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Ecosystem-based Approaches for Resilience Building in Himalayan Landscapes

Insights for Climate Change and Disaster Risk Reduction

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Editors
Y. D. Imran Khan
WOTR- Centre for Resilient Studies (W-CReS)
Watershed Organisation Trust (WOTR)
Pune, Maharashtra, India

Sunil Nautiyal
Centre for Ecological Economics and Natural Resources (CEENR)
Institute for Social and Economic Change (ISEC)
Bengaluru, Karnataka, India

G. B. Pant National Institute of Himalayan Environment, Kosi - Katarmal, Almora, Uttarakhand, India

Mrinalini Goswami
Researcher in Sustainability Science
Bengaluru, Karnataka, India

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Chapter 8
People's Perceptions, Practices, and Traditional Knowledge on Climate Change in Meghalaya

Joram Beda, Albert Chiang, Vivek Lyngdoh, Marbakor Mary Lynrah, Amica L. Nongrang, Evenstone Wahlang, and Nivanaliza Wahlang

Abstract Climate change is a reality that is experienced globally. However, climate response planning requires an understanding of local and sector-specific vulnerabilities and the extent of their impacts. Recording people's perceptions of climate change and their traditional knowledge of resources and resource utilisation for their day-to-day activities is important in understanding past climate experiences and finding ways to tackle their impacts at the local and sectoral levels. The tribal communities in Meghalaya, through long-term trial-and-error experiments, have developed an elaborate, functional, and generally democratic system of conservation and management of forests and associated natural ecosystems, now offering a rich source of Indigenous traditional knowledge. The indigenous tribes of Meghalaya can be classified into three main groups—*Khasi*, *Pnar* or *Jaintia*, and *Garo*. The *Khasi* and *Jaintia* are believed to be the descendants of the Proto-Australoid Monkhmer race. In contrast, the Garo are descendants of the Tibeto-Burman race, who migrated from Tibet. Their cultural traits and ethnic origins remain distinctive due to their geographical isolation. The State of Meghalaya is governed under the Sixth Schedule of the Indian Constitution, which provides spe-

J. Beda
Meghalaya Climate Change Centre, Government of Meghalaya, Shillong, India

Meghalaya Basin Development Authority, Government of Meghalaya, Shillong, India

Planning, Investment Promotion and Sustainable Development Department, Government of Meghalaya, Shillong, India

A. Chiang (✉)
Meghalaya Climate Change Centre, Government of Meghalaya, Shillong, India

BRIC-Institute of Bioresources and Sustainable Development, Imphal, India
e-mail: Albert.IBSD@gov.in

V. Lyngdoh · M. M. Lynrah · A. L. Nongrang · E. Wahlang · N. Wahlang
Meghalaya Climate Change Centre, Government of Meghalaya, Shillong, India

Meghalaya Basin Development Authority, Government of Meghalaya, Shillong, India

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cial provisions for administering tribal areas in the northeastern states, including Meghalaya. The Sixth Schedule empowers local governance and ensures that tribal interests are safeguarded. The functions included in the Sixth Schedule are forest conservation, land use regulation, water resources management, and biodiversity conservation to help maintain the region's ecological integrity and ensure that natural resources are used sustainably. The present study adopts the bottom-up approach to understand the climate impacts, identify best practices for adaptation, and look into indigenous practices that have served as sustainable living techniques with the power to overcome challenges. The tribal communities in Meghalaya have preserved and used traditional knowledge for generations as an integral part of life. Sacred groves, living root bridges, bamboo drip irrigation, etc., are some of the unique practices that showcase the local forest-related knowledge and practices and associated social institutions developed over generations under changing environmental conditions by Indigenous communities. These indigenous practices represent an important source of adaptive capacity for local forest-dependent communities in the face of climate change impacts on the ecosystems.

Keywords Climate change · Traditional knowledge · Indigenous · Adaptation · Mitigation

8.1 Introduction

Climate change is one of the biggest challenges faced by the world today. Evidence shows that temperature and rainfall patterns have modified hydrological cycles and biological systems across the globe (Bolan et al. 2024). The Intergovernmental Panel on Climate Change (IPCC) gives convincing evidence that climate change is real and highlights that developed and underdeveloped countries will be the worse affected (IPCC AR5 2013). Further, long-term shifts in annual averages and seasonal patterns of precipitation, temperature, and humidity, as well as erratic and extreme weather events leading to increased risk of floods, drought, and fire, are anticipated for the future (Coumou and Rahmstorf 2012; Hatfield et al. 2011).

IPCC Fourth Assessment Report (2007) noted that Indigenous knowledge is 'an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change'. This was reaffirmed at the 32nd Session of the IPCC in 2010, which stated that Indigenous or traditional knowledge may prove useful for understanding the potential of certain adaptation strategies that are cost-effective, participatory, and sustainable. Therefore, documenting traditional knowledge is essential for understanding the local-level impacts of climate change and the options a community might consider for adaptation appropriate to its ecological and sociocultural environments (UNFCCC 2013). There are two recognised pathways to tackle the issue of climate change, viz. mitigation and adaptation. Adaptation has been recognised as the most workable pathway that can be taken up at all levels, from international and national to local.

Policies are meaningful only when accompanied by local, micro-level adaptation initiatives that help to face the challenges of the changing climate.

Like other parts of the world, Meghalaya is also experiencing the impacts of climate change. Important sectors like agriculture, water resources, forests, human health, sanitation, and rural development are facing the effects of climate change and, given the trend, are likely to be affected in the future (Meghalaya State Climate Change Action Plan 2014). Within the State, the rural population, especially the farmers and marginalised sections, are particularly vulnerable as they often lack adaptive capacity in terms of resources and opportunities to adapt to climate change (Meghalaya State Climate Change Action Plan 2014).

Considering the essentiality of integrating peoples' understanding of climate change and their traditional knowledge (potential adaptation) in adaptation planning, this chapter draws on the peoples' perceptions, traditional knowledge, behaviours, and policy preferences associated with climate change, with particular references to rural areas. It also provides an understanding of climate change vulnerability and the level of awareness of the rural population.

8.2 Study Area

Meghalaya, 'the abode of clouds', is located between 24° 58′ N–26° 07′ N and 89° 46′ E–92° 51′ E and spreads over an area of 22,429 sq. km (Fig. 8.1). Meghalaya, with a boundary length of 1239.61 km, is a landlocked State surrounded by Bangladesh (South and West) and Assam (North and East). The state has 12 administrative districts and 46 blocks, comprising 6459 notified census villages (Directorate of Economics & Statistics 2018). The State has three Autonomous District Councils, viz. Khasi Hills Autonomous District Council, Jaintia Hills Autonomous District Council, and Garo Hills Autonomous District Council give special provisions with respect to the application of laws made by the Parliament and the State Legislature to the tribal areas in Meghalaya.

Meghalaya is a part of the Indo-Myanmar biogeospherical region, one of the world's mega biodiversity regions. Nokrek Biosphere Reserve; Balpakram National Park; Nongkhyllem, Siju, and Baghmara Wildlife Sanctuaries; and a large number of sacred groves found in different parts of the State are the main preserves of biodiversity (State of Environment Report, Meghalaya 2005).

Meghalaya is inhabited by three major tribes: the *Khasi*, *Jaintia,* and *Garo*. Other tribes include *Hajong*, *Koch*, *Karbi*, *Rabha,* and *Bodo*. As per the Census Report, 2011, Meghalaya has a total population of 2,966,889, of which male and female are 1,491,832 and 1,475,057, respectively. With a population growth of 27.95% this decade, the State constitutes 0.25% of India's total population (Directorate of Economics & Statistics 2023). Of the total population, 595,450 (20.07%) live in urban regions, of which 297,572 are males and 297,878 are females. On the other hand, around 2,371,439 (79.93%) constitute the rural population, of which males and females were 1,194,260 and 1,177,179, respectively. The sex ratio in Meghalaya

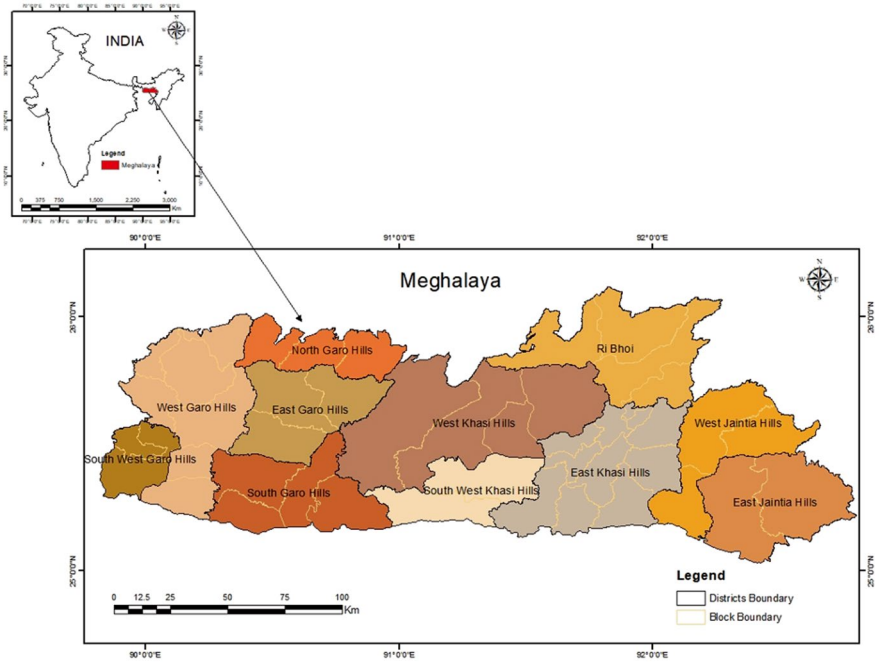

Fig. 8.1 Location map of Meghalaya

is relatively high, with 989 females per 1000 males. The urban region has a higher average literacy rate of 90.79% compared to the rural regions of 69.92%, where the literacy rate of males is 75.95%, and females are 72.89% (Directorate of Economics & Statistics 2023).

8.3 Methodology/Study Approach

As the study is Statewide, it is targeted to cover all rural areas, including 46 blocks under all 12 districts of Meghalaya. So far, the study has covered 163 villages in 10 districts, comprising around 700 cross-sectional participants/respondents. The primary data on people's perception of climate change and its impacts on different sectors, viz. water resources, agriculture, forest, livestock, fishery and human health, and socio-demographic profile, was collected through a well-designed questionnaire. The individual questionnaire was designed and translated into local vernaculars for easy comprehension of the questions. The questionnaires covered all related climate change issues at the local level and allowed the participants to respond based on their knowledge and experiences.

Traditional knowledge and practices are an integral part of the day-to-day life and activities of the rural population. As lives and livelihoods have been impacted

by climate change, it is important to document how people have been using traditional knowledge in their everyday livelihood activities, which can be adopted as an adaptation. The standard approach of focus group discussion (FGD) was adopted to document traditional methods used for weather forecasts and decision-making to protect resources and livelihoods. Besides, traditional knowledge in different sectors like agriculture, livestock, water, forest conservation, and management was also captured. The documentation involved the usage of a semi-structured questionnaire as well as audio-visual devices.

8.4 Results/Findings

8.4.1 People's Perceptions Align with Scientific Predictions Regarding the Impact of Climate Change

The study encompasses a cross-sectional survey of participants at the village level. The target group for the study was the rural population of Meghalaya. Given the study's objectives and the availability of major resources (forest and water) upon which the livelihood activities of the large population depend, an arbitrary selection of survey villages was made. The target group for the survey comprised heterogeneous participants from different age groups, genders, education, and occupations.

The bottom-up approach for identifying local vulnerabilities has been recognised as an important tool globally. These bottom-up and top-down approaches together provide a complete and comprehensive understanding of climate and climate-induced impacts in an area or region. The vulnerability, coping and adaptive capacity, and resilience to climate change could differ from one place to another. International and macro policies are meaningful only when accompanied by local, micro-level initiatives that help them to innovate and adapt to face the challenge posed by the changing climate. Documenting people's perceptions, traditional knowledge, and understanding of climate change and its impacts will play an important role in identifying sectoral vulnerabilities and framing adaptation strategies at local levels.

The study revealed that climate change is already felt in Meghalaya and is expected to continue for a longer period. Crucial sectors like agriculture, water resources, forests, and health are likely to be affected by climate change. The rural population, especially farmers and marginalised sections, tend to be particularly vulnerable as they often lack the resources, power, and opportunities to adapt to climate change.

The findings from the present study validate what the IPCC Fifth Assessment Report (2013) confirmed: climate change is real and affects every aspect of livelihood and natural resources in the state.

8.4.2 Observed Climate Variabilities

Although people are not directly aware of climate change phenomena, they have observed changes in weather patterns over the years through their experiences. The study reveals an increase in temperature, irregular rainfall, an increase in hot days, and a decrease in rainy days over the years. The findings also indicate an increase in the frequency of extreme climate events such as landslides, floods, storms, hailstorms, and drought-like situations in certain parts of the State. These variabilities have significantly impacted their livelihood activities and resources, and the extent of the impact is not limited to a specific sector.

8.4.3 Sectoral Impacts of Climate Change

8.4.3.1 Water Resources

Climate change variability impacts the state's major water sources, such as rivers, streams, springs, bore wells, and ponds. The quality and quantity of water sources, underground and surface, are declining/deteriorating throughout the State.

8.4.3.2 Human Health

Human health is a serious concern in the State, mainly vector and waterborne diseases, which may emerge as a more significant threat due to climate change. People have perceived an increase in the occurrences of malaria and dengue in the State over the last two decades. Random occurrences of cholera have also been perceived as an important health concern in the State.

8.4.3.3 Agriculture

People's livelihoods largely depend on agriculture, the most climate-sensitive sector. As the State is running a deficit in food grains required to meet the food needs of 2.69 million populations, the sector needs extra attention and effective adaptation measures to ensure food security. Farmers' perceptions of climate change reflect a clear recognition of its impacts, particularly evident in shifting sowing periods.

Most of the farmers are aware of climate variability, and in response to that, they have adjusted their crop sowing time by a fortnight to a month. They have also observed increased occurrences and severity of pest attacks compared to the past. The State has faced significant crop damage, mainly by heavy hailstorms followed by heavy storms and drought. The study further shows that several factors have caused a reduction in crop production, and rainfall variability is seen as the most important potential

detriment for crop or food production. Other noticeable factors responsible are variable temperatures, soil quality reduction, and increased pest and weed invasions.

8.4.3.4 Forests

Climate change and forests are closely linked. Meghalaya has forest and tree cover of almost 76% of its geographical area and 0.57 ha per capita of forest and tree cover, which is higher than the national average (ISFR 2021). However, over the last 30 years, communities have perceived a decline in forest cover. Major factors for reducing forest cover are logging, infrastructure/industrial development, forest fires, and agricultural expansion. A significant percentage of respondents also perceived climatic variability as an important factor responsible for the decline in forest cover. There has also been a noticeable decrease in the availability of timber-based forest products like log wood, fuel wood, bamboo, cane, and non-timber forest products like wild vegetables, fruits, potatoes, honey, etc. The study shows that no single factor is responsible for reducing forest cover. Still, a combination of anthropogenic and climatic factors (temperature and rainfall variability) has led to the decline in the forest cover and the supply of timber and non-timber forest products. This may lead to habitat loss of wildlife, causing potential increases in incidences of man-animal conflict, damage to property, and loss of life. Reducing forest and ecosystem services will impact the communities dependent on the forest for their livelihoods.

8.4.3.5 Livestock

The health and productivity of livestock are also perceived to be influenced largely by climate variability (extreme heat and cold) and associated factors like disease outbreaks and water and fodder scarcity. In the last 30 years, there has been a declining trend in livestock rearing, mainly due to diseases and financial constraints. Livestock disease outbreaks have become frequent in the last few years, making the herders reluctant to continue with the traditional activity. The major livestock diseases observed were plague, flu, and seizure in poultry and swine, the main livestock-based activity.

8.4.3.6 Fisheries

The state's fishery sector is in its nascent stage, and much impetus is being given to its development. Though pisciculture has the potential to contribute to food and livelihood security, this practice has not achieved its status of viable economic activity. Fishery, being a climate-sensitive sector, is vulnerable to climate variability. The farmers engaged in fish farming believe climate change influences this sector. Extreme heat has been seen as a significant factor affecting the health and productivity of fish.

8.4.4 Adaptive Strategies and Local Responses

The rural community is aware of climate variability and has used their traditional knowledge to cope with climate vagaries. However, with the changed climate scenario, traditional methods require supplementation with scientific climate adaptation methods. Farmers and labourers constitute the major working group in rural areas engaged in agriculture and allied activities. The study's findings suggest that agriculture emerges as the most climate-vulnerable sector, which will impact State economic development and farmers' livelihoods in the face of climate change.

8.4.5 Impacts of Climate Change: Local Ecological Indicators

Scientists and other observers of the natural environment are now seeing many impacts on the land that appear to be linked to climate change. They have noted climate-induced changes in at least 420 physical processes, species, and communities. They can now say with some certainty that it is affecting different species in different locations in different ways. Microlevel indicators at the local level might be more sensitive to climate change and could serve as early warning systems. Therefore, it is required to identify specific tangible, easily observable, and technically feasible indicators of local climate conditions for a given geographic area. Such indicators for specific regions need to be identified and recorded in the coming years to report changes in the region's climate and the impact those changes have on the region's environment, biodiversity, economy, and quality of human life. The people have provided important clues about climate change based on ecological indicators. Some of the micro-level indicators observed by the village communities are given below:

- One of the most striking indicators, as perceived by the people, is the reduction in nut size and productivity of *Areca catechu.*
- Black rot incidence in *Piper betle* is increasing in many villages in the State.
- Increased incidence of late blight in potatoes recently, causing severe yield losses to the farmers.
- Early ripening of certain plant species can also be a marking indicator of climate change. Notably, guava, wild pepper, and pitcher plant have recently changed their ripening period.
- Enhanced 'gall' formation in *Cinnamomum tamala*, leading to drying of the plant.
- The farmers have changed the sowing time of maize and potatoes.
- The orange fruit growers have noticed a drastic reduction in the quality of the fruit. The fruits look good visually, but the insides are usually infected or rotten.

- In Jaintia Hills, a plague locally called *Kjut Khlam*[1] occurs twice a year during March and December, causing the death of livestock.
- An increased attack of white insects was observed on flowers like *chrysanthemum* and marigold.
- Small insects have been seen attacking the planted paddy seeds in the field.

8.5 Traditional Knowledge: A Coping Mechanism and Adaptative Strategies

IPCC AR 4 (2007) states that Indigenous knowledge is 'an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change'. Traditional knowledge has mainly been used to supplement scientific observations of climate change and its impacts. Traditional knowledge has been recognised as a contributor to a knowledge base, alongside science, for promoting effective adaptation and understanding the impacts of climate change. With the increased global recognition and acceptance of traditional knowledge in observation, assessment, and adaptation planning, it is now seen as a locally available effective measure for climate change adaptation in agriculture, post-harvest grain management, water, health, livestock, forest, soil management, etc. The involvement of communities in decision-making and adaptation planning at the local level provides low-cost, effective, and sustainable adaptation measures.

The rural communities in Meghalaya have preserved and used traditional knowledge for generations as an integral part of life. The focus group discussions reveal much of the traditional knowledge utilised in climate-sensitive sectors such as agriculture, livestock, and human health. Albeit its former relevance, some of the traditional practices have lost their effectiveness. The traditional knowledge documented in the study is provided in the following table (Table 8.1).

Rural communities in Meghalaya are always seen as a huge repository of traditional knowledge and beliefs. These beliefs and practices vary from village to village and community to community, symbolising the State's richness and diversity of knowledge. Rural communities interact closely with nature and can easily observe any behavioural changes in plants and animals.

Some of the interesting observations of rural communities are listed below.

Behavioural Indicators in Predicting Weather Phenomena

- The nesting behaviour of an insect (locally called Jongsok) indicates the number of flood occurrences. One protruding nest twig would indicate one flood and so on. Interestingly, the twig's length indicates the flood's severity and scale.
- The ants coming out from the burrows indicate the onset of monsoon.

[1] "Kjut Khlam" or plague is a generic term used by the Pnar (Jaintia) community in Meghalaya. It translates to "plague-like situation", causing illness or diseases in the livestock population.

Table 8.1 Traditional knowledge and adaptation: sector-wise

	Traditional knowledge and adaptations		
Region	Agriculture	Livestock	Human health
Garo Hills	i. Pomelo (*Citrus maxima*), locally called *jambura*, and a flower locally called *Dosimah* are used as pesticides ii. Crop seeds are stored in earthen pots covered with straw and kept in a particular place called *Ongagre* iii. To keep pests and insects away, the locals would pierce a stick through a crab and place it in the fields iv. The farmers are opting for crop diversification with a growing interest in cash crops like pineapples, rubber, and cashew nut v. In the North Garo Hills region, numerous rice varieties are produced, like Sali, Black Johai, Malbok, Duria, Keju, and Minal (sticky rice). Intercropping of rice variety is practised to protect crops from a mass infestation of insects and pests. Varieties like Keju, Minal, and Malbak are prone to pest attacks, while Black Johai is highly pest resistant (interestingly, despite Black Johai being pest resistant, the locals do not prefer to grow it because of its low yield) vi. The farmers rotate from Indigenous rice variety to hybrid variety after 3 years of cultivation since they noticed a reduction in the yield	i. The cows that are selected for breeding must have no marks located at the back of the navel ii. The juice of the pomelo fruit is mixed with the feed to cure livestock diseases. The fruit is also dried and can be stored for later usage. The tree is widely available and each house has 3–4 trees iii. The root of a plant (locally called Nengribengri budu) is wrapped around the leg of the cow to treat fracture iv. The juice of *Citrus indica* and juice of *Citrus macroptera* are used as medicines to cure the common diseases of cattle. *Citrus macroptera* is mixed with the feed to cure livestock diseases and also to treat the loss of appetite in the animals v. Bamboo shoot is given to pigs to keep them healthy	i. There are herbal medicines that are available and used for menstruation problems, like *Dillenia pentagyna* (Agatchi budu), chram budu, *Careya arborea* (Gimbil budu), and Sokchon budu (least in quantity) ii. Tembil budu is used to treat bone fractures but is not readily available anymore

(continued)

Table 8.1 (continued)

Region	Traditional knowledge and adaptations		
	Agriculture	Livestock	Human health
Jaintia Hills	i. Pest and insect diseases are usually cured by spraying tobacco water on the plants ii. Lime is applied at the tree trunk to prevent disease attacks iii. Tomato is seen to be resistant to pest and insect attacks and can also survive in water-deficit areas	i. A mixture of onion, salt, and turmeric/rice, onion, and turmeric is used for treating poultry diseases ii. Ginger and turmeric are given to livestock to treat cough and cold iii. Sugar syrup is given during dysentery	i. Collection and usage of water from pre-monsoon showers are generally avoided, considering the high concentration of impurities risking human health
Khasi Hills	i. Branches of *Semecarpus anacardium* (Dieng-Sohbhala) and *Pinus kesiya* (Dieng-Kseh) are used for the prevention of pest infestation (white rot) in paddy. These branches are kept near the water inlet to the paddy fields ii. Lime and tobacco mixed with water are used as a pesticide iii. Seeds are visually checked for any deformity and are stored in a dry place iv. Ginger is stored underground v. People prefer to cultivate ginger over *Colocasia*	i. A ginger sp. *Zingiber zerumbet* (local nomenclature Sying blei) is given to the reared animals as part of their feed to prevent heat stress and skin diseases ii. The leaves of *Schima* sp. are tied around the neck of the animals to prevent insect attacks	i. Leaves of *Colocasia* and roots of lily are used to treat fever but are no longer effective ii. A local herb (Miniraid) is used to heal bone fracture iii. Tubers of *Flemingia vestita* (Sohphlang) is eaten as a natural control for intestinal worms iv. Bamboo shoot is considered unhealthy due to its properties to revive illness v. The fluid of an unopened pitcher plant flower (*Nepenthes khasiana*) is used as an eye drop to cure cataracts and night blindness. It is also used in treating gastro-intestinal problems, diabetes, and gynaecological problems

- Birds nesting on top of trees indicate no occurrence of cyclones/thunderstorms, while nesting on big branches indicates heavy rainfall.
- The laying of eggs by insects on cow dung indicates heavy rainfall.
- Spider webs weaved on grass indicate calm weather.
- When the *Chengari* insect makes noise, it symbolises the time to sow paddy.
- An increase in the population of small insects like ants indicates an increase in temperature.
- Coming out of an insect called *Ah Skhang* from its burrow predicts rainfall.
- The arrival of flying ants indicates the time for vegetation to bloom; when they do not, it symbolises delayed blooming.

8.6 Knowledge and Practices Developed Over Generations Under Changing Environmental Conditions by Indigenous Communities

8.6.1 Sacred Groves: Sanctified Solutions for Carbon Sequestration/Sink

The adaptive and mitigation strategies that can be taken up to combat climate change in the State can be drawn by efficient management and utilisation of rich biological diversity and forest wealth. The prevalence of community-conserved forests such as sacred groves can be tapped to adapt and mitigate the changing climate. The hill region has a time-tested local governance mechanism through traditional institutions and is predominantly inhabited by ecosystem people. Traditionally, the tribal communities in Meghalaya have been preserving small patches of virgin forest based on their religious belief since immemorial. Sacred groves represent a traditional way of protecting forests and biodiversity from human interference on grounds of religious beliefs and are considered a key reservoir of biodiversity. Traditional rules support conservation by limiting activities inside the sacred forests. These forests have been reported to be relict forests and may be the only remaining climax vegetation of an area (Gadgil and Vartak 1976). The sacred groves in the State enjoy legal support as they are covered by the United Khasi and Jaintia Hills Autonomous District Council (Management and Control of Forests) Act, 1958. The sacred groves in the State are known as *Law Lyngdoh, Law Niam,* and *Law Kyntang*, depending on where they are located. Around 133 sacred groves have been documented in the state, spread over approx. 2507 ha area across the State (Forest and Environment Department 2023–2024). According to several reports, sacred groves hold tremendous species diversity and richness, even far more than disturbed forests. Besides, sacred groves provide ecosystem services through carbon sequestration, soil erosion control, water quality, and underground water balance, maintaining the hydrological cycle and ecosystem balance (Tiwari et al. 1998). Several perennial streams originate from 58 of these groves, providing water

to the nearby community. The sacred groves also help maintain the ecosystem's health, reduce habitat destruction, conserve the viable population of pollinators and predators, and serve as the potential source of propagules required for colonising wastelands and fallows. The sacred groves still possess a great heritage of diverse gene pools of many forest species, many of which are endemic.

The tribal communities in Meghalaya, through long-term trial-and-error experiments, have developed an elaborate, functional, and generally democratic system of conservation and management of forests and associated natural ecosystems. Several forest and natural resource management lessons can be learned from the institutional structure and decision-making system of the evolving and dynamic institutions of tribal communities of the region.

8.6.2 Living Root Bridges: Weaving Resilience Over Generations

Climate change should not be solved with the same approach that created the problem. Indigenous technological innovations such as the living root bridges, locally known as jing kieng jri, are a testament to the ingenuity of the *Khasi* and *Jaintia* tribes and offer valuable lessons in sustainable living and climate resilience. They exemplify how traditional knowledge and practices can contribute to modern environmental challenges.

Meghalaya receives the highest rainfall in the country. The state houses Mawsynram and Cherrapunjee, which are ranked as the wettest places in the world. The average rainfall at Cherrapunjee during the last 35 years has been 11,952 mm (470 inches), and there were several years when it was substantially more than this. In the past 35 years (1970–2005), the State has experienced increased precipitation. Naturally, the monsoon comes with the risk of periodic floods, storms, and cyclones that destroy all the bridges, except for the state's unique and exclusive living bridges developed by the indigenous people of Meghalaya (Paka 2022). The *Khasi* tribe of Meghalaya has developed this ingenious 'biotechnology' using their 'bio-engineering skills' (Mathew 2005) in dense forests and wet areas prone to environmental disturbances.

The building process involves tweaking the aerial roots of *Ficus elastica*, commonly known as rubber plants, across deep river valleys and gorges (Shankar 2015). These 'ethno-bio-engineered bridges' grow up to 50–100 feet, with a carrying capacity of more than 50 people at once and a life span of around 500–600 years (Chaudhuri et al. 2016), which only get stronger with time, unlike any artificial bridges. They offer potential eco-technology ideas and options for mitigating commutation and other problems in rural areas (Chaudhuri et al. 2016). The *Khasi* applying this technology to damaged steel suspension bridges shows its superior nature, success, and relevance while offering long-term sociological resilience and sustainable community-based infrastructure solutions (Shankar 2015).

Living root bridges are effective adaptive measures without much spending but a community action in dealing with climatic extremes like floods and storms. This local-level approach ensures the sustainability of these structures for future generations. They are incredibly resilient to extreme weather conditions such as heavy rainfalls and flash floods, which are becoming more frequent due to climate change. Unlike conventional bridges, they grow stronger over time and can withstand the harsh climatic conditions of Meghalaya (Paka 2022). They also provide other ecosystem services that mitigate climate change impacts, such as *Ficus elastica*, which absorbs the devious greenhouse gas carbon dioxide from the atmosphere. They aid in soil stabilisation and the prevention of landslides. In addition, they support a diverse range of plant and animal life, contributing to the ecosystem's overall health.

8.6.3 Bamboo Drip Irrigation System: An Inhouse 'More Drop per Crop' Technique

Under present climate variability, water stress is already high, which may exacerbate an anticipated climate change scenario. Although the State is fortunate to have abundant water resources, with Cherrapunjee and Mawsynram being the wettest spots on the earth, it is prone to seasonal water scarcity. Water resources in the State are under tremendous pressure to meet the increasing demand for water for domestic usage, agriculture, energy production, manufacturing, and industrial processes. Climate change impacts are likely to adversely affect the existing water resources, which will further exacerbate the water challenges in the State. Since the scope of these effects is unknown and unpredictable, responsive and flexible adaptation measures are the need of the hour. New and innovative approaches to water resources management and its development are vital to reduce vulnerability and livelihood insecurity among the poorest and facilitate adaptation to the uncertain effects of a changing climate.

Meghalaya has an ingenious system of tapping streams and springwater using bamboo pipes to irrigate plantations. About 18–20 litres of water entering the bamboo pipe system per minute gets transported over several hundred meters and reduced to 20–80 drops per minute at the plant site. The tribal farmers of the Khasi and Jaintia Hills of the Meghalaya Plateau have been practising this system for more than 200 years. However, this system is more prevalent in the 'war' Jaintia Hills than in the 'war' Khasi Hills region (Ryngnga 2018). The tribal farmers use an age-old tradition to drip irrigate crops such as betel leaf and black pepper planted in areca nut orchards or mixed orchards, with the help of locally available bamboo (Jasmine et al. 2018). In this system, water is carried out with the help of different forms of bamboo culms and further distributed into different bamboo water channels for irrigation of cropland (CSE 1998). The drip irrigation system is suitable for water scarcity conditions in the state since soils have poor water-holding capacity and the topography is rocky and undulating (Ryngnga 2018). In hills, natural

perennial streams are the primary water source for domestic and irrigation purposes. The most convenient way is to divert the water from the upper reaches of the hill slope to the lower reaches through gravity flow. This concept is fully utilised, diverting water from the source to the desired lines.

Bamboo drip irrigation practice prevents leakage and loss of water on the way. It also increases crop yield with less water and uses natural, local, and inexpensive materials. The farmers lay out the bamboo networks proficiently to keep the sites productive. The practice involves not cutting trees and shrubs to clear the land to make channels through the forest areas on hills (Jasmine et al. 2018). The farmer goes for settled cultivation when bamboo drip irrigation practice is followed and shifting cultivation is reduced. The bamboo drip irrigation practice helps conserve and preserve the prestigious natural resources in the hilly terrain of Meghalaya (Mishra and Sharma 2001).

8.7 Conclusion

Most adaptations to local climate conditions serve multiple purposes, aligning closely with the ecosystem-based approach (EbA) principles. Local forest-related knowledge and practices and associated social institutions developed over generations by Indigenous and local communities under changing environmental conditions represent a critical source of adaptive capacity for local forest-dependent communities facing climate change impacts. By emphasising the integration of EbA, these practices strengthen ecological resilience and ensure the sustainability of local resources. People's perceptions of climate change and adaptive strategies are valuable for local and regional policy formulation. They can significantly contribute to a macro-level policy framework for global adaptation efforts and goals. Most responses to climatic variability have primarily originated from affected communities rather than external agencies or interventions. Thus, the lessons learned from these communities must be communicated to policymakers and farmers, creating a positive feedback loop that enhances long-term vulnerability reduction efforts through ecosystem-based, community-driven solutions.

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