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PANDA

SIKKIM EIACP HUB'S NEWSLETTER ON FOREST, ENVIRONMENT & WILDLIFE

Special Edition

Sikkim EIACP Hub Publication
On Status of Environment & its Related Issues

MY CHILD FROM WILD

ANIMAL ADOPTION PROGRAM

ADOPT: CONNECT: CONSERVE

Supported by
Ministry of Environment, Forests & Climate Change, Government of India

Hosted by
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SIKKIM STATE EIACP HUB
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PANDA

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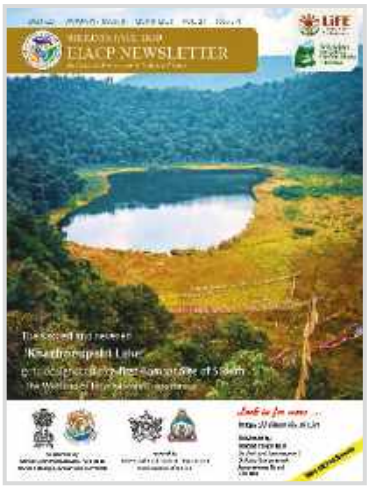

Jan-Mar Vol. 17, Issue 4

DECADAL MILESTONE

The special edition newsletter titled "PANDA" was first published in 1994 by Forest and Environment Department, Government of Sikkim. This publication provided new dimension and insights into the woods for research and explorations in this tiny Himalayan State. However after few issues, the publication was discontinued for unexplored reasons.

Sikkim ENVIS (Environmental Information System) set up in 2006 then revived this special edition publication during 2009 duly commemorating the centenary celebration of Sikkim Forest Department. Thereafter, Sikkim ENVIS/EIACP has been publishing PANDA on annual basis.

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WHAT'S MORE..... page-wise

Current edition

MY CHILD FROM WILD

ANIMAL ADOPTION PROGRAM

ADOPT: CONNECT: CONSERVE

WHAT?

- A community campaign to **support** Zoo Animal Welfare, create a sense of **shared responsibility** and **emotional connection** between **citizens** and **wildlife.**

WHY?

- **Encouraging public participation** in **wildlife conservation**.
- **Fostering kindness and compassion** towards **animals**.
- **Education** and **outreach**.

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Yak


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Himalayan Black Bear


Red Panda


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Lady Amherst's Pheasant


Barking Deer


Common Leopard

Himalayan Griffon Vulture


Indian Peafowl


Leopard Cat


Silver Pheasant


Goral


Ring Necked Pheasant


Golden Pheasant

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Picture: Dr Pradeep Kumar, PCCF -cum- Pr. Secretary and Mr Udai Gurung, CF(Wildlife) presenting the certificate to the Hon'ble Chief Minister of Sikkim Shri Prem Singh Tamang (Golay)

Sikkim achieves a New Milestone in Conservation: 'Khachoedpalri Lake' gets designated as first Ramsar Site of Sikkim, the Wetland of International Importance

On the World Wetland Day i.e. 2nd February 2025, Sikkim celebrated the acknowledgment of its efforts in conservation. The sacred "Khachoedpalri Lake" has been designated as Ramsar Site. This is for the first time that any lake from Sikkim has been designated as Ramsar site.

A Ramsar site is a wetland site designated to be of International Importance under the Ramsar Convention (also known as "The Convention on Wetlands", an international environmental treaty signed on 2 February 1971 in Ramsar, Iran, under the auspices of UNESCO).

Wetlands on the Ramsar list are designated for their high value to the country and the world for the ecosystem services and benefits provided. The Ramsar Convention now recognizes this lake among the world's most ecologically significant wetland areas, for its vital role in supporting diverse ecosystems, wildlife, and local communities.

As the sacred Khachoedpalri Lake is known as a "wish fulfilling lake", folklore and legends associated with it are many. The folklore has generated deep religious interest too. The lake is enveloped in a dense forest cover of temperate vegetation and bamboo. Ecotourism, promoted with the involvement of local communities, not only provides economic benefits but also controls deterioration of biodiversity in the surroundings.

This prestigious recognition marks a pivotal moment in Sikkim's commitment to preserving the rich biodiversity and cultural heritage of this pious lake and also marks a key milestone in Sikkim's environmental conservation efforts. This Ramsar designation ensures that Khachoedpalri Lake will receive international attention and support for its protection. It opens

doors for more sustainable management practices, improved conservation efforts, and a global platform to raise awareness about the importance of wetlands in mitigating climate change. Now with international attention in the area, eco-tourism initiatives will thrive, allowing local communities to benefit economically while also preserving the wetlands. Several efforts for listing lakes in Sikkim under Ramsar Convention were made earlier too but they were not successful.

This recognition has been possible with the Government of Sikkim's relentless efforts and coordination across several ministries and establishments. As we celebrate this achievement, we also recognize that the work doesn't stop here. This milestone represents an opportunity for all of us—Sikkimese people, government agencies, Khachoedpalri Pokari Sarankshan Samiti and other environmental organizations, to unite in safeguarding the future of Khachoedpalri Lake.

Together, we can continue to nurture and protect this natural treasure for generations to come. Let's celebrate this remarkable achievement and redouble our efforts to protect the natural world.

Picture: Khachoedpalri Lake, Sikkim

Picture: The Hon'ble Minister of State for Environment, Forest & Climate Change and Minister of State for External Affairs Shri Kirti Vardhan Singh presenting the Ramsar Site Certificate to the Government of Sikkim represented by Shri S. Elamurugannan, Conservator of Forests (Working Plan), Forest and Environment Department at Parvati Arga Ramsar Site, Gonda, Uttar Pradesh on February 2, 2025.

Let's celebrate this remarkable achievement and redouble our efforts to protect the natural world.
Source: Press Release from Forest and Environment Department, Government of Sikkim

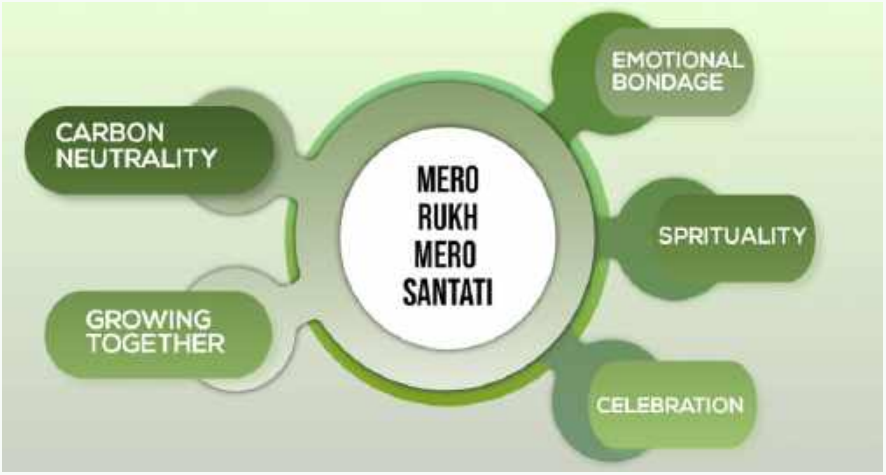
Mero Rukh Mero Santati conferred SKOCH Award 2024

Government of Sikkim's flagship initiative "Mero Rukh Mero Santati", a brainchild and novel initiative of Shri Prem Singh Tamang (Golay), the Hon'ble Chief Minister, has been conferred with the prestigious SKOCH award 2024. SKOCH award is known for its rigorous and independent outcome based assessment process.

To mark this milestone, the award ceremony was organized in New Delhi for national award winners. The award on behalf of State Government of Sikkim was received by Mr Pradeep Kumar IFS, Secretary, Forest and Environment Department. " Mero Rukh Mero Santati' was presented as a Himalayan Harmony and Policy Innovation for a Carbon Neutral Sikkim. This policy innovation of 'Mero Rukh Mero Santati' (MRMS) initiative involves plantation of 108 trees to commemorate birth of every child in Sikkim. The programme anchors itself on five pillars

1. Emotional bondage between parent and child
2. Spirituality.
3. Celebration.
4. Growing together
5. Environmental legacy and Carbon neutrality

The initiative has already been widely acknowledged and appreciated both nationally and globally for its novelty. The initiative gains much more significance in the contemporary times in view of the rising pollution in cities like Delhi, where even breathing is becoming a challenge. The current situation brings out this moot point that just the physical wealth and good education is not enough for our children to live happily. We have to leave a clean environment too for our future generation. " Mero Rukh Mero Santati' not only fosters an emotional bondage between communities and nature but also aims at bequeathing a green legacy and carbon neutral Sikkim for future generations. This is the best life time gift the parents can give to their children.



The State Government has been implementing a green initiative "Mero Rukh Mero Santati" wherein 108 tree saplings are planted for every new born child in the State since February 2023. This initiative aims to strengthen the connect between parents, children and nature by fostering a sense of affinity, reverence and compassion towards Mother Earth leaving a green legacy for future generations. This initiative is rooted in the profound significance of the number '108' within Indian spiritual traditions. 108 trees planted for each child can more than offset the average annual per capita carbon footprint for an Indian citizen at current levels, which is a practical and visionary step towards achieving a 'Net Zero' India, further strengthening the state's commitment to environmental conservation. This initiative has also been lauded at the COP28 Dubai held during December 2023.

Sikkimese society has had an intimate association with nature since time immemorial. We not only revere our mountains, lakes, rivers, caves and springs, but venerate the entire landscape as sacred. This initiative aims to reinforce this age-old bond of our society with nature. To ground this initiative various departments of the Government of Sikkim will converge to facilitate seamless service to the new parent right from enrollment to planting and after care. ASHA, Anganwadi workers, gram panchayats, urban local bodies and forest staff will facilitate the on boarding of the parents.

To ensure wider reach amongst all new born child in the State, the State Government has aligned a new scheme "Sikkim Sishu Samridhi Yojana" wherein the State Government shall open a Fixed Deposit account of Rs. 10,800/- (Rupees Ten Thousand Eight Hundred only) in the name of new born child registered under "Mero Rukh Mero Santati" to be redeemed after the child attains 18 years of age.

Also, the State Government Employees are eligible to draw an advance increment on registration under "Mero Rukh Mero Santati" for having second or further child. Several other benefits have also been aligned to prioritized the MrMs registered beneficiaries in several schemes and programmes of the State Government.

Visit http://sikenvis.nic.in
or http://sikkimforest.gov.in/mrms
to read more.

Butterflies of Dzongu:

Protecting Nature and Discovering More Species

Chocolate-bordered Flitter (*Zographetus dzonguensis*)
This butterfly is named after Dzongu

Blue Duke (*Bassorana durga*)
State Butterfly of Sikkim

Sonam Wangchuk Lepcha
Author, Thamblyok – A Guide to the Butterflies of Dzongu, Sikkim Himalaya
Dzongu, Mangan District, Sikkim – India

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Dzongu, in Mangan District of Sikkim, is a special place filled with natural beauty. It is a home to many different species of butterflies, which are not just beautiful to look at but also helps understand the environment health. As a butterfly enthusiast from Dzongu, I have learned how important it is to protect our land for both the butterflies we already know about and the new ones we might discover.

Butterflies are more than just pretty insects. They are like messengers from nature, telling us whether the environment is doing well or not. When butterflies are happy and thriving, it usually means the forests, rivers, and plants around them are healthy too. But if their numbers go down, it could be a sign that something is wrong, like pollution or deforestation.

In Dzongu, 368 species of butterflies have already been recorded, but there's a good chance that more species are yet to be discovered through field studies. This shows how important it is to keep Dzongu's environment safe, so we don't miss out on discovering new butterflies.

Since 2016, butterfly field studies have been conducted in Dzongu across several types of forests like Tropical Semi-evergreen Forest (TSF), Sub-tropical Hill Forest (STF), Wet Temperate Forests (WTF), Sub-alpine Forest (SAF). These forest types are crucial for the survival of butterflies and many other species. Each forest provides specific habitats that cater to different needs, such as food, shelter, and breeding sites for butterflies.

Tropical Semi-evergreen Forest (TSF): These forests provide abundant flowering plants, a major source of nectar for butterflies. The dense foliage and warm temperatures make it ideal for many butterfly species.

Sub-tropical Hill Forest (STF): Located at higher elevations, these forests have a unique mix of plants and trees that support species adapted to cooler climates. They also act as important migration corridors for butterflies moving between altitudes.

Wet Temperate Forests (WTF): These forests are cooler and have a high moisture content, supporting plants that are essential for the survival of specific butterfly species. The foggy and wet conditions create a unique environment where butterflies thrive.

Sub-alpine Forest (SAF): As the elevation increases, the vegetation changes, but these forests still provide the essential host plants butterflies need to lay eggs and feed their larvae.

Without these diverse forest types, the survival of many butterfly species would be at risk. The interdependence between butterflies and their host plants makes protecting these habitats crucial. Dzongu's forests not only support butterflies but also many other animals and plants that rely on the same environment. Without them, the delicate balance of the ecosystem could collapse.

Future Field Surveys in Alpine Forests: While much of Dzongu's forest has been surveyed for butterflies, there's still more to discover. In the future, we plan to conduct field surveys in the alpine forest areas, which lie at even higher altitudes. These regions remain unexplored in terms of butterfly diversity. The alpine forests, with their cold, harsh conditions, might reveal new species that have adapted to survive in these extreme environments.

Glacier Lake Outbursts and Landslides: An Urgent Threat to Dzongu's Ecosystem and Communities

In 2023, a devastating glacier lake outburst hit the Mangan District and other as well, causing severe flooding that impacted not only Dzongu's natural habitats but also human lives and properties. The sudden surge of glacial water—triggered by climate-driven melting—destroyed homes, agricultural fields, horticultural areas, government assets, and roads. Tragically, lives were lost, affecting both people and animals caught in the disaster. Frequent landslides, further intensified by heavy rains, continue to disrupt the area. These events underscore the urgent need for

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conservation efforts and community resilience measures to protect the unique ecosystems of Dzongu and Sikkim, ensuring safety and sustainability in the face of growing climate threats.

Dzongu has already given us some exciting discoveries. Here are a few butterflies that were recorded for the first time in Sikkim, and they were found in Dzongu:

1. ***Zographetus dzonguensis*** – This butterfly is called the Chocolate-bordered Flitter and it was named after Dzongu.

2. ***Lethe brisanda*** – Also known as the Dark Forester, it was recorded in Dzongu's rich forests.

3. ***Euaspa milionia*** – This is the Water Hairstreak, another important species discovered in the area.

4. ***Halpe aucma*** – The Gold-spotted Ace is another unique butterfly from Dzongu.

5. ***Euaspa pavo*** – The Peacock Hairstreak adds even more color and life to our forests.

These discoveries show just how special Dzongu is for butterflies, but they also remind us that we have to keep the environment healthy so that these butterflies can continue to live and grow.

The forests, rivers, and plants in Dzongu are not only important for the butterflies that live there today but also for the ones we may discover in the future. If we lose these habitats because of landslides, deforestation, pollution, or other harmful activities, we might lose the chance to find new species of butterflies that are waiting to be discovered. By protecting the environment, we help all living creatures, including butterflies, survive. This is especially important because some butterflies may only live in Dzongu and nowhere else in the world.

A Bright Future for Butterflies and Dzongu: The butterflies of Dzongu are important, and it's our responsibility to protect them. By conserving our forests, rivers, and streams, we're also protecting Dzongu's unique biodiversity and natural heritage.

More Discoveries Await: The discovery of new butterflies like the Chocolate-bordered Flitter shows that there is still so much we don't know about our environment. There are many more species waiting to be discovered, not only in Dzongu's forests but also in the Dzongu's alpine regions, which are yet to be explored fully. These potential new findings will further highlight Dzongu as a treasure trove of biodiversity.

Eco-tourism and Conservation: Dzongu has the potential to become a model for eco-tourism, where visitors can enjoy the beauty of the landscape and butterflies while learning about the importance of conservation. This can provide sustainable income for local communities while ensuring that nature is preserved.

Community-Led Conservation: Dzongu's future lies in the hands of its people. The traditional respect for nature held by the Lepcha community, combined with modern conservation efforts, can ensure a balanced and sustainable future for Dzongu.

Blue Duke (*Bassorana durga*), State Butterfly of Sikkim

Chocolate-bordered Flitter (*Zographetus dzonguensis*), this butterfly is named after Dzongu

Protecting the forests and natural habitats will not only secure the future of butterflies but will also preserve Dzongu's culture and way of life.

Adapting to Climate Change: By planting native trees, preventing deforestation, and supporting efforts to reduce the impact of climate change, Dzongu can build resilience against environmental threats like landslides and floods. This will protect both human settlements and the natural habitats that butterflies and other wildlife depend on.

A bright future for Dzongu means creating a harmonious balance between nature and human activity. By working together to protect the environment, we ensure that future generations can continue to enjoy the beauty of butterflies and the rich natural world of Dzongu.

Let's work together to protect Dzongu's environment, not just for the butterflies we see today but also for the new ones that may be discovered in the future. In doing so, we are also securing a sustainable and thriving future for Dzongu itself.

Advancing butterfly documentation and conservation through Citizen Science in the Sikkim Himalaya

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1. Introduction

In recent years, alarming decline in insect population, including butterflies, have raised urgent conservation concerns worldwide. Studies reveal that approximately 40% of insect species are facing population decline due to a combination of habitat loss, pollution, pathogen infection, and climate change (Sánchez-Bayo and Wyckhuys, 2019). Butterflies are especially vulnerable, with population decline recorded in Europe (van Swaay et al., 2006), the United States (Breed et al., 2012; Forister et al., 2019), and Asia, including countries like Japan (Nakamura, 2011) and Singapore (Theng et al., 2020). In the Himalayan region, which hosts a rich diversity of butterfly species, about 28.37% of butterflies are considered high conservation priorities, protected under India's Wildlife Protection Act (1972) (Dewan et al., 2024). Himalayan butterfly species are classified as threatened in the Red Data Book of India (Gupta & Mondal, 2005). The decline of butterfly population is particularly concerning in Sikkim and the Eastern Himalaya, where habitat conversion due to human activity places additional stress on butterfly population.

Butterflies are vital to ecosystems, serving as pollinators and indicators of environmental health (Ghazanfar et al., 2016). They help maintain plant diversity, supporting food web that sustain other species (Greenwood, 1987). Sensitive to climate and habitat changes, butterflies act as early warning signs for ecosystem shift. Declining butterfly population in regions like the Himalayas highlight broader environmental threats that can affect biodiversity and human well-being (Acharya and Chettri, 2011). Therefore, it is crucial to make management plans to conserve them. A lack of comprehensive long-term data on Himalayan biodiversity and its distribution has hindered the development of effective conservation strategies. Without data on population trends, species' responses to environmental pressures, or the extent of habitat fragmentation, policymakers lack the insights needed to protect these vulnerable species. In contrast, other regions have long-term monitoring programs that have successfully informed conservation strategies. Initiatives such as the UK Butterfly Monitoring Scheme, European Butterfly Monitoring Scheme, and the North American Butterfly Monitoring Network which are all citizen science programs have generated invaluable data on butterfly population trends and resilience.

Citizen science initiatives in documenting biodiversity refer to the involvement of non-expert members of the public in scientific research, specifically in the collection, analysis, and sharing of biodiversity data (Chandler et al., 2017). This collaborative approach harnesses the observations, skills, and enthusiasm of everyday people to contribute to the study and conservation of species and ecosystems. Citizen science projects can range from documenting local wildlife sightings, tracking the health of ecosystem, or monitoring species populations, to more complex tasks like analyzing environmental changes or measuring biodiversity indicators. The primary value of citizen science in biodiversity lies in its ability to gather large amounts of data over vast geographic areas and long periods, something that would be difficult or impossible for professional scientists to achieve alone (Bonney et al., 2009). This type of science has become especially important in biodiversity research, as it helps track changes in species distribution, monitor endangered species, and contribute to the development of more informed and effective conservation strategies. By providing large-scale temporal and spatial data, these programs offer evidence of biodiversity declines and the impact of anthropogenic factors and climate change. Insights from these efforts have led to actionable strategies for protecting biodiversity

and their habitats across the world (Chandler et al., 2017).

Drawing inspiration from these successful programs, the Big Butterfly Month initiative was launched to mobilize butterfly data from India. Though still in early stages, this program has already mobilized citizens across the country to participate in butterfly monitoring works. Together, initiatives like Big Butterfly Month (BBM) represent a hopeful step forward, showcasing how community-driven conservation can enrich biodiversity databases and inform more effective conservation policies in fragile ecosystem.

2. Big Butterfly Month: a national program to engage citizens in monitoring butterflies

Big Butterfly Month India, a citizen science campaign launched in 2020, has become a significant resource for collecting valuable data on butterfly diversity across the country. This initiative unites enthusiasts, students, nature lovers and experts to gather valuable data that deepens our understanding of these beautiful insects during the month of September. Through butterfly walks, observation submissions, and other activities, participants actively contribute to safeguarding butterfly habitats across India. The primary data gathering method is using citizen science portals like iNaturalist app, India Biodiversity Portal, and the count form of the BBM.

This initiative emphasizes the power of community by partnering with schools, wildlife groups, and local communities to host awareness events and workshops focused on butterfly conservation. Citizen scientists can share their sightings, connect with experts, and improve their identification skills, empowering them to play a hands-on role in conservation efforts and nurturing a greater appreciation for butterflies. Additionally, the initiative embraces an open data-sharing philosophy, allowing researchers and professionals to access the data for their studies and research.

3. Citizen Science Initiative and BBM in Sikkim

ATREE Eastern Himalaya, in collaboration with its partners, has played a crucial role in organizing and promoting citizen science initiatives across Sikkim and neighboring regions. Its involvement in programs like National Moth Week, City Nature Challenge, and Big Butterfly Month has been especially valuable in encouraging public participation in biodiversity documentation. In a recent initiative (Pradhan et al., 2023), ATREE engaged 170 citizens in butterfly monitoring and documentation. Through workshops and training sessions, participants, in addition to their individual observations, made valuable contributions to iNaturalist. These contributions accounted for nearly 52.22% of the region's known butterfly species, surpassing the findings of many formal research studies (Table 1). This citizen-led approach has demonstrated its potential to bridge data gaps in biodiversity monitoring, particularly in under-studied regions like the Himalayas. In addition to increasing species records, this citizen science initiative has fostered environmental stewardship and raises awareness about biodiversity among the local community.

4. Big Butterfly Month 2024: Building Knowledge Through Interactive Training

In 2024, ATREE Eastern Himalaya organized workshops aimed at fostering a citizen science approach by involving students with the skills and knowledge to identify and document butterfly species in their local ecosystems. The workshops took place across four institutions namely Nar Bahadur Bhandari Government College, Sikkim Alpine University, Sikkim Government College, and Sikkim University. Each session combined lectures with hands-on field activities, offering students both theoretical knowledge and practical experience in butterfly conservation. On the first day at each location, participants were introduced to the basics of butterfly diversity and identification. Engaging interactive sessions, covered topics such as butterfly anatomy, behavior, and their ecological importance. The sessions also emphasized the role of citizen science in biodiversity documentation and included training on using the iNaturalist app to upload butterfly observations. This blend of classroom instruction and real-world application helped students understand the significance of their contributions to biodiversity records. On the second day, students ventured into various natural habitats to apply their new knowledge. Guided by ATREE experts and faculty members, they documented butterfly species in locations such as college campuses, riverbanks, and forest patches. This fieldwork allowed students to refine their identification skills and contribute valuable data to local biodiversity initiatives.

The highlight of the programme is given below:

I. **Nar Bahadur Bhandari Government College (September 4-5):** Over 70 students attended lectures, with 20 actively participating in the documentation. Their fieldwork at the college campus and nearby Tadong led to the identification of

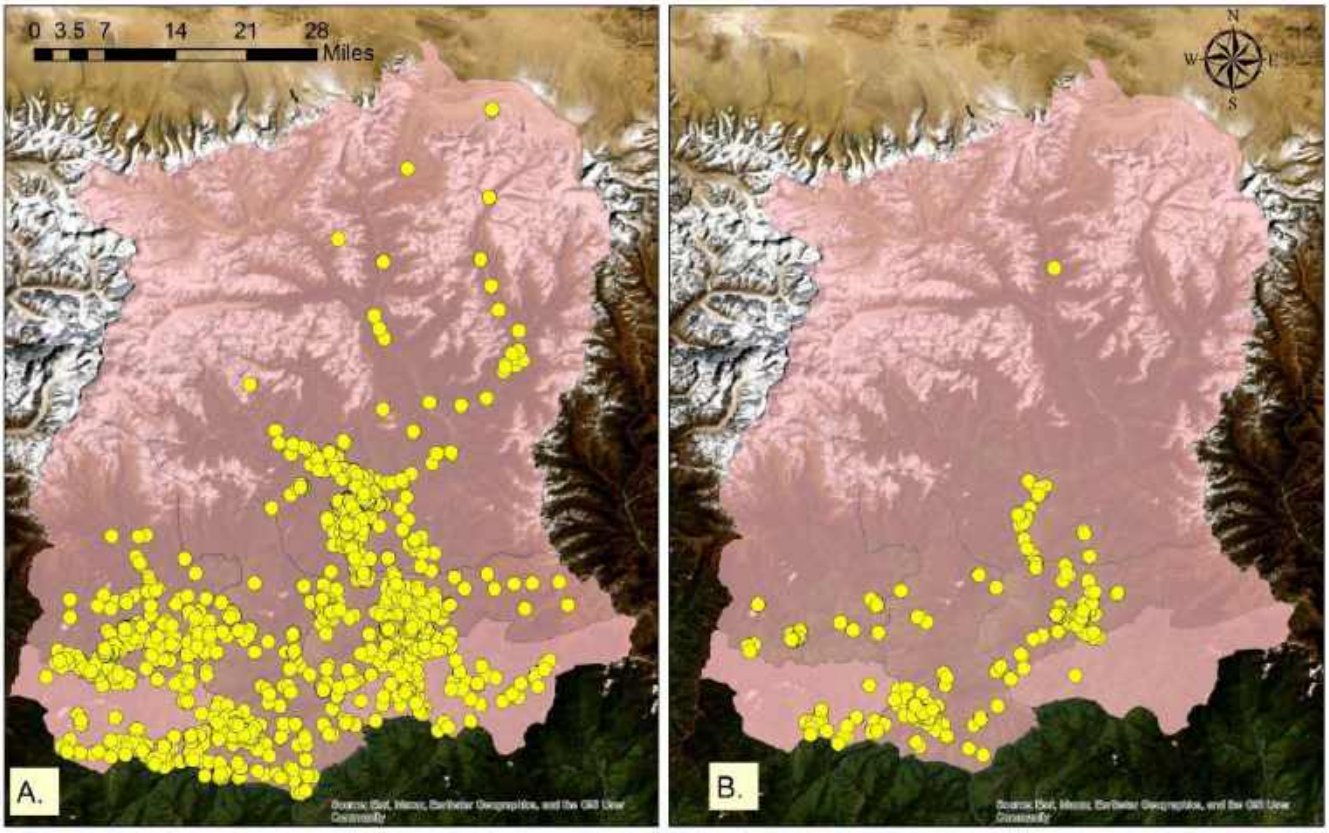

Figure 1: Map showing the spatial record of butterflies made through iNaturalist app (a citizen science platform) in Sikkim, Eastern Himalaya India: A. Overall records; B. Records made during BBM 2024

29 butterfly species, highlighting the campus as a significant green space within urban Gangtok.

II. **Sikkim Alpine University (September 10-11):** With 45 participants, the event included lectures and field documentation along the Rangeet River at Kitchu Dumra. Students recorded 28 butterfly species, contributing valuable data to the university's biodiversity knowledge.

III. **Sikkim Government College (September 12-13):** Sixty students participated in lectures and field activities, documenting an impressive 59 butterfly species at the college campus and surrounding areas. This outcome underscores the importance of the campus as a biodiversity hotspot.

IV. **Sikkim University (September 19-20):** Thirty-one students and scholars joined ATREE for lectures and fieldwork around 6th Mile in Gangtok, documenting 41 species. This effort emphasized the role of urban green spaces in supporting local wildlife.

Table 1: Highlights of butterfly records on the iNaturalist Platform for Sikkim, Eastern Himalaya

Timeline	Observations	Observers	Species Richness	Percentage of the Total Species recorded in Sikkim
Overall	6156	383	376	52.22 %
BBM 2024	2025	141	235	32.6 %

By the end of the workshop series, participating students had contributed significant data to citizen science platforms, enriching biodiversity records and supporting local conservation efforts. The workshops not only equipped students with practical skills but also inspired a new generation of environmental advocates committed to preserving Sikkim's natural heritage. Through these initiatives, students across Sikkim joined the broader effort to protect butterfly diversity, contributing essential data that aids in the monitoring and conservation of these vital pollinators. In total throughout the month of September

Figure 2: Photos of activities conducted during the Big Butterfly Month 2024 om Sikkim, Eastern Himalaya, India

when BBM 2024 was being conducted a record of 235 species of butterflies was made. As Big Butterfly Month progresses, it remains dedicated to expanding environmental education and promoting citizen-led conservation across Sikkim.

5. Conclusion

In conclusion, citizen science proves to be a powerful tool for researchers and biodiversity experts, particularly in regions like the Sikkim Himalaya. As demonstrated by our initiative, involving local communities through workshops and training not only enhances public awareness but also generates substantial data that significantly contributes to scientific knowledge. The participation of individuals in documenting butterfly species on platforms like iNaturalist resulted in the record of over 50% of the region's known butterfly species, a contribution that surpasses many formal research studies. This highlights the potential of citizen science to supplement traditional research efforts, filling data gaps, and providing a more comprehensive understanding of biodiversity patterns. By harnessing the collective effort of communities, we can expand research coverage, improve monitoring capabilities, and empower local stakeholders to play an active role in conservation. Citizen science, therefore, acts as a vital bridge between the scientific community and the public, driving both research and biodiversity conservation forward.

6. Acknowledgements

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The socioeconomic and ecological consequence of bamboo flowering on the community

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Bamboo is a perennial, semelparous plant belonging to family Poaceae. The term "semelparous" refers to plants that use all of their resources during a single reproductive phase before failing and dying as a whole. Although semelparity is present in all annual and biennial plants, it is rare in perennials (*Agave* and *Bambusa* spp.).

Perennial plants that are semelparous may be using this trait to trick or overcome potential seed predators. The former may do this by not reproducing seasonally, while the latter may do so by producing so many seeds that predators are unable to eat them all.

Out of 125 bamboo species found in India, 30 is known from Sikkim (Tamang et al., 2013). Bamboo comprises an important non-timber forest resource (NTFP). It holds great socio-economic and cultural significance to the people of Sikkim (Bain, 2020). People have relied on bamboos for food, medicine, shelter, household items, furniture and other ethno-religious purpose. From an ecological standpoint, bamboo plants help sequester carbon, reduce soil erosion, give numerous species food and habitat, and conserve water (Wu et al., 2024).

In plants, the appearance of flower and their development into fruit gives assurance for their propagation. However, bamboos can be propagated both vegetatively and also through seeds. The mass synchronous flowering of some bamboo species in temperate habitat of Sikkim was observed this year namely in the species, *Phyllostachys aurea (*André) Rivière & C.Rivière (Katha baas) and *Himalayacalamus hookerianus (Munro) Stapleton* (Pareng) (Fig. 1). Flowering in bamboos vary from species to species with flowering intervals ranging from 10-120 years (Tenzin et al., 2021). The interesting thing about bamboo flowering is that the bamboo culms die 1-2 years after mast seeding providing spaces for the growth of new seedlings (Wu et al., 2024).

Flowering in bamboo brings a renewed growth as well as changes in the ecology and socio-economy of the region. It is seen as a bad omen in some parts of India. The subsequent dying of bamboo plants after flowering, negatively affects the ecology and economy of the area. The rise in rodent population following bamboo fruiting and the lack of food supply to animals like pandas after their culm termination in areas where bamboo is a dominant vegetation will cause instability in the ecology (Janzen, 2003; Wu et al., 2024). Moreover, the dry remains of the dead bamboo culms may trigger catastrophic forest fires while their shallow roots will be ineffective in controlling soil erosions and landslides. Locally, the supply of household items made from bamboo will be rare. Impoverished section of people who relies on bamboo for food, shelter and living will also be affected. Certain religious ceremonies requiring bamboo materials will have to find an alternate as the supply will deficient.

Flowering in bamboo brings along with it a drastic structural change. This phenomenon turns to be metamorphic for the bamboo plant and is likely to affect the activities and livelihoods of beings dependent on it as well.

Fig.1. Fruits and habit of (A) and (C) *Phyllostachys aurea*; (B) and (D) *Himalayacalamus hookerianus*

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Review on medicinal plants used for wound healing effects from Sikkim Himalaya Region

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Abstract:

Background: Traditional healing practices rooted in centuries old practices in different communities throughout the globe and have potential health benefits to the millions of peoples. In this present review, we aimed to collect the medicinal plants used for wound healing effects mainly found in Sikkim Himalaya region. The scientific data were collected from different scientific repositories such as PubMed, Science direct, Research gate, Willy, Core, 1Library, etc. The inclusion and exclusion of the review topics on the selected medicinal plants having wound healing effects were included. The keyword used during the literature review were "MEDICINAL PLANTS", "WOUND HEALING EFFECTS", 'SIKKIM HIMALAYA", "DOSAGE PREPARATION", "LOCAL NAME-NEPALI", "PART USED", "MODE OF ADMINISTRATION".

Results: A total of 10 medicinal plant species belonging to 10 families, 10 genera are mainly used for wound healing effects found in Sikkim Himalaya, summarized in Figure1 and Table1, if any other species will be found in the future, we will add up accordingly. The literature revealed- leaf, fruit, bark & underground tuber are mostly used, followed by whole plant (Graph1), and commonly used form of preparation was paste and extract form (Graph2).

Conclusion: It was concluded that, the traditional practices in Sikkim Himalaya have long-standing knowledge on the therapeutic uses of medicinal plants. Additional investigation on wound healing activities from the collected plants, phytoconstituents separation and description of the active components, may lead to the identification of novel therapeutic candidates in a selected field in the future.

Keywords: Medicinal Plants, Local medicines, Sikkim Himalaya, Wound healing effects.

Background:

According to the World Health Organization (WHO), "Traditional medicine is defined as the sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness." Herbal medicines include herbs, herbal materials, herbal preparations and finished herbal products that contain an active ingredient, parts of plants, or other plant materials, or combinations (WHO). This type of healing has been used for ages in the Sikkim Himalaya, and this review work describes some of its traditional practices, particularly with reference to the preparation and processing of botanical ingredients and the system's underlying elements of trust and belief. The knowledge regarding the use of medicinal plants has been passed from generation to generations and only a specific group knows about the details of it [1-3]. Documentation and prioritization of

traditional medicines used by local community is essential for: (a) Conservation, (b) Management of species in the particular region, and (c) Increase knowledge regarding locally available plants and their usability. The state of Sikkim possesses a vast richness of flora and fauna. The majority of tribal and rural groups that use organic farming methods rely on traditional medical systems to address their illnesses. The goal of the current study is to comprehend how the rural people of Sikkim employ common plants as remedies and the local health customs associated with them. This review work is a part of an initiative to document data for future phytochemical and pharmacological studies, which can serve as a starting point for future drug discovery for various ailments, in addition to contributing to the discussion and preservation of traditional knowledge and medicinal plants. Sikkim is the Himalayan landlocked state of India. It is bound on the north by China (Tibet plateau), on the east by Chumbi valley of Tibet and Bhutan, on the west by Nepal and on the south by Darjeeling district of West Bengal [4]. Geographically Sikkim lies between 27°05'- 28°07' N latitude and 88°31'-56'E longitude, which is one of the smallest but biologically most diverse Himalayan States in India[5].

Methodology:

The scientific data were collected from the different scientific repositories such as PubMed, Science direct, Research gate, Willy, Core, 1Library, etc. Inclusion and exclusion of the review topics were based on the medicinal plants used for wound healing activities and are included. The keyword used during the literature review were "MEDICINAL PLANTS", WOUND HEALING EFFECTS", SIKKIM HIMALAYA", "DOSAGE PREPARATION", "LOCAL NAME-NEPALI", "PART USED", MODE OF ADMINISTRATION".

Data Collection, Documentation and identification of plant species

The inclusion and exclusion of the review topics on the selected medicinal plants having wound healing effects were included. The keyword used during the literature review were "MEDICINAL PLANTS", WOUND HEALING EFFECTS", SIKKIM HIMALAYA", "DOSAGE PREPARATION", "DOSAGES", "LOCAL NAME-NEPALI", "PART USED", MODE OF ADMINISTRATION"[7]. The international and national plant name indexing (www.ipni.org), (www.theplantlist.org), (www.bsi.gov.in), (www.sikkimforest.gov.in) were used to validate plant scientific name, families. Each medicinal plant's specimens were closely monitored, examined closely, and identified using accepted literature [8-11].

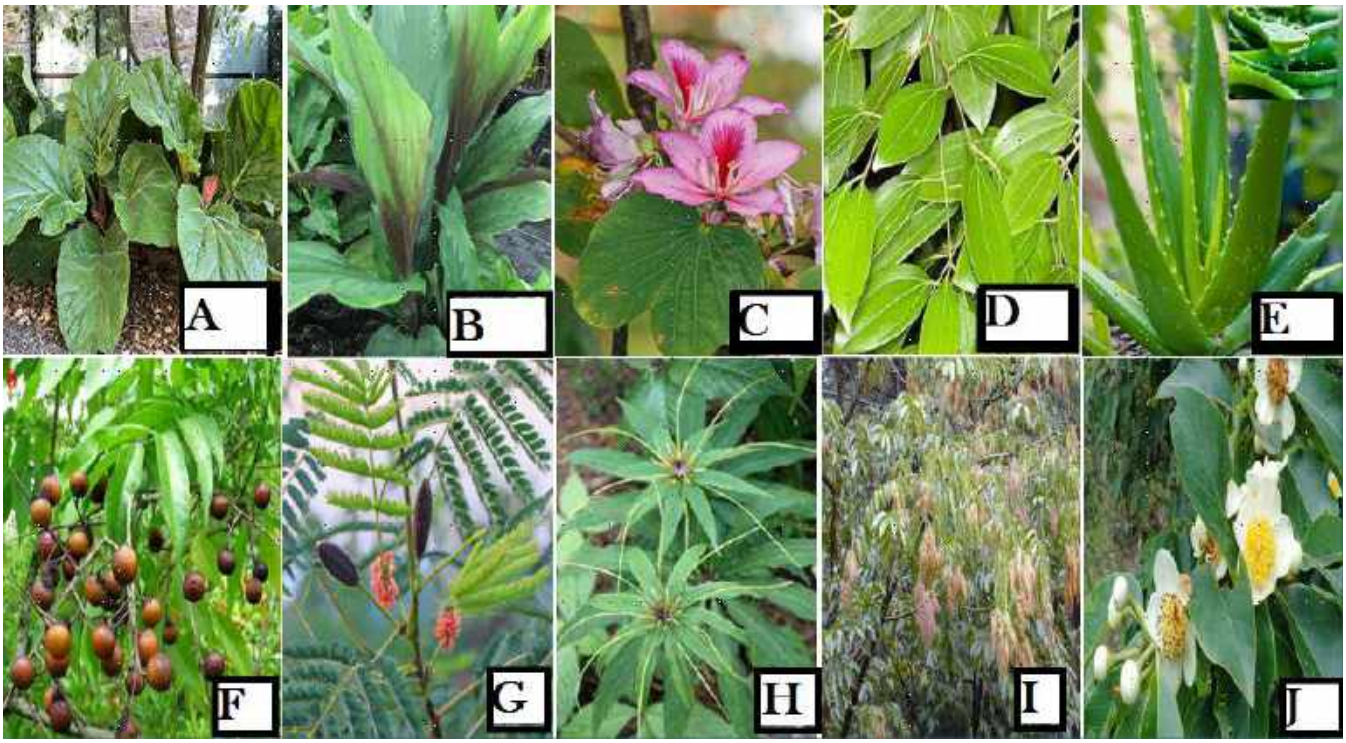


Figure1. Medicinal Plants having wound healing effects,

A: *Bergenia ciliata,* B*: Kaempferia rotunda,* C*: Bauhinia variegate,* D*: Eucalyptus globulus,* E*: Aloe barbadensis,* F*: Sapindus mukorossi,* G*: Acacia concinna,* H*: Paris polyphylla,* I*: Terminalia myriocarpa,* J*: Schima wallichii.*

Statistics:

The review result on the medicinal plants having wound healing effects from Sikkim Himalaya region were analyzed and presented in the tabular and graphical presentation within the manuscript by using the software- Microsoft Excel 2013.

Findings and Discussion:

A total of 10 medicinal plant species belonging to 10 families, 10 genera are mainly used for wound healing effects found in Sikkim Himalaya, summarized in Figure1 and Table1, if any other species will be found in the future, we will add up accordingly. The literature revealed- leaf, fruit, bark & underground tuber are mostly used, followed by whole plant (Graph1), and commonly used form of preparation was paste and extract form (Graph2).

Table1. Medicinal plants used for Wound healing activities

Sl. No.	Scientific name & Family	Local name	Habitat	Part used	Dosages Preparation	Mode of Administration (MoA)	References
1.	*Bergenia ciliata* Family- *Saxifragaceae*	Pakhanbet(N)	*On moist rocks and under forest shade*	Whole plant	Powder or triturate, boil with water-extract	Oral	[12], [13], [14]
2.	*Kaempferia rotunda* Family- *Zingiberaceae*	Bhuichampa(N)	Monsoon forests and open grassland- Altitude: 1700ft	Underground tuber	Paste of tuber root can be used for wound	Oral/Topical	[15], [16]
3.	*Bauhinia variegate* Family- *Fabaceae*	Koirala(N)	Mixed deciduous forest at altitudes from 500–800 m	Flower	Dried flower used for wound healing	Topical, Oral	[17], [18], [19], [20]
4.	*Eucalyptus glob* Family- *Myrtaceae*	Tarpin(N)	Western Ghats, altitudes between 900-1500 m	Leaf	Leaf oil can be used on wound and fungal infections	Topical	[21], [22]
5.	*Aloe barbadensis* Family- *Asphodelaceae*	Ghewkumari(N)	Widely distributed- 1300 to 2600m in dry, rocky and/ or exposed places	Leaf	For burn, the gel is applied directly on the burnt area.	Oral/Topical	[23], [24], [25], [26], [27]
6.	*Sapindus mukorossi* Family- *Sapindaceae*	Rittha(N)	lower foothills and midhills of the Himalayas altitudes of up to 1,200 metres	Fruit	Fruit juice used to wash wounds	Topical application	[28], [29], [30]
7.	*Acacia concinna* Family- *Mimosaceae*	Shikakai (N)	South Asian tropical areas altitude 50-1050 metres	Fruit	Decoction/extract	Oral/Topical	[31], [32]
8.	*Paris polyphylla* Family- *Melanthiaceae*	Satuwa (N)	Temperate region altitude between 1300 and 1800metres	Underground tuber	Tuberous roots paste can be apply on cuts and wounds	Oral/Topical	[33]

Sl. No.	Scientific name & Family	Local name	Habitat	Part used	Dosages Preparation	Mode of Administration	References
9.	*Terminalia myriocarpa Famliy- Combretaceae*	Pani saaj (N)	Evergreen forests- North East India up to 700 m altitude	Bark	Bark extract	Oral/Topical	[34], [35]
10.	*Schima wallichii Family- Theaceae*	Chilauney (N)	Tropical-subtropical forests, altitude 600-1500 m	Bark	Bark paste applied externally on deep cut and wounds	Bark extract	[36], [37], [38]

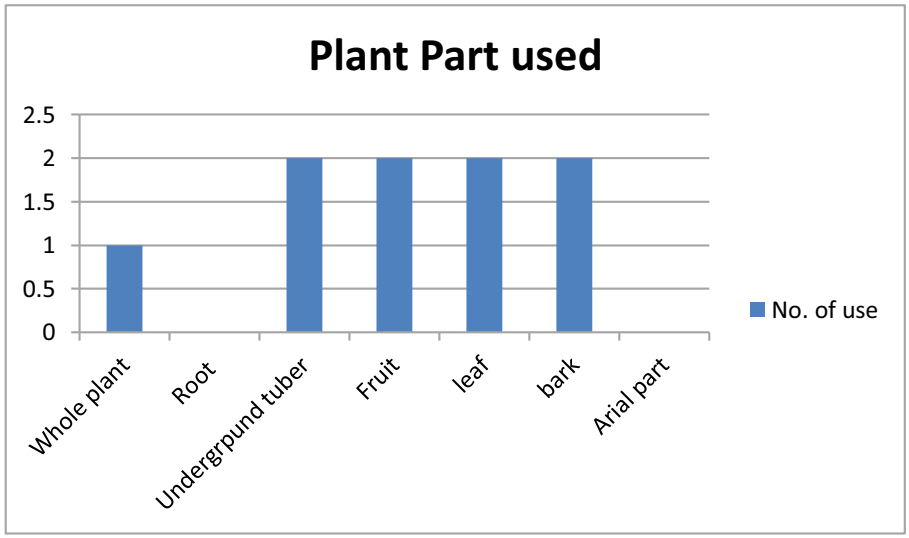
Other researchers have also documented the aforementioned species. While conducting literature search in various Sikkim Himalaya climate zones, (Singh *et a.,l* 2002, Pradhan *et al.,* 2008, Panda *et al.,* 2010, Idrisi *et al.,* 2010, Das *et al.,* 2012, Bharati *et al.,* 2012, Badola *et al.,* 2013, Lepcha *et al.,* 2019, Tamang *et al.,* 2023, Bhutia K.N *et al.,* 2023, Nepal

A *et al.,*2024), also discovered that people continue to use these traditional medicinal knowledge to treat other chronic diseases such as diabetes, asthma, fever, jaundice, leprosy, diarrhea, the common cold, dysentery, bronchitis, menstruation disorders, tooth infections, and headaches.

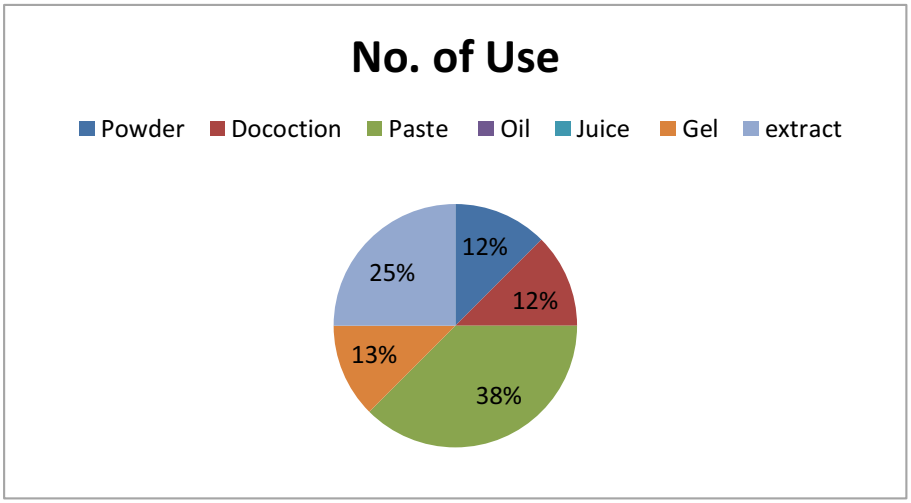
Conclusion:

From the above literature review, it was concluded that, the traditional practices in Sikkim Himalaya have long-standing knowledge on the therapeutic uses of medicinal plants. Additional investigation on wound healing activities from the collected plants, phytoconstituents separation and description of the active components, may lead to the identification of novel therapeutic candidates in a selected field in the future.

Graph1: Plant Part used:



Graph2: Different forms of dosage used to treat wound:



- **Ethics approval and consent to participate**

Human participants were not involved (No clinical study). Only verbal conservations were done with full consent of the participant. Ethics approval is not applicable.

- **Consent for publication**

Not Applicable.

- **Availability of data and materials:**

The datasets generated during and/or analyzed during the current review study are available from the corresponding author on reasonable request.

- **Conflict of Interest**

The author has no conflict of interest to disclose.

- **Funding**

Not applicable.

- **Authors' contributions**

S.B & T.U.K, responsible for selection of the review work and designing of the review manuscript. S.D.S & SB, involved in the major data collection. S.B & S.D.S, contributed for drafting, designing, formatting and referencing of this review draft article and communicating with esteemed journal having good reputation in the scientific fields. All authors have read and approved the manuscript.

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STUDY OF KALO PHOKARI (LAKE) AND NAGI LAKE AT NAMTHANG- CAUSES OF DRYING UP AND REJUVENATION STRATEGY

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1. Brief History

Kalo Phokari and Nagi Lake located at Namthang block are natural lakes which once flourished in the region and provided aesthetic as well as recreational value to the local people. Beside these, the lakes also supported the natural wildlife and vegetation of the region.

Sometime between the year 2013 and 2015, Kalo Phokari of Nagi lost its water retaining capacity leading to drying up of the Lake. The same had happened at Nagi Lake, few km below Kalo Phokari almost 20 years ago. The drying up of Kalo Phokari could have been due to many natural factors but the drying up of Nagi Lake was solely due to human interference. The latter was cemented to increase the retaining capacity of lake, but turned out to be a total disaster leading to drying up. Several authorities have tried to rejuvenate the Nagi Lake but have failed to do so. Some of the method used by them includes building concrete structure around the lake, refilling of Nagi Lake on 2011 and use of plastic flooring to retain water.

The last construction work around both the Lakes was done under the mission Amrit Sarovar, dated 26/7/22 to 10/9/22. The construction included high wall around Nagi Lake and Structural development work and nallahs at Kalo Phokari.

2. Study area

Kalo Phokari is situated at 27°10'15" N, 88°27'36" E. at an elevation of 1,782.75m above sea level near Nagi Hanuman Mandir, approximately 1.5 km from road and 4 km from the nearest town. The vegetation includes *Cryptomeria japonica, Alnus nepalensis, Eriobotrya spp., Ostodes paniculata, Choerospondias axillaris, Grevillea robusta, Ficus hookeri and Ficus benghalensis.*

Nagi Lake is situated at 27°10'01" N, 88°28'14" E at an elevation of 1,581m above sea level near Norbu Choeling Monastery. The vegetation around the lake is low and mostly includes *Alnus nepalensis,* with shrubs and few *Schima wallichii.*

3. Methodology

The study was conducted on 16th Nov 23 by the DFO, ACF and Field staffs accompanied by local guides. The geographical information was collected with the help of GPS points and the satellite imageries of both the Lakes across various timelines were studied with the help of Google Earth. The primary data was collected with the evaluation of site and focused discussion with the field staffs and local people.

The discussions included local knowledge on the site, possible reasons for depletion of lake, on site vegetation analysis, practices done in past to revive the lakes and analysis of construction done in past.

4. Analysis

Kalo Phokari

Fig1: From left to right; Satellite images showing water at Kalo Phokari during the year 2009, 2012 with water and 2023 completely dried.

- Based on the study it was evident that the Kalo Phokari (lake) was a rain fed lake and now had no water retaining capacity.
- The topography of the place hinted that the surrounding water flowed inwards towards the depressing point thus creating the lake.
- From the nature of vegetation it was evident that the lake served as a water hole for local and wild animals and possible source for water springs/sprouts in lower areas around Namthang.
- Attempt was made to revive the lake in 2022 almost 7 years after the lake dried during which construction of drains leading towards the depression to be refilled by rain water was undertaken. Locals state that plastic flooring was placed at the lake in an attempt to capture water and reduce water percolation but failed.

Nagi Lake

Fig 2: From left to right; Satellite images showing Nagi Lake during the year 2009 (dried) and 2011(attempt to rejuvenate the lake).

- Based on the study the team found out that the Nagi Lake (Phokari) was a rain fed and has also lost its water retaining capacity.
- An attempt to revive the lake was made in 2011 but failed, the lake is now completely dried.
- The local reported that the water had dried almost 20 years ago after the human intervention by use of cement concrete to increase the lake's retaining capacity.

5. Conclusion

1) There are no permanent water sources for both the lakes.

2) As analyzed further, it can be concluded that depletion of water at Kalo Phokari could have been due to many factors.

a) It is also reported by the forest staffs that one of the reason could be the plantation of *Cryptomeria japonica,* which as now emerged as a dominant species of the area .

b) It may be due to development of unseen hairline cracks at the base of the lake because of the roots of the trees and occurrence of earthquakes.

c) However, even after its loss of water retaining capacity, the lakes still serves as a place for deposition of excess water runoff during the peak monsoon season, thus, arresting the flow of runoff and reducing the velocity of runoff and collecting, making it slowly percolate through the bottom of the lake. This may have served as flood control during monsoon and have prevented landslides in the lower stream side.

3) These lakes have served as reservoirs to excess rainfall during monsoon thus, recharging ground water and springs.

6. Rejuvenation Strategy

Due to unavailability of nearby water source and from the study and information collected, it is clear that the rejuvenation of Kalo Phokari will require extensive research and funds to be able to clearly state the possibility of rejuvenation for the Lake.

For the Nagi Phokari, the site can meanwhile be rain fed as well as refilled simultaneously through construction of water harvesting tank to feed the lake. The Lake if filled has the potential to be used as water source for the nearest town Namthang which has a major water crisis throughout the year.

This can be successful if the abrupt seepage from the sides and bottom of the lake can be controlled and brought to a stage where it functions as a natural lake (i.e. natural lateral and vertical movement of water).

7. Field Photographs

The images shown are from the field visit at Nagi Lake and Kalo Phokari, Nagi, Namthang, South Sikkim on 16th Nov 23. conducted under The Divisional Forest Officer along with Assistant Conservator of Forest and Field staffs.

Photo: Field team at Nagi Lake.

Present image of Kalo Phokari.

Present image of Nagi Lake.

Fig 01: Study site: Tsomgo Lake complex

Exploring the Importance of High-altitude Lakes of Sikkim: A Preliminary study on herpetofauna and mammals of Tsomgo Lake, Sikkim

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INTRODUCTION

Sikkim is a small northeastern state of India with a geographical area of just 7,096 km². It is a part of the Eastern Himalayan Biodiversity hotspots (Chettri and Tamang, 2024). Sikkim is blessed with more than 200 lakes, whose serene beauty attracts tourists from all over the world (Maharana et al. 2000). Amongst the many lakes of Sikkim, some are above 3000 meters and are considered high-altitude wetlands. High altitude wetlands (HAWs) are defined as areas of temporary or permanent saturation located 3000 m above sea level that lie between the tree and permanent snow lines (Khan and Baig, 2017). High-altitude lakes store glacial meltwater and release it gradually, sustaining continuous water discharge in downstream areas while preventing sudden release (Singh & Jina, 2019). High-altitude lakes are not only the sources of drinking water, but they are also considered sacred for their spiritual and religious significance (Chettri et al. 2021). HAWs have huge ecological significance and provide ecosystem services to millions of people far from their source. While the water flowing from the high-altitude wetlands sustain the lives and livelihoods of millions of people, it can be a major source of disaster. Recently, several disasters related to HAWs have occurred frequently in the Himalaya, including Sikkim. Hence, HAWs are life-sustaining ecosystems but can turn into life-threatening natural hazards.

Religious and Ecological significance of lakes in Sikkim

Out of the many lakes in Sikkim, some of the famous ones hold religious and cultural significance. Some of the religiously significant lakes in Sikkim are: Guru Dongmar Lake, situated at an elevation of 5,154 m in North Sikkim; Tso Lhamo Lake, located few kilometres away from Guru Dongmar Lake near Dongkhyala Pass, at an elevation of 5,100 meters in North Sikkim; Khecheopalri Lake, situated in West Sikkim at an elevation of 1,800 m; and Tsomgo Lake, located in the Gangtok district at an elevation of about 3,753 m (Government of Sikkim, Ecclesiastical Affairs Department). In addition to lakes of religious importance, there are many hot springs located in different parts of Sikkim, which are considered highly sacred and religious. Hot springs are located both in low elevation, namely Borong (1767m), Polok (929m), and at high elevation, namely Yumthang (3564 m) and Yumesamdong at an elevation of 4724 m.

Although the locals considered all lakes in the Himalayan mountains as sacred, Khecheopalri Lake in the Sikkim Himalaya is considered the most sacred. Many folklores are associated with it, and it is famous as a "wish-fulfilling Lake" (Uprety et al. 2012). This lake, which holds both religious and ecological significance, was declared as the first Ramsar site of Sikkim and is one among the 89 Ramsar sites in India on February 2, 2025 (Ramsar Sites Information Service https://rsis.ramsar.org/).

Ramsar sites are managed to balance conservation efforts with sustainable use, ensuring that the ecological, economic, and cultural functions of these wetlands are preserved for future generations. Ramsar Convention is an intergovernmental treaty adopted on 2 February 1971 in the Iranian city of Ramsar, for the conservation and sustainable use of wetlands (Ramsar Sites Information Service https://rsis.ramsar.org/)

The traditional belief that lakes are sacred should be preserved alongside scientific conservation efforts, as it helps protect these water bodies and their surroundings. This approach prevents human encroachment and promotes sustainable ecotourism. For instance, a common folklore among Sikkimese and Nepali-speaking Himalayan communities warns against polluting water sources, linking it to displeasure and illness. Engaging with locals through cultural and environmental

perspectives can strengthen lake conservation efforts by integrating religious values with ecological awareness.

TSOMGO LAKE

Tsomgo is one of the high-altitude lakes of Sikkim with an elevation of approximately 3753m above mean sea level (Fig. 1). When we visited Tsomgo Lake for the first time, we were mesmerized by the scenic beauty of the landscape with a pristine lake surrounded by an undulating meadow. The rich diversity of pines and rhododendrons was breathtaking. Tourists were enjoying the natural beauty of the place and taking pictures while happily loitering around. Then questions arose in our minds: will this beauty last forever? Will our future generations witness the enchanting beauty of Tsomgo Lake? That thought made us a little worried.

Our main purpose for visiting Tsomgo Lake was to collect preliminary data, primarily focused on two different taxa: herpetofauna and mammals. We visited Tsomgo Lake from May to August 2024 (Fig 2). During our visit, we not only gathered information on herpetofauna and mammals but also became more familiar with the environment, vegetation, and the daily activities of the local people.

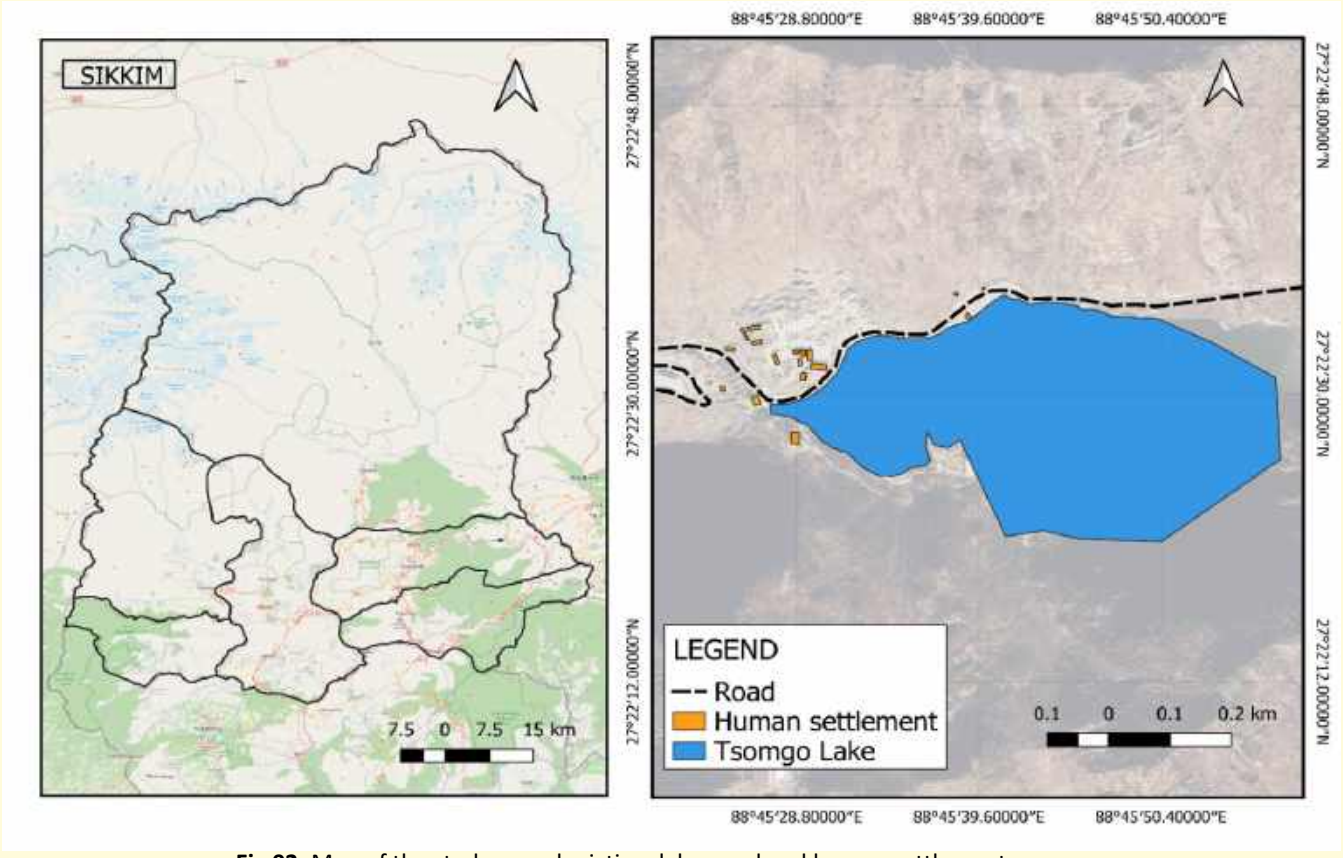

Fig 02: Map of the study area depicting, lake, road and human settlement.

Herpetofauna

Herpetofauna, composed of amphibians and reptiles, is a crucial component of ecosystems. They are threatened worldwide and are declining rapidly, mostly due to anthropogenic pressures (Chettri et al. 2011). According to Stuart et al. (2004), most herpetofauna are threatened and are declining more rapidly than birds and mammals due to anthropogenic activities.

Scientific documentation of the herpetofauna of the Tsomgo Lake region is lacking. During our visit in May 2024 for sampling, we explored almost all the streams near the lake, hoping to encounter adults, egg clutches, or small free-swimming larvae of amphibian species, but we could not find any. We assumed that the water was still not warm enough for spawning.

For amphibian sampling, we employed the VES (Visual Encounter Survey) method, which is considered an effective technique for amphibian sampling (Boullhesen et al. 2021). We also spoke with local people to inquire whether they had encountered any herpetofauna species in their locality; their responses varied. Some questioned, "How could it be possible to find frogs or toads in such a cold place?". While others claimed to have occasionally seen amphibians in the pipelines coming from small water sources in the streams above the lake. These differing statements sparked our curiosity about the amphibian species in the area. Despite our consistent efforts, we had to return empty-handed, without finding any amphibian species in the region.

When we revisited the area in July, we observed several changes in the lake's ecosystem. The small streams within a 100-meter proximity of the lake, where we had previously laid quadrats and conducted visual encounter surveys in the hopes of finding amphibians, were completely dried up, and some had even changed course. These sudden changes in the streams may have been caused by the deposition of mud from grazing yaks, as we observed many yak footprints in the area.

The following day, we explored the streams where water was consistently flowing. To our great excitement, we found egg clutches of

amphibians. However, these egg clutches were infested by some nematode larvae (Fig. 3-A). The tadpoles in these clutches were few (14 to 15). The egg mass was located approximately 100 meters from the lake complex. We also noticed many faecal materials from dogs and yaks near the egg clutch, so it is possible that the infestation was due to larvae of flies feeding on the faecal matter. Though we could not identify the larvae, it is an indication of pollution around the lakes. About 100 meters above the first egg clutch, we found another amphibian egg clutch with over 70 healthy tadpoles (Fig. 3-B). Hence, it is very important to analyse the lake water so that the main cause of pollution can be understood. Based on the elevational distribution, the tadpoles encountered at this elevation (above 3,000 meters) may belong to *Scutiger sikkimensis* or *Scutiger boulengeri* (Chhetri et al. 2010).

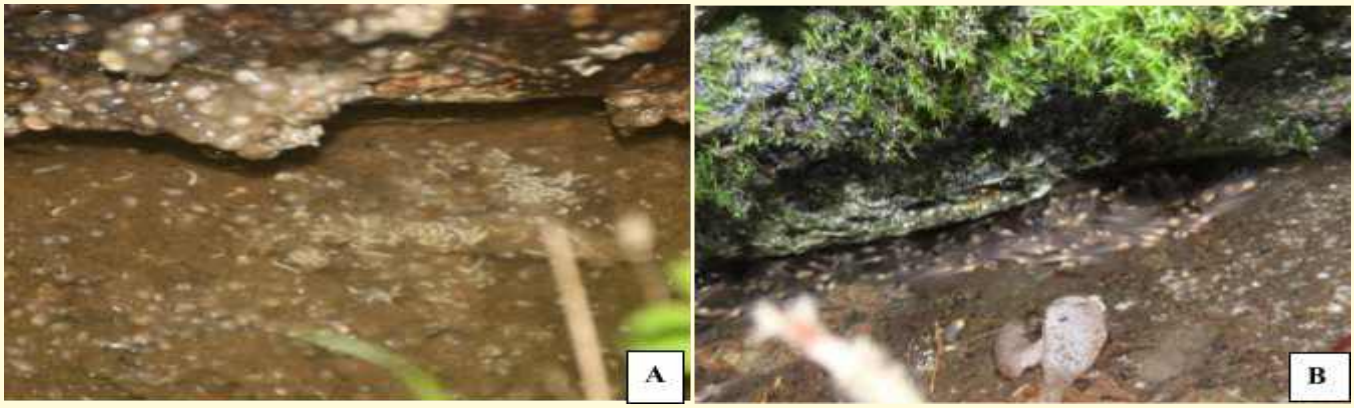

Fig 03: Larval infestation in the egg mass of an amphibian species, which was found within 1000m of the Lake **(A)**, and large numbers of healthy tadpoles in the undisturbed habitat **(B)**

Mammals

Mammals play a crucial role in maintaining healthy and balanced ecosystems (Lacher et al. 2019). They regulate animal populations, support plant life, and contribute to environmental stability. Some mammals (rodents, herbivores) serve as prey for larger animals, while others are predators (tigers, leopards) themselves. Additionally, mammals have significant ecological and cultural importance in human society. Therefore, studying and protecting these species is essential.

Mammals possess unique adaptations that help them survive in challenging environments, including extreme cold, limited oxygen, and seasonal food scarcity in harsh climatic conditions (Joshi et al. 2020). However, challenges are not limited to this. Large carnivorous mammals are facing a global decline due to various human-related threats, including habitat loss, fragmentation, overexploitation, persecution, and a reduction in prey availability. Slow reproductive rates, wide-ranging behaviours, low population densities, and high energy demands make them particularly susceptible to the pressures exerted by human activities (Justa and Lingdoh, 2023).

During our survey in May 2024 around Tsomgo Lake, we observed several mammal species, including Pika (*Ochotona* sp.), Weasel (*Mustela* sp.), and Goral (*Naemorhedus* sp.). Among them, Pikas and Weasels were the most commonly encountered. Pika is a key food source for carnivores such as Yellow-throated marten (*Martes flavigula*), Snow leopard (*Panthera uncia*), Himalayan weasels (*Mustela sibirica*), and Red fox (*Vulpes vulpes*) (Bhattaacharyya et al. 2019). Pikas are particularly important as environmental indicators as they are highly sensitive to climate change (Bhattacharyya et al. 2019). As global temperatures rise, pikas are forced to move to higher altitudes in search of cooler habitats, making it increasingly difficult for them to find food and refuge (Yandow et al. 2015).

Despite their small size, pikas play a vital role in the ecosystem and are hence referred to as ecosystem engineers. They help regulate plant growth and contribute to maintaining plant diversity in the region (Liu et al. 2022). The presence of these mammals is crucial to the ecological health of Tsomgo Lake's surroundings. Without them, the entire ecosystem could become unbalanced and unsustainable.

The mammals in this area are not only fascinating to observe but also essential for ecosystem stability. If these species were to disappear, the entire food web could collapse. Without predators like the snow leopard, herbivores might overconsume vegetation, leading to habitat degradation (Schmitz 2003). Similarly, the absence of small mammals like pikas would disrupt the food chain, affecting numerous species at higher trophic levels. Conserving these mammals is not just about protecting individual species; it is about preserving the entire ecosystem. By safeguarding these animals, we also protect the land, water, and natural resources supporting wildlife and human communities. Conservation efforts should focus on habitat preservation, sustainable tourism management, and preventing illegal hunting to ensure their survival.

During our field survey around Tsomgo lake, we observed several challenges faced by the mammal populations. These threats arise from human-induced factors like livestock grazing, increasing tourism, increasing population of feral dogs, etc., placing significant pressure on wildlife and the environment. Addressing these issues is critical in ensuring the long-term survival of these species and maintaining the ecological balance of the region.

Fig 04: Pika (*Ochotona* sp.) (A) and Himalayan Goral (*Naemorhedus goral*) (B) at the Tsomgo lake complex

Potential threats to Tsomgo lake

We observed many anthropogenic activities at Tsomgo lake. Litter thrown by locals and tourists, along with domestic waste found to be swept away by rainwater and scattered by feral dogs, which were found stuck around the boulders and stagnant water in the streams. Despite the promotion of ecotourism in the area and regular cleanliness drives conducted by the "Pokhari Sanrakshan Samiti," a local organization dedicated to protecting Tsomgo Lake, some organisms, especially small animals like herpetofauna, may be facing threats due to growing settlements and tourism in the region. The presence of nematode larvae in the water channels significantly reduces the tadpole populations of endemic and restricted-range species like *Scutiger sikkimensis*. Most nematode larvae could be associated with faecal matter. Hence, it is important to monitor the pollution surrounding the lake area. Herpetofauna are ectothermic (cold-blooded) animals and have a narrow range of environmental tolerance due to their physiology and naked skin. Due to climate change, high elevations are facing more warming, and this may have a direct impact on the breeding ecology of herpetofauna. Amphibians and reptiles are the key bioindicators of environmental health and habitat quality, and they can provide baseline information to help assess habitat conditions (Mifsud et al. 2014). However, anthropogenic activities and unregulated tourism are likely to threaten their habitats.

Similarly, high-altitude mammals are increasingly under threat. Livestock grazing animals such as yaks compete with wild animals like the Goral (*Naemorhedus* spp.) for food. We observed several areas where livestock had overgrazed, making it harder for wild animals to find sufficient food. Further, direct interaction between wild and domestic animals will not only aggravate the conflict, but it also increases the risk of acquiring new diseases unknown to wild populations. Additionally, a newly constructed road passing near Tsomgo lake has fragmented the land, restricting the free movement of animals. During our communication with locals, we gathered information about direct conflicts between humans and bears. In the Tsomgo lake region, there is a food supply store for the Indian Army. Local workers informed us that bears sometimes enter the storage facility and destroy food supplies.

One of the major issues we observed in the area was the increasing activity of feral dogs. Feral dogs are neither fully wild nor domesticated; they survive independently of human intervention by hunting, scavenging, and sometimes feeding on human garbage (Green et al. 1994). They were found throughout the area and pose a threat to small mammals, birds, and even locals and tourists. Their growing population and activity could disrupt the natural ecosystem. During the breeding season of dogs, we observed more than 100 dogs roaming around the lake complex.

Due to the continuous construction work and alteration of land use patterns, Tsomgo lake is also facing a siltation problem and is becoming smaller day by day. Locals said that the lake was much clearer and wider before. Water level fluctuation and exploitation of the lake can have huge effects on biodiversity (Tiberti et al. 2019), which may largely affect the wetland and wetland-dependent species like mammals, birds, and herpetofauna in specific, while in general affecting the entire biodiversity of the high-altitude region.

Conclusion

Among the many unexplored and less researched areas of the earth, high-altitude wetlands are one where uniquely adopted organisms exist, but we have very little knowledge about them. Due to the isolated valleys and mountains, high-altitude areas, including HAWs, are isolated, thus resulting in many endemic species. However, most of the species are becoming threatened due to increasing anthropogenic pressures and climate change. Minor vertebrates like reptiles and amphibians are the least studied and hence the least known, but are highly threatened due to their physiological condition, slow dispersal, and high sensitivity to climatic changes. Many mammals are also becoming victims of the increasing human-wildlife conflict. Most of the high-altitude wetlands are either sacred religiously or are places of high tourism importance. Both these factors exert huge pressure on native biodiversity, and since most of the flora and fauna found in HAWs are endemic, it is very urgent to study the detailed ecology of the species found in the vicinity of HAWs. Further, we need a detailed roadmap of HAWs for sustainable tourism so that the place remains pristine and sacred for religious and eco-tourism activities.

The International Union for Conservation of Nature and Natural Resources (IUCN) defines ecotourism as: “environmentally responsible travel and visitation to relatively undisturbed natural areas, to enjoy and appreciate nature (and any accompanying cultural features—both past and present) that promotes conservation, has low negative visitor impact, and provides for beneficially active socio-economic involvement of local populations” (IUCN, 1996). The International Ecotourism Society (TIES) proposed a revised definition of ecotourism in 2015 as, “responsible travel to natural areas that conserves the environment, sustains the well-being of local people, and involves interpretation and education," specifying that education is directed toward both staff and guests (TIES, 2015).

Every resident must be made aware of the importance and potential threats of the lakes, not only from a religious perspective but also from a scientific aspect. This Earth does not belong solely to us; every organism has an equal right to survive without our interference. We must try to reduce further habitat destruction and keep the natural ecosystem undisturbed because our conservation efforts are not a compensation for habitat destruction. HAWs, which sustain millions of lives upstream and downstream, can become furious, resulting in disasters if not taken care. Our memories have not faded away with the horrifying experience of GLOF (disaster of HAWs) in Sikkim in 2023. Hence, this dynamic ecosystem should be thoroughly studied with regard to both abiotic to biotic components and their complex interaction so that we will have comprehensive data about the whole lake complex. Such data is crucial for management, conservation and potential risk associated with these high-altitude lakes.

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Dual Realities: Glacial Lakes as Biodiversity Hotspots and GLOF Threats

Sangay G. Bhutia, IFS
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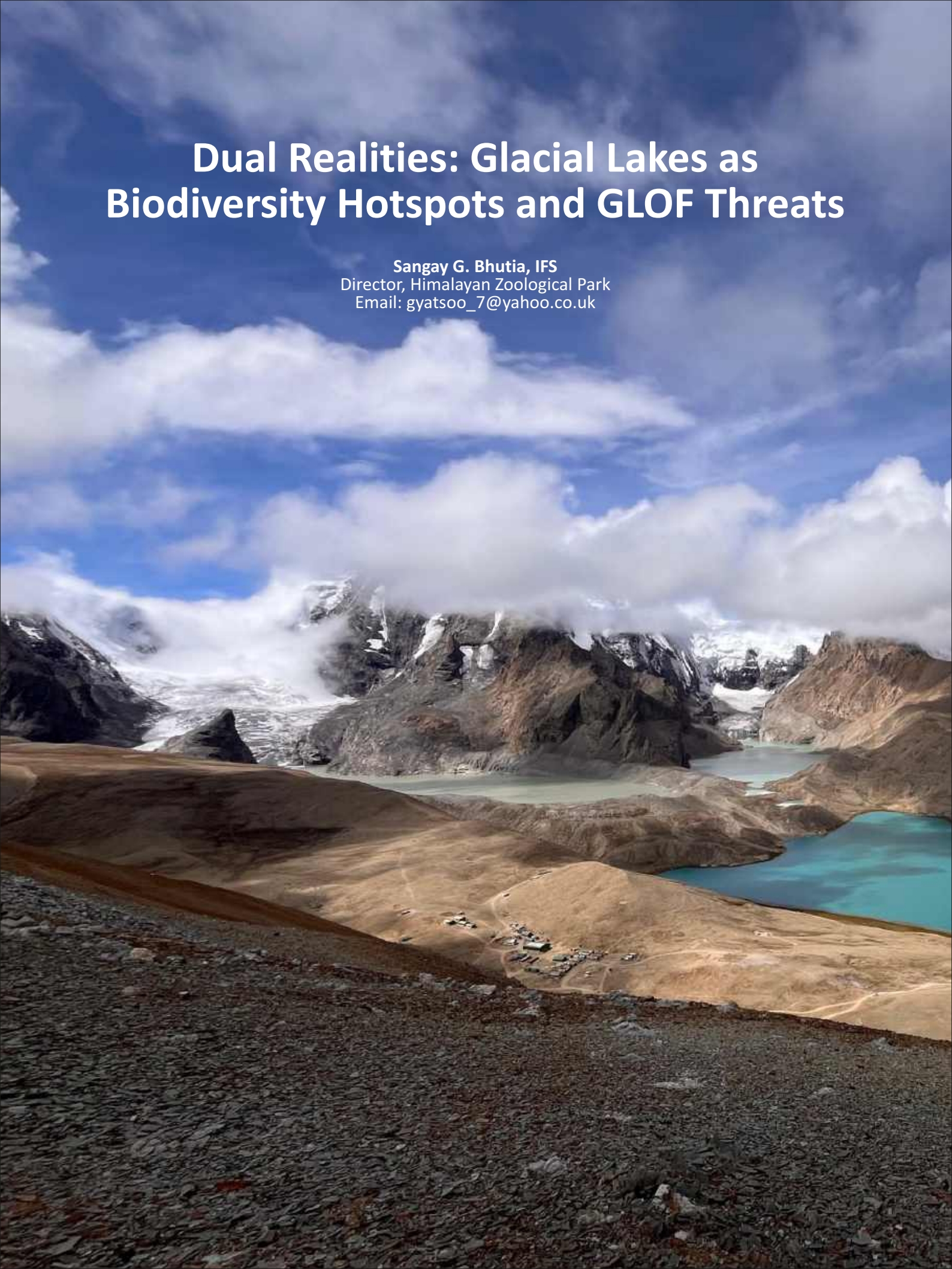

As rightly quoted by one of my seniors, our view of lakes as forester has always been one of awe and reverence, a biodiversity hotspot. But during my recent expedition as part of a team of Glacial Lake Outburst Flood (GLOF), I found myself looking at these lakes from a startlingly new perspective—not just as havens of life, but as ticking time bombs, poised to unleash destruction.

My journey through the rugged terrain took me to five pristine lakes at elevations exceeding 4,500 meters, each telling its unique story of formation and transformation. The journey was supposed to be an expedition focused on glacial lake outburst floods (GLOFs), but what it truly revealed was something far more profound a harsh and undeniable truth about the impacts of climate change. As we trekked higher into the mountains, through the valleys that cradle glacial lakes, the evidence of a rapidly warming world was all around us. The shrinking glaciers, swelling lakes, and increasingly unpredictable weather patterns weren't just scientific phenomena, they were symbols of an ongoing environmental injustice. The people of the Himalayas have lived in harmony with this landscape for generations, for these communities, the glaciers and lakes has always been sacred but now they are being forced to pay for a problem they did not create. Is this the price we pay for, having negligible carbon footprint, or are we paying the price for the unchecked industrial development and consumption-driven economies downstream.

Our fieldwork incorporated a range of techniques, including GPS mapping, depth measurements, and surveys of moraine stability for assessing the risks and categorizing these lakes under highly, moderate and low risked, along with risk assessment the team also formulated a baseline strategy for mitigation measures , taking into consideration the environment and ecological aspect of the landscape.

As I left the expedition, the once-pristine glaciers and lakes felt different. I could no longer see them as mere symbols of natural beauty, but as reminders of the urgent fight ahead. The Himalayas may be thousands of miles from the industrial centres of the world, but they are on the frontlines of the climate crisis. The people who live here are fighting a battle they didn't choose, but one they must now endure. Collaborative efforts between scientists, governments, and local communities are essential to safeguard lives and preserve the fragile ecosystems of these breath taking landscapes.

Picture: **Gurudongmar glacial lake complex, Sikkim, India**

An exploration of traits associated with butterflies and birds at Tsomgo Lake, a High-Altitude Wetland of Sikkim

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Introduction

Global glacier cover, an essential indicator of climate change and the availability of water resources, play a crucial role in ecosystems and human livelihoods. Approximately 10% of the Earth's land surface is covered by glaciers, of which round 726,000 square kilometers is primarily concentrated in polar regions and high mountain ranges, including the Himalaya. Himalaya, also known as the "Third Pole" and the "Water Tower of Asia", is home to four of the world's 36 Global Biodiversity Hotspots (Khan et al., 2017; Xu et al., 2019). High-Altitude Wetlands (HAW) in the Himalaya host diverse flora and fauna, and forms a vital habitats and breeding grounds for various species. It is crucial to manage these wetlands due to their utmost significance in water recharge and biodiversity conservation. They also serve as natural reservoirs that facilitate water infiltration into underground aquifers, replenishing water sources for nearby communities and ecosystems (Ghosh and Chakraborty, 2021). Sikkim hosts 526 lacustrine wetlands, which includes 215 high-altitude water bodies. Tsomgo Lake (27° 22′ 31″ N to 88° 45′ 50″ E) (Fig. 1), a significant high-altitude wetland in Sikkim, is situated at an elevation of 3753 meters, covering an area of 23 hectares (Tambe et al., 2007). The lake measures 836 meters in length and has a maximum width of 427 meters, a reported maximum depth of 15 meters with moderate turbidity (Panigrahy et al., 2012).Due to its unique geographical and physical attributes, Tsomgo Lake is the most visited lake in Sikkim, potentially attracting huge number of visitors annually. Increase in tourism at Tsomgo Lake has greatly benefited the local economy, serving as an important economic lifeline, particularly for small businesses and local communities. Rise in tourism has been able to enhance many job opportunities, directly benefiting hoteliers, tour operators, taxi drivers, shopkeepers, guides and local communities. But the increasing tourism at Tsomgo Lake has also led to several adverse impacts such as pollution, solid waste accumulation, unmanaged drainage, etc. In response to these challenges, many conservation initiatives and mitigation strategies are at place at Tsomgo Lake. The Tsomgo Pokhri Samrakshan Samiti (TPSS), formed in 2008, is an example of a community-led effort involving local residents, taxi drivers, shopkeepers, and government departments. TPSS is dedicated to lake conservation, and involved in managing the sustainable practices of eco-friendly tourism.

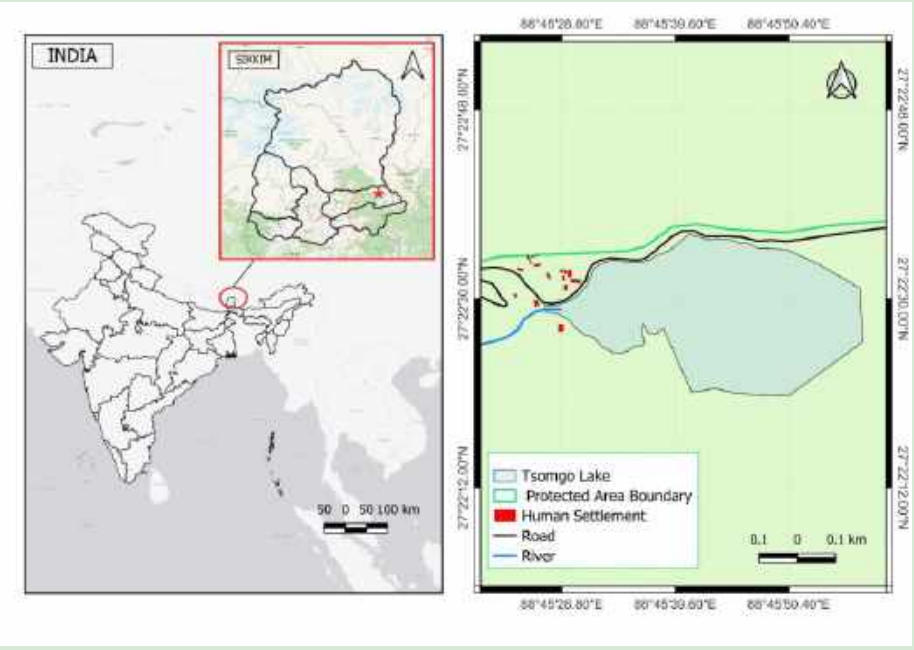

Figure 1: Map depicting the study site: Tsomgo Lake, a high-altitude wetland in Sikkim.

2. Methodology

2.1 Butterflies

Butterfly sampling was conducted using the Transect Count, also known as the Pollard Walk method (Pollard, 1977). For this study, permanent transects, each 500 meters in length, were established at the complex of Tsomgo Lake. Butterfly species observed were documented directly on-site. Species that could not be immediately identified were photographed and subsequently identified using the reference book "Butterflies of India" by Isaac Kehimkar (Kehimkar, 2008) and the online resource (www.ifoundbutterflies.org).

The recorded observations encompassed species identification, abundance, habitat types, larval host plants, and specific behaviours.

2.2 Birds

For the assessment of bird diversity in the wetlands, line transect method was used following Buckland et al. (1993). A total of two transects were established at Tsomgo Lake for the present study. Each transect extended for 1,000 meters with a width of 30 meters on either side. To systematically collect data, the bird species were recorded within an interval of 100m for 10 minutes duration. During these observations, various parameters including species diversity, abundance, and specific feeding behaviour of the birds encountered during the study were noted. Each transect was surveyed approximately for three hours, which provided adequate time to gather data on the bird populations and their behaviour within the designated transects.

2.3 Methodological challenges for faunal sampling at high altitudes due to unpredictable weather conditions

Conducting field observations of butterflies and birds at high altitudes poses challenges due to unpredictable weather conditions, were cloudy, rainy, or windy days can significantly limit observation opportunities (Acharya et al., 2025). Snow cover and extreme cold temperatures restrict the activity of high-altitude butterflies to very short duration, thus limiting the time available for data collection. As ectotherms, butterflies depend on external heat sources to regulate their body temperature. Hence, maximum sunlight availability effect their critical life-history activities, such as nectar feeding, mating,and oviposition. At lower altitudes, the optimal timing for butterfly field observations is typically from 10:00 am to 1:00 pm. However, a specified observation window cannot be established at high altitudes, as the duration of solar exposure dictates data collection. High-altitude butterfly observation can yield productive results even in the early morning at 7:30 am, contingent to sufficient sunlight intensity.

To effectively monitor butterflies at high altitudes, researchers often need to be in the field from early morning hours until afternoon, as weather conditions can change unpredictably within a short span of the day. Brief periods of bright sunshine can sometimes occur, providing an essential observation opportunities that must be capitalized effectively. Short sunlight durations are important as butterflies demonstrate heightened activity during these times, engaging in vital behaviors such as mating, nectar feeding, and oviposition etc.

Similarly, field observations on birds at high-altitudes are also strongly influenced by unpredictable weather conditions, which often limit visibility and reduce bird detectability.While the widely accepted time for bird sampling is during morning (6:00 am – 9:00 am) and evening hours (3:00 pm – 6:00 pm), sustained rainfall and overcast skies in the present study area prohibit evening surveys. Consequently, bird monitoring had to be opportunistic and mostly restricted to morning hours, resulting in an irregular pattern of sightings. The absence of evening observations introduces a potential bias in activity data, highlighting the need for extended surveys across varying times when weather permits.

3. Findings and observations

3.1 Utilization of floral and food resources by birds and butterflies

During the field study conducted at Tsomgo Lake, the feeding and foraging behaviours of few species of butterflies and birds were enumerated. Three butterfly species—Common Blue Apollo *(Parnassius hardwickii),* Brown Awl *(Badamia exclamations),* and Himalayan Dark Clouded Yellow *(Colias fieldii)*—were documented during the fieldwork. All three species were primarily observed in wetland edge and shrubland habitats. *P. hardwickii* was found to utilise *Senecio raphanifolia* as nectar sources (Fig. 2). These plant species are reported to occur near Tsomgo Lake (Gogoi et al., 2021). The nectar plant for *B. exclamationis* was not recorded during this study. *B. exclamationis* is reported at an altitude of up to 3,400 meters (Kehimkar., 2008). Interestingly, the species was also observed in the Tsomgo wetland.

Similarly, White-collared Blackbird *(Turdus albocinctus)* (Fig. 2) was observed feeding on the earthworms. Study have shown that birds feed on earthworms during breeding season (Fan et al., 2017). Similarly, Citrine Wagtail *(Motacilla citreola)* and White Wagtail *(Motacilla alba)* foraged on insects on the shore of the Tsomgo Wetland. Mallard species was found to be feeding on phytoplankton, zooplankton, and various vertebrates present within the wetlands.

Figure 2: Female of Common Blue Apollo (Parnassius hardwickii) nectaring on Senecio raphanifolia (a); and White-collared Blackbird (Turdus albocinctus) feeding on earthworm (b) at Tsomgo wetland.

3.2 Adaptive behavioural strategies of *Parnassius hardwickii* in high-altitude environment

Despite unpredictable weather conditions and limited sunshine, *Parnassius hardwickii* exhibited rapid nectaring behaviour, spending only 3-5 seconds on each flower. Such activity enabled them to efficiently forage in more flowers while minimizing time spent on those plants with less nectar content.

High-altitude butterflies demonstrate efficient thermoregulation (Somme 1989). It was observed that *P. hardwickii* minimises basking time, efficiently orienting their wings and bodies towards the sun to maximise heat absorption and quickly resume their other activities. However, when sunlight is less intense, resting individuals may open their wings to bask without taking flight, maximising heat absorption under suboptimal conditions. In response to changing weather conditions, they rapidly seek shelter within bushes or under leaves, maintaining a closed-wing posture to minimise heat loss. Roosting typically involves close-wing positioning, allowing them to effectively conserve body heat during prolonged periods of cold weather, which can be overnight or for a few days until the weather becomes favorable.

3.3 Oviposition and breeding activities of few butterfly and bird species

Parnassius hardwickii, was observed engaging in mating behavior and subsequent ovipositing activities. The species exhibited a solitary egg-laying pattern, with two to three eggs deposited on a single plant. During periods of optimal solar exposure, gravid females were observed to engage exclusively on rapid oviposition, ceasing all other activities. Interestingly, the eggs were found on two to three different plant species. However, the specific larval host plant for *Parnassius hardwickii* remains unidentified and needs further observation.

The mallard or wild duck *(Anas platyrhynchos)* is a migratory bird that has been recorded to breed in the wetlands of Kashmir (Ahanger et al., 2013; Habib et al., 2017). However, we also observed the signs of its breeding at Tsomgo Lake in Sikkim. While we recorded two fledglings of mallards, we could not find any nests or remnants of eggs in the wetland. These observations have added new breeding sites of this species in the Himalaya. Since the breeding season was almost over at the time of study, focused study during breeding season might be helpful in locating active nests which provides an opportunity to explore reproductive strategies and breeding success.

3.4 Anthropogenic activities potentially affect butterflies and birds

Globally, the primary factors contributing to wetland loss include urbanisation, changes in land use, development of infrastructure, pollution from industrial waste and agricultural runoff, and climate change and its variability (Bassi et al., 2014). Changes in the regional climate are driving rapid and significant alterations in ecosystems, including high-altitude wetlands. These impacts are further intensified by human activities such as uncontrolled tourism, pollution, altered grazing practices, and infrastructural development (Sharma et al., 2020; Verma et al., 2021). In the High-Altitude Wetlands of the Changthang Wildlife Sanctuary, such anthropogenic pressures have directly led to the decline in breeding and roosting behaviour of sensitive bird species like the Great-crested Grebe *(Podiceps cristatus).* Many similar threats exist in the study area which might impact birds, butterflies and other biodiversity but needs further exploration.

Among the emerging threats, the presence of feral dogs has become a serious ecological concern in high-altitude wetlands including Tsomgo. These dogs not only compete with native wildlife for resources but also exhibit aggressive behaviour toward local and migratory birds. During preliminary observations, migratory birds such as the Ruddy Shelduck *(Tadorna ferruginea)* and Mallard (*Anas platyrhynchos)* were frequently targeted by feral dogs, resulting in physical harm, stress, and in some cases, mortality (Fig. 3). Notably, fledglings of Mallards were observed to be particularly vulnerable, with feral dog attacks leading to nest abandonment and breeding failure. Such disturbances extend beyond direct predation; they also disrupt natural behaviours, causing birds to avoid key foraging or nesting areas, which can impact their energy budgets and reproductive success. The long-term presence of feral dogs not only threatens individual bird species but also alters the structure and dynamics of the broader avian community, and potentially affect other wildlife reliant on similar habitats.

Figure 3: The feathers of Ruddy Shelduck (Tadorna ferruginea) at Tsomgo Lake. The birds are potentially preyed by the feral dogs.

4. Conclusion

This short-term observation at Tsomgo Lake, a high-altitude wetland in the Himalaya, highlights their importance as significant habitats for birds, butterflies and other animals. These wetlands not only support high diversity and unique community composition; it also provides feeding and breeding habitats for many animal species including birds and butterflies. High altitude wetlands attract enumerable number of tourists which enhances the income and supports livelihoods of the local community. However, there are several threats, especially associated with tourism and infrastructural development, which are impacting the range of biodiversity and their habitats. Hence, long term well designed multidisciplinary study including various taxa is necessary to understand the species occurrence, habitat usage and threats experienced by fauna of the area. Sustainable, regulated and ecofriendly tourism practices, managed drainage system, strategic mitigation of feral dog population are necessary steps to maintain balance between economic, environmental and cultural dimensions associated with this wetland.

Acknowledgements

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Exploring Biodiversity in Home Gardens: A Vital Practice for Sustainable Ecosystems & Food Security

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Introduction

A home garden, also referred to as a kitchen garden, involves cultivating plants and vegetables in small plots close to the household. Although this practice is common in both urban and rural settings, its role in biodiversity conservation is often underestimated. In light of the current challenges of habitat destruction and fragmentation, home gardens play a vital role in preserving biological and cultural diversity (Galluzzi et al., 2010; Idohou et al., 2014). These gardens also serve as sustainable environments for conserving traditional crop varieties, ensuring food security, and maintaining crop genetic diversity (Sthapit et al., 2014). Beyond conservation and food security, home gardens offer additional benefits such as improving mental and physical health and fostering stronger human-nature connections (Marques et al., 2021; Lampert et al., 2021). Their role in enhancing community resilience, particularly during crisis like the COVID-19 pandemic, has been well documented (Kumar, 2021; Theodorou et al., 2021). In rural areas, home gardens are essential for supporting and enriching the broader agricultural ecosystem, providing critical services such as pollination, habitats for various animals, and facilitating genetic material exchange among plant species within and beyond the gardens (Engels, 2001).Although urban home gardens are not directly linked to the larger agro-ecosystem, they still contribute significantly to enhancing air quality, reducing CO_2 emissions and temperatures, and offering opportunities for livelihoods, social engagement, and recreational activities (Van Veenhuizen, 2006;Viljoen et al., 2009). The composition of home gardens varies depending on the ecological factors of the region and the cultural background of the communities (Sunwar et al., 2006). Typically, home gardens include a mix of trees, vegetables, fruits, field crops, spices, herbs, and ornamental and medicinal plants (Kumar and Nair, 2004). In a study conducted in Chicago's urban gardens, 123 edible plant taxa from 25 families and 288 ornamental plants were documented (Taylor et al., 2017). In Meghalaya's Garo district, home gardens exhibited high tree diversity (Marak et al., 2023), while three districts in Indonesia showed a greater diversity of fruit plants (Elfrida, 2020). Similarly, a study in Assam, India, found that fruits were dominant in the composition of home gardens (Das & Das, 2015), whereas in Mizoram, India, the gardens had a balanced mix of trees, shrubs, and herbs (Barbhuiya et al., 2016). In Meghalaya, spices and fruit plants from home gardens contribute around 7% of the annual gross income of the War Khasi community (Tynsong & Tiwari, 2010), and the economic impact of home gardens has also been noted in Mon district, Nagaland (Konyak et al., 2022). Home gardening is a common practice in Sikkim, where home gardens typically consist of herbs, medicinal plants, ornamental plants and fruits. These gardens play a vital role in preserving and promoting the cultural diversity of the various ethnic groups in Sikkim, including the Lepcha, Bhutia,and Nepali communities. For instance,plants like Tulsi (*Ocimum tenuiflorum*)and Peepal (*Ficus religiosa*), which hold deep cultural significance for the Nepali community, are frequently found in their home gardens. In addition to cultural diversity, these gardens support rich biological diversity. Jha et al. (2020) documented high avian and mammal diversity in Sikkim's kitchen gardens. Despite their crucial biological and cultural importance, home garden shave not been extensively studied. With much research focused onagro ecosystems and forest ecosystems, home gardens remain under explored. Therefore, further research on home gardens and their diversity could contribute to the management and conservation of their biological richness. Considering the widespread practice of home gardening in Sikkim, we conducted preliminary research on few home garden plots in Namchi district, Sikkim, India, to document their biodiversity. The goal was to understand how even small-scale home gardening can contribute to ecosystem sustainability and support significant biodiversity.

Material and Methods

Study area

The present study was carried out in Gumpa Ghurpisey, located approximately 3 km from Namchi town, within the Namchi-Singhithang constituency of Namchi district, Sikkim. Namchi, situated at 27.17°N and 88.35°E, stands at an elevation of 1,315 meters above sea level. According to the 2011 Indian census, the town has a population of 12,194, with males comprising 52% and females 48%. The region offers a panoramic view of the snow-capped Khangchendzonga range and the expansive Rangit valley, as well as vistas of Darjeeling and Kalimpong, making Namchi a picturesque location nestled among the hills. Gumpa Ghurpisey covers an area of 172 km² and has a total of 329 households, with a population of 1,596. Males make up 51% of the population, while females account for 49% (Census of India, 2011)(https://sikkim.gov.in/DepartmentsMenu/urban-devhousingdepartment/Municipality/namchimunicipal-corporation#).

Data Collection

A survey was carried out in six home gardens in Gumpa Ghurpisey, Namchi, over the course of one month, from April to May 2024. Observations were conducted twice daily, from 6:00 to 8:00 AM and 3:00 to 6:00 PM. During these designated times, the home garden plots were thoroughly examined for biodiversity across various taxa. The species observed during the survey were recorded and photographed for later identification. Species identification was achieved through consultations with experts by uploading the observations to iNaturalist and through personal communication. Table 1 shows the details of the six home gardens where survey was conducted.

Table 1: Details of the study plots and their coordinates

Plot Code	Plot Locality	Cordinates	Plot Area (Approx.)
Plot A	Above Namchi Public School	27° 10 ' 13" N 88° 22' 05" E	200 m2
Plot B	Nadak Gumpa area	27° 10' 22" N 88 ° 22' 18" E	50 m2
Plot C	Phalidara Road	27° 10 ' 31" N 88 ° 22' 24" E	120 m2
Plot D	Above NPS canteen	27 ° 10 ' 27" N 88° 22' 22" E	150 m2
Plot E	Towards Damthang Road	27° 10 ' 16" N 88 ° 22' 15" E	100 m2
Plot F	PHE Compound	27° 10 ' 18" N 88° 22' 23" E	50 m2

Results

Floral Diversity

The majority of the plant grown were ornamental (45%) followed by vegetables (40%), fruits (10%) and medicinal plants (5%) (Fig 1). The commonly grown vegetables include maize, spinach, peas, chilly, potato and pulses. This vegetables grown are used mainly for the household intake.

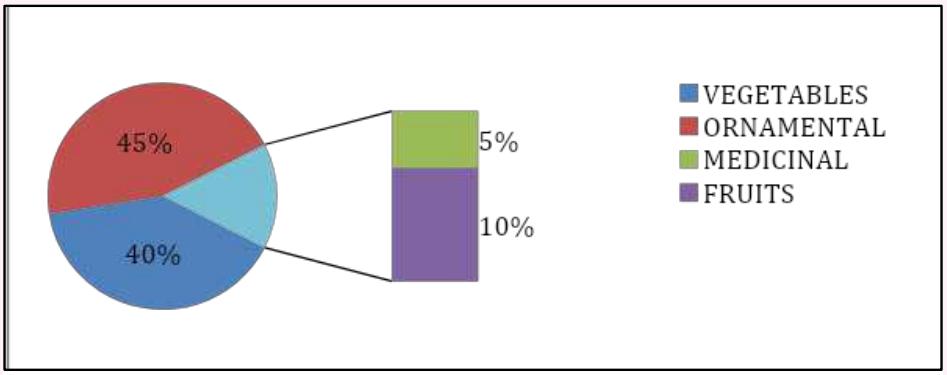

Fig 1 : Floral resources distribution in home Gardens of Upper Ghurpisey, Namchi Sikkim"

Faunal diversity

The study documented a total of 43 faunal species across various taxa. These included two species each from the classes Mammalia and Reptilia, three species from class Arachnida, ten species from the class Aves, and 26 species from the class Insecta (Fig 2). Within the class Insecta, eight species were butterflies, and nine were moths, both belonging to the order Lepidoptera. Additionally, nine species were recorded from the orders Coleoptera, Orthoptera, Neuroptera, and Hemiptera. The mammalian species identified were monkeys and squirrels, while the reptiles recorded were the Oriental Garden Lizard and the Sikkim Ground Skink. Tables 2, 3, 4, 5 and 6 provide the lists of class Aves, butterfly species, moth species, other species from the class Insecta, and species from the class Arachnida, respectively.

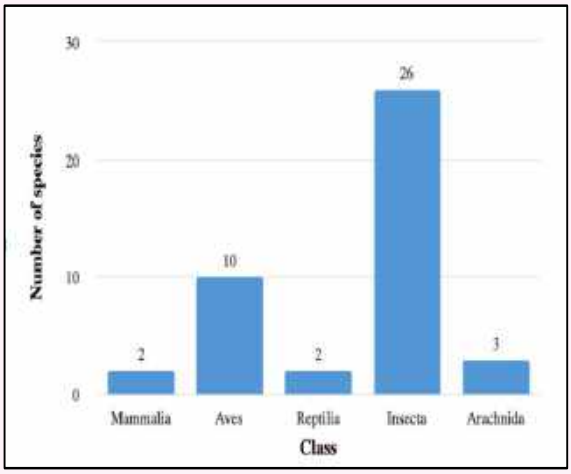

Fig 2:Distribution of faunal resources based on classes in home gardens of Upper Gurpisey, Namchi, Sikkim

Table 2: List of names of species and family of class Aves.

Sl. No.	Common Name	Scientific Name	Family
1	Black Drongo	*Dicrurus macrocercus*	Dicruridae
2	Grey- Winged Blackbird	*Turdus boulboul*	Turdidae
3	Blue Whistling -Thrush	*Myophonus caeruleus*	Muscicapidae
4	Himalayan Bulbul	*Pycnonotus leucogenys*	Pycnonotidae
5	Red-Vented Bulbul	*Pycnonotus cafer*	Pycnonotidae
6	Stripe-Throated Yuhina	*Yuhina gularis*	Zosteropidae
7	Rufous- Breasted Bush Robin	*Tarsiger hyperythrus*	Muscicapidae
8	Verditer Flycatcher	*Eumyias thalassinus*	Muscicapidae
9	Oriental Turtle-Dove	*Streptopelia orientalis*	Columbidae
10	Red- billed Leiothrix	*Leiothrix lutea*	Leiothrichidae

Table 3: List of butterfly species and their respective families under order Lepidoptera of class Insecta.

Sl. No.	Common Name	Scientific Name	Family
1	Green Duke	*Euthalia sahadeva sahadeva*	Nymphalidae
2	Indian Tortoiseshell	*Aglais caschmirenis*	Nymphalidae
3	Red- Spot Jezebel	*Delias descombesi*	Pieridae
4	Indian Cabbage White	*Pieris canidia*	Pieridae
5	Three-Spot Grass Yellow	*Eurema blanda*	Pieridae
6	Lime Blue	*Chilades lajus*	Lycaenidae
7	Rufous- Breasted Bush Robin	*Dodona dipoea*	Riodinidea
8	Paris Peacock	*Papilio paris*	Papilionidae

Table 4: List of moth species and their respective families under order Lepidoptera of class Insecta.

Sl. No.	Common Name	Scientific Name	Family
1	Magpie Moth	*Abraxas martaria*	Geometridae
2	Wavy Velvet Hawkmoth	*Clanis undulosa*	Sphingidae
3	Vestal Tiger-Moth	*Spilosoma vestalis*	Erebidae

Sl. No.	Common Name	Scientific Name	Family
4	-	*Gazalina transversa*	Notodontidae
5	Small Emperor Moth	*Eudia pavonia*	Saturniidae
6	White Spring Moth	*Lomographa vestaliata*	Geometridae
7	Snout Moth	*Endotricha trichophoralis*	Pyralidae
8	Bean Tussock Moth	*Pida patrana*	Pyralidae
9	Aerial Brown Moth	*Ozarba aeria*	Noctuidae

Table 5: List of other species under the class Insecta.

Sl. No.	Common Name	Scientific Name	Family
1	Leaf Mimic Katydid	*Pterophylla camellifolia*	Tettigoniidae
2	Indian Honey Bee	*Apis cerana indica*	Apidae
3	Bumble bee	*Bombus lapidarius*	Apidae
4	Elephant Weevil	*Orthorhinus cylindrirostis*	Curculionidae
5	Green Lacewings	*Chrysoperla sp.*	Chrysopidae
6	Oriental beetle	*Adoretus ictericus*	Scarabaeidae
7	Oil Beetle	*Meleo campanicollis*	Meloidae
8	Indian Cicada	*Cicada sp.*	Cicadoidea
9	Ladybird beetle	*Coccinella quinquepunctata*	Coccinellidae

Table 6: List of Spider and scorpion species and their respective families under class Arachnida

Sl. No.	Common Name	Scientific Name	Family
1	Asian Forest Scorpion	*Heterometrus sp.*	Scorpionida
2	Huntsman Spiders	*Heteropoda sp.*	Sparassidae
3	Comb Footed Spiders	*Chrysso sp.*	Theridiidae

Fig 3: Pictures of home gardens located in the Study Area

Fig 4: (A) Indian Cabbage White (B) Indian Tortoiseshell

(A)

(B)

Fig 5: (A) Indian Ground Skink (B) Indian Honey Bee

(A)

(B)

Discussion

The present study documented diverse faunal and floral resources within the home gardens of Upper Gurpisey, Namchi, Sikkim. Among the floral resources, ornamental plants were the most dominant, followed by vegetables, medicinal plants, and fruits. A similar abundance of ornamental plants in home gardens was observed by Taylor et al. (2017) in urban gardens of Chicago. Rich medicinal plant diversity in home gardens has also been reported in Nepal (Sthapit et al., 2004).

Another Nepal-based study found that vegetable species dominated,followed by food, fodder, and spices. In the Garo Hills of Meghalaya, India, fuelwood was the most prevalent resource, followed by vegetables and fruits (Marak et al., 2023). Cultivation of wild edibles is a common practice in Angami home gardens of Nagaland (Singh and Teron, 2015). In Bangladesh, Bradhan et al. (2012) highlighted home gardens' importance in conserving tree species in fragmented, human-dominated landscapes. Species composition in home gardens often depends on ecological and ethnic factors, but both rural and urban home gardens play a vital role in conserving plant species diversity.

The faunal resources recorded in this study included 43 species: 10 avian species, 26 Insecta, 3 Arachnida, and 2 species each of mammals and reptiles. Similar studies have emphasized the diversity of faunal resources in home gardens. Jha et al. (2020) surveyed 67 home gardens across different altitudinal gradients in Sikkim, noting rich avian and mammalian diversity. Karunaratha et al. (2012) reported 66 butterfly species from five families in home gardens, including three vulnerable, six near-threatened, and one endemic species. Kumar and Sharma (2017) observed traditional home gardens in Assam as suitable feeding and nesting sites for Baya Weaver birds.

Goulart et al. (2011) in Brazil identified home gardens as critical for conserving frugivorous bird species. Subba et al. (2018) highlighted home gardens' role in rearing domesticated animals such as pigs and goats. Singh et al. (2021) compared agri-silviculture systems, home gardens, and tea gardens, finding that animal diversity was highest in home gardens.

Practicing sustainable home gardening fosters ecosystems that support local species, providing habitats for fauna from five different classes. These gardens encourage species evolution with minimal disturbance, balancing trophic levels while offering fresh produce and diverse plant varieties. They attract pollinators such as bees and butterflies, essential for crop pollination and ecosystem health. Using native plants helps preserve local biodiversity, while green spaces reduce the heat island effect. Organic pest control and natural manure are often used, making home gardens eco-friendly.

Furthermore, home gardening raises awareness about biodiversity and ecosystem conservation, deepening individuals' connection to nature. Although the study area covered less than 80 square meters—just 0.1% of Sikkim's 7,096 square kilometers, which includes 2,650 square kilometers of forest—it recorded numerous taxa, with some likely remaining undocumented. This highlights the potential of home gardening to conserve and support biodiversity. By practicing home gardening widely, local species can be preserved, potentially avoiding extinction or inclusion on the IUCN's endangered list.

Home gardening also supports biodiversity conservation, provides healthy food, and offers additional household income, as native crops adapted to the climate are cultivated.

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Decline of Livestock Keeping, Cultural Practices, and Knowledge Systems in the Sikkim Himalaya

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Abstract

In the Sikkim Himalaya, traditional livestock keeping and pastoralism are rapidly declining due to socio-economic, environmental, and cultural challenges. The Dokpa, Lachenpa and Lachungpa community, in high-altitude regions like Lhonak Valley and the Gurudongmar-Tsho-Lhamu plateau, is increasingly abandoning transhumant grazing practices. This shift is driven by changing social values, limited access to modern education and healthcare, and the physical hardships of herding. In 1998, a ban on grazing in subtropical to subalpine regions of East, West and South Sikkim was imposed under the assumption that it would prevent forest degradation and preserve biodiversity. However, the expected balance between forest ecosystem health and regulated grazing as a management strategy was not realized. As a result, younger generations are migrating to urban centers, while older herders face increasing difficulties due to harsh weather conditions, poor market access, and inadequate veterinary services. The expansion of infrastructure (roads, hydropower projects), man-animal conflict, unregulated tourism, and climate change further exacerbate the loss of grazing lands, forests, and biodiversity.

Traditional ecological knowledge related to livestock production, such as indigenous veterinary practices, fodder classification, and cultural rituals like the Udhauli/Ubhauli puja and Goth-Dhup puja, is rapidly disappearing following the grazing ban. These knowledge systems, integral to both biodiversity conservation and herder livelihoods, are at risk of being lost. Despite their critical role in maintaining ecological balance through sustainable grazing practices, a disconnect between conservation goals and pastoral livelihoods hinders effective land management. Collaborative efforts between herders and conservationists are crucial to reconcile these differences and develop sustainable grazing strategies. The decline of traditional herding underscores the urgent need for targeted policy support that recognizes the ecological and socio-cultural importance of high-altitude pastoralism, ensuring the long-term sustainability of both these practices and the biodiversity they sustain.

Keywords: Livestock keeping, traditional knowledge systems

Introduction

Since the time of the *Treta Yuga*, when Lord Krishna was a cattle herder, traditional livestock keeping has been closely tied to access to forest or pasture resources, which were typically managed as community or common property. According to the *Shrimad Bhagavad Mahapurana*, in its 10th Canto, Lord Krishna and his brother Balaram are extensively described as herders in Dwarka. The practice of *Gochar* (village grazing) or *Gaucharan* has ancient roots, dating back thousands of years. In many Hindu temples across India, besides the designated *Gaucharan* (forestland reserved for grazing), there are also grazing areas under the temple's control, known as *Devaban*. Similarly, several monasteries in Sikkim maintain surrounding monastery forests, which are used for both resource extraction and grazing. This practice likely influenced Chogyal Sidkeong Tulku, the Maharaja of Sikkim, to demarcate *Gaucharan* and *Khasmal* forests for community grazing and resource use (Achayra and Sharma 2013).

With the influence of globalization, infrastructural development and with evolving policies, Common property resources in the Himalayas are rapidly declining, resulting in significant impacts on the livelihoods of smallholder livestock keepers, agropastoralists, and nomadic pastoralists (Chettri 2015; Sharma and Chettri). Many are being forced to abandon livestock keeping and seek wage labor in towns, cities, or work as porters in the tourism sector. As a consequence, indigenous livestock breeds—developed and evolved over generations—are facing the risk of extinction or are already on the brink of disappearance. In response to market demands for milk, high-yielding exotic breeds have been introduced to replace traditional livestock, further undermining local breeds.

To address this issue globally, the international community adopted the "Global Plan of Action for Animal Genetic Resources" (GPA) in September 2007, under the guidance of the Food and Agriculture Organization (FAO). The GPA emerged after extensive government discussions dominated by scientists, but civil society organizations emphasized that local livestock breeds cannot be conserved *ex situ*—outside of the production systems in which they evolved. Without integrating these breeds into their traditional environments, their unique adaptive traits would be lost, along with the traditional knowledge systems that sustain them. A crucial group of biodiversity stewards, along with a significant portion of biodiversity, often falls through the cracks of this system: nomadic pastoralists and the livestock breeds they have developed over centuries. Roaming between villages, they are key food producers who do not rely on soil cultivation, while simultaneously conserving and enhancing biodiversity. There are a few studies following the ban on grazing in Sikkim in 1998 focusing on the impact of grazing. Singh et al. (2022) concluded that, rather than displacing pastoral communities, a successful conservation plan should involve integrating local knowledge and institutions to identify pathways for cultural and conservation co-existence in South Asia's pastoral landscapes. This approach must prioritize issues of equality and sustainability.

Luxom et al. (2022), in their study of nomadic pastoralism in North Sikkim, draw on inputs from the Dokpas to offer recommendations for creating a supportive environment that ensures the continuation of traditional herding practices. This is crucial for the survival of pastoralism in the region, which is currently reliant on fewer than two dozen elderly Dokpas. Pastoralism in high-altitude ecosystems in Ladakh has been shown to enhance soil nutrient profiles, particularly in areas where traditional practices, such as temporary settlements and animal resting places, are maintained, whereas areas with declining pastoral practices exhibit a decline in soil fertility (Ladon et al. 2024).

This paper explores the rich traditional livestock production practices and the unique high-low altitude transhumant systems, highlighting the invaluable indigenous knowledge held by herding communities—knowledge that has nearly disappeared following the ban on grazing.


Livestock grazing in the farm-forest agroforestry systems


Discussion with Chogya Pala at Muguthang Trans-Himalaya on the vulnerability of Yak Grazing. He and his companion *Dokpa* are the last to continue herding

The last surviving *Dokpa* at Muguthang practicing nomadic pastoralism

Conservation of Biodiversity and Associated Knowledge

Herders' biodiversity connected ecological knowledge

In a true sense, when livestock are considered a principal component of any farming system whether natural, traditional, modern, or organic biodiversity goes beyond just genetics. The ability of pastoralists and their livestock to thrive in diverse, often challenging environments is not solely determined by genetic factors; it is also deeply rooted in learned behaviors. This learning encompasses not only the mental capacity of animals but also the fundamental functions of their bodies, such as their digestive and immune systems. Learning plays a critical role in biodiversity, as young animals acquire essential knowledge and skills by observing their mothers and other herd members. Over time, this accumulated knowledge enables them to adapt to and survive in varying ecological conditions, making learning an integral part of the broader diversity of life.

Some examples to their best instinct and recapitulative capacity, they know

1. Which plants to eat and in which combinations: Livestock learn from their mothers and herd members which plants are safe to eat and how to combine them for optimal nutrition. This knowledge is passed down over generations, helping animals adapt to local plant varieties and ecosystems.

2.How to negotiate plants' defense mechanisms: Animals also learn how to navigate challenges such as thorny plants, seasonal toxicity, or other defensive traits of plants. Over time, they become skilled at avoiding harmful plants and focusing on those that are safe and nutritious.

3. How to negotiate difficult terrain and manage environmental stress: Livestock learn to manage heat stress, extreme weather, and challenging terrains through experience. They understand the best times to move, where to find shade, and how to avoid areas prone to flooding or extreme temperatures.

4. How to adapt to severe watering regimes: In areas with unpredictable or limited water sources, livestock learn to manage their hydration needs by adapting to the availability of water, whether through grazing on moisture-rich plants or moving to areas where water is more consistently available.

5. How to behave in a herd: Social learning within the herd is crucial for survival. Animals learn how to interact, protect each other, and follow herd dynamics for safety, foraging, and movement. This collective behavior is essential for maintaining order and minimizing risk.

6. How to relate to humans: Livestock also develop learned behaviors in relation to humans, understanding how to respond to commands, human presence, and interaction. For example, during seasonal migrations from lower hills to higher mountains, animals that are familiar with the area can guide the herd to the best grazing grounds, ensuring that others follow established routes to optimal pasture.

The mutual dependence of genetics, environment, and knowledge underscores the importance of maintaining pastoral breeds in site in the locations and production systems where they have evolved. Livestock must be allowed the space to learn, interact, and pass on their acquired skills to other animals in the herd, as well as to their offspring. This process is an essential aspect of breeding in a pastoral system.

In contrast, contemporary approaches to enhancing meat production, such as deep-freezing semen or eggs, can preserve genetics but fail to address the adaptability of animals to changing environmental conditions. More importantly, these methods do nothing to preserve the critical learned behaviors and competence that are integral to survival in specific locations and climates, as seen in regions like the Sikkim Himalaya. For example, the yaks of Tsho-Lhamu-Gurudongmar, Lhonak, or Lhashar Valley are adept at identifying the best grazing areas and returning to their herds by evening. This skill, honed over generations, cannot be preserved or replicated by frozen genetic material. Reconstituting a pastoral breed from such frozen genetics is simply not feasible, as it overlooks the crucial learning and adaptation that defines these breeds' survival and success in their unique environments.

Cultural dimension related to trans-humant grazing

Udhauli/Ubhauli puja

During the grazing season, pastoralists celebrate *uubhauli* (the upward movement of herds) and *uudhauli* (the downward movement of herds) at specific times of the year before relocating their herds. *Udhauli* and *Ubhauli* parva are auspicious festivals, especially among the Kirant ethnic communities. Beyond the movement of herders to the *Lek* and *Auul* grazing grounds, these celebrations are vibrant and lively occasions, intended to commemorate the migration of birds, fish in sacred rivers, and animals to lower altitudes as winter approaches, and to higher altitudes when summer begins.

Uudhauli puja performed at Sang by an ex-herder

Udhauli means "descent", which explains its connection to the down-slope movement of wildlife. This is an indication of the change of season, manifests a variety of information such as the beginning of a new season, time for the movement of livestock, sowing of new crops, indication of a good season, or an indication of diseases and pests etc. The date of *Udhauli* Parva is set on the full moon of the month of *Mangsir* according to Nepali calendar which falls either first or second week of December every year. It generally lands in December on the Gregorian Calendar. During the festival, there is a worshiping of "Mother Earth" called *"Bhumi Puja*", where the different ethnic groups thank the land for the most recent harvest, and for good grasses and fodder for livestock.

The indigenous communities celebrate *Ubhauli* and *Udhauli* puja, which involves the worship of the earth deity responsible for providing food. *Ubhauli* is celebrated before monsoon or beginning of agriculture for well-being and good health of the livestock, family members and good crop production and harvest. Indigenous communities perform rituals such as *Sansari puja* and pray for sufficient rainfall, protection of crops from diseases and pests, and for good harvest. In the past all these festivals was considered as making the movement from low altitudes to higher summer pasture.

Uudhauli symbolizes the beginning of winter when the herds gradually come down to lower altitudes and when harvesting is almost complete. In this ceremony they thank to earth deity for a good harvest and wish for a good harvest next year. During the puja the priest recite the names of the lakes: *Dhenda pokhari, Mechi pokhari, Kali pokhari, Jata pokhari, Sun pokhari, Khechiberi pokhari, Nil pokhari, Saat pokhari, Dalley pokhari, Changu pokhari, Chim-chim pokhari, Seti pokari, Dudh pokhari, Kamal pokhari, Bhaley-dhunga pokhari.* They recite the names of the mountains: *Pathibhara, Chulachuli, Kumbhakarna, Sagarmatha, Khangchendgzonga,* etc. Then they pray to the deities of the mountain that is believed to travel from the mountains to the hills: *Himalma khelny Banraja Ban rani Patley Budeni* for protection against hail-storm, windstorm, thunderstorm, excessive snowfall, erratic rainfall, landslides, etc.

Similarly they recite the names of male and female deities: *Singha Devi, Maharani Thakurani,, Raktakali, Purbakali, Uttarkali, Pacchhimkali, Dakhinkali, Bhadrakali, Ultakali, Bhimsinkali, Bhagawati, Saatbahini, Saatmai, Sansari mai, Sorahsaya mai, Kali-dankini, Budibaju, Pachim-balaji Baba Bairagi, Banraja Banrani, Siddhamarga Jhankri Jhakreni,, Mahakali-bhagawati, , Bhagawati, Bhotey lamalameni, Budibaju, soahar sikari, Budibaju maharani lai namaskar*. They salute all the goddess deities that are believed to reside on rivers, lakes, forests, cliffs, waterfalls, water sources, caves, etc.

The deities of the livestock *Goth* are recited: *GoTh ka Dhani Mahadeu, Maharudra, Ganga-bala-Sarasota, Aindey deuta Kainda barma, Gauri Gosain, Dolakhaka Panch Pandav bal-gopal ko rakchya gara. Bastu bhauko rakchya gara.* "Please protect us, our children, our livestock and our forests, rivers, water bodies and sources, mountains and cliffs, protect us from diseases, and natural calamities."

Then the priest recite the names of the deities that are believed to protect their livestock, and *GoTh, GoThla,* families and the landscape. They are: *Mahadeu Maharudra, Kulthani, Baramasta, Ritthey Jhanri, Bandevi, Maharani Thakurani, Parameswani, Banbasini, Chamkii Budeni, Seti Budeni, Kali Budeni, Patle Budeni, Ekley Budeni, Kuthukey Budeni, Kurley Budeni, Ringatey Budeni, Khachhadey Budeni, Dabrey Budeni, Thumsey Budeni, Jal Budeni, Thal Budeni, Bhutbhutey Budeni, Theuley Budeni, Paggla Budeni, Thelwa Budeni, Bala Budeni, Chamchamey Budeni, Airii Budeni, Bairi Budeni, Auley Budeni, Leki Budeni.*

Now they recite the name of the serpents and snake gods: *Naag-nageni, Dulwa Naag, Chalwa Naag, Amber Naag, Sankar Naag, Seti Naag, Kali Naag, Basuki Naag, Airey Naag, Khairey Naag, Pakha Naag.*

They also recite the names of the rivers of the Himalayas : *Teesta mai, Kokh mai, Jogmai, Kanaka mai, Ramphu Mai, Chota- Rangeet, Bada Rangeet, Ratnam mai, Rangeet Mai, Jog-jogeni, Mom mai, Kamber, Aun-Barun, Kaveri, Dudh kosi, Sunkosi, Tama kosi, Sapta kosi, saat kosi lai namaskar.* They offer many fruits, vegetables, egg, chicken, hen, or sacrifice a male goat to please the deities. This is followed by recitation of the main temples: *Nepal Dekhika Buda Nilakahntha, Bala-nilakantha, Gujeswori, Pashupati, Kamachhe mai lai namaskar. Panch-Pandav Thakur, Dalung saharma utpanna bhayeaka timi Bhimsin lai namaskar.*

Gobardhan puja and worshiping ox

Goru Tihar, or *Govardhan Puja*, is celebrated on the fourth day of *Tihar (Yemapanchak)*, the festival of lights. This day is special due to the famous mythological story behind it. According to the legend, a severe drought once plagued the village of Vrindavan. The villagers, in an attempt to bring rain, worshiped Lord Indra, the God of Rain. However, Lord Krishna persuaded the villagers that it was the Govardhan Hill, not Lord Indra, that provided the rainfall. Angered by Krishna's persuasion, Lord Indra unleashed a torrential downpour, storms, and floods. In response, Lord Krishna lifted the Govardhan Hill with his little finger, providing shelter and protection to the villagers from the severe weather. Since then, people have created small hillocks of *gobar* (cow dung) to symbolize Govardhan Hill, decorating them with flowers and worshiping them in gratitude for the protection.

Another significant aspect of this day is *Goru Tihar*. According to tradition, the *Goru (ox)* is believed to be the messenger of the river goddess *Yamuna*, sent to deliver messages to her brother, Yama, the God of Death. Additionally, the ox is the vehicle of Lord Shiva, represented by the sacred Nandi.

On this day, oxen are worshipped for their essential role in farming, particularly in ploughing fields. It is believed that anyone who ties the sacred thread, known as *Doro*, worn during *Janai Purnima*, around the tail of an ox will be guided to heaven by the ox, crossing the mythical river *Baitarani*. As part of the celebrations, delicious offerings are made to the oxen, honoring their invaluable contribution to agricultural life and prosperity.

Livestock Breed Conservation

Livestock herders and smallholder farmers in Sikkim maintain animal breeds that may not hold immediate commercial value but possess significant potential in the face of evolving environmental and economic conditions. These herders are, in essence, preserving *option values*—the latent value that certain livestock traits may have under future circumstances. Such values are often linked to *survival traits*, such as the ability to resist specific diseases or adapt to harsh environmental conditions. Should these diseases become more prevalent, or if traditional control measures become unsustainable, the traits could become highly valuable. These adaptive characteristics are preserved by allowing animals to live in their natural environments, where they continue to experience natural selection pressures.

At the same time, they are exposed to evolving ecological conditions and emerging diseases, which may further shape their resilience. However, with the growing threat of climate change and unprecedented climatic shifts, this process can have both positive and negative consequences: while animals may develop new adaptive traits in response to changing conditions, some of their traditional *option values* may be lost in the process.

Pastoral livestock breeds often retain unique abilities to defend themselves against predators. For instance, the *Siri cow* and *local Bhainsi* breeds in Sikkim are known for their defensive behavior, using their long, pointed horns to protect their calves from wild animals. These livestock breeds are typically kept in environments where they have evolved, and their continuous exposure to local conditions allows them to retain the adaptive traits necessary for survival in specific climates, terrains (such as stony or swampy ground), and altitudes. When removed from their original environments for extended periods, however, animals may lose these vital survival traits. A similar phenomenon is seen with the North Ronaldsay sheep of the Orkney Islands in Scotland, which have adapted to a diet of seaweed. When transferred to different environments with

The young calves and milking of Semi-domesticated Chauri at Muguthang waiting for the uncertainties and vulnerabilities

alternative food sources, the natural selection pressures that once maintained their unique dietary adaptation may no longer be present, leading to the loss of these traits (Woolliams et al., 2008). Thus, the preservation of traditional livestock breeds in their native habitats is crucial for maintaining their unique adaptive capabilities.

In some cases, traditional livestock keepers continue to keep their breeds despite a lack of economic incentives. They feel a moral obligation, regard their animals as sacred, or believe that the animals provide certain ritual functions that cannot be transferred to exotic animals. Pastoralists and smallholder farmers can provide valuable inputs to breed characterization and inventory. They are often aware of the existence of breeds that have not been identified in national inventories or through breed registration systems. Small-scale livestock keepers live closely with their livestock, and in general have an excellent understanding of their production environments and of breed characteristics, such as behaviour, hardiness and ability to cope with environmental and climatic stresses, production potential, management and feeding requirements, and disease resistance.

They also know the specific traits of individual bloodlines. All this knowledge could greatly assist in advancing breed-development programmes and research on breed comparisons and comprehensive valuation of local breeds.

Indigenous biological knowledge systems of livestock production

Science has yet to fully explore and validate the depth of indigenous biological knowledge systems that have shaped the evolution of livestock genetic resources over time.

These systems, developed through careful breeding of pure lines, have given rise to breeds that are uniquely adapted to a wide range of agroclimatic zones. Over centuries, Sikkim's indigenous livestock breeds—such as *Bastu-GoTha, Chauri-GoThla, Bhedi-GoThla, Bhainsi-GoTha, and Bakhra-GoTha*—have evolved through selective breeding to thrive in diverse environments, from tropical lowlands at 300 m elevation to alpine regions and even the harsh Trans-Himalayan zones at altitudes of up to 5500 masl. Particularly in the case of *GoThala*, these herders and their animals have migrated seasonally, grazing on natural vegetation or crop residues, maintaining a tradition of pastoralism that has been honed over generations.

The untold story of smallholder herders and pastoralists in Sikkim is that their livestock are specialists. These breeds are highly adapted to challenging environments, thriving in conditions that are too harsh for less hardy types—whether in hot, cold, dry, or steep terrains, or even under cliffs. Unlike modern, high-maintenance breeds that require specialized feed, housing, and care, indigenous breeds are well-suited to natural conditions.

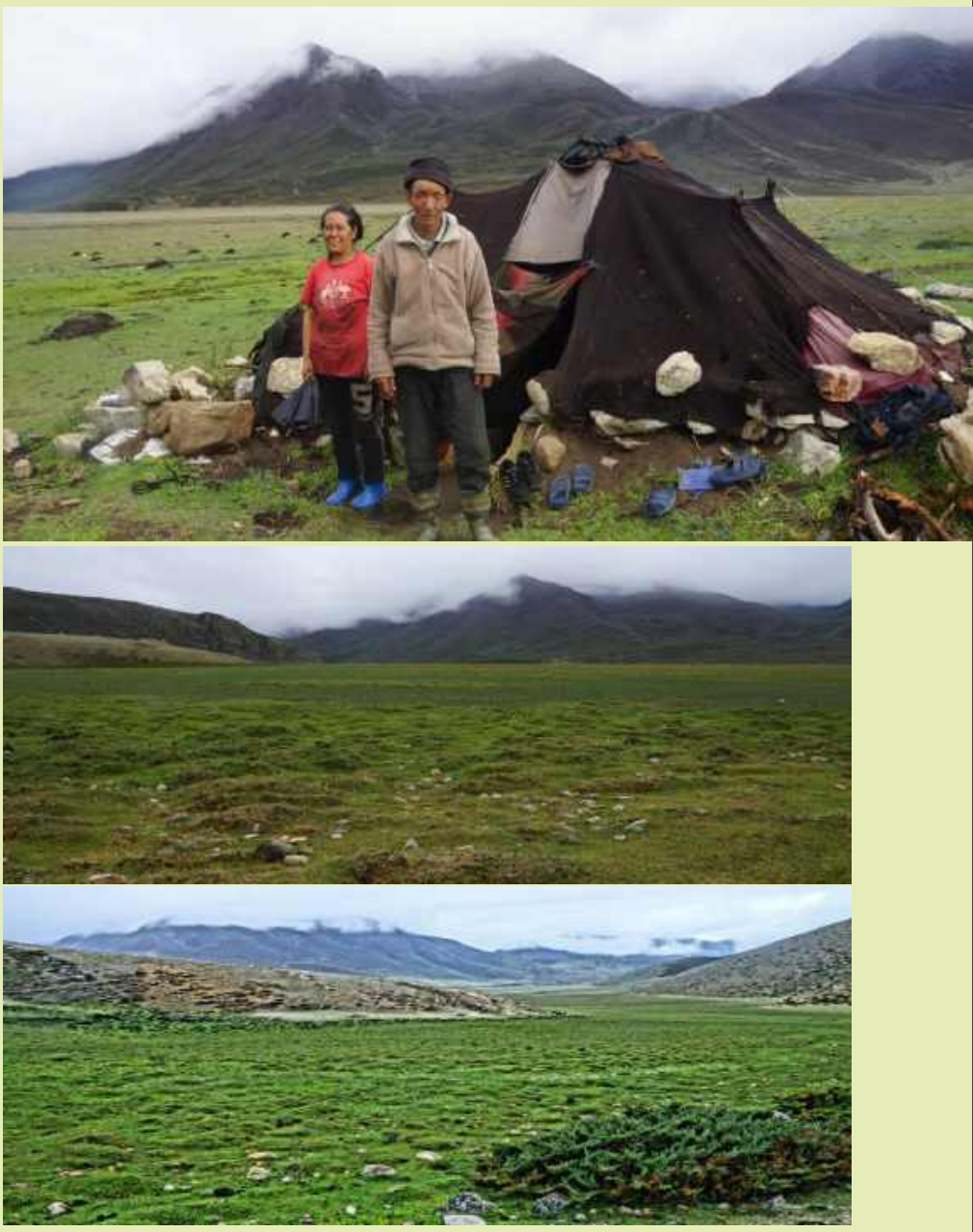
They are also versatile generalists: unlike single-purpose modern breeds, they provide multiple benefits, including milk, manure, meat, wool, hides, and offspring. They also perform vital roles such as pulling ploughs, carrying loads, and serving as a store of wealth.

In this way, they are more than just animals; they are integral to the social and economic fabric of the community, acting as a unifying force and a cornerstone of sustainable livelihoods.

FGDs, walk-and-talk interviews, and key informant interviews with herders and smallholder dairy farmers revealed that pastoralists classify animals first by status (sex, age, and whether pregnant, lactating, or castrated), then by color, pattern, and distinctive features like horn shape. Often, all animals in a herd are named, with females of the same lineage sharing similar names. This detailed knowledge of each animal's genetic relationship allows herders to make informed breeding decisions and avoid inbreeding. Despite the lack of written records, pastoralists, such as the Lachenpa and Dokpa of North Sikkim, and the Gurung and Mangar of West Sikkim, Bahun of Dhanbari East Sikkim, memorize the ancestry of their animals over generations. They also remember specific details like the age at which a cow first calved or when a sire was first used for breeding. In the case of loaned heifers, they track the animal's age, number of calves, and their gender. This oral record-keeping system was lost after the introduction of high-yielding breeds and the ban on forest grazing in Sikkim.

Interestingly, similar knowledge exists in other parts of India. For example, the Malvi camel breed of Madhya Pradesh was identified based on information from *Raika* camel pastoralists (Köhler-Rollefson & Rathore, 1996), and the Banni buffalo in Kutch, Gujarat, is now being officially recognized as a separate breed, with ethno-historical details showing its independent evolution from the Murrah buffalo. In Sikkim, *Bastu-GoTha* pastoralists also maintain biodiversity and animal genetic resources by preserving breeds like *Siri* and *Pahadey* cattle, *Singhari* and *Kalo* goats, and various yak breeds (e.g., Phe-Yak, Lho-Yak, Urang, Dzomo). These breeds possess traits like disease resistance, drought tolerance, and adaptability to extreme climates, which could be valuable for future breeding programs. Essentially, Sikkim's livestock keepers are doing what global seed banks do—they conserve genetic resources for an uncertain future marked by climate change and conflict, with minimal environmental cost.

The knowledge systems of the Dokpa, Lachenpa, Lachungpa, Gurung, Mangar, Limboo, Sherpa, Bhutia, Chettri, and Brahmin, combined with deliberate breeding and management practices, have been crucial in developing highly adaptive livestock breeds. These communities structure their animal genetic resources through social breeding mechanisms, creating semi-closed gene pools. Indigenous knowledge includes identifying individual animals in large herds, maintaining mental pedigrees, traditional classification systems, and preserving breeding institutions like village breeding bulls. Breeding goals are culture- and location-specific, with selection guided by methods like mating control, castration, and removal of undesirable animals. Many livestock keepers also experiment with breeding independently, further enhancing the resilience of their livestock.



The vast free grazing pastures at Muguthang looks without the Yaks. These pastures are left for months for growing grasses, a traditional management of pasture management in a rotational system

This study found that herders possess extensive knowledge of grazing behavior and intentionally modify grazing patterns by slowing, stopping, or redirecting the herd. These modifications aim to increase grazing intensity in less-preferred patches and reduce grazing selectivity in heterogeneous swards. Livestock keepers consciously adapt their animals to new environments and changing conditions. When introducing preferred breeds into new ecological zones, pastoralists may crossbreed them with local males to enhance offspring adaptation to the new environment. Additionally, herders may provide extra care to animals at risk to help them cope with environmental challenges.

Livestock keepers have developed their breeds to thrive under specific conditions, including climate, vegetation, parasites, diseases, and management systems, and to perform certain functions, such as providing food and labor. The survival of these breeds relies heavily on access to grazing land, feed, and water sources. If these resources are restricted—whether through fencing, conversion to cropland, overgrowth, designation as protected areas, or political boundaries—livestock keepers' ability to sustain their breeds diminishes significantly. Therefore, access to grazing land and natural resources is essential for maintaining traditional livestock systems. However, preserving these systems does not mean halting change. In fact, change is necessary to lift livestock keepers out of poverty.

In Nepal, for example, Baruwal sheep and Sinhal goats depend on a traditional transhumant system. Sheep in this mountainous region are used for carrying loads, creating opportunities to combine migratory sheep and goat farming with ecotourism (Ghimire et al. 1998). Similarly, in Peru, stock-raising communities have integrated the use and development of Criollo sheep and other local breeds with efforts to address social and poverty-related challenges (Flores et al. 2007).

Ghanashyam Sharma with Shri Singey Dokpa at his house at Thangu, the only sheep herder in the Gurudongmar-Tsho-Lhamu plateau

Knowledge on indigenous system of medicine

The herders communities before the ban on grazing, when living in the GoTh in the forest areas had a practice of collection of a large number of medicinal plants (30-45 species) for curing common ailments to humans and also to their cattle. The animal and human health care services were not accessible to them and thus they were dependent on the traditional knowledge system on indigenous system of medicine. As a result of ban on grazing, the collection of medicinal herbs for various ailments could not continue and eventually the knowledge related to their use pattern declined drastically.

Bhakmilo (*Rhus chinensis*) processing for making *Bhakmilo-chuk*

Mel (*Docynia indica*) washed for making *mel-chuk*

Traditional healers and healing system

Interviews and observations revealed that traditional systems of medicine are actively practiced within herders' families in rural areas. The most commonly harvested medicinal plants include *Nardostachys grandiflora*, *Picrorhiza kurroa*, *Juniperus prostata*, *Podophyllum hexandrum*, *Rhododendron setosum*, *R. nivale*, as well as wild edible plants such as nettles, wild onion, ground orchids, edible lichens, fungi (*Agaricus* spp.), edible ferns, and various species like *Gentiana*, *Aconitum*, *Meconopsis*, *Ephedra*, and more. Plants with religious significance, like *Juniperus* and *Rhododendron setosum*, are also commonly used.

In the Lachen Valley, including the Thangu and Lhonak areas, the collection of medicinal and aromatic plants (MAPs) and other non-timber forest products (NTFPs) is largely regulated and controlled by the Lachen Dzumsa. The most important medicinal plants collected in this region include *Ophiocordyceps sinensis*, *Nardostachys grandiflora*, *Podophyllum hexandrum*, *Rhododendron setosum*, *R. nivale*, *R. decipense*, *Picrorhiza kurroa*, and *Juniperus prostata* (Table 1). Similarly, in the Lachung, Yumthang, Yumesamdong, and Zema areas, while similar species of MAPs and NTFPs are collected, they are regulated by the Lachung Dzumsa.

Table 1 Collection of NTFPs /MAPS in the project sites.

Important areas	Species Collected	Collection sites
Trans Himalaya region		
Gurudongmar-Tso-Lhamu Plateau, Lhonak Valley, Lashar Valley	Mushroom, Nettle, Wild Spinach, wild onion, *Saussurea gossypiphora, Aconitum ferox, A. heterophylla*, *Rhododendron anthopogon, Meconopsis* sp. *R. desipiens, Juniperus recurva., Nardostachys* sp., *Picrorhiza* sp., *Cordyceps sinensis., Ephedra gerardiana, Rheum nobile, Swertia multicaulis* *Rhodiola himalensis* *Podophyllum hexandrum*	Tso-Lhamu, Gurudongmar, Donkung, Giagong, Cetung, Gowa, Gochung, Yangdi, Chuma, Lechen Chopta, Thumphoo, Taling, Chuma, Gochung, Gowa, Giagong, Cetung, Shugu, Lazey-Lazung, Donkung, Gyaou, Phoge, Khangzung, Lechen, Muguthang, Naku, Pasi, Silling, Dolmasampa, Theula
Alpine region		
Yumthang-Yumesamdong, Dongkila, Thengu-Byamzey	Wild spinach, *Cordyceps sinensis*, Mushroom *(Agaricus sp.)*, Nettle (*Urtica sp.*), Wild onion, fern shoot *Orchis latifolia, Picrorhiza* sp., *Swertia multicaulis* *Rhodiola himalensis, Panex pseudogensing,* *Podophyllum hexandrum Berginia ciliata, Nardostachys jatamansi, Aconitum* sp, *Artemisia vulgaris, Abies densa, Juniperus recurva, Cardamine macroflora, Arisaema griffithii*	Jelep La, Nathula, Rabdong, Kupup, Gnathang, Laxman Chowk, Senebelly, Tholung, Green Lake, above Yumthang, Yumesamdong, Kupup, Gnathang, Thegu, Laxmanchowk, Chokechowk, Lungthung, Phadamchen, Rabdong, Firing Dara, Menmoi cho area, Yakla
Sub-alpine region		
Lachen, Lachung, Kyongnosla, Yambong	Seabuckthon (*Hippophae* sp.), Mushroom (*Agaricus* spp.), Nettle (*Urtica* spp.), wild onion, *Heracleum wallichii, Juniperus* spp., *Rhododendron* spp., *Orchis latifolia, Picrorhiza* sp., *Aconitum* spp., *Nardostachys jatamansi, Swertia chirata, Rheum australe, Berginia ciliata, Dactylorhiza hatagirea*	Zema, Lachen village, Lachung valley, Kyongnosla, Yambong, Naya patal, Chittrey, Khedi Chopta Valley, Byamzay, Samdong, Katao

Important areas	Species Collected	Collection sites
Temperate region		
Labdang, Pokhri-Narkhola, Yuksom, Sindrangpong	Fern shoots, *Agaricus* spp., Bamboo shoots, Nettle (*Urtica* spp.) , wild onion, *Ophiocordyceps sinensis*, Resin, Tamarkay, *Arisaema speciosum*, *Iris* sp. *Dioscorea deltiodes, Heracleum wallichii*, Majhito *(Rubia manjith)*, Pipla, *Swertia chirata, Juniperus* spp*., Rhododendron thomsonii, R. setosum, R. anthopogon, Orchis latifolia, Edgeworthia gardneri, Picrorhiza* sp*., Aconitum* spp*., Nardostachys* sp*., Swertia chirata, Rheum australe, Berginia cilata, Taxus wallichiana, Dactylorhiza hatagirea, Heracleum wallichii, Astilbe rivularis, Rubia manjith,* Hudchur, Khokim	Sindrabong, Chunzom, Chongri village, Gnom, Yuksom-Khyongtey, Tsong, Hungry, Dubdi, Labdang village and periphery, Pokhri-Narkhola, Lachen, Zema, Lachung valley Sindrabong village, Chongri, Yambong, Labdang, Pokhri-Narkhola, Onglathang, Jor-Pokhri, Lampokhri, Yuksam-Khyongtey

Aiselu (*Rubus ellipticus*) in Lachung

Achuk (*Hippophae salicifolia*) in Lachen Valley

Knowledge of food supplements

In addition to crops cultivated on local farms, a large number of wild plants are also used to prepare traditional food items. Some of the plants used are nettle (*Girardinia diversifolia*), 'chinday' (*Pentapanax leschnaultii yam*, *Dioscorea alata*), 'koiralo' *(Bauhinia variegata)*, 'halhalay' *(Rumex nepalensis)*, 'kabra' (*Ficus virens*), 'kanney cheu' (*Pleurotus sajor-caju*), 'kukurdainu' (*Smilex zeylanica*), 'laharay timbur' (*Zanthoxylum oxyphyllum*), 'lapsi' (*Choerospondias axillaries*), 'nakima' (*Tupistra nutans*), 'patle sishnu' (*Urtica parviflora*), 'shimrayo' (*Nasturtium officinale*), 'sauney ningro' (*Diplazium maximum*), 'sil timbur' (*Litsaea citrata*), and 'tite ningro' (*Diplazium laxifrons*) (Sharma et al. 2016). The ethnic communities of Sikkim prepare a number of fermented and non-fermented foods including as many as 15 different local instant pickles depending upon the season.

Sawney niguro (*Diplanzium maximum*)

Lekh-ko-kalo chipley/Titey niguro (*Diplazium dilatatum*)

Sikkim has a huge diversity of mushrooms many of which are edible, while a large number of species are non-edible and some are poisonous. Das (2009) has reported as many as 120 species of mushroom from the Barsay Rhododendron Sanctuary and adjoining areas of Khangchendzonga National Park. Of the total, 39 species are edible, 65 are non-edible and 16 are poisonous. The mushrooms have immeasurable economic importance mainly for marginal herders families while economic evaluation, technology for domesticating these mushrooms and value addition such as drying and packaging is lacking.

Two very important products, *kinema* and *maseura* are the most important fermented vegetables. *Dahi*, *mohi*, *gheu*, *chhurpi* (hard), *chhurpi* (soft), *chhu*, *somar,* and *philu* are fermented milk-products. *Sukako maacha*, *gnuchi*, *sidra* and *sukuti* are fermented fish products. *Marcha*, *kado-ko-jaand* or *chyang*, *bhaati jaand*, and *raksi* are the alcoholic beverages. *Dhendo*, *phulaurah*, *momo*, *thukpa* or *gyathuk*, *pakku*, *kodo-ko-roti*, *phapar-ko-roti*, *chambery*, *achar*, *su zom*, *pongu-zom*, *khu-zom*, *wachipa*, *alum*, *foldong*, *falki*, *chhwelaa*, *kwanti*, *chatamari*, and edible ferns, are some of the traditional non-fermented foods of Sikkim which are part of the daily food of the indigenous communities

Knowledge of curd churning (*Moi parnu*) in traditional system

The churning of curd (*Moi-parnu*) is a vital aspect of daily life and holds cultural and identity significance for smallholder livestock keepers, herders, and pastoralist families. This process involves separating butter from curd, which has been fermented in a *pham* (a cylindrical wooden vessel), through centrifugation using a series of traditional devices.

One of the primary tools used in this process is the *Theki*, a large wooden pot used to churn curd into butter and buttermilk. The *Theki* is cylindrical in shape, with a narrow neck and a flared, fan-like mouth (*Theki-ko-chhato*). It is typically made from durable woods such as *Daar* (*Boehmeria rugulosa*), *Khamari* (*Gmelina arborea*), *Koiralo* (*Bauhinia variegata*), *Badar* (*Artocarpus lakoocha*), or *Katahar* (*Artocarpus heterophyllus*), which are also used in the fermentation of milk. Most herders use the *Theki* to ferment milk into *dahi* (curd).

Another crucial tool in the churning process is the *Madani*, which works in conjunction with a *Saro* (a long, cylindrical wooden structure). The *Saro* serves as the base where the *Madani* is inserted. The *Madani* is made of several parts: a long cylindrical shaft about 4.5 inches in diameter and approximately one meter long, with four *Pora* (blades) attached to one end. The *Madani* is crafted from woods like *Bajranth* (*Quercus lamellosa*) or *Katus* (*Castanopsis indica*). The *Pora*, also made from the same type of wood as the *Saro*, features four blunt, blade-like structures that are used to whirl the curd, effectively functioning as a traditional centrifuge. This method, while simple, is highly effective in separating butter from curd.

Moi-pareko (curd churning) through traditional methods

Ghiu jhike-ko, manual extraction of butter from *Moi* (butter milk)

Wooden utensils (*Theki Madani Pangro Pham* etc) used by herders

The *Neti* is a rope wound around the *Saro*, with two free ends made from small cylindrical wooden pieces called Koila, which are used to hold the rope and move it to and fro by hand. The *Neti* is traditionally made from the fiber of Oodal-ko-paat *(Sterculia villosa)* or a grass-like plant, *Babiyo (Eulaliopsis binata).*

Ghurro is a flat structure with a hole at one end to hold the *Saro* of the *Madani* in place. At the other end, a rope is tied to secure it to a supporting structure. While *Ghurro* can be made from various types of wood, *Falat* and *Katus* are considered the best choices for durability and functionality.

Once the *Madani* is inserted into the *Theki* containing the curd, the *Neti* is moved back and forth to rotate the *Madani,* which churns the curd. Over several days, the accumulated curd in the *Theki* is churned to separate the butter. To ensure smooth and efficient churning, the *Madani* is held in place by the *Ghurro,* while the *Neti* continues to rotate it inside the *Theki.*

The process can be speed up by adding hot water at the midpoint, which helps in separating the butter. However, care must be taken with the timing and quantity of water added, as excess hot water later in the process may reduce the butter yield. Proper control of these variables ensures the efficient separation of butter from the curd.

Theki, Madani, Pham, neti, Koila, Ghiu etc. related to *Moi Parnu*

The completion of the butter churning process is indicated by moving the *Pora* around the surface of the churned liquid, where the butter separates from the buttermilk and begins to accumulate around the *Madani*. This process typically takes about 20-25 minutes. Once the butter has fully separated, it is carefully removed and collected, while the remaining buttermilk is gathered in a *Dhungro* or any other wooden vessel/container. Butter churning is usually done early in the morning and can be carried out by both men and women, depending on their availability. After the butter is extracted, it is boiled (*ghiu kharnu*) to refine it, resulting in clarified butter, which is used in traditional dishes or eaten with rice by the indigenous communities. Buttermilk plays a crucial role in the diet of the herder's family, as it is an essential part of their daily food menu. Family members often drink buttermilk instead of water, valuing its nutritional and hydrating properties.

Traditional practice of after harvest paddy processing

Cattle have historically been a vital source of power in integrated traditional farming systems. However, with the decline in the population of oxen, farmers are facing significant constraints in continuing their agricultural practices. Indigenous oxen, such as the Siri cattle, have long been used for all agricultural operations, as well as post-harvest processing. One such activity is *Daain* post-harvest processing of paddy.

In the *Dain* process, oxen are tied in a line around a central post (*May*) with a *Damlo* (rope), arranged according to their size, with the largest ox placed closest to the post. The oxen are then chased to move in a circular pattern, typically with children tasked to guide them. Meanwhile, *Danyeerey* (laborers) thrash bundles of paddy by beating them on the ground, while *Paral* (hay) is spread around the *May*.

Once the thrashing is complete, the oxen are released, and the *Paral* is reshuffled using an *Akhaney* (a bamboo rod with a hook on one end) before being stored on a *Machh*, a bamboo structure located near the cattle shed. The *Paral* is stored for future use, especially during times of fodder scarcity. Afterward, the *Danyeerey* collect the grains and spread them around the May using a *Nanglo* (winnowing fan) in a specific technique to ensure even distribution. Other laborers perform *Dhan-Bataunu*, fanning the grains to separate the husk by moving around the May.

Once the winnowing is complete, the paddy is collected into *Murey-bora* (jute sacks that hold approx. 50 kg) and counted by the number of *Muri* (20 pathi, with 1 *pathi*=2.5 kg). Households with the highest number of *Muri* are considered *Dhani* (wealthy) families. The final product is stored in a *Dhikuti* (a large wooden container), *Bhakari* (a cylindrical basket made from bamboo splits), or *Kotho* (a large bamboo basket). These containers are coated with cow dung both inside and out. To protect the grains, they are first covered with leaves of *Simali* (*Vitex negundo*), followed by a layer of ash. Finally, the opening is sealed with a plaster of cow dung to prevent pest infestations, significantly reducing the risk of damage.

The paddy is used based on a *Sanchita* system, carefully managed to account for "critical moments," festivals, rituals, and the arrival of guests. Herder families also use the term *Joho*, referring to the practice of securing grain for difficult situations, thereby ensuring food security by storing a variety of crops for unforeseen periods.

Traditional *Dain gareko* for separating the paddy from the hay; this practice is almost gone due to unavailability of oxen in the villages

Knowledge of herders households on fermented/Non-fermented products

The herders of Sikkim, while staying in the *GoTh* (cattle sheds) within the forests, have traditionally prepared a wide variety of naturally fermented milk products. These include *dahi, mohi, gheu, soft-chhurpi, hard-chhurpi, dudh-chhurpi, chhu, somar, maa, philu, and shyow* (Rai et al. 2017).

To prepare *dahi*, herders use wooden vessels and the milk of cows, buffalo, or yaks, which is boiled for 15-30 minutes using dried hardwood as fuel. In the Bhutia and Lepcha communities, *philu* is a cream-like fermented product made by pouring fresh milk into a wooden vessel, where a mesh of dried creepers or sticks is placed inside. The milk is poured into the vessel 2-3 times a day and kept for 6-7 days, though some families may ferment it for up to 15 days.

Herders also process *mohi* into *soft-chhurpi* and *hard-chhurpi,* which they sell in weekly markets. To make soft-chhurpi (*or chhu or sheden*), *mohi* is boiled for about 15-20 minutes until it separates. The mixture is then cooled to room temperature and filtered through a *chalni* (local sieve) until the water drains out. The solid residue is the *soft-chhurpi,* while the drained liquid is called *chena.* Some herders further process *chhurpi* by storing it in airtight containers for 15-20 days to make *somar.*

Another important dairy product is *Bigauti*, prepared immediately after a cow, buffalo, or yak has calved. The milk fed to the newborn calf is separated, and the remaining milk is boiled until it thickens, creating *Bigauti.* In Sanatana Dharma culture, the milk of a cow is not fermented until 21 days after calving, as the cow is considered "polluted" until then. Today, however, herders purify cows or bhainsi on the seventh day after calving. The morning milk is boiled to make *Bigauti,* wrapped in a leaf of the *Dudh-aauney-brikshya* (sap-giving tree), and offered to the deities in a ritual known as *Saatpokey.* After this purification process, the milk is considered fit for consumption and is offered to the household deity.

Another popular product is *Kurauni,* made by boiling the milk of indigenous cows or buffaloes for an extended period until it becomes semi-solid. *Kurauni* is a highly prized dish, often presented to respected family members during festivals as part of a *Koseli* (cultural gift).

When herders kept large numbers of cattle in the forests, they prepared numerous fermented and non-fermented products. The diverse ethnic communities of Sikkim consume a wide range of traditional foods. Major fermented foods and beverages include *Khalpi, Masyaura, Fulaura, Selroti, Kinema, Gundruk, Sinki, Mesu, Chhurpi, Dahi, Mohi, Ghiu, Jandh,* and *Rakshi.* Non-fermented foods include *Chiura* (flattened rice), *Makai-ko-roti* (corn bread), *Makai-ko-dhindo* (corn porridge), *Phapar-ko-roti* (millet bread), *Kodo-ko-roti* (finger millet bread), *Bhuteko-makai-mulako-saag* (corn and mustard leaf curry), *Bhatmas* (roasted soybeans), *Khir* (sweet rice pudding), *Dhakane* (a type of dough), *Puwa, Chamrey, Kasaar, Khoa, Chook, Chiuri ghiu* (ghee), and *Amilo* (fermented millet dish).

Common beans are utilized in various ways, such as in split and whole forms for *dal*, as dry beans, or as green pod vegetables. Bean flour is used to make *roti* (bread), *dhindo* (thick porridge), and *Khichari* (a dish of rice and beans cooked together). The beans also serve as folk medicine for treating ailments like diarrhea, dropsy, dysentery, diabetes, and kidney problems.

Knowledge of local cattle to identify preferred species

The indigenous small holder livestock keepersand herders/pastoralists have categorized the fodder on the basis of defined purposes (Table 2).

Obano ghans *(Warm fodder)*

Those palatable plant species are generally feed in moist and cold season, so that cattle will not suffer from cold e.g. *F. semicordata*, *F. subincia, G. optiva, Bambusa* and *Dendrocalamus hamiltonii*, *Cyperus species*, *Ascendra butyracea*, *Bauhina purpurea*, *B. variegata*, *Thysanolaena maxima*, *Eulaliopsis binata*, *Gmelina arborea*, *Callicarpa arborea*, *Castanopsis indica*, *C. hystrix*, *C. purpurella*, *Mallotus philippinensis*, *Quercus lamellosa*, *Capioedium assimile*, *Albizia lebbeck*, *Imperata cylindrica*, *Arundinaria maling*, *Bambusa nutans*, *Yushinia maling*, *Arudinaria hookeriana*, *Dendrocalamus sikkimensis*, *Bridelia retusa*, etc.

Cheeso ghans *(Cold fodder)*

Young tender parts of palatable plant species, consumed by cattle but not preferred by farmers for cattle feeding because those fodder cause loose stool disease to livestock e.g. *Litsea monopetala*, *Garuga pinata*, *Erythrina arborescens*, *Albizia microphylla*, *Musa paradisica*, *Nasturtium officinale*, *Polygonum viviparum*, *Toona ciliata*, *Viola biflora*, or tender maize saplings, etc.

Posilo ghans *(highly nutritious fodder)*

Quality and quantity of milk per cattle increases after feeding such plants e.g. *Premna latifolia*, *F. nemoralis*, *F. auriculata*, *F. benjamina*, *F. glomerata*, *F. hookeri*, *F. infectoria*, *Launaea aspleniifolia*, *Artocarpus lakoocha*, *Grewia optiva*, *Cynodon dactylon*, *Vicia angustifolia*, *Artocarpus heterophylla*, *A. lakoocha*, *Saurana nepaulensis*, *Celtia tetranda*, *Cissus adnata*, *Morus indica*, *Oplismenus compositus*, *Pathenocissus himalayana*, *Ficus nemoralis*, *Pennisetum purpureum*, *Eragrostis tenella*, *Cyanotis cristata*, *Digitaria ciliaris*, *Rapidophora* sp., *Dendrocalamus hamiltonii*, *Prunus napaulensis*, etc. Herders believe that these fodder increase fat in milk of lactating animals.

Beekhalo Ghans *(Poisonous fodder)*

Some fodders are poisonous in large dose or when fed new flush of leaves and buds e.g. *Lyinoa ovalifolia* can be fatal in young stage; Osyris wightiana and Neolistia cuipala could be fatal in large doses. *Albizia chinensis*, *Hedychium spicatum*, *Rhododendron barbatum*, *Lyinoa ovalifolia*, *Ostodes paniculatus*, rhizome of *Arisema* spp., seeds of *Gynocardia odorata*, *Albizzia odoratissima*, *Melastoma malabaricum*, *Manihot esculenta*, and *Prunus cerasoides* may cause serious problem in some conditions.

According to habit, herders have categorized fodder into two:

I. Daale ghans (Tree fodder), and

ii. Bhuin ghans (Herbaceous fodder)

Herders and farmers of the Sikkim Himalaya classify trees grown in cropping land into *Rukho* (unfertile) as they can thrive in water/fertility stress conditions, and *Malilo* (fertile) for positively affecting species on the succeeding crop. *Alnus nepalensis*, *Albizia spp.*, Sesbania sp., *Trifolium sp.,* annual legumes are commonly used as green manuring species. Based on the nature of the farmland herder family plant socio-ecologically suitable species.

Table 2 Local names related to fodder.

Feeds	Description and use in different times of seasons
Dhan-ko-paral	Hey of paddy
Kodo-ko-Naruwa	Crop residue of finger-millet
Daaley-Ghans	Tree fodder
Bhui-Ghans	Grass fodder
Dudhilo-Ghans	Nutritious grass that increase milk production
Posilo-Ghans	Nutritious grass that improve the health of cattle
Dudh-Pagarney-Ghans	Fodder that immediately increase milk production

Knowledge on use of cow dung/urine

Under the traditional farming system, livestock dung plays a crucial role as a plant nutrient and is extensively utilized by herders. Apart from being used as manure, dung also serves as an Ayurvedic medicine and biological pesticide. In Sikkim, herder families use dung for various purposes, such as pasting houses, threshing floors, and the bamboo or straw mats of cylindrical grain storage structures known as *Bhakari.* This practice not only strengthens the *Bhakari* but also makes it more durable, as dung acts as a natural disinfectant. Additionally, strings of *Bhakari, Kotho,* or wooden *Dhikuti* (grain containers) are pasted with dung before storing grains, and a heap of dung is placed on top of the container to seal it air-tight. This method helps minimize grain infestation, as cow dung acts as an insect and pest repellent. Cow dung and urine are also employed as natural pesticides in organic farming to control pests and insects in horticultural crops.

In Sikkim, herders and smallholder livestock keepers use cow urine as a low-cost agricultural manure. Since the Vedic period, cow urine has been used extensively in traditional Indian agriculture for both medicinal and agricultural purposes. Among organic fertilizers, cow urine is considered a rich source of nitrogen, as well as containing essential nutrients like sulfur, phosphorus, potassium, sodium, manganese, carbolic acid, iron, silicon, chlorine, salt, enzymes, and hormones. Farmers use cow urine to boost the productivity of horticultural crops, such as mandarin oranges, as well as to promote the growth of various vegetables.

Traditional artifacts and craftsmanship of the herders

Traditional herders and pastoralists had deep knowledge of making artifacts and crafts made up of bamboo, cane, wood, and fibres. Bamboo and cane baskets *(Doko, Tokri, Thunsey, Dalo, Bhakari, Kotho, Mandro, Nanglo, Chalni, Bhuney, Deli, Petaro, etc.)*, ropes *(Namlo, Damlo, Neti, Bariyo, Jhikwa-damlo, Latthha, Choya, etc.)*, wooden containers *(Theki, Pham, Tolung, Madani, Guptey, Harpee, Bhutuney, Gariyo, Aari, Halo, Dhudhero, Dhungro, Juwa, Harish, Nidal etc.),* bamboo containers *(Dhungro, Dhiri, Dudhero, etc.).*

Leaves used as fodder; *Chitro, Bhakari,* mat used as roof cover; *Damlo,* rope made from a bamboo culm to tie livestock, *Choya,* bamboo splits used to tie fence, roof etc.; *Doko, Dalo, Deli, Thunsey, Tokri, Bhuney etc.*, baskets used to carry fuelwood, crops, fodder, store grains etc.; floor-mat; *Bar-barnu,* fencing to protect farms, gardens; *katera,* a shelter for livestock, *Egra-ko-ghar,* used in the construction of a traditional house; *Dhaja-uthaunu,* supporting pole for a Buddhist prayer flags; bamboo scaffolding; *Thangro,* support to creeper crops/vegetables; *Tama,* young shoots used as vegetable, etc. Knowledge of making *Radi* (large size woollen mat), *Asani* (small size woollen mat), *Lukuni* (woollen coat) out of sheep wool has almost disappeared after the grazing ban. This was one of prominent cash earning source to the sheep herding families. Similarly, Yak hair is also used to make large size ropes, or tents. With the changing time the knowledge of utilizing such resources have disappeared.

There is a need to examine this aspect since livestock play an important role in the household economy of rural farmers. Efforts should focus on development/ extension in improving the marketing prospects of livestock production to allow farmers to derive more income from livestock products, and maintenance of the depleting agricultural ecosystems. This will enhance to fulfil the purpose of Sikkim Organic Mission of the Government of Sikkim.

An ex-herder of MWLS, Shri Rup Narayan Dhakal, showing up his bamboo-made traditional containers

The transhumant herder during the time of grazing used local terminologies which was the basis to transfer the knowledge of herding to the upcoming herders (Table 3, 4). This knowledge was associated to grazing, pasture management, economic activities, day-to-day activities, livestock based product development, livestock production system, forest management, and management of integrated farming system.

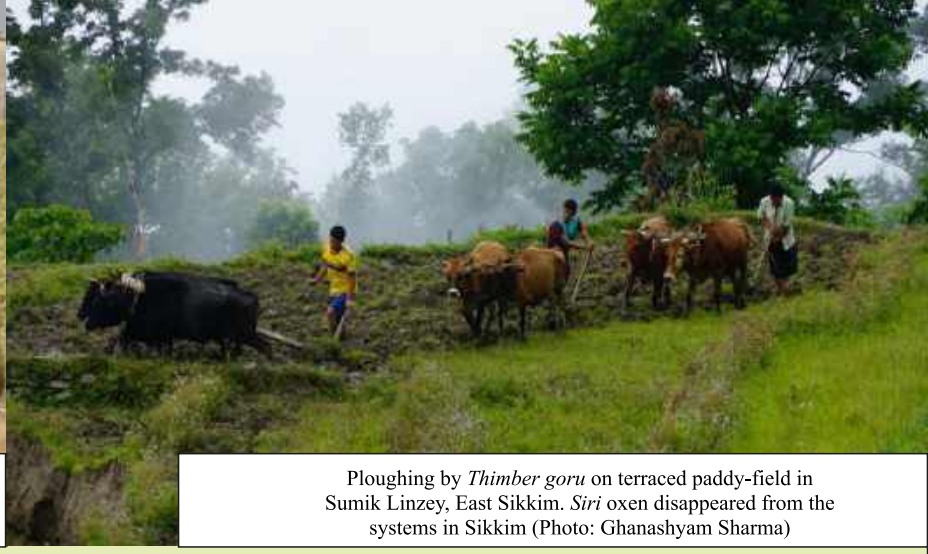
Changing policies, influence of globalization in the name of economic prosperity, and changing socio-economic dynamics have devalued herding system. It has driven all the youth away from herding which has emerged as another important factor shaping the future of herding in the region. As the youths are increasingly connected to the outside world away from the region. As a result of policy change the knowledge related to mountain integrated farming, and management of socio-cultural landscape has been transforming with time.

Table 3 Terminologies used by the herders related to grazing until grazing in the forest was prevalent.

Sl. No.	Livestock sheds	Explanation
1	*Gai-GoTh*	Herds of cow, bull, oxen, calves, and also includes the cowshed
2	*Bhaisi-Goth*	Herds of buffalo, bull, oxen, calves, and also includes the cowshed
3	*Bhedi-Goth*	Herds of sheep, male/female, lambs, and also includes the shelter-shed
4	*Chauri-GoTh*	Herds of cow, bull, oxen, calves, and also includes the the stone enclosure where they rest in the night
5	*Bakhara-GoTh*	Herds of goat, male/female sheep, lambs and also includes the goat-barn or shed together
6	*Goth-GoTh*	Livestock enclosure in pastures some distance from homestead; livestock shed
7	*GoThala*	Herder/shepherd/pastoralist

Sl. No.	Livestock sheds	Explanation
8	*Gai GoThla*	Cow grazers, Cow keepers
9	*Bhainsi GoThala*	Buffalo grazers, Buffalo keeper
10	*Bhedi GoThla*	Sheep grazers, sheep keepers
11	*Chaunri Gai GoThala*	Yak herders
12	*Bakhra GoThala Goat*	herders, goat keepers
13	*Bakhra-ko-Bagal*	A herd of goats
14	*Gai-GoTh*	A herd of cattle
15	*Bhainsi-GoTh*	A herd of Buffalo
16	*Bhedi-GoTh*	A herd of sheep
17	*Chauri GoTh*	A herd of yak
18	*Bathan*	A large number of livestock
19	*Tagaro*	A bamboo mat used as a door in the cattle enclosures
20	*Bhakari*	Large size bamboo mats made up of splits of Yushinia maling or other bamboos species used for roofing the GoTh, or a temporary cattle shed
21	*Khuttey-launu*	Tie one of the back foot of a cow while milking
22	*Paat-ko-Damlo*	A rope made up of fibres of Sterculia fulgens, S. villosa used to tie cattle
23	*Choyako-Damlo*	A rope made up of bamboo splits used to tie cattle
24	*Bet-ko-dalo*	A finely woven basket made up of Calamus split
25	*Yakal*	A wooden frame for loading at the back of a horse or a yak
26	*Thakpa-dori*	A large size long rope
27	*Bari*	An un-irrigated sloping agricultural land
28	*Khet*	Terraced irrigated paddy field
29	*Khetala*	farm labour; working on others' fields for payment or as labour exchange
30	*Bachi-dan*	donation, reward, gift or free to a priest
31	*Gai-dan*	Cow donation, reward, gift or offer to a priest free of cost to revive sin or please the god before a puja, or at the time of death rituals
32	*Gau puja (Lakshmi-puja)*	Cow is revered as a mother or goddess Lakshmi and is worshipped on the Amawashya (no-moon) day of Kartik month of lunar calendar
33	*Goru-puja/ Hali-Tihar*	Goru (Ox) puja is performed by all the Hindu household. Ox are important animals for farmers as they are used for the purpose of agriculture.
34	*Gobardhan puja*	Herders community construct a mountain of cow-dung on a conical shape that represent the Gobardhan Parvat (mountain with auspicious natural wealth).
35	*Perma*	A cashless system of labour exchange between an informal group of house holds in farm activities
36	*Pewa*	a saving of money by a member of a family, or owing a cow, goat, sheep, chicken. Freedom is given to the member to utilize the resource at his/her interest
37	*Daijo*	Gift of assets or money given by the parents or brothers to a daughter or a sister for her to take to her husband's house. Sometime a milking animals is gifted.
38	*Adiyan*	A farmland given to a household for cultivation on the agreement that 50% of the produce will be paid to the landowner.
39	*Ek-Hal-ko-melo*	Land measurement; Hal means yoke, pair of bullocks, oxen, or plough; Melo means farm-task, farm work or programme. A farm land ploughed by a pair of bulls in a day is Ek-hal-ko-melo.
40	*Ropain*	An auspicious rice transplanting day
41	*Jhikwa-Damlo*	A rope made up of fibres/or bamboo splits used to tie a calf while milking its mother
42	*Thekka-Patta*	Contract work

Siri bull in Bhutan (https://learnnaturalfarming.com/siri-cattle-breed/)



Ploughing by *Thimber goru* on terraced paddy-field in Sumik Linzey, East Sikkim. *Siri* oxen disappeared from the systems in Sikkim (Photo: Ghanashyam Sharma)

Table 4 Local terminologies used by the herders for their livestock.

Local terminologies	Definition
Bacho	A male calf
Bachi	A female calf
Laino Gai	A milking cow during its full milking period
Duhuyney Gai	A cow that gives milk
Bakernu Gai	A cow that about to stop giving milk, amount of milk reduced by 90%
Thakawto Gai	A cow who's milking period is over by 60%
Lutey-gai	A weak cow
Ugraunu	Regurgitation of the swallowed food to re-chew for foregut fermentation
Dudhalu	A cow that gives enough milk compared to its body size
Gai-pagarnu	Before milking a calf will shock so as to stimulate the mammary glands so that milking is easy
Betey	Number of times the cows have delivered
Gaulachan	A lump of tissue found on the neck of some local cows considered as a boon to the herd for prosperity
Gai-Chokhyaunu	Purifying a newly delivered cow after seven days by offering the deity Bigauti (boiled milk until it becomes thick)
Sat-aptre-badhnu	Bigauti is put on a long leaf folded for seven times putting Bigauti in each fold in the name of the deities and it is wrapped in another leaf and kept on the roof
Korali	An adult cow (before or after delivery)
Goru Khojnu	A cow starts mooing asking for mating with a bull
Goru-misauni	Letting a bull to mate with a cow
Gai-sepinu	A situation of a cow that releases a white discharge showing an indication that it requires immediate mating
Tharo gai	A cow that has never shown symptoms of for a bull
Bhaa-ko-gai	A cow under gestation period
Tharo-gai	A cow that is not become a mother
Byauuney gai	A pregnant cow

Local terminologies	Definition
Pautha-basnu	A cow that shows indication of its immediate delivery
Fhancho	The mammary gland (milk contained is measured by the size of the Fhancho)
Khirilo, Larakka pareko	Well built, strong
Local names (cows)	Muduli, Phurki, Darmi, Pangri, Gothu, Jhuli, Tari, Sinduri, Kaili, Mali, Pundi, Lalmu, Phurki, Chadarki, Sinduri, Kali, Phali
Local names (bulls)	Muduley Phurkey Pangrey, Jhuley, Darmey, Tarey, Sindurey, Kailey, Kalwa, Chandarkey, Pundey, Biu-Goru (seed bull)
Buffalo	**Definition**
Huney Bhainsi	A buffalo who's milking period is over by 60%
ThaBakernu Bainsi	A buffalo that gives milk
Dukwto Bhainsi	A buffalo who's milking period is over by 60%
Laino Bhainsi	A milking buffalo during its full milking period
Pado	A male calf
Padi	A female calf
Rango	A bull buffalo
Bhainsi pyanu	A milking man will pat on the back of the buffalo so as to indicate buffalo to release its milk
Dudh lukaunu	The milking female is so intelligent that it will not allow the milk to come out if it is unhappy
Local names of the Buffalo	Chaurey, Kali
Oxen, Bull	**Definition**
Hal-Goru	A pair of bullocks for ploughing
Ekbaili-ka-goru	A pair of bull that completed a season farming
Hal-bahar	A newly trained pair of bulls
Hal-mileka goru	A pair of bull with equal built, size and shape
Rang mileka goru	A pair of bull with similar colour and body pattern, head size and horn length and shape

Names of sheep	**Female:** *Dhwali, Hansi, Phushri, Jhetho-Hansi, Mailo-Hansi, Pudki, Tudki, Ghopti;* **Male:** *Thuba*
Names of goats	**Female:** *Ghorli, Kali, Thadi, Chirki, Chanauti, Singhari, Seti, Pudki, Chanauti etc.; Male: Sigharey, Kaley, Ghorley, Dhuwasey, Setey etc.*

These terminologies are relevant to the culture, religion, rituals and ecology of the landscapes and was thus used by the indigenous communities ever since they started livestock production system and conservation of their surroundings (Table 5). *Dhungel-Kharka* was established by the *Dhungel* herders around 200 years ago which is located above Parakha-Machong in the RF.

Table 5 Indigenous terminologies used by the herders on the grazing locations and pasturelands.

Sl. No.	Grazing spaces	Grazing forests
1	*Kharka*	An open path of land with a very few trees and the pasture for grazing, and also a place for establishing Barkhey, a permanent house shelter constructed to stay by the herders
2	*Dadeli*	A grazing pasture, which had undergone forest fire long long ago and is named after the event
3	*Nagi*	An open pasture land without trees and shrubs mostly on the top of the mountain, small ponds are built for harvesting or storing rain water for cattle
4	*Deurali*	Usually a mountain top forests, a sacred forest, and also a forest used for grazing and offering rituals to the deities that protects the livestock, herders, avoids landslides, or other natural calamities
5	*Dhap*	A mountain forest top smaller than a Nagi pasture
6	*Charan*	Grazing forests
7	*Lekh*	High altitude forests, alpine areas
8	*Aauul*	Low altitude areas, subtropical and warm temperate regions
9	*Byansi*	Flat paddy field with short terraces along the river valleys (Danak Byansi, Samardung Byansi, Pithang Byansi, Kopchey Byansi, Sanfg Byansi, Darmdin Byansi …)
10	*Kachhadd*	Lower warm temperate forest with along the small river and rivulets
11	*Ghasilo*	Forests or terraces with full of good quality fodder

During the era of transhumant pastoralism, herders maintained a strong network of families engaged in resource sharing through a barter system. This system allowed them to exchange various resources, such as grains, vegetables, butter, milk, curd, cheese, or cash, under the principle of *Paincho* (returning the same or equivalent resource) within a pre-agreed time period. Another exchange system known as *Sata-satt* involved swapping one resource for another between neighboring families, often from upstream and downstream areas.

Typically, this exchange involved seeds—such as those of potatoes, maize, paddy, beans, fruits, buckwheat, wheat, and barley—helping to improve the quality and yield of crops. In addition to the exchange of physical goods, these interactions also facilitated the sharing of knowledge about resource use, management, and conservation. For instance, herders would exchange information about crop seed conservation, the best practices for livestock production, and methods for sustaining and improving the herd for future generations. In such a system, traditional weighing methods were employed for the bartering process (Table 6), ensuring fair exchanges and strengthening the mutual trust between herder families.

Table 6 Terms associated to weight, money exchange, etc. used by the traditional communities before 1980.

Sl. No.	Weight used by the herders	Description
1	*Dhaa-r-ni*	Weight of approximately 2.4 kg
2	*aanaa / anna*	coin – a sixteenth of a rupee – nowadays not common
3	*adhiya*	tenant farmer
4	*mohor/mohur*	8 aanaa silver piece; 1 mohr = 50 paise
5	*Sh-aer*	Weight measurement: approximately 800 grams; equivalent to 2 mana
6	*Maa-nu*	Weight measurement; one mana is 10 handfuls, approximately 400 grams
7	*Muu-ri*	Weight measurement for cereals contained in a sack approximately 4 feet tall and 1 foot in diameter; approximately 64 kg (one muri is equivalent to 20 pathi)
8	*Paa-thi*	Weight measurement, approximately 3.2 kg (one pathi is equivalent to 8 manas); can also refer to the brass or copper vessel which contains a pathi of grain
9	*Ek-doko*	Anything such as corns, or fuelwood, or potatoes etc. on a bamboo basket (a basket with upside elaborated)
10	*Char-paathey Theko*	A specialised cylindrical wooden vassal with a circular opening used for churning, and with a capacity of 32 mana
11	*Ek-Thunsey*	Measuring in a meanly woven bamboo basket (large size) for paddy, buckwheat, maize, rice, oilseeds etc. for distribution or for exchange or for bartering
12	*Ek-Dalo*	Measuring in a meanly woven bamboo basket (Smaller size) for paddy, buckwheat, maize, rice, oilseeds etc. for distribution or for exchange or for bartering Used for keeping grains, tubers etc.
13	*Ek-murey-bora*	A full sack of grains, potatoes, cardamom, or ginger, anything related to agriculture produced used for letting it to nearby town for selling, or for exchange with the neighbouring households in lieu of something

Veterinary knowledge systems and practices*: Indigenous veterinary knowledge systems*

Since time immemorial, the Himalaya herders, smallholder livestock keepers, agro-pastoralists and nomadic pastoralist's basic medical treatments have been the herbs and medicines of animal origin. Although modern veterinary system of treatment is available in major centres, due to the lack of accessibility, appropriate leadership, information, network and recognition of their livelihood these communities are yet to get access to such modern veterinary services. Therefore, they are still dependent on their traditional veterinary medical knowledge and are mostly dependent on medicinal herbs growing in their areas for treatment of various ailments. However, this valuable local knowledge has turned increasingly fragile and susceptible to rapid erosion with the expansion of biomedical paradigms and replacement of traditional resources with modern systems (Ahmed et al. 2016).

Apart from climate change vulnerability, disease is another significant factor contributing to the decline in yak populations. Ethno-veterinary medicine, which has been used for animal healthcare since the domestication of livestock species, offers a cost-effective treatment alternative, especially in primary healthcare settings in remote areas. Sikkim boasts a rich heritage of folk healers who possess vast knowledge of herbal medicine passed down through generations, specifically for the healthcare of livestock.

Ethnoveterinary science involves the practical knowledge used to treat and prevent animal diseases, focusing on the use of medicinal plants to address various ailments in domesticated animals. This indigenous veterinary knowledge has a long history (Table 7), and while these medicinal plants are not commercially traded for veterinary

A sick Chauri at Muguthang (Photo: Ghanashyam Sharma)

purposes, their exceptional traditional value holds significant potential for scientific validation. Biochemical analysis could confirm the therapeutic efficacy of these plants, leading to bioprospecting of these genetic resources.

Despite the advances in modern veterinary medicine, many villagers continue to rely on traditional practitioners and herbal remedies for their livestock's healthcare (Sharma et al. 2012). This enduring reliance highlights the importance of preserving indigenous knowledge and exploring its potential for modern applications in animal health management.

Moreover, this traditional veterinary knowledge system which is passed through generations by the indigenous communities of Sikkim is disappearing over the years while the knowledge as such as can be of much significance not only in the present regime of ABS agreements, Intellectual Property Rights, Patent Rights, etc., but also for new or alternative drug discovery and development of scientific knowledge base.

Ophiocordyceps sinensis

Rheum australe

Table: 7

Sl. No.	Animals, ailments/ diseases	Medicinal plants used	Methods of treatment
1	Fertility problem in cow	1. rhizome of *Curcuma longa Linnaeus (Hardi)* and 2. seeds of *Brassica campestris Linnaeus (Tori)*	About 500 gm seed-powder of *Brassica campestris* and three tea-spoonful powder of *Curcuma longa* dried rhizome are mixed well and is divided into three equal doses and given once daily in the morning for 3 consecutive days.
2	Bleeding from broken horn in oxen	1. rhizome of *Curcuma longa Linnaeus(Hardi)* 2. stem bark of *Calotropis gigantea (Aank)*, and *(seeds of Brassica campestris Linnaeus (Tori)*	About 100 gm powder of *Curcuma longa* dried rhizome is mixed with 200 gm bark paste of *Calotropis gigantea* and one teaspoonful of seed oil of *Brassica campestris* and applied twice a day for a week.
3	Bone fracture of cattle	1. bark of *Engelhardtia spicata (Thulo mauwa)* 2. *Acacia pennata (Arari)* 3. *bark of Schisandra neglecta (Kursinglo),* 4. whole plant of *Viscum articulatum (Harchur)* 5. bark of *Terminalia bellerica (Barro)* 6. seeds of *Lepidium sativum (Chausor),* 7. stem of *Saccharumofficinarum Linnaeus (Ukho)* 8. rhizome of *Curcuma longa (Haldi)* 9. rhizome of *Kaempferia rotunda (Bhuichampa)*	The bark of *Engelhardtia spicata*, *Schisandra neglecta, Terminalia bellerica,* seeds of *Lepidium sativum,* stem of *Saccharum officinarum,* rhizome of *Curcuma longa, Kaempferia* rotunda and branches of *Viscum articulatum* in equal parts are crushed and boiled in about three litres of water till it turns into gummy paste. This gummy paste is spread over a paper and applied on the fractured part and then bandaged. The application is allowed to remain unchanged for a month during which the wound is healed.
4	Bone dislocation of cattle	1. rhizome of *Kaempferia rotunda (Bhui champa)* 2. branches of *Viscum articulatum (Harchur)* 3. grains of *Zea mays (Makai)*	Dried branches of *Viscum articulatum* along with dried rhizome of *Kaempferia rotunda* and grains of Zea mays in equal parts and a little sugar are crushed and made into powder and boiled it in about two liters of water till it turn into gummy paste. The paste is applied and bandaged on dislocated bones.
5	Cold sickness in goat	1. fruits of *Datura metel (Dhaturo)* 2. bulb of *Allium cepa (Piaz)* 3. resin of *Canarium strictum (Gokul dhoup)*	The fruit of *Datura metel*, bulb of *Allium cepa* and resin of *Canarium strictum* in equal parts are crushed and made into paste and given about 100gm orally, thrice daily for 5 consecutive days.
6	Cough in cattle	1. bulb of *Allium sativum (Lasun)*	2 – 3 bulbs of *Allium sativum* are crushed and made into paste and is given along with feeds, twice daily for 3 consecutive day.
7	Cuts and wounds in cattle	1. whole plant of *Drymaria cordata(Abijalo)* 2. leaves of *Acorus calamus (Bojo)*	The paste of whole plant of *Drymaria cordata* or the leaf paste of Acorus calamus is applied to cuts and wounds.

Sl. No.	Animals, ailments/ diseases	Medicinal plants used	Methods of treatment
8	Diarrhoea in cow	1.fruit of *Litsea cubeba (Siltimbur)* 2. tender shoots of *Cannabis sativa (Ganja),* 3. fruits of *Rhus chinensis (Bhakmilo)* 4. rhizome of *Acorus calamus (Bojo)*	The infusion of about 100 gm of dried fruits *Litsea cubeba* and 200 gm of fresh tender shoots of Cannabis sativa is given twice daily for 3 consecutive days. Decoction of about 250 gm dried fruits of Rhus chinensis is given thrice daily for 3 consecutive days. Decoction of about 250 gm rhizome of Acorus calamus is given thrice daily for 4 consecutive days.
9	Dog bite in cow and buffalo	1. fruits of *Datura metel (Kalo dhaturo)* 2. root-stock of *Smilax ferox (Kukurdainu),* whole plant of *Equisetum diffusum (Salli)* 3. rhizome of *Tectaria macrodonta (Kalo Niguro)* 4. rhizome of *Curcuma caesia (Kalo hardi)* 5. root of *Mirabilis jalapa (Lankarsani)* 6. bark of *Betula utilis (Saur)*	The fruits of *Datura metel,* root-stock of Smilax ferox, rhizome of *Curcuma caesia* and *Tectaria macrodonta,* roots of *Mirabilis jalapa*, bark of *Betula utilis* and whole plant of *Equisetum debile* in equal parts are crushed and made into powder. About 200 gm of the powder is given with water twice daily for 10 consecutive days.
10	Fever in cattle	1. Seeds of *Heracleum sp.(chimphing)* 2. seeds of *Litsea cubeba (Sil-timbur*) 3. fruits of *Fagopyrum esculentum (Phaper)*	About 100 gm seeds of each of *Heracleum wallichi* and *Litsea citrata* along with the fruits of *Fagopyrum esculentum* are crushed and made into paste and given to the cattle, thrice daily for 4 consecutive days.
11	Foot and mouth diseases in cow	1. leaves of *Azadirachta indica (Nimpati)* fruits of *Fagopyrum esculentum (Phaper)*	About 25 – 30 ml of leaf juice of *Azadirachta indica* is given thrice daily for 10 days and the paste of the fruits of *Fagopyrum esculentum* is applied externally.
12	Intestinal warms in calf	1. roots of *Coix lacryma-jobi (Bhirkaulo)* 2. seeds of *Brassica campestris (Tori)*	About 50 ml root extract of *Coix lacryma-jobi* is given twice daily for 3 consecutive days. Or about 50 – 70 ml of *Brassica campestris* seed-oil is given twice daily for 3 consecutive days
13	Retention of placenta in cow, buffalo and goats	1. leaves of *Thysanolaena latifolia* 2. *Thysanolaena maxima (Amliso)* 3. leaves of *Saccharum officinarum (Ukhu)* *Zea mays (Makai)*	Leaves of *Thysanolaena latifolia* or *Saccharum officinarum* are fed to the cow and buffalo after the delivery. However, grains or powder of grains of *Zea mays* are fed to goats.
14	Infestation of ticks in dog and calf	1. tender shoots of *Lyonia ovalifolia (Angeri)* 2. *Nicotiana tabacum (Surti)*	Fresh juice or paste of tender shoots of *Lyonia ovalifolia* mixed with little amount of common salt is applied externally, twice daily for a week. Juice of fresh leaves of Nicotiana tabacum is applied all over the body, twice a day for a week.
15	Yoke gall in ox	1. rhizome of *Curcuma longa (Hardi)* 2. seeds of *Brassica campestris (Tori)*	About 100 gm powder of *Curcuma longa* dried rhizome mixed with seed-oil *Brassica campestris* is applied on yoke gall, twice daily for 10 consecutive days.

Sl. No.	Animals, ailments/ diseases	Medicinal plants used	Methods of treatment
16	Milk fever in cow	1. Root of *Trychosanthus tricuspidata*	100 gm of *Trychosanthus tricuspidata* root is crushed into paste which is given twice every day for 10 days.
17	Infection of round worms (nematodes), tapeworms(cestodes) and flukes (trematodes)	1. Fruits of *Rhus similiata*	Around 200 gm of fruits of *Rhus similiata* is orally fed to the cattle twice daily for three days

Sharma and Sharma (2010); Sharma et al. (2012), Field interviews with local herders, pastoralists, and traditional healers

There are several other important ethnoveterinary plant species such as *Ophiocordyceps sinensis, Bergenia ligulata, B. ciliata and B. stracheyi, Acorus calamus, Nephrolepis cordifolia, Emblica officinalis, Swertia chirayita, Terminalia chebula, Rubia manjith, R. cordifolia, Asparagus racemosus, Rhododendron arboretum, Docynia indica, Rhus chinensis, Hippophae salicifolia, Brassica campestris, Diplazium dilatatum, Saccharun officinarum, Diplazium himalayensis , Emblica officinalis, Trachyspermum ammi, Stephania gladulifera, Aesandra butyracea, Musa paradisica, Oryza sativa, Gynocardia odorata, Curcuma longa, Azadirachta indica, Heracleum wallichi, Aconutum bisma Tinospora cordifolia, Tamarindus indica, Kaempferia galanga*l, and Curcuma *caesia*

Bikhma (*Aconutum bisma*)

Chimphing (*Heracleum wallichi*)

Current survey can be useful to implement the use of phyto-therapeutics and other remedies of herbal and non-herbal origin for diseased animals, and, as elderly farmers held most of the knowledge, it can contribute to the conservation of ethno-veterinary knowledge in the region.

In addition of TPK, herder practices of zootherapy constitutes an essential part of the traditional pharmacopoeia of the Sikkim Himalaya. Although knowledge of zootherapy sharply disappeared soon after the ban on grazing, some of the zootherapeutic practices are still in use in spite of the development of modern veterinary system. A total of 19 animal species were reported by herders as being used in 26 traditional zootherapeutic remedies for either human or animal health purposes until the late 1980s and a few such practices is still continued. The species the traditional practitioners used are: *Gangato (Himalaya potamon spp.), Shankhe kira (Pila globosa), Masheer fish (Tor putitora), hill stream trout (Schizothorax sp.), Blue Whistling Thrush (Myophonus caeruleus), eggs and parts of snake (Naja naja), tree frogs other amphibians (Xenophrys sp, Amolops spp., Nanorana spp., Xenophrys spp.,), Bhalu (Ursus thibetanus), parewa (Columba spp.), Griffon vulture (Gyps himalayensis), Kasturi mirga (Moschus chrysogaster),*

Dumsi (Hystrix indica), Salak (Manis pentadactyla), Syal (Canis aureus), Bandar (Semnopithecus schistaceus), and Munal (Ithaginis cruentus). These are some of the animals used in indigenous system of medicine used for curing both domesticated livestock and human ailments. Based on the traditional veterinary practitioners the medicinally used animal parts were skin, fat, feathers, horns, eggs, bones, milk, liver, heart, blood, and leather. The medicinal use of animal-derived remedies for treating various disorders in humans and in their animals is a centuries-old tradition of the indigenous practitioners.

Cultural and religious practices

Goth-Dhup puja

A highly celebrated ritual of the Nepali community is the *goth-dhup puja.* On this day the relative of the same family names milk their cows or buffalo and bring all the milk to a goth of a one of the chosen family goth from among the herder households. On this day, the herders worship their deity related to domestic animals.

The deity is served with kheer (rice-milk pudding) and also by sacrificing a Bhale (rooster), a male goat or a sheep. They perform the ritual so as to please the GoTh deity to protect their cattle from illness, diseases, carnivores, or from natural calamities.

The deity is also offered with pan cakes, milk, butter and new buds of titey pati (Artemisia vulgaris), and grains and indigenous delicacies of the first harvest. The senior herder, or the head of the family mainly the male will perform the rituals while other herders assist him for preparing the offerings, etc.

During the ritual, the performer will recite by offering butter (churned from the butter milk) to the burning coal and invite all the names of deities of the forests, waterfalls, lakes, alpine areas, mountains, rivers (such as Teesta, Rangeet, Ramphu and their tributaries), deorali (a sacred forest landscape), devithan (goddess of the springs, streams and rivers), and ban-ko-sikari (hunter deity), Ban-jhankri (forests healer deity) for good health, excellent cattle production, excellent crop productivity, protection from landslides, fire hazards etc. This one day ritual will continue for around 4-6 hours.

This ritual has been completely discontinued after the ban on grazing.

Animal sacrifice on Siddhey Puja

Siddhey puja, a ritual of male goat sacrifice was a customary practice of many herders family. This ritual was performed to please the nature deity during the Dasain festival. A small patch of forest belonging to a family will be declared as Siddhey-Thhaan, the trees here will be conserved and feeling any one of them will result into unforeseen circumstances such as landslide, sickness etc.

Animal Sacrifice on Bhimsin Puja

Bhimsiney-Thuba, a male matured sheep in the herd is reared meant for sacrificing to deity Bhimsen, who look after the herd and the herder, and protect them from evil spirits, sickness,diseases, and unnatural death. So to make it happy, every year some herding families had the ritual practice of sacrificing the sheep.

Animal sacrifice kul-puja

Many Chetrri and Brahmin families based on their ancestral lineage belong to different Kul (name given to the spiritual deity of the respective family clans). Once in four or five years based on their tradition, they organize mass Kul-Puja (offering of animal sacrifice). Each households belonging to that particular Kul or Clan has to rear male goat only meant for the Kul, and is fed with care. On the appointed day all the households belonging to that Clan or Kul gather, establish a wide place by fencing around especially in the open Bari or Khet land mostly during the winter days, and at the centre construct a Thhaan, the ritualist preparation of the deity (by keeping animal horns, bones, river stones, twigs of different plants in
bundles, conch, rice spread on the banana leaf, an oil lamp, water Vass with flowers, flower bouquets, etc. all assembled in a finer decorative manner). The entire Kul or the Clan households will have only one Kul-ko-Dhami (family shaman), the ritual practitioner. He would chant different mantra throughout the day, shivers all day long as his body has mounted by the deity, and finally the goats compulsorily brought from each close relative households are sacrificed. As soon as the goat heads are chopped-off, Kul-ko-Dhami would immediately lift up the body and drink the blood oozing out of the neck of the animal, and he would take a round of the fenced area and finally he would offer the body and the head to the deity at the Thhaan. The meat at the end of the day will be cooked and offered to all the family members. Thus, herders family will rare an animal meant for Kul-puja and that will me meant for a particular wish such as a son, a daughter, or to get rid of a sickness etc. During the Kul-puja, the neighbours of other Clan, Kul are also invited and will be offered meat and offer feast.

Mar-hanney

On the seventh day of the auspicious Nauratha (the nine day celebration of Goddess Durga during Dasain festivals that falls during the month of October), the herders family had a traditional practice of *Mar hanney* "sacrificing either a male goat, or a male sheep or a Buffalo". The meat and blood is offered to the deity and the blessed meat is eaten by the family or distributed in the neighbours as well. This ritual is still prevalent in many ethnic communities in Sikkim, Darjeeling and in Nepal. For many indigenous communities, sacrifices are essential to Dashain (the great festival that runs for around 14 days) and provide the Prasad (offerings of God), or blessed meat, central to the festival's main dishes.

The herders family would keep one or two animal as per the deity, feed more with good grasses and grains and sacrifice on the rituals. Nepalis traditional practitioner describe the spilled blood as an offering to Durga, the festival's warrior goddess, who subsequently draws strength to overcome demons and assorted forces of darkness. From the recent past the sacrifice of coconuts, pumpkins, and other vegetable substitute the animals.

Khadgo-Katney

Indigenous system of medicine and traditional practices of shamanic rituals of treating patients has been an age old practice in the Nepali, Bhutia and Lepcha community in Sikkim. Some evil deity that they consider reside in the water sources, rivers, streams, cliffs or on trees sometimes trouble the humans or livestock, with sickness or cause natural calamity such as landslides, diseases, sickness, hailstorms etc. or cause the farms crops with low productivity/diseases. So to praise such deity, the ritual practitioners called Dhami, and Jhakri (Brahmin/Chettri/Newar communities), Bijuwa (Rai community), Bungthing (Lepcha community) Phedangba (Limboo Community), Lama/Lameni (Bhutia/Lepcha community) would do Bhakal (advance assurance of an animal sacrifice to the deity) of Khadgo-Katney (sacrifice of an animal) saying that the sick person is an innocent being and thus he should be liberated of such sickness. They find an auspicious day, do shamanic Chinta (ritualistic treatment process that usually takes place in the night) and sacrifice an animal. Thus, the herders would keep animals for such unpredictable rituals to cope up the situation.

Herders' practices to change cattle behaviour and their relevance for conservation management

Herders explained that they can influence the frequency of certain behavioral traits in their cattle by encouraging them to graze longer on less-desirable species (indicated by upward arrows) and by slowing or stopping their movement (downward arrows). However, they noted that they cannot transform an extreme negative preference into a strong positive one, or vice versa. To achieve their goals, they employ at least nine different herding techniques. As one herder stated: "Livestock must graze where I want them to. I guide them through patches, or slow them down, or even stop them. This is what I call 'herding.' Without this control, both the livestock and the pasture will deteriorate. We can't always let them graze on their favourite forage, so they must feed on moderately preferred or even less favored species as well."

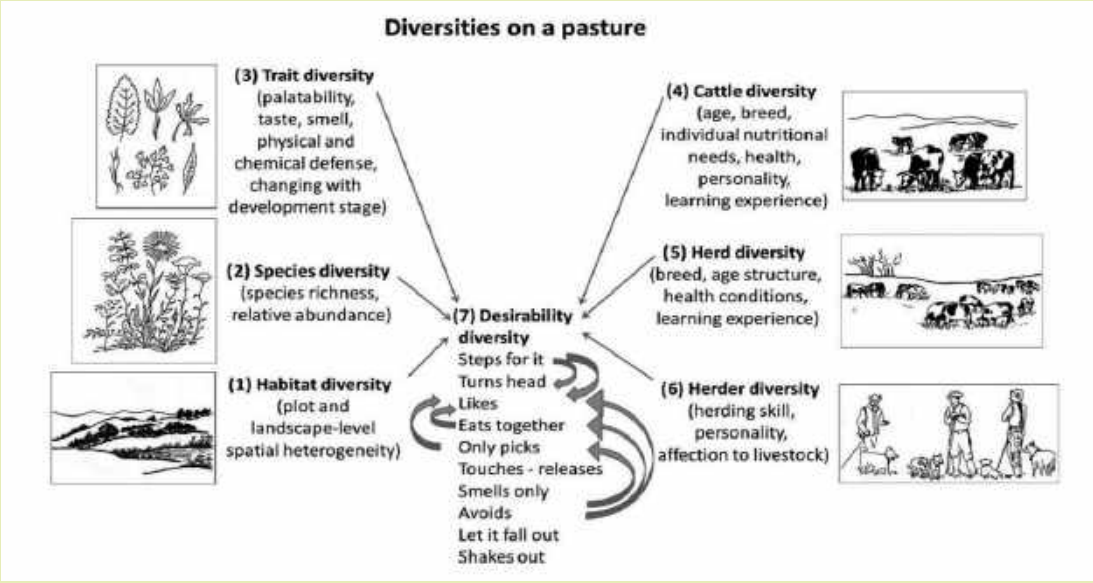


Figure 1 Knowledge co-production with traditional herders on cattle grazing behavior for better management of species-rich grasslands (Adapted from Molnar et al 2020)

Livestock have their own natural grazing preferences and will feed wherever they desire. To manage this, herders must direct them away from their first-choice areas. In temperate to alpine grazing grounds, livestock may graze up to 90 species on good pasture or forest land, about 60 species on moderately preferred pastures, and between 40 to 80 species in cultivated systems. When grazing later in the evening, the number of species may decrease. Livestock generally seek out the best grasslands first, and after grazing, they rest for a while. As dusk approaches, they re-graze the same pasture more meticulously before returning to the herd.

This study revealed that herders actively modify the grazing behavior of their livestock, guiding them from highly preferred pasturelands to less favoured ones. For herders, the "science of herding" involves controlling the movement, distribution, and even the preferences of their livestock.

To do so effectively, herders possess an in-depth knowledge of the plant species on their pastures, particularly those that are "not too rare, not too small."

They understand the conditions that influence livestock preferences, including factors like palatability, the need for nutrients and fiber, taste, texture, and the post-digestive effects of these plants (e.g., whether they help the animals gain weight, are poor forage, cause diarrhoea, or lead to bloating).

Diversity and management significance with mountain herders

Herders' perspectives on pastures in the Sikkim Himalaya are shaped by the rich ecological diversity of the region, which spans from l**ower subtropical** zones to **alpine** and.

Trans-Himalayan agroecosystems (Figure 1). This altitudinal gradient fosters a wide range of habitats, each supporting distinct plant and animal species. In the subtropical zones, pastures are dominated by grasses and shrubs, while higher altitudes feature alpine meadows and cold, rugged terrain where plant species are specially adapted to the harsher environment.

Herders manage this **habitat diversity** through techniques like rotational grazing, ensuring sustainable use of pasture resources. The diverse vegetation supports a variety of livestock, including yaks and cattle in the alpine regions and goats and sheep at lower elevations, with each species adapted to different ecological conditions.

This range of ecosystems, from **subtropical to Trans-Himalayan** areas, also influences the **fodder diversity,** with herders utilizing different kinds of grasses such as **Obano ghans** (warm fodder), **Posilo ghans** (nutritious fodder), and **Cheeso ghans** (cold fodder), ensuring their herds have year-roundaccess to varied and appropriate nutrients.

In addition to **species diversity,** the Sikkim Himalaya is characterized by high **trait diversity, herd diversity, cattle diversity,** and **desirability diversity. Trait diversity** is crucial, as herders select cattle for specific traits like endurance, disease resistance, and milk production, ensuring the adaptability of livestock across the diverse ecosystems.

Cattle diversity, particularly the maintenance of local breeds like yaks that are adapted to cold climates, plays a critical role in sustaining high-altitude pastoralism. **Herd diversity** is also important, with herders typically maintaining mixed-age herds to promote herd health and ensure ecological balance. Furthermore, herders practice **desirability diversity** choosing animals based on specific preferences for traits such as temperament, size, or milk yield, depending on the herd's needs and the environmental challenges they face. **Herders' diversity,** reflecting the various **ethnic groups** in Sikkim, such as the **Dokpa, Bhutia,** and **Lepcha**, further enriches this complex ecological system.

Each ethnic group brings unique knowledge systems, cultural practices, and livestock management strategies to the region, contributing to a broader understanding of how to sustainably manage pastures and maintain biodiversity. This cultural and ecological diversity, from **herders' ethnic practices** to the **livestock diversity** they foster, is essential to sustaining both the traditional pastoral lifestyle and the environmental health of the Sikkim Himalaya.

Study conducted by Ingty (2021) in North Sikkim assessed plant species diversity and ecosystem function in grazed and ungrazed areas, revealing that grazing enhances both plant diversity and ecosystem function, as indicated by higher species richness, diversity indices, and above-ground net primary productivity. The results suggest that grazing, influenced by rainfall and elevation, plays a crucial role in maintaining biodiversity and ecosystem health, and that policies should avoid completely restricting grazing, as it may not meet conservation or socio-economic goals.

Sharma et al. (2024) studied the impact of livestock grazing prohibition in Sikkim analyzed soil nutrient dynamics across different forest types, revealing that controlled grazing areas (CGFs) exhibited significantly higher soil nutrient content, including total nitrogen, phosphorus, organic carbon, and organic matter, compared to ungrazed forests (UGFs) and abandoned pastures (Aks). The findings highlight that regulated and rotational grazing contributes to improved soil health and nutrient availability, emphasizing the need for sustainable grazing management to support forest ecosystem health.

Conclusion

In high-altitude regions like Lhonak Valley, Lhashar Valley, and the Gurudongmar-Tsho-Lhamu plateau, traditional nomadic herding is increasingly under threat.

Changing social values, emerging market trends, and greater awareness of educational and employment opportunities outside the area are leading younger generations, particularly the Dokpa, to abandon herding as a profession. The older generations, once dedicated to this way of life, can no longer continue due to physical limitations, while the youth are drawn to city life, where they seek better education, healthcare, and social opportunities. The hardships of herding—extreme weather, isolation, limited market access, poor animal and human health services, and a lack of government support—make it less appealing, especially when contrasted with the lifestyle in urban areas.

Additionally, the shrinking of grazing lands due to infrastructure development, including roads, hydropower projects, and military establishments, further threatens the survival of nomadic herding. The encroachment on pasturelands, combined with climate change-induced challenges like erratic snowfall and shifting ecological conditions, poses a grave risk to the continuity of this occupation. The growing tourism sector, coupled with new employment options, has further undermined the economic viability of herding. These socio-economic shifts, along with a lack of targeted support for herders, are leading to the gradual erosion of traditional pastoralism, as young people increasingly view their future away from the mountains.

Pastoralist communities face significant threats due to the disconnect between the management objectives of herders and conservationists, despite the fact that both groups may make similar management decisions. Often referred to as "ecological doctors," herders play a crucial role in maintaining the ecological health of pasture ecosystems through careful grazing land management. However, the lack of collaboration between herders and conservationists can hinder effective management of protected, rare, and invasive species.

A true partnership, where herders and conservationists co-design and test new management practices, could offer a more sustainable solution, benefiting both the environment and the livelihoods of pastoralist communities.

Pastures are highly diverse ecosystems, supporting not just species and habitat diversity, but also cattle and herd diversity, as well as varying herding techniques and skills. These forms of diversity are interdependent, meaning a reduction in one type can negatively impact others.

For example, a loss in species diversity may lead to a decline in trait diversity, and reduced herd diversity can harm cattle variety. Research suggests that a more targeted and complex approach to conservation, involving herders, could help maintain higher levels of alpha, beta, and gamma diversity on well-managed pastures. However, conservation policies often overlook the unique socio-cultural, economic, and ecological aspects of high-mountain pastoralism.

Furthermore, unclear rights arrangements and the failure to recognize customary use rights under current forest management policies are key challenges for herders.

Institutionalizing collective measures to address these issues, such as regulating herd sizes and grazing cycles based on pasture capacity, could ensure more sustainable grazing practices and better resource management.

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HARIYO MAKHA

SIKKIM AGAINST POLLUTION
A TRIBUTE TO MOTHER NATURE

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NTRODUCTION:

Hariyo Makha is a small socio-environmental project that was started in 2015 with the aim for protection of Mother Nature. It is a type of Swachh Bharat Abhiyan that works on the areas of Solid Waste Management, Proper Resource Utilisation, Biodiversity, Reducing Human-Wildlife conflict and Sustainable Development.

It consists of a collection of 10 different initiatives all of which are dedicated to Mother Nature. The project also generates small revenues that are utilised in helping needy and drop-out students for getting admissions to NIOS and IGNOU. I feel humbled to mention that until now we have been able to help 20 students in their education out of which 1 has completed Masters' Degree, 2 have become graduates and 3 have passed class 12.

NAWA NIKUNJA PRAKARAN

Hunger is an element of emotional pain that equally affects all living organisms. These days the incidences of wild animals entering into human habitat have become a common scenario. Such situations were also common during our childhood, but the instances had been quite less. Our beautiful culture had then taught us in sparing a portion of our harvest for Mother Nature, and even for animals, birds and insects. However, we are slowly forgetting to acknowledge this symbiotic friendship of mutual respect and co-existence that exists as a part of our ancestral heritage.

It is a nightmare to imagine the algorithm of our so-called developmental journey from an innocent procurer of human needs to a never satisfying ego of human greed that has firstly destroyed our ecosystem and in later phases has been haunting us like a boomerang !!

The problem of an increased number of wild animals, especially monkeys, as well as other animals like peacock, wild pig, deer, porcupine, etc., entering into human habitat has become a major area of concern in our state. Among the various reasons for wildlife entering into human territory, one of the prime reasons is the lack of sufficient food sources in the forest.

Deeply concerned about this increasing problem, an idea was initiated by the Hariyo Makha project. The idea was to enter into the forest area within the wild habitat and plant a sufficient number of fruit trees. Thus with a sufficient number of food sources for wild animals in the forest and engaging them within their own natural habitat, it can be assumed that the percentage of animals entering into the village can subsequently decrease with time.

With this goal of reducing the problem of human-wildlife conflict, a 5 year plan was visualized within the beautiful village of Makha and surrounding areas under Patuk-Singbel GPU, in the Gangtok district of Sikkim. The initiative was named as 'Nawa Nikunja Prakaran' or the 'New Forestry Initiative' that worked on the plantation of fruit saplings directly within the forest area.

The initiative also draws its inspiration from the Hon'ble Chief Minister's vision of the initiative 'Mero Rukh Mero Santati (MRMS)' wherein 108 trees are planted by parents of a newborn in the state. In order to relate it with the existing problems, the Hariyo Makha project focused specifically on the planting of fruit trees.

The first discussions for searching the possibilities of plantation was held with the Ward Panchayats of Patuk-Singbel GPU at GVK, Singbel on 13th June 2024. The idea was appreciated by all of them. Thereafter the area of work was divided into 4 regions with 4 leaders acting as Resource Persons. These included the regions of Makha, Singbel, Patuk and Kokaley all within the same GPU.

Having recently retired as a Block Officer (BO) from Singtam under the Forest Department and due to his active interest and involvement in various environmental programmes, T. P. Neopaney from the Kokaley team was chosen as the Key Resource person of the Nawa Nikunja Prakaran. A rough map was prepared by him that contained 3 regions from the villages of Singbel, Patuk and Kokaley. Other Resource persons were Laxmi Sapkota (retired BO) from Makha team, Hom Adhikari (social worker & reformer) from Singbel team and K. L. Koirala (retired Deputy Director, Horticulture department) from Patuk team. The technical expert was Rupesh Chandra Sharma from Rupesh Photosastra, Makha. The initial core team members were thus formed.

On 3rd July 2024, the team then approached Samdup Tshering Bhutia, Hon'ble Area MLA, Tumin Lingee constituency who also had a wide experience in the field of environmental activities as he had himself been retired from the Forest department. He accepted the request for being the Chief Patron of the initiative. On the same day suggestions were also received from B. B. Gurung, Conservator of Forest (CF), Uday Gurung, Conservator of Forest (CF), and Pradeep Kumar, Secretary, Forest Department. We were then advised to meet Til Hang Limboo, Range Officer (RO) and Nima Tshering Lepcha, Block Officer (BO) at Singtam.

On 19th July 2024, Block officer Singtam along with official staff Balaram Chettri visited all the three spots and suggested that since this was the first attempt, hence plantation be done only in the Gau-charan region of Singbel. Around 30 MG-NREGA workers helped in preparing the land for plantation of fruit saplings.

There had been several interactive meetings to motivate Self Help Groups (SHGs), Ward Development Society (WDS), and surrounding schools under Patuk-Singbel GPU. People from all sections and groups showed their interest in participation in the initiative.

Utilising one of the holidays on 27th July 2024, more than 300 active volunteers assembled at an altitude of over 880 metres for participating in a plantation drive of fruit saplings. The Hon'ble Area MLA himself participated in the fruit plantation drive. The idea was also supported by Block Development Officer (BDO), Rakdong-Tintek BAC. Other participants include Zilla and Ward Panchayats, MG-NREGA workers, local intellectuals, BO Singtam and other forest officials from Forest Department, students of Eco-club and staffs from Government Senior Secondary school, Makha, NGOs like Saraw Club (Makha), Paksam Moonlight Sangh (Paksam); 3 government schools viz Govt. Senior Secondary Makha, Govt. JHS Singbel, Govt. Primary School, Central Patuk; 2 private schools viz Adarsh Vidhya Mandir (Singbel) and Children Preparatory School (Makha); 5 Ward Development Society (WDS) from Singbel, Selebong, Makha, Kokaley and Patuk.

All had gathered at the Goucharan area located at 1 km above the Panchayat Bhawan of Patuk-Singbel PGU. Around 500 fruit saplings and 100 fruit seeds were planted. In the program, 108 fruit saplings were also planted to celebrate the birth of Siara Ishanvi Sapkota, daughter of Tika Ram Sapkota and Bhumika Sharma of Makha. Additionally, 50 more fruit saplings were planted by 50 students of Eco Club Makha along with their mothers under the 'Ek ped maa ke nam' programme. More than 10 fruit saplings were also planted by Shri Paras Nepal of Makha in the memory of his late mother. Speaking on the successful completion of the first phase of Nawa Nikunja Prakaran, the Hon'ble Area MLA congratulated all the participants. He also spoke on the need of working on similar initiatives in the state and also on spreading awareness among common people regarding human-wildlife conflict.

PYARO MAURI INITIATIVE:

Nature has blessed flowers with beauty and fragrance. This brilliance attracts insects that feed on their nectar. Every time an insect sits on a flower, the pollens stick to its legs which is then transported to other flowers. This transfer of pollens produced by anther in one flower to the stigma of another flower of the same species is termed as the cross-pollination and the agents responsible for it are known as pollinators. Birds, insects and even the winds support cross-pollination, but the best pollinators are the bees that alone account for more than 90% of the mechanism. This process is common to all vegetables and fruits. During November 2018, I found many bees feeding on the pollen of white roses in my small garden at Singtam, Gangtok district. The bees used to feed on them until the yellow pollen turned to black in 6-8 days. Since food is always scarce during dry winter seasons, it was obvious that the little bees faced difficulties for survival during the cold seasons from November to February. This incident inspired a new initiative to address the problem of bee conservation. Thus the initiative of 'Pyaro Mauri' or 'Dear bees' was launched as a part of our activity from the Government Senior Secondary School, Makha on 4th December 2018. It was aimed at supporting the bees during the dry winter season by the cultivation of sufficient numbers of mustard seeds.

Nasreen Thapa who was then the Village Level Worker (VLW) under the Agriculture Department helped us in procuring 10 kg of mustard seeds. Additional 10 kg seeds were also donated by Arjun Kumar Chettri, Headmaster, Government Primary School, Rekape, Namchi district. These seeds were then distributed to 65 students, 9 school teachers and 145 common public. They were planted in an area of 10.22 hectares alongside the highway from Singbel to Kokaley under Patuk-Singbel GPU. Some seeds were also cultivated in the areas of Singtam, Sang, Tumin, Raley and Sichey. A total of 31 bee-hives had also been recorded. Unfortunately, this initiative had to be discontinued due to the sudden onset of the corona pandemic in 2020. Last year in November 2023, I performed a small experiment on the importance of cross-pollination at my garden in Singtam. There was a lemon tree at one of its corners. An area of 50 feet x 20 feet was prepared for cultivation of mustard seeds. The mustard seeds flowered at the same time as the lemon tree bearing flowers. Everyday there used to be a whole swarm of bees soaring in the field. Surprisingly, at the end of the harvest, the size and number of lemons also increased by 250% as compared to previous years. The surge in lemon production due to increased number of cross-pollination by bees was practically experimented. Inspired by this incident, a small research was conducted among the students of Government Senior Secondary School, Makha during October of this year. It was found that many villagers have discontinued the cultivation of mustard seeds. Only the villagers having large fields used to cultivate mustard seeds with the sole purpose of obtaining oil. Those with a smaller field area were interested in other vegetables and fruits. Few cultivated mustard seeds but only for consuming it as a vegetable. The importance of mustard cultivation and allowing it to flower for attracting bees for cross-pollination was missing from their practice. This decrease in the food source for bees had also threatened the existence of bees. It was also found that the number of functional bee-hives had also been reduced during the years that showed that the problem had slightly worsened over the years. In order to counter this problem, a group of students from the Eco-club Makha were chosen and were trained on raising awareness on mustard cultivation for attracting bees. They met with the executive members of the Ward Development Society (WDS) at Singbel, Gangtok district and requested a meeting with different Self Help Groups (SHGs). On 26th October 2024, our students represented themselves in a meeting with the SHGs and WDS at Panchayat Office, Singbel. They actively interacted with the

members and shared their knowledge on the importance of cultivating mustard seeds. Another group of students along with some teachers took up the task for the collection of mustard seeds for distribution to everyone in the school and village. Special emphasis was given for the collection of local varieties of seeds preferably yellow mustard (Sinapis alba) and brown mustard (Brassica juncea). Around 15 kg of mustard seeds were locally collected. Thus the Pyaro Mauri initiative was re-launched this year in October 2024 with an aim of raising awareness on bee conservation by planting of mustard seeds. Local people from Patuk-Singbel GPU as well as from other GPUs came forward to contribute towards the initiative by donating mustard seeds. These included Leela Dhar Gautam & Pushpa Gautam (Lingee Payong), Pushpa Lal Regmi & Oma Devi Regmi (Patuk),Gopal Acharya & Yog Maya Regmi (Makha), Rupa Rai (Paksam), Dil Kumari Chettri (Patuk), Hari Prasad Sharma (Namphing), Lakit Lepcha (Aritar, Gurung Gaon), Pavitra Tirwa (Singbel), Laxmi Sapkota (Makha), Madan Sapkota (Makha), Mishika Gautam (Makha), B. B. Chettri (Patuk), Dharmendra Lamichaney (Lingee).

Seeds were distributed to more than 150 volunteers including students, teachers and local farmers.

Everyone was motivated to spare a portion of their land exclusively for mustard cultivation alongside other crops and vegetables. The seeds were left to bear flowers that could attract bees. An area as small as 154 cm2 in flower pots to fields as big as 50 feet x 100 feet have been sown with mustard seeds. The corresponding increase in crop and vegetable production would be visible in the next year and hopefully it would benefit the villagers.

CLEAN PAPER INITIATIVE:

The common trend of using only one side of A4 paper has led to the accumulation of tremendous amounts of paper waste that are either carelessly burnt or sold to rag-pickers without completely being used. The Clean Paper Initiative is aimed at collecting all such pages and utilizing them as rough pages that are given to students for free of cost.

VOLUNTEER PAPER WORKSHOP:

It is an extended version of the Clean Paper Initiative where the semi-used A4 pages are carefully segregated and the clean pages are converted into notebooks that are sold at nominal price. The collected amount is then utilised in helping needy and drop-out students for admission to NIOS and IGNOU. Until now 1,80,000 pages have been upcycled and converted into 1800 notebooks. Last year the District Institute of Education & Training (DIET), Gangtok collaborated with the Hariyo Makha project wherein 30 students of DIET were given training for converting 5000 semi-used A4 pages into 50 notebooks. Semi-used A4 pages from 5 government schools viz. Govt. Sr. Sec. School, Samdong, Govt. Sr. Sec. School, Deorali, Govt. Sr. Sec. School, Rhenock, Kalzang Gyatso Sr. Sec. School, Kabi and Govt. Sec. School, Penlong, and from 2 private schools viz. Manjusri Public school and Mount Zion located in and around Gangtok were collected, segregated and transformed into notebooks by the students of DIET, Gangtok. The success story was also appreciated by journalists from the UAE based international newspaper 'The National'. On 22nd May 2023, one journalist and a cameraman from the newspaper had come from New Delhi to DIET, Gangtok for understanding the work and having interactions with the Principal and students at DIET.The upcycled notebooks were also presented to dignitaries like Secretary and Additional Chief Secretary, Education Department, Member Secretary, Sikkim Pollution Control Board, ENVIS team, and other officials from the Forest Department. The active student volunteers also received certificates for their work. Until now, 7,00,000 semi-used pages of all sizes have been segregated and reused. A gross amount of Rs. 40,000 has also been earned.

NATIONAL CONTEXT & CONTRIBUTION TO ENVIRONMENT:

The 2011-12 MHRD report gives data that there are 1.3 million schools in our country. Irrespective with the variation in the number of students, if we roughly assume that each school generates an average of 10,000 pages annually, then there is a possibility in reuse of: 10,000 x 13,00,000 = 13,00,00,00,000, i.e., 1300 crore pages every year. If we assume that one small tree can generate 5000 pages and require a time span of 30 years of its growth, then we could equivalently save 26,00,000 trees and recover a life-span of 7,80,00,000 years.

PLASTIC UPCYLING INITIATIVE:

The multi-layered wafers of chips and biscuits do not attract scarp-vendors due to lack of financial motivation. Two years of research in 2013-14 led to the idea of utilizing them as book covers in 2015. In 2017, we attempted to cover all the books and copies of the nearby private school Adarsh Vidhya Mandir (AVM). This led to an earning of around Rs. 14,000 which was utilised in helping one student in getting admission to a BA degree under IGNOU. He has recently completed his course and has become

a graduate. In 2019, this idea was donated to the Ward Development Society (WDS) at Singbel, Gangtok district that consisted of 5 Self Help Groups (SHGs) with 53 members. They successfully earned Rs. 21,000 from their works. Until now a total of 90,000 plastic pieces have been upcycled into 8000 book covers.

NATIONAL CONTEXT AND SELF-EMPLOYMENT:

This idea seems very promising if we think about the national context. If we assume that out of 130 crore of Indian population, if 20 crore people consume just one plastic packaged item per day, then the number of scrap covers generated per year is 7200 crore. Assuming a round figure of 5 gm per one plastic, this situation is equivalent to 36 crore kilograms. This is equivalent to 216 crore kilogram of Carbon dioxide if burnt and an uncountable area of land for its disposal. (Assuming that burning 1 kg of plastics releases 6 kg of carbon dioxide in addition to other harmful gases) (Sources: Internet) Following the footsteps of our work, if we imagine a Book Covering Unit out of such plastic pieces, then we could be able to generate not just Self-employment for countless youths, but also help in combating pollution and other demerits arising out of improper disposal. All these can be achieved with a zero dependence on raw materials.

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TRANSFORMING THE OLD PEAR TREES INTO A TREE LIBRARY AT KHECHUPERI SENIOR SECONDARY SCHOOL

SUCCESS STORY

Background

In the picturesque setting of Khechuperi Senior Secondary School, an old pear trees near the assembly ground was posing a danger to the safety of students and staff due to its unstable condition. Instead of resorting to completely cutting down the tree, the school took a creative and sustainable approach under the leadership of Principal In-charge L.M. Limboo.

Initiative and Implementation

He proposed the idea of transforming the old pear tree into a "tree library" – a unique space where students could engage with nature while reading books and exploring the world of literature. With the enthusiastic support of the entire school community, including Teaching, Non-Teaching, Students, and Parents, the idea began to take shape.

Execution and Support

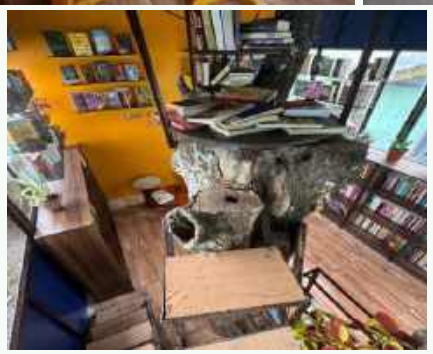
Carefully trim and shape the old pear tree, preserving its structural integrity while ensuring safety for everyone. The trimmed branches and wood were repurposed creatively within the school premises to construct a cozy library space under the shade of the tree.

Impact and Benefits

The transformation of the old pear tree into a tree library has had a profound impact on the school environment and the community at large. Students now have a unique outdoor learning space where they can immerse themselves in books, conduct research, and appreciate the beauty of nature. The initiative has not only enhanced the educational experience but has also fostered a deeper connection with the environment among students and visitors.

Current Status

Today, the tree library at Khechuperi Senior Secondary School stands as a testament to the power of creativity and sustainability in solving challenges. It has become a beloved spot for students and members of the public alike, attracting book lovers and nature enthusiasts who seek solace and knowledge under old pear tree.



Future Plans

Moving forward, the school aims to expand the tree library initiative by adding more seating areas, installing outdoor shelving for books, and hosting educational events, workshops and literary talk with writers or poets under the tree. The success of this project has inspired the school to explore further opportunities for integrating nature, learning, and community engagement.

Conclusion

The journey of converting the old pear tree into a tree library at Khechuperi Senior Secondary School exemplifies the transformative power of innovative thinking and collaborative effort. Principal L.M. Limboo's vision, coupled with the dedication of the school family, has not only mitigated a safety concern but has also created a vibrant hub of learning and literary exploration that enriches the lives of all who visit.

Through this creative initiative, Khechuperi Senior Secondary School continues to inspire its students to think outside the box, embrace sustainability, and cherish the beauty of nature while expanding their horizons through the magic of books.

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