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Responding Threats of Climate Change for a Resilient Maritime Sector of Pakistan



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EXECUTIVE SUMMARY

Climate change is a looming catastrophe, acting as a ‘threat multiplier’ for the existing challenges faced by Pakistan’s maritime sector. With about 1,001 kilometre coastline along the Arabian Sea, Pakistan’s coastal regions in Sindh and Balochistan hold immense ecological significance and economic importance, considerably contributing to the country’s GDP and trade connectivity. However, increasing vulnerabilities due to climate change impact these vital coastal areas. Rising sea levels may result in inundation of low-lying areas, degradation of crucial mangrove forests, compromised water quality, and disrupted ecosystem services. The convergence of natural and anthropogenic factors exposes Pakistan’s maritime sectors to heightened vulnerability.

The existing climate policy landscape showcases considerable efforts, including the National Climate Change Policy, National Adaptation Plan, and Sustainable Development Strategy. Legal frameworks like the National Climate Change Act and Environmental Protection Acts underscore Pakistan’s commitment to environmental protection. Yet, challenges persist due to policy gaps, inadequate monitoring mechanisms, and a lack of coherence among policies and institutions. Moreover, the incoherence among policies post the 18th Amendment, regulatory gaps in emissions standards, and overlooked maritime heritage conservation, hinder effective climate management. Additionally, lack of awareness and education about climate impacts on the maritime sector pose challenges.

Despite these challenges, there are several opportunities for Pakistan’s maritime climate response. These include: leveraging COP 27/28 decisions for climate financing, establishing a National Maritime Disaster Management Authority, and advocating for joint ventures to utilize carbon credits. Aligning national policies and harmonizing international obligations stand as important opportunities. However, threats loom large, encompassing institutional weaknesses, regulatory gaps, and the dominance of traditional fossil fuel-based maritime industries.

In conclusion, Pakistan must focus on ensuring coherence among national policies, coordinated actions, establishing robust mechanisms for maritime climate monitoring, formulating a Maritime Climate Adaptation Plan, commitment to integrating international obligations into domestic frameworks and embracing greener technologies in maritime industries to address the challenges. This comprehensive approach is crucial to fortify Pakistan’s maritime sector against climate threats and aligning it with global climate resilience goals.

1. INTRODUCTION

1.1 Background

a. The oceanic realm, teeming with life and resources, stands as an indispensable cornerstone for sustainable development worldwide. Healthy and resilient marine and coastal ecosystems are not merely natural habitats; they are essential sources of food, energy, and minerals. In addition, the oceans and seas are vital for global trade and maritime transportation networks, which is considered to be the backbone of global economy. Projections anticipate that the ocean economy's value is likely to soar to an impressive \$3 trillion annually by 2030, signifying a noteworthy 5 percent of the global Gross Domestic Product (GDP) (USAID, 2022). This value, however, merely scratches the surface when considering the immeasurable economic, environmental, social and cultural contributions of coastal and marine resources to individual communities and societies.

b. Around 63 percent of the biosphere's total value is attributed to marine ecosystems, predominantly those along coastlines (Trakadas, 2020). Sectors like coastal tourism sustain up to 40 percent of the GDP in select small island developing states. Likewise, marine fisheries provide nearly 20 percent of animal protein intake for billions globally. These few statistics underscore the critical role of these ecosystems in strengthening the resilience of developing nations.

c. Notwithstanding the above, the invaluable oceanic ecosystems face multifaceted challenges, foremost of which is climate change. The oceans, key players in climate regulation, absorb a staggering 90 percent of the excess heat generated by global warming and approximately 25 percent of carbon emissions (Izagirre et al., 2020). Yet, this crucial role comes at a cost which are rising sea levels, ocean acidification, and disruptions in ocean ecosystems. These adverse impacts of climate change are deteriorating the ocean's health. Compounded by pollution, these factors contribute to the disruption of ocean food webs, mass die-offs, and a decline in species diversity.

d. With climate change acting as a threat multiplier, the oceans also grapple with direct human impacts such as over-consumption of natural resources and overfishing. These complex and interrelated challenges demand an urgent and comprehensive understanding, culminating in a holistic, ecosystem-based management approach across sectors. As national ocean economies burgeon at a rapid pace, the need to safeguard and manage these invaluable resources becomes increasingly pressing (UNFCCC, 2022).

e. Pakistan, a country with about 1,001 kilometer coastline along the Arabian Sea, embodies a crucial coastal and marine landscape integral to its ecological, economic, and societal fabric. Its coastal regions in Sindh and Balochistan provinces hold immense ecological

significance. These regions house diverse ecosystems like mangrove forests and deltaic areas vital for biodiversity conservation and marine life sustenance. Economically, these areas support trade activities facilitated by ports and contribute significantly to Pakistan's GDP and trade connectivity as about 91 percent of the country's trade is dependent on maritime transportation (IUCN, 2017).

f. The immense ecological, socioeconomic, and geostrategic prominence of coastal and marine ecosystems cannot be overlooked. While Pakistan is heavily reliant on major maritime sectors like trade, shipping, ports and harbours, fisheries, shipbreaking and recycling, a large segment of economy has supplementary dependencies on a host of other various maritime sectoral economies.

g. The diversity of the vibrant maritime landscape comes with plethora of growing vulnerabilities, notably from the increasing impacts of climate change. Rising sea levels have already led to the inundation of low-lying areas around Balochistan coast and Indus River Delta, degradation of vital mangrove forests, declining water quality, and reduced productivity in fisheries. Coastal areas, especially in Sindh, confront heightened vulnerability due to tidal flat topography and dense industrial activities concentrated around metropolises like Karachi (ADB, 2017; Kidwai et al., 2016; PNSC, 2019).

h. As per the global climate indices, Pakistan ranks among the most vulnerable countries, despite its negligible contribution to global Greenhouse Gas (GHG) emissions. Some of the visible impacts of climate change in Pakistan have been recurrent floods, heatwaves, and degradation in air quality over the past few decades. These negative impacts are considered to be more prominent in the coastal regions of the country.

1.2 Significance of Study

a. The climate change not only has environmental and ecological impacts, it also has social, economic and political repercussions. Unfortunately, the ultimate sufferer is the subject (people) of the country. It needs no emphasis that the climatic change poses challenges to survival and dignity of people and state, ultimately threatening the national security of the country. Climate change is also a major impediment in the achievement of the UN Sustainable Development Goals (SDGs).

b. The confluence of natural and anthropogenic factors renders Pakistan's coastal and marine sectors increasingly vulnerable to the adverse impacts of climate change. Preserving these vital coastal regions, their ecosystems, and the livelihoods of millions necessitates urgent and comprehensive measures (Ali et al., 2020).

c. This research report would help in analysing the state of climate vulnerability of Pakistan through the analysis of global climate indices, policy and implementation gaps. The research report will also help in strategizing a way forward for a resilient maritime sector of Pakistan. The research report will also help in crystalizing climate response measures and policy recommendations.

1.3 Objective of the Study

a. The underlying objective of the research report is to identify the threats of climate change to Pakistan in maritime domain and propose a climate response strategy for the development of a resilient maritime sector. The research report also seeks to examine the policy gaps and voids in implementation and manifestation of regulatory frameworks related to climate change in maritime domain.

b. The tertiary purpose is to identify the global climate indicators and their data gathering mechanism to assess climate vulnerability of various maritime sectors.

c. The study also seeks to carry out SWOT analysis of Pakistan's maritime climate preparedness and response with a view to proffer pertinent recommendations. Efforts have also been to explore opportunities for capacity building and bringing Pakistan in line with the international standards.

d. The central theme of the research report revolves around how Pakistan should respond to climate change for building a resilient and robust maritime sector to benefit from it in the best possible way.

1.4 Problem Statement

a. While the adverse impacts of climate change have been recognized at the national level, there is less recognition of impending threats of climate change in maritime domain. A coordinated, synergetic, comprehensive and coherent response is unfortunately lacking to build a resilient maritime sector of Pakistan.

b. The current national policy and regulatory framework of Pakistan fail to address the issue of climate change in maritime domain. As an example, the National Adaptation Plan 2023, issued of Ministry of Climate Change (MoCC), contains a brief mention about the threats to "coastal and marine areas", but does not wholesomely address the intricacies of climate change in various maritime domains.

c. Addressing these challenges require policy interventions, adoption of sustainable development practices, and cooperation with international partners / stakeholders. These are believed to be the missing links in the overall governance framework to ensure a resilient and sustainable maritime sector of Pakistan.

d. A need is therefore felt to address the conundrum of climate change in maritime domain which is believed to be getting less attention among policymakers and relevant stakeholders at national level. Hence, there is a need to adopt modern research technique like SWOT analysis to explore a way forward.

1.5 Gap of Knowledge

The existing body of research concerning climate change impacts on maritime domains often falls short in comprehensively delineating the full spectrum of maritime activities and their vulnerabilities to climate change. Many studies tend to overlook the intricate interconnections between diverse maritime sectors, neglecting to encompass the entirety of maritime activities, including trade, shipping, fisheries, shipbreaking operations, shipbuilding, coastal tourism and ecosystems. Moreover, these studies frequently lack an in-depth analysis of localized impacts on specific coastal regions, particularly in nations like Pakistan, leading to a gap in understanding the nuanced and multifaceted repercussions of climate change within the maritime domain at both macro and micro levels.

1.6 Research Questions

Pakistan observes frequent climate extreme events and the maritime segment is considered vulnerable, having higher climate risk, degree of which is unknown. Does Pakistan's policy and strategical frameworks respond to the climate risks in its sensitive maritime segment? Concerns linger among stakeholders regarding effective response strategies, given federal and provincial complexities post the 18th amendment. From this, further questions arise:

- a. What are the Pakistan's vulnerability index for maritime sectoral economies considering the climate indicators?
- b. What are the strengths and weaknesses in Pakistan's maritime climate preparedness and implementing response strategies?
- c. What should be the maritime climate response strategy for Pakistan?

1.7 Conceptual Framework / Research Methodology

a. The subject study involved extensive literature review and content analysis to gauge the existing knowledge landscape. This evaluation aimed to determine gaps in national and provincial response strategies vis-à-vis the demands posed by the evolving challenges. Subsequently, intermittent field visits allowed for first-hand examination of the tangible and intangible ramifications of climate change on the coastal and marine ecosystems along Sindh and Balochistan coast. These visits delved into issues like seawater intrusion's effects on

coastal areas, and the experiences of fisherfolk amid changing sea conditions.

b. Engagement with stakeholders formed another crucial facet, involving interviews with diverse communities ranging from fishermen to port authorities, tourism operators, tradespeople, and locals. These interviews served understand domain-specific deviations linked to climate change. Building upon these insights, consultative sessions fostered in-house discussions with NIMA professional. These sessions synthesized the gathered information and experiences to propose robust strategies and recommendations. The goal was to devise effective responses to mitigate climate change-induced devastations impacting Pakistan's maritime sector and its associated economy.

1.8 Limitations and Constraints of Study

a. The study encountered limitations stemming from lack of data availability and authenticity in various maritime sub-sectors. Stakeholder feedback varied, leading to potential gaps in representing all perspectives.

b. The study predominantly emphasized addressing policy and legal framework gaps in Pakistan's maritime climate action. While acknowledging individual sub-sector vulnerabilities briefly, it strived for a holistic vulnerability assessment to ensure overarching, yet comprehensive recommendations.

1.9 Definition of Major Terms

a. **Climate Adaptation:** Climate adaptation refers to the process of adjusting to the current or expected climate change impacts. It involves taking measures to minimize vulnerability and enhance resilience in ecosystems, societies, and economies.

b. **Climate Mitigation:** Climate mitigation involves actions and strategies aimed at reducing or preventing the emission of greenhouse gases (GHGs) to lessen the magnitude of climate change. It focuses on limiting the drivers of climate change to stabilize or decrease its effects.

c. **ECVs (Essential Climate Variables):** ECVs are a set of key climate variables used to describe Earth's climate system. These include parameters like temperature, precipitation, greenhouse gas concentrations, sea level, and ice extent, crucial for understanding climate patterns and changes over time.

d. **Nature-Based Solutions:** Nature-based solutions (NbS) involve utilizing natural ecosystems or processes to address environmental challenges, such as climate change. They leverage the

inherent abilities of ecosystems to provide sustainable and effective means of adaptation and mitigation.

e. **Vulnerability**: Vulnerability refers to the degree to which a system (ecological, social, or economic) is susceptible to harm from climate change impacts. It encompasses factors like exposure, sensitivity, and adaptive capacity.

f. **Sensitivity**: Sensitivity relates to how strongly a system or entity is affected by changes in climate variables. It measures the degree of response or impact that a system experiences due to external changes in climate conditions.

g. **Adaptive Capacity**: Adaptive capacity signifies the ability of a system or community to adjust and cope with changing climate conditions. It involves resources, knowledge, institutions, and infrastructure that enable adaptation to climate change impacts.

h. **Disaster**: A disaster is an event, often sudden and severe, that causes significant disruption, destruction, and harm to communities, leading to widespread human, material, economic, or environmental losses.

2. CLIMATE CHANGE INDICATORS

2.1 Climate Change Indicators

a. An indicator is an indication or a measurement of the presence or occurrence of any process / phenomenon (Di Napoli et al., 2022). In climate science, indicators represent the state or trend of various environmental and societal conditions for a given area, over a specific stretch of time (GCOS, 2020). The Climate Indicators serve as important ways to track and report climatic changes. These can be useful to critically understand the changes occurring in the marine environments. These also help in trend analysis and directing the adaptation and mitigation efforts for a sustainable maritime sector.

c. Multiple technical bodies, including the National Oceanic and Atmospheric Administration (NOAA), European Environment Agency, United States Environmental Protection Agency (US EPA), and National Aeronautics and Space Administration (NASA), have formulated distinct climate indicators (EPA, 2014; NASA, 2022; NOAA, 2023). The climate indicators formulated by these organizations have been primarily adopted by the US and Europe to suit their own environment. For example, the climate indicators formulated by US EPA would include region-specific indicators besides the other (standard) indicators.

d. In addition to above, the World Meteorological Organization (WMO) has also formulated a set of global climate indicators, which are

considered more comprehensive. These are being widely used all over the world. The WMO climate indicators also offer essential support to the efforts of the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) at a global level. Therefore, WMO climate indicators have been used in this study to analyze the scenario of Pakistan's maritime sector.

e. For the sake of clarity, global climate indicators used by various organizations are explained below:

2.2 Global Climate Indicators by WMO

a. The global climate indicators provided by the WMO are key metrics used to assess and communicate the state of the Earth's climate system. These indicators offer insights into various aspects of climate change and its impacts on our planet. They are derived from the analysis of specific data or trends obtained by monitoring a range of physical, chemical, and biological variables called Essential Climate Variables (ECVs) across different regions and timeframes. They offer valuable insights into the health and behavior of the climate system, allowing scientists, policymakers, and the public to understand the trends and potential implications of climate change (WMO, 2019).

b. The climate indicators formulated by WMO fall in following seven categories:

- (1) Surface temperature
- (2) Ocean heat content
- (3) Atmospheric Carbon Dioxide (CO₂)
- (4) Ocean acidification
- (5) Sea level
- (6) Glacier
- (7) Arctic and Antarctic sea ice extent

c. Amongst the above WMO climate indicators, the last indicator i.e. Arctic and Antarctic sea ice extent is not directly relevant to Pakistan barring the global sea level rise resulting from melting of Arctic and Antarctic ice. Remaining indicators have been taken into consideration during the course of research and accordingly incorporated in the study.

2.3 Climate Indicators by US-EPA

a. US-EPA's climate indicators track and communicate observed changes in climate-related causes and effects, aiding in understanding climate trends and informing science-based decision-making. Data, sourced from multiple agencies and institutions, provide evidence of climate change's ongoing impact globally, particularly in the United States (EPA, 2014).

b. There are 48 indicators formulated by US-EPA to monitor the climate trends. These indicators are divided into undermentioned six categories:

- (1) Greenhouse gases (4)
- (2) Weather and climate (9)
- (3) Oceans (5)
- (4) Snow and Ice (12)
- (5) Health and Society (10)
- (6) Ecosystems (8)

c. Amongst the indicators by US-EPA, several do not directly relate to Pakistan due to their localized context (such as Arctic Sea Ice and Great Lakes Ice Cover). Other relevant indicators have been considered in the research report.

2.4 Climate Change Indicators for the Maritime Domain of Pakistan

a. The climate change indicators formulated by WMO and US-EPA that are applicable to the maritime domain of Pakistan are identified with respect to their direct or indirect relevance. In addition, each indicator's data sources in Pakistan are provided against it. Efforts have also been made to identify the institution / organization from where necessary data and information regarding the climate change indicator can be obtained.

b. Currently, the data regarding climate change is gathered by multiple organizations in Pakistan. There is a dire need to have a focal point for data collection where all climate change-related data is received, collated, analysed and utilized. The data may be later disseminated to concerned quarters, if required. It is opined that Ministry of Climate Change (MoCC) might be the most suitable ministry to serve as the focal point for this purpose.

Table 5.1: WMO's Global Climate Indicators

S No	Category	Indicators	Applicability in Global Maritime Domain	Applicability in Pakistan's Maritime Domain		Data Sources for Climate Indicators in Pakistan
				Direct Relevance	Indirect Relevance	
1.	Temperature and Energy	Surface Temperature				Pakistan Meteorological Department (PMD)
		Ocean Heat				PMD
2.	Atmospheric Composition	Atmospheric CO ₂				PMD
3.	Ocean and	Ocean				PMD

	Water	Acidification				
		Sea Level				• HPN (Hydrographer of Pakistan Navy) • Pakistan Council of Research in Water Resources (PCRWR)
4.	Cryosphere	Glaciers				• National Centre for Remote Sensing and Geo-Informatics (NCRG) • PMD
		Arctic and Antarctic Sea Ice Extent				-

Table 5.2: US-EPA's Climate Change Indicators

S No	Category	Indicators	Applicability in Global Maritime Domain	Applicability in Pakistan's Maritime Domain		Data Sources for Climate Indicators in Pakistan
				Direct Relevance	Indirect Relevance	
1.	Greenhouse Gases	U.S. Greenhouse Gas Emissions				-
		Global Greenhouse Gas Emissions				United Nations Framework Convention on Climate Change (UNFCCC)
		Atmospheric Concentrations of Greenhouse Gases				National Oceanic and Atmospheric Administration (NOAA)
		Climate Forcing				Intergovernmental Panel on Climate Change (IPCC)
2.	Weather and Climate	U.S. and Global Temperature				• Goddard Institute for Space Studies (GISS)-NASA • National Oceanic and Atmospheric Administration (NOAA)
		Seasonal Temperature				PMD
		High and Low Temperature				PMD

		s				
		Heat Waves				PMD
		U.S. and Global Precipitation				- Global Precipitation Measurement (GPM) – NASA - PMD
		Heavy Precipitation				PMD
		Tropical Cyclone Activity				- PMD - HPN
		River Flooding				- PMD - Pakistan Water and Power Development Authority (WAPDA)
3.	Ocean	Drought				- National Drought Monitoring Centre - PMD - National Agromet Centre - PMD - WAPDA
		Ocean Heat				PMD
		Sea Surface Temperature				PMD
		Sea Level				- National Institute of Oceanography (NIO) - HPN
		Coastal Flooding				- PMD - HPN - National Disaster Management Authority (NDMA)
		Ocean Acidity				PMD
4.	Snow and Ice	Arctic Sea Ice				-
		Antarctic Sea Ice				-
		Ice Sheets				-
		Glaciers				- PMD - Pakistan Space and Upper Atmosphere Research Commission (SUPARCO)
		Arctic Glaciers				-
		Lake Ice				-
		Great Lakes Ice Cover				-
		Snowfall				PMD

		Snow Cover				PMD
		Snowpack				-
		Permafrost				-
		Freeze-Thaw Conditions				-
4.	Health and Society	Heat-Related Deaths				• PMD • Ministry of National Health Services, Regulations and Coordination (NHSRC) • NDMA
		Heat-Related Illnesses				
		Cold-Related Deaths				
		Heating and Cooling Degree Days				PMD
		Residential Energy Use				Pakistan Bureau of Statistics (PBS)
		Lyme Disease				NIH
		West Nile Virus				NIH
		Length of Growing Season				National Agromet Centre - PMD
		Growing Degree Days				PMD
		Ragweed Pollen Season				-
5.	Ecosystem	Wildfires				-
		Streamflow				• PMD • WAPDA
		Stream Temperature				• PMD • PCRWR
		Lake Temperature				-
		Great Lakes Water Levels and Temperatures				-
		Bird Wintering Ranges				• Pakistan Wetlands Programme (PWP) • International Union for Conservation of Nature (IUCN) Pakistan
		Marine Species Distribution				• Marine Fisheries Department (MFD) • World Wildlife Fund for

		Leaf and Bloom Dates				Nature (WWF)
						National Agromet Centre - PMD

c. This above table has been formulated with a view to understand the intricacies of climate change in the maritime domain of Pakistan. Furthermore, the identified data sources against each indicator will act as a directory for future research.

3. PAKISTAN'S VULNERABILITY IN GLOBAL CLIMATE INDICES

3.1 Climate Vulnerability

a. Climate vulnerability refers to the degree to which a system, community, population, or region is susceptible to harm from climate-related stresses and hazards. It encompasses the exposure, sensitivity, and adaptive capacity of a system in the face of adverse climate impacts (Hussain et al., 2020).

d. Assessments of climate vulnerability are multi-dimensional and can encompass various scales, from local communities to entire nations or regions. They are crucial for informing decision-making processes related to climate adaptation, disaster risk reduction, resource allocation, and policy formulation to build resilience and reduce vulnerabilities in the face of a changing climate (Stockholm Environment institute, 2017). For example, the tropical cyclones mostly occur around the equator between 5 degree to 30-degree latitude in the south Pacific Ocean and Indian Ocean (particularly Bay of Bengal and North Arabian Sea), the Western Pacific Ocean is more prone to typhoons. Accordingly, climate vulnerability of these regions and local communities residing therein would be much higher. Similarly, Pakistan has experienced extreme weather events and has been exposed to torrential rains and floods which have affected coastal regions, particularly Balochistan.

3.2 Global Climate Risk Indices

a. Global climate risk indices play a pivotal role by assessing and quantifying the vulnerability of countries to climate change-induced hazards. These indices integrate various climatic parameters, analysing historical data to predict future risks. Importantly, they offer a comparative framework, enabling nations to benchmark their vulnerability, prioritize actions, and mobilize resources efficiently. The assessment also considers factors such as fatalities, economic losses, and impacts on gross domestic product (GDP) to provide an annual comparative analysis of countries' climate risks and vulnerability.

b. By highlighting vulnerable regions and sectors, these indices steer policymaking, aid in resource allocation, and foster international cooperation to mitigate risks, enhance resilience, and propel

sustainable development amidst escalating climate challenges worldwide (GCOS, 2020).

3.3 Ranking of Pakistan in Global Climate Risk Indices

a. There are three leading climate risk indices which are widely used and referred to in existing pool of literature, worldwide. These are the GermanWatch's Global Climate Risk Index, Climate Change Performance Index (CCPI), and Notre Dame Global Adaptation Initiative (ND-GAIN). These have been developed by various agencies for countries aim to assess and compare exposure and vulnerability to climate-related risks such as extreme weather events, sea-level rise, and food insecurity. These indices aim to provide policymakers and other stakeholders with a comprehensive understanding of the climate risks facing different countries and the populations living within them.

b. These indices serve as a tool for monitoring progress in climate adaptation efforts and can provide a basis for international comparisons. They also help in holding countries accountable, along with better understanding and managing their climate risks, promoting resilience, and reducing the impacts of climate change on people, ecosystems, and economies. Following is a brief breakdown of the notable indices and Pakistan's standing for a better analysis and recommendations:

3.3.1 GermanWatch Global Climate Risk Index 2021

a. **Background.** The Global Climate Risk Index 2021, published by GermanWatch, is an annual report that analyzes the impacts of extreme weather events on countries around the world. The report uses data from the past 30 years to rank countries based on their vulnerability to climate change.

b. **Methodology.** The methodology of the GermanWatch Global Climate Risk Index is based on four factors: the number of deaths, the number of people affected, the economic losses, and the loss in terms of GDP per capita. These factors are used to calculate a Climate Risk Index (CRI) score for each country. The CRI score is calculated by comparing the country's values for each factor to the global average for that factor. The countries with the highest CRI scores are considered to be the most vulnerable to climate change.

c. **Ranking of Pakistan.** According to the GermanWatch Global Climate Risk Index 2021, Pakistan is ranked as the fifth most vulnerable country in the world to climate change. Pakistan has consistently ranked high in the Index due to its exposure to extreme weather events such as

floods, droughts, and heatwaves (Global Climate Risk Index 2021, 2021).

3.3.2 Climate Change Performance Index (CCPI)

a. The Climate Change Performance Index (CCPI) is an annual report published by the Germanwatch, NewClimate Institute and Climate Action Network Europe that assesses the climate protection performance of 60 countries, accounting for over 90% of global greenhouse gas (GHG) emissions. The report analyses the countries' efforts in reducing greenhouse gas emissions, promoting renewable energy, and implementing climate policies.

b. **Methodology:** The CCPI report uses 14 indicators to assess a country's climate performance. These indicators are divided into four categories: GHG emissions, renewable energy, energy use, and climate policy. The countries are then ranked based on their overall performance in these categories.

c. **Ranking of Pakistan:** In the latest Climate Change Performance Index 2021, Pakistan is ranked 133rd out of 163 countries, with a low overall score of 23.63 out of 100. Pakistan is ranked very low on the GHG emissions indicator, with a score of 9.52 out of 100. The country's renewable energy share is also very low, with a score of 8.16 out of 100, indicating a lack of investment in the renewable energy sector. Pakistan's energy use is ranked slightly higher, with a score of 40.32 out of 100, due to improvements in energy efficiency. In terms of climate policy, Pakistan has a low score of 24.82 out of 100, indicating a lack of ambition and progress in implementing climate policies and measures (CCPI, 2023).

3.3.3 Notre Dame Global Adaptation Initiative (ND-GAIN)

a. The Notre Dame Global Adaptation Initiative (ND-GAIN) is a research project by the University of Notre Dame that assesses countries' vulnerability to climate change and their readiness to adapt to the changing climate. The ND-GAIN Country Index ranks countries based on their vulnerability and readiness scores.

b. **Methodology:** The ND-GAIN Country Index methodology combines multiple factors to assess a country's vulnerability and readiness to adapt to the impacts of climate change. The vulnerability score considers exposure, sensitivity, and adaptive capacity of a country's population, ecosystems, and infrastructure. The readiness score reflects the country's ability

to leverage investments and convert them into adaptation actions that enhance adaptive capacity and reduce vulnerability. The ND-GAIN Country Index uses a range of publicly available data sources to gather information about each country's performance in the different factors.

c. **Ranking of Pakistan:** In the latest ND-GAIN Country Index report, which was published in 2020, Pakistan is ranked 124th out of 181 countries, with an overall score of 43.2 out of 100. Pakistan's ranking reflects its high vulnerability to climate change impacts and lower current readiness to adapt. Pakistan's vulnerability score is 45.4 out of 100, ranking 105th globally, while the readiness score is 41 out of 100, ranking 121st globally. This score reflects the country's current inadequate capacity to adapt to the impacts of climate change. This is influenced by factors such as low per capita income, poor infrastructure, and political instability (Notre Dame Global Adaptation Initiative, 2023).

3.3.4 Analysis

a. Analysing the indices' ranking, the nation's vulnerability is notably high due to frequent extreme weather events, inadequate climate policies and their implementation, & a lack of substantial investment and infrastructure. This is particularly alarming considering Pakistan's negligible contribution to global GHG emissions i.e., 0.93%, in comparison to other nations (UNDP, 2022).

b. Due to their complex and sensitive ecological interconnections, the impacts of even slightest change in global temperature are exponentially pronounced on the marine biodiversity of the warm waters of Pakistan - as compared to terrestrial (Antão et al., 2020). Leveraging these findings, this report aims to underscore the immediate need for policy reforms, advocate robust resilience strategies, and provide a data-driven roadmap for investing in climate response measures for Pakistan's maritime sector.

4. STATE OF CLIMATE KNOWLEDGE AND DATA AVAILABILITY

4.1 Data Availability and Access to Climate Knowledge

a. High-quality and accurate data is fundamental for robust climate policy formulation. These data strengthen evidence-based policymaking, facilitating targeted interventions, resource allocation,

and strategic planning to effectively tackle climate change impacts, enhance resilience, and drive sustainable development agendas.

b. In Pakistan, challenges persist in both the scarcity and quality of climate data (Zaheer, 2019). Furthermore, the absence of centralized oversight leads to duplicated efforts and inconsistencies. Insufficient specific data on adaptation and mitigation strategies impedes informed policymaking, highlighting the pressing need for enhanced coordination, resource allocation, and improved data quality in combating climate change impacts.

c. The existing major sources of climate data in Pakistan come from various institutions and agencies such as:

(1) Pakistan Meteorological Department (PMD): Responsible for weather forecasting, early warnings, and climate-related information dissemination.

(2) Global Change Impact Studies Centre (GCISC): Engaged in climate change impact research, providing data, and assisting policymakers.

(3) Pakistan Agricultural Research Council (PARC): Focused on agriculture-related climate data and solutions.

(4) Pakistan Council of Research in Water Resources (PCRWR): Conducts research on various water-related aspects, including quality assessment and management.

(5) Water and Power Development Authority (WAPDA): Deals with water, hydropower, and related research and development.

4.2 Challenges in Climate Data Collection and Collation

a. Acquiring and managing climate data for policymaking necessitates a robust approach. Establishing a climate-ready data capability involves aggregating diverse data from numerous sources, ensuring access to vetted, current information critical for making strategies and monitoring sustainability initiatives.

b. One of the limitations highlighted during the conduct of the study was related to non-availability of adequate climate data. Where available, the data is being collected by more than one organization, resulting into fragmented and disjointed efforts. Pakistan, being one of the developing countries, lacks in access to requisite technology, know-how, and trained human resource, which are available to the advanced countries. This limitation can be addressed only if we are cognizant about the shortcomings. Accordingly, efforts have been

made to highlight some of the glaring challenges in obtaining and utilizing the existing climate data in Pakistan, which are:

(1) **Fragmented Information.** Lack of coordination and communication among ministries and sectors leads to fragmented data collection and dissemination, hindering effective decision-making.

(2) **Lack of Centralized Coordination.** The absence of a centralized system to oversee and avoid overlapping research efforts results in inefficiencies and duplications in climate-related studies. In this regard, MoCC is considered as the most suitable to serve as a centralized source for climate data collection and collation. This will also address the issue of fragmented data.

(3) **Limited Capacity and Resources.** Institutions suffer from inadequate technical, human and financial resources, affecting their ability to generate comprehensive and timely data through the use of latest technologies. Individual departments should ascertain respective shortcomings and initiate appropriate action for capacity enhancement and building up of resources.

(4) **Insufficient Data on Adaptation and Mitigation.** There is a general scarcity of specific information and data on climate adaptation and mitigation, making it challenging for the authorities to formulate new and review existing policies. This study calls for a guiding framework to ensure collection of authentic climate data, followed by expert analysis, ultimately producing plausible climate response data to inform policy decisions.

(5) **Provincial and Local Level Incoherence.** The information system at provincial and local levels is fragmented, lacking legitimacy and authenticity, further impeding effective decision-making, particularly post-18th Amendment. There is an urgent need for synergetic efforts to coordinate data collection and analysis between provincial and local levels in line with the national policies.

c. In order to overcome these challenges and shortcomings, there is a need to modernize data teams, address skill gaps through hiring, partnerships, or training. Collaboration between technology, data leaders, and businesses is crucial to explore innovative possibilities, ensuring effective management and measurement to leverage data for sustainable policymaking.

4.3 Importance of Traditional Climate Knowledge

a. Planet Earth is home to about 370 million indigenous people, described as 'original' or 'first' people with a cultural and historic affiliation with the place they live in (Latulippe & Klenk, 2020). For centuries, such communities have upheld their territories, cultures, and the knowledge that has been passed on through generations against

the overwhelming intrusion of the modern worldviews. Indigenous patterns of living - without significantly altering the environment but rather, forming a cooperative dependency - are considered closest to the contemporary idea of sustainability (Carmichael et al., 2018; Nalau et al., 2018).

b. Indigenous knowledge refers to the collective knowledge, practices, and innovations developed by such communities over generations, rooted in their cultures, traditions, and relationships with the environment. It encompasses a wide range of expertise, including Traditional Ecological Knowledge (TEK), weather forecasting, navigation techniques, and sustainable resource management (Alexander et al., 2011).

c. In the maritime domain, indigenous knowledge plays a crucial role in climate response. For instance, Indigenous Oceanic and Maritime Traditional Knowledge (IOMTK) offers insights into changes in ocean currents, marine species behavior, and weather patterns. Studies by the Intergovernmental Panel on Climate Change (IPCC) highlight the significance of integrating indigenous knowledge with scientific data for comprehensive climate adaptation strategies. Indigenous communities often possess deep insights into local ecosystems and climate variability, offering valuable perspectives for developing resilient adaptation plans, mitigating risks, and sustaining marine resources (Haque, 2019). The value of indigenous knowledge lies in its holistic approach, complementing scientific methods and offering context-specific solutions that contribute to more effective climate response measures in the maritime domain.

d. In Pakistan, indigenous people are not explicitly recognized in the 1973 Constitution, and there is a lack of specific laws safeguarding their rights and benefits. However, certain constitutional articles (e.g., Articles 1, 246, 247, 51, and 59) grant tribal people certain rights and political representation. Despite Pakistan's ratification of international treaties like the International Labor Organization (ILO), national and provincial laws can't be extended to tribal areas without the President's approval. While international treaties like Convention 107 include indigenous and tribal populations, Pakistan has not ratified the updated ILO Convention 169 (ADB, 2017).

e. The World Bank acknowledges that indigenous peoples' lands and resources are integral to their identities, but they face risks from development projects. The 2007 UN Declaration on the Rights of Indigenous Peoples (UNDRIP) is considered landmark but criticized for potentially reinforcing state-centric control. UNDRIP's interpretation of 'self-determination' was constrained, and it does not support forms of self-determination external to existing state structures.

f. As younger generations pursue different opportunities, the transmission of traditional knowledge related to fishing techniques,

coastal navigation, and ecological understanding is diminishing. On top of the diminishing knowledge and skilled human resource, the fact that these communities are not being equipped with updated technologies is the reason that the coastline of Pakistan is experiencing out migrations (Rehman, 2022). Given the limitations of state-centric approaches, there's a pressing need to restructure national frameworks to acknowledge and respect indigenous communities and their cultures. A more flexible, holistic self-determination criteria is required to allow various communities to assert their unique rights and identity in an increasingly globalized world.

g. For the fisher folk communities, the knowledge of factors such as changing water temperatures, wind patterns, species' breeding periods and distribution etc. is imperative to ensure safe and productive fishing trips, which has been delivered by the inter-generational observations and community interactions over the years.

h. Pakistan and the greater South Asian region is particularly vulnerable to climate change, and its impacts on the local fishing communities are manifold (Bhandari & Bhattarai, 2017; Salik et al., 2015). In this regard, the recognition of varying metrological patterns in the open sea, altering catch's species and breeding seasons at the major fishing hotspots is crucial, so is the gradual adaptation to different catch types, their associated sea-venturing and hunting methods. Although the technological advancements in weather and catch movement predictions have made fishing easier, traditional knowledge still plays a vital role and can essentially compliment the technologies to yield an effective nexus of socio-ecological and technological elements that can help these vulnerable communities continually adapt to the inevitable impacts of climate change.

i. In conclusion, the traditional coastal communities in Pakistan are grappling with the erosion of their knowledge due to various factors as explained above. Therefore, there is a need to protect the rights, knowledge and identities of certain coastal communities of Pakistan.

5. MARITIME CLIMATE VULNERABILITY OF PAKISTAN

a. Pakistan's maritime landscape is diverse, encompassing a spectrum of vital sub-sectors crucial for the nation's economic, environmental, and cultural fabric. From the maritime transportation facilitating regional trade to the intricate ecosystems of mangroves and coral reefs providing invaluable services, each facet plays a pivotal role. The infrastructure of ports and harbors, the Gadani Ship Recycling Yard, marine fisheries, and the interdependent livelihoods of coastal communities constitute essential elements (UNCTAD, 2020). Additionally, maritime tourism, heritage sites, energy resources, coastal ecology, and agricultural productivity face the impacts of seawater intrusion.

b. Derived from an extensive literature review encompassing scientific studies, reports, and expert insights from focused group discussions, this report has selected 12 major areas that represent the maritime sector of Pakistan (Table 3). Furthermore, to understand the gaps and opportunities for maritime climate response, the report aims to illustrate a repository of the potential repercussions on these maritime sub-sectors due to climate change. The table's contents provide a nuanced understanding of how climate change influences and amplifies vulnerabilities in Pakistan's maritime domains, offering a holistic perspective for informed decision-making and mitigation strategies.

Table 5.3: Possible Impacts of Climate-driven Challenges faced by Pakistan's Maritime Sectors
Climate Variables

<u>Sectors</u>	<u>Applicable</u>	<u>Possible Impact</u>
Maritime transportation	Ocean: Physical and Biogeochemical; Atmosphere	• Vessel damage due to altering oceanic chemistry and physiology • Degradation of metallic and wooden structures
Ports and Harbors' infrastructure	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere; Atmosphere: Surface, Upper Air	• Degradation of metallic, wooden, carbonaceous, and cemented infrastructure • Loss of infrastructure due to unpredictable and intense extreme weather events • Water logging and salinity
Ship Recycling Operations at Gadani	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere; Atmosphere: Surface, Upper Air	• Coastal erosion by extreme weather events and sea-level rise resulting in the loss of the area of shipbreaking plots • Changing soil properties of the beach
Marine Fisheries	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Habitat alteration and loss due to changing oceanic chemistry and physiology • Fish migration and possible extinction of native species • Fluctuation in plankton populations due to pollution, nutrient variability, etc.
Livelihood of Coastal communities	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Diminishing fish stocks impacting fishing villages • Loss of infrastructure and crops due to extreme weather events • Lack of fresh water due to irregular inflow from upstream • Coastal erosion
Mangroves, Coral reefs, and their ecosystem services	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Loss of mangrove species due to pollution, sea / freshwater intrusion, meteorological events • Marine pollution leading to coral bleaching and species die-off • Frequent oceanic turbulences affecting coral stability
Maritime Tourism	Ocean: Physical, Biogeochemical, and	• Loss of infrastructure due to extreme weather events

	Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Degradation and loss of marine archaeological sites • Polluted waters hindering underwater sports activities • Migration and relocation of coastal communities • Vessel damage due to changing oceanic chemistry • Degradation of infrastructure
Marine Archaeological resources	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Degradation of metallic, wooden, carbonaceous, and cemented infrastructure • Loss of infrastructure due to unpredictable and intense extreme weather events • Water logging and salinity
Energy and mineral resources	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Atmosphere: Surface, Upper Air	• Extreme and erratic meteorological events hindering onshore and offshore energy projects and infrastructure • Pollution and anthropogenic introduction of chemicals • Altering seabed mineral resources due to pollution and changing sea temperatures
Coastal ecology	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Degradation of metallic, wooden, carbonaceous, and cemented infrastructure • Loss of infrastructure due to extreme weather events • Loss of mangroves and associated species/communities • Loss of infrastructure and crops due to extreme weather events • Lack of freshwater due to irregular inflow from upstream • Shrinking of Indus River Delta
Infrastructure alongside the coast	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere; Atmosphere: Surface, Upper Air	• Degradation of metallic, wooden, carbonaceous, and cemented infrastructure • Loss of infrastructure due to extreme weather events • Degradation of foundations due to fluctuating groundwater levels • Damage due to sea-level rise • Water logging and salinity
Agricultural productivity	Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition	• Underground water level fluctuation • Seawater intrusion • Water logging and salinity • Shift in cropping patterns • Loss of arable land due to saltwater intrusion • Crop yield reduction due to soil salinity

c. This exercise of identifying the possible impacts arising from climatic changes has helped in understanding various tangible and intangible factors

on the selected maritime sub-sectors of Pakistan. Based on this, the report further aims to highlight the vulnerability of these sub-sector to identify high-risk sectors, which will help in guiding strategic planning, capacity building, and specific climate response strategies.

d. The author has conceived a matrix (Table 4) to assess the vulnerability ranking of selected maritime sub-sectors based on following three main factors:

- (1) Exposure (degree of climate risk)
- (2) Sensitivity (sector's susceptibility)
- (3) Adaptive Capacity (ability to adjust)

e. Each factor is rated on a scale (e.g., low, moderate, high), giving due consideration to the opinions of the Subject Matter Experts (SMEs) and sector-specific characteristics. The Adaptive Capacity (Column 4) incorporates multiple facets such as existing policies, technological infrastructure, community resilience, and institutional readiness. It is calculated by evaluating the sector's ability to implement adaptation measures, innovate, and respond effectively to climate risks through infrastructure, policies, training / education, and community engagements. The combination of these factors aids in determining the overall vulnerability of maritime sectors of Pakistan.

Table 5.4: Vulnerability Ranking of Selected Maritime Sub-sectors

Maritime sub-sector	Exposure	Sensitivity	Adaptive Capacity	Social Vulnerability	Economic Dependence	Technological Readiness	Ecological Importance	Total Vulnerability Score
Maritime Transportation	Moderate	Moderate	Moderate	High	High	Moderate	Moderate	7
Ports and Harbours' Infrastructure	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	7
Gadani Ship Recycling Yard	Moderate	Moderate	Moderate	High	Moderate	Low	Low	7
Marine Fisheries	High	High	Low	High	High	Low	High	9
Livelihood of Coastal Communities	High	Moderate	Moderate	High	High	Low	High	8
Mangroves, Coral Reefs, and Their Ecosystem Services	High	High	Low	High	Moderate	Low	High	9
Maritime Tourism	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate	6
Marine Archaeological	Medium	High	Low	Low	Medium	Low	Low	7

Resources								
Energy and Mineral Resources	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	6
Coastal Ecology	High	High	Moderate	Medium	Moderate	Low	High	8
Infrastructure Alongside the Coast	High	Moderate	Moderate	High	High	Low	Medium	8
Agricultural Productivity	High	Moderate	Low	High	High	Low	Medium	8

f. The ranking of Pakistan's maritime sectors reflects their vulnerability (V), which is a measure of exposure (E), sensitivity (S) and adaptive capacity (AC). Mathematically, the relationship can be expressed with following equation:

$$(V=E + S - AC)$$

g. While exposure, sensitivity and adaptive capacity are considered to be the main factors, social vulnerability, economic dependency, technological readiness and ecological importance are a few auxiliary factors that contribute to the vulnerability of the said sub-sectors.

h. For the sake of clarity, the reasonings adopted to accord the ranking (**low**, **moderate** and **high**) in Table 5.4 above, is explained with a few examples below.

(1) **Maritime Transportation.** The maritime transportation sector is moderately exposed to the effects of climate change because of the increasing impacts of extreme weather at sea, resulting in vessel damage and navigational complications. Similarly, it is sensitive to increasing ocean acidification and pollution particularly within ports and harbours. Both these have adverse effects on the ships' hull, machinery and hardware. However, the maritime transport sector is believed to be moderately adaptive to climate change as there is immense potential for technological advancements, fuel efficiency improvements, and cleaner energy utilization. International regulations also aim to reduce emissions and promote sustainability. Pakistan's maritime economy is highly dependent on this sector as 95 percent of Pakistan's trade (imports and exports) by volume and 90 percent of the trade by value is conducted through sea. Moreover, 100 percent of the country's petroleum imports are done through sea routes. Any delays in import of petroleum products is likely to create social unrest in the country due obvious reasons. Hence the social vulnerability of the sector remains high as depicted in the table above. With regards to the 'Technological Readiness', the transportation sector of Pakistan is considered to be moderate as the sector is not yet ready to transition to 'Greener Shipping' and embracing the related technologies in the short

or medium term. Overall, the Vulnerability score is assessed to be **7 out of 10**.

(2) **Ports and Harbours' Infrastructure.** Pakistan's ports and harbours are moderately exposed to the effects of climate change because of the robust and durable infrastructure, but remain exposed to the effects of tsunamis, cyclones and coastal erosion. However, the infrastructure is sensitive to climate-driven environmental degradation including corrosion, erosion and inundation. The moderate adaptive capacity can be attributed to the potential of smart port operations that encompass climate and disaster-compatible developments. In addition, periodic multi-hazard risk assessments and training of the workers is crucial. The smart port operations, although introduced on selected terminals at the ports of Karachi (KICT, PICT and SAPT) and Muhammad Bin Qasim, are at a limited capacity. The overall vulnerability score is assessed **7 out of 10**.

(3) **Marine Fisheries.** The marine fisheries of Pakistan are highly exposed to the effects of climate change due to their dependence on oceanic conditions and the complex interconnections within marine ecosystems. The delicate balance is disturbed by the changing ocean temperatures, ocean acidification, and extreme weather events. This leads to increased sensitivity due to the disrupted food chains, habitat degradation and species' relocation or die off. The low adaptive capacity of the sub-sector in Pakistan is attributed to weak policy framework and implementation related to pollution and environmental degradation impacting the fisheries. Moreover, the mangrove forests in the coastal regions of Pakistan, which act as a breeding ground for many fish species, shrimps and lobsters, are greatly affected by the climatic changes. This is further aggravated by unsustainable fishing practices and lack of alternate livelihood opportunities for the fishermen community, especially during two-month fishing ban period. Pakistan's fisheries' export contribution was mere \$496 Mn in FY 22/23 (GDP share 0.2%) where its estimated potential is about \$4-5 billion. This can be achieved by addressing the jurisdictional issues at sea, registration of fishing boats and allocated zoning / catch, along with the promotion of mariculture and aquaculture as alternate livelihood opportunity. Overall, the vulnerability score is assessed to be **9 out of 10**.

(4) **Other Sectors.** Maritime tourism, energy & mineral resources have been ranked as the least vulnerable, while mangroves, coral reefs, and their ecosystem services are ranked the most vulnerable. The rankings primarily highlight deficiencies in technical, policy, and institutional frameworks, especially in vulnerable sectors. They underscore the need to strengthen adaptive capacity, resilience, and social protection while safeguarding ecological significance through enhanced application and development of these frameworks.

6. SWOT ANALYSIS OF PAKISTAN'S MARITIME CLIMATE PREPAREDNESS AND RESPONSE

a. Preparedness in maritime climate domain entails necessary arrangements to cater for eventualities, formulating plans and testing them periodically for the purpose of review and modifications, training and educating the human resource on various aspects of climate response strategies and finally, sharing the requisite information with stakeholders and communities to equip them to deal with emergencies and eventualities. This would require initiating timely actions on implementation plans after a deliberate thought process.

b. Climate response involves mitigation, which is proactive in nature, while adaptation is reactive in nature. Application of both strategies is based on the nature of climate impact, vulnerability, sensitivity, and available resources.

c. SWOT analysis is a strategic planning tool used to evaluate Strengths, Weaknesses, Opportunities, and Threats associated with a particular entity or situation. It offers a comprehensive assessment of internal capabilities (Strengths and Weaknesses) and external factors (Opportunities and Threats), aiding in informed decision-making (Puyt et al., 2023).

d. In the context of assessing maritime climate response, SWOT analysis helps identify strengths in existing policies, weaknesses in regulatory frameworks, opportunities for improvements, and threats posed by the gaps. The given SWOT analysis, a product of intensive literature review and focused group discussions with maritime and climate experts, offers a nuanced understanding of the selected maritime sub-sector's climate preparedness to strategic interventions for enhanced resilience. Number of seminars conducted at NIMA on related maritime topics have also helped in arriving to certain conclusions.

Table 5.5: Strengths

Strengths
S1. Existing policies and strategies related to climate preparedness
S2. Adequate legal arrangements for climate response
S3. Stakeholder engagement at Federal level
S4. Pakistan's commitment to international obligations related to environmental protection and sustainable resource management as a signatory of MEAs
S5. Marine conservation initiatives (mangroves plantation, MPAs etc.)

Table 5.6: Weaknesses

Weaknesses
W1. Lack of coherence among various policies and legal arrangements
W2. Lack of mechanism for regular maritime climate monitoring

W3. Overlapping jurisdiction of federal and provincial departments and institutional ambiguity post-18 th Amendment
W4. Lack of inter-departmental coordination for cross-sectoral linkages
W5. Absence / understatement of climate change in policy frameworks
W6. Absence of mechanism to preserve and utilize traditional climate knowledge
W7. Absence of emissions from maritime transportation in legal frameworks
W8. Lack of budgetary provision for translation of FICCP's Coastal & Marine Ecosystems' strategies into planning and successive implementation at the Federal and Provincial levels
W9. Inadequate awareness/knowledge to tackle sea blindness and climate change
W10. Lacking capacity to gather, collate and analyse climate data

Table 5.7: Opportunities

Opportunities
O1. Establishing coherence between various national policies in maritime climate domain
O2. Development of Maritime Climate Adaptation Plan (Aligned with FICCP 2013)
O3. Revitalization of climate financing through COP 27 / 28
O4. Strengthening regulations for cleaner fuels in shipping
O5. Collaboration for establishment of Emission Control Areas (ECAs) & Marine Protected Areas (MPAs)
O6. Policy revision for maritime emission reduction
O7. National Action Plan for international maritime obligations
O8. Establishment of National Maritime Disaster Management Authority (NMDMA)
O9. Joint ventures and Public-Private Partnerships for carbon credits
O10. Advocate and benefit from capacity building / climate reparation / loss and damages funds
O11. Development of Smart/Blue port infrastructure and facilities

Table 5.8: Threats

Threats
T1. Lack of political will and prioritization of climate action in the maritime sector
T2. Limited institutional capacity and weak regulatory framework for addressing maritime emissions at federal and provincial level

T3. Insufficient resources for climate adaptation and resilience
T4. Shortage of skilled personnel for climate resilience and adaptation measures
T5. Resistance from vested interests
T6. Limited technology and viable alternatives to traditional fuels
T7. International pressure due to inadequate translation of international obligations into national/provincial policies and legal instruments
T8. Extinction of traditional climate knowledge

6.1 Discussion

6.1.1 Strength

a. Pakistan has established a comprehensive framework of policies and strategies to address climate change. These include the National Climate Change Policy (NCCP) of 2012, which was further amended in 2021 to align with evolving climate challenges. Additionally, the Framework for Implementation of Climate Change Policy in 2013 laid out a structured approach to execute climate-related initiatives. Pakistan's National Adaptation Plan (NAP) for the years 2023-2030 provides a forward-looking strategy for climate adaptation efforts. The Nationally Determined Contributions, initially established in 2016 and subsequently updated in 2021, delineate Pakistan's commitments to global climate goals.

b. Further bolstering this framework, Pakistan introduced the National Sustainable Development Strategy in 2017, outlining a holistic approach to balancing environmental, social, and economic development. The National Forest Policy of 2015 emphasizes the crucial role of sustainable forestry in climate mitigation and conservation. To address disaster risk, the National Disaster Risk Reduction Policy of 2013 provides a structured response mechanism. The National Marine Disaster Contingency Plan of 2007 – although equivocal - aims to enhance preparedness in maritime pollution-related scenarios.

c. In the realm of energy, Pakistan is making strides towards sustainability with policies like the Alternative and Renewable Energy Policy of 2019 and the Pakistan National Action Plan for Sustainable Energy for All in the same year. Similarly, the National Action Plan for Sustainable Consumption and Production, also established in 2019, seeks to promote responsible resource management. Biodiversity conservation is addressed through the Pakistan National Biodiversity Strategy and Action Plan of 2017.

d. Most prominently, the incorporation of climate considerations into national security is evident in the National Security Policy of 2022 is a recent feat. Furthermore, the National Adaptation Plan of 2023 builds upon previous efforts, providing an updated framework for climate adaptation in Pakistan. This set of policies and plans underscores Pakistan's commitment to addressing climate change.

e. In addition, Pakistan has strengthened its legal framework to address environmental and climate concerns through a series of legislative measures. The promulgation of the "National Climate Change Act 2017" marked a significant milestone in the country's efforts to combat climate change. This Act provides a structured approach towards climate adaptation and mitigation strategies. Complementing this, the "National Disaster Management Act 2010" outlines a robust framework for disaster preparedness and response, ensuring a coordinated approach in times of crisis. Federal and Provincial Environmental Acts play a pivotal role in environmental protection and conservation. The "Pakistan Environmental Protection Act, 1997" sets the foundation for environmental governance at the federal level, while provinces have enacted their own legislation such as the "Sindh Environmental Protection Act, 2014" and "Balochistan Environmental Protection Act, 2012" to address specific regional concerns. To safeguard natural resources, provincial Forest Acts, particularly the "Sindh Forest Act 2012" and "Balochistan Forest Act 2022," regulate and manage forest resources within their respective regions. The "Pakistan Maritime Security Agency Act 1994" focuses on marine pollution, emphasizing the importance of maintaining clean and healthy maritime environments. Lastly, the "National Energy Efficiency and Conservation Act 2016" underscores the significance of energy conservation and efficiency in Pakistan's sustainable development agenda. These legal arrangements collectively demonstrate Pakistan's commitment to environmental protection and sustainable resource management.

f. At the federal level, stakeholder engagement in Pakistan's climate efforts involves a diverse range of entities. This includes academia, think tanks, and Civil Society Organizations (CSOs) and non-governmental organizations (NGOs) who contribute valuable research and advocacy towards informed climate policies. The Ministry of Climate Change plays a central role in coordinating and implementing these policies, serving as a crucial interface between the government and stakeholders. Additionally, the NDMA is pivotal in disaster preparedness and response, aligning closely with climate resilience strategies. The Pakistan Meteorological

Department provides vital climate data and forecasting capabilities, enabling evidence-based decision-making.

g. Pakistan upholds its international commitments by being a signatory to several Multilateral Environmental Agreements (MEAs). Notably, as a participant in the Paris Climate Agreement of 2015 under the UNFCCC, Pakistan is dedicated to climate action and financial mobilization for sustainable initiatives. The Sustainable Development Goals (SDGs) for the years 2015-2030 encompass a comprehensive global development agenda, with Pakistan actively working towards achieving these 17 interconnected goals, with Goals 13 and 14 directly relating to maritime climate action. Additionally, Pakistan is a participant in the MARPOL, an international convention aimed at preventing pollution from ships, underlining the country's dedication to marine environmental protection.

h. Pakistan is actively engaged in marine conservation initiatives to safeguard its coastal ecosystems. This includes the establishment of Marine Protected Areas (MPAs) which serve as designated zones to preserve and protect marine biodiversity. Furthermore, extensive mangrove plantation efforts are underway, reinforcing coastal resilience and fostering vital habitats for diverse aquatic life. In future, Pakistan could benefit from the "High Seas Treaty" in protecting the deep-sea ecological diversity, contributing towards climate mitigation.

6.1.2 Weaknesses

a. Pakistan faces several weaknesses in its approach to maritime climate management. Firstly, there exists a notable lack of coherence among various policies and legal arrangements, creating potential inconsistencies and inefficiencies in climate-related initiatives post the 18th Amendment. This discrepancy is further compounded by the absence of a mechanism for regular maritime climate monitoring. The scarcity of reliable data and future planning exacerbates the vulnerability of coastal infrastructure to extreme weather events. Moreover, the overlapping jurisdiction of federal and provincial departments, coupled with institutional ambiguity post the 18th Amendment, leads to a fragmented response to maritime climate challenges. This issue is further intensified by a lack of inter-departmental coordination for cross-sectoral linkages, both at the federal-federal and federal-provincial levels.

b. Furthermore, the absence of National Environmental Quality Standards (NEQS) for maritime emissions creates a regulatory gap, particularly given the federal jurisdiction over ports. The lack of harmonized NEQS at both the federal and

provincial levels hinders a unified approach to addressing maritime emissions / discharges. "Merchant Shipping Ordinance 2001" primarily focuses on preventing pollution from ships, yet it lacks provisions concerning air pollutant emissions from all categories of sea-faring vessels. This omission extends to addressing energy efficiency, a critical factor regarding fuel consumption and energy wastage, which remains unacknowledged within the document. Furthermore, air pollutants are not adequately addressed within the highlighting a gap in managing emissions from maritime activities.

c. Similarly, emissions from maritime transportation remain insufficiently addressed in key frameworks like the NCCP 2021 and the NAP 2023. This gap limits the effectiveness of climate strategies within this sector. To address these weaknesses, Pakistan must prioritize the development of marine transport-specific federal and provincial climate change mitigation strategies. Additionally, the gaps in the "Fishing Vessels Inspection Rules" pertaining to the inspection of shipping emissions at the federal level need to be addressed for a more comprehensive approach to maritime climate management.

d. Traditional climate knowledge of coastal communities / fisherfolk is not adequately preserved or utilized within current maritime climate management frameworks, primarily due to the complex recognition criteria of such communities under national and international frameworks, along with the inability to gather, document and integrate their knowledge.

e. Additionally, the "National Maritime Policy 2002" does not explicitly incorporate climate change, which necessitates updating. Although, the "National Security Policy 2022" incorporates climate change as a threat exacerbating factor, it is not categorized as a distinct national security threat like others, potentially overlooking its far-reaching implications. Furthermore, the "National Maritime Disaster Contingency Plan", despite its existence, exhibits ambiguity regarding responsibility mechanisms, necessitating a review for clearer delineation.

f. The underwater and coastal heritage stand as invaluable historical monuments, possessing immense tourism potential. The existing heritage conservation frameworks in Pakistan, such as the National Heritage Conservation Act (NHCA), Sindh Cultural Heritage (Preservation) Act, and the Balochistan Antiquities Act, primarily safeguard terrestrial heritage, while none of these legislations explicitly address maritime archaeology or the preservation of underwater cultural heritage. The absence of dedicated provisions within these acts leaves a gap in the protection and management of Pakistan's maritime

archaeological sites against the repercussions of climate change.

g. Insufficient awareness and education regarding the impacts of climate change on the maritime sector contribute to what is often termed as "sea blindness." Addressing this challenge presents an opportunity for Pakistan to prioritize educational reforms featuring climate concepts, raising public and stakeholder awareness about the implications of climate change on maritime activities. In this regard, instituting a University of Maritime Sciences (UMS) to cover the range of maritime-related education and training could prove to be favorable. The UMS could eventually emulate the structure and functions of the World Maritime University in Malmo, Sweden. Similarly, promoting maritime interests through research organizations, think tanks, and activists is required. By proactively rectifying these weaknesses, Pakistan can significantly enhance its resilience and response capacity in the face of growing maritime climate challenges.

6.1.3 Opportunity

a. The revitalization of climate financing through COP 27/28 decisions represents a critical avenue for securing the financial resources needed to implement ambitious climate initiatives. This influx of funding can be channelled towards transformative projects, such as the development of Smart/Blue port infrastructure for renewable energy integration. Similarly, regulatory enhancements, including stricter fuel standards under the Merchant Shipping Ordinance 2001, offer a clear pathway to greener shipping practices. Formulation of a Maritime Climate Adaptation Plan under the updated Framework for Implementation of Climate Change Policy of 2013 is a crucial step towards ensuring coherence and effectiveness in climate strategies. This comprehensive plan would serve as a blueprint for safeguarding coastal communities, ecosystems and associated economy against the impacts of climate change.

Maritime disasters differ drastically from land-origin disasters, ranging from natural occurrences like cyclones and flooding to anthropogenic incidents such as oil spills and ship collisions. This necessitates establishment of NMDMA in Pakistan, which may run in parallel with the National Disaster Management Authority, specializing in tackling maritime emergencies. NMDMA would address maritime-specific environmental and meteorological disasters by fortifying preparedness to mitigate the ecological and economic impacts of such events.

b. Collaborating with regional and international stakeholders to establish Emission Control Areas (ECAs) on key maritime

routes further demonstrates Pakistan's commitment to global environmental protection. Moreover, revamping the National Environmental Policy 2005 to include targeted measures for emissions reduction in the maritime sector showcases a holistic approach to environmental stewardship. Additionally, developing a national action plan in line with the International Maritime Organization's MARPOL convention underscores Pakistan's dedication to international best practices.

c. Establishing MPAs will ensure the preservation of biodiversity and contribute to climate resilience, the High Seas Treaty or BBNJ is crucial in this regard, provided its clear provisions. Moreover, exploring joint ventures and public-private partnerships for carbon credit utilization provides a valuable avenue for sustainable economic growth while mitigating climate impacts.

d. The opportunity to advocate and leverage capacity-building and climate reparation funds through international funding and technology-transfer initiatives present a promising avenue for bolstering Pakistan's maritime climate response. This avenue allows tapping into crucial financial mechanisms to fortify adaptive measures and address vulnerabilities in the maritime domain. Additionally, ensuring coherence among policies such as the National Water Policy 2018, National Food Security Policy 2018, National Disaster Risk Reduction Policy 2013, and the National Security Policy of Pakistan 2022 is essential. This coherence fosters a synchronized approach, ensuring alignment and synergy between key national policies to effectively tackle climate challenges in Pakistan's maritime sector.

e. However, it is important to acknowledge that seizing these opportunities requires adequate capacity and resources. Building institutional and technical capabilities, alongside compliance with global environmental standards, is imperative to ensure successful implementation.

6.1.4 Threats

a. Pakistan's diverse climate-related policy frameworks showcase intent but face critical challenges hindering effective maritime climate management. Despite these policies, there's a glaring lack of coherence and monitoring mechanisms, intensifying inefficiencies post the 18th Amendment. This deficit aggravates due to unreliable data and cross-sectoral coordination hurdles. The maritime sector grapples with institutional weaknesses and feeble regulatory structures to address emissions at federal and provincial levels. Moreover, insufficient skilled workforce, inadequate funding, and industry

resistance impede resilience efforts. Transitioning to greener technologies encounters hurdles amidst the dominance of traditional fossil fuel-based maritime industries – a major obstacle in promoting a Blue Economy in Pakistan. Securing climate financing, especially for disaster-vulnerable coastal communities, remains a pressing challenge.

b. Adding to the complexity, international obligations aren't seamlessly integrated into national and provincial policies and legal frameworks, inviting external pressure. Case in point is the Hong Kong Convention and the EUSRR for the ship recycling sector. This may be avoided for forthcoming obligations such as High Seas Treaty by ensuring competent representation at the consultations related to the Treaty to present Pakistan's position and demands.

c. Addressing these multifaceted challenges demands a holistic strategy. It necessitates a concerted effort to rectify policy gaps, enhance regulatory frameworks, prioritize funding, promote technological transitions, preserve traditional knowledge, and align international commitments with domestic policies. Establishing robust monitoring mechanisms and bolstering cross-sectoral collaboration are pivotal to fortify Pakistan's maritime sector against escalating climate threats.

7. MARITIME CLIMATE RESPONSE STRATEGY FOR PAKISTAN

a. In navigating the complex interplay of scientific understanding, policy imperatives, and technical advancements, this chapter presents key strategies arising from thorough analyses. The assessments across multiple facets of maritime sub-sectors and their vulnerabilities proffer a strategic pathway, envisioned to strengthen national maritime resilience in the face of anthropogenic climate change. This chapter aims to provide a 'blue'-print for safeguarding maritime interests of Pakistan, while navigating the complexities of economic, environmental and social sustainability along with adaptive governance.

Table 5.9: Maritime Climate Response Strategy for Pakistan

Recommendation	Timeline	Response Type	Responsibility
Ensure coherence among key national policies and legal arrangements for synchronized approaches in tackling maritime climate challenges.	Medium Term	Adaptation	Ministry of Climate Change, National Disaster Management Authority, Ministry of Maritime Affairs, Environmental Protection Agency
Establish mechanisms for regular maritime climate monitoring to improve data authenticity.	Short Term	Adaptation	Ministry of Climate Change, National Institute of Oceanography, Pakistan Meteorological Department, Environmental Protection Agency, Ministry of

Recommendation	Timeline	Response Type	Responsibility
			Maritime Affairs
Develop National Environmental Quality Standards (NEQS) for maritime emissions.	Medium Term	Mitigation	Ministry of Climate Change, Environmental Protection Agency, Ministry of Maritime Affairs, Ministry of Science and Technology
Formulate a Maritime Climate Adaptation Plan in alignment with the Framework for Implementation of Climate Change Policy (FICCP) 2013.	Medium Term	Adaptation	Ministry of Climate Change, National Disaster Management Authority, Provincial Disaster Management Authorities
Address gaps in existing legislation to cover air pollutant emissions and energy efficiency in maritime activities.	Medium Term	Mitigation	Ministry of Climate Change, Ministry of Maritime Affairs, Environmental Protection Agency, Ministry of Law and Justice, Ministry of Climate Change
Develop a National Action Plan to harmonize international maritime obligations with national and provincial policies and frameworks for coherent integration.	Medium Term	Adaptation	Ministry of Maritime Affairs, Ministry of Climate Change, Ministry of Foreign Affairs, Ministry of Law and Justice, Provincial Governments
Create a Maritime Multi-Hazard Vulnerability and Risk Assessment (MMHVRA) for various sub-sectors to deliver a comprehensive understanding of risks in the maritime domain.	Short Term	Adaptation	Ministry of Climate Change, National Institute of Oceanography, Pakistan Navy, Ministry of Maritime Affairs, National Disaster Management Authority
Focus on nature-based solutions (mangrove plantation, coastal belt rehabilitation, MPAs etc.) to reinforce coastal resilience and foster diverse marine habitats.	Short Term	Adaptation	Ministry of Climate Change, Ministry of Maritime Affairs, Provincial Coastal Development Authorities, National Disaster Management Authority
Establish Pakistan's National Maritime Disaster Management Authority (NMDMA) to run in parallel to the existing National Disaster Management Authority, specializing in addressing maritime emergencies.	Short Term	Adaptation	Government of Pakistan, Ministry of Maritime Affairs, National Disaster Management Authority, Pakistan Navy, Ministry of Interior
Establish new and improve existing Marine Protected Areas (MPAs) (especially under upcoming BBNJ) to preserve biodiversity and enhance climate resilience.	Long Term	Adaptation	Ministry of Maritime Affairs, Ministry of Climate Change, Provincial Wildlife Departments, Environmental Protection Agency
Facilitate joint ventures and public-private partnerships for (blue) carbon credit utilization.	Medium Term	Mitigation	Ministry of Maritime Affairs, Board of Investment, Private Sector Partnerships, Climate Change Division

Recommendation	Timeline	Response Type	Responsibility
Incorporate blue carbon in Nationally Determined Contributions.	Long Term	Mitigation	Ministry of Climate Change, Ministry of Maritime Affairs, National Disaster Management Authority, Provincial Environmental Departments
Establish a University of Maritime Sciences, along with reforming school education curricula to foster knowledgeable individuals capable of researching and implementing maritime climate strategies.	Mid Term	Adaptation	Ministry of Education, Ministry of Maritime Affairs, Higher Education Commission
Overcome hurdles in transitioning to greener technologies within traditional fossil fuel-based maritime industries and transportation.	Long Term	Mitigation	Ministry of Maritime Affairs, Ministry of Science and Technology, Ministry of Energy, Board of Investment
Leverage capacity-building and climate reparation funds through international initiatives.	Long Term	Adaptation	Ministry of Foreign Affairs, Ministry of Climate Change, Ministry of Maritime Affairs, National Disaster Management Authority
Promote maritime research, including climate response through research organizations, think tanks, and activist initiatives.	Long Term	Adaptation	Ministry of Maritime Affairs, Ministry of Science and Technology, Research Institutes, NGOs, Civil Society Organizations

b. The convergence of policy and science forms the linchpin for Pakistan's maritime climate response. Recognizing the pivotal role of evidence-based policymaking, governments prioritize informed decisions, reinforcing their strategies to combat climate challenges. The synergistic approach acknowledges the indispensable contribution of science in crafting resilient policies. Initiatives like the 2021–2030 United Nations Decade of Ocean Science for Sustainable Development and the 2021–2030 United Nations Decade on Ecosystem Restoration reinforce this connection, promoting advanced understanding of oceanic and climatic dynamics while incorporating traditional ecological wisdom.

c. In navigating Pakistan's maritime climate challenges, a comprehensive approach encompassing both adaptation and mitigation strategies is imperative. The multifaceted recommendations presented in the study reveal the urgency for immediate adaptation measures, such as systematic monitoring, vulnerability assessments, and coastal resilience reinforcement. At the same time, the necessity for long-term mitigation strategies, including transitioning to eco-friendly technologies and leveraging partnerships for carbon credit utilization, emerges as pivotal for sustained resilience. Therefore, the incorporation of scientific insight with strategic policy interventions becomes the basis for steering Pakistan towards a sustainable future, emphasizing the need for a dual approach encompassing both adaptation and mitigation strategies in pursuit of Blue Economy.

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