Ramagopal V. S. Uppaluri Latha Rangan *Editors*

Conservation of Biodiversity in the North Eastern States of India

Proceedings of NERC 2022



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Foreword

It is a matter of great satisfaction for me that the Indian Institute of Technology Guwahati successfully hosted North-East Research Conclave (NERC) 2022 on May 20–22, 2022. The NERC 2022 was conducted on the theme "Sustainable Science and Technology". Concurrently, Assam Biotech Conclave (ABC) was also organized on May 21–22, 2022. Both events attracted huge participation from policy-makers, researchers, industrialists, the army, and students. Even the participation of schoolchildren was overwhelming.

NERC and ABC had many events including panel discussions, exhibitions, keynote lectures, competitions and paper presentations. Presentation of technical papers forms the core of any research conference. NERC attracted 879 research papers on various themes covering science, technology and humanities. Out of these, some selected papers have been published by Springer Nature in the form of 15 volumes. These papers have been peer-reviewed and thoroughly edited by IIT Guwahati faculty members. I am sure that these volumes will prove to be excellent resource material for research. Most of the papers presented in these volumes highlight the special needs and aspirations of eight states of North-East India. I congratulate and thank authors, reviewers, editors, and publishers for bringing out proceedings.

The motivation for organizing NERC came from none other than Honourable Minister of Education, Government of India, Shri Dharmendra Pradhan Ji. It helped to bring policy-makers, researchers, industrialists, academicians, students, and children into one forum. It is perhaps the rarest Conclave covering almost all possible research themes. For better readability, the Proceedings have been divided into 15 volumes, but each volume reflects diversity in terms of topics and researchers. The only common thread is the sustainable development of North-East India. Invariably, Sustainable North-East India is a prerequisite for sustainable India and the whole world. In that sense, these 15 volumes will serve guiding and stimulating light for all the stakeholders of the development. I am pleased to dedicate these volumes to the nation as a part of Azadi ka Amrit Mahotsav.

Foreword



T. G. Sitharam Director Indian Institute of Technology Guwahati Guwahati, Assam, India

Preface

North-East India is a well-known region of biodiversity. The abrupt alterations in the altitude and the presence of deep valleys and mountains in the region translate into diverse ecological situations. In addition, altering climatic conditions also influence and determine the vegetative pattern of the region. With its extensive and rich flora and fauna being contributed to the climatic and vegetative diversity, the region is well known in recent times as one of the world's few biodiversity hotspots. However, ongoing and continued emphasis on the urbanization-driven developmental pressures on the environment and the global losses in biodiversity did renew research investigations and emphasis on biodiversity conservation.

It is well known that urbanization-oriented development strategies critically detriment harmony in the physiographic, geographical and eco-climatic conditions that sustain the region's endemic flora and fauna. Further, the region's medical plants and endangered taxa need preservation and conservation. This has been emphasized by several national and international agencies and with site-specific conservation strategies for the indigenous species of the region. Thereby, the North-eastern region of India can mark its rich resources for the unleashing of unexplored interspecific biodiversities and eventually promote a better harmonization of urbanization-driven development, biodiversity conservation and sustainable utilization of its natural resources. The diverse agro-climatic condition in the region varies between alpine to tropical environment. Along with this, the soil pH of 4.5–5 is highly favourable in the region for the abundance of various species. Witnessing the implementation of such strategies, the region's rich conservation of biodiversity can serve as a model for other regions in India and abroad.

Notably, biodiversity conservation shall address rising concerns with respect to the conservation of certain hotspots. This region is not only considered a homogenous entity, but a highly diverse mosaic of ecological, social and physiological landscapes that needs intensive analysis and attention for its conservation. With global warming and climate change posing threats to vegetation, plant and faunal diversity, the importance of conserving biodiversity is gaining momentum. Hence, the ongoing research should engage in risk distribution agronomy that can ensure food security in an era of climate change to make this region self-sufficient in all aspects. The human endeavour

to orient towards economic security based on ecological sustainability has a strong role in the conservation of biodiversity. Hence, research strategies encouraging such sustainable economic security for the community's well-being also become a part of the biodiversity conservation research.

With these purposes and sub-objectives, the authors and editors have contributed sixteen book chapters in several sub-themes that elucidate upon the broader perspectives of biodiversity. These sub-themes are (a) conservation of plant biodiversity for sustainable species utilization and ecosystem, (b) restoration and conservation of diversified microbial and animal biodiversity, (c) value-added product development and benefit sharing in biodiversity for the bioprospecting perspective and (d) conservation of biodiversity through critical environmental factors and its sensitivity towards urbanization and holistic methodologies. In these sub-themes, the reader gains useful insights with a knowledge-sharing platform with respect to the diverse backgrounds of the wildlife, ecological and environmental variation with flora and fauna in the North-Eastern region of India. Needless to convey, the potential conservation measures must be conventionally applied to encourage native landraces, intensify cropping by land configuration and sustainability in agriculture.

In the first sub-theme of plant biodiversity conservation, the volume first addresses the plant biodiversity research framework for bottle gourd and okra germplasms in the Garo hills of Meghalaya. Thereafter, the sub-theme elucidates upon the utility of waste precursors to enrich common bean plants through a vivid farming system. Further, the conservation of *citrus indica*, distribution mapping and diversity assessment of *Ilex venulosa*, above-ground biomass and carbon stock estimation using an allometric equation and on-farm conservation of small millets have been delineated in the sub-theme. Thereby, the role of conservation for its germplasm extinction and genetic erosion have been elaborated. The second sub-theme devotes to microbial and animal biodiversity and emphasizes the genotypic and phenotypic characterization based on microbial diversity conservation and Mithun husbandry practices as relevant animal biodiversity conservation practices. The third sub-theme aims to discuss factors affecting the diversity of black rice, value-added product development such as non-leafy vegetable soup formulation and its organoleptic properties, antimicrobial potential of Callistemon viminalis, biopharmaceutical potential of Alpinia Nigra and post-harvest management of temperate fruit crops in a northeast state of India. In the final sub-theme of conservation of biodiversity through critical environmental factors and its sensitivity towards urbanization and holistic methodologies, the eco-sensitive zone Deepor Beel has been mapped and quantified for its urbanization impact. Thereafter, floristic diversity and its significance in bio-cultural aspects have been elucidated as the last book chapter and thereby, prompt upon holistic methodologies for carbon sequestration.

In summary, this volume on 'Conservation of Biodiversity of North-Eastern States: Proceedings of NERC 2022' targeted research investigations from areas such as land and lake biodiversity, plant and animal biodiversity and tourism prospects. The critical role of agro-climatic conditions to foster biodiversity and the region's emphasis on rural existence can be witnessed in all articles. The beneficial outcome of the volume has been summarized as follows. Firstly, this volume will help all

the researchers in their unique field to develop holistic research culture and thereby prompt the exchange of information and thoughts and eventually stimulate new ideas through such holism. Secondly, a sustainable system can be developed to integrate various thoughts and rights of farmers, breeders or village communities in the NE region of India. Such strategies must value the altered agro-climatic and socio-economic conditions of the regional and native communities. Thirdly and most importantly, a conceptual approach can be enabled based on the generalized guidelines provided by the authors in several chapters. Such guidelines will be useful to protect and preserve the co-existence and biological dependence of many species including humankind in the world.

In summary, this volume will provide an immense opportunity for researchers to exhibit a strong willingness to harmonize biodiversity conservation and modern thinking-based development so as to reflect upon the sustainable utilization of ecological resources and thereby ensure livelihood security in the north-east region of India. Thereby, betterment of improved agro-techniques and harmonious entrepreneurship development will provide holistic approaches and can better the self-sufficient status of the region in all possible natural resources. All in all, the volume conceptualizes the indispensable role of biodiversity for healthy human sustenance to eventually prompt the criticality of human dependence on a balanced ecosystem.

Editorial Assistance: Prabhat Kumar Patel, Tinka Singh, Udaratta Bhattacharjee, Sneha Singh, Kumudhini Akasapu, Paushali Mukherjee, Rubeka Idrishi, Aishwarya Jain, Nuruzzaman Choudhury

Guwahati, India

Prof. Ramagopal V. S. Uppaluri Prof. Latha Rangan

About IIT Guwahati

Indian Institute of Technology (IIT) Guwahati, established in 1994, has completed 25 years of glorious existence in 2019. At present, the Institute has eleven departments, seven interdisciplinary academic centres and five academic schools covering all the major engineering, science, healthcare, management and humanities disciplines, offering B.Tech., B.Des., MA, M.Des., M.Tech., M.Sc., and Ph.D. programmes. The institute presently offers a residential campus to 435 faculty members and more than 7,500 students at present. Besides its laurels in teaching and research, IIT Guwahati has been able to fulfil the aspirations of people of the North-East region to a great extent since its inception in 1994. The picturesque campus is on a sprawling 285 hectares plot on the north bank of the Brahmaputra, around 20 km from the heart of Guwahati city.

IIT Guwahati is the only academic institution in India that occupied a place among the top 100 world universities—under 50 years of age—ranked by the London-based Times Higher Education (THE) in the year 2014 and continues to maintain its superior position even today in various International Rankings. IIT Guwahati received 37th global rank in the 'Research Citations per Faculty' category and overall 384 rank in the QS world University Ranks 2023 that were released recently. IIT Guwahati has retained the 7th position among the best engineering institutions in the country in the 'India Rankings 2021' declared by the National Institutional Ranking Framework (NIRF) of the Union Ministry of Education. Also, IIT Guwahati has been ranked 2nd in the 'Swachhata Ranking' conducted by the Govt. of India. Recently, IIT Guwahati has been ranked as the top-ranked University in 2019 for IT developers by HackerRank in the Asia-Pacific region.

Among other frontier areas of research and innovation, IIT Guwahati is working towards augmenting critical science research initiatives in Genomics, Developmental Biology, Health Care and Bioinformatics, Flexible Electronics, Advanced Functional Materials, Sustainable Polymers, Rural Technologies, Renewable Energy, Artificial Intelligence, Disaster Resilience and Risk Reduction and Water Resources and Management. In its silver jubilee year, IIT Guwahati is poised to scale newer heights through all-round growth and development. Indian Institute of Technology Guwahati has dedicated itself to the cause of improving and empowering north-east India through cutting-edge research, region relevant projects, innovations, individual and multilateral collaborations and special initiatives. Being the only IIT in the entire north- eastern region, IIT Guwahati has an immense amount of responsibility to develop the region and empower the people of the region.

While the entire country celebrating the "Azadi ka Amrit Mahotsav"—75 glorious years of Independence, and the great pride with which our nation of more than a billion people has been steadily growing today, IIT Guwahati is strongly committed to support that pace of growth for the entire NE so that we can keep pace along with the rest of the country. The specific areas of focus where IIT Guwahati has been contributing immensely to the region are:

- (a) Infrastructure development across multiple sectors.
- (b) Providing solutions for multiple natural disasters such as recurring floods, landslides, earthquakes, cyclones, hailstorms and other natural calamities.
- (c) Improving the education sector and creating opportunities for employment.
- (d) Internet, telecommunication and cultural integration.
- (e) Technological intervention in interdisciplinary areas.
- (f) Healthcare services and education.
- (g) renewable energy generation (solar, wind, biomass, hydro, geothermal).
- (h) overall industrialization, refining fossil fuels and setting up biorefineries.

Besides bringing in state-of-the-art technical know-how for most of the above sectors, the institute has been partnering with the local governments and enhancing the technological and educational interactions such that the next generation youth are empowered with knowledge, skills and necessary entrepreneurial ability. These measures in Assam as well as other north-east states will usher in a new era of growth. Further, it will provide numerous opportunities for interaction with the ASEAN countries as a part of the Act East Policy of the Government of India and will thereby bring prosperity in the region.

Prof. Parameswar K. Iyer Dean, PRBR, IIT Guwahati

North-East Research Conclave 2022: Towards Sustainable Science and Technology

It is extremely important and imperative to have knowledge-driven growth based on innovation in the case of academic higher education institutes of high repute. The North- Eastern region endowed with rich biodiversity comprises eight states. However, the climatic conditions, limited connectivity, lack of research infrastructure/ institutes, territorial conflicts and the mountainous terrain of these regions are major impediments to the research ecosystem in the North-East. Quality higher education focusing on industry-academia collaboration and translational research is extremely beneficial for society. It has also been rightly pointed out by the Hon'ble Prime Minister Sh. Narendra Modi that, "*India cannot develop till Eastern India develops*".



With this idea and as India marks 75 years of Independence, the Indian Institute of Technology Guwahati organized "The North-Eastern Research Conclave" from

20th–22nd May 2022. This grand event was jointly conducted with Science, Technology and Climate Change Department and the Department of Education, Govt. of Assam at IIT Guwahati Campus.

The mission behind the conclave was to showcase the best R&D activities from educational and research institutions across North-East India and to create an environment, conducive to the development of local indigenous technologies and innovations, creating the scope and laying the foundation for entrepreneurship.

In order to attract people and spread awareness about the event, a roadshow was initiated from IIT Guwahati on 7th May 2022 in order to reach all the partnering academic institutes and make them an integral part of the mega event. The Director, IITG, waved the NERC 2022 flag and sent off the road show vehicle from the institute. More than 400 students, staff and faculty participated actively in the roadshow.





A huge response was received from participants throughout the country. The total no. of Participating institutions in this conclave included 7 IITs, 10 NITs, 5 IIITs and other CFTIs, 23 Research Labs, 17 Central Funded Universities and 47 other Universities/Institutes along with about 100 schools. Eminent personalities from industries, start-ups, research councils, and PSUs also joined in.

The presence of dignitaries from important Ministries was observed such as Shri Dharmendra Pradhan, Hon'ble Union Minister of Education and Minister of Skill Development and Entrepreneurship, GOI; Dr. Himanta Biswa Sarma, Hon'ble Chief Minister of Assam State; Dr. Ranoj Pegu, Hon'ble Minister of Education, Government of Assam; Dr. Rajkumar Ranjan Singh, Hon'ble Minister of State for Education, GOI; Dr. Subhas Sarkar, Hon'ble Minister of State for Education, GOI; Shri Keshab Mahanta, Hon'ble Minister of Science Technology & Climate Change, Govt. of Assam and many more.



The inauguration ceremony of the conclave was followed by the signing of an MoU between IIT Guwahati and the Government of Assam to establish 'The Assam Advanced Health Innovation Institute (AAHII)'. This MoU would prove to be a unique partnership between the Government of Assam and IIT Guwahati in order to set up a Research Institution to leverage advanced technologies to transform medical science. This joint venture company will be able to invite participation from intending parties including corporates/businesses/research institutions and philanthropic organizations.



The third edition of Assam Biotech Conclave 2022 was also held as part of NERC 2022. It brought together Biotech Entrepreneurs, industry leaders, researchers, academicians, Government Representatives, policy-makers, innovators and investors together on one platform to explore the possibilities of Biotechnology in North-East India and to discuss the new opportunities in the transition.

Officers from the Indian Army also actively participated in the Conclave. A talk on "Atmanirbhar Bharat—Indian Army Initiatives towards Self Reliance" was delivered by Lt. Gen. D. S. Rana AVSM, YSM, SM General Officer Commanding, Gajraj Corps on 21st May 2022. The talk was aligned with the vision of the apex leadership of the Government of India and initiatives undertaken by the Indian Armed Forces with a focus on the integration of civil-military establishment in the field of self-reliance. He also elucidated that institutions such as IIT Guwahati which has many running research projects and elaborate student exchange and joint collaboration setup with a large number of Countries have the wherewithal to take up defence-related R&D and also facilitate delivery with Industry Partners. He also invited IIT Guwahati to participate in EAST TECH Symposium planned at Kolkata in July 2022. This led to the signing of an MoU between the Indian Army Eastern Command and IIT Guwahati on 7th July 2022 during East Tech 2022. This would further impetus to Indigenization and Raksha Atmanirbharta.



Royal Society of Chemistry, Global battery experiment was performed by more than 1300 students in three sessions starting from 20th May to 22nd May at IIT Guwahati. Along with the Global Battery Experiment, Creating Skilful Educators (Teacher training programme) was also conducted in parallel sessions. Students had arrived from various schools across Assam and other North-Eastern states.





The Guwahati Declaration was launched at the valedictory ceremony of the conclave by Shri Lok Ranjan, Secretary, Ministry of Development of North-Eastern Region (DoNER), in the presence of Shri Kailash Karthik, Deputy Commissioner, Kamrup. The Declaration is intended to create a set of guidelines, through which individual as well as a collective responsibility to promote and encourage innovation at the grass-root level and strive to stimulate and execute indigenization and entrepreneurship, can be taken up.



Science, education, research and innovation are the four pillars on which the development, as well as the work culture of a nation, rests. This was well articulated by the promising number of Exhibitors being seen participating from all across the NE states in the NERC 2022. All the NITs, CFTIs and CFIs were allocated two stalls each, where the delegates showcased the working models of their inventions. Distinctive pavilions were arranged for IIT, NIT, CFIs and CFTIs. Excellent response was obtained from Start-Ups all across the NE states. The Federation of Industry Commerce of North-Eastern Region (FINER) had partnered with NERC 2022 as an Industry Partner and they showcased 50 start-ups as a part of the Exhibition under the FINER Pavilion. Other significant organizations that came forward to showcase their allied R&D start-ups were the Oil and Natural Gas (Oil and Natural Gas Pavilion), Indian Army (Defense Pavilion) and NE-Railway (NE-Railway Pavilion).





Multifarious research work on topics of societal relevance was presented by researchers from different organizations/institutes. The presentations were conducted in oral and poster presentation modes. The thematic areas for these presentations were part of some of the Sustainable Development Goals (SDGs) such as SDG-3: Good health and well-being; SDG-7: Affordable and Clean Energy; SDG-9: Industry, Innovation and Infrastructure; SDG-11: Sustainable cities and communities and SDG-12: Responsible consumption and production. Some of the papers highlighted environmental sustainability, efficiency and management issues, which are important to be presented in the case of North-East regions. Two awards were given under each technical category for these presentations. Overall, the technical sessions were a grand success due to the active cooperation from editors, chairpersons of all the sessions and student volunteers of IITG.



The government of India has taken various steps to encourage women in the field of science and technology. In this line, the IIT Guwahati Woman Researcher Award was approved to recognize the contribution of women Faculty members of IIT Guwahati fraternity. This prestigious award was conferred to Dr. Latha Rangan, who is a Senior Professor in the Department of Biosciences and Bioengineering, Indian Institute of Technology Guwahati, India. Prof. Rangan has played a key role in Plant Biotechnology and Sustainable development, especially in the areas of energy security, food security and medicinal crops.

The Conclave paved the way for creating mass awareness of Research and Innovation for developing a sustainable society. There was knowledge exchange and dissemination that led to the establishment of Centres of Excellence in Translational Collaborative Research and Innovation. This mega event led to the bridging of the gap between Industry–Academia and Creating Hand holding Pathways for setting up long-term collaboration for R&D innovations towards the goal of establishing sustainable NE India. The Conclave brought together over 8000 participants including Hon'ble Ministers, Official Bureaucrats, Eminent Professors, Scientists, Renowned Industrialists, School Children/Teachers and Others delegates. This revolutionized the R&D road map of all the NE states through various dissemination of policies that will benefit the sustainable development of all NE states in near future.

It is an honour and a moment of extreme pride for getting the NERC proceedings published in the prestigious Springer volumes. We would like to thank and acknowledge the globally active publisher Springer for helping us being able to publish the articles in 15 broad areas. We would also like to thank all the authors for their contribution to the grand success of NERC 2022 and wish them great success in all of their future endeavours.



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From the Desk of Chairman of Technical Committee of NERC 2022

North-East Research Conclave 2022 was successfully organized on May 20-22, 2022 with the participation of thousands of delegates. A total of 879 oral and poster papers were presented at the conference on 16 different tracks. The theme of the Conclave was Sustainable Science and Technology, which is very pertinent in the modern era of globalization. Science and technology had to address economic, environmental and social problems of the world. Technology and sustainability are not incompatible. In fact, technology can achieve the goal of sustainability, which also includes preserving our rich cultural heritage. Concurrently with North-East Research Conclave (NERC), Assam Biotech Conclave 2022 was also organized on May 21-22, 2022. These mega events were organized at the Indian Institute of Technology Guwahati (IITG) in physical mode after two years of the pandemic period. Along with IITG, Science, Technology and Climate Change Department & Department of Education, Government of Assam, were also organizers of these events under the patronage of Shri Dharmendra Pradhan Ji, Honourable Minister of Education and Minister of Skill Development and Entrepreneurship in the Government of India, and Shri Himanta Biswa Sarma Ji, Honourable Chief Minister of Assam.

It is a matter of great pleasure that Springer Nature is publishing the select papers from the conclave in 15 volumes. These are Advanced Functional Materials, Low Cost Manufacturing Technologies, Agro and Food Processing Technologies, Artificial Intelligence and Data Science based R&D interventions, Conservation of Biodiversity in the North-Eastern States of India, Disaster Management, Healthcare Research and Related Technologies, Innovative Design for Societal Needs, Policies for Research and Innovation, Research and Innovation for Sustainable Development Goals, Sustainable Environment, Sustainable Energy Generation and Storage, Sustainable Transportation and Urban Development, Teaching and Learning Technologies, Technologies for Rural Development. These volumes are useful archival and reference materials for policy-makers, researchers and students.

As the Chairman of the Technical Committee, I am thankful to all Editors, reviewers and student volunteers who have put tireless efforts to review, select and edit the papers of respective divisions, overcoming the time-constraint. Support provided by Convener, Professor Vimal Katiyar, Dean R&D, IITG, and Co-Conveners Prof.

Subhendu Sekhar Bag, Associate Dean R&D, IITG and Shri Kailash Karthik N, IAS is commendable. It is difficult to express words of gratitude for the Director, IITG, Prof. T.G. Sitharam who has been motivating and guiding all the teams of NERC 2022 and ABC 2022.

Uday S. Dixit Professor Department of Mechanical Engineering and Head Center for Indian Knowledge Systems

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Part I Conservation of Plant Bio-Diversity for Sustainable Species Utilization and Ecosystem

Chapter 1 Morphological Characterization of Bottle Gourd [Lagenaria siceraria.(Mol). Standl.] Germplasms in Garo Hills of Meghalaya



Susmita Chakraborty D and A. K. Chaurasiya D

1.1 Introduction

With fresh and edible portions, vegetables are considered to be an important class of horticultural products. As key food ingredients, they offer promising benefit to humankind in terms of health protection and disease prevention. Among many palatable vegetables, the gourds are often regarded as the oldest and prime cultivars. Belonging to the Cucurbitaceae family, the commonly grown gourds can be associated with the *Cucurbits* and *Lagenaria* genera. Usually, with their color and shape features, the cucurbit genera are popular. However, in Asia, the *Lagenaria* genera are widely cultivated. In this category, the gourds are known by the name of dipper or bottle gourds. With a diploid chromosome number of 22, the bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] belongs to a member of the Cucurbitaceae family and is often grown during the summer and rainy seasons in south-east Asia. The vegetable origins are in Africa. With varying shapes and sizes, the vegetable can be either long, round, or oblong, depending upon the variety. In the Garo Hills, Meghalaya, they are about 15–100 cm in length and in green color. The fruit is often cultivated in a warm environment.

The wild fruit forms exist in India and South African Gulf countries and have huge potential for sustainable agriculture. With about 13% of world vegetable production, India is only next to China. While Indian farmers cultivate various gourd cultivars being made famous by several organizations, their satisfactory yield has not been ensured to date. To circumvent, bypass, and mitigate this issue, cultivars with divergent performance can be targeted. To this effect, many varieties have been investigated by Morimoto and Mvere [1], Morimoto et al. [2]. All these species investigated to date were those that are accustomed to the climate of Asia, Africa, and the New

S. Chakraborty (🖾) · A. K. Chaurasiya

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World. From a crop improvisation perspective, the Cucurbitaceous class of horticultural products are often considered to be a special class in cross-pollinated crops. A clear distinction can be made for the bottle gourd cultivar in terms of its characteristic white flowers, fruit shape, seed shape, and leaf shape [3]. With wider sexual forms and expressions that favor breeding, the bottle gourd cannot be fully crosspollinated. Hence, natural pollination on its own could take place despite being at a lower level. Also, a promising feature of the group is that they don't get affected by inbreeding depression. Further, even if such an effect takes place, it will be highly marginal in comparison to other species that underwent cross-pollination. Thereby, this feature customizes cultivar's improvisation through the single plant-based pure line inbreeding. To check and verify the influence of inbreeding, several objectives need to be assessed. These include higher yield, larger fruit weight, earliness, high female to male flower ratio, desired shape features such as long cylindrical or round fruits, skin persisted with bare hairs, edible stage flesh being non-fibrous in nature, non-bitter tasting fruit, attractive texture of fruit without spots, and good resistance for pests and diseases. With good combinations of genetic diversity and morphological parameters, the dipper gourd plants are highly suitable to adapt, grow well, and provide high yields in altered environmental conditions and ecological diversities [4].

Bottle gourd fruits can be consumed as vegetables or used to make sweets such as halva, kheer, pedha, and barfi, as well as pickles. Even patients can easily digest it as a vegetable. Leaf decoction is an excellent treatment for jaundice. The fruit has a cooling effect having diuretic and cardiotonic properties. The pulp can be used to treat constipation, coughing, and night blindness, as well as an antidote to certain poisons. The plant's extract is used as a cathartic, whereas the seeds are used to treat dropsy. The shapes and sizes of the fruits vary. They are light greenish in color and range in length from 15 to 100 cm. Furthermore, the fruits' dry hard shells have been used to make a variety of everyday items such as bowls, bottles, ladles, containers, fishing net floats, pipes, and musical instruments. Additionally, the seeds and seed oil are edible. Bottle gourd can be grown in dry conditions as well. Depending on the variety, bottle gourd fruits can be long, oblong, or round. Immature fruits can be consumed in a variety of ways. Kofta is one of the most popular preparations. It contains a healthy amount of minerals and vitamins. Its fruit has 95.54% moisture, 10.1 g of vitamin C, 16 IU of vitamin A, thiamine (0.029 g), riboflavin (0.022 g), niacin (0.320 g), carbohydrates (3.39 g), fats (0.02 g), and potassium (150 mg)/100 g. Indian farmers have used various local cultivars and had released (via various organizations) various varieties. However, their output is insufficient. Varietal performance may be useful in solving this issue. Many authors have studied bottle gourd variability, including Morimoto and Mvere [1], Morimoto et al. [2], and others.

Juice is also a popular product. Bottle gourd juice is preferred because it is a natural reservoir of micronutrients and nutritional elements. Additionally, it has been noted for having high concentrations of vitamin C, vitamin B complex, β -carotene, minerals, polyphenols, and carbohydrates. The demand for bottle gourd juice has recently increased due to its reputation as a health drink owing to its nutritional and phytochemical composition. Owing to the health benefits of bottle gourd juice, the

extraction of high-quality juice with the greatest retention of bioactive components is a difficult task for processors. Reduced pigment loss during processing is of utmost importance to the processors because the color is a crucial quality determinant. The majority of vegetable juices, including bottle gourd juice, not only turn brown after extraction, but also lose nutrients. Enzymatic activity encourages chlorophyll losses by reacting with the free hydroxyl groups of chlorophyll, which raises the concentration of hydrogen ions and replace the magnesium ions in the center of the pigment with hydrogen thereby, color loss occurs or the production of pheophytin, a yellow-colored substance takes place. Blanching, for example, inactivates enzymes and destroys vegetative microflora, making it an important step in the production of juices that improves color, cloud stability, and nutritional retention. Polyphenol oxidase (PPO), chlorophyllase, β -glucosidase, elastase, and peroxidases are the main enzymes found in bottle gourd. Except for peroxidase, these enzymes are primarily responsible for nutritional and sensory quality loss in vegetables. Peroxides are the most heat-resistant enzymes, and the lack of residual peroxidase activity would imply that other less heat-resistant enzymes have been destroyed as well. Peroxidases are thus utilized as marker enzymes to assess the effectiveness of blanching. The bottle gourd plant has a variety of purported therapeutic qualities. The bottle gourd is a particularly helpful vegetable in reducing digestive issues like constipation due to its dietary fiber. Consuming fiber has been linked positively to a decline in the incidence of diabetes and coronary heart disease. Studies conducted in India revealed a significant regional variation [5]. Without variability, selection may not be efficacious in a population, in terms of variability, it is the genetic portion of the observable variation that provides indicators of transmissibility and responds to selection. The link between genotypic variability and observed variability represents heritability. This is only because the heritability of quantitative traits is large [6]. Bottle gourd cultivation covers 187 thousand hectares in India, with a production of 3079 thousand metric tons (NHB database, 2018–19). It is critical to conserve agricultural genetic resources in order to meet the world's food and feed demand. Crop improvement is primarily based on extensive germplasm evaluation. The greater the genetic resources, the better the chances of capturing specific traits. As high-yielding varieties spread, this genetic variability comprised of landraces is gradually eroding. Thereby, it resulted in a large-scale depletion of variability. This situation necessitates immediate action to preserve the eroding germplasm.

Bottle gourd is a popular cucurbitaceous vegetable crop grown in Meghalaya's Garo Hills. Numerous native cultivars are available with a wide range of variations in fruit size, shape, and color in the region, but few studies have been conducted to develop this crop in this region. With the aforementioned considerations in mind, a research proposal titled "Morphological Characterization of Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.] Germplasms in Garo Hills, Meghalaya" was undertaken with the goal of studying the morphological characteristics of bottle gourd and identifying superior genotypes.

1.2 Materials and Methods

A field experiment was conducted in 2018 at the horticulture research farm of North Eastern Hill University in Tura district, Meghalaya, India, to morphologically assess the bottle gourd [Lagenaria siceraria (Mol.) Standl.] germplasm in the Garo Hills of Meghalaya. Tura is located at latitude 25° 31′ N and longitude 90° 13′ E with an average elevation of 527 m above the mean sea level. Table 1.1 summarizes the climatological factors that prevailed during the crop growth period as observed at the DAO Research Office in Sangsanggre, Tura, Meghalaya. The following is a description of the materials used, the experimental plan, and the statistical methods deployed for the experimental data.

1.2.1 Experimental Materials

A total of 30 bottle gourd germplasm lines were included as the experimental material that was gathered from locations in the Garo Hills Districts of Meghalaya, India.

Month	Rainfall	No. of days	Humidity (%)		Temperature (°C)	
			Max	Min	Max	Min
January	0.00	0	91	71	28	13
February	10.00	1	92	65	29	10
March	61.70	2	83	63	30	13
April	161.30	10	86	65	31	13
May	383.00	17	90	61	38	19
June	297.60	10	90	69	39	19
July	131.00	8	90	70	39	19
August	81.50	6	90	70	39	18
September	107.80	7	90	60	39	18
October	6.00	1	82	52	32	17
November	27.00	1	80	59	30	18
December	0.00	0	80	50	30	17
Total	1265.90	63	92	50	39	10

 Table 1.1
 Monthly weather report during the cropping season (2018)