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IMPACT OF FUTURE SEA LEVEL RISE ON COASTAL REAL ESTATE AND INFRASTRUCTURE IN INDIA

An Agenda For Policy And Research

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“Though we have some information about potential SLR impacts along the coastline of few metropolitan cities, we still do not know how much area and how many people will be at risk for various levels of sea level rise scenarios in various other coastal regions of the country. An agenda for research should be on mapping the area and population vulnerable to SLR across every coastal district/ city.”

Key Words: Sea level Rise (SLR), Coastal Real Estate, Disaster Risk Reduction, Financing, Urban Planning

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Sea level rise (SLR) is inevitable and so is the risk to the coastal populations and properties. Along the Indian coast, sea levels are rising faster than the global average. Metropolitan cities like Kolkata, Chennai, Kochi and Mumbai would be the most impacted because of sea level rise in future. Mumbai's sea level is estimated to rise to 0.12m by 2040 and a further by 0.21 m by 2060 compared to 0.04 m in 2020. The rise in sea level along Indian coast will pose risk of flash flooding and submergence of many significant coastal properties and road networks. Mumbai had suffered economic losses worth USD 1.75 billion between 2005 to 2015 due to floods. Developing policies to mitigate and adapt to the impacts of SLR in cities on Indian coastline is necessary. SDG 14 also recognizes the need for sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts. Vulnerability mapping of habitats along the coastline in advance will provide ample time to direct the efforts towards mitigation and adaptation. There is also a need to develop new market-based instruments to finance the cost

of disaster risk mitigation and adaptation.

INTRODUCTION

The average global sea level has increased by 76 mm in the last 25 years due to increasing concentrations of green house gases in the atmosphere (Willoughby et al., 2020). The three primary factors attributed to sea level rise (SLR) globally are thermal expansion, melting glaciers, and the loss of polar ice sheets. The main risks arising from a rising sea level are shoreline erosion and degradation, which are amplified by storm surge, permanent land inundation, and saltwater intrusion. Shoreline erosion can occur since rising sea level causes waves to push further inland, even during low-tide. Due to incessant growth of built areas in coastal towns, the natural channels for storm water to drain into the sea are lost. Furthermore, with high tide, the effect of storms are amplified as storm drains are unable to drain into the sea as the high tide (which coincides with storm) pushes the water back on the land. The rise in water table due to

sea level rise and ineffective natural drainage systems will cause permanent inundation of some parts of coastal land or result in chronic flooding. Intrusion of saltwater in ground water is leading to contamination of drinking water supplies and also damaging local agriculture (Alfarrah and Walraevens, 2018). Internationally, there is evidence that flooding risk causes loss in property values and permanent damage to some properties, which may even increase the cost of insurance (Bin et al., 2011).

The debate in India on the risk to properties in coastal areas due to sea level rise is still in very early stages. The socio-economic impact of sea-level rise on coastal towns and properties depends critically on our understanding of risk and its internalisation, and the measures that are instituted to mitigate the risk. The debate on allocation of risk (whether it's a private risk or a social risk) is also crucial to the design of solutions to mitigate and adapt to the risk. Nevertheless the magnitude of social, economic and property value at risk will require options for mitigation and adaptation to the risk.

In this paper, we argue that there is an urgent need to develop appropriate mitigation and adaptation strategies to address the risk that the sea level rise poses.

Section 2 briefly discusses the impact of sea level rise globally and in India on habitats and population. Through literature review, Section 3 highlights the towns and cities that will be highly impacted by sea level rise along the Indian coast. Mitigation and adapting measures will depend on the availability of finance. The financing of disaster management is discussed in section 4. Section 5 discussed the policy development that has impact on disaster risk management. Disaster risk management requires urban planning tools, as highlighted in Section 6. Market mechanisms to complement public finance are discussed in section 7. Section 8 presents preliminary conclusions and an agenda for policy and research.

SEA LEVEL RISE AND ITS PREDICTED IMPACT ON HUMANS AND THEIR HABITATS

The sea-level rise is inevitable and so is the risk to the coastal towns. Even under the most optimistic scenario and implementation of strategies to immediately cut carbon emissions, the sea level could still rise by another 0.5m by 2100 (Kulp and Strauss, 2019). Translating projections related to sea level rise into potential exposure of population to the risk posed by incidences of

flooding in coastal town and cities is critical for coastal planning and for assessing the benefits of climate mitigation measures as well as the costs of failure to act (Kulp and Strauss, 2019). At the global level, the total number of people living in areas which will be affected by flooding caused by sea level rise has been estimated to be 300 million by 2050, and 480 million by 2100 (Kulp and Strauss, 2019). These effects are not distributed uniformly across regions but there are geographical concentration. More than 70% of affected persons will be in eight Asian countries – China, Bangladesh, India, Thailand, Indonesia, Vietnam, Philippines and Japan (Kulp and Strauss, 2019).

Along the Indian coast, sea levels are rising faster than the global average (WMO, 2022). 36 million people who will live in coastal areas in India by 2100 will be affected by coastal flooding and inundation as a result of sea level rise, even if moderate cuts in CO₂ emissions are undertaken (Jayraman, 2019). This is about 8% of the world's population that will be affected by sea level rise. Metropolitan cities like Kolkata (population 4.5 million as per 2011 census), Chennai (population 4.6 million as per 2011 census), Kochi (population 0.6 million

as per 2011 census) and Mumbai (population 12.48 million as per 2011 census) would be the most impacted because of sea level rise in future (Jayraman, 2019). On the east coast of India, sea levels have risen at a rate of 30 mm per year in the Sundarbans delta in the last two decades, leading to 12% loss in the shoreline and causing displacement to approximately 1.5 million people from the delta (Sangomla, 2022).

MAPPING SEA LEVEL RISE ON INDIAN COAST

NASA (National Aeronautics and Space Administration) has developed a visualization

tool which showcases the impact of sea level rise along the Indian coast using IPCC (Intergovernmental Panel on Climate Change) projections (Figure 1). Key observations related to the sea level rise on Indian coast, according to NASA, are (<https://www.hindustantimes.com/environment/nasa-visualises-how-sea-levels-will-rise-in-indian-coastal-regions-101629257135231.html>):

1. By 2040, Mumbai's sea level will rise to 0.12m (Figure 1) and by 2060 it will rise to 0.21 m compared to 0.04m in 2020 based on an intermediate emission

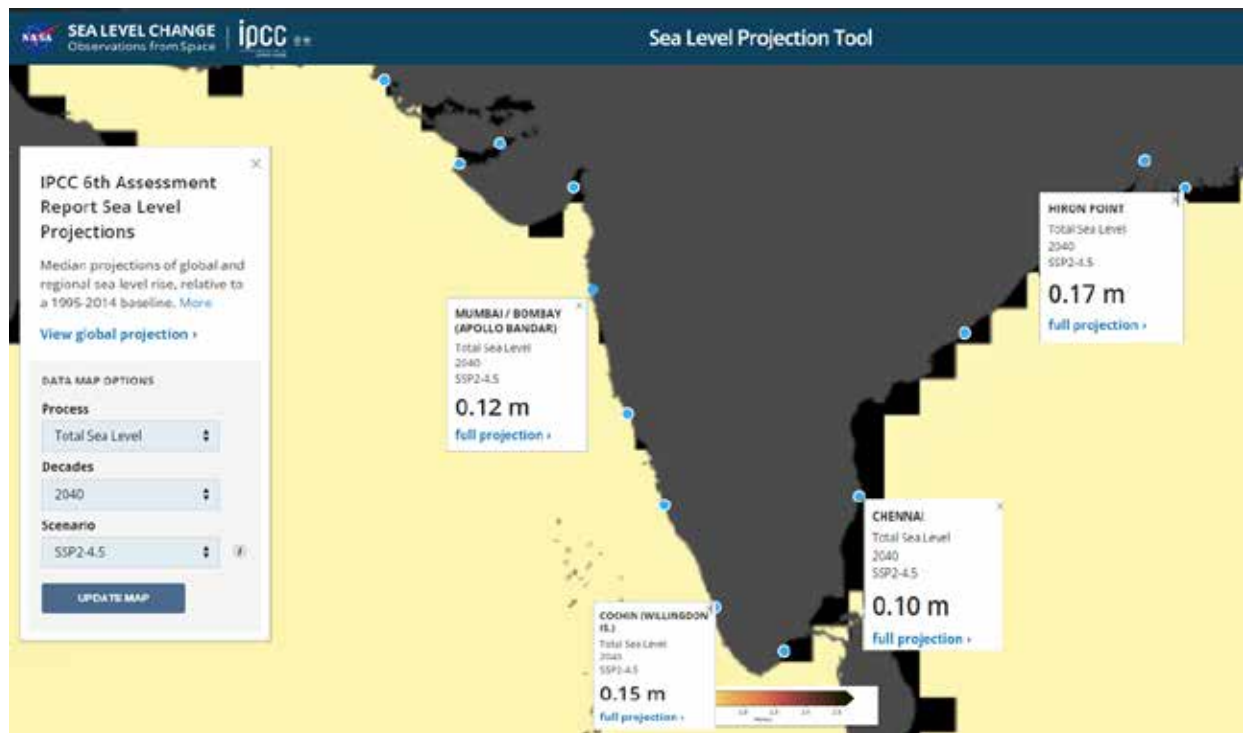
scenario (SSP2-4.5).

2. At Hiron Point in Sundarbans sea level will rise to 0.17m in 2040 compared to 0.06m in 2020 (Figure 1).
3. Chennai will see a 0.10m rise in 2040 compared to 0.03m in 2020 (Figure 1).
4. Cochin will likely see a sea level rise of 0.15m in 2040 compared to 0.06m (Figure 1).

IMPACT OF SEA LEVEL RISE ON COASTAL REAL ESTATE AND INFRASTRUCTURE

While a comprehensive modelling of the impact of sea

Figure 1: SLR visualization along the Indian coast



Source: Authors based on NASA, 2022

level rise on properties along the coast is not available, disparate information suggest that the rise in sea level along Indian coast will pose significant risk of flash flooding and submergence of many of the significant coastal properties and road networks. For example, 998 buildings and 24 km of road network in Mumbai will be impacted by future rise in sea levels by 2050 (Deccan Herald, 2022). During high tide, the number of buildings and road-length in Mumbai that would face the threat of submergence in the future SLR scenario rises to 2490 and 126 km respectively (RMSI, 2022). Key coastal properties under threat due to the SLR include Haji Ali Dargah, Jawaharlal Nehru Port Trust, Bandra-Worli Sea Link and the Western Express Highway. Similarly, 55 buildings in Chennai; 464 buildings in Kochi; 349 buildings in Trivandrum and 206 buildings in Visakhapatnam will be under risk of submergence due to SLR by 2050 (RMSI, 2022). Majority of these buildings will be residential complexes thereby impacting lives and livelihoods of many people. The flash floods which submerged Chennai in November 2015 caused economic losses to the extent of USD 2.2 billion (Business Line, 2018), making these floods most expensive ones in 2015. The insurance claims

by those who had insurance in Chennai was close to 1 billion USD (https://www.business-standard.com/article/current-affairs/chennai-floods-insurance-claims-touch-rs-4-800-crore-116012201026_1.html). This is huge considering that the penetration rate of non-life insurance in India is merely 1% (<https://www.statista.com/statistics/655395/life-and-non-life-insurance-penetration-india/>). Mumbai had suffered economic losses worth USD 1.75 billion between 2005 to 2015 due to floods (Pandey, 2019). The coastal megacities (having more than 10 million population) are losing at least USD 6 billion every year due to extreme flooding events and these losses will increase to USD 1 trillion annually by 2050 if no coping/adaptation strategies are developed and implemented in time (Pandey, 2019).

THE FUNDING GAP

The risk that the sea level rise poses will require disaster management efforts at the societal and individual property owner's level. Considering the scale of the funds required for disaster management (flooding is just one component of disasters that requires management besides drought, groundwater salinity, loss of land/revenue, damage to the infrastructure etc.), the Government of

India has established a total corpus of Rs. 1601 billion (USD 20 billion) for States for disaster management for the duration of 2021-26, of which the Union share is Rs. 1226 billion (USD 15 billion) and States share is Rs. 375 billion (USD 5 billion). This is as per the recommendations of 15th Finance Commission (XV-FC). In addition, the Commission has recommended that for cities with million plus population, a separate fund should be established. So far as the allocation of funds is concerned, the XV-FC has recommended allocation of Rs. 15 billion (USD 0.19 billion) to mitigate the risk of erosion across Indian states and Rs. 10 billion (USD 130 million) for re-settlement of people affected by erosion. In addition, the Commission has recommended allocation of Rs. 5 billion (USD 63 million) each to three most populous Indian coastal cities viz. Mumbai, Kolkata and Chennai for reducing the risk of flooding. When seen relative to the value of economic losses faced in Chennai and Mumbai, these funds are insufficient. The Commission also recommended employing market-based risk management instruments such as insurance schemes for providing financial assistance and relief against the disasters. XV-FC had proposed four insurance interventions, viz. National

Insurance scheme for Disaster related deaths, Synchronising Relief assistance with Crop insurance, Risk Pool for infrastructure protection & recovery, and Access to International Reinsurance for outlier hazard events. These insurance schemes will supposedly provide an additional layer of protection to people in the event of disasters.

While the recommendations of 15th Finance Commission mark an important beginning for proactive disaster management in India, the allocation of funds are inadequate considering the needs. The XV-FC has recommended establishment of separate funds at centre and state level, with major share being retained by the centre. The Finance Commission has stressed strengthening of local governing bodies would be necessary for implementation of disaster management plans. The non financial role for disaster risk management has been allocated to district disaster management authorities (DDMA) (Borah, 2020).

DISASTER MANAGEMENT POLICIES

The Sendai framework for disaster risk reduction 2015–2030, to which 187 countries are signatories, advocates 'substantial

reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries' (UN, 2015, 9). It emphasises 'enhancing disaster preparedness for better response and "build-back-better" in recovery, rehabilitation and reconstruction' as one of the four priority actions (UN, 2015, 11). Addressing the priorities for action proposed by the Sendai framework, India has prepared its National Disaster Management Plan (NDMP), 2016. Basing on the vision for the Sendai framework, India's NDMP aims to 'make India disaster resilient, achieve substantial disaster risk reduction, and significantly decrease the losses of life, livelihoods, and assets—economic, physical, social, cultural, and environmental—by maximising the ability to cope with disasters at all levels of administration as well as among communities (NDMA, 2016, 14).' Resilience at the administrative and community level is an important component of NDMP. While prevention of disasters is a major component of the plan, disasters in their entirety cannot be eliminated. Based on the National Policy for Disaster Management 2009 (NDMA, 2009), NDMP also provides a framework

for recovery and build-back-better. The framework provides for speedy, participative, inclusive reconstruction of housing and infrastructure and recognises the importance of rebuilding lives and livelihood of communities, and lists salient provisions of disaster recovery framework, but it lacks comprehensive rebuilding of all aspects of losses that disaster affected persons face.

No two disasters are similar and no two disaster risk would require similar response. Developing policies to mitigate and adapt to the impacts of SLR in cities is necessary, which requires data. The programs for mitigation and adaptation would emerge from policies. Given the limited availability of public finance for disaster management, vulnerability mapping of habitats along the coastline in advance will help in prioritising areas where disaster management efforts are required. With proper planning, risk to lives and livelihoods could be eliminated. We have an example of Odisha, a state along the eastern coast of India. The state has a coastline of 550 km out of which 28% was impacted by erosion during 1990 and 2016 (Panda, 2020). The villages of Satabhaya in Kendrapada district of Odisha suffered

heavy erosion due to SLR. The State launched a Resettlement and Rehabilitation Policy in 2011 for 571 affected families. These families were popular as India's first "climate refugees", and were compensated with houses, agricultural plots and other facilities at a place 12 km away from Satabhaya (Panda, 2020). With SLR in future, there will be many more climate refugees which needs to be saved and rehabilitated. We need to plan in advance for them.

THE ROLE OF URBAN PLANNING

Planning of coasts is a controversial issue given the importance of coasts in local economy. The Indian coastline underwent substantial modification due to an upsurge in developmental activities, which coupled with SLR, has led to severe coastal erosion. India has already lost 235 km² of land to coastal erosion between 1990 and 2016 (Panda, 2020). In 2019, the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India diluted the coastal protection rules [Earlier rules prohibited construction activity within the 100 metres of the High Tide Line (HTL), however, the new rules notified by the Ministry changed the no development zone to 10 metres from the HTL], thereby allowing more

construction of properties in the coastal zones potentially vulnerable to SLR. These coastal properties will be exposed to future sea level rise and associated flooding.

Urban planning provides an important instrument for sea level rise risk mitigation/adaptation efforts. The disaster management process should focus on sustainable adaptation which can ensure "socially and environmentally sustainable development pathways including both social justice and environmental integrity" (Hurlimann et al., 2014). The disaster risk reduction should be mainstreamed in all the development plans for coastal regions. Gradually the attempt should be to radically expand and enhance disaster risk reduction so that it becomes a normal routine exercise and fully institutionalized within the development agenda. The plans should include both structural and non-structural mitigation and adaptation measures. Structural mitigation measures would require investment on development of robust engineering measures which can resist the impact of hazard. Such measures, if developed in consonance with natural environment, will be long-lasting and more fruitful. Non-structural mitigation measures would involve expenditure on awareness

and capacity building, development of an early warning system, disaster risk reduction (DRR) policies, insurance mechanism to cover the loss of lives and properties. Adaptation efforts would require development of regional coastal adaptation plans outlining the potential risks due to SLR as well as strategies which can be adopted to address them. This part will also require funding towards development of community-led adaptation projects so that shortcomings in the efforts at local scale could be identified and remediated.

India has notified Coastal Regulation Zones (CRZ) regulations in 1991 dividing the landward area upto 500 meters from high tide line (HTL) into four zones and restricting the economic activities in each of these zones as per their ecological sensitivity (<https://www.thehindu.com/features/homes-and-gardens/Building-norms-for-coastal-zones/article14428006.ece>). CRZ-I include areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life. No new construction is permitted in

CRZ-I areas except (a) projects relating to the Department of Atomic Energy; (b) pipelines, conveying systems including transmission lines; and (c) exploration and extraction of oil and natural gas. CRZ-II covers areas that have already been developed up to or close to the shoreline. Construction of buildings is allowed in this zone but only on the landward side of the existing road or on the landward side of existing authorised structures. These newly constructed buildings shall have to adhere with the existing local town and country planning regulations including the existing norms of floor space index (FSI)/ floor area ratio (FAR). CRZ-III include rural coastal villages and coastal areas within municipal limits. In CRZ-III, areas upto 200 meters from the HTL are categorised as 'No Development Zone'. However, activities like agriculture, horticulture, salt-manufacturing are allowed. The land area between 200-500 meter falling in CRZ-III can be used for building constructions; however, only with approval from the MoEFCC (Ministry of Environment, Forests and Climate Change), Government of India. In addition, the construction activities between 200 and 500 metres of the HTL can be taken up if they follow the regulation that the total number of dwelling units

shall not be more than twice the number of existing units, the total covered area on all floors shall not exceed 33 per cent of the plot size, the overall height of construction shall not exceed 9 metres, and the construction shall not be more than 2 floors (ground plus one). CRZ-IV includes coastal areas in the Andaman & Nicobar (A& N), Lakshadweep and small islands, which are not regulated under CRZ-I, CRZ-II, or CRZ-III. In A&N islands, no new construction is allowed within 200 meter of HTL. Buildings can be constructed between 200 and 500 metres from the HTL but they will not have more than 2 floors, the total covered area on all floors will not be more than 50 per cent of the plot size, and the total height of construction should not exceed 9 metres. In Lakshadweep and small islands, construction may be allowed depending on the distance from the HTL and the size of the islands (Sundar, 2016). These regulations have been modified in 2019 by the Government to some extent with permission of construction allowed in some cases to even within 10 m of the HTL which further has accentuated the need to strengthen the planning regulations.

DEVELOPMENT OF PRIVATE MARKET FOR

FINANCING SLR RISK

The financing of disaster management assumes paramount importance in order to develop and implement mitigation/adaptation plans. In India, the source of most of the disaster management funding is government. The funding from the government is mostly directed towards relief and rehabilitation efforts. There is need for pre-emptive planning so that the shocks resulting from SLR can be sustainably absorbed by the coastal communities. Though disaster management authorities (both at central and state levels) have contributed to funding the cost of disaster management, there is a big gap between the requirements and availability of funds. Finance for disaster management in private markets through instruments such as insurance has been largely absent in India. Today, we can find a number of opportunities for private investment in the coastal risk reduction sector. For example, the private investment can be directly targeted to developing resilience for local business or asset. Concessional financing and blended finance opportunities enable private investors to invest in such projects. Concessional finance has been defined as below market rate finance provided by

major financial institutions, such as development banks and multilateral institutions to developing countries to accelerate development objectives (World Bank, 2021). Grants, loans and equity investments are the most common type of concessional finance products. Concessional finance can help in addressing the globally significant development challenges such as climate change mitigation. Blended financing refers to the strategic use of public and philanthropic resources to mobilise private capital for development purposes (Kandasamy, 2022). This type of financing mechanism encourages the involvement of private investors along with public funding instruments in identifying and executing development projects. This type of financing structure typically involve use of instruments like grant capital, debt and equity. Blended financing has several benefits like pooling capital through various/multiple investors which may help in reducing the overall risk and enhance the success rate; and ensuring that projects succeed on achieving social and environmental objectives in addition to financial ones (Kandasamy, 2022).

In particular, when partnering on coastal resilience projects, financial institutions

could adjust cost of capital available for the private sector by adjusting premiums depending on whether the proposed investment includes nature-based solutions (such as development of mangrove corridor along the intertidal zone or belt of Casuarina plantations along the beach to protect the hinterland) and how this increases resilience. The emerging blue carbon market—which businesses are now looking at to offset some of their emissions—is also an opportunity to attract finance for the restoration and protection of coastal marine ecosystems. Development of an insurance market to cover the risk of SLR in coastal areas is another lucrative opportunity. The insurance industry need to understand and appropriately value the risk reduction achieved from natural coastal infrastructure investments, so as to price insurance products appropriately. The insurance market can be developed in following ways (<https://climatechampions.unfccc.int/a-guide-to-private-sector-investment-in-coastal-resilience/>):

1. The construction of natural coastal infrastructure can be financed by an institution/player so that the insurance premiums can be reduced.
2. Financial institutions

can mandate investees or borrowers to go for nature-based insurance.

3. Adoption of parametric insurance mechanism (a type of cover that pays out a pre-agreed amount to a policyholder according to pre-defined event characteristics or parameters) under which the damage to the policyholder is covered as per the incidence (such as storm surge, cyclone).

CONCLUSION

The coastal areas in India will face the risk of sea level rise in the not-so-distant future. This will impact the value of built assets on the coast adversely. Planning and investment at the coastal region and local building level will be necessary to mitigate and adapt to the risk. It is, therefore, important to develop mechanisms which could integrate mitigation and adaptation strategies in the development plans of coastal regions. At the property level, it is important that new market-based instruments are developed that will allow property owners to cover the potential losses. Financing of development plans will require that innovative financing mechanisms such as blue finance, blended finance, concessional financing, etc. are leveraged. These will help in developing

nature-based resilience to SLR. The coastal areas offer immense opportunities for economic gains, which creates opportunities for private players in financing of the risks posed by the SLR.

The Goal no. 14 of the United Nations 2030 Development Agenda- the Sustainable Development Goals (SDG)-calls upon member nations to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development', by sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action. There is, therefore, need to develop research and evidence based policies to mitigate and adapt to the threat of rising sea levels. Though we have some information about potential SLR impacts along the coastline of few metropolitan cities, we still do not know how much area and how many people will be at risk for various levels of sea level rise scenarios in various other coastal regions of the country. An agenda for research should be on mapping the area and population vulnerable to SLR across every coastal district/city. This will help integrate the concept of DRR at the local level of planning and governance and every district/city will be able to

develop an action plan to mitigate/adapt to the risk of SLR and also estimate the resources (financial, physical and capacity) required to address the risk. The policy and research agenda should also focus on developing market-based instruments to finance the risk reduction measures. Private investors may be attracted to invest in nature-based solutions if they are financially viable. Pooling various investors with differing risk-return profiles and investment sources can bridge the funding gap. Finance for disaster management in private markets through instruments such as insurance has been largely absent in India. New insurance products (like parametric insurance) could be designed to cover the losses due to various events. However, the first step is to estimate the cost of mitigation and adaptation risk that coastal towns and cities face. In terms of measures that can be used for mitigation and adaptation of risk associated with sea level rise, international best practices could be reviewed. A holistic approach incorporating physical, socio-economical and financial aspects of the SLR risks will go a long way in protecting lives, livelihoods and coastal infrastructure against the eminent risk of sea level rise.

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