) (Venkataraman 2011). In 1983, 199 coral species from 37 genera were recorded; this number

grew to 208 species from 68 genera in 2003 (Venkataraman 2011). These species mainly belong to the family Acroporidae (70 species), Faviidae (36 species), and Fungiidae (22 species) (Venkataraman 2011). In India, most coral reefs are found in one of four areas—the Gulf of Kutch, the Gulf of Mannar-Palk Bay, the Andaman & Nicobar Islands, and the Lakshadweep Islands. Each location supports a unique assemblage of coral species.

### 1. Gulf of Mannar-Palk Bay

Including barrier, fringing, and patch reefs, the Gulf of Mannar-Palk Bay system on the southeastern coast (between India and Sri Lanka) includes multiple coral reefs that have developed around a string of 21 islands in a 140-km stretch (Edward et al. 2007). With 117 coral species and 510 species of fin fishes, it is a biodiverse area that was notified as a marine national park in 1980 (Edward et al. 2007). Coral cover has fluctuated over the years; when assessed using line transects, live cover increased from 36.98% in 2005 to 42.85% in 2009 before dropping to 37.71% in 2011 (Edward et al. 2012).

### 2. Gulf of Kutch

The Gulf of Kutch, located on India's northwestern coast in the state of Gujarat, is mostly comprised of patchy reefs that are limited in their growth by high salinity, frequent sediment influxes, and temperature fluctuations (Bhatt et al. 2012). Species diversity is also relatively low, with 36 species from 20 genera recorded as of 2011 (Venkataraman 2011). Parts of the area are protected by a marine national park, notified in 1980.

### 3. Andaman & Nicobar Islands

The region basically has fringing, channel and patch type reefs with 588 species of hard corals. Andaman Island has 31 genera and 82 species whereas Nicobar has 43 genera and 103 species. The reef-flat occupies an area of 795.7 km2. Following the 2004 Indian Ocean tsunami, 30% coral cover in northern Andaman and 20% loss in southern Andaman and Nicobar islands were lost by sedimentation & physical destruction. There is not enough recent information about the reefs around northern Andaman and the Nicobar islands to provide a true picture of the current status of the reefs. Coral bleaching due to elevated temperatures, siltation, and tourist activities pose major threats to the coral population here (Majumdar et al. 2018). Some reef areas are protected by the Mahatma Gandhi Marine National Park (notified 1983) and the Rani Jhansi Marine National Park (notified 1996).

### 4. Lakshadweep Islands

The Lakshadweep Islands are the only location with atoll reefs in Indian waters. After the 1998 bleaching event, only about 10% or less live coral cover around all the islands were remaining (Raheem 2012). Lakshadweep's coral cover declined by 50% in the past 24 years due to bleaching (Jayakumar & Sarkar 2024).

## Threats to Indian coral

The major natural threats to corals are salinity, pH, environmental-temperature, disease prevalence, invasive species, and sediment deposition. Anthropogenic threats include coral mining, destructive fishing practices like bottom trawling & dynamite fishing, climate change, and pollution (sewage and industrial chemical discharge) (Edward et al. 2012). Extensive coral mining, especially in Gulf of Mannar and Palk Bay was rampant in 1960s and 1970s with about 2,500 tons of coral mined annually as there was a minimal regulation at that time. In the 1970s Indian reefs were more widespread and suffered fewer anthropogenic impacts, but unsustainable coral mining and overfishing were already starting to take a toll. Decades of direct exploitation, along with overfishing, sedimentation, pollution, destructive fishing practices, resulted in decline in the 20th

century (Muley et al. 2002). Additionally, data and published literature on India coral reefs still remains patchy and inconsistent across studies. Widespread monitoring is needed to accurately assess long-term trends in coral health.

## Coral cover decline

The bleaching event of 1998 has been reported to have increased dead coral cover to about 70% in the Gulf of Kachchh, 40–60% in the Gulf of Mannar, 60–80% in Lakshadweep, and about 80% in the Andaman & Nicobar Islands (Muley et al. 2002). Before the 1990s, coral bleaching was rare as industrial development, and coastal fishing had not been identified. Researchers looked at 23 years of data from India's main coral reefs and found that there had been three bleaching events in 1998, 2010, and 2016 (Thinesh et al. 2025). They studied during short heatwave and long heatwave, and they found during short heatwave some types of coral are tough and don't bleach easily while others are weak and bleach quickly; however, long heatwaves result in mass coral death regardless of coral type (Thinesh et al. 2025). They identify coral types that are most at risk in each location. Acropora (a branching coral) is very vulnerable to bleaching in many areas while big-boulder shaped corals (like Porites) recover better after heat events.

## Restoration Techniques and Indicators of Success:

To combat coral loss, several restoration techniques have been developed across the world. While some were adapted from terrestrial ecosystems, others were emergency interventions in response to specific challenges like substrate stability loss after ship grounding events (Hein et al. 2020). Global restoration interventions can be summarized as the following (Hein et al. 2021)

1. Direct transplantation: Transplanting coral colonies or fragments directly from healthy reefs to degraded reefs.
2. Coral gardening: Transplanting coral colonies or fragments, with an intermediate nursery phase to improve the survival rate.
3. Substrate addition: Adding artificial structures to allow for coral recruitment, coral planting, and/or fish aggregation
   i. Electro-deposition: The structures are connected to an electric current to increase the rate of mineral deposition (required for reef building).
   ii. Green engineering: The structures are designed to imitate natural substrate and be as natural a part of the ecosystem as possible.
4. Substrate manipulation: The substrate is altered or changed to help corals recover.
   i. Substrate stabilization: Removing rubble and stabilizing loose substrate.
   ii. Algae removal: Removing harmful or overgrowing macroalgae.
5. Larval propagation: Releasing coral larvae at a degraded site after an intermediate storage phase to improve the survival rate.
   i. Deployment of inoculated substrate: Placing substrates that have been 'seeded' with coral larvae.
   ii. Larval release: Releasing larvae directly at a restoration site.

These techniques are in use to different degrees. In a systematic review of coral restoration methods, the most common method was coral gardening (48% of reviewed studies), followed by substrate addition (21%), then by direct transplantation (20%). Substrate stabilization was carried out in much fewer studies (4%) and larval enhancement, being a relatively new technique, had the fewest studies at 1.3% (Boström-Einarsson et al. 2020). All methods, however, are expensive and/or time and labour intensive, and several gaps remain in their implementation; for example, fast-growing branching corals are usually planted in preference

to massive slow-growing corals, which are more difficult to fragment for transplantation, and monitoring periods are, on average, too short to establish whether true restoration of ecological function has taken place (Boström-Einarsson et al. 2020). Long-term monitoring is particularly important for corals, as bleaching events can take place years after restoration is carried out (Boström-Einarsson et al. 2020).

Coral restoration is made more complex by the common lack of agreement between the stated objective and the metric being measured, as well as a lack of reporting on basic metrics such as the size of fragments transplanted, and coral growth (Boström-Einarsson et al. 2020); this makes it difficult to compare studies and methods across the world. In general, however, the success of coral restoration projects is mostly measured by coral fragment growth, attachment, and survival; other metrics include coral cover area, coral diversity, fish diversity, and fish abundance (Boström-Einarsson et al. 2020).

## Coral Restoration in India

In response to coral reef decline, India initiated several restoration programs in the early 2000s. These programs focus on restoring degraded reef areas, enhancing coral resilience, and improving local livelihoods through sustainable coastal management. The main restoration efforts are concentrated in the Gulf of Mannar, Gulf of Kutch, Andaman & Nicobar Islands, and Lakshadweep.

### 1. Gulf of Mannar (Tamil Nadu)

The restoration process in the Gulf of Mannar primarily involves coral fragment transplantation. The Ministry of Environment and Forests (MoEF) launched coral restoration in the Gulf of Mannar in 2002 through SDMRI, which developed low-cost, practical techniques using artificial substrates like concrete frames and fish houses (Bhatt et al. 2012). From 2002–2024, 51,183 coral fragments were transplanted which showed survival rates of 55.6–79.5%. Of the 20 species, Acropora spp. had the highest growth rate (up to 16.7 cm/year). Also, spawning of restored corals and increase in reef fish abundance was reported, indicating success of the operation. However, coral mining, destructive fishing methods, bio-invasion, space competition, disease outbreaks, microalgal blooms, and pollution remain as major threats to coral in this region (Edward et al. 2025).

The Tamil Nadu government is now undertaking a major coral restoration project focused on Kariyachalli Island in the Gulf of Mannar, primarily through its Tamil Nadu Sustainably Harnessing Ocean Resources (TNSHORE) initiative. This project involves deploying 8,500 artificial reef modules, restoring seagrass beds, and engaging local fishing communities to combat erosion, and enhance marine biodiversity. The 50 crore initiative is jointly funded by the Tamil Nadu government and the World Bank and is being carried out in partnership with IIT Madras and the Suganthi Devadasan Marine Research Institute (Nivethitha 2025). Restoration efforts will include planting approximately three acres of coral and four acres of seagrass (Nitnaware 2025).

### 2. Gulf of Kutch (Gujarat)

Between 2004 and 2014, multiple coral restoration initiatives were undertaken in the Gulf of Kutch by the National Institute of Oceanography (NIO), Gujarat Forest Department, Wildlife Trust of India (WTI), Tata Chemicals Ltd (TCL), GEER Foundation, and the Zoological Survey of India (ZSI).

#### i. Coral Translocation (2004):

NIO and the forest department translocated over 2,300 live coral colonies from jetty and pipeline corridors near Narara Reef to three safer sites. Species from genera such as Favia, Porites, Goniastrea, and Turbinaria showed 70–98% survival, with growth comparable to natural reefs

(Kamboj 2014).

### ii. Coral Rescue Program (2011–2012):

The forest department, WTI, and TCL conducted India's first coral rescue program at Mithapur Reef, repositioning about 30 upturned corals and conducting awareness drives among local communities (Kamboj 2014).

### iii. Artificial Reef Formation (2011–2013):

Ten artificial reef sites were established using limestone boulders at Mithapur. Coral juveniles (Favia, Favites, Montipora) colonized within a year. In 2013, 22 more artificial reefs were deployed at Laku Point and Mithapur, restoring about 110 $m^3$ of reef area (Kamboj 2014). However, the duration of survival was not mentioned.

### iv. Transplantation of Acropora humilis (2012):

Coral fragments from Agatti Island (Lakshadweep) were transplanted at Mithapur and Laku Reefs. Although initially successful, fragments bleached due to temperature rise (up to 31 0C) after several months (Subburaman et al. 2014).

### v. Transplantation under ICZM Project (2012–2013):

GEER Foundation transplanted 375 coral fragments of Favia speciosa, F. favus, Porites lutea, and P. compressa from donor reefs to Narara Reef. Several fragments showed good radial and substrate growth (Kamboj 2014). However, the duration of survival was not mentioned.

### vi. Coral Transplantation by MNP–ZSI (2014):

The Gujarat Forest Department and ZSI transplanted 1,569 coral fragments across 400 $m^2$ at Pirotan Island to develop a coral park for ecotourism (Kamboj 2014). The survival rate for transplanted corals was 77.57%, with Favia spp. showing high resilience, though some fragments were surviving despite challenges like water currents and sedimentation (Kumar et al. 2017). However, the duration of survival was not mentioned.

### vii. Biorock Coral Restoration Initiative in the Gulf of Kachchh (2020):

For the first time, the Zoological Survey of India (ZSI), in collaboration with the Gujarat Forest Department, initiated coral reef restoration using biorock or mineral accretion technology (electro-deposition on artificial substrate). A biorock structure was deployed on 19 January located approximately one nautical mile off the Mithapur coast in the Gulf of Kachchh (Singh 2020).

## 3. Andaman & Nicobar Islands

Restoration efforts led by the Zoological Survey of India (ZSI) and the Andaman & Nicobar Forest Department began soon after the tsunami in 2004, focusing on the rehabilitation of damaged coral patches through rope nurseries and block transplantation (Levy et al. 2010).

ZSI established coral nurseries to cultivate and transplant heat-resistant coral species. The Reef Watch Marine Conservation initiative, led by local divers and scientists, has successfully transplanted over 2,000 coral fragments since 2020, with a survival rate of 60–70% (Johri 2024). However, long-term survival has not been monitored.

## 4. Lakshadweep Islands

Lakshadweep now has successfully established coral nurseries using asexually reproduced transplants in Kavaratti Island, Lakshadweep archipelago. Acropora muricata showed the highest growth rate there. Assemblage of diverse fishes including 21 species belonging to 10 families at the transplantation site indicates successful restoration at the site (Riyas et al. 2024).

NCSCM supported reef restoration projects, focusing on "assisted recovery" using coral frames

and artificial structures. In 2021, a pilot project near Agatti Island showed encouraging results, with an increase of live coral cover by 15% in just two years (Johri 2024).

After examining the current status and the last 25 years of coral restoration efforts, it can be concluded that India has focused predominantly on methods such as coral transplantation and translocation, with nurseries established only in Lakshadweep. Restoration efforts have also been patchy and irregular. To assess success, most projects have relied on limited indicators primarily the area restored, the number of species or fragments planted or present, and their short-term survival rates. However, very little information on India's coral restoration initiatives is publicly reported, and long-term monitoring data are almost entirely absent. This lack of sustained, systematic monitoring makes it extremely difficult to evaluate the actual effectiveness, ecological impact, and long-term success of these restoration efforts.

## Kunming-Montreal Target Two and the Way Forward

The Kunming-Montreal Global Biodiversity Framework, adopted by the 15th Conference of Parties to the Convention on Biological Diversity in 2022, lays out 22 targets to safeguard our planet's biodiversity in the long term. Of these, Target 2 aims to initiate restoration projects in 30% of degraded terrestrial and aquatic ecosystems. It mandates that restoration efforts be initiated in at least 30% of degraded areas by 2030, with clear objectives to enhance biodiversity, ecosystem functions, ecological integrity, and connectivity. Conserving coral reefs, as a climate-sensitive biological indicator and a hotbed of marine biodiversity, should be a priority for global governments.

While true coral conservation would need the effective reversal of climate change, such a long-term and global process cannot be easily influenced due to economic and intergovernmental considerations. Instead, the immediate mitigation strategy that is feasible at local scales would be coral restoration. However, coral restoration efforts in India currently face several challenges. One major obstacle is the lack of long-term monitoring after restoration to assess the status of coral health over the years, including the return of ecological functioning. Documentation from such activities is also sporadic and suffers from unstandardized reporting, which limits knowledge sharing and scientific advancement. Also, India's coral reefs have not yet been extensively assessed in the natural state, making it difficult to effectively target the corals that most need restoration.

At the national level, most restoration projects are unfortunately small-scale and scattered, implemented in isolated patches rather than through coordinated, large-scale efforts. Although frameworks such as the National Biodiversity Strategy and Action Plan (NBSAP) and TNSHORE exist, the NBSAP lacks any specific strategies for coral restoration, and TNSHORE's scope remains restricted to Tamil Nadu, leaving a significant gap in a cohesive national-level approach. Therefore, to successfully achieve Target 2 with respect to coral restoration, we recommend the following:

- Establishing a robust National Coral Research Team and Action Plan encompassing all coral habitats in India, with at least ten years of dedicated funding and with clear guidelines (see below) that enable effective and appropriate restoration efforts.
- Focusing on ex situ conservation breeding of corals as well as in situ work.
- Keeping up with progress in global research on coral restoration and actively trying new techniques in India.
- Continuous wide-scale monitoring of the four major Indian reeds to assess their health and guide effective restoration strategies.
- Restoration that is location and ecosystem

specific, using native coral species suited to local conditions. Under this, the project should:

- Consider the probability of coral survival as well as the threat status of the native coral community when selecting restoration sites.
- Carry out standardized, holistic progress evaluation beyond the mechanical metrics that are now most commonly in use. Apart from counting transplanting fragments, measuring the area of restored reefs, and tracking growth progress, ecosystem function assessments are required. These should include regularly documenting the vertebrate and invertebrate communities that return to restored reefs, and the ecology of such communities should ideally be compared to the functioning of pristine reefs wherever possible.
- Carry out long-term survival monitoring for a minimum of five years.
- Long-term educational programs in stakeholder coastal communities promote a sense of stewardship of coral reefs.
- A regional IUCN Red List of Ecosystems assessment for coral ecosystems at least once in a decade to assess its risk of collapse and prioritize it accordingly.
- Annual reports of the National Coral Research Team's activities and findings should be published to document restoration progress and challenges. This should be followed by expert reviews and scientific discussions, possibly through national conferences, to refine the coral restoration strategy each year.

## Conclusion

India is home to some of the most diverse coral reefs in the world across four different coastal areas. While the ultimate cause behind their widespread bleaching, climate change cannot be effectively addressed at local scales, focusing on the Kunming-Montreal Target 2 can help mitigate its impacts. Restoration and coral research thus far have been sporadic and not well documented, although increasing efforts have been made over the last two decades or so. We recommend several nationwide measures, including holistic reef health assessment and committed long term monitoring, to improve on current methods and achieve holistic, effective, and long-term coral restoration in all of India's reefs.

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# Aligning India's Mangrove Restoration with Target 2 of Kunming-Montreal Global Biodiversity Framework

## Introduction

Kunming-Montreal Global Biodiversity Framework is an international agreement adopted at COP15 in December of 2022. It strategizes to halt and reverse biodiversity loss by 2030 and achieve a nature positive world by 2050. This framework lists 23 targets to be attained by 2030 and four goals to be achieved by 2050, to build a world that lives in harmony with nature (Convention on Biological Diversity 2024). Although it is not legally binding, the global goals and targets in this agreement help guide action equivalent to the ambitions set by the 196 countries that signed it (WWF 2023). These nations were required to update their national biodiversity plans which describe the actions that add up to achieve the global goals of the framework, and submit them to the United Nations by November of 2024, in the COP16 held in Colombia. These plans must comply with all targets in the Global Biodiversity Framework (GBF) and importantly, be accompanied by a biodiversity financing plan that includes opportunities for private finance mobilization (Convention on Biological Diversity 2024).

In this report, we concentrate on Target 2 of the Kunming-Montreal GBF, with special focus on restoration of Mangrove ecosystems in India.

## Target 2

## Restore 30% of all Degraded Ecosystems

"Ensure that by 2030 at least 30% of areas of degraded terrestrial, inland water, and coastal & marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity" (CBD 2024).


The framework recognizes and highlights that habitat degradation is one of the most debilitating effects that human activities have caused on the natural world, with it the importance of reversing those effects to build back a healthier landscape as well. The target includes terrestrial, inland water, marine, and coastal ecosystems, and stipulates that 30% of each be initiated on effective restoration by 2030.

## Mangrove forests

Mangroves forests are salt-tolerant evergreen forests found in tropical and subtropical coastal areas (approx. between 320 N and 380 S), especially where the sea meets the land, in backwater creeks and river estuaries. The best mangrove forests are found where freshwater and seawater mix regularly, where annual rainfall is above 200 cm and the temperature stays above 20 OC throughout the year (Saenger et al. 1983; Ragavan et al. 2019). These hardy plants are adapted to both freshwater and highly salty water, sometimes even twice as salty as seawater.

They grow well in muddy areas with low oxygen and changing tides (Ragavan et al. 2019). Being specialized to survive in such extreme conditions, mangroves have unique roles to play in this ecotone.

## Ecological importance

Their tangled roots and shallow waters create safe breeding grounds for many fish and small invertebrates (Worthington & Spalding 2019) which also supports local fisheries and sustains the marine food chain. Mangroves are also excellent at storing carbon, keeping it locked in their wood and soil for a long time which helps fight climate change. They absorb excess nutrients, reduce ocean acidification, and trap microplastics, making them important for a healthy environment (FSI 2023). Mangroves help protect coastlines from tsunamis, storms, and soil erosion. Their roots trap sediments and act as a natural barrier. This also reduces costs in loss and repair from calamities (Worthington & Spalding 2019). Mangroves are also a low-cost option, they are self-repairing, and in many places, they are even able to keep up with rising seas. Protecting and restoring mangroves is now seen as an important step for both environmental conservation and sustainable coastal management (Worthington & Spalding 2019).

## Indian Mangroves

Globally, mangroves cover about 137,760 km$^2$ across 118 countries (Giri et al. 2011) where Indian mangroves represent 3.3% of global mangroves and about 56% of global mangrove species. The mangrove habitat of India is broadly divided into three types: deltaic mangroves (eastern coast mangroves), estuarine & backwater mangroves (western coast mangroves), and insular mangroves (those of the Andaman and Nicobar Islands) (Mandal & Naskar 2008).

They are found along the coastlines of nine states and four union territories on the eastern and western coast of the mainland, and on the Islands of Andaman & Nicobar and Lakshadweep (Ragavan et al. 2019). The mangrove coverage is larger and more widespread on the east coast than on the west coast because of its distinctive geomorphological setting.

## Status

Mangrove coverage in India has increased significantly in the last decade. Estimates by the Forest Survey of India show a net increase of 875 km2 during 1987–2017, with a mean annual increase in mangrove coverage of 30.21 km2; the extent of the increase was 112 km2 between 2013 and 2015 and 181 km2 between 2015 and 2017 (FSI 2017).

Although there's an increase in the area, there are inadequacies in most of the mangrove restoration programs from the last two decades, due to poor species selection and lack of understanding of mangrove dynamics. This calls for better understanding of mangroves and the effectiveness of existing conservation methods, and refinement of them for better management (Ragavan et al. 2019).

Hence, the ecological health of mangroves in India remains degraded, and implicit species loss has been witnessed despite mangrove expansion in many regions (Giri et al. 2008, 2015; Hamilton & Casey 2016). The scattered information and knowledge gaps are still a drawback for conservation and management of mangroves (Maxwell 2015).

## Major threats and causes for the loss of mangroves

Mangroves across the world face several serious threats, mainly from aquaculture and agricultural expansion, cutting of trees for timber, fuel & charcoal, pollution, invasive species, and the growing impacts of climate change—including hyper salinity, storm damage, changes in sediment flow, and land erosion. In addition, mangrove areas are being cleared for urban expansion and the development of coastal infrastructure such as roads and ports. These activities are especially common in regions with rapidly growing coastal populations (Worthington & Spalding 2019).

**Table 1. State wise threats for mangrove (Ragavan et al. 2019)**

| Indian states | Threats faced by mangrove ecosystems |
|---|---|
| **West Bengal** | Agriculture, prawn seed collection, reduction in freshwater flow and pollution |
| **Odisha** | Natural calamities, prawn farming, encroachment, and rehabilitation |
| **Tamil Nadu** | Reduction in freshwater flow, invasion of alien species, and over-exploitation of mangroves |
| **Andhra Pradesh** | Agriculture, grazing, developmental activities, invasion of alien species, and aquaculture |
| **Gujarat** | Over-exploitation of mangroves, developmental activities, natural calamities, and coral reef degradation |
| **Maharashtra** | Urbanization and pollution |
| **Karnataka** | Agriculture, tree felling, and pollution |
| **Kerala** | Unsustainable mode of aquaculture practices, mangrove wood for fuel, industrialization & urbanization, and bio-pollution |
| **Andaman & Nicobar Islands** | Agriculture, exploitations for wood and wood products, tourism development-encroachment, and natural calamities such as cyclone, storm & tsunami. |

In India, agriculture and shrimp farming are among the main causes of mangrove destruction, which in turn increases the intensity of coastal disasters. In the table below, the different types of threats at a regional level are discussed. In each state the mangroves are under threat due to the following reasons: A few signs of degradation include stunted trees or shrubs-like appearance, with broken canopy cover and patchy bare areas where dense forests once existed. The most common causes of this degradation include intensive harvesting of timber and fuelwood, reduced freshwater flow, and pollution events such as oil spills. For example, freshwater abstraction from the Indus River has greatly reduced water inflows into the Indus Delta, changing the species composition and biomass of mangroves. Other pressures such as sea level changes, cyclones, and flooding further worsen the condition of these ecosystems (Worthington & Spalding 2019).

## Species composition

India is the world's third richest nation in terms of mangrove plant diversity, trailing behind Indonesia and Australia. Out of the 46 genuine mangrove species, nine hold global significance as "species of conservation importance". India also has the world's highest recorded biodiversity of global mangroves and about 56% of global mangrove species within mangrove forests with a total of 4,107 species (23% flora and 77% fauna). Bhitarkanika in the state of Odisha is popularly known as the 'Mangrove Genetic Paradise' on a global scale (FSI 2023). Floristic compositions are influenced and altered by the constant flux due to both natural forces like sedimentation, erosion, and anthropogenic forces possibly leading to changes in composition and local extinction of some species. All mangrove species are at varying degrees of threat in India, with about 52% of them having low abundance and restricted distribution (Ragavan et al. 2019).

Some Indian mangrove floral species and their IUCN threat status:

**Critically Endangered:** *Sonneratia griffithii*
**Endangered:** *Heritiera fomes*
**Near Threatened:** *Aegialitis rotundifolia*, *Brownlowia tersa*, *Ceriops decandra*, *Phoenix paludosa*, *Sonneratia ovata*
**Least Concern:** *Avicennia marina*, *Cynometra iripa*,

*Excoecaria indica*, *Heritiera littoralis*, *Xylocarpus granatum*
**Data Deficient:** *Aglaia cucullata*

Although the global threat status of some of these species may not be cause for concern, it is important to know that this status might not hold the same locally underlining the need for local assessments or evaluation of threats and stressors it is subject to on ground.

On the other hand, the mangrove provinces that India has parts of are assessed to be experiencing varying degrees of threat as well.

**Southern India - Sri Lanka - CR**
**Western India and Pakistan- VU**
**Bay of Bengal and Andaman- LC**
**(Leal & Spalding 2024)**

## Protection of Mangroves in India

World over, degradation within protected areas is less than half those recorded from outside of protected areas. In India, mangroves found in protected areas represented 76,569.00 ha out of a total 403,784.62 ha. (18.96%) in 2020.

- Proportion lost outside protected areas 7.1%
- Proportion lost inside protected areas 3.6%
- Proportion of unprotected mangrove degraded 0.5%
- Proportion of protected mangrove degraded 0.1%

Although mangroves occur within protected areas, the level and the effectiveness of protection of these mangroves however are unknown. Protection should prevent some drivers of degradation, such as unsustainable timber extraction, and allow recovery. But degrading factors like upstream water abstraction or changes to sediment supplies, or coastal erosion and inundation driven by factors


that occur beyond the protected area boundaries cannot be controlled by the same laws and so some degradation could continue. These challenges point to a critical fact, that protected areas alone cannot conserve mangroves (Worthington & Spalding 2019).

## Past Projects

### Pre-Independence and Early Post-Independence Period (1900–1979): Baseline Management Era

During British administration, mangroves in the Sundarbans and Andaman Islands were managed mainly for timber and fuelwood (Blasco 1975; Banerjee et al. 1989). These activities were resource-driven and aimed at maintaining navigability and preventing erosion rather than ecological restoration.

By the 1960s and 1970s, state forest departments in West Bengal and Odisha began small-scale experimental plantations using Rhizophora and Avicennia species. However, due to limited understanding of hydrology and the use of monocultures, survival rates were often below 40% (Kathiresan & Rajendran 2005).

### 1980–1999: Institutionalization through the National Mangrove Management Programme (NMMB)

India formally began mangrove restoration efforts in the 1980s with the launch of the National Mangrove Management Programme (NMMB) under the Ministry of Environment and Forests (Singh 2001). The programme covered 38 mangrove sites, including areas in Gujarat, Tamil Nadu (Pichavaram, Muthupet), and Andhra Pradesh (Godavari delta).

For example, Gujarat's mangrove cover expanded from 397 km² in 1991 to 991 km² by 1997, mainly due to large-scale Avicennia marina plantations (Singh 2001). Although there was an increase in area, biodiversity recovery remained limited. The absence of community participation, inappropriate site selection, and short-term goals contributed to these shortcomings (Selvam et al. 2010; Giri et al. 2011).

### 2000–2019: Community-Based and Integrated Approaches

In the early 2000s, mangrove management shifted towards hydrological restoration and local participation. The M.S. Swaminathan Research Foundation (MSSRF) implemented the Pichavaram Eco-Restoration Project (2000–2007), restoring 1,477 ha through community-led tidal channel reopening and mixed-species planting, achieving a survival rate of 75–85% (Selvam et al. 2010).

Similarly, the Mahanadi Delta Project in Odisha Integrated Coastal Zone Management (ICZM) principles (World Bank 2015). Despite strong local engagement, funding limitations hindered long-term continuation (Ghosh et al. 2015).

Under the World Bank-funded ICZM Project (2010–2019), multi-stakeholder restoration initiatives in Andhra Pradesh, Gujarat, and Odisha covered over 20,000 ha. Gujarat's community-managed afforestation, supported by private entities, resulted in an 8,300 ha increase in mangrove cover and a 31% rise in fisheries income. These projects demonstrated the value of public-private partnerships, livelihood integration, and scientific baseline mapping, though issues like fragmented monitoring and poor post-project maintenance persisted (Roy et al. 2018).

### 2020–2025: Blue-Carbon and Climate-Resilient Approaches

The current decade aligns mangrove restoration with climate policy, blue-carbon initiatives, and Sustainable Development Goals (SDGs). The MISHTI Programme (2023–present) integrates mangrove conservation into India's Nationally Determined Contributions (NDCs), aiming to enhance shoreline protection and local livelihoods (MoEFCC 2023). The programme operates through joint efforts of government agencies, NGOs, and corporate CSR partners across Gujarat, Maharashtra, Odisha, and Tamil Nadu.

However, implementation challenges remain. For example, in Mumbai, Shaham (2025) observed that 52% of restored sites showed minimal recovery after a decade due to plastic accumulation, invasive species, and poor hydrological maintenance. Broader concerns include urban pollution, funding discontinuities, and inconsistent monitoring frameworks (Bhattacharjee et al. 2025; Mongabay India 2025).

### MISHTI Programme (2023–Present)

The Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI) was launched after India joined the Mangrove Alliance for Climate at COP27 (2022). It focuses on increasing mangrove cover along coastlines and saltpan lands, particularly in the Sundarbans Delta, Hooghly Estuary, and other key wetland regions.

Announced in the Union Budget 2023–24, MISHTI aims to restore approximately 540 km² of mangroves across nine States and three Union Territories over five years, promoting mangroves as vital ecosystems for carbon sequestration, coastal protection, and livelihood security.

The programme identifies four types of areas for restoration:

1. Areas submerged all day with freshwater infusion,
2. Areas with partial freshwater availability,
3. Tidal areas without freshwater infusion, and
4. Non-tidal areas without freshwater.

By 2025, about 22,560 ha of land had been brought under restoration across 13 states/UTs. Most progress occurred in Gujarat (19,220 ha), followed by Tamil Nadu (1,060 ha), Andhra Pradesh (837 ha), and Odisha (761 ha). West Bengal, despite holding the largest mangrove cover (about 2,119 km²), saw only 10 ha of new plantation.

Prime Minister Narendra Modi highlighted Gujarat's success during Mann Ki Baat, noting that mangrove plantations near Dholera now span 3,500 ha, with increased sightings of dolphins, crabs, and migratory birds. Overall, while MISHTI represents a strong national push for restoration, its success will depend on addressing site-specific challenges, sustained funding, and continued local participation.

## Alignment with India's Commitments (NBSAP Goals)

India's national and state-level frameworks emphasize restoring degraded ecosystems - terrestrial, inland water, and coastal with a target of bringing 30% of degraded ecosystems under active restoration by 2030. Policies call for:

- Strengthening ecological connectivity and integrity,
- Promoting ecosystem-based and nature-based solutions,
- Supporting sustainable livelihoods to reduce dependence on natural resources, and
- Encouraging public and private sector investment in restoration and habitat improvement.

## Indicators

All restoration efforts should include appropriate indicators that not only help evaluate the effectiveness of a project but also inform on ways we could alter the approach for better outcomes. It is prudent to have specific indicators at different stages of the process based on the progressive changes that finally lead to an expected outcome. Some indicators that are included in the updated National Biodiversity Strategy and Action Plans (NBSAP) 2024–2030 under Target 2 which are relevant to mangrove restoration are as follows,

- Headline indicator—2.1 Area under restoration
- Component indicators—Land degradation
- Complementary indicator—proportion of Key Biodiversity Areas in favourable condition.
- Other national indicators:
- 2.2 Trends in aquatic ecosystems
- 2.3 Trends in mangrove cover and coastal management
- 2.5 Trends in afforestation and restoration
- 2.9 Extent of restoration of degraded wetlands

The following indicators have to be quantified and recorded at the beginning and during the process of restoration to first establish a baseline and then evaluate the progress made (SWAMP). Apart from these above-mentioned general indicators, there are also some of the specific indicators that can be

used in various aspects to assess progress from different components.

## Physico-chemical indicators

Carbon sequestration: As per Worthington & Spalding (2019) this being one of the common objectives while planting mangroves, the same can be used to evaluate mangrove restoration success as well. India shows a high likely gain from restoration in terms of tons of carbon in the upper meter of soils in restorable areas, a combination of novel carbon sequestration and avoided losses from remaining carbon still found in the soils.

- Sediment properties: Metrics like bulk-density, organic matter, total carbon, total nitrogen, and total phosphorus.
- Hydrology: Water level, pH, frequency, and duration of flooding in the site determines the salinity, nutrient availability and hence the growth of seedlings. Continued monitoring of hydrological factors like hydroperiod, availability of different sources of water can help monitor progress of the operation.

## Biological indicators

- Recruitment, seedling survival, and growth rate: The growth and survival of seedlings can be monitored and recorded at regular intervals and the total percentage survival is used to evaluate the effectiveness. This rate varies with species and can be affected by the suitability of the method used.
- Species composition: Successful restoration manifests in the recolonization and persistence of biotic elements that were associated with a habitat prior to degradation along with the species composition and diversity of the mangrove flora itself. These can be specific flora and fauna that depend on a mangrove ecosystem. For example, in India there are 188 plant species and several species of fish, macroinvertebrates, birds, and reptiles documented to be associated with mangroves that often expand their range into the hinterland mangrove environments (FSI 2023). Realistically, these elements cannot be introduced but can only return in the presence of suitable conditions and resources, and hence they make an excellent natural indicator to evaluate the effectiveness of a restoration effort.
- Vegetation cover: This is more suitable for long-term evaluation or that which employs assisted natural regeneration methods of restoration. It can be quantified using GIS, remote sensing, and Landsat data. This can also be used to evaluate the area brought under effective restoration at the end of 2030 which is a direct indicator of Target 2.

## Recommendations for Effective Mangrove Conservation (2025–2030)

### 1. Defining Clear Pathways for Implementation

To achieve the objectives of the Kunming-Montreal Global Biodiversity Framework the restoration and conservation strategies for mangroves must be clearly defined- including what needs to be done, how, when, and where, along with an upfront assessment of costs, risks, and responsibilities. Without this clarity, even well-intentioned projects risk falling apart and inefficiency.

### 2. Addressing Knowledge Gaps in Indian Mangroves

Indian mangroves remain underexplored in many scientific and ecological aspects. Major gaps exist in understanding forest structure, faunal & genetic

diversity, soil properties, microbial communities, and ecosystem service valuation (Ragavan et al. 2019). Filling these knowledge gaps through systematic, long-term studies is essential for informed management and effective restoration.

As ecological diversity declines globally, the conservation focus has shifted from protecting individual species to safeguarding entire ecosystems. This move toward ecosystem-based management recognizes that mangrove health depends on the complex relationships between living organisms and their environment (Ragavan et al. 2019).

### 3. Integrating Science into National-Level Policy

At the national level, mangrove policy and planning often lack a comprehensive understanding of how different mangrove habitat's function and vary along India's coasts, both ecologically and socially. Since mangrove ecosystems are dynamic and sensitive to change, understanding these interconnections is crucial. Strengthening research on hydrology, biodiversity, and socio-economic factors will enable long-term, integrated, and ecosystem-based management frameworks that preserve mangrove biodiversity and ecological integrity (Ragavan et al. 2019).

### 4. Strengthening Baseline Knowledge and Floristics

The floristic diversity of India's mangroves has not been adequately studied in recent decades (Ragavan et al. 2019). Updated floristic surveys are needed to confirm correct species identification, resolve taxonomic uncertainties, and map accurate distributions along both the east and west coasts. Special attention should be given to rare and threatened species, ensuring that their populations are supported through propagation and assisted regeneration.

### 5. Monitoring and Adaptive Management

Mangrove restoration should be scientifically monitored using hydrological, biological, and sediment-based indicators. These help evaluate short, medium, and long-term restoration outcomes. Regular monitoring enables adaptive management, where interventions are adjusted based on observed results, improving the likelihood of achieving project goals.

However, inadequate monitoring and lack of adaptive management remain widespread. Many projects are treated as one-time planting events without 3–5 years of follow-up, meaning mortality is not corrected and lessons are not learned (Lovelock; Frontiers). Building long-term, data-based management into every project is critical to ensure ecological success and accountability.

### 6. Community-Based Conservation and Local Stewardship

Successful mangrove conservation depends on active community participation. Involving local people from the earliest planning stages through implementation and evaluation creates local ownership and ensures sustainability.

Several studies have shown the success of community-based approaches, such as those in Probolinggo (Pribadiningtyas et al. 2013), Tiwoho (Nurrani et al. 2015), Bekasi (Yuliani & Herminasari 2017), Pasawaran (Alfandi et al. 2019), and Mempawah (Roslinda et al. 2021). In India, initiatives like "Putri Gundul" in Lembur Mangrove Patikang have demonstrated that persuasive, educative, and facilitative methods can restore up to 50% of degraded mangrove areas. Nearly 94% of participants in such programs reported understanding mangrove management and silviculture, proving that knowledge and involvement go hand in hand with ecological success.

### 7. Promoting Mangrove Ecotourism for Livelihoods and Awareness

Mangrove ecotourism can unite conservation with community development. Properly managed, it serves as a platform for research, education, and public awareness, while generating livelihoods. In several regions, community income has increased by over 45% following the development of ecotourism, showing that conservation can directly improve local economies.

Ecotourism also helps establish integrated management systems that reduce disaster risks while promoting environmental and social resilience.

### 8. Adopting Ecosystem-Based Adaptation (EbA)

Mangroves enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change. Implementing Ecosystem-based Adaptation (EbA), a nature-based solution that harnesses ecosystem services to buffer climate impacts, can help coastal communities adapt to sea-level rise, erosion, and extreme weather events. This approach aligns directly with the Kunming–Montreal targets on climate adaptation and biodiversity mainstreaming.

### 9. Strengthening Governance, Inclusivity, and Coordination

Despite numerous programs, mangrove management in India suffers from fragmented governance and poor coordination among government agencies, NGOs, scientists, and local communities. This leads to duplication, unclear responsibilities, and inconsistent results.

Lack of inclusivity in decision-making also limits success. When local communities are excluded, projects fail to gain long-term custodianship and local protection. Strengthening governance means fostering coordination, data sharing, and accountability across all institutions, while ensuring communities are genuine partners, not passive beneficiaries.

### 10. Building Meaningful Collaborations and Accountability

Mangrove conservation must become a shared mission involving researchers, government departments, civil society, and private industries. International commitments already recognize the importance of mangroves, but they must be implemented through on-ground collaboration.

Industries that damage mangrove through construction, aquaculture, or land conversion should be held accountable and required to report transparently on their impacts. Conversely, industries can also be part of the solution by supporting restoration projects and offsetting their environmental footprints. Collaboration between government, academia, and industry can bridge funding and knowledge gaps, making mangrove conservation both economically viable and ecologically sound.

### Conclusion

As the Kunming–Montreal Global Biodiversity Framework sets the theme for countries to pursue shared global goals, it offers both ambition and direction. While the targets are undoubtedly challenging, they provide a collective vision and help guide nations to reimagine a sustainable future. At the very least, to stay on the right track toward ecological balance.

In the context of mangroves, these goals bring nations to restore livelihoods, strengthen coastal resilience, and advance climate action. Restoration can directly support local communities, to meet their conservation and carbon reduction commitments.

Yet, despite this promise, the practice of restoration often remains rooted in outdated or repetitive approaches, rather than being guided by the evolving science of ecological restoration or the nuanced realities of specific ecosystems. The race to appear "green" has, at times, overlooked the ecological and social consequences of poor restoration choices, including the wrong selection of species or the neglect of local context (Roy & Fleischman 2022)

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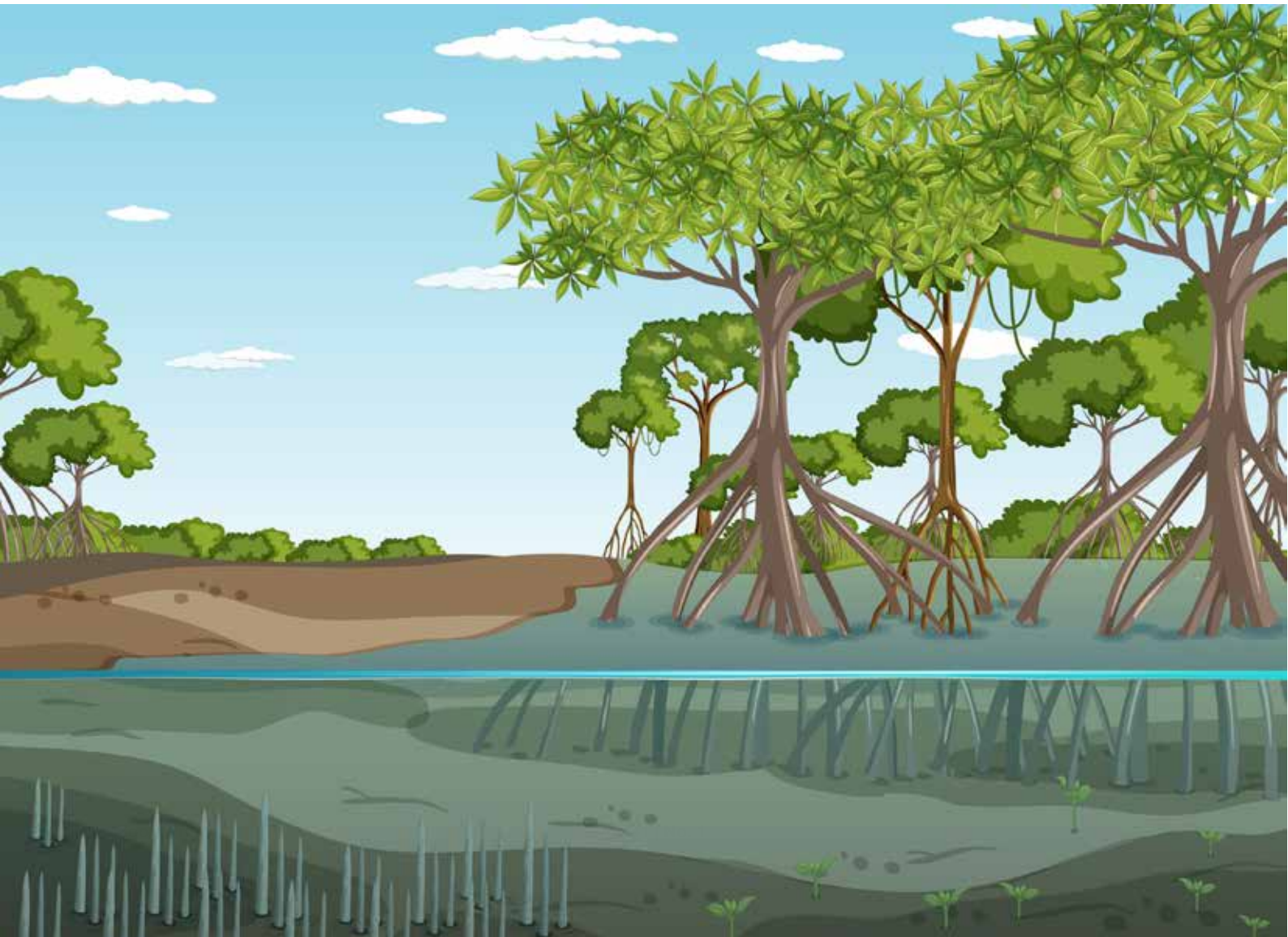

# Fulfilling India's Commitment to Seagrass Restoration in accordance with the Kunming-Montreal Global Biodiversity Framework (Target 2)

## Introduction

The global ocean has 0.1–0.2% of seagrass cover (Duarte 2002). More than 177,000 km2 is the global seagrass coverage of which 30.61% of the total seagrass species is found across the Indian coast (Sachithanandam et al. 2022). Seagrasses are underground flowering plants (Patro et al. 2017), found in shallow marine waters (Geevarghese et al. 2018) along all the tropical temperate coastlines (Prabhakaran et al. 2021). De Groot et al. (2002) classifies 23 ecosystem services provided by seagrasses, they are one of the most highly productive ecosystems (Koshy et al. 2018), yet one of the most threatened globally. Since 1990's they are declining at a rate of approximately 7% (Koshy et al. 2018). Post industrial revolution 30% of the world's seagrass has been lost (York et al. 2017). Unlike other coastal ecosystems such as mangroves and coral reefs, seagrasses don't gain much attention both in scientific research and coastal management plans (Sachithanandam et al. 2022).

## Historic Status of Seagrass Systems in India

Seagrass ecosystems are one of the most poorly studied areas in India and still remains one. Much research needs to be conducted to assess the status at both ecosystem and species level. Since the 1880s seagrass occurrence has been recorded in India and 1959 onwards, literature on seagrass from India is available after it gained attention in the 1950s (Thangaradjou & Bhatt 2018). Particularly in the late 90s and early 2000s, research activities started gaining momentum. Seagrass habitats in India are mainly limited to mudflats and sandy regions, extending from the lower intertidal zone to the depth of 10–15 m along the open shores and lagoons around the islands (Ranith et al. 2024).

## Current Status of Seagrass Ecosystems in India

## Species Diversity

India's coastal waters host 16 recognized seagrass species across seven genera (Patro et al. 2017; Thangaradjou & Bhatt 2018). Molecular studies, including DNA barcoding and fingerprinting, have largely confirmed the taxonomic distinctness of these species, like separating Halophila ovalis from H. ovata, and even suggest potential for discovering further diversity (Mishra & Apte 2021]; Thangaradjou & Bhatt 2018). Karyomorphological data exists for 11 species (Mishra & Apte 2021). Recent field surveys have expanded regional lists, with Halophila decipiens found in deeper waters (6–12 m) of the Andaman & Nicobar Islands (ANI), making it the 11th species recorded there (Immanuel et al. 2016). Dilipan et al. (2018) states that the most recent species of seagrass is Enhalus. Additionally, the IUCN Red List 'Vulnerable' species, H. beccarii ('Ocean Turf Grass'), was newly documented within a restored mangrove site in Kerala (Prabhakaran et al. 2020; Mishra & Apte 2021).

**Table 1. Seagrass species found in India.**

| | Species | Distribution | Reference | IUCN Red List status |
|---|---|---|---|---|
| 1 | *Enhalus acoroides* | Kerala, Tamil Nadu (Gulf of Mannar, Palk Bay) | Geevarghese et al. 2018; Thangaradjou & Bhatt 2018; Short & Waycott 2007 | Least Concern |
| 2 | *Halophila ovalis* | Gujarat, Goa, Kerala, Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Andhra Pradesh, Odisha, West Bengal, Lakshadweep, Andaman & Nicobar Islands. | Thangaradjou & Bhatt 2018; Short 2007 | Least Concern |
| 3 | *H. ovata* | Gujarat, Tamil Nadu (Gulf of Mannar, Palk Bay), Andhra Pradesh, Odisha, West Bengal, Lakshadweep, Andaman &Nicobar Islands. | Thangaradjou & Bhatt 2018; Short & Waycott 2007g | Least Concern |
| 4 | *H. decipiens* | Maharashtra, Tamil Nadu (Gulf of Mannar, Palk Bay), Lakshadweep and Andaman Islands. | Immanuel et al. 2016; Thangaradjou & Bhatt, 2018; Short et al. 2007f | Least Concern |
| 5 | *H. stipulacea* | Tamil Nadu (Gulf of Mannar, Palk Bay) and Andaman Islands. | Thangaradjou & Bhatt 2018; Short et al. 2007h | Least Concern |
| 6 | *H. beccarii* | Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Andhra Pradesh, Odisha and West Bengal. | Thangaradjou & Bhatt 2018; Short et al. 2007e | Vulnerable |
| 7 | *H. ovalis ramamurthiana* | Tamil Nadu (Palk Bay, other sites), Andhra Pradesh, Odisha. | Geevarghese et al. 2018; Thangaradjou & Bhatt 2018 | Not assessed |
| 8 | *H. minor* | Odisha and Andaman Islands. | Thangaradjou & Bhatt 2018; Short et al. 2009 | Least Concern |
| 9 | *Thalassia hemprichii* | Gujarat, Tamil Nadu (Gulf of Mannar, Palk Bay), Lakshadweep, Andaman & Nicobar Islands. | Sachithanandam et al. 2022; Thangaradjou & Bhatt 2018; Short et al. 2007i | Least Concern |
| 10 | *Syringodium isoetifolium* | Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Lakshadweep, Andaman & Nicobar Islands. | Thangaradjou & Bhatt 2018; Short et al. 2008b | Least Concern |
| 11 | *Cymodocea serrulata* | Gujarat, Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Lakshadweep, Andaman & Nicobar Islands. | Geevarghese et al. 2018; Thangaradjou & Bhatt 2018; Short et al. 2008a | Least Concern |
| 12 | *C. rotundata* | Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Lakshadweep, Andaman & Nicobar Islands | Thangaradjou & Bhatt 2018; Short & Waycott 2007a | Least Concern |
| 13 | *Halodule pinifolia* | Gujarat, Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Andhra Pradesh, Odisha, West Bengal, Lakshadweep, Andaman & Nicobar Islands. | Sachithanandam et al. 2022; Thangaradjou & Bhatt 2018; Short et al. 2007b | Least Concern |

| | Species | Distribution | Reference | IUCN Red List status |
|---|---|---|---|---|
| 14 | *H. uninervis* | Gujarat, Tamil Nadu (Gulf of Mannar, Palk Bay, other sites), Andhra Pradesh, Odisha, West Bengal, Lakshadweep, Andaman & Nicobar Islands. | Geevarghese et al. 2018a; Sachithanandam et al. 2022; Thangaradjou & Bhatt 2018; Short et al. 2007c | Least Concern |
| 15 | *H. wrightii* | Tamil Nadu (Gulf of Mannar, Palk Bay, Other sites), Andhra Pradesh, and West Bengal. | Thangaradjou & Bhatt 2018; (Short et al. 2007d | Least Concern |
| 16 | *Rupia maritima* | Gujarat, Tamil Nadu (Gulf of Mannar) and Odisha. | Thangaradjou & Bhatt 2018 | No mention as seagrass on internet/ IUCN website |

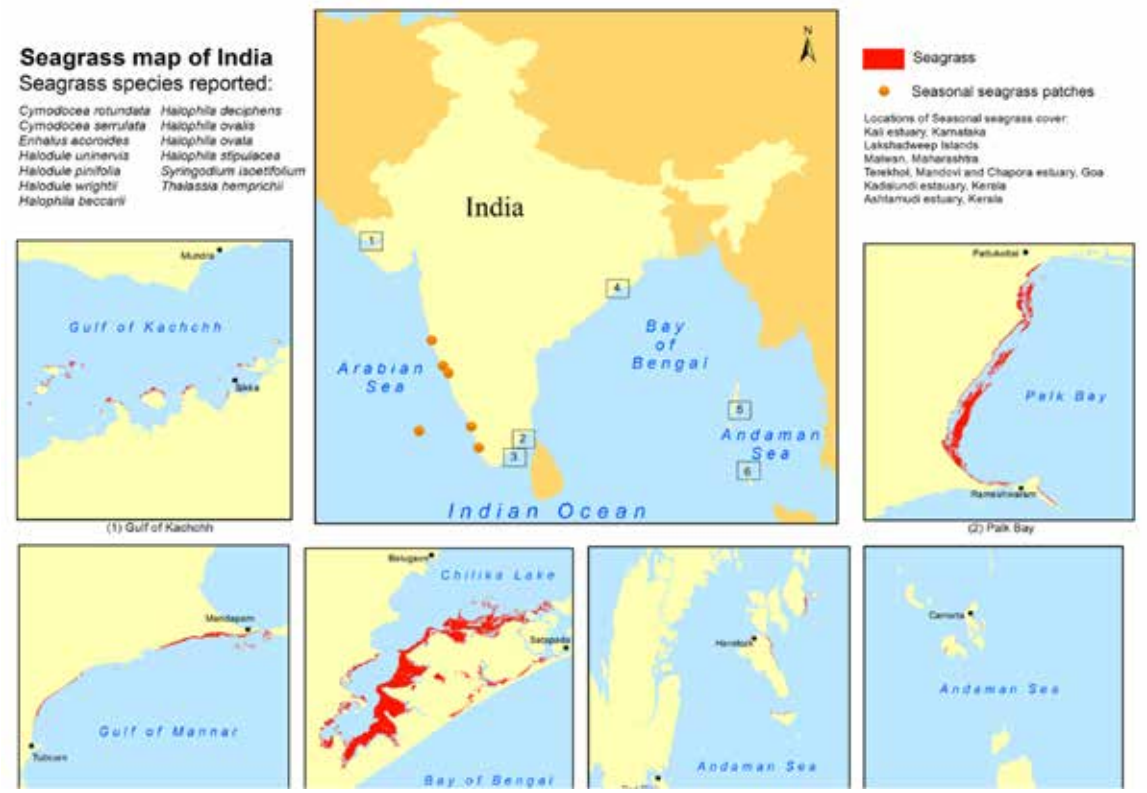


**Image source: Map of Seagrass Distribution patterns in India (Geevarghese et al. 2018).**

## National Extent & Distribution

The most comprehensive recent national estimate suggests India's total seagrass cover spans 516.59 km2 (Geevarghese et al. 2018). This figure was derived using Landsat 8 OLI satellite data, crucially applying standardized atmospheric and water column corrections for improved mapping accuracy (Geevarghese et al. 2018). Seagrass distribution is concentrated in several key regions:

- Map of Seagrass Distribution patterns in India (TNGCC 2024).
- Palk Bay and Gulf of Mannar (Tamil Nadu): Holding approximately 77% of the national total (398.81 km2), this area boasts the highest species diversity (up to 14 species) (Patro et al. 2017; Geevarghese et al. 2018; Thangaradjou & Bhatt 2018).

Chilika Lake (Odisha): Significant area estimated at 85.47 km2 (pre-monsoon), known for seasonal variations and hosting 8 species (Geevarghese et al. 2018; Thangaradjou & Bhatt 2018).

Gulf of Kachchh (Gujarat): Supports 16.99 km2 of seagrass, with 8 species recorded (Geevarghese et al. 2018; Thangaradjou & Bhatt 2018).

Andaman & Nicobar Islands (ANI): Estimates vary; 14.6 km2 mapped comprehensively (Geevarghese et al. 2018), though other studies suggest up to 29.43 km2 (Nobi et al. 2013). Hosts 12+ species (Savurirajan et al. 2015; Immanuel et al. 2016; Thangaradjou & Bhatt 2018).

Lakshadweep Islands: Shows a marked decline, with only 0.72 km2 mapped recently in two key islands (Geevarghese et al. 2018). Hosts 10 species (Thangaradjou & Bhatt 2018).

West Coast Patchiness: Smaller, often seasonal patches, particularly of H. beccarii, occur in estuaries and mangrove areas of Kerala, Karnataka, Goa, and Maharashtra (Arunachalam & Nair 1988; Patro et al. 2017; Prabhakaran et al. 2020; Mishra & Apte 2021).

## Ecological Characteristics

Indian seagrasses inhabit diverse coastal habitats from intertidal zones to subtidal depths (~15–20 m), growing on substrates like mud, silt, sand, and coral debris (Arunachalam & Nair 1988; Immanuel et al. 2016; Patro et al. 2017; Geevarghese et al. 2018). Their growth is influenced by temperature (24–34.5 0C), salinity (18–39 ppt, wider for estuarine species), pH (6–8.9), light availability (affected by turbidity), and nutrient levels (Govindsamy & Arulpriya 2011; Thangaradjou & Bhatt 2018; Mishra & Apte 2021). Biomass typically peaks post-monsoon (Govindsamy & Arulpriya 2011). These highly productive meadows support rich biodiversity (>1250 associated species reported), cycle nutrients, sequester significant carbon (Blue Carbon), stabilize sediments, and attenuate waves (Prabhakaran et al. 2013; Patro et al. 2017; Thangaradjou & Bhatt 2018; Sachithanandam et al. 2022). Concerns exist regarding heavy metal contamination (e.g., Cadmium in Lakshadweep) (Thangaradjou et al. 2013; Thangaradjou & Bhatt 2018). Home to ~750 fish species, 121 other threatened species, although there has been no exclusive study on the flora and fauna associated with seagrasses in India, 1250 number of species it supposedly is in association with (Duarte et al. 2025).

## Trends & Evidence of Degradation

A consistent theme is the decline and degradation of India's seagrass ecosystems due to multiple stressors (Koshy et al. 2018; Mishra & Apte 2021). Global decline has been 1–2% in the past century and nearly 5% of species of seagrass are currently listed as endangered (Duarte et al. 2025). Quantified Losses: Losses have been documented in several regions: Lakshadweep (73 ha lost 2000–2008, with significant further decline suggested) (Nobi & Thangaradjou 2012; Geevarghese et al. 2018); ANI (catastrophic 1619 ha loss post 2004 tsunami, plus 32–68% loss in specific bays after Cyclone Lehar 2013) (Nobi et al. 2013; Sachithanandam et al. 2022); Palk Bay/GoM (historical declines of 9–28% reported in specific studies/periods) (Thangaradjou & Bhatt 2018); and decline of the vulnerable H. beccarii, especially on the west coast (Mishra & Apte 2021).

## Major Threats

Anthropogenic Factors: Key human-induced pressures include coastal development (dredging, construction leading to habitat loss, and turbidity), pollution (Zhang et al. 2023) (nutrient enrichment from sewage/agriculture/aquaculture causing eutrophication and algal blooms; industrial contaminants; solid waste), and destructive fishing practices (bottom trawling, damaging gear like push nets/shore seines, anchoring) (Govindsamy & Arulpriya 2011; Patro et al. 2017; Koshy et al. 2018; Ramesh et al. 2018; Mishra & Apte 2021; Sachithanandam et al. 2022). Major anthropogenic

threats stated by the global forum being the degradation caused by oil spills and excessive tourism activities (GSERWIO 2019).

Natural/Climatic Factors: Natural and climate-related threats include extreme weather events like cyclones and tsunamis causing severe physical damage and sedimentation (Nobi et al. 2013; Sachithanandam et al. 2022); tectonic events causing land uplift (ANI post-tsunami) (Nobi et al. 2013; Patro et al. 2017); climate change impacts (sea-level rise, warming, acidification, increased storminess) (Ramesh et al. 2018); and biological pressures such as intense grazing by protected Green Turtles in Lakshadweep (Koshy et al. 2018; Ramesh et al. 2018).

India currently employs several legislative and policy tools that provide a framework for seagrass conservation, aligning with national goals (like the NBSAP) and contributing towards global targets like the Kunming-Montreal GBF Target 2.

## Existing Legal Protections

Seagrass meadows are designated as Ecologically Sensitive Areas (CRZ-IA) under the Coastal Regulation Zone (CRZ) Notification (2011), which restricts most new development activities within these zones. Mapping under CRZ provides a legal basis for spatial protection (Patro et al. 2017; Ramesh et al. 2018; Mishra & Apte 2021).
The Wildlife (Protection) Act, 1972 offers indirect protection through the establishment of Marine Protected Areas (MPAs) (like Gulf of Mannar Marine National Park) that encompass significant seagrass habitats, and by legally protecting associated endangered species like the Dugong (Schedule I) (Patro et al. 2017; Ramesh et al. 2018).

Pollution impacting seagrass is addressed through the Water (Prevention and Control of Pollution) Act, 1974 and rules under the Environment (Protection) Act, 1986 concerning effluent standards. The Coastal Aquaculture Authority Act, 2005 includes provisions for managing aquaculture waste (Ramesh et al. 2018).

Destructive fishing practices can be regulated under State Marine Fishing Regulation Acts (MFRAs) (Ramesh et al. 2018).

The Biodiversity Act, 2002, provides mechanisms like declaring Biodiversity Heritage Sites (BHS) and establishing local Biodiversity Management Committees (BMCs), which can be leveraged for seagrass conservation (Ramesh et al. 2018).

## Policy Recognition

The National Policy on Marine Fisheries (NPMF), 2017 explicitly recognizes the ecological importance of seagrasses and the need to protect them from anthropogenic impacts (Ramesh et al. 2018; Mishra & Apte 2021).

## Mapping and Monitoring Efforts

A national-level geospatial assessment using standardized remote sensing techniques has provided a crucial baseline estimate of seagrass extent (516.59 km2) (Geevarghese et al. 2018). Community-based monitoring initiatives like Seagrass-Watch exist in some areas (Patro et al. 2017).

## Restoration Examples

While large-scale restoration is limited, successful natural recovery observed in Chilika Lagoon after hydrological interventions demonstrates potential when stressors are removed (Koshy et al. 2018). The colonization of restored mangrove areas by H. beccarii also indicates recovery potential (Prabhakaran et al. 2020). Geospatial techniques have been used to identify potential restoration sites based on past cover (Nobi et al. 2013). GSERWIO 2020 provides general considerations for seagrass restoration, elaborate restoration

methods, restoration site identification, a restoration protocol, monitoring & management plan precise directions, methods of seagrass restoration, site identification, selection criteria, stakeholder engagement, community participation, multidisciplinary approach, spacing- planting units, time frame, monitoring & evaluation techniques, indicators have been provided through actual documentation, and case studies from Mozambique. ('GSERWIO.pdf',n.d.)

## Current Initiatives

In Odisha, IIT-Bhubaneswar with Enhancing Climate Resilience of India's Coastal Communities (ECRICC) Project (supported by Green Climate Fund (GCF) implemented in partnership with the Ministry of Environment, Forest and Climate Change (MoEF&CC) and the government of Odisha) aims at ecosystem-based restoration of seagrass through scientific research and community engagement (Statesman News 2025).

A report on Strengthening Coastal Resilience and the Economy – Tamil Nadu (TN-SHORE) for "Enhancing the Coastal Community's Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar, Tamil Nadu" by Department of Ocean Engineering, IIT Madras, a Tamil Nadu government initiative supported by World Bank, says to restore ecological services by rehabilitation of seagrass as a climate adaptation strategy. During this project three acres of degraded seagrass bed to be restored in 17 seagrass sites (DOE, IIT Madras Report 2025).

In the states of Andhra Pradesh, Maharashtra, and Odisha, Ministry of Environment, Forest and Climate Change (MOEF&CC) has initiated project on "enhancing climate resilience of India's coastal communities" supported by Global Climate Fund (GCF), which aims to work for climate resilience of coastal communities by protecting and restoring 24 natural ecosystems, one being seagrass (Press release, 2022).

Developing Participatory (involving local fishermen communities), Eco-friendly and Low-cost Seagrass restoration method (2016 - 2022) in Palk Bay and Gulf of Mannar by OMCAR in collaboration with PANORAMA foundation. ('Developing Participatory, Eco-friendly and Low-cost Seagrass restoration method (2016 - 2022) | PANORAMA',n.d.)

## Strategies

Achieving significant restoration and ensuring the long-term health of India's seagrass meadows requires dedicated future actions that are built upon existing frameworks, and the following strategies aim to align with national biodiversity goals (NBSAP) and international commitments like the Kunming-Montreal Global Biodiversity Framework (GBF), particularly focusing on restoring 30% of degraded ecosystems by 2030, as included in Target 2:

- The goal to restore 30% of degraded coastal ecosystems by 2030 directly applies to India's seagrass meadows, where significant losses and degradation have been documented (Nobi & Thangaradjou 2012; Nobi et al. 2013; Paulose 2013; Thangaradjou & Bhatt 2018; Sachithanandam et al. 2022). Future strategies must focus on identifying these degraded areas and implementing effective restoration to meet this target.
- NBSAP doesn't have any exclusive provision for the seagrass conservation/restoration mentioned under National Biodiversity Targets and Monitoring Framework (MoEFCC 2024). Definition and integration of actionable relevant to India to fulfil the KMGBF Target 2 include:

## Action 1: Prioritize Restoration Sites

Future efforts require a systematic national inventory and assessment to identify and quantify degraded seagrass areas suitable for restoration, based on factors like documented historical loss (e.g., ANI, Lakshadweep), ecological significance, feasibility, and the potential to manage threats effectively (Nobi et al. 2013; Koshy et al. 2018; Thangaradjou & Bhatt 2018; Sachithanandam et al. 2022). Geospatial suitability modeling can aid this process (Nobi et al. 2013). Assessment and inclusion of seagrass ecosystems of India on IUCN Red List for ecosystems is the need of the hour since no seagrass ecosystems have been assessed. ('IUCN Ecosystems',n.d.)

## Action 2: Implement Effective Restoration

Meeting the 30% target necessitates active restoration interventions. This involves researching, standardizing, and scaling up cost-effective techniques like transplantation of shoots/rhizomes, or potentially seed-based methods, tailored to Indian species and conditions. Careful site selection, use of appropriate & genetically diverse donor populations, and facilitating natural recovery by removing stressors are crucial for success (Nobi et al. 2013; Koshy et al. 2018; Thangaradjou & Bhatt 2018; Prabhakaran et al. 2020). Following the restorative continuum provided by the SER and the general/specific restoration guidelines of the KM-GBF Target 2 necessitates immediate action. (Delivering restoration outcomes for biodiversity and human well-being 2024).

## Action 3: Threat Mitigation

Restoration success is fundamentally linked to reducing ongoing pressures. Future strategies must emphasize rigorous enforcement of existing environmental laws (CRZ Notification, Water Act, EPA rules, MFRAs) to curb impacts from unmanaged coastal development, pollution (sewage, industrial, agricultural, aquaculture), and destructive fishing practices (trawling, damaging gear, anchoring) (Ramesh et al. 2018; Mishra & Apte 2021). Ecosystem-based approaches are needed to resolve conflicts, such as managing turtle grazing impacts in Lakshadweep while respecting conservation laws (Koshy et al. 2018; Ramesh et al. 2018).

## Action 4: Strengthen Science and Monitoring

Addressing knowledge gaps is critical. Future research should prioritize restoration ecology, population dynamics, climate change impacts, resilience studies, genetic connectivity, and the economic valuation of seagrass ecosystem services (Koshy et al. 2018; Thangaradjou & Bhatt 2018; Mishra & Apte 2021). Building National Information System for Environmental Restoration (SNIRA), which will be an integrated platform for consolidated information about all the existing restoration projects in the country. SNIRA will have integrated datasets from projects using diverse restoration approaches, like ecological restoration and rehabilitation, implemented by government and non-government agencies, academic institutions, civil society, indigenous groups, and local communities, promoting transparency, collaboration, and ultimately sharing the best practices, errors made and lessons learned. Inclusion of advanced technological methods like remote sensing, GIS & drone based monitoring ,and photo/videographic records (Delivering restoration outcomes for biodiversity and human well-being 2024).

Establishing systematic, regular, and standardized national monitoring programs using consistent remote sensing and field verification protocols is essential to track trends and evaluate interventions (Geevarghese et al. 2018; Koshy et al. 2018; Thangaradjou & Bhatt 2018).

### Action 5: Enhance Policy and Governance

A primary future direction is the finalization and dedicated implementation of the recommended comprehensive National Plan of Action for seagrass conservation and management. Seagrass conservation needs further integration into broader coastal management frameworks like ICZM and MPA planning, and securing dedicated funding for research, monitoring, enforcement, and restoration is imperative (Koshy et al. 2018; Ramesh et al. 2018).

### Action 6: Community Engagement

Long-term success relies on involving local communities. Future strategies should actively utilize platforms like Biodiversity Management Committees (BMCs) and community monitoring programs (e.g., Seagrass-Watch), incorporating traditional knowledge and building local stewardship. Increasing public and policymaker awareness about the value of seagrass ecosystems is also crucial (Newmaster et al. 2011; Patro et al. 2017; Koshy et al. 2018; Ramesh et al. 2018; Mishra & Apte 2021).

## Success Indicators

The success of restoration of seagrass is low (globally 30% success) and cost of restoration is high (Van Der Heide et al. 2007). Short-term monitoring program doesn't give clear picture of successful restoration so long-term monitoring should be done to identify the success of restoration, e.g., seagrass restoration near Tampa Bay, Florida long-term monitoring showed seagrass recovery was slow during first three years and rapid recovery from fourth year (McSkimming et al. 2016). Assessment of increased water quality (Tomasko et al. 2018), area, habitat quality (shoot density) (Fonseca et al. 2000), species richness (McSkimming et al. 2016), and net change of seagrass population (shoot recruitment v/s mortality) (Short & Duarte 2001) using economic tools to compute replacement ratio (it is based on injured seagrass bed recovering themselves intrinsically in comparison to restoration efficacy) (e.g., using Habitat Equivalency Analysis (HBA)) (Fonseca et al. 2000) will help determine success of seagrass recovery.

## Categories:

- Species-specific monitoring indicators-
- Survival rates: Percentage (%) of the numbers of individual transplants that survived.
- Aerial coverage: Surface area (in m2) covered per planting unit should be recorded until coalescence.
- Shoot Density: Shoot density count.
- Braun Blanquet Score can be used to assess the success of restoration efforts in terms of species diversity, density and abundance (Bell et al. 2008).

## Conclusion

Based on the data provided above, we can conclude that an ecosystem-based recovery plan is of utmost requirement. Conservation of flagship species like Dugongs and Turtles are important, but conservation of seagrass is equally or more important since these are fodder/habitat for those species. Region wise and species-based seagrass studies are a necessity at the moment, since very little data is available in terms of quantitative threat assessment, considering the temporal aspects of seagrass system deterioration. Even the IUCN Red List has little to no data on threat assessment in the Indian context. The strategies section above reflects the immediate actionable. These actionable are a must for the achievement of the KM-GBF(T2) goals for a better future for seagrasses and dependent species.

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# Mentorship Trip Report: On the Plateaus of Kasargod

As part of the RHATC course (2025–26), we went for an eight-day mentorship programme in Kerala. The theme of our mentorship was "Ecological restoration of the lateritic plateaus of Kasargod, Kerala". During this period, we visited several lateritic plateau sites across Kasargod District. We were hosted by Shyamkumar Puravankara, an architect, local conservationist, and member of the Kasargod District Biodiversity Management Committee. He is interested in traditional and sustainable architecture and is an avid birder as well. Since he's committed towards conservation of northern Kerala's lateritic plateaus, he generously took us to various sites around the landscape to help us understand its unique ecology.

The first sight of a lateritic plateau left us amazed. As we visited during winter, the grasses were dry, resulting in vast golden stretches that seemed to glow in the sunlight. These plateaus are locally known as 'para'. They are formed through extensive weathering caused by rainfall, temperature variations, and wind. Rich in iron and aluminium, the soil of plateaus has a distinct reddish-brown colour. They are misclassified as wastelands; however, the hidden beauty of these plateaus is extraordinary. They form a mosaic of grasslands, forest patches, and water pools, with a multitude of small microhabitats like crevices, boulders, exposed rock, and seasonal wetlands. Each of these habitats supports a different world of life. To truly see the hidden richness of these plateaus, one needs patience, time, and complete attention to how it changes with the seasons, from seeming barren in summer to becoming flushed with life in the monsoon. The microhabitats support ephemeral plant species, amphibians, birds, mammals, invertebrates, and reptiles, and many endemic species are found only on these plateaus, as harsh extremes of temperature and precipitation require specialized adaptations to survive.

One of the most fascinating aspects of lateritic plateaus is how plants grow on such hard, rocky surfaces. The answer lies in biological soil crusts, commonly known as biocrusts, the true heroes of these ecosystems. Biocrusts are thin layers composed of algae, lichens, fungi, cyanobacteria, and bryophytes. They appear as a blackish-brown layer on the rock surface and are very easy to overlook. When we first saw them, we assumed it was simply black rock. Later, we realized that this thin layer was biocrust which is something small yet incredibly important, as they trap soil and moisture, carrying out nutrient cycling, and allow plants to root in them. Without them, the survival of plants in these arid and nutrient-poor conditions would be extremely difficult. Through this mentorship, we began to understand that what appears lifeless at first glance is actually a fragile and highly specialised ecosystem, quietly supporting an incredible diversity of life.

## Day one – 17 Dec 2025

We reached the first location, Ariyittupara, bright and early at around 6:45 AM. It was a lovely, peaceful landscape that mostly consisted of grassland on the laterite, with patches of forest in depressions and crevices. We took a long walk through the golden grassland as mist evaporated in the sunlight, photographing birds, and recording the common plants we

Biocrust supporting *Polycarpia corymbosa* on exposed rock. © Sanjana VK.

knew. In the groves, we saw several invasives like *L. camara, C. odorata, A. auriculiformis*, and *Casuarina*, some of which Shyam told us had been planted by the forest department. We also saw a lot of bird diversity, such as the vernal hanging parrots which came to feed on the *Casuarina*, as well as porcupine and potentially jungle cat scat on the red soil trail we were following. Shyam told us that the area had been earmarked for a large solar farm project, but some of the groves would remain protected because they were sacred groves (called 'kaavu'). They would also only be installing panels on completely flat areas, as the rocky slopes (though gentle) are difficult to work on. It was bittersweet to learn that such a beautiful landscape would soon be devastated, as solar panels raise the ambient temperature significantly and don't allow anything to grow nearby.

After breakfast, we visited Kayyurpara, where we saw a permanent pool on a laterite plateau grassland, with some stunted trees growing along the bank. A Little Egret was using the area to forage, and Shyam told us it was a good area to see raptors. There were also some groves here, though much fewer, and one grove had a house built inside it, with two cows grazing nearby. We asked about human use of the plateaus and learned that people rarely use the plateaus apart from occasionally cutting tall grass for roof thatching, allowing their cattle to graze during the monsoon (though most people tend to feed them at their homes), and using pools for washing. Installing boundary

Solar farm at Vellooda. © Pathak Hrishikesh.

Entering Kayyurpara. © Sanjana VK.

**The laterite road leading into Ariyittupara, Ariyittupara at sunrise, making field notes. © Sanjana VK.**

walls around ponds also reduces the ebb and flow of water, preventing the water level from changing naturally. Nearby, there were coconut plantations that had been set up on private land on the plateau.

One side of the grassland held a laterite mine, where bricks of laterite stone had been cut out to use for building. We learned that laterite bricks are the cheapest locally available building material, that each mine yields a few thousand bricks and can be used to build around five houses, and that miners do not quarry below 6 m as the stone becomes too brittle to use for building. After a glimpse of a Booted Eagle, we visited another pool nearby, where we saw several more raptors (Crested Serpent Eagles, a Brahminy Kite that flew down to drink water, and a rare Montagu's harrier). At the pool, we saw signs of human use like discarded soap, but it also supported a variety of beautiful water plants and ephemeral vegetation that grew on the banks.

After a break for lunch, we left again in the evening to visit Koyithattapara, where we saw several more abandoned mines. It was disconcerting to see these red scars left on the landscape on one side of the road while grassland and forest stood intact on the other. Here, power lines also criss-crossed the grassland-forest mosaic landscape, and we saw more litter (plastic water bottles and alcohol bottles) than we had seen before. We learned that mines are always dug on private land but may sometimes be illegal, and that the quarry owner has an obligation to ensure that the leftover debris is replaced in the mine, but this doesn't happen. We also saw invasive species of grass growing on the debris piles that had been abandoned. The forest patches had many *Syzygium caryophyllata* trees, which had short but broad canopies. The species is a characteristic of lateritic landscapes and classified as 'Vulnerable'.

This site also had a dry wetland that supported *Nymphoides krishnakesara*, a 'Critically Endangered' endemic species of the lateritic plateaus that was described only nine years ago, making it a potential site to establish a Biodiversity Heritage Site. We saw a few cattle grazing in that area, which could be a potential threat. Lastly, we visited Karindalam, where we saw 17 Little Ringed Plovers crossing a large dry wetland, and once more saw the grassland-forest mosaic laid over the gently rolling plateau. Here some construction was ongoing

**The Koyithattupara landscape; a mine site at Koyithattupara; Abandoned debris at a Koyithattapara mine; Invasives growing on a debris pile; Cattle grazing at Koyithattupara. © Sanjana VK.**

Seven Little Ringed Plovers at a dry wetland. © Sanjana VK.

for a college building, as well as for some new electricity towers, and litter was present. We waited till dark to catch a glimpse of a few Jerdon's Nightjars before heading home for the day, tired but happy to have seen how beautiful the plateaus appear during sunrise as well as sunset.

## Day two – 18 Dec 2025

We set out early in the morning to visit a perennial stream in Periya, which hosted the endemic *Crinum malabaricum*. We were joined by Dr Biju Punnakot, an assistant professor at the Government College Kasaragod. As a botanist who has described several new species from these lateritic plateaus, his expertise was invaluable. His deep knowledge of the local flora turned our walk into an intensive learning session.

We followed a narrow path between coconut plantations until we reached the stream. The water level was low, and the metre-long, ribbon-like leaves of *Crinum malabaricum* lay across the stream bed, looking as if they were paused in time, preserving the direction of the water flow. Standing there, Dr Biju described the

**Measuring the length of *Crinum malabaricum* leaves. © Sanjana VK.**

**Ananthapuram hillside with the bauxite mining plant; *Lepidagathis ananthapuramensis*. © Sanjana VK.**

plant's ecology, while simultaneously pointing out several other species in the close proximity. As we walked back along the road, it became a challenge to keep pace with him as he identified almost every species in sight. We hurriedly clicked photos and took detailed notes, creating a record of his identifications to aid our future reports.

Next, we moved towards Periya para, a natural lateritic plateau featuring a pool often used by locals for daily activities. En route, Shyam suddenly stopped the car, having spotted a bird. Although we were initially unsure of the ID, we later confirmed it to be a Blyth's Pipit, a rare species to sight. We parked and began our walk toward the site. Along the way, we passed through a grassland and Dr Biju guided us through the grass taxonomy, pointing out the *Lepidagathis keralensis* which was prevalent in this area. We took a moment for a photo session amidst the grassland before reaching the pond. Here, the water body supported a rich diversity of aquatic flora and Dr Biju identified various species of *Eriocaulon*, *Blyxa*, and *Nymphoides indica*. We stopped by the water body for a while before heading to a Kudumbashree-run hotel for a cheap and delicious breakfast.

During the drive to the next site, we asked Dr Biju how one goes about identifying grasses. He recommended different field guides, and our conversation deepened as he discussed the region's orchid diversity, mentioning genera like *Habenaria*, *Dendrobium*, *Bulbophyllum*, and *Oberonia*. He also spoke of the ephemeral, post-monsoon carnivorous plants that appear on the plateaus, including *Drosera* species and more than 20 species of *Utricularia* (bladderworts). It was astonishing to learn that around 650 species of angiosperms exist in the laterites of Kasaragod.

We then reached Ananthapuram, the only known location for *Lepidagathis ananthapuramensis*, a point endemic species with an area of occurrence of less than 5 $km^2$. Tragically, it is threatened by bauxite mining in the area. Dr Biju showed us how this species differs from the common *Lepidagathis keralensis*, while the latter is a thorny creeper that hugs the laterite, the point endemic *L. ananthapuramensis* grows vertically. We also observed an interesting micro-climatic feature: the laterite rock here felt noticeably cooler compared to other areas we had visited. Directly opposite this site stood the Ananthapuram Temple, famous for the legend of a "vegetarian" crocodile. We took a walk through the temple premises and were fortunate enough to spot the mugger crocodile resting in the shade behind the temple. The temple itself is surrounded by a lateritic pool, which serves as a home for this reptile.

***Strobilanthes integrifolia* in bloom.**
**© Sanjana VK.**

After a refreshing break for coconut water, which was much needed after the heat of the field, we visited the biodiversity park of the Government College Kasaragod. The park appeared to be in ruins, with an atmosphere suggesting no one had stepped inside for a long time. However, there was a surprise for us. As soon as we entered, Dr. Biju was amazed to see *Strobilanthes integrifolia* (a kurinji species) in bloom. Since this species blooms only once every seven years, it was a joyous moment for him. Dr. Biju walked us through the park, pointing out the *Strychnos nux-vomica* from which Kasaragod is said to derive its name. We also observed a fallen *Acacia*; its shallow root system had failed to penetrate the hard laterite, causing it to topple, which is a clear lesson in why non-native species often struggle here.

He then led us to the bamboo botanical garden, which is also a 'Pachaturuth'. This term refers to a Kerala government initiative aimed at increasing green cover by creating mini-forests on waste or fallow lands. Fortunately, this site was not in good condition; it was dried up and appeared to have lacked watering for a long time. The bamboo here had been sourced from the Uravu Bamboo Nursery, one of the largest in southern India. While walking back, we spotted a rodent that had made its home inside a bamboo clump. We tried to photograph it, but it fled its grass nest. Before leaving, Biju discussed other *Strobilanthes* species found in the area, such as *S. jomii*, *S. integrifolia*, and *S. ciliata*. We then proceeded to have lunch near the college and bid farewell to Dr. Biju, and thanked him for his time and insights in the field.

Following lunch, Shyam took us to the Kasaragod Saree Co-operative Sale Centre. These sarees are a geographical indication (GI) tagged product, and it was wonderful to witness the making process of these traditional textiles.

We ended our day at Bekal Fort. Inside, we saw a landscape that had been "beautified" by clearing the native vegetation to create clean lawns. Shyam explained that the fort used to host many native grass species, but since the beautification efforts, they have all been cut down and replaced with conventional lawn species, allowing invasive species to take over. We watched a White-bellied Sea Eagle soaring above us and enjoyed the cool sea breeze. We ended the day sharing some pickled pineapple, enjoying a beautiful sunset.

## Day three – 19 Dec 2025

We began the day by travelling to Azhithala, where Shyam wanted to take us for beach combing (surveying for birds along the shoreline). It was a refreshing change of

Beach combing at Azhithala. © Sanjana VK.

Woolly necked stork at Vellooda. © Sanjana VK.

landscape, and we spotted various waterbirds along the way, including Eurasian Curlews, Whimbrels, a White-bellied Sea Eagle, and Black-bellied Terns. We also saw a number of martins, which Shyam told us are quite rare in this area. It was a challenge to capture photos of these fast-flying birds, and we were highly unsuccessful in doing so. Towards the end of our walk, we reached the river mouth, which had been modified into a boat channel for fishing, resulting in ongoing erosion of the shore. After a long walk across the beach, we took a bus back to the parking area. On the way, we stopped for breakfast, where we enjoyed several local breakfast dishes and snacks.

Shyam then took us to his family home to meet his mother and sister. It was a beautiful sight, as the house featured the same sustainable architectural style and use of local materials as his home, where we were staying. After a brief introduction, Shyam showed us pictures of birds he had taken when he had just started birding. We then left for Vellooda. Shyam had told us that this area had been converted into a solar farm and that there were also laterite brick mines nearby. As we walked towards the site, we passed through a grassland which, like the others we had seen, held many native shrub patches in the depressions. We came across a nearly dried-up water body and were observing the landscape when suddenly, a woolly-necked stork flew in and stood right in front of us. It was an amazing sight to see such a large bird up close.

However, the view of the solar farm was disheartening. It was painful to see how the landscape had been destroyed in the search for renewable energy. While discussing this with Shyam, we learned that these solar farms raise the ambient temperature by more than 5 degrees compared to the average, which

prevents biodiversity from coming up in the area. On the other side of the plateau, we saw a degraded mining site where the debris piles were filled with invasive grasses, similar to Koyithattupara. We took note of the location coordinates and left the area, ending our day with another reminder of the threats these plateaus face.

## Day four – 20 Dec 2025

On the fourth day of our field visit in Kasargod, we visited a nearby wetland to observe birds. The wetland was a water-filled paddy field that supported a rich diversity of bird life. We observed several species such as the Lesser Whistling Duck, Fulvous Whistling Duck, Pheasant-tailed and Bronze-winged Jacana, Grey Heron, Grey-headed Swamp Hen, Northern Pintail, Gadwall, and White-breasted Waterhen. This visit highlighted the importance of wetlands and paddy fields as crucial habitats for waterbirds.

After this, we visited SEEK (Society for Environmental Education in Kerala), an NGO dedicated to nature education and conservation that has been established for around 40 years in Kasargod. SEEK actively conducts workshops and eco-club activities to create environmental awareness and to provide hands-on experiences with nature, especially for students and local communities.

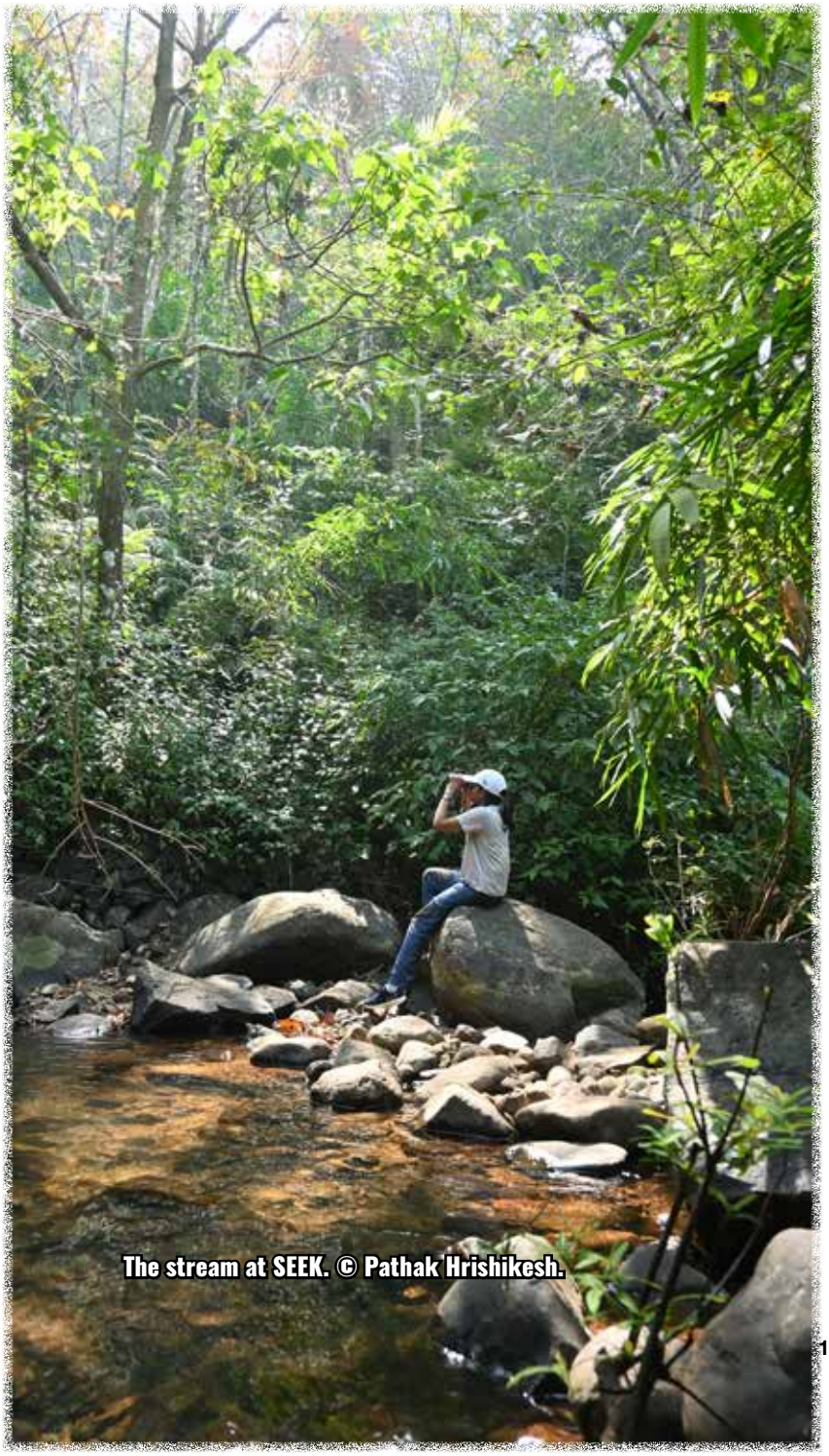
The centre has a spacious campus that can accommodate around 100 people at a time. The area surrounding the building is rich in diverse plant species, creating a vibrant habitat for many butterflies and birds. As we walked around the campus, we were amazed by the large number and variety of butterflies, fluttering everywhere, making the place feel alive. We also observed several bird species, adding to the serenity and ecological richness of the site. A stream flows close to the campus, supporting a wide range of aquatic and semi-aquatic life. We observed crabs, fishes, snails, slugs, dragonflies, and damselflies in and around the stream. There was also a small dam constructed above the stream.

To reach the dam, we climbed along the stream, moving over large boulders and uneven, rocky surfaces. What began as a simple observation soon turned into an adventurous stream-climbing experience. The entire experience was thrilling, refreshing, and truly memorable, leaving us with a sense of gratitude and admiration for such well-protected natural spaces.

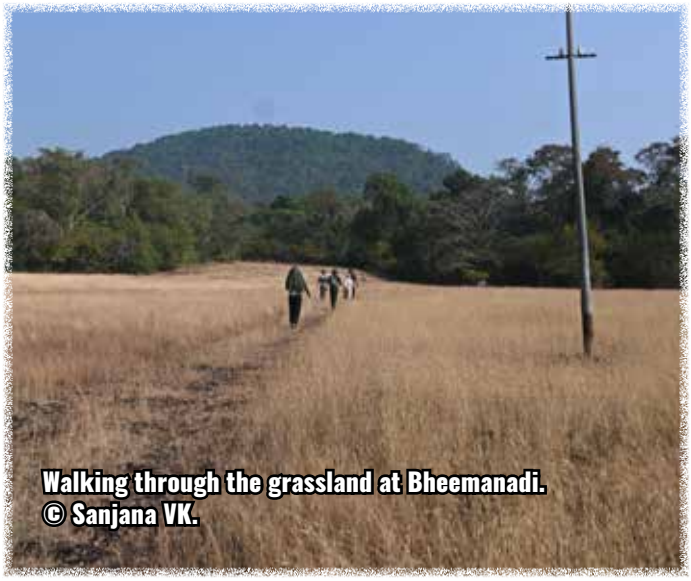
After lunch, we visited the Bheemanadi Reserve Forest. This was the only protected area we visited during the trip, and as it was closer to the Western Ghats rather than the coast, we noticed that the forest patches were larger and more contiguous, sometimes entirely enclosing grassland patches, rather than the other way around as we had seen before. We walked 3–4 km from the start of the forest to the end and returned the same way. At the end of the forest, there were agricultural plantations and we also saw rubber plantations.

The walk through the forest was a good experience. Inside the forest, we saw a small shrine and a permanent water pool. We saw grey wagtails, bulbuls, a black-naped monarch, and chestnut headed- bee-eaters bathing in the water, as well as a lone green sandpiper. It was interesting to watch how the birds dipped their beaks and fluttered their feathers in the water, then flew back to nearby branches. We also observed some invasive plants growing in the water. Near the bank, we saw *Eriocaulon* species, and there were trees surrounding the pool which provided shelter and habitat for birds. While walking in the grassland we also

The paddy wetland. © Sanjana VK.



The stream at SEEK. © Pathak Hrishikesh.



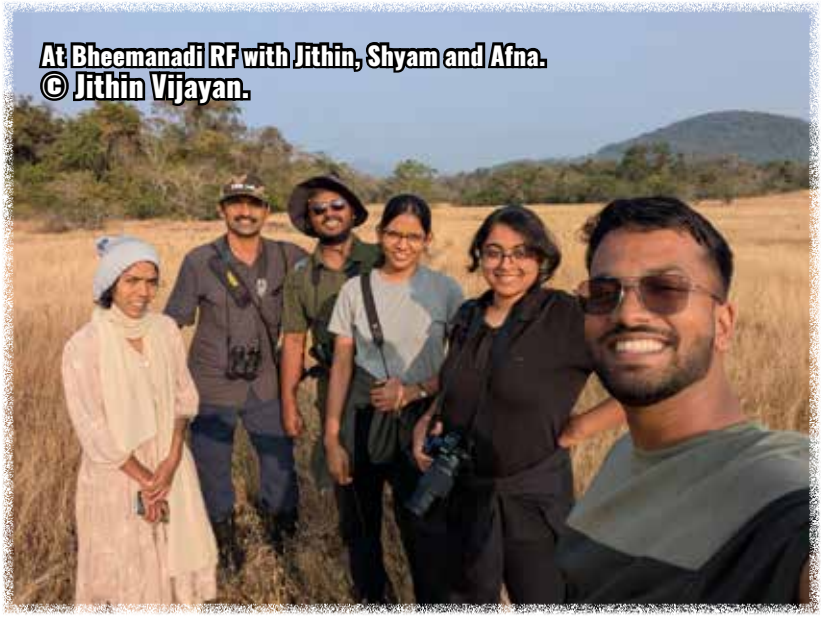
Walking through the grassland at Bheemanadi. © Sanjana VK.

*Memcylon* sp. © Shreya Yadav.

observed a beautiful katydid. On the dry grass it looked like a leaf. We also noticed human intervention in the forest, local people use forest paths to collect wood. Mud roads constructed by the forest department were also being used by local people. Such activities were identified as potential threats to the forest ecosystem and its resources.

## The rest of the trip

The first five days of our mentorship were spent visiting different lateritic landscapes of Kasargod. From these site visits, we gathered information from field observations and interactions with local people. We documented plants, different grass species, and many bird species, and also observed several lateritic mining pits. After the site visits, we stayed at our place and started reading literature. Through this, we tried to connect what we observed in the field and understand it in relation to the published studies, as well as design a preliminary restoration plan addressing the threats we had seen. While reading, we learned more about lateritic plateaus. Some papers on the flora of northern Kerala were particularly helpful in improving our understanding.



At Bheemanadi RF with Jithin, Shyam and Afna. © Jithin Vijayan.

We had questions regarding mining sites, such as how quarry owners select sites and what criteria they use. With Shyam's help, we interacted with a quarry owner. This interaction helped clear our doubts, such as how miners select sites to quarry, and also helped us understand the quarry owner's perspective.

Jithin Vijayan (CEROS Lab, Nature Conservation Foundation) travelled to Kasargod to share his knowledge on rocky outcrops. He also accompanied us once more to Bheemanadi, with his researcher friend Afna, and explained lateritic plateaus and their diverse flora and fauna. He showed us the biocrust layer, which we had earlier mistaken for black rock. His knowledge helped us understand lateritic plateaus better. He and Afna also spoke to local people about their perceptions of lateritic plateaus and shared insights from their responses. He further guided us on how to structure questions for perception studies.

Jithin also arranged a Zoom call with Dr. Aparna Watve, who works on rocky outcrops and plateaus in Maharashtra. She spoke about lateritic plateaus and their hidden flora and fauna. We also discussed our restoration plan for the lateritic plateau with her. Her inputs helped us think more clearly and logically about restoring the landscape. Interacting with and learning from all these people helped refine our understanding and gave us a clearer perspective on lateritic plateaus.

## Sitewise comparison

Below, we include two tables detailing the different sites we visited and the ecosystems and threats we observed at each.

| Site number | Location | Conservation notes | Vegetation type |
|---|---|---|---|
| 1 | Ariyittupara | 3 grass species described from here | Grassland, forest groves |
| 2a | Kayyurpara | | Grassland, pool |
| 2b | Kayyurpara | | Grassland, pool |
| 3 | Koyithattapara | Rare endemic - *Nymphoides krishnakesara* | Grassland, forest groves, dry wetland |
| 4 | Karindalam | | Grassland, forest groves, dry wetland |
| 5 | Periya stream | Rare endemic - *Crinum malabaricum* | Running stream |
| 6 | Periyapara | | Grassland, pool |
| 7 | Ananthapuram | Rare endemic - *Lepidagathis anathapuramensis* | Grassland |
| 8 | Vellooda | | Grassland, forest groves, dry wetland |
| 9 | Bheemanadi | | Grassland patches, forest patches, pool |

| Site number | Location | Solar farm | Laterite mining | Bauxite mining | Plastic littering | Livestock grazing | Natural resource use | Plantations | Power lines | Invasives |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ariyittupara | ✓ | | | ✓ | | ✓ | | | ✓ |
| 2a | Kayyurpara | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| 2b | Kayyurpara | | | | ✓ | | ✓ | ✓ | | ✓ |
| 3 | Koyithattapara | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | Karindalam | | | | ✓ | | ✓ | | ✓ | ✓ |
| 5 | Periya stream | | | | | | | | | |
| 6 | Periyapara | | | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| 7 | Ananthapuram | | | ✓ | | | | | | ✓ |
| 8 | Vellooda | ✓ | ✓ | | ✓ | | ✓ | | | ✓ |
| 9 | Bheemanadi | | | | ✓ | ✓ | ✓ | | | ✓ |

## Learning outcomes

Through this mentorship, our understanding of the laterite plateaus saw a shift from seeing it as barren rock to recognizing it as a complex mosaic of ecosystems. We learned to identify the hidden life that sustains this ecosystem, from the microscopic biocrusts that support plant growth to the rare point-endemics found only in specific seasonal pools. Our field visits, guided by experts, taught us to observe the landscape's resilience against extreme heat and rain, and highlighted the importance of surrounding habitats in supporting diverse bird and insect life.

We also gained an understanding of the specific threats facing these landscapes, observing how laterite mining and solar farms permanently alter

Exploring the forest. © Sanjana VK.

*Lepidagathis ananthapuramensis.*
© Sanjana VK.

*Nymphoides indica* at Kayyrupara.
© Sanjana VK.

A mine site at Koyithattupara. © Sanjana VK.

Booted eagle at Kayyurpara.
© Sanjana VK.

Invasives growing on a debris pile.
© Sanjana VK.

Two curlews at the beach. © Sanjana VK.

A stream ruby at the stream.
© Pathak Hrishikesh.

The egret at Kayyurpara.
© Sanjana VK.

the terrain and raise local temperatures. We realized that actions, like beautification at the fort can lead to the loss of native biodiversity to invasive species. However, our learning went beyond just observation. Through literature reviews, interactions with quarry owners, and perception studies guided by experts, we understood that conservation is deeply tied to people. This experience helped us to bridge the gap between scientific theory and the reality on the ground, helping us think logically about future ecological restoration. Overall, we had a wonderful visit and were very fortunate to have the chance to glimpse these beautiful landscapes of northern Kerala.

## Acknowledgements

We thank Dr Sanjay Molur and Trisa Bhattacharjee at Zooreach for arranging this trip for us as part of the RHATC course. We are deeply grateful to Shyam, for hosting us and helping us learn as much as we did. Lastly, we thank Dr Biju, Jithin, and Dr Aparna for taking the time to speak to us and give us much needed advice on our restoration project.

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Ariyittupara at sunrise. © Sanjana VK.

# From Landscape Understanding to Restoration Planning: A Mentorship Field Report from the Anamalai Foothills, Tamil Nadu.

## Introduction

As a part of the 15 days mentorship program under the Ram Hattikuddur Advanced Training in Conservation, the fellows were split into three different teams and were sent to places with different landscapes. We were all assigned the task to understand the landscape, search for a potential restoration plot and to come up with a detailed restoration plan for that plot. Our team went to Sethumadai, a place at the foothills of Anamalais, Tamil Nadu for 10 days, from 16 to 25 December 2025.

## Interaction with Mr. Sarvanan

After reaching Sethumadai, we first interacted with Mr. Sarvanan, the owner of Iyal Thottam farm. He shared how he has been doing organic farming there since the last 14–15 years. He owns about 18 acres of land there, with all coconut and arecanut plantations. He also discussed how chemical farming done in all the adjacent farms affect the soil, microbes, and other biodiversity.

We explained our motive and intentions to him, to which he said there's no abandoned farms in the area that we can take up for restoration. He suggested that we should visit the forest area in order to understand the landscape. He also mentioned that a tribe called the Malasars live in the forest with whom we can talk. He connected us to a local guide who could accompany us for a trek in the forest.

## Trek to Sarkarpathy Village through the forest

A local person took us for a trek to Sarkarpathy Village through the nearby forest. We observed quite a long stretch of invasives and non-natives by the trail, like *Lantana camara*, *Chromolaena odorata*, etc. On one side of the trail there was a huge water canal which is a part of the Parambikulam-Aliyar Project.

We got to see many dung, scats, and pellets samples of elephants, bears, dholes and other wild ungulates respectively. In the mix of native and non-native trees, on the other side of the canal; there were also some tussock grass patches on the rocky surfaces.

It was when we reached a view-point, we got to observe the vegetation and plantations at the foothills. It looked beautiful at the first sight until we could see the mosaics of the non-native

Interaction with Mr. Sarvanan. © Dharun Prashant.


Trek with a local guide. © S. Naufal Nazium.


Water canal along the trail. © Srijita Pal.


Fresh Bear scat. © Srijita Pal.


Tussock grass patch. © Srijita Pal.


View of vegetation at the foothills from the view point. © M. Nishigandha.

*Eucalyptus*, invasive vegetation, and Coconut plantation along the horizon.

We observed butterflies like Blue Mormon, Southern Birdwing, along with many birds like, Asian Fairy Bluebird, Crested Serpent Eagle, Paradise Flycatcher, Lesser Flameback, etc. We also saw an Indian Giant Squirrel feeding on a *Ficus* sp. tree.

At Sarkarpathy, we first saw the hydro-electric power station. After that, as we moved forward there was a tribal settlement of the Malasars, ahead of which was a Ficatorium (exclusive nursery of *Ficus* species) of the Tamil Nadu Forest Department on the way. With a capacity of nurturing 2,000 saplings time, it grows saplings of 31 *Ficus* spp. from their cuttings collected from all over Nilgiris. But, at that point of time, there were only about 150 cuttings, and the saplings were under maintained.

## Meeting District Forest Officer of Pollachi

We were fortunate enough to get a chance to meet Mr. Devendra Kumar Meena, DFO and deputy director of Anamalai Tiger Reserve, Pollachi. On explaining to him about our mentorship project and our agenda of visiting him, he very kindly suggested to us to look at a forest patch along the road towards the Sarkarpathy Village from Sethumadai where the forest department is removing *Lantana*. He also connected us to Mr. Gnanabalmurugan, Range Officer of Pollachi, who further connected us to Forester Mr. Murugesan, who drove us all the way to the site from the Range office at Thatturpirivu.

## Visiting our potential restoration site

Accompanied by forester Mr. Murugesan, we reached the site. From there, forest watcher Mr. Jayaganesh took us into the patch and showed


Lesser Flameback. © M. Nishigandha.


Indian Giant Squirrel. © M. Nishigandha.


Sarkarpathy Power House. © M. Nishigandha.

Ficatorium of Tamil Nadu Forest Dept. © Srijita Pal.

DFO Office, Meenkarai road, Pollachi. © Srijita Pal.


The invasive species removal site. © Srijita Pal


Picture with Forester Mr. Murugesan and Forest watcher Mr. Jayaganesh. © Srijita Pal.

us around. He said the whole understorey was filled with *Lantana*, which the forest department is now removing. They have also marked the *Eucalyptus* trees to eventually remove them in the near future under TN-PIPER. We observed a lot of hoof marks, which we thought could be of cattle, but there were no traces of cattle dung. It was when we saw the pellets, we came to know that all the hoof marks were of wild ungulates. We documented a few native plants like *Pongamia pinnata, Ficus bellerica* as well as non-native trees like *Eucalyptus* and Tamarind that were there in the patch. Later, Mr. Jayaganesh and Mr. Murugesan informed us that seeds of some grass species have been sown in the *Lantana* removed area by the forest department. They asked us to contact forest official Mr. Vikram if we want to know more about it.

Perception Interviews at Sarkarpathy Village

In order to understand the landscape and people in the area, we went to have a conversation with local tribal people at Sarkarpathy. We first talked to some elders of the village, they said that they're a part of the Malasar tribe that majorly lives in Nagarouth historically. They moved down to Sarkarpathy to work as labourers in the Parambikulam-Aliyar water canal construction project in the 1960s and settled there. With all this, their dependence on forest products reduced, their livelihood shifted majorly to daily wage labour employed by the forest department.


Perception Study of people from Malasar tribe and Forest watchers. © Srijita Pal & M. Nishigandha.

They've also started receiving ration supplies from the Public Distribution System. Most of the elders said that, with time the forest has also changed a lot, it was denser with a better water availability. The people there do identify that plants like *Lantana camara, Senna spectabilis*, etc. which widespread in the forest in recent years with the increase in forest disturbances. They've also noticed that these plants are blocking the growth of other plant species that historically grow there. Also, we came to know that none of the families keep cattle, as that could attract interactions with tigers and other wild carnivores.

## Meeting Mr. Vikram (forest official)

We met Mr. Vikram to know more about the plots, their plan of intervention and to obtain information about the grass species that were sown in the patch. He informed that seeds of 3 grass species *Cenchrus ciliaris*, *Cynodon dactylon,* and *Panicum dichotomiflorum* in the ratio of 3:1:1 respectively. He said that all these are palatable and drought resistant species. The seeds were collected in the month of October and were sown in November.

## Interaction with Mr. Chandrasekar Rathnam

One evening, we got to meet Mr. Chandrasekar Rathnam, wildlife photographer and co-founder of a Pollachi based NGO named 'Wild and Dark Earth'. He gave us valuable insights about the flora, fauna, people, and land use changes over the years in Sethumadai and surroundings. He also gave us a few contacts to network in the area for our purpose.

## Trek to Nagarouth and Engagement with the Malasars.

We went to the Nargarouth tribal village by following the water canal route. We traversed the route along the water canal coming from

**Picture with Mr. Chandrasekar Rathnam. © Srijita Pal.**

**Interviewing residents of Nagarouth. © M. Nishigandha.**

Parambikulam and going to Aliyar which formed the boundary of the reserve forest. We passed through a lot of coconut, cacao, and areca plantations. This route is commonly used by elephants. We could see the signs of elephant presence including fresh elephant dung; telling that they have recently passed through.

Conversation with auto driver Mr. Ganesh revealed a lot of details about how the land has been through many transitions. Until the 2000s this buffer zone land was leased to the people for farming, crops such as groundnut, ragi, and other millets were harvested. Later, the land was declared as a reserved forest. Signs of earlier agricultural modification are visible and much of the area is dominated by invasive plant species. We started trekking from one point along the canal, accompanied by a local person to guide us through the forest. We spotted birds like, Asian Fairy Bluebird, Yellow-footed Green Pigeon, orioles, barbets, beaters and a few raptors, Malabar Giant Squirrel, etc.

Sarkarpathy, Old Sarkarpathy, and Nagaroth villages are connected with each other through this route and people often use motorcycles on these paths. It is a highly sensitive area in terms of elephant encounters. The village is located inside the forest. There we saw a shrine (stone deity) worshipped by the Malasar community. We also noticed a few concrete foundations built through government housing schemes for tribal people, situated in the middle of the forest. We interacted with a few people present in the village trying to understand their dependence on the forest, use of forest resources, changes they have seen in the forest over the years, vegetation, density, and their interactions with wildlife. It revealed that earlier they lived entirely inside the forest and depended on hunting for meat, tubers and honey for food, and trees-herbs for medicine.

Map of project area [Source_ Google Earth]


Project plot survey with Mr. Jayaganesh.
© M. Nishigandha.

In recent years their lifestyle has changed significantly. Most of them now work as daily wage laborers in farms around Sethumadai and with the forest department removing invasive species and doing small-scale agriculture inside the forest growing crops such as coffee, pepper, and banana. The government provides them with ration supplies, solar panels once every five years for each household, and concrete houses. However, construction of houses has stopped due to the lack of proper road access, making it difficult to transport building materials. The community expressed that they themselves want to shift out of the forest, as their dependency

on forest resources has reduced as access to livelihoods and medical facilities outside the forest is better. About three years ago, they requested land allotment to relocate outside the forest, but the request was denied.

We also noticed the spread of garbage and plastic waste inside the forest around the tribal settlement which was disheartening to see.

## Mapping our Restoration Site

We revisited the site, again accompanied by Mr. Jayaganesh. With all the understanding about the region and landscape that we developed in these few days, we decided to make our detailed project report on how to restore the forest patch that was suggested by the DFO. We mapped the project area that we selected. It is situated in the Ayiramgal beat of the Sethumadai west section, Pollachi range. We selected two plots, one as control plot (10.4872$^0$ N, 76.8613$^0$ E) and the other as the treatment plot (10.4877$^0$ N, 76.8616$^0$ E ) each of 20 ha located on either sides of the Sarkarpathy road. The slopes extend east to north-eastward of the southern western ghat. The altitude varies between 300–400m.

## Visit to Parambikulam

One day, we went towards Parambikulam to look into the changing vegetation. It was all coconut and arecanut plantations at the foothills. As we started going uphill towards Parambikulam, both sides of the road were full of the invasive plant *Ageratina* and some *Lantana*. On the way, we spotted a Sambar Deer, many Spotted Deers, a Forest Owlet, Nilgiri Langurs, Indian Giant Squirrel, Wild Boars, etc. Also, there were many Bonnet Macaques near the Parambikulam Tiger Reserve; their wild behavior has now changed because of human interference. People often feed them food which seems to have altered their wild instincts and cling around the humans who come for safari. The forest looked like it was just a teak plantation. Tall teak trees all around with *Lantana* and *Ageratina* in the understory with some mat grass at some patches. There were a few bamboo patches also but all of them were dead. The Parambikulam Reservoir and forest view from the high point gave us an idea of mosaics of the forest and dominant vegetation. We went there with the motive to find some patch with majorly native vegetation if not completely, but we failed.

## Conclusion

Our field observations showed that large parts of the area are highly disturbed due to plantations, spread of invasive species, and loss of native under storey vegetation. At the same time, signs of wildlife such as ungulate tracks, scats, and sightings of arboreal mammals indicated that the landscape is still being actively used by fauna and has the potential for recovery.

Interactions with forest department officials gave us insights into ongoing management activities like *Lantana* removal and grass seed sowing. Discussions with locals helped us understand long-term changes in land use and vegetation.

Conversations with the Malasar community were equally important, as they shared their experiences of how the forest structure, water availability, and plant diversity have changed over time. The trip highlighted the extent of invasive species inside the tiger reserve, how teak monocultures have altered the landscape in terms of vegetation, soil erosion, and faunal occupancy.

All these activities together helped us understand the landscape and come up with a detailed project report on an ecological restoration action plan for the selected plot in the foothills of the Anamalai range.

## Learning Outcomes

It was three months in the fellowship, we explored multiple theoretical and practical aspects of conservation. We had multiple field trips to various organizations working in the ecological restoration space. After all this exposure, this mentorship was our experimental ground where we had to integrate all our insights, learnings and knowledge that we gained through the course of fellowship.

- First thing we had to do was to coordinate with people, find contacts, and network with them to gain a clear and practical understanding of the ecological and social conditions of the Anamalai foothill landscape.
- These networks and multiple conversations with people around provided us with the basic information which compelled us into digging deeper and extracting relevant data that we needed in the planning of the restoration program.
- We had to interact with the government officials and other forest staff where only one of us knew the local language, this emphasized the team co-ordination and communication that is needed for a project to work smoothly.
- We visited multiple sites in the region and documented all our observations which helped to back up our conclusions in the DPR, this highlighted the importance of detailed written and photo documentation.
- The fact that we had to vacate our first accommodation in a very short notice in the middle of the mentorship helped us learn to tackle the unexpected situation and find a cost effective resolution.
- The mentorship exercise was kind of a reality check in terms of engaging with stakeholders, authorities, understanding

**Some fauna documented in Parambikulam (Calotes sp., Sambar Deer, Spotted Deer).**

landscape in the feasibility context, temporal requirement of restoration, and idea about all the different players who can control, alter or compliment the restoration initiative.

- It gave us an insight about how detailed and broad our baseline has to be to identify the monitoring indicators and to achieve the anticipated success while we are considering the area for restoration.
- It also helped us bring out our strengths and weaknesses with each other and compliment each other while working as a team for a common goal.


## Acknowledgements

We sincerely thank Dr Sanjay Molur and the Zoo Outreach Organisation for organizing this course and giving us this wonderful learning opportunity. We extend our gratitude to Mr Devendra Kumar Meena, I.F.S., range officer Mr Gnanabalamurugan, forester Mr Murugesan, Mr Vikram, Mr Jayaganesh and other forest department staff for granting permission, extending their cooperation, and supporting our work. We are grateful to Saravanan and his team for accommodating us during the field visit. Our sincere thanks to Gayathri and Arul for their support and hospitality. We'd also like to thank Sriram Murali and Chandrasekhar who provided us with all the contacts of government officials and extended great moral support through the time of our field work. We also want to thank Latha and Ravichandran for compliance with the finances and other official work. Our extended gratitude to all the RHATC 5 fellows for all the fun moments they shared with us during this time. Lastly, we thank all the people who shared their knowledge and experiences about the surrounding landscape, which greatly enriched our learning.

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# Inselbergs of Tumakuru

On the night of 16 December 2025, the three of us set off towards Bengaluru and then on to Tumakuru with one goal in mind: learn as much as possible about inselbergs and rocky outcrops in the time we had in Tumakuru and eventually develop a Detailed Project Report outlining an action plan for the ecological restoration of one of these rocky outcrops.

Inselbergs are isolated granite and gneiss hills that punctuate the plains and are vital landscapes. These ecosystems are often dismissed as 'wastelands', but they host unique microhabitats, endemic plants & animals, freshwater features, and cultural sites.

The next morning, we met with B.N. Sachin who works with Wildlife Awareness and Reptile Conservation Organisation (WARCO) and visited three main areas around Tumakuru exploring the different inselbergs.

## Devarayanadurga Hill:

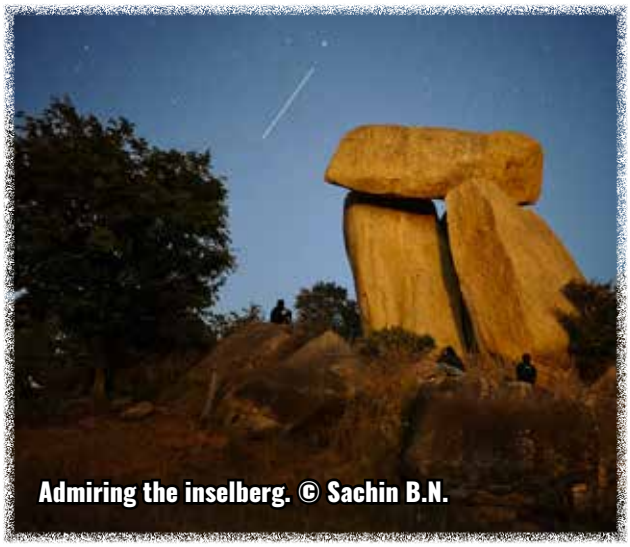
Devarayanadurga is a Reserve Forest. Historically, this landscape was dominated by grasslands, as evident from photographs from around 1850 showing open rocky hills with sparse vegetation. At present, most parts of the hills support dry deciduous vegetation, with dense green cover in several areas.

To observe the landscape at a glance, we stopped at a viewpoint area that is under high tourism pressure. A ropeway project has been proposed to boost tourism further. Tourism-related impacts observed include littering, blasting carried out for road expansion, and open gutters that have altered natural water flow. These open drains also pose a risk of trapping small wildlife. Fencing has been installed to prevent cattle grazing, which has also restricted wildlife movement. Artificial lighting installed for visitor safety has resulted in light pollution.

A view of Devaranyadurga. © G. Pannagasri.

Soon after, we visited an open rocky viewpoint behind the Bhoga Lakshminarasimha Temple. Evidence of past quarrying was observed in the form of chipped granite surfaces. Although quarrying activity appears to have stopped. The area is heavily littered, including empty alcohol bottles and plastic waste largely associated with temple activities. Garbage is being burned at several locations, and in some places, surrounding vegetation has also been affected by fire.

Invasive species observed include *Tecoma stans* (yellow bells) and *Chromolaena odorata*. Signs of logging were noted along the access path. Lichens and mosses were observed growing on rock surfaces which form one of the microhabitats of inselbergs.


Admiring the inselberg. © Sachin B.N.

## Sri Rajendrappa Swami Gudi – Aregujjanahalli Betta

A temple and a community gathering hall are present on the hilltop which are accessible through a drive right on the inselberg's rocky surface. There was evidence of pressure on wildlife in the form of snares indicating hunting activity. A water body with *Nymphoides* sp. (white aquatic flowers) was present on the rock surface.

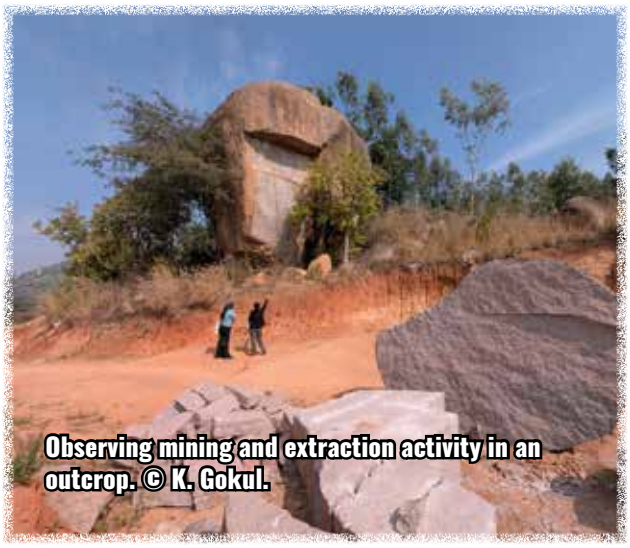
Threats observed include agricultural encroachment, evidence of earlier mining activity, plantations of eucalyptus on hilltops and non-natives like Agave, *Vinca rosea*, *Chromolaena odorata*. Parts of the area are used for processing and storing agricultural harvest. Fencing on one side by the forest department plantation restricts animal movement. Close to the temple, littering of plastic waste was observed.

Maranayakanapalya Bamboo Plantation
This site is locally known as the bamboo plantation area, as bamboo has been planted extensively at the hill base by the forest department. Based on information from a local resident, three Sloth Bears regularly use this site as habitat. Signs indicating leopard territorial marking were observed. Other wildlife sightings included spiders, flock of Plum-headed Parakeets, and other birds. A man-made water hole was also seen at the base of the inselberg. Threats include monoculture plantations, grazing, extraction of resources like firewood and fodder, forest fires, intentional burning of grasses, and invasive species.

## 12th Battalion KSRP, Tumakuru

On 18 December 2025, we got the opportunity to visit a restoration effort at the 12th Battalion of Karnataka State Reserve Police, Tumakuru. On the way there our hired scooter started spurting out fuel and had to be dealt with immediately.


Interaction with Commandant Hamza Hussain. © Sachin B.N.


Observing mining and extraction activity in an outcrop. © K. Gokul.

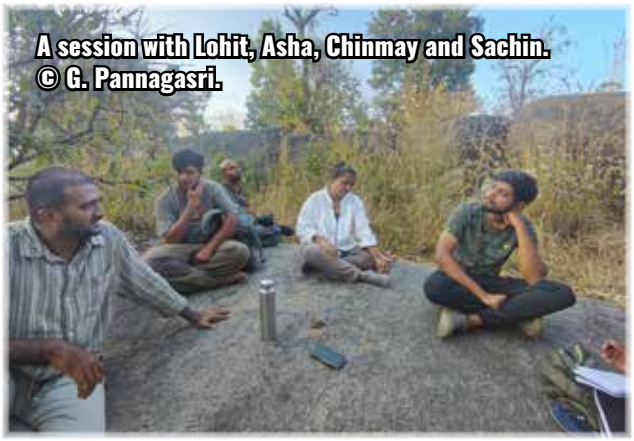
Repaired for the time being and accompanied by a pumpkin we headed to the battalion where we met Hamza Hussain, Commandant of the 12th Battalion who wished us well for our project and was interested in hearing our observations about their initiative. We were shown around by S. Raghunandan who is currently leading the aforestation project at the battalion. He showed us the different tree species that had been planted on the hill and told us about their uses and identification characters.

Based on interactions with police personnel, the area was historically a grassland with open rocky patches. The hills that currently surround this project are also exposed to boulders dominated by grass, which is the natural vegetation type in the area. We observed that there were no measures taken to control invasives, a potential hindrance for growth of native species, we were told literature need not be consulted to take up restoration as long as you observe what is naturally there and increase its density. We believe that it is a drawback as literature review for confirming the nativity and learning from past restoration efforts can be extremely beneficial if not essential before trying to restore a habitat. Hence, there was a lack of habitat-specific planning or ecological approach to restoration and rather the focus was on greening an otherwise naturally grassy habitat albeit using tree species found to be native to the region in a broad sense. The effort was not systematically monitored which means there wouldn't be any way to analyse scientifically the changes that the planting will bring in the ecosystem there, not allowing for appropriate course correction and management either.

Monitoring, documentation, and disseminating findings from efforts like these can be useful to another trying to undertake restoration.

## Thimmanayakanahalli Kere

On 19 December 2025 we started off early with Yogi, a local and a caretaker at Eesha Farmhouse and went through the vegetation patch past the Thimmanayakanahalli Kere (a lake) that leads to the foot of the Setupalya Betta, a hill. The lake was adjacent to a eucalyptus plantation which transitioned into a scrubby patch dominated by *Lantana camara* and *Chromolaena odorata*, along with some native tree species. Surprisingly, there was barely any regeneration of eucalyptus in this adjacent area. Pongamia, Jamun, and bamboo appear to have been planted by the forest department. The landscape includes mixed patches with a small stream flowing across the area twice. Camera trap records from this



A session with Lohit, Asha, Chinmay and Sachin. © G. Pannagasri.

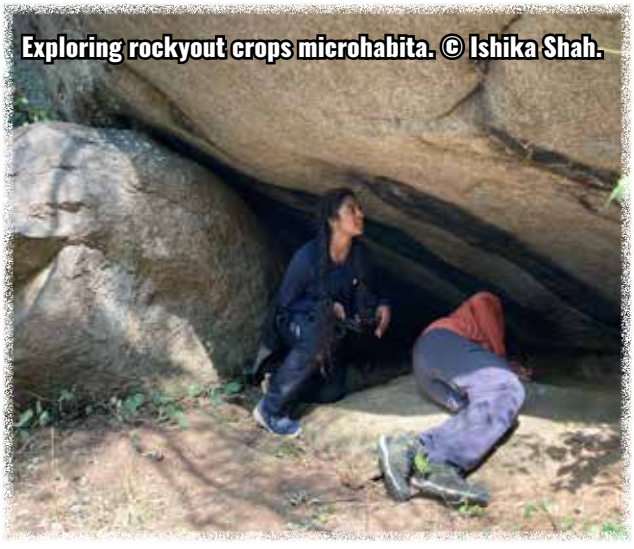
Plague containing details of plant planted by forest department in Thimmanayakanahalli Kere. © G. Pannagasri.

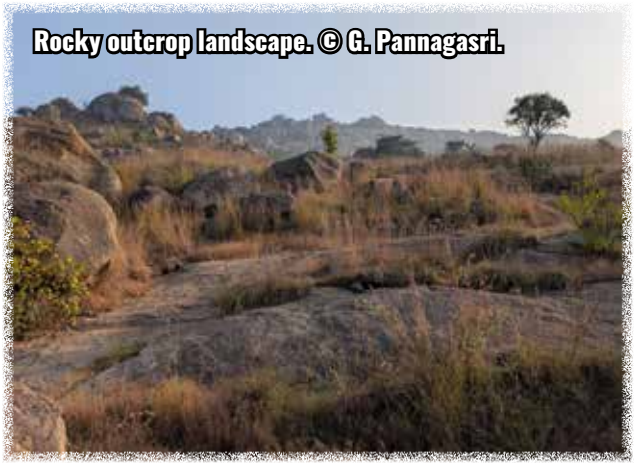
region between 2006 and 2020 have shown the presence of wildlife like Striped Hyena, Leopard, Wild Boar, Sloth Bear, and Jungle Cat. Mixed tree patches contained native trees and shrubs with moderate *Chromolaena* presence. Tussock grasses dominate several areas. Inselbergs on both sides are covered with bamboo and other trees, with *Chromolaena* present in patches. We got to learn the local Kannada names of the plants and trees that are common to the area along with some of their uses from Yogi.

Later after lunch and resting, we had the opportunity to interact with and interview Y.T. Lohith, a wetlands specialist at WWF-India and Asha, an artist and educator. We learned regarding their experience in this landscape, the way they work with communities and also realised how connected water bodies around here are to the inselbergs. We made a bonfire and discussed more about the region and about how they started working in the area.

## Setupalya Betta hillocks

On 20 December 2025, we visited the hillocks close to our accommodation. Even though it looked intact from the outside, it had multiple threats which included agricultural encroachment, soil extraction for areca nut and ragi plantation, extraction of granite blocks, non-native and invasives like eucalyptus, *Lantana camara*, *Chromolaena odorata*, custard apple.


Exploring rockyout crops microhabita. © Ishika Shah.


Rocky outcrop landscape. © G. Pannagasri.

On the same day, we also visited the hillock next to the previous one. It was a difficult climb with no pathway and dominated by thorny bushes. While climbing we witnessed bear scat, fodder and wood extraction, and the common invasives. We were surprised to see non-natives like tamarind and neem growing at the top of the hill. While coming back from the hill, we saw more than 10 species of butterfly. By this time, all three of us were in love with the rocky outcrops. With each passing day we felt more connected to these outcrops.

## 12th Battalion – Alternate Hill

On 21 December 2025, we started off early on a foggy morning to the field, on one scooter to Koratagere. We climbed the hill that's next to KSRP's campus. This hill was dominated by dense perennial grasses, with rocks largely obscured. Invasive species such as agave, *Chromolaena odorata*, and *Lantana camara* were observed mainly at the vegetation fringe and lower slopes. Downhill areas also include horse gram cultivation, custard apple trees, and pongamia. Trees were sparse, stunted, and widely spaced.

Threats include increasing invasive species, agricultural expansion closer to the road, potential future encroachment, and plantation drives by the police department.

## A visit to Janastu:

Followed by that, we rode back to Devarayanadurga to Janastu's Iruway Rural Research Lab to attend their annual flagship programme called Anthill Hacks, a week-long un-conference where people from different disciplines like ecology, business, technology, and social work come together to share their work around a set theme. This year the theme was "Commons" and accordingly there was a talk on community gardening being a lucrative practice for small landholders. Sheshadri Ramaswamy who works on floral biodiversity especially in southern India discussed with us his views on inselbergs and the native flora that's commonly found on them where he described to us what the typical characteristics of the vegetation would be. We attended a couple more engaging session and it was really heartening seeing the community they've built, free for everyone to be themselves, especially the kids.

## Halekote Betta via Jenugundu Jungle Trail

On 22 December 2025, we climbed the Devarayanadurga Betta, past the Penakonda gate to the Bhoga Lakshminarasimha Temple. We were taken there by T.V. Praveen, a local floriculturist and wildlife enthusiast. The area contains multiple caves, and it holds a great historical significance. The hilltop is dominated by grasses, while surrounding areas are densely vegetated with trees.

Biodiversity observed includes spiders, Blue-faced Malkoha, Verditer Flycatcher, Indian Peafowl, quails, evidence of leopard and bear presence, ferns, lichens, and agama lizards. Threats include tourism pressure, plastic pollution, fire, cattle grazing, extraction of fodder or wood, agricultural encroachment, hunting, and invasive species such as *Chromolaena*, *Lantana*, eucalyptus, *Tecoma*, and neem.

## Kavalgutte

On 24 December 2025, we set off to a hillock in Koratagere. The hill supports extensive grass cover with fewer trees. Grass diversity is high, ranging from tall tussock grasses (up to 1.8 m) to short grasses (~0.3 m). Short thorny shrubs are sparsely distributed. Trees are mostly restricted to the hill fringes, with very few on the top. Epilithic ficus species were observed.

Biodiversity observed includes high butterfly diversity, spiders, agama lizards, and Painted Spurfowl. Threats include agricultural encroachment (groundnut, castor, pigeon pea, ragi, guava), with up to four layers of cultivation extending from the fringe to near the top. Invasive species include Lantana, Chromolaena, Neem (less abundant compared to other sites).

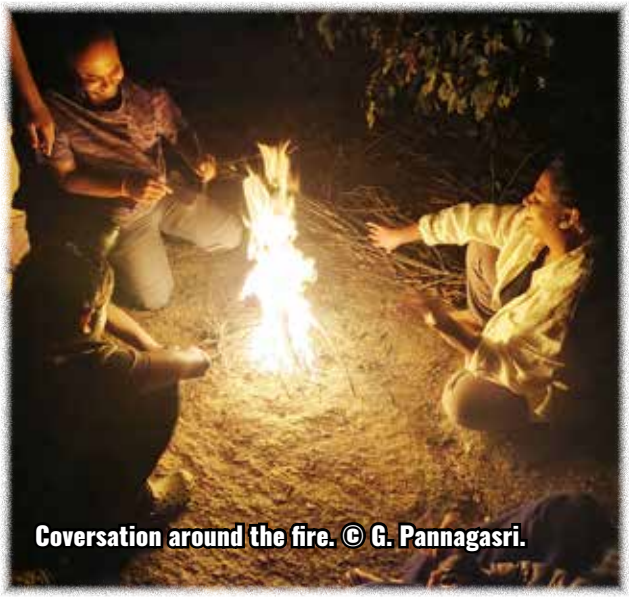
A stream flows around the base, forming what appears to be a man-made pond. We decided this would be the rocky outcrop that we would develop our action plan for.

Agricultural activity at Kavalgutte. © K. Gokul

## Perception studies:

On the same day, we prepared questionnaires and went out for surveys. We covered the local area and spoke to people across different age groups, from children to older adults. Some common perceptions about the use of fire for management of grasses emerged: (1) burning grasses in dry season provides better grass once rains return; (2) fear of wildlife, especially snakes and leopards; (3) difficulty moving through tall grasses; and (4) poor visibility, which makes people worry about leopards being nearby and has led to livestock losses.

Interacting with the locals. © K. Gokul.



Coversation around the fire. © G. Pannagasri.

Because of these concerns, burning the grass has become a common practice among local people. Interestingly, during our discussions, some children showed curiosity about the landscape and expressed interest in learning more and supporting conservation activities. By the end of our mentorship, we developed a detailed project report (DPR) titled “Action Plan for Ecological Restoration of Kavalgutte - A Rocky Outcrop in Tumakuru District”. We chose Kavalgutte because it is threatened by agricultural encroachment, invasives, livestock grazing, and burning of grasses. DPR proposes multiphasic step by step processes of possible approaches with scientific, landscape-specific, and community-linked action plans for ecological restoration of Kavalgutte. The plan prioritises stopping degradation first, allowing natural regeneration where possible, and using active restoration only where necessary and at appropriate magnitude.

These neglected landscapes host several endemic and endangered species, catering to several specialist reptiles, birds, mammals, amphibians by providing microhabitats. They also influence the nutrient and water supply in nearby areas. Thus, it is important to protect

An agama basking on the rocks. © G. Pannagasri.

these landscapes. We hope the action plan we developed will help in its restoration.

## Acknowledgement:

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**G. Pannagasri, K. Gokul & Ishika Shah**
RHATC Fellows 2025–26, Zoo Outreach Organisation, Coimbatore, Tamil Nadu, India.

**Citation:** Pannagasri, G., K. Gokul & I. Shah (2026). Inselbergs of Tumakuru. RHATC 2025–26 Special Issue, In: *Zoo's Print* XLI(1): 88–94.

Last day with the team. © Sachin B.N.

# Imaginary Animal Creation Activity

## Species: *Kalaana rhatcensis* (Mace-tailed Kalaana)

*Creator: P. Hrishikesh*

This imaginary animal is a solitary, herbivorous creature primarily inhabiting the Amazon basin rainforests.

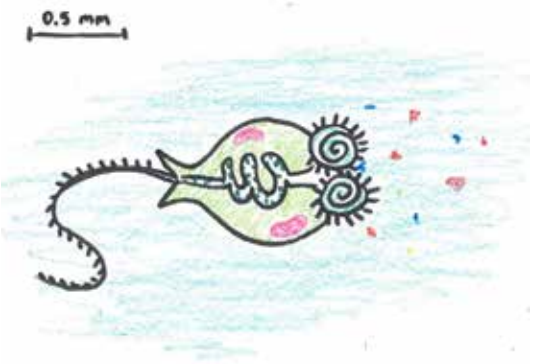
**Physical Characteristics and Defense:** It possesses a shell with a flower at the top, which serves as a food source when regular sustenance is scarce. For defense, it utilizes a club located at the end of its tail. When dormant and inside its shell, it resembles a large flower at first sight.

**Behavior and Life Cycle:** The animal is mostly dormant and solitary. Its life cycle is notable for its unique reproductive strategy: it mates only once and then the female migrates to Hawaii to lay eggs. The males remain behind and eventually die of old age. The average lifespan is exceptionally long, estimated to be around 200 years.

**Ecology and Status:** In aquatic environments, its main predator is the shark. Due to very limited research, the current population numbers for this species are unknown.

## Species: *Plastiphagia mycofidus*

*Creator: G. Pannagasri*




A symbiotic relationship where the rotifer houses the fungus in its digestive tract and wheel organs, in turn receiving simpler hydrocarbons from the digested microplastics. Filter feeders are its biggest threat but its tail is lined with nematocysts that pack a painful sting to other threats. The coronated wheel organs at the oral opening help filter out sand and other debris from the ocean water, and fungi lining them help filter in mostly plastic. In the absence of microplastics, it switches to sustaining on nutrition through photosynthesis. They also have asymmetrically placed respiratory organs to avoid suffocation during conjugation.

# Species: *Walkipisci sri*

Creator: Srijita Pal

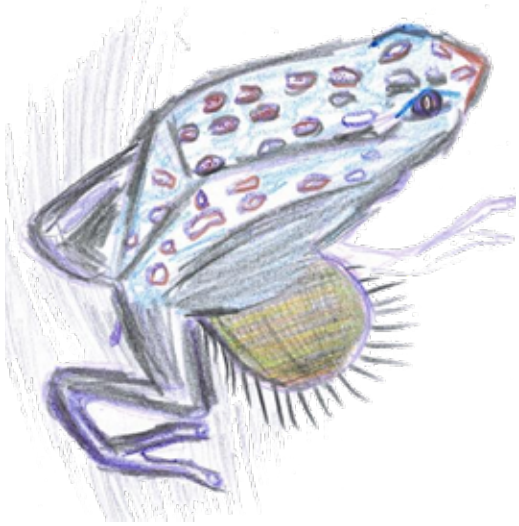
As per the brief given, we had to draw a species from our imagination that does not exist on Earth, with adaptive physical features which will help it survive climate change in the long run. I've always had weird thoughts like what if humans had tails or wings, what if fishes had wings. One of those thoughts were 'What if fish had legs and could walk and survive on land as well?'.

So, I have put this thought on paper. Here goes the description of this 'Walking Fish': This is a fish that can do both, walk on land and swim in water. So, I've named it 'Walking Sri Fish' after my name (Srijita). Also, I've given it a scientific name – Walkipisci sri, walki as it can walk, pisci for it being a fish, and again sri after my name. It can live in both land and water, thus, has both lungs and gills to respire. Has pointy hard scales and electric current in its tail for defence. Eats insects, for that it has a long sticky tongue which helps it to catch insects. It's blue-green in colour so that it can get mixed up in the greens of grasses and blues of water.

Also, I feel with the growing freshwater pollution, pollution in the ocean, and other issues like over fishing, fishes being not considered as 'wildlife' and eventually not being given enough protection, the fishes hypothetically might evolve to adapt and survive on land. Then, they might have legs and look somewhat similar to this. It was really fun to draw an imaginary creature.

# Species: *Bursatus asiatica* (A common Ballfrog)

Creator: M. Nishigandha



This is a frog evolved from a Bullfrog adapting to climate change and rising temperatures. The depressions or burrows on the back are for better thermoregulation and play both mechanical and chemical role in regulating the body temperatures. The big sac adjoined to the abdomen is also a multipurpose easily inflatable and deflatable pouch developed for:

1) a reservoir for carrying water in the drier and harsher climates,
2) it also serves as a bag to carry it's own tadpoles,
3) during the time of hibernation the frog can get inside the sac, save space and camouflage in the ground.

The thorny structure on the outer surface of the sac acts as defense from the predator turning the frog into a spiky ball, looking like a Datura fruit yet much smaller in size.

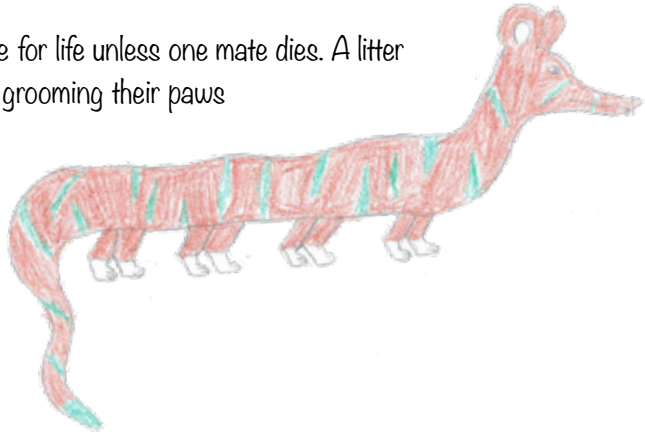
# Species: White-footed caterpillar mouse

*Creator: Sanjana Vadakke Kuruppath*

**Description:** A common small eight-legged omnivorous mammal, related to both mustelids and rodents. Average length (snout to tail) is 10 for both sexes. Fur is sandy to dark brown with dark green stripes, except for the paws, which are cream to white. Canines are slightly long as its preferred prey is beetles.

**Habitat:** Forages for fruit and insects in trees and bushy undergrowth, and sleeps and nests in underground burrows. It has successfully adapted to human-modified areas, living under cupboards and in rafters under tile roofs. It also scavenges from garbage dumps and kitchens. It is increasingly considered a household pest.
Physiology: Adept at running, swimming and climbing due to their strong and touch-sensitive paws. Fur can be shed at will to adapt to temperature fluctuations.

**Behaviour and reproduction:** A monogamous species, they mate for life unless one mate dies. A litter can have between 8 to 12 pups. Much of the rest time is spent in grooming their paws to keep them in good condition. They live in colonies of up to 25 individuals per burrow. As they are preyed upon by mesocarnivores, snakes and raptors, they have developed camouflage, are quick to bite if touched, and make a shrill shrieking sound to alert colony mates when cornered or lifted.



# Species: Vibranto Na-Bi

*Creator: Shreya Yadav*

Vibranto Na-Bi, a colorful butterfly is my imaginary creature. The name "Vibranto" means 'vibrant color' and "Na-Bi" means butterfly in Korean. It is found in garden, trees, forest, agricultural land etc. You will find this butterfly almost everywhere. It has two legs which help it while walking and it has sharp toenail to fight and walk. Vibranto has a tooth which is used to eat soft leaves, flower petals and to protect itself from danger. When humans try to harm, it will use the teeth to bite. The wings have black, red and blue color. It looks amazingly colorful. The body has red dots which release a chemical. The secretion of chemical help them to avoid human. If humans come in contact with this chemical, they will get allergic reaction and in some severe cases it will cause death. Vibranto will be eaten by only big animals like tiger, wolf, lion etc., This butterfly has 1 month life span. Usually, butterflies have a week, but I gave it at least a month to live so that it can see more into this world and humans can admire it from distance without capturing it.

I intentionally have not given long life span because I don't want it to live more in this cruel world where it can get hurt. I want it to be safe from humans because wherever humans put hand on anything it starts destroying. I want it to live peacefully.

# Species: XLR8-A Climate Resilient Fish of the Future

Creator: Sajahan Naufal Nazium

XLR8 is a highly specialized, migratory fish imagined to evolve in a future Earth facing severe climate change, heavy pollution, and extreme temperature fluctuations. This species combines traits seen in different aquatic animals and survives through an advanced algae–animal symbiosis that provides energy, camouflage, and protection from toxins. XLR8 represents how aquatic life may adapt to harsh and unstable environments. The most unique feature of XLR8 is its symbiotic algae-covered skin. The algae grow within special grooves on the fish's body and help it blend into its surroundings, such as kelp forests, algal blooms, polluted harbours, and nutrient-rich waters. This camouflage reduces the risk of predation and allows the fish to ambush prey effectively. The algae also play a nutritional role by producing energy-rich compounds that support the fish during food shortages.

XLR8 has photo-receptor cells in its fins that capture sunlight even in murky or polluted water. The collected energy powers algal photosynthesis, allowing the algae to produce sugars, fats, and amino acids that supplement the fish's metabolism. In addition, the algae can absorb and neutralize heavy metals and toxic chemicals, turning the fish's skin into a living filtration system that allows survival in heavily polluted environments.

Physically, XLR8 is well adapted for flexible feeding and defence. It possesses a baleen-like filter plate that enables it to feed on plankton, microalgae, and organic debris in degraded ecosystems. At the same time, it retains sharp inward-curved teeth for active predation, making it an opportunistic omnivore. Modified front fins form claw-like appendages that help it grip surfaces such as rocks, mangrove roots, and submerged structures. Sensitive barbels allow it to detect chemicals, vibrations, and toxins in the water.

XLR8 shows extreme environmental tolerance. It can survive in both very cold and very hot waters using antifreeze and heat-shock proteins. It moves freely between freshwater, brackish, and marine habitats. A modified air bladder allows it to survive for long periods in oxygen-poor waters. Ecologically, XLR8 acts as an indicator of extreme environmental degradation and serves as a biological bridge between fragmented aquatic ecosystems.

# Species: Susukai

Creator: Ishika Shah

*Hello, I am "SUSUKAI" an alien species. I have hug wing which is hydrophobic in nature. My wings protect me from both rain and sun. I have antenna through which I communicate. I live in forest, desert and also in ocean but I don't like ocean much. I eat flash and blood but I mostly suck the blood out of my prey and leave the flesh for other species. I am very destructive in nature but I am scared of ants, once they enter my ear I get annoyed a lot. Initially researchers thought that I have arrived from some other universe and categorized me as an alien species (dumb humans) but I have evolved in earth.*

# Species: Homo Straits

*Creator: K. Gokul*


Post sixth extinction, most of the life forms vanished from the earth, but some of the remains of last lived group of Homo sapiens developed a genetic mutations model that left the growth of new species with high adaptability for the extreme fluctuations of the planet earth's post extinction. Homo straits has adapted for a borrowing lifestyle and primarily live around subterranean habitats.

**Characteristics:**

Slimy body, short and slightly bent body structures, some are shapeless.
Lost eyesight – Eyes reduced to photoreceptive pits that can detect vibration and the magnetic fields.
Expandable nose/snout – To dig through the underground, the nose can inflate and deflate like a fleshy drill to sense prey underground.
Developed finrays and limbs – Arms and legs can fold onto while burrowing. It moves using muscular ripples, like worms.
Antennae – Instead of ears, it has developed antennae-like that detect sound vibrations and helps communicate with other species.

**Behaviours:**

Borrowing – it helps soil nutrients and aerates underground ecosystems. Hence, Homo straits is the new keystone species.
Mating – emerge to the surface only for few hours to mate and goes back to borrowing habitat.
Echo-language – it communicates through rhythmic low-frequency burrow rumbles that travel through the ground. Antenna helps to receive the frequencies.
Symbiotic relationship - mutualism with fungal and underground roots network which helps them in understand and live underground while there's harsh environmental fluctuations in the surface. Some species even have living fungi colonies on their backs that help digest minerals deposits. In return, their burrowing behaviour helps in constant flow of the nutrient cycling in the soil which boasts the fungal network and roots systems of tree.

**Taxonomic notes:**

There's a notable divergent evolutionary in these species – Homo straits and Homo cannoins.
Homo straits feeds on algae, fungi, and bacteria and can live for so long without eating.
Homo cannoins feeds on worms and they're well known for their cannibalistic behaviour and they need to feed on something constantly.
*Notes and field observations from some of the last remains of Homo sapiens from the planet Mars.

**Citation:** RHATC Fellows (2025-26). Imaginary Animal Creation Activity. RHATC 2025–26 Special Issue, In: *Zoo's Print* XLI(1): 95–99.

# THE CHARM OF BAT CHAT: THE SRINIVASULUS AT ZOOREACH

On the 11th and 12th of November, the Srinivasulu family—Aditya, Bhargavi, and Chelmala visited Zooreach to take two days of classes for us as part of the Ram Hattikudur Advanced Training in Conservation. Chelmala (affectionately called Srini) is a professor of zoology at Osmania University, and heads the Wildlife Biology and Taxonomy Lab there. He's also the director of their Centre for Biodiversity and Conservation Studies (CBCS). Bhargavi is a post-doctoral scientist at CBCS as well as a PhD research guide at Zooreach, and their son Aditya has just finished his PhD at the University of Reading. All three research a very underappreciated group of animals – bats!

For our first class, Srini took us through the bats of southern Asia, their diversity, taxonomy, and ecology. We learned that India has an amazing 137 bat species, representing all bat families, and they all have unique ways of adapting to their habitats. Despite the popular belief that all bats echolocate, only the ones that eat insects do; the others, like flying foxes, which are frugivores, are actually much more visual animals. Each bat has a specific sonotype, or type of call, and none of their calling frequencies overlap! That means that evolution has allowed them to neatly partition the frequencies they use, just like radio stations do. Their call patterns are so unique that they can be identified just from the shape of the recorded sonogram.

**Aditya introducing us to his PhD research. © G. Pannagasri.**


**Sanjay introducing Chelmala. © G. Pannagasri.**

We also learned that bats that hunt fast flying insects have a membrane called the uropatagium that connects the hind legs, which increases their manoeuvrability in the air, letting them make quick turns to catch their prey. Most bats are K selected, meaning that they breed slowly, live for a long time, and have only one or two pups at a time; unlike R selected species like rats, which breed frequently and have many offspring. This means that bats can't easily recover from population loss, and with a lot of negative prejudice against them, they are becoming increasingly threatened.

In the afternoon, Bhargavi took us through bat taxonomy and systematics. We got to see and handle bat skulls. Some were small enough to cap a fingertip, while some were comparable to cat skulls. We learned about the different identifying measurements that you need to record from specimens to make a positive ID, such as forearm length, canine tooth length, and condylobasal length (the length from the tip of the snout to the back of the skull); and what the teeth can tell you about the animal's feeding ecology. We also learned

**Bhargavi and Aditya explaining how to measure bat skulls. © K. Gokul.**

about general principles of systematics, such as the difference between a holotype (the type specimen of a species, which defines what the species is supposed to look like) versus a paratype (all other preserved specimens of a species). Reliable, well-preserved specimens are extremely important to accurately identify the species you study, and to build a solid foundation for the discovery of new species in the future.

**Searching for bats with ultra-sound detectors. © G. Pannagasri.**

Later that evening, Aditya taught us about bat communication and echolocation, including what different sonotypes look like, how nose leaves guide sound to the bats' ears to help them hear better, and the difference between short, specific echolocation calls and longer, more complicated communication calls. An interesting point was that bats click more and more frequently as they zero in on their prey, ending in a continuous rush called a feeding buzz. Lastly, we learned about how the atmosphere, prey, and environment affect how bats call. For example, bats that call at high frequencies need to be closer to their targets because the calls attenuate faster in the atmosphere. Therefore, they're usually low flying and hunt slower, heavier insects. Bats also need to compensate for the Doppler effect and for sound reflected off of habitat features like bushes, trees, or buildings, which they do instinctually. Afterwards, we went out with a couple of different kinds of ultrasound detectors to see what we could find; and we recorded seven different species right around us in the middle of Coimbatore! It was incredible to realise that these nocturnal animals were so close to us every day, just hidden because we didn't know how to look for them. That single day opened up a window into a world none of us had ever known existed.

The next morning, Aditya took us through his doctoral research. He looked at how climate change and abiotic factors (especially anthropogenic ones like light) are projected to affect bats in southern Asia in the future, using ecological niche modelling techniques. A very interesting finding was that not only do different species have different levels of sensitivity to these different factors, but about a third would actually benefit from them, a third would not be much affected either way, and a third would be detrimentally affected. It was a nice example of the kind of work that can be done by exploring secondary data that has already been recorded; you just need to know where to find the knowledge gap.

In the afternoon, Bhargavi talked about the conservation story of the Kolar Leaf-nosed Bat.

A rare and elusive species, she and her team discovered a single colony while exploring a cave in a granite hill in the village of Hanumanahalli in Karnataka. While they were thrilled to find it, the hill was under immediate threat from granite mining, which was taking place on all the surrounding hills as well. They immediately started talking to the community, mining department, and local forest department, telling them about this wonderful little bat and how it can only be found in this one cave in the whole country. Bhargavi stressed that what worked for them was always keeping local representatives in the loop about their work. They also always visited with the attitude that they were only there to study the bat with the community's cooperation, as it was their bat to take care of.

After years of effort, they first managed to get a mining restriction passed on that hill, and then got the community to rally and give away their rights to the granite hill so it could be protected as a conservation reserve. Currently, the Kolar leaf-nosed bat is under Schedule 1 of the Wildlife Protection Act; definitely a triumph to be proud of. We ended the day by watching a nice short film about Bhargavi, Chelmala, and the Kolar Leaf-nosed Bat by Scientific American. It was very inspiring to hear about how years of committed effort led to such a successful conservation story.

The family also accompanied us on our field trip to Coorg in the Western Ghats. Throughout the four days they were with us, they were endlessly patient

**Close - up of bat skull specimens of two different species. © G. Pannagasri.**

with all our questions, showed us how to set up ultrasound recorders for overnight bat monitoring, helped us identify species of all taxa, accompanied us on early morning bird walks, and sat down with us for interesting conversations about bat conservation in wild and urban spaces in India. We had a ton of fun hanging out with them, and deeply appreciate the time they took to spend with us that let us learn so much about so many interesting topics. We sincerely hope all future RHATC batches also get the chance to learn about bats — and a bunch of other creatures — with the bat family!

**Sanjana Vadakke Kuruppath**
RHATC Fellow 2025–26, Zoo Outreach Organisation, Coimbatore, Tamil Nadu, India.

**Citation:** Sanjana, V.K. (2026). The Charm of Bat chat: The Srinivasulus at Zooreach. RHATC 2025–26 Special Issue, In: *Zoo's Print* XLI(1): 100–102.

**Examining bat skulls. © K Gokul.**

**Discussing restoration. © Sanjana VK.**

**Early morning birding. © G. Pannagasri.**

**In Coorg together. © G. Pannagasri.**

**Examining a spider-web on the trail. © Sanjana VK.**

# “From Checklists to Celebrations”: Following the Flight of Selvaganesh

## Introduction

The RHATC ‘Follow the Leader’ sessions are designed to expose fellows to practitioners who exemplify leadership in conservation, individuals who bridge scientific knowledge, grassroots action, and innovative community engagement. On 21 September 2025, we the RHATC fellows had the privilege of learning from Mr. K. Selvaganesh, a teacher from Valparai in Tamil Nadu’s Western Ghats, and an active contributor to bird conservation through both cultural initiatives and citizen science. The session was deeply instructive, showing how a schoolteacher’s enthusiasm for birds can ripple outward to students, communities, and global conservation networks. Selvaganesh’s pioneering practice of celebrating the annual arrival of the grey wagtail, his extensive contributions to eBird, and his leadership in student birding activities formed the backbone of this ‘Follow the Leader’ interaction.

## About the Leader: K. Selvaganesh

K. Selvaganesh was an English teacher at Cinchona Government High School in Valparai, and is presently posted at Coimbatore. Though his professional role is to teach English language to kids, his personal passion for birds has transformed his classroom into a hub of ecological awareness. Over the past thirteen years, he has blended birdwatching with pedagogy, encouraging students to look closely at the living world around them.

What distinguishes Selvaganesh is his ability to turn observation into celebration. In 2015, he began a tradition of welcoming the Grey Wagtail Motacilla cinerea, a small migratory bird that breeds in the Himalaya and spends winter in southern India. Noticing the bird’s regular seasonal return, he framed its arrival as a cause for joy. At his school, students began to mark the wagtail’s first sighting with distribution of sweets, symbolic of welcoming a guest. Over time, the event grew into a local awareness campaign: posters appeared in public spaces, students created educational content, and the wagtail became a symbol of ecological connectivity for the people of Valparai.

This act of celebration is more than symbolic. The wagtail tradition has sparked curiosity amongst students and other people of the area, which ultimately raised awareness about migratory birds.

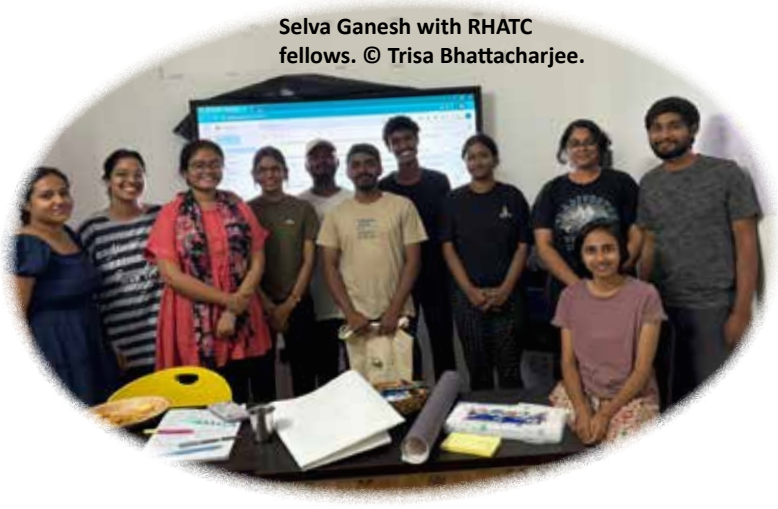
## Contribution to eBird and Citizen Science

Another key dimension of Selvaganesh’s leadership is his sustained contribution to eBird, the world’s largest citizen science database for birds. In a community where many students lack smartphones or internet access, he devised a creative system: students make paper checklists of birds they observe, which he reviews and later uploads to eBird.

This simple practice ensures that:

- Student observations become part of a global database, contributing to research on bird migration, abundance, and distribution.
- Young people experience their birdwatching as scientifically valuable, not just recreational.
- Data from Valparai and surrounding Western Ghats landscapes add to larger conservation planning efforts.

Beyond eBird, Selvaganesh and his students have participated in projects such as the Coimbatore Bird Atlas, seasonal bird counts like the Pongal



**Selva Ganesh with RHATC fellows. © Trisa Bhattacharjee.**

Bird Count, and events including the City Nature Challenge (CNC). His systematic approach ensures that even small-scale student observations feed into large-scale datasets that are shaping the State of India's Birds assessments.

## Learnings from the Session

During the "Follow the Leader" session, Selvaganesh shared his insights across five broad themes. His explanations blended practical field experience, cultural narratives, and scientific resources, making the content both accessible and rigorous.

**1. Bird Behaviour and Identification**

We were introduced to the importance of observing behaviour as a tool for identification. Selvaganesh illustrated this through:

- The hornbill's breeding behaviour- females sealing themselves inside cavities, dependent on the male for food.
- Flight patterns as identifiers, such as the hornbill's heavy, "helicopter-like" wingbeats.
- Field distinctions like the Black Drongo's white cheek patch compared to the Ashy Drongo's uniform coloration.
- Common birds, such as the Asian Green Bee-eater, were highlighted as essential starting points. Selvaganesh emphasized that conservation awareness grows when we pay attention to everyday species, not just the rare or endangered.

**2. Endemism and Migration**

The Western Ghats, where Selvaganesh works, is rich in endemic species such as the Malabar Whistling Thrush and the Nilgiri Laughing Thrush. He reminded us that such species, restricted to small ranges, act as ecological indicators whose conservation is globally significant.

Migration stories captured another dimension of birds' lives:

- The Grey Wagtail, central to his celebration, migrates from the Himalaya to southern India.
- The Amur Falcon, famous for its transcontinental journey and stopovers in Nagaland.
- The Pied Cuckoo, long celebrated in Indian culture as the harbinger of the monsoon.
- By weaving natural history with culture, he showed us how migration links continents and cultures, underscoring the need for cross-border conservation.

**3. Bird Atlases and Citizen Science**

Selvaganesh drew our attention to ongoing large-scale monitoring:

- The Kerala Bird Atlas, completed over five years, providing a benchmark for state-level biodiversity data.
- The Coimbatore Bird Atlas, a regional effort that mapped habitat-level bird diversity.
- Seasonal counts such as the Pongal Bird Count, which engage birders across Tamil Nadu.
- He also directed us on how to use apps like eBird and MYNA to learn about birds and also to contribute to the citizen science platforms.

**4. Ecology and Behaviour**

Selvaganesh also introduced us to ecological concepts illuminated by bird behaviour:

- Murmurations, the coordinated flight patterns of starlings and other species, as strategies for predator evasion.
- Brood parasitism, with examples like the Yellow-billed Babbler hosting cuckoos.
- These discussions reinforced the idea that birds are not isolated entities but participants in complex ecological networks.

**5. Conservation Frameworks and Resources**

Finally, he directed us to resources that can guide future conservation efforts:

- Bird Count India and the State of India's Birds Report for reliable national datasets.
- The People's Biodiversity Register (PBR) as a tool for documenting local ecological knowledge.
- These tools, he emphasized, empower fellows like us to move from passive observation to active contribution in conservation science.

## Reflections as RHATC Fellows

For us, three key reflections emerged:

1. Conservation can be joyful. The grey wagtail celebration shows how a festive act, sharing sweets can anchor ecological awareness. By making bird migration part of cultural practice, Selvaganesh ensures that even non-birders connect with conservation.

2. Citizen science democratizes knowledge. Through eBird, even paper checklists from schoolchildren in

This Tamil Nadu hill station welcomes winter migrant, Grey wagtail, with posters

Published - September 12, 2020 05:01 pm IST - Coimbatore

The posters, printed in Tamil and English and pasted at various spots in Valparai, welcome the bird that travels all the way down from the Himalayas

WILSON THOMAS

student pasting posters welcoming the Grey wagtail in Valparai

**Hindu article covering the welcoming of Grey wagtail at Valparai.**

Valparai school celebrates the arrival of Grey wagtail from the Himalayas

Published - September 16, 2022 09:33 pm IST - COIMBATORE

WILSON THOMAS

The Government High School, Cinchona, celebrates the arrival of

**Hindu article covering the celebration at valparai school on return of the Grey wagtail.**

eBird

K. Selvaganesh, December eBirder of the Month

**eBird's congratulations for Selva Ganesh for being the highest contributor.**

Valparai feed into global datasets. Conservation is no longer the monopoly of researchers; anyone can contribute meaningfully.

3. Every bird matters. While much attention often goes to rare or endangered species, Selvaganesh reminded us that documenting and celebrating common birds is just as critical. They form the ecological fabric upon which rarer species depend.

## Conclusion

The RHATC 'Follow the Leader' session with K. Selvaganesh highlighted a form of leadership that is humble, rooted, and transformative. As a teacher, he has inspired his students to see birds not just as creatures in the sky but as neighbors, migrants, and teachers themselves. As a citizen scientist, he has strengthened India's bird monitoring networks. And as a cultural innovator, he has shown how traditions like the wagtail celebration can bind communities to conservation. For us fellows, this was not just a lesson in ornithology but in leadership itself. To follow a leader like Selvaganesh is to recognize that conservation does not begin in conference halls or research labs alone, it can begin in a classroom, with a child's checklist, or with a box of sweets shared in joy at the sight of a returning bird.

## Gratitude

We are immensely grateful to Zoo Outreach Organisation and to Ram Hattikudur Advanced Training in Conservation for arranging such an enriching and insightful session. A special note of gratitude to Mr. K. Selvaganesh for sharing his inspiring experiences and journey in birding, which truly motivated us to observe and appreciate birds with a deeper perspective.

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**Srijita Pal**
RHATC Fellow 2025–26, Zoo Outreach Organisation, Coimbatore, Tamil Nadu, India.

**Citation:** Pal, S. (2026). "From Checklists to Celebrations": Following the Flight of Selvaganesh. RHATC 2025–26 Special Issue, In: *Zoo's Print* XLI(1): 103–105.

# A session with Sriram Murali – all about night skies and fireflies.

Sriram Murali, a firefly specialist, Dark Earth advocator, filmmaker, National Geographic explorer, former Google data analyst, and one of the most impactful storytellers, we came across. His journey of advocating on dark Earth, stars, and light pollution started in 2011 when he saw sky full of stars in Yosemite National Park, California.

During COVID, in search of a perfect place to star gaze in his home town Pollachi, he came across a huge population of fireflies; that's when he got curious and interested in fireflies. He co-founded Wild and Dark Earth (WiDE), an NGO that works for conservation of nocturnal species in India. His session with us was about, what he calls the love of his life—stars and fireflies—the search for the former lead to the discovery of the latter. What a coincidence that both produce their own light, stars through nuclear fusion and fireflies through a process called bioluminescence and both of them are affected by light pollution!Sriram talked about the ecology and lifecycle of fireflies and how they depend on spring rain. He showed us numerous videos, in one such video, firefly larva was eating a leech that really fascinated all of us, in other video thousands of fireflies were synchronizing, something that felt surreal, none of us had seen something like that before.

To solve the problem of light pollution from core, he is working with policy makers to come up with policies that would bring on ground change, he shared his experience of discussing light pollution at an environment conclave by Kerala State Pollution Control Board, where government is willing to bring policy change.

His session on light pollution, gave us a new perceptive of how we connect light pollution to wildlife and conservation. He shared one of his experiences where he discovered fireflies in the middle of New York city, fireflies glow in dark but its presences in the middle a city is self-explaining the damage we have done to nature. One of his phrases, "naturally dark space is wild space" will be the one of the takeaways from his sessions as none of the protected area is protected from light pollution.

Sriram introduced us to "Lost in Light", a short film on how light pollution effect night sky, the movie received massive response and got featured in several of film festivals bringing light to the issue of light pollution. His other movies include "Saving the dark", "Minmini" and "In Search of the starts". He is keen in educating children and communities. Sriram shared his experience of having a session with children studying Vedic scriptures where he talked about light pollution, inspired them, and he was too amazed by the depth of their knowledge about nature.

We RHATC fellows are delighted and inspired by meeting Sriram Murali, who gave up his job as Google's data analyst the same job people in India dream of, who's humbleness, innocence, love, and dedication for fireflies was so evident in his interaction with us. Sriram Murali is an example that people from different field can contribute to conservation and bring much needed change, all that is needed is "will".

**RHATC fellows with Sriram Murali. © Trisa Bhattacharjee.**

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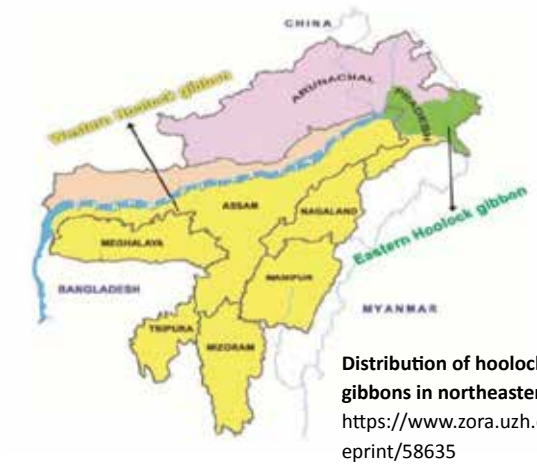
# Hoolock Gibbons – India's only Ape: victim of unscientific practices!

Seventeen primates are found in India of which 11 occur in tropical and subtropical forest of northeastern states of India (Medhi et al. 2007). One such primate found in northeastern India is the Western Hoolock Gibbon *Hoolock hoolock* and the Eastern Hoolock Gibbon *Hoolock leuconedys*. The main threat to hoolock gibbons are habitat destruction and fragmentation- tree felling, encroachment, jhum cultivation, monoculture tree plantation, and poaching (Choudhury 2006). The important factor for the decline of primates population is hunting and trade for their medicinal value (Daolagupu et al. 2021). But gibbons have no medicinal value (Hon 2019); it's a myth and has no scientific basis. Hoolock gibbons contribute to the 57% of the primates used for ethnozoological practices in northeastern India.

In Assam, tribes like Biate and Karbi use different body parts of hoolocks for painless parturition, rheumatism, dizziness, hernia, pertussis. In Arunachal Pradesh, tribes like Monpa and Tangsa use different parts of Hoolock for serious fever, typhoid, malaria, pox, asthma, tuberculosis, and liver cirrhosis. In Mizoram, the Lushai tribe uses the hoolock blood and flesh to cure different ailments like tooth decay, bee sting, toothache, headache to name some (Daolagupu et al. 2021). The Tangsa tribe of Arunachal Pradesh consider the hoolock to be bad omen and any unexpected death of the family member is blamed on them; they hunt hoolocks, cut them into pieces and don't consume them as they consider them to be bad omen, rather they throw the meat pieces in the jungle for the monkeys (Jugli et al. 2020).




**Distribution of hoolock gibbons in northeastern India.** https://www.zora.uzh.ch/id/eprint/58635

The IUCN Red List shows a suspected reduction of 50% over three generations and categorises *Hoolock hoolock* as 'Endangered' based on forest loss, hunting, and live capture for pet trade. Whereas *Hoolock leuconedys* is categorised as 'Vulnerable' and suspected that population will decline by more than 30% in the next three generations, mainly threatened by habitat loss, hunting for both meat and "traditional medicine". Hunting is less documented but it is one of the major threat for the hoolock gibbons. Importance of hoolock gibbons is beyond ecology as it is part of the biodiversity of the northeastern region. We need to educate people on myths and come up with community based long term measures to save gibbons with whom we share our common ancestry!

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# The Hatha Jodi Superstition and the Illegal Trade of Monitor Lizards

The Bengal Monitor Lizard *Varanus bengalensis* faces a significant threat to its survival in India due to illegal wildlife trade driven by superstition. While habitat loss remains a concern, a primary driver of their decline is the demand for a talisman known as "Hatha Jodi". This trade relies on a fraudulent practice where parts of a protected reptile are sold as rare plant roots.

**The Myth Versus Biological Reality:** "Hatha Jodi" (translating to "clasped hands") basically refers to the root of the Tiger's Claw plant *Martynia annua*. Folklore suggests that this root, which naturally resembles two hands joined in prayer, confers wealth, legal victory, and protection upon the owner. However, the genuine *Martynia annua* root is rare. To meet the high demand found in local markets and online export platforms, poachers substitute the root with the hemipenes (reproductive organs) of male Monitor Lizards. When extracted and dried, these organs shrink and curl, morphologically mimicking the shape of the plant root. Unsuspecting buyers unknowingly purchase and worship the severed organs of a reptile rather than a botanical specimen.

**Methods of Extraction:** The harvesting process involves severe trauma to the animal. To ensure the hemipenes retain the specific shape required for the scam, poachers typically capture the lizards alive. The animals are immobilized, often by fracturing the vertebral column or clubbing. In many documented instances, the glands are surgically extracted while the lizard is still conscious. The animals are subsequently left to die from physical trauma and blood loss. The scale of this illicit trade was highlighted in 2017, when the Wildlife Crime Control Bureau (WCCB) seized hundreds of these specimens during coordinated raids across Odisha, Madhya Pradesh, and Rajasthan.

**Legal Status**: The Bengal Monitor Lizard is a protected species under Indian and international law. It is listed under Schedule I of WPA 1972, placing it in the highest protection category alongside the Tiger and Rhinoceros. Poaching, trading, or possessing parts of this animal is a non-bailable offense punishable by up to seven years in imprisonment. Furthermore, the species is listed under Appendix I of CITES (Convention on International Trade in Endangered Species), which bans all international commercial trade.

**Ecological Impact:** The extraction of Monitor Lizards has drastic effects on local ecosystems and agriculture. As apex scavengers and carnivores, these reptiles provide essential ecosystem services. They consume carrion, preventing the spread of pathogens, and regulate populations of agricultural pests, including rodents and insects. By removing these natural pest controllers, trade inadvertently damages the agricultural stability that devotees hope to protect.

**Conclusion:** The "Hatha Jodi" trade is a clear demonstration of how a lack of scientific understanding contributes to destruction of biodiversity. This practice not only involves consumer deception but also violates wildlife protection legislation. Effective conservation of the Bengal Monitor Lizard requires not only strict legal enforcement but also scientific awareness campaigns to help the public distinguish between a botanical root and the anatomical parts of an endangered reptile.

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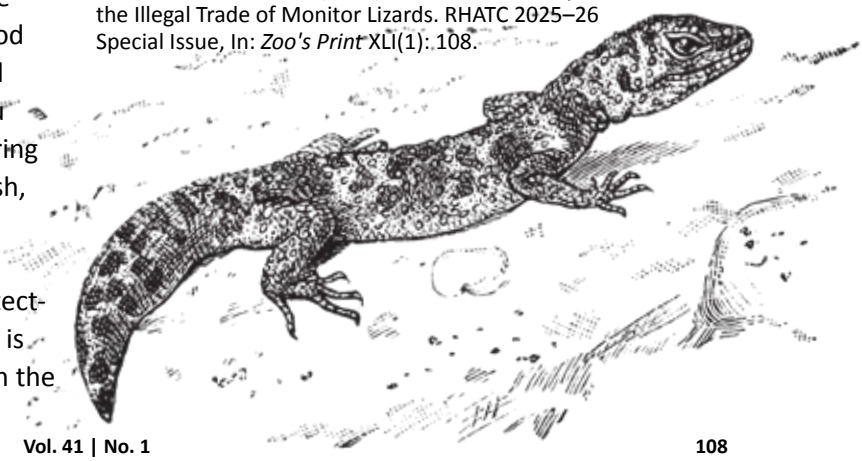

# Aamai in the House: Superstition, Symbolism, and the Truth Behind the Turtle

In Tamil Nadu, animals are deeply woven into language, belief systems, and everyday wisdom. One such well-known proverb is “Aamai puguntha veedu vizhathu” a house that a turtle enters will not prosper. Over generations, this saying has shaped fear, avoidance, and even hostility toward turtles. But is turtle truly a bad omen, or is this belief a mix of symbolism, misunderstanding, and myth?

Traditionally, turtles were seen as slow and inactive. In a society where hard work meant survival, being slow was mistaken for laziness. This led to the idea that a turtle entering a home would make its people inactive. Another belief arose from the turtle’s habit of withdrawing into its shell when disturbed. People assumed this reflected fear and withdrawal, symbolizing a household losing its energy and progress.

There is also a historical layer. Sailors observed turtles returning to their birthplace to lay eggs and sometimes followed them for navigation. Sea travel was dangerous, and many sailors never returned. Over time, uncertainty and loss associated with seafaring were indirectly linked to turtles, strengthening the negative image.

However, many scholars point out that this proverb was never meant to insult the animal. The turtle was symbolic, representing four human traits that ruin a household:
Poramai (jealousy), Iyalamai (helplessness), Muyalamai (laziness), and Theendamai (social discrimination). A house filled with these qualities will indeed fail – no turtle required.

Science completely breaks the myth. Turtles are not lazy, they are energy-efficient survivors. Pulling into the shell is not fear but a powerful defense mechanism that has helped them survive for over 200 million years. Ecologically, turtles maintain healthy water bodies, control algae, recycle nutrients, and indicate environmental balance.

Sadly, superstition sometimes turns into cruelty. In parts of Tamil Nadu, turtles have been harmed due to fear. Earlier, in some parts of Tamil Nadu, turtles were hunted due to the belief that their meat, fat, or shell could cure weakness, joint pain, or skin problems. These are folk beliefs without scientific proof. Today, all turtles are protected by law and killing them harms nature and water ecosystems.

If a turtle enters a house, it is not a curse. It is a sign of habitat loss, climate stress, or flooding.

Perhaps it is time to read the proverb correctly: When jealousy, laziness, and discrimination enter a house, it collapses. Not when a turtle does.

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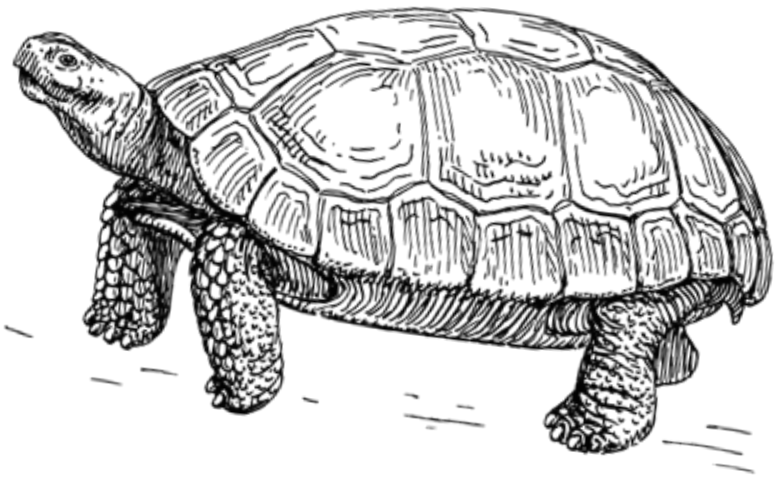


# The Red Sand Boa Vs. A Quicksand of Superstitions

Most snakes in India are riddled with superstitions while Red Sand Boa is shrouded in them, making it one of the most illegally trafficked snakes in India. Early on, most of us are introduced to snakes along with superstitions as a package deal. Their reputation precedes them in many cases, especially now with the increase in urbanisation, we come across more superstitions than snakes themselves. The Red Sand Boa (RSB) *Eryx johnii* is a snake that is popularly believed to have two heads. In reality, on one end it possesses its actual head while on the other end its tail resembles its head, not to grant someone double the wishes but to protect itself from a predator's attack that could be fatal. A deceived predator attacking its rear end rather than its head could be lifesaving. Unfortunately, the very characteristic that is supposed to save its life has become the reason for its peril in the hands of insatiable humans.

RSB is a docile, nocturnal, non-venomous snake that burrows in loose soil with less vegetation and feeds on mice, frogs, and lizards (Mongabay 2025). There are a slew of superstitions that pull this harmless species out of its place underground. While some believe that it can lead people to hidden treasures (due to its burrowing nature), others believe having it in their house brings wealth or "Lakshmi". It goes by the moniker "Double engine" in the black market and "Do Muha Saanp" (Two headed snake in Hindi) locally, which leads to people believing in the superstition that it is a mythical two-headed snake that has the ability to change their lives (Parmar & Kaiser 2022).

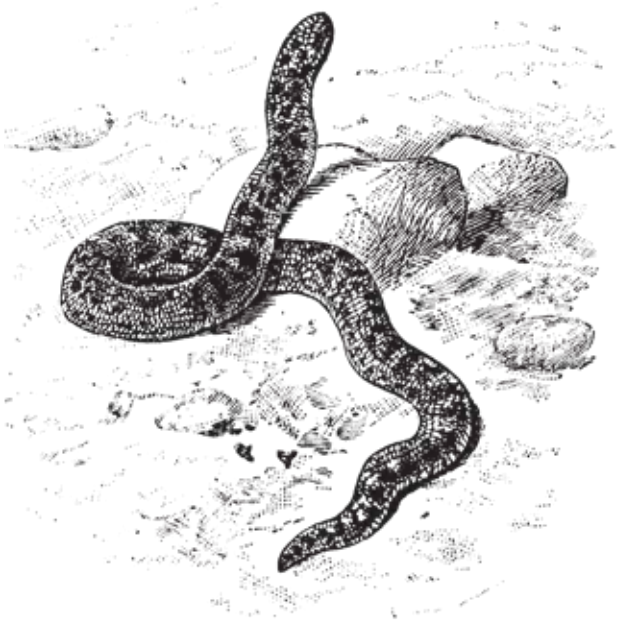
One might wonder what is the harm in keeping a harmless snake in their house and 'taking care' of it. There are a few good reasons why a Red Sand Boa doesn't belong in your living room or pooja room:

1. **Illegal:** The RSB is listed under the Schedule 1 of the Wildlife (Protection) amendment Act 2022 giving it the highest protection status, equivalent to that of Tigers. This makes trading it a punishable offence and one has to be permitted by the Chief Wildlife Warden to possess one, which is only given for specific reasons like scientific studies and zoological parks.

2. **Imbalance** all around you: removing a snake from its natural habitat not only disrupts its behaviour but can also make way for a venomous snake to take its place and bring humans closer to a fatal snake bite. If not that, it will definitely lead to an increase in its prey population, some of which are considered pests by humans that can carry harmful pathogens.

3. **Superstitions** often come with **cruelty**

- People believe that the heavier the snake, the more wealth it can attract. This also means that those involved in the business of trading them take to extreme measures like forcing the snake to ingest steel or lead balls to increase its weight (Mongabay 2025), to get a heavier payout as snakes over the weight of 3 kg are preferred. This stresses the animal out and causes physical injuries in the process which can be fatal.
- RSBs are also rented out for large sums of money, for 'black magic' rituals. Some such



rituals involve extraction of blood, cuts on the body, blunt trauma using hammers, etc. which is believed to 'calm spirits' (Paul 2022). The blood of RSB alone is sold illegally as it is believed to bestow supernatural powers to the consumer and to cure chronic illnesses which is not scientifically proven till date. In one of the more creative superstitious narratives, a meteor shower that supposedly occurred in southern India between 1000 and 1300 AD led to the accumulation of an isotope of Iridium, a rare element, in the tissues of this snake alone, dubbed as bio-iridium, is believed to have the abilities to cure AIDS (The New Indian Express 2012).

- Owing to these superstitions, this species has a high demand in local as well as international markets. Snakes have been found being trafficked across state borders and overseas to countries like Malaysia, China and the Gulf countries for their assumed medicinal and supernatural properties (Antony 2017).

4. **Compounded crime** - Other than illegal capture and trading, this racket is associated with more crime. There have been cases of assault and theft when the buyers did not agree on a steep prize set by the trader (Paul 2022). In other instances, RSBs were stolen from zoos in Mumbai (Bhagat 2011) and Kerala (Emmanuel 2009) among others to feed the demand.

In addition to the direct threats mentioned above, these snakes face the threat of habitat loss. Since they require dry open landscapes with loose soil to burrow under, the current land use change due to urban development and expansion of human settlements into their natural habitat shrinks suitable burrowing ground to inexistence (Parmar & Kaiser 2022). Despite being protected under the law, compounding factors like these have led to decreased populations and sightings of this species (Mongabay 2025) which, if not rectified soon, could potentially turn this species to be one more that we only hear about.

**Acknowledgements**
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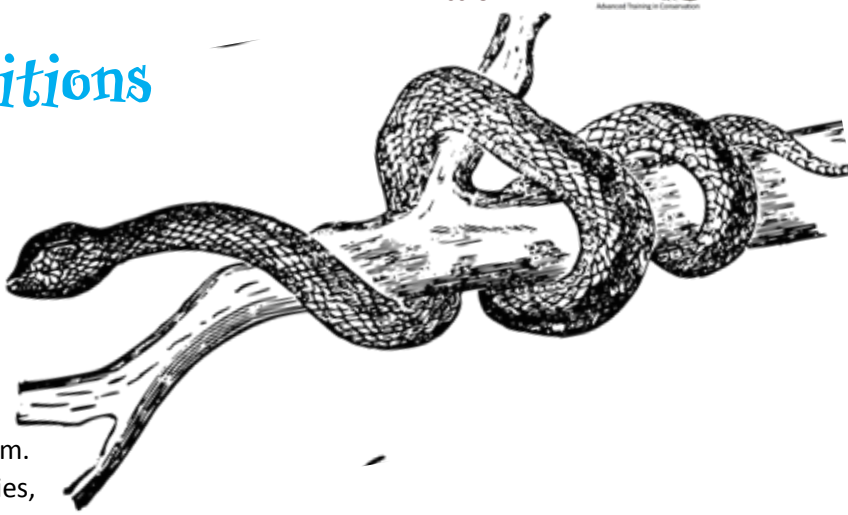
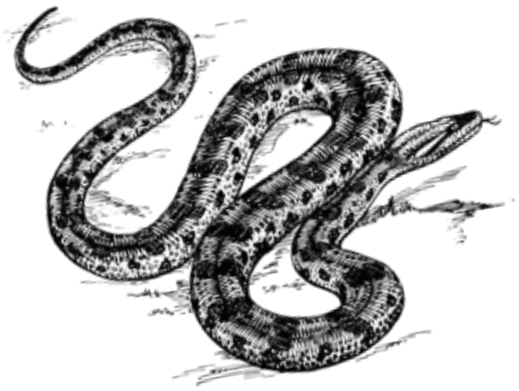
# Scapegoats of Superstitions



Snakes have been integral part of mythology and culture all around the world. They have lived in our history as symbol representing a wide range of concepts from rebirth, healing, and wisdom to fertility, danger, and deception. Different beliefs and the myths around snakes have shaped our perceptions of them and our relationship with them. It also has been changing from different geographies, races, cultures throughout the times. Many such beliefs still exist, and they are changing the ways these animals live on the planet which is dominated by us humans. We know very little about snakes which serves as a great ground for the fears and myths to root easily.

We will address two such myths from India in this article that have been turning detrimental to the species' existence for many decades. The infamous myth around the snake is that they take revenge of its partner's (mate) death. This belief, being so strong, has completely dominated how people perceived them in Vidarbha region of Maharashtra. As a child I grew up listening to all the stories of their vengeance and atrocities. So, whenever a snake was spotted in the vicinity, two guys who knew how to kill them would be called with their gear. One person would pin the snake to the ground with a wreck-like strong metal instrument, and the other one would smash the head first so that the snake cannot see the killers. And then the rest of the body would be smashed at 2–3 places until it stopped wriggling. Such an unfortunately brutal way to die at the hands of an unlettered human! The idea of



venomous/non-venomous, harmless and deadly, was far behind the curtain of fear and superstitions, hence no species was spared from this cruelty. It's a proven fact that snakes cannot remember human faces, cannot perceive emotions as humans do, they are non-monogamous, and they are incapable of taking revenge; but it was driven redundant by the superstitions.

Another contradictory belief is that snakes are godly; they are worshiped on 'Nagpanchami' a designated festival for the snakes. It is commonly seen around in Maharashtra, snakes are fed milk as an offering on that day. As the times are changing and things are becoming commercial, this festival also capitalized on the lives of snakes. Most Shiva temples are the hub for this farce as Lord Shiva is portrayed wearing a Spectacled Cobra around his neck. Indian mythology represents it as the symbol of control over death, fear, ego, and other worldly desires.

They start catching the snakes a few days/month before the festival from their burrows and holes. This process doesn't show any mercy towards the species rather it gets torturous after this. They are kept in either earthen or woven bamboo pots and starved for food and water before the actual festival. On the festival day, there's a public display of these animals being handled by the snake charmers, other Shiva devotees and the visitors of the temple. Because of starvation and dehydration it tends to eat/drink whatever that's offered first, which portrays that they drink milk. Snakes being cold-blooded reptiles, do not possess enzymes to digest milk. Milk ends up poisoning them. Research has shown that they even develop pneumonia and eventually die. One in four

snakes die during catching, extraction, and keeping, while the venomous snakes may die while their fangs are being pulled out/or being burnt off before such public displays, few are injured/ traumatized and it reduces their survival chances. So, all in all 60,000–70,000 snakes die each year around this festival.

Superstitions are again one of the anthropogenic issues that has put a species under great threat. We need to debunk these myths that can potentially drive the population to extinction and disrupt the ecological balance. Strong education and awareness about the ecology and behavior of the species is crucial to dissolve these superstitions and increase peoples' receptiveness towards the species. More scientific knowledge about snakes needs to be simplified and shared around the occasions and festivals. Understanding the snakes in the bigger context of ecology is a great possibility for true coexistence.

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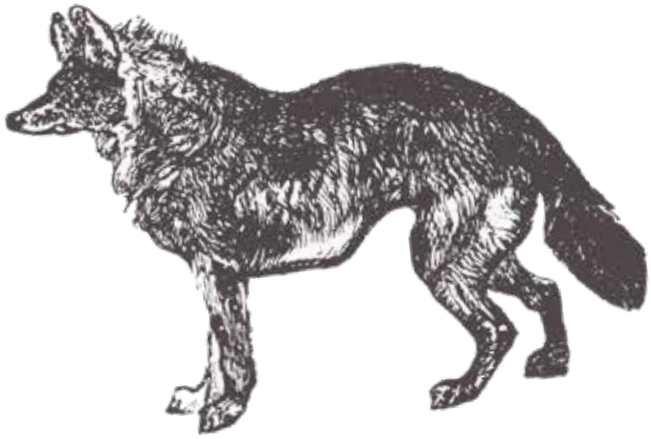
# Of the Golden Jackal and Her Horn

If you've ever heard of black magic, you might know about voodoo dolls from movies, or noticed lemons and chillies on a string hung on new cars to counter the evil eye. But have you heard of magical superstitions that revolve around wild animals? In India, a biodiversity-rich country, we actually have quite a few. One of the most interesting of these is the myth of the jackal's horn.

For those who've never encountered a jackal, let me describe them to you. Golden Jackals, the species native to India are about the size of a medium-sized dog, with a short muzzle, slightly rounded ears, a black saddle-shaped patch on their backs, and a black tip to their fluffy tails. They get their name from their golden-brown fur. They usually live in closely knit family groups of up to five individuals. They have a broad, omnivorous diet in the wild, and have been documented to scavenge from the kills of larger predators like wolves and tigers, sometimes eating right alongside these larger carnivores, who don't seem to mind! These shy animals are also capable of coexisting with humans, as their flexible habits let them include garbage dumps in their foraging patches. However, this coexistence can lead to their death because of car accidents, or contracting diseases like rabies from street dogs, or being poisoned by people for hunting small livestock or stealing fruits from plantations.

So, what do they have to do with black magic? Well, across southern Asia, the folklore of many communities includes the myth that jackals have a small 'horn' on the back of their skulls, usually hidden by their fur. This horn is supposed to have many magical properties, such as protecting the owner from evil spirits, bringing good luck and wealth, allowing the owner to see in the dark, granting the owner wishes, and reappearing magically if it's lost. This makes them a popular item used and sold by black magic practitioners.



Of course, jackals have no horns or any body parts resembling horns, but advertisements for these artifacts are commonly found, indicating the existence of a thriving black market. When some jackal horns were forensically examined, researchers found that they were actually made up of everything from bird talons, dog claws, and cow hooves to fur from foxes, goats, cats, and mongoose. Still, the international trade in jackal horns is widespread enough to potentially be a significant threat to jackal populations, as well as other wild species that might be used to make the fake horns.

Unfortunately, there hasn't been much research on trade in jackal body parts compared to more well-known species like tigers or elephants, which means we don't have much data to understand how pressing the problem is. Jackal poaching continues to slip under the radar because the species is considered to be widespread, common, and adaptable, although it could be part of a much larger wildlife crime network. It is important for the agencies working on wildlife crime to focus on all wild species, and hopefully, studies on where enforcement is needed are carried out sooner rather than later. In the meantime, if you hear anyone talking about jackal horns, be sure to tell them they don't exist and never have!

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RHATC
ASSIGNMENT

# Superstitions and the Gecko: A Lesson in Coexistence

Superstitions have been part of human life for centuries and surprisingly not limited to the nation, culture, and geography. They arise from fear, faith, and sometimes unknown reasons. In India, these beliefs are rooted in culture and traditions, influencing how we see certain animals, one such superstition is about tiny, wall-climbing lizards. There are many superstition stories revolving around this small creature, the Gecko, across the world.

In my hometown in Uttar Pradesh, there is a superstition that killing a Gecko brings bad omen to the family. And if a gecko falls on your body, then you have to spread salt on your roof to remove the negative energy. When I started digging into this superstition, I came across many other beliefs around geckos. In my own region, I found that when geckos fall, they spread rice all over the body. These stories are passed down from generation to generation without any valid explanations.

Proverbs, sayings, and information provided by numerous informants show that the common small house geckos are regarded as ominous creatures associated with ill fortune. They are also considered highly impure, and thought to be carriers of leprosy and other diseases (Frembgen 1996).

How can a little creature have the power to bring misfortune? It's unreasonable to spread salt on the roof when a gecko falls. Salt has antibacterial and antifungal qualities that help kill germs and bacteria, but how salt removes the misfortune is beyond understanding.

In southern Portugal, for example, locals believe that geckos are poisonous and cause skin diseases when they touch a person. A study by (Ceríaco et al. 2011) found that about 25% of the local people believed geckos were poisonous, while 24% thought they transmitted skin diseases (da Silva et al. 2011). Like us, these beliefs have made the local people afraid of lizards, even though this animal is harmless and helps by eating mosquitoes and other insects.

Another study by Ceríaco (2012) showed that "the presence of folklore and negative values clearly predicts persecution and anti-conservation attitudes towards reptiles" (da Silva et al. 2012). This shows that superstition can influence people's behavior with these animals, leading to fear and even killing rather than coexistence.

Due to the fear of bad omen, people chase the lizards away. What if everyone starts believing in this superstition? What will happen to its population? These are questions we forget while chasing the lizards away.

Geckos play a vital role in maintaining the household and garden ecosystem. They are excellent insect population controller; feeding on mosquitoes, flies, cockroaches, and other small insects. If gecko populations decline it will have harmful effects to humans and crops. These also act as prey for birds and snakes. Harming them disrupts the ecological balance and it leads to an increase in insect population.

A more recent study by da Silva et al. (2021) found that fear and hatred towards reptiles decreases when people have more contact and awareness about them. This indicates that knowledge and awareness play a significant role in moving communities beyond fear and superstition.

Overall, it is important to understand that these small creatures do not bring bad luck to anyone, in fact, in most cases, they act in our favour. Our fear and false belief only harm the environment and disturb the balance of life around us. We should learn to coexist and respect every life that contributes to the nature' harmony.

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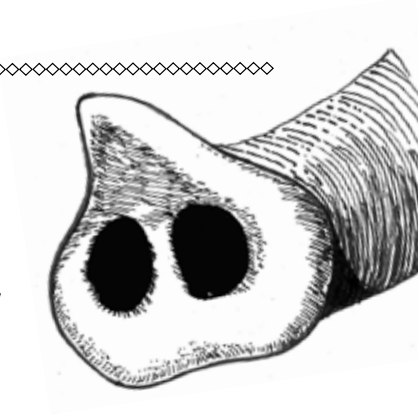

# Behind the Blessings

The colorful and intricately designed ornaments and clothes with decorative parasols, aromatic scented incense and flowers all around, festival drumbeats, and crackers popping everywhere; featuring elephants as the most adorned for the massive crowd gatherings. It is one of the most visually striking rituals around Kerala, yet in reality, people rarely see or choose not to bother, what goes behind the scenes as a preparation.

Elephants are chained throughout the day with very limited to no movement space, poorly fed, brutalised using weapons like bull hooks and long polls with poking spikes, mostly kept in solitary, and they undergo a torturous training where they are tied up and beaten for several days to weeks until they obey the mahouts command. Many, if observed closely, have poorly treated wounds on their bodies, blood strains around their ankles, tears oozing from their eyes, and some are even blind and never treated. These prolonged abuses affect both the physical and mental health causing severe stress to these magnificent creatures, all for the sake of human entertainment and blessing ceremonies.

Elephants in the wild are highly intelligent, social animals with complex emotional lives. In the wild, they live in close-knit family groups, travel long distances every day, forage for a wide variety of vegetation, and rely heavily on social bonding for survival and well-being. Adult elephants can walk up to 20–30 km a day, communicate through low-frequency sounds, and display strong memory. Confinement, isolation, loud noises, and unnatural routines directly contradict their natural ecology and behaviour. Such conditions often lead to psychological distress, explaining why captive temple elephants frequently exhibit signs of trauma and unpredictability.

The tradition of keeping elephants in temples dates back a long time. However, the actual period when temples started associating themselves with elephants remains unclear. Traditionally, elephants were kept to carry water from river to bath deity, stood only for auspicious hours and were otherwise allowed to roam freely in the forest areas associated with temples. With changing times, the temples lost its forest area, and the source of water changed. Over time and the ever changing various cultural norms, they started exploiting elephants by training them to bless the devotees in return for money and food.

The beliefs and practices differ from state to state. In Kerala, elephants have become almost an essential part of major festivals and daily worship. One of the largest gathering includes Thrissur Pooram, placing the elephants as the centre of the celebration. By contrast, temples in Tamil Nadu and Karnataka traditionally keep mostly female elephants for blessings and rituals as the males can be problematic during their musth. In Tamil Nadu, famous temples

like Srirangam and Madurai have well-known elephants that circle the temple offering blessings. In Maharashtra and Andhra Pradesh, where temple elephant numbers are smaller, the animal's image still appears in ceremonies. Across regions, the beliefs are similar—a blend of religious symbolism, status, divine association, economic benefit, ritual roles, and traditions that have turned into pride. A 2019 survey by India's Ministry of Environment, Forest & Climate Change (MoEFCC) reported 2,454 elephants in captivity across India. Out of which 96 with temples and religious institutions, 1,687 are privately owned in which most are rented for festivals as ceremonial elephants earn more than $10,000 per festival. However, trading captive elephants is banned, but legally possessed captive elephants can still be gifted and it creates a significant loophole in the law. Despite bans, wild elephants continue to meet demands in temples especially, in the southern part of the country. The recent, 2022 amendment to Wildlife (Protection) Act has centralised the power to frame the rules regarding the transfer of the elephants and leaving the state government leaving little to no role.

This brings us to an uncomfortable but necessary question: do we truly need elephants in temples to practice faith? When devotion demands suffering, restraint, and lifelong captivity for a wild animal, it is worth rethinking what tradition really stands for.

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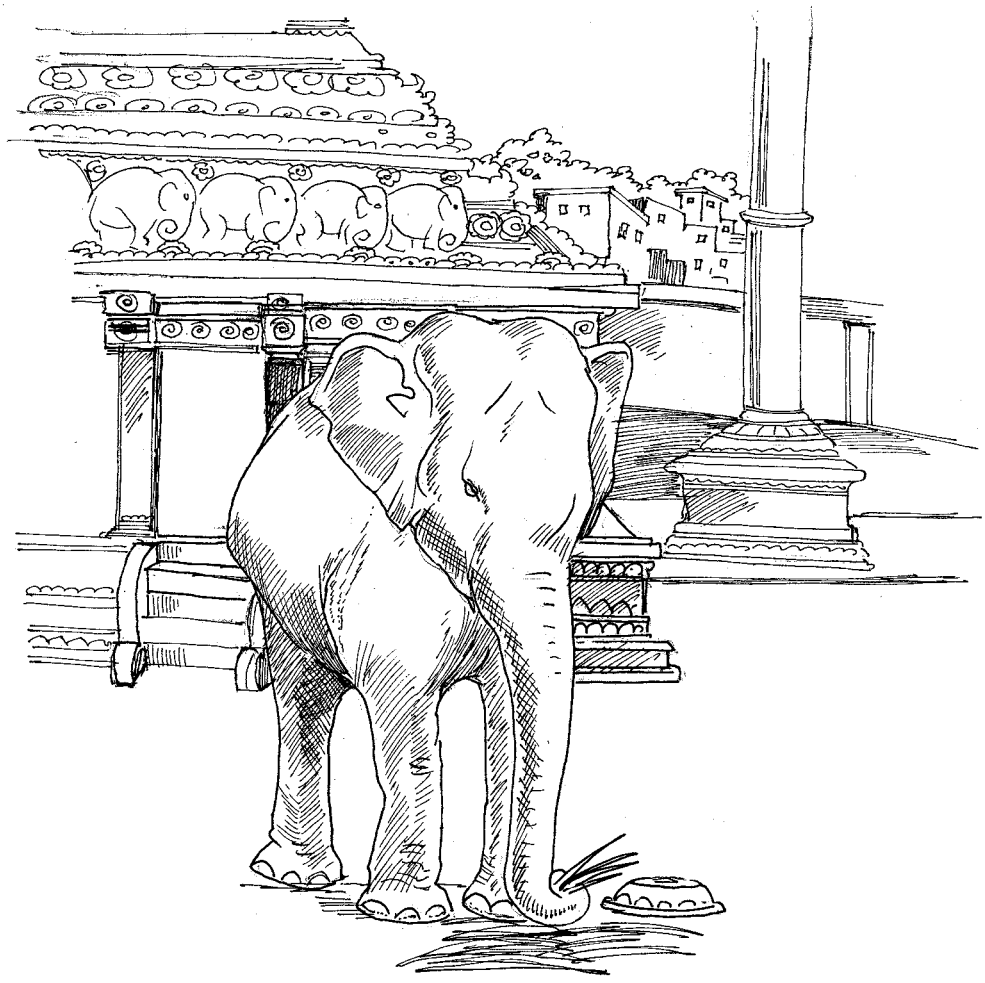


# Superstition, Symbolism, and Suffering: The Hidden Cost of India's Peacock Feather Trade

The Indian Peafowl *Pavo cristatus*, celebrated as India's National Bird, holds immense cultural and religious importance. In Hinduism, the peacock feather is one of the most sacred symbols. Lord Krishna is eternally depicted with it adorning his crown, embodying divine love and humility. Lord Kartikeya (Murugan) rides a peacock symbolising triumph over ignorance. In Buddhism, the peacock represents purity and transformation (ResearchGuru 2022). Among Sufi communities in southern Asia, peacock motifs appear as metaphors for divine beauty and the splendour of paradise (Utrecht University 2020). Christian art in India has also embraced the bird's symbolism of resurrection and immortality because of its cyclical moulting and feather renewal. In several tribal and folk cultures, peacock feathers are integral to rituals for fertility, rainfall, and protection from evil spirits (ResearchGuru 2022).

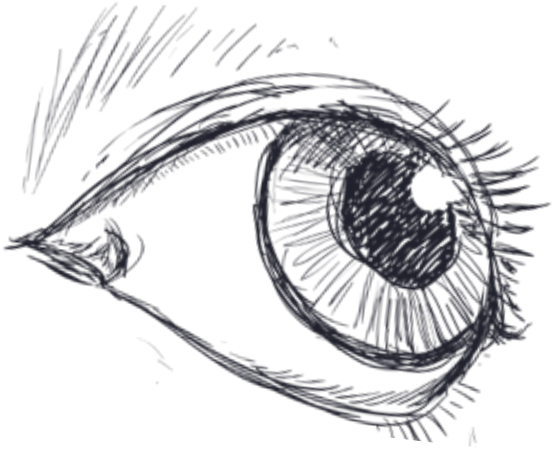
This rich symbolism, however, has also contributed to unchecked superstitious practices. The belief that possessing or gifting a peacock feather attracts good fortune and wards off evil has created a lucrative market for real feathers (BWC India 2025). However, scientifically and biologically, they are just specialized feathers grown by male peafowl for display and courtship. They do not have any supernatural power or effect on a person's fortune, success, or future.

Although peafowl naturally moult each year, providing an ethical source of feathers, traders frequently prefer fresh, vibrant feathers that fetch higher prices (Wildlife SOS 2025). To obtain them, birds are restrained or plucked alive, often leading to pain, infection, or death. Field investigations by conservation groups report instances of peafowl held in captivity solely for feather harvesting (BWC India 2025).

Also very recently, in Pune, 11 people from Uttar Pradesh were arrested with over 400 kg of peacock feathers, seized for illegal trade, violating the Wildlife (Protection) Act, 1972, which lists the Indian Peafowl under Schedule I (Hindustan Times 2025). These findings reveal how superstition-driven demand is fuelling a shadow economy that thrives on cruelty and weak enforcement.


Source: https://www.mypunepulse.com/pune-forest-dept-seizes-500-kg-peacock-feathers-11-arrested/

Traditional medicinal beliefs also perpetuate exploitation. In parts of Tamil Nadu and Rajasthan, powdered feather "bhasma" is used for asthma or epilepsy despite the absence of scientific validation



(Down To Earth 2021). Such practices merge folk medicine with superstition, reinforcing demand even among communities aware of legal restrictions.

The ecological consequences are equally concerning. Removing feathers before the breeding season impairs courtship displays, while capturing birds or disturbing nests reduces reproductive success. Local population declines have been observed where intensive collection occurs alongside habitat degradation.

Ending this cruelty does not mean rejecting cultural tradition. Instead, awareness campaigns should emphasise that peafowl shed feathers naturally and that purchasing plucked feathers encourages illegal trade. Religious and community leaders can promote symbolic alternatives; printed motifs, artificial feathers, or offerings made from other sustainable materials. Greater vigilance at local markets and online platforms, combined with strict implementation of the Wildlife (Protection) Act, is essential. Educational outreach in schools can reshape beliefs, helping people appreciate the bird's beauty in the wild rather than as decoration. Ultimately, it's our responsibility to ensure that peacocks remain dancing in the monsoon, not suffering for a superstition.

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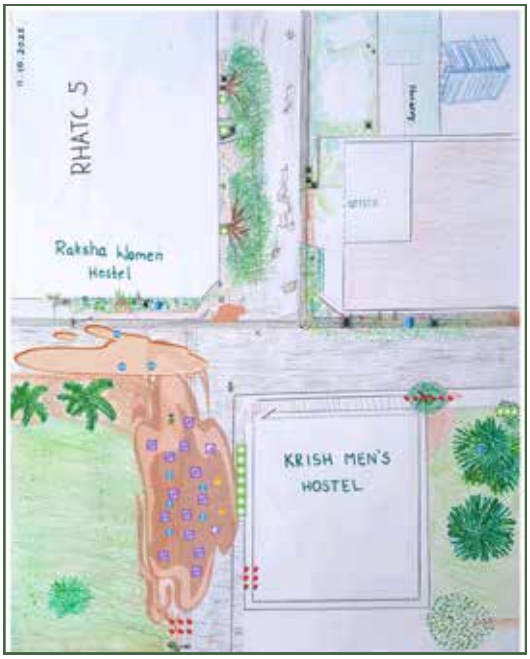
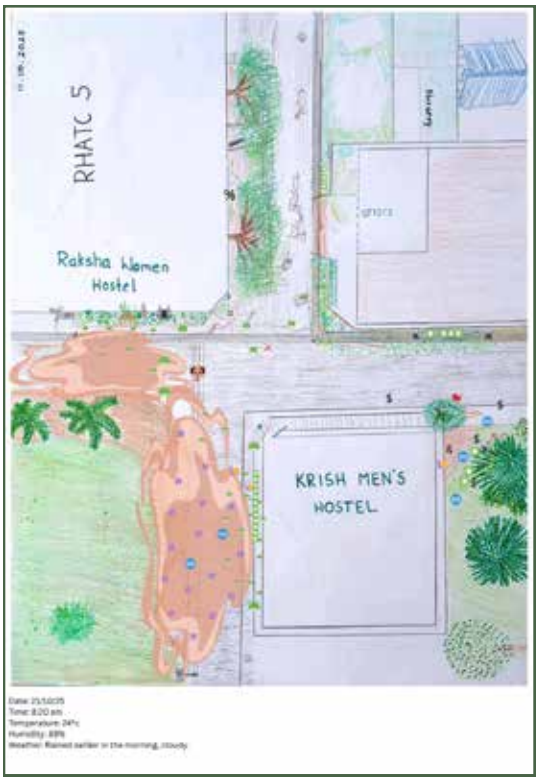
# BIO-MAPPING AROUND THE RHATC SITE

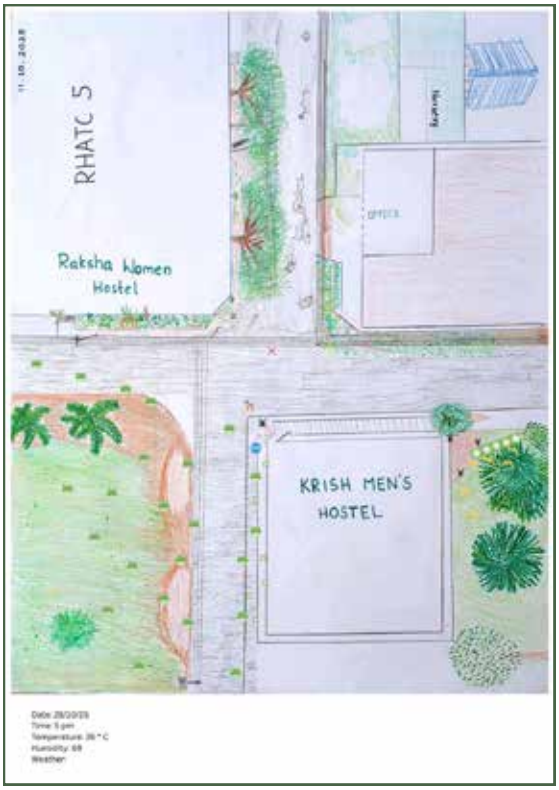
As a part of RHATC, one of the activities that we undertook was biomapping around our office once every fortnight at a fixed time. Biomapping is a simple tool to document the different landscape features around you, both natural and man-made, and observe the different life forms that they support - be it plants, animals or fungi. It helped us visualise and appreciate the changes in their numbers and activity over time with fluctuations in weather conditions and seasons.

We started noticing the subtle patterns in the biodiversity that lives alongside us and how they are impacted by our actions. From the first to the last observation it is evident that the environment around us is dynamic. For instance, a temporary puddle that formed in an empty site over the monsoon supported flies, mosquito larvae, frogs from eggs, tadpoles to froglets, dragonflies and much more! And after it dried up grasshoppers took their place.

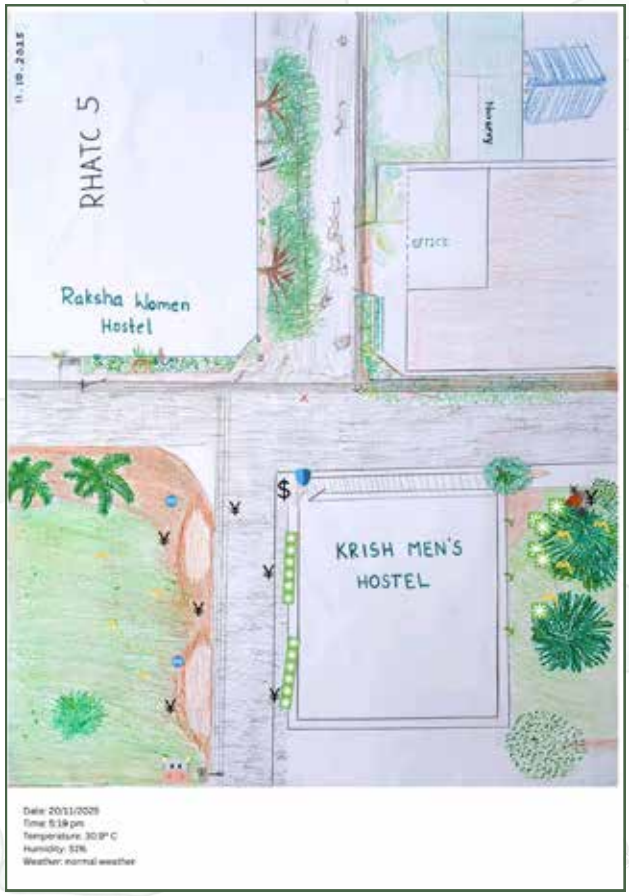



**Over two months the change in species found around us. In all there were 12 observations. These 5 images showcase the changes to the landscape and diversity best.**




**Same day in November**
**Morning and evening recording.**




## Legend

Odonate
Spider
Egg
Pupa §
Frugivorous bird
Insectivorous bird
Omnivorous bird
Coleopteran
Lizard
Hymenopteran
Dipteran ¥
Ant
Ant hill/nest ? Δ
Gastropod @
Earthworm
Anuran
Tadpole
Snake
Mosquito
Fungi
Millipede and centipede %
Roach &
Moth $
Orthopteran:
Slug/snail:

**K. Gokul, Pathak Hrishikesh, Sanjana Vadakke Kuruppath, S. Naufal Nazium, M. Nishigandha, G. Pannagasri, Srijita Pal, Ishika Shah & Yadav Shreya.**
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# Reflections on Restoration efforts from the Field Trips: RHATC 2025-26

As part of the Ram Hattikudur Advanced Training in Conservation (2025–26), we undertook five field trips designed to align with this year's RHATC theme of ecological restoration. Each visit provided us with practical, on-ground exposure to different restoration models, management strategies, and the challenges faced by diverse landscapes. Here, we present a compilation of our critical perspective on the field sites we visited, highlighting how each location approaches restoration and the lacunae we identified. This comparative essay is meant to provide an understanding of the different ongoing restoration efforts we saw in India, and to identify indicators of an appropriate versus inappropriate restoration project.

Here, we use the term restoration to refer to the process of assisting the recovery of any damaged ecosystem, with the goal of re-establishing its natural structure, functions, species composition (both flora and fauna), and ecological resilience. This can be either done by active interventions like planting native trees and removing the non-native trees, or passively like removing pressures to let nature recover on its own. Planting trees irrespective of whether they are native or non-native, and whether the site itself was a grassland or forest, is referred to as afforestation. Planting trees to cover land used for some invasive or destructive purpose, such as mining, is referred to as reclamation.

## Nilgiri Biosphere Nature Park

NBNP was started in 1993 by the Coimbatore Zoological Park Society, a group of business owners who were interested in establishing a zoo in the city, after Sally Walker convinced them that a botanical garden/nature park would be of more value. Situated in Anaikatty, close to the Kerala border, NBNP has a petting zoo as well as a nature trail that winds through a large tract of restored land. It sells tickets for admission to the public, and also has a playground as well as a camping ground.

NBNP. © B. Ravichandran.

### PROS:

- It is primarily composed of a great diversity of species native to the local forest type.
- The method of selecting and planting species was scientific, such as shading the saplings that needed it and planting different species with adequate space between them.
- It includes a nursery where native saplings are available for sale, potentially helping restoration efforts elsewhere.

A lot of thought has been put into the educational value of the park, e.g., species tags on most of the trees we saw; information boards about different topics at frequent intervals; nature observation foldouts provided; discovery sheds for rest, writing, and learning that focused on different taxa every few hundred metres, with some creative ways of sparking curiosity such as the pugmarks of different species cast in concrete in the mammal shed and Eric Ramanujan's artwork in the insect shed.

Wild mammals travel through the area to reach the forest nearby, so the park provides some degree of connectivity and shelter for them. There is also an attractive butterfly garden that sees high butterfly diversity during the migration period.

### CONS:

- NBNP still has a few individuals of alien species like Casuarina sp. which had been used as windbreakers to shelter native saplings while they were growing.

- It clearly functions more as an education-cum-recreation area than as a restoration area. It seemed quite commercial with the playground, campground, and petting zoo, and may become more so in the future.
- There are no restrictions on human presence to protect biodiversity, and no regulations about appropriate behaviour inside the park. Some domestic animals were also there (dogs and goats).
- Compromised ecological function, with little undergrowth or avian fauna.
- There is no evidence of systematic monitoring of either flora or fauna to understand the ecological health of the park or the spread of non-natives.
- The park lacks a dedicated guide to bring out NBNP's full educational value, as people can easily ignore the boards and other educational material.
- There are no restrictions on the sale of nursery saplings, potentially contributing to the spread of species native to this region to other bioregions.
- Some infrastructure aspects need maintenance, like broken educational boards

## Puducherry
## Pitchandikulam Forest

Pitchandikulam Forest, started by Joss Brooks in the 1970s, was one of the first independent initiatives to increase green cover on barren land. Supported by Auroville, they focused on regreening and then restoring 75 acres of land in Puducherry.

### PROS:

- They actively include native species of underrepresented tropical dry evergreen forest (TDEF) in their restoration efforts, a relatively rare forest type that has been almost entirely lost in the natural state.
- They collect seeds from reference sites (sacred groves) and started a nursery for native species.
- They built a close-knit community who live in the forest and are dedicated to its upkeep, as well as connected with several other restoration practitioners, corporates, and government officials.
- They have a holistic attitude towards understanding the landscape, with value given to the wealth of historical tradition of local communities. This included cultural and ecological practices (encompassing a range of aspects from burial rituals, to seed storage, to serial ponds to capture rainwater).


Pitchandikulam forest. © G. Pannagasri.

### CONS:

- They continue to plant non-native species in some campuses, which could impair ecological interactions in the forest.
- The forest, while fairly large and developed in structure, doesn't seem to hold many animal species and pointed to a lack of ecological function and/or diversity.
- There is little to no monitoring of the trees to understand how and why they are growing the way they are (and how to help them grow better). The only indication of monitoring was from some camera trapping they had done 10 years ago, which showed a good range of mammals, but such monitoring needs to continue to understand the ecological trajectory of the forest.
- There didn't seem to be any outreach to locals about the forest and why they're maintaining it.
- We saw nothing about any documentation or publications from the work they've been doing, which could be very valuable given their long experience in the area.
- A trained ecologist had clearly never been involved in any part of their work - doing so could have significantly improved the ecological function.
- The number of staff is quite small while the work they need to do is quite a lot, resulting in

a diffused focus that does not allow them to execute any single project with the attention it deserves.

## Auroville Botanical Garden (AvBG)

AvBG was started in 2000 by the people from the Auroville community in Puducherry to reestablish human-nature connections and to provide nature education for children. Later, they stepped into consultancy around landscaping and restoration of degraded and mined landscapes. Currently AvBG engages in eco-landscaping, mine eco-restoration, afforestation, conservation & research, nature education, ecological awareness & training programs, and provides courses on ecological horticulture.

### PROS:

- Significant and diverse workforce from all over the world, which brings in multiple approaches and practices of restoration.
- They grow forest species with a dedicated nursery and plant them where appropriate for restoration, guided by appropriate reference sites and historical research.
- They are able to work in a way which fetches rich clientele (Hyatt, RAMCO Cement, Hidesign) and constant funding inflow. For example, they are flexible in terms of using a temporary solution that appeals to the CSR which fetches them time and funding to potentially work towards restoration in the long run.
- AvBG has focussed on building eco-parks, landscaping for 5-star resorts and township management, that helps people to understand the shift from supposedly degraded/barren land to the functional/beautiful one.
- Their research and development wing is active in terms of understanding corporate policies, soil condition, plant taxonomy, social engagement, and ongoing restoration efforts across the country.

### CONS:

- They have strong corporate engagement which can limit their work as they have to fetch quick results, which sometimes pushes them into planting non-native, fast growing trees. This is an obstacle to the ecological restoration of the landscape, even if the non-natives are not invasives.
- They mentioned that they are planting non-native / invasive trees at degraded mining sites, while historically, Tamil Nadu was mostly grassland, making it afforestation rather than ecologically appropriate restoration.
- Many of their projects focus on creating 'eco-parks', townships, and 'sustainable' timber harvesting system by setting up permanent study plots of Acacia auriculoformis, which are only for aesthetic afforestation or commercial use and don't support ecological functioning at all.

Their monitoring mechanisms focus on corporate reporting, such as measuring the carbon stock and sequestration for their selected site. The indicators they use are therefore lacking in ecological parameters, with no evaluation of support for biodiversity.

## Mangrove forest

Twenty years ago the forest department started mangrove restoration in the estuarine area along the East Coast Road.

### PROS:

- Potentially provided some habitat for local biodiversity (though this needs to be verified).

### CONS:

- The restoration site was not meant for the mangrove restoration, the site was a non-mangrove area.
- Only a few species around 6–7 were planted, no species diversity was observed. Out of which only 2–3 which could adapt survive.
- Basic principles of restoration were not taken into consideration starting from: identification of restoration targets based on reference ecosystems, identifying barriers preventing natural recovery, monitoring, and interventions.


Mangrove forest restoration site Pondichery. © G. Pannagasri.

## Aurovanam

Aurovanam is an effort by Pitchandikulum Forest Consultancy to revive the Matrikunj estate. It's called Nature's Lab where they emphasize grassroots education on natural farming, herbal medicine, and seed preservation. Aurovanam has a blue-green center and also has a nursery/vegetable garden that serves as a repository of rare and exotic edible plants.

### PROS:

- They have done the reclamation of the Ousteri lake, it has a dense, rapidly growing forest that complements their objective of restoration.
- The seed bank helps preserve the variety of native and non-native edible plants, including many traditional varieties.


Aurovanam Shiva showing the seeds and explaining about the seed bank. © G. Pannagasri.

- The place serves as a great education outreach site that helps establish the connection between children and nature. For example, the vegetable and herb garden makes it exciting for education and exploration for children because of the variety of edible plants.

### CONS:

- The reclamation of the lake ecosystem shows a lot of non-natives and in fact invasive species on the site which defies the purpose of restoration.
- The exotic plants in the vegetable and herb garden spread wrong information about the native species.
- As it's an education center, the onus lies on Aurovanam to provide authentic and scientific information which seems to be not taken seriously.

## Sacred groves:

- We visited two sacred groves, Putthupet and Ooreni, both considered to be religious sites.

### PROS:

- They are the last remaining natural fragments of TDEF species, acting as a reservoir for the future.
- Some of the trees are still tagged and used as a study site, providing ecological information about TDEF species.

### CONS:

- Both groves are highly fragmented and have relatively low species diversity due to long term ecological disturbances.
- There are no policies being strictly implemented to minimize human disturbance due to activities like expansion of temple infrastructures, agricultural encroachment, timber collection, grazing of cattle, and plastic pollution
- Local management actively plants some non-natives and invasives. This prevents natural regeneration.
- There is little to no awareness about how unique these groves are and why they need protection.
- Removing seeds for nursery stalls regeneration.



## Nadukkupam

### PROS

- Strong environmental education for students: Dedicated teachers lead plantation drives, kitchen gardens which support butterflies and local flora and fauna learning. They have a separate education centre with student-made arts/crafts used in village awareness programs like puppet shows, dramas, Villu Paatu storytelling, student-crafted props & costumes, native rice seed bank, and infographics on the bioregion.
- They carried out valuable livelihood supporting activities in Nadukuppam that helped reach out to the local community, such as arranging for medical/veterinary care camps and toilets and water at the local government school, and livelihood activities like spirulina production.
- Water retention and landscape modification: Transformed barren, eroded land into a fertile landscape via hydrology redesign (drainage paths to interconnected ponds).


### CONS

- Presence of non-native trees: While most school grounds and restoration areas prioritize natives, a few non-native varieties risk ecological imbalance and reduced biodiversity benefits. There is no reason for them to be planted at all.
- Incentive programs diverging from core restoration: Ayurveda, spirulina farm, and medical & veterinary camps for humans and cattle can generate community support but may not directly advance eco-restoration objectives.
- Livestock interference: Cattle roaming in the forest area undermines restoration by compacting soil, damaging saplings, and increasing erosion risks around water bodies which are not supporting restoration.

## Siruseri Twin Lakes:

The twin lakes of Seruseri on the outskirts of Chennai, Periya lake and Chitteri earlier were divided by a small path and later made as a road which then slowly turned the lakes into a landfill. The lakes underwent rejuvenation efforts under a project which began in 2019, supported by a CSR initiative of Tata Consultancy Services and guided by Indian Institute of Technology (IIT Madras). The work was executed by Pitchandikulam Forest consultants with support from SIPCOT for a maintenance part which is approved by PWD and Siruseri Panchayat and Public Cooperation.

### PROS:

- Removed all the waste dumped in the lake area
- Achieved the present water level in three years

by rainwater harvesting only.
- The project ensured that washing of clothes and utensils in the lakes was restricted, thereby regulating and maintaining water quality.
- As we were informed, wildlife such as wild boars and porcupines have been spotted visiting the lake, indicating the return of some ecological functions.
- Managed to have the cooperation of the Siruseri Panchayat and local public.

### CONS:

- After removal of all the waste, desilting was undertaken and the mud extracted from the lake was used to create hillocks around the banks, without taking into account whether hillocks were ever there in that landscape historically.
- The depth of the lake was increased to 15 ft by excavation.
- The site included huts on the hillocks for people to sit in, which creates scope for human disturbances to the habitat.
- The waterbody today hosts fishes such as tilapia, snakeheads, and a few more ornamental fishes (no native fishes in the lake).
- No restrictions on local people for engaging in fishing and bathing in the lakes.
- No sight of any birdlife.
- Dominance of invasive species such as eucalyptus and acacia, along with other non-native trees, raises questions about the long-term ecological health of the rejuvenated zone.
- Wide gaps between trees and a lack of undergrowth were observed, both indicators of ecological stress and degradation.
- The forest department plans to commercialize the area by clearing a patch of the forest to build a cafeteria, which would increase human footprint, disturb the fragile ecosystem, and risk undoing the rejuvenation efforts that were undertaken.

Siruseri Twin Lakes Restoration Project. © Unknown.

There didn't seem to be much attention given to ecology and protecting a natural ecosystem. The project leaned more towards beautification and a 'green' space designed for recreation.

## Ooty
## Upstream Ecology

Upstream Ecology is a restoration non-profit company that primarily focuses on solutions based on plant ecology. They predominantly work in the Nilgiris on shola-grasslands, shola forests, and wetlands, with emphasis on restoring ecological services through reviving habitats. For example, the Shola-grassland restoration project is supposed to aid absorption and retention of water in the andic soil with the help of native grass root networks.

### PROS:

- They possess a holistic perspective towards the landscape that they work with, including hydrology and historical ecology, and recognize the importance of restoration in conserving those habitats.
- They have the ability to work with a wide range of stakeholders from farmers to the forest department and involve interested students through interning/volunteering opportunities.
- The native nursery not only supplies plants for their restoration activities but sells saplings to others who are keen on having native plants on their property in the region.
- They have their own nursery which cultivates endangered native species of plants across plant types, belonging to different landscapes.

### CONS:

- Although they aim to rebuild the 'form' or structure of the ecosystem through their restoration activities, there is a need for more emphasis on bringing back the function of the ecosystem too, with respect to supporting different faunal associations.
- Plant species are chosen (whether single or multi


Upstream Ecology Nursery. © B. Ravichandran.

spp.) with a primary focus on the use by specific animals, such as in Thaishola where they planted only Tripogon bromoides for Nilgiri Tahr alone and bamboo on the river bank in Mudumalai for elephants.

- Need for monitoring: The restoration plots are initially monitored once in 4 days until the plants are faring well, after which the sites are visited once in 6 months to assess survival and growth (not systematic or quantified) and to check whether the plants are being used by the specific target animals (e.g., Nilgiri Tahr for Shola-grassland site). Systematic monitoring is an important part of a well-rounded restoration effort and can help approach setbacks more scientifically, which is lacking here.

## Coorg
## Rainforest Retreat

Rainforest Retreat is an eco-lodge located within Mojo Plantation, Coorg, managed by Sujatha, Maya, and Anurag Goel. The site emphasizes organic farming, biodiversity conservation, and minimal ecosystem disturbance. It supports ecological research and nature-focused tourism, while promoting plantation techniques such as composting, natural pest repellents, and leaving decaying logs to maintain microhabitats.

### PROS:

- Organic farming reduces chemical impact on soil and water and helps support existing biodiversity.
- Undisturbed undergrowth and decaying logs support insects, fungi, and microhabitats.
- Active documentation in the form of booklets and checklists aids research and biodiversity knowledge.
- Eco-tourism provides education and awareness about sustainable agriculture and forest ecosystems to interested visitors, researchers, and students.

### CONS:

- They planted non-native species alongside native ones in landslide patches to stabilize the land, potentially due to a lack of complete ecological knowledge, which could affect native flora.
- Use of invasive plants like Lantana camara for repellents may encourage their persistence.
- Biochar production process is poorly understood and may have environmental risks like increasing carbon emissions.
- Civet coffee promotion raises ethical concerns and may encourage wildlife exploitation.

## Valparai
## Nature Conservation Foundation

NCF was established in 1996, and they work in various aspects of ecological research, conservation and education. On our trip to Valparai, we interacted with Dr T.R. Shankar Raman, a wildlife scientist whose focus is mainly on the ecology and conservation of tropical forests and Dr Divya Mudappa, whose goal is to improve the scientific understanding of patterns and processes in tropical ecosystems. They have


Rainforest retreat. © Sanjay Molur.

been heading NCF's project on Western Ghats forest research in Valparai since, with the goal of restoring degraded rainforest patches in coffee plantations.

## PROS:

- Referring to historic and scientific research: Before starting the restoration work, their preliminary efforts included looking at historical references and conducting scientific research. Using sources like Flora of Anamalai Hills (1921) and traditional knowledge gathered by talking to local people, they designed their benchmark sites and grounded their approach in the landscape's past.
- Systematic nursery management: They maintain a dedicated nursery for native species where they don't arrange species in order but mixed, which helps in preventing the spread of diseases. They use locally sourced seeds and seedlings and maintain diversity by collecting year-round and choosing multiple parent trees to ensure genetic variation.
- Ethics: They minimize harm to wild populations like collecting seeds from roadsides, following best nursery care practices and avoiding sale or transfer of saplings to other eco-regions.
- Responsiveness to threats: From the beginning, they also identified potential threats and built threat mitigation into the entire restoration process. For example: they collaborated with the highway department to put barricades along the roadsides so that cattle don't enter the restored site, and to maintain mud banks along roadsides so that they don't need to be cemented.
- Robust monitoring: They follow a robust long-term monitoring process through different stages of recovery that track form, function, diversity, and relationships, such as the LEMON (Long-term Ecological MONitoring) plot.
- Learning through experimentation: Their commitment and dedication can be seen in how they keep experimenting with new techniques in various aspects from nursery management and seeding methods to planting saplings and dealing with invasive species.
- Transparency: They document and scientifically publish both failures and successes, which highlights their transparency.

Valaparai restoration plots. © Ravichandran.

- Involvement of local community members: This nursery is systematically managed by well-trained staff from the local Kadar community.
- Long-term commitment: Their presence in the landscape over 25 years has allowed NCF to develop an immense depth of knowledge, and they are still learning about the ecosystem and how to improve on their restoration efforts This shows the importance of long-term dedication to a particular ecosystem to achieve success that can be sustained in the long run.
- Education and awareness: Alongside all this field work, they also focus on education. Their well-designed, artistic, and scientifically sound Nature Interpretation Centre helps educate and create engagement with the public.

## CONS:

- Lack of popular communication: Their restoration work is not well known even among the people of Valparai because of limited popular communication. This also connects to their Nature Interpretation Centre, which is a treasure with a lot of scope for educating local people and especially tourists, but remains under-used.
- Lack of community outreach: Another concern is that the restoration work has limited community involvement. If more communities were involved and educated about the work, it could develop a sense of pride and it would directly benefit the restoration sites (for example, grazing of cattle could be brought down).

## CONCLUSION

Comparing most of the different restoration (and non-restoration) sites we've been to, taught us

that there are a range of practices that try to support natural ecosystems, with different degrees of success. While non-forest areas like coffee plantations can still support a certain amount of biodiversity, making it imperative to promote nature-friendly practices like organic farming, there are also misguided restoration efforts, such as by Pitchandikulam Forest, where non-native species are actively planted, potentially negatively impacting the functioning of the forest. We also learned that there is no substitute for scientifically restored forest (apart from pristine forest, which is becoming increasingly rare!). The only example we saw of truly scientific and effective restoration work, carried out by ecologists, was by NCF in Valparai. However, even there, we saw that their work could potentially have been more successful if they had explored the potential for outreach and education to the fullest. Therefore, restoration needs equal attention to science as well as the social outreach aspect in order to be successful in the long run, with attention paid to all the vital ecological parameters of form, function, relationships, and diversity of species.

## ANNEXURE

### The Liana Trust

The Liana Trust is an NGO founded by Gerry Martin, focusing on snake conservation, human-snake conflict mitigation, and environmental education in rural and agricultural areas. The trust runs a serpentarium for antivenom venom supply, rescues and rehabilitates wildlife, conducts research, and engages local communities through education and organic farming initiatives. The previously degraded farmland now supports enhanced biodiversity including birds, herpetofauna, and mammals.

#### PROS:

- Scientific snake rescue and captive care reduce human-snake conflict.
- Serpentarium provides venom for anti-venom production free of cost, supporting public health.
- Each and every individual in the captive is provided optimal conditions and regularly monitored.
- Quarantine unit is present for safety and hygiene purposes.

The Liana trust, Hunsur. © Sanjay Molur.

- Rescues do not fully translocate snakes, rather promote co-existence
- Education programs raise awareness in schools and communities, promoting coexistence, prevention and treatment for snake bites (myth busters).
- Initiative for organic farming projects support biodiversity and provide alternative income for farmers.
- Biodiversity enhancement via owl perches and to reduce snake-human interactions.Maintaining exotic reptiles with proper management and welfare protocols.
- Trying to provide an alternate supply chain for organic farmers until they get organic certification. It's an incentive to help the initiative keep going.

#### CONS:

- Owl perch initiative is based on a success model from Thailand. Initiatives for other species like carnivorous bats can be considered.
- Promoting monoculture of bees could introduce diseases to local native species.
- Rescued and maintaining species like red ear slider, pacu etc. which are invasive

### NCBS Plot – Thithimati

The NCBS Plot is an 85 acre estate bordering Brahmagiri Wildlife Sanctuary, leased for long-term ecological research. The area contains primary forest degraded by selective wood lopping and grazing. NCBS monitors tree dynamics such as carbon sequestration, methane emission, and litter fall, while also documenting mammal diversity using camera


Thithimati NCBS plot. © Sanjay Molur.

traps. The plot hosts 148 plant species, with all native trees, supporting studies on forest recovery and ecosystem function.

### PROS:

- Ecological monitoring of trees.
- It's a window of opportunity for new scientific research and forest restoration initiatives.
- Most trees are native, preserving local flora because of minimal disturbance selective lopping currently allows natural regeneration\\

### CONS:

- Community grazing and cattle management remain challenging; local engagement is sensitive.
- Convincing local people about conservation can lead to conflict or resentment toward wildlife.
- Limited active intervention in some degraded patches may slow restoration.

MCBT. © P. Kritika.

## MCBT

Madras Crocodile Bank Trust was established in 1976 to breed Indian crocodile species in captivity for conservation. Their operations have expanded to venom collection and herpetology research, including the captive breeding of other endangered species like Batagur kachuga.

### PROS:

- Well-designed educational material to help raise awareness about herpetofauna and their conservation importance, helping in educational outreach.
- Well-established centre for herpetological research in India.
- High conservation value as it breeds endangered species for reintroduction to wild (in addition to zoo transfers)

### CONS:

Snake venom extraction was not done scientifically or with attention to ecological ramifications/snake welfare, or with robust traceability.

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# Importance of perception studies and consequences of bypassing it

Humans are social animals, we share the natural world with all other life forms. Although it is highly interdependent relationship, but it is greatly unequal. We exploit nature in a way no other species does. Thus, in order to conserve, we need to understand how people see, perceive, process, and infer the ecosystem, environment, and species they live with. It becomes immensely important to know how they use the services provided by these natural ecosystems and what role human behavior plays in exploitation or conservation of natural resources. As part of our session during the Ram Hattikudur Advanced Training in Conservation, learning the importance of understanding stakeholder perception in conservation, we got in to conversations of different situation where this study is needed and where not. The following article gives examples of different conservation scenarios, analyses whether perception study is needed, and tries to debate what would happen if the same was not done.

## Situation 1—Starting an Ecotourism Project to support wildlife conservation.

Whenever starting an ecotourism project mapping different stakeholders like resident community, gram panchayat, regional tourism department, and other NGOs working in the region is the first step. It is followed by the second step of understanding how all of these people perceive their ecosystem, what does tourism or ecotourism mean to them, and how they could contribute to conserving them. If the perception studies are not done for such a project it might lead to negative situations like lack of support from the local community. Also, we would miss on the local traditional and historical knowledge that could help the project grow better and potentially gain new roots and acceptance from the community. If not collaborated or included, the communities might feel left out, exploited, confused and thus not cooperating later. The project could lose out on an opportunity to employ locals who are familiar with the landscape and can be excellent for hospitality/ as nature guides. The project could also contribute to the empowerment of the local community and make the conservation efforts sturdier. Skipping this baseline might put us into issues like non-cooperation and hostility and eventually project failure.

## Situation 2—Conducting a Camera Trap Study to understand wildlife movement in an area.

While designing a camera trap survey, engaging with the local community before setting up camera traps is a foundational step for successful research. It's an opportunity to build trust by understanding local knowledge, correcting fears of being spied on, and addressing genuine privacy concerns, like being filmed while hunting. This dialogue transforms a project from an intrusion into a partnership, as communities share invaluable insights on land use and regional wildlife that led to better science.

Ignoring this groundwork is unsafe and risky. Without community support, expensive equipment often gets stolen or damaged, fostering a hostile environment where researchers are met with suspicion. This could lead to unreliable data, compromised research goals, and wasted resources. Ultimately, skipping the conversation with local people doesn't just risk the project but can poison the well for future conservation efforts, proving that this (community) human-centered approach is not just beneficial, but essential.

## Situation 3—Planning a restoration project in a degraded landscape

If we are starting a restoration project studying perception becomes crucial from the point of view of the collection of historical data and understanding the biogeography of the place through the eyes of communities that have been residing in the space

for generations. This helps us understand and evaluate the history of a given place, the livelihoods opportunity, their dependence on the trees and plant species around for the timber and NTFP produce. This also help us understand ethnobotanical significance of the forest in their lives, any reference sites or sacred groves if they have, any myths and beliefs around any particular species. Thus, it's crucial in designing the restoration project, to help us select the native species that we want to include in the nursery, identify motivated people from the community, and eventually empower them to take the ownership and responsibility of the work. This way the project has a well set exit strategy. When it comes to the restoration of the pasture lands it is extremely important to understand the seasons, grazing & harvesting patterns, and paths of the herding communities as there could be some unsustainable practices that might hinder in the conservation impact. If the restoration plan is implemented without doing the perception studies, it could create conflict between local people, researchers or the implementation agencies.

## Situation 4—Declaring a parcel of Forest as a Protected Area

Declaration of the protected area is a significant event in a locality especially for the forest dwelling local communities and other stakeholders like zoologist, ecologist, anthropologists, governmental, and non-governmental bodies working for the community welfare in order to understand the ecological, economic, and social dependency and potential impact. If these studies are ignored or not given enough weightage at the beginning, it could start friction between the community and forest department that could potentially turn harmful for wildlife. It could also lead to the amplification of human wildlife negative interaction like poisoning and retaliatory killing of the animals. It also becomes crucial to understand the boundaries and demarcation of the forest land, encroached land, and private/agricultural land, its usage by the community, if they are using that land for harvesting wood and NTFP, agriculture or some other purpose. It gives us an understanding of potential impact it can have on the community to tweak our interventions.

## Situation 5—Planning a compensation-based human-wildlife coexistence model

For mitigation of human wildlife interactions through compensation drives, perception studies are essential. The need is to understand the interaction first in order to mitigate it. So, what are peoples' perceptions about the wildlife that is around them, what are the myths or beliefs that are threats for wildlife or the community perceives as threats to themselves from the wildlife, and their socio-economic status becomes essential to know. Different stakeholders in this process that are needed to be understood are the local communities NGOs, FD, government administration, local village authorities, funders, scientists/ecologist, industries, visitors, and tourism people. It is crucial for an organization to do it to build trust with the community, and to design robust and ecologically sound solutions. It also helps evaluate the loss for just compensation, build efficient and sturdy mitigation plan with cooperation from all the stakeholders that perception study can facilitate. If we bypass the perception studies and directly jump to the mitigation plan we might face non-cooperation from the community, leading to an inefficient mitigation plan that could collapse midway. It is greatly unsustainable in terms of its rooting mechanism and the worst of all could be misjudgement of the value of the damage.

All these different scenarios give us a peek into the nitty-gritties of the community perceptions. Hence for successful implementation of any conservation project, it becomes crucial to do the perception studies and develop the project based. This will ensure a lasting impact and contribute to better conservation efforts.

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# The Implementation of Animal Laws in India: Navigating Compassion, Culture, and Contradictions

## 1. Evolution of Animal Laws in India

India's relationship with animals has had a long and varied history. Contemporary literature on the history of animal welfare in India often cites cultural and religious practices that revere animals or prescribe that no violence should be committed against them (e.g., Berti 2019; Sharma et al. 2019; Shad & Joglekar 2022), particularly ahimsa, or non-violence against all living creatures. One of the earliest examples of the practical implementation of principles is recorded in the rock edicts of King Ashoka, who, after his conversion to Buddhism, banned the imperial hunting of wild animals and restricted the use of animals for food (Draper 1998).

Later, during the colonial period, India saw conflicting attitudes towards animals and their use. On the one hand, an attitude of benevolent rule over purportedly childish, uneducated, and immature Indians extended to the animals that they used, as Indians were considered to be incapable of behaving towards them with kindness or tolerance (Chakrabarti 2010). On the other, the British committed large-scale exploitation of India's natural resources that included native wildlife and domestic animals; wildlife was commonly exterminated in state-sponsored drives from the 1880s onwards, and Indian stray or 'mongrel' dogs, though objects of empathy were hunted by the British using their own dogs and widely utilized for vivisection experiments (Chakrabarti 2010). Neither was there an attitude of concern for animal welfare that included all animals among Indians. For example, in the early 20th Century campaigns for protection of cows, which was primarily led by Hindus in opposition to Muslim and Christian practices of beef consumption, were shaped more by religious identity politics than by welfare concerns (Chakrabarti 2010).

It was the institution of the first Indian Society for the Prevention of Cruelty against Animals (SPCA) by a British resident of Kolkata in response to the suffering of 'labouring and domestic animals' that provided the impetus for the first animal welfare legislation in India (Chakrabarti 2010). This was the 1869 Act for the Prevention of Cruelty to Animals for Bengal. Though later extended to the rest of India in 1890–1891, it only included draft and sport animals used by Indians, with no mention of British use of animals in research or sports (Chakrabarti 2010). Post-Independence, when Rukmini Devi Arundale, who revitalized Bharatanatyam in India and was the first woman to be nominated to the Rajya Sabha, pushed for more stringent legislation to sufficiently address cruelty to animals in 1954 (Berti 2019) the Prevention of Cruelty to Animals Act (PCA) was passed in 1960. It established the Animal Welfare Board of India (AWBI) as the statutory advisory body to the central government on animal welfare issues. Subsequent rules expanded its reach: the Application of Fines Rules (1978), Capture of Animals Rules (1979), and decentralization through the SPCA Rules (2001). More recently, the Animal Birth Control Rules, 2023 updated the regulatory regime for sterilization and vaccination of street dogs and cats, reflecting a modern public-health as well as welfare perspective. A proposed amendment to the PCA in 2022 seeks to strengthen penalties and introduce the concept of "gruesome cruelty", but has not yet been enacted.

Despite these developments, challenges persist. India is currently one of the largest producers of animal products in the world; it was the second largest producer of beef in 2023 (Fleck 2024), the second largest producer of eggs in 2023 (Poultry Products | APEDA, n.d.), and the largest producer of milk over two decades (Hussain 2020); it also has one of the largest dog populations in the world, of which the vast majority are stray or free-ranging (Gompper 2014). These raise pressing questions about the adequacy and reach of existing animal welfare laws.

## 2. Colonial Legacy, Comparative Acts, and Structural Gaps

The Prevention of Cruelty to Animals Act (PCA), 1960, draws heavily from British legislation, in some cases

**Table 1. Comparison of selected passages from British and Indian animal welfare Acts. Underlined sections have identical meanings and/or are identically phrased.**

| Protection of Animals Act, 1911 (British) | The Prevention of Cruelty to Animals Act, 1960 (Indian) |
|---|---|
| (Under 'Definitions', c)<br>The expression "captive animal" means any animal (not being a domestic animal) of whatsoever kind or species, and whether a quadruped or not, including any bird, fish, or reptile, which is in captivity, or confinement, or which is maimed, pinioned, or subjected to any appliance or contrivance for the purpose of hindering or preventing its escape from captivity or confinement; | (Under 'Preliminary', 2.c):<br>"captive animal" means any animal (not being a domestic animal) which is in captivity or confinement, whether permanent or temporary, or which is subjected to any appliance or contrivance for the purpose of hindering or preventing its escape from captivity or confinement or which is pinioned or which is or appears to be maimed; |
| (Under 'Offences of cruelty', a):<br>(If any person) shall cruelly beat, kick, ill-treat, over-ride, over-drive, over-load, torture, infuriate, or terrify any animal, or shall cause or procure, or, being the owner, permit any animal to be so used, or shall, by wantonly or unreasonably doing or omitting to do any act, or causing or procuring the commission or omission of any act, cause any unnecessary suffering, or, being the owner, permit any unnecessary suffering to be so caused to any animal; | (Under 'Cruelty to animals generally', 11.a):<br>(If any person) beats, kicks, over-rides, over-drives, over-loads, tortures or otherwise treats any animal so as to subject it to unnecessary pain or suffering or causes or, being the owner permits, any animal to be so treated; |
| (Under 'Injured animals', 1)<br>If a police constable finds any animal so diseased or so severely injured or in such a physical condition that, in his opinion, having regard to the means available for removing the animal, there is no possibility of removing it without cruelty, he shall, if the owner is absent or refuses to consent to the destruction of the animal, at once summon a duly registered veterinary surgeon, if any such veterinary surgeon resides within a reasonable distance, and, if it appears by the certificate of such veterinary surgeon that the animal is mortally injured, or so severely injured, or so diseased, or in such physical condition, that it is cruel to keep it alive, it shall be lawful for the police constable, without the consent of the owner, to slaughter the animal, or cause or procure it to be slaughtered, with such instruments or appliances, and with such precautions, and in such manner, as to inflict as little suffering as practicable, and, if the slaughter takes place on any public highway, to remove the carcass or cause or procure it to be removed therefrom. | (Under 'Cruelty to animals generally', 13.3):<br>Any police officer above the rank of a constable or any person authorised by the State Government in this behalf who finds any animal so diseased or so severely injured or in such a physical condition that in his opinion it cannot be removed without cruelty, may, if the owner is absent or refuses his consent to the destruction of the animal, forthwith summon the veterinary officer in charge of the area in which the animal is found, and if the veterinary office certifies that the animal is mortally injured or so severely injured or in such a physical condition that it would be cruel to keep it alive, the police officer or the person authorised, as the case may be may, after obtaining orders from a magistrate, destroy the animal injured or cause it to be destroyed [in such manner as may be prescribed]. |

reproducing provisions verbatim while losing clarity and safeguards in the process. A comparison with the British Protection of Animals Act, 1911, highlights these shortcomings. For instance, while the British law provided detailed definitions for terms such as "captive animal" and specific procedures for euthanasia, the Indian version simplified these provisions, sometimes drastically, and introduced additional procedural hurdles, such as requiring magistrate approval for destroying mortally injured animals. The comparison below demonstrates the dilution of provisions in the Indian Act as well as phrases that were taken verbatim from the British 1911 Act.

Evidently, British animal welfare laws – even from more than a century ago – are more nuanced than Indian laws (Srinivasan 2013). The discrepancy has increased with the advent of the British Animal Welfare Act of 2006. This Act consolidates many different pieces of legislation to create one cohesive

and more relevant Act that addresses a wide range of aspects of animal welfare, from video recordings of animal fights to the time limit within which an animal welfare violation can be prosecuted in court, and the explanatory notes of this act state that 'The provisions of the 1911 Act no longer reflect modern practice' (Department for Environment, n.d.). It follows that the Indian PCA, which still draws imperfectly from the British 1911 Act, is not adequate to ensure modern animal welfare.

For example, the British 2006 Act explicitly names and defines those actions that cause 'unnecessary suffering', which the currently prevailing 1960 Act in India fails to do despite using the same term and determining that is a punishable offence. It also refers to scientific definitions, such as stating that the Act applies to animals, which are defined as '(all) vertebrate(s) other than man' and does not apply to 'an animal while it is in its foetal or embryonic form', while the Indian Act states only that it applies to animals which are 'any living creature other than a human being'. The Indian Act may therefore be argued to apply to insects like cockroaches and agricultural pests, potentially making their killing a punishable offence unless it can be proved that they were not subjected to 'unnecessary suffering', which cannot be proved without evidence that they feel pain at all. Indeed, this classification would technically include living creatures like plants, fungi and bacteria.

The Animal Birth Control Rules, 2023 under the PCA, which is relatively recent, states that incurably ill and mortally wounded dogs can be euthanised, during specified hours, after being diagnosed by a team appointed by the Local Animal Birth Control Monitoring Committee consisting of the Jurisdictional Veterinary Officer, the project-in-charge and a representative of the Board or State Board. Although this procedure accounts for possible ethical violations by involving multiple stakeholders, it prolongs the animal's suffering needlessly by restricting the execution to a certain time period when the law fundamentally aims to prevent unnecessary pain to an animal.

Many such lacunae indicate the pressing need for a complete revision of the act to reach modern standards. In practice, the PCA's emphasis has been on domestic and livelihood animals rather than comprehensive welfare. The limitations of the PCA are further complicated by its interaction with another cornerstone of Indian animal law - the Wildlife Protection Act, 1972 (WPA).

## 3. Overlap between the PCA and WPA

A landmark legislation, the Wildlife Protection Act, 1972 (WPA), along with the PCA forms the backbone of the legal framework that deals with animals (excluding humans). The WPA and PCA (as well as subsequent Rules enacted under it) share several clauses, particularly those pertaining to welfare, cruelty, and confinement - providing guidelines for handling, housing conditions, transport stipulations and conditions under which an animal can be euthanized or harmed (in case of self-defense).

The PCA mainly deals with preventing 'unnecessary suffering' of animals especially those in human custody or interaction, while also regulating performing animals (Sec. 22) through provisions such as "If any person treats any animal cruelly he shall be punishable" (PCA Sec. 11) and "It shall be the duty of every person having the care or charge of any animal to take all responsible measures to ensure the well-being of such animal" (PCA Sec. 3). On the other hand, the WPA is primarily concerned with the protection of wild species and their habitats. It bans hunting (Sec. 9) and restricts possession, sale, or transfer of wild animals (Sec. 40). It says, "No person shall hunt any wild animal specified in Schedule I to IV" (WPA Sec. 9) and "No person shall acquire, receive, keep in his possession, sell or transfer any wild animal" (WPA Sec. 40). But when they are kept by humans (in temples, zoos, or circuses), they are treated as captive wild animals under the PCA which states that "No person shall exhibit or train any performing animal unless registered" (PCA Sec. 22) although the PCA fails to recognise or define wild animals in the first place. Hence, instances involving captive wild animals are not explicitly referred to the WPA.

As a result, enforcement agencies are often uncertain about whether the PCA or the WPA applies. This jurisdictional confusion enables offenders to exploit legal grey areas, particularly when cultural or religious justifications are invoked.

## The 2022 Amendment

The proposed PCA amendment for 2022, which is yet to be passed, aims to address several shortcomings by defining "gruesome cruelty", imposing harsher punishments, penalties suitable to current economic standards and establishing responsibilities of care. The PCA is strengthened by these changes, particularly for communal and domesticated animals. Nevertheless, the structural issue of PCA–WPA overlap remains unresolved by the change. It still doesn't properly handle religiously or traditionally motivated captive animal issues, nor does it clearly legalize the transfer of wildlife-related cruelty cases to the WPA. Therefore, the amendment essentially ignores the jurisdictional conflict and captive animal concerns, even while it improves deterrence for cruelty in general.

Recent events show how serious this issue is. In May 2023, police and PETA raided the Karur Latha Circus in Neyveli, Tamil Nadu, rescuing several animals including a baby monkey, which were being forced to perform without permits (Express News Service 2023). In another instance, the Kerala High Court questioned the Guruvayur temple committee about whether its elephants at Punnathur Aanakotta were being misused for non-ritual purposes, raising welfare concerns (TOI 2025). Elsewhere, a study of 25 temple elephants in Tamil Nadu revealed problems such as chaining, isolation, concrete enclosures, and injuries (Srikrishna 2022). These cases highlight how both laws technically apply, but because of unclear boundaries, captive wild animals continue to fall into a regulatory vacuum despite being "protected" under the law.

## 4. Difficulties in Implementation

From a conservation point of view, the implementation of the law is restricted by great complexity at various levels. Enforcement is often undermined by political influence, limited institutional capacity, and the anthropocentric priorities of the judiciary. The boards and committees, for instance the AWBI, can be politically influenced, as six Members of Parliament are mandated to be members. This makes the AWBI and their decisions questionable given that the issues at hand require specific scientific knowledge, usually lacking in those that hold power.

Implementation of the Rules under the PCA pertaining to the monitoring and execution of duties stipulated often involve approval from specific committees or a long chain of command slowing it down. For instance, in the Animal Birth Control Rules, 2023 the reproductive organs removed from male and female dogs for during sterilization have to be stored and disposed of only after inspection and approval by a team of four officials. Although this specificity enforces accountability and thorough execution it employs more personnel than necessary.

The failure of India's judiciary system to attend the 50 million criminal and civil cases highlights the systemic issue exacerbated by political interference (Gill 2024). This picture of legal operations when humans are directly involved as the culprit and the victim makes it difficult to imagine how critically the criminal cases pertaining to animals and wildlife would be dealt with. Additionally, even if cases are successfully prosecuted in court, the penalties that can currently be imposed under the PCA are woefully inadequate, with the highest penalty for cruelty to animals in ordinary circumstances (that is, outside of cruelty to laboratory or performing animals) being one hundred rupees or a jail term of up to three months.

Overall, the implementation of the PCA becomes challenging because of the loopholes, contradictions and overlaps with the WPA. These include:

- Potential for political influence in the formulation and execution of Rules under the Act
- Lack of scientific measures, nuance and detail in the phrasing of rules and definitions
- Overcomplicated monitoring and evaluatory mechanisms in the execution of the laws requiring a host of officials to move procedures forward.
- Grey areas between the PCA and WPA, regarding captive wild animals
- Lack of stringent penalties to effectively deter instances of cruelty to animals

These limitations are best understood through case studies, which reveal how contradictions between law and practice play out on the ground.

## 5. Case Studies of Implementation

### On stray dogs:

In India, dogs hold a unique and conflicted status. A large part of the population is neither entirely wild nor fully domesticated but exist as free-ranging "community animals", often fed, named, and cared for by the residents of a street. This acceptance, however, lives alongside a deep-seated fear of aggression and disease due to an estimated 30–35 million stray dogs and the tragic distinction of accounting for 36% of the world's rabies deaths (Sreekandan 2025).

The Prevention of Cruelty to Animals Act, 1960 (PCA) formed the basis for the modern Animal Birth Control (ABC) Rules of 2023, which mandate a scientific and compassionate solution: catching stray dogs, sterilising and vaccinating them, and releasing them back into their original territories. This approach acknowledges their territorial nature and their right to live without undue suffering (Press Information Bureau 2025).

However, this is where a fundamental contradiction emerges between the laws we have framed and the actions often taken against dogs. This conflict was brought into sharp focus in August 2025 when, following a rise in dog-bite incidents, the Supreme Court ordered the removal of all stray dogs from public areas in Delhi-NCR to shelters (Reuters 2025). This directive, aimed at ensuring public safety, directly opposed the PCA and the ABC Rules' core principle of sterilise-and-release. It represented a significant shift towards a fear-driven, human-centric policy that prioritised removal over coexistence.

The backlash was immediate and fierce. Animal welfare organisations, veterinarians, and citizens argued that India's shelter system is woefully inadequate to house even a fraction of its 30 million-plus stray population. They labelled the order a "death warrant," predicting that overcrowded and underfunded shelters would simply become sites of a different kind of cruelty (TOI 2025). Responding to the public outcry, the Court revised its order on August 22, 2025. It created a compromise, allowing healthy, sterilised dogs to be returned to their areas while mandating that only rabid or incurably aggressive dogs be confined. The court also called for the creation of designated feeding zones and the drafting of a national policy for stray dog management (MacRae 2025). Despite this course correction, the underlying tension persists and contradicts the treatment that wild animals are given under the same Act.

On one hand, the PCA and the Indian Penal Code criminalise the poisoning or killing of dogs. On the other, frustration and fear at the community level often lead to brutal acts of vigilantism. Such incidents reveal the deep chasm between legal ideals and lived reality, as seen in contrasting cases. In Pune, after several dogs were poisoned, two individuals were arrested under IPC Section 429. Here, the court took a firm stand by remanding them in police custody, thereby affirming the legal process (TNN 2010). In stark contrast, after a mass poisoning of nearly 20 dogs in Mugalivakkam, Chennai, an FIR was filed under the same laws but no arrests were ever made. In this instance, the court was unable to take any stand as the case never reached the judiciary due to investigative failure, leaving the crime unpunished (Shekhar 2016). The Supreme Court's initial order, while coming from a place of authority, echoed the same impulse for removal seen at the village level, illustrating India's judiciary system's weak commitment to providing justice within India's legal boundaries when the need to pacify the public takes over.

### On Temple Elephants:

The tradition of keeping elephants in temples dates long back. However, the actual time when temples started associating themselves with elephants is not clear. Traditionally, elephants were kept to carry water from the river to bathe the deity, they would stand for auspicious hours and were allowed to roam free in the forest associated with the temple. Temples tend to mainly maintain female elephants because of the occurrence of musth in male elephants during which they show aggressive behaviour making it risky for them to perform in rituals. With the changing time, the temples lost their forest area, and the source of water changed. With time these temples were not able to generate revenue and started exploiting elephants instead by making them "bless" the devotees (Varma et al. 2009).

In the original 1972 Wildlife (Protection) Act the Asian Elephant Elephas maximus was listed in Schedule I affording it the highest level of protection, the same

as tigers, lions, and rhinos. This meant no hunting, capture, or trade, except under extraordinary circumstances and with official permission (Sections 9 & 11), although legally possessed captive elephants can be gifted. It creates a loophole in the law. Despite bans, wild elephants continue to be captured to meet demands in temples, especially in the southern part of the country, as they are the only wild species that individuals may legally own in captivity, subject to ownership certificates from the Chief Wildlife Warden, and transfers including sale or gifting require prior approval (WPA, Sections 40 & 42).

Legally owned elephants may be used for religious, tourism, or ceremonial purposes, provided they are not subjected to cruelty, with states empowered to regulate their transport and use. Their welfare in captivity is governed by the Prevention of Cruelty to Animals Act, 1960 (PCA, Section 11), and the captive elephants (Transfer or Transport) Rules and Management and Maintenance Rules of 2021, which prohibit abuse, set standards for housing, food, chaining, exercise, veterinary care, and require monitoring and record-keeping.

Despite these provisions, enforcement remains weak: many elephants in temples and tourism are overworked, chained for long hours, denied exercise, or used without AWBI registration. Illegal transport and transfers continue, inspections are infrequent, and political or religious pressures often undermine compliance. Courts have emphasized that PCA and WPA must be applied together, mandating monitoring committees and welfare oversight; however, exceptions on religious or traditional grounds persist, leaving significant gaps between legal standards and actual practice.

The issue in this matter is that temple elephants get very little time to exercise, averaging around one hour a day and are chained for more than 16 hours a day, limiting their movement. Moreover, blessing ceremonies in a crowded temple means highly restricted and altered behaviour that may have negative physical and psychological effects on the elephant, contributing to a poorer quality of life compared to that of their wild counterparts. Centre for Cellular and Molecular Biology (CCMB) studies in 2019 says that prolonged participation of elephants in religious ceremonies puts elephants under severe stress (Special Correspondent 2019).

Recently, a male elephant injured 24 humans in a mosque feast, Malappuram, Kerala. Kerala high court took the suo moto cognizance and mandated 3-m distance between two elephants, 5m between an elephant and flaming torches, 8 m between an elephant and the public or percussion displays and 100 m between elephants and fireworks. This limited the participation of elephants based on availability of space which affected Kerala's largest religious festival Thrissur Poornam. The festival organisers approached the Supreme Court saying maintaining 3m distance is impractical. The Supreme Court reversed the order of the high court stating the court should not involve in law making and reverted the safety norms under Kerala Captive Elephants (Management and Maintenance) Rules, 2012. This reversal shows the Supreme Court's ignorance for both the elephants' welfare and citizens' safety.

Additionally, the recent 2022 amendment to the WPA has centralised the power to frame the rules regarding the transfer of elephants and the state government has no role in it. These changes have allowed loopholes in the laws and hence requires re-evaluation of the need for temple elephants and the ambiguity that this provision creates in the case of employing wild animals for any reason.

## Conclusion: Unresolved Questions and Shortcomings

As discussed in the earlier sections, the PCA requires several amendments in order to make it competent to serve all animals or even those that it defines poorly. On the surface, the Act and the Rules under it have detailed procedures and clear instructions regarding involved personnel but it fails to consider and elucidate fundamental definitions, such as "unnecessary suffering," leading to inconsistent interpretation. Persistent overlap between PCA and WPA, particularly regarding captive wild animals, create loopholes in penalties, ownership, and transfer provisions. These overlapping jurisdictions and definitional gaps are compounded by broader implementation challenges, where politics, capacity, and enforcement mechanisms not only limit the effectiveness of both laws but evidently skew how

different animals are served. On one hand stray dogs that are a result of domestication are deemed worthy to roam free while elephants that belong in the wild are deemed expendable to be tamed and confined for human usage for revenue production and religious practices. These unresolved issues point to a pressing need for comprehensive reform that consolidates overlapping provisions, introduces scientific clarity, and ensures enforceable welfare standards. Until then, the gap between law and justice for animals in India will remain wide.

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