Peatlands of India:
An Overview and Future Roadmap

Ministry of Environment, Forest and Climate Change

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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International Climate Initiative

Wetlands International

Peatlands of India: An Overview and Future Roadmap
Technical Report

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Front Page Photo credit: Tso Kar Wetland Complex, Dhruv Verma/ WISA

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INTERNATIONAL CLIMATE INITIATIVE

Wetlands International

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GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT FOREST AND CLIMATE CHANGE

Foreword

India's rich and diverse ecosystems have always been a source of pride and resilience, to which we add a critical chapter with the first assessment of peatlands in the country. Peatlands have long been overlooked in India's environmental discourse, often due to a lack of clear definitions, inventories, and dedicated policies. This study by the Ministry of Environment, Forest and Climate Change, in collaboration with GIZ and WISA has addressed that gap, by aligning peatland identification criteria with global best practices while tailoring them to India's diverse ecological conditions. It provides not just data, but a framework defining what constitutes a peatland in the Indian context, identifying their extent, and quantifying their carbon stocks. Such knowledge is essential for informed policy and effective action.

The approach used was scientifically rigorous, using satellite-based probability mapping followed by field validation and carbon stock estimation. It establishes the need for region-specific conservation approaches, considering the distinct characteristics of peatlands across the Himalayas, North-East, Trans-Himalayas, and Western Ghats. This study will serve as the starting point for a more expansive national effort. Extending peatland probability mapping to other bio-geographic zones and transforming probability layers into detailed distribution maps will be critical for policy planning and field-level implementation. These actions can guide sustained conservation, restoration, and monitoring efforts while supporting integrating peatlands into India's national climate strategies, such as the National Action Plan on Climate Change and wetland conservation programmes under NPCA, addressing both mitigation and adaptation priorities.

This report marks not only a milestone for wetland ecosystem management in the country, but also a collective call to action. Let us build on this momentum to ensure that peatlands receive the recognition, protection, and stewardship they urgently deserve.

(Rajat Agarwal)

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Khecheopalri Lake, Sikkim

Photo credit: Purva Shah / GIZ

Executive Summary

Peatlands, despite covering only 3-4% of the global land surface, hold nearly one-third of the world's soil carbon. Their conservation is critical for global climate goals due to their role in carbon sequestration, hydrological regulation, and biodiversity support. However, in India, the extent and condition of peatlands remain largely unaccounted for in national inventories and policies. In the above context, the Ministry of Environment, Forest and Climate Change (MoEF&CC) in collaboration with GIZ and Wetlands International South Asia and Stichting Wetlands International, the Netherlands initiated inventorisation and assessment of peatlands in India and have estimated the extent of Indian peatlands, assessed their carbon stock, evaluated threats, and proposed management strategies.

The project followed a phased methodology, beginning with a scoping phase to review peat occurrence, ecological and hydrological conditions, and paleo records. A peatland probability map was developed for key biogeographic zones - Himalayas, Trans-Himalayas, North-East, and Western Ghats using Sentinel-2 satellite imagery. Thematic layers representing peatland indicators such as vegetation, water, organic soil, and topography were compiled to identify potential peatland areas. Field validation involved assessments at nearly 35 sites across the probability gradients, refining the initial peatland probability estimates. Based on the analysis, the maximum probable peatland extent is estimated to be 310,000 hectares, accounting for approximately 0.4% of the total geographical area of the four biogeographic zones studied.

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Changthang Wetland

Carbon stock assessments were conducted across five peatland clusters using standardised coring processes. Soil samples were analysed for physical (depth, bulk density), chemical (organic carbon percentage, pH), and biological parameters. The findings revealed significant variability in carbon storage potential across different biogeographic regions. The Himalayas exhibited the highest median carbon stock at 92.5 tonnes per hectare, followed by the Trans-Himalayas (62.27 tonnes/ha), Northeast (54.73 tonnes/ha), and the Western Ghats (19.28 tonnes/ha). These results highlight the importance of region-specific conservation strategies. Threat analysis identified key pressures on peatlands, including hydrological regime alterations, resource exploitation, unregulated tourism, and climate change.

Defining peatlands within a national context is crucial for conservation efforts. The study proposes thresholds for peatland identification: (a) a minimum peat depth of 10 cm within the top 1 m of soil and (b) soil organic carbon content of at least 8% or carbon density of at least 0.05 g/cm^3. These criteria align with international definitions and support India's climate and wetland conservation policies.

A dedicated programmatic framework for peatland conservation under the National Program for Conservation of Aquatic Ecosystems (NPCA) is recommended. The strategy should include integrated peatland management, protection of intact sites, restoration of degraded peatlands, climate risk mitigation, and governance mechanisms. A peatland monitoring framework is also developed to support evidence-based policy making and management planning.

This study represents an initial effort to establish a baseline for peatland extent, carbon stock, and management needs in India. Further work is required to refine peatland mapping, standardise definitions, and enhance research collaborations. The growing institutional interest in peatland conservation presents an opportunity to develop a National Peatlands Initiative, fostering long-term protection and sustainable management of these critical ecosystems.

Photo credit: Apoorva Thapa / WISA

01 BACKGROUND & RATIONALE

Peatlands are unique and rare wetland types which despite covering around 3-4% of the world's land surface, contain up to one-third of its soil carbon (UNEP, 2022). Safeguarding carbon locked in peatlands is essential to achieving the global climate goals. Damaged peatlands are a major source of greenhouse gas emissions, along with concomitant loss in their ability to sequester carbon, regulate hydrological regimes and support biological diversity.

Peatlands is a general term used for land with naturally accumulated layers of peat near the surface (UNEP, 2022; Ramsar, 2002). Peatlands include both ecosystems that are actively accumulating peat, and degraded peatlands that no longer accumulate but in contrast, lose peat. 'Peat' has been defined as "dead, partly decomposed plant remains (but still macroscopically recognisable) that have accumulated and have been conserved on the spot where they have been produced (in situ)". Peat-accumulating peatlands are wetlands due to the presence of high-water table which creates anoxic conditions necessary for peat accumulation and preservation. Degraded peatlands no longer accumulate peat and may, when transformed, not appear as wetlands. Peatlands are typically classified using hydrological, botanical and physiognomic features; however, these tend to dissipate when peatlands are drained, converted or used intensively (Minasny et al., 2023).

In addition to their immense capacity to slowly sequester and store carbon, peatlands offer a wide array of valuable ecosystem services. They are vital to the water cycle, acting as natural reservoirs that store and filter water, regulate streamflow, and help mitigate flood impacts by slowing peak flows. Peatlands also support unique biodiversity, providing habitat for specialised plants and animals that sustain the livelihoods of millions. Moreover, these distinctive wetlands often preserve archaeological artifacts and contain layered records of past environmental conditions, offering crucial insights for understanding long-term climate patterns and projecting future climate change (UNEP, 2022).

Available literature indicates the presence of peatlands in India's Himalayan, northeastern, and coastal regions. These landscapes support peatlands in high-altitude marshes, riverine floodplains, and coastal wetlands, such as Khecheopalri in Sikkim (Jain et al., 2004; Neill et al., 2020); Chandertal, a Ramsar Site in Himachal Pradesh (WISA, 2020); Greater Pamba Basin (Kumaran et al., 2016) and the Vembanad region of Kerala (Narayana, Priju, and Rajagopalan, 2002); and peat deposit sites in the Nilgiris region of Tamil Nadu (Thomas et al., 1974).

Peatlands are not identified as a separate category in the national ecosystem types or land-use/land-cover classification systems. India is amongst the few countries globally with a detailed geospatial wetland inventory and one of Asia's largest networks of Ramsar Sites. The 'National Wetlands Inventory Atlas' which provides data on wetland numbers and extent in 2017-18 prepared by the Space Application Centre does not identify peatlands a distinct wetland type.

Information on peatland extent in India is primarily available from global assessments and varies between 0.1

to 5.71 million hectares (Gumbricht et al., 2017; UNEP, 2022; WI and IMCG, 2009; Xu et al., 2018). These discrepancies arise from differences in the definitions and mapping techniques used in global and regional assessments. Recent evaluations employing machine learning models (e.g., Gumbricht et al., 2017; Melton et al., 2022) have primarily relied on training datasets from temperate regions and Southeast Asia, potentially leading to overestimate of peatland extent in India. These variations are attributed to differences in the definitions of peatlands and mapping methodologies employed. National estimates of peat and peaty soils by ICAR-NBSS&LUP (Kumar et al., 2020) indicate their extent to be approximately 0.27 million hectares.

In order to differentiate peatlands from other carbon rich wetlands, different countries have adopted specific criteria related to the minimum depth of surface organic layer and minimal percentage of organic carbon needed to term a wetland as a peatland. The peat depth affects the potential time period and the total amount of GHG emissions likely to be released if the peat is exposed or drained. The threshold proportions of organic carbon determine the boundary between mineral and organic soils. Various countries and peatland-centric intergovernmental initiatives use different definitions as per their local context and purpose which may range from conservation and protection to resource use and harvesting. The UNFCCC (2006, 2014) thus recommends countries to establish specific thresholds to define peatlands based on national contexts, ensuring consistency across land areas and over time.

Although a wealth of information exists on global peats, there is overall lack of information regarding tropical peat deposits in Indian subcontinent except few studies from the Nilgiris Hills, in southern India, that of Himalayan Basin and western coast. A detailed inventory of peatlands in India is therefore essential for determining the magnitude of carbon stocks and greenhouse gas emissions from peat to support carbon emission reduction. Therefore, the present assessment was envisaged to advance sustainable peatland management by improving mapping and monitoring of peatlands in India and to encourage urgent action to integrate peatlands into national climate strategies and programmes.

Jugmargi nallah (near Tarsar lake), J&K

Photo credit: Anil Fartiyal / WISA

The inventory and assessment of peatlands initiative is a part of the Indo-German Support Project for Climate Action in India, commissioned by the International Climate Initiative (IKI) and the Federal German Ministry for Economic Affairs and Climate Action (BMWK), implemented by the Ministry of Environment, Forest and Climate Change (MoEF&CC) and GIZ and executed by Wetlands International South Asia and Stichting Wetlands International. The objectives of the assignment included - development of an estimate of peatland extent in India, assessment of threats and management needs, and propose a national framework for peatland conservation and restoration in the country.

The development of this technical report has immensely benefited from the discussions at the two national workshops organised in New Delhi on February 14-15, 2024, and December 10, 2024. These workshops drew international and national experts from Center for International Forestry Research (Indonesia), Greifswald Mire Centre (Germany), Wetlands International Global Office (Netherlands), Indonesia and China, Indian Institute of Technology Delhi, National Centre for Sustainable Coastal Management (NCSCM), the National Centre for Earth Science Studies, GB Pant National Institute of Himalayan Environment, Space Application Centre, Agharkar Research Institute and several other national Universities and Institutes. Aspects of peatland inventorisation and management were extensively discussed with experts from the Global Peatland Assessment Programme of the United Nations Environment Programme. Two regional workshops with State Wetland Authorities and subject matter experts were also organised to discuss the findings of the mapping exercises.

Tso Kar, Ladakh

Photo credit: Arif Ahmed / WISA

02

PEAT & PEATLANDS IN INDIA:

Current state of knowledge

India is known to have peatland ecosystems distributed across Himalayan, North-East and Coastal regions. The inherent biophysical and geographical diversity of the landscapes impart different characteristics to peatlands, leading to the occurrence of peatlands in high-altitude marshes, riverine floodplains, and coastal marshes of the country.

In Himalayan and North-East BGZ, temperate or high-altitude peatlands can be characterised by *wetlands or grasslands that grow in humid soils, accompanied by graminoids (sedges), bryophytes (moss) and other herbaceous plants, associated with water sources of different origin, whether surface, underground or subsurface. They form soils with high organic content in saturated conditions (hypoxia), generally located above 2500 m amsl, or lower at higher latitudes.*

Similarly, the tropical and coastal peatlands in India can be characterised by *tropical or sub-tropical rainforests, swamps and marshes, ox-bow lakes, and coastal marshes and lowlands behind mangroves, that grow in nutrient-poor, acidic soils and waterlogged conditions can form peat. These systems usually have dicot trees, palms, mangroves, sedges, reeds, grasses and other flora, that form peat, generally located at lower altitudes and latitudes (sea-level to approximately 1500m amsl).*

In the Himalayan region, Jain et al. (2004) and Neill et al. (2020) have established the ecological baselines of the temperate peatland of Khecheopalri in Sikkim. Peatland assessment as a part of wetland management planning has also been undertaken for Chandertal, a Ramsar Site in Himachal Pradesh (WISA, 2022). Peat and peatlands in southern India have been studied by Kumaran et al., (2016) with a focus on the Greater Pamba Basin and by Narayana, Priju, and Rajagopalan (2002) in Vembanad region of Kerala. Thomas et al. (1974) documented 47 locations of peat deposits in the Nilgiris region of Tamil Nadu.

The northeast and eastern parts of India, house a network of small and dispersed peatlands in West Bengal, Manipur, Nagaland, Arunachal Pradesh and Meghalaya. Paul et al., (2019; 2020) have extensively researched the physico-chemical properties of peat deposits in Assam, Tripura and other states, and have reported peat deposits are prominent on elevated and dome-shaped lands as well as shallow basins. The presence of peatlands in West Bengal has been indicated in the studies by Reddy, Sahu, and Ghosh (2014).

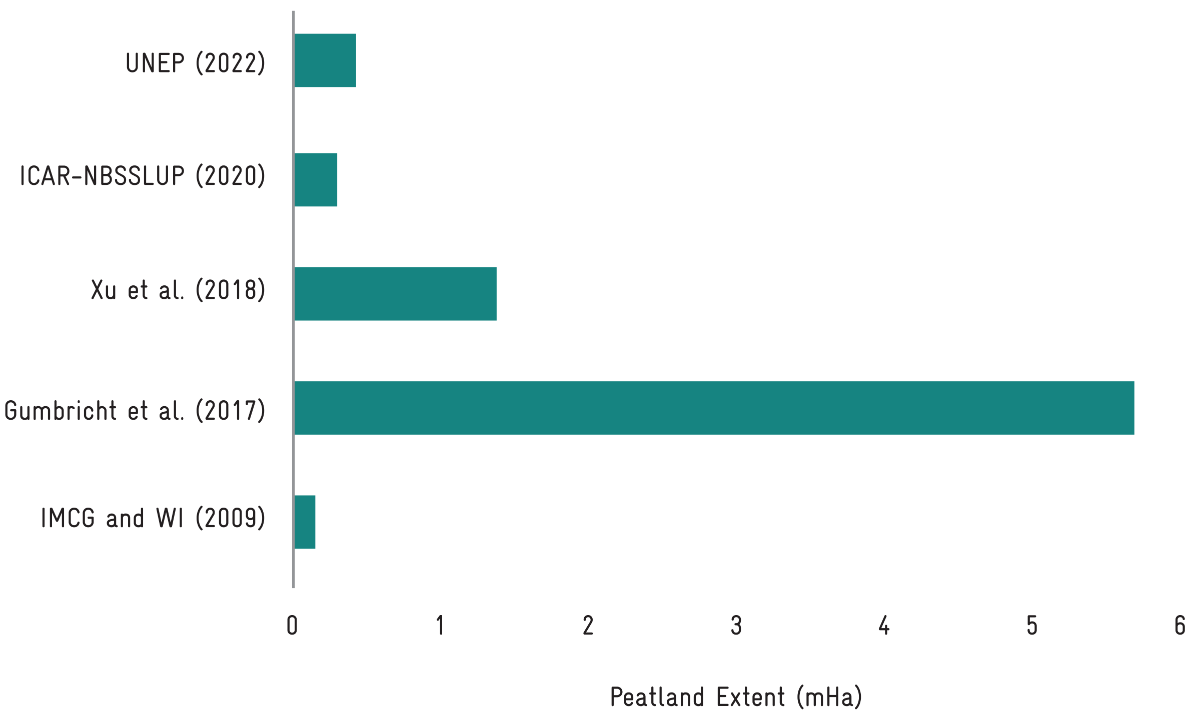
However, there are a few national estimates of peatland extent in India. ICAR-NBSS&LUP (Kumar et al., 2020) estimated that India has around 0.27 million hectares of peat and peaty soils, which are defined as soils developed in low-lying coastal marshes or depressions from dried lakes in alluvial and coastal plains, areas often formerly occupied by mangrove swamps.

Much of the data on peatland extent in India derives from global assessments, which generally highlight significant knowledge gaps regarding peatland coverage in the region. In 2008, Wetlands International and the International Mire Conservation Group (IMCG) of the Greifswald Mire Centre provided one of the first global peatland assessments for the UNFCCC, estimating India's peatland extent at 0.1 million hectares (WI and IMCG, 2009). WI and IMCG adopted Joosten & Clarke's (2002) peatland definitions for global consistency, defining peat as material with at least 30% dry mass organic matter and peatlands as areas with naturally accumulated peat at the surface, with a minimum peat depth of 30 cm. This IMCG-GPD definition aligns with the FAO's histosols definition, which also includes shallow peat over ice or rock.

Gumbricht et al. (2017), using remote sensing and GIS, identified around 5.71 million hectares of peatlands in India, primarily in riverine floodplains, Himalayan foothills, and coastal tracts. Xu et al. (2018), using a meta-analysis and PEATMAP, reported India's peatland area at 1.35 million hectares, though excluding parts of the Western Himalayas and riverine areas noted by Gumbricht Xu et al. (2020) highlighted that varying peatland definitions impact PEATMAP's consistency, as data from the Harmonized World Soil Database (HWSD) v1.2 uses organic soils as peatland proxies, potentially underestimating areas with stricter organic layer criteria.

The Global Peatlands Assessment (UNEP, 2022) later estimated India's peatland coverage at 0.4 million hectares. UNEP's definition includes land with a naturally accumulated peat layer at the surface, covering both ecosystems actively accumulating peat and degraded peatlands (Convention on Wetlands, 2018b). As can be seen in Figure 1, there is a high variation in the reported peatland extent in India. This variation is due to differences in the peatland definition and mapping methods used for estimating distribution and extent at global and regional scales. More recently, the assessment derived from machine learning (such as Gumbricht et al., 2017; Melton et al., 2022) used training datasets from mostly temperate regions or Southeast Asian countries and thus may have overestimated the peatland extent in India.

Figure 1: Peatland extent of India estimated by global and country-level studies



03 PEATLAND INVENTORY & ASSESSMENT

3.1 Mapping Peatlands in India

3.1.1 Peatland Mapping Framework

Multiple methods have been used to map peatlands from field level to global, however the basic framework includes collection of data from field surveys and ancillary sources followed by mapping with earth observation data obtained via remote sensing. As 'peat' cannot be mapped remotely, peatland mapping is often based on proxies such as topographic, geomorphic, climatic, pedologic and hydrologic features that can indicate the presence of peat. In situations where no baselines are available, a peatland probability map derived using a combination of these proxies is a useful starting point so as to identify sampling locations wherein the presence of peat can be confirmed and the definitional thresholds applied.

The current assignment focused on identifying and characterising peatlands from four biogeographic zones of India, namely, the Himalayas, Trans-Himalayas, North-East and Western Ghats. These biogeographic zones were selected based on the review of available literature and global datasets on the distribution of peatlands in India. To assess the extent of peatlands in the four biogeographic zones, peatland probability maps were developed. These maps indicate probabilities of peatland occurrence based on supporting descriptors.

Five descriptors namely soil (soil organic carbon, bulk density and moisture), water (presence of surface inundation or saturation), vegetation (type and density),

Tso Kar Wetland Complex

Photo credit: Arif Ahmad / WISA

Figure 2: Classification scheme of the peatland descriptors

	Peat occurence probability (high)	Peat occurence probability (moderately high)	Peat occurence probability (moderate)	Peat occurence probability (moderately low)	Peat occurence probability (low)
Soil	Soils with very high organic carbon content (SOC>8%)	Soils with high organic carbon content (SOC 6-8%)	Soils with low organic carbon content (SOC 4-6%)	Mineral soils with very low organic carbon content (SOC 2-4%)	Mineral soil with no organic carbon content (SOC 0-2%)
Vegetation	Meadows and grasslands	Shrubs	Dense vegetation	Barren to very low vegetation	No vegetation
Hydrology	Permanent and shallow	Temporarily flooded	Wet and exposed soil surface	Non-aqueous surface	Glaciers
Topography	Level to nearly level (0-3 Degree)	Gently sloping to undulating (3-6 Degree)	Undulating to rolling (6-9 Degree)	Rolling to moderately steep (9-12 Degree)	Steep slope (12 Degree and above)
Climate	Moderate land surface temperature (16-24°C)	Low land surface temperature (8-16°C)	High land surface temperature (24-32°C)	Very low land surface temperature (0-8°C)	High land surface temperature (Below 0°C)

topography (slope and terrain driven water accumulation), and climate (land surface temperature) were used to assess the suitability of the landscapes which support peatlands. Selected based on the available literature and guidance manuals on peatland mapping such as FAO (2020), these descriptors were classified on a scale of 1 to 5 with 1 being the least conducive environment for peatland formation and 5 being the most conducive (Figure 2). The classification scheme was corroborated with scientific literature and mapping manuals on peatland mapping and delineation (Melton et al., 2022; FAO, 2020).

The peatland probability maps for different biogeographic zones were developed using the Google Earth Engine cloud computing platform and GIS software. The process involved analysing satellite data from Sentinel-1 (radar) and Sentinel-2 (optical), along with the SRTM digital elevation model, for the Himalayan, Trans Himalaya, North-East, and Western Ghats biogeographic zones. An overlay analysis was conducted on classified layers of soil organic carbon, bulk density, normalised difference vegetation index, normalised difference water index, topographic wetness index, land surface temperature, slope, and vertical polarisation coherence using the raster calculator in GIS software. Assuming equal contributions from all variables, a direct sum was calculated and then divided by a factor representing the number of descriptors and a classification threshold.

$$\text{Peatland Index} = \frac{(\text{SOC} + \text{BD} + \text{NDVI} + \text{NDWI} + \text{TWI} + \text{LST} + \text{VV} + \text{Slope})}{(\text{Number of descriptors} * \text{Classification Threshold})}$$

$$\text{Peatland Probability (\%)} = \text{Peatland Index} * 100$$

SOC: Soil Organic Carbon, BD: Bulk Density, NDVI: Normalized Difference Vegetation Index, NDWI: Normalized Difference Water Index, TWI: Topographic Wetness Index, LST: Land Surface Temperature, VV: Vertical Polarization

After generating the maps, specific sampling sites were selected for validation. Field observations, along with existing peatland data for India, were used to assess the accuracy of the probability model. Sampling was conducted at 35 sites across 10 states and union territories within the Himalayan, Trans-Himalayan, Northeast, and Western Ghats biogeographic zones, covering elevations ranging from 75 to 4,300 meters above sea level. The maps were refined based on these field validations to improve their accuracy. Field assessments were conducted in pre and post monsoon across all biogeographic zones.

3.1.2 Estimate of Peatland Extent in India

Based on the analyses, the maximum probable peatland extent is estimated to be 310,000 hectares, accounting for approximately 0.4% of the total geographical area of


Wetlands of Kashmir Valley
Photo credit: Apoorva Thapa / WISA

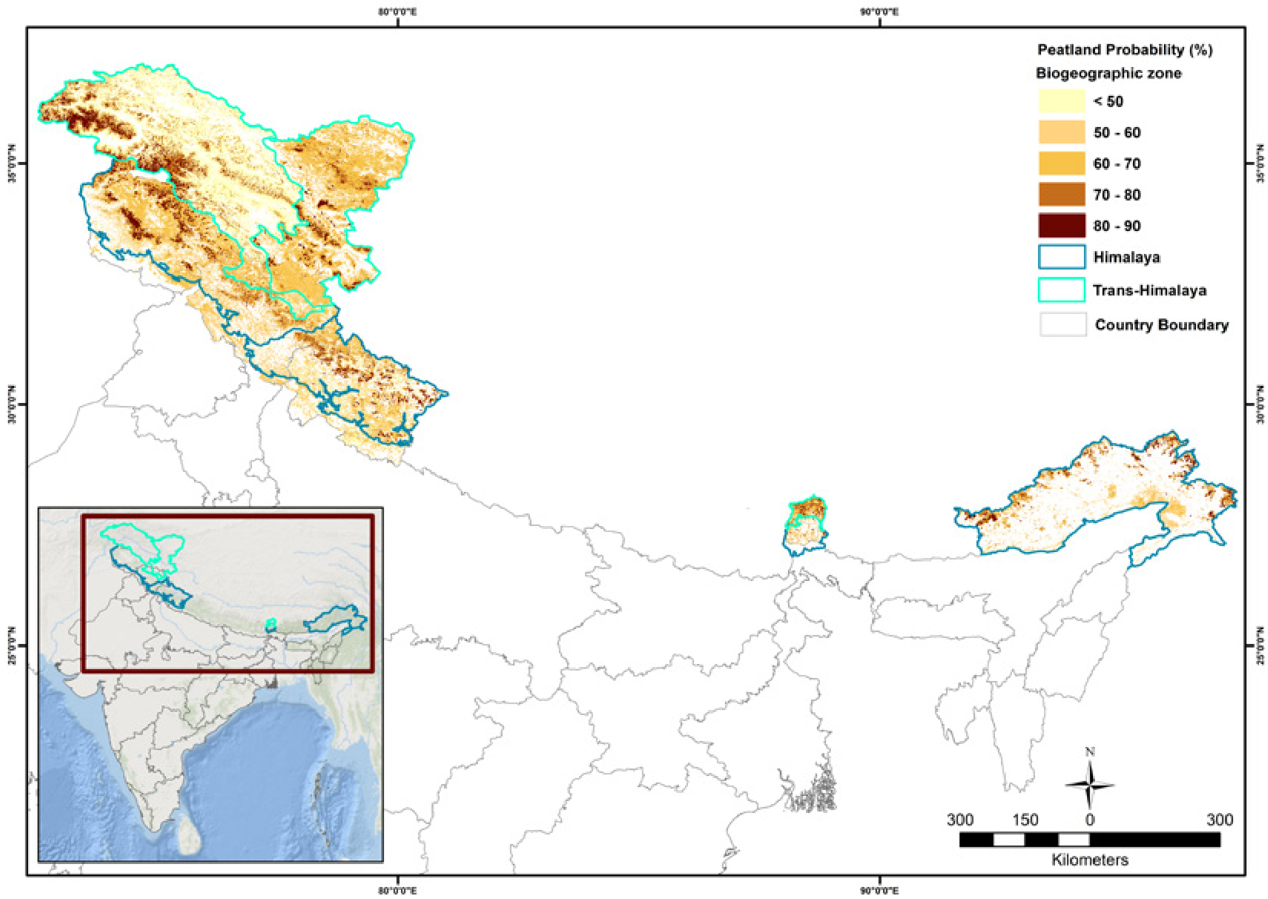
the four biogeographic zones studied (Himalayas, Trans Himalayas, Northeast, and Western Ghats) (Map 1-4). Although Coasts biogeographic zone remains unexplored in the current assignment, probability of locating coastal peatlands is significant and efforts would be made to identify peat supporting landscapes in the subsequent map iterations. The estimated probability of peatland areas varies across India's biogeographic zones. In the Northeast, potential peatlands cover approximately 0.5% of the total area (~80,000 hectares). Most medium to high-probability pixels are situated at elevations between 75 and 3,000 metres, predominantly within forest and cropland areas, followed by rangelands and wetlands land-use/land-cover (LULC) classes. The floodplains of the Brahmaputra River are unlikely to have surface peat due to high sediment flux. Field validation in Nagaland and Meghalaya identified peat in some areas. Dzukou Valley (~2500m amsl), in Nagaland has a shallow peat layer up to 30 cm deep. Doyang, Mekokla and wetlands in Wokha were found to have low peat potential. In Meghalaya, peat was found near springs in the meadows of Jowai.

In the Himalaya and Trans Himalaya biogeographic zones, potential peatlands account for approximately 0.4% of the total area (~180,000 hectares). Most medium to high-probability pixels are concentrated in mid- to high-altitude regions, ranging from 1,500 to 5,000 metres, predominantly within rangelands and wetlands. In Ladakh, shallow surface peat is found in locations like Tso Kar, Hanle Marshes, and Chushul Marshes, with Tso Kar showing sporadic peat distribution but rich carbon content. Khecheopalri in Sikkim, a temperate peatland dominated by moss and sedges, features thick peat vegetation with soil organic carbon levels ranging from 17-40% and peat thickness reaching up to 4 feet near the lake. In Himachal Pradesh, locations such as Chandertal, Miyar Valley, and Kareri, situated in mid to high altitudes, which were surveyed in other projects of Wetlands International South Asia, also contain shallow surface peat with high soil organic carbon.

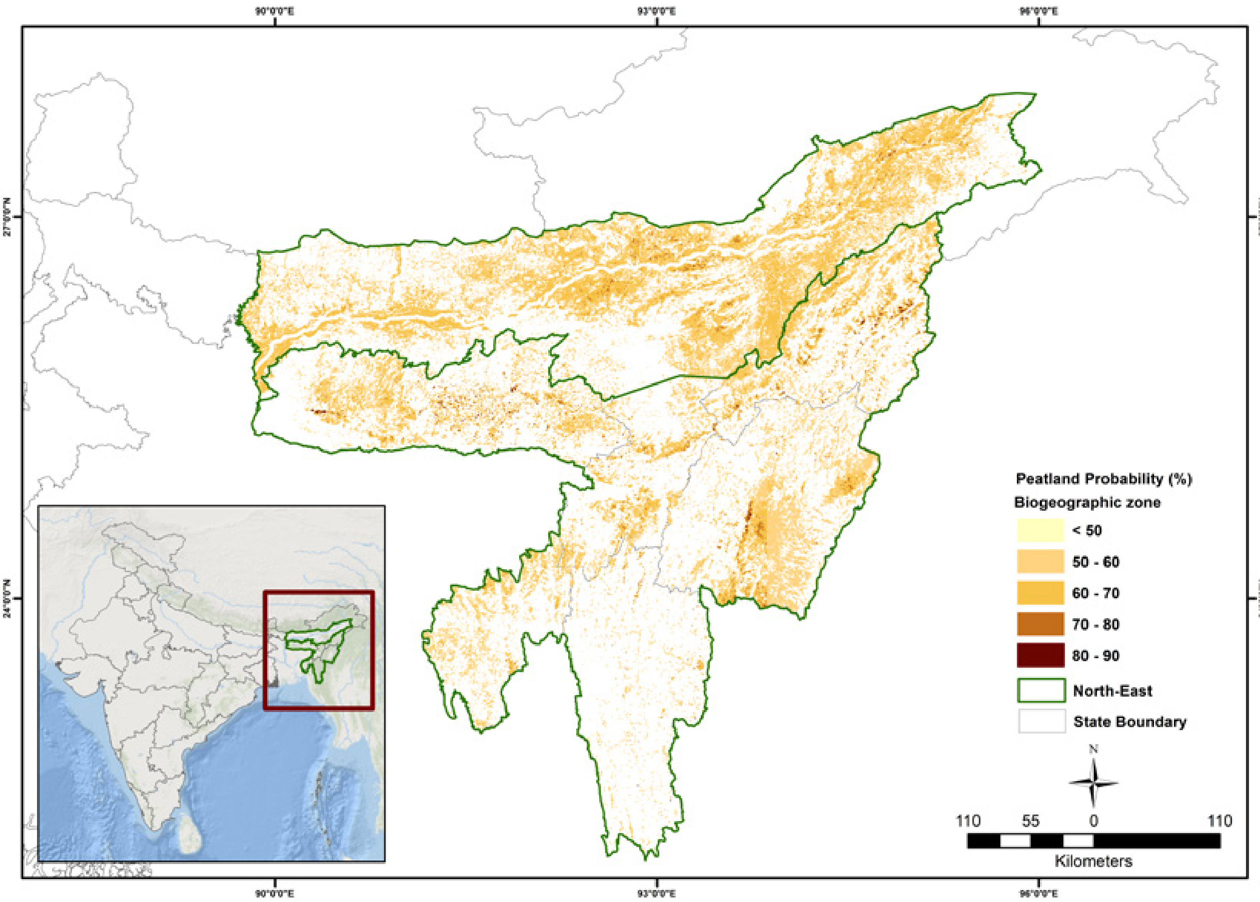
In the Western Ghats biogeographic zone, peatland probability area covers about 0.4% of the entire Western Ghats (~50,000 Hectares). Majority of the medium to high probability pixels are found in the LULC classes tropical rainforests and grasslands, water, and paddy fields. Sampling in Myristica swamp locations in the Kulathupuzha and Shendurney forest ranges, along with one wetland complex and a grassland area was conducted in post-monsoon period of 2024. During the field assessments in December 2024, the environment appeared conducive to peatland formation in Myristica Swamps, yet many of the swamps did not have presence of peat. Rather, these swamps had mineral soils with varying range of soil organic carbon and depth profiles. However, the top 1-meter surface contained silt deposits from nearby streams, leaving the swamps devoid of peat. A total of five Myristica swamps were sampled within the Kulathupuzha and Shendurney regions. Results from Devikulam, Sita Devi wetland indicated favourable conditions for peat formation, but the top layer had high proportions of mineral soil. While the soil exhibited high organic content, the likelihood of it being classified as a peatland was low.

A comparative assessment of the peatland probability map developed under the current assignment with the Global Peatland Assessment (GPA) map reveals significant differences in coverage and precision. The GPA map, based on literature, categorizes peatlands into peat-dominated areas (~8300 Ha) and peat in soil mosaics (~345000 Ha), estimating a total of approximately 354,464 hectares in India, with locations spanning the Northeast, Western Ghats (mainly Kerala), parts of the Himalayas, and the Sundarbans. The mapping approach developed under the project identifies numerous peatland locations in the Himalayas, Trans Himalaya, Northeast, and Western Ghats beyond the areas reported by the GPA, suggesting a more comprehensive representation of peatland areas, while acknowledging the need for refined mapping to enhance accuracy and better represent these vital ecosystems.

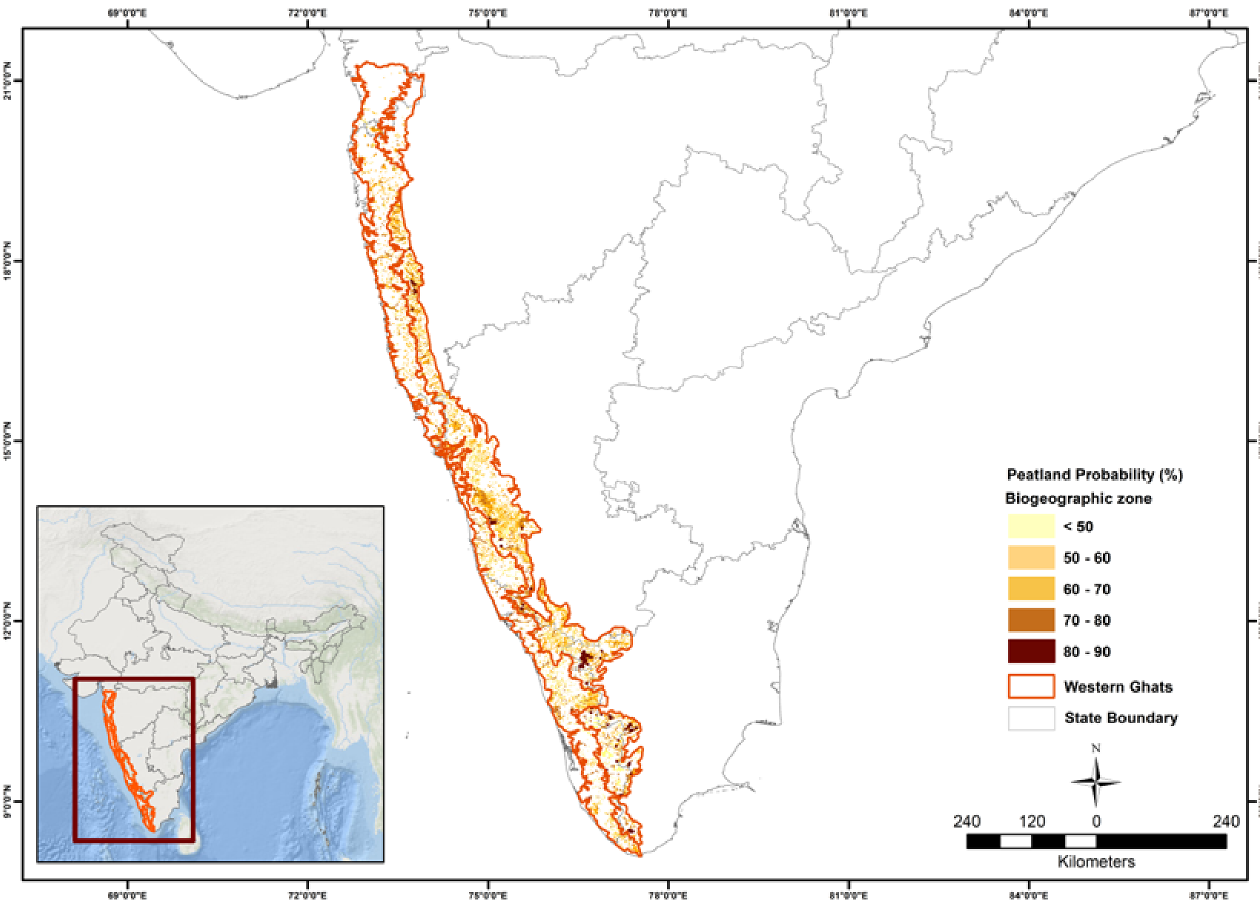
Map 1: Probable peatland extent in Himalayas and Trans-Himalayas biogeographic zones of India



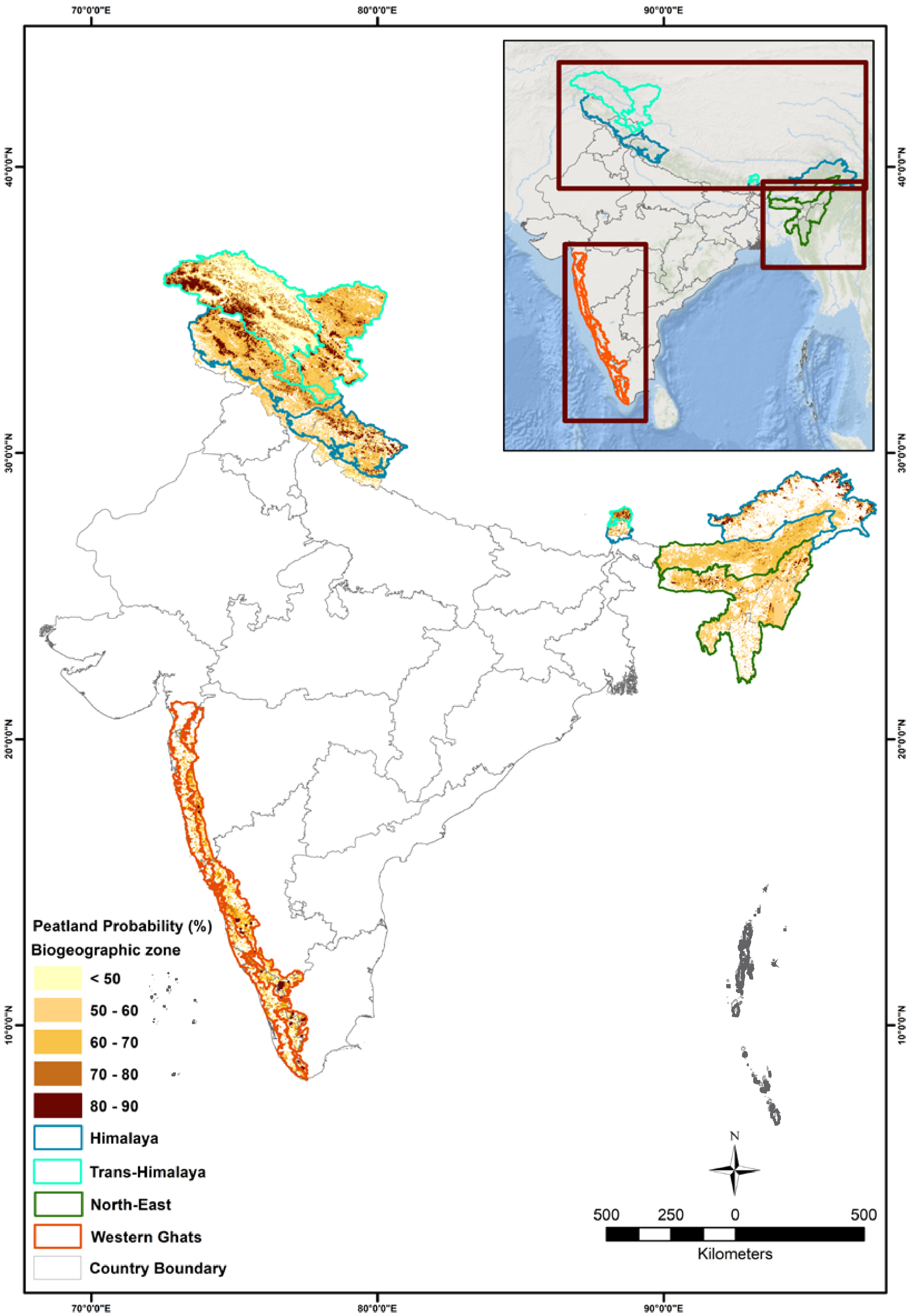
Map 2: **Probable peatland extent in Norh-East biogeographic zone of India**



Map 3: **Probable peatland extent in Western Ghats biogeographic zone of India**



Map 4: Probable peatland extent in four priority biogeographic zones of India



3.2 Peatland definition, typology and profile

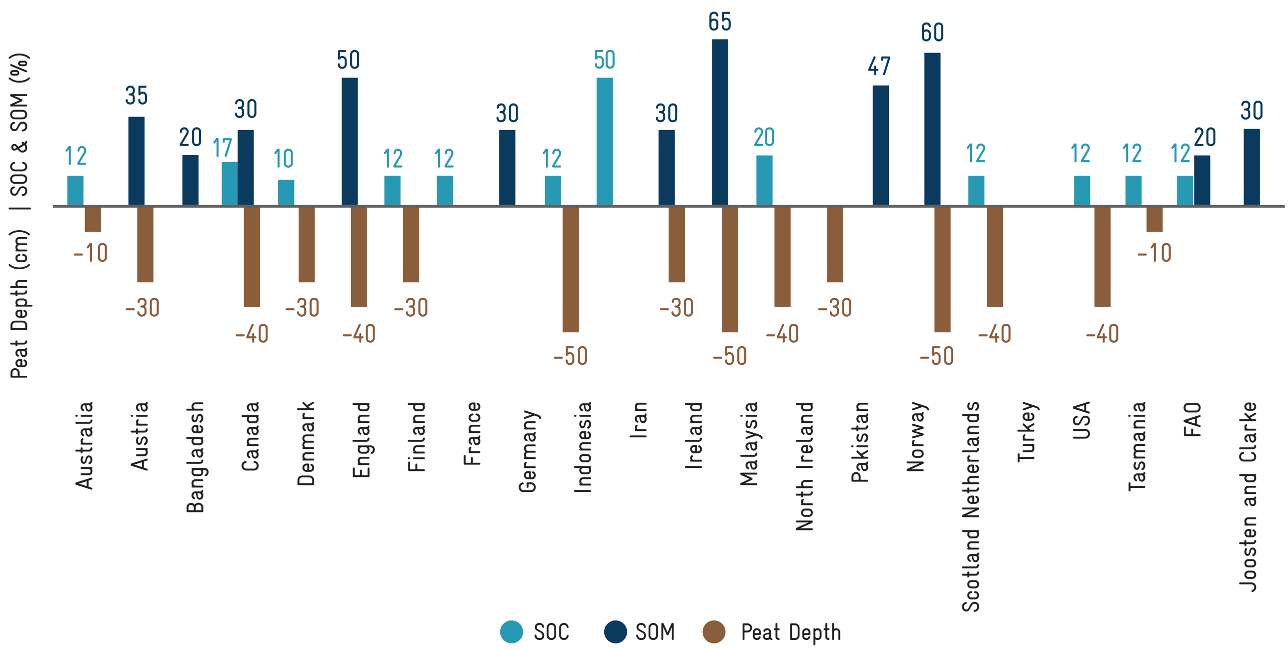
Development of peatland extent needs to be based on a clear definition of these ecosystems. Peatland is a general term for land with a naturally accumulated layer of peat near the surface. Peatlands include both ecosystems that are actively accumulating peat, and degraded peatlands that no longer accumulate but in contrast lose peat (UNEP 2022). This definition is consistent with that established by the Convention on Wetlands (COP 8 Resolution VIII.17) (Ramsar Convention on Wetlands 2018).

Going by the definition, land with any thickness of in-situ peat is a peatland. The IPCC or the IMCG have therefore not recommended a fixed threshold for peat depth and encourage country specific definitions which are consistently applied to generate national maps and statistics. Beyond peat depth, different countries have used Soil Organic Carbon or Soil Organic Matter as a characterising variable. In the past the purpose of peatlands definitions was tightly linked with soil mapping (developed for the mapping conducted in the field). Currently, as the importance of peatlands for climate mitigation and adaptation, for water management, water resources protection, soil protection, and biodiversity conservation, is being recognised, these old definitions do not always capture the diverse values of these ecosystems. However, these definitions are still in use, because the existing soil or peatland maps are still the best source of information on peatland presence and distribution (current and past).

In many countries, mostly where peatlands occupy larger areas, the definition of peat and peatlands was first developed by soil scientists for soil classification and mappings and was very much related with the management practices. In soil sciences, peat is classed within organic soils which is characterised by the proportion of organic matter contained in the soil. As the soil classifications for different countries were developed by national experts and depends on the local context, also the definition or lack of definition of peatlands and inclusion of peat soil in the classification differs per country. The parameters most often used in the definitions, except for the basic one (presence of peat) are: a) the minimal depth of peat, and b) organic carbon content (%, based on dry weight). Additionally, the definitions may include information on minimal size of the individual peatland or on soil bulk density. Also, the development of the area and the soil processes (e.g. peat forming, peat compaction, mineralisation, change of porosity, subsidence, forming of aggregates etc.) play a role in identifying a peatland.

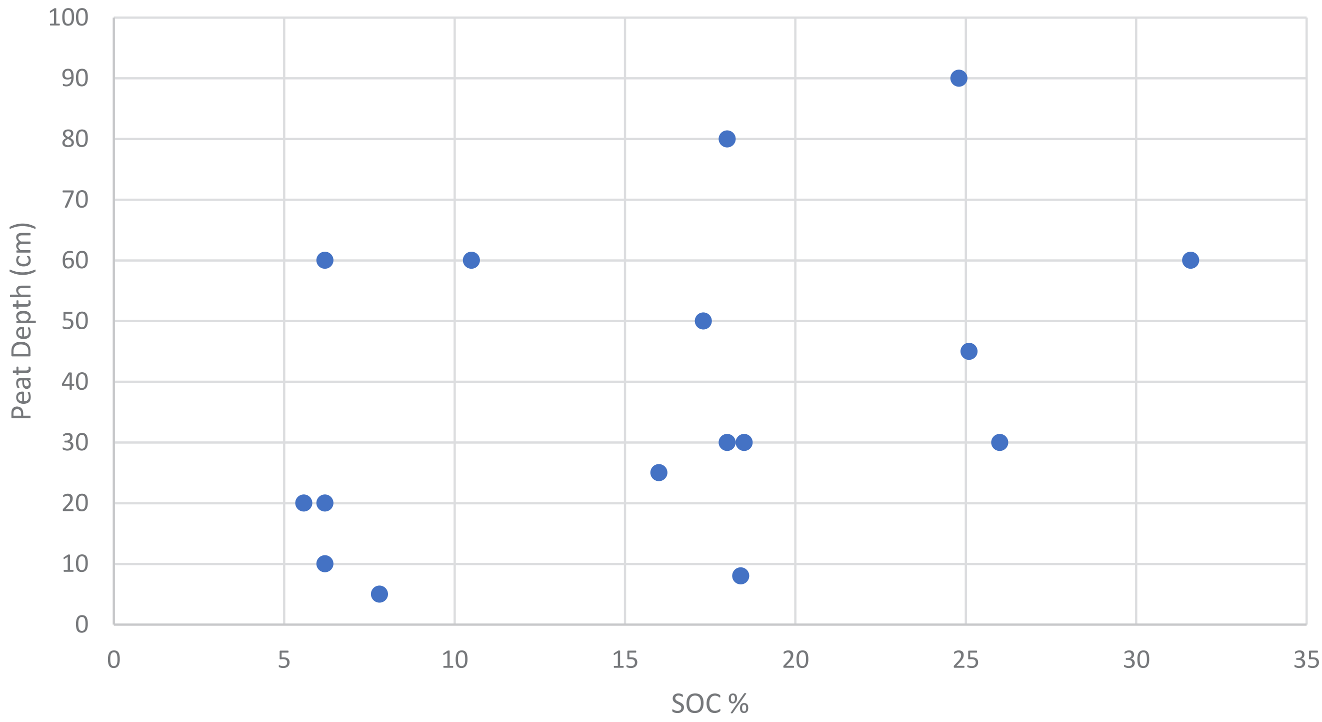
Over 100 soil samples from potential peatland sites were

Figure 3: Peatland definition used by different countries and international organisations



collected and analysed for peat depth from surface, soil carbon content, and other soil parameters. These were used as a basis of establishing specific thresholds to enable identification of these ecosystems. These thresholds were presented and discussed at the national stakeholder consultation workshops. The relationship between peat depth from surface and soil organic carbon content of samples having 5% or more SOC (in terms of the percentage of dry weight of soil sample) is presented in Figure 4.

Figure 4: Soil Organic Carbon and Peat Depth from surface observed from soil sampling at peatland sites (n=16)



Based on the analysis, the following criteria are proposed for identifying peatlands in India: a) a peat depth of at least 10 cm within the top 1 m of soil, and b) soil organic carbon content (by weight) at least 8% or carbon density at least 0.05 g/cm³. The rationale for this definition was discussed during the consultation meetings held in February and December 2024, substantiated with field level insights. The proposed thresholds in line with international definitions and typologies, enable distinction between other wetland types and peatlands, incorporate carbon density to indicate volumetric carbon content, and set wider thresholds for peat thickness to enable inclusion of shallow peatlands and larger areas for management interventions. The lower threshold of SOC is also in line with FAO (2020) and Lourenço et al. (2022) where it is recommended to consider the overall volumetric carbon content in the peatland, as SOC% reveals little about it. Similarly, the IPCC (2013) and FAO (2020) suggest keeping peat thickness of at least 0.1 m to define a peatland, ensuring shallow peatlands that may or may not be waterlogged and may include or lack vegetation, are identified for conservation. UNEP (2022) also echoes the argument that a peatland definition with a depth threshold of 10 cm could be beneficial from a climate policy perspective.

Figure 5: Expert consultation at MoEF&CC

A country-level definition of peatlands enables several essential aspects, such as management actions, standardised inventory, assessment and monitoring, meeting national and MEA commitments, and sustainable utilisation for developmental planning. Developing a peatland definition and classification system for the country presents multifaceted opportunities for India as:

- Climate Change Mitigation and Disaster Resilience: Identification and restoration of peatlands can significantly contribute to climate change mitigation by locking vast amounts of carbon, aiding in achieving the national emissions reduction targets outlined in Nationally Determined Contributions (NDC), under the Paris Agreement on climate change.
- Wetlands of National and International Importance: Wetland Peatlands inventory and conservation planning will also support the implementation of the *Amrit Dharohar* initiative wherein carbon stock and GHG assessments will aid in the conservation of unique values of Ramsar Sites in India.
- Biodiversity Conservation: The inventory and assessment initiative will also contribute to enhancing biodiversity habitat conservation through the identification of ecological corridors and Other Effective Area-Based Conservation Measures (OECM), which further bolsters ecosystem resilience and contributes to various commitments under the Kunming-Montreal Global Biodiversity Framework and National Biodiversity Targets.
- Sustainable livelihoods: Investing in the conservation and restoration of identified peatlands (and clusters) can create job opportunities (such as nature-tourism) and potentially incentivise voluntary environmental actions undertaken by diverse stakeholders under the MoEF&CC Green Credit Program.
- Science and Technology: Peatlands also offer immense potential for scientific research and innovation, providing opportunities for advancing knowledge in climate science, hydrology, and ecology.

3.3 Peatland classification

In addition to peatland definition, a classification system is needed to simplify understanding of peatland ecosystems, identify general principles of working of the peatland area, and consequently steer decisions on management, conservation and restoration. The kind of similarities or differences within different classes (categories) is defined by the purpose of classification. Much of the classification systems that exist today are based on understanding of European, Russian and North American peatlands. There are multiple nomenclature and definitions of peatlands reflecting the use and management applied on peatlands in the past, diversity of habitats, ecosystems, and underpinning processes.

Current peatland classifications incorporate a range of factors, including soil science, biodiversity, and carbon storage, reflecting the interests of a wide array of stakeholders, such as scientists, farmers, foresters, peat extractors, land use planners, and conservationists (Lindsay, 1995; Lindsay, 2016; International Peatland Society, 2021). Consequently, these classification systems vary depending on their specific purpose and disciplinary focus.

The peatland classification systems use specific properties such as:

- Source of water: ombrogenous, topogenous, soligenous (bogs, fens, topogenous mires)
- Source of water logging and behaviour of the water supply: geogenous, ombrogenous, soligenous, lithogenous, thalassogenous
- Degree of humification: fibric, haemic, sapric
- Nutrient level: oligotrophic, mesotrophic, eutrophic
- Based on peat forming habitat: sedge fen, moss fen, reed fen, raised bogs, blanket bogs, swamp forest bogs etc. (related to vegetation type)
- Mineral soil water boundary: ombrotrophic and minerotrophic
- Textures and type of peat (origin of peat): Reed peat, Sphagnum moss peat, woody peat, sedge peat, etc.

Next to that the peat soils can be also classified based on soil characteristics:

- Soil acidity and content of minerals: acidic soils, alkaline peat etc.
- Based on soil composition: organic and ash content: peat, muck, organic soil

A critical aspect of any classification system is to determine the purpose served - which may range from understanding key processes that sustain these ecosystems to focusing on management needs.

In the context of India, research on peatland ecology, hydrology, and related aspects is still in its early stages. Thus, initiating conservation efforts with a general classification system based on fundamental characteristics could provide valuable guidance for peatland management decisions. We propose a classification scheme based on:

- botanical composition, distinguishing moss peat, sedge peat, and woody peat;
- degree of decomposition, categorized as weakly, moderately, or strongly decomposed; and
- hydrogenetic origin (refers to the role of water in peat formation and by the role of the mire in landscape hydrology), classifying mire peat as Ombrogenous mires that are fed only by precipitation, and Geogenous mires that are also fed by water which has been in contact with the mineral bedrock or substrate.

This foundational information is critical for establishing a national-level classification system, which is presently lacking in India. Leading institutions and research agencies should therefore prioritise the compilation and analysis of comprehensive data on peatland soils and their environmental contexts, supporting the identification, conservation, management, and restoration of these unique ecosystems. The classification system should be adaptable with scope for improvement over time as new knowledge and practices become available.

3.4 Peatland values

The peatland sites in the four biogeographic zones were commonly characterised by vegetation such as moss (*Sphagnum* and brown moss), *Carex*, *Phragmites*, and *Typha* species. The vegetation type serves as crucial habitat for migratory birds and regional wildlife and is widely used for human sustenance in the form of fodder, cultural offerings and livelihood related items. For instance, the Tso Kar Wetland Complex supports medicinal and aromatic plant species that provide both ecological and economic value. The peatlands in Keibul Lamjao National Park, located in the southern part of Loktak Lake, provide a vital habitat for the globally endangered Sangai deer (*Rucervus eldii*). In Ladakh, peatlands such as the Tsokar and Hanle marshes are the only breeding grounds for the Black-necked Crane (*Grus nigricollis*). Similarly, in the Sundarbans, peatland habitats support the globally endangered Royal Bengal Tiger (*Panthera tigris tigris*), further underscoring the importance of these ecosystems for biodiversity conservation.

Figure 6: Peatland sites in the Trans-Himalayan, Himalayan, and North-East biogeographic zones of India

Peatlands in Ladakh

Dzukou Valley, Nagaland

Loktak Lake, Manipur

Chandertal, Himachal Pradesh

Peatlands in high and mid-altitude areas regulate the hydrological regimes by storing and gradually releasing glacial or snow melt such as Tso Kar in Ladakh and Hokersar in Kashmir. These ecosystems consist of waterlogged soils rich in organic matter, which enables them to retain large volumes of water. During the warmer months, as glaciers melt, peatlands absorb and store this meltwater, reducing the risk of downstream flooding and ensuring a steady supply of water to surrounding areas. Over time, peatlands slowly release the stored water, maintaining base flows in rivers and streams even during dry seasons. This gradual release helps sustain freshwater availability for local communities, agriculture, and biodiversity. Additionally, by moderating the flow of glacial melt, peatlands reduce erosion and sedimentation in downstream ecosystems, preserving water quality and aquatic habitats. Peatlands also function as natural filtration and purification systems, effectively collecting and storing heavy sediments and pollutants from upstream water sources. These ecosystems trap contaminants within their organic-rich soils, preventing them from entering downstream waterways. The dense vegetation and waterlogged conditions in peatlands slow water flow, allowing suspended particles, heavy metals, and other pollutants to settle and be absorbed or broken down by microbial activity. A notable example is the peatlands in Loktak Lake, Manipur, where this filtration capability significantly contributes to maintaining water quality.

Beyond ecological services, peatlands hold immense cultural and spiritual importance. Khecheopalri Lake in Sikkim, for instance, is a revered religious site for local communities. Additionally, peatlands act as natural archaeological archives, such as findings from the Kashmir Valley, which provided insights into post-glacial vegetational history (Sharma, 1968). Economically, peatlands are invaluable for local livelihoods. Sites like Loktak Lake in Manipur and the Sundarbans in West Bengal support communities through resources such as fisheries and fertile soil for agriculture. High-altitude peatlands like Tso Kar and Hanle Marshes in Ladakh or Chandertal in Himachal Pradesh serve as vital grazing grounds for livestock, supporting pastoralist livelihoods. Furthermore, the scenic beauty and ecological richness of peatlands, such as Tso Kar in Ladakh and Khecheopalri Lake in Sikkim, attract tourists, contributing to tourism-driven economies.

Tso Kar Wetland Complex

Photo credit: Dhurv Verma / WISA

3.5 Carbon stocks in peatlands

The role of peatlands as carbon stores has received high attention due to their crucial contribution to climate change mitigation and made them central to discussions on global carbon sequestration strategies. The study evaluated the peat carbon stock across five peatland sites in India, taking into account specific depths and soil organic carbon (SOC%) at each location. Site selection was based on a probability map and existing literature. After identifying suitable peatland sites, habitat types with observed peat presence, such as marshy areas, were selected. A line transect, typically spaced 50-250 meters apart, depending on the size of the sampling site, was established within each site, and a 1x1 meter quadrat was laid at regular intervals along each transect to collect peat soil samples. These samples were subsequently analysed by a government-accredited laboratory to determine key physicochemical parameters, including soil organic carbon, pH, and bulk density. These parameters were then used to calculate the carbon stock per unit area for selected sites across the four biogeographic zones, using the following formula (Joosten et al., 2016):

The volumetric assessment of carbon stock in the peatland patches was done using the following equations:

Peat Volume (**V**) = Peatland Area (**A**) x Peat Depth (**D**) (eq1)

Carbon Density (**CD**)= peat bulk density (**BD**) x Soil Organic Carbon (**SOC**) (eq 2)

Peat carbon stock (**CS**) = Peat volume (**V**) x Carbon Density (**CD**) (eq 3)

Where,

A *is the area of the peatland patch in* m^2 *recorded in the field*

D *is the depth of the peat layer in m from surface in m recorded in the field*

BD *is the ratio of peat dry weight to its volume expressed in kg/m3 and assessed in laboratory*

SOC *is the portion of organic residues in soil sample in various stages of decomposition expressed in percentage of dry weight and assessed in laboratory*

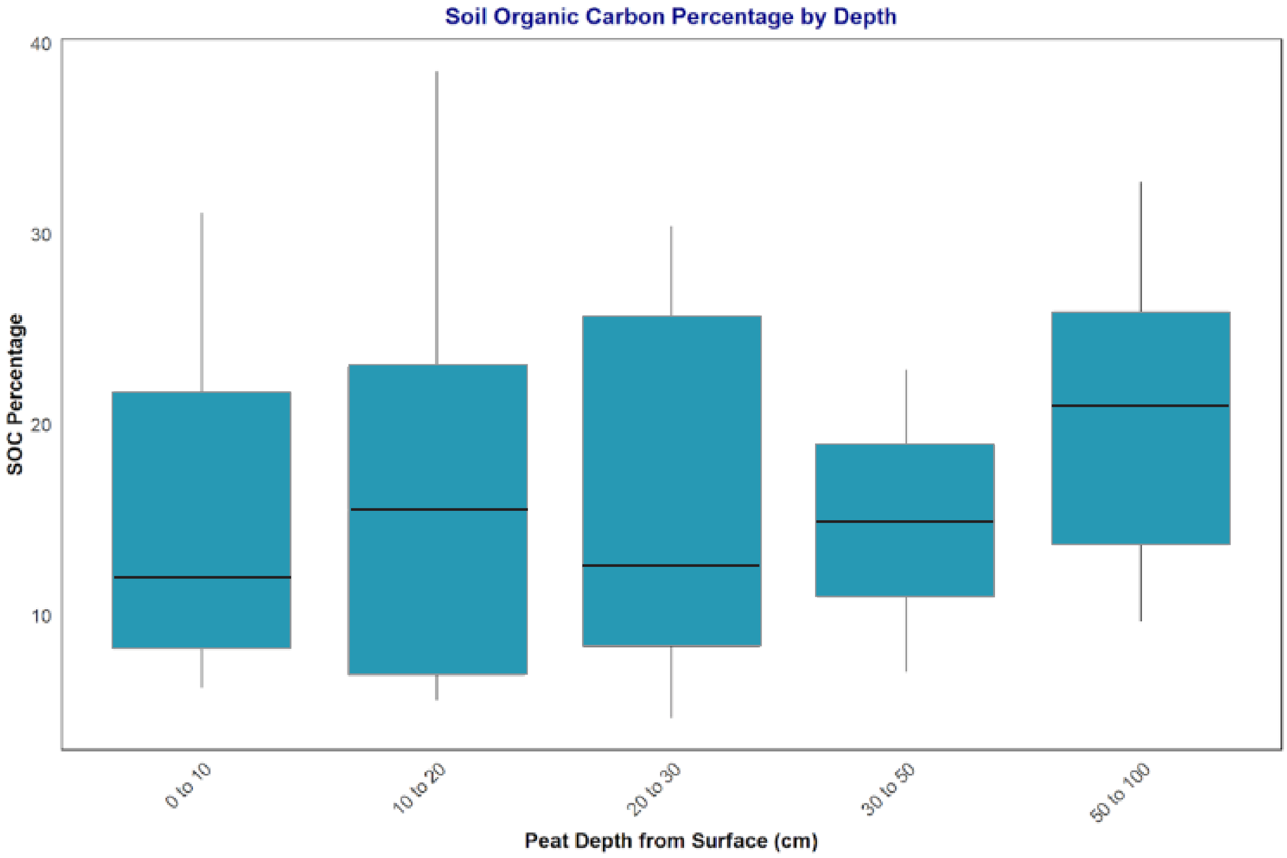
V *is the volume of peat in peatland patch expressed in* m^3

CD *is the carbon density in peatland patch expressed in* kg/m^3

CS *is the total carbon stock in a peatland patch expressed in kg or tonnes. This is further divided by A to derive stock in kg/ha*

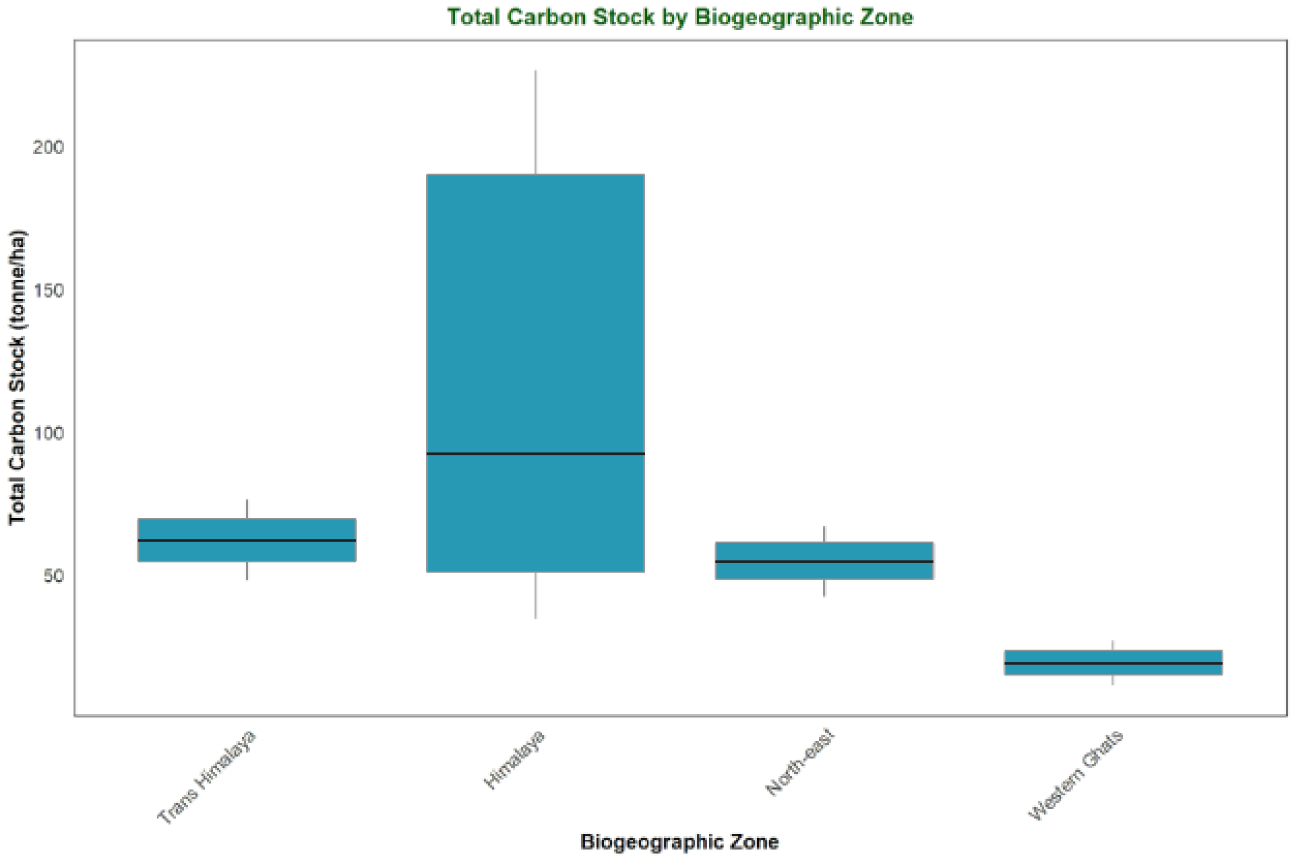
Significant variations in soil organic carbon (SOC%) were observed across sampled sites at varying soil depths (Figure 7). In the Tso Kar Wetland Complex, Ladakh, SOC% ranged from 7% to 31% for peat depths up to 30 cm. At Chandertal in Himachal Pradesh, SOC% varied between 11% and 21% for peat depths up to 20 cm. In Jammu and Kashmir, peat depths at Mirgund and Hokersar ranged from 0.8 to 4 metres, with SOC% between 19% and 42%. Saat Tal Lake in Uttarakhand, characterised by peat depths of up to 2 metres, exhibited an SOC% of approximately 17%. At Khecheopalri Lake in Sikkim, peat depths reached 1.2 metres, with SOC% ranging from 17% to 39%. In contrast, the Dzukou Valley in Nagaland showed peat depths of up to 30 cm, with SOC% varying from 6% to 27%. In Kerala, sites such as Devikulam and Uthiran Chira displayed peat depths of up to 30 cm, with SOC% ranging from 8% to 20%. These results highlight the diverse carbon storage capacities of peatlands across different depths and organic carbon content in various biogeographic regions. Figure 7 summarises the SOC% recorded at different depths within 1 m top soil at the sampled peatland sites.

Figure 7: Soil Organic Carbon (SOC) percentage recorded at different depths within 1 m topsoil at the sampled peatland sites (n=63)



The per-hectare carbon stock across sampled peatland sites from four biogeographic zones, as summarised in Figure 8, reveals significant variability in carbon stock in top 1 m soil surface. Among these zones, the Himalayas exhibit the highest median carbon stock at 92.5 tonnes per hectare, highlighting their importance as a major carbon sink. This value is approximately one and a half times greater than the median carbon stock in the sampled peatlands of Trans-Himalayas (62.27 tonnes/ha) and the Northeast (54.73 tonnes/ha), reflecting the relatively higher carbon content of the Himalayan peatlands, potentially due to differences in peat depth, organic matter accumulation, and climatic conditions that favour carbon sequestration. The carbon stock in the Himalayas is also nearly five times greater than that of the Western Ghats, where the median value is just 19.28 tonnes/ha, which could be attributed to shallow layer of peat with intermittent layers of sediments and mineral soil in top 1 m. Using the carbon stock per hectare and the estimated peatland area (refer to Section 3), the total carbon stock across the four biogeographic zones can be approximated. The Himalaya and Trans-Himalaya zones hold an estimated 13.9 million tonnes of carbon, the North-East region 4.4 million tonnes, and the Western Ghats approximately 1 million tonnes. However, it is important to note that these estimates are indicative and subject to uncertainties, as they rely on both the probable extent of peatland areas and extrapolated values of carbon stock per unit area. The peatland distribution across the biogeographic zones is based on preliminary mapping and available literature, which may not fully capture the actual extent on the ground. Similarly, the carbon stock per hectare has been derived from limited site-specific data and generalised across broader areas, which may not account for local variability in peat depth, decomposition stage, vegetation type, and climatic conditions. Therefore, while these figures provide a useful approximation of the carbon stock potential, more detailed field-based assessments and refined mapping are necessary to improve the accuracy and reliability of these estimates.

Figure 8: **Box plot of Carbon Stock per ha up to one meter from the surface in peatlands**



Peat sampling at Hokersar

Photo credit: Apoorva Thapa / WISA

3.6 Threats to Peatlands

Lack of awareness of the presence of peatlands, and relevant management practices has led to peatlands being highly degraded and lost in many landscapes. Hydrological regime alterations, such as changes in water inflow and outflow for agricultural and domestic purposes, have been observed in regions like Hanle Marshes in Ladakh and Dzukou Valley in Nagaland. Dredging operations in Kashmir's wetlands, such as Hokersar and Khajjiar in Himachal Pradesh, have severely damaged peatlands, and loss of most of the carbon store. Overexploitation of resources, including unsustainable harvesting, overgrazing, water abstraction, and mining, threatens the integrity and productivity of peatland ecosystems, with excessive grazing particularly noted in Tsokar, Leh, and Chandertal in Himachal Pradesh. Additionally, small-scale peat extraction has been recorded in Kashmir and Kerala. Unregulated tourism—characterized by unsustainable infrastructure development, off-road driving, and increased water use—presents localized risks, seen in sites like Tsokar and Khecheopalri Lake. Climate change exacerbates these issues, leading to unpredictable weather, droughts, and higher evapotranspiration, disrupting water balances.

An overview of threats assessed in peatland landscapes in four biogeographic zones is summarized in Table 1.

Table 1: Threats observed at peatlands under the project

Biogeographic zone	Peatland cluster	Extraction	Conversion for alternate land use	Modification of natural hydrological regimes	Unsustainable grazing	Plantation	Unsustainable tourism	Linear infrastructure development; fragmentation
Himalayas (< 2,500 m amsl)	Khecheopalri	Not relevant	Low	Low	Not relevant	Not relevant	Medium/ High	Medium
North-east (< 2,500 m amsl)	Dzukou Valley	Medium	Low	High	Not relevant	Not relevant	Low	Not relevant
Trans-Himalaya (above 2,500 m amsl)	Chandertal	Medium	Low	High	Low	Not relevant	High	Not relevant
Trans-Himalaya (above 2,500 m amsl)	Tsokar	Medium	Not relevant	Medium	Medium	Not relevant	Medium	Medium
Himalayas (below 2,500 m)	Mirgund	High	High	Medium	Medium	High	Low	Low
Western Ghats	Devikulam	Low	Low	Low	Low	Low	Low	Low


Photo credit: Saadan Hussain / WISA

Peatland conversion in Ziro Valley, Arunachal Pradesh


Photo credit: Apoorva Thapa / WISA

Disturbed flow regime, Hanle Marshes, Ladakh

04

ALIGNMENT OF PEATLAND CONSERVATION

with international and national policies and programmes

Protection and conservation of natural ecosystems have long been ingrained in traditional and cultural practices of India. These values are deeply embedded in the country's citizen charter and policy frameworks and are further reinforced by India's commitments to various international environmental agreements and conventions such as the Convention on Wetlands (Ramsar), United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD), Convention to Combat Desertification (UNCCD) and others which have a high degree of alignment with peatlands conservation and sustainable management. Although peatlands are not explicitly addressed in the national commitments and targets to these MEAs, their ecological and climate significance makes them worthy of inclusion in various strategies and action plans.

Foremost of these is the Convention on Wetlands, to which India has been a party since 1981. The three pillars of the Convention, namely the List of Wetlands of International Importance, wise use and international cooperation, provide opportunities for peatland conservation in the underpinning national actions. The Ramsar Strategic Plan (2016–2024) emphasises increasing the representation of under-represented wetland types and ensuring ecological connectivity across landscapes. Recognising peatlands in India as a distinct wetland type can play a pivotal role in achieving these goals, while also opening opportunities under the National Plan for Conservation of Aquatic Ecosystems (NPCA) for the conservation and restoration of India's peatlands. Incorporating a geospatial inventory of peatlands into the National Wetlands Inventory would provide valuable insights into the extent and distribution of peatlands in India. The *Amrit Dharohar* Scheme, through its four components—Species and Habitat Conservation, Wetlands Carbon, Wetland Tourism, and Livelihoods - directly aligns with peatland conservation objectives. Research on peatland-specific attributes such as carbon sequestration potential, GHG flux, hydrodynamics, biodiversity, and other ecosystem services is critical for generating baseline data in India. Capacity development programs, community-based monitoring initiatives and CEPA initiatives will support the development of diagnostic management strategies and action plans for peatland restoration and conservation in India.

Peatlands are significant carbon sinks and play a critical role in regulating greenhouse gas (GHG) fluxes. Incorporating peatland conservation, restoration, and sustainable management into India's climate strategies could significantly contribute to achieving the national goal of creating a cumulative carbon sink of 2.5–3 $GtCO_2$ by 2030. Their immense carbon sequestration potential makes peatlands essential for enhancing India's carbon sink capacity and resilience to climate change.

While the National Action Plan on Climate Change (NAPCC) broadly recognises wetlands as tools for climate change mitigation, the Nationally Determined Contributions (NDCs) lack explicit mention of wetlands and peatlands in GHG accounting and reporting to the UNFCCC. Identifying and sustainably managing peatlands through ecosystem-based approaches is critical to achieving NDC targets and complements forestry-focused interventions. Accurately accounting for GHG emissions from drained and degraded peatlands, as well as carbon removals by healthy peatlands, in national inventories for UNFCCC reporting offers several benefits.

India, as a signatory to the Convention on Biological Diversity (CBD), has integrated biodiversity conservation into its national strategies, namely the National Biodiversity Strategy and Action Plan (NBSAP) and National Biodiversity Targets (NBTs). These frameworks align with global goals under the Kunming-Montreal Global Biodiversity Framework, emphasising ecosystem restoration, sustainable use, and equitable participation in biodiversity governance. Peatlands act as crucial nodes within a landscape, providing connectivity for wildlife by acting as corridors, refuges, and water sources, especially in fragmented landscapes; their ability to store water and regulate water flow can also contribute to broader landscape connectivity by influencing the surrounding ecosystems. These ecosystems have immense potential for integration into India's NBSAP.

Munnar wetlands, Kerala

Photo credit: Dhruv Verma / WISA

Recognising peatlands as distinct ecosystems could support global and national targets, such as biodiversity-inclusive land-use planning (NBT 1), ecosystem restoration (NBT 2), and sustainable management of agriculture, forestry, and other land uses (NBT 10). Inventorying and monitoring peatland health would aid in achieving these targets, complementing India's focus on wetland conservation under initiatives like the Amrit Dharohar Scheme. Peatlands also align with efforts to mitigate climate change (NBT 8) and combat invasive species (NBT 6). Additionally, these ecosystems provide an opportunity to strengthen biodiversity communication, awareness, and capacity building (NBTs 20, 21, 22), integrating local communities into conservation efforts. Conservation and management of peatlands can contribute to achieving the CBD's 30x30 goal of protecting 30% of land and water resources by 2030. Moreover, financial mechanisms such as the Global Environment Facility (GEF) could bolster funding for peatland actions, enhancing India's climate resilience and biodiversity conservation outcomes.

India is a signatory to the United Nations Sustainable Development Goals (SDGs) through the Government of India - United Nations Sustainable Development Cooperation Framework (GoI-UNSDCF). Peatland conservation contributes to multiple SDGs, including SDG 13 (Climate Action), SDG 15 (Life on Land), SDG 14 (Life Below Water), and SDG 6 (Clean Water and Sanitation). Although, peatlands are not explicitly identified in SDG-related national strategies, the following schemes and initiatives of the Government of India can support peatlands conservation in India:

The National Water Policy (2012) and National Irrigation Policy (2005) provide guidelines on sustainable water management and efficient irrigation practices, but they do not specifically address peatlands. However, the absence of explicit mention of peatlands in these policies means their presence remains unacknowledged and their protection is not a priority in water resource management strategies. Integrating peatland conservation within these frameworks could improve water retention, enhance

Structural modification or high tourism pressure in Chandertal, Himachal Pradesh

Photo credit: Saadan Hussain / WISA

agricultural sustainability, especially in High-altitude areas, and help in the preservation of local hydrological and climatic functions provided by peatlands.

Conservation and restoration of peatlands is widely recognised as a nature-based solution for combating land degradation and desertification under the United Nations Convention to Combat Desertification (UNCCD). In India, where 80% of the known peatlands are classified as degraded (UNEP, 2022), sustainable management of peatlands contribute to Land Degradation Neutrality (LDN) and Sustainable Land Management (SLM) by improving soil health, enhancing carbon storage, and boosting water retention capacity, making them integral to sustainable land restoration efforts. Practices under SLM can include the prevention of over-drainage and unsustainable agricultural expansion onto peatlands. Rejuvenation and restoration of degraded peatlands can also contribute to India's targets set for the Bonn Challenge, wherein the country has pledged to bring under restoration 13 million hectares of degraded land by 2020 and an additional 8 million hectares by 2030.

There are several national policies and programmes which can complement peatlands conservation. The National Tourism Policy (2002) and National Strategy for Ecotourism (2022) promote eco-tourism, emphasising the need to conserve sensitive ecosystems. India's National Wildlife Action Plan (2017-2031) identifies conservation of inland aquatic ecosystems as one of the 17 priority areas and envisages development of a national wetlands mission and a national wetlands biodiversity register (MoEF&CC 2017). Mainstreaming the full range of wetlands ecosystem services into developmental planning is listed as the objective of the national wetlands programme (MoEFCC 2019). Likewise, integration of wetlands in river basin management has been identified as a strategy for the management of river systems (MoWR 2012). The National Water Policy (2012) recommends adoption of a basin approach for water resources management and identifies conservation of river corridors, water bodies and associated ecosystems as an essential action area (MoWR 2012). The guidelines on Integrated Water Resources Management issued in 2016 by the Central Water Commission recommends using water balance as a basis for planning at basin level and ensuring that upstream and downstream impacts are taken into account.

However, peatlands, as vital components of wetland ecosystems, are often overlooked. Tourism development in these areas, such as through schemes like Swadesh Darshan (2014) and the Prashad Scheme for infrastructure development, can lead to land-use changes, including the drainage of peatlands for resorts or other tourist facilities. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) has a mandate to provide wage employment while promoting sustainable natural resource management. MGNREGS can support activities such as peatland rewetting, restoration, and afforestation which are critical for maintaining their ecological integrity. In remote and rural areas of the Himalayas, Northeast and other potential regions, MNREGS projects on watershed management and water-soil conservation, can prevent peatland drainage and degradation. Moreover, the scheme's emphasis on afforestation and soil conservation could be extended to include peatlands, integrating their ecosystem services values into rural development planning, enhancing community livelihoods and fostering community stewardship for restoration of peatlands and their nearby landscapes under MGNREGS.

However, capturing these synergies requires a dedicated peatlands programme, the contours of which are elaborated in the following section.

05 A ROADMAP FOR PEATLANDS RESTORATION & CONSERVATION IN INDIA

5.1 Rationale for a national programme

Peatlands in India, despite having a purported extent of 0.35 million hectares, make a disproportional contribution to the carbon flux as well as provide vital hydrological regime regulating functions and habitat for biodiversity of high conservation significance. There is a well-developed body of research and practice that underlines the need for conservation and management of these ecosystems to be guided by specialised inventories (inadequately captured by national wetland inventories to date), delineation and demarcation within landscapes, conservation and restoration actions which preserve carbon stock, conserve and sustain peat forming conditions, monitoring ecosystem health for adaptive management, building specific capacities and collaborations targeted at peatlands conservation, and communication and outreach. An enabling policy environment is also needed to ensure that peatlands figure appropriately in relevant sector policies and programs such as those related to climate change, biodiversity, agriculture, water and tourism.

India has a well-developed programmatic framework for wetlands conservation, currently known as the National Plan for Conservation of Aquatic Ecosystems (NPCA). The NPCA has a goal of 'developing and maintaining a network of healthy wetlands which contribute to human well-being through their diverse ecosystem services, as well as sustaining diversity and populations of wetland-dependent species'. Despite over four decades of implementation of the national programme, peatlands have failed to acquire the needed policy and programmatic emphasis. Continuing with

Dzukou Valley, Nagaland

Photo credit: Dhruv Verma / WISA

business-as-usual renders these ecosystems at the risks of under representation and misclassification in wetland inventories, continued degradation and conversion to other land uses, inappropriate management abetting landscape transformation detrimental to ecosystem health and integrity, and weak regulatory support.

The uniqueness of peatlands and the high significance of their ecosystem services and biodiversity values require a dedicated programmatic framework and strategy for conservation, restoration and sustainable management of these ecosystems. Specifically, a dedicated national programme would ensure:

- The extent and condition of peatlands are scientifically assessed and periodically monitored
- Intact peatlands are secured and efficiently managed to ensure that carbon stocks and peat forming conditions are preserved and maintained
- Peatlands are managed and degraded peatlands restored using ecosystem appropriate methods and technologies with clearly defined objectives and outcomes
- Capacities, research and partnerships to support peatland conservation, restoration and management are developed
- Peatlands are integrated in all relevant sectoral development plans, programmes and investments
- Dedicated resources for conserving, restoring and sustainably managing peatlands are available
- Peatlands are appropriately included in international commitments and reporting systems for various conventions and treaties

It is highly desirable that the national programmatic framework for peatlands operates within the overall architecture of wetland conservation so as to ensure policy and programmatic coherence, and also justifying the fact that peatlands are a specific wetland type.

5.2 Programmatic framework

The national peatlands programme will have a **goal** to 'Conserve, Restore and Sustainably manage peatlands in India'. The purpose would be to:

- Conserve carbon stock and reduce GHG emissions from peatlands
- Maintain and enhance biological diversity inhabiting and dependent on peatlands (ecological networks)
- Maintain and enhance hydrological regime regulation capacity of peatlands
- Preserve cultural and recreational values related with peatlands
- Integrate peatland conservation and sustainable management in relevant sectoral plans, programmes and investments

Following **strategies** will be used to achieve the goal and purpose:

5.2.1 Integrated peatland management based on hydrological units

The hydrology of peatlands is fundamental to their development. Peatlands accumulate carbon over time because immersion by water reduces the rate of decay in comparison with rate of production. The spatial and temporal variability of hydrological processes has therefore a significant impact on whether peatlands shall act as store or source of GHGs. The peatlands in India are, in most places, located as patches within forests, agricultural lands and others, with their hydrology closely determined by the land use in the adjoining areas. It is therefore prudent to manage peatlands based on hydrological units, which can be defined as a distinct hydrological system that includes peat deposits and their associated surface and groundwater dynamics, which collectively sustain the ecological and biogeochemical functions of the peatland. Managing peatlands based on hydrological units allows for consideration of interconnectedness of peatlands or peat mosaics with their hydrological regimes, land uses and development plans and programs.

5.2.2 Protection of intact peatlands and rehabilitation and restoration of degraded peatlands

Intact and pristine peatlands must be conserved and protected to ensure maintenance of their ecosystem services and biodiversity values. Strategies for protection and conservation will include preventing adverse changes in peatland hydrology, land-use in the surrounding areas through enforcement of extant regulations, management planning, surveillance and communication and outreach measures. These peatland areas shall also be closely monitored for various parameters including carbon content, ecosystem health, etc.

Rehabilitating and restoration of degraded peatlands is essential to prevent peat subsidence, carbon emissions, and associated decline in ecosystem services and biodiversity values. Several of the peatland sites in the Himalayan and Trans-Himalayan and North-east BGZ, as described in section 3.4, are in degraded state due to changes in hydrological regime (For e.g. Kashmir Valley and Dzukou valley) or have been converted into other land use types such as agriculture (For e.g. Tso Kar in Ladakh). Rehabilitation and restoration of such peatland sites would majorly involve rewetting and vegetation regeneration with specific interventions varying by the peatland types and extent of degradation. For instance, restoration of peatlands in Ladakh would need regular monitoring of hydrological regimes and active interventions to mitigate adverse impacts of tourism and grazing in the catchment. Rehabilitation and restoration actions will be planned at the peatland hydrological unit scale and closely monitored for outcome success. It is also recognised that rehabilitation and restoration cannot bring back all ecosystem services and biodiversity values and thereby conservation and protection remains a priority.

Peatland restoration needs to be guided by clear restoration goals, which describe in concrete terms the expected outcomes of restoration activities. In several cases, recovering optimal conditions for peat conservation and renewed peat accumulation requires active intervention to restore water tables to the peat surface accompanied by recovery or restoration of peat-forming vegetation. The re-establishment of peat-forming vegetation may create conducive conditions for renewed peat accumulation and the regaining of important ecosystem processes such as hydrological regime regulation. Restoring hydrology through effective damming of drainage structures must be guided by strategic planning of locations and spacing of hydraulic structures to increase rewetting effectiveness and use of local material. For effective restoration, monitoring and evaluation systems need to be in place, and the lessons learned should be incorporated into future planning.

In order to guide effective restoration and rehabilitation actions, investment into peatland research and monitoring is fundamental. The peatland research should include establishing robust standards for measuring, monitoring and reporting on carbon sequestration and emissions, GHG flux, hydrodynamics, biodiversity and ecosystem services in both intact and degraded peatlands.

5.2.3 Climate risks mitigation and adaptation measures for peatlands

Peatlands interact with climate through release and uptake of GHGs. Peatlands remove carbon dioxide from the atmosphere creating a net cooling effect. However, the decay process in peatlands leads to release of methane which has a warming effect. Over a longer period of time, however, methane emissions have been observed to reach an equilibrium and the net carbon dioxide uptake being more prominent. Degraded peatlands are globally a major source of GHG emissions. Global estimate arrives at a total volume of emissions from degraded peatlands of more than 1,940 Mt CO_2e per year (UNEP, 2022).

Wetlands, including peatlands, are among the most vulnerable ecosystems to climate change. Warmer soils and changes in hydrological conditions have been observed to have a significant impact on the ability of peatlands to store carbon and the type of vegetation that grows on these ecosystems. It is therefore urgent that peatland restoration and conservation are included in climate change mitigation and adaptation actions. UNEP (2022) estimated that India's total volume of GHG emissions from degraded peatlands is 15.5 Mt CO_2e per year. Investments into conservation and rewetting of peatlands need to be considered as an integral component of climate change mitigation actions. Legal protection is essential to prevent the drainage and degradation of these ecosystems, supported by incentive-based mechanisms like carbon credits and payments for ecosystem services to promote sustainable practices. This integrated strategy ensures long-term ecosystem stability, contributes to global climate goals, and supports the well-being of communities dependent on these critical landscapes.

Image 2: Stakeholder consultation meeting held at MoEFCC, New Delhi to discuss peatlands inventory, definition and management strategy

5.2.4 Consideration of full range of peatland ecosystem services values and trade-offs in sector plans, programmes and investments

Peatlands support a multitude of ecosystem functions and services such as water regulation, nutrient cycling, habitat for species, livelihood support, recreational and cultural values. It is important that all these values are considered and suitably embedded in developmental plans, programmes and investments. For instance, agriculture sprawl, hydrological fragmentation and peat extraction for fuel threaten peatlands in Kashmir Valley, tourism and grazing impact carbon-rich soils of peatlands in Ladakh, and concretisation of peatland margins and their water channels impacts peat hydrology in high-altitude peatlands in Uttarakhand. Given the nascency of peatland knowledge in the country at present, a beginning can be made by making peatland inventories available to decision makers and practitioners at various levels to ensure that the plans and programmes do not adversely impact these ecosystems. A comprehensive communication and outreach strategy on peatland values and its management needs to be developed and disseminated within the identified stakeholders. Innovative awareness campaigns targeting government, private sector, and communities are critical for promoting sustainable peatland management practices.

5.2.5 Well-defined governance mechanisms for peatlands protection, conservation and sustainable management

India has a well-defined wetland governance architecture for regulation and management of wetlands. Recognising peatlands in India as a distinct wetland type under the National Plan for Conservation of Aquatic Ecosystems (NPCA) can provide a clear governance framework for conservation and management of peatlands in India. Embedding peatlands in the Wetlands (Conservation & Management) Rules, 2017 will provide necessary regulatory support and legal biting to address drivers of peatland degradation and secure their ecological integrity.

The institutional framework, with the MoEFCC at the apex and State or Union Territory Wetland Authorities (SWA) are the nodal agencies for the protection, management, and monitoring of wetlands within their jurisdiction. These authorities shall develop a comprehensive digital inventory of peatlands, develop a comprehensive list of activities to be regulated and permitted in peatlands and PHU, and develop strategies for peatlands conservation, restoration and management. The District Wetlands Committees shall support the SWA in implementing the conservation and management strategies through liaison and coordination with site and district level stakeholders.

The MoEFCC and SWA shall also invest in capacity building, knowledge development and exchange, and awareness activities for practitioners, users and stakeholders to implement conservation and restoration actions. Knowledge and awareness improvement along with tangible demonstrations on the ground should be further strengthened through provision of capacity building and improved regional cooperation on sustainable peatland management.

5.3 Thematic areas and activities

The programmatic framework to implement this strategy can be structured around six thematic areas elaborated in Figure 9 below.

Figure 9: Programmatic framework for peatlands management in India

INVENTORY AND ASSESSMENT

- National peatland definition and typology
- Baseline peatland map
- Ecosystem health cards

CAPACITY DEVELOPMENT, COMMUNICATIONS AND OUTREACH

- Awareness campaigns
- Training programmes
- Strengthening research management interface
- Knowledge exchange

CONSERVATION AND RESTORATION

- Management based on peatland hydrological units
- Regulating adverse land use, land cover change, and hydrological alterations
- Rehabilitation and restoration
- Addressing livelihood interlinkages
- Peatland fire management

INSTITUTIONS AND GOVERNANCE

- Legal framework to support conservation of pristine peatlands and prohibiting conversion and degradation of intact peatlands
- Site-level management arrangements
- Inter-sectoral and inter-agency coordination

MONITORING AND RESEARCH

- Standards for measuring, monitoring and reporting on peatlands and emissions
- Impacts and consequences of climate change
- Peatland restoration practices
- Sustainable agro-practices
- Biodiversity, ecosystem functions and services

FINANCE AND RESOURCE MOBILIZATION

- Development of an investment framework and fund
- Convergence with conservation and development sector plans and programmes
- Partnership with private sector

Theme 1

Inventory and assessment

Sustainable management of peatlands requires a comprehensive peatland inventory which can inform the decision makers and managers on the status and trends in peatland extent as well as in condition. The peatland probability mapping conducted thus far needs to be extended to the remaining biogeographic zones and probability maps converted into specific distribution maps. At site level, the inventory needs to be structured around peatland hydrological units which can enable management of water regimes, land use and land cover, and livelihood systems to ensure integrity of the peatlands. The inventory should also enable application of zoning concepts enabling demarcation and core protection, development goals with clear conservation and management targets. The peatland inventory must be incorporated into the national wetlands inventory programme.

In addition to the inventory, it is proposed to apply specific typology to indicate various types of peatlands and their governing features to support their restoration and management. The proposed peatland typology under the same project based on key features is presented below:

- botanical composition, distinguishing moss peat, sedge peat, and woody peat
- degree of decomposition, categorised as weakly, moderately, or strongly decomposed
- hydrogenetic origin, classifying peat as groundwater-fed or surface and rainwater-fed

Specific activities to be implemented under this theme are as follows:

- Establishment of a national peatland definition and typology
- Baseline peatland mapping to assess extent, distribution and condition
- Publication of ecosystem health cards every two years to capture changes in wetland condition and management

Theme 2

Conservation and Restoration

This theme focuses on protecting intact peatlands (wherein ecosystem functions of the peatland are close to an undisturbed or pristine peatland) and restoring degraded peatlands. During the surveys relatively undisturbed peatlands were found mostly located in the higher elevations of Himalayas and within protected areas of Western Ghats, North-East and Himalayas. The protected area management plans for these regions need to be modified to incorporate peatland mosaics and their linked hydrological units and ensure that anthropogenic pressures on such systems are prevented. Management prescriptions for these areas also need to ensure that natural hydrological regimes of peatlands are not disturbed and peatlands are not converted into alternate habitats.

Rehabilitation and restoration interventions are needed in landscapes where peatlands are currently degraded (such as the wetland complex within Jhelum Basin in Kashmir, Ziro Valley in Arunachal Pradesh, Loktak wetland complex in Manipur). These interventions must aim at restoring hydrological regimes, allowing natural regeneration of peat forming vegetation and addressing land-use conflicts. In several parts, peatlands form a component of livelihood strategies such as agriculture, horticulture, grazing and others. Unless the livelihood aspects are addressed, the success of restoration and rehabilitation measures is highly constrained. In such circumstances, management of peatland areas shall endeavour to align livelihood systems with peatland ecosystem functioning and provide incentives to communities for ecosystem stewardship.

The current wetland management planning guidelines are insufficient to cater to the specific needs of conservation and peatland management. In several cases, interventions to increase water holding capacity in peatlands has led to removal of peat and peat-forming vegetation. It is therefore imperative to develop guidance to enable site managers in deciding site specific interventions so that integrity of peatlands is maintained.

Specific activities to be implemented under this theme are as follows:

- Management based on peatland hydrological units
- Regulating adverse land use and land cover change, hydrological alterations
- Rehabilitation and restoration
- Addressing livelihood linkages
- Peatland fire management

Theme 3

Monitoring and research

Monitoring and research are cross-cutting elements to support evidence-based management. In 2020, an inventory, assessment and monitoring framework for Indian Wetlands was adopted by the MoEF&CC as an overarching framework to enable defining the core information base required to describe the wetland, set management objectives and establish monitoring indicators. A national peatland monitoring programme, which would be built around monitoring of specific peatland sites, as well as broad-scale landscape processes and climate features is proposed to be established. These are further elaborated in Section 5.4.

There is an overall lack of peatland research in the country. Details such as peat thickness and age, type of peat-forming vegetation, and hydrological conditions are available for a few sites. A basic dataset is needed on various peatland ecosystem features and governing factors to develop management plans. A set of national standards or guidelines are needed to ensure uniformity in data collection and analysis, methods and procedures for mapping, monitoring, measuring and reporting on peatlands is needed to facilitate integration into carbon credit programs in future. Innovative awareness campaigns targeting governments, private sectors, and communities are critical for promoting sustainable peatland management practices, such as no-drainage, no-burn agriculture, and water management.

Strengthening cooperation among experts, peatland managers, and institutions is essential for building capacity and sharing knowledge. Capacity-development programmes for agencies entrusted with peatland management must cover elements of introduction to peatland systems and their hydrological and ecological dynamics, techniques for management of carbon stocks and GHG emissions, sustainable use practices, fire risk prevention, monitoring, and other need-based topics. Improved collaboration among academic institutions, NGOs, development agencies, and governments can accelerate research and the dissemination of best practices. The research needs to be interdisciplinary to enable a comprehensive approach to peatlands conservation and management.

Specific activities to be implemented under this theme are as follows:

- Establishment of standards for measuring, monitoring and reporting on peatlands and emissions
- Assessments of impacts of climate change on peatlands and possible mitigation and adaptation measures
- Development of landscape and context specific peatland restoration approaches and methods
- Identification of sustainable agro practices that can balance peatlands conservation and use
- Research on biodiversity, ecosystem functions and services to establish baselines and inform management practices

Theme 4

Capacity Development, communications and outreach

Building institutional and community capacity is essential for effective peatland management in India. This thematic area focuses on equipping stakeholders with the knowledge, skills, and tools required for sustainable peatland conservation. Targeted training programmes for Wetland Authorities, Climate Change Directorate, Wetland and Protected Area Managers, peatland dependent communities and CSOs, researchers and academicians will enhance technical expertise in peatland restoration, monitoring, and sustainable use practices.

A robust communication and outreach strategy, similar to CEPA strategy for Ramsar Sites in India, is crucial to raise awareness about the ecological, cultural, and economic significance of peatlands. Increased awareness of the special characteristics of peatlands and peat soils is an integral component of successful peatland protection. Community engagement programmes will emphasize the role of local stakeholders as custodians of peatlands, fostering stewardship and ownership. By strengthening the Indian Peatland Initiative, with support from Wetland Knowledge Partners to the MoEF&CC, this thematic area will ensure a coordinated approach to peatland research and integrated management, aligning with national and global conservation goals.

Specific activities to be implemented under this theme are as follows:

- Awareness campaigns
- Training programmes
- Strengthening research management interface
- Knowledge exchange

Theme 5

Institutions and governance

Peatlands, as open systems, are impacted by a range of developmental and resource management decisions taken at the scale of landscape, river basins and beyond. The MoEF&CC at central government level and State Wetland Authority play an important role in ensuring integrated management of peatlands to harmonise programmes by government and private entities, avoiding conflicting outcomes detrimental to peatlands.

Effective peatland management requires policies that prioritise sustainable practices, moving away from drainage-based approaches. National policies conflicting with peatland conservation must be identified and resolved. A diverse range of actors—including local communities, private companies, investors, government bodies, research institutions, and NGOs are involved in peatland use, management, and restoration. These stakeholders often have differing interests and perceptions, leading to conflicts over management priorities.

A nuanced understanding of governance complexities and stakeholder dynamics is essential. Stakeholder cooperation should be informed by comprehensive mapping to identify areas of common interest, foster dialogue, and facilitate participatory processes. Institutional arrangements for conservation and sustainable management of peatlands are defined by the ability to ensure integration of site management within broad scale environmental and developmental programming (at PHU scale) and enabling stakeholder participation.

Finance and resource mobilisation

Currently there are no specific mechanisms for financing peatland conservation and restoration efforts in India. Much of the financing for wetland conservation, to which peatlands are aligned with, rely heavily on public sources of financing. It is imperative to create a dedicated scheme supported by central government and with co-financing from the state government to finance peatland conservation and restoration projects. In addition, peatland conservation and restoration should also be built into related conservation and development sector plans and programmes such as Wetland Management Plans, Soil and Water Conservation Plans, Protected Area Management plans, and Climate Change Action Plans. Assessing the benefits and cost of peatland conservation, restoring and sustainable management is crucial to secure these ecosystems. In several cases, such actions are likely to have considerable distribution impacts. It is thus important that the ecosystem service values provided by peatlands are assessed and adequately considered in land use decisions that damage, degrade or destroy peatlands.

Voluntary carbon markets support decarbonisation and carbon mitigation by allowing companies and other institutions to voluntarily set emission reduction targets and purchase carbon offset in markets of carbon credits. The credits can be used for funding conservation and restoration of carbon sequestering natural systems such as peatlands. Considerable potential exists for voluntary carbon markets to expand in coming years and support peatland conservation and restoration projects. Mechanisms such as Green Bonds (debt instruments, the proceeds of which are exclusively used to finance or re-finance projects with environmental benefits) can also be used to close the financing gap.

5.4 A Framework for Peatland monitoring

Putting in place a robust and comprehensive peatland monitoring program is crucial for evidence-based policy and programming for these ecosystems.

Developing a peatland monitoring plan requires addressing the following inter-related requirements of peatland inventory and assessment. Therefore, it is imperative to embed peatlands monitoring within an overarching framework of WIAMS to address the overall information needs for wetland management and to provide a decision-support system. Specific objectives to embed peatland monitoring within WIAMS are as follows:

- Developing an up to date and scientifically valid information on status and trends of peatland features and influencing factors
- Establishing a baseline for measuring change in ecosystem components, processes and services
- Informing site manager, decision makers and stakeholders on status and trends of peatland ecological character
- Supporting compliance to national and state regulatory regimes
- Determining impacts of developmental projects and identifying risks to peatland ecological character and develop response strategies
- Assessing the effectiveness of peatland management

5.4.1 Monitoring parameters and methods

Available international guidance on peatland monitoring lays emphasis on designing peatland monitoring programmes based on condition (pristine, drained and restored peatlands) and geographic location (tropical, temperate and boreal) and landscape context (hydrological unit of peatland, land-use and human interactions, geology and geomorphology).

The central tenets of monitoring peatlands In India are climate action, biodiversity conservation, and wise-use of peatland resources. Based on these monitoring purposes, the peatlands monitoring framework presents the key monitoring parameters and indicators, monitoring approach, and data sources (Table 2).

Table 2: Peatlands monitoring framework comprising parameters, scale, frequency, approach and data sources

Monitoring parameter	Scale	Indicator	Suggested minimum frequency	Monitoring Approach and data sources
Peat extent	Peatland	Peat area	Annually	GIS and Remote Sensing UAV (drones) Field assessments
		Peat depth and thickness	Once	Field assessments SAR satellite data
Peat soil	Peatland	Soil Organic Carbon % age	Annually	Field assessments and laboratory tests Literature review
		Soil moisture	Seasonally	
		Bulk density	Seasonally	
Peatland hydrological regime	PHU	Water source	Seasonally	GIS analysis and Field assessments
		Water spread and level	Seasonally	GIS analysis and Field assessments (Dipwells (Image 2), LiDAR)
		Water quality pH EC DO	Seasonally	Field assessments and laboratory tests Literature review
Hydrological connectivity	PHU	Percentage functional channels	Seasonally	GIS analysis and Field assessments
GHGs emission and removal	Peatland	Carbon dioxide and methane flux	Seasonally	Field assessments (Flux towers (Image2) /meter and CarboScen)
Biodiversity	Peatland	Peat forming vegetation Type (Species) Abundance	Annually	Field assessments
	PHU	Floral richness and abundance	Annually	Field assessments
		Faunal richness and abundance	Annually	Field assessments
		Habitat type and extent	Annually	Field assessments and Remote Sensing – GIS analysis
Ecosystem services and livelihoods	PHU	Number of beneficiaries/users quantity of peatland resource – regulated/extracted	Annually	Socio-economic surveys
Policy setting	PHU	Extant rules	Once in three years (as per management cycle)	Literature review, expert consultation
Management regime and Stakeholder coordination	PHU		Once	Stakeholders' consultation

Image 2: Peatland monitoring instruments

Flux Tower (Source: Google)

Dip-wells (Source: CAFRE)

5.4.2 Implementing peatland monitoring

Peatlands monitoring should be taken up as an integral part of the site management plan. Monitoring objectives, parameters, frequency of data collection, data storage and analysis methods, human and financial resources, and overall institutional arrangements must be clarified within the plan. Monitoring of parameters such as GHG flux, carbon storage and hydrology and hydrodynamics require specific instrumentation and will need trained staff for data collection and analysis. It is recommended that the site management enters into a collaboration with an accredited research agency to conduct the monitoring on a regular basis. It is also important that inter and intra site comparisons of various parameters are periodically done to assess the robustness of monitoring. In future, as peatland restoration is linked with carbon markets to access funds, it will be important to align monitoring systems to the relevant quantification, monitoring, reporting and verification standards for Greenhouse Gas (GHG) emission reductions and removals. At the time of writing this report, the methodology for rewetting drained tropical peatlands (VM0027 OF VERRA) is currently inactive.

5.4.3 Quality control and reporting

Quality control and monitoring systems are required to ensure the scientific credibility of peatland sampling, laboratory analysis, collation and reporting. This ensures prevention of introduction of random and systematic errors in data collection, analysis and reporting. It is imperative that a Quality Management and Assurance System is developed for the peatlands monitoring program to determine:

- Specification of objectives for sampling program
- Data quality objectives: maximum amount of uncertainty that can be tolerated to ensure that the data is fit for intended use/Maximum limit of uncertainty to ensure the data is fit for intended use
- Sampling program design: statistical robustness of sampling framework means to ensure that the samples are representative of environment, sample recording, procedures for minimizing impact
- Documentation: procedures for field sample record keeping and methods documentation
- Processing validity: specially for water quality and biological components
- Data quality control methods: processes for quality control samples, duplicates, replicates
- Performance audit procedures: data and systems audit

A periodic review of the peatland's monitoring programme is essential to determine the extent to which management objectives are achieved, and the monitoring system remains relevant for the ecological state of a peatland. The periodic review should aim at enhancing the efficiency of the monitoring system to be able to assess ecosystem condition, landscape-scale processes affecting the ecological character of the peatland and related management. The review process should include documentation on the way wetland inventory and assessment are being used to support management planning and policy goals. This should also include identification of appropriate mechanisms to ensure that peatland monitoring is continued in the event of a funding shortfall.

Reporting constitutes an important element of a monitoring programme. The intended user group, format, style and peer-review requirements are to be set in the initial phases of the establishment of the monitoring program. Periodic reports, for example, as a part of annual report to the State Wetlands Authority should aim to provide the summary of the outcomes. Special publications, for example, wetland atlas constituting thematic maps on various parameters are intended to inform stakeholders on wetland status and trends. Outcomes of specific assessments such as GHG flux assessment or carbon stock assessment could be made available in the form of a technical report with an extended summary for general readership. As monitoring programmes get sophisticated over time, real time monitoring options can be explored.

Khecheopalri Lake

Photo credit: Ankur P

06 CONCLUSION

The current study is a novel attempt to establish a preliminary baseline on peatland extent and distribution, carbon stocks and threats and management regime in India. To progress further, a comprehensive peatland inventory must be developed to inform decision-makers and managers of the status and trends in peatland extent and condition. The peatland probability mapping conducted thus far needs to be extended to the remaining biogeographic zones, and probability maps must be converted into specific distribution maps.

Progressing the work on peatlands would also require an agreement on the definition and thresholds for peatland delineation and demarcation on the ground. The current work provides a basis for such discussions.

There is an overall lack of peatland research in the country. Strengthening cooperation among experts, peatland managers, and institutions is essential for building capacity and sharing knowledge. Consultations held during the duration of the project indicated a high level of interest amongst several institutions to conduct peatland research and support management. It will be important to build on this interest to establish a National Peatlands Initiative to bring together academic and research institutions towards the development of a robust inventory and management protocol.

Wetlands of Kulathupuzha

Photo credit: Dhruv Verma / WISA

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08

ANNEX 1:
KEY INFORMATION FROM THE PEATLAND ASSESSMENT SITES

Tso Kar Wetland Complex, Ladakh

Photo credit: Apoorva Thapa

Name of the site	Location (coordinates)	State	Peat thickness (in 1m)	Peat profile (1m)	Ecosystem	Peat vegetation	Source of water	Water level	SOC %	Soil pH	Key ES	Key threats
Khecheopalri	27°20'57.20"N 88°11'17.80"E	Sikkim	30 cm to 100 cm	Light brown, Sphagnum moss	Lake with peat on periphery	Sphagnum moss, Saccharum sp.,	Surface run-off and precipitation	Saturated	17-39	6.5 to 7.6	Religious and Cultural values, Water regulation, Biodiversity support, Nutrient regulation	Introduction (there was a discussion that exotic fish such as Chinese carp were being added to the pond)
Saat Tal, Uttarkashi	31° 1'41.03"N 78°46'24.55"E	Uttarakhand	60 cm	Light brown compact peat	Marsh	Moss, Sedges	Surface run-off and precipitation	Fully saturated	7-17	6-6.2	Water regulation, Biodiversity support, Nutrient regulation, Sediment transport/ regulation	Physical regime change
Hanle	32.79141111 78.95710278	Ladakh	10 cm	Dark loose peat with sediments	Marsh or Wet Grassland	Grasses, aquatic vegetation	Surface run-off and precipitation	Fully saturated	8.2-9.5	6-8	Water regulation, Food and fodder, Biodiversity support, Nutrient regulation, Sediment transport/ regulation, Cultural association, Livelihoods	Physical regime change, Extraction, Introduction
Tso Kar	33°19.543' 77°57.457'	Ladakh	10 cm	Dark loose peat with sediments	Marsh or Wet Grassland, High altitude meadow	Grasses	Surface run-off and precipitation	Fully saturated	6.5-31	5-9	Water regulation, Climate regulation, Food and fodder, Biodiversity support, Nutrient regulation, Livelihoods	Physical regime change, Extraction, Introduction
Startsapuk Tso	33.259 78.0524	Ladakh	10 cm	Dark loose peat	Marsh or Wet Grassland	Grasses	Surface run-off and precipitation	Partially saturated	4.7-7.7	6-10	Water regulation, Climate regulation, Food and fodder, Biodiversity support, Nutrient regulation, Livelihoods	Physical regime change, Extraction, Introduction

Name of the site	Location (coordinates)	State	Peat thickness (in 1m)	Peat profile (1m)	Ecosystem	Peat vegetation	Source of water	Water level	SOC %	Soil pH	Key ES	Key threats
Chushul	33.57928° 78.62405°	Ladakh	5 cm	Very Dark loose peat	Marsh or Wet Grassland, High altitude meadow	Grasses	Surface run-off and precipitation	Fully saturated	7-8	6	Water regulation, Climate regulation, Food and fodder, Biodiversity support, Nutrient regulation	Physical regime change, Extraction, Introduction
Dzukou valley	25° 33′ 13.6152″ N, 94° 3′ 57.2904″ E	Nagaland	30 cm		Marsh or Wet Grassland	Sedges, Parnasia spp, Brown and sphagnum moss	Surface run-off and precipitation	Fully saturated	9-19	4.3-5.2	Biodiversity regulation; Sediment transport/regulation; Cultural; Livelihood	Structural modification; Extraction
Jowai	25°23′46.35″N, 92°9′41.77″E	Meghalaya	30 cm		Grassland	Sphagnum moss, grasses	Spring	Partially saturated	5-6	5-5.2	Food and fodder, Livelihood	Extraction; Introduction
Vaikom Keri	9° 41′ 2.22″ N, 76° 26′ 40.12″ E	Kerala	20 cm		Agriculture		Surface run-off and precipitation	Partially saturated	17.3	3		Physical regime change
Kulathupuzha myristica swamp	8°49′14.24″N 77° 2′51.73″E	Kerala	-	Sediment	Forest swamp	Myristica trees	Surface run-off and precipitation	Partially saturated	4-16.2	5-5.7	Water regulation, Biodiversity support, Nutrient regulation, Sediment transport/ regulation	Physical regime change
Devikulam wetland	10° 2′ 58.41″ N 77° 8′ 55.08″ E	Kerala	20 cm	Organic soil with sediment	Marsh	Sedges	Surface run-off and precipitation	Fully saturated	8.4-12.7	5.7-6.6	Water regulation, fodder	Physical regime change (fragmentation by road, rubber/tea plantation causing sediment inflow)

Name of the site	Location (coordinates)	State	Peat thickness (in 1m)	Peat profile (1m)	Ecosystem	Peat vegetation	Source of water	Water level	SOC %	Soil pH	Key ES	Key threats
Mirgund	34.120575 74.644693	Jammu and Kashmir	>3 m	Peat soil mixed with sediment layers	Marsh or Wet Grassland	Grasses	Surface run-off and precipitation	Unsaturated	19.4–42.4	5.7-6.3	Water regulation, Climate regulation, Food and fodder, Nutrient regulation, Livelihoods	Physical regime change, Structural modification, Extraction
Hokersar	34.109857 74.716194	Jammu and Kashmir	>2 m	Soft peat layer with woody material	Marsh or Wet Grassland	Grasses, Sedges, aquatic vegetation	Surface run-off and precipitation	Fully saturated	22.8–28.1	5.7-6.5	Water regulation, Climate regulation, Food and fodder, Biodiversity support, Nutrient regulation, Livelihoods	Physical regime change, Structural modification, Extraction
Shallbhugh	34.15677 74.7221	Jammu and Kashmir	1.5 m	Soft peat layer with woody material	Marsh or Wet Grassland	Grasses, Sedges, aquatic vegetation	Surface run-off and precipitation	Fully saturated	12.6–38.5	5-6.3	Water regulation, Climate regulation, Food and fodder, Biodiversity support, Nutrient regulation, Livelihoods	Physical regime change, Structural modification, Extraction
Chandertal trench	32°28'7.38"N 77°36'40.71"E	Himachal Pradesh	30 cm	Dark loose peat	Alpine Marsh	High-altitude vegetation (sedges, Carex, etc)	Surface run-off and precipitation	Partially saturated	11-21		Biodiversity support, Fodder	Physical regime change