Pt. Govind Ballabh Pant

POPULAR LECTURE: XII

Prof. Mukunda Dev Behera

September 10, 2025
at
Gangtok, Sikkim

G.B. Pant National Institute of Himalayan Environment (NIHE)
(An Autonomous Institute of Ministry of Environment, Forest & Climate Change, Govt. of India)
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Dr. Mukunda Dev Behera is a distinguished scientist specialized in ecological climatology, natural resource conservation, and sustainable forest management. He has made outstanding contributions to ecosystem services, carbon accounting, biodiversity assessment, and nature-based climate solutions. His work bridges theory, modeling, field experimentation, and Earth observation advancing understanding and management of ecosystems under a changing climate. Through pioneering applications of remote sensing, spatial statistics, and advanced modeling, he has developed novel methods to assess vegetation variables, biodiversity distribution, and carbon dynamics, thereby significantly contributing to climate change mitigation through vegetation carbon management. A key area of his current research involves creating digital twins at the intersection of forest vegetation and the monsoon climate in India and South Asia, a pioneering approach set to transform ecosystem monitoring.

Dr. Behera is an Associate Professor at the Centre for Ocean, River, Atmosphere, and Land Sciences (CORAL) at the Indian Institute of Technology Kharagpur, and directing the Spatial Analysis and Modelling (SAM) Laboratory. Under his leadership, the SAM Lab has become a center for excellence in sustainable forestry and climate solutions, effectively integrating field-based measurements with sophisticated spatial modeling. Earlier in his career at the Indian Space Research Organization (ISRO), he made significant contributions to sustainable forest management and natural resources conservation through the application of satellite Earth observation technologies.

He has made pioneering contributions in technology transfer and national database development. His work has been adopted by government agencies, such as land and water resource monitoring systems implemented by the Tripura State Forest Department, Jhum fallow management practices transferred through the NMHS-MOEF&CC program, and an angiospermic plant diversity database developed for the National Biodiversity Authority of India. He has executed over 36 nationally and internationally funded research and consultancy projects. Scientific contributions of Dr. Behera have been widespread recognized. He served as a Review Editor for the IPCC AR6 Working Group II and as an editorial board member for leading journals such as *Biodiversity and Conservation, Tropical Ecology, Environmental Assessment and Monitoring, PLOS Climate, and Environmental Research Communication*. He currently serves as Vice Chair of COSPAR-A3 on Land Processes and Morphology. His accolades include the The scope and impact of his work have been honored through numerous competitive fellowships and awards. These include the Vaibhav Host Fellowship (DST, 2024–27), the Australian Award Fellowship (2023), the Faculty Excellence Award of IIT Kharagpur (2022), the National Geomatics Applications Award from ISRO (2022), fellowships from the International Society of Environmental Botanists (2020) and the Indian Water Resources Society (2021). His earlier international fellowships include the Erasmus Mundus Fellowship at the University of Twente, the French Ministry of External Affairs Fellowship, and the CSIR JRF/SRF for doctoral research. He has also held visiting positions at JAMSTEC in Japan, the University of Southampton in the UK, the University of Montana in the USA, and the University of Reading in the UK.

As a prolific scientist, Dr. Behera's academic output includes 162 peer-reviewed journal articles, over 110 additional publications, and 10 edited books. As a dedicated mentor, he has guided 06 post-doctoral fellows, more than 24 doctoral researchers, nearly 80 M.Tech. and undergraduates. His innovative approach, integrating remote sensing, modeling, and ground-based observations, has not only advanced academic knowledge but has also provided tangible solutions for forest conservation and climate resilience, solidifying his stature as a global leader in sustainability science.

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Towards Achieving Sustainable Development Goals in Northeast India: Scaling Nature-based Solutions with Geospatial Technology

Mukunda Dev Behera

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Distinguished colleagues, esteemed scientists, policymakers, and community leaders, It is a privilege to stand before you today and speak about the promise of Nature-based Solutions (NbS) guided by geospatial technology as a pathway to achieving the Sustainable Development Goals (SDGs) in one of the most ecologically diverse and culturally vibrant regions of our planet - Northeast India.

This region, nestled within the Indo-Burma biodiversity hotspot and flanked by the Himalaya, the Brahmaputra valley, and the lush hill ranges of Sikkim, Arunachal Pradesh, Meghalaya and Mizoram, represents not just a geographic corner of India but an epicenter of ecological wealth and indigenous knowledge. Its dense forests, fertile valleys, unique agro-ecosystems, and intricate cultural traditions offer a living laboratory where we can explore how nature itself provides the foundation for sustainable development. Yet, Northeast India also stands at a crossroads. It faces challenges of poverty, food insecurity, fragile healthcare systems, educational disparities, gender inequality, water stress, and vulnerability to climate change. Large-scale infrastructure projects, unplanned urbanization, and unsustainable resource extraction threaten to erode the very ecological foundations on which communities depend.

In this context, NbS - actions that protect, restore, and sustainably manage ecosystems - emerge not merely as conservation strategies but as powerful instruments to deliver multiple SDGs simultaneously. Supported by modern tools such as satellite remote sensing, GIS-based planning, and ecological modeling, NbS can be scientifically assessed, scaled, and replicated in ways that combine traditional wisdom with contemporary science.

Let us begin our journey by examining how NbS in Northeast India can be woven into the pursuit of the SDGs: ending poverty, ensuring food security, promoting health, advancing education, empowering gender equality, and guaranteeing water for all. NbS transform energy, work, infrastructure, inequality, cities, and production. From micro-hydropower in Arunachal to organic farming in Sikkim, from bamboo economies to living root bridges, the message is clear: development

does not have to degrade nature - rather can regenerate it. NbS in Northeast India contribute to climate action, life on land and water, peace, and global partnerships. NbS can effectively address SDGs by using remote sensing and geospatial technology to guide, monitor, and scale up interventions. These goals, taken together, reveal the region's potential to inspire not only India but the entire world.

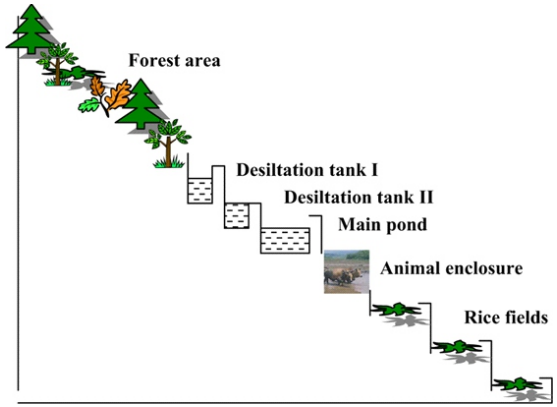
SDG 1: No Poverty

At the heart of sustainable development lies the eradication of poverty. Poverty in Northeast India (NEI) is often not just about income but about limited access to ecosystem services - fertile soil, clean water, fuelwood, fodder, fish, and forest products. When ecosystems degrade, communities lose their most basic assets.

Here, NbS provide resilience against poverty by anchoring livelihoods in ecosystem regeneration. Take, for instance, the revival of community-managed forests in Nagaland, where traditional village councils oversee rotational access to timber and non-timber forest products. Remote Sensing (RS), which leverages satellite and drone imagery, provides the data needed to identify vulnerable populations, enhance sustainable livelihoods, and build resilience to climate shocks. This is particularly relevant in Northeast India, where the population heavily depends on natural resources and indigenous farming practices. By combining high-resolution nighttime lights satellite data with other spatial datasets, one can identify areas with low economic activity and a lack of access to electrification. Socio-economic mapping using geospatial technology is critical for guiding NbS that directly address poverty. Agroforestry, which combines trees with crops and/or livestock, is a traditional NbS in Northeast India that can be optimized with RS based site suitability to combat poverty.

The transition into a 100% organic state in Sikkim has fundamentally redefined

poverty reduction. By eliminating chemical inputs and relying on organic manure and agroecological practices, farmers have reduced input costs and accessed premium markets. RS of soil organic carbon and productivity trends has confirmed that such organic transitions are both environmentally and economically sustainable. Across Meghalaya, the restoration of sacred groves, once under threat, has strengthened access to wild foods, fruits, and traditional medicines - demonstrating how cultural conservation traditions translate into practical poverty alleviation. NbS interventions are addressing the degradation of wetlands in the Chatla wetland in Assam's Barak Valley through wetland restoration for fisheries. Traditional practices like Zabo farming can be monitored with remote sensing - water availability and soil health support these indigenous systems, which are key to sustainable food security and poverty reduction. Landslide hazard mapping, flood early warning systems, land holdings mapping, and biodiversity enrichment and income diversification benefitting from geospatial technology, are the NbSs.

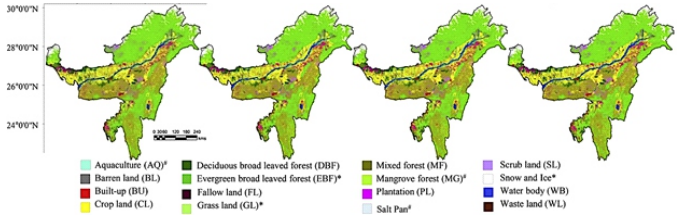


In each of these examples, poverty reduction is not framed as external aid but as community-led ecosystem regeneration. The forests, rivers, and soils become the banks where the poor store their wealth - wealth that grows as ecosystems heal.

SDG 2: Zero Hunger

Food security in Northeast India is deeply intertwined with landscape management. The region's unique agro-ecosystems - from shifting cultivation in the hills to wet rice cultivation in the valleys - reflect centuries of adaptation to difficult terrains and variable climates. Integrated NbS and RS approaches can be used to promote food security and sustainable agriculture by enhancing crop monitoring and restoring degraded ecosystems. RS helps in monitoring of crop growth and health, detection of pest infestations, and assessment of the extent of

cultivation area; Precision farming helps to optimize planting, fertilization, and irrigation, increasing yield and resource efficiency; and early warnings for crop failure due to pests, diseases, or drought, enabling timely interventions to protect food supply.



Land use and Land Cover Dynamics at Decadal Scale 1985-2015 (Behera et al., 2018)

In Arunachal Pradesh, the Apatani rice–fish farming system where paddy fields are ingeniously designed to support both rice cultivation and fish rearing. This system not only produces high yields without chemical fertilizers but also enhances protein intake, exemplifying an NbS that has stood the test of time. Remote sensing of water regimes in these terraces allows scientists to study micro-hydrology and ensure that such systems remain resilient in the face of climate variability. In Mizoram, experiments with alder-based agroforestry have revived degraded jhum fields. By interplanting nitrogen-fixing alder trees with cash crops such as ginger and turmeric, farmers have restored soil fertility, reduced the fallow period, and improved yields. The orange–alder agroforestry model in Sikkim, where fruit orchards are integrated with soil-binding trees, preventing erosion on steep slopes while generating income through orange harvests. The RS data support the promotion of sustainable, high-value crops like cardamom and kiwi, complementing traditional farming and enhancing food security in Arunachal Pradesh. The traditional agroecological practices in Meghalaya, such as the bamboo drip irrigation system and the management of sacred groves, are natural NbS; and RS helps monitoring the health of these groves and assess water resources, providing data to optimize these traditional systems and ensure consistent water supply for agriculture. The Agarwood plantations in Tripura provide a high-yield, high-value NbS that diversifies income and reduces reliance on staple crops, improving overall food and economic security. In Mizoram, NbS supports livelihoods based on non-timber forest products and helps restore degraded land, enhancing the region's overall ecosystem health and food security. In Manipur (Loktak Lake), NbS protects the lake's rich biodiversity and fish production, which supports the livelihoods of many families.

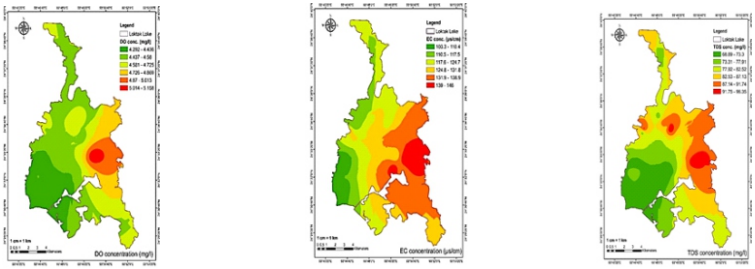
Thus, hunger alleviation in Northeast India is not about expanding chemical agriculture but about scaling indigenous NbS that enhance soil, water, and biodiversity services - the very foundation of food systems. The potential for upscaling are (i) Implementing standardized frameworks that map and quantifying NbS benefits can attract further investment and drive large-scale adoption, (ii) Platforms like the NER District SDG Index can track progress and facilitate knowledge sharing enabling the replication of successful NbS models, (iii) Empowering local communities with user-friendly mobile apps and training can enhance their participation in data collection and monitoring, ensuring culturally sensitive and contextually relevant NbS, (iv) Creating green bonds and carbon markets, can attract private investment in NbS, linking them to existing economic sectors like agriculture and fisheries, and (v) Expanding access to RS data and analysis tools for local government and community groups can build capacity and accelerate NbS implementation, fostering a more food-secure and resilient future for the region.

SDG 3: Good Health and Well-Being

Northeast India faces unique public health challenges, including a high burden of vector-borne diseases (e.g., malaria, Japanese encephalitis), health impacts from disasters like floods and landslides, and limited access to healthcare in remote areas. The NbS addresses these challenges by improving environmental quality, mitigating disaster risks, and promoting well-being through access to healthy ecosystems. RS provides the critical data to understand the complex links between environmental factors and health outcomes. It enables the targeted deployment of NbS and the real-time monitoring of their health benefits. RS for NbS in public health includes disease monitoring and early warning, environmental quality assessment including air and water, mental and physical well-being, disaster risk reduction and health. NbS, guided by RS, addresses health challenges related to climate change, disease, and environmental quality by leveraging the region's rich natural capital.

Sikkim`s State Action Plan for Climate Change and Human Health (SAPCCHH) recognizes the link between rising temperatures, erratic rainfall, and climate-sensitive diseases. NbS interventions like spring shed rejuvenation and reforestation help stabilize water sources and reduce the spread of vector-borne diseases. Assam state utilizes RS to monitor the extent and health of wetlands, guiding restoration efforts and help predicting potential vector breeding sites, strengthening early warning systems. The wetland conservation in Assam's Deepor Beel, a Ramsar site that sustains fisheries, regulates floods, and filters pollutants. Communities around the Beel depend on its fisheries for protein intake, and its water-purifying capacity reduces contamination risks. Remote sensing of

wetland shrinkage and water quality dynamics provides the evidence base for targeted restoration, ensuring health benefits flow to downstream populations in Guwahati. The RS data informs NbS like slope stabilization through reforestation, which protects rural settlements from landslides in Nagaland. This reduces displacement and minimizes the risk of injuries and epidemics that often follow disasters. Arunachal Pradesh's Pakke Declaration aligns with the SDGs, including a pillar dedicated to the "Health and Well-being of All". Similarly, the restoration of Loktak Lake in Manipur, where phumdis (floating biomass islands) are managed for water quality and fish diversity, has direct impacts on community health and nutrition. Traditional practices of controlled biomass harvesting, when reinforced with scientific monitoring of algal blooms via RS sensors, create a healthier aquatic ecosystem. Air quality and mental health also connect with NbS. Forest belts around Shillong, when conserved, act as green lungs for the city. Exposure to green spaces has been correlated with reduced stress and better cognitive outcomes, a reminder that NbS deliver not just physical but psychological well-being.



Phumdis in Loktak Lake: Spatial water quality map of DO (mg/l), EC (µs/cm), and TDS (mg/l)

In essence, the health agenda for Northeast India cannot be isolated from ecology. NbS provide low-cost, preventive healthcare solutions by securing the natural determinants of health. Integrating RS data on environmental health indicators into regional health dashboards, like the NER District SDG Index, can provide a more comprehensive view of well-being. Expanding the use of RS-based early warning systems for diseases (e.g., dengue, malaria) across the Northeast can improve preparedness and reduce outbreaks. As urbanization increases, using RS to plan and monitor green urban infrastructure can help mitigate the urban heat island effect, reduce air pollution, and provide mental health benefits. Training local communities, health workers, and officials in using RS-derived data can empower them to manage NbS for public health at the grassroots level.

SDG 4: Quality Education

Education in the Northeast must be understood not only as access to schools and curricula but also as exposure to knowledge systems that prepare a student for sustainable future. The Northeast Indian states face unique educational challenges, including limited access to quality education in remote areas, a need for culturally relevant and hands-on learning, and a high dependency on natural resources that requires a deep understanding of environmental issues. NbS can act as living classrooms, providing practical, interdisciplinary learning experiences that foster environmental stewardship and equip students with valuable skills for sustainable development. NbS serves both as a curriculum and a classroom. RS and geospatial technology provide a powerful tool to bring complex environmental data into the classroom, connecting theory with real-world, local applications.

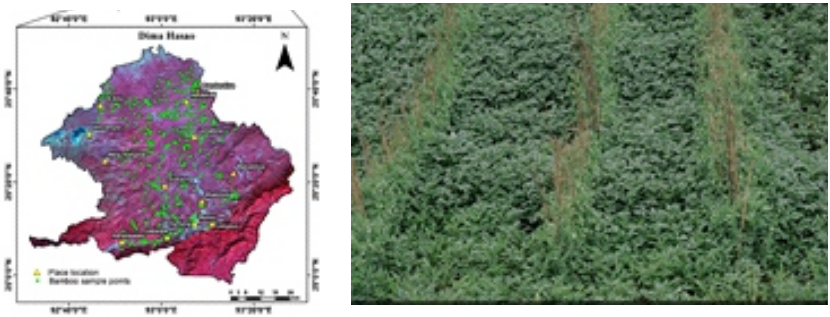
The Nature Learning Club in Assam adopts a "catch them young" approach, working with school nature clubs to promote conservation. The Changlangshu has adopted a place-based nature education project in Nagaland fosters local leadership for education based on place values. The Green School program in Gobuk in Arunachal Pradesh engages children through outdoor exploration and creative expression inspired by local ecology and culture. Sikkim's schools, as part of its organic mission, have incorporated modules on composting, seed saving, and soil ecology. Such experiential education creates a generation that sees NbS not as abstract concepts but as everyday realities. In Meghalaya, community-driven projects around the living root bridges serve as open-air classrooms. These bridges, woven over generations by training rubber fig roots, are marvels of bioengineering that inspire both cultural pride and ecological literacy. Documenting them via a nature asset registry, creates powerful educational content, linking indigenous engineering with modern science.

Universities across the region are also embedding RS & geospatial based ecosystem monitoring into curricula, training young scientists to map forests,

wetlands, and glaciers. By building this scientific literacy in NbS, education becomes a direct driver of sustainable development. Fostering stronger partnerships between academic institutions, government agencies, NGOs, and the private sector can support school-based NbS projects and provide students with real-world learning opportunities. Engaging students and local communities in citizen science projects that use RS to monitor local NbS can foster a sense of ownership and responsibility for environmental stewardship. Thus, NbS expand the classroom beyond walls - into forests, fields, and rivers - preparing citizens to value and sustain the very ecosystems that sustain them.

SDG 5: Gender Equality

NEI often perceived to have better gender development indicators than the rest of India, still faces significant gender inequalities, especially in economic participation, decision-making, and coping with environmental challenges. Indigenous women, who are often primary managers of natural resources, are disproportionately affected by environmental degradation and climate change. NbS address gender disparities by creating equitable opportunities for resource access, decision-making, and economic empowerment. Geospatial technologies expose and quantify gender-based vulnerabilities and monitor the outcomes of gender-inclusive NbS. RS combined with socio-economic data, can map gender-specific vulnerabilities to climate change such as female-headed households living in climate-sensitive areas or increased labor burden on women due to water scarcity/ deforestation.



LH: Bamboo Mapping from Satellite Data; RH: Sombaria Potato – Organic farming in Sikkim

Angami women in Nagaland have traditional conservation practices with strict harvesting protocols to ensure sustainability. In the matrilineal societies of the Khasi and Garo, women traditionally inherit property and have significant decision-making power over natural resources. The women-led Konamak fishing

cooperative in Loktak lake advocates against destructive development projects and implements sustainable harvesting practices. In Sikkim, women farmers are at the forefront of the organic movement, and their expertise in composting, seed selection, and integrated pest management has transformed agriculture into a space of empowerment. Dhara Vikas in Sikkim has not only revived springs but also restored dignity and time to women, enabling them to pursue education and entrepreneurship. Women around Loktak Lake - famously organized as the "Ima Keithel" or mothers' market - are central actors in sustaining fishery-based livelihoods. By planting bamboo groves for fuel and handicrafts, women reduce drudgery while generating income.

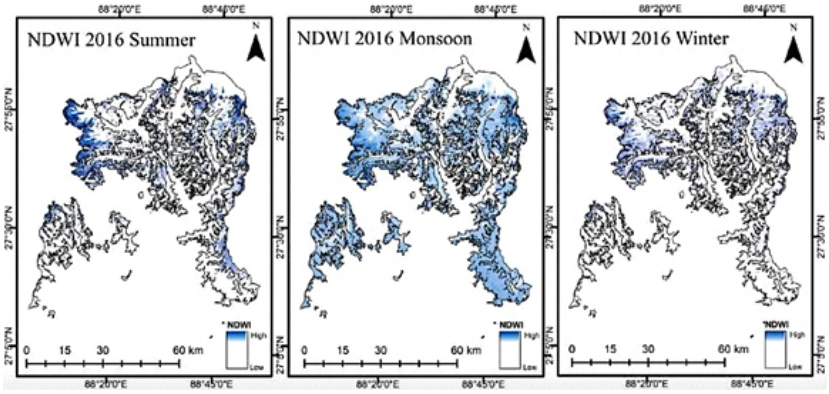
Moving beyond simply including women, NbS projects should be designed using a gender-transformative approach that addresses underlying power inequalities. Gender-responsive NbS could be linked to financial mechanisms like climate finance, ensuring that women's contributions are monetized and properly compensated. In short, empowering women is a practical necessity for scaling NbS, and RS based data integration helps to manage and plan adaptation strategies.

SDG 6: Clean Water and Sanitation

Water is the lifeline of NEI, flowing through mighty rivers like the Brahmaputra, Teesta and Barak, as well as countless springs and streams. Erratic rainfall, climate change, deforestation, and urbanization lead to both floods and water scarcity. These challenges impact access to clean and affordable drinking water, especially for remote and vulnerable communities. NbS to water management includes restoring wetlands, regenerating forests, and protecting spring-sheds. RS provides the data needed to understand water availability, quality, and distribution, enabling the effective deployment and monitoring of NbS.

The spring-shed rejuvenation efforts of Sikkim's Dhara Vikas program identifies recharge zones through geospatial mapping, digging recharge pits, planting deep-rooted trees, and reducing grazing pressure, entire villages have seen perennial springs flow again. This aquifer-based springshed management uses RS to identify recharge zones (often hilltop forests) for aquifers. The NbS involves measures like trench construction and afforestation in these recharge areas to enhance groundwater storage and ensure spring sustainability. The community-led catchment conservation around sacred groves has ensured sustained water flows to downstream villages in the Meghalaya. These communities have essentially built green dams that regulate hydrological cycles more effectively than any engineered dam could. Wetland systems like Deepor Beel and Loktak also serve as natural wastewater treatment plants, filtering pollutants and maintaining water quality for surrounding settlements. Monitoring their chlorophyll content and

turbidity through RS provides real-time indicators of ecosystem health, enabling adaptive management. By recognizing rivers, springs, and wetlands as living infrastructures, NEI demonstrates that water security is not a function of pipes and pumps alone, but of healthy, functioning ecosystems.



Satellite derived seasonal Normalized Difference Water Index (NDWI) Images of Sikkim

Integrating river and water information systems, developed with geospatial technology can create a regional water management platform. The successful integration of NbS into water management plans, supported by RS data, can be used to attract green financing and incentivize sustainable practices.

SDG 7: Affordable and Clean Energy

The NEI possess vast, untapped renewable energy potential, particularly in hydropower, biomass, and solar. However, persistent energy poverty, reliance on traditional biomass, and challenges in developing and transmitting large-scale clean energy have hindered the achievement of affordable and clean energy. NbS can reduce reliance on traditional biomass, provide biomass for modern energy, and support ecosystem services vital for energy generation (e.g., micro-hydropower). RS provides a cost-effective method for assessing the potential of various renewable energy sources such as map land use and crop residue biomass, identify suitable locations for decentralized bio-power generation, analyse site suitability to identify optimal locations for small-hydro projects, and identify suitable sites for grid-connected and off-grid solar projects, particularly for rooftop and decentralized applications.

NbS provides pathways forward. Micro-hydropower systems, designed to work

with the natural flow of streams without damming them, are already providing clean energy to remote villages in Arunachal Pradesh and Nagaland. By using run-of-the-river models, communities gain electricity for lighting, irrigation, and small enterprises, while rivers continue to flow freely. RS based monitoring of watershed health ensures these systems remain viable by preventing sedimentation and monitoring flow regimes. In Manipur, households are adopting biogas plants that use livestock manure and agricultural residues to generate clean cooking fuel - biomass-to-energy transition. In Sikkim, the promotion of solar-powered irrigation pumps combined with organic farming illustrates how renewable energy and NbS reinforce each other. Converting agricultural residues into briquettes or pellets for clean cooking or electricity is an NbS that reduces reliance on polluting traditional fuelwood. Loktak Lake, which is a nuisance. An NbS involves harvesting water hyacinth overgrowth in Loktak lake and converting it into biomass energy.

Thus, energy security in Northeast India does not have to mean ecological compromise. NbS, coupled with decentralized renewable technologies, can deliver affordable and clean energy while preserving rivers, forests, and soils. RS can support the creation of integrated energy plans that combine different NbS (e.g., agroforestry for biomass, small hydro, and solar) to provide resilient and diverse energy systems. Standardized frameworks, can be used to attract green financing and market-based mechanisms like green credits, promoting sustainable energy practices. Empowering communities with geospatial tools for monitoring energy resources and projects can foster greater ownership and ensure projects are locally appropriate. RS-derived data can inform energy policies that support decentralized, sustainable energy systems while mitigating potential environmental damage from large-scale projects.

SDG 8: Decent Work and Economic Growth

NEI face challenges related to economic diversification, infrastructure deficits, and low-wage employment, especially in rural and remote areas. NbS can act as engines for sustainable economic growth by generating green jobs, promoting sustainable value chains for natural products, and fostering eco-tourism. RS identifies economic opportunities ensuring that economic growth is equitable and environmentally sustainable by supporting resources inventory and valuation, eco-tourism planning, sustainable agriculture and value chains, and infrastructure development.

Bamboo grows rapidly on degraded lands, stabilizes soil, and sequesters carbon in Tripura and Mizoram - bamboo enterprise. When harvested sustainably, it provides raw material for handicrafts, furniture, and even bio-based construction. The bamboo value chain employs thousands, with women artisans playing a

prominent role. RS allows planners to map bamboo resources and plan harvest cycles, ensuring both ecological and economic sustainability. The restoration of sacred groves and their integration into eco-tourism circuits has created jobs for local youth as guides, hospitality providers, and conservation stewards in Meghalaya. Similarly, the living root bridges, globally admired as UNESCO tentative heritage sites, are generating employment in tourism without destroying ecological foundations. NbS-guided RS mapping of tourist inflow and ecological carrying capacity ensures that eco-tourism remains sustainable. Sikkim's organic branding provides the farmers access to higher-value markets, and tourism thrives on the image of a "green state." Eco-certified products - from ginger to buckwheat - are creating employment opportunities not only in agriculture but also in processing, packaging, and marketing.

In all these cases, work is not created at the cost of nature but in harmony with nature. Integrating RS data on green job creation and value chain development can provide a more granular and evidence-based picture of progress. Investment in green infrastructure, can generate 20–32 million jobs by 2030 in India. In NEI, this could involve NbS for road stabilization and ecological corridors. Ensuring fair wages and safe working conditions for the NbS workforce, as highlighted by reports on decent work, can be monitored through on-the-ground validation of RS data. By recognizing NbS as engines of livelihood, NEI can grow an economy that is both inclusive and regenerative.

SDG 9: Industry, Innovation, and Infrastructure

NEI face significant infrastructure deficits and unique challenges, including a rugged terrain, seismic vulnerability, and exposure to extreme weather events like floods and landslides. Traditional "grey" infrastructure solutions are often costly, fragile, and not well-suited to the region's socio-ecological context. Industrial development is needed but must be sustainable to protect the region's rich biodiversity. NbS offer a resilient, cost-effective, and multi-functional approach to infrastructure development, such as ecological corridors, green infrastructure, and ecosystem restoration, can enhance the resilience of engineered systems while providing co-benefits for biodiversity and communities. Geospatial technology is crucial for informing and guiding sustainable infrastructure development, facilitating innovation in resource management and monitoring by supporting site suitability analysis, monitoring and resilience, sustainable industrial planning and innovation in resource management. NbS offer resilient infrastructure alternatives that combine human ingenuity with natural processes instead of grey infrastructure.

The living-root bridges of Meghalaya are perhaps the most iconic example. Woven

from aerial roots of rubber fig trees over generations, these bioengineered structures are self-strengthening, flood-resistant, and require no external material. They are living laboratories of biological infrastructure innovation. Planting deep-rooted trees such as alder and bamboo on slopes provides a living infrastructure of soil stabilization, reducing landslide-disaster risks while greening the landscape in Arunachal Pradesh – Pakke declaration. Industrial pollution from processes like rubber latex manufacturing in Tripura can be subjected to bioremediation of rubber processing wastewater using algae. Sikkim's waste management practices, including plastic ban, support a cleaner environment and create local economies based on recycling – Circular Economy. The production of bamboo bottles is an NbS promotes circular economy. Geospatial assessments have identified clusters with high biomass potential, guiding the establishment of decentralized biofuel plants in Assam, turning agricultural waste into clean energy. This Zabo farming, an integrated farming system combines crops, livestock, and fisheries, is an NbS for water and soil conservation

NbS demonstrates that infrastructure can be root, leaf, and soil, providing resilience through living systems, rather than steel and stone in NEI. Standardizing the assessment and monitoring of NbS through RS can help secure sustainable infrastructure and innovation. This integrated approach allows for the creation of resilient infrastructure, the promotion of sustainable industrial innovation, and the protection of the region's invaluable natural capital, directly contributing to the achievement of SDG 9.

SDG 10: Reduced Inequalities

Inequalities in NEI exist based on factors like ethnicity, gender, and geographical location. These inequalities are often exacerbated by climate change and environmental degradation, which disproportionately affect marginalized groups. Remote villages lack access to resources that towns enjoy, and marginalized groups often face exclusion from mainstream development programs. NbS can bridge these gaps by creating localized solutions that empower the marginalized. NbS offer a pathway to reduce these inequalities by ensuring equitable access to natural resources, empowering marginalized communities, and strengthening inclusive governance over these resources. RS can monitor resource distribution, assess the impacts of NbS on different social groups, and ensure that interventions are inclusive and transparent.

By organizing cooperatives to manage fish stocks sustainably, even landless households gain access to nutritious food and income through community fisheries in Assam's beels (oxbow lakes). Remote sensing of lake productivity using

chlorophyll indices allows equitable allocation of fishing rights. The management of Loktak lake by women vendors of the Ima Keithel market demonstrates how NbS can reduce gendered inequality, control the fish trade, ensuring livelihoods and bargaining power for households that might otherwise be marginalized. The customary land tenure systems, when combined with scientific mapping of ecosystem services, ensure that benefits from forests are equitably distributed within and across clans in Nagaland. Such hybrid governance models reduce both social and spatial inequalities. Documenting traditional land rights with modern technology reinforces customary practices and promotes gender equality in resource governance. Sikkim's transition to organic farming has reduced inequality between small farmers and larger producers, and even marginal farmers gained entry into premium markets.

NbS reduce inequality because they localize wealth in ecosystems and distribute it through community institutions, thereby accommodating inclusivity. The successful use of RS to monitor NbS and their equitable outcomes should be integrated into flagship government schemes. By combining NbS with RS, NEI can build on its strengths in community governance and indigenous knowledge to address complex inequalities. This integrated approach ensures that development is not only sustainable but also inclusive and equitable, leaving no one behind.

SDG 11: Sustainable Cities and Communities

The cities and human settlements of NEI are undergoing rapid urbanization, posing significant challenges such as uncontrolled expansion, increased vulnerability to floods and landslides, heat island effects, and environmental degradation. NbS can address these challenges by providing green infrastructure (parks, green roofs), restoring critical ecosystems (wetlands), and using nature to manage risks, thereby by weaving ecology into city planning. Geospatial technology is crucial for monitoring urban growth, identifying vulnerable areas & disaster risk assessment, environmental quality monitoring, green infrastructure planning and implementation of NbS.

The protection of Umiam Lake catchment forests directly impacts the city's water supply. By conserving upstream forests, the city avoids expensive water treatment costs and secures reliable supply. RS of land-use change in the catchment provides data for urban planners to act before crises emerge. The restored Deepor Beel wetland enhances Guwahati's flood resilience while providing co-benefits like improved water quality, biodiversity, and recreational space. The urban forestry programs are integrating green belts and riverbank plantations into city planning in Gangtok, reducing landslide risks while providing recreational spaces. Spring-shed management enables consistent water supply for urban residents and

supports sustainable water management. The link between NbS and mental health in urban environments is becoming increasingly clear, with access to green spaces improving well-being for urban residents. The preservation of unique cultural and ecological heritage, such as 'Living-root' bridges promotes sustainable tourism, and strengthens community livelihoods. The community composting projects turn organic waste into fertilizer, reducing landfill pressure and creating circular urban economies in Imphal. The data-driven NbS helps protect urban infrastructure, reduce disaster risk, and increase community safety in Nagaland.

Thus, sustainable cities in NEI should be ecologically rooted, culturally distinctive, and resiliently green. Expanding initiatives to create green spaces and restore ecosystems can be scaled up regionally. A NEI region-wide plan could identify and prioritize green infrastructure projects based on RS data, maximizing their collective impact on climate resilience and urban well-being. Using geospatial technique, the roads and buildings can be designed to incorporate natural drainage systems and green roofs in order to improve resilience and sustainability.

SDG 12: Responsible Consumption and Production

The global challenge of sustainable consumption and production resonates strongly in the NEI. Rising consumerism threatens to displace traditional frugality, while industries often prioritize profit over ecology. NbS restore balance by making production systems inherently circular and resource-efficient.

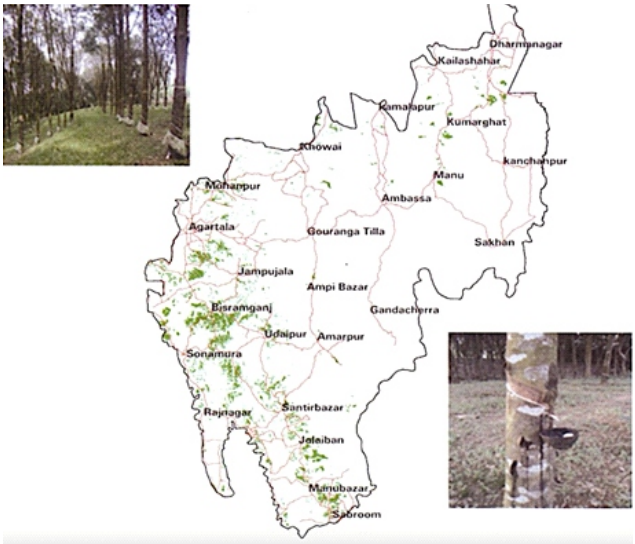
The organic farming revolution embodies responsible production in Sikkim. By banning chemical pesticides and fertilizers, the state has aligned agriculture with ecological cycles. Composting, vermiculture, and bio-pesticides ensure that production does not degrade ecosystems. Consumers, in turn, demand organic products, creating a responsible consumption loop. The community forest rules restrict hunting seasons and timber extraction, aligning consumption with regeneration cycles in Nagaland. Wildlife corridors derived using geospatial tools help ensure that these customary rules match ecological realities. The bamboo crafts industry in Tripura exemplifies low carbon & energy footprint production. Bamboo regenerates rapidly, and artisans turn it into baskets, mats, and furniture - products that are biodegradable and locally sourced. When marketed as eco-products, they appeal to consumers seeking sustainable alternatives. In Assam's wetlands, rotational fishing practices ensure that fish stocks replenish before harvest- responsible production rooted in NbS.

By emphasizing cycles of regeneration, the Northeast demonstrates that consumption and production can be life-affirming rather than life-depleting.

SDG 13: Climate Action

The NEI is highly vulnerable to the impacts of climate change due to its fragile ecosystems and the heavy dependence of local communities on natural resources. These impacts include altered rainfall patterns, increased frequency of floods and landslides, and threats to biodiversity and water resources. The Himalayas are warming faster than the global average and droughts now regularly disrupt lives. NbS offer a dual approach to climate action, providing both mitigation (e.g., carbon sequestration through afforestation) and adaptation (e.g., increased resilience to floods via wetland restoration) benefits. Geospatial technology is crucial for monitoring climate change impacts, planning and implementing NbS, and quantifying their mitigation and adaptation benefits.

Nature-based Solutions are the first line of climate defense here. In Arunachal Pradesh, community-led afforestation programs are expanding alder and oak plantations on degraded slopes. These trees are not only carbon sinks; their root systems stabilize soils, preventing landslides that climate change is intensifying. Remote sensing allows us to measure biomass accumulation, giving communities tangible proof of their climate contributions. In Sikkim, the Dhara Vikas initiative has emerged as a flagship climate adaptation practice. NbS deliver dual climate benefits: carbon sequestration through reforestation and adaptation through water security. Loktak lake acts as natural flood buffers, absorbing excess water during monsoons and releasing it gradually in drier months. Protecting and restoring this wetland is therefore a cost-effective climate adaptation measure.



Distribution of Natural Rubber in Tripura state in future climate (Roy et al., 2014)

The Arunachal Pradesh and Khasi Hills Community REDD+ project assists the Khasi people in regenerating forests and ancient sacred groves. This is an NbS for both climate mitigation (through avoided deforestation and increased carbon sequestration) and adaptation (by protecting ecosystems that provide water and biodiversity). Nagaland practices community forestry, an NbS that can contribute to carbon sequestration and climate resilience. The Zabo farming system is another NbS that promotes sustainable land and water management. Tripura incorporates NbS into its State Action Plan on Climate Change (SAPCC). Mizoram uses NbS to restore degraded forests, enhancing carbon storage and reducing soil erosion.

So, climate action in the Northeast is not only about solar panels or electric vehicles. It is about working with nature's intelligence to create adaptive landscapes, regenerative forests, and living water systems that together act as shields against climate chaos. Mainstreaming NbS into State Action Plans on Climate Change (SAPCCs) and other development programs can enhance their effectiveness.

SDG 14: Life below Water

Life below water is focused on marine resources, but its principles of conservation and sustainable use are crucial for freshwater ecosystems. NEI is landlocked but exceptionally rich in freshwater biodiversity, with vast river systems (Brahmaputra, Teesta and Barak) and numerous wetlands (beels, oxbow lakes) including hundreds of high-altitude lakes that are under threat from pollution, encroachment, climate change, and unsustainable exploitation. NbS can improve water quality, support fisheries, and enhance climate resilience. Geospatial technology is essential for monitoring and managing these freshwater resources, thereby provides a cost-effective way to track changes in water bodies, assess water quality, and guide conservation efforts across the catchments.

Integrated management of Barak-Meghna River basins, informed by RS data on wetland health and climate impacts, led to more resilient freshwater ecosystems and better outcomes for biodiversity and local communities. The community cooperatives introduce rotational fishing, regulate mesh sizes, and replant aquatic vegetation across lakes and wetlands in Assam. Protecting Loktak is not just about water; it is about sustaining life below water in its most interconnected sense. High-altitude lakes in Sikkim and Arunachal Pradesh, such as Tsomgo and Shilloi, are sacred to local communities. Here, NbS take the form of community guardianship - no large-scale infrastructure, no heavy machinery, simply the age-old recognition that water bodies are living entities deserving protection.

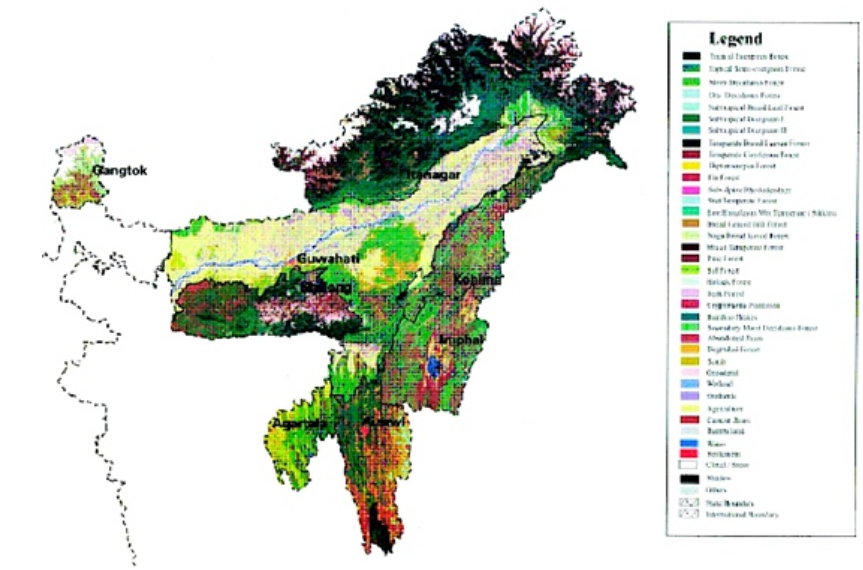
NbS ensure that the aquatic systems of NEI remain nurseries of life, buffers of climate, and sources of community well-being. Scaling up urban NbS, such as constructed wetlands for wastewater treatment, informed by RS, can benefit both urban and downstream aquatic ecosystems.

SDG 15: Life on Land

NEI is part of a global biodiversity hotspot, with unique terrestrial ecosystems, including rainforests, wetlands, and alpine meadows. However, the ecosystems face significant threats, including deforestation, land degradation (from shifting cultivation, or jhum), habitat fragmentation, and loss of biodiversity due to unsustainable practices and climate change. NbS focus on protecting, restoring, and sustainably managing terrestrial ecosystems to address these challenges. These solutions include afforestation, forest and watershed management, and protection of critical habitats. Geospatial technology provides the tools to monitor the health and extent of these ecosystems at various scales.

Villages in Nagaland designate parts of their forests as conservation zones, where hunting and logging are prohibited - Community-managed forests. Other parts are used sustainably for fuelwood, bamboo, and non-timber products. This mosaic approach maintains biodiversity while supporting livelihoods. Satellite imagery clearly shows that forests under community stewardship retain higher canopy cover and wildlife movement compared to state-managed lands. The sacred groves of Meghalaya are patches of forest, often just a few hectares, harbor rare orchids, ferns, and medicinal plants. Because they are spiritually protected, they remain biodiversity reservoirs even as surrounding landscapes change. They are living NbS - micro-forests that stabilize microclimates, conserve water, and preserve species. Sikkim again stands out with its statewide organic farming movement. By rejecting chemical fertilizers and pesticides, it has reduced soil degradation, maintained pollinator populations, and kept rivers free of toxins. Organic farming here is not only about consumer markets; it is a land-based NbS that preserves the ecological base of agriculture. Then there are innovations like alder-based agroforestry in Nagaland. Farmers integrate alder trees with crops, benefiting from nitrogen fixation, soil fertility, and shade. Such systems show how life on land can be nurtured while sustaining human needs.

The message is clear: the Northeast is not merely a repository of biodiversity. It is a living classroom of NbS where forests, farms, and communities thrive together. Protecting life on land here is protecting the very lungs and watersheds of South Asia.



Land Use and Forest Cover Map of Northeast India

SDG 16: Peace, Justice, and Strong Institutions

At first glance, peace and justice may seem distant from NbS. But look closer, and the link becomes evident. Much of the conflict in NEI - whether inter-ethnic tensions or disputes over land and resources - has roots in access to natural assets. Forests, rivers, and land are not just ecological entities here; they are cultural and political ones.

By embedding NbS within community governance systems, peace and justice are strengthened. For example, Nagaland's village councils manage forests and fisheries under customary law. When combined with scientific monitoring - say, through GIS mapping of forest cover - these councils gain legitimacy and authority. Resource disputes diminish because decisions are transparent and locally owned. In Meghalaya, the management of sacred groves is often tied to traditional institutions like the Dorbar Shnong. These institutions mediate access and enforce protection, reinforcing both cultural authority and ecological stewardship. When governments recognize and support these customary systems, they create hybrid governance that is both strong and just. Sikkim's policy to declare itself fully organic was not a technocratic imposition but a democratic decision with community buy-in. Farmers, extension workers, and local bodies were consulted, ensuring that the shift was participatory. The success of the organic transition owes much to this inclusive governance.

Peace and justice are not abstract ideals. In the Northeast, they are woven into whether a community feels ownership over its forest, its water, its land. NbS create a platform for ecological peacebuilding, where stewardship replaces contestation, and regeneration replaces extraction.

SDG 17: Partnerships for the Goals

Finally, let us turn to partnerships. No region, no community, can achieve sustainability alone. The Northeast's NbS successes only gain strength when partnerships link local knowledge with scientific expertise, state policy with community initiative, and local markets with global opportunities.

Consider the Kanchenjunga Landscape Initiative, which brings together Sikkim, Bhutan, and Nepal to conserve transboundary ecosystems. Here, forests and rivers do not recognize political borders, and so NbS become a shared agenda across nations. Such partnerships scale up local successes to regional resilience. At a national level, partnerships between institutions like IITs, state governments, and village councils are helping to map carbon stocks, water flows, and biodiversity corridors. These partnerships ensure that satellite data and local observations reinforce each other. Even global markets are part of this story. Sikkim's organic produce and Meghalaya's eco-tourism circuits connect local livelihoods to global consumers who are increasingly demanding sustainability. Partnerships with ethical supply chains ensure that farmers and artisans receive fair returns while ecosystems remain intact.

Most importantly, partnerships must be intergenerational. The youth of the Northeast are already global citizens, adept with digital tools and deeply connected to their landscapes. Schools that integrate ecological education with fieldwork are creating a generation that sees NbS not as projects but as identities. Thus, SDG 17 reminds us: when we connect village to satellite, indigenous wisdom to modern science, and community action to global solidarity, NbS become not isolated examples but scalable movements.

Upscaling NbS and Geospatial techniques in NEI

Northeast India, with its rich biodiversity, high rainfall, fragile mountain ecosystems, and dependence on natural resources, presents both opportunities and challenges for sustainable development. The region is highly vulnerable to climate change, land degradation, shifting cultivation pressures, and resource-use conflicts. Nature-based Solutions (NbS)-interventions that leverage ecosystem services for addressing societal challenges-offer an integrated pathway to achieve climate resilience, livelihood security, and sustainable development. RS and geospatial technologies can play a pivotal role in scaling NbS by providing data-driven insights, monitoring capabilities, and decision-support tools for policymakers and local communities.

Mapping and Prioritizing NbS Hotspots: Geospatial tools enable identification of

ecological hotspots where NbS can generate maximum co-benefits. High-resolution satellite imagery, LiDAR, and UAV data can map forest cover, wetlands, watersheds, and degraded areas at multiple scales. In Northeast India, such mapping can identify priority zones for wetland restoration (e.g., Loktak Lake), forest regeneration in Jhum fallows, or catchment management in flood-prone Brahmaputra and Barak basins. Spatial multi-criteria decision analysis can integrate ecological, socio-economic, and climatic parameters to prioritize interventions.

Monitoring Carbon Sequestration and Biodiversity Outcomes: Satellite-derived vegetation indices (NDVI, EVI, LAI) and hyperspectral data allow monitoring of photosynthetic activity, biomass, and carbon stocks, directly supporting NbS-based climate mitigation programs. Carbon accounting in shifting cultivation landscapes and community-managed forests can guide REDD+ projects and carbon markets. Remote sensing also supports biodiversity monitoring by tracking habitat change, corridor connectivity, and fragmentation, critical in a region with tigers, elephants, and endemic species.

Enhancing Water Security through Geospatially Guided NbS: Water stress and flooding coexist in Northeast India. RS and GT can assess watershed hydrology, soil erosion hotspots, and groundwater recharge zones, guiding NbS like spring-shed management, riparian vegetation restoration, and agroforestry. For example, catchment restoration in Sikkim's Teesta basin can be scaled using DEM-based modeling, rainfall-runoff simulations, and satellite rainfall estimates, reducing both drought risk and downstream flood intensity.

Strengthening Community-Based Forestry and Agroforestry: Community institutions in Northeast India manage large forest areas through traditional systems. Geospatial tools can support participatory mapping of community forests, monitoring of resource extraction, and planning of agroforestry mosaics. By integrating indigenous knowledge with satellite data, resilient NbS practices such as alder-based agroforestry in Nagaland or bamboo plantations in Mizoram can be scaled while preserving cultural practices.

Disaster Risk Reduction and Climate Adaptation: Landslide-prone hills, floodplains, and cyclone-exposed valleys demand ecosystem-based disaster risk reduction. RS-driven landslide susceptibility maps, combined with NbS like bioengineering (vetiver grassing, bamboo check-dams), can stabilize slopes. Wetland restoration in floodplains can attenuate floods, while mangrove regeneration in Assam's estuarine stretches strengthens coastal resilience. RS and GT provide real-time monitoring, early warning, and long-term resilience planning.

Policy and Decision Support Systems: NbS scaling requires robust decision-support frameworks. RS-GT platforms can feed into state-level natural capital accounting, spatial planning, and integration of NbS into SDG targets. Cloud-based systems (Google Earth Engine, Bhuvan) and AI-driven analytics can

democratize access to data for planners, NGOs, and communities.

Conclusion: Weaving the Story Together

Ladies and gentlemen, we have journeyed through all 17 Sustainable Development Goals, seen through the lens of NbS in NEI. What emerges is not just a checklist of projects but a living narrative of resilience and innovation.

From the micro-hydropower of Arunachal to the sacred groves of Meghalaya, from the bamboo enterprises of Tripura to the organic revolution of Sikkim, from Loktak Lake's wetlands to the living root bridges of Cherrapunji – each story is a thread in a larger tapestry. Together, they show that development can be regenerative, that prosperity can be inclusive, and that modern science can walk hand in hand with ancient wisdom. As climate crises deepen, food systems falter, and inequalities widen, these examples of NbS offer not only hope but practical blueprints. By integrating RS and geospatial tools with local ecological knowledge, NEI can scale NbS for carbon management, biodiversity conservation, water security, and climate adaptation. Such an approach can create resilient landscapes, reduce poverty, and contribute to achieving multiple SDGs. The challenge lies not only in technological innovation but also in capacity-building, community engagement, and institutional coordination to ensure NbS become mainstream development strategies in the region.

So let us invest in the intelligence of ecosystems, let us trust the ingenuity of communities, let us scale the NbS successes of the NEI. In doing so, we are reimagining development itself - from extraction to regeneration, from scarcity to resilience, from division to harmony on the path to achieving SDGs.

References:

Behera MD, Tripathi P, Das P, Srivastava SK, Roy PS, Joshi C, Behera PR, Deka J, Kumar P, Khan ML, Tripathi OP, Dash T and Krishnamurthy YVN. 2018. Remote Sensing based Deforestation analysis in Mahanadi and Brahmaputra River Basin in India since 1985, Journal of Environmental Management, 206: 1192-1203.

Ray D, Behera MD and Jacob J. 2014. Indian Brahmaputra Valley Offers Significant Potential for Cultivation of Rubber Tree. Current Science 107(3): 461-469.

About the Institute

Govind Ballabh Pant National Institute of Himalayan Environment 'NIHE' was established at Kosi-Katarmal, Almora Uttarakhand in 1988 as an autonomous Institute of the Ministry of Environment, Forests and Climate Change (MoEF&CC), Govt. of India. The Institute is identified as a focal agency to advance scientific knowledge, evolve integrated management strategies, demonstrate their efficacy for conservation of natural resources and ensure environmentally sound development in the entire Indian Himalayan Region. Apart from undertaking Research and Development and demonstration on its own, the institute has established linkage between national and international organisations committed to environment and development linked issues in mountainous regions. All the activities of the Institute are essentially multidisciplinary in nature based on a conscious efforts to interlink natural and social sciences to promote sustainable development. GBPNIHE functions in a decentralized manner with its HQs at Kosi-Katarmal, Almora, Uttarakhand and six Regional Centres, namely – Ladhak Regional Centre (Leh), Garhwal Regional Centre (Srinagar-Garhwal), Himachal Pradesh Regional Centre (Mohal, Kullu), Sikkim Regional Centre (Pangthang, Gangtok), North-East Regional Centre (Itanagar) and Mountain Division (MoEF&CC, New Delhi)

About the Sikkim Regional Centre

Sikkim Regional Centre, established in 1989, has been taking up Research & Development activities in Eastern Himalayan States, with particular focus in Sikkim and hilly region of West Bengal (Darjeeling and Kalimpong districts). Center's activities are focussed on the issues relevant to the Sikkim Himalaya with due consideration of geo-environmental conditions, ecosystem approach, community participation, socio-economics, sustainable development and capacity building. Significant activities tie-up with governmental agencies, non-governmental agencies for State and people of Sikkim Himalaya.

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Pt. G. B. Pant Popular Lectures
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(Former Chief Secretary, Govt. of Sikkim)

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Shri Sonam Wangdi Bhutia, I.A.S.
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III - Popular Lecture (2016)
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IV - Popular Lecture (2017)
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