# NEXUS OF CLIMATE CHANGE, SUSTAINABLE DEVELOPMENT GOALS AND VULNERABILITY OF MARITIME SECTORS – CASE OF PAKISTAN

***Fasiha Safdar***

*fasiha.nima@bahria.edu.pk*

***Wajih Ur Rehman***

*wajihurrehman2014@gmail.com*

***Salman Ul Haq***

*ulhaqsalman14@gmail.com*

*National Institute of Maritime Affairs,*

*Bahria University, Shangrilla Road, Sector E-8, Islamabad, Pakistan.*

The seas and coasts worldwide are vulnerable to climate change because of being at the natural ecosystems, at the forefront of changing weather patterns. The maritime sector of any country has the potential of transforming it into an economic force if sustained and managed properly. Oceans provide great ecosystem services, benefitting coastal communities in the process as well. However, increasing vulnerabilities due to climate change impact the 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. A case of maritime sector's vulnerability, studying Pakistan as a case, has been presented here in light of the changing properties of the Indian Ocean. The role of sustainable development in uplifting the local coastal communities and reducing vulnerability of the maritime sector has been explored in the study as well.

**Keywords**: climate change, vulnerability, maritime sector, SDGs, coastal communities.

## 1.Introduction

Temperatures are rising, not only on land but also in the oceans. Intergovernmental panel on Climate Change (IPCC) has repeatedly proclaimed that human-induced climate change is real and happening at full pace. According to the World Meteorological Organisation (WMO), 2023 was the warmest year on record with the highest temperatures not only on land but also in seas around the globe and unprecedented levels of ocean acidification, sea level rise and ice sheets/glacier retreat. IPCC has reported that global surface temperature have reached 1.1°C above 1850-1900 in 2011-2020 while the increase in ocean water temperatures lies around 0.88°C during the same period (Calvin et al., 2023).

The unprecedented rise in global temperatures has had a drastic impact on the ocean systems of the world. Because of their valuable services to the climate and biodiversity, oceans are at the core of the climate change crisis. The most evident impacts of ocean warming, and ocean acidification are manifested in the form of negative effects on food production from fisheries and shellfish aquaculture in some oceanic regions.

Oceans also play an important part in regulating the climate of Earth; by not only acting as a sink for Carbon Dioxide but also for extra heat in the atmosphere (IPCC, 2013). Due to higher heat capacity of water, large bodies of water can absorb heat and store it. Excess $CO_2$ also gets absorbed into the bodies of water, making them acidic and ultimately harming the millions of fish and other marine biodiversity forms. The ocean doesn't just store solar radiation, it also helps to distribute heat around the globe. Powered by solar radiation, Earth's rotation and evaporation, Ocean currents help to distribute heat and wind around the planet (NOAA). Without these vital services, biodiversity on the planet could not have thrived, however, all these services have been compromised due to changing temperatures of water bodies and related impacts of climate change.

In the past 30 years (since 1990), marine heatwaves have increased in frequency by around 50% (Smale et al., 2019). These heatwaves are a result of a vast range of events happening at different spatial and temporal scales, from localized factors such as air-sea heat flux to large-scale climatic processes, such as the El Niño Southern Oscillation (ENSO) (Smale et al., 2019). Marine heat waves have been defined as "periods when daily sea-surface temperatures (SSTs) exceed a local seasonal threshold (that is, the 90th percentile of climatological SST observations) for at least 5 consecutive days" (Hobday et al., 2016). Marine heatwaves have been given increased importance in the recent years because they have a range of ecological impacts like loss or shifting of aquatic species, bleaching of coral reefs and economic impacts due to losses in fish productivity.

## 2. Climate change impacts in the indian ocean

Indian Ocean has attained great significance over the years and has evolved into the most concentrated area where global economic activity meets political interests. It is a home to world's busiest waterways and chokepoints (Fatima & Jamshed, 2015). However, the importance of Indian Ocean is not only limited to its political and economic significance, it's ecological and environmental significance is also paramount.

Recent research and the Intergovernmental Panel on Climate Change (IPCC) reports point out that the Indian Ocean and the western Boundary Current have warmed the fastest since the 1950s. The Sea Surface Temperature (SST) warming trend in the Indian Ocean was strongest during the last seven decades (1950–2020), at a rate of 0.12°C per decade. These trends are very small compared to the projected surface warming of 3°C between 2020 and the end of the century, if emissions from human activities continue to increase at the current rate (Roxy et al., 2024).

The geography of Indian Ocean makes a majority of the Indian Ocean filled with the tropical warm water, with a permanently warm surface temperature of greater than 28°C, and is therefore often called the "heat engine of the globe"(Beal et al., 2020).

Warming trend in the Indian Ocean has impacts on the temperature and rainfall on land. It has contributed to increasing monsoon droughts and floods, and pre-monsoon heatwaves over South Asia by altering the temperature gradient between land and sea surface temperatures (Wang et al., 2020). It has also led to repercussions in Eastern Africa in the form of more frequent droughts and occasional locust outbreaks (Roxy et al., 2024), a phenomena which has also been observed to a surprisingly frequent extent in Pakistan's agricultural plains as well, threatening food security in this region.

The increase in ocean heat content has resulted in a rise in sea level via thermal expansion of seawater, a potential increase in extremely severe cyclones and their rapid intensification. Sea Surface Temperatures drive the circulation patterns through process like El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD)(Kumar et al., 2024). SST, thus has a crucial role in regulating terrestrial climate as an influential external factor, manifesting it's impacts on drought conditions, precipitation, temperature, soil moisture, and photosynthetic activity of vegetation, highlighting the link between oceans and terrestrial ecosystems.

The increase in atmospheric $CO_2$ and the associated ocean warming have very likely contributed to biogeochemical changes in the tropical Indian Ocean. These biogeochemical changes include the observed decreasing trends in pH, dissolved oceanic oxygen concentrations and marine phytoplankton distribution in the tropical Indian Ocean. Combined, the more frequent marine heatwaves and biogeochemical changes potentially impact the marine ecosystem and fisheries in the tropical Indian Ocean (Roxy et al., 2024; Smale et al., 2019; Hobday et al., 2016).

## 3.Climate change impacts on coastal areas of Pakistan

Mean monthly temperature data from Pakistan Meteorological Department has been used to investigate the changing patterns of temperature over Pakistan in this section. Figure 1 shows a significant ($p$-value $< 0.0001$) increase of 0.028$^\circ$ C /year over 41 years from 1978-2018. The increase is steeper in the duration of 2008-2018, rise being 0.07 $^\circ$ C/year. Similarly, there is a significant increase in temperatures during all seasons in Pakistan. Highest increase is observed in pre-monsoon season with 0.05 $^\circ$ C/year. There is an increasing evidence that increasing SST in the Indian Ocean have resulted in increased heat waves in the pre-monsoon season in the Indian Subcontinent and a decrease in monsoon rainfall in the Indian subcontinent (Kumar et al., 2024; Roxy et al., 2024).

This increase in temperatures has been further investigated by calculating the trends in different climatic zones of Pakistan over different seasons. Figure 2 presents the precipitation trends in the as classified in the study by Safdar et al., 2023.

**Figure 1.**

*Temperature trends over Pakistan. The rise in temperature is steeper in the recent years 2008-2018 (0.07 ° C /year) as compared to the long term trend from 1978-2018 (0.028˚C/year)*

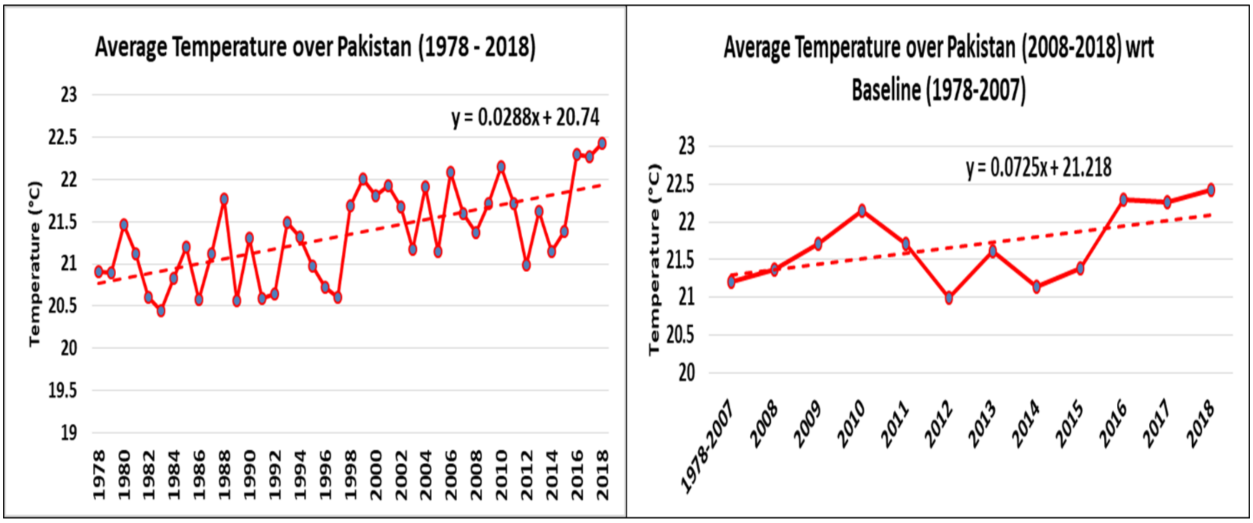
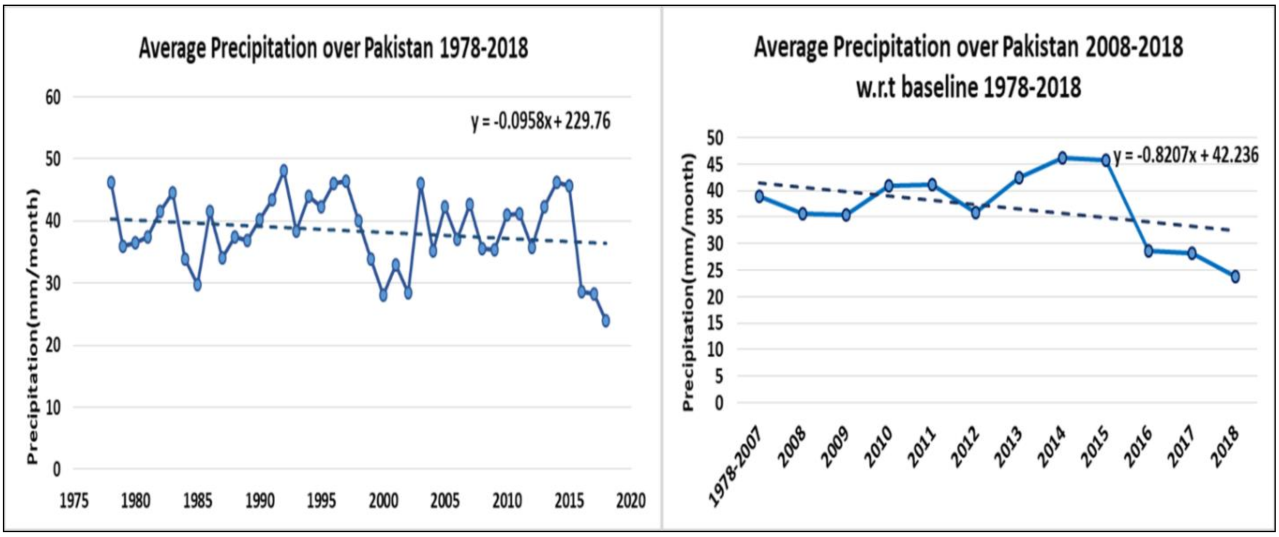



**Figure 2.**

*Precipitation trends over Pakistan. The fall in precipitation is steeper in the recent years 2008-2018 as compared to the long term trend from 1978-2018.*




According to the temperature and precipitation changes because of climate change in Pakistan, there has been a reduction in flow of river Indus. As a result, the creeks of Indus delta virtually converted to tidal creek with high salinity value and high pollution load and Sea water intruded up to 65-100 kms within coastland.

Sea water intrusion contaminates the ground water aquifers and adversely affects the agricultural soils. Due to marked decline in agriculture land the local community has shifted their traditional profession of agriculture to fishing. This has brought about decline in fish catch (Alamgir et al., 2015).

The decline in wetland productivity has resulted in the local population being more vulnerable to climate change problem and in fact most of the people are living below poverty line where the standard of living is well below as compared to any national or international standard. This area is typically vulnerable for tropical cyclones. Although the frequency of cyclones has not increased significantly but the intensity has increased at an alarming rate. Pakistan has mangrove forest coverage of around 150,000 ha, which has been steadily increasing over the last 30 years. However, the growth of mangroves in Pakistan is facing serious threats including climate change, salt-water intrusion, a shortage of fresh water due to upstream dam construction and agriculture, pollution, and urbanization. Pakistan has no comprehensive laws for the protection of mangroves or wetlands, although there are numerous policies and Acts which provide for the protection of mangroves and which control and monitor their threats. Due to weak institutions, the implementation of these policies and Acts has become difficult.

## 4.Vulnerability of maritime sectors – case of Pakistan

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.

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 1). 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 1.**

*Possible Impacts of Climate-driven Challenges faced by Pakistan's Maritime Sectors*

| Sectors | Climate Variables Applicable | Possible Impact |
|---|---|---|
| **Maritime transportation** | Ocean: Physical and Biogeochemical; Atmosphere | • Vessel damage due to altering oceanic chemistry and physiology<br>• 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<br>• Loss of infrastructure due to unpredictable and intense extreme weather events<br>• 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<br>• 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<br>• Fish migration and possible extinction of native species<br>• 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<br>• Loss of infrastructure and crops due to extreme weather events<br>• Lack of fresh water due to irregular inflow from upstream<br>• 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<br>• Marine pollution leading to coral bleaching and species die-off<br>Frequent oceanic turbulences affecting coral stability |
| **Maritime Tourism** | Ocean: Physical, Biogeochemical, and Biological/ecosystems; Land: Hydrosphere, Cryosphere, Biosphere, Anthroposphere; Atmosphere: Surface, Upper Air, Atmospheric Composition | • Loss of infrastructure due to extreme weather events<br>• Degradation and loss of marine archaeological sites<br>• Polluted waters hindering underwater sports activities<br>• Migration and relocation of coastal communities<br>• 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<br>• Loss of infrastructure due to unpredictable and intense extreme weather events<br>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<br>• Pollution and anthropogenic introduction of chemicals<br>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<br>• Loss of infrastructure due to extreme weather events<br>• Loss of mangroves and associated species/communities<br>• Loss of infrastructure and crops due to extreme weather events<br>• Lack of freshwater due to irregular inflow from upstream<br>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<br>• Loss of infrastructure due to extreme weather events<br>• Degradation of foundations due to fluctuating groundwater levels<br>• Damage due to sea-level rise<br>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<br>• Seawater intrusion<br>• Water logging and salinity<br>• Shift in cropping patterns<br>• Loss of arable land due to saltwater intrusion<br>• Crop yield reduction due to soil salinity |

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.

## 1. Nexus of sustainable development goals with environmental conservation and reducing climate change impacts on oceans

The journey towards the SDGs began with the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden (Bettelli, 2021). This conference marked a turning point in the global recognition of environmental issues and the need for sustainable development. The conference led to the creation of the United Nations Environment Programme (UNEP), which has played a crucial role in promoting environmental sustainability globally (Gasteiger, 2023).

### The Brundtland Commission and Agenda 21 (1983-1992)

In 1983, the United Nations created the World Commission on Environment and Development, also known as the Brundtland Commission, which defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Gasteiger, 2023). This definition has been a guiding principle for sustainable development efforts ever since. The commission's report, "Our Common Future," was published in 1987 and emphasized the need for sustainable development that balances economic, cultural, and environmental issues.

The first United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, was held in Rio de Janeiro in 1992 (Gasteiger, 2023). The conference adopted Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development. Agenda 21 addressed various aspects of sustainable development, including poverty eradication, energy, water and sanitation, health, and human settlement.

### The Millennium Development Goals (2000-2015)

In 2000, the United Nations General Assembly adopted the Millennium Declaration, which responded to the world's foremost development challenges at the time (Bettelli, 2021). The declaration led to the formulation of the Millennium Development Goals (MDGs), a set of eight goals with numerical sub-targets and deadlines. The MDGs aimed to reduce extreme poverty and hunger, achieve universal primary education, promote gender equality, reduce child mortality, improve maternal health, combat HIV/AIDS and other diseases, ensure environmental sustainability, and develop a global partnership for development (Gasteiger, 2023).

The MDGs drove progress in several areas, including reducing income poverty, providing access to water and sanitation, and driving down child mortality. However, the MDGs faced criticism for lacking strong objectives, disparities between nations, and not adequately addressing issues of equity and gender (Gasteiger, 2023).

### The Transition to Sustainable Development Goals (2012-2015)

The United Nations Conference on Sustainable Development (Rio+20) in 2012 served as a pivotal 20-year follow-up to UNCED, where Colombia initially proposed the concept of Sustainable Development Goals (SDGs) during a preparatory event. This idea gained traction and was later endorsed by the United Nations Department of Public Information.

Subsequently, the UN General Assembly Open Working Group (OWG) on Sustainable Development Goals was formed in January 2013 to delineate specific SDGs. After extensive deliberations, the OWG presented a comprehensive framework comprising 17 SDGs and 169 associated targets to the 68th session of the General Assembly in September 2014. Following thorough review, the UN General Assembly approved the Secretary-General's Synthesis Report on December 5, 2014, solidifying the OWG's proposals as the foundation for the post-2015 SDG agenda (Jayasooria & Yi, 2023), (Wadhwani & Malpani, 2023).

**The Adoption of the Sustainable Development Goals (2015)**

The 2030 Agenda for Sustainable Development, adopted by the United Nations General Assembly in 2015, encompasses 17 Sustainable Development Goals (SDGs) aimed at addressing a wide array of global challenges concerning the well-being of both the planet and humanity (Guachalla, 2023). The SDGs build upon the MDGs and aim to end poverty, protect the planet, and ensure peace and prosperity for all. The SDGs are designed to be action-oriented, concise, aspirational, global, and universally applied to all countries (Bettelli, 2021).

The adoption of the SDGs marked a significant milestone in the history of sustainable development, as it unified nations and states in a global effort to address the complex challenges facing humanity. The SDGs have driven progress in various areas, including poverty reduction, education, health, and environmental sustainability (Gasteiger, 2023).

**SDG 14 – Life Below Water**

The Sustainable Development Goals (SDGs), adopted in 2015, encompass 17 goals addressing global challenges and promoting sustainable development worldwide (Haas, 2023). SDG 14, "Life Below Water," specifically aims to conserve and sustainably use oceans, seas, and marine resources for sustainable development (Arora, 2023). Implementing SDG 14 is crucial due to the oceans' significant role in regulating climate, providing food and livelihoods for billions, and supporting diverse marine life (Wadhwani & Malpani, 2023). The interconnectedness of the SDGs underscores the importance of achieving each goal to ensure a sustainable and equitable future for all. The SDGs provide a comprehensive framework for action, requiring collaboration among governments, businesses, civil society, and individuals to work towards a more sustainable world.

**SDGs which complement SDG-14 for fighting climate impacts on oceans and ocean communities**

SDG-14, which focuses on "Life Below Water," is complemented by SDG-13, which addresses "Climate Action," in fighting climate impacts on oceans and ocean communities (Sachs, 2015). SDG-13 aims to combat and curb human-induced climate change, which is crucial for protecting marine ecosystems and addressing the challenges faced by oceans due to climate impacts. By working towards both SDG-13 and SDG-14 simultaneously, efforts can be made to mitigate the effects of climate change on oceans, promote sustainable management of marine resources, and ensure the well-being of ocean communities in the face of environmental challenges (Sachs, 2015).

Furthermore, investing in the sustainable livelihood practices and ecosystem preservation would help meet the targets of SDG1: Reduced Poverty, SDG2: Zero Hunger, SDG3: Good Health and Wellbeing, SDG4: Gender Equality, and others and vice versa. There is need for inclusive and integrated approach to link SDGs for the improvement in coastal sector. Integrating SDGs in all policies related to maritime sector can significantly reduce the vulnerabilities of the sector. The SDGs would help make policies which are climate mitigative and adaptive.

## 2. Importance of traditional climate knowledge

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).

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).

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.

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).

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.

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 (Ur 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.

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.

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). 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.

## Conclusion

The UN's Sustainable Development Goals 11: "Sustainable cities and communities" and 13: "Climate Action" highlight the need for a collaborative and multidisciplinary approach to limit the vulnerability of such communities to the physical, social, economic, and environmental impacts of climate change. There is need for inclusive and integrated approach to link SDGs for the improvement in coastal sector.

The traditional coastal communities in Pakistan are grappling with the impacts of climate change and limited knowledge due to various factors. Therefore, there is a need to protect the rights, knowledge, and identities of certain coastal communities of Pakistan in the wake of challenges like changing weather patterns and accompanied challenges. Integrating SDGs into the development plans of a country can reduce vulnerabilities of any sector (in this case, maritime sector).

Pakistan's coastal ecosystems have enormous potential to capture & store large amounts of $CO_2$, thereby providing cost-effective 'blue carbon' solutions. Blue carbon is carbon captured by the ocean and coastal ecosystems, and normally covers mangroves, tidal marshes and seagrass, which play an important role in minimizing coastal erosion and sea level rising, combating the global climate crisis by absorbing carbon, nurturing land and marine biodiversity, and supporting human well-being.

## Reference list


ADB. (2017). Climate Change Profile of Pakistan. In *ADB*. https://doi.org/10.22617/TCS178761

Alamgir, A., Khan, M., Shaukat, S., Kazmi, J., Qureshi, S., & Khanum, F. (2015). Appraisal of Climate Change Impacts on the Coastal Areas of Sindh Using Remote Sensing Techniques. *American-Eurasian J. Agric. & Environ. Sci.*, *15*, 1102–1112. https://doi.org/10.5829/idosi.aejaes.2015.15.6.12667

Arora, P. (2023). Life below land: The need for a new sustainable development goal. *Frontiers in Environmental Science*, *11*. https://doi.org/10.3389/fenvs.2023.1215282

Beal, L. M., Vialard, J., Roxy, M. K., Li, J., Andres, M., Annamalai, H., Feng, M., Han, W., Hood, R., Lee, T., Lengaigne, M., Lumpkin, R., Masumoto, Y., McPhaden, M. J., Ravichandran, M., Shinoda, T., Sloyan, B. M., Strutton, P. G., Subramanian, A. C., … Parvathi, V. (2020). A Road Map to IndOOS-2: Better Observations of the Rapidly Warming Indian Ocean. *Bulletin of the American Meteorological Society*, *101*(11), E1891–E1913. https://doi.org/10.1175/BAMS-D-19-0209.1

Bettelli, P. (2021, January 29). *What the World Learned Setting Development Goals*. International Institute for Sustainable Development. https://www.iisd.org/articles/deep-dive/what-world-learned-setting-development-goals

Bhandari, M., & Bhattarai, K. (2017). Institutional Architecture For Sustainable Development (SD): A Case Study from Bangladesh, India, Nepal, and Pakistan. *SocioEconomic Challenges, 1*, 6–21. https://doi.org/10.21272/sec.1(3).6-21.2017

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., … Péan, C. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.* (First). Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-9789291691647

Carmichael, B., Wilson, G., Namarnyilk, I., Nadji, S., Brockwell, S., Webb, B., Hunter, F., & Bird, D. (2018). Local and Indigenous management of climate change risks to archaeological sites. *Mitigation and Adaptation Strategies for Global Change*, *23*(2), 231–255.

Fatima, Q., & Jamshed, A. (n.d.). The Political and Economic Significance of Indian Ocean: An Analysis. *South Asian Studies*.

Gasteiger, S. (2023, February 28). Road to 2030 | A brief history of the Sustainable Development Goals (SDGs). *Virchow Foundation | Virchow Prize for Global Health*. https://virchowprize.org/vf-road-to-2030-history-of-sdgs/

Guachalla, F. J. A. (2023). Embracing the SDG 2030 and Resilience for Monitoring and Learning in Emergency and Developing Projects. *Medical Sciences Forum*, *19*(1), Article 1. https://doi.org/10.3390/msf2023019006

Haas, B. (2023). Achieving SDG 14 in an equitable and just way. *International Environmental Agreements: Politics, Law and Economics*, *23*(2), 199–205. https://doi.org/10.1007/s10784-023-09603-z

Haque, M. (2019). Indigenous Knowledge and Practices in Disaster Management: Experiences of the Coastal People of Bangladesh. In *Disaster Risk Reduction: Community Resilience and Responses* (pp. 59–72). https://doi.org/10.1007/978-981-10-8845-2_4

Hobday, A. J., Alexander, L. V., Perkins, S. E., Smale, D. A., Straub, S. C., Oliver, E. C. J., Benthuysen, J. A., Burrows, M. T., Donat, M. G., Feng, M., Holbrook, N. J., Moore, P. J., Scannell, H. A., Sen Gupta, A., & Wernberg, T. (2016). A hierarchical approach to defining marine heatwaves. *Progress in Oceanography*, *141*, 227–238. https://doi.org/10.1016/j.pocean.2015.12.014

IPCC (2013): Rhein, M., S.R. Rintoul, S. Aoki, E. Campos, D. Chambers, R.A. Feely,

S. Gulev, G.C. Johnson, S.A. Josey, A. Kostianoy, C. Mauritzen, D. Roemmich,

L.D. Talley and F. Wang, 2013: Observations: Ocean. In: Climate Change

2013: The Physical Science Basis. Contribution of Working Group I to the

Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Jayasooria, D., & Yi, I. (2023). The Sustainable Development Goals. In *Encyclopedia of the Social and Solidarity Economy* (pp. 310–320). Edward Elgar Publishing. https://www.elgaronline.com/display/book/9781803920924/book-part-9781803920924-54.xml

Kumar, V., Chu, H.-J., & Anand, A. (2024). Impacts of Sea Surface Temperature Variability in the Indian Ocean on Drought Conditions over India during ENSO and IOD Events. *Journal of Marine Science and Engineering*, *12*(1), Article 1. https://doi.org/10.3390/jmse12010136

Latulippe, N., & Klenk, N. (2020). Making room and moving over: Knowledge co-production, Indigenous knowledge sovereignty and the politics of global environmental change decision-making. *Current Opinion in Environmental Sustainability*, *42*, 7–14. https://doi.org/10.1016/j.cosust.2019.10.010

NOAA,https://oceanexplorer.noaa.gov/facts/climate.html#:~:text=Ocean%20currents%20act%20much%20like,solar%20radiation%20reaching%20Earth's%20surface.

Roxy, M. K., Saranya, J. S., Modi, A., Anusree, A., Cai, W., Resplandy, L., Vialard, J., & Frölicher, T. L. (2024). Future projections for the tropical Indian Ocean. In *The Indian Ocean and its Role in the Global Climate System* (pp. 469–482). Elsevier. https://doi.org/10.1016/B978-0-12-822698-8.00004-4

Sachs, J. (2015, July 1). *Achieving the Sustainable Development Goals*. https://www.semanticscholar.org/paper/Achieving-the-Sustainable-Development-Goals-Sachs/019175f937d25793e3a73e8f23af4e4a07cb6b86

Safdar, F., Khokhar, M. F., Mahmood, F., Khan, M. Z. A., & Arshad, M. (2023). Observed and predicted precipitation variability across Pakistan with special focus on winter and pre-monsoon precipitation. *Environmental Science and Pollution Research*, *30*(2), 4510–4530. https://doi.org/10.1007/s11356-022-22502-1

Smale, D. A., Wernberg, T., Oliver, E. C. J., Thomsen, M., Harvey, B. P., Straub, S. C., Burrows, M. T., Alexander, L. V., Benthuysen, J. A., Donat, M. G., Feng, M., Hobday, A. J., Holbrook, N. J., Perkins-Kirkpatrick, S. E., Scannell, H. A., Sen Gupta, A., Payne, B. L., & Moore, P. J. (2019). Marine heatwaves threaten global biodiversity and the provision of ecosystem services. *Nature Climate Change*, *9*(4), 306–312. https://doi.org/10.1038/s41558-019-0412-1

UNCTAD. (2020). UNCTAD Handbook of Statistics 2020 - Merchant fleet. https://stats.unctad.org/handbook/MaritimeTransport/MerchantFleet.html

Ur Rehman, W. (2022). *Re-imagining indigeneity: From mountains to coast | By Wajihur-Rehman - Pakistan Observer*. https://pakobserver.net/re-imaginingindigeneity-from-mountains-to-coast-by-wajih-ur-rehman/

Wadhwani, D., & Malpani, P. (2023). *United Nations Sustainable Goals: Global to Local Need of the Hour* (SSRN Scholarly Paper 4426147). https://doi.org/10.2139/ssrn.4426147