PAKISTAN
BLUE CARBON RAPID ASSESSMENT

Policy Recommendations for the Revision of Nationally Determined Contribution

May 2021

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1 PROBLUE is an umbrella multi-donor trust fund, administered by the World Bank, that supports the sustainable and integrated development of marine and coastal resources in healthy oceans.

Abbreviations and Units

ADP	Annual Development Programme
ALOS PALSAR	Advanced Land Observing Satellite Phased Array type L-band Synthetic Aperture Radar
ATR	Avions de transport regional
BEPA	Balochistan Environmental Protection Agency
BOR	Board of Revenue
BTR	Biennial Transparency Report
BUR	Biennial Update Report
BUR1	First Biennial Update Report
CBD	Convention on Biological Diversity
CBO	Community-based organization
CDA	Coastal Development Authorities
CFU	Climate Finance Unit
CITES	Convention on International Trade in Endangered Species
cm	Centimeter
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Conference of Parties
C_{org}	Organic carbon
CPEIR	Climate Public Expenditure and Institutional Review
CTU	Clarity, transparency and understanding
DBH	Diameter at breast height
EEA	Environmental-Economic Accounting
EIA	Environmental Impact Assessment
EPA	Environment Protection Agency
ESRF	Eco-System Restoration Fund
ETF	Enhanced Transparency Framework
FREL	Forest Reference Emission Level

GCF	Green Climate Fund
GCISC	Global Change Impact Studies Centre
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic Information System
GoP	Government of Pakistan
GST	Global stock take
ha	Hectare
ICTU	Information to facilitate clarity, transparency and understanding
IEE	Initial Environment Examination
INGO	International non-governmental organization
IPCC	Intergovernmental Panel on Climate Change
IRSA	Indus River System Authority
ISI	Institute for Scientific Information
IUCN	International Union for Conservation of Nature
km	Kilometer
KWSB	Karachi Water and Sewerage Board
Landsat	Land Satellite
LULUCF	Land-use, land-use change and forestry
m	Meters
MAF	Million acre-feet
MEA	Multilateral environmental agreement
MFF	Mangroves for the Future
MGD	Million gallons per day
MoCC	Ministry of Climate Change
MoMA	Ministry of Maritime Affairs
MPA	Marine protected area
MRV	Monitoring, reporting and verification
NbS	Nature-based solutions
NBSAP	National Biodiversity Strategy and Action Plan

NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution
NFMS	National Forest Monitoring System
NGO	Non-governmental organization
NIO	National Institute of Oceanography
ODA	Official development assistance
PA	Protected Area
PAI	Protected Areas Initiative
PES	Payments for Environmental Services
PCMF	Pakistan Coastal Mangrove Forests
PSDP	Public Sector Development Programme
PVC	Polyvinyl chloride
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SCDA	Sindh Coastal Development Authority
SDG	Sustainable Development Goal
SEPA	Sindh Environment Protection Agency
SFD	Sindh Forest Department
sq. km.	Square kilometer
STP	Sewage treatment plants
TBTT	Ten Billion Tree Tsunami
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UTM	Universal Transverse Mercator
WWF	World Wildlife Fund

Units	Conversion
Hectare (ha)	1 ha = 0.01 sq. km.
Kilometer (km)	1 km = 0.62 miles = 3280.84 feet
Tonne (t)	1 t = 907.185 kg = 200 pounds
Gallons (G)	1 G = 3.78 liters
Acre (A)	1 A = 0.40 ha
Foot (ft.)	1 ft. = 0.30 meter
Celsius (C)	1°C = 32°F

Currency Exchange Rates

Currency Unit	Exchange Rates (effective May 18, 2021)	
Pakistan Rupee (PRs)	$1 = PRs 152.92	PRs 1 = $0.0065

All dollar amounts are US dollars unless otherwise indicated.

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Executive Summary

The Government of Pakistan (GoP) has initiated an analysis of Pakistan's blue carbon exposure, relevant carbon stock trends, and the sector's potential for climate action in the context of Pakistan's upcoming submission of revision of its Nationally Determined Contribution (NDC). Through its national process, the GoP requested rapid assessment support by the World Bank to be concluded in a few months. The objective of the rapid assessment is to support the GoP to enhance its commitments in the revised NDCs through blue carbon ecosystems and prepare for the next round of revision.

Blue carbon has been a part of the first NDCs for adaptation measures under the Paris Agreement in several countries in the world. To meet the emissions reductions commitments set under the NDCs, nature-based solutions (NbS) offer fundamental and cost-effective actions in comparison to technology-based solutions. Blue carbon ecosystems such as mangroves, tidal marshes, and seagrass meadows, have been proposed as a cost-efficient NbS. Blue carbon ecosystems in Pakistan could serve as an asset in delivering Pakistan's NDC through carbon sequestration and adaptation.

There are two coastal states in Pakistan—Sindh and Balochistan—and both states are endowed with coastal ecosystems. Mangrove forests in the Indus Delta, Sindh are the seventh largest arid mangrove ecosystem in the world. However, Pakistan coastal ecosystems have been considerably exploited to yield short-term economic dividends over the years. As a consequence, the remaining mangrove forests are in a highly degraded state and offer an opportunity for restoration on a massive scale along with carbon mitigation and ecosystem benefits.

Currently, Pakistan has a National Climate Change Policy (NCCP) of 2012 and a Framework for Implementation of Climate Change Policy (2014-2030) to tackle the causes of climate change and to build the country's resilience to the impacts of climate change. Environmental policymaking is mainly a responsibility of the provinces. Sindh adopted the Sindh Environment Protection Act 2014 (SEPA) that serves the purpose of legislative framework for climate change and environment. Balochistan has the Balochistan Environment Protection Act 2012 that covers prohibition of the import of hazardous and electronic wastes, solid waste management, water resources management, alien species, and living modified organisms.

As part of the rapid assessment, a first-pass estimate of Pakistan's blue carbon stocks was conducted, and the potential for emissions reductions are presented. Mangrove forests occupy an area of approximately 1,464 sq. km. according to the most recent mapping effort of 2020. In total, mangrove forests and mapped tidal marshes store approximately 21 million tonnes of organic carbon or 76.4 million tonnes of carbon dioxide equivalent (CO_2e). Through replanting efforts by the Sindh Forest Department, the Indus Delta has experienced a net gain in mangrove area in recent years. However, mangroves in the vicinity of Karachi and across Balochistan remain at risk.

Information on other blue carbon ecosystems, in particular, tidal marshes and seagrass meadows, is very limited. Basic data, including extent of area and conservation/restoration trends, is mostly not available. This rapid assessment highlights the importance of improving blue carbon inventory and relevant reporting capacities in Pakistan. This includes the need for the national (cross-economy) greenhouse gas (GHG) inventory that is regularly submitted to the United Nations Framework Convention on Climate Change (UNFCCC), to be updated by applying *2013 IPCC Wetland Supplement to IPCC 2006 Guidelines*. There also needs to be improved coordination with the Reducing Emissions from Deforestation and Forest Degradation (REDD+) Pakistan office for field data to better estimate blue carbon stocks.

Carbon financing for blue carbon is still in its nascent phase, with a few small projects that have come online, and larger projects are anticipated for the near future. In the last year or two, there has been a substantial increase in interest by private and international finance sectors to invest in blue carbon activities. Using a mangrove reforestation action that might remove 25 million tonnes of carbon dioxide (CO_2) by 2050, this rapid analysis found that using the terrestrial forest price of carbon credits of $3 and aspirational blue carbon prices of $12-20, revenue generated would be $75 million and $300-500 million, respectively. Carbon removals would continue beyond 2050, sustaining ongoing revenue.

This year's revision of Pakistan's NDC offers the opportunity to draw attention to the country's coastal habitats and their relevance for climate change mitigation and adaptation. The fresh document can build on Pakistan's first NDC from 2016. The 2016 NDC also referred to the functional role of wetlands in the context of "flood management". The NDC revision should make explicit reference to blue carbon and/or blue carbon habitats (coastal wetlands) with respect to (1) setting out the NDC scope and methodological approaches; (2) identifying data and capacity needs and efforts; (3) enhancing the NDC ambition by formulating specific mitigation Contribution related to blue carbon/coastal wetlands; (4) defining explicit adaptation actions

on coastal wetlands; and (5) focusing on blue carbon finance options to support future conservation and restoration work.

This rapid assessment presents action points towards the development of the Blue Carbon Action and Financing Roadmap that will address and implement the following recommendations. The recommendations are presented in two sets: the first focuses on research and outreach, while the second is on blue carbon implementation. In order to strengthen research and outreach foundation in Pakistan, it will be ideal to (1) improve mapping and monitoring of blue carbon ecosystems through time; (2) update the national GHG inventory and prepare for national NDC accounting; (3) evaluate key pressures on blue carbon ecosystems in Pakistan; (4) invest in research to evaluate and map co-benefits provided by blue carbon ecosystems; and (5) strengthen education, training, and engagement.

In order to proceed towards blue carbon implementation in Pakistan, it will be ideal to (1) review and improve institutional arrangements; (2) work on capacity building; (3) review and implement climate change adaptation options; (4) review and implement climate change mitigation options; and (5) seek different sources and modalities of financial resources options. A common Blue Carbon Action and Financing Roadmap should be prepared covering the next five to 10 years and outlining key responsibilities, tasks, action items, and follow-up concerning institutional arrangements and governance strategies, inclusive of local communities.

The integration of blue carbon in the NDC update and implementation should involve deep engagement with extended stakeholders, including the local potential affected communities, civil society and private sector actors. It must also include a good information campaign on the benefits, incentives including potential Payment for Ecosystem Services (PES), and ownership of the conservation of the local mangrove stocks as a practical opportunity for livelihood enhancements and revenue source. Such processes should be streamlined in the NDC update procedure.

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Chapter 1. Background and Objectives

The Government of Pakistan (GoP) has initiated a preliminary analysis of Pakistan's blue carbon exposure, relevant carbon stock trends, and the sector's potential for climate action in the context of Pakistan's upcoming submission of revision of its Nationally Determined Contribution (NDC). Blue carbon refers to coastal wetlands, namely mangroves, tidal marshes, and seagrass meadows, and the multitude of ecosystem services they provide, including climate change mitigation and adaptation.

Through its national process, the GoP requested rapid assessment support by the World Bank to be concluded in a few months. Due to limited timeframe and budget, the report is based on literature review, using mostly secondary data collected from available resources. The assessment was conducted in the following five steps:

1. Literature Review: To understand the current state of blue carbon ecosystems and review of enabling conditions in Pakistan for the blue carbon sector;
2. Inventory Assessment: To estimate the carbon potential of blue carbon ecosystems in Pakistan;
3. Strategic Consultations: To collect data for evidence building and refining proposed strategies;
4. Policy and legal framework analysis: To identify gaps and limitations in the existing framework; and
5. Compiling recommendations for a draft of roadmap development.

The objective of the rapid assessment is to support the GoP to enhance its commitments in the revised NDC through blue carbon ecosystems. In line with commitments under the Paris Climate Agreement, the GoP is committed to a strategic transition towards low carbon development while strengthening national resilience to climate change (Ministry of Climate Change 2016). Pakistan's vulnerability to adverse impacts of climate change is established and well-recognized[2], and there is a need to build strong adaptation capacity across the country contributing to emissions reductions. In preparation for Pakistan's second NDC submission, there is an opportunity to consider the combined adaptation and mitigation benefits of coastal ecosystems management as part of a wider initiative on Agriculture, Forestry and Other Land Uses. In 2014, leading up to Conference of the Parties (COP) 21, Pakistan announced the One Billion Tree Tsunami initiative to recover forest ecosystem. This important initiative was extended in 2019 to the Ten Billion Tree Tsunami, including a commitment to recover one billion mangrove trees (Dawn 2020). Planting of mangroves in the province of Sindh has begun. The importance and benefit of planting mangroves is well recognized, but its area, carbon amount, potential expansion area and amount have not been quantified and valued. The report was one of the first summaries of such quantification.

The report is composed of seven chapters. Chapter 1 discusses the background and objectives, followed by Chapter 2, focusing on blue carbon-related global trends. Chapter 3 reviews blue carbon coastal ecosystems in Pakistan and Chapter 4 takes stock of the blue carbon-related policies. Chapter 5 presents the first-pass estimation of the blue carbon inventory in the country. Chapter 6 summarizes recommendations to this year's NDC revision. Chapter 7 provides recommendations for Pakistan to strengthen the foundations of research and outreach on blue carbon and proceed towards the Blue Carbon Action and Financing Roadmap.

2 According to the Global Climate Risk Index, published by Germanwatch, Pakistan is ranked as the fifth-most vulnerable country to climate change (Sönke et al. 2020).

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Chapter 2. Blue Carbon-related International Trends

The concern of ever-increasing global greenhouse gas (GHG) emissions and the consequent need to shift towards a low carbon economy led to the signing of the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). One hundred and ninety-six countries signed the Paris Agreement at the 21st Conference of the Parties (COP21) on December 12, 2015. The Agreement obliges countries to lower their GHG emissions, aiming to limit global temperature increases below 2 degrees Celsius (°C), whilst pursuing efforts to limit global warming to 1.5°C, compared to pre-industrial levels. The Agreement also requires countries to prepare, maintain, and communicate their Nationally Determined Contributions (NDCs) to devise short- and long-term action plans for climate change adaptation and mitigation to transition to climate-resilient and low carbon economies, and to make financial flows consistent with committed climate actions under the NDCs. Countries are obliged to update their NDCs every five years with enhanced commitments.

The Paris Agreement necessitates signatories to track progress towards achieving the agreement's objectives, known as the Enhanced Transparency Framework (ETF) under Article 13. Guidance on the ETF is provided by the Katowice Climate Package agreed at COP24, and it sets the rules for countries to track progress in achieving their NDCs. This information will feed into the Global Stock Takes (GST) of progress every five years, commencing from 2023, essentially informing the parties about the ways to enhance commitments in subsequent NDCs. The requirements under ETF are notably different from the previous reporting mechanism. The ETF requires all parties to use the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines and *2013 Wetlands Supplement* to report on GHG inventories, perform mandatory key category analysis, apply higher tier methods to the key categories, adopt consistent time-series reporting, perform uncertainty analysis, and implement quality assurance and control strategies (UNFCCC 2019).[3] The planned reporting under ETF provides countries like Pakistan with the chance to take stock of the current national situation and to plan and adopt necessary measures to develop a roadmap that will enable the country to report for ETF by 2024. Besides, the countries are in the process of submitting revised NDCs; this is an opportunity for including commitments that will help countries prepare for ETF.

To meet the commitments set under the NDCs, nature-based solutions (NbS) are considered a fundamental and cost-effective action in comparison to technology-based solutions. Parties around the world are harnessing the benefits of NbS to not only mitigate emissions and to adapt to a changing climate, but also to take advantage of socio-economic gains. Evidence shows that conservation, rehabilitation, and climate-informed management of ecosystems can provide one-third of the economic mitigation needed until 2030 by tapping the mitigation potential of 10-12 gigatonnes of CO2 (UN Global Compact 2019).

In this context, blue carbon ecosystems (for example, mangroves, tidal marshes, and seagrass meadows) have been proposed as a cost-efficient NbS (Bindoff et al. 2019). The term 'blue carbon' refers to all the carbon that is stored and sequestered in the ocean, with these three ecosystems being the main key players

3 Moving from Tier 1 to Tier 3 shows a reduction in the uncertainty of GHG estimates at a cost of an increase in the complexity of measurement processes and analyses.

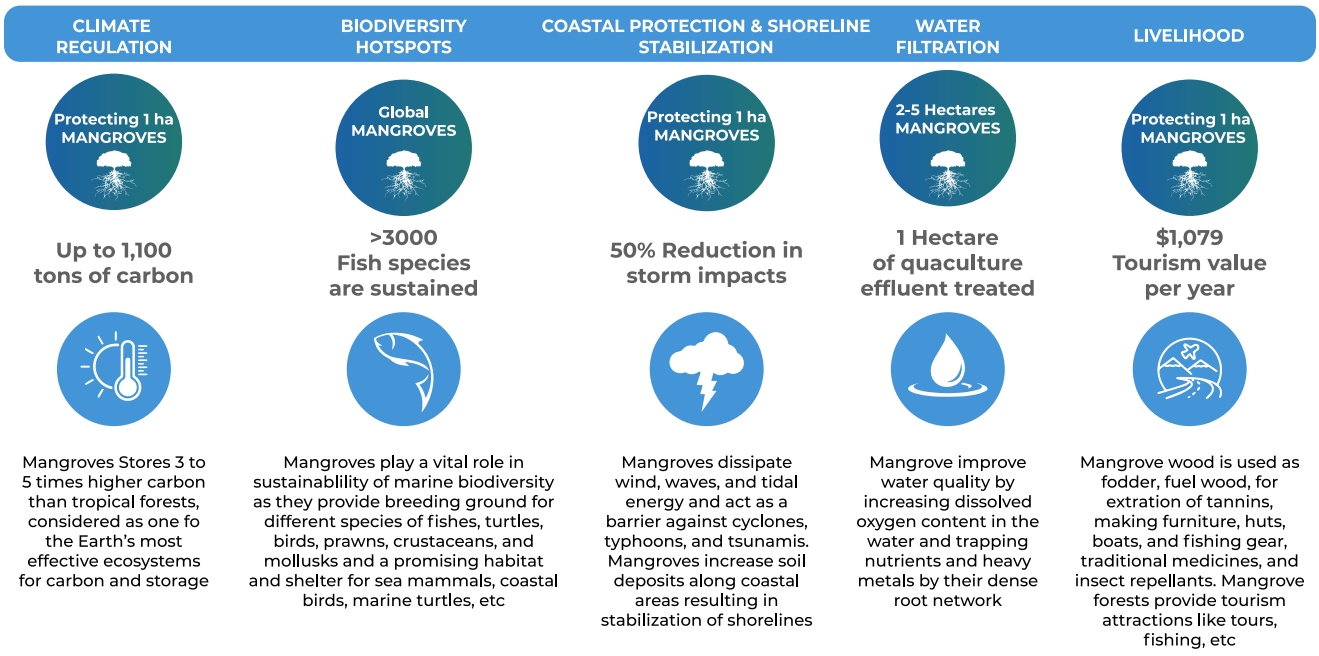
(McLeod et al. 2011; Herr and Landis 2016). Mangroves, seagrasses, and tidal marshes are among the most efficient natural carbon sinks, which capture and store carbon, both in terms of biomass as well as in the form of soil carbon. Soil carbon is continuously removed and locked in the ground at millennial timescales (McLeod et al. 2011; Duarte 2017), resulting in reduced atmospheric carbon concentrations that contribute to global warming. In addition to sequestering carbon, blue carbon ecosystems also support fisheries, enhance biodiversity, and protect shorelines from erosion, extreme weather events, sea level rise, and support human spiritual wellbeing (McLeod et al. 2011; Himes-Cornell et al. 2018). Example of sampling of blue carbon in mangroves is shown in Figure 2.1.

Being recognized not only for carbon mitigation but also for coastal protection, livelihood opportunities, and eco-tourism, blue carbon in mangroves has been considered as a potential NbS for meeting the commitments under the Paris Agreement (Figure 2.2). However, coastal development and climate change are threatening the capacity of these ecosystems to sequester and store carbon. As with important terrestrial carbon sinks (for example, tropical forests and permafrost regions), ecosystem degradation can shift blue carbon ecosystems from carbon sinks to carbon sources, releasing carbon back to the atmosphere (Pendleton et al. 2012).

Figure 2.1: Sampling of Blue Carbon in Mangroves

Note: a) Soil sample being collected in mangroves using a 1 m long PVC pipe that is gently hammered into the sediment to a depth of at least 1 m; b)-d): various samples of soil carbon sampled with PVC pipe.
Source: Blue Carbon Lab, Deakin University, Australia

Figure 2.2: Ecosystem Services and Resources Provided by Mangroves

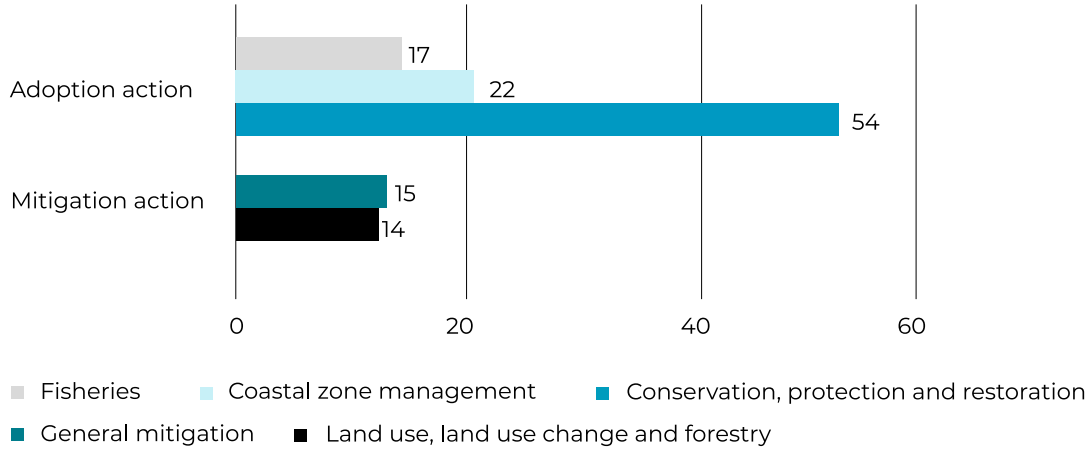


Source: Rafique 2018; Flint et al. 2018; Reef Resiliance Network 2020; Sheaves 2017

Blue carbon has been a part of the very first NDCs; under adaptation measures, the maximum number of countries referred to conservation, protection, and restoration efforts in their NDCs followed by coastal zone management. A few countries are prioritizing identification of vulnerable ecosystems and declaring them as protected zones for effective management. For instance, India's NDC identified Coastal Regulation Zones to restrict industrial operations in vulnerable zones by implementing Integrated Coastal Zone Management programs and identified Island Protection Zones to create bio-shields as a protection against disasters (Ministry of Environment Forest and Climate Change India 2015). Similar to India, Bangladesh also included Coastal Zone Management as an adaptation measure (Government of Bangladesh 2015). Pakistan, on the other hand, has never had a comprehensive coastal management plan. A plan at the national level would help communicate clear sectoral targets for restoration, conservation, and management, with clarity on roles and responsibilities of stakeholders.

A few countries prioritized ocean-based economic opportunities, such as sustainable maritime tourism and climate-smart fisheries, using coastal ecosystem services as an adaptation measure (Figure 2.3). Cabo Verde's NDC makes reference to promoting sustainable coastal maritime tourism and sports as a blue economy initiative (Government of Cabo Verde 2015). This is one sector that Pakistan can explore. Besides, including these opportunities in NDCs will help align these commitments with national priorities.

Figure 2.3: Parties including Blue Carbon Actions under NDC Categories



Source: Herr and Landis, 2016b

Mitigation measures under land-use, land-use change and forestry (LULUCF) mostly address conservation and replantation of mangroves. Although mangroves reforestation initiatives have been undertaken under the Ten Billion Tree Tsunami (TBTT) movement in Pakistan for adaptation benefits as stated in Box 2.1, mitigation co-benefits of restoring these ecosystems are currently missing. This provides an opportunity for Pakistan to articulate its blue carbon mitigation potential to enhance commitments in the NDC.

By learning from other countries' commitments and building on the existing policy context, Pakistan needs to strengthen current initiatives and improve governance of these ecosystems. The Ministry of Climate Change (MoCC) recently announced Astola Island (0.6 percent of the total protected area in Pakistan) as the first-ever marine protected area (MPA) under the Protected Areas Initiative (PAI) that will have a management plan and legislative interventions to protect it. Pakistan's PAI has been initiated in

Box 2.1: Pakistan Ten Billion Tree Tsunami (TBTT)

TBTT: Goal of 10 billion tree plantation across the country in five years

- Under the 10 billion Tree Project, Sindh has a target of planting 1.5 billion trees mainly in mangrove areas (Ali 2019).
- **Protected Area Initiative (PAI):** This initiative is being kick-started with the announcement of 15 national parks including Astola Island, Pakistan's first marine protected area (Khan 2020b).
- **Green Stimulus Package** introduced in the wake of COVID-19 offers green jobs in existing and new projects under TBTT to daily wage earners envisaging greater engagement of communities, especially women and youth in multiple activities such as nursery raising, plantation, maintenance, infrastructure, and conservation activities in protected areas (Khan 2020a).
- **Instigated Voluntary Plantation Drives:** For example, Pakistan Navy planted over four million mangroves along the coastal belt of Sindh and Balochistan and World Wide Fund WWF-Pakistan with JS Bank initiated a drive to plant 100,000 mangrove saplings along the coastal belt of Balochistan (The News 2019).
- A recent estimate of mangrove forests in the country indicates that since 1990 these forests have increased at an annual growth rate of 3.74 percent (Gilani et al. 2021).

recognition of the benefits that these protected areas offer in terms of mitigating greenhouse gas (GHG) emissions, creating a payback mechanism through recreational activities, eco-tourism, green jobs creation, creating buffers for vulnerable communities, and contribution to food security. Through the NDC, Pakistan can further strengthen the Initiative to align these targets with National Biodiversity Strategy and Action Plan (NBSAP) and National Forest Policy to expand the protected area network from the current 13 percent to a target of 15 percent by 2023. For instance, Ecuador committed to further strengthen its national protected areas to combat climate change (Ministerio del Ambiente Ecuador MAE 2019). Similarly, Chile's revised NDC also outline plans for MPAs in the short- and long-term to mitigate the impacts of storm events, reduction in ocean productivity, changes in environmental conditions and species distribution, and ocean deoxygenation and acidification (Government of Chile 2020).

The effective blue carbon actions in the NDCs revolve around the need for a holistic approach for climate, biodiversity, and development, including partnerships between local communities, investors, engineers, private sector, civil society, and global communities. These measures in the NDCs provide opportunities to achieve policy recognition and tap funds available at global platforms, such as the Green Climate Fund (GCF). Pakistan currently lacks the data and the capacity to report on these ecosystems. The public sector is not aware enough about ways to overcome these barriers in order to effectively benefit from these financial opportunities. Including the targets to strengthen Pakistan's blue carbon, inventories will assist the country in prioritizing the work on improved financial flows that are directed towards data collection and strengthening in-house public sector capacities to adopt the *2013 IPCC Wetlands Supplement for Inventory Reporting*.

Blue carbon ecosystems in Pakistan could serve as assets in delivering NDC through carbon sequestration and adaptation under the Paris Agreement. Mangrove forests in the Indus Delta, Sindh, are the seventh largest arid mangrove ecosystem in the world with huge carbon mitigation potential (WWF 2018). Pakistan, under the TBTT, has set the goal to replant a billion trees starting in 2021; through the Reducing Emissions from Deforestation and Forest Degradation Programme (REDD+), 350,000 ha will be restored and maintained. Coordination with the REDD+ Pakistan office for field data will improve understanding and better estimate blue carbon stocks and potential. Pakistan can benefit not only from this mitigation potential but also from community adaptation prospects offered by these ecosystems to enhance commitments under the revised NDC. In 2020, the incumbent Prime Minister of Pakistan announced a 'Blue Economy Policy' for Pakistan, aimed at revitalizing the existing shipping sector and enabling the transformation of potentially untapped sectors (Ministry of Maritime Affairs 2020). A key motivation of the policy is to maximize the enormous potential of the region's blue carbon economy. It aligns with changing national priorities and incentivizes further development and inclusion of such measures in the NDC for Pakistan to ensure multiple long-term successes. Pakistan not only considered blue carbon in the first NDC in 2016, but has also been working since then to enhance its carbon commitments and revise the country's NDC. A blue carbon strategy and related targets in the revised NDC will provide a foundation for a sustainable stewardship of the ocean.

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Chapter 3. Coastal Ecosystems in Pakistan

Pakistan is endowed with coastal ecosystems which are home to some important biodiversity hotspots, and some of these have been notified as protected areas (Table 3.1). Blessed with a coastline of approximately 1,100 km distributed between two provinces, Sindh (approximately 350 km) and Balochistan (approximately 700 km), the coastal areas offer varying climatic conditions and physical characteristics that are favorable to support rich biodiversity including mangroves, corals, and reefs.[4] Among the biodiversity hotspots, there are national parks, sea turtle nesting beaches, wildlife sanctuaries and Ramsar convention wetlands. Out of 19 Ramsar sites, eight sites including Rann of Kutch, Nariri Lagoon, Juboh Lagoon, Indus Delta, Miani Hor, Astola Island, Ormara Turtle Beach, and Jiwani, are located along coastal areas.

Table 3.1: Biodiversity Hotspots along Pakistani Coasts, Marine Ecosystems, and Protected Areas

Biodiversity hotspots	Description and location
Ramsar sites	• Out of 19 Ramsar sites of Pakistan, eight sites including Rann of Kutch, Narri Lagoon, Juboh Lagoon, Indus Delta at Sindh coast, Miani Hor, Astola Island, Ormara Turtle Beach and Jiwani are located along the Balochistan coastal areas
National parks	• Hingol National Park along the Makran coast is the only national park bordering the coast in the Lasbela district of Balochistan
Wildlife sanctuaries	• The Rann of Kutch, Keti Bundar (North) and Keti Bundar (South) Wildlife Sanctuaries in Sindh • The Kurkhera Wildlife Sanctuary has an area in Miani Hor • Buzi Makola Wildlife Sanctuary comprises of the entire Kalmat Hor along the Balochistan coast
Sea turtle nesting beaches	• Sandspit and Hawksbay beaches near Karachi, and Ormara-Taq Beach, Astola Island and Daran beaches along the Makran coast • Nesting sites of marine turtles that lay eggs on these beaches during July to December • Famous Sandspit and Hawksbay beaches are two of 11 globally most important beaches that thousands of green turtles use as their nesting grounds
Churna Island	• Small uninhabited island located in the Arabian Sea • Known for its high value biodiversity with variety of habitats, such as: • Diversified coral assemblage around Churna • Kaio Islands and the rich mudflats and oyster reefs
Astola Island	• First protected marine area of Pakistan • Ecologically important as it is inhabited by colonies of corals • Sandy beach provides nesting ground for the globally threatened green turtle (Chelonia mydas)
Mangroves (Sindh and Balochistan coasts)	• Provides breeding grounds for fish and shrimps • Home to resident and migratory birds

Source: MFF Pakistan 2016

4 Coastline length differs depending on sources. This report uses a figure of 1,100 km, taken from FAO (FAO 2021).

Currently, mangrove forests exist at five sites within Pakistan's coastline: Indus Delta (which includes the largest mangrove coverage in Pakistan, representing 95 percent of the total mangrove cover of the country), Sandspit, Sonmiani, Kalmat Khor, and Jiwani (see Gilani et al. 2021 for a full description of spatio-temporal changes in the mangrove cover in Pakistan between 1990-2020). However, in the past, these ecosystems have declined dramatically because of coastal development and habitat degradation. Currently, they are exposed to added pressures from future changes in climate. For example, *Avicennia marina* is the most dominant species along the Pakistan's coastline, while four other species (*Bruguiera conjugata, Ceriops rox burghiana, Rhizophora apiculate,* and *Sonneratia caseolaris*) have already disappeared from the country, even though mangrove coverage has increased in the past few years. Pakistan has increased mangrove coverage from 477 sq. km. in 1990 to approximately 1,464 sq. km. in 2020, with a 3.74 percent annual rate of change (Gilani et al. 2021). Despite the importance of mangrove forests, there exists a large knowledge gap about the distribution extent and carbon storage capacity of coastal wetlands in Pakistan, mainly for tidal marshes and seagrass meadows.

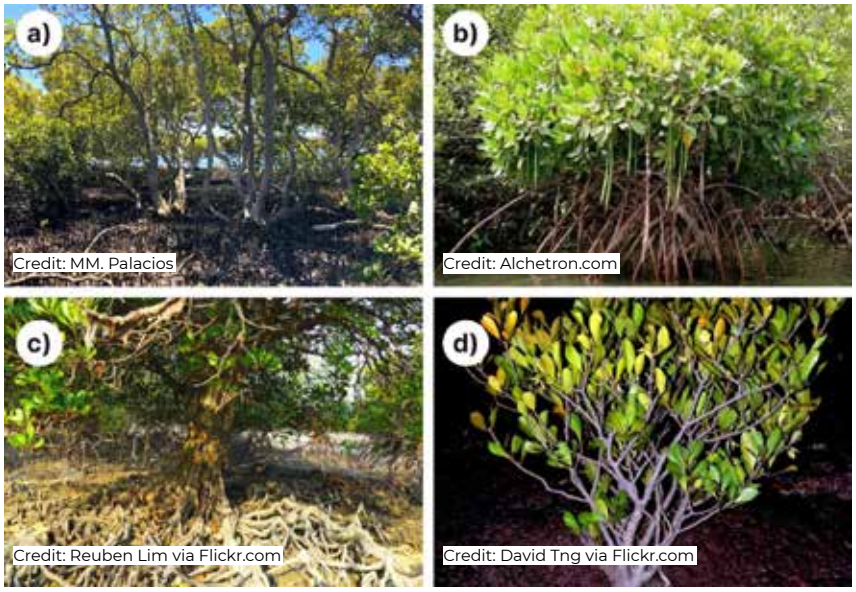
In the Indus Delta, there are historical reports of eight mangrove species (*B. conjugata*, *C. tagal*, *C. roxburghiana*, *R. apiculata*, *R. mucronata*, *Aegiceras corniculatum*, *A. marina,* and *S. caseolaris*), once existing in the region (Aziz and Khan 2001). Currently, the mangrove forest in the Indus Delta is dominated by *A. marina*, whereas *R. mucronata*, *C. tagal,* and *A. corniculatum* are present in smaller numbers (Figure 3.1) (Aziz and Khan 2001; Gilani et al. 2021). Currently, Pakistan has multiple ongoing mangrove restoration projects aiming to increase and restore forest cover which are being carried out throughout the coastline. As part of this effort, the Indus Delta Mangrove Project (which includes an area of approximately 350,000 ha) has replanted extensive areas of mixed plantations of *A. marina* and *R. apiculata* and localized plantings of *C. tagal*.

The coastline of Sindh is shared by two coastal segments: Indus Delta and Karachi City Coast. Karachi is an urban region with the only developed maritime hub in Pakistan. Karachi coastal area constitutes of two ports, a nuclear power plant, fish harbors, industrial estates, and steel mills. On the other hand, the Indus Delta covers 85 percent of the Sindh coast, has small settlements of fishermen communities in the network of creeks with no major infrastructural development or industrial activity. The Indus Delta is part of the five largest delta systems of the world, and includes 17 creeks, mudflats, wetlands, estuarine systems, and a continental shelf (Rafique 2018).

The Balochistan coast has two segments: Lasbela and Gwadar, characterized by four types of land forms, namely raised beaches, sand dunes, playas,[5] and pediments[6] (Mangroves for the Future 2020). The Balochistan coast is different from the Sindh coast in terms of climatic conditions influenced by monsoon and Mediterranean-type weather. In addition, Sindh's ecosystems receive freshwater from precipitation and from the Indus River, while Balochistan coast relies only on precipitation.

5 Dry, vegetation-free, flat area at the lowest part of an un-drained desert basin.
6 Formulates when running water washes over it in intense rainfall events.

Figure 3.1: Common Mangrove Species in Pakistan



Note: Dominant mangrove species include (a) *Avicennia marina*; (b) *Rhizophora mucronata*; (c) *Ceriops tagal;* and (d) *Aegiceras corniculatum.*

The surface temperatures for the Indus Delta, Karachi coast, and Balochistan coast range between 23.8-28.7°C, 23.5-29.1°C, and 23.5-29.3°C, respectively. The Sindh coast has seen a historic increase in minimum mean temperature and reduced average rainfall with occasional cloud bursts (Khan et al. 2015), while the Balochistan coast is hyper-arid to arid. Historical data shows that these coasts are experiencing warmer weather and continuous wet periods associated with increasing sea surface temperatures (Abbas et al. 2012).

Mangroves in Pakistan are located along the entire coast line of Sindh, except for some areas of Badin District, and Balochistan in patches of lagoons of Miani Hor, Kalmat Hor, and the estuary of Gwadar Bay (Rafique 2018). Mangroves in the Indus Delta are recognized as internationally important, and the wetland was designated as a Ramsar site in 2002 (Pillai 2003). To date, eight mangrove species have been reported in Pakistan, namely *Avicennia marina, Rhizophora mucronata, Aegiceras corniculata, Ceriops tagal, Sonneratia caseotaris, Rhizophora apiculata, Bruguiera conjugate,* and *Ceriops dodecandra* (Sindh Forest Department 2020). Of these, *Bruguiera conjugata, Ceriops roxburghiana, Rhizophora apiculate*, and *Sonneratia caseolaris* have become extinct (Ghafoor 1984; Gilani et al. 2021).

Coastal communities in Pakistan rely on marine and coastal fisheries along the mangrove that provide livelihoods to more than 125,000 households in Sindh alone. Conventional shipping gear and 15,000 fishing vessels are employed in fishing activities along Pakistan's coasts (Government of Pakistan 2017). According to the Sindh Forest Department, mangrove forests of the Indus Delta provide subsistence to an estimated 200,000 people that reside over an area of approximately 600,000 ha and contribute approximately $100 million annually to the national exchequer from the export sector.

Pakistan's coastal ecosystems have been considerably exploited to yield economic dividends over the years (Box 3.1). Box 3.1 describes the man-made and climate-induced reasons for ecosystem degradation in coastal areas of Sindh and Balochistan that have been identified in the literature.

Karachi city has approximately 14.9 million people (Mazhar 2018). The environmental degradation in this region is due to thermal pollution, oil spills, tar-balls, and plastic and toxic effluents, including heavy metals from industrial and agricultural practices and urban municipal waste that have caused huge damage to coastal areas. The Ministry of Climate Change (MoCC) conducted a study—Marine Litter Action Plan-Status Report—in 2018, which highlighted that marine and coastal pollution from port activities is not as harmful as the pollution from inland flows of untreated sewage and industrial waste. Moreover, it recommended compiling authentic inventories on the potential sources and quantity of marine debris to prioritize waste streams for an effective action plan (Qaimkhani 2018).

According to the Sindh Environment Protection Act 2014 (SEPA), Karachi city generates 22,000 tonnes per day of solid waste that includes 14,000 tonnes per day of municipal waste and 8,000 tonnes per day of industrial waste, of which 40 percent is classified as hazardous waste and is disposed openly (SN Waste Management 2020). The Karachi Water and Sewerage Board (KWSB) also reports that wastewater discharges from registered industries in Karachi amount to between 77.2 to 472 MGD into the Arabian Sea. Three industrial effluent treatment plants or sewage treatment plants (STPs) in Karachi have the capacity to handle 151 MGD altogether, but all of them are non-functional. Similarly, 36 percent of wastewater generated from domestic sources is treated in Karachi (WWF 2019). Collectively, this mismanaged waste has converted natural streams (Lyari and Malir rivers) into open sewers. Consequently, the beaches have become large sewage ponds with stinking odor and blackish water, which in turn lead to environmental degradation.

Despite the fact that the most prominent ecological feature of Indus Delta is its mangrove forests, these forests have been degraded due to upstream dam construction and agricultural activities. These are the primary factors causing progressively altered discharge patterns of freshwater from the Indus River, reduced silt, and high nutrient flows, which lead to eutrophication and anoxic conditions. As a consequence, this reduces fish stock in the area and could potentially influence other ecosystem services provided by this area (Chaudhry 2017; Government of Pakistan 2017). Since 1947, Pakistan has built 19 barrages, 43 canal systems, 38 take-offs, three storage dams, and 12 link canals along the Indus River, thereby decreasing water discharge and increasing seawater intrusion into the Indus delta (Pirzada 2019). Historical data on the release of water flow below Kotri Barrage shows that water discharge has further decreased over the years with the construction of Mangla and Tarbela dams (Hassan 2016). The water released into the Delta during 1938-39 amounted to 90 million acre-feet (MAF), but this has drastically reduced in volume to 1.7 MAF in 2017-18 (Kunbhar 2019). Furthermore, the World Bank reported that sediments reaching the Indus Delta have decreased from 270 million tonnes annually at pre-development levels to 13 million tonnes (Young et al. 2019).

Lack of freshwater flowing into the delta from upstream also leads to augmented saline seawater intrusion due to rising sea levels. Consequently, this further renders the region infertile. The Indus Delta has shrunk by 92 percent primarily due to seawater intrusion, so that the Delta now occupies only 100,000 ha as compared to 1,290,000 ha two hundred years ago (Siyal 2018). Approximately 90 percent of groundwater has turned brackish due to seawater intrusion. Furthermore, the Indus Delta is reported to experience low precipitation including prolonged heat waves and persistent droughts. This can intensify the misery of local communities. In 1951, the Delta produced 5,000 tonnes of fish, which has reduced to 300 tonnes in recent years (Nasir and Akbar 2012). In addition, these areas are subjected to uncontrolled tree-cuttings and unrestricted grazing by cattle, camels, goats, and buffalos. Leaves of *Avicennia marina* are considered best fodder for animals, subsequently limiting their regeneration. Due to these reasons, around 1.2 million people from the Delta have migrated to Karachi in search of other livelihood, as reported by The Third Pole in 2019 (Shah 2019). The Sindh Forest & Wildlife Department (SFD) launched the 'Monsoon Tree Planting Campaign'

in 2020 to plant mangroves at Keti Bandar. The provincial government, according to SFD, has taken effective measures to protect and irrigate replanted coastal areas. For instance, the relevant officials from SFD are given the responsibility to file a case against any person found cutting trees (Express Tribune 2020). Reports on the effectiveness of the protection initiative are not available yet; however, local activists have reported that mangroves are still potentially threatened by clearing for commercial needs by outsiders rather than by local communities (Khaskheli 2020).

Box 3.1: Pakistan Coastal Ecosystem Degradation

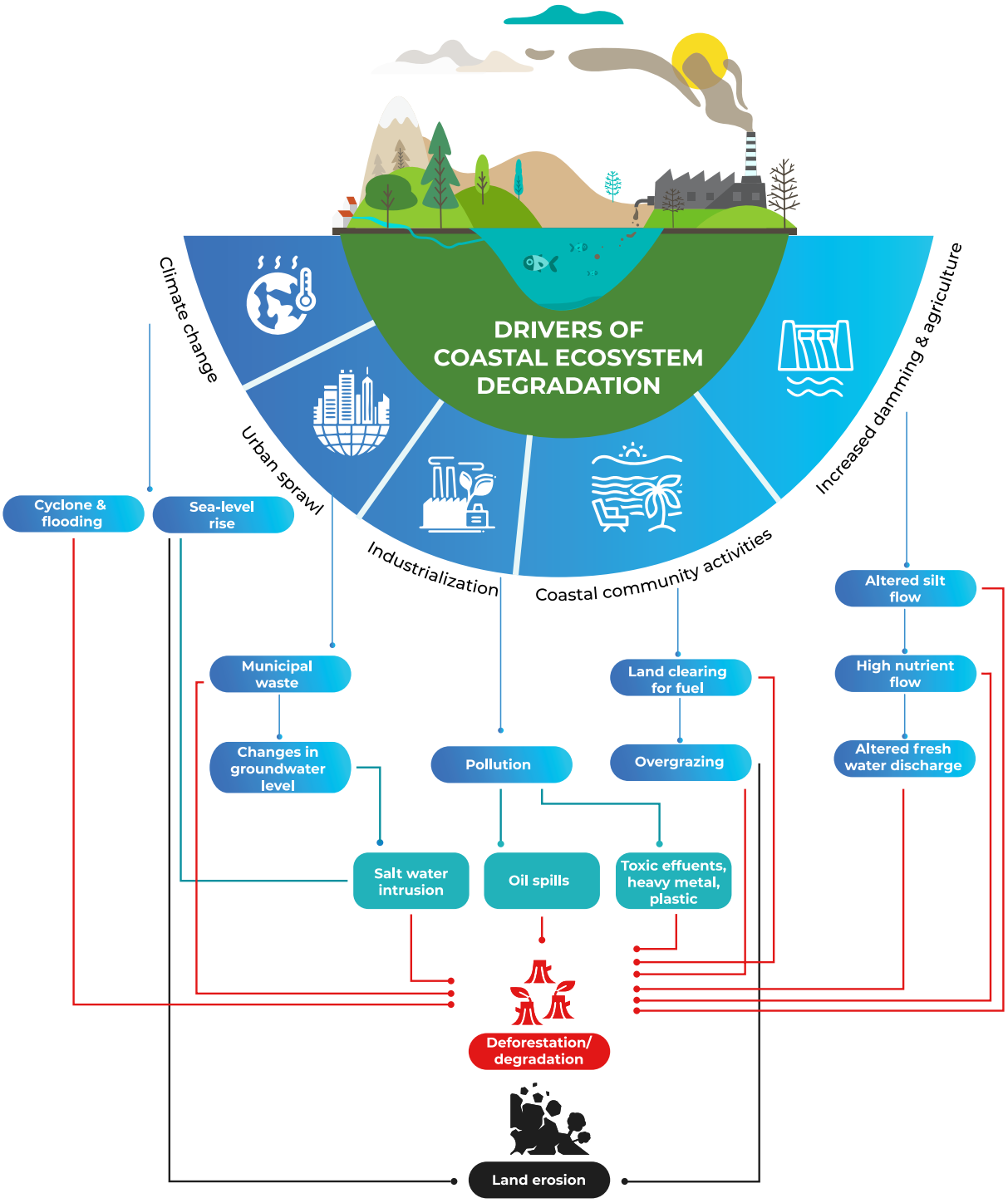
Pakistan's marine and coastal areas have been degraded because of increased urbanization, industrialization, upstream damming resulting in depleted freshwater discharge below Kotri barrage, ship breaking activities and unsustainable resource consumption. All these factors have led to high levels of pollution and overexploitation of resources.

Approximately 90,000 tonnes annual oily discharge from ships and more than 400 MGD of effluents and 8,000 to 14,000 tonnes of solid wase from urban areas is discharged in harbor areas (Ministry of Climate Change 2013; Ministry of Climate Change 2017). Pakistan is also challenged by this degradation in the form of augmented expenses of maintenance of vessels due to pollution in harbors and loss of strategically important mangroves.

Balochistan has limited mangrove forests at Miani Hor, Kalmat Hor, and Jiwani, Gwadar Bay (Gilani et al. 2021). Similar to Sindh, these mangroves have also been exploited as a source of wood for construction, fodder for livestock, and as domestic fuel. For instance, the Makran coastal community depends on fisheries, animal husbandry, and agriculture. However, construction of road infrastructure in 2013 led to easy access to markets for camels and camel-related products' trade. Hence, communities started raising more camels, causing unsustainable consumption of mangroves. This exploitation has also led to the erosion of shores, loss of cover, and stunted growth, and the deterioration of mangrove habitats has resulted in loss of biodiversity and reduced production of fish, shrimps, and crabs which are commercial products of great importance for these coastal communities (Hameed Baloch et al. 2014). Figure 3.2 gives the details at a glance.

In the long term, Pakistan and its coastal communities can only continue to reap the benefits of coastal and marine ecosystems by adopting sustainable practices. Conserving, protecting, and restoring these ecosystems will support carbon mitigation while encompassing wider economic dividends. The coastal areas of Sindh and Balochistan are vulnerable to hazards such as tsunamis and cyclones, which not only put physical but also socio-economic pressures on local communities (Oxfam 2016). The plantations around the coastal belts are the first line of defense against these threats. Therefore, raising community awareness on the importance of protecting these ecosystems should also be included in the mandate of provincial environment and forestry departments.

Figure 3.2: Summary of Drivers of Coastal Ecosystem Degradation in Pakistan



Sources: Chaudhry 2017; Ministry of Climate Change 2017; Qaimkhani 2018

Credit: SkycopterFilms Archives/Shutterstock.com

Chapter 4. Blue Carbon-related Policies in Pakistan

Currently, Pakistan has a National Climate Change Policy (NCCP) 2012 and a Framework for Implementation of Climate Change Policy (2014-2030) to tackle the causes of climate change and build the country's resilience to the impacts of climate change (Ministry of Climate Change 2012; Government of Pakistan 2013). NCCP distinctly addresses coastal and marine ecosystems and delineates an adaptation plan for effective management of these ecosystems. The measures, however, fail to identify mitigation benefits of these ecosystems and the quantification of future climate conditions like sea level rise that can impact the coasts. Pakistan has been making efforts to establish and implement biodiversity frameworks with the National Forest Policy 2015 (Ministry of Climate Change 2015) and the Pakistan National Biodiversity Strategy and Action Plan (NBSAP) 2015 (Government of Pakistan 2017) with a mandate to conserve biodiversity, including coastal ecosystems in the country. Another important measure that these documents identify is the importance of exercising contemporary techniques such as remote sensing and Geographic Information System (GIS), to carry out research activities for monitoring the forest covers in an effective manner and ensures provision of financial resources and technical support for this purpose. The more recent National Sustainable Development Strategy 2017 presents a plan for Sustainable Development Goals (SDG)—in particular SDG 14—with a focus on reducing marine pollution, sustainably managing marine and coastal ecosystems, regulating

fish harvesting, and investing in research and evidence building for designing pragmatic management plans. However, none of these efforts identify the mitigation potential of coastal ecosystems and risk assessments linked to changing climatic conditions of coastal areas.

Pakistan is a signatory to 15 multilateral environmental agreements (MEAs) (Table 4.1) out of which seven directly or indirectly instigate the formation of policies and action plans for sustainable management of coastal ecosystems (Ministry of Climate Change 2020). The Ministry of Climate Change (MoCC) has planned initiatives to meet the objectives of these conventions and protocols through the Mangroves for the Future (MFF) regional program in collaboration with the International Union for the Conservation of Nature (IUCN), REDD+ Readiness Preparation Proposal, and the Federal Forest Policy 2015. Mangroves are part of forests defined under the Federal Forest Policy 2015 and the REDD+ Pakistan Programme. In a REDD+ Pakistan programme, two pilot mangrove ecosystem sites in Sindh (parts of Port Qasim Authority and Korangi Fish Harbor around Korangi and Phitti Creeks and adjoining areas) and Balochistan (Miani Hor in Lasbela District) will be conserved and maintained while promoting Payments for Environmental Services (PES[7]) (Pakistan Coastal Mangrove Forests (PCMF) PES Scheme 2019). The REDD+ Readiness Programme is the first effort initiated in the country to quantify carbon stocks for mangroves in Sindh (Pakistan Forest Institute 2018). The REDD+ Pakistan Programme also plans to account for soil organic carbon from these pilot areas. Pakistan developed the Forest Reference Emission Level under this initiative in 2019 with an objective to report national contribution to mitigate GHG emissions, which included mangrove forests.

Table 4.1: List of Pakistan's MEAs, Conventions, and Protocols to Protect Blue Carbon Ecosystems

Forestry and Biodiversity
1. Convention on Biological Diversity
2. Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora
3. Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)
4. Convention on the Conservation of Migratory Species
5. United Nations Convention to Combat Desertification (UNCCD)
Climate Change
6. Paris Agreement PA
Regional Seas
7. United Nations Convention on the Law of the Sea (UNCLOS)

At a provincial level, Sindh adopted the Sindh Environment Protection Act 2014 (SEPA) that presents a legislative framework for climate change and environment. SEPA has adopted Initial Environment Examination (IEE) and Environmental Impact Assessment (EIA) Regulations 2014 for commencing environmental impact assessments and examinations in the planning of public sector development projects (SEPA 2014). In addition, Sindh has developed a Climate Change Policy in coordination with the Planning and Development Department, which is yet to be approved. With regard to the UN Sustainable Development Goals, SDG 13 that aims to identify Climate Action as a cross-cutting priority will be integrated in strategic planning for future action plans (Sindh Planning & Development Department 2018).

7 Payment for Environmental Services (PES): incentives offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service. The underlying philosophy of these programs is market creation and enhancement, which aims at creating and strengthening the role of the market mechanism in guiding the allocation and use of resources and providing economic incentives for forest conservation.

Balochistan has the Balochistan Environment Protection Act 2012 that prohibits the import of hazardous and electronic wastes, solid waste management, water resources management, alien species, and living modified organisms. It also stipulates monitoring of activities to prevent environmental degradation from ports and shipping, fisheries, ship dismantling, shipping traffic (oil tankers and vessels) and dredging, oil and gas mineral exploration, and activities related to coastal power plants, oil refineries, and industries (BEPA 2012). However, an action plan to mainstream NCCP is missing in the act.

At the federal level, MoCC is the lead organization that is responsible for national policy, plans, strategies, and programs regarding ecology, forestry, wildlife, biodiversity, and desertification. The current government's initiatives like the Ten Billion Tree Tsunami (Box 2.1) and the Protected Areas Initiative (PAI) are the exemplars that confirm a conducive political environment. After the 18th constitutional amendment, provinces were delegated the authority to make environmental protection decisions, whereas the federal government is still in charge of international treaties, conventions and agreements, and national planning. Subsequently, each province has its own Environment Protection Agency (EPA) and forestry, fisheries and wildlife departments that have legislated provincial laws for the management of forests, fisheries, and wildlife resources. For the exclusive economic zone of the country, however, the federal government regulates marine fisheries under the Exclusive Fishing Zone (Regulation of Fishing) Act, 1975 (amended in 1993) and the Deep-Sea Fishing Licensing Policy 2018.

Forestland ownership and tenure arrangements to protect coastal and marine resources are absent at the national level. Provincial Boards of Revenue (BORs) have the authority to issue land-use rights to public and private entities. In 1958, BOR Sindh declared 364,000 ha of mangrove forestland as protected forest and gave responsibility to Sindh Forest Department (SFD) for protection and management. SFD, however, in 1973 leased 64,400 ha to Port Qasim Authority with a condition to protect forests. Later in 2010, the Government of Sindh declared all mangroves as protected forests that are being exploited by grazing animals because of weak regulatory system (Beresnev et al. 2016). In Balochistan, only 294 ha of mangrove areas are protected by the Forest Department, while the remaining forest is the property of Balochistan BOR or local communities.

To control marine pollution, many laws, policies, and conventions are applicable in Pakistan (Table 4.2). But the lack of awareness and weak implementation of these laws have already brought Pakistan's marine ecosystems to current pollution levels where 90,000 tonnes per year are oily discharge from ships and more than 400 MGD are industrial and municipal effluents (Ministry of Climate Change 2013; Tahir 2017). Furthermore, Pakistan Environment Protection Act 1997, under Section 17, sets penalties for non-adherence to the act where a maximum penalty of PRs 1 million (approximately $6,560) is applicable; however, the minimum penalty is not specified, which provides a window for offenders to negotiate the penalty. Besides, this legislation does not specify levels of offence; for instance, in some cases environmental discharges have long-lasting impacts for which one-time penalty is not enough, and the polluter should pay for clean-up and rehabilitation afterwards.

The Provincial Government of Balochistan has divided environment- and climate change-related roles and responsibilities between two departments, namely, the Forest and Wildlife Department and the Environment, Sports and Youth Department. This fragmented approach of the Provincial Government is further highlighted by its organizational structure, where the Forest and Wildlife Department is the focal body for NCCP mainstreaming, while the provincial EPA is under the Environment, Sports and Youth Department which is responsible for climate change governance (Government of Balochistan 2004; Government of Balochistan 2018). This arrangement exacerbates clear coordination within the province to develop a climate

change strategy or action plan and will require reshuffling for effective blue carbon ecosystem planning and monitoring.

Table 4.2: Acts and Policies for Coastal and Marine Pollution Abatement

Act and Policies	Year	Issuing Authority
Karachi Port Trust Act	1886	Karachi Port Trust
Ports Act	1908	Federal Government
Pakistan Environment Protection Act	1997	Federal Government
National Environment Quality Standards	2001	Federal Government
National Environment Policy	2005	MoCC
National Institute of Oceanography Act	2007	National Institute of Oceanography
National Climate Change Policy	2012	MoCC
Balochistan Environmental Protection Act	2012	Government of Balochistan
The Sindh Local Government Act	2013	Government of Sindh
The Sindh Environmental Protection Act	2014	Government of Sindh
Hospital Waste Management Rules	2014	MoCC
Sindh solid Waste Management Board Act	2014	Government of Sindh
Maritime Security Agency Act	1995 (revised 2016)	Ministry of Maritime Affair MoMA
The Sindh Industries Registration Act, (un-approved)	2017	Government of Sindh

On the other hand, Sindh has the Climate Change, Environment and Coastal Development Department that houses SEPA to monitor compliance with the Sindh Environment Protection Act, 2014 and Sindh Coastal Development Authority (SCDA) (Environment Climate Change & Coastal Development Department 2018). Coordination for climate change response in Sindh is better as compared to Balochistan because a single department is leading scoping and planning in line with the Planning and Development Department. Even with such a strong institutional and policy environment, Sindh needs to develop better financing mechanisms and integration of cross-sectoral departments such as forestry, fisheries and wildlife, for targeted approaches to contribute to national climate change commitments.

The challenges posed by climate change make it essential for countries to restore and maintain ecosystems to have a resilient socio-economic setting. One way to achieve this is through protected areas. However, weak governance of these areas resulted in poor management of protected sites. In 2020, the MoCC launched the PAI, aiming to enhance protected areas from the current 13 percent to 15 percent by 2023, as well as to manage these reserves through effective governance and legislative interventions while creating nature-based jobs for indigenous communities.

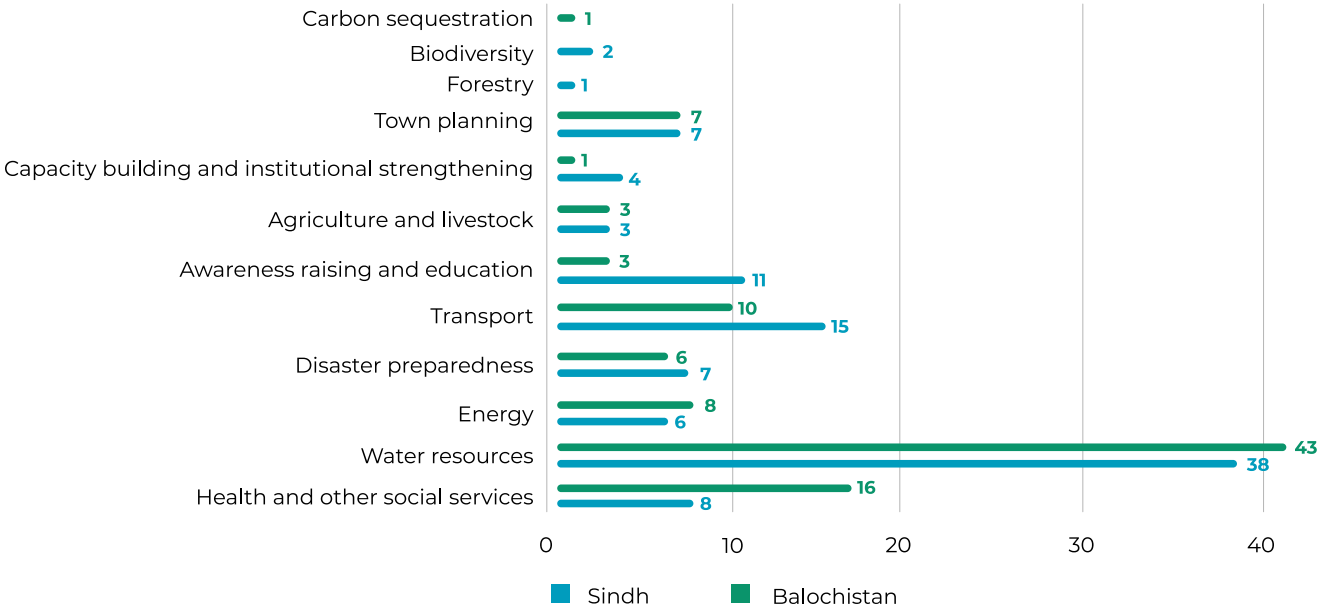
The First Marine Protected Area (MPA), Astola Island, was also notified under PAI. Astola Island was first declared a MPA in 2017 under the Balochistan Wildlife Act 2014 when IUCN defined it as IUCN's Category IV Habitat/Species Management Areas, which prohibited certain activities (Mangroves for the Future 2017). The MoCC claims that it was not protected according to guidelines for protected areas, and weak legislation led to poor management of the island. Hence, it was again declared a MPA under PAI (Khan 2020b).

According to Pakistan's first Nationally Determined Contribution (NDC), the financial resources required for adaptation and mitigation measures are completely dependent on foreign assistance. For this purpose,

the Climate Finance Unit (CFU) was established under MoCC for financial mobilization from international institutions and funds such as Green Climate Fund (GCF) and Global Environment Facility (GEF), to name a few. CFU assists in building capacities and raising awareness of the provinces to implement NCCP 2012 as well as the NDC. Moreover, the MoCC's Ecosystem Restoration Initiative aims to institute an independent, transparent, and comprehensive financial mechanism called Eco-system Restoration Fund (ESRF). The purpose is to finance projects and programs under the initiative including nature-based adaptation and mitigation projects.

According to the Pakistan Climate Public Expenditure and Institutional Review (CPEIR), 6.7 percent to 8.4 percent of the federal budget has been invested for climate change-related activities from 2011 to 2016; this is the lowest among all federal institutions.[8] The allocated budget for climate change-related activities is primarily allocated for energy sector mitigation (90 percent of total mitigation projects) and the transport sector (10 percent) (UNDP 2017). This shows that national priorities have been dictated by immediate needs over the years. However, in the past two years, Pakistan saw a shift when the Ten Billion Tree Tsunami was marked as the first and only project of MoCC to be financed by the federal Public Sector Development Programme (PSDP) budget. Even after this shift, MoCC relies on international grants and loans for NDC and NCCP implementation.

Figure 4.1: Complete Allocation of 2014-15 Development Budget Expenditures to Climate-relevant Tasks in Sindh and Balochistan



At a provincial level, forestry departments receive national budgets through recurrent and development budgets (Figure 4.1). The recurrent budget covers the department's administrative and routine functions, whereas the development budget is aimed for conservation, plantation, and other forest development activities.8F9 The development budget is encompassed by Federal PSDP, Provincial Annual Development Programme (ADP), and donor funding (Box 4.1).

8 Including education, defense, and housing.
9 Recurrent budget covers establishment charges, consumables, operational, and transport charges besides expenditure on routine works such as felling, marketing, and transportation of products.

The capacities of provincial forest departments are reported to be insufficient to tap international funds available through different platforms like GCF and REDD+ primarily due to lack of technical skills and understanding of design proposals (FAO 2020). Provincial resources are allocated in cooperation with planning and finance departments. Therefore, it is imperative to sensitize and educate provincial entities that have a crucial role to mainstream climate change in planning and implementation.

Box 4.1: Development Budget Expenditures for Climate-relevant Tasks

For Balochistan, ADP financing is contributed by federal assistance and internal resources. Ninety-five to 97 percent of ADP financing for Balochistan came from internal sources between 2012 to 2015 and could not acquire any sizeable foreign funding. The division of ADP funds allocation for climate change projects shows that Balochistan allocates budget for service delivery improvement, and only 0.4 percent for environment, 0.76 percent for fisheries, and 0.24 percent for forestry (Figure 4.1).

For Sindh, with the provincial capital Karachi being the commercial and industrial hub of Pakistan, the share of provincial resources to ADP has increased over the years, where the federal government contributed eight percent in 2014-15 and external sources were acquired in the form of loans. The division of ADP funds allocation for climate change projects shows that Sindh allocated smaller shares for awareness raising and education, agriculture and livestock, capacity building and institutional strengthening, and carbon sequestration and forestry. Sindh has added additional fields to the ADP project format connecting the effect of future development projects with the SDGs and climate change (UNDP 2017).

The current study performed an extensive desk review of existing policy documents, legal frameworks, MEAs, and international commitments that Pakistan is a signatory to. These were sourced from the internet, peer-reviewed journals, textbooks, and government and non-government archives. The primary focus was to identify the gaps and barriers in management of blue carbon ecosystems in Pakistan. Secondary literature available on initiatives, policies, and strategies adopted by Pakistan and other countries were thoroughly reviewed. Lessons learnt, especially from developing countries, were taken into account to visualize ways in which similar actions could be taken in Pakistan regarding management of blue carbon ecosystems.

Pakistan's blue carbon ecosystems are under pressure from natural and man-made causes. The government, at both national as well as provincial levels, has responded to these threats by developing and implementing policies and introducing targeted initiatives. However, there are a number of gaps and challenges that need to be addressed (Table 4.3).

Table 4.3: Policy Gaps to Deal with Blue Carbon Ecosystem Degradation Threats

Threats as identified in Chapter 3	Gaps in Policy and Implementation
• Municipal waste • Industrial and commercial activity at ports (oil spills, toxic effluents, infrastructure development, dredging, etc.)	• Lack of cross-sectoral planning and coastal management • Lack of law enforcement
• Overgrazing • Illegal wood cutting • Land clearing for aquaculture • Unsustainable fishing	• No clear allocation of responsibilities • Insufficient capacities of regulatory authority and local departments • Lack of community knowledge on land tenure • Lack of measures targeted at building community awareness, education and technical capacity
• Altered silt flow • Altered freshwater discharge • High nutrient flow • Changes in groundwater level	• Lack of cross-sectoral planning and coastal management
• Sea level rise • Land subsidence • Saltwater intrusion	• Lack of a national and sub-national plan to gather data

It may be noted that the effective management of these ecosystems is challenged by weak law enforcement due to limited budgetary capacities of regulatory authorities, institutional inconsistencies, overlapping responsibilities and institutions' contribution to planning, development, and lack of clarity in budget allocation. Based on literature review of the national context and gaps in the policies and implementation to deal with ecosystem degradation, Table 4.4 assesses the weaknesses of existing conditions and identifies the opportunities to address them. Exploring these options will form the basis for the government to better manage these ecosystems in the country to deliver NDC commitments.

Table 4.4: Blue Carbon Policy Gap Analysis

Weaknesses and Gaps	Opportunities/Measures
Institutions and Policies	
• An inadequate coordination among different entities is leading to disconnected planning • Given the cross-cutting nature of the challenges, policies fail to cater cross-sectoral issues that are deteriorating the coastal and marine ecosystems like nutrient flow from upstream agricultural activities causing eutrophication	• Multi-stakeholder collaboration steered by the MoCC and mainstreaming through line and provincial departments with a focus on blue carbon ecosystems to formulate a holistic strategy • Clear allocation of responsibilities

Table 4.4: Blue Carbon Policy Gap Analysis (contd.)

Weaknesses and Gaps	Opportunities/Measures
• In the current institutional framework, financial allocations for the development of projects, including biodiversity and ecosystem services, are done at the federal level by the Ministry of Finance and Ministry of Planning, Development and Reforms, and provincial planning departments • It is an existing challenge for local departments to pitch rightly for the environmental initiatives without any economic valuation data • The lack of data, awareness, and technical capacities of local authorities, are critical for ecosystem valuation	• National and provincial capacity building for coastal ecosystem valuation
• Responsibilities after the 18th amendment are not lucid as marine and coastal ecosystems are governed by multiple provincial departments (EPAs, CDAs and Forestry) with weak coordination leading to poor translation of NCCP 2012 into programmatic interventions by provinces • Sindh EPA has drafted the Sindh Climate Change Policy 2017 to streamline the initiatives with NCCP 2012 and SDGs, however, the policy is yet to be approved • Balochistan has no policy on climate change or climate action rendering the application of NCCP 2012 challenging	• National coastal management plan with clear allocation of responsibilities
• Pakistan's Water Apportionment Accord 1991 was signed between the provinces to build consensus on the quantity of water of Indus River system that will be allocated to provinces (Indus River System Authority 1991) • The Accord fails to identify apportionment for environmental flows[10] or for any other ecosystems service for Sindh	• Coastal ecosystem valuation • Revision of accord to address the shortcomings
Enforcement	
• The nature of the blue carbon solutions is such that it requires a bigger role of the local communities for participatory management of these ecosystems. It is because the capacity of EPAs is weak. Hence, a decentralized approach where communities are incentivized to protect these ecosystems can serve as an opportunity to reduce the load from EPAs. • Project planning and development has not channeled this factor for sustainability of the replantation initiatives	• Pilot participatory management by communities • Voluntary regimes with monetary benefits for local community

10 According to the Brisbane Declaration and Global Action Agenda on Environmental Flows (2018), Environmental flows describe the quantity, quality, and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems.

Table 4.4: Blue Carbon Policy Gap Analysis (contd.)

Weaknesses and Gaps	Opportunities/Measures
• Pakistan's laws on maritime pollution have weak penalties • Additionally, lack of institutional responsibility and coordination between the responsible agencies hinders pollution control • The technical capacities of provincial EPAs to carry out the review of EIAs is limited and often experts of the field are unavailable, thereby, putting the entire process in jeopardy • Besides, limited financial resources have resulted into ineffective law enforcement. Hence the provincial forest departments have not been able to control forest encroachment and illegal logging (Beresnev et al. 2016)	• Capacity building of local departments • Pilot financial models to support these departments, e.g., introduce carbon levies for industries and use it to finance EPAs, revenue from tourism
Knowledge and Data Management	
• Existing policies are catering adaptation measures to support livelihood and protect the coasts from climate-induced disasters • However, they fail to identify the need to collect baseline data for these ecosystems and management of annual data at national and sub-national levels that can aid in evidence-based planning • The data on area extent that has been collected by different entities like under REDD+ is not accessible hence, limiting the effectiveness of planning • Similarly, limited data exists on the impacts of climate change and man-made causes on these ecosystems	• Setting up national inventories and comprehensive monitoring plan • Setting up information sharing platform at national level • Involve public and private research institutes, academia and independent think tanks to manage data gaps

The Readiness Assessment of Pakistan further narrows down the priorities for the NDC. This assessment is based on the guidelines developed by the Blue Carbon Initiative to identify entry points for Pakistan to include blue carbon ecosystems in NDC for enhanced commitments (Thomas et al. 2020). For each of the conditions, the readiness level is defined, and observations are summarized in Table 4.5.

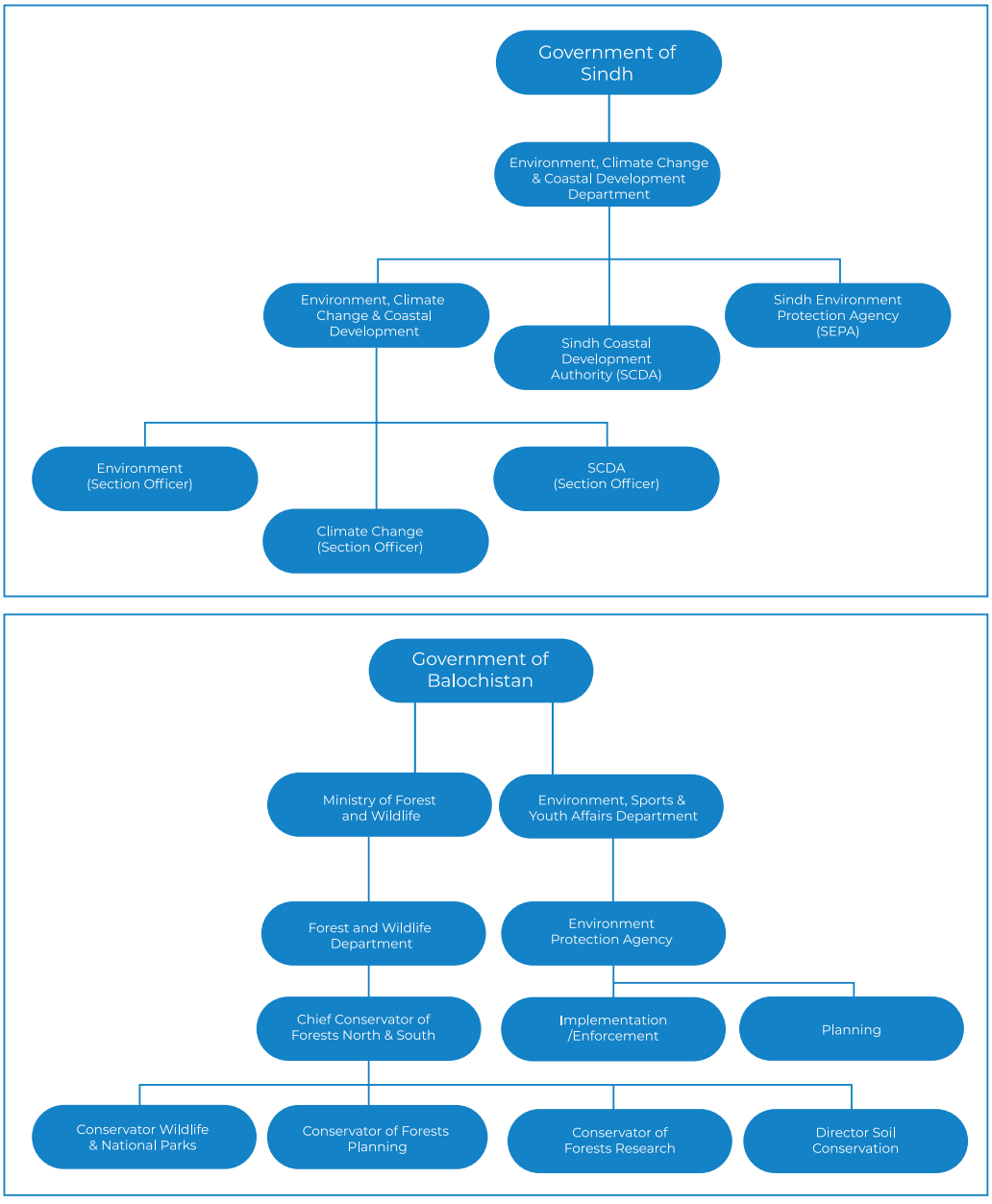
Table 4.5: Pakistan Readiness Assessment

Element	Condition	Remark
Institutional arrangement (Figure 4.2 illustrates the provincial institutional arrangements)	Weak coordination and cross-sectoral linkages	At the national level, the Framework for Implementation of the Climate Change Policy (2014-2030) by MoCC defines the roles and responsibilities of stakeholders to implement coastal and marine adaptation plans. It identifies provincial CDAs to take action along with EPAs and forestry departments. Under the Constitution of 1973, however, forestry comes under the provincial domain. The provincial forestry departments for their part have not embraced the CDA concept. The forestry department of Balochistan, for instance, has appointed a forest conservator as a focal point for coordinating NCCP plans at the national level which is limited to mangrove plantation. In addition to this, Balochistan EPA (BEPA) housed in the Balochistan Environment Sports and Youth Affairs department has been mandated with compliance and planning for protecting marine resources. The weak coordination between MoCC and cross-sectoral entities such as forestry department, BEPA, Balochistan CDA, and disaster management authority challenges evidence-based planning in view of changing climate and implementation of plans as guided by NCCP. Further clarity on the federal-provincial and cross-sectoral roles and institutional restructuring will play a vital role in improved coordination and management of these resources.
National Policy Framework	Potential role for adaptation and mitigation highlighted	NCCP identifies adaptation and mitigation potential of blue carbon marine ecosystems.
Provincial Policy Framework	Absent	Sindh and Balochistan both lack a comprehensive policy framework to manage blue carbon ecosystems.
Data on habitat extent and carbon stocks	Limited data on habitat extent	This first-pass estimate of blue carbon stocks presented in this report is the first national effort to be undertaken. Data utilized for current estimates was limited, with partial information in mangroves, little information for tidal marshes and no information on seagrass meadows. In addition, there was a lack on comprehensive data of carbon stocks and sequestration rates in different locations and species along Pakistan's blue carbon ecosystems.
Data on drivers for ecosystem degradation	Limited data on climate-induced drivers and weak compliance to regulations	Man-made drivers for degradation are identified and understood (Figure 2.2) however, regulatory measures to control these impacts have failed to do so. Data on impacts of climate change is limited and effects are not completely understood.

Table 4.5: Pakistan Readiness Assessment (contd.)

Element	Condition	Remark
Financial strategy for policy implementation	Structure at national level exists for finance mobilization	MoCC depends completely on international finance for NCCP and NDC implementation. Recently, MoCC is exploring innovative financing schemes such as carbon pricing to raise ministry's budget. The capacities of provincial departments are reported to be insufficient to tap international funds available through different platforms like GCF primarily due to lack of technical skills and understanding to design proposals. Provinces shared the need for support from MoCC to mobilize finance.

Figure 4.2: Provincial Institutional Arrangements for Sindh and Balochistan Provincial Governments



Credit: Shutterstock.com

Chapter 5. Blue Carbon Inventory in Pakistan

The first-pass estimates of blue carbon stocks and the potential for emissions reductions are discussed in this chapter, including a detailed explanation of data and methods that were used to support the carbon inventory presented in this report.

Developing a carbon inventory requires three main steps that involve understanding and estimating (1) past and present distribution of blue carbon ecosystems, (2) carbon stock within the area of interest along the coast, as the focus of this report is to estimate carbon at national scale, and (3) potential carbon emissions that are expected to result from changes in the landscape. Below is the description of the data collection for each step.

The distribution of extent for blue carbon ecosystems comes from different existing sources, including mangroves and tidal marshes. Currently, there is no information available on the distribution of seagrass meadows in Pakistan, with global distribution maps of this ecosystem showing large uncertainties (McKenzie et al. 2020; UNEP-WCMC 2020). After an extensive literature search and contacting key stakeholders in the country, the local partner of this project, Prudence Consulting, in collaboration with a team from the Pakistan's Ministry of Climate Change (MoCC), was only able to gather a spatial data for the distribution of mangrove forests in the country.

Based on existing information, the most recent and up-to-date dataset of mangrove change through time is from Gilani et al. (2021), who classified mangrove distribution over the last three decades (1990-2020) using Landsat 30 m spatial resolution satellite images. Mangrove area estimates for Pakistan are also available through global datasets. For example, the most widely used global mangrove extent map is from Giri et al. (2011), who classified mangrove distributions for 2000 using Landsat 30 m spatial resolution satellite images. At the global scale, there exists the Global Mangrove Watch dataset, which estimated mangrove global distribution for 1990, 2007-2010, 2015 and 2016 (Thomas et al. 2017; Bunting et al. 2018), which were based on the classification of ALOS PALSAR and Landsat sensor data and included previous global distributions (Spalding et al. 2010; Giri et al. 2011). As showed by Gilani et al. (2021), mapped mangrove distributions at global scale shows a difference in mangrove coverage area, which reinforces the need to use mapped mangrove distribution at the national scale. Therefore, the data available in Gilani et al. (2021) (Table 5.1 and Figures 5.1-5.2) were chosen to inform the carbon stocks included in this report.

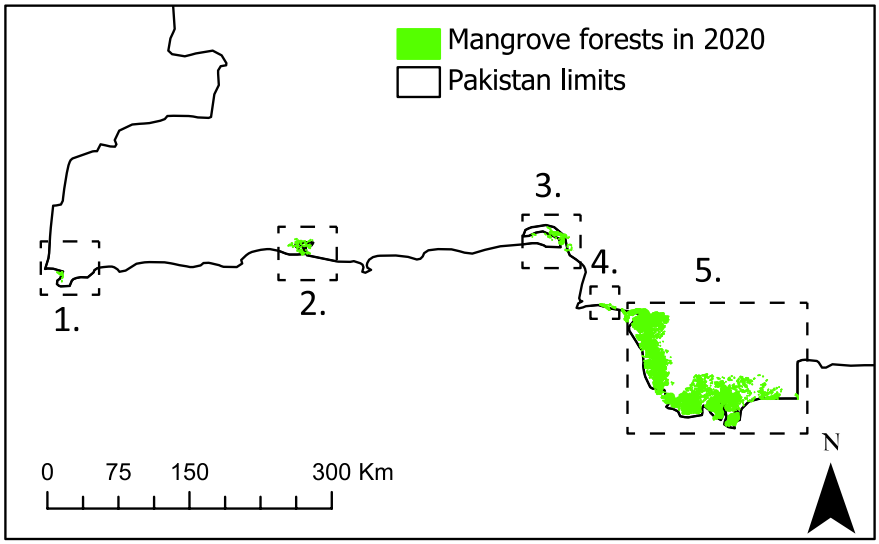
Tidal marshes are distributed along Pakistan's coastline and primarily comprise for five species: *Arthrocnemum indicum, Atriplex stocksii, Cressa cretica, Suaeda fruticose, and Urochondra setulose* (Patro et al. 2017). However, based on the information available, Pakistan lacks mapped information on the habitat extent for tidal marshes, with information on area extent limited to areas within mangrove forests. Globally, large uncertainty exists in the mapped distribution of tidal marshes, with the current global map not showing any area coverage of this ecosystem in Pakistan (Mcowen et al. 2018).

Table 5.1: Existing Information on Distribution of Blue Carbon Ecosystems in Pakistan

Ecosystem	Area (sq. km)	Spatial data available?	Reference year	Region	Study
Mangrove forests	535.22	Yes (UNEP)	2000	Global	Giri et al. 2011
	687.60	Yes (UNEP)	2010	Global	Bunting et al. 2018
	587.25	Yes (UNEP)	2016	Global	Bunting et al. 2018
	336.45	Yes, via (Pakistan Forest Institute, 2018)	2017	Pakistan (limited areas of mangroves in Sindh and Balochistan)	Pakistan Forest Institute, 2018b
	1,023	Yes, via World Wide Fund (WWF)-Pakistan	2017	Pakistan (national assessment)	WWF-Pakistan
	981.28	No	2009	Pakistan (national assessment)	Abbas et al. 2012
	1,463.59	**Yes, via WWF-Pakistan**	**2020**	**Pakistan (national assessment)**	Gilani et al. 2021
Tidal marshes	**44.70**	**No**	**2009**	**Pakistan (mapping limited to the area of mangrove forests)**	Abbas et al. 2012
Seagrass meadows	No information available				

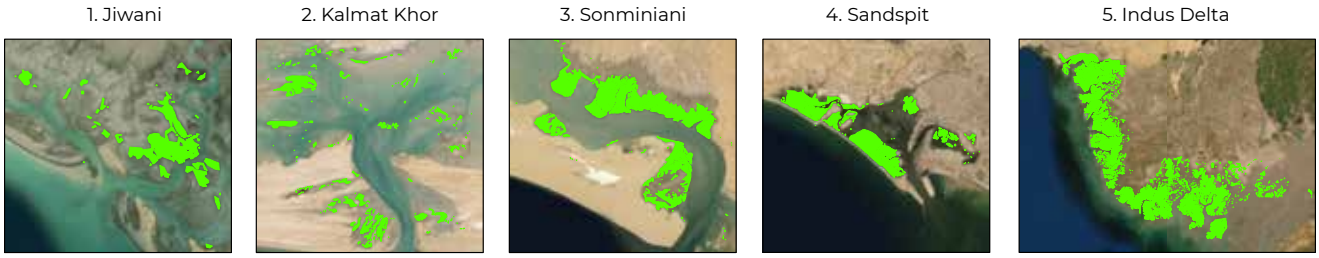
Note: Best available information for Pakistan, used to inform this report, is shown in bold. (a) Here, 'no' means that the team did not have access to this spatial dataset. The search for spatial dataset was conducted by Prudence Consulting with the support from the MoCC until December 10, 2020.
Sources: (1) UNEP-WCMC 2021; (2) UNEP-WCMC 2019

Figure 5.1: Distribution of Overall Mangrove Forests in Pakistan in 2020



Note: Areas denoted by numbers: 1: Jiwani; 2: Kalmat Khor; 3: Sonmiani; 4: Sandspit; and 5: Indus Delta.
Source: Gilani et al. 2021

Figure 5.2: Distribution of Mangrove Forests in Pakistan in 2020



Sources: **Basemap:** Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community; **mangrove distribution:** Gilani et al. 2021

5.1 Carbon Stocks Literature Review

A literature review on blue carbon data (that is, mean carbon stocks and tonnes of organic carbon per hectare) was conducted to inform the carbon inventory. The platforms used to research blue carbon information for Pakistan and nearby regions include the Institute for Scientific Information (ISI) Web of Science, Google Scholar, and the Coastal Carbon Atlas. Search terms included: Pakistan, India, Iran, Indus Delta, Arabian Peninsula, mangroves, tidal marshes, seagrass meadows, blue carbon, coastal wetlands, organic carbon, carbon stocks, aboveground, belowground, and soil sediment.

In the literature review, it was found that Pakistan, as part of the REDD+ Readiness Study on Payment for Ecosystem Services in Mangroves (Pakistan Forest Institute 2018)[11], has already collected data on mean carbon stocks (tonnes of organic carbon per hectare) for sediment, below- and aboveground carbon pools. According to this report, sampling was conducted on 79 sample plots and it was limited to one pilot site located in Sindh (Pakistan Forest Institute 2018). In the same study, carbon sequestration has been estimated at 9.10 tonnes of carbon dioxide equivalent (CO_2e) per hectare per year in biomass and 7.68 tonnes of carbon dioxide (CO_2) per hectare per year in soils (Pakistan Forest Institute 2018). However, the carbon sequestration value for mangrove soil is higher than expected for the region and type of sediment. Therefore, it requires further verification to adopt these values for future estimates. This study adopted as a conservative approach, and carbon sequestration data from the Arabian Peninsula, which reports values of 2 tonnes CO_2e per hectare per year for the top 30 cm of soil was used (Crooks et al. 2019).

Additional studies with valuable information on carbon stocks for mangrove forests in the region were found during the literature review, including global predictions for mangrove carbon stocks (Hamilton and Friess 2018; Sanderman et al. 2018; Simard et al. 2019). However, these global predictions were based on mangrove extents from 2000 (Giri et al. 2011) and the years between 2000-2012 from the Continuous Mangrove Forest Cover for the 21st Century (Hamilton and Casey 2016). Furthermore, these predictions also lacked regional data to inform their models, which can potentially increase the uncertainty of these estimates for Pakistan. As showed by Gilani et al. (2021), mapped mangrove distribution at a global scale shows a difference in mangrove coverage area, which could lead these global predictions to underestimate carbon stocks in Pakistan, and therefore reinforces the need to use mapped mangroves at national scale. Then, the mean carbon stocks data sampled at Sindh (Pakistan Forest Institute 2018) was used to estimate Pakistan's first-pass assessment of carbon stocks in mangroves.

11 https://www.redd-pakistan.org/wp-content/uploads/2019/02/Final-PES-Design-Document-Mangroves.pdf

For tidal marshes, the information on carbon stocks was not available for Pakistan or nearby locations under similar conditions. For the current assessment, Intergovernmental Panel on Climate Change (IPCC) default values for mineral soil carbon stocks were adopted (IPCC 2014; Kennedy et al. 2014a). The following section describes the methods used to estimate total carbon stocks for both ecosystems.

Table 5.2: Existing Information on Mean Carbon Stocks for each Ecosystem Type in Pakistan

Ecosystem	Carbon pool	Mean carbon stock (tonnes C_{org} ha^{-1})	Region	Study
Mangrove Forests	Aboveground	9.20	Pakistan (Port Qasim Authority	Institute of Business Management Karachi, 2016
		24.40	**Pakistan (Sindh)**	Pakistan Forest Institute 2018
	Belowground	**10.22**	**Pakistan (Sindh)**	Pakistan Forest Institute 2018
	Aboveground + Belowground	92.66±1 in post-monsoon 95.2±17.4 in pre-monsoon	Gwadar Creek Bay (Iran, close to the border with Pakistan)	Savari et al. 2020
	Soil (1 m)	227.1±11.86 in post-monsoon (in 1 m of soil) 227.3±11.71 in pre-monsoon (in 1 m of soil)		
		8.6 (in 10 cm of soil)	Pakistan, Indus Delta	Kristensen et al. 1992
		233.73	**Pakistan (Sindh)**	Pakistan Forest Institute 2018
		286	Global (IPCC default values for mineral soils)	Kennedy et al. 2014
	Pneumatophores + litter	**2.95**	**Pakistan (Sindh)**	Pakistan Forest Institute 2018
Tidal marshes	Aboveground	NA		
	Soil (1 m)	**226**	**Global (IPCC default values for mineral soils)**	Kennedy et al. 2014
Seagrass meadows	Aboveground	NA		
	Soil			

Note: The best mean carbon data available for each carbon pool and ecosystem in Pakistan, which was used to inform this report, is in bold. Aboveground: leaves, branches, stems; belowground: roots.

5.2 Estimate of Carbon Stocks

Carbon inventories need to follow international standards and guidelines available in the IPCC's *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (IPCC 2014) and other sourcebooks (such as Howard et al. 2014). The IPCC guidelines show that carbon inventories can be calculated at different levels of certainty, depending on data availability, with three tiers of detail. Tier 1 is the one with highest uncertainty, while Tier 3 is the one with highest complexity and certainty.

Considering the current data availability in Pakistan, the first-pass assessment of blue carbon stocks in Pakistan followed a Tier 1 approach, that is, where the IPCC default values for mineral soils were used to estimate carbon stocks (IPCC 2014; Kennedy et al. 2014a) for tidal marshes and Tier 2 approaches, that is, where the mean carbon stock data collected in Pakistan was used (IPCC 2014; Kennedy et al. 2014a) for mangrove forests to develop the blue carbon inventory. The estimate of blue carbon stocks in Pakistan was based on the best available information on spatial distribution of coastal wetlands. Pakistan lacks mapped information on the habitat extent for tidal marshes; information on area extent is currently limited to areas within mangrove forests and seagrass meadows, and therefore, results presented in this report are likely conservative. In this report, the distribution area of each ecosystem was used to estimate country-level carbon stocks for mangroves and tidal marshes. For mangroves, carbon stocks included above- and belowground stocks and soil.

To estimate the changes of carbon stocks in mangroves between 1990 and 2020, the following steps were taken:

1. It was assumed that carbon stocks per area (tonnes per hectare) remained the same through time for the following carbon pools: aboveground, belowground, pneumatophores, and litter; and
2. For soil stocks, the first step was to estimate the area difference between 1990 and 2020. Then, the carbon stocks in 1990 were estimated by multiplying the mangrove area in that year by the mean carbon average of 233.73 tonnes per year. In sequence, it was assumed that the gained mangrove areas between 1990 and 2020 accumulated soil carbon at a rate of 2 tonnes CO_2e per hectare per year (approximately 0.54 tonnes of organic carbon per hectare per year; Crooks et al. 2019).

5.2.1 Mangrove Carbon Stocks

As part of this study, the size of the mangrove forests that are currently being conserved by protected areas in Pakistan was also evaluated. After an extensive literature search and contacting key stakeholders in the country, the local partner, Prudence Consulting, with the support from a team at Pakistan's MoCC, was not able to access spatial data showing the limits of protected areas in Pakistan. Hence, the World Database on Protected Areas (UNEP-WCMC and IUCN 2020) was used to extract this information for Pakistan. This global dataset encompasses 142 protected areas within the country, ranging from I to V International Union for Conservation of Nature (IUCN) categories. All layers were projected to the Universal Transverse Mercator coordinate system (UTM). Spatial analyses were undertaken in ArcGIS Pro 2.4.3 (ESRI 2011) and R version 3.6.1 statistical software (R Core Team 2019).

Mangrove forests occupy an area of approximately 1,464 sq. km. in Pakistan, according to the most recent mapping effort for 2020 (Gilani et al. 2021). When combining this information with the mean carbon stocks in different carbon pools derived from the sampling as part of Pakistan's 2018 REDD+ Readiness study (Pakistan Forest Institute 2018) in Sindh, it was found that existing mangrove forests potentially store approximately 19.8

million tonnes of organic carbon (or 72.8 million tonnes of CO_2e) (Table 5.3). If the spatio-temporal mangrove cover change from 1990 (477.22 sq. km.) to 2020 (1,463.59 sq. km.) (Gilani et al. 2021) are taken into consideration, Pakistan has increased its total carbon stocks from 12.9 million tonnes of organic carbon (or 47.5 million tonnes of CO_2e) in 1990 to 19.8 million tonnes of organic carbon or 72.8 million tonnes of CO_2e in 2020 (which represents an increase of approximately 6.9 million tonnes of organic carbon) currently. In addition, when assuming a soil carbon sequestration of 2 tonnes of CO_2e per hectare per year (or approximately 0.54 tonnes of organic carbon per hectare per year; Crooks et al. 2019), it is estimated that existing mangrove forests and newly restored areas could potentially sequester 79,760 tonnes of organic carbon per year (or 292,718 tonnes CO_2e per year) in the top 30 cm of soil. This could potentially represent an increase of 2.9 million tonnes of CO_2e by 2030 or 8.8 million tonnes of CO_2e by 2050 in the top 30 cm of soil, assuming that existing mangrove forests remain accumulating carbon at the same sequestration rate and are not degraded or lost (for instance, due to coastal development, sea level rise, etc.). In mangroves, soil coring to 1 m usually provides an appropriate estimate of carbon accumulated in the sediment; therefore, future studies should consider collecting carbon data up to 1 m to further investigate carbon sequestration rates in Pakistan.

In general, mangrove soils store >70 percent of carbon, with approximately 9.8 percent being stored in belowground biomass and 19.6 percent in aboveground biomass (Hamilton and Friess 2018). The carbon estimates presented in this report (Table 5.3) follow this same trend, with most of the carbon being stored in the sediment (1990: 11.1 million tonnes of organic carbon; 2020: 14.3 million tonnes of organic carbon), followed by aboveground biomass (1990: 1.2 million tonnes of organic carbon; 2020: 3.5 million tonnes of organic carbon), and belowground biomass (1990: 487,719 tonnes of organic carbon; 2020: 1.5 million tonnes of organic carbon). It is important to highlight that different results could be achieved if these results are compared to global predictions that also used different prediction models to estimate mangrove carbon stocks. For example, Simard et al. (2019) estimated total aboveground carbon at 961,184 tonnes of organic carbon and total carbon stocks at 15.8 million tonnes of organic carbon in Pakistan based on the mangrove distribution map from Giri et al. (2011) as reference cover map. For soil carbon stocks, for example, Sanderman et al. (2018) estimated soil carbon stocks at approximately 20 million tonnes of organic carbon in Pakistan, which was also based on the mangrove distribution map from Giri et al. (2011) as reference cover map.

Considering the current distribution of mangroves and mean carbon stocks, protected areas in Pakistan cover approximately 440.44 sq. km. of mangrove forests (which included two IUCN categories: national parks and wildlife sanctuaries) in Pakistan. These protected mangrove forests could potentially represent around 11.9 million tonnes of organic carbon (from 1.07 million tonnes of organic carbon aboveground, 450,130 tonnes of organic carbon belowground, 10.3 million tonnes of organic carbon in soils and 129,930 tonnes of organic carbon in pneumatophores and litter). In addition to protected areas, mangrove forests are considered protected forests under Pakistan's law, being managed by provincial forest departments and under provincial forest laws (Pakistan Forest Institute 2018). Here, it is important to highlight that the protection of mature and intact forests along Pakistan's coastline is key, since degradation could trigger release of ancient carbon into the atmosphere. This recommendation aligns with the need to improve mangrove distribution maps by classifying mature and recently restore ecosystems.

5.2.2 Tidal Marsh Carbon Stocks

For tidal marshes, limited information on habitat extent was found in the literature review. Based on the review, this ecosystem has only been mapped in areas of mangrove forests (Abbas et al. 2012) and occupying an area of 44.70 sq. km. in 2009, which is likely to underrepresent the extent of this ecosystem in Pakistan. This

information was combined with the IPCC default value for mean soil carbon stocks for mineral soils (Kennedy et al. 2014b) and showed that mapped tidal marshes store around 1 million tonnes of organic carbon (or 3.7 million tonnes of CO_2e) (Table 5.3). The lack of a comprehensive distribution map of tidal marshes in Pakistan precludes a more detailed analysis of carbon stocks stored by this ecosystem.

5.2.3 Total Blue Carbon Stocks in Pakistan

In total, mangrove forests and mapped tidal marshes potentially store approximately 21 million tonnes of organic carbon or 76.4 million tonnes of CO_2e in Pakistan. It is important to note that these estimates did not deduct for allochthonous carbon, which should be further investigated in future research. If these ecosystems are destroyed and assuming that all organic carbon stored in the upper 1 m of soil is oxidized to carbon dioxide, this could represent an emission of approximately 76.4 million tonnes of organic carbon equivalent back to the atmosphere. The carbon estimates presented in Table 5.3 are likely conservative considering the lack of detailed information on the distribution of each ecosystem and mean carbon data (stock and sequestration rates) sampled in Pakistan, mainly for tidal marshes. It highlights the importance of improving blue carbon inventory in Pakistan. This chapter includes the blue carbon roadmap for Pakistan, enlisting five strategic priorities to help and guide the Government of Pakistan (GoP).

Table 5.3: First-pass Estimate of Blue Carbon Stocks in Mangrove Forests and in Tidal Marshes

Ecosystem	Carbon pool	Mean carbon stock (tonnes C_{org} per hectare)	Area (ha)	Total stock (tonnes C_{org})
Mangrove Forests	**1990**			
	Aboveground	24.40	47,722	1,164,417
	Belowground	10.22		487,719
	Soil	233.73		11,154,063
	Pneumatophores + litter	2.95		140,780
	2020			
	Aboveground	24.40	146,359	3,571,160
	Belowground	10.22		1,495,789
	Soil	233.73		14,327,049
	Pneumatophores + litter	2.95		431,759
Potential blue carbon stocks stored in mangrove forests in Pakistan in 2020 (Tier 2)				19,825,757
Tidal marshes	Soil	226	4,470	1,010,220
First-pass estimate of total blue carbon stocks in coastal wetlands				20,835,977

Note: (1) Habitat extent of tidal marshes considered in this project is limited to the areas where mangrove forests are located, and therefore, is incomplete. References for mean carbon stocks and area used in this analysis are available on Tables 5.1 and 5.2; (2) The changes in carbon stocks for mangroves between 1990 and 2020 were based on the area extent and the potential sequestration rate for this ecosystem; (3) Blue carbon estimates followed a Tier 1 approach for tidal marshes and a Tier 2 approach for mangroves.

5.2.4 Potential Trends for Emissions Reductions

Reforestation of 1.5 billion mangrove trees under the Ten Billion Tree Tsunami (TBTT) initiative, along with conservation of remaining mangroves, offers significant carbon benefits. Recovering mangrove areas is the clearest opportunity for emissions removals. After decades of dramatic decline in extent, recent years have seen a substantial reversal in ongoing losses of mangroves, though risks remain in both Sindh and Balochistan. The Indus Delta is also undergoing erosion due to trapping of sediment within dams within the Indus catchment. Mangrove planting activities by the Sindh Government over the last 30 years have demonstrated the potential to reforest areas of the delta and recover forest. Supporting and expanding these activities is an opportunity for clear emissions removals. It is estimated that the Government of Sindh's Indus Delta Mangroves REDD+ Project, which is being conducted on 350,000 ha, will have removed one million tonnes of CO_2e between 2015 and 2020, and plans for further planting will remove 25 million by 2050 and 150 million by 2075. This project will result in removals equivalent to approximately 0.25-0.50 percent of Pakistan's annual emissions. These activities could be expanded upon.

Conservation of mangroves at risk from disturbance also brings benefits of preventing emissions, though the magnitude of the risks is unclear. The highest carbon stocks of remaining Indus mangroves are found in the oldest stands, which are close to Karachi, and are at risk from development. Mangroves in Balochistan are similarly at risk. Terrestrial areas, above the tides and mangroves, are relatively low in carbon stocks and would be preferential locations for development both from a climate adaptation as well as mitigation perspective.

Mapping the areas that may be returned to the original habitat is key to improve the estimates of potential emissions reductions, where Pakistan could invest in mapping historical distributions of mangroves and tidal marshes to inform and guide restoration projects. This topic is suggested as a Strategic Priority to advance blue carbon research in the country. Furthermore, the monitoring of carbon and area coverage of these recently restored mangroves is essential to improve the estimates presented in this report. The full potential of emissions reductions can be improved when data is available for tidal marshes and seagrasses, if existent, in the country.

5.3 Valuation of Carbon Stocks in the Blue Carbon Market

Carbon financing for blue carbon still remains in its early stages, with a few smaller projects that have come online but larger projects anticipated in the near future. It is also noted that in the last year or two, there has been a substantial increase in interest by private and international finance sectors to invest in blue carbon activities. Some large entities in the private sector are willing to pay a price that recognizes the social and environmental benefits of blue carbon projects as well as climate mitigation benefits. Microsoft, for instance, has expressed willingness to purchase credits at an average of $15 per ton to support its carbon neutral targets (Microsoft 2021). Early small-scale carbon in Kenya and Madagascar are currently selling credits in the $12-20 per ton range (MPA News 2020). Recognizing the high demand and limited number of blue carbon credits available, it is understood that developers of larger projects coming on line this year intend to price the credits at least at $12 per ton. It should also be noted that terrestrial forestry projects typically only attain a price of $3-4 per credit (World Bank and ICAP 2020), substantially lower than blue carbon aspiration and a small fraction of the true social cost of those avoided emissions is estimated to be $51 per ton of CO_2 (Interagency Working Group on Social Cost of Greenhouse Gases 2021).

Using a mangrove reforestation action that might remove 25 million tonnes of CO_2 by 2050, the rapid analysis found that using a terrestrial forest price of carbon credits of $3 and aspirational blue carbon prices of $12-20, the revenue generated would be $75 million, $300-500 million. Carbon removals would continue beyond 2050, sustaining ongoing revenue. Given the absence of data, it is unclear what the potential value conservation of mangroves could be. Equally, there is insufficient data on the financial returns to be gained from conservation and restoration of tidal marsh and seagrass ecosystems, but additional actions could be recognized. It is important to note that the principles of additionality must apply, which means that Pakistan can only receive carbon credits for the carbon stocks enhanced through management actions (such as restoration projects) which would otherwise be lost under business-as-usual actions. Historical distribution maps of blue carbon ecosystems can guide the selection of future restoration projects, but these must be taken in the context of coastal system response to changed sediment delivery as well as to sea level rise. Furthermore, future research should be conducted for better understanding of the extent to which the increase in mangrove coverage is related to conservation efforts and current restoration projects in Pakistan. Research is also needed to gain insight into other management actions (for example, changes in hydrological regimes, future inundation extent due to sea level rise, and removal of current threats) that can influence carbon sequestration in blue carbon ecosystems.

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Chapter 6. Preliminary Recommendations to Pakistan's NDC Revision

Based on preliminary findings, the following list of Pakistan's upcoming Nationally Determined Contribution (NDC) revision recommendations was prepared. While it is difficult to design blue-carbon-specific NDC commitments as long as there is no clarity about the overall structure, scope, and direction of Pakistan's upcoming revised NDC document, a number of options for further consideration are presented below. The first three points are the high priority recommendations, and it is recommended that consideration of the other two also commences. The recommendations were discussed with the Ministry of Climate Change (MoCC) counterparts. It is important, in this context, to consider firstly that the upcoming NDC update offers the opportunity, for countries in general, and Pakistan in particular, to increase mitigation ambition and improve resiliency by enhancing the role of nature, including blue carbon, as a climate solution. Secondly, the lack of comprehensive data is not an argument against inclusion of blue carbon in the NDC (Thomas et al. 2020). Any country with coastal wetlands can address and include blue carbon habitats in its NDC, no matter the data and capacity level. NDCs prepare climate action; they are not by themselves final accounting systems or frameworks. Rather, countries can and should use their NDCs to outline a trajectory and a path forward. Tackling the question of robust accounting data, then, becomes an action point in itself. More broadly, countries may commit, in their NDCs, to undergo, or complete, a "Blue Carbon Readiness" to steer future blue carbon action.

6.1 Blue Carbon Habitat Focus

The NDC—in its introduction, a dedicated context chapter, or elsewhere—should identify Pakistan's coastal wetlands as a relevant topic, clarifying the value in terms of both mitigation and adaptation benefits, threats and vulnerabilities, and specific achievements by authorities and non-state actors to restore previously lost habitats.

Model Language

"Pakistan considers its rich coastal and delta ecosystems—including its mangrove forests, tidal marshlands, and seagrass meadows—of vital importance, when it comes to combatting climate change. As these ecosystems are natural carbon sinks ("blue carbon"), their protection and enhancement are fundamental to reach the mitigation objectives of the Paris Agreement, in particular the 1.5-degree Celsius objective.

Yet, the health of these ecosystems is even more relevant, when it comes to securing food and livelihoods, and protecting coastal communities, settlements and infrastructure from rising sea levels, storms and flooding. Blue carbon habitats are cross-cutting in their value for adaptation, mitigation, and resilience. Their long-term conservation and restoration represent a core commitment of the Government and the people of Pakistan…"

6.2 Scope, Coverage, and Methodological Approaches

Depending on whether Pakistan decides to adopt an economy-wide target or a selective target (covering certain sectors only), the language on scope and coverage will be different. From a blue carbon perspective, it is important to clarify, *expressis verbis,* if emissions and removals from coastal wetlands are included in the NDC and it is equally important to reference the methodological approaches that will be applied for NDC accounting purposes. Relevant guidance for blue carbon habitats has been provided by the Intergovernmental Panel on Climate Change (IPCC)—the *2013 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*, and the *2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories*—and these documents should be explicitly referenced in the NDC. However, given that Pakistan's national reporting system and inventory have not reached an advanced state yet, the Government is advised to condition the methodological commitment on the availability of data and capacity at large. The relevant formulation could be as follows:

Model Language

"Pakistan will strive to use the latest IPCC guidance for the preparation of its inventory and NDC accounting framework. This includes the application of the 2006 Guidelines for National Greenhouse Gas Inventories. Pakistan will consolidate and refine the current data in its first Biennial Update Report (BUR), expected in [add year], and its first Biennial Transparency Report due in 2024 to ensure that Pakistan reports and accounts for emissions and removals in accordance with the 2013 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, and the 2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories…"

6.3 Mitigation Commitment

Countries have wide discretion when formulating their NDC commitments, including their mitigation ambition. While they are required to formulate economy-wide targets, that is, targets that include all economic sectors, including land and wetland use over time, developing countries decide according to their specific capabilities whether and when to include additional targets. Countries are also at liberty to express their targets in absolute terms ('x percent emissions reductions below [1990 emissions] by…'), in relative terms (e.g., 'x percent emissions reductions below business-as-usual by…').

The only requirement set by the Paris Agreement and the Paris Rulebook is that countries, when setting their targets, "provide the information necessary for clarity, transparency and understanding".[12] (often referred to as "CTU" or "ICTU"). ICTU means, among others, clarity about the scope and the coverage (regarding which economic sectors, categories, activities, carbon pools, and greenhouse gases are included), and information on the assumptions and methodological approaches used. It also means that any mitigation commitment made must be quantifiable against a reference point and a date set when the target will be achieved. The Government of Pakistan (GoP) considers that there are no sectoral targets yet to commit in the NDCs, and tries to keep this an open-ended suggestion to avoid any future implications at the moment.

The structure and style of any blue carbon specific targets will depend on the overall NDC structure. If the NDC contains either an economy-wide target or a selective target for land-use, land-use change and forestry

12 Article 4.8, Paris Agreement.

(LULUCF) (including wetlands), it is important to realize that emissions and removals of coastal wetlands will be included and accounted for. This makes it equally important, in this scenario, first, to set out the parameters for quantification accurately, and second, for the GoP to understand the trends in emissions and removals of/ from coastal wetlands as well as the level of control over interventions, so as to make sure that the magnitude of emissions/removals projected for coastal wetlands is well understood when setting the overall target. Pakistan has experience with this kind of analysis from the Forest Reference Emission Level (FREL) exercise it completed recently (Ministry of Climate Change and REDD+ Pakistan 2019). Coastal wetlands, however, are covered in that document only partially and without consideration of soil carbon values or historic and ongoing restoration campaigns.

Given the lack of data on emissions trends and robust reference scenarios, it would seem most tenable to come forward with a commitment to reduce emissions from coastal wetlands and to enhance their carbon sinks by 2030 but defer the identification of specific values to the NDC 2025. Depending on the overall structure of the NDC and the possibility that Pakistan plans to formulate specific REDD+ targets, the coastal-wetlands-specific commitment may be combined with any REDD+ targets. This year's NDC wording, then, could run:

Model Language (High Priority)

"Pakistan will reduce its annual emissions from [coastal wetlands] [deforestation, forest degradation and the degradation of coastal wetlands] and enhance [their] [the] natural carbon sink capacity [of the country's forests and coastal wetlands] by a significant margin compared to the projections for 2030 under a reference level scenario. The [reference level scenario for the coastal wetlands sector] [updated reference scenario for forests and coastal wetlands] as well as specific emissions reductions and carbon enhancement commitments will be established prior to or as part of the submission of Pakistan's next [second] NDC in 2025."

6.4 Adaptation or Horizontal Commitment

Given the crosscutting nature and value of blue carbon habitats it seems opportune to trace the multiple ecosystem services they provide beyond the sphere of climate change mitigation. Several countries have opted to transcend the dichotomy of mitigation commitments and adaptation actions and to create a horizontal or "integration" section that follows an ecosystem-based approach and combines mitigation and adaptation actions for blue carbon habitats and beyond (cf. Government of Chile 2020; Government of Costa Rica 2020). Some countries also position blue carbon habitats at the center of their plans to develop a sustainable blue economy (cf. Government of Belize 2021, forthcoming, and Government Cabo Verde 2021).

It matters little where to place the commitments and actions associated with blue carbon habitats, whether within mitigation, adaptation, or a third horizontal or integration category. What does matter is that the specific commitments and/or actions are designed and presented with as much precision as possible and in a way that allows for close impact reporting on mitigation and adaptation/resilience benefits in the future.

Pakistan undertakes to implement the following [headline] and [implementation] targets:

Model Language

Headline targets

- "Halt and reverse the trend of mangrove deforestation and the degradation of mangroves, tidal marshlands and seagrass meadows [by 2030] [as soon as possible but no later than ____]; and
- Promote the restoration of deforested and/or degraded mangrove habitats, seagrass beds and marshlands as a priority over the period 2021-2030."

Implementation targets

- "By 2022, adopt—through the Ministry of Climate Change, the Ministry of Maritime Affairs, and the Ministry of Finance and Revenue, in coordination with the government services of Balochistan and Sindh—a Blue Carbon Action and Financing Roadmap.
- From 2022 through 2025 and beyond, promote restoration activities for mangroves, tidal marshes, and seagrass beds along the coasts of Balochistan and Sindh and the Indus Delta.
- By 2025, increase coastal areas under protection, notably through the creation of new marine protected areas and the demarcation of extensive no-take zones.
- From 2022, condition all coastal development on a rigid environmental impact assessment that evaluates, in particular, impacts on the capacity of coastal wetlands to employ its ecosystem services, including for mitigation and adaptation.
- Establish a comprehensive and complete inventory of all of Pakistan's coastal wetlands, including seagrass beds.
- Develop a comprehensive monitoring system for coastal wetlands that include monitoring of carbon stock changes.
- By 2030, develop community-focused management plans—with robust performance indicators—for all of the newly established marine protected areas.
- By 2030, all mangrove areas will have community-based management and adaptation.
- By 2030, coastal planning and coastal infrastructure will be regulated at the national, regional, and local level to prioritize the consideration of "blue" nature-based solutions (NbS) and to achieve the country's NDC commitments."

6.5 NDC Finance and Enhanced Ambition Instruments

Pakistan should add a blue carbon focus on its commitments or actions related to finance and the use of mechanisms. The implementing rules for employing the Article 6 Paris Agreement instruments – cooperative approaches (Art. 6.2 Paris Agreement), the sustainability mechanism (6.4 Paris Agreement) and non-market approaches (Art. 6.8) – have not yet been agreed on at the United Nations Framework Convention on Climate Change (UNFCCC) level. The GoP plans to follow the negotiations very closely and will decide to move forward once these rules are finalized. The GoP plans to consider including the recommendations on credits without referencing Article 6 at this point. The following elements are tentatively suggested as a part of rapid assessment, but the GoP will update further:

Model Language

"As part of its Blue Carbon Action and Financing Roadmap—to be adopted in 2022—Pakistan will identify a list of projects and investment opportunities targeting the implementation of the commitments and actions on blue carbon presented in this NDC, as well as concrete financing pathways. These pathways will be informed by a thorough analysis of how best to direct funding from public, official development assistance (ODA), and philanthropic sources for use in different project preparation and financing stages, and how blended financing structures can help reduce risks and attract capital from more commercially oriented equity investors and debt providers.

Pakistan intends to issue a first blue resilience bond targeting nature-based infrastructure solutions as well as sustainable fisheries and the restoration of marshlands for flood reduction by 2025.

Pakistan considers employing the instruments on enhanced ambition provided in Art. 6 of the Paris Agreement. This may include the mitigation mechanism (Art. 6.4 Paris Agreement) as well as bilateral cooperative approaches (Art. 6.2 Paris Agreement) applied to, among others, coastal wetland restoration activities.

Pakistan may also pilot integrated, holistic and balanced non-market approaches (Art. 6.8 Paris Agreement) targeting adaptation benefits for coastal communities (sustainable fisheries, storm protection through nature-based solutions, access to clean water, erosion control, and other) as well and eco-tourism.

Furthermore, Pakistan encourages the involvement of the private sector in implementing its climate ambition across sectors and the development of nature-based solutions that address Pakistan's mitigation and adaptation potential. Private investors may participate in transactions involving the transfer of mitigation outcome through the instruments of Article 6 of the Paris Agreement or using voluntary markets. On request, the Ministry of Climate Change may issue a notification on corresponding adjustments it is prepared to make with respect to any specific transaction."

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Chapter 7. Blue Carbon Action and Finance Roadmap

This chapter presents action points towards the development of a Blue Carbon Action and Financing Roadmap that will address and implement the following recommendations. The recommendations are presented in two sets, one on research and outreach, and the other on blue carbon implementation. Pakistan, as a REDD+ country with coastal habitats, is well placed to extend its Nationally Determined Contribution (NDC) to cover blue carbon habitats. It is recommended to coordinate further between blue carbon initiatives and the on-going REDD+ Programme. Furthermore, clarifying any potential duplication and how the issues of considering mangroves are already accounted for, as well as the separation of soil carbon considerations, are also important.

In addition, the Roadmap has direct links to the UN Sustainable Development Goals (SDGs), which are a set of goals adopted by all Member States in 2015 towards the achievement of the 2030 Agenda for Sustainable Development. As a nature-based solution, the blue economy can help in achieving many of the SDGs by restoring naturally-occurring ecosystems, conserving biological diversity, and indirectly relating to quality and supply of water, food, and water security, sustainable human settlements, poverty eradication, and innovation and development of appropriate infrastructure. While the actions provided here have many indirect links to a number of targets set forth in the SDGs, SDGs 13 (Take urgent action to combat climate change and its impacts), 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development), and Target 6.6 (By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes) in particular are directly related.

7.1 Research and Outreach

In order to strengthen the foundations of research and outreach in Pakistan, it will be ideal to (1) Improve mapping and monitoring of blue carbon ecosystems through time; (2) Update the national greenhouse gas (GHG) inventory and prepare for accounting of the NDC; (3) Evaluate key pressures on blue carbon ecosystems in Pakistan; (4) Invest in research to evaluate and map co-benefits provided by blue carbon ecosystems; and (5) Strengthen education, training, and engagement (Figure 7.1).

Priority A1: Improving Mapping and Monitoring of Blue Carbon Ecosystems through Time

As this rapid assessment has shown, there is a lack of local information, mainly for tidal marshes and seagrass meadows, such as:

1. Lack of accurate distribution maps of tidal marshes and seagrass meadows, which reinforces the need for better mapping of blue carbon ecosystems in the country;
2. Lack of information on carbon stocks and sequestration rates, which lead to use data from global averages or nearby locations.

This lack of information is a major obstacle to present and future blue carbon engagement. It is crucial that Pakistan invests in on-ground and desktop research for precise and effective mapping of blue carbon ecosystems and estimating carbon stocks, carbon stock changes over time, and sequestration rates. This research will facilitate management and conservation of coastal wetlands in the future.

The following specific action items are suggested:

- Build on the recent study by Gilani et al. (2021), which provides a useful first step to map spatio-temporal changes of mangrove cover in Pakistan to identify and monitor restored mangroves through time to allow for better quantification of carbon stocks and stock change;
- Understand the extent to which mangrove cover has increased in the past years is related to conservation efforts and current restoration projects in Pakistan;
- Adapt methods to map mangrove forests to include monitoring of tidal marsh coverage and change through time;
- Invest in seagrass research: (1) Use remote sensing techniques to identify the occurrence and mapping of seagrass meadows within Pakistan's Exclusive Economic Zone, and (2) Work closely with experts to identify which species (if any) exist in the country;
- Develop maps of previous distributions of all three blue carbon ecosystems, if possible, based on remote sensing and/or local knowledge. These maps can help to identify areas for future restoration projects;
- Invest in well-coordinated research projects to evaluate how different management actions (for example, changes in hydrological regimes, future inundation extent due to sea level rise, and avoided degradation from main threats) can influence carbon sequestration through time in blue carbon ecosystems. This research will inform the question, 'how big is the opportunity and where to act' in the country;
- Work closely with academia and/or Geographic Information System (GIS) teams from the REDD+ Programme to develop a long-term monitoring system based on remote sensing to track the coverage changes of blue carbon ecosystems (mangroves, tidal marshes, and seagrasses), in combination with mapped information on the restoration projects being developed in the country. Furthermore, it is important to develop spatial layers of deforestation points to help future studies to estimate potential carbon emissions. This action aligns with the REDD+ Programme sector of National Forest Monitoring System (NFMS) and Monitoring Reporting and Verification (MRV), which has the functions of monitoring and measurement, reporting, and verification;
- Invest in fieldwork campaigns to collect carbon data from mangrove forests, tidal marshes, and seagrass meadows following the Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC 2014; Kennedy et al. 2014b; Howard et al. 2019) to ensure compatibility with international standards. Sampling should systematically consider different species and locations throughout Pakistan's coastline followed by a comprehensive plan to collect data for carbon stocks and sequestration rates (that is, biomass and soil carbon pools). The number of soil samples required to capture carbon variability over Pakistan's blue carbon ecosystem will depend on the sampling scale, for example countrywide, province-wide, or region-wide. However, a minimum of 40 core samples are being suggested as an optimal number for capturing carbon variability across larger scales (Young et al. 2018);
- Analyze fieldwork data to quantify blue carbon stocks and sequestration rates from different ecosystems and locations, following IPCC guidelines (IPCC 2014; Kennedy et al. 2014b; Howard et al. 2019) to ensure compatibility with international standards;

- Consider development of allometric equations based on data sampled in Pakistan;
- Evaluate ways in which new technologies, such as drones and high-resolution satellites, can help improve carbon estimates utilizing information collected in the field;
- Invest in long-term monitoring of carbon stocks and sequestration rates on different blue carbon ecosystems, including the mangroves planted as part of the Ten Billion Tree Tsunami (TBTT) and REDD+ programs.

Priority A2: Update National GHG Inventory and Prepare for National NDC Accounting

As noted previously, limited data exists on blue carbon ecosystems and the impacts of changing climatic conditions on them. NDC commitments can help Pakistan bolster the knowledge base of these ecosystems, and Pakistan should plan its future in such a way that strengthens the monitoring and reporting on these ecosystems as obliged by the Paris Agreement.

These measures should allow for updating the GHG inventory to include blue carbon habitats by applying 2013 *IPCC Wetlands Supplement to IPCC 2006 Guidelines*. The Global Change Impact Studies Centre (GCISC) is a dedicated research institute at the national level under the Ministry of Climate Change (MoCC) with a mandate to conduct baseline science research and has been responsible for reporting under the Convention on Biological Diversity (CBD), the Paris Agreement, and other multilateral environmental agreements. Currently, GCISC is implementing a project on 'Preparation of Pakistan First Biennial Update Report' (BUR1) under the United Nations Framework Convention on Climate Change (UNFCCC) and contributing to the chapters on GHG inventory and MRV. Consistent with these efforts, GCISC is in a good position, to partner with the National Institute of Oceanography (NIO) on the following:

- Update inventory data on coastal wetlands in BUR1 and the first Biennial Transparency Report (BTR) due by 2024;
- Create a state-of-the-art monitoring system to track and trace carbon stock changes in coastal wetlands;
- Coordinate with REDD+ Pakistan office for field data to estimate blue carbon stocks based on on-ground information and avoid duplication in future reporting of blue carbon stocks;
- Design and finance research studies to integrate existing knowledge and data with new research for better understanding of variations in ecosystems and causes to inform the process of decision-making in policy and implementation;
- Perform coastal hazards assessments to map and monitor hazards of sea level rise, sea-water intrusion, flooding, tides, etc. Regular recording of land subsidence will help national and provincial government to decide setback limits for infrastructure development along the coasts and to design adaptation measures for areas vulnerable to soil erosion;
- Conduct research to gather data on the impacts of mangroves on sediment accretion and identify whether the elevation can help prevent sea-level rise.

Priority A3: Evaluation of Key Pressures on Blue Carbon Ecosystems in Pakistan

Despite increases in mangrove coverage over the past years (Gilani et al. 2021), blue carbon ecosystems are still threatened by erosion, land use conversion, overharvesting, and camel grazing. It is necessary to better comprehend sea level rise impacts on Pakistan's coastline and its likelihood to influence distribution of

blue carbon ecosystems in the future. This step is essential to guarantee effective management and future resilience of blue carbon ecosystems. For that, it is suggested to:

- Identify and evaluate main pressures (for example, sedimentation, disruption of water supply) influencing the distribution of blue carbon ecosystems;
- Research on the impacts of sea level rise in the coastline and its likelihood to influence current and potential future distribution of blue carbon ecosystems;
- Develop long-term monitoring of relative sea level rise across Pakistan's coastline. This information will support assessments of the coastal system and disaster risk reduction and identify potential sites for future restoration projects that are resilient to sea level rise;
- Based on the identified main pressures and associated impacts on blue carbon ecosystems, develop management plans that are likely to minimize impacts while at the same time conserve carbon stocks.

Priority A4: Invest in Research to Evaluate and Map Co-Benefits Provided by Blue Carbon Ecosystems

In addition to sequestering carbon, blue carbon ecosystems can provide many other ecosystem services, including coastal protection, support fisheries and biodiversity, water filtration, tourism and recreation, and secure livelihoods (McLeod et al. 2011). The quantification and evaluation of blue carbon ecosystems are likely to help future initiatives to support payments for co-benefits. Quantifying these ecosystem services can help managers and decision-makers to guide future management and restoration actions. Hence, it is suggested to:

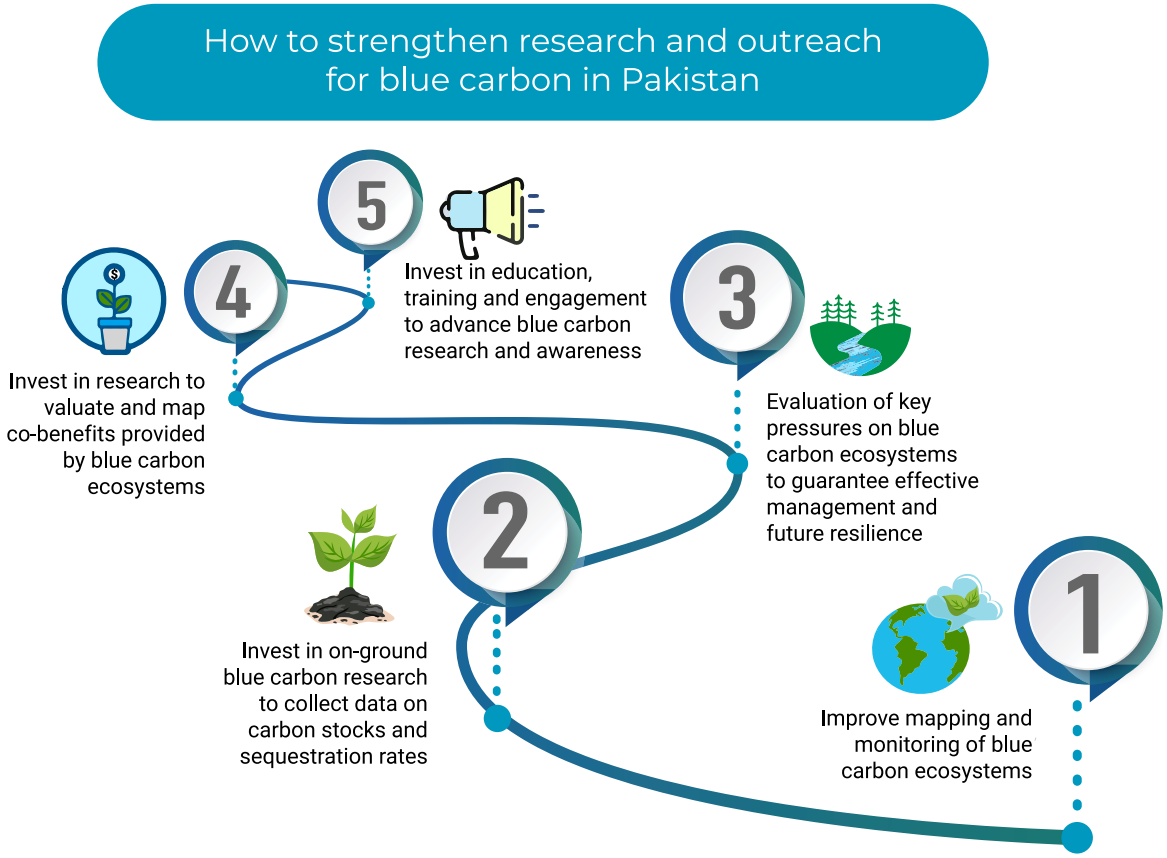
- Collaborate with local and international experts to estimate and quantify different ecosystem services provided by blue carbon ecosystems using robust techniques, such as modeling (InVEST, which is a suite of models that helps to model and value ecosystem services; Sharp et al. 2014), and field sampling including stable isotopes to estimate the contribution of coastal wetlands to fisheries;
- Invest in research to apply the Environmental-Economic Accounting (EEA) Framework, from the United Nations (UN 2014) aiming to optimize the benefits provided by blue carbon ecosystems through protection and restoration.

Priority A5: Strengthening Education, Training, and Engagement

Education, training, and engagement are key to advancing blue carbon research and awareness in Pakistan. In addition, this may help to reach national targets for SDG 4 (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), SDG 5 (Achieve gender equality and empower all women and girls), and SDG 8 (Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all). The Priority A5 aligns with awareness raising and outreach project within the REDD+ Programme. For this purpose, the following actions are prioritized:

- Identify key stakeholders (for example, government, academia, NGOs) aligned with blue carbon projects and research in Pakistan;
- Develop local research capacity through international collaboration to deliver scientific training and up skill workshops;
- Develop community engagement by running 'Citizen Science Days', where community members can have an immersive experience in the field, resulting in the promotion of social awareness and interest on the diverse benefits provided by blue carbon ecosystems.

Figure 7.1: Pakistan Blue Carbon Ecosystem Roadmap presenting Five Strategic Priority Actions



7.2 Blue Carbon Implementation

In order to proceed to Blue Carbon implementation in Pakistan, it will be ideal to (1) Review and improve institutional arrangements; (2) Work on capacity building; (3) Review and implement climate change adaptation options; (4) Review and implement climate change mitigation options; and (5) Seek different sources and modalities of financial resources options (Figure 7.2).

Priority B1: Review and Improve Institutional Arrangements

To overcome institutional inconsistencies, establish management units at provincial levels with participation of stakeholders from sub-national relevant sectors, international non-governmental organizations (INGOs), NGOs, community-based organizations (CBOs), industry, corporations, academia, policy think-tanks, and other private sector entities. The units should be responsible, in the short term, in collaboration with the MoCC, for the development of the Blue Carbon Action and Financing Roadmap—to be prepared by 2022—and, in the long term, to improve the protection and management of coastal and marine ecosystems.

An important aspect of the management units will be to coordinate across government agencies and stakeholders and to ensure synchronization between the roadmap and other policy initiatives, including:

- National Climate Change Policy (NCCP) 2012
- National Biodiversity Strategy and Action Plan (NBSAP) 2015

- The 2021 NDC commitments (under preparation)
- Pakistan's Blue Economy Policy (2020)

Existing legislation and policies may need to be amended and new legislation and policies may need to be written, in response to the development of the roadmap, including:

- Existing Environmental Impact Assessment (EIA) regulations
- Sindh Tourist Guides Act 2011
- Various land tenure laws (to remove unnecessary barriers to the protection of blue carbon ecosystems from man-made causes of degradation)
- Formulating Balochistan's eco-tourism policy or act.

Furthermore, new official investigations may need to be triggered by the provincial management units, in collaboration with MoCC. Among the most urgent investigations, MoCC will first need to conduct socio-economic and environmental impact assessments of reduced freshwater flow into the Indus Delta and environmental flow needs in collaboration with the Indus River System Authority (IRSA). Based on the assessment, Pakistan's Water Apportionment Accord 1991 will be updated to include apportionment of environmental flows including sediment transport and related geomorphic processes as key components while specifying flows.

Priority B2: Capacity Building

Insufficient technical, human, and financial capacities of coastal and marine ecosystem management authorities, including forest, wildlife, and fisheries departments at the local level, are hampering the protection of coastlines. Sustainable solutions lie in capacity building of local governments with the help of Climate Finance Unit (CFU) under MoCC to enable them to prepare and negotiate blue carbon management proposals for funding at national and international platforms. MoCC and provincial governments should prioritize capacity building of provincial environmental protection agencies (EPAs) to monitor compliance with regulations and legal requirements such as the use of remote sensing to assess encroachments. This intervention is vital as Pakistan already has a regulatory framework in the country, but its implementation is challenged by the limited capacities of the public sector.

Pakistan needs to not only invest in the application of new technologies (for example, high-resolution satellites and drones), but also to develop better infrastructure to provide easy access to areas for on-ground research and support in arranging logistics as identified by NIO officials during consultations to have better knowledge of blue carbon ecosystems and oceans. Support to develop scientific methodologies to undertake tasks in line with international practices is also required. For understanding the impacts of climate change on marine ecosystems, MoCC should invest in capacity enhancement of local departments, public research entities, and academia for research by aiding in the adoption of contemporary technologies, providing access to better infrastructure like field laboratories, equipment (field and laboratory) and logistics. Building the capacities of local communities to monitor and report changes in sea currents, sea temperatures, and fish stock movement will help develop understanding of climate change impacts and will also help raise awareness among local communities on climate change.

This priority can directly contribute to SDG 17 on strengthening means of implementation and revitalizing the global partnership on sustainable development. This may be done through enhancing capacity building for blue carbon-related institutions through north-south and south-south cooperation, including data monitoring

and accountability as well as by enhancing access to technologies and innovation for knowledge sharing and capacity building related to blue carbon.

Priority B3: Climate Change Adaptation

The role of natural vegetation to protect coastal zones is widely recognized and Pakistan has been involved in nature-based solutions (NbS) for adaptation. The replantation and restoration of mangrove ecosystems along the coastal areas will act as a natural barrier to control erosion and mitigate the impacts of natural disasters like cyclones. MoCC should support the efforts of provincial governments for coastal area regeneration and involve local communities for management of restored ecosystems. The Indus Delta REDD+ project in Pakistan is going to be a huge contribution to rehabilitate and protect 350,000 ha of coastal area with local community participation, while creating 21,000 livelihood opportunities in the project life of 60 years. In addition, the MoCC should explore and introduce incentives for provincial governments to prioritize such protection and restoration projects with community participation to increase sustainable stewardship. A key consideration would be to give certainty to investors that blue carbon investments are encouraged by the government, that responsibilities are clear (including in terms of the right to transact blue carbon title), and that double counting at NDC level will be prevented, whether a transaction occurs on regulated or voluntary markets.

Pakistan should strengthen existing initiatives for improved adaptation. Building on the Protected Areas Initiative (PAI), MoCC needs to identify vulnerable coastal areas that should be protected from any infrastructure construction or commercial activities. For these identified areas, MoCC should also notify clear demarcation of no-touch zones, demarcation of zones where restoration should happen to help adaptation, and level of activities allowed for its sustainable management. Additionally, MoCC should develop a management plan with clear conservation targets for Astola Island marine protected area (MPA), based on its characteristics, species, habitats, and threats. Moreover, it should also inform new MPAs on potential sites, for example, areas identified by the Mangroves for the Future (MFF) Pakistan (Churna Island/Gawatar Bay/ Indus Swatch/Miani Hor). Astola Island in 2017 and Indus Swatch in 2018 were first notified as MPA; however the work on effective governance and management regimes remained absent (Amar Guriro 2018). To meet Aichi Biodiversity Targets that also requires at least 10 percent of coastal and marine areas to be conserved and managed, MoCC revitalized the plan through PAI. The initiative is people-centric where the plan will be implemented in a phased manner starting with the management plan for a terrestrial protected area, Chinji National Park (The News 2021). The choice of the locations for management plans and their implementation are highly dictated by the finances, and priority in NDCs can help fulfill this gap.

These protected areas are also important for the country from a tourism point of view. Hence, it is the responsibility of MoCC to sustain tourism opportunities through well-designed marine management. An example of managing marine areas is a marine spatial planning program that allows for sustained ecological, economic, and social benefits. All these efforts will provide opportunities to recover those ecosystems sustainably that are threatened by over-exploitation and climate change.

Furthermore, government agencies should assess vulnerabilities of coastal communities to climate change in order to delineate an adaptation plan with the participation of the local community. It should include capacity building of coastal communities for sustainable harvesting of marine organisms, diversifying livelihood opportunities such as sustainable aquaculture, and introducing saline vegetation species, among others, to aid access to basic social services, limit inland migrations, and incentivize the communities to protect ecosystems

as a part of this effort. Pakistan is yet to explore coastal and deep-water marine sources for aquaculture while coastal communities rely completely on natural fish availability for food and livelihood. These communities lack credit, technology, and training, which are all vital engines to building resilient communities. National and sub-national governments should pilot activities to educate and capacitate local communities and the fishing industry for sustainable fisheries management and aquaculture technologies. Along with this, it is a priority for the federal government to define national aquaculture regulations that prohibit destruction of natural blue carbon ecosystems for aquaculture, develop criteria for site selection, necessitate EIAs, develop proper processes for licenses and permits, and also develop policies to attract corporates and entrepreneurs to invest in research and technologies for profitable aquaculture.

SDG 13—on taking urgent action to combat climate change and its impacts—is directly linked to this priority. In particular, Target 13.1 to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters can be directly met through mangrove and wetland ecosystems.

Priority B4: Climate Change Mitigation

The restoration efforts that have been occurring, especially in Sindh, to rehabilitate mangrove forests and to sustain carbon sequestration benefits from existing and newly restored ecosystems will be crucial. The MoCC should define a strategy to avoid carbon dioxide emissions from planned restoration programs and protected areas along Pakistani coasts with continuous monitoring and strict penalties for defaulters. Pakistan is going to plant one billion mangroves under TBTT in three years that will be planned and implemented by provinces. Moreover, under the REDD+, 40,000 mangroves have been planted in the delta, where 350,000 ha will be restored and maintained. To achieve the 'Billion Mangroves" under the TBTT initiative, MoCC should help provincial governments in resource mobilization to help structure and implement replantation (for example, identifying areas and species for mangrove restoration, their management, and monitoring). In addition to plantations, identify potential saltwater intrusion prevention practices (physical or hydraulic) based on tailored research to build evidence for decision-making and pilot demonstration projects.

MoCC should also develop a policy framework/strategy to control marine pollution based on the quantification of marine pollution sources, prioritized waste streams, identified alternative processes, and locations for disposal from urban centers, as well as incentivize industries to opt for environment-friendly processes to tackle growing plastic marine pollution. World Wildlife Fund (WWF) and the United Nations Development Programme (UNDP) are currently partnering with MoCC and provincial governments for the same action; hence, their role in adoption of this measure will expedite the process.

To deal with the stresses of increased upstream damming on mangrove ecosystems in the Indus Delta, it is important to identify proven techniques for sediment management like passing sediment through or around reservoirs and dams, constructing sediment bars that gradually erode to replenish river sediment balance downstream, and so forth.

SDG 13—on taking urgent action to combat climate change and its impacts—is also directly linked to this priority. By integrating climate change measures into national policies, strategies, and planning on blue carbon resources, the Government of Pakistan can meet Target 13.2.

Priority B5: Financial Resources

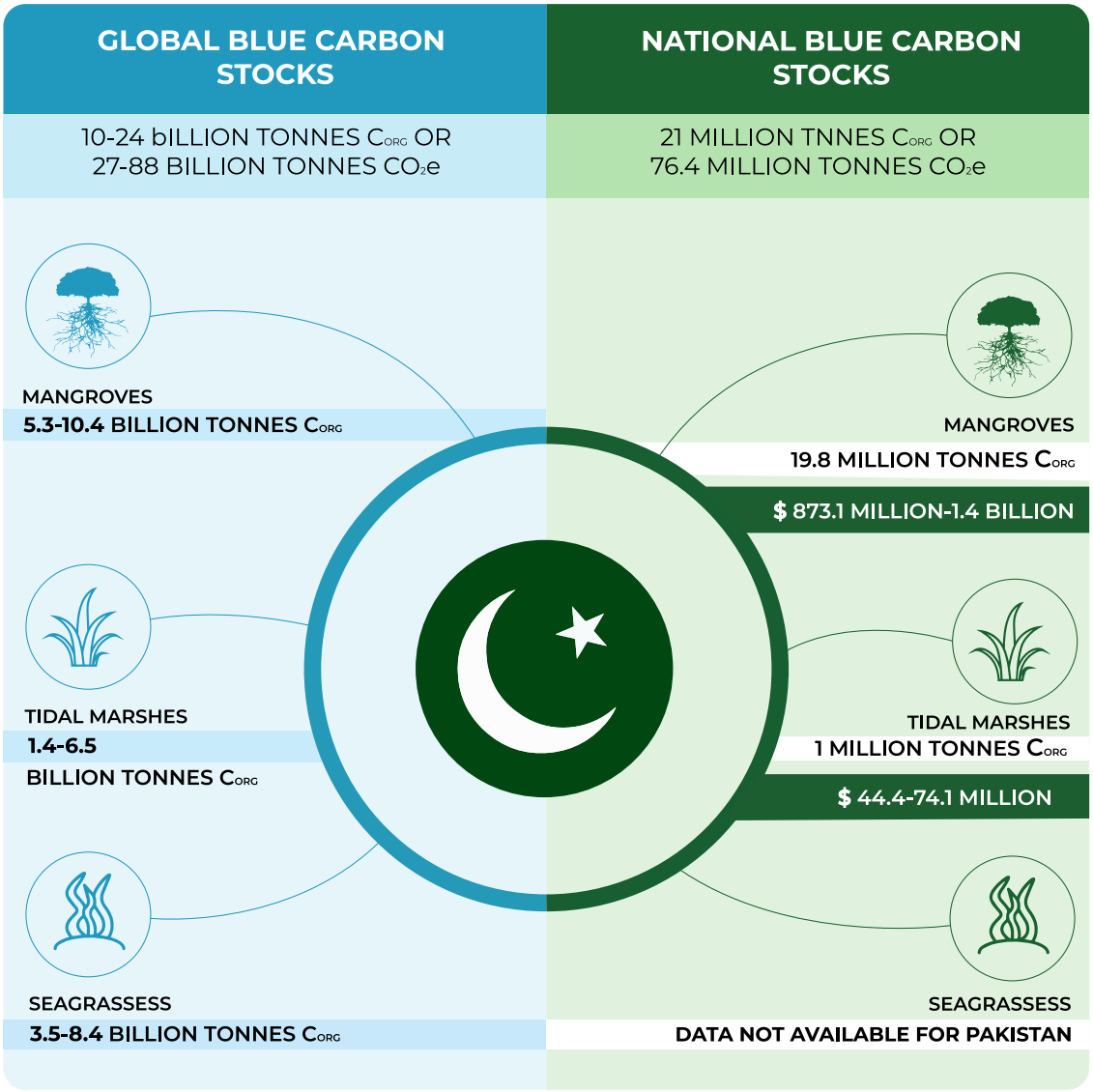
MoCC should explore innovative private finance schemes, such as green bonds/blue carbon bonds and the opportunities for public-private partnerships to mobilize finance for NDC implementation. Pakistan is planning to issue its first green bond to invest in a hydropower project (Gillespie and Ritchie 2021), which means a support mechanism for green bonds has been initiated to assure greater transparency, and improved assistance to issuers, investors, and regulators. For dedicated blue bonds, a conducive policy environment attracts investors to finance blue initiatives. Pakistan should, therefore, have a roadmap to outline its targets for coastal and marine economy with a guarantee of good governance. This also provides opportunities to investors to align the proceeds with national priorities and to confirm that the investment will deliver blue carbon benefits. In addition, MoCC will need to make sure that awareness of provincial governments as well as the corporate sector is raised to build the blue bond market.

The corporate sector's green bond market has shown a boost that is helping them to meet their sustainability agendas. MoCC and provincial departments can target corporates that include the sustainability agenda in their vision, and have experience with green bonds to initiate the process. One such example is PepsiCo Pakistan that has a vision to invest in reducing its GHG footprint through green bonds.

JS Bank, in collaboration with WWF, planted 100,000 mangroves (*Avicennia marina, Rhizophora mucronate,* and *Ceriops tagal*) along the coastline of Miani Hor in 2019, owned by the Revenue Department, Government of Balochistan under its corporate social responsibility. Similar arrangements can be explored to finance conservation initiatives with the corporate sector. In the future, these initiatives should become a part of voluntary carbon markets planned under the National Carbon Market Initiative commenced by MoCC and provincial carbon markets as planned by the Sindh Government. The success of the voluntary markets lies in the awareness of corporate sector on the potential to stand out globally as climate-conscious. NGOs are already taking the lead on this; however, MoCC should initiate this process along with the finalization of carbon market regulations.

The recent COVID-19 pandemic crisis unveiled a sovereign debt crisis where Pakistan, like many developing economies, was forced to borrow more for social safety nets that were added to already existing debts. This situation started a global debate on 'green recovery' and debt-for-nature swap is proposed as an innovative solution to exit the crisis while investing in nature. MoCC is reported to have the indigenously-designed Debt-for-Nature swap scheme in the pipeline for green recovery which shows high political commitment (Khan 2021). In continuation of this effort, MoCC can explore debt relief coupled with blue carbon commitments. For the success of such commitments, MoCC and provinces will need to work on improved coordination and improved governance to sustain benefits.

Figure 7.2: Global and National Blue Carbon Stocks



Note: Pakistan's blue carbon stocks were estimated based on existing information available for mangroves and tidal marshes. Valuation of existing carbon stored in mangroves and tidal marshes are for representation only, since carbon credits are generated only to carbon sequestered through management actions.

Global stocks of blue carbon were estimated following the approach used in Lovelock and Reef (2020), where lower estimates were based on estimates of cover (mangrove 138,000 sq. km. from Bunting et al. (2018), tidal marsh 55,000 sq. km. from Mcowen et al. (2018), and seagrass 325,000 sq. km. from McLeod et al. (2011). Higher estimates are available in Duarte et al. (2013)).

Glossary of Terms

2006 IPCC Guidelines	The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (or 2006 IPCC Guidelines) provide methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases. The guidelines provide advice on estimation methods at three levels of detail: *Tier 1* is the method default values were used to estimate carbon stocks. *Tier 2* is the method where it used mean carbon stock data collected in the country. In this report, the mean data collected in Pakistan for tidal marshes and mangrove forests were used. *Tier 3* is the method with the highest complexity and certainty, including emissions from equipment leaks, to provide more detail for estimating emissions from process vents.
2013 IPCC Wetlands Supplement	The "2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories" or IPCC Wetlands Supplement provides new guidance for countries to cover wetlands.
Above Ground Biomass (AGB)	Biomass contained within the plant's living leaves, branches, stems or aerial shoots.
Aboveground carbon	Organic carbon stored within the plant's AGB. Values reported in tons of carbon per hectare.
Allometric equation/model	Models for mangrove species are usually based on tree height, diameter at breast height (DBH). Equations can be species- or site-specific.
Belowground biomass	Biomass contained within the plant's living roots and rhizomes. May include necromass (litter or any detrital materials).
Belowground carbon	Organic carbon stored within a plant's belowground biomass. Values reported in tons of carbon per hectare.
Carbon stocks	The quantity of carbon contained in a "pool", meaning a reservoir or system which has the capacity to accumulate or release carbon.
Greenhouse gases (GHG)	Gases that absorb and emit radiant energy within the thermal infrared range, which can cause the greenhouse effect (that is, natural process that warms the earth's surface). The primary GHGs in the atmosphere are: water vapor (H_2O), carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3).
IPCC	Intergovernmental Panel on Climate Change is a United Nations body providing scientific information to governments that can be used to develop climate policies.
NDC	Nationally Determined Contribution is a document to communicate national efforts in response to climate change towards achieving the objectives of the UNFCCC, as submitted by a Party, in accordance with the rules of the Paris Agreement.

NbS	The International Union for the Conservation of Nature (IUCN) defines nature-based solutions as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”.
Reducing Emissions from Deforestation and Forest Degradation (REDD+)	The UN REDD+ Programme proposes achieving CO2 emissions reductions, forest conservation, and sustainable development by placing an economic value on forest carbon storage and facilitating the transfer of funds from developed to developing nations through international trade in carbon credits.
Soil/sediment carbon	Organic carbon stored within the soil/sediment. Values reported in tons of carbon per hectare, which is usually reported down to a specific depth (e.g., 100 cm).
Sustainable Development Goals (SDGs)	The UN SDGs are a collection of 17 global goals designed to achieve a better and more sustainable future.

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