



## Sustainable development and biodiversity conservation in North-East India: A review

V. Saio and V. P. Upadhyay<sup>ψ</sup>

North Eastern Regional Office, Ministry of Environment, Forest and Climate Change  
Government of India, Shillong-793 021, India

### ARTICLE INFO

#### Article history:

Received : 4 October 2018  
Revised : 30 November 2018  
Accepted : 6 December 2018

#### Keywords:

Biodiversity,  
Development,  
Industries,  
Northeast India,  
tradition

### ABSTRACT

The present paper reviews the developmental activities of North-Eastern region of India and analyses the threats being experienced on biodiversity loss and ecosystem degradation. The north eastern states are rich in biological diversity and associated traditional knowledge and almost every part of the life and livelihood of local people is intricately connected with natural environment. Most of their livelihood earnings come from natural areas. The developmental pressure has resulted in denudation and conversion of large forest areas thus affecting the survival of flora and fauna. Several species in the region are endemic and critically endangered. We suggest sustainable measures to ensure that development is achieved with an inbuilt mechanism of biodiversity conservation with community participation. The region has potential of becoming knowledge partner with the development authorities through the existing good academic and research institutions. These institutions are capable of analysing and solving various environmental and biodiversity related issues and by providing a proper institutional framework by integrating the universities and research institutions of the region in to a research consortium, the primary goal of undertaking research on ecological problems and biodiversity conservation can be achieved. The development and institution interface as a long term strategy is needed to ensure implementation of biodiversity conservation programmes.

© 2018 Orissa Botanical Society

### 1. Introduction

North-Eastern Region of India comprises of Arunachal Pradesh, Assam, Tripura, Meghalaya, Manipur, Mizoram, Nagaland and Sikkim, covering an area of 262,179 sq kilometres with a population of 45 million as per 2011 census. The region is very rich in natural resources and is well recognised for its diversity of people, plants and animal life. These assets with socially, culturally complex and diversified region in the country, are now acknowledged as having the greatest potential for growth and development of the Region. The North-Eastern Region can be physiographically divided into the eastern Himalayas, the North-Eastern hills, and the Brahmaputra and Barak valley plains. At the confluence of the Indo-Malayan and Palearctic biogeographical realms, the region contains unique habitats characterized by diverse flora and fauna with a high level of

endemism. The region is also home to more than 200 out of 450 of India's tribes with the culture and customs intricately linked to biodiversity conservation (World Bank, 2007).

#### 1.1. Overview of the North-Eastern Region

Arunachal Pradesh is the largest state (area-wise) in the North-Eastern Region with rich alpine geographical diversity and a wide variety of wild life- flora and fauna. About 35% of the population of Arunachal Pradesh depends on agriculture and 17% of total cultivated area is under irrigation. Deposits of dolomite ore, limestone, graphite, quartzite, kyanite, mica iron-ore, copper ore have been reported (Behera, 2004). The state can be divided into five river valleys: the Kameng, the Subansiri, the Siang, the Lohit and the Tirap. The Arunachal Pradesh can be divided into three cultural groups on the basis of their socio-politico-religious affinities.

<sup>ψ</sup> Corresponding author; Email: vp.upadhyay@gmail.com

Assam is known for its vast rolling plains, rarest flora and fauna, lofty green hills, mighty waterways and a land of fairs and festivals. Broadly, the inhabitants of Assam can be divided into three categories, namely the tribal population, the non-tribal population and the scheduled castes. About 63% of the state's population is engaged in agriculture and allied activities. About one sixth of the world's entire tea production comes from the state of Assam and the tea gardens contribute over half of the country's tea production. The state has extensive deposits of oil, coal, limestone, refractory clay, dolomite and natural gas. The oil reserves were discovered in the 19th century and Digboi became Asia's first oil refinery (Sadangi, 2008). Manipur is the land of rich valleys surrounded by beautiful hills and lakes. The picturesque valley of Manipur spreading over an area of 22,327 km. is an isolated hill state. The natural vegetation occupies an area of nearly 67% of the total state geographical area (FSI, 2017). Its economy is primarily agriculture, fisheries, cottage and forestry driven (Gonmei, 2013). Manipur has the highest number of handicrafts units as well as the highest number of craft persons comprising skilled and semi-skilled artisans in the entire North-Eastern region. Handloom is the largest cottage industry in Manipur and the state ranks among the top five in terms of the number of looms in the country (IBEF, 2018).

Meghalaya has historic, geographic and strategic significance for India. It is bound on north and east by the state of Assam, and on south and west by Bangladesh. The three physical divisions in the state are Garo (Western), Khasi (Central) and Jaintia (Eastern) hill divisions. The forest cover in the state is 76.45% of the state's geographical area (FSI, 2017). Meghalaya is basically an agricultural state with about 80 % of its total population being dependent on agriculture for livelihood. The state has a vast potential for developing horticulture due to agro-climatic variations, which offer much scope for the cultivation of temperate, subtropical and tropical fruits and vegetables. The mineral deposits in the state include limestone, coal, and granite among others.

The literacy rate in Mizoram is the second highest in the country. Agriculture is the mainstay for about 50-60% of the population of the state. Maize, paddy, pulses, oilseeds, millets are the crops grown in the state (Government of Mizoram, 2013). In Nagaland, almost all areas are in hilly region which is a continuation of the Burma Arc being joined with the Sub-Himalayan ranges in the north and stretching into the hills of Manipur. Unlike other NE states, the absence of Lakes and waterfalls in Nagaland can be conspicuous with some areas where water accumulates during rainy season and dries up in lean season. Life in Nagaland abounds with

festivals throughout the year as all the tribes have their own festivals, which they greatly cherish. Most of these festivals revolve around agriculture, which is still the mainstay of the Naga society. Over 85% population of Nagaland is directly dependent on agriculture. Naga inhabits the wild, wide-open pastoral countryside.

Tripura is situated between the river valleys of Myanmar and Bangladesh. Encircled almost on the three sides by Bangladesh, it is linked with Assam and Mizoram in the northeast. Tripura lacks an industrial base except for some cottage industries (handicrafts and handloom) and small scale manufacturing units (Govt. of Tripura, 2012). Sikkim is the second smallest state of India bordering Bhutan, Tibet and Nepal. This Himalayan state has a dramatic landscape that includes India's highest mountain, the Kangchenjunga (8,586 m). The Mt. Kangchendzonga, Rivers Teesta and Rangit are magnificent assets of Sikkim with their deep ravines and valleys. The economy of Sikkim is mainly based on agricultural and animal husbandry. Approximately, 11% of the total geographical area is under agriculture. Agriculture is of the mixed type and still at the subsistence level rather than commercial level. There is a vast potential for hydro-electric power generation for which many river valley projects around Teesta and Rangit rivers have been established (ENVIS Centre Sikkim, 2007).

### 1.2. Ecological Importance of the region

The land area in Arunachal Pradesh encompasses mountains with the Himalayan range along the northern borders criss-crossed with ranges running north-south. The state has more than 500 species of birds h of which several birds are highly endangered and endemic *e.g.* white winged duck, Sclater monal, Bengal florican, etc. The rich and varied wildlife available in the state are Elephants, Tigers, Leopards, Jungle Cats, White Gibbon, Red Pandas, and Musk. The "Mithun" (*Bos forntails*) is domesticated in large numbers as well as available in the wild.

In Assam, endangered species of wildlife found includes Golden Langur, Hoolock Gibbon, Pygmy Hog, Hispid Hare, White-Winged Woodduck, Tiger, Clouded Leopard, Swamp Deer, Gangetic Dolphins (Sadangi, 2008). During winter season, flocks of resident and migratory birds make Assam their natural habitat. Guwahati, on bank of the Brahmaputra, is the city which is regarded as the commercial capital of the North-East. Kaziranga, the world-renowned ecosystem in Golaghat and Nagaon district is the home of the great Indian one-horned Rhino. Manas National Park is the only Tiger Reserve of Assam and is also a UNESCO's world heritage site. The Hoolock Gibbon, the Slow Loris, the clouded Leopard, the spotted Linsang, Tragopan, and

four different types of Hornbill are part of the rich natural heritage of Manipur.

The available records on biodiversity of Meghalaya revealed the occurrence of about 3,128 species of flowering plants which contribute to about 18% of the total flora of the country, including 1,237 endemic species (Khan *et al.*, 1997). A wide variety of wild and cultivable plants, edible fruits, leafy vegetables and orchids are found in the forests of Meghalaya. Meghalaya is endowed with a rich orchid flora of nearly 352 species belonging to 98 genera representing 27.08% of the country's orchid flora. A botanical wonder, the pitcher plant (*Nepenthes khasiana*) - an insectivorous species, is found in Jaintia hills, West Khasi hills and South Garo hills of the state (<http://megbiodiversity.nic.in/floral-biodiversity.html>). The wild animals and birds of the state include elephants, tigers, bear, wild buffalo, Hoolock Gibbon etc. (Choudhury, 2003). In Mizoram, forest accounts for nearly 26.76 % of its geographical area (FSI, 2017). The tropical forest of Mizoram has rich variety of flora and fauna. The bamboo groves dominate the lower altitude and orchids of various hues, pinkish-white *Bauhinia*, sparkling Rhododendrons, yellow sunflowers and many other colourful wild flowers are found in the state. Nagaland abounds in serene natural beauty and panoramic views of the hills which in fact are the eastern offshoots of the mighty Himalayas (Sadangi, 2008)

According to the State of Forest Report (FSI, 2017), 59.96 percent of the total geographical area of the state of Tripura is forest, which can roughly be divided into four types, viz. Sal, Garjan, Bamboo and miscellaneous species. The State has rich natural resources. There are 90 mammal species in Tripura and in the aquatic ecosystem 47 species of fish have been found. Endangered species like spectacle monkey, or Chasma Bandar which the state boasts of, is found only in Sepahijala Wild life Sanctuary in Tripura (MoEF&CC, 2012).

The Himalayan state of Sikkim is the storehouse of natural beauty and unique ecosystems like glaciers, alpine meadows and thousands of varieties of wildflowers. Sikkim forest and wilderness areas are inhabited by the Snow-Leopard, Yaks, Bharal or Blue Sheep, Shapi and the endangered Red Panda. Sikkim is a multi-ethnic state. Broadly, the population can be divided into tribal and non-tribal groups. Lepchas, Bhutias, Sherpas are categorized as Scheduled Tribes. Sikkim is a part of hot spot zone, gifted with abundant natural resources and is enriched with about 4500 species of flowering plants, 363 species of ferns and its allies, 11 species of oaks, 28 species of bamboos, 550 species of orchids and 36 species of *Rhododendron*. The

state is also rich in fauna with 144 species of mammals, 550 species of birds and over 600 species of butterflies.

## 2. Initiatives towards sustainable development

### 2.1. Research and Development Infrastructure

Host of reputed research and academic institutions are available in NE region. We have only highlighted a few major institutions involved in ecosystem and biodiversity research. The Institute of Biodiversity and Sustainability Development (IBSD), Imphal, Manipur was established in 2001 under the Department of Biotechnology, Ministry of Science and Technology, Government of India with the main mandate of research on conservation and sustainable utilization of bioresources for the socio-economic development of the region. Its main goal is to work for the scientific management of bioresources in the Indian region falling under Indo-Burma Biodiversity Hotspot, to study and document the unique biodiversity of bio-geographic junction of the Indian and oriental landmasses, to develop biotechnological interventions for sustainable development and utilization of bioresources and to undertake capacity building programmes (human resource development) in bioresources conservation and management. The institute has now established its research centres in the states of Sikkim, Mizoram and Meghalaya. The thrust areas of research of the institute includes study of medicinal plants and horticultural resources, *in vitro* conservation of selected plant resources for sustainable utilization, characterization of plant bioactive compounds and molecular characterization. Bio prospecting of microbial resources such as study of molecular microbial ecology of food and gut fermentation, microbial risk assessment and development of molecular diagnostic platforms, modulation of gut microbiota by fermented foods and building up of a microbial consortium for development of functional foods and bio-ingredients, wildlife conservation using biotechnological tools are other areas being pursued by the institute. IBSD has initiated Entrepreneurship Development Programme for unemployed youth by conducting training programme on sustainable utilization of microbial and botanical products for promoting organic farming, fish hatchery, seed production technology and hands-on training on rearing and post cocoon technology in composite sericulture (IBSD, 2016).

The North Eastern Region Community Resource Management Project (NERCORMP) is a rural development project for six districts of three states of North-East India viz., Assam (Karbi Anglong and North Cachar Hills), Manipur (Ukhrul and Senapati) and Meghalaya (West Garo Hills and West Khasi Hills) with the overall objective of improving the livelihood of vulnerable groups in a

sustainable manner through improved management of resources. It is a joint initiative of the North-Eastern Council, Ministry of DoNER, Govt. of India and International Fund for Agricultural Development (*IFAD*). The aims of NERCORMP include involving the communities more in decision making and planning, to make communities more responsible for the management of their development programmes in order to generate a greater sense of ownership of development interventions and to be more responsive to community's perspectives on needs and priorities. NERCORMP has been concentrating on building up community organisations at the grassroots level called Natural Resources Management Groups (NaRMGs) and Self Help Groups (SHGs). Some major activities include economic and livelihood activities such as promoting viable income generation activities for poor households through production of field crops, horticulture, forestry, livestock fisheries and non-farm activities using sustainable and environmentally friendly activities. It also undertakes programmes involving community based biodiversity conservation, natural resource management and communication activities where communities are assisted to conserve their unique and natural resources and biological diversity, strengthening indigenous institutions and institutionalising new conservation practices and strengthening the information sharing system and documentation of good practices (NERCOMP, 2017).

The CSIR- North East Institute of Science and Technology (NEIST), Jorhat was established in the year 1961 as one of the multidisciplinary laboratories of Council of Scientific & Industrial Research (CSIR) and has been engaged in multidisciplinary R&D work. The mandate of the Institute is to put to effective use the immense material resources of North Eastern region and to provide R&D inputs for developing the economy of the region with the goal to design, develop and deliver knowledge-bases and technologies for gainful application based on natural resources available in region and to improve the quality of life in rural areas. The institute has taken up projects such as bioprospecting, assessment of genetic diversity of medicinal, aromatic and economic plants of North-East India, science and technological interventions in combating malnutrition in women and children. The institute undertakes scientific research on raising of clonal microgarden and validation of microclones of 'Assam Teak' (*Phoebe goalparensis*) through multi-locational trials in North-East Region. The institute provides consultancy services to industries on Environmental Impact Assessment (EIA), biodiversity conservation plan for environmental protection etc. (NEIST, 2017).

The North Eastern Regional Institute of Science and Technology (NERIST) is a science and technology oriented higher education institute in Nirjuli, Itanagar, Arunachal Pradesh funded and controlled by the Ministry of Human Resource and Development, Government of India. The institute has been working for imparting quality education and training to cater to the needs of the region, developing entrepreneurship base in the region and strengthening research and development activities. The Forestry Department of the institute is equipped with infrastructure designed to produce professional personnel with management capacity and ability to take up the future challenges in the field of forestry. The Forestry courses with specializations in the field of forest ecology, wood science and technology, horticulture, taxonomy, ethnobotany, silviculture, biodiversity conservation, wildlife management, biotechnology, microbiology, forest genetics, forest economics and management, environmental restoration etc. have been framed to generate intellectual human resources with better understanding of the conservation aspects and sustainable management of the large forest cover in the North-Eastern states (NERIST, 2014).

The State Forest Research Institute (SFRI) of Arunachal Pradesh was established at Itanagar in 1993 with an aim to increase the understanding and information levels on biodiversity, its conservation and sustainable use recognizing the contributions of local and indigenous communities to the conservation and sustainable utilization of biological diversity through traditional knowledge, practices and innovations. Research and Development platform of the institute includes inventory and documentation of the biological diversity, genetic improvement using biotechnology tools, development of appropriate technological package ensuring bio-safety, silvicultural practices of important forest crops and development of appropriate cultivation and management package along with establishment of referral Herbarium and Museum. It's conservation and management activities involve *ex-situ* conservation and evaluation of germplasms of useful forestry species, establishment of germ-plasm banks, model nurseries, farms and silvicultural plots and *in situ* conservation through tissue culture and cryo-preservation techniques. It also works towards creation of State Biodiversity Information System, including Networking and Information Dissemination System, provides Consultancy Service to public functionaries and user agencies, technology transfer through training and extension services including eco-awareness education.

ICAR Research Complex for North Eastern Hill Region (ICAR RC NEH), Umiam, Meghalaya was established in



1975 by the Indian Council of Agricultural Research (ICAR). Its mandate includes the improvement and development of sustainable farming systems for different agro-climatic and socio-economic conditions of the region, to improve crops, livestock, fishery and to impart training for development of local competence for management of resources to enhance agricultural productivity, to maintain, analyse and project data base resources for perspective planning, to collaborate with the state departments of the region for testing and promotion of improved farming technologies. A web based software SFAR (Soil Fertility Assessment and Recommendation) for assessing the status of soil fertility (poor/medium/high) from the field test results of 12 soil parameters was developed. The institute has all the disciplines of agriculture, horticulture, animal sciences, agricultural engineering, agroforestry, fishery and social sciences to cater to the research needs of the tribal areas of NEH Region including Sikkim. It operates 15 Krishi Vigyan Kendras (KVKs) attached to different centres and HQ for providing on/off campus training to the practising farmers, school dropouts and farm women in the field of agriculture and allied sectors. Considering the entire NEH Region as one unit, the research centres have been so located as to represent the varying altitudes (60-1800 m above MSL) and agro-climates of the region. The research findings of the institute at different centres are being utilized for specific altitudinal range and agro-climatic conditions. It also acts as a repository of information on different farming systems of the region and also provides consultancy (ICAR-RC-NEH, 2016).

There are number of Central and state Universities in the North-East Region. North Eastern Hill University (NEHU), Shillong was set up with the objectives to disseminate and advance knowledge by providing instructional and research facilities in different branches of learning and to pay special attention to the improvement of the social and economic conditions and welfare of the people of the hill areas of the North-Eastern region, and, in particular, their intellectual, academic and cultural advancement. NEHU is a leading University of North East India which attracted students not only from North-East India but from all over the country, as well as scholars from foreign countries. We have now at least one central University in each state besides several state funded and private universities. Various departments and schools have been established in these Universities, which are generating intellectual human resources including research scholars involved in research in different aspects of social, economic, environmental, biological, physico-chemical research platforms pertaining to the North-East region. The department of Environment/ Forestry sciences in these

institutions are capable of carrying out research on areas of natural resource management, environmental monitoring and remediation of degraded ecosystems, forest biodiversity assessment, monitoring and management, forests policies and laws, environmental impact assessment, watershed management, integrated pest management, land reclamation and rural development etc. They can also work on global positioning system studies and micro-seismicity of North-East Region. These institutions are also receiving funding from organisations such as MoEF & CC, DST, DBT, UGC and state governments. The School of Life Sciences, Biochemistry, Biotechnology & Bioinformatics, Botany and Zoology also continue to work on ecosystem-based research and Faculty members are in various Project Advisory Councils/ Task Forces of the funding agencies (NEHU, 2017). These institutions have to undertake studies on impact of development projects on structure and functioning of NE ecosystems.

## *2.2. Regulatory provisions and guideline for sustainable development*

The sustainable development is an approach that aims to ensure that environmental, social and economic progress in the society is achieved without depletion of the natural resources. Therefore, the focus should be on ensuring a strong, healthy and just society. This means that the diverse needs of all people in existing and future communities, personal wellbeing, social cohesion and inclusion, and creating equal opportunity are the components of sustainable development as defined by the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The summit marked the first international attempt to draw up action plans and strategies for moving towards a more sustainable pattern of development. Despite the vast natural resources which could potentially make this region one of the wealthiest regions of India, there are several indications pointing towards natural resource degradation and low economic growth. There are several policy interventions and programmes for economic development of the NE region. Fig. 1 provides details of developmental projects which have been given environmental clearance under EIA Notification of 2006. The setting up of development projects such as Oil Refineries, cement plants, mining, Hydro Electric Power projects, construction of National Highways has been reported to cause ecological degradation and also displace large number of people which can ultimately bring about a drastic change in the demography of North East India. While according environmental clearance (EC), the authorities look at EIA report prepared by the project on likely impact to be created during project implementation in the area. Table 1 provides details of some safeguards stipulated in EC letters for ecosystem improvement and biodiversity conservation.

The Biological Diversity Act, 2002 was India's attempt to realise the objectives enshrined in the United Nations Convention on Biological Diversity (CBD), 1992 which recognises the sovereign rights of states to use their own biological resources. The act aims at the conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner and through a just process. All the NE states have enacted rules to impose restriction on activities related to access to biological resources. The State Biodiversity Boards (SBBs), if deems necessary and appropriate, can take steps to restrict or prohibit the access to biological resources for the following reasons:

- (i) If it is a threatened species, or species that is likely to become threatened due to such access,
- (ii) If it is an endemic species,
- (iii) If the request for access is likely to result in adverse effect on the livelihoods, culture, or indigenous knowledge of the local people,
- (iv) If the request for access is likely to result in adverse environmental impact which may be difficult to control and mitigate,
- (v) If such access would cause genetic erosion or affect the ecosystem function,

- (vi) If the purpose of resource use is contrary to national interest and other related international agreements entered into by the country

Table-2 provides a list of Endangered Species as compiled from National Biodiversity Authority (NBA) for some NE states of the country. The environmental impact assessment reports of some projects brought out significant information on some very important aspects of species and habitat status. On that basis, it was emphasized that Meghalaya has been recognized as a cradle for several endemic species and an important constituent of the biodiversity hotspots spread over North East India. Therefore, as a conservation measure for rich biodiversity of the region, the projects should be initiated on population inventory, propagation and reintroduction of threatened plants and establishment of conservation plots/ areas in respect of following endangered and endemic plants reported to have been occurring in the region:

1. *Pteracanthus griffithianus* (Acanthaceae)
2. *Nepenthes khasiana* (Nepenthaceae)
3. *Argostemma khasianum* (Rubiaceae)
4. *Fimbristylis nigrobrunnea* (Cyperaceae)
5. *Trivalvaria kanjilali* (Annonaceae)
6. *Begonia rubravenia* (Begoniaceae)
7. *Ceologyne ovalis* (Orchidaceae)

Table 1

Important safeguards stipulated under Environmental Clearance for conservation of biodiversity

Sectors	Stipulations for biodiversity conservation
River Valley projects	Biodiversity Management plan, Compensatory Afforestation programme, Identification of species endemic to the project region (e.g. Orchids in Sikkim) and their conservation, Construction of fish hatchery, Documentation and Identification of local aquatic fauna, Biodiversity and Habitat Conservation; Central level Multidisciplinary committee to monitor implementation of environmental safeguards including Biodiversity conservation during project execution.
Mining projects	Precautionary measures to be taken during mining operation for conservation and protection of endangered flora as well as fauna. Action plan for conservation of flora and fauna to be prepared and implemented in consultation with the State Forest and Wildlife Department. Necessary allocation of funds for implementation of the conservation plan to be made and the funds so allocated should be included in the project cost.
Industry projects	Green belt development consisting of plantation with native species in project site and surrounding villages in consultation with local DFO
Refinery projects	Preparation of contingency plan to mitigate adverse impact of increased human activities on wildlife habitats around project area,
Thermal projects	Afforestation and Green belt development consisting of plantation with native species in project site and surrounding villages in consultation with local DFO

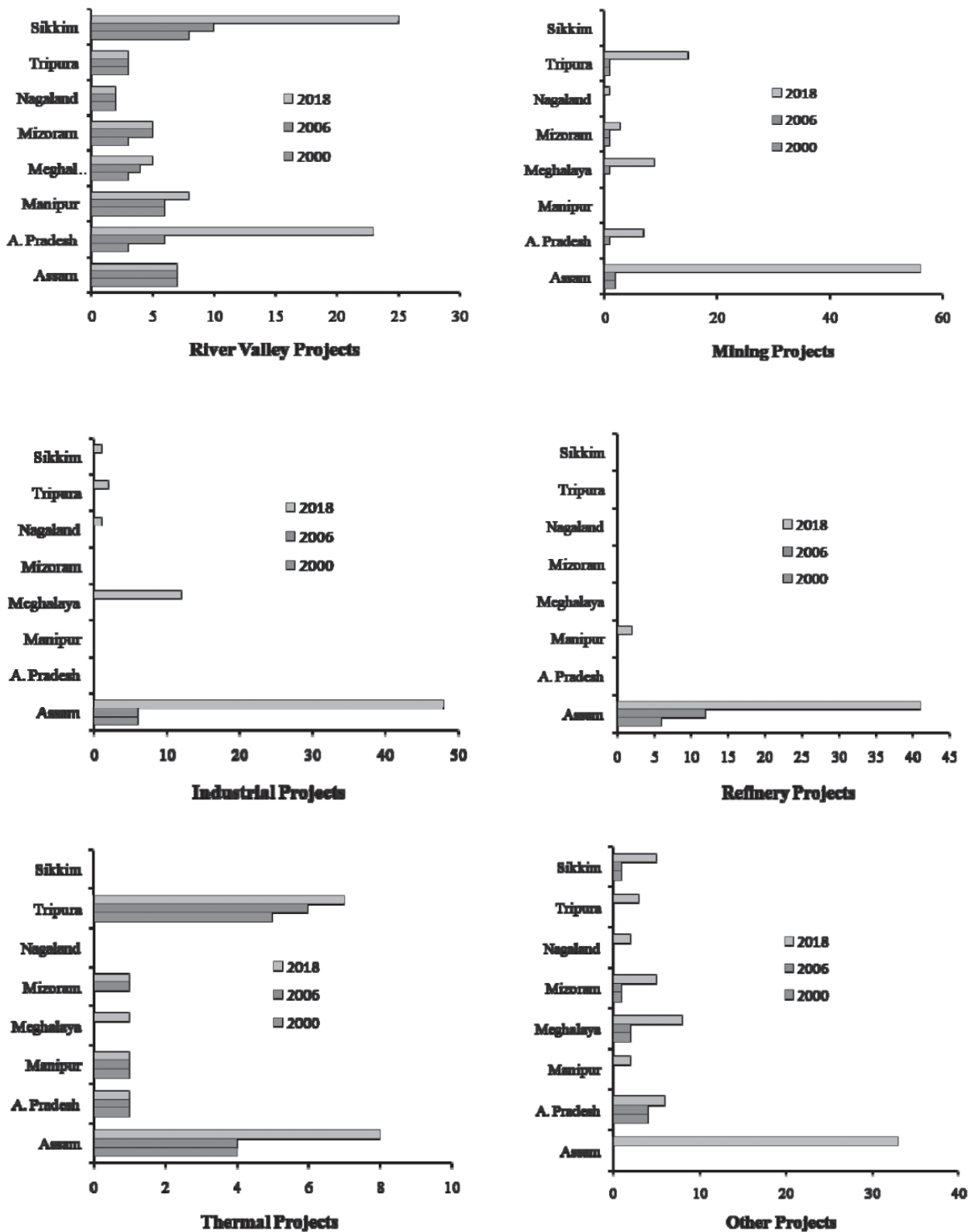


Fig 1. Number of environmental clearances given for construction of developmental projects in states of NE region.

Table 2

List of Endangered Species as compiled from National Biodiversity Authority

Sl. No.	States	Plants	Animals
1.	Meghalaya	<i>Aquilaria khasiana</i> <i>Gymnocladus assamicus</i> <i>Ilex khasiana</i> <i>Jasminum adenophyllum</i> <i>Nepenthes khasiana</i> <i>Nymphaea tetragona</i>	<i>Rhinoceros sondaicus</i> <i>Gyps bengalensis</i> <i>Gyps tenuirostris</i> <i>Sarcogyps calvus</i> <i>Philautus shillongensis</i>
2.	Mizoram	<i>Jasminum wengeri</i> <i>Mantisia wengeri</i> <i>Paphiopedilum spicerianum</i> <i>Paphiopedilum villosum</i> <i>Aquilaria malaccensis</i> <i>Hydnocarpus kurzii</i> <i>Dalbergia pinnata</i> var. <i>acaciaefolia</i> <i>Cinnamomum cassia</i>	<i>Rhinoceros sondaicus</i> <i>Dicerorhinus sumatrensis</i> <i>Felis marmorata</i> <i>Felis timmincki</i> <i>Arctictis binturong</i> <i>Prionodon pardicolor</i> <i>Mustela kathiah</i> <i>Helarctos malayanus</i>
3.	Manipur	<i>Lilium davidii</i> <i>Kalanchoe roseus</i> <i>Rhododendron macabeumum</i> <i>Malus baccata</i> <i>Rhododendron wattii</i>	<i>Rhinoceros sondaicus</i> <i>Dicerorhinus sumatrensis</i> <i>Cervus eldi eldi</i> <i>Ardea insignis Hume</i> <i>Gyps bengalensis</i> <i>Sarcogyps calvus</i>
4.	Tripura	<i>Stichoneuron membranaceum</i>	<i>Gyps bengalensis</i> <i>Sarcogyps calvus</i>

The project proponent should sponsor research and development for conservation of threatened species occurring locally such *Hedychium dekianum* (Zingiberaceae), *Cymbidium eburneum* (Orchidaceae), *Dendrobium devonianum* (Orchidaceae) which, would be carried out by a research or academic institution located in Meghalaya. Further, Conservation Action Plan for preservation of wild fauna shall be formulated and implemented.

### 3. Challenges for sustainable development in North-East India

From the above discussion, it is clear that development challenges in NE region are quite complex compared to other regions of the country. The biodiversity of plants and animals needs conservation interventions, ethno-diversity needs to be protection and development should be sustainable. Tables 3 and 4 provide lists of research projects funded by MoEF, Government of India under two schemes in NE region. While projects in Table 3 relate to development

impact to some extent, there are not many projects in the list addressing the current issues of environmental degradation. We have highlighted a few thrust areas on the basis of our monitoring feedback from the states.

There is strong need to initiate programmes for training and research on environment and development sectors and provide exposure to students and research scholars with latest information in their respective fields of activities and bring them closer to development perspective as far as scientific advancements are concerned. The NE institutions should also involve themselves in consultancy for EIA and biodiversity conservation and monitoring studies for development projects in the region. Although, these institutions continue to produce intellects in academia for the North-East Region and have been directly and indirectly shaping the academic, social and cultural features of the region, the field application and problem solving strategies with a clear vision of sustainable growth and development for the North East region is the need of the hour.



Table 3

List of research projects funded by MoEF&CC under Environmental Research Programme (ERP) in North-East Region (2006-2010).

Sl. No.	Title of the Project	Name of the Institute
1	Phytoremediation of hydrocarbon contaminated soil of Assam.	Dr. S. Deka, Resource Management & Environment Division, Institute of Advanced Study in Science & Technology, Guwahati, Assam.
2	Impact of Natural gas flare on growth and yield development in Rice ( <i>Oryza sativa</i> L.).	Dr. K.K. Baruah, Department of Environmental Science, Tezpur University, Assam.
3	Impact of coal mining on water quality and microbial communities in Jaintia Hills District, Meghalaya.	Dr. H. Kayang Department of Botany, North Eastern Hill University, Shillong, Meghalaya.
4	Trace element analysis of Loktak lake and rivers draining into it and its impact on health.	Prof. N Rajmuhon Singh Dep. Chemistry, Manipur University, Canchipur, Imphal Manipur.
5	Studies on pollution of pond/fishery water of Guwahati with respect to fish health: Remediation by Zeolitic Action.	Dr. Anup Kumar Talukdar Department of Chemistry, Gauhati University, Gauhati, Assam
6	Assessment of toxic elements in water of semi-urban areas of Assam and investigation of the disease related contaminants.	Prof. A.K. Mishra, Department of Chemistry, Gauhati University, Guwahati, Assam
7	Development of environmentally benign process technology for extraction of natural dye of N.E. Region.	Dr. P. G. Rao, North East Institute of Science & Technology, Jorhat, Assam
8	Assessment of anthropogenic activities on soil/water and certain medicinal plants species in and around Bharalu river in Guwahati city.	Dr. Jibon Kotoky, Institute of Advanced Study in Science & Technology, Guwahati, Assam
9	Impact of stone mining on water quality of Tlawng river in Aizawl, Mizoram: Strategy for management of river through eco-restoration of abandoned mine areas.	Dr. B.P. Mishra, Department of Forest Ecology, Biodiversity & Environmental Sciences, Mizoram University, Aizwal, Mizoram.
19	Development of eco-friendly strategies for removal of phenols and other organic compounds form water using highly ordered porous carbon made from tree leaves.	Dr. Prodeep Phukan, Guwahati University, Guwahati, Assam.
11	Selective recovery of ethanol from ethanol-water mixture having the composition of biomass fermentation broth by pervaporation: the efficacy of hydrophobic polyurethane-zeolite mixed matrix membranes.	Dr. Dilip Kumar Kakati, Guwahati University, Assam.
12	Development of a low cost process for fluoride removal from fluoride contaminated water specific to NE Region for public use.	Dr. (Mrs.) Aradhana Goswami, North East Institute of Science & Technology, Jorhat, Assam.
13	Atmospheric deposition of nitrogen and productivity of winter cereal crops in North East India.	Dr. Bhagawan Bharali, Department of Crop Physiology, Assam Agricultural University, Jorhat, Assam.

Table 4

List of projects funded by MoEF&amp;CC under Eco-system Research Scheme (ERS) in North-East Region (2008-2010).

Sl. No.	Title of the Project	Name and address of the Institute
1	Floristic studies on Macrophytic diversity of Nameri National Park (Assam) and Pakke Tiger Reserve (Arunachal Pradesh).	Dr. Nilakshee Devi, Lecturer Deptt. of Botany Guwahati University Guwahati, Assam
2	Studies on the diversity and distribution of soil microarthropod fauna of grassland and adjoining cultivated fields in subtropical ecosystems of Cachar, Assam.	Dr. D.C. Ray, Dept. of Ecology and Environmental Sciences, Assam University, Silchar, Assam.
3	Icthyofaunal diversity and studies on the biology of certain indigenous ornamental fishers of Meghalaya.	Sh. S.N. Ramanujam, Deptt. of Zoology, School of Life Sciences North Eastern Hill University, Shillong, Meghalaya.
4	Algal flora from different habitats of central Assam and conservation of collected strains.	Dr. Farishta Yasmin, Senior Lecturer in Botany, Deptt. of Botany, Nowgong College, P.O. Nagaon, Assam.
5	Distribution and Conservation Strategy of an endangered ornamental fish species <i>Chaca chaca</i> (Ham.- Buch) in Arunachal Pradesh.	Dr. Keshav Kumar Jha, Head, Deptt. of Zoology, Jawahar Lal Nehru College, Pasighat, Arunachal Pradesh.
6	All India Coordinated Research Project on reproductive biology of four rare endangered and threatened (RET) tree species namely; <i>Michelia punduana</i> Hook. f & Thoms.; <i>Rhododendron macabeanm</i> Watt. f. ex Balf; <i>Rhododendron wattii</i> Cowan and <i>Acer oblongum</i> Wall ex. DC. var. <i>microcarpum</i> Hiern of Nagaland & Manipur (NE).	Dr. S.K. Chaturvedi, Head, Department of Botany, Nagaland University, Hqs. Lumami, PO Mokokchung, Nagaland.
7	All India Coordinated Research Project on reproductive biology of four rare, endangered and threatened (RET) tree species namely: <i>Aquilaria malaccensis</i> Lamk. (Syn = <i>Aquillaria agallocha</i> ) (Thymeleaceae), <i>Gymnocladus assamicus</i> Kanj. ex P.C. Kanjilal (Caesalpinaceae), <i>Ilex khasiana</i> (Aquifoliaceae) and <i>Illicium griffithii</i> Hook. f & Thoms. (Illiciaceae) of North East India particularly in Arunachal Pradesh and Meghalaya.	Prof. N. Venugopal, Professor, Centre for Advanced Studies, NEHU, Shillong, Meghalaya.

As per the Strategy Report, 2007 (World Bank, 2007) by the Sustainable Development Department of the World Bank, the process of development and growth in North-Eastern Region of India is being met by many challenges. It reports that for a region to benefit from its natural resource wealth, certain institutional elements must be present which include clear institutional arrangements, participatory decision making by the different levels of stakeholders (ranging from state governments to water users and forest-dependent producers), clear and transparent rules and regulations and equitable enforcement. In addition, an integrated management system is required with regard to

river basins and natural resources. However, these institutional arrangements do not fully exist in the North-East today. Certain developmental issues in all sectors has been taken up by the central government but due to weak state capacity, complex and incomplete institutional arrangements, incomplete knowledge base for the natural resource management and non-involvement of local stakeholders, the current approaches have not yielded the needed benefits to local populations. Therefore, there is a need for an integrated approach that enhances cooperation at and between regional and local levels for developing a shared vision of costs and benefits through strategic planning

and infrastructure interventions that create a sustainable ecosystem to improve the lives and livelihoods of communities and citizens. There is a strong need for better planning for the biodiversity, forestry and water-related sectors. Better management and development could generate the greatest impact by providing communities with assurance that investments in industries and infrastructure are sustainable. Hydropower sector also emerges as one of the best opportunities for development in the region as revenue from hydropower projects could potentially double the region's net state domestic product (NSDP).

The region's wealth of biodiversity has been well highlighted but there are still significant gaps in existing knowledge. The developmental pressure (Fig.1) for economic growth and biotic interferences have resulted in deforestation, mining and quarrying, jhumming, charcoal-making, construction of reservoirs and dams, overharvesting of medicinal plants, drying up of wetlands, overfishing and pollution of water bodies. This has impacted the ecosystems and their components like flora and fauna in the North-Eastern Region. In addition, conflicts between development and conservation are likely to have negative impacts on species conservation. No doubt, the biological resources can be used sustainably and beneficially only at both regional and local levels, by fully involving local communities in the region and make efforts to catalogue and document existing plants and animals and their potential uses. Proper institutional development is necessary by integrating the institutions to a research consortium consisting of the region's universities, to have long term ecological initiatives on biodiversity-related work, for which a considerable part of this can be achieved through implementation of biodiversity-oriented projects in existing universities and institutions of the region. The development and institution interface as highlighted above will go a long way to ensure implementation of biodiversity conservation in NE Region of India.

## References

- Behera, M. C. (2004). *Globalisation and Development Dilemma: Reflections from North-East India*. Mittal Publications, New Delhi.
- Choudhury, A. U. (2003). Meghalaya's vanishing wilderness. *Sanctuary Asia* 23(5): 30–35.
- ENVIS Centre Sikkim (2007). *State of Environment Report Sikkim*, ENVIS Centre Sikkim, Forest, Environment & Wildlife Management Department, Government of Sikkim, Gangtok, pp. 183.
- FSI (2017). *India State of Forest Report, 2017*, Forest Survey of India, Ministry of Environment & Forests, Dehradun.
- Gonmei, G. H. (2013). Hills economy of Manipur: A structural change. *Journ. North East India Studies*. 3(1): 61–73.
- Government of Mizoram (2013). *State Agriculture Plan*, Agriculture Department, Government of Mizoram, Aizawl.
- Government of Tripura (2016). *Economic review of Tripura, 2015-16*, Directorate of Economics and Statistics, Planning (Statistics) Department, Government of Tripura, Agartala, pp. 319.
- IBEF (2018). *Manipur State Report, 2018*, India Brand Equity Foundation, New Delhi.
- IBSD (2016). *Annual Report, 2015-16*, Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur, pp. 146.
- ICAR-RC-NEH (2016). *Annual Report, 2016*, ICAR-Research Complex for North Eastern Hill Region, Umiam, Meghalaya, pp. 179.
- Khan, M. L., Shaily, M. and Bawa, K. S. (1997). Effectiveness of the protected area network in biodiversity conservation, a case study of Meghalaya state. *Biodivers. Conserv.* 6: 853–868.
- Meghalaya Biodiversity Board (2015). *Annual Reports for the years 2012-2015*, Meghalaya Biodiversity Board, Shillong, Meghalaya.
- MoEF&CC (2012). *Protected area network in India*. Ministry of Environment and Forests, Government of India. pp. 32.
- NEHU (2017). *Annual Report, 2016-17*, North Eastern Hill University, Shillong, Meghalaya, pp. 424.
- NEIST (2018). *Annual Report, 2017-18*. CSIR-North East Institute of Science and Technology, Jorhat, Assam, pp. 180.
- NERCORMP (2017). *NERCORMP: Success Stories*. North Eastern Regional Community Resource Management Project, North Eastern Council, Ministry of Development of North Eastern Region, Government of India, Shillong, Meghalaya.
- NERIST (2014). *Annual Report, 2013-14*, North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Itanagar, Arunachal Pradesh, pp.
- Sadangi, H. C. (2008). *Emergent North-East: A way forward*. Isha Book Publications, New Delhi.
- SFRI (2018). *State Forest Research Institute*, Government of Arunachal Pradesh, Itanagar (<http://sfri.nic.in>).
- World Bank (2007). *India-Development and Growth in Northeast India: The natural resources, water, and environment nexus*. Washington, DC, pp. 112.