POLICY BRIEF

OCEAN AND CLIMATE SYNERGIES

Ocean Warming and Sea-level Rise

Recommendations

ENVIRONMENT AND DEVELOPMENT

ESCAP MOVING FORWARD TOGETHER

Authors

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Summary

This policy brief provides an overview of the major impacts of climate change on the ocean in the Asia-Pacific region, focusing on ocean warming, sea-level rise and acidification. The policy brief brings together recommendations for better policymaking in ocean and climate synergies for sustainable development.

Policy pointers

- Urge all member States to step up national efforts to join international efforts to restore the environment. Better adaptation and mitigation efforts can be aided by increased regional collaboration through treaties and conventions.
- Invest in research and development to plan different strategies to adapt to sea-level rise, fish migration and extreme weather events. For instance, investing in blue carbon.
- Conduct assessments on sea-level rise, especially in low-lying coastal zones and small island developing states (SIDS), to prepare evacuation plans and strategies to prevent international migration and internal displacement.
- Increase the adaptive capacity of fisherfolks through early warning systems and satellite technologies.
- Encourage partnerships between the government, the private sector, and all stakeholders to respond to climate change impacts.

Abbreviations

[CO_2]	[Carbon dioxide]
[CRI]	[Climate Risk Index]
[EEZ]	[Exclusive Economic Zone]
[GDP]	[Gross Domestic Product]
[GHG]	[Greenhouse Gas]
[GIS]	[Geographic Information System]
[IPCC]	[Intergovernmental Panel on Climate Change]
[NDCs]	[Nationally Determined Contributions]
[RCP]	[Representative Concentration Pathway]
[SIDS]	[Small Island Developing States]

I. Introduction

Impacts of climate change on the ocean

The Asia-Pacific region is biologically diverse with 71% of the world's coral reefs (Hoegh-Guldberg, 2009), 45% of the world's mangroves (Giri et al., 2011), 66% of world's fisheries production and 89% of aquaculture production (FAO, 2020). Thus, the region is home to over 200 million people who rely on fishery resources and tourism services for food and income, and all these activities depend on marine sustainability. However, the health of the ocean is measurably deteriorating with visible impacts on the coastal ecosystems and biodiversity. The effects of climate change in the region (Fig. 1) are briefly described.

Global warming by human-induced greenhouse gas (GHG) emission significantly increases ocean temperature. Warming causes stratified water columns with less biological productivity leading to a significant reduction of food supply to deep-sea ecosystems and thereby decrease in biomass of benthic biota. Ocean warming has altered rainfall patterns and increased the prevalence of extreme weather events globally, whereas coastal landscapes and adjacent areas are more exposed. Marine species are directly affected by ocean warming as the temperature is a crucial defining component of their habitat. Under warming scenarios, certain species migrate or become more successful at adapting to changes, while others may be unable to adapt due to ecological or geographical barriers and become extinct. The extinction or reduction of even one species affects the balance of the food web in the marine ecosystem. In addition, changes in aquatic communities have far-reaching consequences for both local fishing communities and industrial fishing nations (E.g., Tuna migration in the western Pacific significantly impacts the income of island states).

Rising sea level is the major impact of ocean warming due to the thermal expansion of water and melting ice sheets and glaciers. The global mean sea level increase (average rate 3.7 mm/year) caused a direct threat to coastal regions and low-lying coastal zones, including small island developing states, and the sea level is projected to increase further. Relative sea-level rise contributes to increases in the erosion along most coasts (IPCC, 2021) with wetland flooding, aquifer and agricultural soil contamination, loss of habitat and coastal infrastructure. It is predicted that between 0.66 to 1.7 million people in the Pacific islands and 46% population of Bangladesh and many more coastal populations will be forced to migrate owing to rising sea levels by 2050, along with the loss of coastal resources and infrastructure (Lalit Kumar et al., 2020).

Increased human-induced CO_2 emissions significantly reduced the pH of the ocean. The open ocean surface water pH has been declining by 0.017–0.027 pH units per decade since the late 1980s (IPCC, 2019). These changes in pH have reduced the stability of mineral forms of calcium carbonate (aragonite and calcite). Coral skeletons are made of aragonite, and acidification threatens coral reef ecosystems. It also threatens the sensory abilities of some marine species (Hester et al., 2008; Munday et al., 2009) and the ability of others (Oysters, Mussels, Urchins, Starfish, Sea butterflies, and planktons such as Coccolithophores) to build their skeletons or shells (Fabry et al., 2008), and affects the marine food web. According to studies on corals, the skeleton density of Porites corals could reduce by up to 20.3 % in the twenty-first century owing to acidification alone (Mollica et al., 2018), whereas coral reefs are in jeopardy if ocean pH continues to fall as forecasted in the RCP 8.5 scenario (high greenhouse gas emission scenario).

Marine heatwaves in the south-western pacific

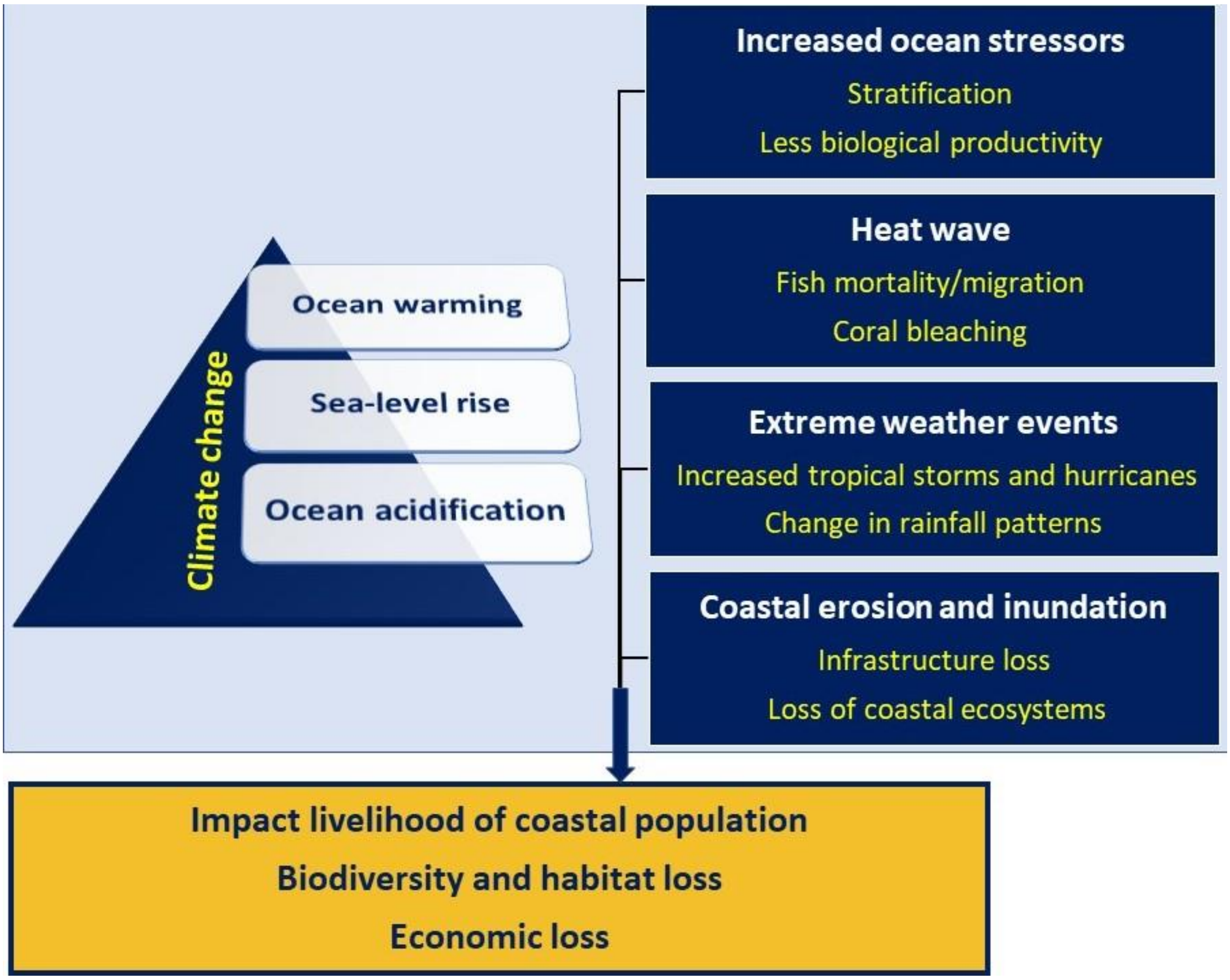
have become more common during the last century. The stagnant ocean conditions caused by the warm, stratified surface layer combined with varying wind patterns lead to heatwaves (prolonged anomalously warm water). The severe successive heatwave occurrences in the south-western Pacific (2016, 2019, 2020) seriously harmed the region's warm water corals, resulting in extensive coral bleaching. In 2016, the heatwave event caused catastrophic coral bleaching in the Great Barrier Reef, northeast Australia, and neighbouring regions (Hughes et al., 2017) and mass fish mortality in the southwest of Fiji (Holbrook et al., 2021). Recent modelling studies report intense warming in the subsurface layers of the western Pacific (Hu et al., 2021), which is worrisome.

The risks associated with extreme events will increase as the global mean temperature rises. According to the Global Climate Risk Index (CRI) 2021, more than 475,000 people died and US$2.56 trillion was lost as a direct result of more than 11,000 extreme weather events between 2000 and 2019. Myanmar, Philippines, Bangladesh, Pakistan, Thailand, and Nepal are among the top ten countries most affected from 2000 to 2019, while more countries and island states appear in the top 20 list. High CRI scores (average weighted ranking) indicate the warning sign that these countries are at risk of either frequent extreme weather events or rare but extraordinary catastrophes, demonstrating the scale of the region's immediate risk (Eckstein et al., 2021).

The combined effects of warming, sea-level rise and acidification will affect nutrient supply, lagoon flushing, and, eventually, ecosystem health in the region. Extreme climate events and human impacts caused considerable decline to coastal ecosystems (mangroves, salt marshes, seagrass meadows) that effectively store carbon through sequestration and provide habitat for marine fauna along with multiple co-benefits. In addition, sea-level rise poses a significant threat to the restricted species ranges on smaller and atoll islands due to limited suitable habitat and limited capacity for rapid adaptation of small islands.

Climate-induced declines in ocean health will have a negative impact on the ocean economy. It is estimated that ocean-based industries and activities contribute hundreds of millions of jobs and approximately US$2.5 trillion to the global economy each year. Climate changes threaten marine life, have a significant impact on ecosystems, and affect millions of people who rely on the ocean for food and livelihood. For instance, ocean warming and other effects of climate change reduce productivities and change the spatial distributions of economically important marine species and their habitats. Changes in aquatic communities have far-reaching consequences for both local fishing communities and industrial fishing nations. Simulated ocean warming and changes in primary productivity during the 21st century are projected to alter the community structure of marine organisms, reduce global marine biomass and the maximum potential catches of fish stocks, whereas pollution and illegal, unregulated, and unreported fishing practices add to the stressors. A Climate Change report estimates that climate-induced declines in ocean health will cost the global economy $428 billion per year by 2050 and $1.98 trillion per year by 2100 (IPCC, 2019). The ocean health index in the region (both for the country's exclusive economic zone and in the high seas) is deteriorating, and innovative approaches are needed. Observed tuna migration from the Exclusive Economic Zone (EEZ) of island states, harsh weather, and the COVID-19 have deprived fishers of their livelihoods and may significantly threaten the economic security of island communities due to their greater reliance on marine resources.

FIGURE 1: SCHEMATIC REPRESENTATION OF THE IMPACTS OF CLIMATE CHANGE ON THE OCEAN (WARMING, SEA-LEVEL RISE, AND ACIDIFICATION) AND ITS FURTHER CONSEQUENCES.



II. Recommendations for policymaking

A. CUTTING DOWN GREENHOUSE GAS EMISSIONS

The scientific community generally agrees that global warming needs to be limited to 2°C above pre-industrial levels to avoid potentially dangerous impacts by the end of the twenty-first century. This requires concentrations of atmospheric CO_2 to remain below 450 ppm, and it can only be achieved through urgent action. The world is addressing climate change in two ways: mitigation and adaptation. Mitigation involves reducing greenhouse gas emissions to alleviate the acceleration of climate change, whereas adaptation involves learning how to live with existing climate change and protecting ourselves against unavoidable future climate change effects (IPCC, 2014). Yet, the implementation of strategies to mitigate or survive under turbulent climatic conditions requires a broad awareness of climate change. A broadened perspective on adaptation and mitigation strategies could help all nations understand the adjustments or actions that can ultimately increase resilience or reduce vulnerability to expected climate and weather changes (IPCC, 2014; 2018).

Limiting global warming to 1.5°C compared to 2°C can significantly reduce the negative impacts of climate change to a particular extent. For instance, by 2100, global sea-level rise would be 10 cm lower with global warming of 1.5°C compared to 2°C. Also, coral reefs would decline by 70–90% in 1.5°C scenarios, while almost all would be lost (Fig. 2) with a 2°C increase (Hoegh-Guldberg, 2014; Hoegh-Guldberg et al., 2017). Moreover, at or above 2°C, the magnitude of the change in droughts and heavy/mean precipitation increase compared to those at 1.5°C. Heavy precipitation and associated flooding events are projected to become more intense and frequent in the Pacific Islands and some regions in Australasia (IPCC, 2021). However, to limit global warming to 1.5°C, rapid, far-reaching, and unprecedented changes in all aspects of society are needed. Global net human-induced CO_2 emissions would have to fall by approximately 45% from 2010 levels by 2030, reaching 'net zero' by 2050 to limit global warming to 1.5°C (Lalit Kumar et al., 2020). In addition to reducing human-induced greenhouse gas emissions, insufficient disaster risk management and undervaluing environmental costs and benefits in decision-making should be carefully evaluated. The urgency of the environmental impacts presented in this policy brief calls for action from countries to step up their national efforts and join international efforts to restore the environment. The focus on low emission development through accelerating the energy transition towards clean energy sources should be promoted, reducing energy intensity through efficiency, integrated waste management, and low-carbon footprint buildings, promoting best practices in agriculture and forestry to preserve natural carbon sinks and reduce emissions of short-lived climate pollutants[1].

1 National Climate Change Strategy 10-20-40 Vision, Federal Government of Mexico.

FIGURE 2: IMPACTS OF OCEAN ACIDIFICATION AT DIFFERENT SCENARIOS IN COMPARISON TO THE SCENARIO AT 2008. REPRESENTATIVE CONCENTRATION PATHWAY (RCP)-2.6 REPRESENTS WARMING BELOW 2°C, WHEREAS RCP-8.5 REPRESENTS A SCENARIO WITH HIGH GHG EMISSIONS.

Source: Hoegh-Guldberg et al., 2007

B. NATURE-BASED SOLUTIONS

Conservation and restoration of blue carbon ecosystems offer an efficient pathway to reduce GHG emissions, particularly for nations with large areas of coastal vegetation and high rates of loss. The highest CO_2 emissions from deforestation of coastal ecosystems (particularly mangroves) were predicted in Southeast Asia and South Asia (West Coral Triangle, Sunda shelf and the Bay of Bengal) due to conversion to aquaculture or agriculture, followed by the Caribbean due to clearing and erosion (Adame et al., 2021). Thus, urgent action is needed in the region. In addition to carbon sequestration, these ecosystems provide valuable services, including coastal protection (from storm surges, flooding, sea-level rise, and coastal erosion) and fisheries that apply to climate adaptation and resilience policies[2].

Moreover, the Global Commission on Adaptation found that the net benefits of protecting mangrove forests, globally, amounting to USD 1 trillion by 2030 (Global Commission on Adaptation, 2019), and increase marine biodiversity, thereby consequently increasing offshore fisheries catch from an average of 40 pounds to 271 pounds per hour (Hussain, 2010).

Countries with significant coastal wetlands (mangroves, seagrasses, and tidal salt marshes) in the Asia-Pacific can recognise the values provided by these ecosystems as a potentially significant contribution to both the mitigation and adaptation goals of their Nationally Determined Contributions (NDCs). This value is additional and complementary, not a substitute, to the critical need for countries to reduce their emissions from other sectors such as energy and transportation[3]. There exists a starting point for any country to recognise the climate values of coastal wetlands within their NDC, no matter the capacity level. However, comprehensively including (all) blue carbon habitats in an NDC carbon accounting framework requires rigorous planning and robust capacities, an exercise best undertaken through a "Blue Carbon Readiness" assessment.

2 Blue Carbon, Integrating Ocean Ecosystems in Global Climate Action, 2021
3 Blue carbon and nationally determined contributions

Some countries may already have undergone such assessments and possess relevant capacities, while others need time to develop them. In either case, countries can use their NDCs and the NDC trajectory to outline their current and intended future blue carbon actions[3]. Investment in these forms of "green infrastructure" such as living coastlines (mangrove forests, dunes, and reef systems) are often more cost-effective (Crook et al., 2019) than "grey infrastructure" (harder, human-engineered coastal structures including floodwalls, floodgates, pipes, dams), or a combination of both green and grey infrastructure can be used based on sea-level projections.

C. PRIORITIZING THE VULNERABLE

Besides the global overview, vulnerable communities in all countries should be given access to information about spatial variation of trends in sea level. The knowledge and development on ocean-climate synergies must be applied to enhance the capacities of these affected communities, including coastal settlements and fisherfolks. It is recommended that governments align their development agenda with climate-hazard mitigation and allow more participation from local communities in policymaking.

Though the Pacific Islands accounts for only 0.03% of the world's total greenhouse gas emissions, this region is facing the greatest impacts of climate change from rising sea levels, warming oceans, coral ecosystem destruction, fish migration and extreme weather (Rogers and Evans, 2011). These coastal communities become more vulnerable as they face severe structural challenges due to their remoteness, economic concentration, and dependence on external flows such as remittances, foreign direct investment, and tourism revenues. The United Nations Conference on Trade and Development (UNCTAD) has underscored the unique issues that Small Island Developing States (SIDS) face, particularly their acute susceptibility to physical and economic shocks beyond their control and urge for specific international responses to their concerns. The main development problem for most SIDS is their vulnerability to a widening range of external shocks, some of which are becoming more frequent and severe due to climate change. Resilience-building, a multi-faceted set of objectives ranging from climate adaptation to economic diversification, is thus the most important development goal for these countries, implying productive capacity-building action in the islands.

Considering the projected threat from sea-level rise and the percentage of human settlements in coastal regions, resettling or relocating affected communities and providing them with the support to adapt to the new environment is a significant challenge for governments. Regional cooperation and partnerships are necessary to prevent internal displacements and international migration. Though SIDS are more vulnerable, some of these island States are still not eligible for concessional financing because they are classified as middle- or high-income countries. As badly affected by the pandemic, it's time to reconsider eligibility for concessional financing to SIDS on vulnerability rather than just income criteria which can save close to 1.5% of GDP annually (Assa and Meddeb, 2021), which can be used for their infrastructure development.

D. INVEST IN RESEARCH AND DEVELOPMENT TO DESIGN ADEQUATE STRATEGIES

In order to identify a holistic and efficient way of integrating sea-level rise adaptation into planning policies, the knowledge gaps should be reduced. As there are only a few studies on the costs of sea-level rise at a global level, significant uncertainties remain, and the need for further research is pronounced. The socioeconomic drivers, sea-level rise scenarios, impacts considered, and damages and losses valued are incomplete (IPCC, 2014). For example, costs of salinity intrusion, land loss due to increased coastal erosion, cost of forced migration due to permanent inundation, the backwater effect, and the impact of sea-level rise in combination with other drivers on ecosystems have not been assessed at global scales. Flood hazard zones can be mapped using spatial analysis (GIS, environment models) to assess the susceptibility of the flood-prone areas, and a setback distance may be fixed based on the predicted rate.

Furthermore, the understanding of coastal changes over the decade and century time scales is also incomplete (Woodroffe and Murray-Wallace, 2012), as the shoreline response is more complex than simple submergence because of factors such as sediment supply, mobilisation, and storage as well as offshore geology. Thus, more work needs to be done to develop predictive models for coastal ecosystems/shorelines based on findings from multi-stressor experiments, both in the field and in the laboratory. Reliable predictions require information on multifactorial experiments performed on communities (preferably in the field) and on time scales of months to years to consider the process of biological acclimation and adaptation (IPCC, 2014).

In addition, there are significant gaps in vulnerability assessment of other specific coastal impacts, such as the modelling of diseases that could affect coastal areas due to climate change, the reactions of tourists to projected climatic change or required adaptation measures for port facilities. Despite the availability of potentially useful climate information, a gap exists between what is useful information for scientists and decision-makers; thus, an effort to reduce the knowledge gap might be considered prior to forming adaptation policies, which requires capacity development strategies. Similarly, the adaptive capacity of fishers can be increased by more robust early warning systems and make satellite vessel tracking systems mandatory for fishing crafts.

E. ENCOURAGE PARTNERSHIPS

Successful adaptive coastal management of climate risks will involve assessing and minimising potential trade-offs with other non-climate policy goals (e.g., economic development, enhancement of coastal tourism) and interactions between adaptation and mitigation. Many coastal zone-based activities and various coastal management strategies involve emissions of GHGs. For instance, limiting offshore oil production may imply a net reduction in GHG emissions and reduce the possibility of oil spillage, resulting in increased resilience and, consequently, could prove positive for adaptation. Financial, technological, institutional, and other barriers (geographic barriers, ecosystem degradation, habitat fragmentation) exist for implementing responses to current and projected negative impacts of climate-related changes in the ocean, whereas such barriers can be overcome by regional cooperation.

Increased cooperation and coordination across governing bodies, across scales, jurisdictions, sectors, policy domains, and planning horizons can enable effective responses to ocean changes and sea-level rise. Regional cooperation, including through the effective implementation of existing treaties and conventions, can help with adaptation and mitigation; nevertheless, the extent to which regional policy frameworks can help respond to impacts and losses caused by changes in the ocean is currently limited. Institutional arrangements that provide strong multiscale linkages with local and indigenous communities benefit adaptation. Coordination and complementarity between national and transboundary regional policies can support efforts to address resource security and management (IPCC, 2014). For instance, remoteness represents significant additional challenges to SIDS' economic development as well as to their response mechanisms.

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