Capacity building in biodiversity science in North East India

T. P. Sajitha and G. Ravikanth

Although India occupies only 2.4% of the world's total land mass, its diverse geographic and climatic conditions have given rise to four biodiversity hotspots. This land mass is enriched with 7–8% of the global documented species with more than 45,500 plant and 91,000 animal species being recorded[1]. The continental drift which resulted in mass exchange of species between the Gondwanan and Laurasian land masses is considered to have contributed to this diversity that India enjoys.

A confluence of three different geological origins, North East (NE) of India has an abundant range of ecological habitats. The region is known as a geographic gateway for much of the country's rich biodiversity and is a part of two biodiversity hotspots in the world, the Himalaya and Indo-Burman[2]. Contributing to this is the wide range of geographic, climatic, cultural and economic diversity. This region occupies 7.7% of India's total land area and 65% of its total biodiversity with a significant level of endemism in plant and animal species. An estimated 50% of Indian flowering plants are endemic to this region and several reports suggest that about 1350 plant species with medicinal properties, 665 species of consumable plants and 899 plant species with additional usage occur in this region[3]. Besides, 72% of the country's orchid biodiversity resides in the states of NE India, of which 14.29% species are endemic to this region[4]. The faunal diversity is equally rich with 818 species of birds of which 23 are endemic, more than 300 species of edible insects and 146 species of amphibians with 53 endemics[5–7].

A wide altitudinal range (600 to >3500 m amsl) gives the NE its array of forest types – alpine, subtropical pine, subtropical broadleaved to tropical wet and tropical semi-evergreen. The ecosystem services provided by these forest systems are numerous from provisioning (products like food, natural medicine or fuel), regulating (climate, water or air regulation), cultural (spiritual enrichment, recreation, social gathering) to supporting services (soil formation and retention, oxygen production, nutrient cycle)[8]. These forests are storehouses of natural resources which deliver livelihood benefits to a large number of forest-associated communities of the region. The eight states of NE India with a total geographic area of 262,179 sq. km support an estimated human population of 45,486,784 (Table 1). The forest area of this region is recorded to be 17,051 sq. km (refs 9, 10). About 220 distinct ethnic groups, including 200 tribes are housed in this region[11]. The association of these communities with the forest has existed since thousands of years. Both floral and faunal resources are part of the rich cultural base of these ethnic communities.

Traditional agriculture has been the chief source of livelihood of people of the region with jhum cultivation being practised at a large scale across all the states. The diverse landscape also houses an abundant diversity of cereals and other food crops, wild food plants, cash crops, medicinal and aromatic plant resources, ornamentals, timber and other economic plants[12]. Besides, a large group of locals thrive on the collection and trade of non-timber forest products (NTFPs). Faunal resources like animals, edible insects and fishes are consumed as a rich source of protein (Table 2)[13–33]. Majority of the tribal communities residing in and around the forests depend directly or indirectly on the wild bioresources for their livelihood and also as a source of medicine, beside other uses.

The bioresources of the NE have a huge economic value and the importance of ecosystem services provided by this rich biodiversity is ever increasing. A major part of the region still holds potential for new discoveries, but the difficult terrain and remote locations make it inaccessible for documentation[12]. Ironically, one of the most demanding environmental issues today is to conserve this biodiversity. These resources are threatened by a number of intrinsic and extrinsic factors. Changes in land use and its cover, illegal deforestation, introduction of exotic species are all posing immense threat to this biodiversity. Indiscriminate and unsustainable methods of harvesting NTFPs from natural forests have been shown to degrade and reduce forest cover. This in turn jeopardizes the livelihood of a number of forest-dependent populations of the region[11,34]. Adding to this are concerns of an expanding human population, industrial and agricultural development along with a lack of coordination in governance and policy-making. The effects

Table 1. Forest area and population density of the states in North East (NE), India

States	Geographical area (km^2)	Forest cover in 2019 (km^2)	Total population (Census 2011)	Tribal population (Census 2011)	Population density (Census 2011)
Arunachal Pradesh	83,743	66,688	1,383,727	951,821	17
Assam	78,438	28,327	31,205,576	3,884,371	398
Manipur	22,327	16,847	2,570,390	902,704	115
Meghalaya	22,429	17,119	2,966,889	2,555,861	132
Mizoram	21,081	18,006	1,097,206	1,036,115	52
Nagaland	16,579	12,486	1,978,502	1,710,973	119
Sikkim	7096	3342	610,577	206,360	86
Tripura	10,486	7726	3,673,917	1,166,813	350

Note: Tribal population is from the total population.
Sources: India State of Forest Report (2019), Forest Survey of India, Ministry of Environment and Forests, Government of India (GoI). Census of India (2011), Office of the Registrar General and Census Commissioner of India, Ministry of Home Affairs, GoI.

Table 2. Floral and faunal bioresources of the states in NE India

Bioresources	Example	Major uses	Reference
Floral resources			
Cereal crops and pulses	Wild varieties of rice, millet, maize, pigeon pea, lablab bean, French bean, lentil, cowpea, green gram, black gram	Consumption, economical	13
Wild edible plants	Flowering plants (*Wallichia* sp.), tree ferns (*Cyathea* and *Angiopteris*), aroids and wild yams (*Dioscorea* sp.), leafy vegetables, fruits (*Artocarpus*, *Phyllanthus*, *Annona*, *Averrhoa*, *Persia*, *Aegle*, *Passiflora*) and seeds	Consumption	14–16
Cash crops	Tea, coffee, rubber, ginger, cardamom, cinnamon	Economical	17
Fruit crops	*Citrus*, banana, mango, *Pyrus*, *Rubus*, *Prunus*, *Garcinia*, *Artocarpus*, *Phyllanthus*, Khasi mandarin, pear, plum, *Passiflora*, pineapple, guava, wild kiwi	Economical	18
Medicinal plants	*Rauvolfia serpentina*, *Solanum khasianum*, *Dioscorea proceri*, *Acorus calamus*, *Berberis aristata*, *Centella asiatica*, *Cinnamomum tamala*, *Coptis teeta*, *Emblica officinale*, *Bacopa monnieri*, *Curcuma angustifolia*, *Ocimum sanctum*, *Ricinus communis*, *Terminalia bellirica*	Ethnomedical, economical	19, 20
Ornamental plants	Orchids, *Anthurium*, *Rhododendron*, palm	Ethnomedical, economical	17, 21
Timber tress	Sal, teak, *Dipterocarpus turbinatu*, *Terminalia myriocarpa*, *Cinnamomum glanduliferum*, *Morus laevigata*	Economical, household	17
Other trees	Gymnosperms (*Pinus*, *Cedrus*, *Picea*, *Abies*, *Taxus*), bamboo, rattans, canes	Economical, household	22
Non-timber forest products	Plant-derived (firewood, medicine, wild food, essence, construction, dye, rope, broom, packaging material)	Consumption, ethnomedical, economical	11
Algal resource	*Lemanea* sp., *Anabaena*, *Nostoc*, *Calothrix*, *Cylindrospermum*	Ethnomedical, consumption, biofertilizer	23–25
Faunal resource			
Wild animals	Mithun, wild pigs, buffalo, yak, barking deer, rodents, Galliformes	Consumption, religious	17, 26
Edible insects	Silkworms, red ants, termites, grasshoppers, crickets, beetles, wasps, pentatomid bug	Consumption, ethnomedical	27, 28
Sericigenous insects	Insects of families Bombycidae and Saturniidae – *Theophila religiosa*, *Bombyx mandarinia* and *Antheraea compta*	Economical	29, 30
Honey-producing	*Apis cerana*, *Apis mellifera*	Consumption, economical	28
Fish	*Puntius* sp., *Setipinna phasa*, *Schizothorax richardsonii*, *Labeo dero*, *Acrossocheilus* spp., *Channa*, *Gudusia chapr*, *Pseudeutropius atherinoides*, *Cirrhinus reba*	Consumption, economical	31–33

can be severe in the form of climate change which not only increases the risk of flooding, landslides and droughts, but can cause an irreparable loss to natural habitats and thereby diversity.

According to the IUCN Red List (https://www.iucnredlist.org/search), from a total of 3173 species recorded for different levels of threat and concern, 256 species of animals and plants were found to be threatened (Critically Endangered, Endangered and Vulnerable) in the eight states of NE India (Figure 1). Unscientific utilization and overexploitation of the bioresources will result in an imbalanced ecosystem. A decreased level of exploration and utilization will hinder eco-friendly development. To achieve a balance between ecosystem conservation and provision of livelihood security for the communities associated with the forests, an exclusive policy as well as extensive exploration and inventorization of the bioresources are required.

Over the last 20 years, there have been a number of exploratory studies on the flora and fauna of NE India. Major areas have been the medicinal and aromatic plants used by different communities of the region. The plants used by traditional herbal practitioners for various ailments and their applications have been studied by many scientific groups across the region. A total of 890 species of orchids belonging to 165 genera have been reported from the NE. The use of these orchids in folk medicine has also been discussed[19,35]. In case of faunal diversity, edible insects find an important place in the dietary system of various ethnic groups. In five states of the NE, viz. Arunachal Pradesh (158 species), Manipur (46 species), Nagaland (41 species), Assam (38 species) and Meghalaya (16 species) edible insects are consumed[36]. Although a number of exploratory studies have been reported in pockets on the floral and faunal bioresources of the region, an extensive study of the rich biodiversity is being undertaken through a multi-institutional project on 'Bioresources and sustainable livelihoods in Northeast' funded by Department of Biotechnology, Government of India. In the present study we document the population size, distribution, life history and ecology, harvest and use of the bioresources and threats faced by it. The study also explores opportunities for sustainable scientific exploitation of bioresources.

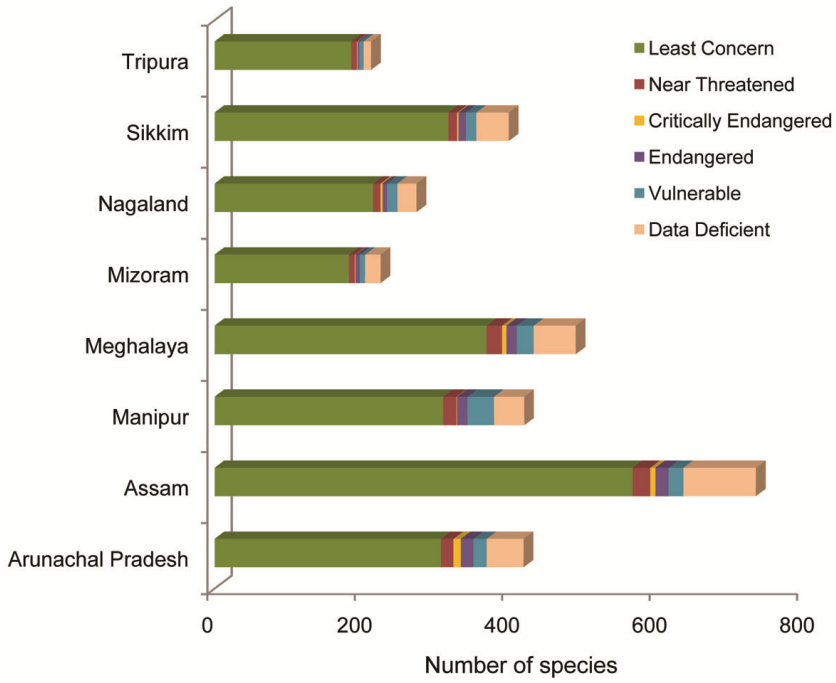

Figure 1. IUCN classification of floral and faunal species of the states in North East India at different levels of threat.

However, strong human and technical resources in biodiversity science are critical for the assessment, monitoring and management of biodiversity. Human resources and institutions necessary to generate knowledge about bioresources, or to deal with challenges of new concepts such as bioeconomy and sustainable development goals are inadequate in India as a whole, but more so in the NE. Biodiversity science is a rapidly changing field, with new concepts and tools emerging every day. Institutional capacity to fully explore the biodiversity of Eastern Himalaya, assess its value in regional economy, examine the impact of climate change on biodiversity and biodiversity-based livelihoods, and organize an adequate policy response to the negative impacts of global environmental change is limited due to inadequate institutional and policy frameworks and weak human resources.

The involvement of citizens in the conservation scenario is also insufficient in the NE. The forest-dwellers exploit the bioresources for their immediate uses and are unaware of the monetary profit of these products when they are processed or marketed. This calls for the creation of greater awareness for sustainable and economical utilization of the bioresources for the forest inhabiting communities. This can be achieved only if a larger community of people from the region, along with scientists, policy makers, students and general public participate with regard to environmental issues. Further, exploring the rich biodiversity of the NE, evaluating its value for the regional economy as a whole, observing any effect of climate change either on biodiversity or livelihoods associated with it would help in mitigating the impacts of climate change. The information thus generated can help organize adequate policy responses to counteract any inadequate threat to the environment. This can also help strengthen institutional policy frameworks and encourage the general public to maintain their resources.

Citizen science programmes have been demonstrated to be a popular means to increase awareness among the general public about biodiversity. They have also been active participants in collecting biodiversity data and a number of biological interactions (www.indiabiodiversity.org). Therefore, it is important to develop a comprehensive communication strategy to convey the ecological and economic significance of bioresources to the custodians of the region. Under the same project on 'Bioresources and sustainable livelihoods in Northeast' and involving all the stakeholders, a major programme has been launched to strengthen human capacity and communication about bioresources, ecosystem services and bioeconomy through a series of targeted workshops, short courses and communication products like newsletters, websites, blogs and social media-based campaigns to involve the public.

This strategical approach would result in a better equipped human resource ready to deal with any upcoming issue related to either exploration of bioresources or a sustainable use of it. Regular workshops and short courses have being conducted to expose participants to advanced research in the area and to address critical problems in biodiversity science, as it is a rapidly changing field. Communication through various print and digital tools will enable the researchers, general public and policy-makers be informed of major developments in biodiversity science, and relevant national and international agreements and policies concerning the science and use of bioresources. Thus, the multi-institutional programme aims not only to explore the existing diversity of the region, but also to strengthen human capacity to address modern challenges of biodiversity and sustainability.

1. Tiwari, B. K. and Rynjah, I., In *Managing India's Forests in a Changing Climate*, Tetra Tech, Vermont, USA, 2017, pp. 63–80.
2. Tripathi, R. S., Roy, A., Kushwaha, D., Lalnunmawia, F., Lalnundanga, L. H., Lalnunzira, C. and Roy, P. S., *J. Biodivers. Bioprospect. Dev.*, 2016, **3**, 1–9.
3. Dutta, B. K. and Dutta, P. K., *Indian J. Tradit. Knowl.*, 2005, **4**(1), 7–14.
4. Pal, R. and Singh, D. R., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 31–44.
5. Frost, D. R., Amphibian species of the world: an online reference. Version 6.0, American Museum of Natural History, New York, USA, 2016.
6. Saikia, P. K. and Saikia, M. K., *J. Assam Sci. Soc.*, 2000, **41**(2), 379–396.
7. Sangma, R. H. C., Pal, R. and Singh, D. R., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 253–267.
8. Duraiappah, A. K. *et al.*, In *A Report of the Millennium Ecosystem Assessment*, World Resources Institute, 2005.
9. India State of Forest Report, Forest Survey of India, Ministry of Environment and Forests, Government of India (GoI),

2019; http://fsi.nic.in/isfr19/vol1/chapter2.pdf
10. Census of India, Office of Registrar General and Census Commissioner of India, Ministry of Home Affairs, GoI, 2011; https://censusindia.gov.in/
11. Dattagupta, S. and Gupta, A., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 311–322.
12. Purkayastha, J., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 3–19.
13. Das, A. *et al.*, *Indian J. Agron.*, 2016, **61**, 129–143.
14. Namsa, N. D., Mandal, M., Tangjang, S. and Mandal, S. C., *J. Ethnobiol. Ethnomed.*, 2011, **7**(1), 31.
15. Saikia, B. H. A. S. K. A. R., Rawat, J. S., Tag, H. and Das, A. K., *J. Frontline Res. Arts Sci.*, 2011, **1**, 44–53.
16. Chase, P. and Singh, O. P., *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 45–60.
17. Das, A. K., Tag, H. and Bharali, P., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 21–28.
18. Asati, B. S. and Yadav, D. S., *ENVIS Bull. Himalayan Ecol.*, 2004, **12**(1), 1.
19. De, L. C., *Int. J. Dev. Res.*, 2016, **6**(11), 10104–10114.
20. Shankar, R., Tripathi, A. K., Anku, G., Neyaz, S. and Rawat, M. S., *J. Drug Res. Ayurvedic Sci*., 2017, **2**(2), 104–117.
21. Paul, A., Khan, M. L. and Das, A. K., *J. Am. Rhododendron Soc.*, 2010, **64**(2), 81–84.
22. Das, A. K., Nath, P. C. and Khumbongmayum, A. D., *Indian For.*, 2010, **136**(9), 1205–1212.
23. Oinam, G., Singh, K. O. and Tiwari, O. N., *Biosci. Biotechnol. Res. Commun.*, 2010, **3**(1), 26–32.
24. Singh, M. R., *Electron. J. Environ. Agric. Food Chem.*, 2011, **10**(5), 2262–2271.
25. Syiem, M. B., Nongbri, B. B., Pinokiyo, A., Bhattacharjee, A., Nongrum, N. A. and Hynniewta, L., *J. Appl. Natl. Sci.*, 2010, **2**(1), 134–139.
26. Aiyadurai, A., *Int. J. Galliformes Conserv.*, 2011, **2**, 61–73.
27. Ronghang, R. and Ahmed, R., *Bioscan*, 2010, **2**, 515–521.
28. Sangma, R. H. C., Pal, R. and Singh, D. R., In *Bioprospecting of Indigenous Bioresources of North-East India*. Springer, Singapore, 2016, pp. 253–267.
29. Peigler, R. S. and Naumann, S., In *A Revision of the Silkmoth Genus Samia*, University of the Incarnate Word, San Antonio, USA, 2003, pp. 227.
30. Natesh, S., *Biotechnol. News*, 2008, **3**(5), 3.
31. Thapa, N., Pal, J. and Tamang, J. P., *Int. J. Food Microbiol.*, 2006, **107**(1), 33–38.
32. Jeyaram, K. *et al.*, *Indian J. Tradit. Knowl*., 2009, **8**, 115–121.
33. Thapa, N., Pal, J. and Tamang, J. P., *Indian J. Fish*., 2007, **54**, 121–125.
34. Sodhi, N. S. and Brook, B. W., *Biodiversity Crisis in Southeast Asia*, Charles Darwin University Press, 2009, pp. 84–90.
35. De, L. C., Rao, A. N. and Singh, D. R., In *Bioprospecting of Indigenous Bioresources of North-East India*, Springer, Singapore, 2016, pp. 61–75.
36. Chakravorty, J., *J. Biodivers. Bioprospect. Dev.*, 2014, **1**(124), 1–6.

ACKNOWLEDGEMENT. We thank Department of Biotechnology, New Delhi for funding the project on 'Bioresource and sustainable livelihoods in Northeast' (BT/01/17/NE/TAX).

T. P. Sajitha and G. Ravikanth are in the Ashoka Trust for Research in Ecology and the Environment, Royal Enclave, Srirampura, Bengaluru 560 064, India.*
**e-mail: sajitha.tp@atree.org*