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INTRODUCING CLIMATE RESILIENCE AS THE FIFTH PILLAR OF THE SAGARMALA PROGRAMME

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31 January 2021

1. This article seeks to highlight the glaring gap between the planned activities within SAGARMALA and the long-term climate-change-induced threats facing coastal regions in India. It first discusses some of the more prominent impacts of climate change on India's coastal infrastructure and highlights the likelihood of their continuing to amplify and accelerate in the near-term future. It thereafter advocates the introduction of a new 'fifth' pillar upon which SAGARMALA must rest — one that is centred upon building 'climate resilience'. The paper provides an outline of contemporary global and national initiatives being taken by other countries to better adapt their ports to the impacts of climate change. Finally, it seeks to contextualise the criticality of climate-resilient and sustainable port infrastructure to India's ongoing endeavour to transition from a 'Brown Economy' to a 'Blue Economy'.

Snapshot Overview of SAGARMALA

2. India's maritime sector in general and maritime trade in particular, play critical roles in the economic development of the country. Around 95 per cent of India's annual merchandise trade (by volume) is carried through sea. Of course, this fact is not lost on the central government, which has, especially in recent years, put in place a whole slew of measures to enhance the capacity of the maritime sector. Most notably, in 2015, the Government of India (GoI) launched the SAGARMALA programme, a nationwide multi-decadal 'port-led development' plan for India. SAGARMALA focusses upon the country's 7,516 km long coastline, 14,500 km of potentially navigable waterways, and the broader maritime sector. SAGARMALA aims to double the capacity of Indian ports by 2025, ensure "last-mile connectivity" where ports will be connected to the nearest highway and railway line, and, establish Coastal Economic Zones (CEZs). Indeed, the stated vision of SAGARMALA is to "reduce logistics cost[s] for both domestic and EXIM cargo with minimal infrastructure investment".[1] The four principal pillars of this megaproject are: (1) port modernisation, (2) port connectivity, (3) port-led industrialisation, and (4) coastal-community development. Although the first three pillars and the thrust-lines along which they are developed are sharply focussed upon ports and the follow-through mechanisms accordingly seek to improve

[1] Ministry of Shipping, Government of India, SAGARMALA National perspective Plan, April 2016, http://sagarmala.gov.in/sites/default/files/5457695312te1.pdf

efficiency and productivity, and although SAGARMALA is coherent with India's endeavour to transition to a 'Blue Economy',[2] there is little or no evidence of the existence of a critical 'fifth pillar', namely, 'resilience', especially resilience in the face of climate change'

3. Thus, while the government is moving ahead at full speed to execute its plans for coastal development, manifestations of climate change, such as sea-level rise; tropical revolving storms (cyclones) that are more frequent, more ferocious, but whose path is less predictable; and associated storm-surges, are all threatening India's vast and densely populated coastline.

Climate Change Impacts on India's Coastal Infrastructure

4. **Sea Level Rise and Extreme Weather Events in the Indian Ocean**. Driven by climate change, sea-level rise in the North Indian Ocean was recorded to be between 1.06 to 1.75 mm per year during the 1874-2004 period.[3] The average rate of rise has since accelerated to 3.3 mm per year since 1993, which is comparable to the current rate of global mean sea-level (GMSL) rise. However, there could be significant differences at the local-level and it is these local-level variations that pose a very significant threat to the country's coastal infrastructure. Some of the major ports in India are experiencing a higher rate of sea-level rise than the average rate. For instance, between the years 1948 and 2013, the sea level at Diamond Harbour in Kolkata has risen at a rate of around 4.6 mm a year. Similarly, between the years 1970 and 2013, Haldia port has experienced a sea-level rise of 2.93 mm a year.[4] The Bay of Bengal as a whole is experiencing much faster sea-level rise than the broader North Indian Ocean and the Global Mean Sea Level (GMSL). Superimposed upon this acceleration in sea-level rise, are extreme weather events such as abnormally high tides, floods, storm surges, etc., associated with tropical revolving storms that are becoming more frequent, more intense, and, at the same time, less predictable. Combined together, accelerations in local sea level, powerful cyclonic storms, abnormally large tidal ranges, and, storm surges, could result in a series of devastating impacts in the near-term future.

5. **The Vulnerability of India's Port Infrastructure**.

(a) In the wake of increasingly frequent and intense extreme weather events, any substantial damage caused to critical coastal infrastructure, such as ports, could easily lead to a complete system-breakdown in several Indian coastal cities that are at high risk from climate-change-driven disasters. The World Bank has estimated that the adverse impacts of

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[2] The Blue Economy is defined by the World Bank as *"sustainable use of ocean resources for economic growth, improved livelihood and jobs and ocean ecosystem health."*, https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy

[3] R Krishnan, J Sanjay, G Chellappan et al, *Assessment of Climate Change over the Indian Region*, A Report of the Ministry of Earth Sciences, Government of India, Pune: Springer, 2020

[4] G Seetharaman, "Coastal Concerns: Rising Sea Levels Will Inundate Coastal Areas Sooner than Projected", Economic Times, 10 Nov 2019, https://economictimes.indiatimes.com/news/politics-and-nation/coastal-concerns-rising-sea-levels-will-inundate-coastal-areas-sooner-than-projected-/articleshow/71985765.cms

extreme weather events, under a worst-case scenario, could cost India about 2.8 per cent of its GDP by 2050.[5]

(b) The year 2019 witnessed as many as eight cyclonic storms in a single year — the highest since 1976 — of which six were recorded as 'very severe' cyclones, each of which affected millions of coastal residents.[6] Last year (2020), the catastrophic 'Extremely Severe Cyclonic Storm' (Cyclone Amphan) ravaged the state of West Bengal in the month of May. It caused widespread damage to the region amidst the coronavirus pandemic, the economic losses in the region were estimated at around USD 13.2 billion.[7] The event also caused severe disruptions in the port supply-chains and logistics of the Kolkata Port Trust (KoPT), which had to suspended cargo operations and railway operations, while the Central Permit Office had to kept shut for more than 24 hours so as to prevent further damage to the port's infrastructure. Similarly, the port authorities at Visakhapatnam, Gangavaram, Sandheads, Dhamra, and Paradip Port Trust and Gopalpur Port had to take precautionary measures, wherein all cargo-handling operations and all of inbound and outbound movements of vessels were suspended.[8] Despite adopting all precautionary measures, port-infrastructure at Haldia, Budge Budge and at Kukrahati suffered significant damage.[9] Several port services remained disrupted even after the cyclone. For instance, damage to the roads caused significant hindrance to the movement of trucks to the port, vital internet services remained unavailable, and consequent supply-chain disruptions posed large delays in the provision of essential services.

(c) Ports are critical nodes in the supply chain of public services as well as private sector goods for urban agglomerations in their vicinity. There are a number of cases of severe climate-induced damage and disruption to ports around the world, which India — and the executive structures of SAGARMALA — need to learn lessons from. Several of these cases are from countries that are generally considered to be 'advanced' in port operations and yet illustrate a striking lack of resilience. For instance, in 2005, Hurricane Katrina made landfall at Hallandale Beach, Florida, USA, causing a major devastation at the port of New Orleans, which was a critical node for the export of agricultural crops like wheat, corn, and

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[5] Business Line Staff, "Climate Change can cost India 2.8% of GDP by 2050", *Business Line*, 28 June, 2018, https://www.thehindubusinessline.com/economy/climate-change-can-cost-india-28-of-gdp-by-2050-world-bank/article24282307.ece

[6] Kunal Kambli, "Throwback to a Stormy Year: A Look at the 8 North Indian Ocean Cyclones of 2019", *India News,* 03 Jan 2020, https://weather.com/en-IN/india/news/news/2020-01-03-stormy-year-8-north-indian-ocean-cyclones-2019

[7] Vedika Sud and Prema Rajaram, "Cyclone Amphan Caused an Estimated $13.2 Billion in Damage in India's West Bengal: Government Source", CNN, 22 May 2020, https://edition.cnn.com/2020/05/22/weather/cyclone-amphan-damage-intl-hnk/index.html

[8] "Kolkata Port Takes Precautions against Severe Cyclonic Storm Amphan", Maritime Gateway, http://www.maritimegateway.com/kolkata-port-takes-precautions-severe-cyclonic-storm-amphan/

[9] Jayanta Gupta, "Cyclone Amphan: Situation Returning to Normal at Kolkata and Ports", Times of India, 22 May 2020, https://timesofindia.indiatimes.com/city/kolkata/cyclone-amphan-situation-returning-to-normal-at-kolkata-and-haldia-ports/articleshow/75899875.cms

soyabeans.[10] Similarly, the port of Hong Kong suffered an estimated loss of USD 627 million per day in 2018, when Typhoon Mangkhut shut down its nine terminals for two days.[11] Given the concentration of population, assets, and services associated with ports, the consequences are non-linear, and to quantify the loss in socio-economic terms remains challenging. Moreover, the risk of cascading disasters is also high, because the ports and shipping sector is integrated-with and interdependent-upon other sectors. Where India is concerned, it is sobering to reflect upon the fact that even well before the acceleration in the various manifestations of climate change that have already been mentioned, extreme weather events — despite their far lower frequency and intensity at the time — nevertheless had large-scale adverse effects, particularly upon states located on India's eastern coast. As a case in point, a 2011 study found that between the years 1823 and 1900, tropical revolving cyclones and storm surges were a key reason for the decline of ports in Odisha.[12] Unless resilience is an intrinsic and central element of contemporary port development — especially that envisaged via SAGARMALA, — how much greater might be the decline over the foreseeable future, wherein the frequency and ferocity of these types of extreme-weather events is going to be so much higher?

6. **Future Projection**. By 2100, steric sea level *("Steric sea level is the variation of the ocean volume due to density changes (expansion and contraction of water masses), through ocean salinity (halosteric) and ocean temperature (thermosteric) variations")*[13] in the North Indian Ocean is estimated to "rise by about 300 mm relative to the average over 1986-2005 under the RCP 4.5 [mid-range] scenario, with the corresponding projection for the GMSL projected at 180 mm".[14] It would certainly be worse under the 'business-as-usual', high emissions scenario. There are also some inherent uncertainties associated with the melting of the Greenland and Antarctic ice sheets and glaciers, which are notoriously difficult to predict. This notwithstanding, actual observations made over recent decades suggest that climate change is moving much faster and farther than had been predicted in model-based projections. Therefore, it would be wise to prepare for the worst-case sea-level-rise scenarios. Even a marginal increase in the sea level in the Indian Ocean would be enough to threaten millions of livelihoods and billions of dollars' worth of infrastructure. According to one estimate, the

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[10] Austin H Becker, Michele Acciaro, Regina Asariotis, Edgard Cabrera, Laurent Cretegny, Philippe Crist, Miguel Esteban, et al. "A Note on Climate Change Adaptation for Seaports: a Challenge for Global Ports, a Challenge for Global Society", Climatic Change 120, No 4, 2013, 683-695

[11] Yoon Kim and Lindsay Ross, "Ports: An Industry Guide to Enhancing Resilience", Resilience Primer, Four Twenty Seven Inc. and Resilience Shift, UK, March, 2019, ttps://www.resilienceshift.org/wp-content/uploads/2019/10/RP-Ports_Final_Pages.pdf

[12] Tripati Sila, and AS Unnikrishnan, "Role of Cyclones and Other Factors in the Decline of the Ports of Northern Orissa", Current Science, 2011, 305-312

[13] Andrea Storto et al, Paper for the 5th International Conference on Reanalysis, Copernicus Marine Service, https://climate.copernicus.eu/sites/default/files/repository/Events/ICR5/Posters/36_S4_Storto.pdf

[14] R Krishnan, J Sanjay, G Chellappan et al, "Assessment of Climate Change over the Indian Region", Report of the Ministry of Earth Sciences, Government of India, Pune: Springer, 2020

population in Low-Elevation Coastal Zones (LECZ) in India is projected to grow to over 120 million by 2030 and 216 million by 2050.[15]

7. **Incorporating Resilience into SAGARMALA**.

(a) The government of India released its big picture document on SAGARMALA in 2016, with a key emphasis on capacity building, as highlighted in its subtitle, "Ports to Prosperity".[16] The document envisioned the concept of *"port-led development"* as a 'game changer' that would reduce the costs of logistics through the creation of Coastal Economic Zones (CEZs), create efficient multi-modal connectivity, and, further, provide employment opportunities to communities in adjoining areas.

(b) The SAGARMALA initiative does envisage a roadmap for the growing needs of the nation but it does not address the question of uncertainty that may arise due to scenarios such as rising sea-levels, or the non-feasibility of fossil-fuel-based economic models in the coming decades. In the maritime domain, the value of resilience can be understood in various ways, but the basic idea is centred upon tackling this uncertainty and ensuring critical functionality of ports under both normal and extraordinary circumstances. Long-term sustainability of ports is not only critical from an infrastructure resilience point of view, but also from a business accountability perspective. As these environmental threats grow in both scale and frequency, the emphasis on accounting for their impact on business and transparency will grow, and therefore, sustainability-reporting of ports will prove to be critical for stakeholder-engagement.[17] Climate Resilience, therefore, is not merely an adaptive strategy against the vagaries of climate but offers a unique perspective on investment in the future of ports. Therefore, the importance of the proposed 'fifth' pillar of SAGARMALA lies in its focus on the bigger picture of resilience that avoids the trap of short-term policy-making.

(c) On an increasingly global basis, the maritime sector is recognising the importance of long-term sustainability of ports and is responding to the threats of climate change. A study conducted on the port of Rotterdam, Netherlands found that the impact of flooding was to cause a rise of nearly 86 per cent in trading-costs — *excluding* the damage to the infrastructure itself. The Rotterdam City authorities thereafter invested time, effort and money in developing an integrated approach, which was evident from its adoption of

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[15] B Neumann, AT Vafeidis, J Zimmermann , RJ Nicholls, "Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment", *PLoS ONE,* Vol 10, 3 (2015), e0118571, https://doi.org/10.1371/journal.pone.0118571

[16] Ministry of Shipping, "SAGARMALA: The Big Picture", September 2016 http://sagarmala.gov.in/sites/default/files/Sagarmala_the_Big_Picture.pdf

[17] Rüdiger Hahn, and Michael Kühnen, "Determinants of Sustainability Reporting: A Review of Results, Trends, Theory, and Opportunities in an Expanding Field of Research", Journal of Cleaner Production, Vol 59, 2013, 5-21

Rotterdam Climate Proof (2008) and the Rotterdam Climate Change Adaptation Strategy (2013),[18] both of which focus on enhancing resilience by strengthening port infrastructure against storm surges and sea level rise. Likewise, the Port of San Diego (California) designed a 'Climate Mitigation and Adaptation Plan', wherein multiple stakeholders, including nearby communities, were involved in sharing responsibilities to protect critical utilities during emergencies.[19]

(d) In the aftermath of COVID19, the European Sea Ports Organization (ESPO) has released its climate-change adaptation strategy for European ports, which recognises ports as critical infrastructure, and pledges to invest in climate-proofing and the mainstreaming of climate-change adaptation in EU legislation.[20] Many global organisations have also taken cognisance of the climate-resilience aspect of maritime trade and transport. The World Association for Waterborne Transport Infrastructure (PIANC) has set up a special task group that focusses upon the resilience of transport systems, both in maritime and inland waterborne spheres.[21] Likewise, the International Finance Corporation (IFC) initiated a number of case studies and projects, as part of its own 'Climate Risk Series', to understand climate risks and its potential impact on seaborne trade.[22] The United Nations Conference on Trade and Development (UNCTAD), too, has focussed upon climate-change impacts and challenges in port-adaptation as part of its ongoing focus on sustainable transport.

(e) It is important for the SAGARMALA initiative to take a similarly long-term view of port-led development — one which prioritises a risk-based approach to present and future climate-change impacts. The mainstreaming of climate resilience in port-led development models has both strategic and economic benefits. However, port-planning in India currently favours short-term economic benefits instead of resilience and long-term sustainability, which probably remain low priorities because of the high costs for first movers and lack of data-driven analysis of climate risks. Therefore, government led initiatives such as SAGARMALA, which can absorb the first mover risks, are critical for paving the path for private investors.

8. **Way Forward**.

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[18] Rotterdam Climate Initiative, "Rotterdam Climate Change Adaptation Strategy", City of Rotterdam 70, 2013

[19] C Hooven, J Hirsch, M White, D Daugherty, L Moran Messner, and D Kim, "Port of San Diego Climate Mitigation and Adaptation Plan", in *Ad Hoc Expert Meeting on Climate Change Impacts and Adaptation: A Challenge for Global Ports*, reproduced by the United Nations Conference on Trade and Development, Geneva, Switzerland, https://unctad.org/sections/wcmu/docs/AHM2011_2_22_Hooven_en.pdf, 2011

[20] "Climate Change Adaptation Position Paper." 03 September, 2020, ESPO, https://www.espo.be/views/climate-change-adaptation-position-paper

[21] "Resilience of the Maritime and Inland Waterborne Transport System (MIWTS)", PIANC Resilience TG 193, https://www.pianc.org/uploads/files/EnviCom/ToR/ToR-EnviCom-193.pdf

[22] "Account for Climate Risk", International Finance Corporation, World Bank Group

(a) The big-picture objectives of the SAGARMALA programme for port-led economic development, are highly commendable and very promising. However, the success of this ambitious programme, the economies of India's coastal states, and, in fact, the fate of India's Blue Economy, rely heavily upon the long-term stability and security of the port-infrastructure over multiple decades. In view of this, there is an urgent need for government authorities at the centre-, state-, and district-levels to pay focussed attention to ensuring resilience of port-infrastructure against the growing impacts of disasters such as floods, cyclones, and storm surges, compounded by sea-level rise and hotter ocean temperatures, all of which are being exacerbated by man-made (anthropogenic) climate change.

(b) Climate resilience is critical for safeguarding the long-term investments that need to be made in ports. As the threat of climate change intensifies, it will become a key decision-making criterion in the minds of potential investors. The wide range of uncertainties associated with the impacts of climate change, both in terms of the magnitude and the timeframe, make it simultaneously difficult and essential to plan for all possible scenarios. Moreover, the local impacts could vary widely as well, depending on a number of natural factors such as geography, topography, and atmospheric and ocean conditions, as also human-controlled factors such as population density, construction practices, urban planning and management, etc. The solutions, therefore, would have to take into account the uncertainties and the local-level challenges or constraints.

(c) In this context, the National Maritime Foundation has recently initiated a long-term research endeavour to study the impacts of climate change on coastal infrastructure security vis-a-vis the threats to port infrastructure, including the support infrastructure and critical supply chains. The study will develop a resilience-centred policy framework comprising guidelines and tools to incorporate climate resilience during the planning stages of coastal development projects. One of the main focus areas of the study will be to create a generic framework for an efficient top-down approach, where the national-level policy would guide, support, and encourage sustainability and resilience in the development initiatives at the state- and district-level. Additionally, in order to highlight the local-level challenges, a number of case studies will be conducted on some of India's key coastal urban agglomerations — the cities of Visakhapatnam, Kolkata, Mumbai, and Chennai, to name just a few — which are expected to see the greatest increase in infrastructure development activity and are the most vulnerable to extreme weather events. The framework so created will be applied and tested via these case studies in order to create a comprehensive set of policy recommendations relevant to a number of ministries and local authorities of the Government of India.

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